2014 Project Abstract

For the Period Ending June 30, 2016

PROJECT TITLE: Northwest Minnesota Regional Aquatic Invasive Species Prevention Pilot
PROJECT MANAGER: Julie Goehring
AFFILIATION: Red River Basin Commission
MAILING ADDRESS: 1120 28th Ave N, Suite C
CITY/STATE/ZIP: Fargo, ND 58102
PHONE: (701) 356-3183
E-MAIL: Julie@redriverbasincommission.org
WEBSITE: http://www.redriverbasincommission.org/
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2014, Chp. 226, Sec. 2, Subd. 04c
APPROPRIATION AMOUNT: $219,000

Overall Project Outcomes and Results

Aquatic Invasive Species (AIS) spread has become one of the top concerns as it threatens the recreational and economic viability of the surface water resources of the Red River of the North watershed. According to the Minnesota Department of Natural Resources Infested Waters report (2016), Zebra Mussels have invaded the Otter Tail, Pelican and Red River systems. The Local Governmental Units (LGU's) are implementing plans to address AIS issues at the county level, but introduction into our river systems necessitate a regional approach to education, outreach and management of AIS within the Red River of the North watershed. The goal of this pilot project was to expand AIS work from a largely county based process to a watershed scale through partnerships between LGU's. The project targeted three main watersheds, Buffalo, Otter Tail and Wild Rice, which make up the Red River drainage basins of Becker, Clay, Otter Tail and Wilkin Counties.

The project focused on three specific outcomes including 1) Coordination with LGU's to develop effective AIS communication and management. 2) Develop and distribute educational materials that support best management practices for AIS. 3) Expand and leverage opportunities to develop and deliver an AIS program based on best management practices that are replicable throughout the region.

The project made significant progress toward the coordination of the LGU's within the three watersheds and four counties. All endorsed the watershed approach and included this strategy in their local plans. The Red River Basin Commission staff met monthly for the duration of the project with AIS LGU's to integrate the watershed approach and worked directly with over 20 groups and 6000 individuals including natural resource managers, lake property owners, students, teachers and researchers.

Educational materials and management resources including; AIS Risk Assessments for the targeted watersheds, an AIS mobile application, GIS based AIS maps, AIS identification cards, information brochures and promotional items and multiple surveys, presentations and ads were all developed and disseminated by the Red River Basin Commission for the watershed approach to AIS management as a result of the project.

Project Results Use and Dissemination

Educational materials and management resources developed by the Red River Basin Commission were disseminated to local groups, state agencies, national and international AIS related peer groups through the Red River Basin Commission website, public presentations and educational workshops.

Additionally, targeted media messages included regionally branded print media and radio AIS promotions that run along with other timely water conservation messages daily during prime listening time were adopted for reaching a regional listening audience of 71,500 weekly.

The resources developed including the Aqua.mn mobile application - https://aqua.mn/ and website- http://www.redriverbasincommission.org/ are designed so citizens can access educational materials and resources with links back to county based resources, watershed partner resources and Minnesota Department of Natural Resources AIS tools and information.

The AIS Risk Assessments that use science, fact and logic to identify and quantify vectors of risk assist in planning for zebra mussel management. These assessments were shared with and are used by watershed districts, local units of government, lake associations and others, to support the prioritization of funding and activities, including inspection and decontamination, to curtail and prevent the spread of zebra mussels and other AIS species to Minnesota's lakes and rivers. The AIS Risk Assessment GIS Tool allows users to interactively explore the infestation risks of lakes and rivers in the project area, and visualize where aquatic invasive species have been sighted. It serves as a digital companion to the static maps generated in the reports. The AIS Risk Assessment GIS Tool can be accessed on ArcGIS Online via the link:
http://www.arcgis.com/home/webmap/viewer.html?webmap=2a3a1ecbc1ca414b875c0b8feed7463a

The Red River Basin Commission lead efforts to collect, review and distribute current AIS survey data and watershed scale demographic data within the targeted project region. The survey initiatives were aimed to help determine the current knowledge, attitude and interest in AIS issues affecting Minnesota's lakes region. A final survey results report was shared with watershed districts, LGU's, lake associations and others and is attached to the LCCMR Final Report.

As a basin wide focused organization the Red River Basin Commission is continuing to take action in coordinating efforts between organizations focused on AIS. The Red River Basin Commission through the facilitation of the Red River AIS Technical and Science Team and multiple other working groups will continue to sustain and build upon the watershed scale AIS strategy for the Red River of the North International Watershed.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan Final Report

Date of Report: August 15, 2016

Date of Work Plan Approval: June 4, 2014

Project Completion Date: June 30, 2016

PROJECT TITLE: Northwest Minnesota Regional Aquatic Invasive Species Prevention Pilot

Project Manager: Julie Goehring

Organization: Red River Basin Commission (RRBC)

Mailing Address: 1120 28th Ave N, Suite C

City/State/Zip Code: Fargo, ND 58102

Telephone Number: (701) 356-3183

Email Address: Julie@redriverbasincommission.org

Web Address: http://www.redriverbasincommission.org/

Location: Becker, Clay, Otter Tail and Wilkin County

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$219,000**
	Amount Spent:	**$199,420**
	Balance:	**$ 19,580**

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 04c

Appropriation Language:
$219,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the Red River Basin Commission to develop aquatic invasive species prevention strategies on a watershed scale and develop materials to sustain watershed scale decision-making and implementation. This initiative must be coordinated with the Department of Natural Resources and outdoor heritage fund activities for locally based invasive species control. Specific reporting and analysis of outcomes and findings of this alternative approach must be provided to enable duplication in other regions of the state.

I. PROJECT TITLE:
Northwest Minnesota Regional Aquatic Invasive Species (AIS) Prevention Pilot

II. PROJECT STATEMENT:
Aquatic Invasive Species (AIS) spread has become one of the top concerns especially as it relates to emerging nonnative species that threaten the recreational and economic viability of the surface water resources of the Red River of the North watershed. The greatest area of immediate concern is centered on the counties of Becker and Ottertail in Minnesota, where according to the Minnesota Department of Natural Resources Infested Waters report (4-29-2013), three species, Zebra Mussel, Faucet Snail and Flowering Rush alone have invaded 35 lakes and wetlands, with Zebra mussels also listed in the Otter Tail, Pelican and Red River systems.

The Local Governmental Units (LGU's) are implementing plans to address the issues within the lakes and wetlands at the county level, but introduction into our river systems necessitate a regional approach to education, outreach and management of nonnative species evolving within the Red River Basin. Additional data supporting this idea comes from Becker and Otter Tail county data related to nonresident riparian property ownership which exceeds 63% Becker and 55% Otter Tail indicating that future transport of nonnative species to other regions of the watershed are of significant concern for this region.

The goal of this pilot project is to expand Aquatic Invasive Species work from a largely county based process to a larger context or "watershed scale" through partnerships with local government units. We will target the three main watersheds, Buffalo, Otter Tail and Wild Rice, which make up the Red River drainage basins of Becker, Clay, Otter Tail and Wilkin Counties.

Three specific outcomes will include 1) Coordination with Local Government Units (LGU's) to develop effective AIS communication and management for basin residents. 2) Develop and distribute educational materials that support proper practices for AIS outreach education and citizen engagement planning strategies at the watershed scale. 3) Expand and leverage opportunities with state, federal and provincial agencies and institutions efforts to develop and deliver an AIS program based on promising practices and newer more innovative methods that are replicable throughout the Red River of the North Watershed.

III. PROJECT STATUS UPDATES:

Project Status as of January 1, 2015:
The project staff has made significant progress coordinating with the LGU's within the three watersheds and four counties. All have endorsed the watershed approach and are including this concept in their local plans. Additionally, Becker, Clay and Otter Tail have contributed five thousand dollars each as members of the Red River Basin Commission, Joint Powers Board member counties to support efforts of this regional pilot and Buffalo/Red, Pelican River and Wild Rice Watershed Districts have contributed the same amount as watershed partners. The Red River Basin Commission staff is meeting monthly with the county AIS committees and integrating our planning with local plans, engaging the local government and citizen groups in regional brand development and moving forward with activity plans that are targeted to the riparian property owners and users based on the demographic profile within each watershed. Expanded opportunities underway have included an AIS tour and workshop with regional participation, including participants from our pilot partners in Minnesota, and guests North Dakota and Manitoba local government units. The RRBC coordinated a formal meeting with agency leads from each state and province as well as representatives from U.S Fish and Wildlife Service meeting to begin discussions on developing a plan for the Red River of the North Watershed that will support leveraging for long term sustainability of AIS efforts. The forming of an AIS technical science team was also discussed and will become one of the first steps taken in 2015.

Project Status as of September 1, 2015:
The staff continues to coordinate with the Local Units of Government however, the infusion of AIS aid dollars at the county level has changed the dynamics of the promotion of a "regional approach" to AIS work. The counties receiving small amounts of AIS aid like Traverse County, have begun contacting the RRBC to seek assistance to help make the most effective use of resources already developed through our regional AIS approach for their local outreach efforts. The counties receiving larger AIS aid amounts like Becker and Otter Tail, with a combined total of more than $800,000 of new funding in 2015, are re-evaluating plans they had in place and are adjusting to plan for management of the new resources. The abundance of funding is helping them target local needs but limiting growth of some of the "regional approach" priority efforts that counties and watershed partners were excited about at the beginning of this project. The RRBC has begun working with the local leadership to facilitate more intentional communication and coordination of AIS activities especially to lakes that border

county boundaries including better coordination of AIS inspection programs, decontamination services and sharing of successful local efforts across jurisdictional boundaries.

One of the encouraging results we are seeing from our preliminary survey data is that majority of local residents and lakes users, answering this survey question, would support an additional fee in the five dollar range collected at the local or watershed level to support aquatic invasive species efforts. This and other survey information will be presented and discussed during focus group meetings we are planning with our partners within the regional project site. If an AIS or natural resource type fee were initiated at the watershed scale the funds could be managed by a watershed district or other regional entity and partner efforts with county based AIS programs and target specific AIS needs as they arise that affect a watershed region.

The educational materials and outreach tools the RRBC is developing including the Aqua.mn app- https://aqua.mn/ and our website- http://www.redriverbasincommission.org/ are designed so citizens can access regional materials and resources we are developing with links back to county based resources, watershed partner resources and links to Minnesota Department of Natural Resources AIS tools and information. As an example, the MNDNR has developed a statewide GIS based decontamination map, we were able to integrate that link into the Aqua.mn app so any user with our app can find statewide decontamination facilities without having to search any further than the app on their mobile device. Our resources are being designed to be more nimble and adaptable as information changes or is updated regardless of where development of the resource takes place.

The RRBC is collaborating closely with the MNDNR AIS staff in the region and state. We are taking a lead role in supporting a plan for managing the newly discovered Red River zebra mussel infestation coordinating with our regional AIS specialist. We are also coordinating efforts with the state Invasive Carp coordinator, as the new Minnesota Invasive Carp plan is being developed. The RRBC will be written into the new state plan as the lead agency coordinating efforts to implement plan strategies for the Red River of the North Watershed. A spring 2016 meeting is being planned with our regional project technical science team and the MNDNR state coordinator to develop share information across jurisdictions and begin localizing the invasive carp plan to the needs of the watershed system.

Project Status as of April 1, 2016:
As a basin wide focused organization the RRBC is taking action in coordinating efforts between organizations focused on AIS. The RRBC has facilitated the organization of a Red River AIS Technical and Science Team. This effort will share information, and leverage and sustain promising practices for the basin through discussion of threats and actions from a basin/watershed approach. The AIS Technical and Science Team has representation from the entire basin (MN, ND, SD, and Manitoba). The AIS Technical and Science Team is seeking to establish goals and tasks for the basin that can serve to move efforts in the basin forward, identify roles each government unit and the RRBC can have in achieving those goals, and explore funding for sustaining the promising practices for the basin approach. Formal meetings are planned for the spring of 2016 to gather all the stakeholders for detailed discussion of AIS in the Red River Basin.

The RRBC continues to work closely with the MNDNR in supporting a plan for managing the Red River zebra mussel infestation and identifying the risk invasive carp pose for the Red River. The Red River basin AIS Technical Team through discussions did identify the need to change the sampling timetable for zebra mussels in the Red River. In the past the sampling on the US side was completed in June and July. This was too late in the season to catch the peak production of veligers. We will need to take this type of cross-border discussions on a broader scale as we attempt to address future AIS infestations that will be coming. The RRBC attended an invasive carp forum where promising practices for monitoring and controlling the spread of invasive carp were discussed. The RRBC will continue to develop and share information across jurisdictions to sustain promising practices for the basin and begin localizing the Minnesota invasive carp plan to the needs of the watershed system.

Amendment Request May 27, 2016:
This amendment request is to correct the budget for future expenses and update the personnel information related to changes within personnel (2 FTEs) managing this project. The RRBC is requesting that Julie Goehring be accepted as the current project manager (0.25 FTE) and Aaron Ostlund as the current Field Technician (0.8 FTE). These personnel changes include changes in billable rates but will not result in exceeding any budgeted salary totals. Additionally, the RRBC is requesting to shift salary funds ($500) into travel expenses to cover future expenses for coordination with county and watershed LGU activities.

Amendment Approved by LCCMR 6-3-2016

Overall Project Outcomes and Results:
Aquatic Invasive Species (AIS) spread has become one of the top concerns as it threatens the recreational and economic viability of the surface water resources of the Red River of the North watershed. According to the Minnesota Department of Natural Resources Infested Waters report (2016), Zebra Mussels have invaded the Otter Tail, Pelican and Red River systems. The Local Governmental Units (LGU's) are implementing plans to address AIS issues at the county level, but introduction into our river systems necessitate a regional approach to education, outreach and management of AIS within the Red River of the North watershed. The goal of this pilot project was to expand AIS work from a largely county based process to a watershed scale through partnerships between LGU's. The project targeted three main watersheds, Buffalo, Otter Tail and Wild Rice, which make up the Red River drainage basins of Becker, Clay, Otter Tail and Wilkin Counties.

The project focused on three specific outcomes including 1) Coordination with LGU's to develop effective AIS communication and management. 2) Develop and distribute educational materials that support best management practices for AIS. 3) Expand and leverage opportunities to develop and deliver an AIS program based on best management practices that are replicable throughout the region.

The project made significant progress toward the coordination of the LGU's within the three watersheds and four counties. All endorsed the watershed approach and included this strategy in their local plans. The Red River Basin Commission staff met monthly for the duration of the project with AIS LGU's to integrate the watershed approach and worked directly with over 20 groups and 6000 individuals including natural resource managers, lake property owners, students, teachers and researchers.

Educational materials and management resources including; AIS Risk Assessments for the targeted watersheds, an AIS mobile application, GIS based AIS maps, AIS identification cards, information brochures and promotional items and multiple surveys, presentations and ads were all developed and disseminated by the Red River Basin Commission for the watershed approach to AIS management as a result of the project.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Coordination with Local Government Units
Description: This pilot project will support the development of AIS prevention strategies and resources that focus beyond the local level supporting a watershed based approach within the targeted project area and expand Aquatic Invasive Species work to the "watershed scale" through partnerships with local government units within three watersheds, Buffalo, Otter Tail and Wild Rice, which make up the Red River drainage basins of Becker, Clay, Otter Tail and Wilkin Counties.

The RRBC working collaboratively with our County Commissioner based Joint Powers Board will coordinate with LGU's to develop effective AIS communication and management for basin residents. The engagement process will include working closely with county AIS staff and their task force groups. Coalition of Lake Associations (COLA) groups, Watershed and Soil and Water Conservation Districts (SWCD) managers and local Lake

Associations that are within key destination, infested waters and waters directly connected rivers within the targeted watersheds.

The plan will include a survey of riparian property owners, regional businesses and natural resource partners (riparian audience). Survey methodologies will include, an electronic and paper survey to gauge riparian audience attitude, knowledge and interest in invasive species prevention and management and planned observational methods at destination water access sites to form baseline knowledge. Survey results will be reported to LGU'S and natural resource community to help prioritize strategies that support watershed approach to AIS efforts.

This pilot project will establish a Geographic Information System (GIS) database that focuses on the science of an individual watershed ecosystem based on physical and chemical features favorable to grow and sustain new species. This database will help managers and decision makers establish targeted programs that direct resources in a more cost effective manner. The GIS database will use current surface water quality data, lake monitoring data and physical landscape features to create a map within each watershed's most vulnerable water bodies.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 109,165
Amount Spent: $ 93,210
Balance: $ 15,955

Activity Completion Date: June 30, 2016

Outcome	Completion Date	Budget
1. Develop & administer survey to establish baseline information around AIS Attitude, knowledge and interest. Including reporting of preliminary results by 2015 Red River Basin Commission (RRBC) International Water Conference.	January 15, 2015	$ 22,000
2. Facilitate regional meetings and educational efforts with AIS task force, COLA and local lake association to support and develop the watershed approach to AIS prevention and management. Lead efforts to establish an Integrated AIS plan developed at watershed scale within each of the targeted watersheds.	June 30, 2016	$ 70,000
3. Develop GIS data base for use by LGU's, citizens and decision makers	November 1, 2015	$ 17,165

Activity Status as of January 1, 2015:

- An initial AIS attitude, knowledge and interest survey has been developed and was tested in limited scope during the first six months of this project. The survey will be introduced during the January 2015 Red River Basin Commission (RRBC) International Water Conference. Distribution and survey efforts targeting riparian property owners will be one of the key activities during 2015 outreach efforts.
- The RRBC staff have been active participants and members of the Becker County AIS Panel and the Otter Tail County AIS Task Force, participants at both county based COLA's (coalition of lake associations) and presented and facilitated discussions with each of the counties and watershed districts within in the pilot project area.
- The RRBC joint powers board, has requested that the RRBC host a one day workshop for the sixteen counties in the Red River Basin to assist with AIS planning as counties develop local efforts in prevention, education and management with state supported AIS prevention aid dollars.
- Hosted a one day AIS tour and informational session for decision makers, citizen volunteers and service providers on Pelican Lake to show impact zebra mussels and other AIS species are having on the recreational resources and economy in this region. Participants had a chance to see zebra mussels as they were extracted from the lake, hear from local lake service providers about the

impacts to their businesses and learn from local programs about efforts considered success stories that are leading to potential promising long term practices.

- Developed a first of its kind, AIS risk assessment tool that uses science, fact and logic to plan for zebra mussel management. These assessments will be used by watershed districts, local units of government, lake associations and others, to support the prioritization of funding and activities to curtail and prevent the spread of zebra mussels and other AIS species to Minnesota's lakes and rivers. The Wild Rice and Pelican River Watershed AIS assessments have been completed and are currently under peer review, with Buffalo/Red River and Otter Tail to be started in 2015. Upon completion of each watershed assessment, the data will be integrated as maps available as part of the GIS data base development.
- The RRBC is delineating "sub watershed" drainage systems, five completed, which will allow for targeting of specific recommended activities highlighted in each watersheds AIS risk assessment.

Activity Status as of September 1, 2015:

- The AIS attitude survey was mailed out to 1353 households (232 in the Rose lake watershed and 1121 in the Cormorant lakes watershed). Additionally our local partners have supported the purchase and deployment of 4 tablet devices containing the survey at area lakes service providing businesses. Initial survey response of 450 participants through August 15 is being reviewed and summarized. It is anticipated the report from this first group will be published by early November. The survey will be opened for a second round in mid-September to target fall and winter lakes and river users.
- The RRBC continues to be active in the Otter Tail AIS task force (OTAISTF) and our staff are now actively participating in subcommittee efforts contributing to education and outreach as a partner delivering the regional AIS message. The RRBC assisted the task force in organizing a face to face networking event and coordinated youth outreach promotional item development for the OTAISTF. The RRBC also facilitated a meeting between the Otter Tail AIS task force leadership and the Becker County AIS coordinator to explore more effective cross county boundary efficiency for AIS prevention and education. The RRBC is an active participant in the Otter Tail Coalition of Lake Association (COLA) and Becker COLA monthly meetings providing regional AIS updates and support.
- The RRBC participated in 3 MNDNR Regional AIS workshops in Fergus Falls, Bemidji, and Thief River Falls, providing overview of the Regional AIS Approach and assisting with facilitation in small group discussion.
- The RRBC presented the findings of its AIS Risk Assessment tool to the Becker and Otter Tail AIS staff and to the Buffalo/Red River Watershed District, the Wild Rice Watershed District, the Pelican River Watershed District, and the Cormorant Watershed district board of Directors. The tool helps prioritize AIS related resource planning and management and we are working to move this and similar AIS resources to a GIS level format to allow users to connect with those GIS based AIS tools in Minnesota that will help in decision-making.
- The RRBC participated in the Big Cormorant Lakes Spring Fling, advocating a watershed scale approach to AIS policy. The outreach staff is working directly with the Cormorant watershed leaders to develop outreach activities that meet the needs of this diverse riparian property owner and user group. More than 45% of the users and property owners within this watershed come from North Dakota and states outside of Minnesota
- At the invitation of the Buffalo Red River Watershed District, the RRBC conducted AIS outreach with a booth at the Barnesville Showcase in Barnesville MN. Participants, many of whom visit area lakes in neighboring counties have had little community based exposure to AIS issues and information.
- The RRBC participated in the River Keepers outreach clinic in Moorhead, MN. Approximately 150 young people visited various stations, including RRBC's about aquatic invasive species.
- The RRBC in collaboration with the Otter Tail COLA, attended and participated in 3 fishing tournaments, delivering the watershed message, distributing materials, and providing media based radio interviews.
- The AIS Risk Assessment GIS tool is live and can be accessed on ArcGIS Online via the link: http://www.arcgis.com/home/webmap/viewer.html?webmap=2a3a1ecbc1ca414b875c0b8feed7463a The AIS Risk Assessment Tool allows users to interactively explore the infestation risks of lakes and rivers

in the project area, and visualize where aquatic invasive species have been sighted. It serves as a digital companion to the static maps generated in the report. One challenge of GIS data sets that are developed is the frequency of information updates. The intent is that these data are accurate and up to date but often agency budgets limit staff time available to provide timely information updates. The RRBC has made it a priority to maintain updated data with the GIS tools we have developed as a result of the AIS Risk Assessment Tool

Activity Status as of as of April 1, 2016:

- The Regional AIS knowledge, attitude, and interest survey is complete. RRBC staff formally presented the results of the survey to the Cormorant Watershed District, the Buffalo/Red River Watershed District, the Otter Tail County AIS Task Force, and to staff at Becker County Soil and Water Conservation District. Survey feedback was positive and encouraging. Of special note was the respondents willingness to pay an additional fee to fund AIS prevention activities. The results of the survey will be compiled in a report that will be provided in the final update.
- The expansion of the infestation of zebra mussels in the Red River that occurred in 2015 took a lot of people by surprise. Zebra mussels were found in Pelican Lake in the Ottertail River watershed in 2009. They were found in extremely limited numbers at one location in the Red River at Wahpeton/Breckenridge area in 2010. This is where the Ottertail River empties into the Red River. Subsequent sampling in the period of 2010 to 2014 showed no increased infestation. Spring 2015 zebra mussels were found at the US/Canadian border for the first time. Sampling for zebra mussels was then completed in June 2015 along the whole length of the Red River US from Wahpeton to Canadian border and large numbers of veligers were found at every location sampled.

Final Report Summary:

The project made significant progress toward the coordination of the Local Governmental Units (LGU's) within the three watersheds, Buffalo, Otter Tail and Wild Rice, which make up the Red River drainage basins of Becker, Clay, Otter Tail and Wilkin Counties. All of the targeted LGU's endorsed the watershed approach and included this strategy in their local plans. The Red River Basin Commission (RRBC) staff met monthly for the duration of the project with AIS LGU's to integrate the watershed approach and worked directly with over 20 groups and 6000 individuals including natural resource managers, lake property owners, students, teachers and researchers. The engagement process included working closely with county AIS staff and their task force groups, the Coalition of Lake Associations (COLA) groups, Watershed and Soil and Water Conservation Districts (SWCD) managers and local Lake Associations that are within the targeted watersheds. Educational materials and management resources developed as a result of the project were disseminated to these groups for the watershed approach to AIS management.

The RRBC developed and disseminated an AIS Risk Assessment tool to the Becker and Otter Tail County AIS staff and to the Buffalo/Red River Watershed District, the Wild Rice Watershed District, the Pelican River Watershed District, and the Cormorant Watershed District board of directors. The tool helps prioritize AIS related resource planning and management. In an ideal world, all AIS prevention programs would be applied to all lakes. In reality, budgets are always limited, so prioritization of programs based on risk is necessary. In order to have a watershed strategy for AIS program management, the vectors of spread for each lake needs to be determined. The risk assessment process identifies the vectors of spread for the lakes in the watershed. For headwaters lakes there is no risk of infestation from upstream, so any new infestation would come from lake users (boats, boat lifts, docks, etc). For lakes in a river chain, both lake users and upstream lakes need to be considered as potential vectors of spread. By identifying vectors of risk for AIS and analyzing environmental and social factors a risk assessment is effective for guiding AIS program development. This process identifies lakes with high public use ratings that should be at the highest priority for boat inspections at public accesses. Additionally, lakes that are already infested should have boat-washing stations nearby for decontamination, and all lakes should be targeted with a watershed-wide education program. The AIS Risk Assessment Reports can be inserted directly

into county's AIS Plans and guide the use of the county's AIS funds in the most efficient and effective way possible.

The AIS Risk Assessment GIS Tool allows users to interactively explore the infestation risks of lakes and rivers in the project area, and visualize where aquatic invasive species have been reported. It serves as a digital companion to the static maps generated in the reports. One challenge of GIS data sets that are developed is the frequency of information updates. The intent is that these data are accurate and up to date but often agency budgets limit staff time available to provide timely information updates. The RRBC has made it a priority to maintain updated data with the GIS tools we have developed as a result of the AIS Risk Assessment GIS Tool. The AIS Risk Assessment Reports and GIS Tool can be accessed through the RRBC website- http://www.redriverbasincommission.org/ or directly on ArcGIS Online via the link: http://www.arcgis.com/home/webmap/viewer.html?webmap=2a3a1ecbc1ca414b875c0b8feed7463a

The RRBC as part of the watershed approach to AIS prevention and management developed a survey to help determine the current knowledge, attitude and interest in AIS issues affecting Minnesota's lakes region. The survey was administered to a riparian audience that included property owners, recreational water users and businesses who benefit from this regions diverse surface water resources. Respondents were asked questions to measure current "knowledge" they feel they have related to AIS, their "attitude" regarding management of invasive species and personal "interest" in taking an active role to manage and prevent the spread of invasive species. As an example, more than 90% of respondents recognize the words "clean, drain, dry" from the Stop Aquatic Hitchhikers campaign which is designed to prompt action when leaving a waterbody after a recreational outing. The "clean, drain, dry" message has nationwide outreach and has been adopted to provide consistency and repetition for outdoor oriented travelers and resource users. Respondents also expressed a high degree of confidence relating to ability to identify a zebra mussel (72%), knowing how to report a potential aquatic invasive species (75%) and having spent time in the past searching for AIS information (59%). Respondent's attitude toward management of AIS are both supportive and positive in nature. A large majority disagree with the following negative views, AIS is a problem we can do little about (79%) and no matter what we do we will not prevent AIS (70%). The majority agree with and support the following actions:

- The need for more access restrictions (79%)
- Supporting lake management that is best for the lake, not people (78%)
- Inspection for all watercraft leaving infested waters (74%)
- Supporting "rapid response" strategies to chemically treat newly infested lakes (67%)
- Support efforts to place a higher priority for decision making on protecting lakes over recreation and lakeshore resident interests (64%)

While knowledge and attitudes are important measures to know and understand, one's interest in taking action as a citizen and resource user becomes the keystone habit and building block for long-term impacts. A vast majority, 91 % of respondents, expressed interest in doing their part to prevent the spread of aquatic invasive species. The majority of the respondents also expressed interest in the belief that it is all lake users' responsibility to reduce AIS spread (85%), that they would be willing to share information with other to help prevent AIS (86%) and a high majority would be willing to pay more, $2-$5 for local AIS management support (76%). Many area lakes have some form of organized group, usually a Lake Association so respondents were asked about their interest in knowing about lake associations and volunteering. Only 44% responded as being interested, while 18% were not interested, with 38% replying with a neutral response. Less than half of the respondents expressed an interest in engaging as a volunteer but when combined with those respondents indicating a "neutral" preference there is an opportunity to recruit up 82% of this respondent group as a potential volunteer at the local level. Respondents were also asked about their opinion in taking precautions to prevent the spread of nine AIS species that are either present in or emerging as a threat to invade the Red River Basin. Based on a five point scale with 5 being extremely important, the first tier included Zebra mussel

(4.78), Asian carp (4.41), Eurasian water milfoil (4.34) and Curly leaf pondweed (4.04) and the second tier, Spiny water flea (3.95), mystery snail (3.84), Flowering rush (3.77), Rusty crayfish (3.74), and Yellow iris (3.56). Of interest in the comment section of the survey, a number of respondents expressed little or no knowledge of the second tier AIS species. How respondents prefer to learn about AIS is interesting especially knowing the majority are over fifty years old; Internet (52%) ranked as the number one preference followed by, printed media (49%), Newspaper/magazine (39%), radio/television (35%), smart phone/mobile device (20%), Attending a class/workshop (19%). A final survey results report is attached to this report and contains graphs from the responses to each of the survey questions, a visual approach using word clouds to show popularity of lakes in this survey group and a map of each watershed with the lake to lake travel pattern of lake property owners in each watershed.

A remaining balance of 16,454 for activity 1 is a result of project personnel changes during the second year of the project. The personnel turnover resulted in an overall shift in billing rates as well as significant time devoted to the project from the RRBC Executive Director for which we did not seek reimbursement.

ACTIVITY 2: Material development and distribution

The pilot project will expand programs like the "Stop Aquatic Hitchhikers" campaign and State Agency Invasive Species resources and educational materials to the Red River Basin, including a focus to "regionally brand" resources to fit the impact area (Red River Watershed) in an effort to support ownership and sense of place connections to the decisions that citizens of this region make as they relate to surface water impacts from nonnative species.

In an attempt to emphasize the watershed approach at least three lake associations in each watershed (Buffalo, Otter Tail, Pelican and Wild Rice) will be targeted for planning and training to make a personal connection to local property owners. In these instances branding will be scaled to reflect the sub-watershed (Buffalo, Ottertail/Pelican, and Wild Rice) that are immediately impacted by decisions of each local riparian user. This effort will directly distribute educational materials to 1000 riparian property owners whose activities directly impact their watershed. Additional materials will be distributed through partners (sporting goods/bait distributors, real estate agents, civic groups and service industry businesses) to reach an additional 4000 participants.

To support the current trend of mobile media as a tool for sharing and receiving information, this project will expand on two successful mobile applications (apps) developed for the Red River Watershed, "River Mapper" and "CRED- Flood reporting" by developing an invasive species app to these mobile based educational tools. Organizational arrangement for this phase will mirror existing mobile apps of which examples include: Minnesota Department of Natural Resources (MN DNR) Lake finder, PaddleNet-Launch Sites, Early Detection and Distribution Mapping System (EDD Maps). These apps are examples of phone or tablet based apps that promote citizen engagement, education and reporting of information and data for science and additional citizen participation.

The mobile environment will serve to target a younger demographic for gathering data and disseminating branded educational material content and as a tool to engage those participants who are or will be engaged as citizen scientists. This will be a critical component to support and validate the GIS data planned for the project site. The plan is to develop and test this app creating a field tested version ready for release and distribution as a tool for use across Minnesota and the region.

In an effort to help determine the potential effectiveness of branding resources to impact at the watershed scale, focus group sessions will be conducted within each county to gather citizen response to print and mobile materials. The results of this feedback will be used for future planning of prevention and management activities

that invest resources in a more clearly defined manner. Results will also be used to develop promising practices for larger scale watershed and education and outreach planning throughout the state of Minnesota.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 77,335
Amount Spent: $ 73,814
Balance: $ 3,521

Activity Completion Date: March 15, 2016

Outcome	Completion Date	Budget
1. Develop and distribute regionally branded AIS educational materials within project site. Targeting a minimum of 5000 citizens	March 15, 2016	$ 50,000
2. Develop and field test "Invasive App" in counties and watersheds within project	June 30, 2015	$ 17,335
3. Conduct a minimum of 10 focus group sessions to evaluate and summarize effectiveness of branded materials and Invasive mobile tools	December 31, 2015	$ 10,000

Activity Status as of January 1, 2015:

- Have begun development of an AIS brand that is specific and recognizable to this region. The first branded slogan: "*Get your AIS off the boat!*" ties into the existing "Clean, Drain, Dry" campaign and will be used along with print material, web resources and creatively distributed using a waterproof cell phone pouch and a chamois boat drying towel. These educational items have been endorsed by our project collaborators, and will be distributed as part of our educational efforts to reach and engage riparian property owners, business community and younger demographic audiences.
- A fully functioning test "beta" version of our mobile AIS App, has been created and initial testing has taken place this fall to verify functionality and accuracy. The App, which will be deployed for full field testing in 2015, allows a user to capture both image and location data of a suspected AIS species and upload the information to a cloud based server for screening by RRBC staff prior to forwarding reports to DNR AIS specialists and AIS scientists working in this region. The App contains a resource library connected to the existing resources of Minnesota Sea Grant and the Minnesota Department of Natural Resources so users can seek out more information while out on the water. Includes a "take action" section that encourages users to get involved with a local COLA or lake association, or as a volunteer with the Minnesota DNR AIS volunteer monitoring program. And includes a mapping feature utilizing the Minnesota DNR Recreation Compass map. The map allows the user to verify accuracy of the report they are making as well as using the AIS App for recreational purposes beyond AIS reporting. Bids for App. Development were advertised with inquiries by Houston Engineering, North Dakota State University, Computer Science Department and Myriad Mobile. The bid was awarded to Houston Engineering, the only bidder who came in at budgeted amount and with most complete deliverables proposed based on the request for bids solicitation.
- Focus group activity not yet begun.

Activity Status as of September 1, 2015:

- "Get your AIS off the Boat" branded items distributed at fishing tournaments, pubic accesses, and other outreach events. The materials which are contemporary and unique have been popular with both the fishing and recreational lake user community. The RRBC staff have provided education, outreach and facilitation activities that have resulted in material and information distribution to 3750 citizens through this spring and summers outreach efforts.
- The waterproof AIS ID field cards have been well received. They are suitable for wet environments, fit in a tackle box or boat storage bay and are detailed enough so an average lake user could compare the AIS

species on the card with a plant or animal found in the lake. Approximately 4000 cards identifying eleven different AIS species have been distributed to date.

- RRBC partnered with the Traverse County Sherriff's department to distribute "Get your AIS off the Boat" to educate 200 participates in the Lake Traverse fishing tournament.
- RRBC assisted the Otter Tail County AIS taskforce in selecting promotional items for younger members of the public. These included Frisbees with an AIS message and honorary AIS inspector badges. Otter Tail county AIS inspectors are distributing these items at public accesses in the county.
- Aqua.mn the AIS reporting app for smartphones has been field tested this summer by staff out in the field. It has been promoted at area fishing tournaments, area schools, and at public boat landings. Becker county AIS inspectors have installed the app on their personal devices and have promoted it during their inspection duties at boat landings.
- The Aqua.MN is being considered by the MN DNR as one of the potential frameworks to develop their planned statewide AIS mobile reporting Applications. Minnesota based Houston Engineering, submitted a proposal based on the Aqua.mn development and field testing and is one of the finalists for consideration for the MNDNR statewide AIS mobile application project.
- Focus group activity has been conducted with the Otter Tail AIS leadership to determine which educational materials are most useful to support their local efforts, with the boat towels and AIS cards being seen as having appeal to help engage citizens to take action. The smartphone waterproof cases have been popular with the younger generation and with recreational (swimming, paddle sport) lake users.
- Focused discussion around the mobile application "Aqua.MN", led to the Otter Tail Coalition of Lake Associations (COLA) developing and submitting a proposal for Lessard Sams funds to develop a similar app for tracking boat and equipment movement.

Activity Status as of as of April 1, 2016:

- RRBC Staff conducted 7 focus groups with the Otter Tail AIS Task Force, The Cormorant Watershed District, The Pelican River Watershed District, and Becker County staff to discuss and refine branded AIS outreach items. Feedback on the ID cards and cell pouches has been favorable. Suggestions included making the cards larger and adding more species.
- Aqua.MN continues to be a success. A survey respondent commented that they enjoy the app and the information it features. At this point the web based version will be maintained. Further development of the app to launch Apple and Google Play compatible versions has been determined to provide little advantage. The web based version can be accessed from computer and portable devices and allows for updates in real time without the need to seek approval from application hosts. Additional development to allow for Apple, Google Play, and other versions is estimated to cost three times the original engineering costs.

Final Report Summary:

Educational materials developed by the RRBC were disseminated to local groups, state agencies, national and international AIS related peer groups through the RRBC website, public presentations, targeted advertisement and educational workshops. The project expanded the "Stop Aquatic Hitchhikers" and "Clean, Drain, Dry" campaigns to the Red River Basin with development of an AIS brand that is specific and recognizable to this region. The branded slogan: "*Get your AIS off the boat!*" ties into the existing "Clean, Drain, Dry" campaign and was used along with print material, web resources and distributed promotional items. These educational items were distributed as part of our efforts to reach and engage riparian property owners, the business community and younger demographic audiences. Branded items distributed at fishing tournaments, pubic accesses, and other outreach events included waterproof AIS identification field cards, waterproof cell phone pouches, chamois boat drying towels and light weight day packs. The materials which are contemporary and unique have been popular with both the fishing and recreational lake user community. The RRBC staff have provided

education, outreach and facilitation activities that have resulted in material and information distribution to 4,400 citizens.

Additionally, targeted media messages including regionally branded print media publications and radio AIS promotions were adopted for reaching additional audiences beyond the fishing and recreational lake user community. The RRBC contributed to the monthly Otter Tail COLA newsletter providing news worthy columns and an Op-ed piece called "Beyond the Bait Bucket" which is designed to get local AIS leaders thinking about impacts of current efforts while incorporating a targeted slant to thinking about potential for more effective education for local citizens. The RRBC have created "Ripple Effect" radio promotions that air on the clear channel regional radio (KFGO AM 790) that specifically target an AIS related message. Ripple effect promotions are a contracted service the RRBC has with KFGO and AIS ads are running along with other timely water conservation messages daily during prime listening time. These messages are reaching a regional listening audience of 71,500 weekly.

The fight against AIS requires a variety of approaches, but a key component is informing and more importantly engaging the public. Exploring and evaluating a multi-faceted approach for motivating and engaging the public on the AIS issue lead to the development of the Aqua.mn mobile application - https://aqua.mn/. Mobile or tablet based applications that promote citizen engagement, education and reporting of information and data capture this multi-faceted approach. Aqua.mn allows a user to capture both image and location data of a suspected AIS species and upload the information to a cloud based server for screening by RRBC staff prior to forwarding reports to Minnesota DNR AIS specialists and AIS scientists working in this region. The application contains a resource library with images and descriptions of AIS and is connected to the existing resources of Minnesota Sea Grant and the Minnesota DNR so users can seek out more information while out on the water. The application includes a take action section that encourages users to get involved with a local COLA or lake association, or as a volunteer with the Minnesota DNR AIS volunteer monitoring program. Aqua.mn also includes a mapping feature utilizing the Minnesota DNR Recreation Compass map. The map allows the user to verify accuracy of the report they are making as well as using the AIS application for recreational purposes beyond AIS reporting. It has been promoted at area fishing tournaments, area schools, at public boat landings, public presentations and educational workshops to engage citizen scientist in proactively monitoring for AIS.

The Aqua.mn application was considered by the Minnesota DNR as one of the potential frameworks to develop their planned statewide AIS mobile reporting applications. Ultimately, the Minnesota DNR selected an alternative application platform, EDDMapS, for managing data about observations of terrestrial and aquatic invasive species, recording the designation of bodies of water infested by invasive species and for providing invasive species information to DNR decision-makers and the public. EDDMapS had already been developed for monitoring terrestrial invasive species in Minnesota. The Minnesota DNR found that it was more cost effective to continue development of this platform over adopting and integrating the Aqua.mn application for AIS.

The RRBC is working with Houston Engineering, Inc. to identify future utilization opportunities for Aqua.mn. Currently Houston Engineering, Inc. is working with Kandiyohi County to build an AIS tracking and information application that will expand Aqua.mn. The proposed expansion will allow users to be able to upload a picture of a suspected AIS and utilize image recognition to tell them if it is an invasive species. If the image recognition produces a positive result, a form opens to report the AIS to the Minnesota DNR and get more information on decontamination. The application will continue to provide additional information about AIS and how to avoid their spread. In order to enable high usage, the web based application will be further developed for Android and Apple platforms. The RRBC is supporting this effort to expand Aqua.mn to further engage citizen scientist in proactively monitoring for AIS in Minnesota.

ACTIVITY 3: Leveraging to sustain promising practices

Description: As a function of the overall coordination effort by the project director, time will be devoted to developing promising practices that can be integrated throughout Minnesota and the Red River Watershed. The RRBC board of directors, water quality and fish and wildlife work group members will engage in a strategy that will support leveraging of resources from North Dakota and Manitoba to sustain and build upon the watershed scale decision-making and thinking around AIS program development for the Red River of the North International Watershed.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 32,500
Amount Spent: $ 32,395
Balance: $ 105

Activity Completion Date: 4/30/2016

Outcome	Completion Date	Budget
1. Establishment of a working technical science team to address current and future needs for watershed scale invasive species prevention and management	09/30/2015	$17,500
2. Develop and initiate a base funding strategy to support sustainability of AIS program efforts for Northwest Minnesota and the Red River Watershed	4/30/2016	$15,000

Status as of January 1, 2015:
The RRBC coordinated a one day meeting that included agency representatives from Minnesota Department of Natural Resources, University of Minnesota, North Dakota Game and Fish, Manitoba Conservation and the U.S. Fish and Wildlife Service to discuss overall Watershed needs related to AIS prevention, education and management. The discussion include supporting the development of a technical science team and initial conversations related to future funding to support sustainability for this region and the Red River Watershed.

Status as of September 1, 2015:

- The RRBC is coordinating with key scientists from: Minnesota Department of Natural Resources (MNDNR), University of Minnesota Aquatic Invasive Species Research Center (MAISRC), Concordia College Moorhead, North Dakota Game and Fish (NDGF), Valley City State University, South Dakota Game, Fish and Parks (SDGFP), Manitoba Conservation and Water Stewardship, and RMB Environmental labs. This technical group is providing emerging AIS issue related information to the RRBC, advising on current and future AIS sustainability needs and providing expertise to the RRBC for distribution within our Regional AIS project and throughout the larger Red River Watershed.
- Team participants provided a workshop at the 2015 RRBC International land and water summit conference in Winnipeg, Manitoba and will be providing a similar workshop as part of the 2016 conference in Grand Forks. They will also gather for a one day technical workshop in 2016 coordinated by the RRBC and the MNDNR Invasive carp coordinator to discuss the future challenges invasive carp might create if they enter the Red River system.
- The RRBC staff in the Manitoba office coordinated a one day watershed issues conference which included Science team member Candice Parks from Manitoba Conservation and Water Stewardship providing an Aquatic Invasive Species, Manitoba update. Staff from the U.S. Office along with Minnesota delegates from the RRBC Board of Directors attended the workshop. Board member engagement plays an important role as the RRBC defines its long term strategy for AIS leadership in this region of Minnesota and within the International watershed that is affected by the actions of people using the water resource of Northwest Minnesota.

Status as of as of April 1, 2016:

- The RRBC continues to work closely with the MNDNR, North Dakota Department of Game and Fish and Manitoba Water Conservation and Stewardship in supporting a plan for managing the Red River zebra mussel infestation and identifying the risk invasive carp pose for the Red River. The RRBC attended an invasive carp forum where promising practices for monitoring and controlling the spread of invasive carp were discussed. The RRBC will continue to develop and share information across jurisdictions to sustain promising practices for the basin and begin localizing the Minnesota invasive carp plan to the needs of the watershed system.
- The RRBC is facilitating the organization of a Red River AIS Technical and Science Team in an effort to leverage and sustain promising practices for the basin through discussion of threats and actions from a basin/watershed approach. The AIS Technical and Science Team is seeking to establish goals and tasks for the basin that can serve to move efforts in the basin forward, identify roles each government unit and the RRBC can have in achieving those goals, and explore funding for sustaining the promising practices for the basin approach. Formal meetings are planned for the spring of 2016.

Final Report Summary:
The RRBC coordinated with key scientists from; Minnesota Department of Natural Resources, University of Minnesota Aquatic Invasive Species Research Center, Concordia College Moorhead, North Dakota Game and Fish, Valley City State University, South Dakota Game, Fish and Parks, Manitoba Conservation and Water Stewardship, U.S. Fish and Wildlife Service and RMB Environmental Labs in the organization of a Red River AIS Technical and Science Team. The RRBC facilitates the Red River AIS Technical and Science Team in an effort to leverage and sustain promising practices for the basin through discussion of threats and actions from a basin/watershed approach. The AIS Technical and Science Team establishes goals and tasks for the basin that can serve to move efforts in the basin forward, identifies roles each government unit and the RRBC have in achieving those goals, and explores funding for sustaining the promising practices for the basin approach. Workshops, meetings and conference calls have been facilitated as part of this effort including; an AIS workshop at the 2015 RRBC International land and water summit conference in Winnipeg, Manitoba, meetings supporting a plan for managing the Red River zebra mussel infestation and identifying the risk invasive carp pose for the Red River and discussions identifying the need to shift the sampling timetable for zebra mussels in the Red River Basin from June and July to earlier dates to catch the peak production of veligers. Future workshops and meetings will focus on this type of cross-border discussions on a broader scale as we attempt to address future AIS infestations that will be coming. The RRBC will continue to develop and share information across jurisdictions to sustain promising practices for the basin.

Additionally, the RRBC collaborates with many AIS focused groups in the Red River Basin including; North Dakota Game and Fish Aquatic Invasive Species Committee, Minnesota Invasive Carp Forum, International Water Institute, FM River Keepers and Prairie Waters Education and Research Center. This collaboration effort allows for the sharing of information and resources among all the groups working on AIS.

The RRBC sponsored and participated in the 2016 International Legislators Forum in Grand Forks, ND. The International Legislators Forum is an annual meeting of legislators from the Red River Basin that provides an avenue for representatives to discuss various regional issues. The International Legislators Forum focused on AIS among other topics in 2016. The discussion focused on the need to collaborate between states and province and work to slow the impacts of AIS on the environment and economy.

The RRBC has partnered with the US Army Corps of Engineers in developing the Comprehensive Watershed Management Plan to identify gaps and needs for the Red River Basin. The plan is intended to help identify what could be the next generation of success stories in the Red River Basin. The plan focuses on six resource management areas including; flood risk management, water quality, water supply, recreation, soil health and fish, wildlife and ecosystem health. Within the focus area of fish, wildlife and ecosystem health a goal of maintaining existing habitat and restoring natural systems in the basin has been adopted. This goal includes focusing on three problems the basin faces; habitat loss, habitat degradation and unfamiliarity of ecosystem

functions and values. Invasive species fall under the habitat degradation portion of the plan and have been a targeted as an issues of emphasis for current efforts to prevent further degradations of habitat. Objectives within the plan to address the AIS issues include; preventing and managing the spread of invasive species, developing opportunities for education to aid in the understanding and appreciation of fish, wildlife and natural processes and increasing stakeholder and public knowledge of fish, wildlife and natural processes. Through this partnership and publishing of the Comprehensive Watershed Management Plan the RRBC is hoping to provide direction and continue facilitating efforts to mitigate the impacts AIS have to the Red River Basin.

The RRBC through the AIS Technical and Science Team and the multiple other working groups will continue to sustain and build upon the watershed scale decision-making and thinking around AIS for the Red River of the North International Watershed.

V. DISSEMINATION:

We will communicate outcomes of what we learn to local groups, state agencies, and national AIS related peer groups through the RRBC website, public presentations and educational displays. We will develop a set of "promising practices" that other Minnesota watersheds and community groups can use to assist in planning for cost effective AIS related programs. We will create targeted media messages for print media and radio spots as part of our "Ripple Effect" water minutes that currently air in this region on clear channel radio. Details of survey results will available as a final report to LCCMR and other project partners and we will create summary fact sheets and other documents that supports the RRBC's long term strategy to expand watershed scale AIS efforts throughout the Red River Watershed, Minnesota and the region. The "Invasive App" will be shared and promoted for use throughout Minnesota and the Red River Watershed.

Activity Status as of January 1, 2015:

- Set up and staffed an informational display at the Douglas County Aquatic Invasive Species Workshop.
- Set up and staffed an educational display at the Upper Midwest Invasive Species Conference in Duluth.
- Presented at the Red River Basin Monitoring Advisory Committee Meeting.

Activity Status as of September 1, 2015:

- The RRBC staff have created five "Ripple Effect" radio spots air of the clear channel regional radio (KFGO AM 790) that specifically target an AIS related message. Ripple effect ads are a contracted service the RRBC has with KFGO and AIS ads are running along with other timely water conservation messages daily during prime listening time. These messages are reaching a regional listening audience of 71,500 weekly.
- At the request of the Otter Tail COLA staff is contributing to their monthly newsletter providing news worthy columns and an Op-ed piece called "Beyond the Bait Bucket" which is designed to get local AIS leaders thinking about impacts of current efforts while incorporating a targeted slant to thinking about potential for new and more effective education for local citizens.
- Hosted an AIS plenary workshop during the RRBC International Land and water summit conference in January in Winnipeg. More than 250 participants, learned about Red River Watershed AIS issues from experts with the Minnesota Department of Natural Resources, North Dakota Game and Fish and Manitoba Conservation and Water Stewardship. The workshop also provided the opportunity for many of our technical team members to meet each other and build connections for our long term efforts.
- The watershed AIS Assessment tools which were developed for this project outline most effective practices for preventing and managing zebra mussels and other AIS species. This tool has now been used by three other Minnesota counties with their County based AIS aid, to help target most effective practices based inland water management for aquatic invasive species.
- The RRBC staff met with the FM River Keepers organization to develop cooperative outreach efforts for urban audiences from the Moorhead, MN and Clay County area to support dissemination of materials for regional users who fish along the Red River in Clay County Minnesota. Additional outreach strategies will be planned for 2016 spring and summer events.

Activity Status as of as of April 1, 2016:

- The RRBC continues to run "Ripple Effect" AIS ads along with other timely water conservation messages with KFGO.
- Aqua.MN continues to be promoted as an AIS tool for regional and state utilization.
- The RRBC continues cooperation and coordination with intergovernmental agencies to develop and share information across jurisdictions to sustain promising practices for the basin.

Final Report Summary:

Educational materials and management resources developed by the Red River Basin Commission were disseminated to local groups, state agencies, national and international AIS related peer groups through the Red River Basin Commission website, public presentations and educational workshops. The "Get your AIS off the boat!" and "Clean, Drain, Dry" campaign efforts to reach and engage riparian property owners, the business community and younger demographic audiences provided education, outreach and facilitation activities that have resulted in material and information distribution to 4,400 citizens.

Additionally, targeted media messages including regionally branded print media publications and radio AIS promotions were adopted for reaching additional audiences beyond the fishing and recreational lake user community. The RRBC contributed to the monthly Otter Tail COLA newsletter providing news worthy columns and an Op-ed piece called "Beyond the Bait Bucket". The RRBC have created "Ripple Effect" radio promotions that air on the clear channel regional radio (KFGO AM 790) that specifically target an AIS related message. Ripple effect promotions are a contracted service the RRBC has with KFGO and AIS ads are running along with other timely water conservation messages daily during prime listening time. These messages are reaching a regional listening audience of 71,500 weekly.

The resources developed including the Aqua.mn mobile application - https://aqua.mn/ and website- http://www.redriverbasincommission.org/ are designed so citizens can access educational materials and resources with links back to county based resources, watershed partner resources and Minnesota Department of Natural Resources AIS tools and information.

The AIS Risk Assessments that use science, fact and logic to identify and quantify vectors of risk assist in planning for zebra mussel management. These assessments were shared with and are used by watershed districts, local units of government, lake associations and others, to support the prioritization of funding and activities, including inspection and decontamination, to curtail and prevent the spread of zebra mussels and other AIS species to Minnesota's lakes and rivers. The AIS Risk Assessment GIS Tool allows users to interactively explore the infestation risks of lakes and rivers in the project area, and visualize where aquatic invasive species have been sighted. It serves as a digital companion to the static maps generated in the reports. The AIS Risk Assessment GIS Tool can be accessed through the RRBC website- http://www.redriverbasincommission.org/ or directly on ArcGIS Online via the link:
http://www.arcgis.com/home/webmap/viewer.html?webmap=2a3a1ecbc1ca414b875c0b8feed7463a

The Red River Basin Commission lead efforts to collect, review and distribute current AIS survey data and watershed scale demographic data within the targeted project region. The survey initiatives were aimed to help determine the current knowledge, attitude and interest in AIS issues affecting Minnesota's lakes region. A final survey results report was shared with watershed districts, local units of government, lake associations and others and is attached to this report.

As a basin wide focused organization the Red River Basin Commission is continuing to take action in coordinating efforts between organizations focused on AIS. The Red River Basin Commission through the facilitation of the Red River AIS Technical and Science Team and multiple other working groups will continue to sustain and build upon the watershed scale AIS strategy for the Red River of the North International Watershed.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Explanation
Personnel:	$ 186,020	*Julie Goehring, Project Manager: $56,028 (66% salary, 34% benefits); .25 FTE for 2 years*
		Leah Thevdt, Outreach Specialist: $33,933 (66% salary,34% benefits); .25 FTE for 2 years
		Aaron Ostlund, Project Field Technician: $96,060(85%salary, 15% benefits) 1 FTE for 2 years
Professional/Technical/Service Contracts:	$ 25,480	Houston Engineering "invasives App" Develop and Beta test including developer fees for research of existing apps, writing code, artwork and building functionality of app for IOS/Android platforms
		RMB Environmental labs, GIS data acquisition, input and mapping support. RMB currently houses the lake and stream water quality , so working directly with the lab ,rather than using the International Water Institute (IWI) will save time and expenses for the GIS mapping portion of the project
		River Keepers, Survey collection and analysis
		Regionally branded AIS educational material organization and distribution including printed Id cards, boat sponges and towels for watercraft cleaning, printed plastic bag for distributing materials, floating key fobs, refrigerator magnets, etc.
Printing:	$ 1,500	Riparian property owner survey print and distribution
Travel Expenses in MN:	$ 6,000	Mileage, lodging, meals for travel within project site and within MN portion of Red River Basin
TOTAL ENRTF BUDGET:	**$ 219,000**	

Explanation of Use of Classified Staff: NA

Explanation of Capital Expenditures Greater Than $5,000: NA

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 3 FTE (2 year total)

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

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			

RRBC- Joint Powers Board Becker, Clay, Otter Tail	$15,000 (received)	$15,000	**Support for RRBC staff time to do pre-grant coordination work, meeting with project partners.**
RRBC	$2,500	$2,500	**Contract work for Mobile App. Discovery Phase**
Red River Watershed Management Board	$25,000 (not received)	$0	**Project Support, basin wide expansion support and sustainability planning**
Buffalo/Red, Pelican, Wild Rice Watershed Districts	$15,000 (received)	$15,000	**Project support, for risk assessment, coordination, outreach materials and regional brand development**
TOTAL OTHER FUNDS:	**$32,500**	**$32,500**	

Note: We proposed local support from the counties involved in our Joint Powers Board advisory board at $7500, individual county members of the RRBC-Joint Powers Board have contributed $15,000 to the project as participating county members resulting in an increase of proposed funds. The three watershed districts involved have committed an additional $15,000 to support the project with funding increasing total other funds proposed and committed to the project to $57,500. The Red River Watershed Management Board funding will be requested in 2016 as part of the base funding support to maintain longer term commitment to regional AIS watershed scale critical needs.

