Lake McCarrons Aquatic Invasive Species Management Plan

Capitol Region Watershed District
Saint Paul, MN

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Prepared for:

Capitol Region Watershed District

1410 Energy Park Drive,
Suite 4
St. Paul, MN 55108

WENCK

Responsive partner.
Exceptional outcomes.

Prepared by:
Tom Langer

WENCK
7500 Olson Memorial Hwy Suite 300
Golden Valley, MN 55427
Phone: 763-252-6800
Fax: 763-479-4242

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1.0 Introduction

1.1 Project Purpose

Lake McCarrons is a 73-acre lake located in Roseville, Minnesota. Lake McCarrons is known to have established populations of three aquatic invasive species (AIS): Eurasian watermilfoil (*Myriophyllum spicatum; EWM*), curlyleaf pondweed (*Potamogeton crispus; CLP*) and common carp (*Cyprinus carpio*). As the only lake within the Capitol Region Watershed District (the District) with a public boat launch, Lake McCarrons is likely the most prone to further introduction of AIS as human boat traffic is a primary vector of AIS movement across the landscape. In 2014 and 2015 the District was involved with harvesting of aquatic plants (including AIS) for the sole purpose of increased recreation access. Through this involvement it became apparent to the District that consideration of AIS and their influence on Lake McCarrons should be an important aspect of active management on Lake McCarrons.

The District's mission is to protect, manage and improve the water resources within the watershed. With growing concern of AIS within the state of Minnesota, the District identified a need to develop an AIS management plan for Lake McCarrons. The goal of this plan is to develop a framework to managing AIS that:

- Controls existing AIS populations within Lake McCarrons
- Prevents the introduction of new AIS into Lake McCarrons
- Includes current and unforeseen AIS
- Involves multiple stakeholder groups

Efforts to minimize the influence of AIS across the state are being researched with new techniques and methods being pursued, therefore this plan provides the current state of knowledge and is meant to be updated and complimented with new data and information as it becomes available. The sections of the plan include:

- Section 2.0 provides an overview of the current condition of Lake McCarrons, outlining the water quality and biological condition of Lake McCarrons. This section provides context to the importance of AIS management and protection initiatives for Lake McCarrons.

- Section 3.0 outlines an AIS management framework developed specifically for this project. This section provides a general breakdown of the framework and how it will be used to manage AIS.

- Section 4.0 discusses the evaluation and determination of appropriate actions for managing AIS populations pertaining to Lake McCarrons. This section follows the AIS management framework outlined in Section 3.0.

2.0 Current State of Lake McCarrons

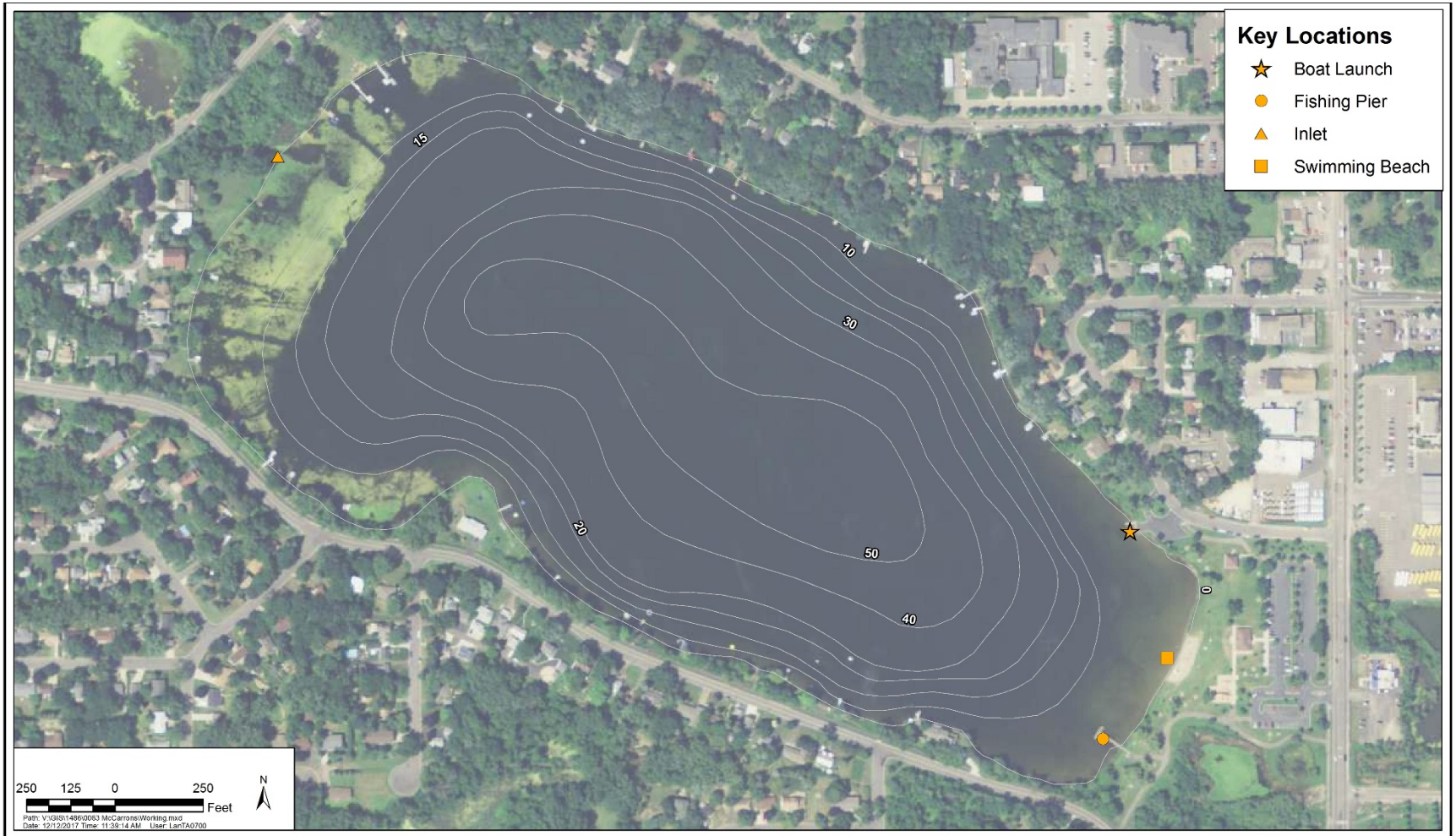
Deep lakes of Minnesota persist across a continuum of water quality and biological health, from clear waters and highly diverse native biotic communities to turbid algal-dominated waters with little biotic diversity. A healthy lake ecosystem provides numerous ecosystem services from foraging, spawning and nursery habitats for fish, macroinvertebrates, and waterfowl, to the sequestering and recycling of nutrients, carbon, and pollutants, to various aesthetic and recreational opportunities. Water quality and biotic community conditions within the lake serve as surrogates to quantify the condition of these ecosystem services and the overall health of the lake. This section provides a general description of Lake McCarrons and the condition of water quality and biotic communities within the lake. Understanding the current health of Lake McCarrons provides context and value to restoration and protection initiatives.

2.1 Overview of Lake McCarrons

Lake McCarrons is a deep lake with sharp depth changes along the north and south shorelines, gradual depth changes along the east and west shorelines, and a deep open water area in the center of the basin (Figure 2-1). These bathymetric characteristics provide various habitat conditions across the basin. The western littoral (depth ≤ 15 ft.) area is comprised of soft sediments, heavy vegetation growth and a stream inlet. The eastern littoral area is comprised of harder sediments, limited vegetation growth, a public park, boat launch and fishing pier. The northern and southern littoral areas are comprised of residential landscape and a narrow band of aquatic vegetation growth. This diversity of habitats and substrate within the basin support various native species and, consequently, non-native AIS as well. Due to the lake's diverse habitat, no single species is believed to be able to dominate the entire basin.

2.2 Water Quality

Water quality condition in Minnesota lakes is evaluated using three parameters: total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth. TP is a limiting nutrient for algal growth in lakes, Chl-a correlates to algal biomass as it is the primary pigment in aquatic algae, and secchi depth is a physical measurement of water clarity. These parameters are interrelated and serve as proxies to describe water clarity and lake productivity, therefore, as nutrient and lake productivity increase we typically see an increase in TP and Chl-a concentrations and a decrease in Secchi depth and water clarity. The decrease in water clarity due to algal production equates to a decrease in light penetration through the water column causing a shading effect on the submerged aquatic vegetation (SAV) community. SAV communities impacted by light limitation often have reduced species richness, a decreased vegetation coverage, biomass and maximum growing depth, and have growing conditions that favor turbid tolerant species. A loss in SAV also has cascading impacts up the food web to other communities (fish, invertebrates, waterfowl) within the lake.



CAPITOL REGION WATERSHED DISTRICT	WENCK ASSOCIATES Responsive partner. Exceptional outcomes.	DECEMBER 2017
Lake McCarrons		Figure

Figure 2-1. Bathymetry of Lake McCarrons and main AIS vectors into the lake.

2.2.1 Lake McCarrons Water Quality Condition

The water quality of Lake McCarrons has been a focus of monitoring since the late 1980s. Early monitoring records documented elevated TP and Chl-a concentrations and poor Secchi depth suggesting a poor water quality condition. In response to impaired water quality conditions, the District pursued an aluminum sulfate treatment in 2004. Since 2004 the lake has significantly improved in water quality and no longer exceeds impairment threshold for Secchi, TP and Chl-a (Figure 2-2). Current water quality conditions of the lake are supportive of a healthy aquatic ecosystem.

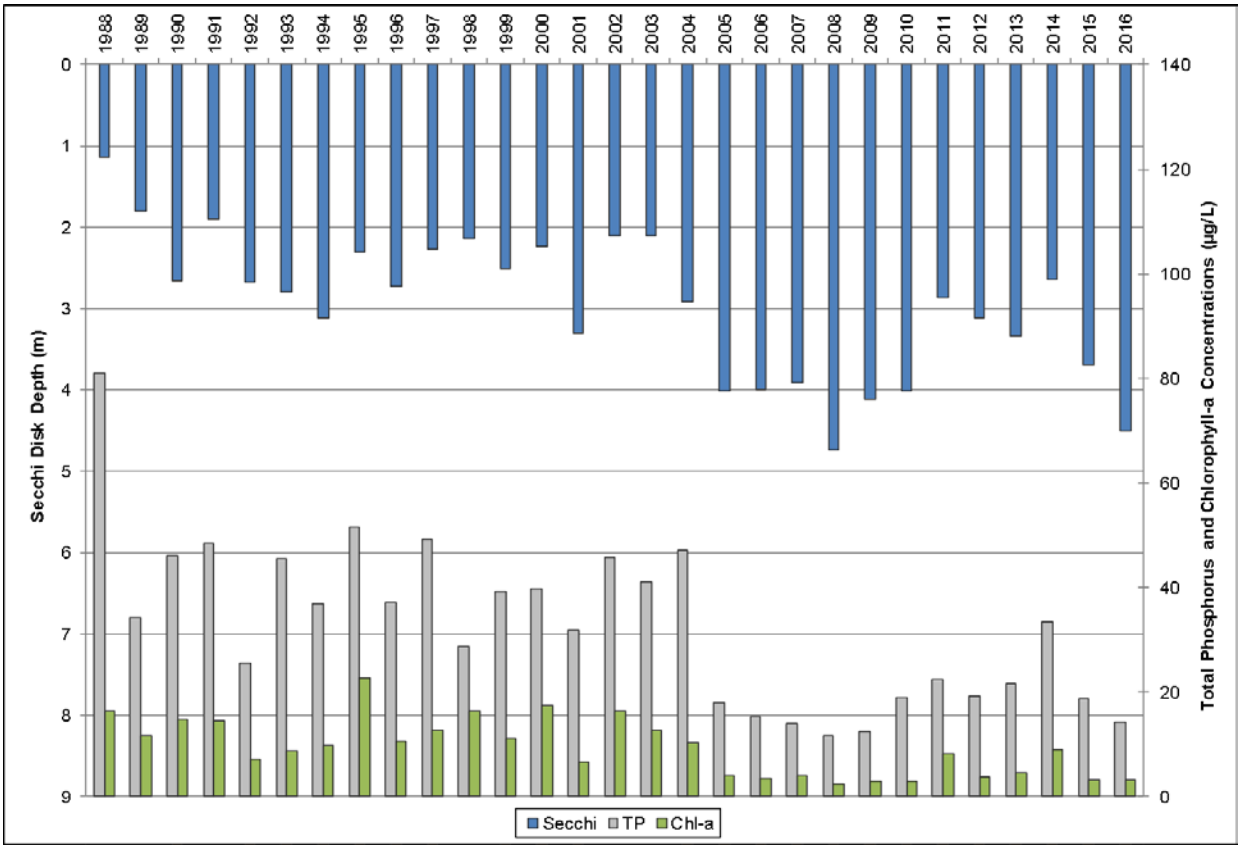


Figure 2-2. Lake McCarrons historical annual average Secchi/TP/Chl-a comparison. Image copied (CRWD, 2016).

2.3 Biotic Communities

Biotic communities play an important role in maintaining water quality and ecosystem health. Healthy, native, and diverse vegetation, fish and invertebrate communities support greater ecosystem resilience to disturbances and promote water quality. AIS can diminish the services provided by a healthy ecosystem by displacing native organisms, altering food webs, and impairing recreational opportunities. However, drastic shifts in ecosystem functions do not always occur and AIS can coexist with native species below detrimental densities. The Minnesota Department of Natural Resources (MnDNR) has developed tools that utilize biotic community based information (AIS included) to monitor and evaluate the health of the lake ecosystems through an organism-disturbance framework. These tools provide a numeric score based on the community composition that can be compared to impairment thresholds to quantify lake health from a biotic perspective.

2.3.1 Lake McCarrons Vegetation Community Condition

Many people perceive SAV as "weeds" portraying a negative connotation to vegetation in lakes. While nuisance levels of AIS and other SAV can diminish lake health, understanding the importance of SAV as habitat, food, a nutrient recycler and a sediment stabilizer provides value to restoration and/or protection initiatives (Figure 2-3).

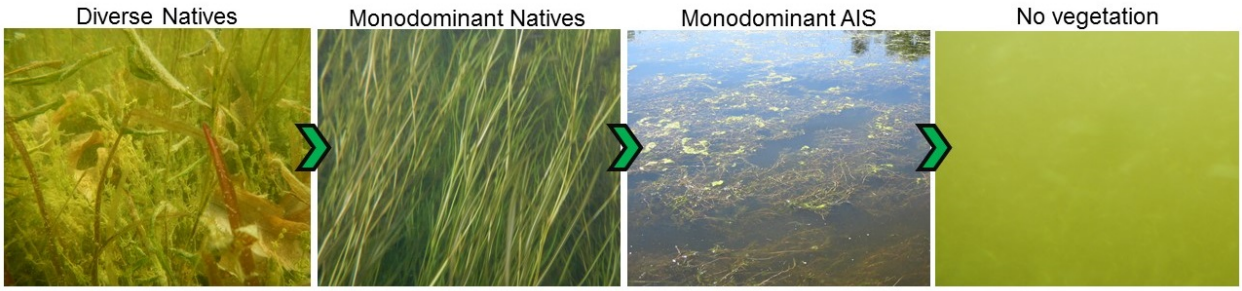


Figure 2-3. Biotic community health continuum portrayed using submerged aquatic vegetation.

The MnDNR's Floristic Quality Index (FQI) is an assessment tool used to determine the biological health of the SAV community. The FQI utilizes species richness and the habitat specificity (C-score) of each species identified to score community health (Equation 1). Scores are compared to a threshold for context and classification of biological impairment status. Greater scores typically are comprised of diverse native communities with decreased scores losing diversity and increasing monodominant communities to habitat patches void of species (Figure 2.3).

Equation 1. $FQI = \overline{C_{Score}} * \sqrt{No.of\ Species}$

Point intercept surveys were conducted every summer month from 2014-2016 on Lake McCarrons. During a given survey year, 11-14 species of submerged and floating leaf species were observed within Lake McCarrons. The majority of the vegetation growth has been observed within the western littoral area of the lake and supported high occurrences of coontail and EWM. The vegetation community did not meet the biological impairment thresholds for FQI in 2014- 2016 and for species richness in 2014- 2015 (Table 2-1) suggesting impairment in aquatic life for vegetation within the lake.

Impaired FQI scores are the result of observing a reduced number of species and/or the current species observed having relatively low C-scores (common species). Lake McCarrons' vegetation community would benefit from increased species richness and/or an increased presence of more habitat specific species. Impaired FQI scores are most often associated with external nutrient loading, internal nutrient loads, and/or other human disturbances (i.e. watershed disturbances, shoreline degradation, SAV treatments, AIS introductions) to the vegetation community. With recent improvements to the water clarity of Lake McCarrons, impaired vegetation communities are not believed to be the result of current water clarity conditions in the lake, therefore other factors are likely more limiting to the SAV community.

Table 2-1. Lake McCarrons averaged frequency of occurrence from annual sampling efforts and corresponding floristic quality index summary.

FQI Score			16.6	16.0	18.2
FQI Status			Impaired	Impaired	Impaired
Species Richness			11	11	14
Species Richness Status			Impaired	Impaired	Supporting
Common Name	**Scientific Name**	**C-Score**	**2014**	**2015**	**2016**
Coontail	*Ceratophyllum demersum*	3	49.8	44.7	56.3
Muskgrass	*Chara sp.*	7	9.8	--	3.7
Canada waterweed	*Elodea canadensis*	3	1.7	1.4	1.7
Lesser duckweed	*Lemna minor*	5	--	--	11.0
Eurasian watermilfoil	*Myriophyllum spicatum*	3	42.2	69.9	52.3
Slender naiad	*Najas flexilis*	6	17.6	17.1	16.7
White water lily	*Nymphaea odorata*	6	4.8	7.9	14.3
Sago Pondweed	*Potamogeton pectinata*	3	--	--	4.0
Large leaf pondweed	*Potomogeton amplifolius*	7	3.3	13.5	--
Curly-leaf pondweed	*Potomogeton crispus*	3	1.7	17.8	4.0
Leafy pondweed	*Potomogeton foliosus*	6	4.9	1.3	12.7
Clasping pondweed	*Potomogeton richardsonii*	5	6.3	1.3	8.0
White-water Crowfoot	*Ranunculus aquatilis*	7	--	--	4.3
Wild celery	*Valisneria americana*	6	4.8	5.4	10.3
Watermeal	*Wolffia spp*	6	--	1.3	6.3

*MnDNR deep lake impairment threshold for 2b Ecoregion FQI = 18.6, species richness = 12.