VII. PROJECT STRATEGY:

A. Project Partners:

This project is in cooperation with Becker, Clay, Otter Tail and Wilkin Counties and the watersheds of Buffalo, Otter Tail/Pelican, and Wild Rice. Additional Partners include: Joe Eisterhold, MN DNR Invasive Species Specialist, Neil Powers, USFWS, Manager – Tamarac National Wildlife Refuge, Wayne Goeken, International Water Institute, Christine Laney, FM River Keepers, Laura Bell, University of Minnesota-Crookston, Doug Jensen, MN Sea Grant Program- University of Minnesota, Robert Borash, RMB Environmental Labs, Andre Delorme, Valley City State University, Fred Ryckman, North Dakota Game and Fish- Invasive Species Specialist.

This is the base group is currently providing expertise to the RRBC and will serve as the core group to provide technical and content expertise as part of a "technical planning team".

B. Project Impact and Long-term Strategy:

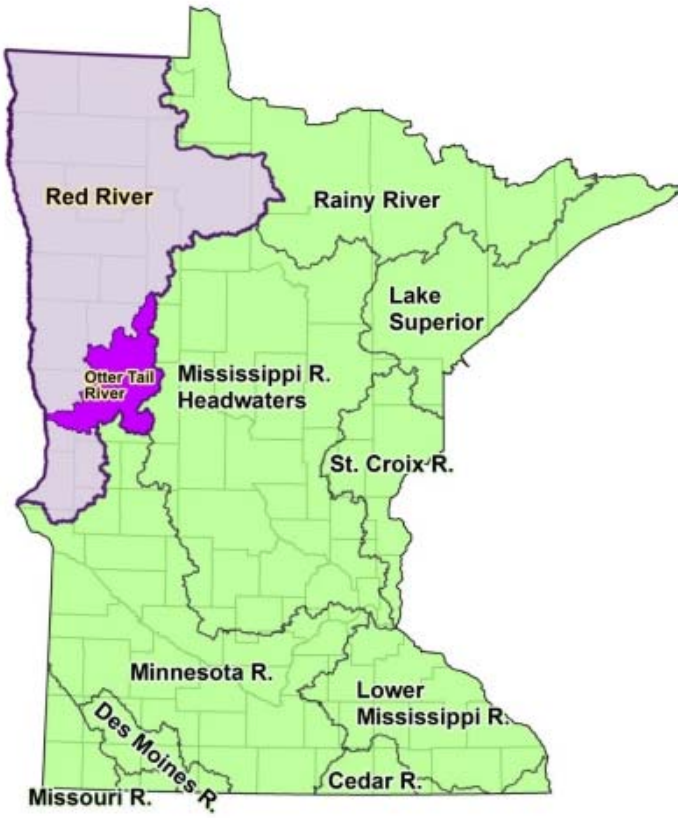
The project will serve to expand AIS thinking and planning beyond the local level using a watershed approach for the Red River Watershed. Both promising practices and new educational tools will be part of sustainability planning effort that will involve expansion of the project to the Red River of the North watershed and throughout the state of Minnesota. The Red River Watershed Management Board (RRWMB) will serve as the partner that supports articulation of long term strategies on the Minnesota side of the watershed. Their support will directly reflect the Minnesota Association of Watershed Districts (MAWD)" support through partnerships with lake associations in providing aquatic plant management and controlling invasive species". The RRBC long term strategy will include planning that will leverage additional resources from North Dakota and the Province of Manitoba to provide multi-jurisdictional leadership in RRBC Goal area 2: Aquatic and Riparian Ecosystem Health.

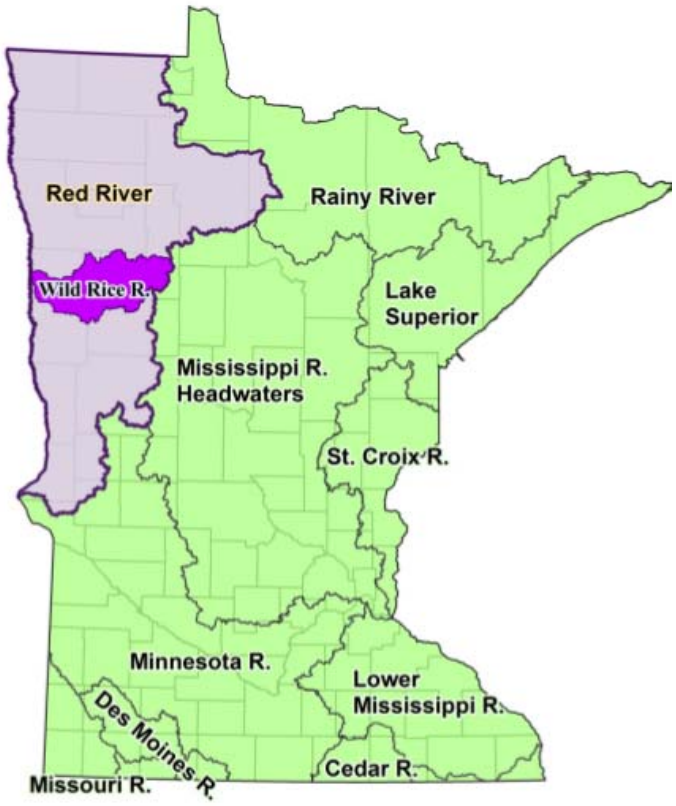
C. Spending History: N/A

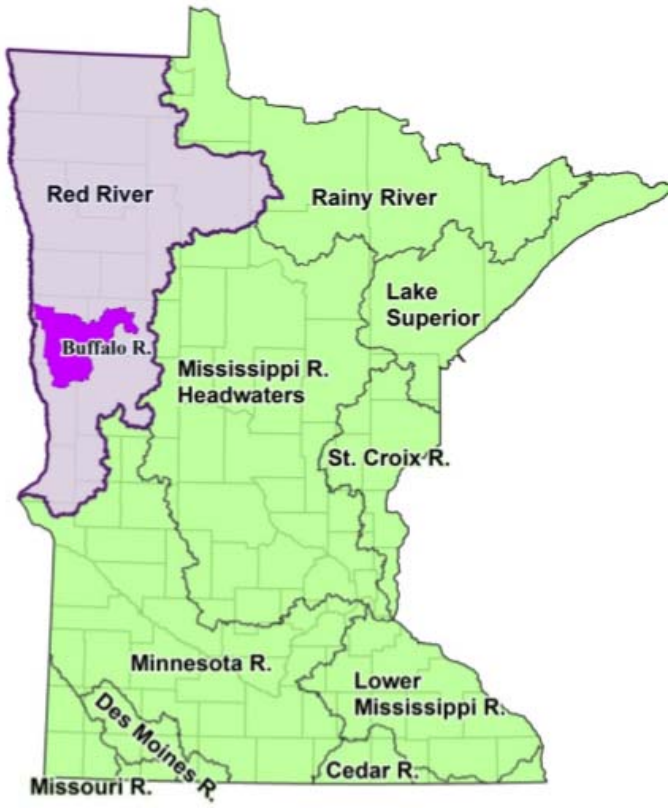
VIII. ACQUISITION/RESTORATION LIST: N/A

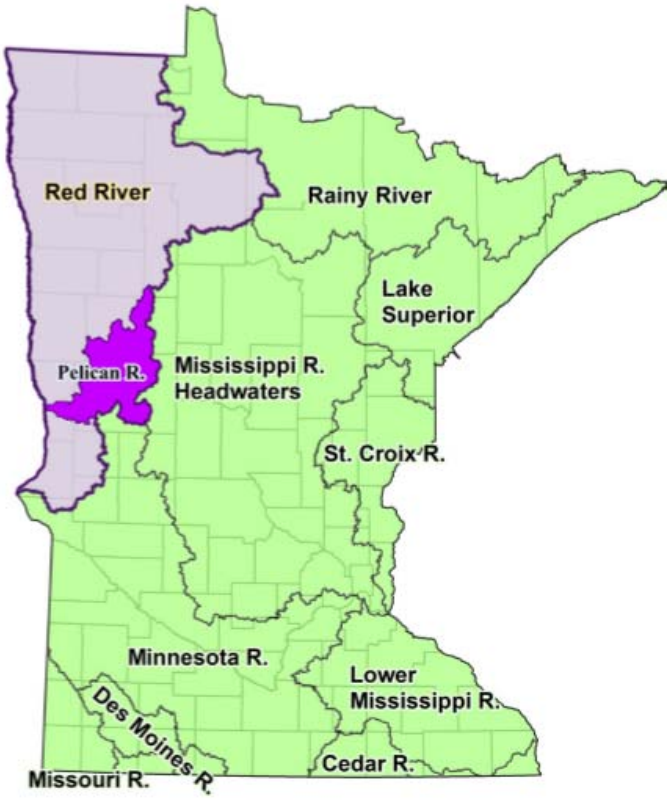
IX. VISUAL ELEMENT or MAP(S):

Below are Maps of MN with the Red River Basin highlighted in light purple and targeted watersheds highlighted in dark purple.

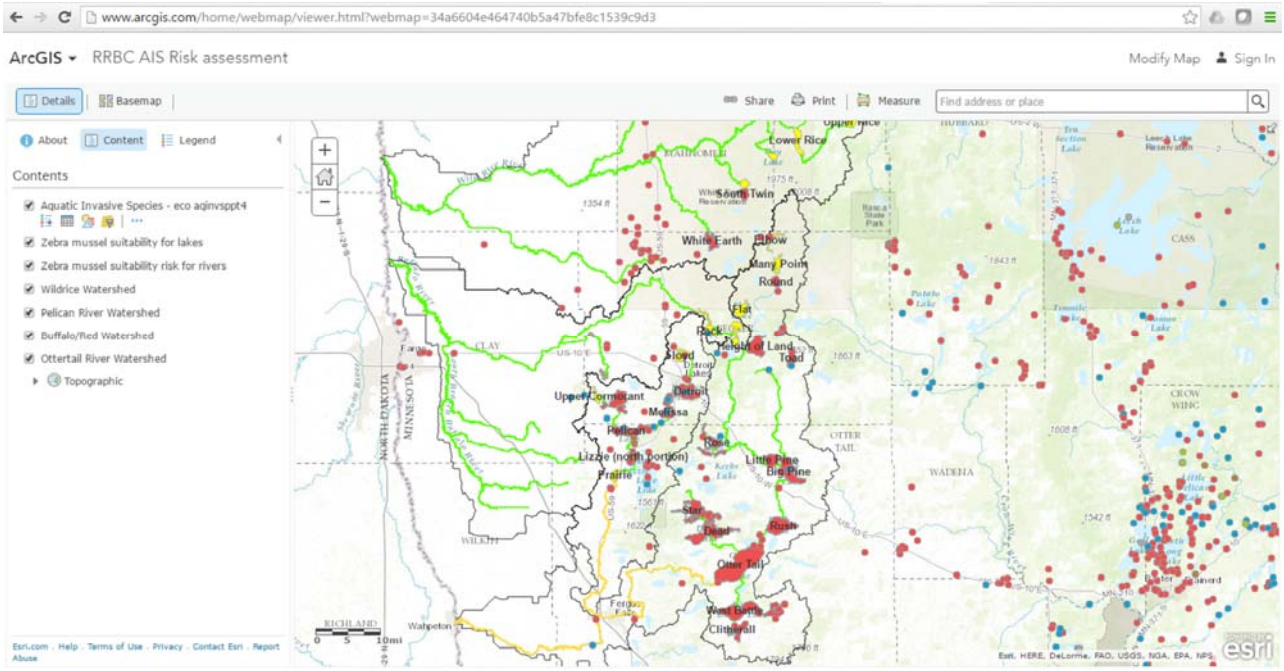




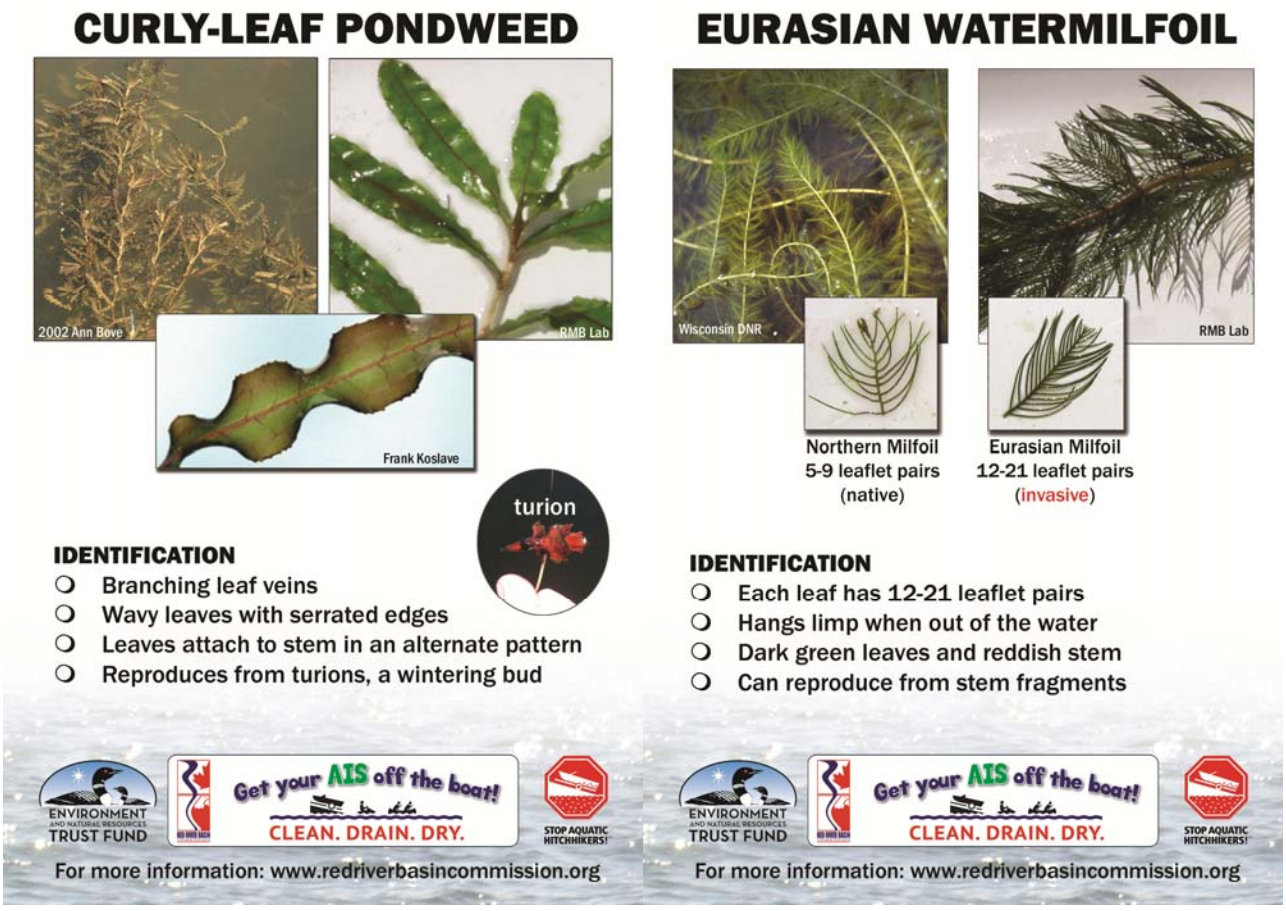




Below is a screen shot from the AID Risk Assessment GIS Tool



Below are the AIS Identification cards utilized for educational and outreach materials



FLOWERING RUSH

IDENTIFICATION

1. Pink umbrella-shaped flowers
2. Leaves are triangular in cross section
3. Grows in dense emergent stands in lakes
4. Can also grow submerged in rivers

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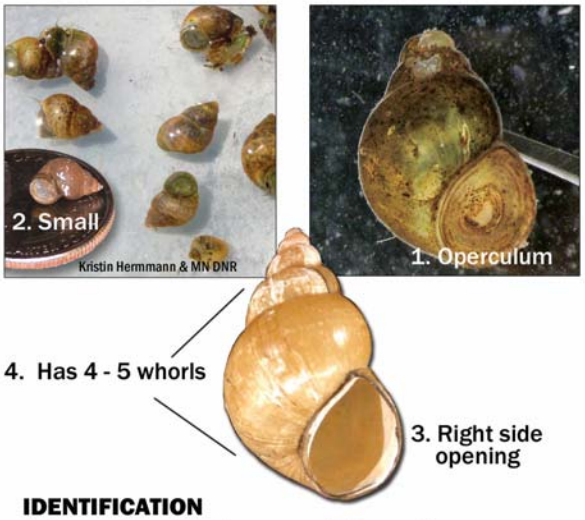
FAUCET SNAILS



IDENTIFICATION

1. Operculum (door) covers shell opening
2. Small, up to 1/2 inch long
3. Shell opening on the right side when pointed up
4. Has 4 - 5 whorls, light brown to black

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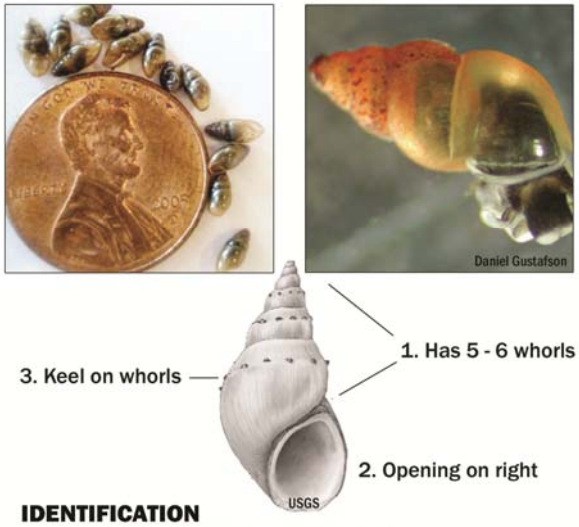
NEW ZEALAND MUD SNAIL



IDENTIFICATION

1. Has 5 - 6 whorls
2. Opening on right side when shell pointed up
3. Keel (ridge) on whorls could be present or absent
4. Has an operculum (door to opening)

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PURPLE LOOSESTRIFE

IDENTIFICATION

- Height 3 - 7 feet
- Spike covered with many purple flowers
- Downy, smooth-edged leaves
- Grows along wetlands and shorelines

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RUSTY CRAYFISH

IDENTIFICATION

- 1. Dark, rusty spots on each side of the carapace
- 2. Black bands at the tips of claws
- Adults are 3-5 inches long
- Overall tan color, especially on legs
- Larger claws than native crayfish

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QUAGGA MUSSEL

IDENTIFICATION

- D-shaped shells
- Alternating white and brownish stripes
- Usually paler color near hinge
- Adults are ¼ to 1 ½ inches long
- Usually found attached to a hard surface
- Rounder than Zebra mussels

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SPINY WATERFLEA

IDENTIFICATION

1. Clumps look and feel like gelatin
2. Black eye spots are visible
3. Long tail with spines

Prefer deep lakes, but can also be in shallow

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YELLOW IRIS

IDENTIFICATION

- Grows 2 - 3 feet tall
- Grows along shores in shallow water
- Deep yellow flowers, 2 or 3 on one stalk
- Blooms May through July
- Competes with native shoreline vegetation

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X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: N/A

XI. RESEARCH ADDENDUM: N/A

XII. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than January 1, 2015, September 1, 2015 and April 1, 2016. A final report and associated products will be submitted between June 30 and August 15, 2016.

Red River Basin Commission

Vision: *A Red River Basin where residents, organizations, and governments work together to achieve basin-wide commitment to comprehensive integrated watershed stewardship and management*.

Mission: *To create a comprehensive integrated basin-wide vision, to build consensus and commitment to the vision, and to speak with a unified voice for the Red River Basin.*

Northwest Minnesota Regional Aquatic Invasive Species (AIS) Prevention Pilot

Riparian Audience Knowledge Attitude and Interest Survey

Funding provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources

Purpose: The Red River Basin Commission (RRBC) as part of the watershed approach to aquatic invasive species (AIS) prevention and management developed a survey to help determine the current knowledge, attitude and interest in AIS issues affecting Minnesota's lakes region. The survey was administered to a riparian audience that included property owners, recreational water users and businesses who benefit from this regions diverse surface water resources.

Methods: The initial survey was administered as a mail survey to property owners within a defined "lake level watershed". Two watersheds, Cormorant Lake Chain in Becker County and Rose Lake watershed in Otter Tail County, were selected in the first round. In addition to a paper survey, an electronic version was promoted as part of outreach efforts with the placement of mobile tablets between June 1 and September 30, 2015 at three lakes area businesses in Becker and Otter Tail County. Each business promoted the opportunity for walk in customers to take the survey. The results from the survey efforts, 350 responses (Rose 76, Cormorant 142, and Tablets 132), have been combined in this report to provide an overall summation of response to the AIS issues experienced in this region.

Demographics: Respondents represented, males (62%) and Females (38%) with a majority in their mid-50's or older (57%), followed by, mid 40's to mid-50's (29.5%), mid 30's to mid-40's (18%) and those under 35 (13.5%). The top type of watercraft ownership recoded was, fishing boat (55%), recreation boat (51%), canoe/kayak (35%) and personal watercraft (20%). The majority, Sixty seven percent of respondents report using the area lakes fifteen or more times annually.

Results: Respondents were asked questions to measure current "knowledge" they feel they have related to AIS, their "attitude" regarding management of invasive species and personal "interest" in taking an active role to manage and prevent the spread of invasive species. As an example, more than 90% of respondents recognize the words "clean, drain, dry" (CD2) from the Stop Aquatic Hitchhikers campaign which is designed to prompt action when leaving a waterbody after a recreational outing. The CD2 message has nationwide outreach and has been adopted to provide consistency and repetition for outdoor oriented travelers and resource users. It is interesting to note from 9% of the respondents regarding the (CD2) message, that it is still not recognized by lake users in this this group. Respondents also expressed a high degree of confidence relating to ability to identify a zebra mussel (72%), knowing how to report a potential aquatic invasive species (75%) and having spent time in the past searching for AIS information (59%).

Respondent's attitude toward management of AIS are both supportive and positive in nature. A large majority <u>disagree</u> with the following negative views, AIS is a problem we can do little about (79%) and no matter what we do we will not prevent AIS (70%). The majority <u>agree</u> with and support the following actions:

- The need for more access restrictions (79%)
- Supporting lake management that is best for the lake, not people (78%)
- Inspection for all watercraft leaving infested waters (74%)
- Supporting "rapid response" strategies to chemically treat newly infested lakes (67%)
- Support efforts to place a higher priority for decision making on protecting lakes over recreation and lakeshore resident interests (64%)

While knowledge and attitudes are important measures to know and understand, one's interest in taking action as a citizen and resource user becomes the keystone habit and building block for long-term impacts. A vast majority, 91 % of respondents, expressed interest in doing their part to prevent the spread of aquatic invasive species. The majority of the respondents also expressed interest in the belief that it is all lake users' responsibility to reduce AIS spread (85%), that they would be willing to share information with other to help prevent AIS (86%) and a high majority would be willing to pay more, $2-$5 for local AIS management support (76%). Many area lakes have some form of organized group, usually a "Lake Association" so respondents were asked about their interest in knowing about lake associations and volunteering. Only 44% responded as being interested, while 18% were not interested, with 38% replying with a neutral response. Less than half of the respondents expressed an interest in engaging as a volunteer but when combined with those respondents indicating a "neutral" preference, there is an opportunity to recruit up 82% of this respondent group as a potential volunteer at the local level.

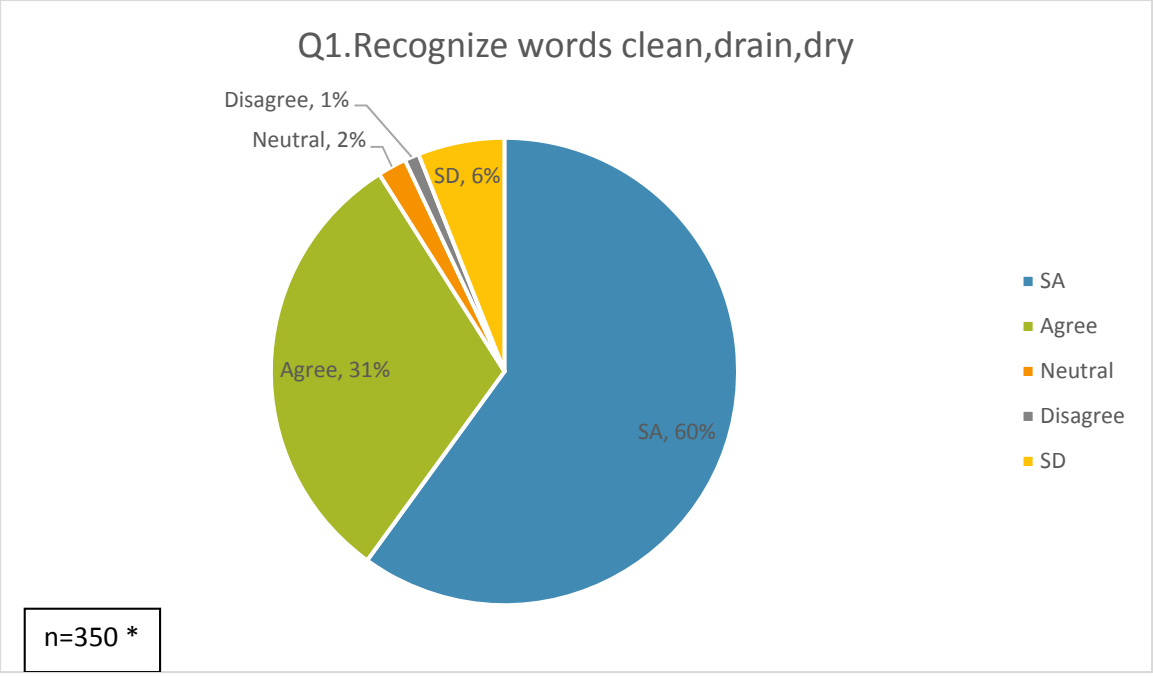
Respondents were also asked about their opinion in taking precautions to prevent the spread of nine AIS species (question 12) that are either present in or emerging as a threat to invade the Red River Basin. Based on a five point scale with 5 being extremely important, the first tier included Zebra mussel (4.78), Asian carp (4.41), Eurasian water milfoil (4.34) and Curly leaf pondweed (4.04) and the second tier, Spiny water flea (3.95), mystery snail (3.84), Flowering rush (3.77), Rusty crayfish (3.74), and Yellow iris (3.56). Of interest in the comment section of the survey, a number of respondents expressed little or no knowledge of the second tier AIS species.

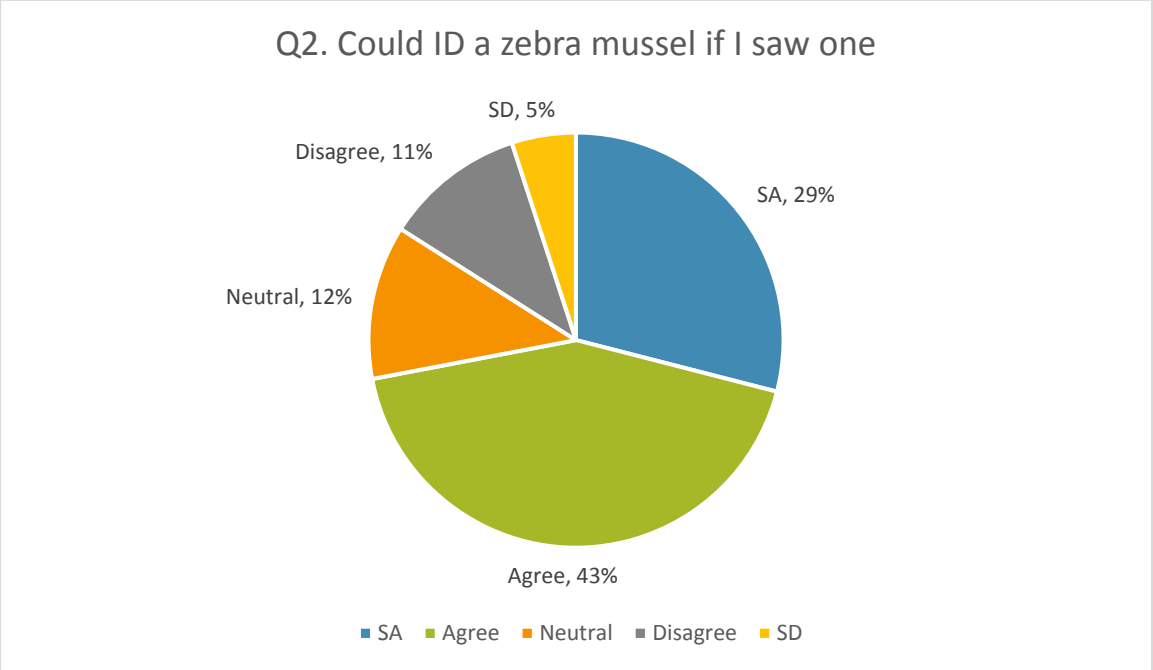
How respondents prefer to learn about AIS is interesting especially knowing the majority are over fifty years old. Internet (52%) ranked as the number one preference followed by, printed media (49%), Newspaper/magazine (39%), radio/television (35%), smart phone/mobile device (20%), Attending a class/workshop (19%).

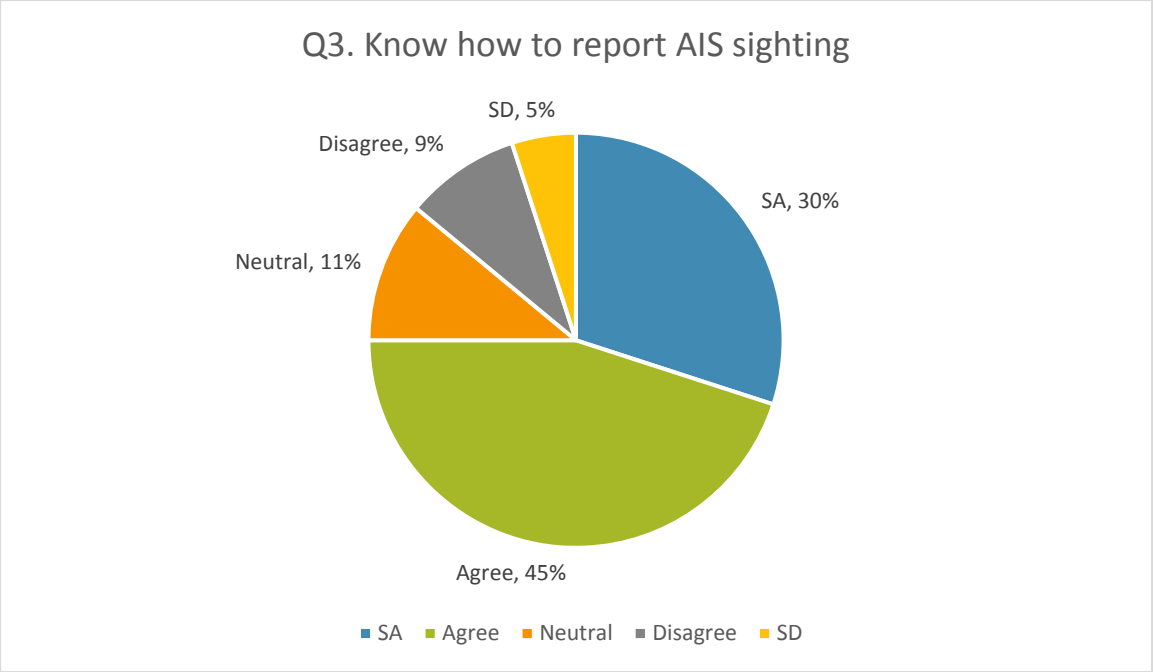
The following section contains graphs from the responses to each of the survey questions, a visual approach using word clouds to show popularity of lakes in this survey group and a map of each watershed with the lake to lake travel pattern of lake property owners in each watershed.

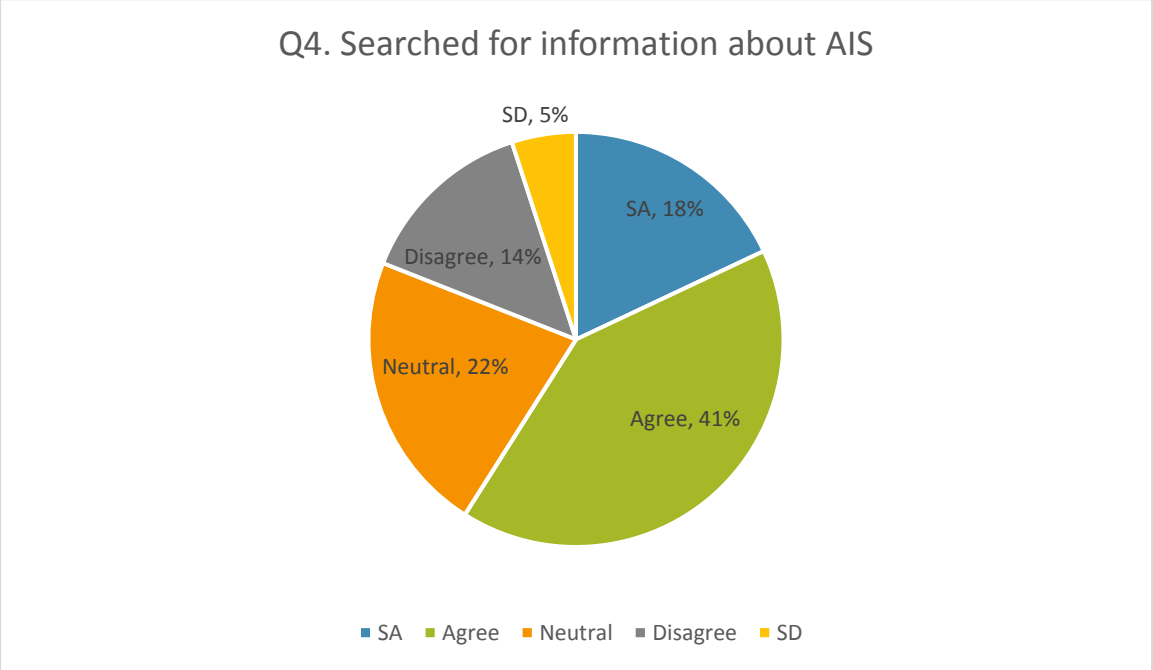
RED RIVER BASIN COMMISSION

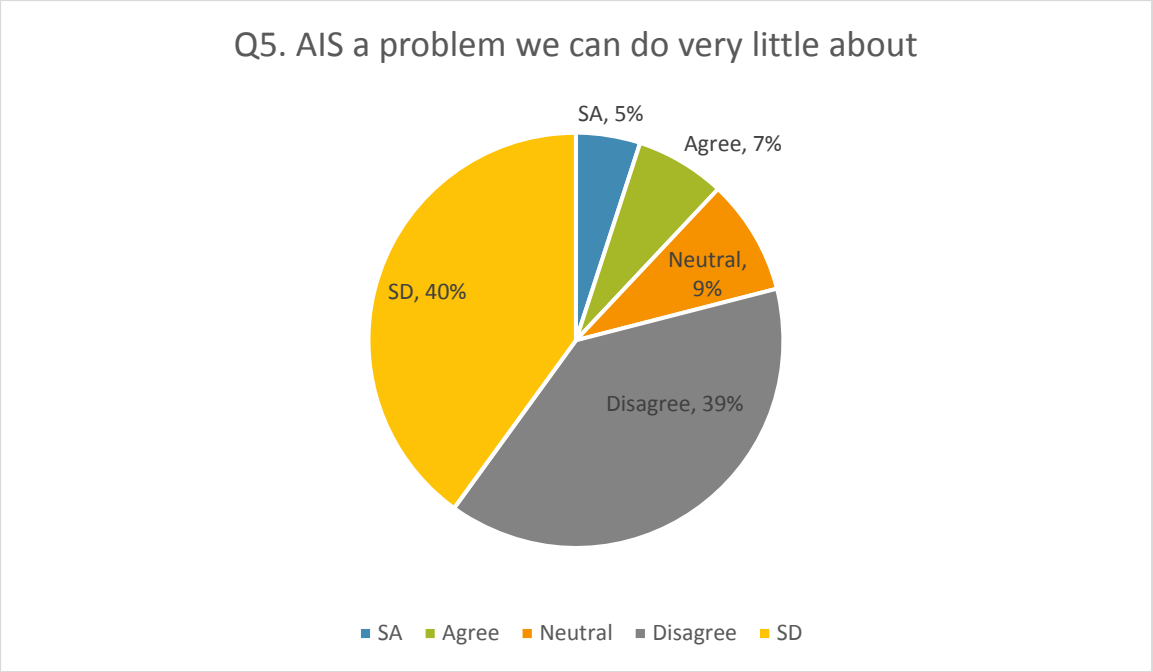
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

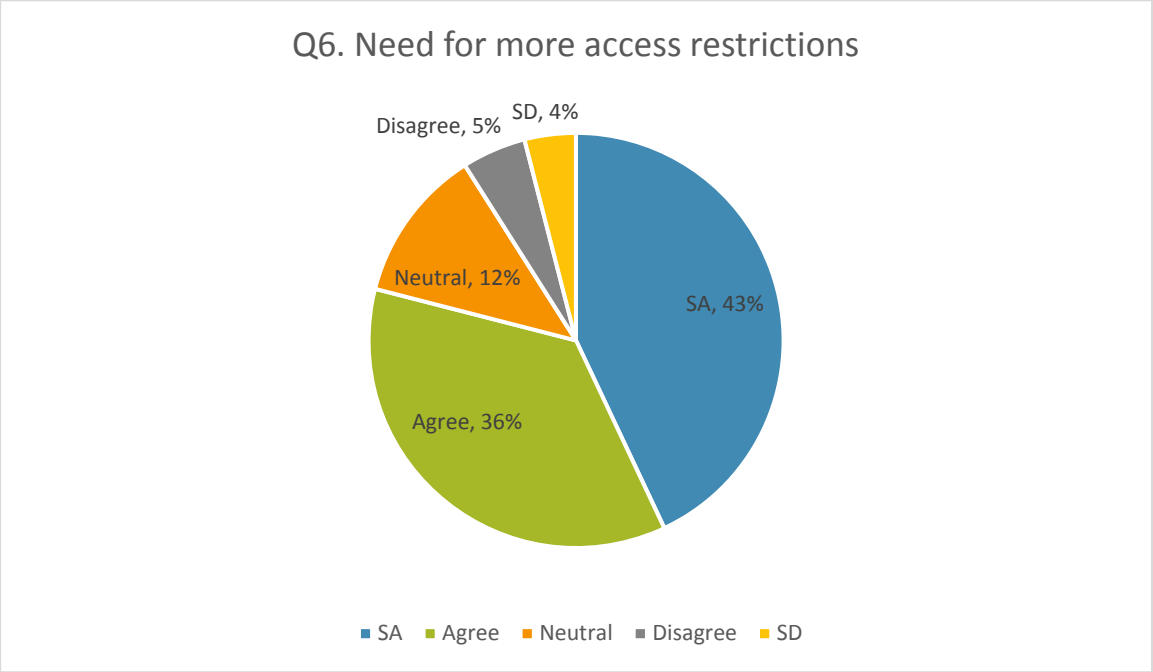

Q1.Recognize words clean,drain,dry
Disagree, 1%
Neutral, 2%
SD, 6%
Agree, 31%
SA, 60%
SA
Agree
Neutral
Disagree
SD
n=350 *

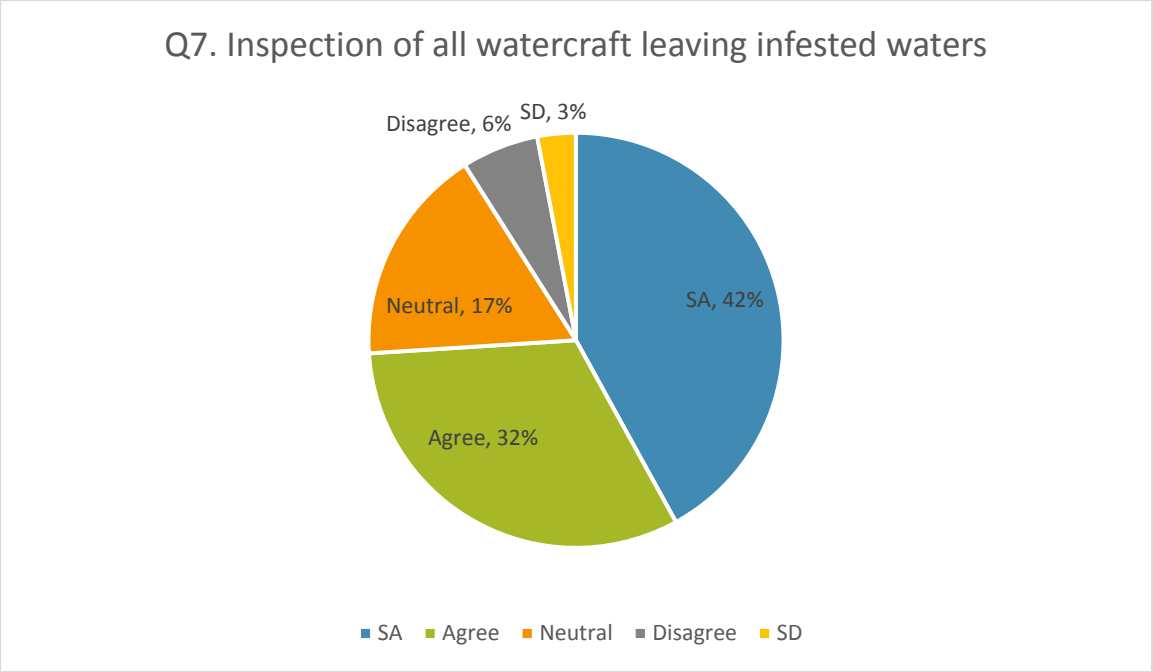

Q2. Could ID a zebra mussel if I saw one
SD, 5%
Disagree, 11%
SA, 29%
Neutral, 12%
Agree, 43%
SA
Agree
Neutral
Disagree
SD

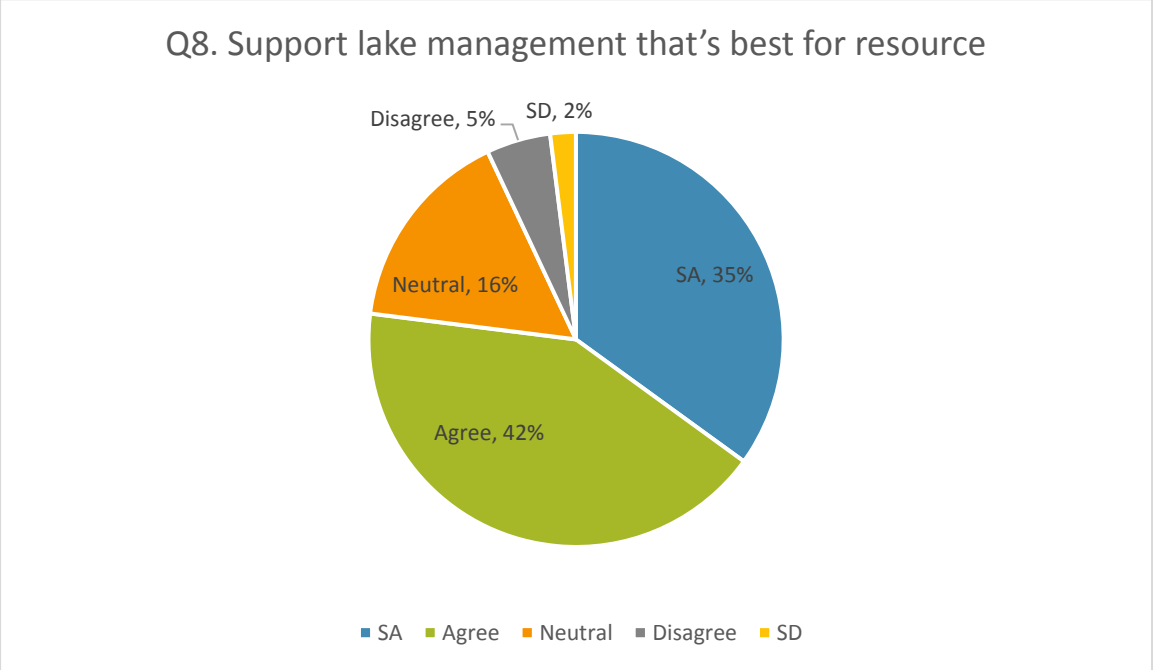

Q3. Know how to report AIS sighting
SD, 5%
Disagree, 9%
SA, 30%
Neutral, 11%
Agree, 45%
SA
Agree
Neutral
Disagree
SD

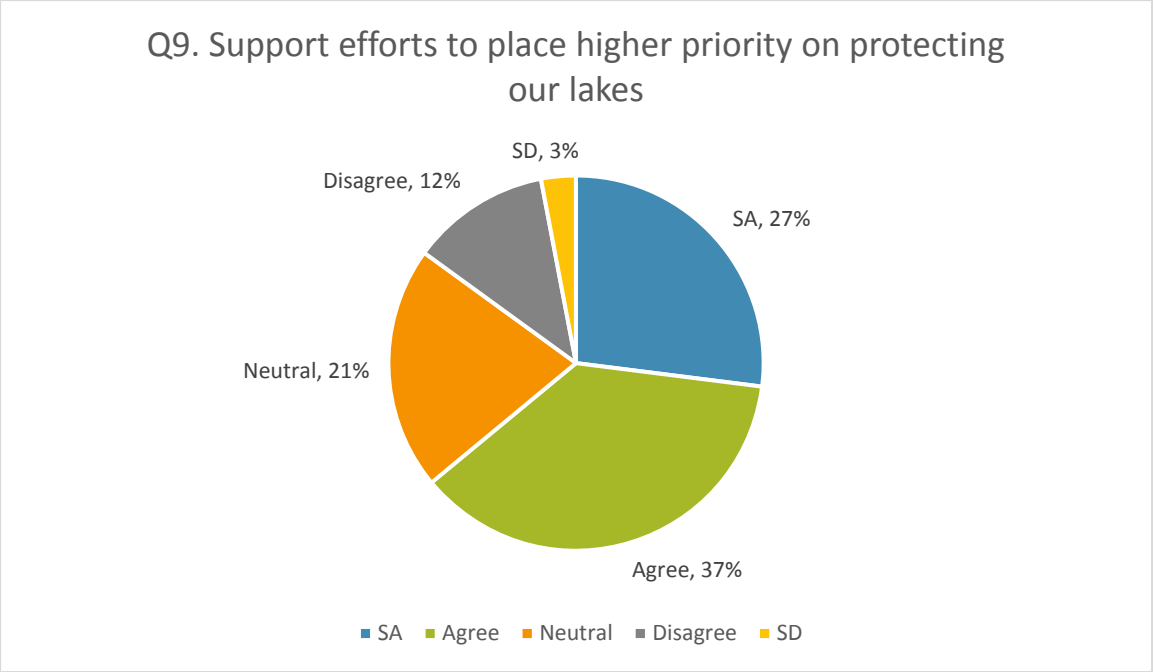

Q4. Searched for information about AIS
SD, 5%
SA, 18%
Disagree, 14%
Neutral, 22%
Agree, 41%
SA
Agree
Neutral
Disagree
SD

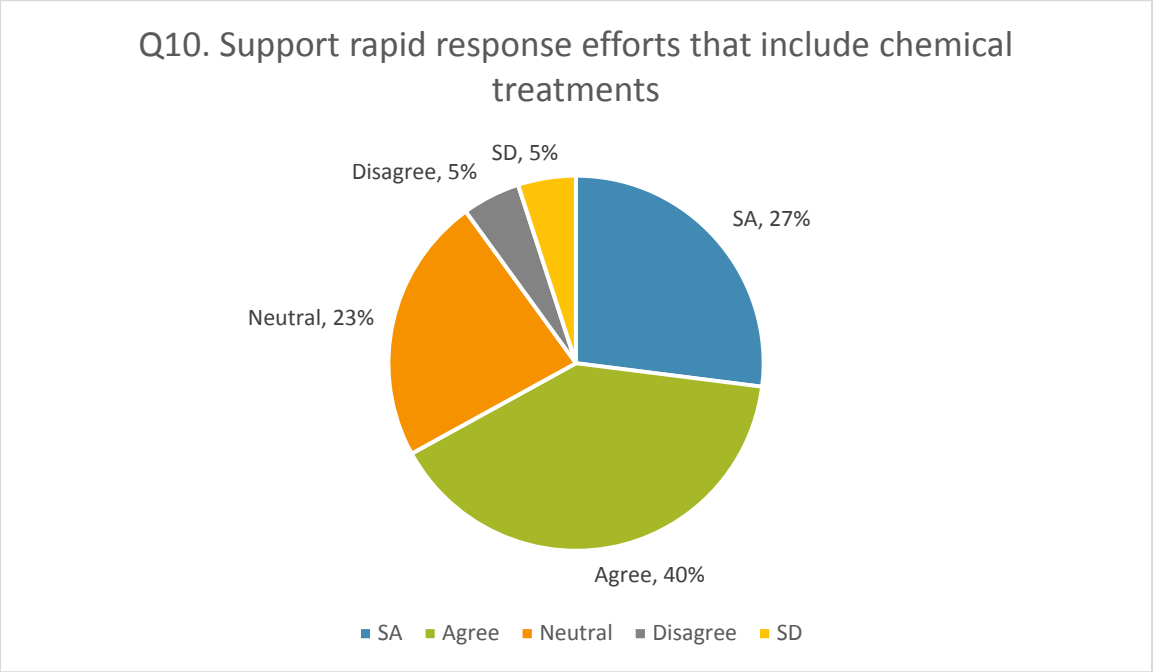

Q5. AIS a problem we can do very little about
SA, 5%
Agree, 7%
Neutral, 9%
Disagree, 39%
SD, 40%
SA
Agree
Neutral
Disagree
SD

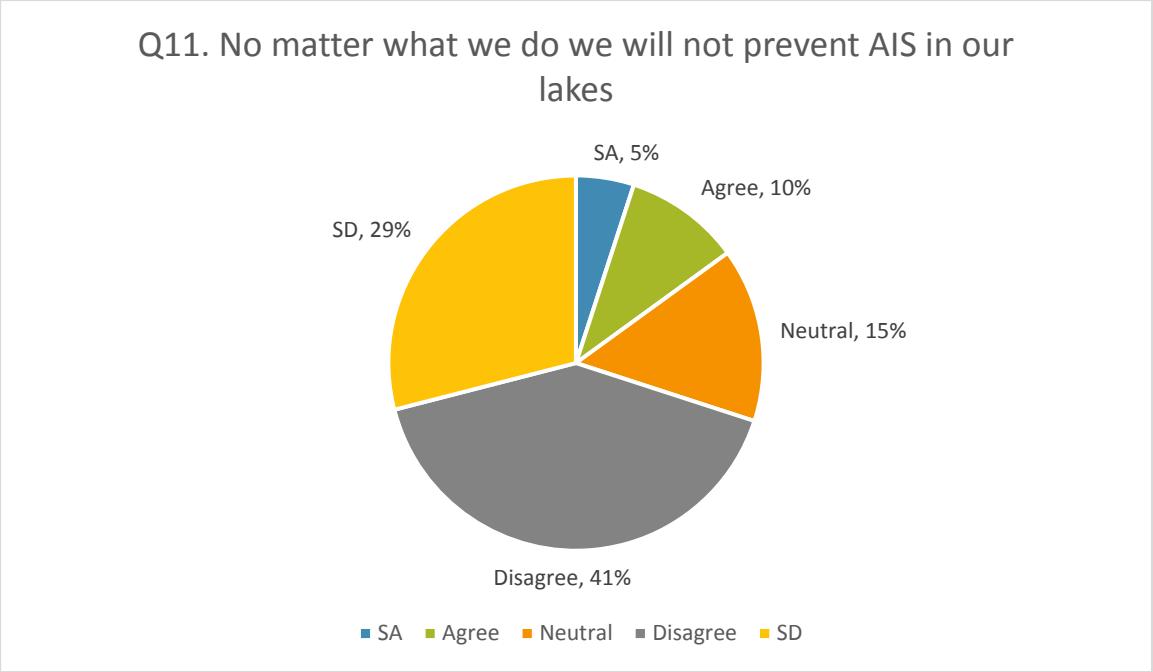

Q6. Need for more access restrictions
Disagree, 5%
SD, 4%
Neutral, 12%
SA, 43%
Agree, 36%
SA
Agree
Neutral
Disagree
SD


Q7. Inspection of all watercraft leaving infested waters
Disagree, 6%
SD, 3%
Neutral, 17%
SA, 42%
Agree, 32%
SA
Agree
Neutral
Disagree
SD


Q8. Support lake management that's best for resource
Disagree, 5%
SD, 2%
Neutral, 16%
SA, 35%
Agree, 42%
SA
Agree
Neutral
Disagree
SD

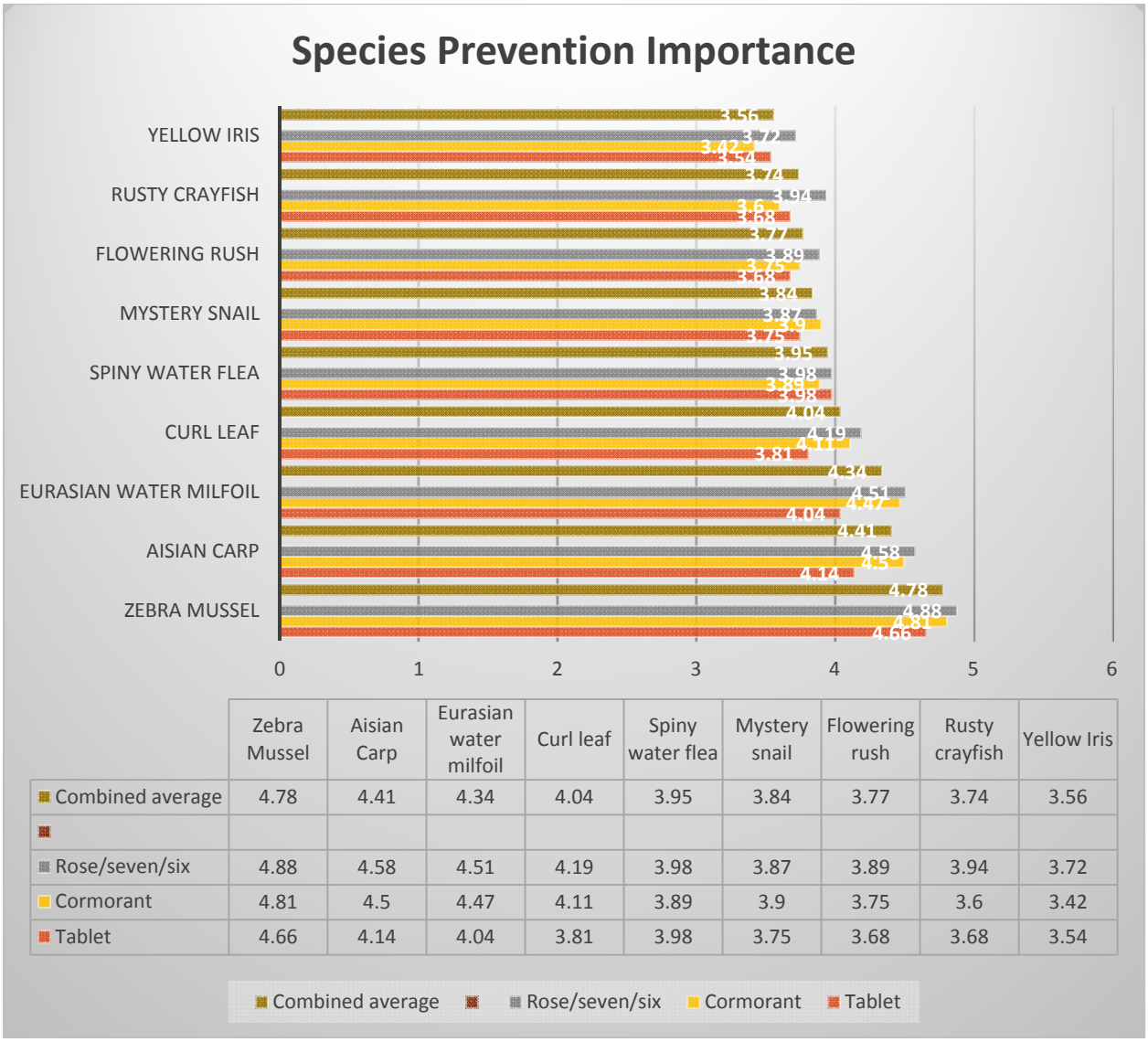

Q9. Support efforts to place higher priority on protecting our lakes
SD, 3%
Disagree, 12%
SA, 27%
Neutral, 21%
Agree, 37%
SA
Agree
Neutral
Disagree
SD


Q10. Support rapid response efforts that include chemical treatments
SD, 5%
Disagree, 5%
SA, 27%
Neutral, 23%
Agree, 40%
SA
Agree
Neutral
Disagree
SD

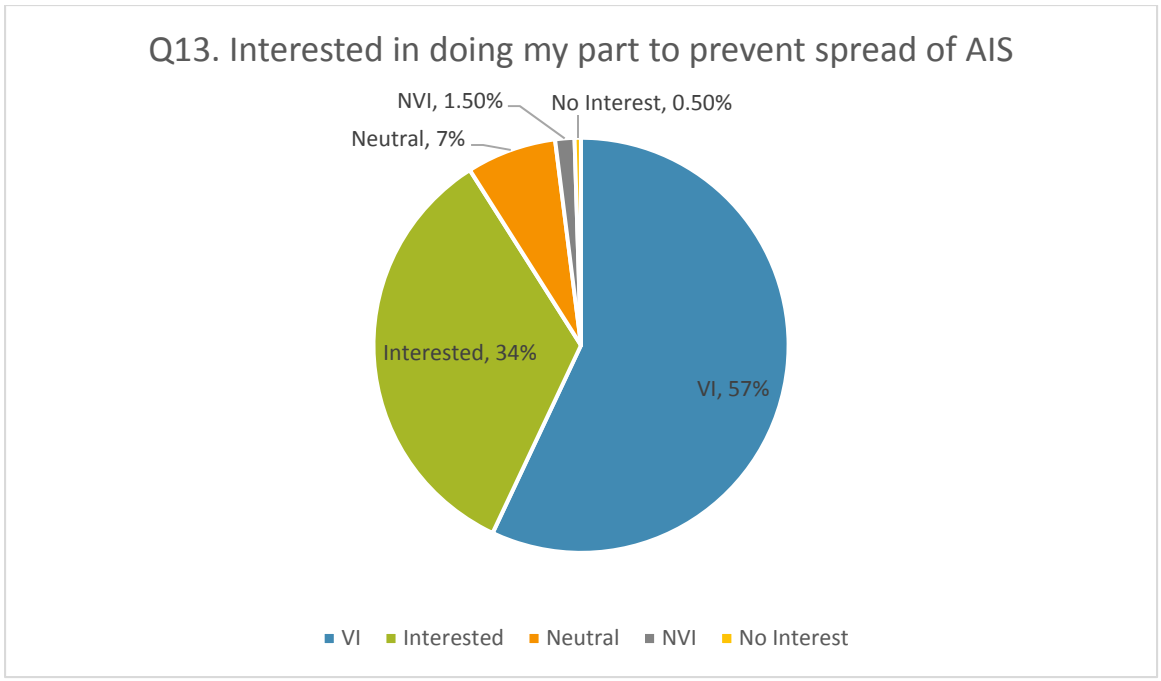


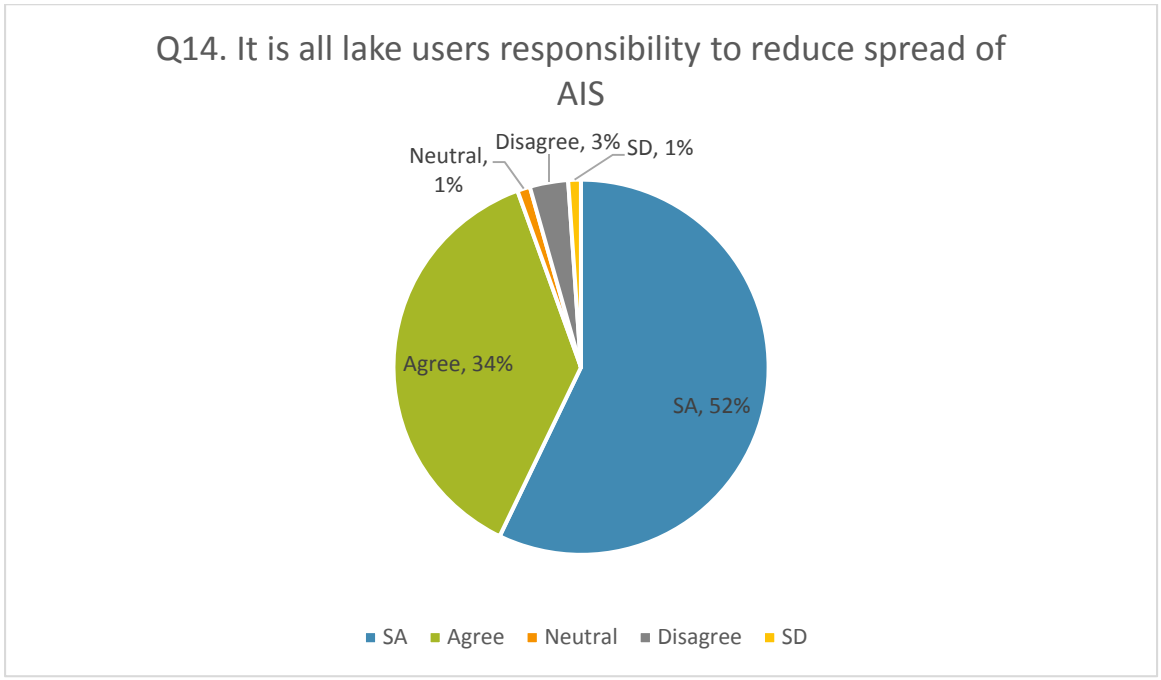
*Survey response based on a total of 350 respondents with the following breakdown: Cormorant watershed mail survey = 142, Rose Watershed mail survey = 76 and tablet based survey = 132.