2.3.2 Lake McCarrons Fish Community Condition

Indices of Biotic Integrity (IBIs) are currently being developed by the MnDNR to assess the health of fish communities in deep lakes throughout Minnesota. Lake McCarrons does not fit the minimum size requirement (>100 acres) to be considered an assessable lake with current IBIs. However, trap and gill net surveys have been conducted on the lake allowing inferential assessment of the fish community within the lake. A community comprised of many species from different trophic guilds is viewed as healthy and supporting of ecosystem services.

11 recorded trap and gill net surveys have been conducted on Lake McCarrons since the 1950s. Throughout these surveys a total 19 different species have been observed within the lake with swings in community balance (Figures 2-4). The most recent 2016 survey observed 11 species and a relatively balanced fishery between trophic guilds. A variety of total lengths were observed within these species classifications suggesting that multiple year classes also exist with the lake. Surveys observed a limited amount of benthivore species (i.e. carp, bullhead). These results suggest that the fishery on lake McCarrons is in relatively good condition.

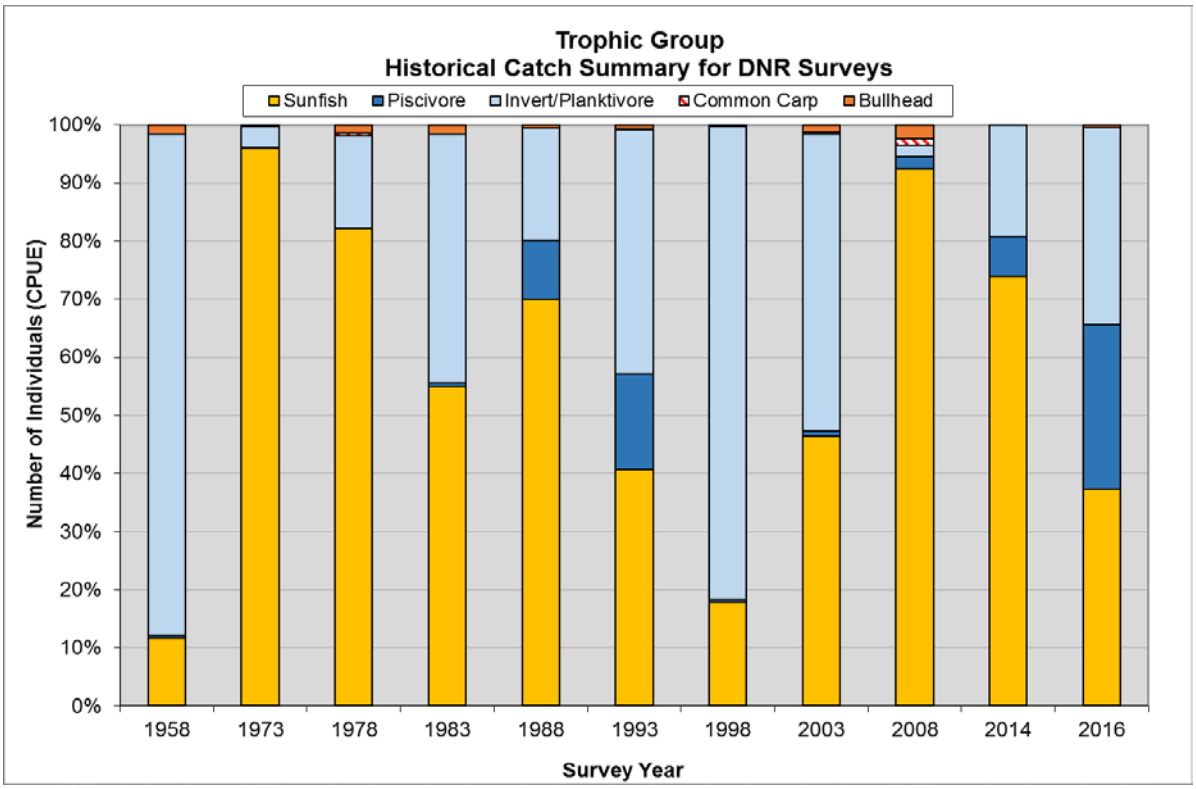


Figure 2-4. Lake McCarrons total fish catch summaries by species or trophic guild.

2.4 Summary of Current Conditions

Overall the current condition of water quality and biotic communities within Lake McCarrons suggest a relatively healthy ecosystem. Lake management activities should focus on protection and enhancement to continue promoting water quality and a healthy lake ecosystem.

- McCarrons provides various habitat conditions due to the lake bathymetry.
- Overall water quality conditions within Lake McCarrons have improved significantly since the 2004 alum treatment.
- McCarrons' vegetation health is slightly below biological impairment thresholds due to lack of species and/or habitat specific species.
- McCarrons' fish community appears balanced with limited occurrence of undesirable species.

3.0 AIS Management Framework

A step-wise process and criteria based approach was developed in which AIS will be managed on Lake McCarrons (Figure 3-1). A step-wise process assists CRWD with making management decisions pertaining to AIS within or concerning to Lake McCarrons with relative ease and clarity. The framework is not limited to any species, sampling method, or treatment option, rather, its generality allows any AIS to be reviewed. The framework is adaptive and agile to accommodate species with limited information, yet, supports species specific indices as they become available or are developed to update the District's management decisions. The framework is intended to be data driven from monitoring efforts, however, some subjective assignment was inevitable in developing this framework due to limited knowledge of current and future AIS.

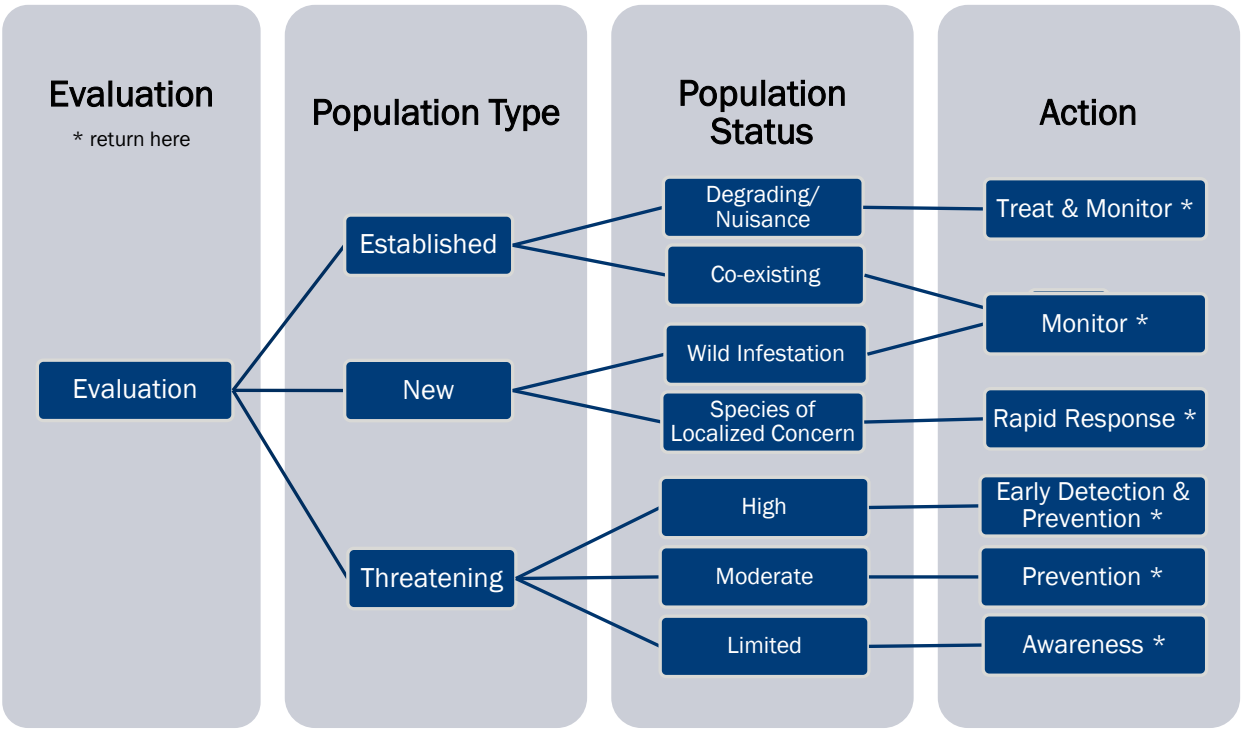
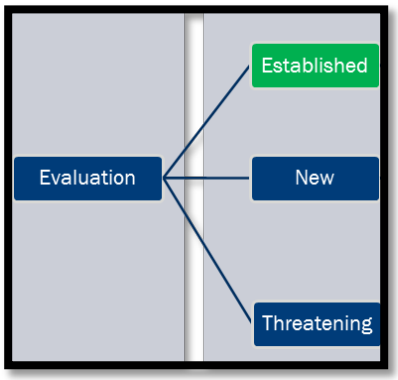


Figure 3-1. AIS management framework for Lake McCarrons.

The framework starts with an initial evaluation of the community and assignment of an AIS population to one of three population types: Established, New or Threatening. If an AIS is present in the lake, the use of historic monitoring efforts or date of infestation information can be used to determine whether the population is New or Established. AIS not present or documented in the lake are considered a Threatening population. Threatening is not used to imply harm, rather to acknowledge that further review and assessment is needed to determine the level of threat posed by the AIS. Following the evaluation and assignment of a population type, each AIS population is subject to a population status review. The review uses criteria to assign a population status which dictates the ensuing action appropriate to managing the AIS population.

4.1 Established Populations



Established populations are those that have a historic record of occurring in the lake and no documentation that they have been eradicated. Established AIS populations are either a degrading/nuisance population or a coexisting population that is interspersed with the native species in the community. Populations status determination is made using density and coverage criteria. Greater density and coverage indicates greater AIS impact or nuisance potential.

4.1.1 Degrading/ Nuisance populations

Degrading populations of AIS impact the health, recreational and/or aesthetic pleasure provided by Lake McCarrons. It is the intention of CRWD to evaluate the feasibility of AIS treatment when an established AIS population becomes degrading or a nuisance on Lake McCarrons. The population status criteria are intended to maximize the effectiveness of treatment activities, protect native biotic communities, and conserve resources for AIS populations that can be effectively managed. Degrading/ nuisance populations are considered to exist when:

<u>EWM and CLP populations:</u>

- Occur in an area at least five contiguous acres in size (Appendix A).

-And-

- Occur in a monoculture (>75% of total observed biomass); (Langer *et al.* 2017)

<u>Common Carp populations:</u>

- When density estimates surpass 100kg/ha (89lbs/acre) across the basin (Bajer *et al.* 2009).

An established AIS population that does not meet the prior criteria will be classified as a co-existing population (see section 4.1.2).

If a new infestation AIS population (Section 4.3) is reclassified as an established species the following criteria will be used unless updated research for the species can provide more effective criteria for defining a degrading/nuisance population. Population status assignment for submerged aquatic vegetation AIS will follow above EWM and CLP criteria, fish AIS will follow common carp criteria, and no invertebrate population control/ eradication efforts have been conducted on a lake ecosystem to our knowledge, therefore, established invertebrate population criteria need to be evaluated and reviewed with the MnDNR AIS Specialist if they become established within the lake.

4.1.1.1 Treatment

Treatment feasibility assessment will be pursued once a population reaches a degrading/nuisance population level. Treatment will be pursued if determined to be economically feasible and likely to have a net positive impact on lake health. Treatment activities are intended to control the population, not eradicate it, resulting in a population change from degrading/nuisance to co-existing. Eradication is welcomed but can be economically draining and may be biologically detrimental to do so. During the feasibility assessment, a review of the current treatment options and discussion with the MnDNR AIS

Specialist will be conducted to determine the most effective and appropriate treatment. The treatment methods, rules and regulations governing AIS are subject to change in years to come. The District will pursue best management strategies that abide by regulation changes with the goal to protect or enhance the biotic community condition within Lake McCarrons. The most current management guidance for the District pertaining to vegetation, fish and macroinvertebrate AIS as of April 2018 are: (http://www.dnr.state.mn.us/invasives/laws.html)

Aquatic Plant Management

The management of aquatic plants in public waters in Minnesota is regulated by Minnesota Statute, Section 103G.615, Chapter 6280. Public waters are described by the state as body of water 2.5 acres or larger within a city limit or 10 acres or larger in a rural setting. Certain management activities do not require a permit as they are intended for individual property owners to pursue on a relatively local scale. The District will only pursue management activities that require an Aquatic Plant Management (APM) permit as these efforts pertain to relatively larger ecosystem scale activities that have a greater overall impact on the lake. Greater detail to the rules, regulations and current methods for managing aquatic plants in Minnesota lakes and a description of common management techniques is provided in Appendix A.

Invertebrate Management

The management of invertebrate communities are managed by the MnDNR within public lakes. Historically, invertebrate populations are a less managed and sampled species by the MnDNR and have been evaluated within the research division of the agency. The most common form of invertebrate management is intended to treat swimmers itch in which pesticide applications are used to target the host (snails) of the parasite. Regulations that do exist are primarily related to specific transportation and treatment of invertebrate AIS. Minnesota prohibits placement (or the attempt to place) into state waters a watercraft, trailer, or plant harvesting equipment that has invasive species attached (i.e. zebra mussels); (Minn. Stat. § 84D.10). Minnesota requires a person leaving state waters to drain boating-related equipment before transporting the watercraft and associated equipment on to public roads (Minn. Stat. § 84D.10 and Minn. R. 6216.0500).

Fisheries Management

The management of fish communities within public lakes is managed by the MnDNR fisheries division. The use of barriers, exclosure, enclosures or any methods that capture and collect fish in public waters requires permitted approval by the MnDNR. The transportation and stocking/dumping of fish into a waterbody also requires MnDNR approval. Certain instances where barriers or structures alter the flow of water will require additional permitting through the MnDNR Ecological and Water Resources division.

4.1.1.2 Treatment Monitoring

If any treatment activity is pursued, specific evaluation protocols should be developed to collect pre- and post- treatment community information. This level of information will assist with determining the effectiveness of treatment activity(ies) and whether adjustments to treatment methods need to be made. In addition to a specific treatment evaluation protocol, the basin wide sampling protocol and sampling schedule should be maintained so that a change in the population status can be determined. When the population status is downgraded to one that is co-existing, treatment may need not be pursued.

4.1.2 Co-existing Populations

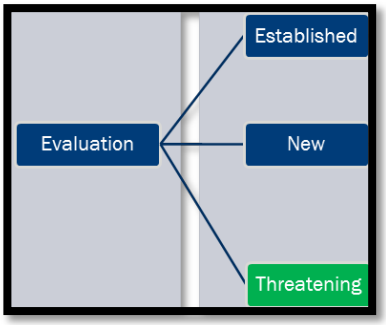
Co-existing AIS are not perceived to cause significant ecological degradation or nuisance impairments on a basin-wide scale. It is the intention of CRWD to monitor co-existing AIS populations with no treatment. A population will be considered co-existing if it does not meet the criteria to be considered a degrading/nuisance population (Section 4.1.1).

4.1.2.1 Monitoring

A co-existing population of AIS does not require treatment as the efforts to eradicate the population are costly and may have negative and unintended consequences to the native communities within Lake McCarrons. Rather, continued monitoring will ensure that the District is vigilant to population changes and appropriate actions are implemented.

4.2 Threatening Populations

Many AIS could become established in Lake McCarrons, however, their ability to colonize and reach degrading/nuisance levels is species dependent and warrants species specific management consideration. Population status classifications were developed to simplify and organize threatening species for management purposes. A threatening population is classified as a species of high, moderate or limited concern. Exposure and habitat suitability criteria are used to determine the correct population status and the ensuing management action. Context, criteria and management actions are provided in the following subsections.



4.2.1 Threatening Invaders

The list of threatening and emerging AIS in Minnesota continues to grow as we begin to understand the ecology of AIS and assess our nation's waterbodies. The MnDNR currently considers 16 species on its Minnesota infested waters species list (Table 4-1). Certain AIS that have a long historic presence in Minnesota (CLP and common carp), widespread distribution and/or are regulated by the MnDNR (i.e. Rusty Crayfish) are not placed on the infested waters list, yet, these species are AIS and will be managed as such by the District.

Table 4-1. Infested Waters Species.

Organism Type	Species
Fish	bighead carp
Fish	grass carp
Fish	round goby
Fish	ruffe
Fish	silver carp
Fish	white perch
Invertebrate	faucet snail
Invertebrate	New Zealand mud snail
Vegetation	Brazilian waterweed
Vegetation	brittle naiad
Vegetation	Eurasian watermilfoil
Vegetation	flowering rush
Vegetation	starry stonewort
Invertebrate	red swamp crayfish
Invertebrate	spiny water flea
Invertebrate	zebra mussel

Any foreign species that can be introduced may be considered a threat, however, not all foreign species that are introduced become established. If an AIS does become established it may or may not reach densities that cause significant ecological or nuisance impairments. The ability of a foreign species to invade a new area and proliferate is related to exposure events and habitat suitability of a given waterbody (Equation 2).

Equation 2. $Establishment\ threat = Exposure\ risk + Suitability\ potential$

Exposure risk indices predict the likelihood of new introduction, while suitability potential indices predict the likelihood of successful establishment and proliferation once introduced. Since each AIS has its own exposure rate and suitability preference, predicting AIS establishment is highly variable. To assist with understanding the threat posed by an AIS to Lake McCarrons, a rapid assessment tool was developed to review any AIS with a limited base of information. This tool utilizes a rudimentary approach in assigning risk ratings to one exposure risk and two suitability potential indices for a given AIS. Under each index a species receives a rating of high, moderate, low or minimal. Once assigned a rating, achievement criteria are used to determine the establishment threat status of a given AIS population. A given threatening population is assigned a status of high, moderate or minimal which dictates the appropriate management action(s). The following subsections describe this tool in greater detail and how it is used to determine the threat status of an AIS population.