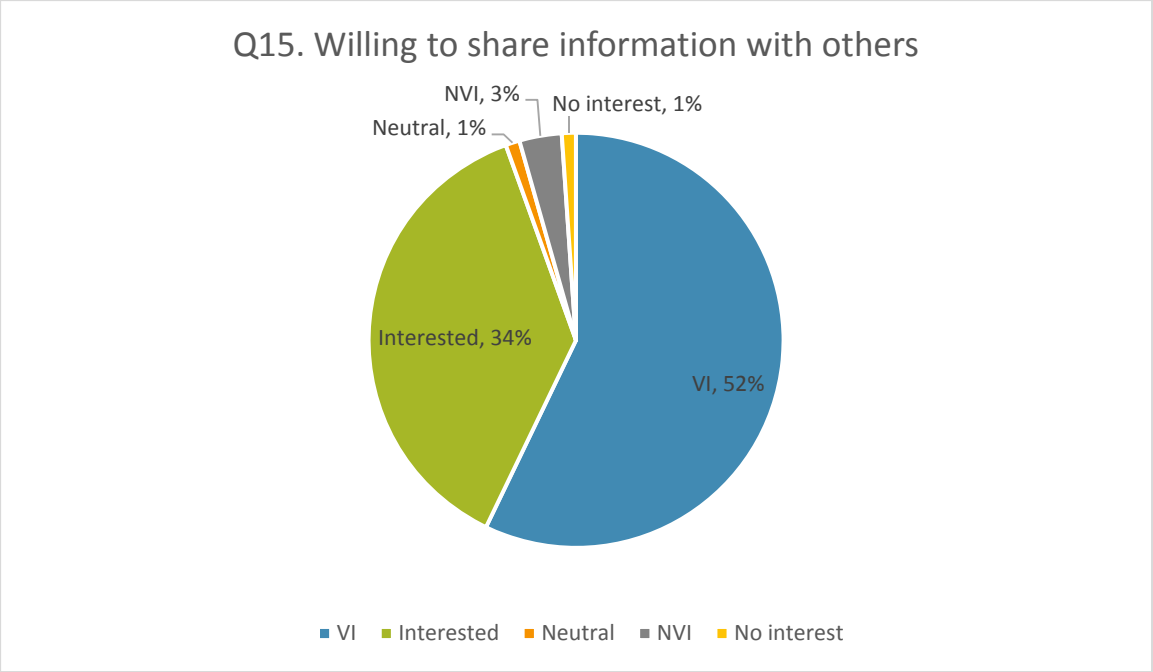
Three android tablets were placed at the following locations, The Lake Place in Lake Park, Lakeland General Store, Dunvilla and Pine Hurst Resort, Naytahwaush (June-September) to randomly collect survey information from summer lakes oriented travelers who are the primary audience for these businesses.

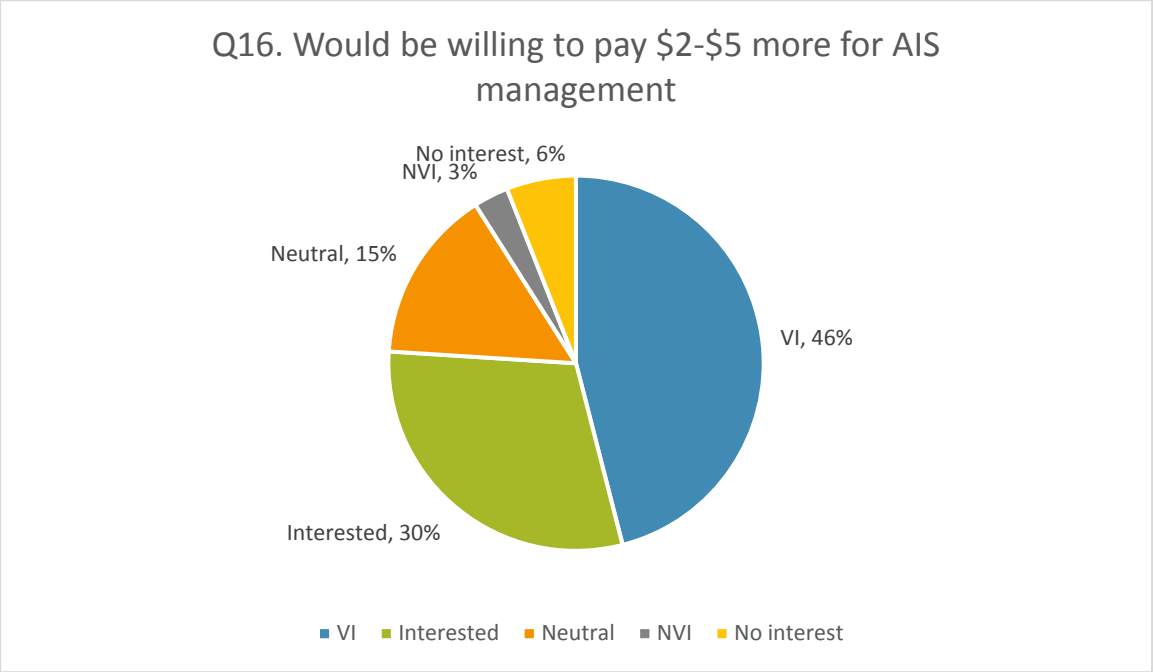


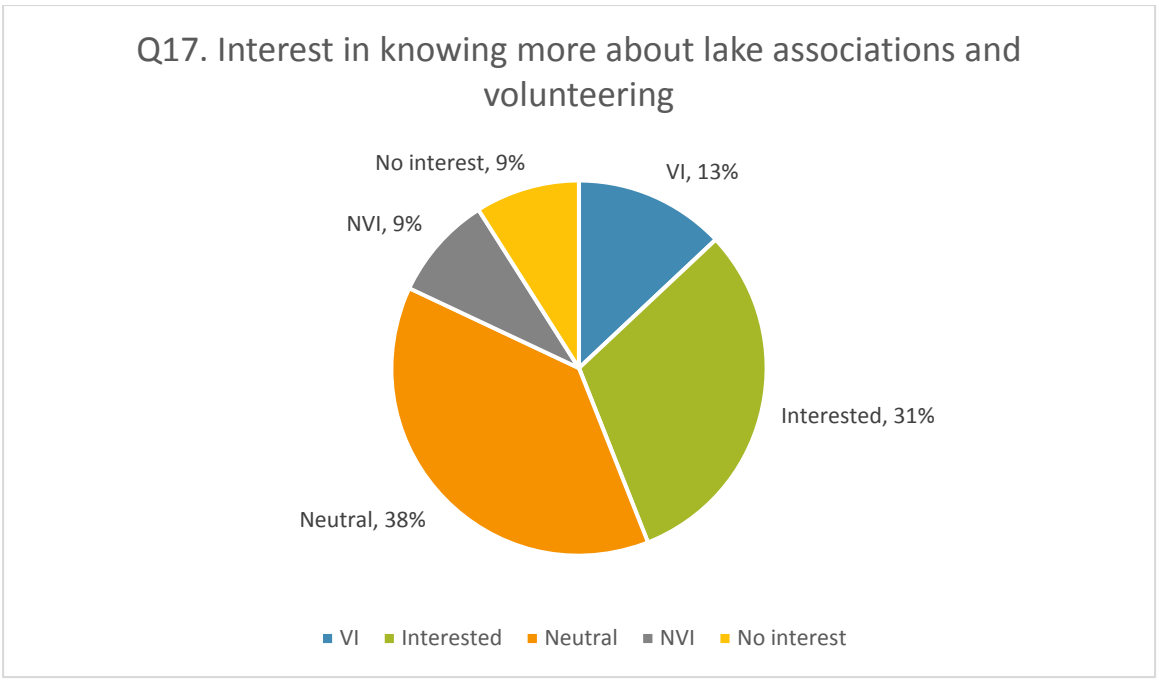
	Zebra Mussel	Aisian Carp	Eurasian water milfoil	Curl leaf	Spiny water flea	Mystery snail	Flowering rush	Rusty crayfish	Yellow Iris
Combined average	4.78	4.41	4.34	4.04	3.95	3.84	3.77	3.74	3.56
Rose/seven/six	4.88	4.58	4.51	4.19	3.98	3.87	3.89	3.94	3.72
Cormorant	4.81	4.5	4.47	4.11	3.89	3.9	3.75	3.6	3.42
Tablet	4.66	4.14	4.04	3.81	3.98	3.75	3.68	3.68	3.54

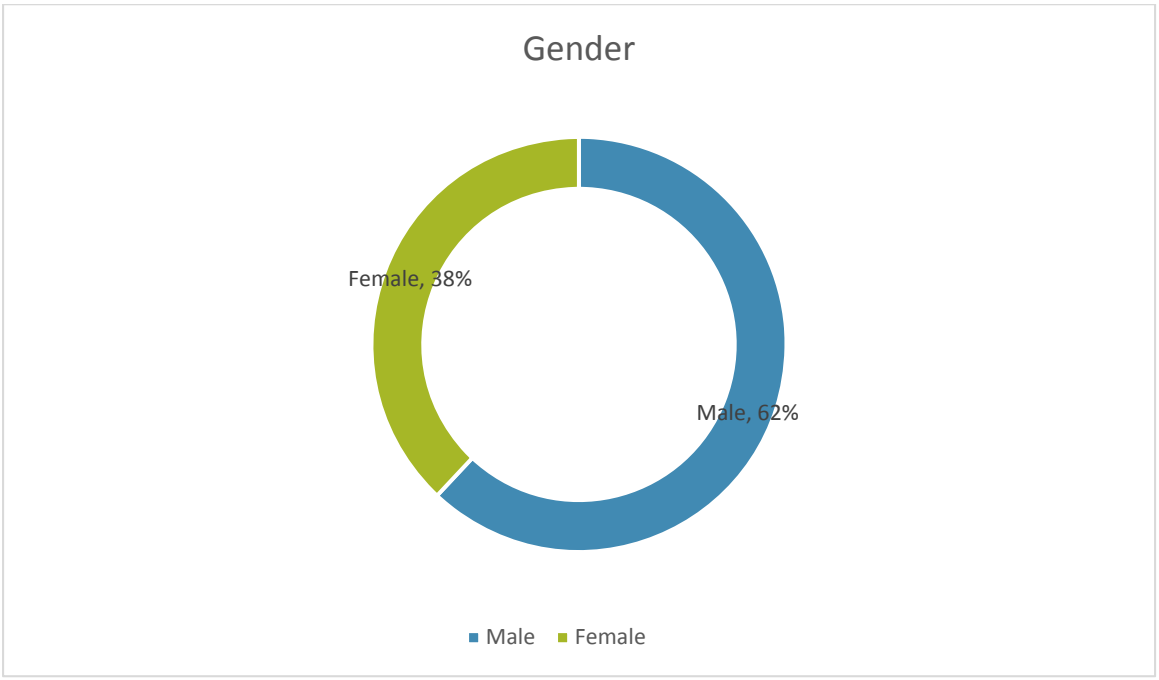

Q13. Interested in doing my part to prevent spread of AIS
NVI, 1.50%
No Interest, 0.50%
Neutral, 7%
Interested, 34%
VI, 57%
VI
Interested
Neutral
NVI
No Interest


Q14. It is all lake users responsibility to reduce spread of AIS
Neutral, 1%
Disagree, 3%
SD, 1%
Agree, 34%
SA, 52%
SA
Agree
Neutral
Disagree
SD

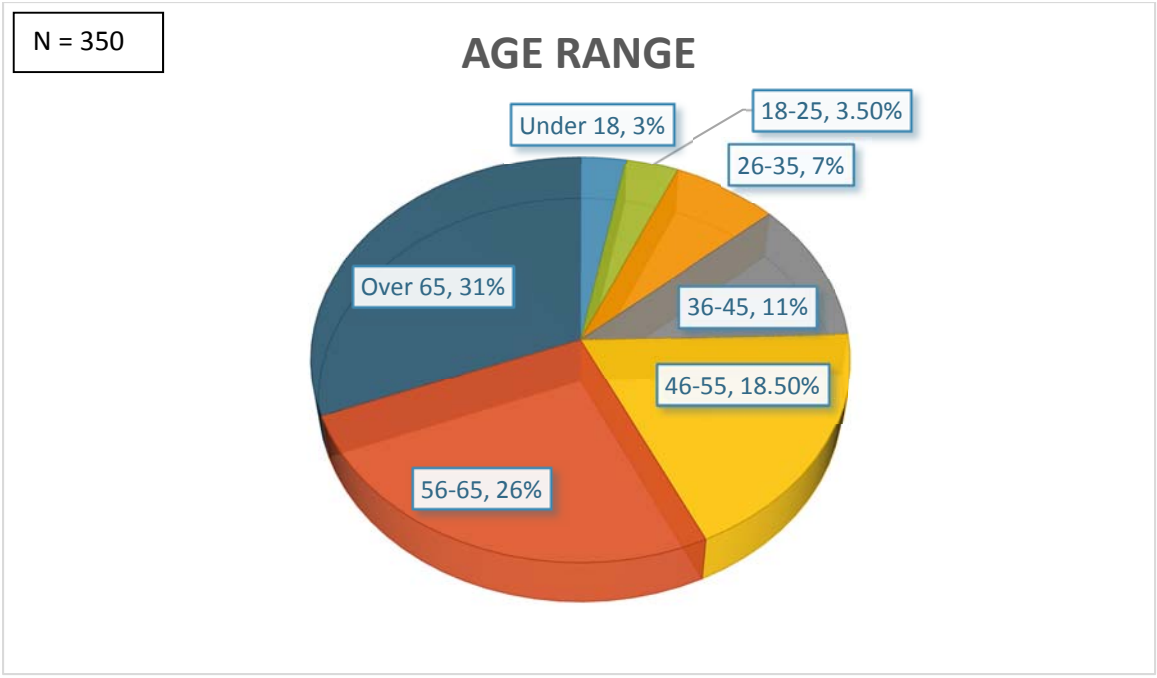

Q15. Willing to share information with others
NVI, 3%
No interest, 1%
Neutral, 1%
Interested, 34%
VI, 52%
VI
Interested
Neutral
NVI
No interest


Q16. Would be willing to pay $2-$5 more for AIS management
No interest, 6%
NVI, 3%
Neutral, 15%
VI, 46%
Interested, 30%
VI
Interested
Neutral
NVI
No interest

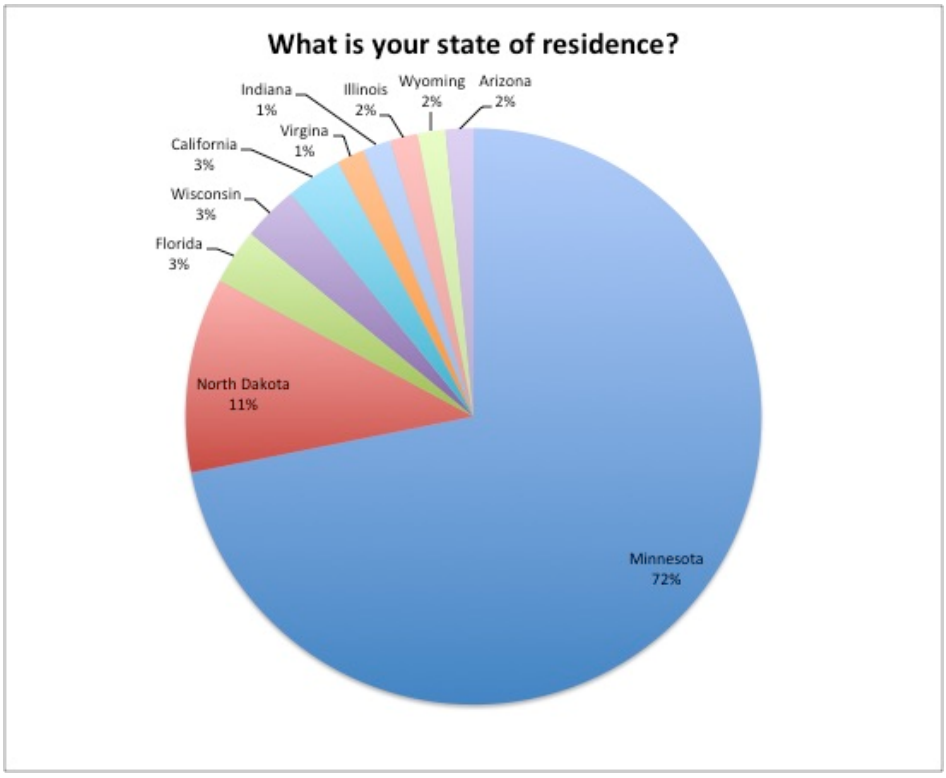

Q17. Interest in knowing more about lake associations and volunteering
No interest, 9%
VI, 13%
NVI, 9%
Interested, 31%
Neutral, 38%
VI
Interested
Neutral
NVI
No interest


Gender
Female, 38%
Male, 62%
Male
Female

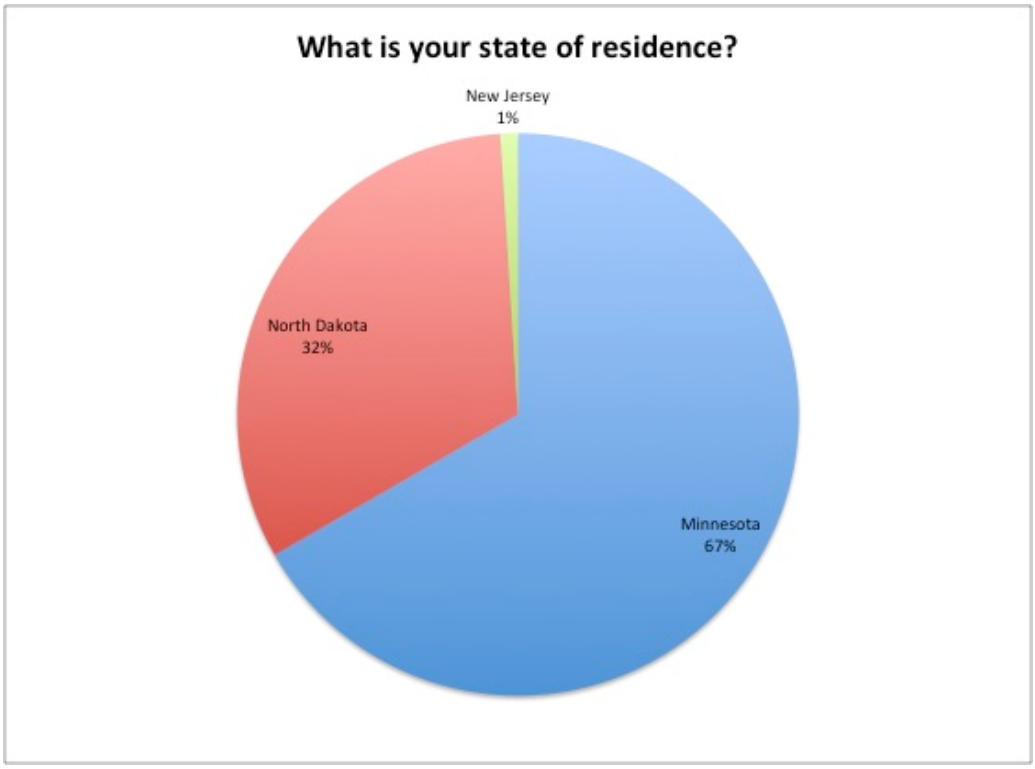
N = 350



Rose Watershed



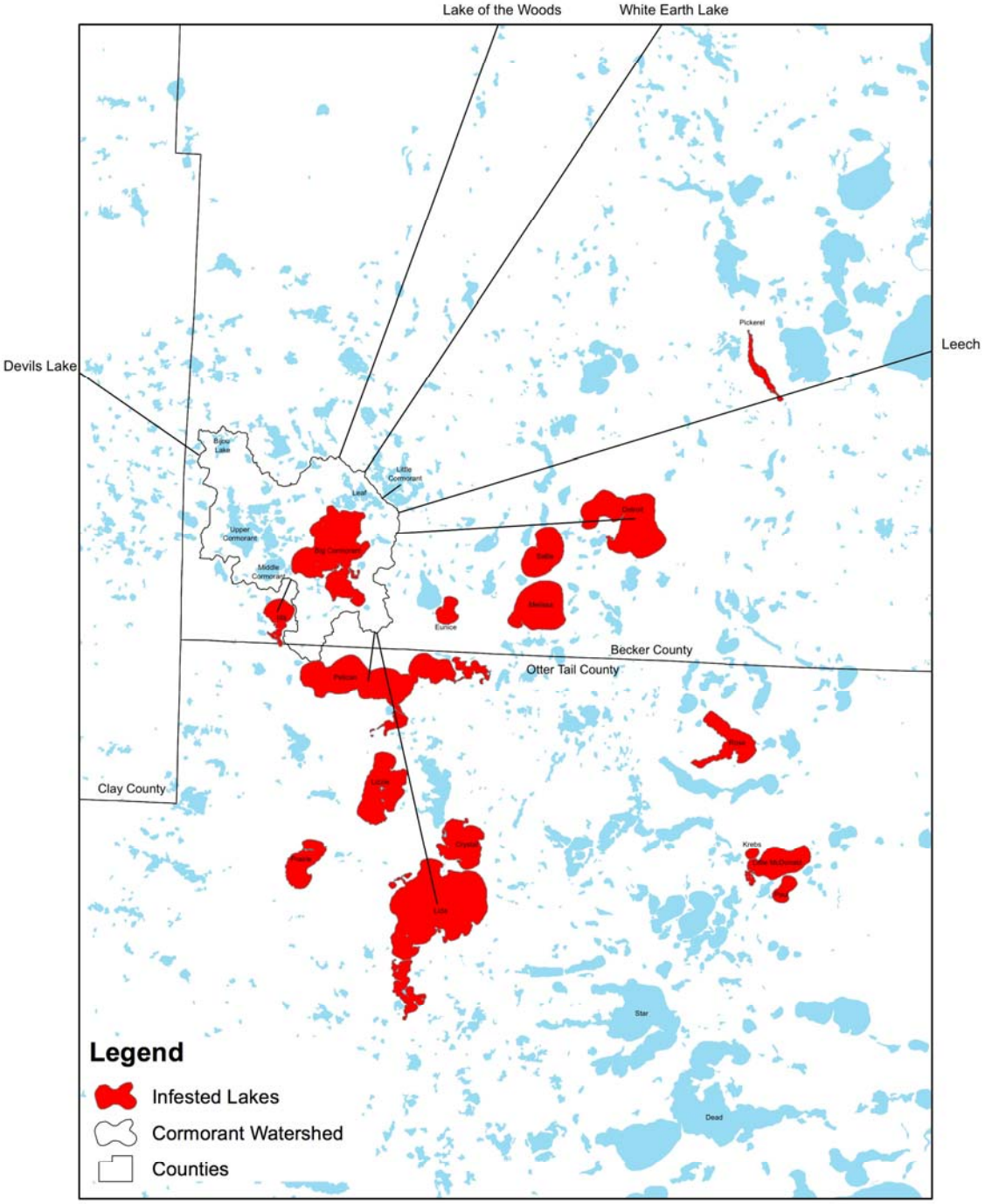
Cormorant Watershed



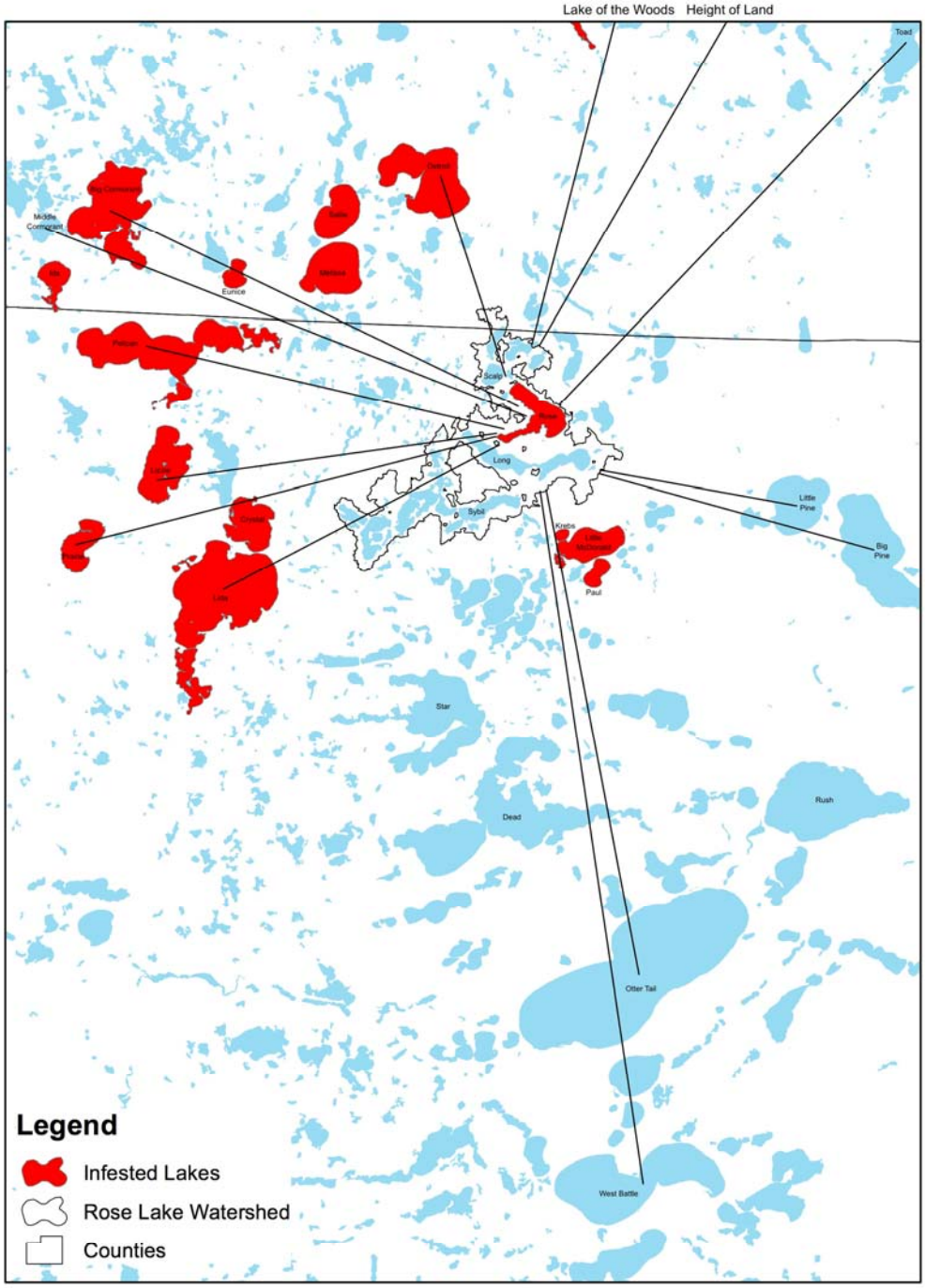
Word Clouds that reflects identified lake usage based on number of times an individual lake was referred to in survey question. The larger the lake name, the more times it was reported as a fishing or recreation destination by survey participants.

Lake property owner participants were also asked what if any other lakes they travel to for recreation other than their home lake, below is the travel pattern established from responses within the Rose Lake and Cormorant lakes sub watersheds. Lakes shaded in "red" have been confirmed as lakes with one or more aquatic invasive species infestation. One of the common perceptions of lake property owners is that fisherman and recreational boaters who travel to lakes country for pleasure are the biggest threat to spreading AIS. We ask respondents to this survey, which lakes they visit and then converted their reply's to a map that highlights this pattern of travel beyond their small watershed. The first map is the Rose Lake respondents and the second is the Cormorant Lakes respondents. Travel in both groups includes a pattern to area lakes that are infested as well as regional destination lakes that are noted as popular fishing destinations.

Which Other Lakes do you Visit?



Which Other Lakes do you Visit?



Participant Comments:

Rose Watershed

- What is to stop someone from taking a five gallon pail and filling it with water from an infected lake and dumping water into an uninfected lake, could IS be spread that easy?
- I would be willing to pay more to support AIS management if it was truly going toward species management.
- Have attended a DNR class and was certified but it only lasted 2 years. Why make it so hard for volunteers? (My teachers license lasts 5 years)
- We need more education on flowering rush, yellow iris, mystery snail and spiny waterflea for the general public.
- Don't know what a Chinese mystery snail is.
- Have never heard of flowering rush, yellow iris, curly leaf pondweed, rusty crayfish, mystery snail or spiny waterflea.
- We do not dare bring our boats to other sites anymore due to invasive species.
- Boats/water toys from infested lakes should not be allowed to go on other lakes.
- Would like to learn more about AIS from webinars.
- I have heard a group of over age 50 property owners go kayaking on area lakes, am not sure how well they clean and dry their kayaks as they come and go, could they be infecting other lakes? Please pass on to DNR.

Cormorant Watershed

- My part is keeping my own boat clean, nothing else.
- Willing to pay more if it was for power washers to clean boats before they leave the lake.
- I support efforts to protect our lakes but, efforts should be in the area of changing rules for property owners that are grandfathered in.
- I support lake management planning by NR agencies, but I do not agree with their ideas.
- The real invasive species are humans that strip shorelines of natural habitat and leak fertilizer into our lakes. Why isn't more done in this area?
- More should be done to reverse the damage older lots are doing to lakes.
- We really need an outlet on Cormorant, we have 5-6 lakes dumping in water with very little release. Docks and lifts have to be moved multiple times per year which is a big job.
- My boat stays on Cormorant, I am afraid to trailer my boat even to have it serviced.
- We need better communication, please!

- Use part of the sales tax, my taxes have gone from $2,500- $46,000 in 10 years, Use this increase. I pay property tax, most users don't!
- You cannot keep wildlife from spreading some of these species. I believe the majority of lake owners try to keep from spreading the problem, however you always have a few idiots.
- Eventually they will die out, I feel we use way too many chemicals already.
- I think the DNR has plenty of funds to take care of this, we are taxed enough as lake shore owners.
- Thanks for the information, I will pass it on.
- They put inspection on one lake in the cormorant chain instead of all access points- it's a waste of time, effort and resources, All or nothing!
- Not familiar with flowering rush, yellow iris, rusty crayfish, Chinese mystery snail, or spiny water flea.
- Television/radio and internet have larger audiences.
- I like your new App!
- The ability to drain the ballasts of wakeboard boats is a big problem.
- Too my knowledge "rapid response" has not been very successful-new options need to be investigated.
- Would be willing to pay more if we included lake resident representatives in ways to manage funds.
- Only consider chemical treatment if it does not have other adverse effects.
- Don't know about, flowering rush, yellow iris, rusty crayfish, Chinese mystery snail, or spiny water flea.
- There is a lack of will to do what we need to do.
- When it comes to protecting our lakes, we have agencies that have different views of what should be done.
- Rapid response, we love going for swims in chemical dumps.
- No will to do what is needed.
- You get more than you need now- take the money from this survey and use it.
- Control the organizations and you control the people.

Tablet Comments

- Very much a concern, I have been doing my part.
- I feel for the most part the spread of invasive species is caused by fisherman who do not own lake property they go freely from lake to lake taking water in bait buckets thus spreading the problem.
- Fisherman can just fill a jug from the lake to take along in case DNR is present rather than taking water from home.

- Add a tax to boat owners who are not property owners.
- Concerned with infested lakes and effect on lake property values.
- Our lake association is quite active in spreading information and soliciting help in protecting our lakes.
- The government needs to discover a way to kill the zebra mussels in our lakes.

Acknowledgements:

Survey Design & Hosting Support,

NDSU Group Decision Center (GDC)

Survey Collection and Data Input Support

River Keepers

Funding provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR)

Basin wide AIS Survey— Question Set

Local and regional leaders have been working to help educate citizens about the importance of preventing the spread of aquatic invasive species, in your opinion, how you feel about this issue that is affecting the quality of our lakes, rivers, streams and ponds in this region. Your participation in this survey will help local leaders understand what citizens know and how they feel about invasive species and how best to plan activities that support clean healthy recreation use of our lakes.

Please read and rate the following statements based on what you know about aquatic invasive species

1) I recognize the words ***clean***, ***drain***, ***dry*** and know what I need to do after a day at the lake

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

2) I could identify a zebra mussel if I saw one at an area lake

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

3) I know who to contact if I find an invasive plant or animal and want to report it

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

4) I have searched for information and read about aquatic invasive species information to help me learn more about this issue

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

5) Aquatic invasive species are a problem we can do very little about regarding prevention of their spread to other areas

- ❍ Strongly Agree
- ❍ Agree
- ❍ Neutral
- ❍ Disagree
- ❍ Strongly Disagree

Please read and rate the following statements as way to help prevent the spread of aquatic invasive species in our lakes and rivers.

6. We need a Plan for more access restrictions on infested lakes

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

7. We need to require inspection and decontamination of all watercraft leaving infected waters

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

8. I support lake management planning by our Natural Resource Agencies that focuses on what is best to support water quality of our lakes and rivers, rather than what is best for people and recreation.

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

9. I support increased efforts to protect our lakes and feel that protection needs to be a higher priority than fishing, recreation and lakeshore living for decision makers working with lake management.

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

10. Whenever possible, we should use “rapid response” efforts through chemical treatments to reduce aquatic invasive species in newly infested lakes and rivers

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

11. It’s useless, no matter what we do, we will not prevent aquatic invasive species from getting into our lakes and rivers

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

12. In your opinion, how important is it that lake users and property owners take precautions to prevent the spread of certain aquatic invasive species? 0 – Unsure to 5- Extremely Important

_____ Flowering Rush
_____ Yellow Iris
_____ Curly Leaf Pond weed
_____ Eurasian water milfoil
_____ Rusty Crayfish
_____ Asian Carp
_____ Chinese mystery snail
_____ Spiny water flea
_____ Zebra Mussel

13. I am interested as a lake/river user in doing my part to help reduce the spread of aquatic invasive species

- ❍ Not at All Interested
- ❍ Not Very Interested
- ❍ Neutral
- ❍ Somewhat Interested
- ❍ Very Interested

14. I believe it is all lake users' responsibility to help reduce the spread of aquatic invasive species

- ❍ Strongly Disagree
- ❍ Disagree
- ❍ Neutral
- ❍ Agree
- ❍ Strongly Agree

15. I am willing to share information with friends, relatives, etc. who are also lake users

- ❍ Not at All Interested
- ❍ Not Very Interested
- ❍ Neutral
- ❍ Somewhat Interested
- ❍ Very Interested

16. I would be willing to pay more ($2-$5) for fishing/boating licenses to support aquatic invasive species management

- ❍ Not at All Interested
- ❍ Not Very Interested
- ❍ Neutral
- ❍ Somewhat Interested
- ❍ Very Interested

17. I am interested in knowing more about local/regional lake associations and the opportunities to help out as a volunteer

- ❍ Not at All Interested
- ❍ Not Very Interested
- ❍ Neutral
- ❍ Somewhat Interested
- ❍ Very Interested

Background: This information will help determine the preferences of different users to learn more about aquatic invasive species.

18. Where is your primary resident?

- ❍ US
- ❍ Canada
- ❍ Other _____

Answer If Where is your primary resident? US Is Selected

US Postal code?

Answer If Where is your primary resident? Canada Is Selected

Canada Postal code?

Answer If Where is your primary resident? Other Is Selected

Other postal code?

20. What Lake(s) do you visit most?

21.

- ❍ Male
- ❍ Female

22. Age range:

- ❍ Under 18
- ❍ 18-25
- ❍ 26-35
- ❍ 36-45
- ❍ 46-55
- ❍ 56-65
- ❍ over 65

23. I visit and use lakes/rivers in this area (Becker, Mahnomen, and Otter Tail County) (times per summer)

- ❍ 1-5
- ❍ 6-10
- ❍ 11-15
- ❍ More than 15
- ❍ Never

24. I own at least 1 type of the following watercraft (check all that apply)

- ❑ Fishing boat
- ❑ Recreation boat
- ❑ Kayak/Canoe
- ❑ Paddle board
- ❑ Duck hunting boat
- ❑ Personnel watercraft
- ❑ Other _____
- ❑ None
- ❑

25. I would prefer to learn about aquatic invasive species from: (check all that apply):

- ❑ Attending a class or workshop
- ❑ Newspaper/magazine
- ❑ Television/radio
- ❑ Internet
- ❑ Smart phone (social media, downloaded app or information sent to my mobile device)
- ❑ Printed media
- ❑ Other _____

Funding provided by the Minnesota Environment and Natural Resources Trust Fund as recommended by the Legislative-Citizen Commission on Minnesota Resources (LCCMR)

Environment and Natural Resources Trust Fund

Final Attachment A: Budget Detail for M.L. 2014 Environment and natural Resources Trust fund Projects

Project Title: Northwest Minnesota Regional Aquatic Invasive Species Prevention Pilot

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 04c

Project Manager: Julie Goehring (Replaces Joe Courneya - Jan. 2016)

Organization: Red River Basin Commission

Final Requested Period - January 1 to June 30, 2016 **Project Ending Date - June 30, 2016**

	Activity 1: Coordination with County & Watershed LGU's			Activity 2: Educational Material Development & Distribution			Activity 3: Leveraging Support and Resources to Sustain Promising Parctices			PROJECT TOTALS		
BUDGET ITEM	**Revised Activity 1 Budget**	**Amount Spent**	**Balance**	**Budget**	**Amount Spent**	**Balance**	**Budget**	**Amount Spent**	**Balance**	**TOTAL BUDGET**	**TOTAL SPENT**	**TOTAL BALANCE**
Personnel (Wages and Benefits)	$98,465.00	$82,510.45	$15,954.55	$54,555.00	$51,225.06	$3,329.94	$32,500.00	$32,395.83	$104.17	$185,520.00	$166,131.34	$19,388.66
Joe Courneya,Project Manager: $56,028 (66% salary, 34% benefits); .25 FTE for 2 years		$17,398.26			$14,316.05			$11,407.09			$43,121.40	
Julie Goehring, Project Manager: $13,605(66% salary, 34% benefits); .25 FTE for 6 months		$6,877.50			$3,360.00			$3,360.00			$13,597.50	
Leah Thevdt, Outreach Specialist: $33,933 (66% salary,34% benefits); .25 FTE for 2 years		$10,411.25			$16,519.16			$4,774.20			$31,704.61	
Spencer McGrew,Project Field Technician: $96,060(85%salary, 15% benefits) 1 FTE for 2 years		$33,925.62			$14,991.05			$5,277.00			$54,193.67	
Aaron Ostlund,Project Field Technician: $23,560 (85%salary, 15% benefits) 0.8 FTE for 5 months		$13,897.82			$2,038.80			$7,577.54			$23,514.16	
Professional/Technical/Service Contracts												
Houston Engineering "invasives App" Develop and Beta test including developer fees for research of existing apps, writing code, artwork and building functionality of app for IOS/Android platforms. Bids solicited and contract awarded to Low bidder, Houston Engineering, Minneapolis.		$0	$0.00	$10,280	$10,280.00	$0.00			$0	$10,280	$10,280	$0.00
RMB Environmental labs, GIS data acquisition, input and mapping support. RMB currently houses the lake and stream watre quality , so working directly with the lab ,rather than using the International Water Institute (IWI) will save time and expenses for the GIS mapping portion of the project	$3,700.00	$3,700.00	$0.00			$0.00			$0.00	$3,700.00	$3,700.00	$0.00
River Keepers, Survey collection and analysis	$1,000.00	$1,000.00	$0.00			$0.00			$0.00	$1,000.00	$1,000.00	$0.00
Equipment/Tools/Supplies												

Regionally branded AIS educational material organization and distribution including printed Id cards, boat sponges and towels for watrecraft cleaning, printed plastic bag for distributing materials, floating key fobs,refrigerator magnets, etc			$0.00	$10,500.00	$10,309.07	$190.93	$0.00	$0.00	$0.00	$10,500.00	$10,309.07	$190.93
Printing												
Riparian property owner survey print and distribution	$1,500	$1,500.00	$0.00			$0			$0	$1,500	$1,500	$0.00
Travel expenses in Minnesota												
Mileage,lodging, meals for travel within project site and within MN portion of Red River Basin	$4,500.00	$4,500.00	$0.00	$2,000.00	$2,000.00	$0.00		$0.00	$0.00	$6,500.00	$6,500.00	$0.00
COLUMN TOTAL	**$109,165.00**	**$93,210.45**	**$15,954.55**	**$77,335.00**	**$73,814.13**	**$3,520.87**	**$32,500.00**	**$32,395.83**	**$104.17**	**$219,000.00**	**$199,420.41**	**$19,579.59**

Wild Rice River Watershed

AIS Prioritization

A planning tool developed for AIS risk management and prevention

2014

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

RED RIVER BASIN COMMISSION

Report Date:	March 2, 2015
Funded by:	Environment and Natural Resources Trust Fund (ENRTF) Red River Basin Commission Becker County Clay County Otter Tail County Wilkin County Pelican River Watershed District Buffalo Red River Watershed District Wild Rice River Watershed District
Project Partners:	Red River Basin Commission Becker County Clay County Otter Tail County Wilkin County Pelican River Watershed District Buffalo Red River Watershed District Wild Rice River Watershed District
Assessment Development:	Moriya Rufer, RMB Environmental Laboratories, Inc
Authors:	Moriya Rufer, RMB Environmental Laboratories, Inc Joe Courneya, Red River Basin Commission Emelia Hauck, RMB Environmental Laboratories, Inc Spencer McGrew, Red River Basin Commission Robert Borash, RMB Environmental Laboratories, Inc
Data Sources:	Minnesota Department of Natural Resources Minnesota Pollution Control Agency Pelican River Watershed District International Water Institute Pelican Group of Lakes Improvement District Lake Associations

Project Contacts:

Joe Courneya
Red River Basin Commission
1120 28th Ave N., Suite C.
Fargo, ND 58102
218-790-0706
joe@redriverbasincommission.org
http://www.redriverbasincommission.org

Spencer McGrew
Red River Basin Commission
1120 28th Ave N., Suite C.
Fargo, ND 58102
701-356-3183
spencer@redriverbasincommission.org
http://www.redriverbasincommission.org

Moriya Rufer
RMB Environmental Laboratories
22796 County Highway 6
Detroit Lakes, MN 56501
218-846-1465
moriyar@rmbel.info
http://rmbel.info

Table of Contents

Introduction

Background

Aquatic Invasive Species (AIS) are aquatic plants and animals that are not native to Minnesota, and cause environmental changes to our waters, have negative economic consequences to our communities, or are harmful to human health. Minnesota's natural resources are threatened by a number of Aquatic Invasive Species such as Zebra mussels, Flowering rush, Eurasian watermilfoil and Asian carp. Invasive species are usually spread by humans.

Zebra mussels are particularly harmful because they spread so rapidly and there are currently no effective treatment options. They attach to hard surfaces such as boats, docks, boat lifts, aquatic plants, and water intake pipes, and can clog pipes, cut feet, and damage boats. Zebra mussels have a large economic impact to water treatment facilities, lakeshore owners, lake recreators, and the tourism industry.

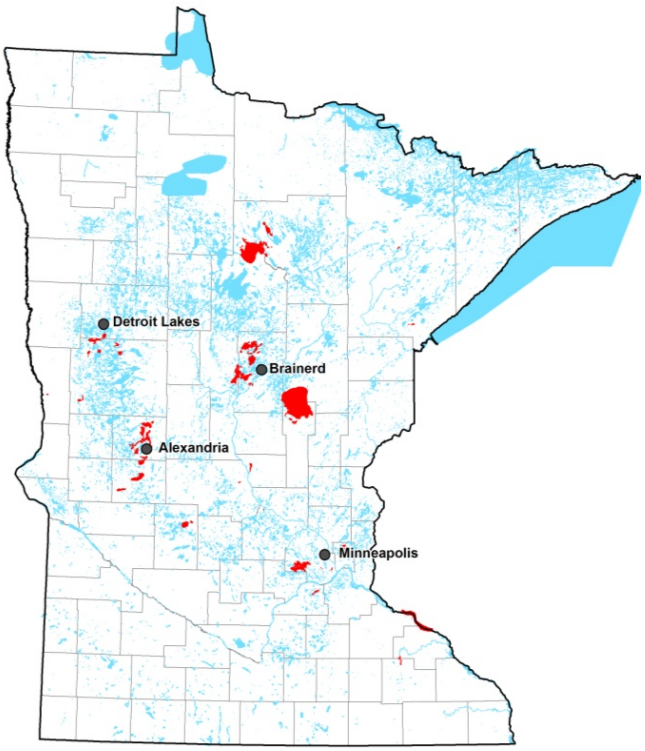


Figure 1. Minnesota Lakes infested by Zebra mussels, 2014.

Zebra mussels also affect the aquatic ecosystem by filtering out microscopic plankton from the water, and therefore removing the food source for other aquatic organisms. This has implications up the food chain, such as affecting fish populations.

As of 2015, approximately 60 lakes in Minnesota are infested with Zebra mussels (MNDNR 2014) (Figure 1). The infestations are clustered around areas with high traffic lakes such as Brainerd, Alexandria, Detroit Lakes and Minneapolis. This pattern of spread is consistent with what has been seen in Michigan, another state with Zebra mussel infested lakes (Johnson *et al.* 2006).

In order to slow or stop the spread of Zebra mussels in Minnesota, a concentrated effort is required. Ideally, unlimited resources would be available to protect all lakes, but in reality budgets are always limited. Therefore, prioritizing lakes due to their risk of infestation is helpful in creating and implementing an AIS management plan.

Project Goals

The goals of this project were to assess the risk of Zebra mussel infestation in the Wild Rice River Watershed in order to prioritize funding and efforts to prevent the further spread of Zebra mussels. Vectors of spread were evaluated for each lake such as connectivity to other water bodies and public use. In addition, the suitability of each water body to Zebra mussel establishment was evaluated considering water chemistry, substrate, dissolved oxygen and temperature. A report card was developed for each water body showing the available data and assigned risk category.

These risk ratings can be used in AIS management plans to prioritize lakes for specific prevention measures. A summary table using the assessments to form management recommendations is provided (Table 16). This table can used to guide the most efficient use of AIS funds in the most effective way possible.

Setting

Watersheds

A basin is the area of land drained by a river or lake and its tributaries. Minnesota has 4 divides. All water in Minnesota eventually flows into 1 of 4 rivers. The divides are made of 8 major drainage basins (Figure 2). Each drainage basin is made up of smaller units called watersheds, which correspond to the drainage of a tributary or lake system.

Watersheds are categorized as major or minor. A minor watershed is the smallest category of watershed. A group of minor watersheds that eventually flows into a common stream, such as the Wild Rice, forms a major watershed. A group of major watersheds that flow into a common river, such as the Red River, form a basin. A group of basins that flow into a common river form a divide.

The Red River of the North Basin stretches from northeastern South Dakota and west-central Minnesota northward through eastern North Dakota and northwestern Minnesota into southern Manitoba. It ends where the Red River empties into the southern end of Lake Winnipeg.

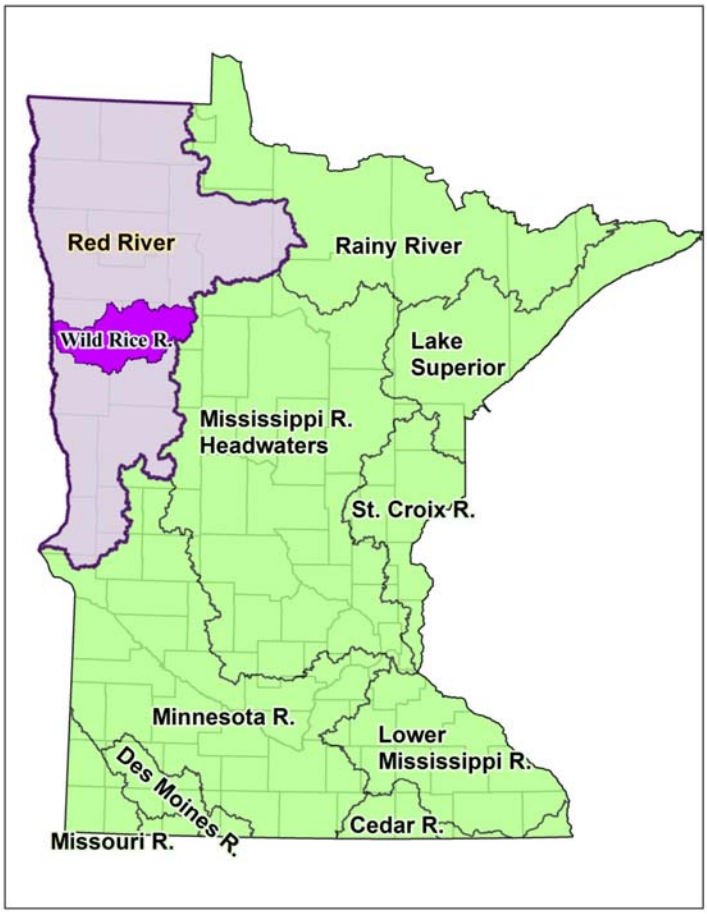


Figure 2. Minnesota showing all major drainage basins, the Red River Basin, and the Wild Rice Watershed.