4.2.2 Exposure Risk

Movement of AIS across the landscape is largely attributed to unintended movement via boat traffic. Modeling exposure risk associated with boat traffic movement requires highly detailed information about where boat movement is occurring, how frequently and from which lakes. It also requires knowing whether the boats moving between lakes carry viable AIS. This network of connections is complex and requires large sources of information which limits rapid assessment. However, Lake McCarrons is thought (assessed through boat launch inspection surveys) to receive the greatest amount of traffic from relatively local groups. AIS transported shorter distances have an increased likelihood that they can encounter suitable conditions sooner than species that are transported greater distances. An exposure risk index was developed based on proximity to Lake McCarrons (Table 4-2). Municipal boundaries were used rather than a direct radius measurement, as AIS efforts are often managed at municipal limits, thus providing means to govern and manage boating traffic.

Table 4-2. Exposure risk index.

Exposure Risk	Location
High	In Watershed District
Moderate	In County
Low	In Adjacent County
Minimal	Greater Minnesota

4.2.3 Suitability Potential

Climatic conditions, in lake habitat, and biotic interactions influence suitability for AIS establishment. A species' fundamental niche is often thought of as the environmental conditions that support a given species, whereas, a species' realized niche is where it is observed. The realized niche is smaller than the fundamental niche as additional factors limit the species from occurring (i.e. competition, barriers, climate). Modeling suitability requires an understanding of both niche spaces requiring site specific information and an understanding of the biology for a given species which limits rapid assessment.

Suitability was modeled using two different indices: habitat condition and similar species indices. Both indices may not always be utilized due to unknown information. In cases where both indices are used and have differing potential classifications the higher of the two ratings (conservative approach) will be used to describe suitability.

4.2.3.1.1 Habitat Conditions Indices

Habitat conditions are associated with food/nutrient availability, habitat conditions, and open niche space to become established. The current understanding of suitable conditions is highly variable among AIS and various suitability assessments can be considered. Specific indices do exist for certain AIS (Appendix B); however, their specificity limits their use to select species or systems. A general habitat conditions index was developed to provide rapid assessment of suitable conditions (Table 4-3).

Table 4-3. Habitat conditions index.

Suitability Potential	Available Habitat/Resources
High	Yes (widespread)
Moderate	Yes (moderate)
Low	Yes (limited)
Minimal	No (poor)

4.2.3.1.2 Similar Species Index

Many AIS have a similar native counterpart (i.e. northern watermilfoil and Eurasian watermilfoil) or come from a similar family (i.e. muskgrass and starry stonewort are charophytes) in which they often compete for similar resources and occupy similar niches. Reviewing current and historic species lists and observed locations within a lake provides context to whether and where conditions may persist to support a specific AIS. Not all AIS may have an existing counterpart but still pose a threat to the lake. A similar species index was developed to provide additional suitability assessment (Table 4-4).

Table 4-4. Similar species index.

Suitability Potential	Similar species (abundance)
High	Yes (widespread)
Moderate	Yes (moderate)
Low	Yes (rare)
Minimal	No

4.2.3.2 Establishment Threat

The suitability potential and exposure risk indices were used to assign ratings for a threatening AIS. These are compared to different achievement criteria to determine a population status. Threatening populations are classified into one of three levels with specific management actions recommended for each. A species' threat can be:

1. **High**
   High threat species pose the greatest concern to the ecological and recreational health of Lake McCarrons. It is believed that these species, if established, could quickly become a degrading/nuisance population within Lake McCarrons. A species will be considered a high threat if it has:
   - A moderate or higher suitability (habitat conditions or similar species) rating.
     -And-
   - A moderate or higher exposure risk rating.

2. **Moderate**
   Moderate threat species pose a similar concern for the health of Lake McCarrons but are currently limited by either distance or suitability. Specifically, a threatening species of moderate concern differs from a high concern species in one of two ways: its proximity to Lake McCarrons is more distant or its suitability preference is limited within the lake. A species will be considered a moderate threat if it has:
   - A moderate or higher suitability (habitat conditions or similar species) rating.
     -Or-
   - A moderate or higher exposure risk rating.

Species that are considered a moderate threat due to meeting the suitability criteria are a concern because distance (exposure events) is the limiting factor for establishment in Lake McCarrons. If these species become established they would have the ability to co-exist within the community and possibly reach degrading/nuisance levels.

Species that are considered a moderate threat due to meeting the proximity criteria are a concern because they have a greater probability of being exposed to Lake McCarrons. These species have a reduced likelihood of becoming established if introduced due to the habitat conditions. If these species did become established would only persist at a co-existing population level. However, lake conditions are not stable over time and conditions could become more favorable to the species increasing the likelihood of establishment due to increased habitat suitability. If they became established they could reach degrading/nuisance population levels.

3. **Limited**
   Limited threat species pose a limited concern for the health of Lake McCarrons. These species are not close in proximity and the current habitat conditions within the lake are believed to poorly support the species. A species will be a limited threat if it has:
   - A suitability (habitat conditions or similar species) rating less than moderate.
     -And-
   - An exposure risk rating less than moderate.

4.2.4 Management Actions

Appropriate management action(s) will be dictated by the population status of threatening AIS species. Awareness and acknowledgement of limited concern AIS will be documented by the District but will not be the sole reason for greater management activities. These species are not perceived to cause an immediate threat to the lake and a conservation of resources is thought to be a greater need. Prevention efforts will be assessed for all AIS of high or moderate concern. These species pose a greater level of threat to the lake and are thought to be worth the resources needed to pursue preventative actions. Early detection monitoring will be assessed for all AIS of high concern. High concern species pose the greatest threat to the lake and a high level of preventative actions and early detection monitoring are worth the resources needed to pursue these actions. Greater detail of these actions is provided in the following subsections.

4.2.4.1 Prevention

Preventing the spread of AIS is often thought to be the most effective AIS management technique. Prevention techniques are not limited to a specifically defined list of items, rather, they are intended to be variable and adaptive depending on target audience and available resources. The MnDNR has established regulations and a list of various prevention techniques and materials. The prevention techniques, renditions of these techniques or new and creative techniques can be pursued by the District. Prevention techniques consist of regulations, education and outreach. (http://www.dnr.state.mn.us/invasives/ais/outreach.html)

4.2.4.1.1 Transporting Species Regulations

Minnesota has developed several state laws and a tiered system intended to minimize the introduction and spread of invasive species in the state. Species are classified into one of four categories: prohibited, regulated, unregulated nonnative species, or are unclassified and remain as unlisted nonnative species. The classification system establishes the level of regulation and allowable uses for each species. (http://www.dnr.state.mn.us/invasives/laws.html)

4.2.4.1.2 Education & Outreach

Outreach and educational opportunities provide individuals and community members the ability to contribute to AIS prevention efforts. These efforts can vary in their design, target audience and who participates, but all can fall under the prevention action item. Suggestions from the MnDNR:

Print materials

- Brochures
- Calendars
- Fact sheets
- Watch cards
- Boat launch signs
- Door hangers

Hands on

- Boat inspectors
- Early detectors trainings
- Youth events
- Educational showcases
- Field visits

Example

The University of Minnesota based Minnesota Aquatic Invasive Species Research Center (MAISRC) has developed an AIS detection program that looks to train citizen scientists and professionals to monitor changes in populations of AIS over time and in specific locations (link to website). There is a minimum level of service required to become a certified AIS Tracker. The program provides a unique hands-on experience for people to learn how to identify and report information about AIS populations.

The Stop Aquatic Hitchhikers national education program began in 2002 and was designed to raise awareness and empower people to become part of the solutions to AIS management (link to website). The program's primary message is Clean, Drain, Dry (and Dispose for anglers) which has been adopted in the state through local water groups. The MnDNR supports the clean, drain and dry program by mandating the following regulations to prevent the spread of AIS across waterbodies:

- A person leaving waters of the state must drain all water from water-related equipment, including bait containers, live wells, and bilges, by removing the drain plug before transporting the watercraft and equipment from the water access or riparian property.
- Drain plugs, bailers, valves, or other devices used to control the draining of water from ballast tanks, bilges, and live wells must be removed or opened while transporting watercraft and water-related equipment.
- A boat lift, dock, swim raft, or associated equipment that has been removed from any water body may not be placed in another water body until a minimum of 21 days have passed.

4.2.4.2 Early Detection

Early detection monitoring is a priority for threatening populations of high concern. Early detection efforts can reduce the probability of an introduction becoming an established population. Early detection efforts range in their expense and investigation depending on the AIS, available resources and knowledgeable identifiers. In some cases, early detection may require certain sampling equipment or the ability to access different areas of the lake. Early detection monitoring is intended to target specific areas/locations where AIS may enter the lake or are most likely to establish a stronghold. Areas to include in early detection monitoring on Lake McCarrons include:

- Public boat launch
- Public fishing pier and beach
- Inlet to the lake

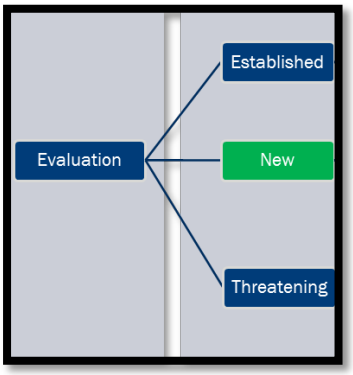
Additional sampling areas should be considered within the lake depending on the species. Vegetation grows most heavily along the western littoral area but also along the northern and southern shorelines. Random patches in these locations could be selected for detection monitoring. Invertebrate and fish AIS pose a more difficult target organism as they are relatively mobile species. When implementing detection, it is important to look in areas where the species is most commonly observed during various life stages and at a given time of the year. Identification of these different habitat areas are outlined in Figure 4-1 and were developed from historic vegetation surveys. Specific sampling rigor should be vetted with groups conducting the assessment and/or depending on available resources.

Ramsey Conservation District (RCD) and Ramsey County currently conduct routine biological monitoring on Lake McCarrons. Monitoring includes twice yearly basin-wide point intercept surveys to assess the vegetation community, yearly zebra mussel veliger tows, and periodic inspection of the boat launch area for zebra mussels and invasive vegetation species.

Examples

Minnehaha Creek watershed district has implemented an early detection monitoring plan which has initiated a rapid response in two different lake ecosystem: Christmas Lake (link to publication) and Lake Minnewashta (link to report). The success of these two ecosystems varied yet provide examples of how early detection monitoring plays an important role in AIS management of high concern AIS populations.

4.3 Rapid Response to New Infestation



In responding to new invasions time is critical. A timely response is the best predictor of eradication success. Acting fast will minimize the potential for the species to spread across the lake where cost, logistics and feasibility of treatment quickly become overwhelming, decreasing treatment success. Responding to new invaders is dramatically influenced by the amount of monitoring conducted or execution of an early detection program.

The dynamics between a given AIS and Lake McCarrons is unique, therefore, no single response strategy can be predeveloped and applied in all situations. However, a general theme and approach can be applied to ensure timely and effective measures are taken. Initial response should:

1. Monitor – Make the detection
2. Report - Report the suspected detection
3. Confirm – state or private specialists can confirm the species identity
4. Communicate – Inform public of incident

Suspected detections (step 1) will be handled by the District. These initial inquiries will be reviewed and directed to the MnDNR AIS specialist (step 2) as needed or to confirm the species (step 3). CRWD will work with the MnDNR on communicating new AIS occurrence within Lake McCarrons to the public (step 4). After confirming a positive identity, an assessment will determine what type of infestation has occurred and what the ensuing action will be. A new occurrence will be classified as either a localized species of concern infestation or a wild infestation. Coverage and suitability criteria will be used to determine the correct population status.

RCD is preparing species specific rapid response plan frameworks, contractors and treatment options that will serve as supplemental guidance for CRWD and the McCarrons AIS Management Plan.

4.3.1 Localized Species of Concern

A localized species of concern is a population that poses a significant ecological detriment or nuisance level threat, is spatially localized, eradication success is high, and any treatment will have a minimal impact on the native community. A species will be considered a localized species of concern if:

- The species has a moderate or higher suitability rating (Section 4.2).
  -And-
- Initial infestation is localized to a contiguous area no greater than one acre in size.

4.3.2 Wild Infestation

A new infestation of an AIS population will be considered a wild infestation on Lake McCarrons when the population is not localized or it is not a significant threat to the lake. A species will be considered a wild infestation if:

- The species has a suitability rating less than moderate (Section 4.2).
  -Or-
- Initial infestation is greater than one contiguous acre.

4.3.3 Management Actions

Appropriate management action(s) will be dictated by the population status of new infestations. New infestations are subject to one of two management actions: monitor the population or rapidly respond to the new occurrence. The rapid response scenario requires a high level of cost, time and effort. A feasibility and logistic assessment will be conducted as part of the initial response plan to ensure all required activities can be carried out to have the greatest likelihood of eradication.

4.3.3.1 Rapid Response (Treatment)

Treating a new infestation is meant to target localized species of concern infestations. Species identified as such in the lake will proceed with the following response strategy:

1. Feasibility Assessment – Review locations, control options, methods, funding
2. Execute the Plan – Execute response and control measures
3. Follow up Monitoring – Determine effectiveness of plan execution

The District along with the MnDNR will conduct a feasibility assessment (Step 1). Local partners and stakeholder groups (MnDNR Communications, neighborhood association, City, and local partners) will be brought into the development and execution of the developed plan (step 2)

If a treatment occurs then appropriate follow-up monitoring and evaluation will follow (step 3) to determine success of eradication efforts and that the species has not spread to other areas of the lake.

4.3.3.2 Monitoring Only

Monitoring only will occur when a new infestation is considered a wild infestation. Wild infestation scenarios present concerns with the populations coverage, eradication feasibility or treatment that would result in significant impacts to the native community. Continued monitoring of the population will evaluate the impact it has on Lake McCarrons. Should a wild infestation become an established population, large scale treatment may occur if the population reaches degrading or nuisance levels within the lake (Section 4.1).

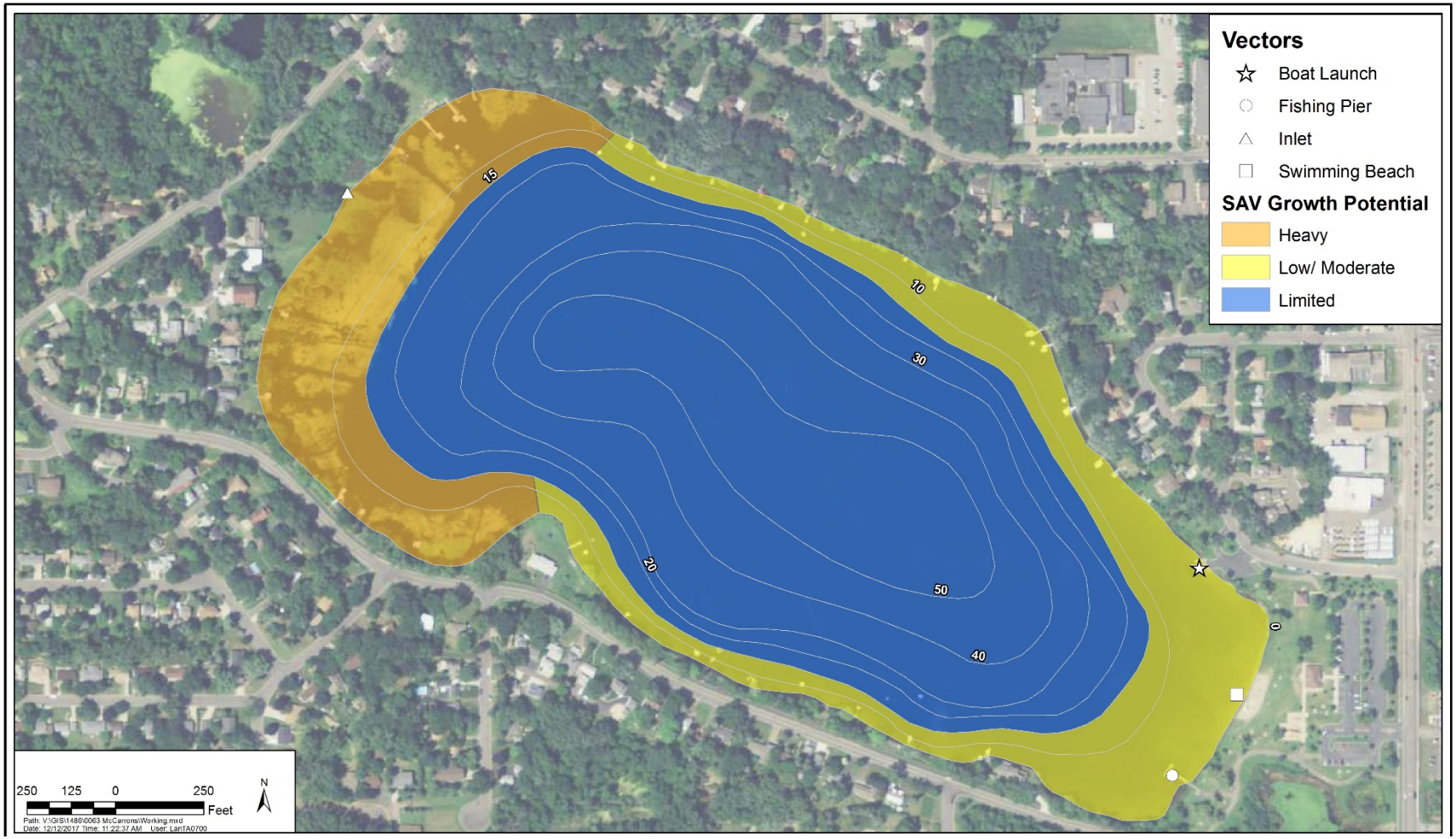


Figure 4-1. Target habitats for AIS within Lake McCarrons.

5.0 Coordination

Effective coordination among stakeholders is essential if AIS are to be managed successfully within Lake McCarrons. It is important to recognize the various stakeholders, their interest in the lake, and what their role may be regarding AIS management. With new infestations in particular, a timely response is important. It is essential that all parties understand and agree upon the role they will take from early detection, to potential treatment and beyond. The primary identified stakeholders are listed below and specific roles are outlined in Table 5.1.