The Minnesota portion of the Red River Basin covers about 37,100 square miles in northwestern Minnesota in all or part of 21 counties. It is home to about 17,842 miles of streams and 668,098 acres of lakes.

The terrain of the Red River Basin in Minnesota is very diverse; from the flat, intensively farmed plain just east of the length of the Red River, to the rolling uplands full of trees and lakes in the east-central portion of the basin, to the extensive wetlands in the northeast.

The Wild Rice River Major Watershed represents an area of about 1,629 square miles, including areas of substantial portions of Mahnomen and Norman counties, and very small portions of Clay, Becker, Polk, and Clearwater counties (Figure 3).

The Wild Rice River Watershed is a drainage basin of the Red River and the major tributaries of the watershed are Mosquito Creek, Marsh Creek, Twin Lake Creek, White Earth River, and the south branch of the Wild Rice River.

Wild Rice River Watershed

The Wild Rice River Watershed is located in the Red River Basin of the north (Figure 3). Its headwaters start in Upper Rice Lake and Mosquito Creek. From there the river flows west with other lakes such as Roy, Twin Lakes and White Earth Lake flowing into it. It joins the Red River near Halstad, MN.

There is one taxing entity, the Wild Rice River Watershed District, in the Wild Rice River Watershed that has jurisdiction over the area.

Predominate land uses / land covers are Row Crops (53%), Forest (23%), Wetlands (9%), Grass/Pasture/Hay (8%), and Residential/Commercial Development (4%). Agricultural land use in the basin is significant, accounting for over 60% of the overall watershed acres. Development pressure is moderate to considerable in some areas, with occasional farms, timberland, and lakeshore being parceled out for recreation, lake or country homes (NRCS).

As of the end of 2014, there are no aquatic invasive species infestations in the Wild Rice River Watershed.

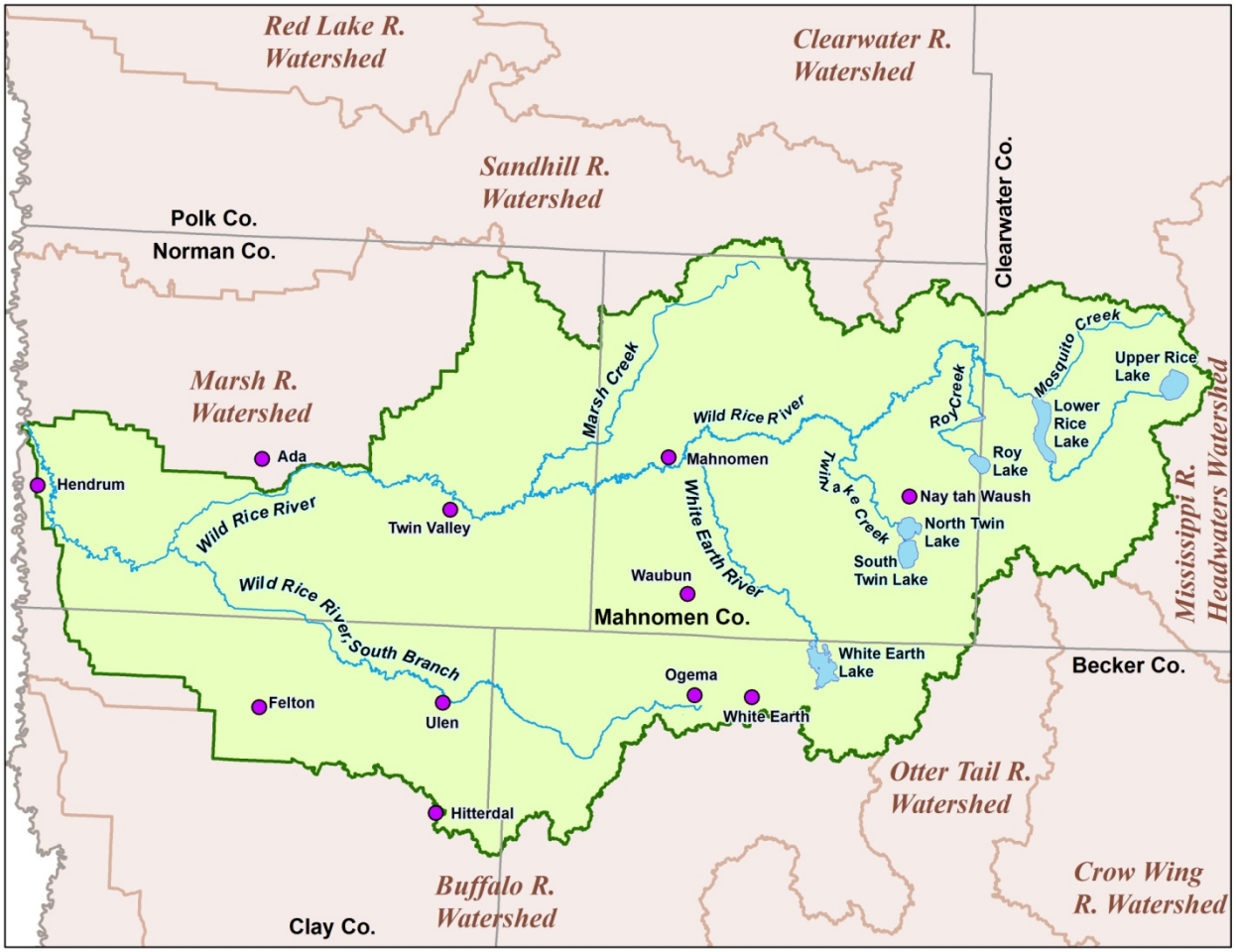


Figure 3. Wild Rice River Watershed.

Zebra Mussel Risk Assessment

Lake Methods

All the major lakes in the Wild Rice River Watershed have water chemistry, temperature, and dissolved oxygen data available (Table 1). These data were collected by lake associations, River Watch, International Water Institute, Clearwater SWCD, Mahnomen SWCD, the Minnesota Pollution Control Agency, Minnesota Department of Natural Resources, the Wild Rice River Watershed District, and were used in the Zebra mussel risk assessment for lakes.

Table 1. Major lakes in the Wild Rice River Watershed.

Waterbody name	Lake DOW
White Earth	03-0328-00
North Twin	44-0023-00
South Twin	44-0014-00
Roy	44-0001-00
Upper Rice	15-0059-00
Lower Rice	15-0130-00

Water Connectivity

One of the highest risks to a water body becoming infested with Zebra mussels is if a nearby upstream lake is infested (Horvath 1996). Infested lakes can serve as a source of Zebra mussel veligers for downstream water bodies and adjacent lakes; however the inter-lake distance must be fairly close for the spread to be possible. Various studies have suggested a downstream veliger dispersal of 1-18 km (0.6-11 miles) in small streams (Lucy *et al.* 2005; Horvath *et al.*1996). In this assessment, lakes that have an infested lake already identified less than 20 km (12 mi) upstream are at a high risk of infestation since the Zebra mussels could spread downstream (Table 2). Lakes that are in a chain have a moderate risk because if any upstream lakes get infested with Zebra mussels (<20 km), they could spread downstream. Headwaters lakes have a very low risk of infestation through water connectivity.

In addition to stream connections, adjacent water bodies have the potential to infest each other via boats going from one lake to another, regardless if the lakes are connected or not.

Table 2. Water connectivity and the related risk of Zebra mussel infestation.

Water Connectivity Category	Risk of infestation
Headwaters lake	Low risk
Chain of lakes (<20 km apart)	Moderate risk
Upstream infested lake (<20 km apart)	High risk

Public Use

Boats and water related equipment have been shown to be one of the largest vectors in the spread of Zebra mussels (Johnson *et al.* 2001). Public use can be measured by some surrogate statistics. First, the number of public accesses and related parking spots are known on each lake. The more public accesses on the lake, the more potential boats can use the lake. Secondly, the number of resorts and hotels on the lake are documented through the Detroit Lakes Area Chamber of Commerce. The hotels and resorts on the lake attract local and regional visitors, increasing the risk of infestation. Thirdly, the number of fishing tournaments and special events on lakes is documented through a permitting process. Fishing tournaments and special events draw visitors to the lakes. And finally, the homeowners on the lake own an average of one dock/boat lift/boat per property. The purchase of an infested boat lift or other water

related equipment has been the source of several documented new infestations in Minnesota. This use relationship coupled with transport of boats and water equipment from lake to lake, increases the probability of infestation. "Destination lakes" for popular fish species like walleyes and muskies along with popular recreation waters for boating and swimming are at increased risk for infestation.

Public access inspections data was reviewed for each lake, but difficulty in standardizing data across lakes challenges the reliability of these data to be used as part of public use data for the final risk assessment.

The numbers used represent boating units per summer. For parcels, an average of one boat per parcel was used in the calculation. For fishing tournaments, the total boats participating in the tournament was used.

For access parking and resort units, the numbers were multiplied by 15 weeks of summer between Memorial Day and Labor Day for an estimated total summer use. This number is likely underestimated, but the ratings still come out the same either way, showing that the calculations are very robust (Tables 3-4). In weighting the resorts and accesses by the 15 weeks of summer, they are weighted appropriately compared to the resident parcels.

Table 3. Public use rating calculations.

Lake	Parcels*	Access Parking*	Resort Units*	Fishing Tournaments*	Total*	Risk Rating
White Earth	175	75	1260	110	1620	Moderate
North Twin	63	0	1695	0	1758	Moderate
South Twin	148	150	1275	0	1573	Moderate
Roy	61	60	0	0	121	Low
Upper Rice	35	0	0	0	35	Low
Lower Rice	0	0	0	0	0	Low

**All numbers are the total number of boats for the 15 weeks of summer.*

Table 4. Use ratings and assigned risk for Zebra mussel infestation.

	Low Risk	Moderate Risk	High Risk
Total Boat Units (the sum of public access parking spaces, resort units, lake parcels and special events)	0-700	701-2,000	2,000+

Water Chemistry

Available water quality data was compiled and analyzed for each major lake and stretch of river in the Wild Rice River Watershed. The average was calculated for each available parameter. The values were then compared to the ranges in Table 5 to determine the potential for Zebra mussels to establish and reproduce in the water body. Calcium was considered first, based on its importance in shell formation (Mackie & Schloesser 1996); however calcium data were not available for all water bodies. Next, alkalinity, hardness and pH were considered (Mackie & Claudi 2010; Hincks & Mackie 1997). Lastly, Secchi depth, chlorophyll a and total phosphorus were considered, although they are not sufficient parameters alone to assess risk (Mackie & Claudi 2010).

Total phosphorus and chlorophyll a are useful for determining the lake's trophic state, which does affect suitability for Zebra mussels. Zebra mussels thrive best in mesotrophic lakes (Karatayev *et al.* 1998, Nelepa 1992). Eutrophic lakes have a lower suitability due to too much phosphorus and chlorophyll a, and usually softer substrates.

Table 5. Water column Zebra mussel suitability criteria (Mackie and Claudi 2010).

	Risk		
Parameter	**Low Little Potential for Larval Development**	**Moderate (survivable, but will not flourish)**	**High (favorable for optimal growth)**
Calcium (mg/l)	8-15	15-30	>30
pH	7.0-7.8 or 9.0-9.5	7.8-8.2 or 8.8-9.0	8.2-8.8
Hardness (mg/L)	30-35	55-100	100-280
Alkalinity (mg/L)	30-55	55-100	100-280
Conductivity (umhos)	30-60	60-110	>110
Secchi depth (m)	1-2 or 6-8	4-6	2-4
Chlorophyll a (ug/L)	2.0-2.5 or 20-25	8-20	2.5-8
Total Phosphorus	5-10 or 35-50	10-25	25-35

Substrate Suitability

One of the reasons Zebra mussels are such a nuisance is that they attach to hard substrates via their byssal threads. Zebra mussels prefer a hard substrate for attachment although they will attach to plants as well (Karatayev et al. 1998). In lakes, they have been documented to colonize on rocks, docks, boatlifts and water intake pipes. Lakes with mainly soft substrate and not many man-made structures may not be as supportive to Zebra mussel colonization. Plants have just moderate suitability because in Minnesota they die off at the end of each summer, meaning the Zebra mussels that are attached to them must crawl to other substrates or die off during winter (Karatayev et al. 1998). Comments are made for each water body, its dominant substrate, and its likelihood to support Zebra mussels. The substrate types were determined by the MNDNR (Table 6).

Table 6. Substrate descriptions and their suitability to Zebra mussel survival.

Substrate (MNDNR)	**Description**	**Suitability to Zebra mussels**
Muck	Decomposed organic material	Low
Marl	Calcareous material	Low
Silt	Fine material with little grittiness	Low
Sand	Diameter less than 1/8 inch	Low
Submerged macrophytes	Underwater rooted plants	Moderate
Gravel	Diameter 1/8 to 3 inches	High
Fubble	Diameter 3 to 10 inches	High
Boulder	Diameter over 10 inches	High

Temperature

Zebra mussels begin reproduction when water temperature is above 12 C, but ideal reproduction temperature occurs above 17-18 C (McMahon 1996). The upper thermal limit for North American Zebra mussels occurs somewhere around 30 C (McMahon 1996) The optimal temperature range for zebra mussel spawning in North America is estimated to between 18-26 C.

In Minnesota, lakes are usually ice-covered on average from November to March. During the ice-covered season, it is assumed that the water temperature is too cold for Zebra mussel spawning. However, the Zebra mussels do over-winter at the bottom of the lake (Mackie *et al.* 1989).

In summer, Minnesota lakes rarely exceed 30 C (86 F); therefore, it is likely that the Zebra mussels reproduce all summer once the water temperature reaches 17-18 C. This occurrence has been documented in Pelican Lake, where Zebra mussel veligers were first found at 18 C in 2012 and 19 C in 2013 (Rufer 2013).

The maximum temperature was reported for each lake and the risk was assigned based on if the lake exceeded 32 C in mid-summer or not (Table 7). The lake's mixing regime and period of hypolimnetic anoxia were also noted as research has found that few Zebra mussel veligers occur below the thermocline in temperate lakes (Mackie *et al.* 1989).

Table 7. Temperature values and their impact on Zebra mussel survival.

Survival Potential	Temperature Range	Risk Rating
Prevent zebra mussel establishment	> 32 C	Low
Little impact on mussel survival	8 – 31 C	High

Infestation Risk Rating

The two main vectors of spread for Zebra mussels are lake connectivity and public use. The risks from these two categories were combined for an overall risk of infestation rating for each lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 8).

Table 8. Combined infestation risk rating using public use and connectivity.

	Public Use Total Boat Units	Connectivity	Combined Risk Rating
Low Risk	0-700	0 = Headwaters Lake	0-1,000
Moderate Risk	701-2,000	2,500 = Chain of Lakes	1,000-6,000
High Risk	2,000+	5,000 = Infested or Infested lake upstream	6,000+

Zebra mussel Suitability Rating

The two main factors for zebra mussels thriving in a lake are suitable water chemistry and suitable substrate. The risks from these two categories were combined for an overall suitability rating for each lake. This suitability rating can be interpreted as the probability that Zebra mussels will thrive in the lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 9).

Table 9. Combined Zebra mussel suitability rating using water chemistry and substate.

	Water Quality	Substrate	Combined Risk Rating
Low Risk	0 = The majority of averages in green category.	0 = Sand, Silt, Muck	0 - Low
Moderate Risk	500 = The majority of averages in yellow category.	500=Submerged macrophytes	1000 - Moderate
High Risk	1,000 = The majority of averages in red category.	1,000 = Rocks, Gravel, Rubble	2000 - High

River Methods

Water chemistry data have been collected throughout the Wild Rice River Watershed by the International Water Institute, Wild Rice Watershed District, the Minnesota Pollution Control Agency, Clearwater SWCD, Mahnomen SWCD and Norman SWCD (Figures 7-8). For this assessment, the Wild Rice River and its tributaries were separated into the following sections for report cards (Table 10, Figure 4). Mosquito Creek and Roy Lake Creek did not have any water quality data, so that is why they are not included in this table.

Table 10. Wild Rice River and tributary sections in this report.

Section	Stream
1	Wild Rice River: Headwaters
2	Wild Rice River: Lower Rice Lake to Twin Lake Creek
3	Twin Lake Creek
4	Wild Rice River: Twin Lake Creek to White Earth River
5	White Earth River
6	Wild Rice River: White Earth River to Marsh Creek
7	Marsh Creek
8	Wild Rice River: Marsh Creek to South Branch
9	South Branch Wild Rice River
10	Wild Rice River: South Branch to Red River

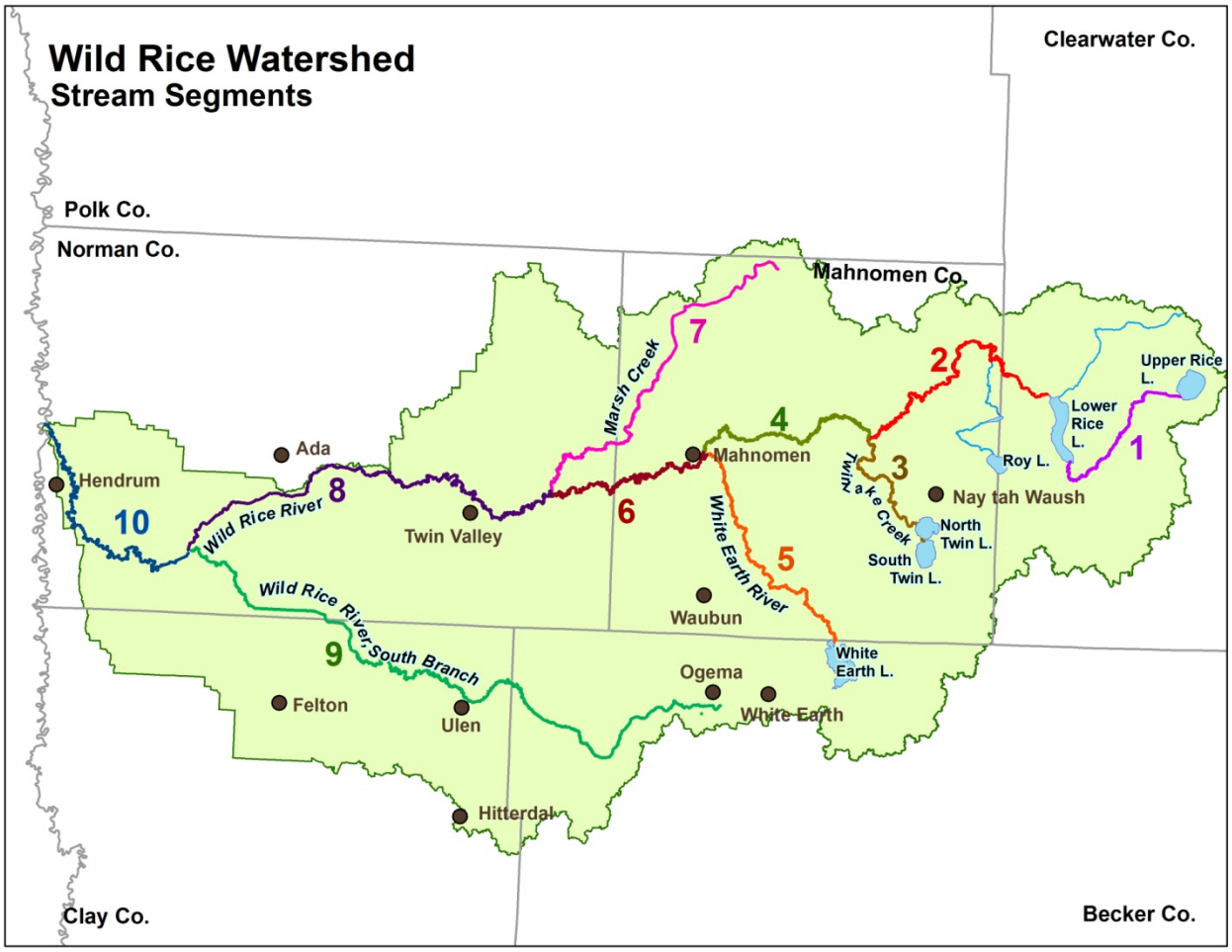


Figure 4. Numbered stream segments in this report. Text descriptions of each section can be found in Table 10.

Unlike lakes, rivers are not usually ideal habitat for Zebra mussels. Studies have shown that the turbulence in streams and rivers causes high Zebra mussel veliger mortality and assists in preventing the veligers from settling on hard substrates (Horvath & Lamberti 1999). Without an infested lake upstream continually supplying the stream with Zebra mussel veligers, the stream is unlikely to sustain a large population on its own. Although streams can be pathways for downstream infestations, the probability of Zebra mussel veliger survival decreases with distance downstream (Horvath & Lamberti 1999; Horvath *et al.* 1996).

For small streams (like the headwaters and tributaries of the Wild Rice River), even the presence of an infested lake upstream supplying veligers will probably not allow the stream to support populations of Zebra mussel adults. Strayer (1991) found that in streams <10 meters wide (33 feet) there were no stable adult Zebra mussel populations. Zebra mussel adults seem to only survive in the largest rivers (>100 m wide) or large pools and stagnant backwaters.

Turbulence & Flow

Studies show that turbulence or shear may be the limiting factor for Zebra mussel survival in streams and rivers (Horvath & Lamberti 1999). Although specific flow rates are not determined, it appears that in streams and rivers, zebra mussels are only self-sustaining behind dams and stagnant backwaters. Therefore, for the purposes of this risk assessment, any stream sites are considered to have low risk due to the flow in the river, even if there is no flow data available.

Downstream Dispersal

Zebra mussel veliger abundance has been shown to decrease exponentially with distance in small streams (<30m wide). A small number of veligers have been found 10-18 km (6-11 miles) downstream of an infested lake in studied stream systems (Horvath *et al*.1996; Horvath & Lamberti 1999). In heavily vegetated wetland stream systems, the dispersal distance has been found to be about 1 km (0.6 mile), which is much lower. There are a few possible factors affecting Zebra mussel veliger survival in wetlands streams, including aquatic vegetation, low water velocity, unsuitable water characteristics, limited substrate availability, and/or increased predation pressure (Bodamer & Brossenbroek 2008). These results show that protecting aquatic vegetation from removal, limiting stream dredging, and installing wetlands could help as a barrier for spreading Zebra mussels downstream.

The Wild Rice River is heavily vegetated, somewhat cloudy (turbid). DNR data and local observations indicate sandy substrates in the upper portion of the watershed and silty turbid substrates in the lower portion of the watershed (Appendix 1). These characteristics are limiting to Zebra mussel veliger survival. Taking into account the literature and the condition and habitat of the river, for the purposes of the risk assessment for the Wild Rice River, 32 km (20 mi) is considered the longest a veliger could theoretically travel (Table 11). This distance of 32 km is very conservative, but until further research is conducted a better estimate is not available.

Water Quality

The water chemistry ranges from Mackie and Claudi 2010 (Table 5) can be applied to streams; however, more applicable water quality parameters to streams are turbidity and total suspended solids. Turbidity has been shown to limit Zebra mussel survival. Although acute exposures to high turbidity can negatively affect a Zebra mussel population, they are able to compensate for some high exposure (McMahon 1996). Chronic high turbidity has a greater negative effect on Zebra mussel survival, as it inhibits their filtering ability (McMahon 1996, Karatayev *et al.* 1998). Mackie and Claudi (2010) suggest upper limits for Zebra mussel survival for total suspended solids at 96 mg/L and turbidity at 80 NTUs, if the turbidity is caused mainly from sediment suspension. The combination of high temperature and high turbidity seem to be most stressful to Zebra mussels (Alexander 1994). For the purposes of this study, the Mackie and

Claudi (2010) numbers are used as guides, but further research is needed to be more decisive conclusions can be made (Figures 5-6).

Minnesota Pollution Control Agency (MPCA) assessments have resulted in some portions of the Wild Rice River being listed as impaired for turbidity. Minnesota's turbidity standard is 25 NTUs, which is under the threshold of 80 NTUs indicated by Mackie and Claudi (2010). The portions of the river that are listed as impaired include: Marsh Creek and the main stem of the Wild Rice River from Marsh Creek to the Red River.

Infestation Risk Rating

In the Wild Rice River Watershed, the primary lakes are at the headwaters of the river, and there is considerable distance between the lakes and the main stem of the Wild Rice River. Because a continual source of Zebra mussel veligers from a lake is needed to sustain a stream population of Zebra mussels, distance from the nearest upstream lake is the limiting factor for an infested stream. The second most important factor in transporting Zebra mussel veligers is the presence of aquatic vegetation and wetlands (Bodamer & Brossenbroek 2008). In streams, public use is a larger threat to downstream lakes than the stream itself (Table 11).

Table 11. Infestation Risk Rating for streams and rivers.

	Risk Rating		
	Low	**Moderate**	**High**
Connectivity	No lakes connected	No upstream infested lakes	Upstream infested lakes
Distance from nearest upstream lake*	>32 km (20 mi)	10-32 km (6.2-20 mi)	0-10 km (0-6.2 mi)
Presence of aquatic vegetation/wetland conditions	Yes	Minimal	No
Public use	No public use	Fishing, ricing, bait harvest, waterfowl hunting, paddle sports	Motorboating, camping, fishing, bait harvest, waterfowl hunting, paddle sports
Overall rating	>32 km (20 mi) from nearest upstream lake	10-32 km (6.2-20 mi) from nearest upstream lake	0-10 km (0-6.2 mi) from nearest upstream lake

**possible limiting parameter for streams*

Suitability Risk Rating

Total suspended solids data were available from the Wild Rice River and its tributaries. Results show that the average total suspended solids are well below the threshold of 96 mg/L on most sites, although in some sites the maximum is over the threshold (Figures 5-6). Therefore, the total suspended solids are most likely not chronically limiting to Zebra mussels. It appears that flow is the main potential limiting factor to Zebra mussel establishment, so it was given the most weight when considering suitability (Table 12).

Table 12. Infestation Risk Rating for streams and rivers.

	Risk Rating Low	Moderate	High
Habitat suitability/substrate	Muddy water, silty mucky substrate	Clear to cloudy water, gravel and rocks	Clear water, rocky, very low flow
Flow rate*	High flow	Moderate flow	Low flow, dams and stagnant backwaters
Water chemistry*	Average turbidity and/or total suspended solids over the thresholds	Maximum turbidity and/or total suspended solids over the thresholds	Average and maximum turbidity and/or total suspended solids under the thresholds
Maximum temperature	>30 C	--	<30 C
Average dissolved oxygen	<7 mg/L	--	> 7 mg/L
Overall rating	High flow and high turbidity and/or total suspended solids	Moderate flow and low turbidity and/or total suspended solids; rocky substrate	Low flow, dams and backwaters and low turbidity and/or total suspended solids; rocky substrate

**possible limiting parameter for streams*

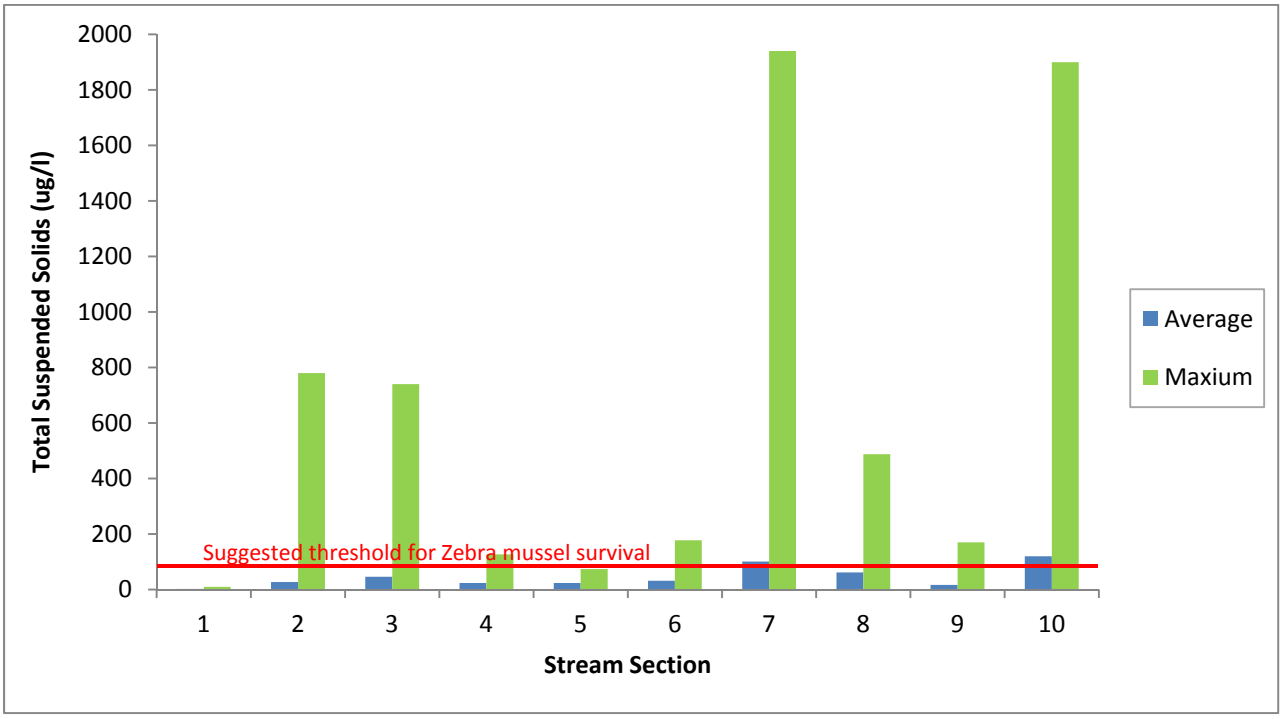


Figure 5. Total suspended solids monitoring data for each stream section in the Wild Rice River Watershed. See Table 10 and Figure 4 for reference on the stream sections.

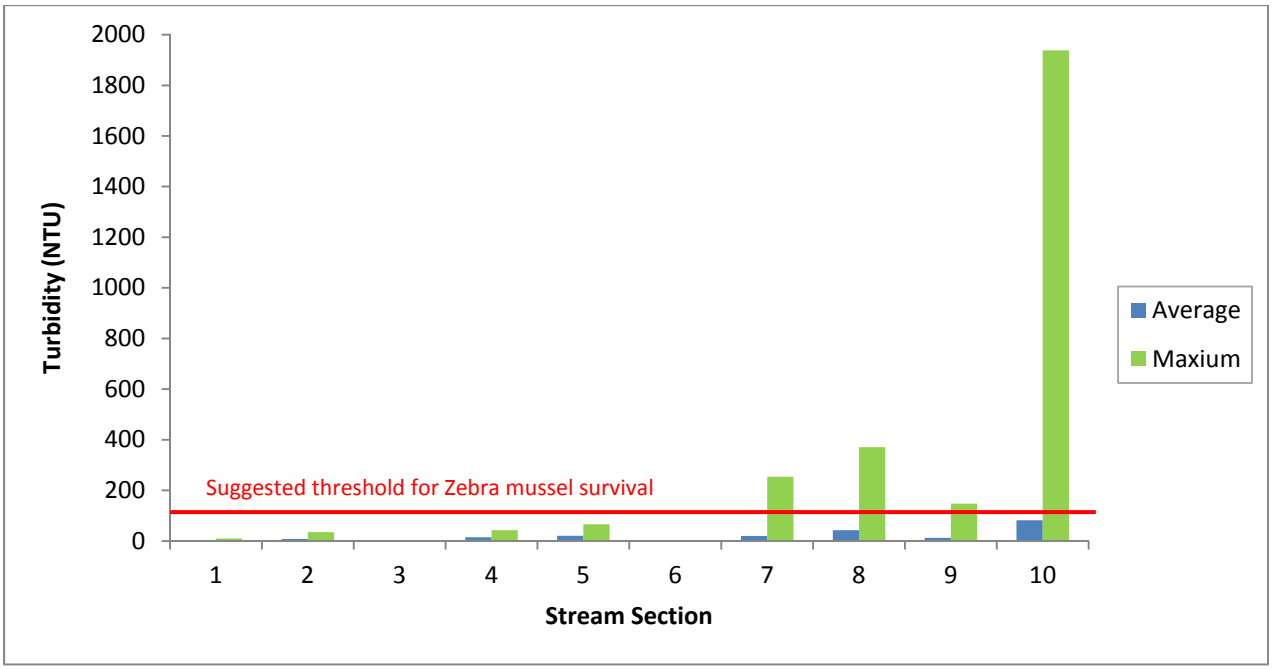


Figure 6. Turbidity monitoring data for each stream section in the Wild Rice River Watershed. See Table 10 and Figure 4 for reference on the stream sections.

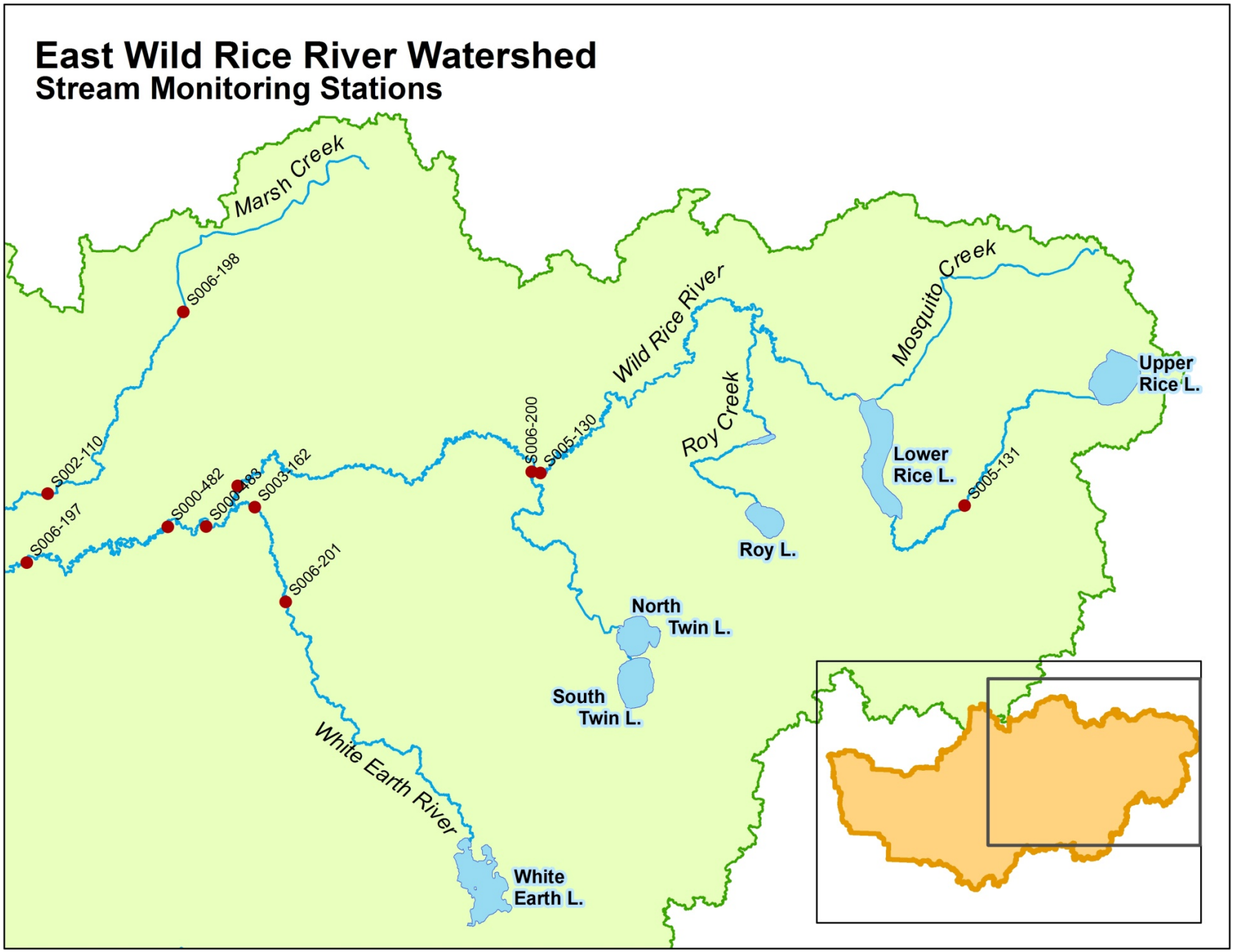


Figure 7. Wild Rice River Watershed eastern stream monitoring sites (MPCA).

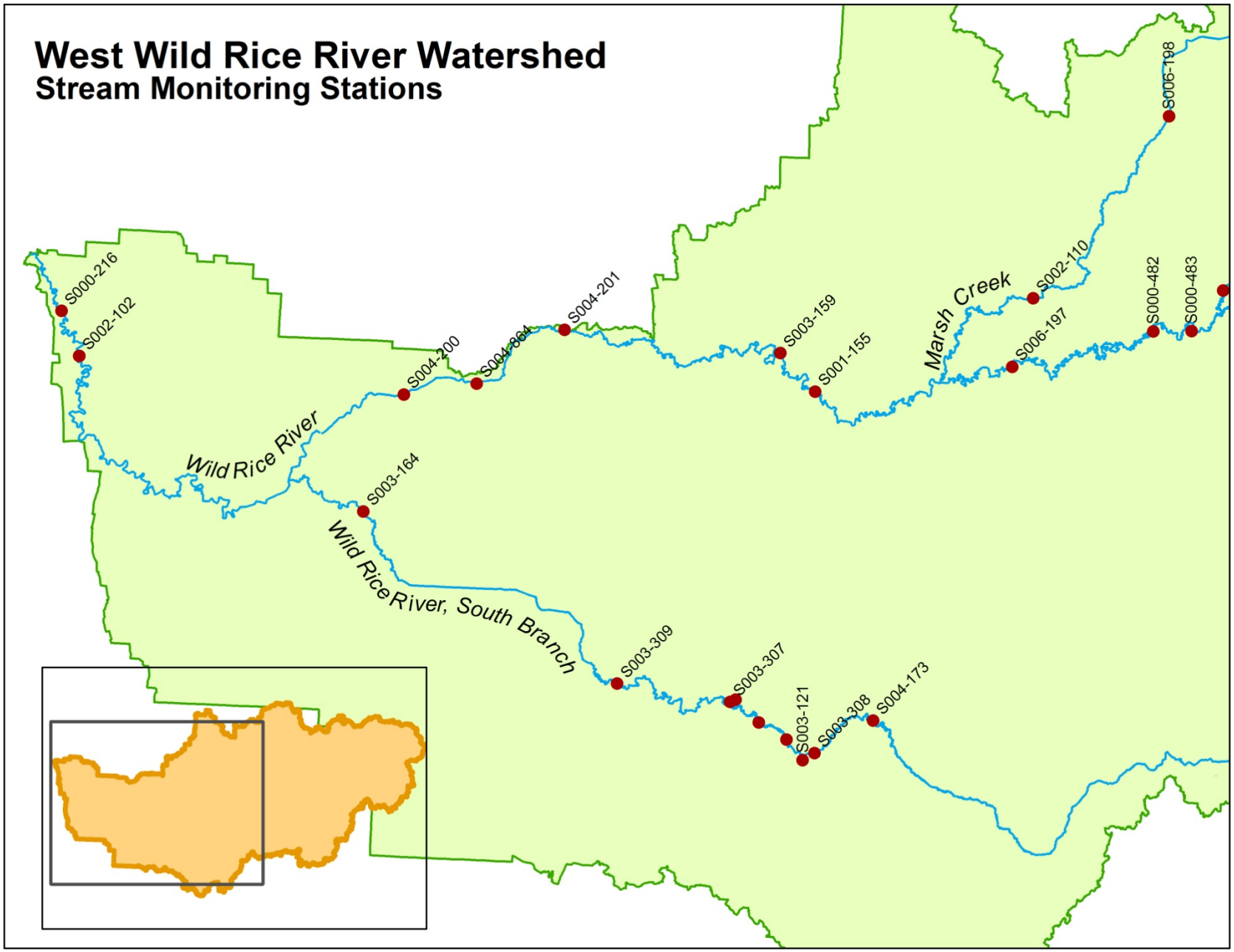


Figure 8. Wild Rice River Watershed western monitoring sites (MPCA).

Lake Risk Assessment Summary: White Earth Lake

Infestation Risk Rating: Moderate
1. Connectivity: Moderate
2. Public Use: Moderate

Suitability Risk Rating: High
1. Water Chemistry: High
2. Substrate: High

Characteristics
Major Basin: Red River
Location: North of Detroit Lakes
Surface Area: 1,989 acres
Percent Littoral: 30%
Max Depth: 120 ft
Inlet: Gull Creek

Summary

White Earth Lake has an upstream lake with substantial development (Tulaby Lake), which gives it a moderate connectivity rating. It also has two resorts with cabins and RV camping spots, and a fair amount of development, giving it a moderate public use risk. If Zebra mussels were introduced into White Earth Lake, they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Top of watershed	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (175)	1,620	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,445)		
Substrate Suitability (mean abundance, DNR)		Rubble, Sand, Boulder	42.1, 25.4, 19.6	High

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Conductivity*	uS/cm	NA	0	>110
Secchi Depth	ft	13.6	373	6.6-13.1
Chlorophyll a	ug/L	3.3	41	2.5-8.0
Total Phosphorus	ug/L	13.2	41	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	21.7 °C (5 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: North Twin Lake

Infestation Risk Rating: Moderate
1. Connectivity: Low
2. Public Use: Moderate

Suitability Risk Rating: Moderate
1. Water Chemistry: High
2. Substrate: Low

Characteristics
Major Basin: Red River
Location: East of Mahnomen
Surface Area: 956 acres
Percent Littoral: 94%
Max Depth: 16 ft
Inlet: Badboy Creek & South Twin Lake

Summary

North Twin Lake is downstream from South Twin Lake, but there are no upstream lakes from South Twin Lake. There is moderate public use in North and South Twin Lakes, with two resorts and some residents. If Zebra mussels were introduced to North Twin Lake, they would do moderately well due to soft substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	1 upstream lake	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (63)	1,758	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1695)		
Substrate Suitability (mean abundance, DNR)		Sand, Silt, Muck	66.1, 29.4, 22.2	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.6	10	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Conductivity*	uS/cm	NA	0	>110
Secchi Depth	ft	9.28	68	6.6-13.1
Chlorophyll a	ug/L	7.4	10	2.5-8.0
Total Phosphorus	ug/L	21.4	10	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26 °C (10 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: South Twin Lake

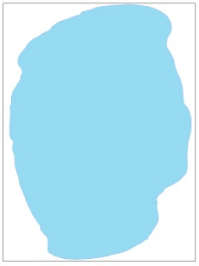
Infestation Risk Rating: Moderate

1. Connectivity: Low
2. Public Use: Moderate

Suitability Risk Rating:

1. Water Chemistry: High
2. Substrate: High

Characteristics
Major Basin: Red River
Location: East of Mahnomen
Surface Area: 1,118 acres
Percent Littoral: 47%
Max Depth: 29 ft
Inlet: 2 minor



Summary

South Twin Lake is a headwaters lake, so the main risk of infestation comes from lake residents and visitors. There is moderate public use in North and South Twin Lakes, with two resorts and some residents. If Zebra mussels were introduced into White Earth Lake, they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (148)	1,573	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,425)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	83.3%, 6.1%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	32.4	10	>30
pH*		8.5	54	8.2-8.8
Alkalinity*	mg/L	164.4	18	100-280
Conductivity*	uS/cm	295	43	>110
Secchi Depth	ft	9.86	69	6.6-13.1
Chlorophyll a	ug/L	4.3	35	2.5-8.0
Total Phosphorus	ug/L	16.2	56	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk

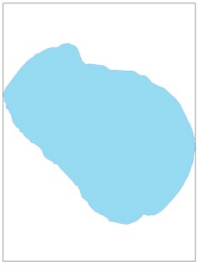
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.1 °C (404 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Roy Lake

Infestation Risk Rating: Low
1. Connectivity: Low
2. Public Use: Low

Suitability Risk Rating: Moderate
1. Water Chemistry: High
2. Substrate: Low

Characteristics
Major Basin: Red River
Location: South of Bagley
Surface Area: 689 acres
Percent Littoral: 93%
Max Depth: 16 ft
Inlet: Roy Lake Creek



Summary

Roy Lake is a headwaters lake, so there is little risk of infestation from upstream. In addition, the lake has low development and public use. If Zebra mussels were to be introduced into Roy Lake, they would do moderately well due to the substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (61)	121	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (60)		
Substrate Suitability (mean abundance, DNR)		Sand, Muck, Detritus	43.3%, 42.8%, 33.9%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.4	53	8.2-8.8
Alkalinity*	mg/L	192	5	100-280
Conductivity*	uS/cm	336.4	53	>110
Secchi Depth	ft	6.9	244	6.6-13.1
Chlorophyll a	ug/L	9.1	24	2.5-8.0
Total Phosphorus	ug/L	28	29	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk

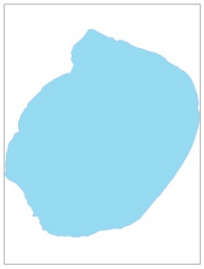
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.76 °C (54 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Upper Rice Lake

Infestation Risk Rating: Low
1. Connectivity: Low
2. Public Use: Low

Suitability Risk Rating: Moderate
1. Water Chemistry: High
2. Substrate: Low

Characteristics
Major Basin: Red River
Location: South of Bagley
Surface Area: 1689 acres
Percent Littoral: 100%
Max Depth: 13 ft
Inlet: None



Summary

Upper Rice Lake is managed by the DNR for wild rice. It is a headwaters lake, so there is no upstream AIS risk. There is also very little public use and development on the lake. If Zebra mussels were introduced to the lake they would do only moderately well due to the soft substrates.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (35)	35	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Unavailable, but most likely soft substrates because it is managed for wild rice	NA	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.2	18	8.2-8.8
Alkalinity*	mg/L	135	1	100-280
Conductivity*	uS/cm	267	19	>110
Secchi Depth	ft	6.8	27	6.6-13.1
Chlorophyll a	ug/L	7.0	20	2.5-8.0
Total Phosphorus	ug/L	21	21	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk

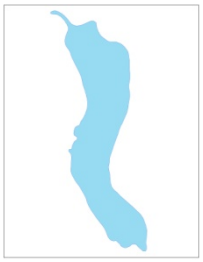
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25 °C (21 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Lower Rice Lake

Infestation Risk Rating: Low
1. Connectivity: Low
2. Public Use: Low

Suitability Risk Rating: Moderate
1. Water Chemistry: High
2. Substrate: Low

Characteristics
Major Basin:
Location: South of Bagley
Surface Area: 2044 acres
Percent Littoral: 100%
Max Depth: NA
Inlet: Wild Rice River



Summary

Upper Rice Lake is managed by the DNR for wild rice. It only has one lake upstream, so there is low AIS risk. There is also no public use or development on the lake. If Zebra mussels were introduced to the lake they would do only moderately well due to the soft substrates.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	1 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (35)	35	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance, DNR)		Unavailable, but most likely soft substrates because it is managed for wild rice	NA	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Conductivity*	uS/cm	NA	0	>110
Secchi Depth	ft	NA	0	6.6-13.1
Chlorophyll a	ug/L	NA	0	2.5-8.0
Total Phosphorus	ug/L	NA	0	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	High
Dissolved oxygen	NA	<7 mg/L	High

Stream Risk Assessment Summary: Wild Rice River Headwaters

Infestation Risk Rating: Low

1. Connectivity: Low
2. Distance from lakes: Moderate
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: High
3. Substrate: Moderate
4. Dissolved Oxygen: High

Characteristics

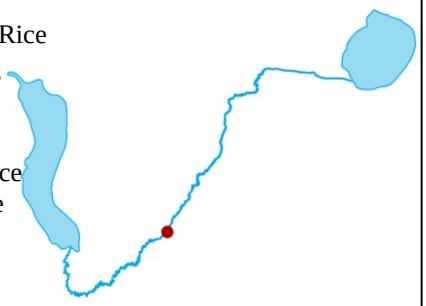
Major Basin: Wild Rice

County: Clearwater

Site: S005-131

Location: Upper Rice Lake to Lower Rice Lake

Length: 18.3 miles



Summary

The headwaters of the Wild Rice River starts in Upper Rice Lake, and then flows west through Lower Rice Lake to the Wild Rice River. This stretch of stream could become infested if Upper Rice Lake became infested, and Upper Rice Lake has a low infestation risk. Therefore, there is a low infestation risk to this reach of the Wild Rice River.

Attribute	Description	Infestation Risk
Water Connectivity	Headwaters	Low
Distance from nearest upstream lake	18.3 miles	Moderate
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Waterfowl hunting, ricing	Moderate
Habitat Suitability/Substrate	Clear water, gravel	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	26.6 (28)	>32 C	High
Dissolved oxygen average (mg/L)	9.0 (27)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	388	597	28	>110
Total Suspended Solids*	mg/L	2.8	10	20	<96
Turbidity*	NTU	3.9	9.7	36	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Wild Rice River at Twin Lake Creek

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: Moderate
3. Substrate: Moderate
4. Dissolved Oxygen: High

Characteristics

Major Basin: Wild Rice

County: Mahnomen

Site: S005-130

Location: Lower Rice Lake to Twin Lake Creek

Length: 32.8 miles

Summary

This site on the Wild Rice River is just before Twin Lake Creek joins it. In order for Zebra mussels to be present in this location, a source (Roy or Upper/Lower Rice Lakes) would be needed to continually introduce veligers to the stream; however, those lakes are over 32.8 stream miles away. Therefore, this stretch of the river has a low infestation risk rating.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 3 uninfested lakes	Moderate
Distance from nearest upstream lake	32.8 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability/Substrate	Clear water, gravel	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	26.7 (52)	>32 C	High
Dissolved oxygen average (mg/L)	9.5 (51)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	408	583	56	>110
Total Suspended Solids*	mg/L	27.6	780	47	<96
Turbidity*	NTU	8.4	35.2	42	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Twin Lake Creek

Infestation Risk Rating: Moderate

1. Connectivity: Moderate
2. Distance from lakes: Moderate
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: Moderate
3. Substrate: Moderate
4. Dissolved Oxygen: High

Characteristics

Major Basin: Wild Rice

County: Mahnomen

Site: S006-200

Location: South Twin Lake to Wild Rice River

Length: 15.5 miles

Summary

Twin Lake Creek flows from South Twin Lake north into the Wild Rice River. If South and North Twin Lakes became infested, the stream could become infested. The stream flow would likely be the limiting factor for Zebra mussel survival within the stream itself. In order for Zebra mussels to be present in the stream, a source (South Twin Lake) would be needed to continually introduce veligers to the stream.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 2 uninfested lakes	Moderate
Distance from nearest upstream lake	<15.5 miles	Moderate
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports, hunting	Moderate
Habitat Suitability/Substrate	Cloudy water, gravel, rocks	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	26.5 (21)	>32 C	High
Dissolved oxygen average (mg/L)	9.2 (21)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	364	763	22	>110
Total Suspended Solids*	mg/L	46.3	740	22	<96
Turbidity*	NTU	NA	NA	0	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Wild Rice River

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: Moderate
3. Substrate: Moderate
4. Dissolved Oxygen: High

Characteristics

Major Basin: Wild Rice

County: Mahnomen

Site: S003-163

Location: Twin Lake Creek to White Earth River

Length: 27.1 miles

Summary

This section of the Wild Rice River runs from Twin Lake Creek to White Earth River. If South and North Twin Lakes became infested, the veligers are not likely to make it this far into the White Earth River. Therefore, the infestation risk rating for this section of stream is low.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 4 uninfested lakes	Moderate
Distance from nearest upstream lake	42.6 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability/Substrate	Clear water, gravel, rocks	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	26.2 (47)	>32 C	High
Dissolved oxygen average (mg/L)	9.0 (47)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	434	572	33	>110
Total Suspended Solids*	mg/L	24	127	19	<96
Turbidity*	NTU	15	43	32	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: White Earth River

Infestation Risk Rating: Moderate

1. Connectivity: Moderate
2. Distance from lakes: Moderate
3. Vegetation: Yes
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: High
3. Substrate: Moderate
4. Dissolved Oxygen: High

Characteristics

Major Basin: Wild Rice

County: Mahnomen

Sites: S006-201
S003-162

Location: White Earth Lake to Wild Rice River

Length: 26.2 miles

Summary

The White Earth River runs from White Earth Lake to the Wild Rice River. If White Earth Lake became infested, the stream could become infested near the lake. The stream flow and vegetation would likely be the limiting factors for Zebra mussel survival within the stream itself. The distance is great enough that if White Earth Lake was infested, the veligers are not likely to make it all the way to the Wild Rice River.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 1 uninfested lakes	Moderate
Distance from nearest upstream lake	<26.2 miles	Moderate
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability/Substrate	Cloudy water, gravel, rocks	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	25.4 (92)	>32 C	High
Dissolved oxygen average (mg/L)	8.6 (92)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	269	764	79	>110
Total Suspended Solids*	mg/L	24	74	43	<96
Turbidity*	NTU	21	66	56	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Wild Rice River

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Moderate
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: Moderate
3. Substrate: Moderate
4. Dissolved Oxygen: High

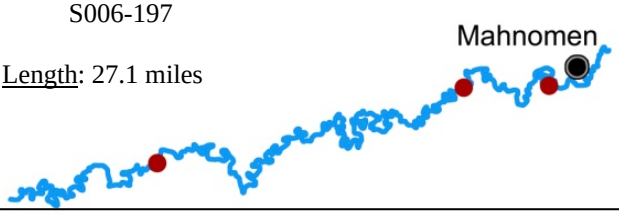
Characteristics

Major Basin: Wild Rice County: Mahnomen & Norman

Sites: S000-483
S000-482
S006-197

Location: White Earth River to Marsh Creek

Length: 27.1 miles



Summary

This section of the Wild Rice River runs from White Earth River to Marsh Creek. The distance from any upstream lakes is great enough that veligers are not likely to make it this far downstream. The stream flow would likely be the limiting factor for Zebra mussel survival within the stream itself.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 5 uninfested lakes	Moderate
Distance from nearest upstream lake	53.3 miles	Low
Presence of aquatic vegetation/wetland conditions	Minimal	Moderate
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability/Substrate	Cloudy water, gravel, rocks	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	20 (1)	Unknown	Low
Maximum Flow (cfs)	20 (1)	Unknown	Low
Summer maximum temperature (C)	24.5 (22)	>32 C	High
Dissolved oxygen average (mg/L)	9.7 (22)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	150	150	1	>30
Hardness	Mg/L	270	270	1	100-280
Specific Conductance	uS/cm	448	821	23	>110
Total Suspended Solids*	mg/L	32	178	23	<96
Turbidity*	NTU	3	3	1	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Marsh Creek

Infestation Risk Rating: Low

1. Connectivity: Low
2. Distance from lakes: Low
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: Low
3. Substrate: Low
4. Dissolved Oxygen: High

Characteristics

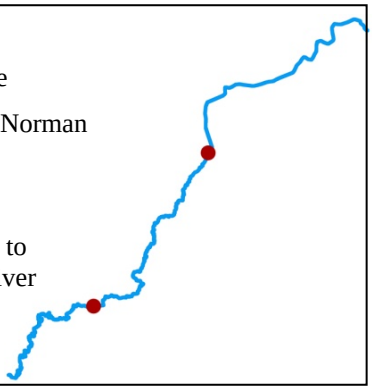
Major Basin: Wild Rice

County: Mahnomen & Norman

Sites: S002-110
S006-198

Location: Marsh Creek to Wild Rice River

Length: 33.4 miles



Summary

Marsh Creek runs from its origin to the Wild Rice River east of Twin Valley. Observations and total suspended solids results show that the creek is cloudy and turbid. Therefore, it has a low suitability to Zebra mussels. In addition, it has no lakes along its reach, so there is a low risk for Zebra mussels to infest the creek.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 0 lakes	Low
Distance from nearest upstream lake	0 upstream lakes	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability/Substrate	Muddy, cloudy water	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	27.0 (92)	>32 C	High
Dissolved oxygen average (mg/L)	9.1 (92)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	637	977	79	>110
Total Suspended Solids*	mg/L	101	1,940	42	<96
Turbidity*	NTU	20	254	56	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Wild Rice River

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Moderate
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: Moderate
3. Substrate: Moderate
4. Dissolved Oxygen: High

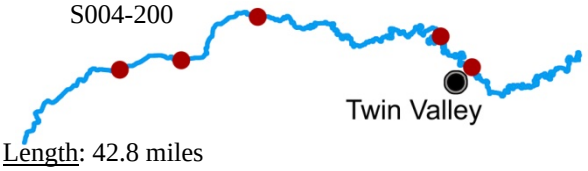
Characteristics

Major Basin: Wild Rice

County: Norman

Sites: S001-155
S004-201
S004-864
S004-200

Location: Marsh Creek to South Branch



Length: 42.8 miles

Summary

This section of the Wild Rice River runs from Marsh Creek to the South Branch of the Wild Rice River. Observations and total suspended solids results show that the creek is somewhat cloudy and turbid. Therefore, it has a low suitability to Zebra mussels. In addition, it has no lakes along its reach, so there is a low risk for Zebra mussels to infest the creek.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 5 uninfested lakes	Moderate
Distance from nearest upstream lake	96.1 miles	Low
Presence of aquatic vegetation/wetland conditions	Minimal	Moderate
Public Use	Fishing, bait harvest, paddle sports	Moderate
Habitat Suitability/Substrate	Cloudy water, sand, gravel, rocks	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	316 (31,612)	Unknown	Low
Maximum Flow (cfs)	536 (31,612)	Unknown	Low
Summer maximum temperature (C)	31.0 (155)	>32 C	High
Dissolved oxygen average (mg/L)	9.3 (146)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	64.8	75.9	7	>30
Hardness	Mg/L	242	245	2	100-280
Specific Conductance	uS/cm	501	659	144	>110
Total Suspended Solids*	mg/L	61.7	488	102	<96
Turbidity*	NTU	42.7	371	128	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Wild Rice River South Branch

Infestation Risk Rating: Low

1. Connectivity: Low
2. Distance from lakes: Low
3. Vegetation: Moderate
4. Public Use: Moderate

Suitability Risk Rating: Low

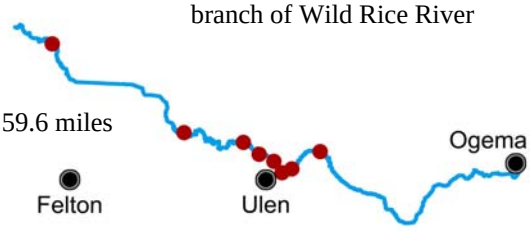
1. Flow Rate: Low
2. Water Chemistry: Moderate
3. Substrate: Moderate Risk
4. Dissolved Oxygen: High Risk

Characteristics

Major Basin: Wild Rice County: Becker, Clay, Norman

Sites: *See below Location: Ogema to main branch of Wild Rice River

Length: 59.6 miles



Summary

The South branch of the Wild Rice River runs from Ogema northwest to the main branch of the Wild Rice River. There are no large lakes connected to this river, so there aren't likely sources of Zebra mussels to infest it. *Monitored sites include: S003-164, S003-165, S003-307, S003-308, S003-309, S004-172, S004-173.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 0 lakes	Low
Distance from nearest upstream lake	0 lakes upstream	Low
Presence of aquatic vegetation/wetland conditions	Minimal	Moderate
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability/Substrate	Cloudy water, sand, gravel, rocks	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	36.2 (1,979)	Unknown	Low
Maximum Flow (cfs)	60 (1,979)	Unknown	Low
Summer maximum temperature (C)	29.4 (334)	>32 C	High
Dissolved oxygen average (mg/L)	9.95 (320)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	682	1,510	310	>110
Total Suspended Solids*	mg/L	16.7	170	108	<96
Turbidity*	NTU	12.8	148	268	<80

**possible limiting parameter for streams*

Stream Risk Assessment Summary: Wild Rice River Terminus

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Moderate
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low Risk
2. Water Chemistry: Low Risk
3. Substrate: Low Risk
4. Dissolved Oxygen: High Risk

Characteristics

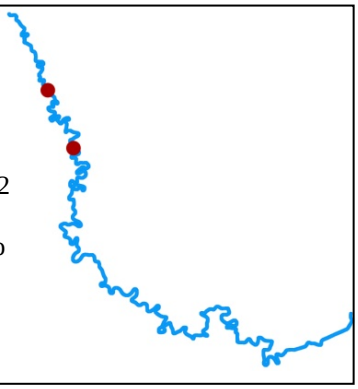
Major Basin: Wild Rice

County: Norman

Sites: S000-216, S002-102

Location: South Branch to Red River

Length: 30.5 miles



Summary

The final stretch of the Wild Rice River runs from the south branch to its pour point into the Red River. This stretch of the river is very fast flowing and turbid, which could be unsuitable to Zebra mussels. It is listed as impaired for turbidity by the Minnesota Pollution Control Agency. In addition, it has no lakes along its reach, so there are aren't likely sources of Zebra mussels to infest the lake.

Attribute	Description	Infestation Risk
Water Connectivity	Flows from 5 uninfested lakes	Moderate
Distance from nearest upstream lake	126.6 miles	Low
Presence of aquatic vegetation/wetland conditions	Minimal	Moderate
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability/Substrate	Muddy, cloudy water	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	936.6	Unknown	Low
Maximum Flow (cfs)	9,640	Unknown	Low
Summer maximum temperature (C)	27.5 (398)	>32 C	High
Dissolved oxygen average (mg/L)	8.7 (396)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	165	420	55	>30
Hardness	Mg/L	308	382	57	100-280
Specific Conductance	uS/cm	529	1,600	403	>110
Total Suspended Solids*	mg/L	120	1,900	403	<96
Turbidity*	NTU	82	1,938	592	<80

**possible limiting parameter for streams*

Results and Analysis

Results

The lakes in the Wild Rice River Watershed resulted in differing infestation and suitability risk ratings (Table 13). In general terms, the headwaters lakes came out with the lowest infestation risk ratings because they have no water bodies upstream. The headwaters lakes in the Wild Rice River Watershed include Upper and Lower Rice Lakes. Lakes that had moderate infestation risk ratings were White Earth, South and North Twin Lakes. These lakes came out as moderate because of the public use and residential development (Figure 13).

No lakes in the Wild Rice River Watershed scored high for infestation risk. This is mainly because many of the lakes do not have other lakes flowing into them, and compared to the Detroit Lakes area they have lower public use.

White Earth and South Twin Lake in the Wild Rice River Watershed resulted in a high Zebra mussel suitability rating (Figure 17). The lakes in northwest Minnesota are considered hardwater lakes from glacial deposits of calcium carbonate (limestone) (Wetzel 2001). All of the lakes in this study had suitable water chemistry, including calcium, for Zebra mussel growth and development.

The limiting factor that resulted in some lakes receiving a moderate suitability rating was substrate. Zebra mussels are not able to attach silt, muck, and sand directly. In areas with these substrates, the Zebra mussels will attach to plants, native mussels, and pieces of wood or stones (Karatayev et al. 1998). Therefore, lakes that have predominantly silt, muck and sand have a low substrate suitability rating. These lakes also tend to be more eutrophic, and Zebra mussels do not thrive in eutrophic lakes like they do in mesotrophic lakes (Karatayev et al. 1998, Nelepa 1992). The lakes with moderate suitability ratings included Roy, North Twin, Upper Rice and Lower Rice Lakes (Table 13).

The Wild Rice River itself is a pathway for the spread of Zebra mussels downstream. Zebra mussel establishment in streams is limited by turbulence and flow, therefore the river itself is likely not a major source of zebra mussels. The headwaters reach of the Wild Rice River in Clearwater and Mahnomen Counties County is uninfested and remote, and therefore received a low infestation rating. The downstream reaches of the Wild Rice River are too far away from the lakes for them to be a source of Zebra mussels, so they received a low infestation rating as well.

White Earth and South Twin Lakes were determined to be at greatest risk in the watershed for infestation, and they are most suitable for Zebra mussels to thrive, which means they should be targeted for protection (Table 13).

Table 13. Summary of risk ratings and prioritized recommendations taking into account the risk.

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of 9/9/2014	AIS Program Prioritized Recommendations
White Earth	03-0328-00	Moderate	Moderate	High	No AIS	1. Public Access Inspections 2. Education 3. Early Detection Monitoring
North Twin	44-0023-00	Moderate	Moderate	Moderate	No AIS	1. Education
South Twin	44-0014-00	Moderate	Moderate	High	No AIS	1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Roy	44-0001-00	Low	Low	Moderate	No AIS	1. Education
Upper Rice	15-0059-00	Low	Low	Moderate	No AIS	1. Education
Lower Rice	15-0130-00	Low	Low	Moderate	No AIS	1. Education
Wild Rice River: Headwaters		Moderate	Low	Low	No AIS	1. Education
Wild Rice River: Lower Rice Lake to Twin Lake Creek		Moderate	Low	Low	No AIS	1. Education
Twin Lake Creek		Moderate	Moderate	Low	No AIS	1. Education
Wild Rice River: Twin Lake Creek to White Earth River		Moderate	Low	Low	No AIS	1. Education
White Earth River		Moderate	Moderate	Low	No AIS	1. Education
Wild Rice River: White Earth River to Marsh Creek		Moderate	Low	Low	No AIS	1. Education
Marsh Creek		Moderate	Low	Low	No AIS	1. Education
Wild Rice River: Marsh Creek to South Branch		Moderate	Low	Low	No AIS	1. Education
South Branch Wild Rice River		Moderate	Low	Low	No AIS	1. Education
Wild Rice River: South Branch to Red River		Moderate	Low	Low	No AIS	1. Education

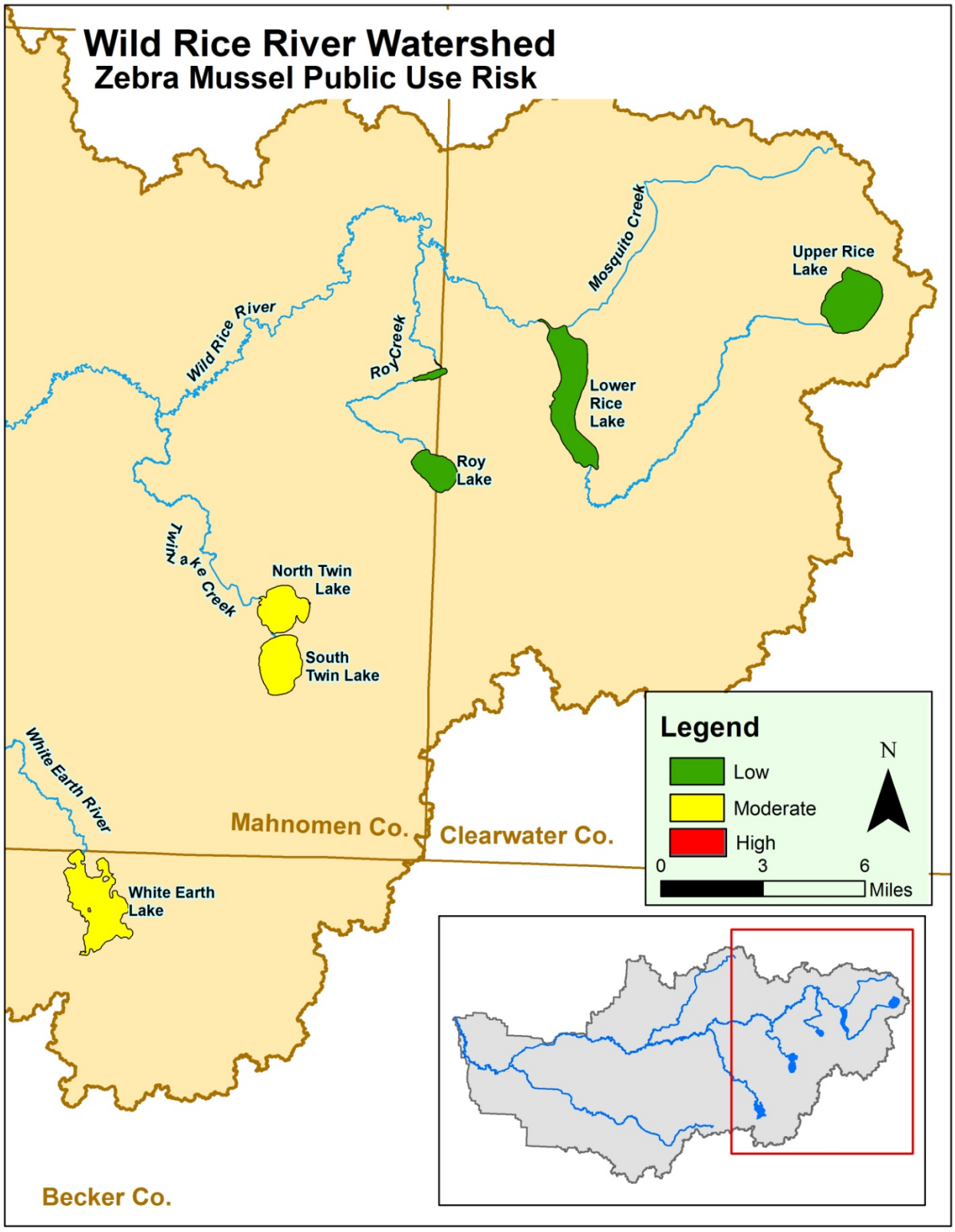


Figure 9. Public use risk ratings for Wild Rice River Lakes.

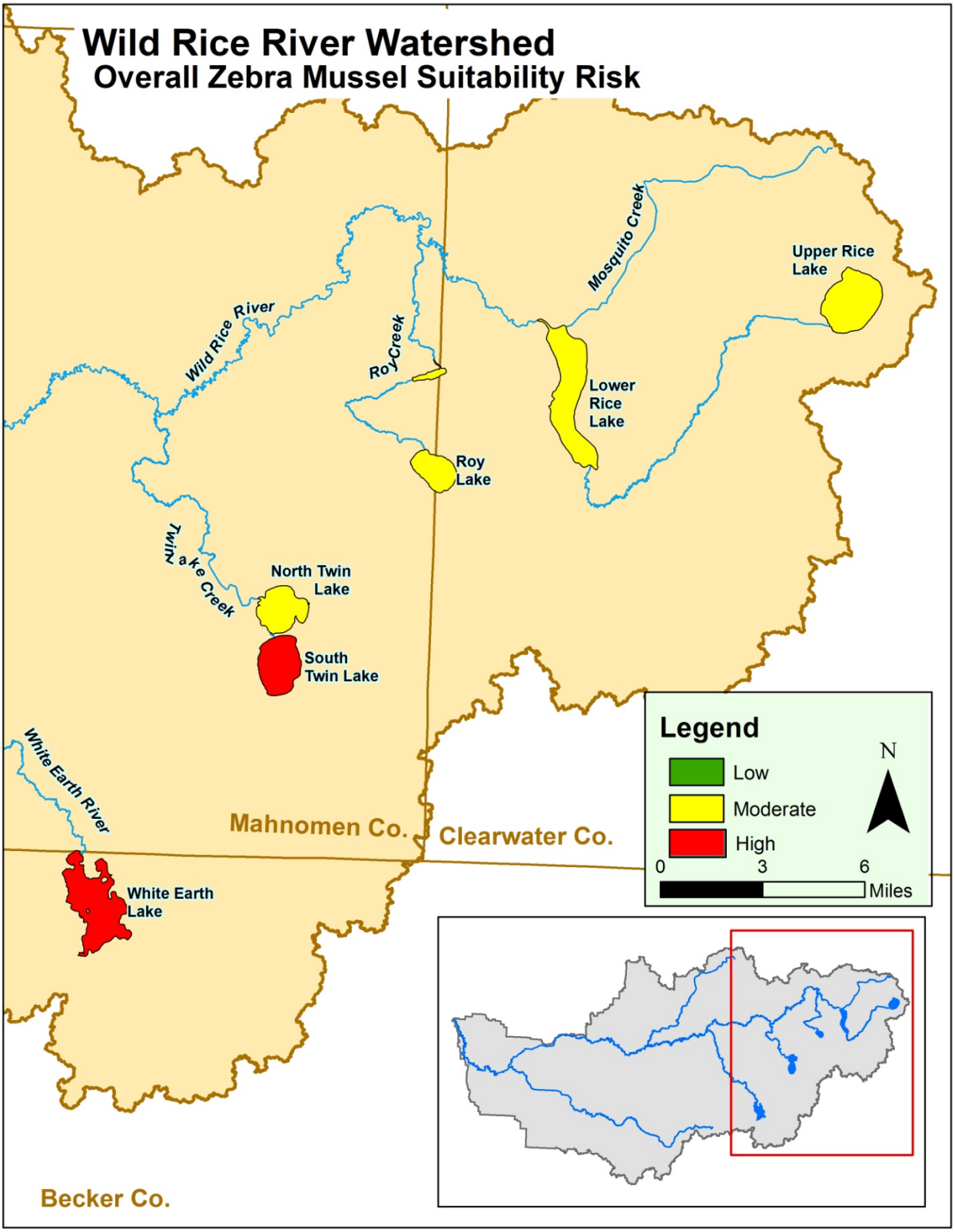


Figure 10. Lake suitability ratings to Zebra mussel survival.

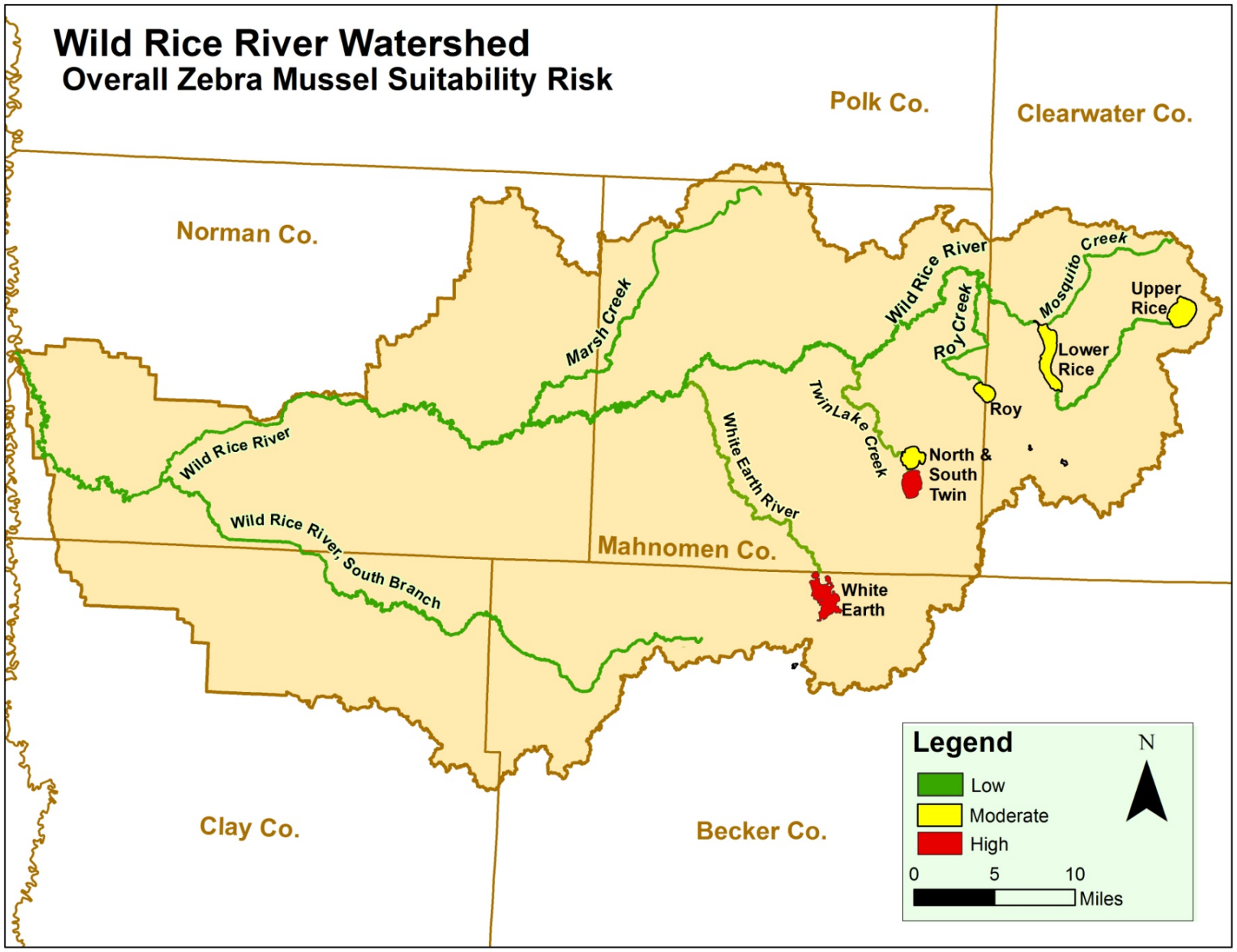


Figure 11. Lake and stream suitability ratings to Zebra mussel survival.

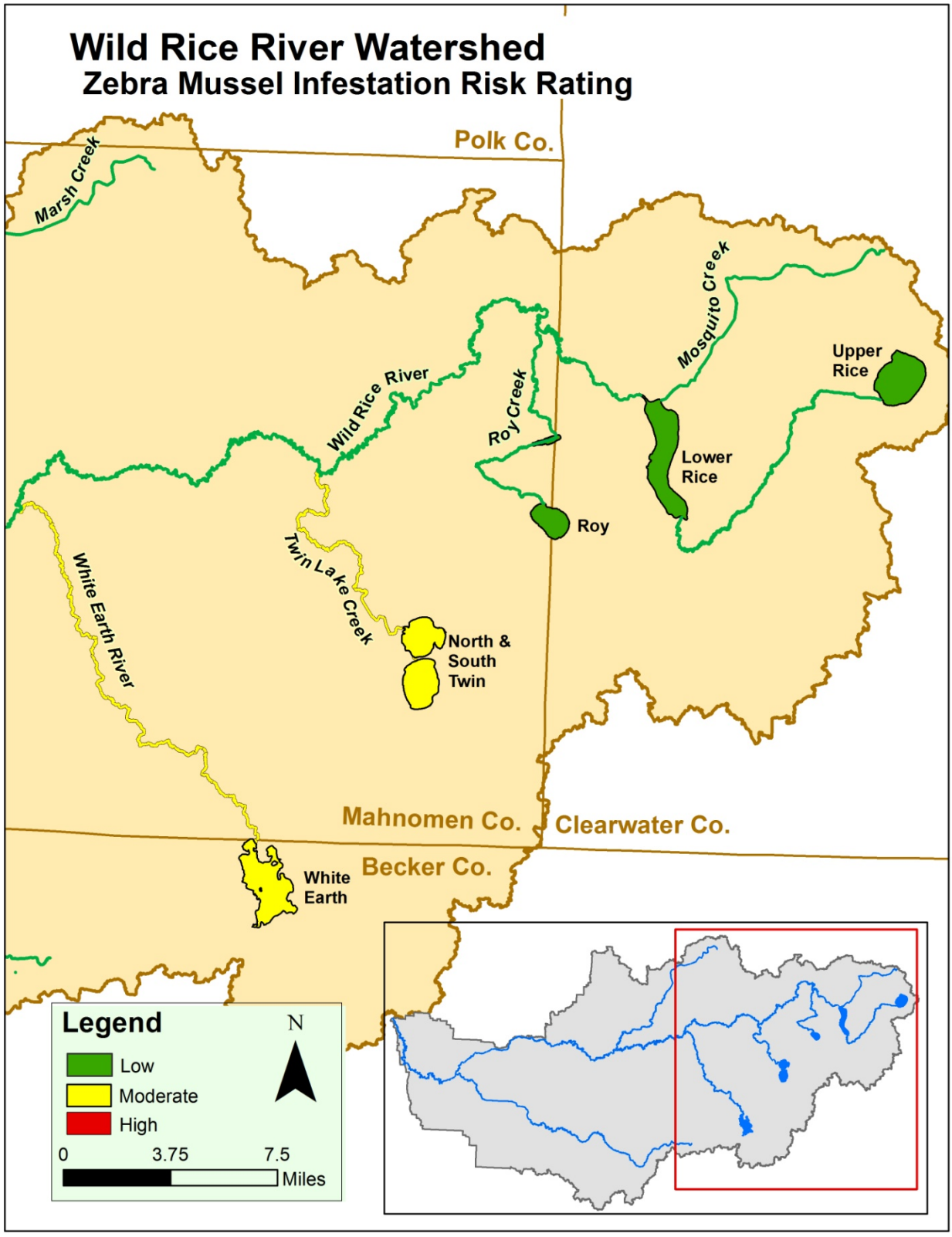


Figure 12. Zebra mussel infestation risk rating, eastern half of Wild Rice River Watershed.

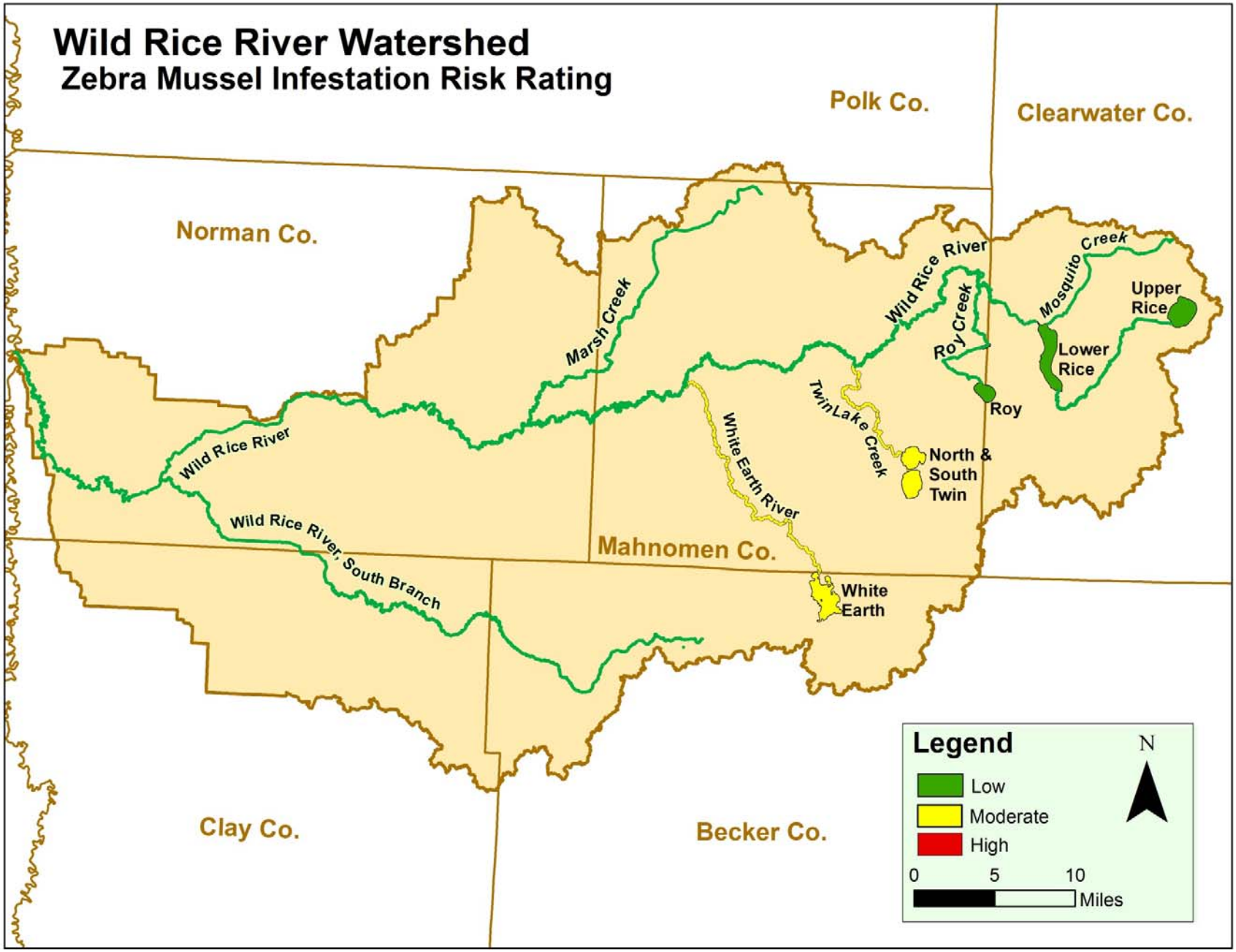


Figure 13. Zebra mussel infestation risk rating for the Wild Rice River Watershed lakes and rivers.

Data Gaps

This study identified some data gaps in the Wild Rice River Watershed. Calcium is the most important water chemistry parameter when evaluating Zebra mussel habitat suitability. Many lakes did not have any historical calcium data. Since they are hardwater lakes, it can be presumed that their calcium is high enough for Zebra mussel survival, but it is better to have the actual data numbers for evaluation. The data gaps are indicated on the lake report cards. See the table below for a summary of parameters needed for each water body (Table 14).

Table 14. Summary of data gaps for water bodies in the Wild Rice River Watershed.

Waterbody Name	**Lake DOW**	**Parameters Needed**
White Earth	03-0328-00	Calcium, pH, Alkalinity, Conductivity
North Twin	44-0023-00	Calcium, Alkalinity, Conductivity
South Twin	44-0014-00	None (Tier 1 Sentinel Lake)
Roy	44-0001-00	Calcium
Upper Rice	15-0059-00	Calcium
Lower Rice	15-0130-00	Calcium, pH, Alkalinity, Conductivity, Secchi depth, Chlorophyll a, Total Phosphorus, Temperature, Dissolved Oxygen
Wild Rice River: Headwaters		Flow, Calcium, Hardness
Wild Rice River: Lower Rice Lake to Twin Lake Creek		Flow, Calcium, Hardness
Twin Lake Creek		Flow, Calcium, Hardness, Turbidity
Wild Rice River: Twin Lake Creek to White Earth River		Flow, Calcium, Hardness
White Earth River		Flow, Calcium, Hardness
Wild Rice River: White Earth River to Marsh Creek		None
Marsh Creek		Flow, Calcium, Hardness
Wild Rice River: Marsh Creek to South Branch		Flow
South Branch Wild Rice River		Flow, Calcium, Hardness
Wild Rice River: South Branch to Red River		None

Vectors of Spread – Infestation Routes

In order to have a watershed strategy for AIS program management, the vectors of spread for each lake needs to be determined. This risk assessment process also identifies the vectors of spread for the lakes in the watershed. For headwaters lakes there is no risk of infestation from upstream, so any new infestation would come from lake users (boats, boat lifts, docks, etc). For lakes in a river chain, both lake users and upstream lakes need to be considered as potential vectors of spread.

Zebra mussels can be transferred from infested waters through several different pathways. Below are the pathways prioritized as to highest risk. These pathways are highly dependent upon the time of year and the stage in the Zebra mussel life cycle. The risk pathway ratings for time of year is shown in Table 13.

1. Connectivity via a river or stream.
   An upstream infested lake is a sure bet for infesting downstream lakes if the stream distance between lakes is short enough.

2. Transfer of equipment from lake to lake.
   The transfer of a large breeding adult Zebra mussel population from one lake to another on an infested boat lift, dock, swim raft or other water-related equipment has a very high probability of infesting a lake.

3. Transfer of mussels hitchhiking on vegetation or mud on boat and trailers.
   The risk of hitchhiking mussels depends somewhat on the time of year. When vegetation dies off in the fall, the Zebra mussels fall off into the sediments. Therefore, Zebra mussels are only attached to plants from approximately June to September. Zebra mussels can't be transferred alone in mud because they do not thrive in soft substrates; they need to be attached to a hard surface.

4. Transfer of veligers or mussels from live wells, bilges, and any area of the boat that holds water.
   The risk of veliger transfer depends greatly on the time of year. In infested lakes in northwest Minnesota, it has been documented that Zebra mussel veligers are at peak concentrations in early July (Rufer 2015). *Therefore, July is the month of the year where veliger transfer from lake to lake has the highest risk for infestation. Research has shown that veligers are non-existent during the ice-covered season, so there is no risk of veliger transfer in the winter* (Rufer 2014).

5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.
   The risk of mussel transfer on boats is highest in July through September, because that is when the mussels are reproducing and settling on new hard surfaces.

6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.
   The risk of veliger transfer on gear depends somewhat on the time of year. July and August would be the times of highest risk throughout the year. Overall, this pathway is considered to be very low risk potential because the amount of water transferred is so small.

Risk – Time of Year

The risk of Zebra mussel infestation varies by the time of year. Data sources show that in Minnesota, the time of year that has the highest concentration of Zebra mussel veligers matches up with the highest use time for the public (Pesch & Bussiere 2014, Rufer 2015). The implications of these data indicate that additional prevention measures should be implemented during July to prevent Zebra mussel spread.

In Pesch and Busierre's (2014) survey of 2nd Homeowners in Central and West Central Minnesota, the highest use time of year was July, at an average of 16 days during that month (Figure 14, Pesch & Bussiere 2014). Rufer's monitoring of Zebra mussel veligers in Pelican Lake, a Zebra mussel infested lake in Otter Tail County, shows the peak density for Zebra mussels is in July (Figure 15, Rufer 2015).

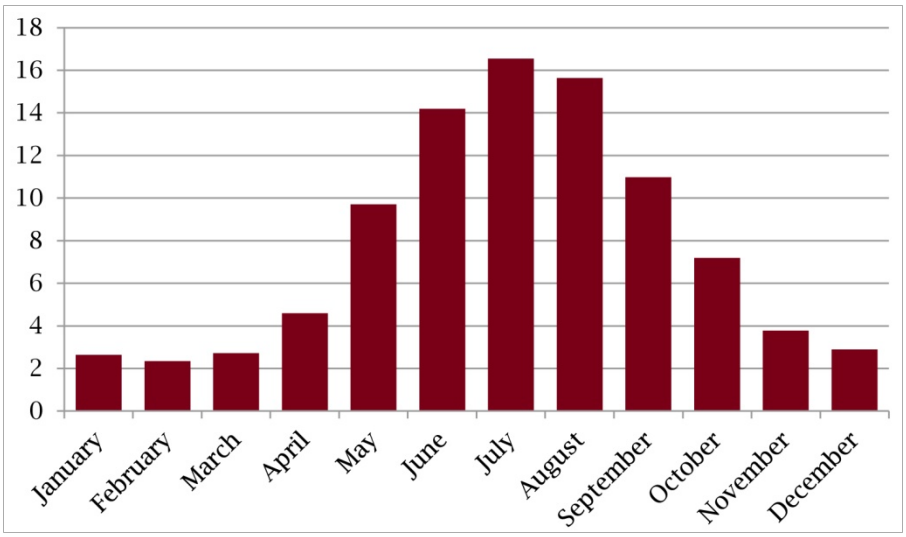


Figure 14. Average number of days occupied per month (n=552) from Pesch & Bussiere 2014.

The full report can be downloaded from this link:
http://www.extension.umn.edu/community/research/reports/docs/2014-2nd-Homeowners.pdf

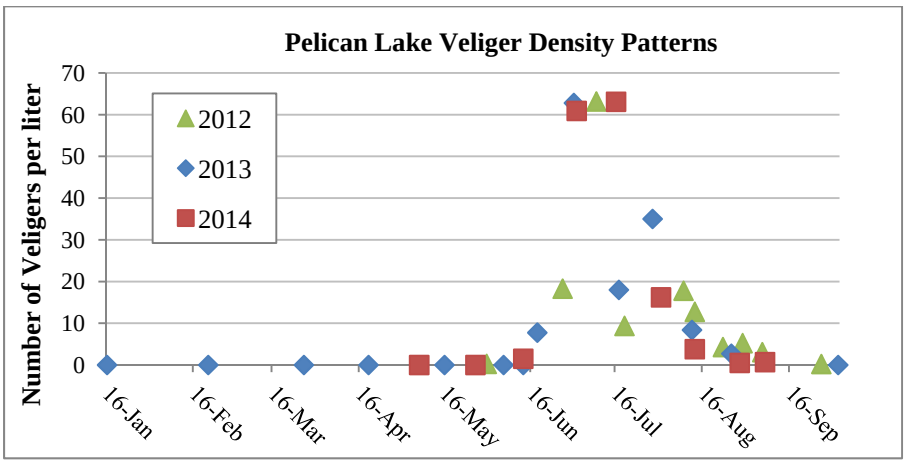


Figure 15. Veliger densities in Pelican Lake, 2012-2014 from Rufer 2015.

The full report can be downloaded from this link:
http://pgolid.org/wp-content/uploads/2014/01/PGOLID-Veliger-Report-2012-2014.pdf

Table 15. Summary of risk pathways depending on the time of year. The Zebra mussel life stage for the pathway is indicated in italics.

	Typical Minnesota Open Water Season							Typical Minnesota Ice-covered season				
Risk Pathway	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**
1. Connectivity via a river or stream.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
2. Transfer of equipment from lake to lake.	insignificant	insignificant	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
3. Transfer of mussels hitchhiking on vegetation or mud on boats, trailers and gear.	Low *Adults & juveniles*	Low *Adults & juveniles*	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Moderate *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant
4. Transfer of veligers via water in boats (live wells, bilges, etc) and float planes.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.	insignificant	insignificant	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Moderate *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant
6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant

AIS Program Management Recommendations

In an ideal world, all Aquatic Invasive Species (AIS) prevention programs would be applied to all lakes. In reality, budgets are always limited, so prioritization of programs due to risk ratings is necessary. Due to the differing risk ratings, programs can be individualized to fit each lake's risk category (Table 14). Lakes with high public use ratings should be at the highest priority for boat inspections at public accesses. Lakes that are already infested should have boat-washing stations nearby for decontamination. All lakes should be targeted with a watershed-wide education program.

The assessments in this report result combine the report cards with the risk of time of year (Figure 15) in the following specific Aquatic Invasive Species Program Management Recommendations (Table 16). This portion of the report can be inserted directly into the county's AIS Plan, and guide the use of the county's AIS funds in the most efficient and effective way possible.

Table. 16. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Watercraft Inspections	Priority 1: • White Earth • South Twin Priority 2: • All	Priority 1: July Priority 2: August	County	TBD	This activity depends on available funding. If limited funding is available, focus inspections on White Earth and South Twin Lakes in July as the best use of funds.
Early Detection Monitoring: *Adult Zebra mussels*	Priority 1: • White Earth • South Twin Priority 2: All	Priority 1: September Priority 2: Every other week from late June to mid-September	Volunteers	$0	a. Place a cinder block in 5-8 feet of water near the public access and any other heavily used areas of the lake, and have the volunteers check the block (pull it up or snorkel) every other week from late June to mid-September. Record results on the MN DNR's website: http://www.dnr.state.mn.us/volunteering/zebramussel_monitoring/report.html. b. In September, conduct a lake-wide inspection of docks and boat lifts as they are removed from the lake.
Early Detection Monitoring: *Zebra mussel veligers*	None, since no lakes rated as a high risk for infestation	July	County, Watershed District, or Lake Associations	$360	Collect plankton tow samples in early and late July for veliger analysis. Early detection allows for possible treatment.

Table 16 continued on the next page

Table. 16 continued. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Monitoring: Invasive Plants	Priority 1: • White Earth • South Twin Priority 2: • All	Mid to late June	County, Watershed District, or Lake Associations	TBD	Conduct plant surveys to look for aquatic invasive plants. Mid to late June will catch Curly-leaf pondweed, Flowering rush, and Eurasian watermilfoil. .
Water Quality Monitoring	See Table 14 for data gaps.	May – September	Lake Associations, watershed	TBD	Monitor lakes for missing parameters shown in Table 14. Priority parameters for each lake would be Calcium, Alkalinity, pH and Specific Conductance as they have the most effect on Zebra mussel suitability.
Education and Outreach	Priority 1: • White Earth • South Twin Priority 2: All	Priority 1: 4th of July week Priority 2: Memorial day to labor day Priority 3: Year round	County and watershed	TBD	Conduct a consistent watershed-wide education program to schools and the general public. In high tourism areas such as resorts, focus *additional* education around 4th of July since that is the highest risk time of the year for spread.
Decontamination	None yet, as none have Zebra mussels yet	Priority 1: July Priority 2: August	County, DNR, or private business	TBD	Provide decontamination opportunities for boats leaving infested lakes. Inform boaters on where the decontamination station is located.
Rapid Response Plan	All	Year round	County or watershed	TBD	Put together a plan of the chain of contacts if a new infestation is found and the steps to determine if treatment is possible. Having a plan in place allows for quick action if there is a new infestation.

Table 16 can be used as a framework for the best way to use available funding, as it shows when the priority time of year is and what the priority lakes are for each activity. For example, if funding is limited for watercraft inspections at public accesses, the funding should first be used to cover White Earth and South Twin lakes in July.

For early detection monitoring, ideally all lakes would be monitored for adult Zebra mussels because if trained volunteers are used there is no monetary cost, but there is a large benefit.

For education, because the highest risk time of the summer and one of the highest tourism times of the summer intersect on 4th of July week, focus *additional* targeted education and outreach during this time of year at resorts.

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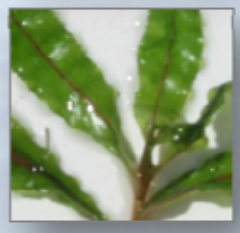
Otter Tail River Watershed

AIS Prioritization

A planning tool developed for AIS risk management and prevention

2014



ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

RED RIVER BASIN

Report Date:	February 25, 2015
Funded by:	Environment and Natural Resources Trust Fund (ENRTF) Red River Basin Commission Becker County Clay County Otter Tail County Wilkin County Pelican River Watershed District Buffalo Red River Watershed District Wild Rice River Watershed District
Project Partners:	Red River Basin Commission Becker County Clay County Otter Tail County Wilkin County Pelican River Watershed District Buffalo Red River Watershed District Wild Rice River Watershed District
Assessment Development:	Moriya Rufer, RMB Environmental Laboratories, Inc
Authors:	Moriya Rufer, RMB Environmental Laboratories, Inc Joe Courneya, Red River Basin Commission Emelia Hauck, RMB Environmental Laboratories, Inc Spencer McGrew, Red River Basin Commission Robert Borash, RMB Environmental Laboratories, Inc
Data Sources:	Minnesota Department of Natural Resources Minnesota Pollution Control Agency Pelican River Watershed District International Water Institute Pelican Group of Lakes Improvement District Lake Associations

Project Contacts:

Joe Courneya
Red River Basin Commission
1120 28th Ave N., Suite C.
Fargo, ND 58102
218-790-0706
joe@redriverbasincommission.org
http://www.redriverbasincommission.org

Spencer McGrew
Red River Basin Commission
1120 28th Ave N., Suite C.
Fargo, ND 58102
701-356-3183
spencer@redriverbasincommission.org
http://www.redriverbasincommission.org

Moriya Rufer
RMB Environmental Laboratories
22796 County Highway 6
Detroit Lakes, MN 56501
218-846-1465
moriyar@rmbel.info
http://rmbel.info

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Introduction

Background

Aquatic Invasive Species (AIS) are aquatic plants and animals that are not native to Minnesota, and cause environmental changes to our waters, have negative economic consequences to our communities, or are harmful to human health. Minnesota's natural resources are threatened by a number of Aquatic Invasive Species such as Zebra mussels, Flowering rush, Eurasian watermilfoil and Asian carp. Invasive species are usually spread by humans.

Zebra mussels are particularly harmful because they spread so rapidly and there are currently no effective treatment options. They attach to hard surfaces such as boats, docks, boat lifts, aquatic plants, and water intake pipes, and can clog pipes, cut feet, and damage boats. Zebra mussels have a large economic impact to water treatment facilities, lakeshore owners, lake recreators, and the tourism industry.

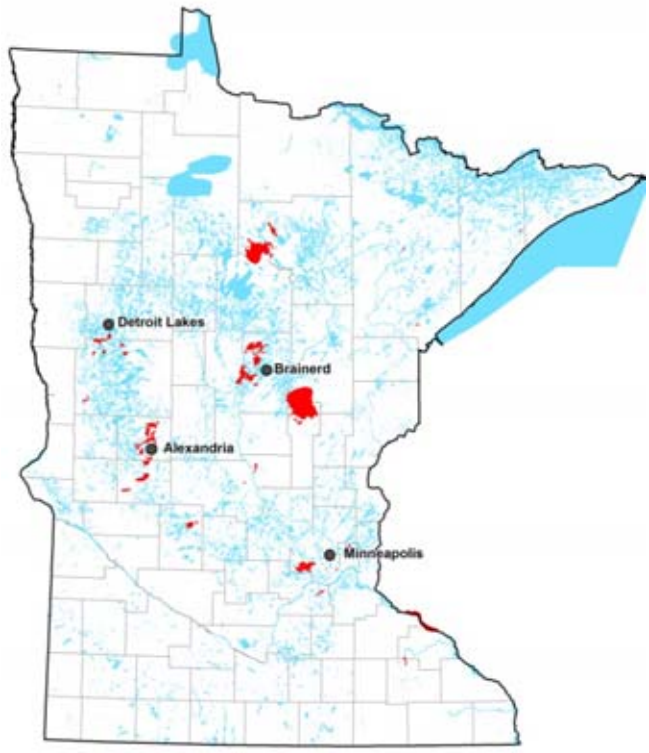


Figure 1. Minnesota Lakes infested by Zebra mussels, 2014.

Zebra mussels also affect the aquatic ecosystem by filtering out microscopic plankton from the water, and therefore removing the food source for other aquatic organisms. This has implications up the food chain, such as affecting fish populations.

As of 2015, approximately 60 lakes in Minnesota are infested with Zebra mussels (MNDNR 2014) (Figure 1). The infestations are clustered around areas with high traffic lakes such as Brainerd, Alexandria, Detroit Lakes and Minneapolis. This pattern of spread is consistent with what has been seen in Michigan, another state with Zebra mussel infested lakes (Johnson *et al.* 2006).

In order to slow or stop the spread of Zebra mussels in Minnesota, a concentrated effort is required. Ideally, unlimited resources would be available to protect all lakes, but in reality budgets are always limited. Therefore, prioritizing lakes due to their risk of infestation is helpful in creating and implementing an AIS management plan.

Project Goals

The goals of this project were to assess the risk of Zebra mussel infestation in the Otter Tail River Watershed in order to prioritize funding and efforts to prevent the further spread of Zebra mussels. Vectors of spread were evaluated for each lake such as connectivity to other water bodies and public use. In addition, the suitability of each water body to Zebra mussel establishment was evaluated considering water chemistry, substrate, dissolved oxygen and temperature. A report card was developed for each water body showing the available data and assigned risk category.

These risk ratings can be used in AIS management plans to prioritize lakes for specific prevention measures. A summary table using the assessments to form management recommendations is provided (Table 16). This table can used to guide the most efficient use of AIS funds in the most effective way possible.

Setting

Watersheds

A basin is the area of land drained by a river or lake and its tributaries. Minnesota has 4 divides. All water in Minnesota eventually flows into 1 of 4 rivers. The divides are made of 8 major drainage basins (Figure 2). Each drainage basin is made up of smaller units called watersheds, which correspond to the drainage of a tributary or lake system. Watersheds are categorized as major or minor. A minor watershed is the smallest category of watershed. A group of minor watersheds that eventually flows into a common stream, such as the Otter Tail, forms a major watershed. A group of major watersheds that flow into a common river, such as the Red River, form a basin. A group of basins that flow into a common river form a divide.

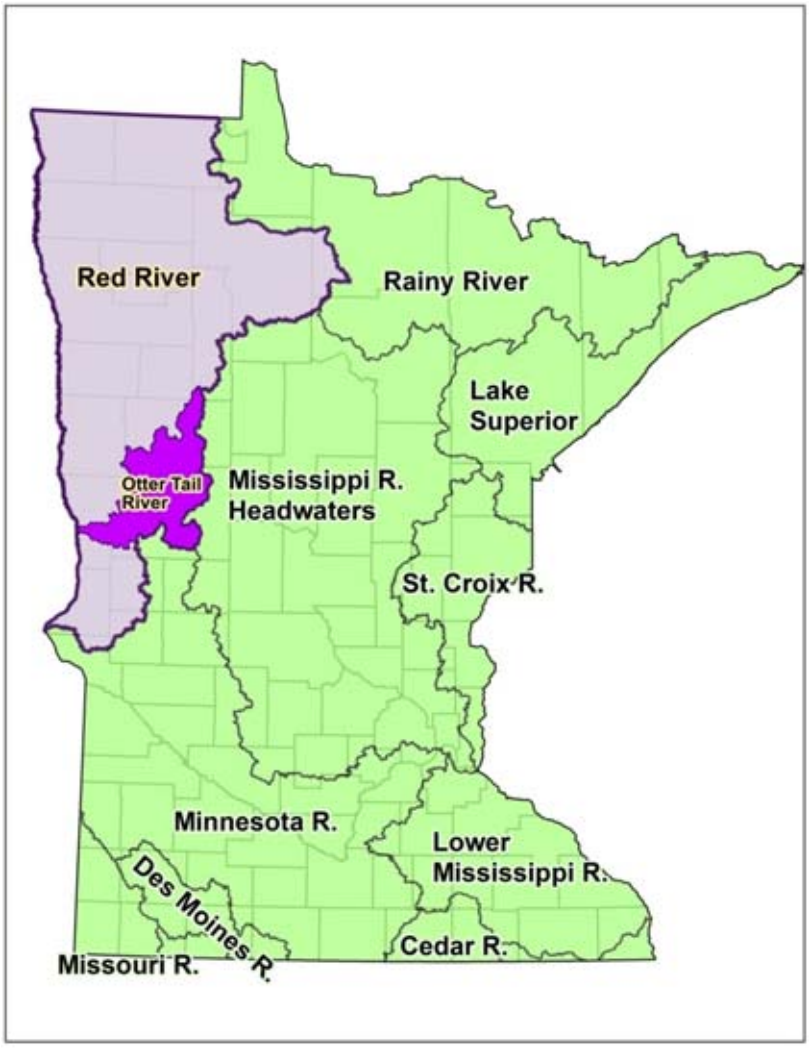


Figure 2. Minnesota showing all major drainage basins, the Red River Basin, and the Otter Tail River Watershed.

The Red River of the North Basin stretches from northeastern South Dakota and west-central Minnesota northward through eastern North Dakota and northwestern Minnesota into southern Manitoba. It ends where the Red River empties into the southern end of Lake Winnipeg.

The Minnesota portion of the Red River Basin covers about 37,100 square miles in northwestern Minnesota in all or part of 21 counties. It is home to about 17,842 miles of streams and 668,098 acres of lakes.

The terrain of the Red River Basin in Minnesota is very diverse; from the flat, intensively farmed plain just east of the length of the Red River, to the rolling uplands full of trees and lakes in the east-central portion of the basin, to the extensive wetlands in the northeast.

Otter Tail River Watershed

The Otter Tail River Major Watershed represents an area of about 1,920 square miles, including areas of substantial portions of Otter Tail, Becker and Wilkin counties, and very small portions of Clay and Clearwater counties (Figure 3).

The Otter Tail River Watershed is a drainage basin of the Red River and the major tributaries of the watershed are the Ottertail and Pelican Rivers. Where the Otter Tail River joins the Bois de Sioux River is considered to be the headwaters of the Red River. The majority of the lakes in the Red River Basin are found in the Otter Tail River Watershed.

Figure 3. Otter Tail River Watershed with lakes and streams assessed in this report shown in blue.

There are no watershed districts in the Otter Tail River Watershed; however, the Tamarac National Wildlife Refuge encompasses the headwaters of the watershed and there are numerous Lake Improvement Districts. Lake Improvement Districts have taxing authority on the lakeshore properties, and therefore have an income source to use to combat invasive species. The Lake Improvement Districts in the Otter Tail River Watershed include the Pelican Group of Lakes Improvement District, the Pine Lakes Improvement District, the Little McDonald, Kerbs & Paul Lakes Improvement District, the Big McDonald Lake Improvement District, the Devils Lake Improvement District, and the South Turtle Lake Improvement District.

Pelican River Watershed

The Pelican River Watershed is a subwatershed of the Otter Tail River Major Watershed (Figure 4). Its headwaters start north of Floyd Lake in Campbell Creek. From there it flows south through Floyd Lake, through the City of Detroit Lakes to Detroit, Sallie, Melissa, Pelican, Lizzie and Prairie Lakes. From Prairie Lake it flows south and joins the Otter Tail River near Fergus Falls.

There are two taxing entities in the Pelican River Watershed that have jurisdiction over the area. The Pelican River Watershed District encompasses the northern portion of the watershed through Lake Melissa. Pelican Lake has a Lake Improvement District, which encompasses Pelican, Bass, Fish and Little Pelican Lakes and includes all lakeshore properties.

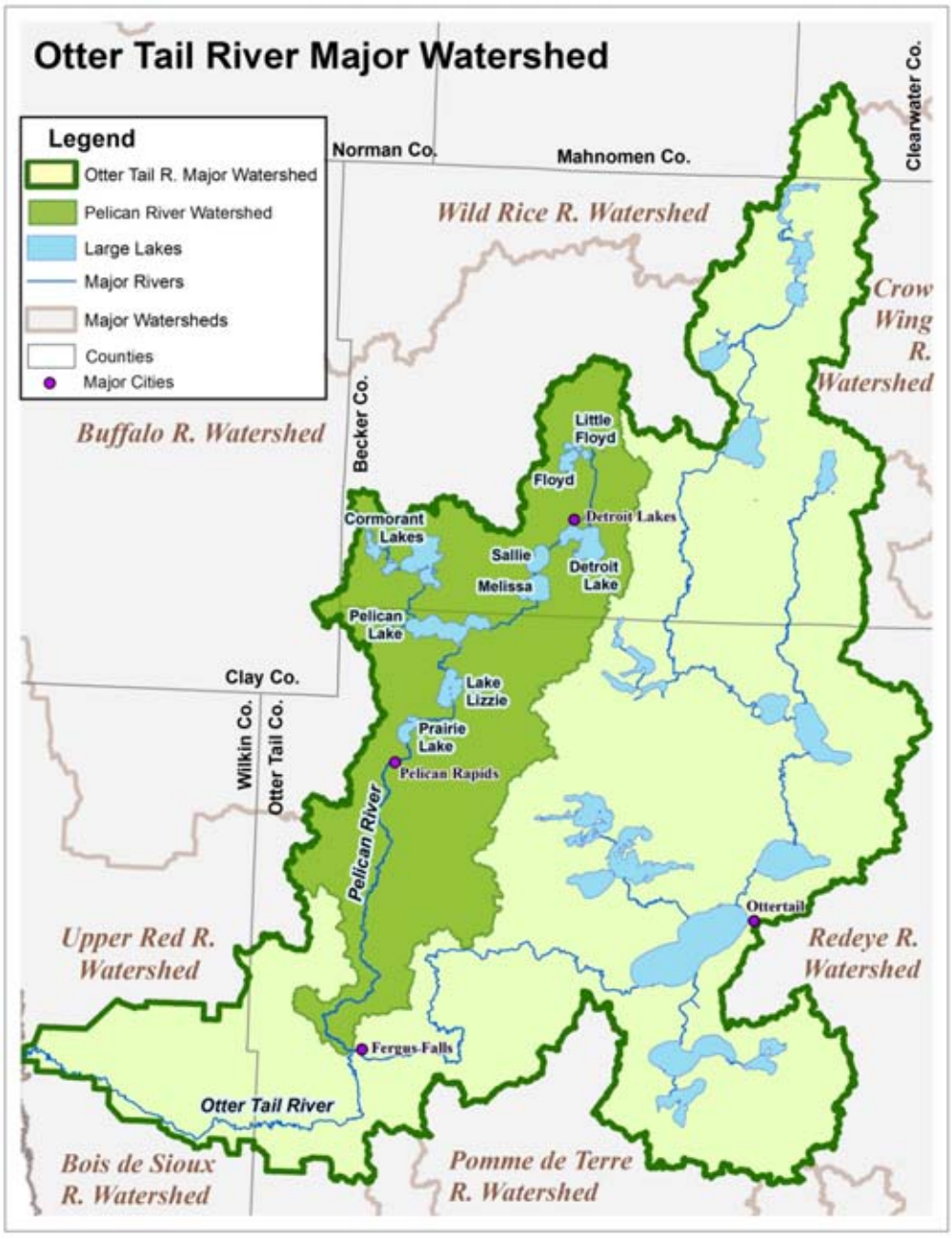


Figure 4. Otter Tail River Watershed and Pelican River Subwatershed with its lakes and rivers.