Ramsey County / Ramsey Conservation District (RCD)
RCD has taken on the role of AIS coordination for Ramsey County. The development of a county New Infestation Response Plan is underway that will outline the steps to be taken in the event of a new infestation including coordination with the DNR, lists of contacts for stakeholders, treatment resources, and potential contractors. In addition, CRWD contracts with RCD to perform aquatic vegetation surveys on Lake McCarrons. Ramsey county would be a major funding source in the event of a new infestation. The county owns the boat launch at McCarrons, funds boat inspections, and has updated AIS related signage at the launch. The county also conducts lake monitoring which includes chemical and physical parameters as well as targeted AIS surveys.

Capitol Region Watershed District
CRWD has developed the Lake McCarrons AIS management plan, and would therefore be the first point of contact for management of AIS in the lake. CRWD is a source of funding for current aquatic plant surveys and could provide funding for AIS control, new infestation rapid response, and follow-up monitoring.

Minnesota Department of Natural Resources
Treatment of existing AIS species would require the involvement of the MN DNR to obtain a permit. All new AIS detections get reported to the MN DNR. They are an integral partner in any rapid response process. The MN DNR would provide funds, expertise, assistance with AIS confirmation, public communications, equipment, and legal authority.

City of Roseville
Lake McCarrons is located within the City of Roseville. Lake shore owners are Roseville residents.

Lake Shore Owners and Frequent Lake Users
Lake shore owners and lake users have an interest in the health or usability of the lake. This group is an important vector for both gathering and disseminating information on the lake. There is an opportunity for both formal and informal monitoring of AIS in the lake. A member or members of this group could serve as an important AIS point of contact on the lake.

Table 5-1. AIS management framework tasks, responsible parties and timeframe.

Plan Component	Responsible Parties	Task	Description	Timeframe or Frequency
Evaluate (Routine Surveys)	CRWD, RC/RCD	Aquatic Vegetation Surveys	Survey the areal extent and composition of the aquatic vegetation community within the lake.	Twice yearly
	CRWD	Invertebrate Surveys	Survey and assess the composition of the invertebrate population within the lake.	TBD
	MnDNR	Fisheries Surveys	Conduct trap, gill net, and near-shore fish surveys.	~10 year intervals
AIS Management Framework	CRWD	Classify known AIS	Classify all AIS in Minnesota as established, new, or threatening with respect to Lake McCarrons.	Yearly or as new AIS emerge
Established AIS Populations	CRWD, MnDNR	Aquatic Plant Management	Determine whether population meets treatment criteria, evaluate treatment options, and conduct cost-benefit analysis. Treat the population if treatment is indicated by analysis.	Indicated by treatment information and follow-up monitoring
		Invertebrate Management		
		Fisheries Management		
	CRWD	Follow-up Monitoring	Develop and execute a monitoring plan to evaluate post-treatment effects.	As indicated by management plan
Threatening AIS Populations	CRWD	Determine Threat Status	Determine the threat status of MN AIS and periodically reevaluate using exposure and suitability indices.	Yearly or as new AIS emerge
	CRWD, RC/RCD	Early Detection Monitoring	Conduct regular monitoring aimed specifically at detecting AIS of greatest concern.	As indicated based on best available information for the AIS of concern
	RC/RCD	Boat Launch Inspections	Inspect boats entering and exiting lake for compliance with AIS regulations.	At a minimum, weekends during peak boating season/hours
	CRWD, RC/RCD, Lake Residents and Users	AIS Detector Training	Promote & facilitate citizen AIS Detector training.	Yearly
		Educational Materials	Distribute and/or develop AIS educational materials.	Ongoing
		Community Events	Promote and/or facilitate public education events with a focus on AIS.	

Plan Component	Responsible Parties	Task	Description	Timeframe or Frequency
Rapid Response to New AIS Infestation	CRWD	Report Detection	Report the suspected detection to the MN DNR AIS specialist.	Immediately following detection
	MnDNR	Confirm Detection	MN DNR will confirm the presence of AIS in the lake.	Following CRWD report of detection
	CRWD, RC/RCD, MnDNR, Lake Residents and users	Response Feasibility Evaluation	Review AIS locations, controls, methods, and funding.	Following confirmation of AIS presence
		Communicate New Infestation	Communication to stakeholders regarding new infestation.	
	CRWD, RC/RCD	Execute Response Plan	Execute response and control measures.	As indicated based on best available information for the AIS of concern and result of feasibility evaluation
	CRWD	Follow-up Monitoring	Develop and execute a monitoring plan to determine the effectiveness of plan execution.	As indicated by monitoring plan

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Appendix A: Vegetation Treatment

Vegetation Control
This section describes the rules, regulations and current methods for managing aquatic plants in Minnesota lakes and a description of common management techniques.

Aquatic plant management (APM) permits may be issued to provide riparian access, enhance recreational use, control AIS, manage water levels, and protect or improve habitat. Separate permits are required for controlling natives for recreational access and controlling AIS. A specific list of criteria is considered to determine if a permit should be granted. A permit will not be issued to improve the appearance of undeveloped shoreline or for aesthetic reasons alone. A permit also cannot be issued in areas given special designations, such as Scientific and Natural Areas or in areas posted as protected fish spawning areas.

Chapter 6280.0250 allows certain activities without an APM permit. Specifically, mechanical control of submerged aquatic plants is allowed by individual property owners in an area not to extend along more than 50 feet or one-half the length of the owner's total shoreline, whichever is less, and not to exceed 2,500 sq. ft. plus the area needed to extend a channel no wider than 15 feet to open water. These rules also allow for the mechanical control of floating-leaf aquatic plants to obtain a channel extending to open water with the provisions that the channel is no more than 15 feet wide and follows the most direct route to open water, the channel is maintained by cutting or pulling, and the channel remains in the same location from year to year. The skimming of duckweed or filamentous algae from the surface of a water body is also allowed without a permit.

An APM permit is required for all other activities below the Ordinary High Water (OHW) level not mentioned above, including all herbicide control of aquatic plants, relocating or removing vegetation, and installing or operating an automated aquatic plant control device (weed roller).

<u>Permitted Activities</u>

Herbicide Treatment
A permit is required for all chemical control of aquatic plants. Herbicide control of aquatic plants is limited to an area that does not exceed 15% of the littoral area (typically ≤15 feet depth) of a lake. Only specific pesticides that are labeled for use in aquatic sites can be used, and they must be applied per the label instructions. Application can occur as frequently as the applicant desires; however, the frequency must be approved by the DNR. In herbicide applications, timing, concentration, herbicide used, target species, wind, water flow and water temperature are among the many factors to consider when applying herbicide to control AIS and SAV.

Mechanical Treatment
Mechanical control of aquatic vegetation typically involves the cutting, pulling, raking or otherwise removing or altering aquatic plants by physical means. Removal can occur as frequently as the applicant desires; however, the frequency must be approved by the MnDNR. Some of the conditions of permitted mechanical control of aquatic plants include:

- the vegetation must be immediately and permanently removed from the water;
- the mechanical control may not exceed 50% of the total littoral area of the lake
- control methods must not change the course of the water; and

- mechanical control for recreational access must be conducted in the same location year after year; locations can vary year to year for AIS control based on pre-control surveys.

The combination of herbicide and mechanical removal is not to exceed a total littoral area of 50%. Therefore, if 15% of the littoral area is treated with herbicide only 35% can be harvested by mechanical methods.

Specialized Treatment Options
There are additional forms of plant management (i.e. dredging, hydrovacing, biomats) that exist, however, these methods are only approved by the MnDNR in very rare and special cases. These methods attempt to alter or block the sediment with the goal to reset the seed bank and substrate conditions. These methods can be cost prohibitive, require extensive permitting and research assessments; therefore, further insight or literature review of these methods was not investigated at this time.

Transplanting
A permit is required for the relocation and transplanting of all native SAV. The transport and relocation of any AIS is illegal and is not permitted by the MnDNR. Transplanting is an effective technique when lake conditions are suitable for plant growth when the seed bank and/or abundance of native species in a lake has been depleted. The native vegetation species used in transplanting is typically acquired from areas within the lake and/or from neighboring lakes.

Current research is underway at the University of Minnesota that is monitoring transplanting success of various species through time. Preliminary results are promising, yet, controlling other limiting factors (i.e. light availability, nutrient loading, fisheries management) may need to occur in conjunction with transplanting activities. Transplanting alone has been shown to have little to no improvement in the SAV community. Verhfstad et al. (2017) suggested that once light is no longer limiting, seed propagules or the seed bank within a lake has a greater influence on which species will come back rather than lake sediment chemistry. Therefore, continued efforts to promote and facilitate seed bank restoration and/or transplanting of SAV may produce favorable SAV communities during water quality restoration efforts.

Current State of Milfoil and Curlyleaf Control
Various control methods have been used to manage EWM and CLP populations in lake ecosystems. The success of controlling populations has varied but little to no follow up monitoring has been performed to effectively quantify and share knowledge. However, what information is available we summarize in the proceeding paragraphs. It is important to understand that 100% eradication is not likely and the continued presence of the species is likely within the lake. Therefore, treatment objectives should be considered before treatment activities are pursued.