History of AIS in the Otter Tail River Watershed

Plants

Curly-leaf pondweed

Curly-leaf pondweed is a common invasive plant in the Otter Tail River Watershed (Figures 7-8). It is unknown when it was first established; however, it was most likely introduced to the state by accident in the early 1900s when common carp were intentionally brought to Minnesota. Curly-leaf pondweed has been in Minnesota so long that many people do not realize that it is a non-native species (DNR).

As of 2013, Curly-leaf has been found in Detroit, Sallie, Melissa, Upper Cormorant, Middle Cormorant Pelican, Toad and Big Pine Lakes (Figure 8). It is possible that it exists in other lakes as well and is just not documented.

Flowering Rush

Flowering Rush, an invasive emergent plant, was first identified in Deadshot Bay in the mid-1970's and spread into the Big Detroit Lake by the end of that decade (Figures 5-6). It is thought that it was purchased from a nursery and planted in Deadshot Bay intentionally due to its showy pink flowers. By the early 1980's it was found in many places around Big and Little Detroit; and moved down the Pelican River to Muskrat, Sallie and Melissa.

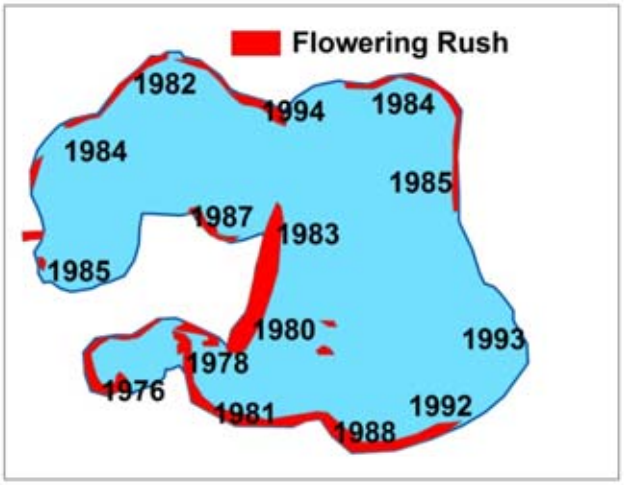


Figure 5. Map of Detroit Lake showing the spread of Flowering rush (prwd.org).

Flowering rush was mechanically harvested from 1967 to the mid 2000s in an effort to keep it under control. In the 2000s the Pelican River Watershed District (PRWD) began chemical herbicide treatment. Initial herbicide treatments were not deemed successful, so in 2010 PRWD adopted a ten-year plan to research effective ways to control Flowering rush. This research has proved successful, and the herbicide *Diquot* has significantly reduced Flowering rush in Detroit, Sallie and Melissa Lakes in the past couple years.

Figure 6. A Flowering rush plant showing its pink flower and emergent reed-like vegetation.

Figure 7. Curly-leaf pondweed turion (wintering bud) (left), and young Curly-leaf pondweed plant beginning to curl (right).

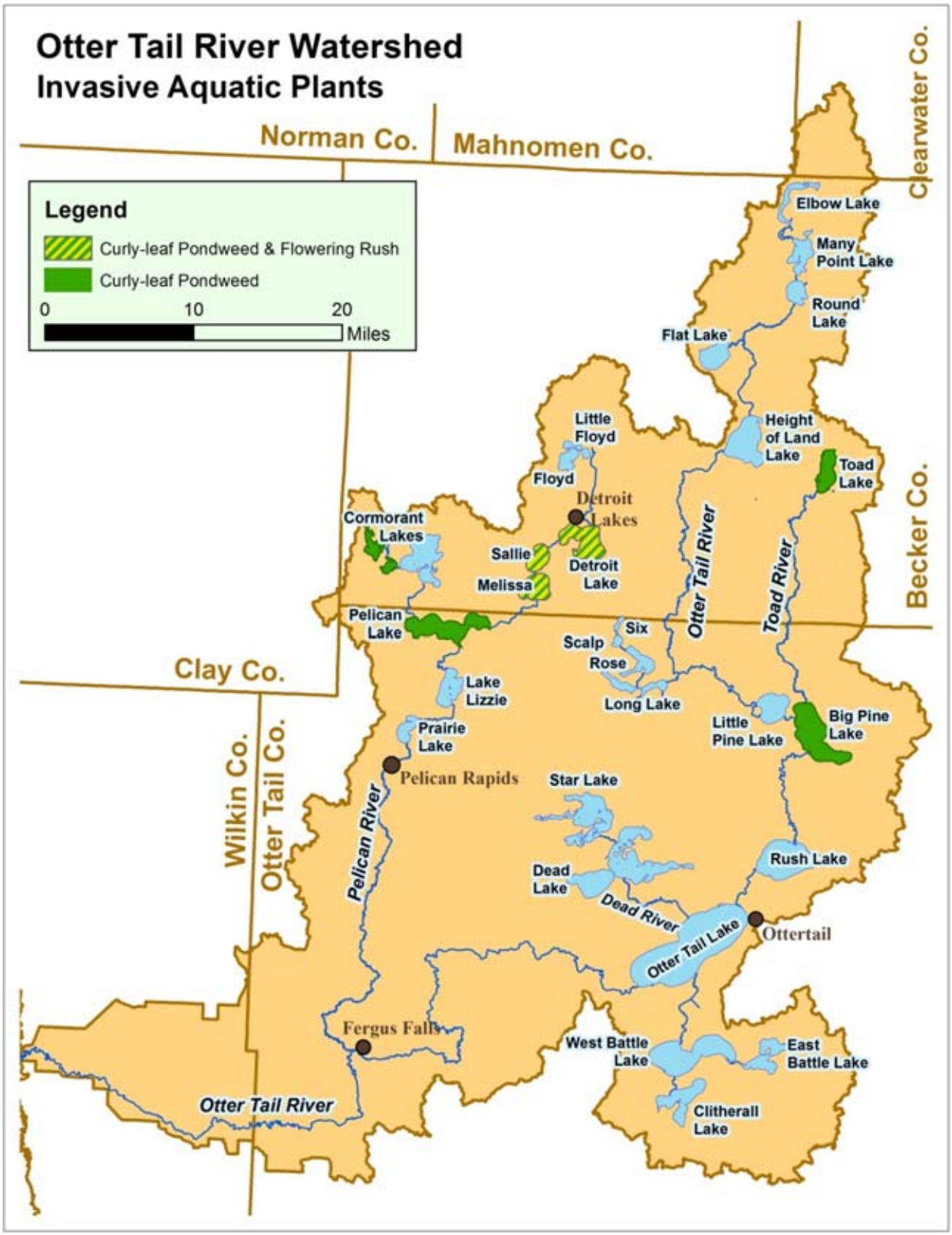


Figure 8. Aquatic plant infestations in the Otter Tail River Watershed.

Zebra mussels

Pelican River Watershed

Zebra mussels were first discovered in the Pelican River Watershed in Pelican Lake. A property owner found them in September of 2009 and the MNDNR confirmed their establishment after a survey that same day. In that survey, larger Zebra mussels were found (1/2-3/4 inches long), which could mean that the mussels had already been there for a year.

After confirmation in Pelican Lake, the MNDNR looked for Zebra mussels in Lake Lizzie, the next lake downstream. They found a few Zebra mussels attached to boat lifts at this time. From this information, it is probable that the Zebra mussels in Lake Lizzie came down the Pelican River from Pelican Lake; however, it also could have been an independent infestation.

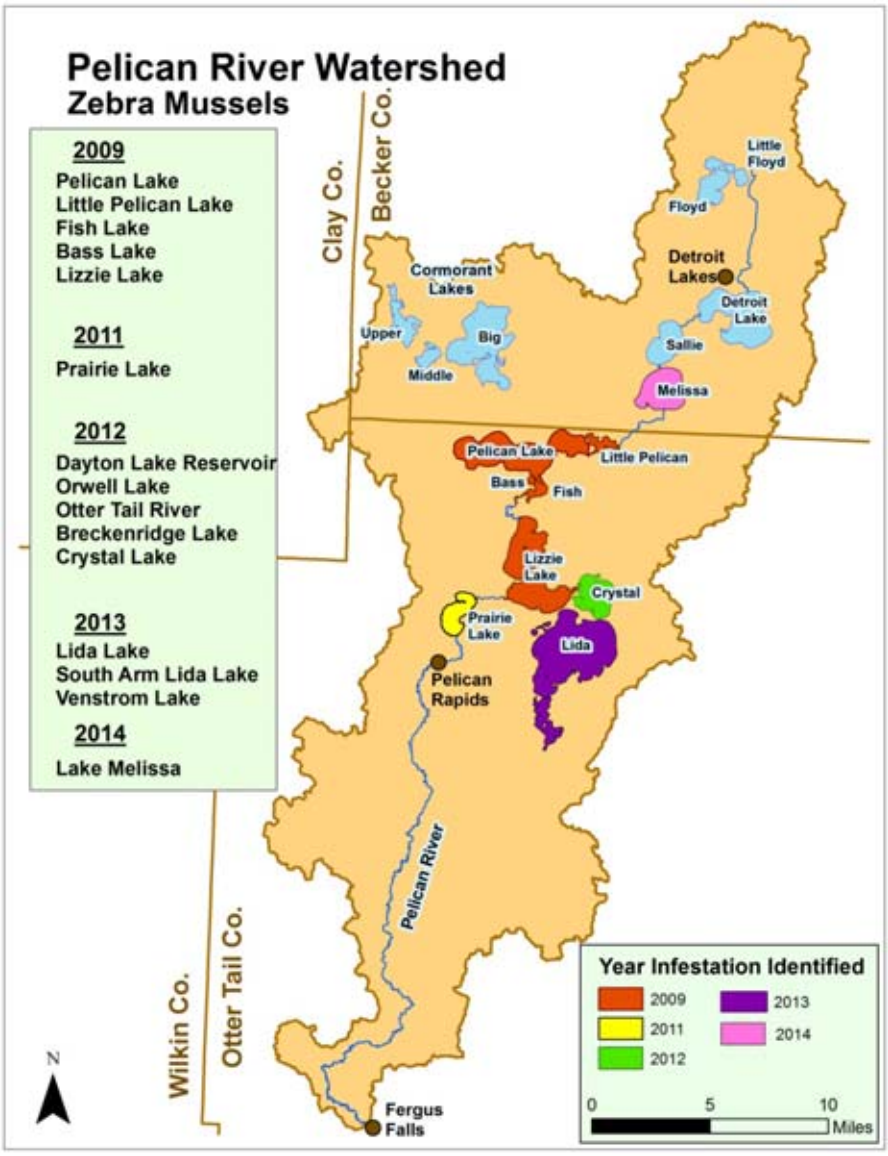


Figure 9. Zebra mussel infestation history in the Pelican River Watershed.

In 2011, Zebra mussels were found in Prairie Lake. Again, it is probable that these mussels came downstream from Lake Lizzie. Therefore, it took approximately two years for the zebra mussels to become fully established in Lake Lizzie and move down the river to Prairie Lake (Figure 9).

In 2012, Zebra mussels were found in the Otter Tail River after it's confluence with the Pelican River. From Orwell Reservoir, they have spread into Wilkin County (Figures 11-12). In 2013, they were found in Lake Lida (Figure 9).

As of 2013, Zebra mussels had only been found downstream from Pelican Lake. This means that for five years after the Pelican Lake infestation, they had only likely spread downstream in the Pelican River by flow. As of 2014, this changed and zebra mussels were found in Lake Melissa, which is upstream of Pelican Lake. This upstream spread could be due to lake users such as boaters or property owners purchasing infested equipment such as docks and boat lifts (Figure 9).

Rose Lake

Zebra mussels were found in Rose Lake in September of 2011, and were traced to a single infested boat lift as a source (Figure 11). In October 2011 the infested area was treated with copper sulfate to attempt eradication since they were only found in a small area. Zebra mussel adults (3) were found in the treated area during a survey in 2012. No survey was conducted in 2013. A snorkel survey in 2014 found no adult zebra mussels. Additional monitoring is planned for summer of 2015 to determine if Zebra mussels are established in Rose Lake. For planning purposes, it is imperative to determine if Rose Lake is infested with Zebra mussels because it has major implications for the rest of the Otter Tail River Watershed. Zebra mussels could potentially spread from Rose Lake downstream to Otter Tail Lake.

Little McDonald, Kerbs, Paul and Rusche Lakes

In 2012, Little McDonald, Kerbs, Paul and Rusche Lakes tested positive for Zebra mussel veligers and was listed as infested (Figure 11). Tests in 2013 and 2014 were negative for Zebra mussel veligers. Future monitoring will be beneficial in determining if these lakes are truly infested or not. As of 2015, there is no natural outlet to this group of lakes, so there is likely no downstream spread risk.

Pickerel Lake

In 2014, one adult Zebra mussel was found in Pickerel Lake and the lake was listed as infested (Figure 11). No other Zebra mussels were found in 2014, so future monitoring should determine if there is a thriving adult population in the lake.

Figure 10. Adult Zebra mussels on a sampling plate on Pelican Lake, 2013.

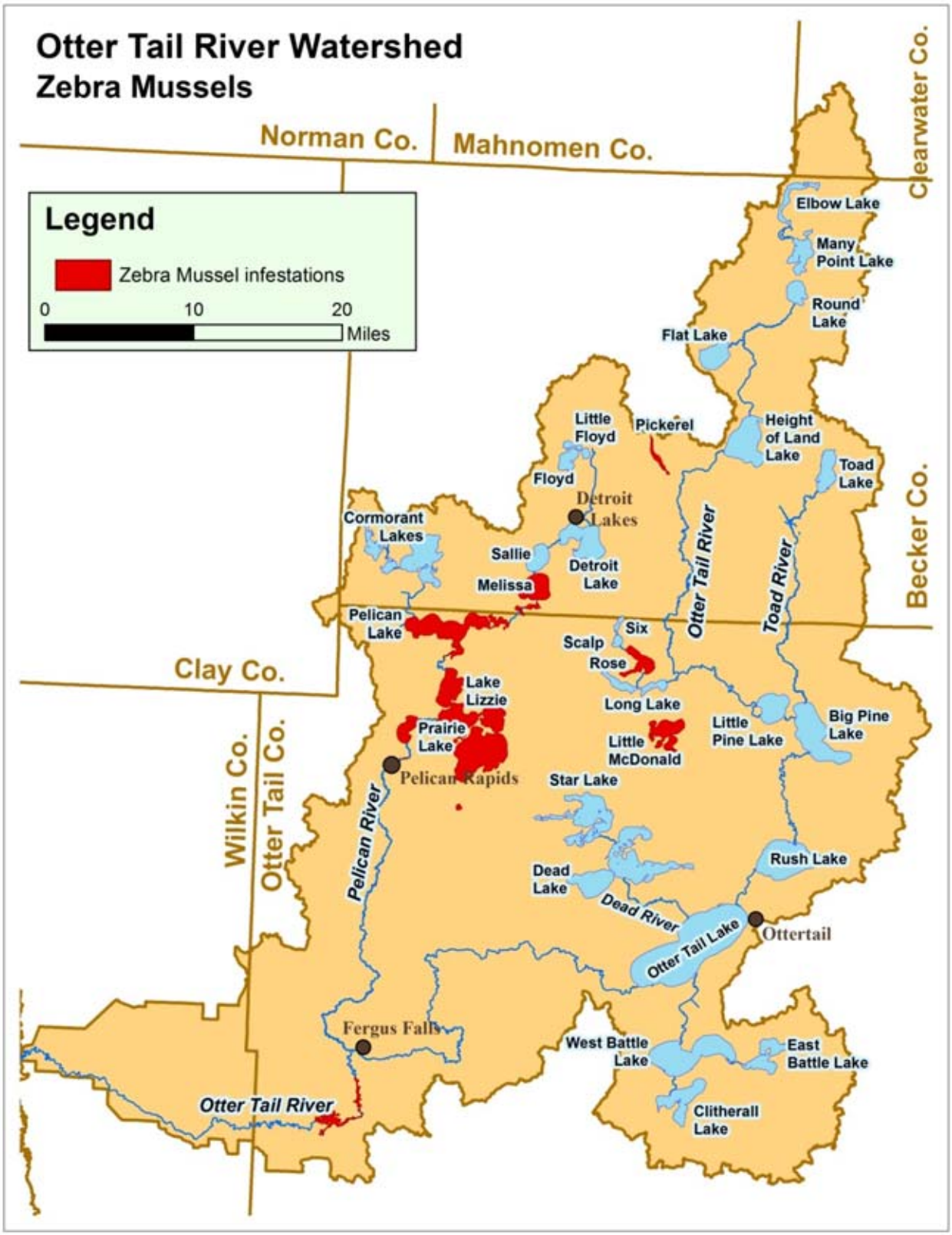


Figure 11. The spread of Zebra mussels in the Pelican River Watershed from 2009-2013.

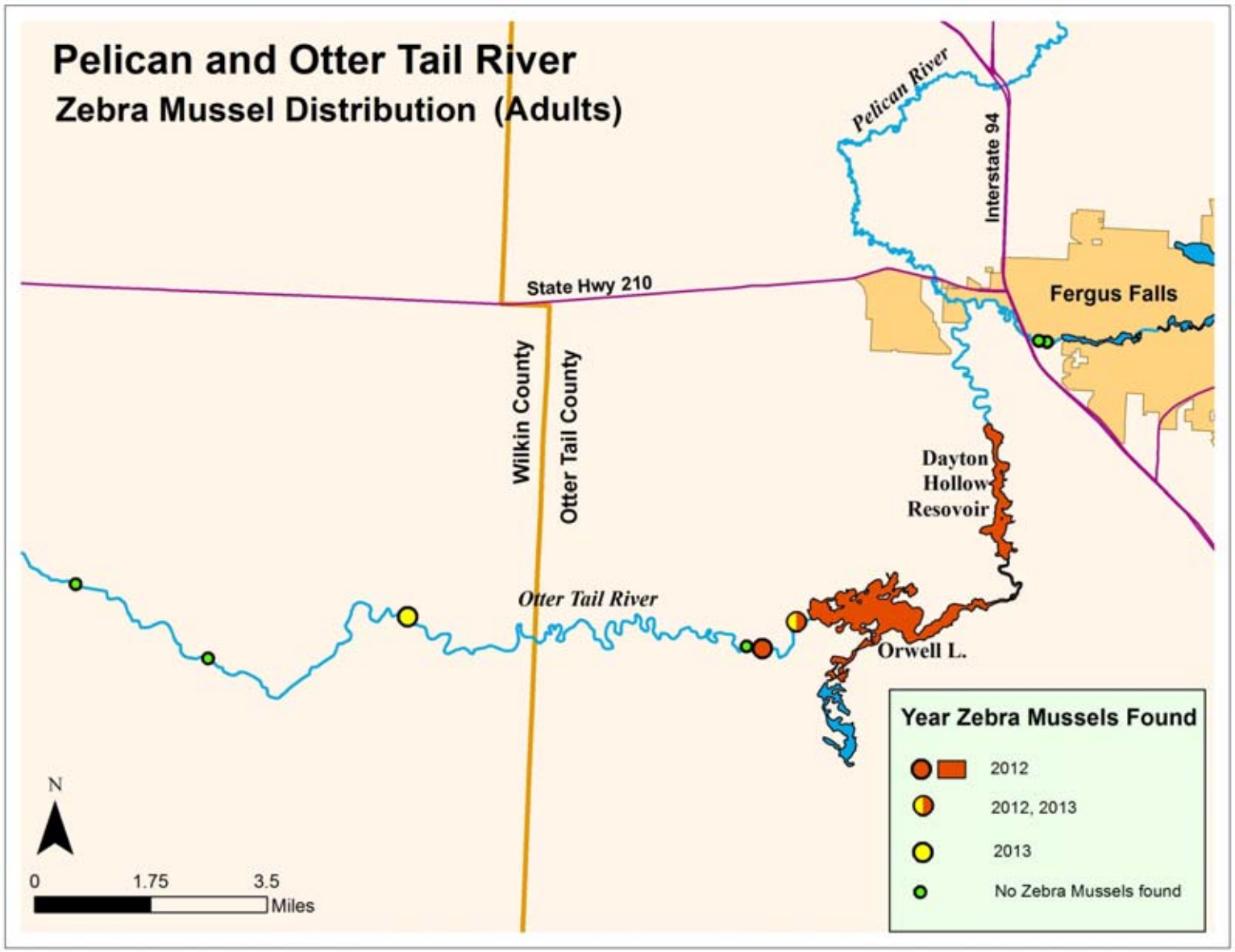


Figure 12. The spread of zebra mussel adults in the Otter Tail River.

Zebra Mussel Risk Assessment

Lake Methods

All the major lakes in the Otter Tail River Watershed have water chemistry, temperature, and dissolved oxygen data available (Table 1). These data were collected by the Pelican River Watershed District, Lake Associations, Otter Tail COLA, Tamarac National Wildlife Refuge, the Minnesota Pollution Control Agency, the Department of Natural Resources and the Pelican Group of Lakes Improvement District, and were used in the Zebra mussel risk assessment for lakes.

Table 1. Major lakes in the Pelican River Watershed.

Lake Name	**Lake ID**
Upper Cormorant	03-0588-00
Middle Cormorant	03-0602-00
Big Cormorant	03-0576-00
Big Floyd	03-0387-02
Little Floyd	03-0386-00
Detroit	03-0381-00
Sallie	03-0359-00
Melissa	03-0475-00
Little Pelican	56-0761-00
Pelican	56-0786-00
Lizzie	56-0760-00
Prairie	56-0915-00
Elbow	03-0159-00
Many Point	03-0158-00
Round	03-0155-00
Flat	03-0242-00
Height of Land	03-0195-00
Toad	03-0107-00
Six	56-0369-00
Scalp	56-0358-00
Rose	56-0360-00
Long	56-0388-02
Little Pine	56-0142-00
Big Pine	56-0130-00
Rush	56-0141-00
Star	56-0385-00
Dead	56-0383-00
Otter Tail	56-0242-00
West Battle	56-0239-00
East Battle	56-0138-00
Clitherall	56-0238-00

Water Connectivity

One of the highest risks to a water body becoming infested with Zebra mussels is if a nearby upstream lake is infested (Horvath 1996). Infested lakes can serve as a source of Zebra mussel veligers for downstream water bodies and adjacent lakes; however the inter-lake distance must be fairly close for the spread to be possible. Various studies have suggested a downstream veliger dispersal of 1-18 km (0.6-11 miles) in small streams (Lucy *et al.* 2005; Horvath *et al.*1996). In this assessment, lakes that have an infested lake already identified less than 20 km (12 mi) upstream are at a high risk of infestation since the

Zebra mussels could spread downstream (Table 2). Lakes that are in a chain have a moderate risk because if any upstream lakes get infested with Zebra mussels (<20 km), they could spread downstream. Headwaters lakes have a very low risk of infestation through water connectivity.

In addition to stream connections, adjacent water bodies have the potential to infest each other via boats going from one lake to another, regardless if the lakes are connected or not.

Table 2. Water connectivity and the related risk of Zebra mussel infestation.

Water Connectivity Category	**Risk of infestation**
Headwaters lake	Low risk
Chain of lakes (<20 km apart)	Moderate risk
Upstream infested lake (<20 km apart)	High risk

Public Use

Boats and water related equipment have been shown to be one of the largest vectors in the spread of Zebra mussels (Johnson *et al.* 2001). Public use can be measured by some surrogate statistics. First, the number of public accesses and related parking spots are known on each lake. The more public accesses on the lake, the more potential boats can use the lake. Secondly, the number of resorts and hotels on the lake are documented through the Detroit Lakes and Fergus Falls Area Chambers of Commerce. The hotels and resorts on the lake attract local and regional visitors, increasing the risk of infestation. Thirdly, the number of fishing tournaments and special events on lakes is documented through a permitting process. Fishing tournaments and special events draw visitors to the lakes. And finally, the homeowners on the lake own an average of one dock/boat lift/boat per property. The purchase of an infested boat lift or other water related equipment has been the source of several documented new infestations in Minnesota. This use relationship coupled with transport of boats and water equipment from lake to lake, increases the probability of infestation. "Destination lakes" for popular fish species like walleyes and muskies along with popular recreation waters for boating and swimming are at increased risk for infestation.

Public access inspections data was reviewed for each lake, but difficulty in standardizing data across lakes challenges the reliability of these data to be used as part of public use data for the final risk assessment.

The numbers used represent boating units per summer. For parcels, an average of one boat per parcel was used in the calculation. For fishing tournaments, the total boats participating in the tournament was used.

For access parking and resort units, the numbers were multiplied by 15 weeks of summer between Memorial Day and Labor Day for an estimated total summer use. This number is likely underestimated, but the ratings still come out the same either way, showing that the calculations are very robust (Tables 3-4). In weighting the resorts and accesses by the 15 weeks of summer, they are weighted appropriately compared to the resident parcels.

Table 3. Public use rating calculations.

Lake	Parcels*	Access Parking*	Resort Units*	Fishing Tournaments*	Total*	Risk
Pelican	999	600	4,065	70	5,734	High
Big Cormorant	643	360	3,930	70	5,003	High
Otter Tail	1,258	1,320	2,040	380	4,998	High
Big Pine	495	750	3,555	50	4,850	High
Detroit	608	240	3,330	40	4,218	High
Rush	430	435	2,445	70	3,380	High
West Battle	707	645	1,500	50	2,902	High
Dead	443	540	1,095	0	2,078	High
Star	443	570	435	0	1,448	Moderate
Melissa	397	300	720	0	1,417	Moderate
Clitherall	384	30	885	0	1,299	Moderate
Toad	183	225	795	0	1,203	Moderate
East Battle	423	120	630	0	1,173	Moderate
Many Point	88	15	990	0	1,093	Moderate
Round	149	75	795	0	1,019	Moderate
Middle Corm	198	270	495	0	963	Moderate
Sallie	236	495	75	0	806	Moderate
Elbow	293	30	285	36	644	Low
Rose	163	300	180	0	643	Low
Height of Land	141	480	0	0	621	Low
Floyd	380	225	0	0	605	Low
Little Pine	309	225	60	0	594	Low
Upper Corm	233	150	150	0	533	Low
Lizzie	337	165	0	0	502	Low
Little Floyd	111	120	180	0	411	Low
Long	236	15	120	0	371	Low
Scalp	117	60	0	0	177	Low
Prairie	138	36	0	0	174	Low
Six	76	75	0	0	151	Low
Little Pelican	120	0	0	0	120	Low
Flat	20	0	0	0	20	Low

**All numbers are the total number of boats for the 15 weeks of summer.*

Table 4. Use ratings and assigned risk for Zebra mussel infestation.

	Low Risk	Moderate Risk	High Risk
Total Boat Units (the sum of public access parking spaces, resort units, lake parcels and special events)	0-700	701-1,999	2,000+

Water Chemistry

Available water quality data was compiled and analyzed for each major lake and stretch of river in the Otter Tail River Watershed. The average was calculated for each available parameter. The values were then compared to the ranges in Table 5 to determine the potential for Zebra mussels to establish and reproduce in the water body. Calcium was considered first, based on its importance in shell formation (Mackie & Schloesser 1996); however calcium data were not available for all water bodies. Next, alkalinity, hardness and pH were considered (Mackie & Claudi 2010; Hincks & Mackie 1997). Lastly, Secchi depth, chlorophyll a and total phosphorus were considered, although they are not sufficient parameters alone to assess risk (Mackie & Claudi 2010).

Total phosphorus and chlorophyll a are useful for determining the lake's trophic state, which does affect suitability for Zebra mussels. Zebra mussels thrive best in mesotrophic lakes (Karatayev *et al.* 1998, Nelepa 1992). Eutrophic lakes have a lower suitability due to too much phosphorus and chlorophyll a, and usually softer substrates.

Table 5. Water column Zebra mussel suitability criteria (Mackie and Claudi 2010).

	Risk		
Parameter	**Low Little Potential for Larval Development**	**Moderate (survivable, but will not flourish)**	**High (favorable for optimal growth)**
Calcium (mg/l)	8-15	15-30	>30
pH	7.0-7.8 or 9.0-9.5	7.8-8.2 or 8.8-9.0	8.2-8.8
Hardness (mg/L)	30-35	55-100	100-280
Alkalinity (mg/L)	30-55	55-100	100-280
Specific Conductance (umhos)	30-60	60-110	>110
Secchi depth (m)	1-2 or 6-8	4-6	2-4
Chlorophyll a (ug/L)	2.0-2.5 or 20-25	8-20	2.5-8
Total Phosphorus	5-10 or 35-50	10-25	25-35

Substrate Suitability

One of the reasons Zebra mussels are such a nuisance is that they attach to hard substrates via their byssal threads. Zebra mussels prefer a hard substrate for attachment although they will attach to plants as well (Karatayev et al. 1998). In lakes, they have been documented to colonize on rocks, docks, boatlifts and water intake pipes. Lakes with mainly soft substrate and not many man-made structures may not be as supportive to Zebra mussel colonization. Plants have just moderate suitability because in Minnesota they die off at the end of each summer, meaning the Zebra mussels that are attached to them must crawl to other substrates or die off during winter (Karatayev et al. 1998). Comments are made for each water body, its dominant substrate, and its likelihood to support Zebra mussels. The substrate types were determined by the MNDNR (Table 6).

Table 6. Substrate descriptions and their suitability to Zebra mussel survival.

Substrate (MNDNR)	**Description**	**Suitability to Zebra mussels**
Muck	Decomposed organic material	Low
Marl	Calcareous material	Low
Silt	Fine material with little grittiness	Low
Sand	Diameter less than 1/8 inch	Low
Submerged macrophytes	Underwater rooted plants	Moderate
Gravel	Diameter 1/8 to 3 inches	High
Rubble	Diameter 3 to 10 inches	High
Boulder	Diameter over 10 inches	High

Temperature

Zebra mussels begin reproduction when water temperature is above 12 C, but ideal reproduction temperature occurs above 17-18 C (McMahon 1996). The upper thermal limit for North American Zebra mussels occurs somewhere around 30 C (McMahon 1996) The optimal temperature range for zebra mussel spawning in North America is estimated to between 18-26 C.

In Minnesota, lakes are usually ice-covered on average from November to March. During the ice-covered season, it is assumed that the water temperature is too cold for Zebra mussel spawning. However, the Zebra mussels do over-winter at the bottom of the lake (Mackie *et al.* 1989).

In summer, Minnesota lakes rarely exceed 30 C (86 F); therefore, it is likely that the Zebra mussels reproduce all summer once the water temperature reaches 17-18 C. This occurrence has been documented in Pelican Lake, where Zebra mussel veligers were first found at 18 C in 2012 and 19 C in 2013 (Rufer 2014).

The maximum temperature was reported for each lake and the risk was assigned based on if the lake exceeded 32 C in mid-summer or not (Table 7). The lake's mixing regime and period of hypolimnetic anoxia were also noted as research has found that few Zebra mussel veligers occur below the thermocline in temperate lakes (Mackie *et al.* 1989).

Table 7. Temperature values and their impact on Zebra mussel survival.

Survival Potential	Temperature Range	Risk Rating
Prevent zebra mussel establishment	> 32 C	Low
Little impact on mussel survival	8 – 31 C	High

Infestation Risk Rating

The two main vectors of spread for Zebra mussels are lake connectivity and public use. The risks from these two categories were combined for an overall risk of infestation rating for each lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 8).

Table 8. Combined infestation risk rating using public use and connectivity.

	Public Use Total Boat Units	Connectivity	Combined Risk Rating
Low Risk	0-700	0 = Headwaters Lake	0-1,000
Moderate Risk	701-2,000	2,500 = Chain of Lakes	1,000-6,000
High Risk	2,000+	5,000 = Infested or Infested lake upstream	6,000+

Zebra mussel Suitability Rating

The two main factors for zebra mussels thriving in a lake are suitable water chemistry and suitable substrate. The risks from these two categories were combined for an overall suitability rating for each lake. This suitability rating can be interpreted as the probability that Zebra mussels will thrive in the lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 9).

Table 9. Combined Zebra mussel suitability rating using water chemistry and substrate.

	Water Quality	Substrate	Combined Risk Rating
Low Risk	0 = The majority of averages in green category.	0 = Sand, Silt, Muck	0 - Low
Moderate Risk	500 = The majority of averages in yellow category.	500=Submerged macrophytes	1,000 - Moderate
High Risk	1,000 = The majority of averages in red category.	1,000 = Rocks, Gravel, Rubble	2,000 - High

River Methods

Water chemistry data have been collected throughout the Pelican River by the Pelican River Watershed District, the International Water Institute and the Minnesota Pollution Control Agency (Figures 14-17). For this assessment, the watershed was split into nine sections (Table 10, Figure 13).

Table 10. Stream Sections in the Otter Tail River Watershed (Figure 13).

Section	Name
1	Pelican River, Becker County
2	Pelican River, Otter Tail County
3	Otter Tail River Headwaters
4	Otter Tail River, HOL to Pine Lakes
5	Otter Tail River, North Otter Tail Lake
6	Otter Tail River to Fergus Falls
7	Dead River
8	Battle Creek
9	Toad River

Unlike lakes, rivers are not usually ideal habitat for Zebra mussels. Studies have shown that the turbulence in streams and rivers causes high Zebra mussel veliger mortality and assists in preventing the veligers from settling on hard substrates (Horvath & Lamberti 1999). Without an infested lake upstream continually supplying the stream with Zebra mussel veligers, the stream is unlikely to sustain a large population on its own. Although streams can be pathways for downstream infestations, the probability of Zebra mussel veliger survival decreases with distance downstream (Horvath & Lamberti 1999; Horvath *et al.* 1996).

For small streams (like the Pelican River and the headwaters of the Otter Tail River), even the presence of an infested lake upstream supplying veligers will probably not allow the stream to support populations of Zebra mussel adults. Strayer (1991) found that in streams <10 meters wide (33 feet) there were no stable adult Zebra mussel populations. Zebra mussel adults seem to only survive in the largest rivers (>100 m wide) or large pools and stagnant backwaters.

Figure 13. Pelican River stream segments used in this report.

Turbulence & Flow
Studies show that turbulence or shear may be the limiting factor for Zebra mussel survival in streams and rivers (Horvath & Lamberti 1999). Although specific flow rates are not determined, it appears that in streams and rivers, zebra mussels are only self-sustaining behind dams and stagnant backwaters. Therefore, for the purposes of this risk assessment, any stream sites are considered to have low risk due to the flow in the river, even if there is no flow data available.

Downstream Dispersal
Zebra mussel veliger abundance has been shown to decrease with distance in streams. Veligers have been found 10-18 km (6-11 miles) downstream of an infested lake in stream systems (Horvath *et al*.,1996). In heavily vegetated wetland stream systems, the dispersal distance has been found to be about 1 km (0.6 mile), which is much lower. There are a few possible factors affecting Zebra mussel veliger survival in wetlands streams, including aquatic vegetation, low water velocity, unsuitable water characteristics, limited substrate availability, and/or increased predation pressure (Bodamer & Brossenbroek 2008). These results show that protecting aquatic vegetation from removal, limiting stream dredging, and installing wetlands could help as a barrier for spreading Zebra mussels downstream.

The Pelican and Otter Tail Rivers have some submerged vegetation, are usually lined with emergent vegetation, have sandy/rocky substrate and mostly clear water. Taking into account the literature and the condition and habitat of the river, for the purposes of this risk assessment, 32 km (20 mi) is considered the longest a veliger could theoretically travel (Table 11). This distance of 32 km is very conservative, but until further research is conducted a better estimate is not available.

Water Quality
The water chemistry ranges from Mackie and Claudi 2010 (Table 5) can be applied to streams; however, more applicable water quality parameters to streams are turbidity and total suspended solids. Turbidity has been shown to limit Zebra mussel survival. Although acute exposures to high turbidity can negatively affect a Zebra mussel population, they are able to compensate for some high exposure (McMahon 1996). Chronic high turbidity has a greater negative effect on Zebra mussel survival, as it inhibits their filtering ability (McMahon 1996, Karatayev *et al.* 1998). Mackie and Claudi (2010) suggest upper limits for Zebra mussel survival for total suspended solids at 96 mg/L and turbidity at 80 NTU, if the turbidity is caused mainly from sediment suspension. The combination of high temperature and high turbidity seem to be most stressful to Zebra mussels (Alexander 1994). For the purposes of this study, the Mackie and Claudi (2010) numbers are used as guides, but further research is needed to be more decisive conclusions can be made.

Infestation Risk Rating
In the Pelican River Watershed, the lakes are fairly close in proximity to each other, and therefore the distance between lakes is likely short enough to transport veligers to downstream lakes. It is thought that the Zebra mussel infestation in Pelican Lake moved downstream to Lizzie and Prairie Lakes. Because a continual source of Zebra mussel veligers from a lake is needed to sustain a stream population of Zebra mussels, distance from the nearest lake is the limiting factor for an infested stream. In streams, public use is secondary, and a larger threat to downstream lakes than the stream itself (Table 11).

Table 11. Infestation Risk Rating for streams and rivers.

	Risk Rating Low	Moderate	High
Connectivity	No lakes connected	No upstream infested lakes	Upstream infested lakes
Distance from nearest upstream lake*	>32 km (20 mi)	10-32 km (6.2-20 mi)	0-10 km (0-6.2 mi)
Presence of aquatic vegetation/wetland conditions*	Yes	Moderate	No
Public use	Fishing, paddle sports	Fishing, ricing, bait harvest, waterfowl hunting, paddle sports	Motorboating, camping, fishing, bait harvest, waterfowl hunting, paddle sports
Overall rating	>32 km (20 mi) from nearest upstream lake and the presence of aquatic vegetation and wetland conditions	10-32 km (6.2-20 mi) from nearest upstream lake, and some aquatic vegetation and wetland conditions	0-10 km (0-6.2 mi) from nearest upstream lake

**possible limiting parameter for streams*

Suitability Rating

Total suspended solids data were available from the Pelican and Otter Tail Rivers. Results show that it is well below the threshold of 96 mg/L (Figures 14-16). Therefore, the total suspended solids are likely not limiting to Zebra mussels. It appears that flow is the main potential limiting factor to Zebra mussel establishment, so it was given the most weight when considering suitability (Table 12).

Table 12. Suitability Rating for streams and rivers.

	Risk Rating Low	Moderate	High
Habitat suitability/substrate	Muddy water, silty mucky substrate	Clear to cloudy water, gravel and rocks	Clear water, rocky, very low flow
Flow rate*	High flow	Moderate flow	Low flow, dams and stagnant backwaters
Water chemistry*	Average turbidity and/or total suspended solids over the thresholds	Maximum turbidity and/or total suspended solids over the thresholds	Average and maximum turbidity and/or total suspended solids under the thresholds
Maximum temperature	>30 C	--	<30 C
Average dissolved oxygen	<7 mg/L	--	> 7 mg/L
Overall rating	High flow and high turbidity and/or total suspended solids	Moderate flow and low turbidity and/or total suspended solids; rocky substrate	Low flow, dams and backwaters and low turbidity and/or total suspended solids; rocky substrate

**possible limiting parameter for streams*

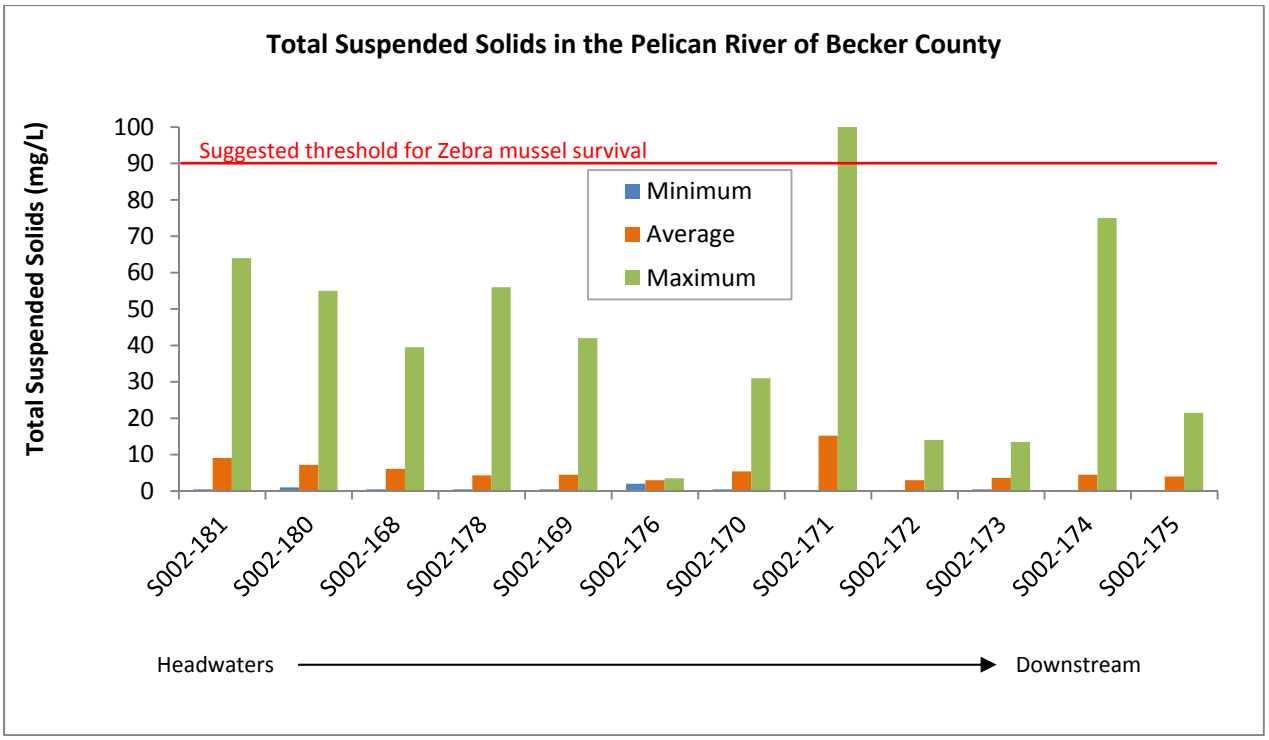


Figure 14. Total suspended solids results in the Pelican River of Becker County. Refer to site locations in Figure 12.

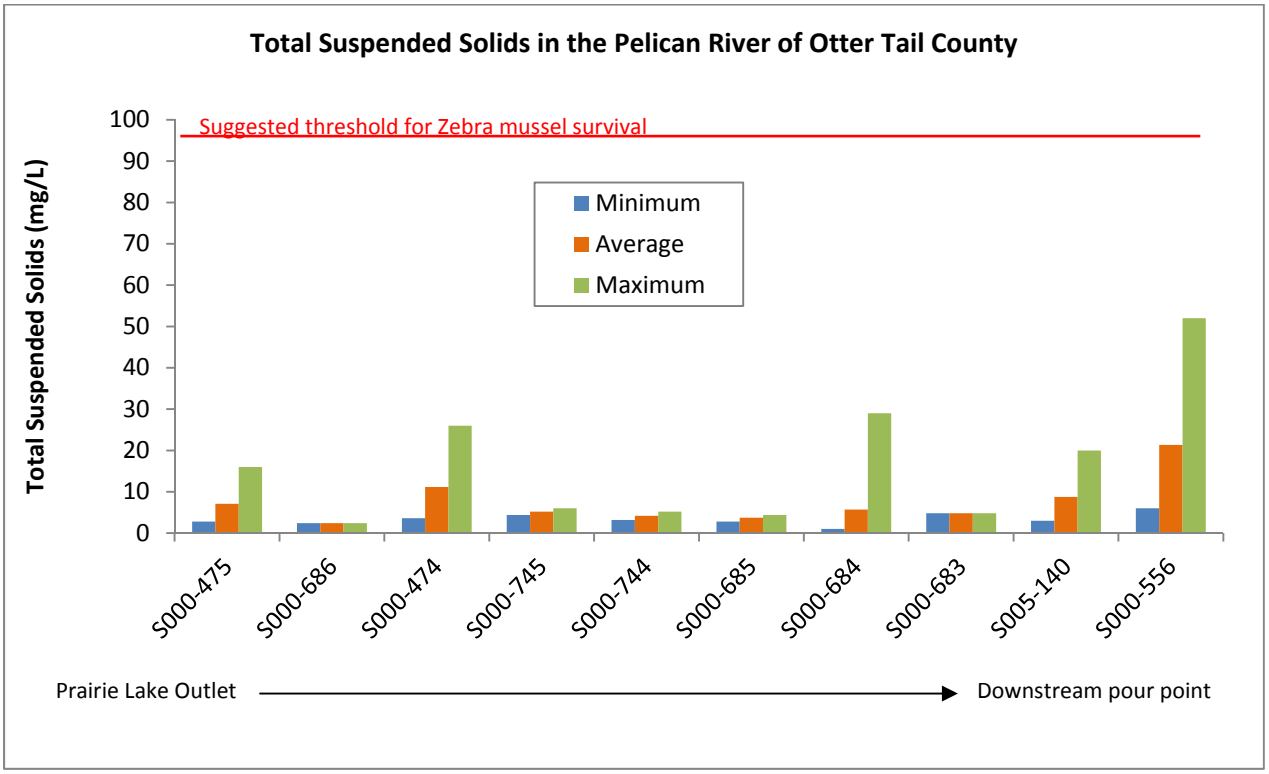


Figure 15. Total suspended solids results in the Pelican River of Otter Tail County. Refer to site locations in Figure 13.

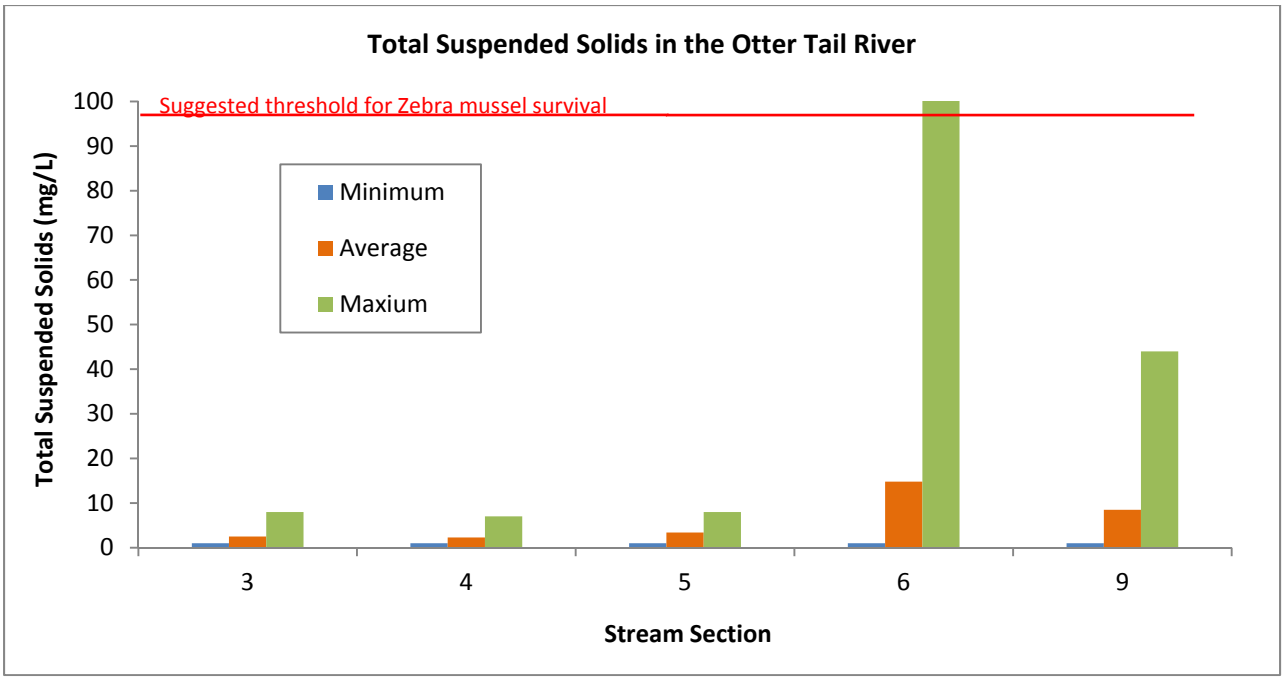


Figure 16. Total suspended solids results in the Otter Tail River. Refer to stream sections in Table 10, Figure 13.

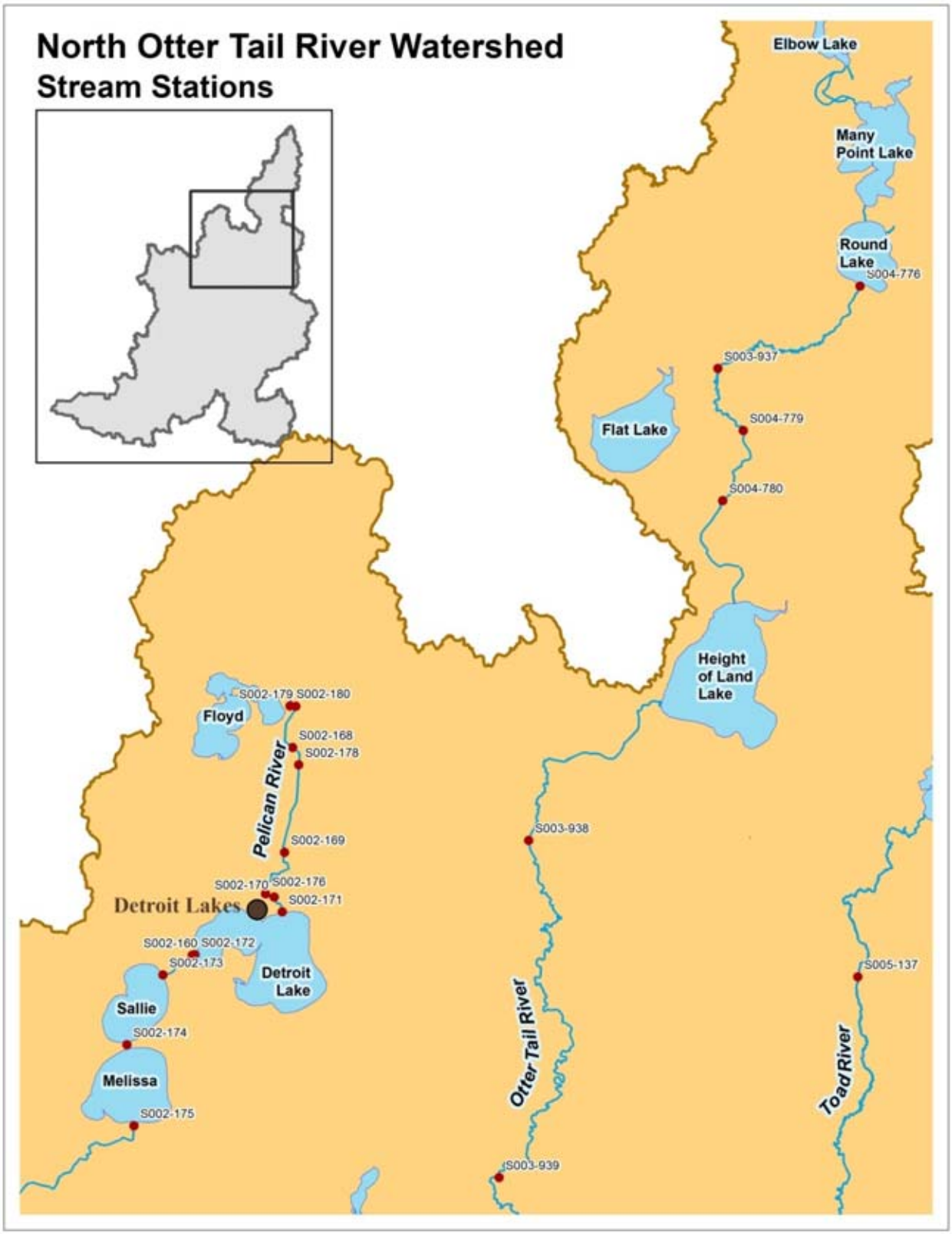


Figure 17. Stream monitoring sites in the Otter Tail River Watershed of Becker County.

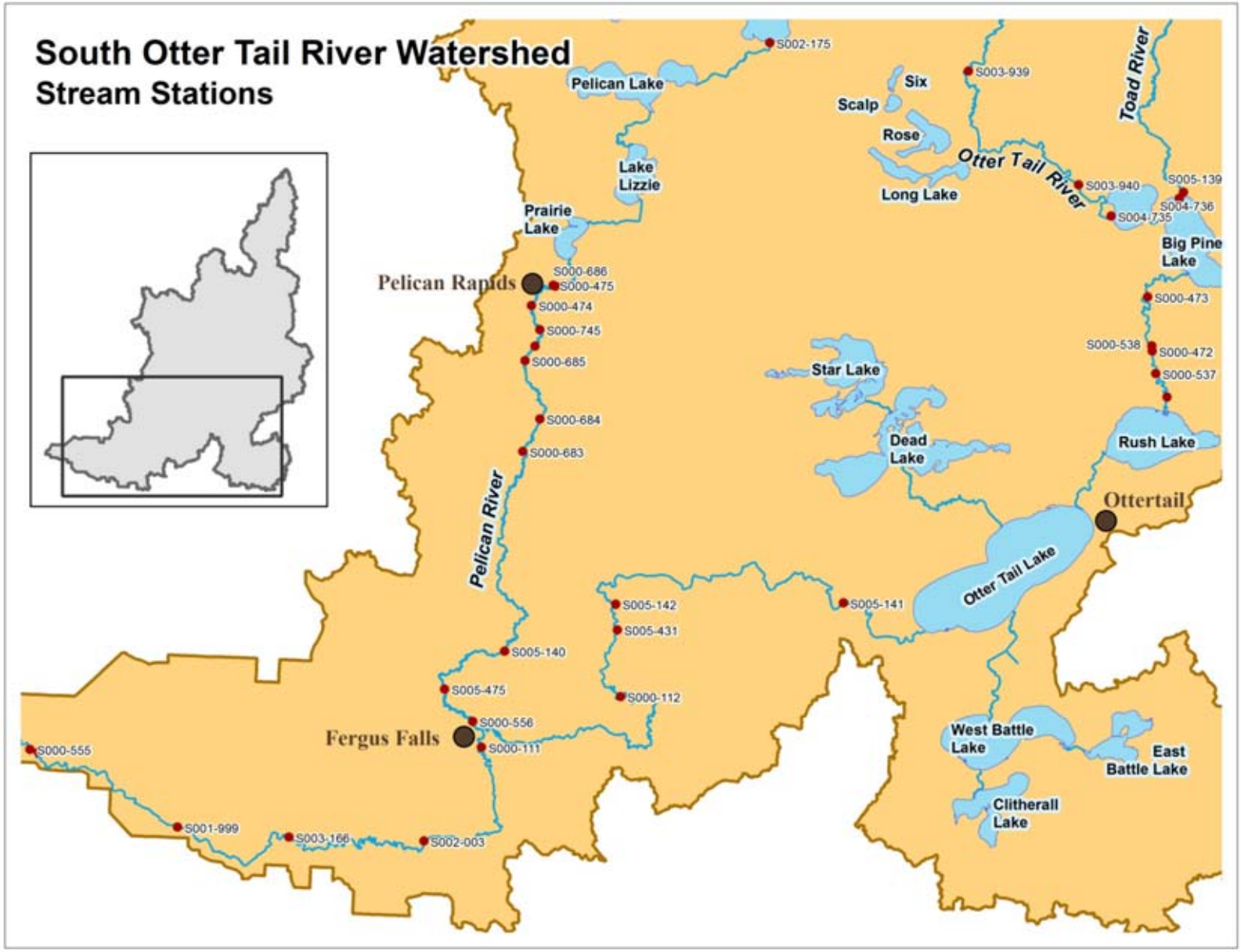


Figure 18. Stream monitoring sites in Otter Tail County.