Herbicide treatment of CLP is typically conducted in the early spring when water temperatures are between 50-60°F and warming. At this period in the growing season there is typically little to no native SAV growth, therefore, chemical treatments are meant to target CLP only. Effective chemical concentrations of endothall need to be sustained in target areas and can be greatly influenced by wind and water currents. Treatments are documented as being most effective when large (>5 acres) vegetation stands of CLP can be targeted with dosage concentrations persisting at 0.75 to 1.5 ppm for 12 – 24 hours. If large treatable plots do not exist, small areas may be treated but typically require greater concentrations (1.5 to 2.0 ppm or more) to have effective results (MnDNR 2013). Treatment

of CLP appears to have the greatest result at lowering reproductive success with repeated treatment for 2-3 years. Johnson *et al.* (2012) found that curlyleaf frequency, biomass and turion density were drastically reduced with repeated treatments, however, complete eradication of viable turions was not achieved suggesting that the population was at least short term controlled. Efforts by Jones *et al.* (2012) demonstrated that though PC treatment was effective at controlling CLP, there was little change in the native vegetation community. Only select species were observed to increase in biomass after treatments, suggesting that other factors (i.e. water clarity, fish community, viable seed bank) were limiting the establishment and increase in native species and biomass.

Herbicide treatment of EWM is typically conducted in mid-summer when EWM areas have been delineated. At this period in the growing season there can be many other SAV growing, therefore, chemical treatments need to be careful that dosing is conducted in a method that reduces the potential of negatively influencing non-targeted areas and species. EWM is typically treated with an auxin-mimic, usually triclopyr or 2,4-D herbicides. Effective chemical concentrations need to be sustained in target areas for 12-24 hours and can be greatly influenced by wind and water flows. Treatments are most effective when large vegetation stands are dosed at concentrations persisting at 2 to 4 ppm. Dissipation of herbicides in small plots reduces effectiveness, while increasing dosage to achieve sustained concentrations can drift and harm non-target species (such as waterlilies); (Nault *et al*. 2014, MnDNR 2013). A growing concern among EWM infested waterbodies is the ability of the species to hybridize with native milfoil species. Hybridized milfoil has been shown to grow faster and may be more resilient to herbicides (LaRue *et al.* 2013) and hybridized milfoil is speculated to occur more frequently in herbicide treated lakes (Thum *et al.* 2017). This growing concern warrants consideration in the use of herbicide treatment in EWM infested waters, as ineffective treatment may foster hybridization and greater difficultly in long-term management.

Technologies and research into mechanical harvesting are growing as the need and desire of lake managers continues to grow. Mechanical harvesting typically occurs when vegetation reaches the water's surface and is visible. A project piloted by Minnehaha Creek Watershed District in 2013 assessed the effectiveness of cutting methods on CLP populations and found that the timing and depth at which the vegetation is cut had a significant influence on the amount of turions observed in the sediment. Turions are a seed like structure in which new CLP stems can sprout. The conclusions of this assessment acknowledge that traditional cutting methods likely will not control populations of CLP, rather they provide lake managers a method to improve recreation on infested waterbodies. This research also highlighted that conducting cuttings deeper and earlier may be more effective at controlling the population and turion densities but continued research is needed and should expand to other species.

In general, long-term control of EWM and CLP has not been overly assessed to date. It is uncertain if the species are completely killed or undergo seasonal injury, rebounding later in the year or in proceeding years. In addition, there is little information on the long-term effect and recolonization of native or desired SAV species. Follow up monitoring is not required to treatments and is often not pursued. Managers should consider current limitations if pursuing treatment of EWM and CLP populations as the results are often short-lived and continued treatments can deplete available resources.

Appendix B: Suitability Assessments

This section contains species specific suitability assessments for curlyleaf pondweed, Eurasian watermilfoil and zebra mussels that could be used in Minnesota and was obtained from McComas *et al*. (2014).

Table B1. Curlyleaf pondweed nuisance potential and habitat indicators.

Growth Potential	pH (su)	Bulk Density (g/cm3 dry)	Organic Matter (%)	Fe:Mn Ratio
Light	<7.4	>1.04	0.1 - 5	>4.5
Moderate	7.4 - 7.7	0.52 - 1.03	6 -20	1.6 - 4.5
Heavy	>7.7	<0.51	>20	<1.6

Table B2. Eurasian watermilfoil nuisance potential and sediment habitat indicators.

Growth Potential	NH_4 Conc. (ppm)	Organic Matter (%)
Light	<4	<0.5 & >20
Moderate	4 - 10	0.6 - 2 & 18 - 20
Heavy	>10	3 - 17

Table B3. Zebra mussel nuisance potential and habitat indicators for shell formation.

Growth Potential	Calcium (mg/L)	pH (su)	Alkalinity (mg/L)	Conductivity (umhos)
Light	<15	<7.8 or 9.0 - 9.5	<55	<60
Moderate	15 - 30	7.8 - 8.2 and 8.8 - 9.0	55 - 100	60 - 110
Heavy	> 30	8.2 - 8.8	>100	>110

Table B4. Zebra mussel nuisance potential and habitat indicators for food availability.

Growth Potential	$Chlorophyll_a$ (ug/L)	TP (ug/L)
Light	<2.5 or >20	<10 or >35
Moderate	8 -20	10 - 25
Heavy	2.5 - 8	25 - 35

Table B5. Zebra mussel nuisance potential and habitat indicators for substrate preference.

Growth Potential	DO (mg/L)	Substrate
Light	<7	muck, sand
Moderate	7 - 8	sand, gravel, plants
Heavy	>8	cobble, rock

Appendix C: Risk Assignment

Table C is a summary of the text described above and the corresponding threat level for AIS located in adjacent counties or are species on the Minnesota invasive species list. This exercise can be expanded to any AIS. No species were observed to have moderate or higher ratings in both exposure and in at least one of the suitability indices, therefore, no species are rated as a high concern. Species of high concern would be subject to both early detection and prevention actions. Many species were observed to have moderate or higher ratings in either the exposure or in at least one of the suitability indices, therefore, these species are rated as a species of moderate concern. Species of moderate concern are subject to prevention action items. A smaller list of species was observed at less than a moderate classification in both exposure and suitable habitat/ similar species indices, therefore, these species are rated as limiting concern. Species of limited concern are subject to awareness and no other management action.

Table C. Proximity and suitability assessment of AIS to Lake McCarrons.

Organism Type	Species	Exposure	Suitability - Similar Species	Suitability - Habitat Conditions	Threatening Status
Fish	bighead carp	Moderate	Low	Minimal	**Moderate**
Fish	grass carp	Moderate	Low	Minimal	**Moderate**
Fish	round goby	Low	Minimal	Minimal	**Limited**
Fish	ruffe	Low	Unknown	Minimal	**Limited**
Fish	silver carp	Minimal	Low	Minimal	**Limited**
Fish	white perch	Minimal	Unknown	Minimal	**Limited**
Vegetation	Brazilian waterweed	Low	Low	Moderate	**Moderate**
Vegetation	brittle naiad	Low	Low	Moderate	**Moderate**
Vegetation	flowering rush	Moderate	Minimal	Minimal	**Moderate**
Vegetation	starry stonewort	Minimal	Moderate	Moderate	**Moderate**
Invertebrate	faucet snail	Minimal	Unknown	Moderate	**Moderate**
Invertebrate	New Zealand mud snail	Minimal	Unknown	Moderate	**Moderate**
Invertebrate	red swamp crayfish	Low	Unknown	Minimal	**Limited**
Invertebrate	rusty crayfish	Low	Unknown	Minimal	**Limited**
Invertebrate	spiny water flea	Minimal	Unknown	Low	**Limited**
Invertebrate	zebra mussel	Moderate	Unknown	Low	**Moderate**

Fish AIS currently pose a relatively limited threat to lake McCarrons. Habitat preference of the current AIS fish tend to be oriented to river or the Great Lakes ecosystems. Bighead and Grass carp do score a moderately under the rubric as their presence is noted to occur in the Minnesota River.

Invertebrate AIS currently pose either a limited or moderate threat to Lake McCarrons depending on the species. It is unclear the current invertebrate community within the lake, therefore no assessment could be made to similar species. Rather suitability indices were considered based on general habitat preferences of the species. Snail species pose a moderate threat due to moderate habitat suitability potential as they tend to persist in vegetated littoral habitats. Zebra mussels pose a moderate threat due to their current proximity to Lake McCarrons as they exist within Ramsey county, however, the Lake McCarrons is believed to have limited substrate to support a large mussel population. Crayfish and flea species pose a limited threat as they have a low exposure rating and a low suitability preference within Lake McCarrons. Both organism types are perceived to have limited habitat conditions within Lake McCarrons. Flea species tend to be supported in deep coldwater systems, while crayfish tend to build burrows in rocky and clay substrates.

Vegetation AIS likely pose the greatest concern of the AIS organism types to Lake McCarrons. This statement is supported by the fact that two vegetation species are dominant species within the lake: curlyleaf pondweed and Eurasian watermilfoil. Emergent vegetation poses a lesser threat due to limited habitat within Lake McCarrons, however, Flowering Rush poses a moderate threat due to its current proximity to the lake.

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