Lake Risk Assessment Summary: Floyd Lake

Infestation Risk Rating: Low
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Otter Tail
Location: North of Detroit Lakes
Surface Area: 1,177 acres
Percent Littoral: 73%
Max Depth: 34 ft
Inlet: Campbell Creek

Summary

The only probable vector of spread for Floyd Lake is by humans and their boats/equipment since it is a headwaters lake. If Zebra mussels were introduced into Floyd Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (380)	605	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (225)		
Substrate Suitability (mean abundance, DNR)		Sand, Silt	56.3%, 33.3%	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.6	63	8.2-8.8
Alkalinity*	mg/L	197	8	100-280
Specific Conductance*	uS/cm	380	53	>110
Secchi Depth	ft	9.6	82	6.56-13.12
Chlorophyll a	ug/L	3.8	19	2.5-8
Total Phosphorus	ug/L	17.6	35	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 C (218 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Little Floyd Lake

Infestation Risk Rating: Low
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Otter Tail
Location: North of Detroit Lakes
Surface Area: 214 acres
Percent Littoral: 44%
Max Depth: 34 ft
Inlet: Pelican River

Summary

The only probable vector of spread for Little Floyd Lake is by humans and their boats/equipment since its only upstream lake is Floyd Lake (a headwaters lake.) If Zebra mussels were introduced into Little Floyd Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	One upstream headwaters lake	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (111)	411	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (300)		
Substrate Suitability (mean abundance, DNR)		Sand, silt, muck	45%, 32 %, 27%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Count	Suitable Range
Calcium*	mg/L	NA	0	>30
pH*		8.3	471	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	umhos	407.1	394	>110
Secchi Depth	ft	8.6	306	6.56-13.12
Chlorophyll a	ug/L	8.8	94	2.5-8
Total Phosphorus	ug/L	29.2	255	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

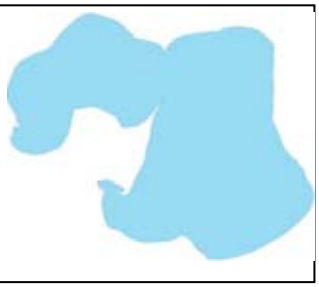
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.9 °C (316 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Detroit Lake

Infestation Risk Rating: High
1. Connectivity: Moderate Risk
2. Public Use: High Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Otter Tail
Location: Detroit Lakes
Surface Area: 3,067 acres
Percent Littoral: 62%
Max Depth: 89 ft
Inlet: Pelican River



Summary

Detroit Lake has a moderate probability of infestation from upstream since there is only one main lake upstream, and no current Zebra mussel infestations upstream of the lake. Due to its location within the City of Detroit Lakes, the lake has very high public use, which is high risk. If Zebra mussels were introduced into Detroit Lake they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	One upstream lake	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (608)	4,218	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (3610)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel	47%, 13%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.1	737	8.2 - 8.8
Alkalinity*	mg/L	186.4	14	100 - 280
Specific Conductance*	uS/cm	410.4	587	>110
Secchi	ft	10.2	355	6.56-13.12
Chlorophyll a	ug/L	8.3	41	2.5 - 8
Total Phosphorus	ug/L	25.4	43	25 - 35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 C (309 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Sallie

Infestation Risk Rating: Moderate
1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 1272.88 acres
Percent Littoral: 45%
Max Depth: 50 ft
Inlet: Pelican River

Summary

Lake Sallie is in the middle of a chain of lakes, which is a moderate infestation risk. If any upstream lakes become infested, it will spread to Lake Sallie. Lake Melissa, which is immediately downstream from Lake Sallie is infested. If Zebra mussels were introduced into Lake Sallie they would likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 immediate downstream infested lake	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (236)	806	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (570)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	80%, 14%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	486	8.2-8.8
Alakalinity*	mg/L	190.0	5	100-280
Specific Conductance*	uS/cm	413.5	437	>110
Secchi Depth	ft	7.5	411	6.56-13.12
Chlorophyll a	ug/L	18.3	88	2.5-8
Total Phosphorus	ug/L	37.0	346	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.7 °C (287 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Melissa INFESTED

Overall Risk Rating: INFESTED
1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 1,850 acres
Percent Littoral: 51%
Max Depth: 37 ft
Inlet: Pelican River

Summary

Lake Melissa is currently infested with Zebra mussels, which is why the overall risk rating is high. Due to suitable water chemistry and substrate, Zebra mussels are likely to thrive in Lake Melissa.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	4 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (397)	1,417	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,020)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	82%, 10%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	304	8.2-8.8
Alkalinity*	mg/L	200	1	100-280
Specific Conductance*	uS/cm	392.8	271	>110
Secchi Depth	ft	8.8	246	6.56-13.12
Chlorophyll a	ug/L	11.3	11	2.5-8
Total Phosphorus	ug/L	23.0	18	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	29.3 °C (357 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Upper Cormorant

Overall Risk Rating: Low

1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Ottertail
Location: West of Detroit Lakes
Surface Area: 926.83 acres
Percent Littoral: 51%
Max Depth: 29 ft
Inlet: From Bijou Lake

Summary

The most probable vector of spread for Upper Cormorant Lake is by humans and their boats/equipment since it is a headwaters lake. If Zebra mussels were introduced into Upper Cormorant Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (233)	533	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (300)		
Substrate Suitability (mean abundance)		Sand, silt, muck	25%, 39%, 35%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi	ft	7.4	91	6.56-13.12
Chlorophyll a	ug/L	13.4	44	2.5-8
Total Phosphorus	ug/L	31.1	44	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.4 °C (19 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Middle Cormorant

Infestation Risk Rating: Moderate
1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: West of Detroit Lakes
Surface Area: 408.72 acres
Percent Littoral: 35%
Max Depth: 40 ft
Inlet: Upper Cormorant Lake

Summary

Middle Cormorant Lake is in the middle of a chain of lakes, which is a moderate infestation risk. If any upstream lakes become infested, it could spread to Middle Cormorant Lake. If Zebra mussels were introduced into Middle Cormorant Lake they would most likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Uninfested Chain of Lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (198)	963	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (765)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel	73%, 42%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.9	4	8.2-8.8
Alkalinity*	mg/L	194	5	100-280
Specific Conductance*	uS/cm	342	5	>110
Secchi Depth	ft	11.4	416	6.56-13.12
Chlorophyll a	ug/L	5	17	2.5-8
Total Phosphorus	ug/L	16.2	17	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 °C (15 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Big Cormorant

Overall Risk Rating: High
1. Connectivity: Moderate Risk
2. Public Use: High Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: West of Detroit Lakes
Surface Area: 3657.06 acres
Percent Littoral: 22%
Max Depth: 75 ft
Inlet: Middle Cormorant Lake

Summary

Big Cormorant Lake has a moderate probability of infestation from upstream since it is in a chain of lakes. Due to its location and size, the lake has very high public use, which is high risk. If Zebra mussels were introduced into Big Cormorant Lake they would most likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Uninfested Chain of Lakes	4 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (643)	5,003	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (4,360)		
Substrate Suitability (mean abundance, DNR)		Sand, Rubble, Gravel	55%, 30%, 33%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range for Zebra Mussels
Calcium*	mg/L	NA	0	>30
pH*		8.7	10	8.2-8.8
Alkalinity*	mg/L	250	11	100-280
Specific Conductance*	uS/cm	460	8	>110
Secchi	ft	18.9	178	6.56-13.12
Chlorophyll a	ug/L	4.0	78	2.5-8
Total Phosphorus	ug/L	25.2	89	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

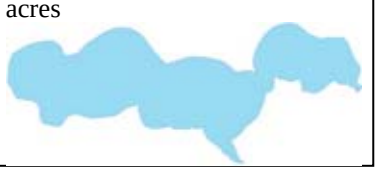
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.9 °C (23 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Pelican Lake INFESTED

Overall Risk Rating: INFESTED
1. Connectivity: High Risk
2. Public Use: High Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 3962.88 acres
Percent Littoral: 41%
Max Depth: 55 ft
Inlet: Pelican River



Summary

Pelican Lake is currently an infested lake (listed in 2009), and has a high infestation risk rating. In fact, it had the highest public use score in the Otter Tail River Watershed. Its substrate and water chemistry is suitable for Zebra mussel establishment and growth.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of infested lakes	2 infested lakes upstream	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (999)	5,734	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (4,735)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	78.8%, 18.3%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	35	55	>30
pH*		8.4	75	8.2-8.8
Alkalinity*	mg/L	192.5	12	100-280
Specific Conductance *	uS/cm	394.8	75	>110
Secchi	ft	12.8	192	6.56-13.12
Chlorophyll a	ug/L	4.8	116	2.5-8
Total Phosphorus	ug/L	14.6	116	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.5 °C (37 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Little Pelican Lake INFESTED

Overall Risk Rating: INFESTED
1. Connectivity: High Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 345 acres
Percent Littoral: 74%
Max Depth: 25 ft
Inlet: Pelican River

Summary

Little Pelican is currently an infested lake due to its connection with Pelican Lake; however, very few Zebra mussels have been found. It has a moderate suitability rating due to its substrate and eutrophic status.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	Connected to infested lake	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (120)	120	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance)		Silt, Muck	NA	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	34	55	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	180	10	100-280
Specific Conductance *	uS/cm	412	12	>110
Secchi Depth	ft	8.5	87	6.56-13.12
Chlorophyll a	ug/L	9.8	87	2.5-8
Total Phosphorus	ug/L	23.9	87	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.5 °C (38 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Lizzie INFESTED

Overall Risk Rating: INFESTED
1. Connectivity: High Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: North of Pelican Rapids
Surface Area: 1,900acres
Percent Littoral: 43%
Max Depth: 66 ft
Inlet: Pelican River

Summary

Lake Lizzie is infested with Zebra mussels (listed in 2009). Its substrate and water chemistry is suitable for Zebra mussel establishment and growth.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 upstream infested lake	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (337)	502	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (165)		
Substrate Suitability (mean abundance)		Sand, Rubble, Gravel	42%, 33%, 25%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	3	8.2-8.8
Alkalinity*	mg/L	193.3	3	100-280
Specific Conductance *	uS/cm	NA	0	>110
Secchi Depth	ft	12.7	61	6.56-13.12
Chlorophyll a	ug/L	5.3	62	2.5-8
Total Phosphorus	ug/L	16.1	62	25-35
Turbidity	mg/L	1.2	3	<96

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6 °C (27 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Prairie Lake INFESTED

Overall Risk Rating: INFESTED
1. Connectivity: High Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Ottertail
Location: Pelican Rapids
Surface Area: 1,002 acres
Percent Littoral: 80%
Max Depth: 22 ft
Inlet: Pelican River

Summary

Prairie Lake is infested with Zebra mussels (listed in 2011). Its water chemistry is suitable for Zebra mussel establishment and growth, but spread may be limited by the substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	3 upstream infested lakes	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (138)	174	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (36)		
Substrate Suitability (mean abundance)		Sand, Silt	72.1%, 15.4%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	1	8.2-8.8
Alkalinity*	mg/L	180	1	100-280
Specific Conductance*	uS/cm	380	1	>110
Secchi Depth	ft	9.8	44	6.56-13.12
Chlorophyll a	ug/L	5.8	43	2.5-8
Total Phosphorus	ug/L	20.6	44	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.8 °C (27 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Elbow Lake

Overall Risk Rating: Low

1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Ottertail
Location: North of Detroit Lakes
Surface Area: 985 acres
Percent Littoral: 24%
Max Depth: 70 feet
Inlet: Bottom Creek, Bear Creek, Moore Lake

Summary

Elbow Lake is at the very top of the Otter Tail River Watershed, and there are no upstream lakes. It has a moderate suitability rating due to sand and soft substrates and suitable water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters Lake	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (293)	644	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (351)		
Substrate Suitability (mean abundance)		Sand, Silt, Marl	60.8%, 40.4%, 15.8%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	18	8.2-8.8
Alkalinity*	mg/L	182.5	8	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	18.2	54	6.56-13.12
Chlorophyll a	ug/L	3.6	24	2.5-8
Total Phosphorus	ug/L	12.4	35	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.1°C (8 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Many Point Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Ottertail
Location: North of Detroit Lakes
Surface Area: 1,700 acres
Percent Littoral: 44.3%
Max Depth: 91.9 feet
Inlet: Otter Tail River

Summary

Many Point Lake is at the top of the Otter Tail River Watershed, with only Elbow Lake upstream. It is close enough to Elbow Lake so that if Elbow Lake became infested, the Zebra mussel veligers could move downstream. It has low use except for the Many Point Scout Camp.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 upstream headwaters lake	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (88)	1,093	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,005)		
Substrate Suitability (mean abundance)		Sand, Marl, Silt	58.8%, 57.9%, 42.5%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.8	11	6.56-13.12
Chlorophyll a	ug/L	5.3	12	2.5-8
Total Phosphorus	ug/L	14.7	12	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Round Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating:

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: North of Detroit Lakes
Surface Area: 1094.18 acres
Percent Littoral: 51.35%
Max Depth: 68.2 feet
Inlet: Otter Tail River

Summary

Round Lake has a moderate infestation risk rating due to the presence of upstream lakes and its public use. The public use on Round Lake mainly comes from a Tamarac National Wildlife Refuge campground on the west side. This use is considered lower risk than a resort. If Zebra mussels were introduced to Round Lake they likely establish due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (149)	1,019	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (870)		
Substrate Suitability (mean abundance)		Marl, Sand, Silt, Gravel	48.3%, 36.7%, 28.3%, 16.7%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	13.1	127	6.56-13.12
Chlorophyll a	ug/L	7.6	12	2.5-8
Total Phosphorus	ug/L	19.3	12	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Flat Lake

Overall Risk Rating: Low

1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low

Characteristics
Major Basin: Ottertail
Location: North of Rochert
Surface Area: 1,837acres
Percent Littoral: 100%
Max Depth: 19 feet
Inlet: Egg River

Summary

Flat Lake is located within the Tamarack National Wildlife Refuge and outlets to the Otter Tail River. It is a shallow lake with wild rice on the north and west sides of the lake. It has a low infestation risk rating and a moderate suitability rating.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters Lake	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (20)	20	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability		Muck, sand, wild rice	NA	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	27.0	1	>30
pH*		8.69	21	8.2-8.8
Alkalinity*	mg/L	117.5	4	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.2	73	6.56-13.12
Chlorophyll a	ug/L	7.3	13	2.5-8
Total Phosphorus	ug/L	33.2	13	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6°C (71 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Height of Land Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: East of Rochert
Surface Area: 3,788.2 acres
Percent Littoral: 91.1%
Max Depth: 20.9 feet
Inlet: Otter Tail River, North Twin Lake

Summary

Height of Land Lake has a relatively low public use rating, but there are three upstream lakes. The water chemistry and substrates are suitable for Zebra mussels.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (141)	621	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (480)		
Substrate Suitability (mean abundance)		Sand, Silt, Detritus, Gravel	66.3%, 45%, 12.5%, 10.4%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	11	8.2-8.8
Alkalinity*	mg/L	154	5	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	5.9	25	6.56-13.12
Chlorophyll a	ug/L	11.9	20	2.5-8
Total Phosphorus	ug/L	35.0	20	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	22°C (2 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Toad Lake

Overall Risk Rating: Moderate
1. Connectivity: Low Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: East of Rochert
Surface Area: 1,700 acres
Percent Littoral: 43%
Max Depth: 29 feet
Inlet: 4 minor inlets

Summary

Toad Lake does not have any upstream lakes draining to it, but it has a moderate public use rating. If Zebra mussels were introduced to Toad Lake they would likely establish due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters Lake	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (183)	1,203	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,020)		
Substrate Suitability (mean abundance)		Sand, Silt, Rubble, Gravel	63.8%, 32.1%, 28%, 15%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.6	8	8.2-8.8
Alkalinity*	mg/L	165	4	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.9	397	6.56-13.12
Chlorophyll a	ug/L	12.1	43	2.5-8
Total Phosphorus	ug/L	24.5	43	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26°C (24 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Lake Six

Overall Risk Rating: Low
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: High
1. Water Chemistry: Moderate Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: SW of Frazee
Surface Area: 193 acres
Percent Littoral: 34%
Max Depth: 130 feet
Inlet: None

Summary

Lake Six has no upstream lakes and a low public use rating, so the risk of infestation is low. If Zebra mussels were introduced to Lake Six they would likely establish due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters Lake	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (76)	151	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (75)		
Substrate Suitability (mean abundance)		Gravel, Sand, Rubble	48%, 28%, 15%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	1	8.2-8.8
Alkalinity*	mg/L	148	5	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	22.1	75	6.56-13.12
Chlorophyll a	ug/L	2.3	25	2.5-8
Total Phosphorus	ug/L	9.2	25	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.8°C (18 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Scalp/Seven Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating:

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: SW of Frazee
Surface Area: 251.3 acres
Percent Littoral: 45.4%
Max Depth: 89.8 feet
Inlet: Six Lake

Summary

Lake Seven has just one upstream lake and a low public use rating, so the risk of infestation is moderate. If Zebra mussels were introduced to Lake Seven they would likely establish due to suitable substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 upstream headwaters lake	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (117)	177	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (60)		
Substrate Suitability (mean abundance)		Sand, Gravel, Rubble	73.3%, 20.8%, 4.2%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.8	4	8.2-8.8
Alkalinity*	mg/L	166.7	3	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	23. 7	128	6.56-13.12
Chlorophyll a	ug/L	2.6	46	2.5-8
Total Phosphorus	ug/L	10	46	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	14.1°C (84 observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Rose Lake INFESTED

Overall Risk Rating: Moderate
1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: SW of Frazee
Surface Area: 1,200.5 acres
Percent Littoral: 54.3%
Max Depth: 136.8 feet
Inlet: From Lake Seven

Summary

Zebra mussels were found in Rose Lake in September of 2011, and were traced to a single infested boat lift as a source. In October 2011 the infested area was treated with copper sulfate to attempt eradication. Zebra mussel adults (3) were found in the treated area in 2012. No survey was conducted in 2013. A snorkel survey in 2014 found no zebra mussels. Additional monitoring is planned for summer of 2015 to determine if Zebra mussels are established in Rose Lake.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (163)	643	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (480)		
Substrate Suitability (mean abundance)		Sand, Rubble, Gravel	62.5%, 18.8%, 16.7%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	10.9	73	6.56-13.12
Chlorophyll a	ug/L	5.8	12	2.5-8
Total Phosphorus	ug/L	14.8	12	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	NA	>32 C	Likely High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Long Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: East of Vergas
Surface Area: 1,288. 8 acres
Percent Littoral: 42.8%
Max Depth: 127.9 feet
Inlet: Rose Lake

Summary

Rose Lake, which is designated as infested with Zebra mussels, is located directly upstream and adjacent to Long Lake. If 2015 monitoring in Rose Lake confirms Zebra mussels (See page 44), Long Lake would change to a high infestation risk due to connectivity.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (236)	371	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (135)		
Substrate Suitability (mean abundance)		Sand, Muck, Gravel	60%, 30%, 10%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	156.7	3	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	9.0	209	6.56-13.12
Chlorophyll a	ug/L	8.9	52	2.5-8
Total Phosphorus	ug/L	23.3	52	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.8°C (32observations)	>32 C	High
Dissolved oxygen	NA	<7 mg/L	Likely High

Lake Risk Assessment Summary: Little Pine Lake

Overall Risk Rating: Moderate
1. Connectivity: Moderate Risk
2. Public Use: Low Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: North of Perham
Surface Area: 2080.3 acres
Percent Littoral: 36.7%
Max Depth: 71.9 feet
Inlet: Otter Tail River

Summary

Little Pine Lake has a moderate infestation risk. Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in 2015, Little Pine Lake's infestation rating would change to high (red).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	8 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (309)	594	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (285)		
Substrate Suitability (mean abundance)		Sand, Rubble, Gravel	80%, 15%, 5%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.28	6	8.2-8.8
Alkalinity*	mg/L	187.9	6	100-280
Specific Conductance*	uS/cm	355	2	>110
Secchi Depth	ft	7.66	129	6.56-13.12
Chlorophyll a	ug/L	16.13	38	2.5-8
Total Phosphorus	ug/L	28.5	38	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.2°C (18 observations)	>32 C	High
Dissolved oxygen	8.5 (15 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Big Pine Lake

Overall Risk Rating: High

1. Connectivity: Moderate Risk
2. Public Use: High Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: East of Perham
Surface Area: 4,730 acres
Percent Littoral: 50.2%
Max Depth: 70.6 feet
Inlet: Otter Tail River, Toad River, Nitche lake, Alvis Creek

Summary

Big Pine Lake has a high infestation risk due to very high public use. In addition, Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in 2015, Big Pine Lake's connectivity rating would change from moderate (yellow) to high (red), and the overall infestation risk rating would remain high (red).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	9 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (495)	4,850	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (4,355)		
Substrate Suitability (mean abundance)		Sand, Rubble, Muck	75%, 16%, 8%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	22	8.2-8.8
Alkalinity*	mg/L	184.4	18	100-280
Specific Conductance*	uS/cm	360	12	>110
Secchi Depth	ft	6.9	568	6.56-13.12
Chlorophyll a	ug/L	21.1	45	2.5-8
Total Phosphorus	ug/L	36.2	45	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6°C (18 observations)	>32 C	High
Dissolved oxygen	7.9 (25 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Rush Lake

Overall Risk Rating: High

1. Connectivity: High Risk
2. Public Use: High Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: North of Ottertail
Surface Area: 5,233.8 acres
Percent Littoral: 67.1%
Max Depth: 65 feet
Inlet: Otter Tail River, Boedigheimer Lake

Summary

Rush Lake has a high infestation risk due to very high public use. In addition, Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in 2015, Rush Lake's connectivity rating would change from moderate (yellow) to high (red).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	10 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (430)	3,380	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (2,950)		
Substrate Suitability (mean abundance)		Sand, Silt, Muck, Gravel	68%, 20.3%, 15%, 7%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	30	8.2-8.8
Alkalinity*	mg/L	148.6	19	100-280
Specific Conductance*	uS/cm	320	9	>110
Secchi Depth	ft	6.4	67	6.56-13.12
Chlorophyll a	ug/L	12.9	50	2.5-8
Total Phosphorus	ug/L	29.7	52	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.1°C (33 observations)	>32 C	High
Dissolved oxygen	8.6 (15 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Star Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: SW of Dent
Surface Area: 4,454 acres
Percent Littoral:58.6%
Max Depth: 90 feet
Inlet: Round Lake, Elbow Lake

Summary

Star Lake has a moderate infestation risk rating and a high public use rating. If Zebra mussels were introduced into Star Lake, they would likely establish due to suitable hard substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (443)	1,448	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,005)		
Substrate Suitability (mean abundance)		Muck, Rubble, Sand, Gravel	40%, 25%, 25%, 10%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	183.3	3	100-280
Specific Conductance*	uS/cm	NA	0	>110
Secchi Depth	ft	14.2	294	6.56-13.12
Chlorophyll a	ug/L	6.23	43	2.5-8
Total Phosphorus	ug/L	17.12	43	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.7°C (6 observations)	>32 C	High
Dissolved oxygen	8.1 (6 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Dead Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: High Risk

Suitability Risk Rating:

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: West of Richville
Surface Area: 7,567.1 acres
Percent Littoral: 90.9%
Max Depth: 60.6 feet
Inlet: Dead River, Star Lake, Peterson Lake

Summary

Dead Lake has a moderate infestation risk rating and a high public use rating. If Zebra mussels were introduced into Dead Lake, they would likely establish due to suitable hard substrate and water chemistry.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (443)	2,078	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,635)		
Substrate Suitability (mean abundance)		Sand, Silt, Gravel, Muck	61%, 20%, 16%, 13%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.6	18	8.2-8.8
Alkalinity*	mg/L	196.7	12	100-280
Specific Conductance*	uS/cm	340	18	>110
Secchi Depth	ft	10.0	276	6.56-13.12
Chlorophyll a	ug/L	7.6	189	2.5-8
Total Phosphorus	ug/L	23.5	190	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.4°C (108 observations)	>32 C	High
Dissolved oxygen	9.5 (25 observations)	<7 mg/L	High

Lake Risk Assessment Summary: Otter Tail Lake

Overall Risk Rating: High

1. Connectivity: High Risk
2. Public Use: High Risk

Suitability Risk Rating:

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: West of Ottertail
Surface Area: 14,074.2 acres
Percent Littoral: 47.7%
Max Depth: 111.5 feet
Inlet: Otter Tail River, Dead River, Lake Blanche

Summary

Otter Tail Lake has a high infestation risk due to very high public use. In addition, Rose Lake is upstream, and is infested with Zebra mussels. If Zebra mussels are confirmed in Rose Lake in 2015, Otter Tail Lake's connectivity rating would change from moderate (yellow) to high (red).

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	11 upstream lakes	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (1258)	4,998	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (3,740)		
Substrate Suitability (mean abundance)		Sand, Gravel, Rubble	85%, 10%, 5%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.1	19	8.2-8.8
Alkalinity*	mg/L	171	19	100-280
Specific Conductance*	uS/cm	326	13	>110
Secchi Depth	ft	11.7	226	6.56-13.12
Chlorophyll a	ug/L	6.7	149	2.5-8
Total Phosphorus	ug/L	18.0	149	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27°C (48 observations)	>32 C	High
Dissolved oxygen	8.0 (15 observations)	<7 mg/L	High

Lake Risk Assessment Summary: West Battle Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: High Risk

Suitability Risk Rating:

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: East of Battle Lake
Surface Area: 5,565.4 acres
Percent Littoral: 60.3%
Max Depth: 108 feet
Inlet: Clitherall Lake,
East Battle Lake

Summary

West Battle Lake has a moderate infestation risk rating due to high public use and just two upstream lakes. If Zebra mussels were introduced into West Battle Lake, they would likely establish due to suitable water chemistry and hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (707)	2,902	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (2,195)		
Substrate Suitability (mean abundance)		Sand, Gravel, Rubble	80%, 14%, 9%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.61	70	8.2-8.8
Alkalinity*	mg/L	182	10	100-280
Specific Conductance*	uS/cm	352	14	>110
Secchi Depth	ft	13.1	369	6.56-13.12
Chlorophyll a	ug/L	3.4	63	2.5-8
Total Phosphorus	ug/L	13.0	63	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.7°C (44 observations)	>32 C	High
Dissolved oxygen	8.4 (20 observations)	<7 mg/L	High

Lake Risk Assessment Summary: East Battle Lake

Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating:

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: North of Vining
Surface Area: 1,985.1 acres
Percent Littoral: 41.9%
Max Depth: 86.9%
Inlet: Brandborg Creek, Stuart Lake

Summary

East Battle Lake has a moderate infestation risk rating due to moderate public use and just two upstream lakes. If Zebra mussels were introduced into East Battle Lake, they would likely establish due to suitable water chemistry and hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	2 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (423)	1,173	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (750)		
Substrate Suitability (mean abundance)		Sand, Gravel, Muck	55%, 20%, 20%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	12	8.2-8.8
Alkalinity*	mg/L	207.1	7	100-280
Specific Conductance*	uS/cm	347	10	>110
Secchi Depth	ft	12.54	87	6.56-13.12
Chlorophyll a	ug/L	5.36	88	2.5-8
Total Phosphorus	ug/L	15.43	88	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	23.4°C (48 observations)	>32 C	High
Dissolved oxygen	9.3 (10 observations	<7 mg/L	High

Lake Risk Assessment Summary: Clitherall Lake

Overall Risk Rating: Moderate

1. Connectivity: Low Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: South of Citherall
Surface Area: 2539.8 acres
Percent Littoral: 56.48%
Max Depth: 68.6 feet
Inlet:

Summary

Clitherall has a moderate infestation risk rating. There are no upstream lakes to supply Zebra mussels to Clitherall Lake, and it has a moderate public use rating. If Zebra mussels were introduced into Clitherall Lake, they would likely establish due to suitable water chemistry and hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters Lake	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (384)	1,299	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (915)		
Substrate Suitability (mean abundance)		Sand, Gravel, Rubble	73%, 23.3%, 18%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.8	10	8.2-8.8
Alkalinity*	mg/L	175	6	100-280
Specific Conductance*	uS/cm	337	7	>110
Secchi Depth	ft	13.8	170	6.56-13.12
Chlorophyll a	ug/L	4.3	70	2.5-8
Total Phosphorus	ug/L	11.2	70	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.3°C (22 observations)	>32 C	High
Dissolved oxygen	8.8 (24 observations)	<7 mg/L	High

Stream Risk Assessment Summary: Pelican River, Becker County

Infestation Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Distance from lakes: High Risk
3. Public Use: Moderate Risk
4. Vegetation: Low Risk

Suitability Risk Rating: Low

1. Flow Rate: Low Risk
2. Water Chemistry: Moderate Risk
3. Substrate: High Risk
4. Dissolved Oxygen: High Risk

Characteristics

Major Basin: Otter Tail

County: Becker

Location: Floyd Lake to Lake Melissa

Length: 20 miles

Summary

The Pelican River in Becker County is uninfested with Zebra mussels upstream from Lake Melissa. Due to its connectivity to lakes, it is at a high risk for infestation. The stream flow would likely be the limiting factor for Zebra mussel survival within the stream itself. In order for Zebra mussels to be present in the stream, a source would be needed to continually introduce veligers to the stream.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<6 miles between lakes	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, bait harvest, paddle sports	Moderate
Habitat Suitability	Sand, Gravel, Rocks	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	42 (2,016)	Unknown	Low
Maximum Flow (cfs)	153 (2,016)	Unknown	Low
Summer maximum temperature (C)	27.5 (108)	>32 C	High
Dissolved oxygen average (mg/L)	7.7 (114)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	NA	NA	0	>110
Total Suspended Solids	mg/L	5.7	2,054	2,068	<96
Turbidity	NTU	NA	NA	0	<80

Stream Risk Assessment Summary: Pelican River, Otter Tail County

Infestation Risk Rating: INFESTED

1. Connectivity: High Risk
2. Distance from lakes: Low Risk
3. Vegetation: Moderate Risk
4. Public Use: Moderate Risk

Suitability Risk Rating: Moderate

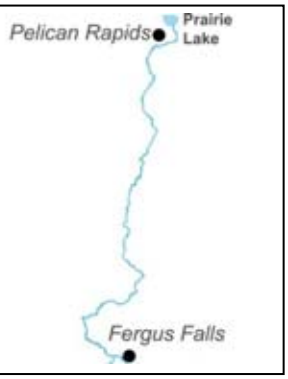
1. Flow Rate: Low Risk
2. Water Chemistry: High Risk
3. Substrate: High Risk
4. Dissolved Oxygen: High Risk

Characteristics

Major Basin: Otter Tail

Location: Pelican Lake to Otter Tail River (Pelican Rapids to Fergus Falls)

Length: 64 miles



Summary

The Pelican River is infested with Zebra mussels downstream from Pelican Lake to its pour point at the Otter Tail River near Fergus Falls, MN. The stream flow is likely the limiting factor for Zebra mussel survival within the stream itself, although there are many Zebra mussel source lakes along the stream that continually introduce veligers to the stream.

Attribute	Description	Infestation Risk
Water Connectivity	Infested	High
Distance from nearest upstream lake	64 miles	Low
Presence of aquatic vegetation/wetland conditions	Moderate	Moderate
Public Use	Fishing, bait harvest	Moderate
Habitat Suitability & Substrate	Clear, Sand, Gravel, Rocks	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	33 (6)	Unknown	Low
Maximum Flow (cfs)	83 (6)	Unknown	Low
Summer maximum temperature (C)	27.5 (108)	>32 C	High
Dissolved oxygen average (mg/L)	7.7 (114)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	102	139	10	>30
Hardness	Mg/L	244	284	10	100-280
Specific Conductance	uS/cm	410	470	83	>110
Total Suspended Solids	mg/L	10	52	80	<96
Turbidity	NTU	6	22	128	<80

Stream Risk Assessment Summary: Otter Tail River Headwaters

Infestation Risk Rating: Moderate

1. Connectivity: Moderate
2. Distance from lakes: High
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating:

1. Flow Rate: Low
2. Water Chemistry: High
3. Substrate: High
4. Dissolved Oxygen: High

Characteristics

Major Basin: Otter Tail

Location: Elbow Lake to Height of Land Lake

Length: 29 miles

Summary

The Otter Tail River Headwaters starts in Elbow Lake and flows through a few lakes to Height of Land Lake. The distance between lakes in this area are short enough that veligers could possibly spread downstream. The presence of aquatic vegetation and wetland conditions along the stream; however, could affect the ability of veligers to travel downstream and for adults to establish.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<12 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Clear water, sand & boulders	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	24.14 (72)	>32 C	High
Dissolved oxygen average (mg/L)	7.02 (60)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	300	352	60	>110
Total Suspended Solids	mg/L	2.6	8	63	<96
Turbidity	NTU	0.9	3.8	63	<80

Stream Risk Assessment Summary: Otter Tail River from HOL to Pine

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: High
3. Substrate: High
4. Dissolved Oxygen: High

Characteristics

Major Basin: Otter Tail

Location: Height of Land Lake To Little Pine Lake

Length: 43 miles

Summary

The section of the Otter Tail River between Height of Land Lake and the Pine Lakes is 43 miles, which could be too far for Zebra mussel veligers to travel. In addition, aquatic vegetation and wetland conditions can aid in preventing spread downstream.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	43 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Clear water, sand & boulders	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Low
Maximum Flow (cfs)	NA	Unknown	Low
Summer maximum temperature (C)	26.5 (51)	>32 C	High
Dissolved oxygen average (mg/L)	8.55 (51)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	309.4	370	51	>110
Total Suspended Solids	mg/L	2.4	7	45	<96
Turbidity	NTU	1.7	7.3	68	<80

Stream Risk Assessment Summary: Otter Tail River, North Otter Tail Lake

Infestation Risk Rating: Moderate

1. Connectivity: Moderate
2. Distance from lakes: High
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: High
3. Substrate: High
4. Dissolved Oxygen: High

Characteristics

Major Basin: Otter Tail

Location: Big Pine Lake to Otter Tail Lake

Length: 21 miles

Summary

This section of the Otter Tail River flows from Big Pine Lake to Otter Tail Lake. Because the lakes are close together on this stretch, it has a moderate infestation risk rating as veligers could travel to downstream lakes. The suitability to adult Zebra mussel establishment is low due to the presence of wetlands and sufficient flow.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<11 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Clear water, sand & boulders	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	64.2 (1)	Unknown	Low
Maximum Flow (cfs)	64.2 (1)	Unknown	Low
Summer maximum temperature (C)	26 (41)	>32 C	High
Dissolved oxygen average (mg/L)	9.25 (41)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	76.4	83	7	>30
Hardness	Mg/L	165	180	7	100-280
Specific Conductance	uS/cm	353	375	33	>110
Total Suspended Solids	mg/L	3.4	8	30	<96
Turbidity	NTU	2.8	9.5	48	<80

Stream Risk Assessment Summary: Otter Tail River to Fergus Falls

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Moderate

1. Flow Rate: Low
2. Water Chemistry: Moderate
3. Substrate: Moderate
4. Dissolved Oxygen: High

Characteristics

Major Basin: Otter Tail

Location: Otter Tail Lake to Fergus Falls

Length: 48 miles

Summary

This stretch of the Otter Tail River flows from Otter Tail Lake to Fergus Falls, where it joins with the Pelican River. Because the lakes are not close together on this stretch, it has a low infestation risk rating. The substrate and water chemistry are suitable for Zebra mussels, but the high water flow rate keeps the suitability at moderate instead of high. Zebra mussel adults were found downstream of Fergus Falls, so this stretch of river is suitable for adult establishment.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested Chain of lakes	Moderate
Distance from nearest upstream lake	48 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Cloudy water, sandy, boulders	Moderate

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	521.73 (22)	Unknown	Low
Maximum Flow (cfs)	874 (22)	Unknown	Low
Summer maximum temperature (C)	30 (223)	>32 C	High
Dissolved oxygen average (mg/L)	10 (225)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	97	97	1	>30
Hardness	Mg/L	199.6	240	27	100-280
Specific Conductance	uS/cm	387.8	970	234	>110
Total Suspended Solids	mg/L	14.8	760	173	<96
Turbidity	NTU	6.89	46.8	227	<80

Stream Risk Assessment Summary: Dead River

Infestation Risk Rating: Moderate

1. Connectivity: Moderate
2. Distance from lakes: High
3. Vegetation: Low
4. Public Use: Low

Suitability Risk Rating: Low

1. Flow Rate: Low
2. Water Chemistry: NA
3. Substrate: Low
4. Dissolved Oxygen: NA

Characteristics

Major Basin: Otter Tail

Location: Star Lake to Otter Tail Lake

Length: 15 miles

Summary

The Dead River flows from Star Lake through Dead Lake to Otter Tail Lake. This stretch of the river is heavily vegetated and flows through numerous wetlands, which can limit Zebra mussel establishment. The distance between lakes is short; however, which means that if Star Lake became infested, Zebra mussel veligers could move downstream from Star Lake into Dead Lake. The suitability for Zebra mussel adults to establish in this stream stretch is low.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<8.6 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Minimal	Low
Habitat Suitability & Substrate	Wetlands	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Some flow = low
Maximum Flow (cfs)	NA	Unknown	Some flow = low
Summer maximum temperature (C)	NA	>32 C	NA
Dissolved oxygen average (mg/L)	NA	<7 mg/L	NA

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	NA	NA	0	>110
Total Suspended Solids	mg/L	NA	NA	0	<96
Turbidity	NTU	NA	NA	0	<80

Stream Risk Assessment Summary: Battle Creek

Infestation Risk Rating: Moderate

1. Connectivity: Moderate
2. Distance from lakes: High
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

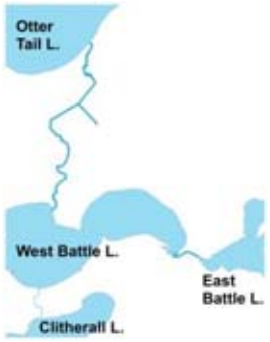
1. Flow Rate: Low
2. Water Chemistry: NA
3. Substrate: Low
4. Dissolved Oxygen: NA

Characteristics

Major Basin: Otter Tail

Location: Otter Tail Lake to East Battle Lake

Length: 18 miles



Summary

Battle Creek flows from West Battle Lake to Otter Tail Lake. This stretch of the river is heavily vegetated and flows through numerous wetlands, which can limit Zebra mussel establishment. The distance between lakes is short; however, which means that if West Battle Lake became infested, Zebra mussel veligers could move downstream from West Battle into Annie Battle and Blanche Lakes to get to Otter Tail Lake. The suitability for Zebra mussel adults to establish in this stream stretch is low.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<7.2 miles	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability & Substrate	Wetlands	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	NA	Unknown	Some flow = low
Maximum Flow (cfs)	NA	Unknown	Some flow = low
Summer maximum temperature (C)	NA	>32 C	NA
Dissolved oxygen average (mg/L)	NA	<7 mg/L	NA

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	NA	NA	0	>110
Total Suspended Solids	mg/L	NA	NA	0	<96
Turbidity	NTU	NA	NA	0	<80

Stream Risk Assessment Summary: Toad River

Infestation Risk Rating: Low

1. Connectivity: Moderate
2. Distance from lakes: Low
3. Vegetation: Low
4. Public Use: Moderate

Suitability Risk Rating: Low

1. Flow Rate:
2. Water Chemistry:
3. Temperature:
4. Dissolved Oxygen:

Characteristics

Major Basin: Otter Tail

Location: Toad Lake to Big Pine Lake

Length: 26 miles

Summary

The Toad River flows from Big and Little Toad Lakes into Big Pine Lake. There are no other lakes along this stretch of river, so the distance could be too great for Zebra mussel veligers to travel. This river is also heavily vegetated, which would limit Zebra mussel adult establishment.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	26 miles	Low
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, paddle sports	Moderate
Habitat Suitability	Cloudy, tea-stained water, wetlands	Low

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	94.9 (9)	Unknown	Low
Maximum Flow (cfs)	230 (9)	Unknown	Low
Summer maximum temperature (C)	27.7 (61)	>32 C	High
Dissolved oxygen average (mg/L)	9.65 (61)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	407	503	65	>110
Total Suspended Solids	mg/L	8.5	44.0	49	<96
Turbidity	NTU	5.6	29.7	80	<80

Results and Discussion

Results

The lakes in the Otter Tail River Watershed resulted in differing infestation and suitability risk ratings (Table 13). In general terms, the headwaters lakes came out with the lowest infestation risk ratings because they have no water bodies upstream. The headwaters lakes in the Otter Tail River Watershed include Floyd, Little Floyd, Upper Cormorant, Elbow, Six, and Flat Lakes.

Lakes with high infestation risk ratings, high public use, and high suitability include Pelican, Big Cormorant, Detroit, Big Pine, Rush and Otter Tail (Table 13). These lakes are all part of chains of lakes, so have risk from connectivity. The highest risk to these lakes; however, is their public use (Figure 19). They have the most resort units, public accesses, and property owners of any lakes in the watershed. Public use risks come from both lake visitors via boats and lake property owners via boats, boat lifts, docks and other water-related equipment. Pelican Lake was the first lake in the watershed to become infested with Zebra mussels, and it also had the highest public use rating of all the lakes in the watershed (Table 3).

West Battle and Dead Lake have high public use risks, but moderate infestation risk (Table 13). This resulted from a low risk in connectivity to other lakes. These lakes would be the second priority as far as risk in the watershed.

Most of the lakes in the Otter Tail River Watershed resulted in a high Zebra mussel suitability rating (Figure 22). The lakes in northwest Minnesota are considered hardwater lakes from glacial deposits of calcium carbonate (limestone) (Wetzel 2001). All of the lakes in this study had suitable water chemistry, including calcium, for some Zebra mussel growth and development.

The limiting factor that resulted in some lakes receiving a moderate suitability rating was substrate. Zebra mussels are not able to attach silt, muck, and sand directly. In areas with these substrates, the Zebra mussels will attach to plants, native mussels, pieces of wood or stones, or clump together on themselves (Karatayev et al. 1998). Therefore, lakes that have predominantly silt, muck and sand have a low substrate suitability rating. These lakes also tend to be more eutrophic, and Zebra mussels do not thrive in eutrophic lakes like they do in mesotrophic lakes (Karatayev et al. 1998, Nelepa 1992). The lakes with moderate suitability ratings included Prairie, Little Pelican, Floyd, Little Floyd, Upper Cormorant, Many Point, Elbow and Flat (Table 13, Figure 22).

The Otter Tail River and Pelican River are pathways for the spread of Zebra mussels downstream. Zebra mussel establishment in streams is limited by turbulence and flow, therefore the river itself is likely not a major source of zebra mussels, but if the downstream lake is close enough, veligers can be transferred from one lake to another.

Table 13. Summary of risk ratings and prioritized recommendations taking into account the risk.

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of March 2015	AIS Program Prioritized Recommendations
Upper Cormorant	03-0588-00	Low	Low	Moderate		1. Education
Middle Cormorant	03-0602-00	Moderate	Moderate	High		1. Education
Big Cormorant	03-0576-00	High	High	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Big Floyd	03-0387-02	Low	Low	Moderate		1. Education
Little Floyd	03-0386-00	Low	Low	Moderate		1. Education
Detroit	03-0381-00	High	High	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Sallie	03-0359-00	Moderate	Moderate	High		1. Education 2. Early Detection Monitoring
Melissa	03-0475-00	Moderate	High	High	Infested with Zebra mussels	1. Decontamination station 2. Education
Little Pelican	56-0761-00	Low	High	Moderate	Infested with Zebra mussels	1. Decontamination station 2. Education
Pelican	56-0786-00	High	High	High	Infested with Zebra mussels	1. Decontamination station 2. Education
Lizzie	56-0760-00	Low	High	High	Infested with Zebra mussels	1. Decontamination station 2. Education
Prairie	56-0915-00	Low	High	Moderate	Infested with Zebra mussels	1. Decontamination station 2. Education
Elbow	03-0159-00	Low	Low	Moderate		1. Education
Many Point	03-0158-00	Low	Moderate	Moderate		1. Education
Round	03-0155-00	Low	Moderate	High		1. Education
Flat	03-0242-00	Low	Low	Moderate		1. Education
Height of Land	03-0195-00	Low	Moderate	High		1. Education
Toad	03-0107-00	Moderate	Moderate	High		1. Education
Six	56-0369-00	Low	Low	High		1. Education
Scalp	56-0358-00	Low	Moderate	High		1. Education

Table 13 continued. Summary of risk ratings and prioritized recommendations taking into account the risk.

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of March 2015	AIS Program Prioritized Recommendations
Rose	56-0360-00	Low	Moderate	High	Infested with Zebra mussels	1. Intensive Monitoring (adults and veligers) 2. Education
Long	56-0388-02	Low	Moderate	High		1. Education
Little Pine	56-0142-00	Low	Moderate	High		1. Education
Big Pine	56-0130-00	High	High	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Rush	56-0141-00	High	High	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Star	56-0385-00	Moderate	Moderate	High		1. Education
Dead	56-0383-00	High	Moderate	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Otter Tail	56-0242-00	High	High	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
West Battle	56-0239-00	High	Moderate	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
East Battle	56-0138-00	Moderate	Moderate	High		1. Education
Clitherall	56-0238-00	Moderate	Moderate	High		1. Education

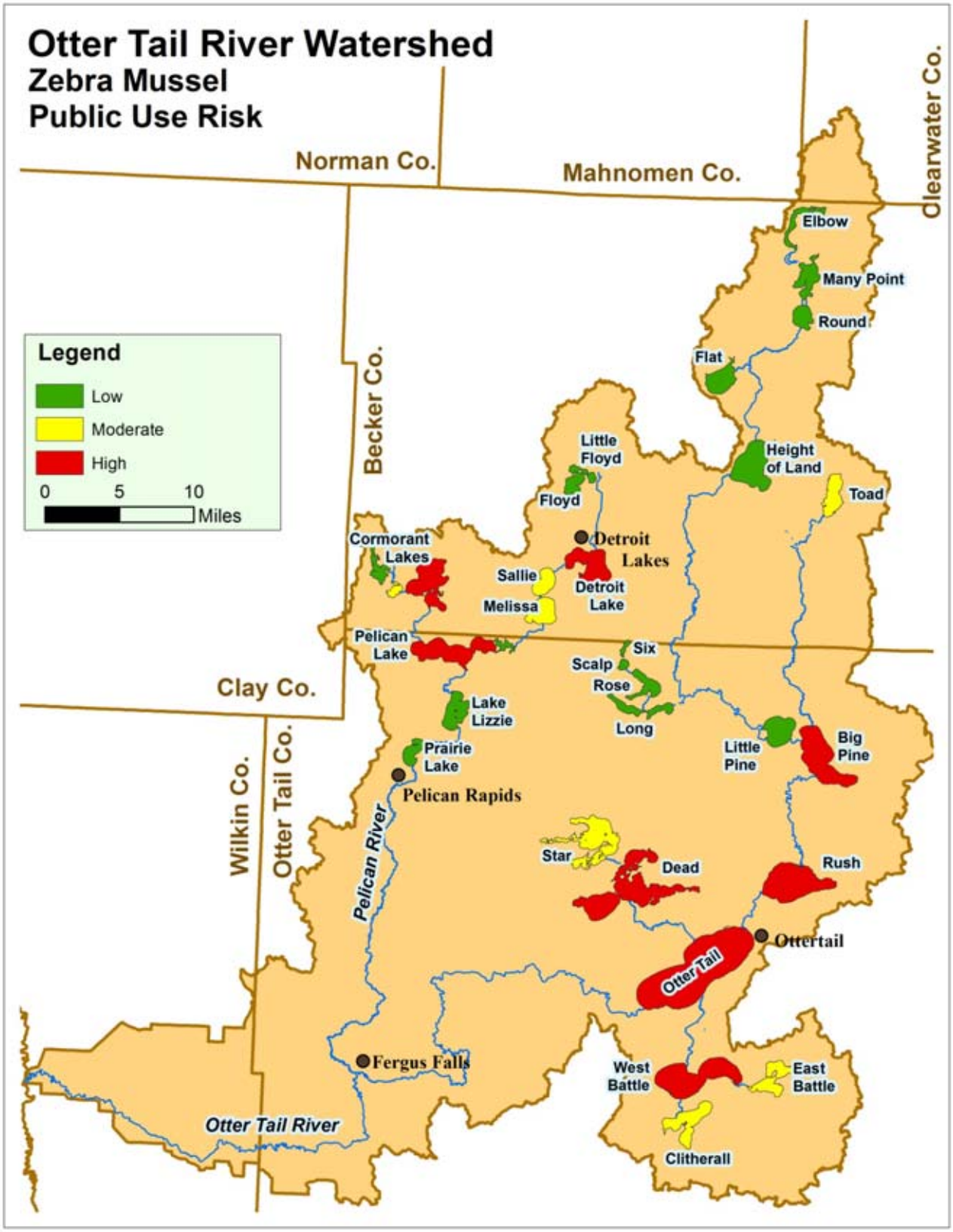


Figure 19. Public Use Risk Rating for lakes in the Otter Tail River Watershed.

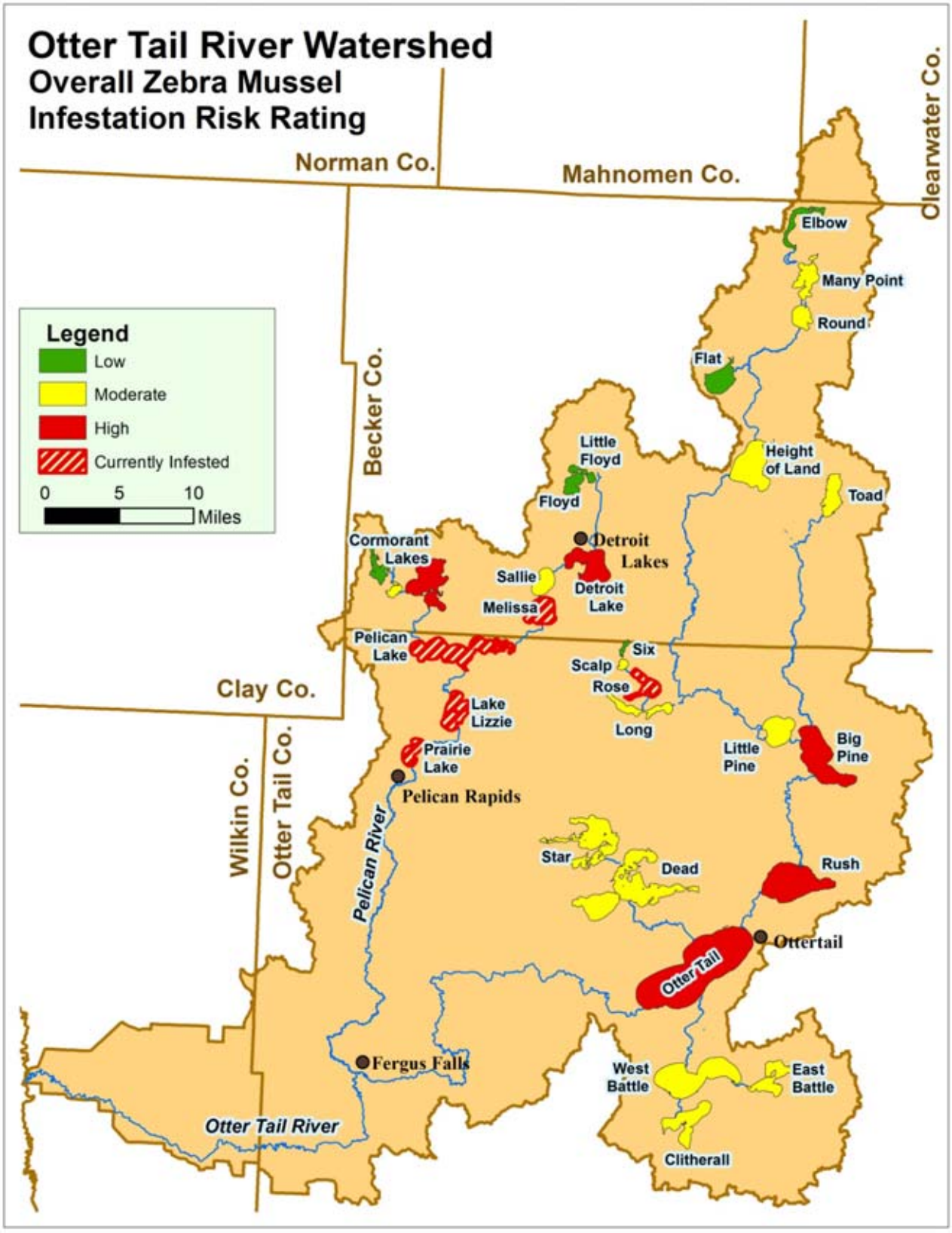


Figure 20. Overall Zebra mussel Infestation Risk Rating for lakes in the Otter Tail River Watershed.

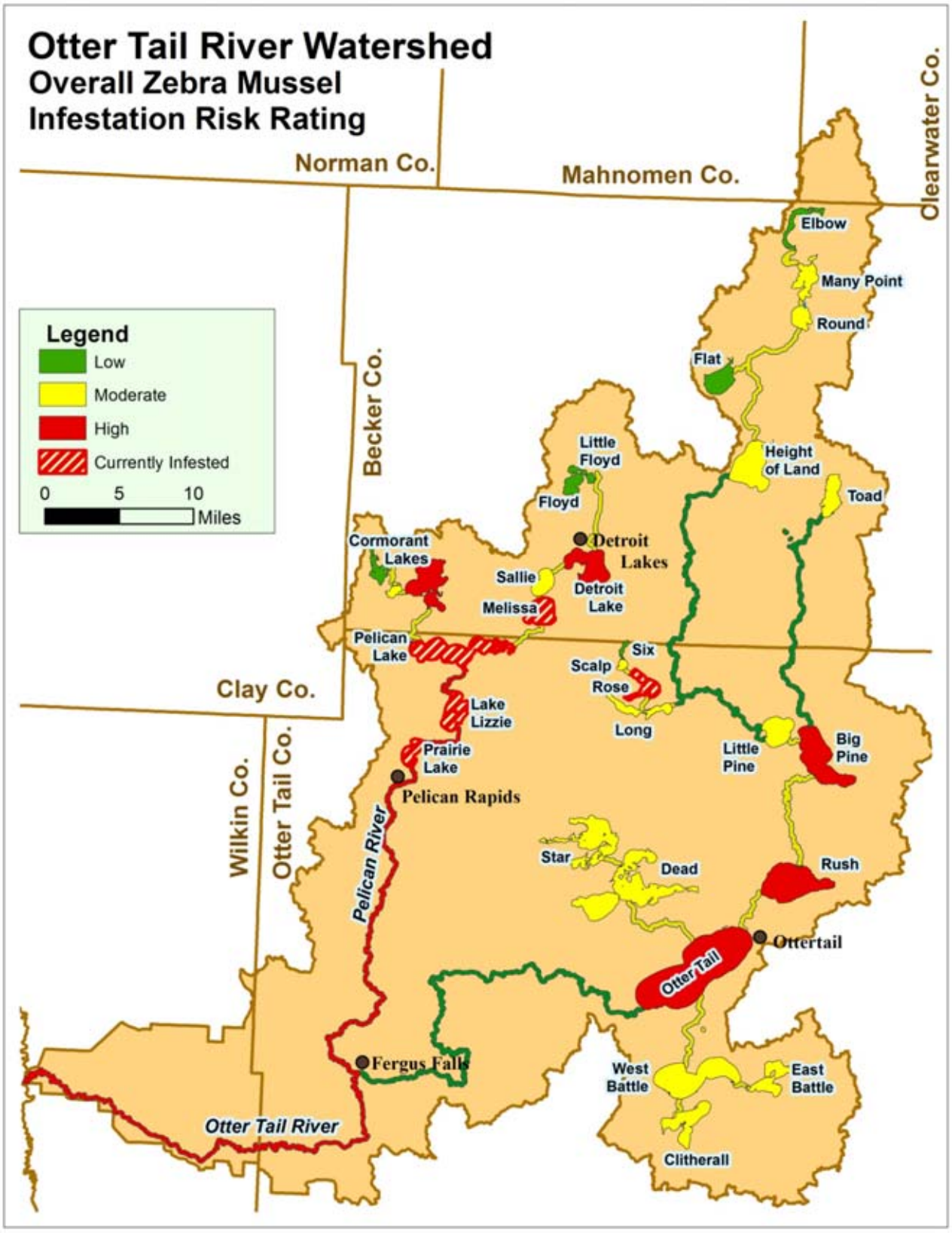


Figure 21. Overall Zebra mussel Infestation Risk Rating for lakes and streams in the Otter Tail River Watershed.

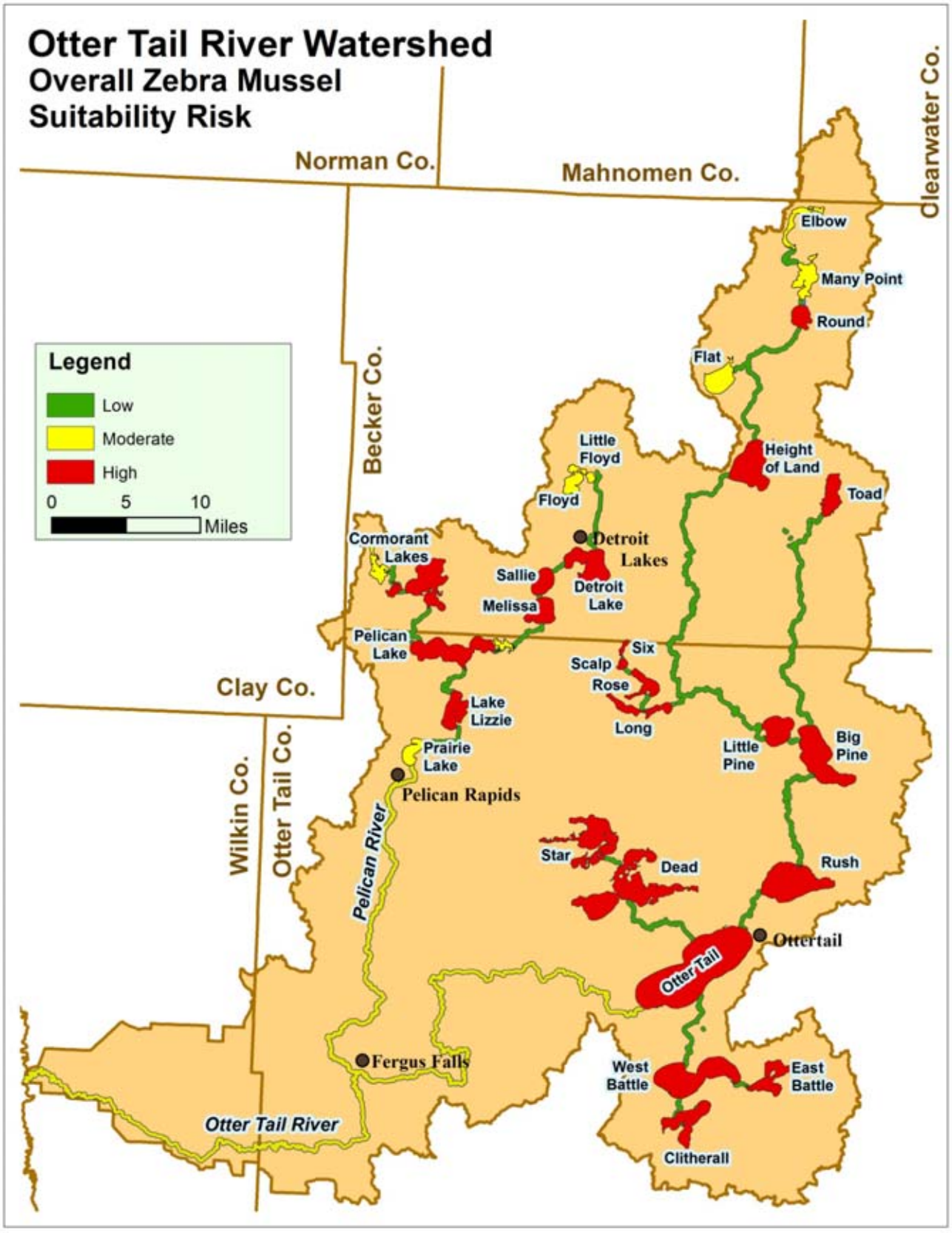


Figure 22. Overall Zebra mussel suitability risk rating in the Otter Tail River Watershed.

Data Gaps

This study identified some data gaps in the Otter Tail River Watershed. Calcium is the most important water chemistry parameter when evaluating Zebra mussel habitat suitability. Many lakes did not have any historical calcium data. Since they are hardwater lakes, it can be presumed that their calcium is high enough for Zebra mussel survival, but it is better to have the actual data numbers for evaluation. It is recommended that this data be collected to assist with overall verification of water chemistry. Lakes and streams with populations of freshwater mussels offer an additional level of habitat suitability to also support non-native mussel species. These data gaps are indicated on the lake report cards. See the table below for a summary of parameters needed for each lake (Table 14).

Table 14. Summary of data gaps for water bodies in the Otter Tail River Watershed.

Water Body Name	Lake ID	Parameters Needed
Upper Cormorant	03-0588-00	Calcium, pH, Alkalinity, Specific Conductance
Middle Cormorant	03-0602-00	Calcium
Big Cormorant	03-0576-00	Calcium
Big Floyd	03-0387-02	Calcium
Little Floyd	03-0386-00	Calcium, Alkalinity
Detroit	03-0381-00	Calcium
Sallie	03-0359-00	Calcium
Melissa	03-0475-00	Calcium
Pelican	56-0786-00	None
Little Pelican	56-0761-00	pH
Lizzie	56-0760-00	Calcium, Specific Conductance
Prairie	56-0915-00	Calcium
Elbow	03-0159-00	Calcium, Specific Conductance, Dissolved Oxygen
Many Point	03-0158-00	Calcium, pH, alkalinity, Specific Conductance, Temperature, Dissolved Oxygen.
Round	03-0155-00	Calcium, pH, alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Flat	03-0242-00	Specific Conductance, Dissolved Oxygen
Height of Land	03-0195-00	Calcium, Specific Conductance, Dissolved Oxygen
Toad	03-0107-00	Calcium, Specific Conductance, Dissolved Oxygen
Six	56-0369-00	Calcium, Specific Conductance, Dissolved Oxygen
Scalp	56-0358-00	Calcium, Specific Conductance, Dissolved Oxygen
Rose	56-0360-00	Calcium, pH, alkalinity, Specific Conductance, Temperature, Dissolved Oxygen
Long	56-0388-02	Calcium, pH, Specific Conductance, Dissolved Oxygen
Little Pine	56-0142-00	Calcium
Big Pine	56-0130-00	Calcium
Rush	56-0141-00	Calcium
Star	56-0385-00	Calcium, pH, Specific Conductance
Dead	56-0383-00	Calcium
Otter Tail	56-0242-00	Calcium
West Battle	56-0239-00	Calcium
East Battle	56-0138-00	Calcium
Clitherall	56-0238-00	Calcium

Table 14 continued. Summary of data gaps for water bodies in the Otter Tail River Watershed

Water Body Name	Parameters Needed
Pelican River, Becker County	Calcium, Hardness, Specific Conductance, Turbidity
Pelican River, Otter Tail County	None
Otter Tail River Headwaters	Flow, calcium, hardness
Otter Tail River, HOL to Pine Lakes	Flow, calcium, hardness
Otter Tail River, North Otter Tail Lake	None
Otter Tail River to Fergus Falls	None
Dead River	Flow, temperature, D.O., calcium, hardness, specific conductance, TSS, turbidity
Battle Creek	Flow, temperature, D.O., calcium, hardness, specific conductance, TSS, turbidity
Toad River	Flow, calcium, hardness

Vectors of Spread – Infestation Routes

In order to have a watershed strategy for AIS program management, the vectors of spread for each lake needs to be determined. This risk assessment process also identifies the vectors of spread for the lakes in the watershed. For headwaters lakes there is no risk of infestation from upstream, so any new infestation would come from lake users (boats, boat lifts, docks, etc). For lakes in a river chain, both lake users and upstream lakes need to be considered as potential vectors of spread.

Zebra mussels can be transferred from infested waters through several different pathways. These pathways are highly dependent upon the time of year and the stage in the Zebra mussel life cycle. The risk pathway ratings for time of year are shown in Table 15.

1. Connectivity via a river or stream.
   An upstream infested lake is almost certain to infest downstream lakes if the stream distance between lakes is short enough.

2. Transfer of equipment from lake to lake.
   The transfer of a large breeding adult Zebra mussel population from one lake to another on an infested boat lift, dock, swim raft or other water-related equipment has a very high probability of infesting a lake.

3. Transfer of mussels hitchhiking on vegetation or mud on boat and trailers.
   The risk of hitchhiking mussels depends somewhat on the time of year. When vegetation dies off in the fall, the Zebra mussels fall off into the sediments. Therefore, Zebra mussels are only attached to plants from approximately June to September. Zebra mussels can't be transferred alone in mud because they do not thrive in soft substrates; they need to be attached to a hard surface.

4. Transfer of veligers or mussels from live wells, bilges, and any area of the boat that holds water.
   The risk of veliger transfer depends greatly on the time of year. In infested lakes in northwest Minnesota, it has been documented that Zebra mussel veligers are at peak concentrations in early July (Rufer 2014). *Therefore, July is the month of the year where veliger transfer from lake to lake has the highest risk for infestation. Research has shown that veligers are non-existent during the ice-covered season, so there is essentially no risk of veliger transfer in the winter* (Rufer 2014).

5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.
   The risk of mussel transfer on boats is highest in July through September, because that is when the mussels are reproducing and settling on new hard surfaces.

6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.
   The risk of veliger transfer on gear depends somewhat on the time of year. July and August would be the times of highest risk throughout the year. Overall, this pathway is considered to be very low risk potential because the amount of water transferred is so small.

Risk – Time of Year

The risk of Zebra mussel infestation varies by the time of year. Data sources show that in Minnesota, the time of year that has the highest concentration of Zebra mussel veligers matches up with the highest use time for the public (Pesch & Bussiere 2014, Rufer 2015). The implications of these data indicate that additional prevention measures should be implemented during July to prevent Zebra mussel spread.

In Pesch and Busierre's (2014) survey of 2nd Homeowners in Central and West Central Minnesota, the highest use time of year was July, at an average of 16 days during that month (Figure 14, Pesch & Bussiere 2014). Rufer's monitoring of Zebra mussel veligers in Pelican Lake, a Zebra mussel infested lake in Otter Tail County, shows the peak density for Zebra mussels is in July (Figure 15, Rufer 2015).

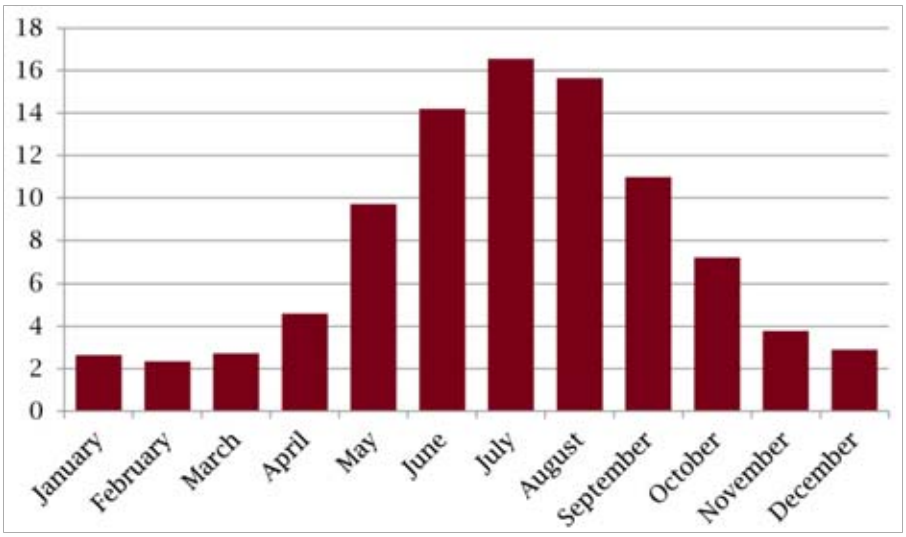


Figure 23. Average number of days occupied per month (n=552) from Pesch & Bussiere 2014.

The full report can be downloaded from this link:
http://www.extension.umn.edu/community/research/reports/docs/2014-2nd-Homeowners.pdf

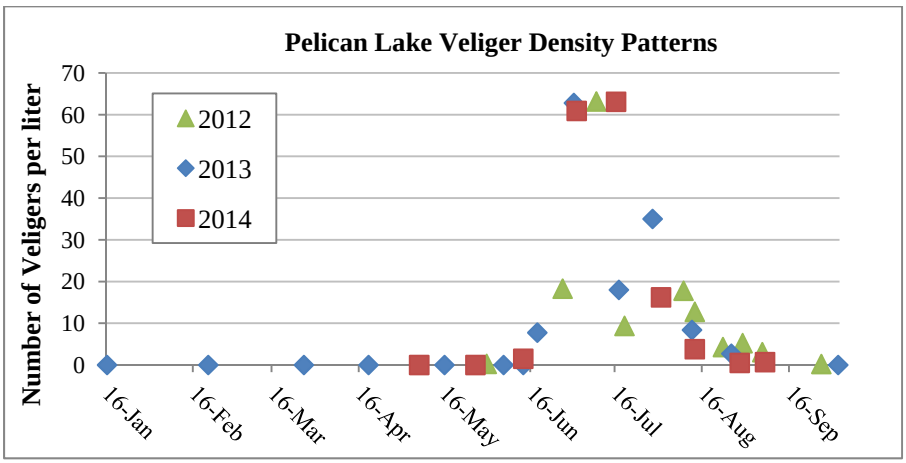


Figure 24. Veliger densities in Pelican Lake, 2012-2014 from Rufer 2015.

The full report can be downloaded from this link:
http://pgolid.org/wp-content/uploads/2014/01/PGOLID-Veliger-Report-2012-2014.pdf

Table 15. Summary of risk pathways depending on the time of year. The Zebra mussel life stage for the pathway is indicated in italics.

	Typical Minnesota Open Water Season							Typical Minnesota Ice-covered season				
Risk Pathway	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**
1. Connectivity via a river or stream.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
2. Transfer of equipment from lake to lake.	insignificant	insignificant	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
3. Transfer of mussels hitchhiking on vegetation or mud on boats, trailers and gear.	Low *Adults & juveniles*	Low *Adults & juveniles*	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Moderate *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant
4. Transfer of veligers via water in boats (live wells, bilges, etc) and float planes.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.	insignificant	insignificant	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Moderate *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant
6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant

Sources: Zebra mussel veliger time-of-year risk was taken from Rufer 2014.
Zebra mussel adult and juvenile time-of-year risk was taken from Mackie & Claudi 201, Mackie 1996, McMahon 1996.

AIS Program Management Recommendations

In an ideal world, all Aquatic Invasive Species (AIS) prevention programs would be applied to all lakes. In reality, budgets are always limited, so prioritization of programs due to risk ratings is necessary. Due to the differing risk ratings, programs can be individualized to fit each lake's risk category (Table 13). Lakes with high public use ratings should be at the highest priority for boat inspections at public accesses. Lakes that are already infested should have boat-washing stations nearby for decontamination. All lakes should be targeted with a watershed-wide education program.

The assessments in this report result combine the report cards with the risk of time of year (Figure 15) in the following specific Aquatic Invasive Species Program Management Recommendations (Table 16). This portion of the report can be inserted directly into the county's AIS Plan, and guide the use of the county's AIS funds in the most efficient and effective way possible.

Table. 16. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Watercraft Inspections	Priority 1: • Detroit • Big Cormorant • Big Pine • Rush • Otter Tail Priority 2: • West Battle • Dead Priority 3: • Middle Cormorant • Sallie • Toad • Star	Priority 1: July Priority 2: August	County	TBD	This activity depends on available funding. If limited funding is available, focus inspections on Priority 1 lakes in July as the best use of funds. If more funds are available, add in Priority 2 and 3 lakes in July. Next, add in August.
Water Quality Monitoring	See Table 14 for data gaps.	May – September	Lake Associations, COLA	TBD	Monitor lakes for missing parameters shown in Table 14. Priority parameters for each lake would be Calcium, Alkalinity, pH and Specific Conductance as they have the most effect on Zebra mussel suitability.

Table 16 continued on the next page.

Table. 16 continued. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Early Detection Monitoring: *Adult Zebra mussels*	Priority 1: • Detroit • Big Cormorant • Big Pine • Rush • Otter Tail • West Battle • Dead Priority 2: • All	Priority 1: September Priority 2: Every other week from late June to mid-September	Volunteers	$0	1. In September, conduct a lake-wide inspection of docks and boat lifts as they are removed from the lake. 2. Place a cinder block in 5-8 feet of water near the public access and any other heavily used areas of the lake, and have the volunteers check the block (pull it up or snorkel) every other week from late June to mid-September. Record results on the MN DNR's website: http://www.dnr.state.mn.us/volunteering/zebramussel_monitoring/report.html.
Early Detection Monitoring: *Zebra mussel veligers*	• Detroit • Big Cormorant • Big Pine • Rush • Otter Tail • West Battle • Dead	July	County, Watershed District, or Lake Associations	$450 ($90/sample)	Collect plankton tow samples in early and late July for veliger analysis. Early detection allows for possible treatment.
Monitoring Zebra mussels in questionably infested lakes	• Rose • Little McDonald • Kerbs • Paul • Rusche • Pickerel	July and September	Volunteers, DNR, County	TBD	All the target lakes have had some evidence of Zebra mussels found in the past, but the Zebra mussel population has not taken over the lake. 1. Monitor these lakes for Zebra mussel veligers in July. 2. Monitor these lakes for adults in June-September a. In September, conduct a lake-wide inspection of docks and boat lifts as they are removed from the lake. b. Place a cinder block in 5-8 feet of water near the public access and any other heavily used areas of the lake, and have the volunteers check the block (pull it up or snorkel) every other week from late June to mid-September. Record results on the MN DNR's website: http://www.dnr.state.mn.us/volunteering/zebramussel_monitoring/report.html

Table 16 continued on the next page.

Table. 16 continued. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Monitoring: Invasive Plants	Priority 1: • Detroit • Big Cormorant • Big Pine • Rush • Otter Tail Priority 2: All	Mid to late June	County, Watershed District, or Lake Associations	TBD	Conduct plant surveys to look for aquatic invasive plants. Mid to late June will catch Curly-leaf pondweed, Flowering rush, and Eurasian watermilfoil.
Education and Outreach	All	Priority 1: 4th of July week Priority 2: Memorial day to labor day Priority 3: Year round	County and watershed	TBD	Conduct a consistent watershed-wide education program to schools and the general public. In high tourism areas such as Detroit Lakes, Perham, and Ottertail, focus ***additional*** education around 4th of July since that is the highest risk time of the year for spread.
Decontamination	Melissa Pelican Lizzie Prairie	Priority 1: July Priority 2: August	County, DNR, or private business	TBD	Provide decontamination opportunities for boats leaving infested lakes. Inform boaters on where the decontamination station is located.
Rapid Response Plan	All	Year round	County or watershed	TBD	Put together a plan of the chain of contacts if a new infestation is found and the steps to determine if treatment is possible. Having a plan in place allows for quick action if there is a new infestation.

Table 16 can be used as a framework for the best way to use available funding, as it shows when the priority time of year is and what the priority lakes are for each activity. For example, if funding is limited for watercraft inspections at public accesses, the funding should first be used to cover Detroit, Big Cormorant, Big Pine, Rush and Otter Tail lakes in July. After that, if more funding is available, add in West Battle and Dead Lakes in July, and so forth.

For monitoring, ideally all lakes would be monitored for adults because if trained volunteers are used there is no monetary cost, but there is a large benefit. There are, however, some unique Zebra mussel infestations in Otter Tail County, namely Rose, Little McDonald, Kerbs, Paul, Rusche, and Pickerel Lakes (described on pages 10-11). These lakes should be intensively monitored in 2015 to determine whether Zebra mussels are indeed established. This intensive monitoring consists of testing for Zebra mussel veligers in July, and looking for adults all year. A comprehensive search of all docks and boat lifts removed from the lake in September should be completed as well.

For education, because the highest risk time of the summer and one of the highest tourism times of the summer intersect on 4th of July week, focus *additional* targeted education and outreach during this time of year near high risk lakes.

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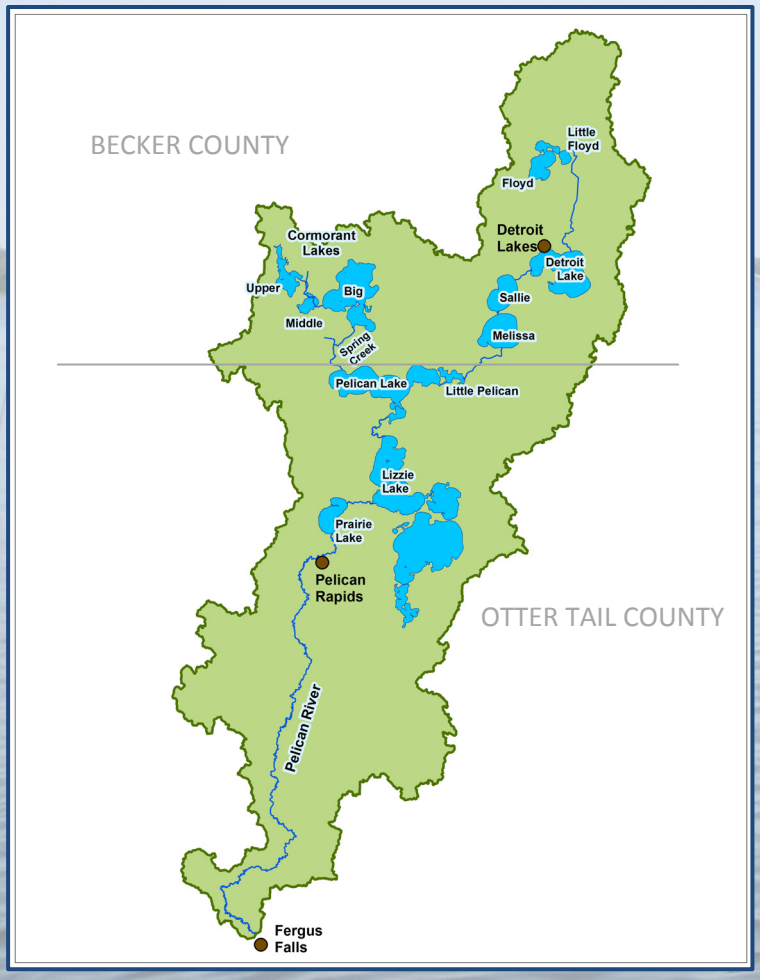
Pelican River Watershed

AIS Prioritization

A planning tool developed for AIS risk management and prevention

2014



ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

RED RIVER BASIN COMMISSION

Report Date:	March 2, 2015
Funded by:	Environment and Natural Resources Trust Fund (ENRTF) Red River Basin Commission Becker County Clay County Otter Tail County Wilkin County Pelican River Watershed District Buffalo Red River Watershed District Wild Rice River Watershed District
Project Partners:	Red River Basin Commission Becker County Clay County Otter Tail County Wilkin County Pelican River Watershed District Buffalo Red River Watershed District Wild Rice River Watershed District
Assessment Development:	Moriya Rufer, RMB Environmental Laboratories, Inc
Data Sources:	Minnesota Department of Natural Resources Pelican River Watershed District International Water Institute Pelican Group of Lakes Improvement District Lake Lizzie Association Prairie Lake Association Cormorant Lakes Watershed District Becker County Otter Tail County

Project Contacts:

Joe Courneya
Red River Basin Commission
1120 28th Ave N., Suite C.
Fargo, ND 58102
218-790-0706
joe@redriverbasincommission.org
http://www.redriverbasincommission.org

Spencer McGrew
Red River Basin Commission
1120 28th Ave N., Suite C.
Fargo, ND 58102
701-356-3183
spencer@redriverbasincommission.org
http://www.redriverbasincommission.org

Moriya Rufer
RMB Environmental Laboratories
22796 County Highway 6
Detroit Lakes, MN 56501
218-846-1465
moriyar@rmbel.info
http://rmbel.info

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Introduction

Background

Aquatic Invasive Species (AIS) are aquatic plants and animals that are not native to Minnesota, and cause environmental changes to our waters, have negative economic consequences to our communities, or are harmful to human health. Minnesota's natural resources are threatened by a number of Aquatic Invasive Species such as Zebra mussels, Flowering rush, Eurasian watermilfoil and Asian carp. Invasive species are usually spread by humans.

Zebra mussels are particularly harmful because they spread so rapidly and there are currently no effective treatment options. They attach to hard surfaces such as boats, docks, boat lifts, aquatic plants, and water intake pipes, and can clog pipes, cut feet, and damage boats. Zebra mussels have a large economic impact to water treatment facilities, lakeshore owners, lake recreators, and the tourism industry.

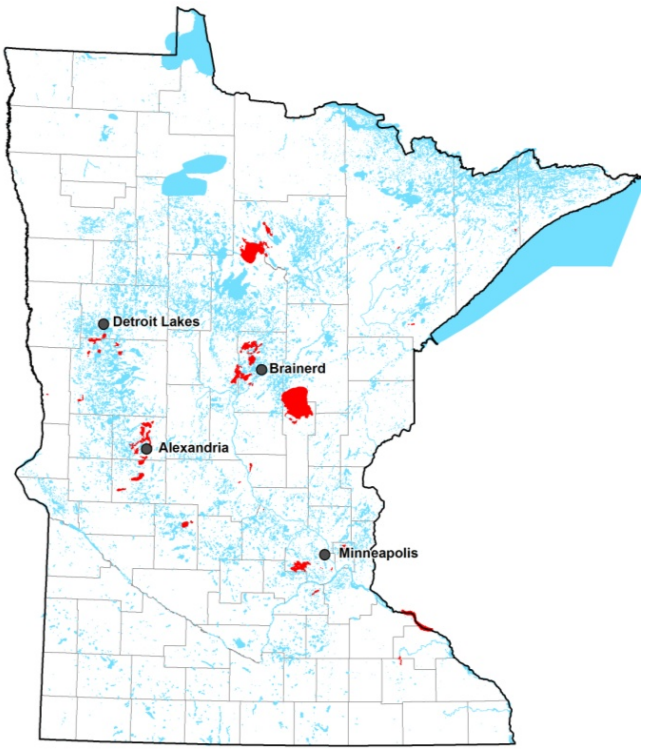


Figure 1. Minnesota Lakes infested by Zebra mussels, 2014.

Zebra mussels also affect the aquatic ecosystem by filtering out microscopic plankton from the water, and therefore removing the food source for other aquatic organisms. This has implications up the food chain, such as affecting fish populations.

As of 2014, approximately 60 lakes in Minnesota were infested with Zebra mussels (MNDNR 2014) (Figure 1). The infestations are clustered around areas with high traffic lakes such as Brainerd, Alexandria, Detroit Lakes and Minneapolis. This pattern of spread is consistent with what has been seen in Michigan, another state with Zebra mussel infested lakes (Johnson *et al.* 2006).

In order to slow or stop the spread of Zebra mussels in Minnesota, a concentrated effort is required. Ideally, unlimited resources would be available to protect all lakes, but in reality budgets are always limited. Therefore, prioritizing lakes due to their risk of infestation is helpful in creating and implementing an AIS management plan.

Project Goals

The goals of this project were to assess the risk of Zebra mussel infestation in the Pelican River Watershed in order to prioritize funding and efforts to prevent the further spread of Zebra mussels. Vectors of spread were evaluated for each lake such as connectivity to other water bodies and public use. In addition, the suitability of each water body to Zebra mussel establishment was evaluated considering water chemistry, substrate, dissolved oxygen and temperature. A report card was developed for each water body showing the available data and assigned risk category.

These risk ratings can be used in AIS management plans to prioritize lakes for specific prevention measures. A summary table using the assessments to form management recommendations is provided (Table 14). This table can used to guide the most efficient use of AIS funds in the most effective way possible.

Setting

Watersheds

A basin is the area of land drained by a river or lake and its tributaries. Minnesota has 4 divides. All water in Minnesota eventually flows into 1 of 4 rivers. The divides are made of 8 major drainage basins (Figure 2). Each drainage basin is made up of smaller units called watersheds, which correspond to the drainage of a tributary or lake system. Watersheds are categorized as major or minor. A minor watershed is the smallest category of watershed. A group of minor watersheds that eventually flows into a common stream, such as the Otter Tail, forms a major watershed. A group of major watersheds that flow into a common river, such as the Red River, form a basin. A group of basins that flow into a common river form a divide.

The Red River of the North Basin stretches from northeastern South Dakota and west-central Minnesota northward through eastern North Dakota and northwestern Minnesota into southern Manitoba. It ends where the Red River empties into the southern end of Lake Winnipeg.

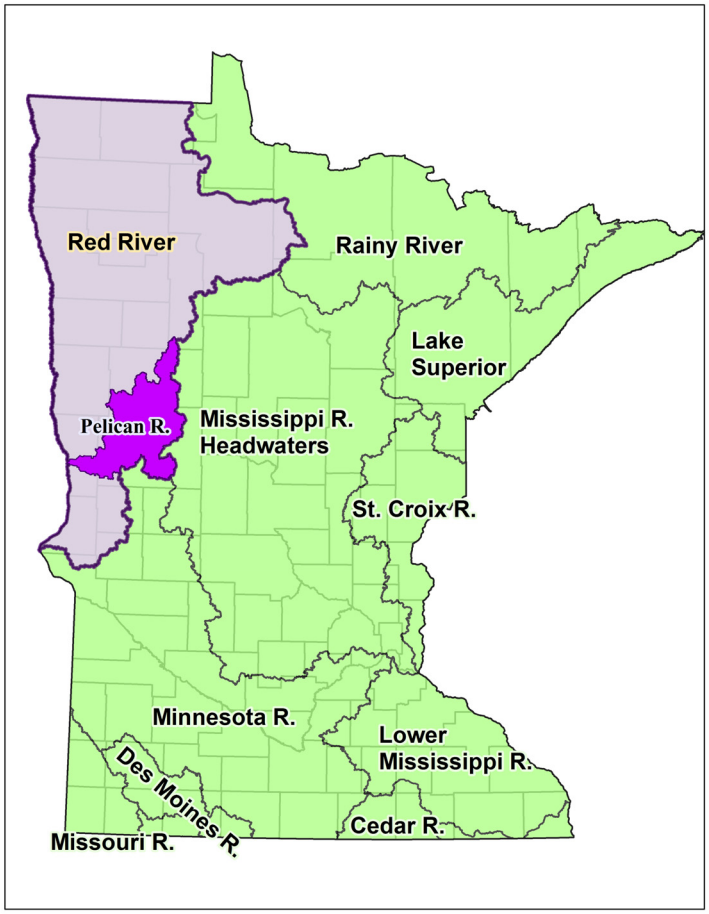


Figure 2. Minnesota showing all major drainage basins, the Red River Basin, and the Otter Tail River Watershed.

The Minnesota portion of the Red River Basin covers about 37,100 square miles in northwestern Minnesota in all or part of 21 counties. It is home to about 17,842 miles of streams and 668,098 acres of lakes.

The terrain of the Red River Basin in Minnesota is very diverse; from the flat, intensively farmed plain just east of the length of the Red River, to the rolling uplands full of trees and lakes in the east-central portion of the basin, to the extensive wetlands in the northeast.

The Otter Tail River Major Watershed represents an area of about 1,920 square miles, including areas of substantial portions of Otter Tail, Becker and Wilkin counties, and very small portions of Clay and Clearwater counties (Figure 3).

The Otter Tail River Watershed is a drainage basin of the Red River and the major tributaries of the watershed are the Ottertail and Pelican Rivers. Where the Otter Tail River joins the Bois de Sioux River is considered to be the headwaters of the Red River. The majority of the lakes in the Red River Basin are found in the Otter Tail River Watershed.

Pelican River Watershed

The Pelican River Watershed is a subset of the Otter Tail River Major Watershed (Figure 3). Its headwaters start north of Floyd Lake in Campbell Creek. From there it flows south through Floyd Lake, through the City of Detroit Lakes to Detroit, Sallie, Melissa, Pelican, Lizzie and Prairie Lakes. From Prairie Lake it flows south and joins the Otter Tail River near Fergus Falls.

There are two taxing entities in the Pelican River Watershed that have jurisdiction over the area. The Pelican River Watershed District encompasses the northern portion of the watershed through Lake Melissa. Pelican Lake has a Lake Improvement District, which encompasses Pelican, Bass, Fish and Little Pelican Lakes and includes all lakeshore properties.

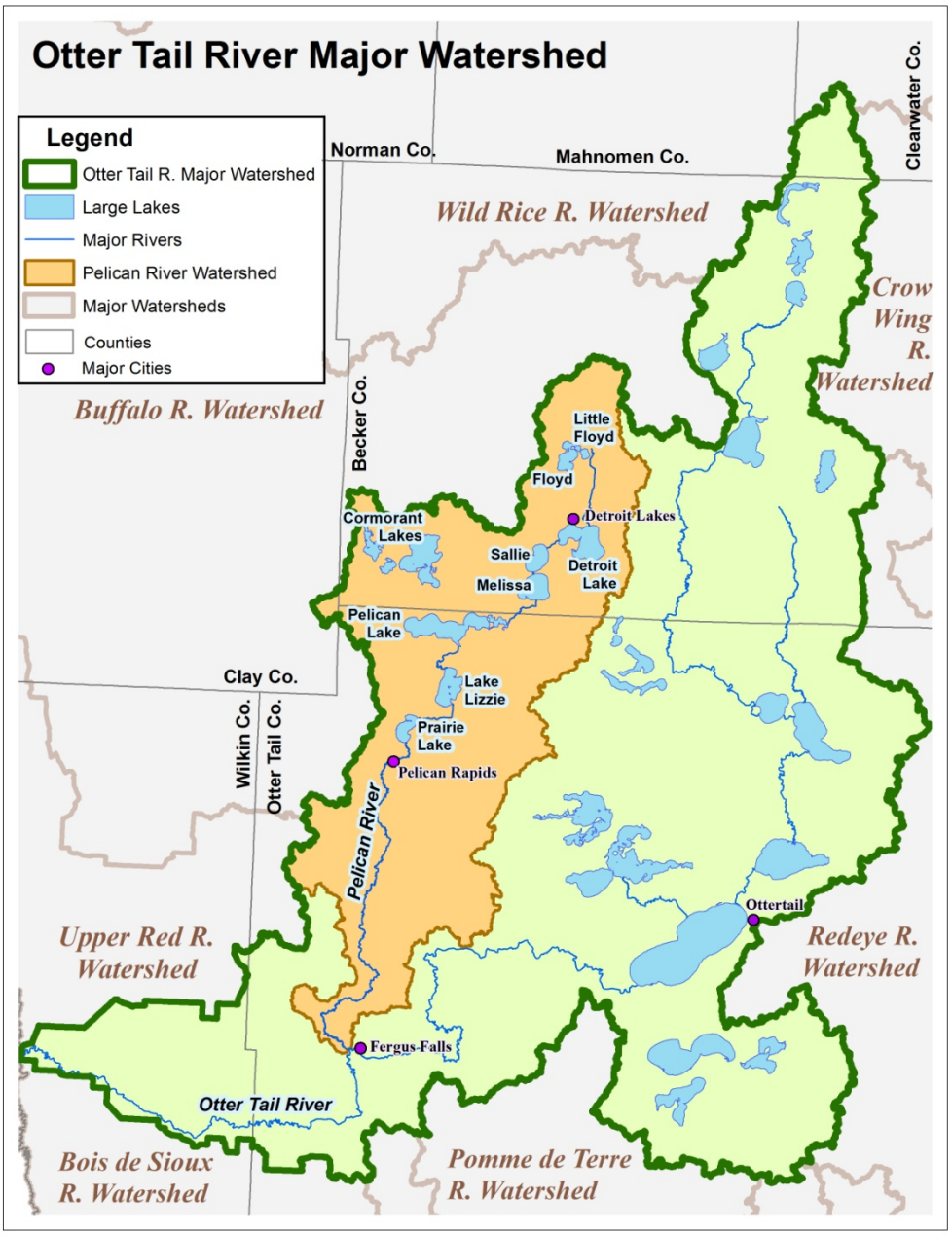


Figure 3. Otter Tail River Watershed and Pelican River Subwatershed with its lakes and rivers.

History of AIS in the Pelican River Watershed

Plants

The first aquatic invasive species (AIS) documented in the Pelican River Watershed was Flowering rush, an emergent plant (Figure 5). It is thought that it was purchased from a nursery and planted in Deadshot Bay intentionally due to its showy pink flowers.

Flowering Rush was first identified in Deadshot Bay in the mid-1970's and spread into the Big Detroit Lake by the end of that decade (Figure 4). By the early 1980's it was found in many places around Big and Little Detroit; and moved down the Pelican River to Muskrat, Sallie and Melissa.

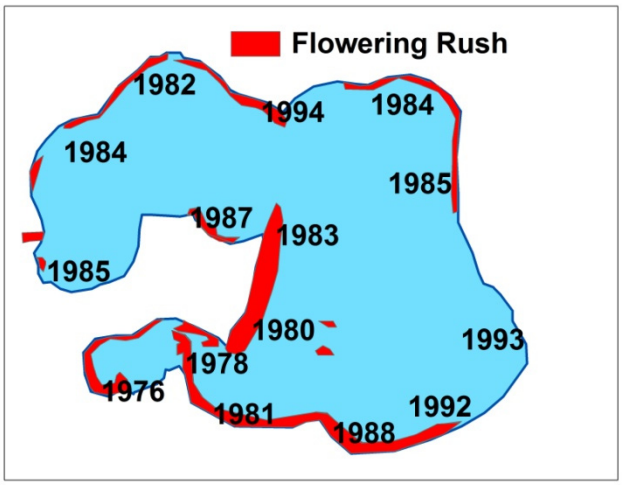


Figure 4. Map of Detroit Lake showing the spread of Flowering rush (prwd.org).

Flowering rush was mechanically harvested from 1967 to the mid 2000s in an effort to keep it under control. In the 2000s the Pelican River Watershed District (PRWD) began chemical herbicide treatment. Initial herbicide treatments were not deemed successful, so in 2010 PRWD adopted a ten-year plan to research effective ways to control Flowering rush. This research has proved successful, and the herbicide *Diquot* has significantly reduced Flowering rush in Detroit, Sallie and Melissa Lakes in the past couple years.

Curly-leaf pondweed is also a common invasive plant in the Pelican River Watershed (Figure 6). It is unknown when it was first established; however, it was most likely introduced to the state by accident in the early 1900s when common carp were intentionally brought to Minnesota. Curly-leaf pondweed has been in Minnesota so long that many people do not realize that it is a non-native species (DNR).

As of 2013, Curly-leaf has been found in Detroit, Sallie, Melissa, Upper Cormorant, Middle Cormorant and Pelican Lakes (Figure 7). It is possible that it exists in other lakes as well and is just not documented.


Figure 5. A Flowering rush plant showing its pink flower and emergent reed-like vegetation.


Figure 6. Curly-leaf pondweed turion (wintering bud) (left), and young Curly-leaf pondweed plant beginning to curl (right).

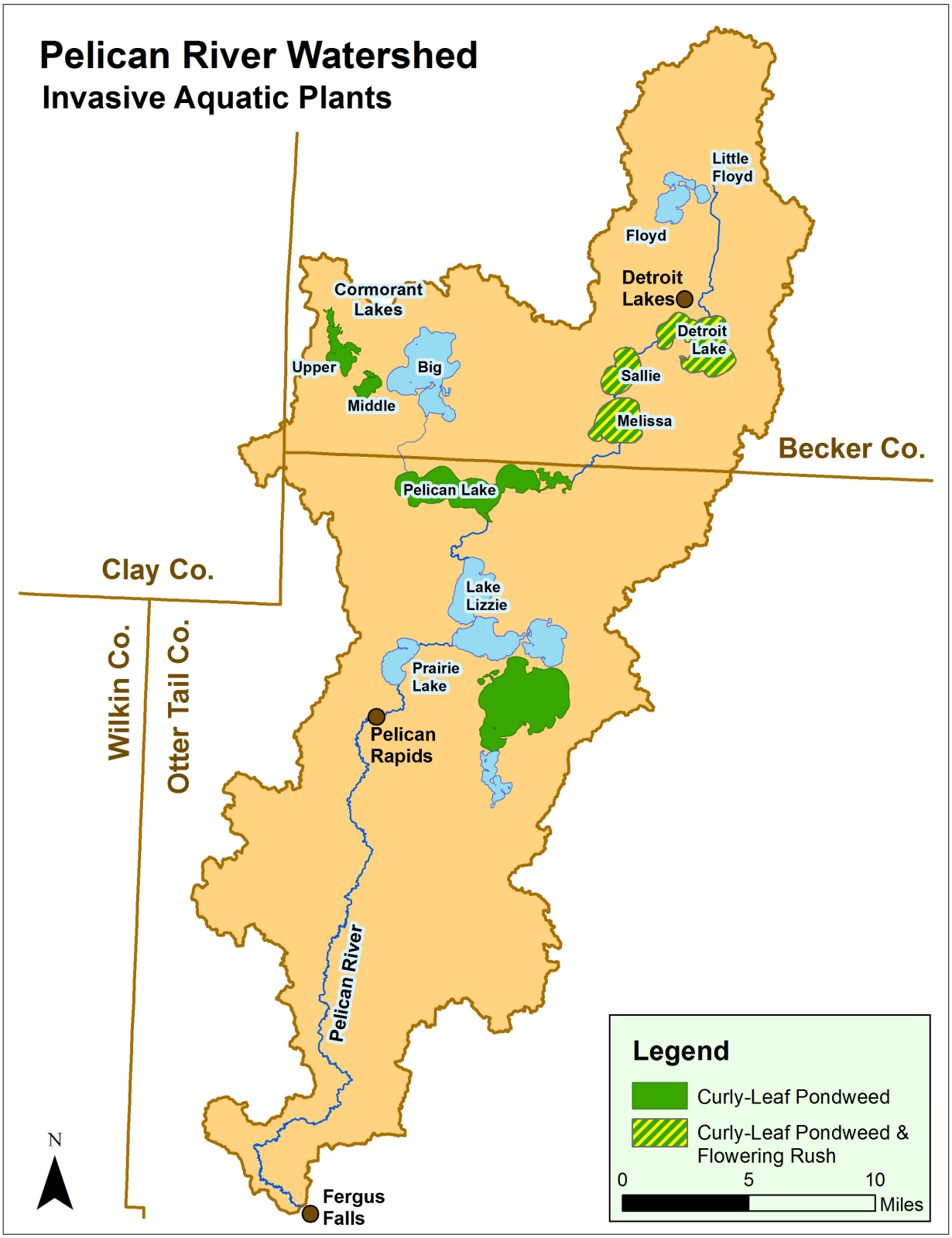


Figure 7. Aquatic plant infestations in the Pelican River Watershed.

Zebra mussels

Zebra mussels were first discovered in the Pelican River Watershed in Pelican Lake. A property owner found them in September of 2009 and the MNDNR confirmed their establishment after a survey that same day. In that survey, larger Zebra mussels were found (1/2-3/4 inches long), which could mean that the mussels had already been there for a year.

Figure 8. Zebra mussels on a sampling plate in Pelican Lake, 2013.

After confirmation in Pelican Lake, the MNDNR looked for Zebra mussels in Lake Lizzie, the next lake downstream. They found a few small Zebra mussels attached to boat lifts at this time. The Zebra mussels in Lake Lizzie could have come down the Pelican River from Pelican Lake; or it could have been an independent infestation. Downstream dispersal is discussed in further detail on page 18 of this report.

In 2011, Zebra mussels were found in Prairie Lake. Again, it is possible that these mussels came downstream from Lake Lizzie, but it also could have been an independent infestation. It was approximately two years between the infestation in Lizzie and Prairie Lakes. (Figure 9).

In 2012, Zebra mussels were found in the Otter Tail River after it's confluence with the Pelican River. From Orwell Reservoir, they have spread into Wilkin County (Figure 10). In 2013, they were found in Lake Lida (Figure 9).

As of 2013, Zebra mussels had only been found downstream from Pelican Lake. This means that for five years after the Pelican Lake infestation, no lakes in Becker County were infested. As of 2014, this changed and zebra mussels were found in Lake Melissa, which is upstream of Pelican Lake. This upstream spread was most likely due to lake users (Figure 9).

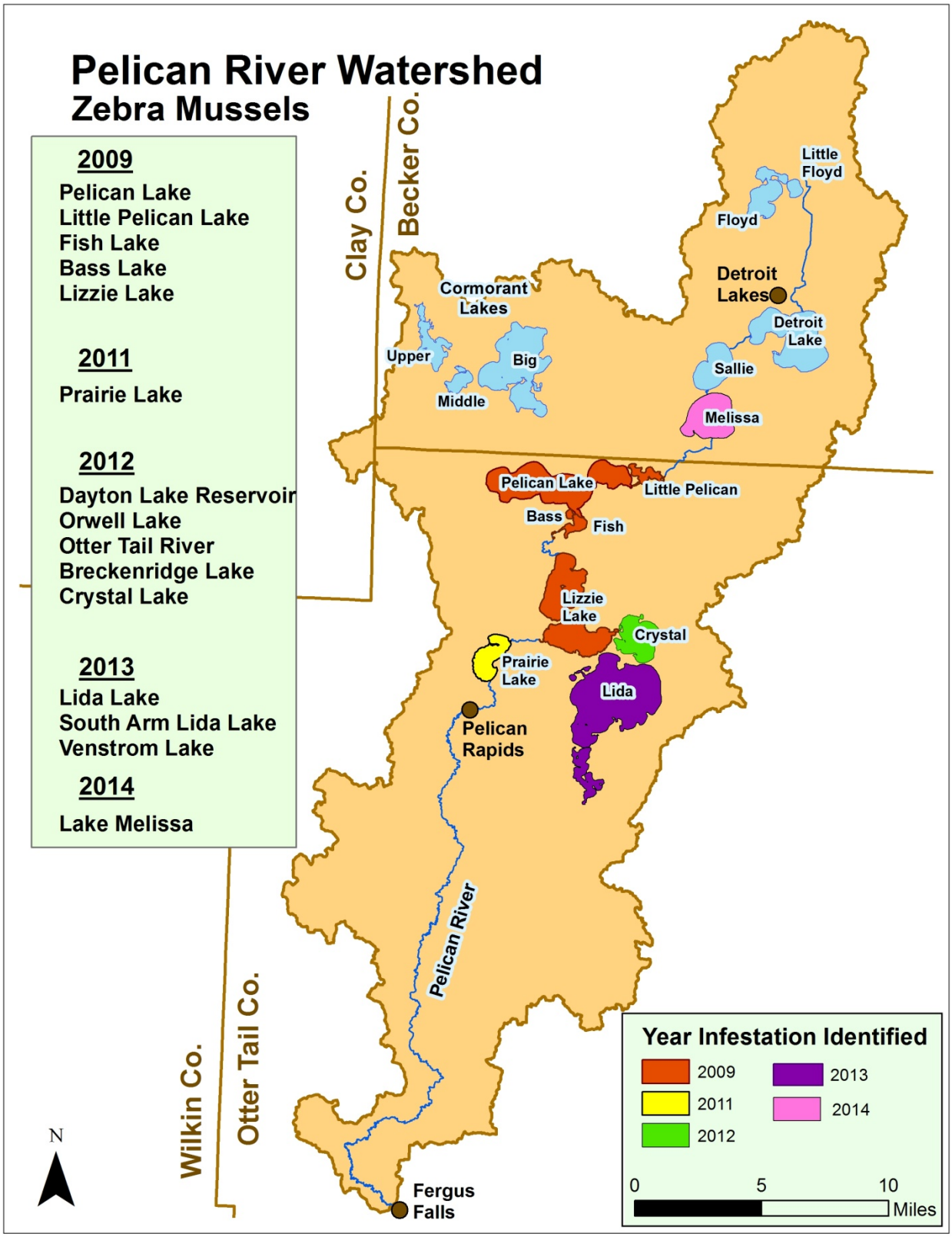


Figure 9. The spread of Zebra mussels in the Pelican River Watershed from 2009-2013.

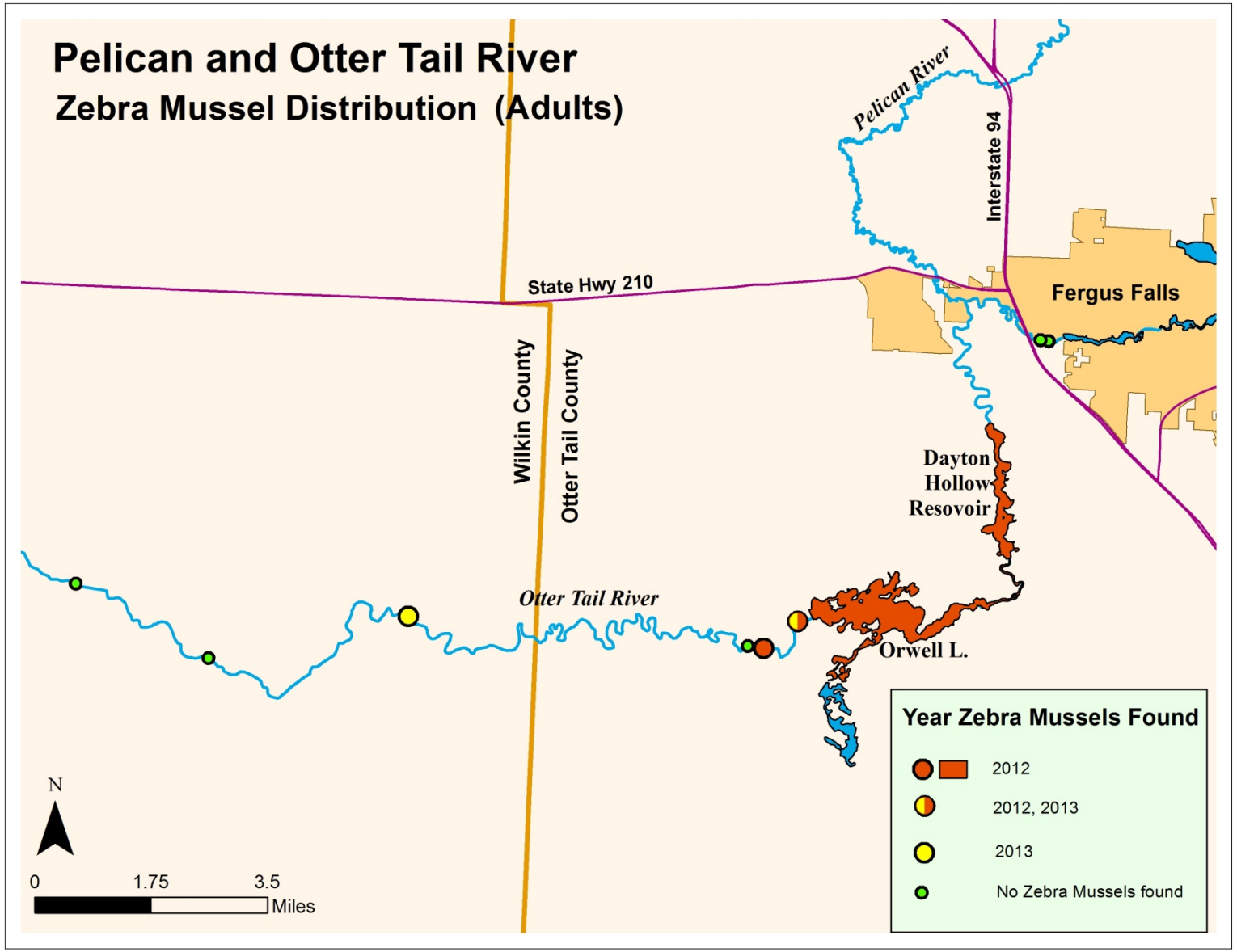


Figure 10. The spread of zebra mussel adults in the Otter Tail River.

Zebra Mussel Risk Assessment

Lake Methods

All the major lakes in the Pelican River Watershed have water chemistry, temperature, and dissolved oxygen data available (Table 1). These data were collected by the Pelican River Watershed District, Lake Associations, and the Pelican Group of Lakes Improvement District, and were used in the Zebra mussel risk assessment for lakes.

Table 1. Major lakes in the Pelican River Watershed.

Lake Name	Lake ID
Upper Cormorant	03-0588-00
Middle Cormorant	03-0602-00
Big Cormorant	03-0576-00
Big Floyd	03-0387-02
Little Floyd	03-0386-00
Detroit	03-0381-00
Sallie	03-0359-00
Melissa	03-0475-00
Pelican	56-0786-00
Little Pelican	56-0761-00
Lizzie	56-0760-00
Prairie	56-0915-00

Water Connectivity

One of the highest risks to a water body becoming infested with Zebra mussels is if a nearby upstream lake is infested (Horvath 1996). Infested lakes can serve as a source of Zebra mussel veligers for downstream water bodies and adjacent lakes; however the inter-lake distance must be fairly close for the spread to be possible. Various studies have suggested a downstream veliger dispersal of 1-18 km (0.6-11 miles) in small streams (Lucy *et al.* 2005; Horvath *et al.*1996). In this assessment, lakes that have an infested lake already identified less than 20 km (12 mi) upstream are at a high risk of infestation since the Zebra mussels could spread downstream (Table 2). Lakes that are in a chain have a moderate risk because if any upstream lakes get infested with Zebra mussels (<20 km), they could spread downstream. Headwaters lakes have a very low risk of infestation through water connectivity.

In addition to stream connections, adjacent water bodies have the potential to infest each other via boats going from one lake to another, regardless if the lakes are connected or not.

Table 2. Water connectivity and the related risk of Zebra mussel infestation.

Water Connectivity Category	Risk of infestation
Headwaters lake	Low risk
Chain of lakes (<20 km apart)	Moderate risk
Upstream infested lake (<20 km apart)	High risk

Public Use

Boats and water related equipment have been shown to be one of the largest vectors in the spread of Zebra mussels (Johnson *et al.* 2001). Public use can be measured by some surrogate statistics. First, the number of public accesses and related parking spots are known on each lake. The more public accesses on the lake, the more potential boats can use the lake. Secondly, the number of resorts and hotels on the lake are documented through the Detroit Lakes Area Chamber of Commerce. A lot of resorts and hotels

on the lake show that there are many visitors to the lake outside the immediate area, which poses more risk for infestation. Thirdly, the number of fishing tournaments and special events on lakes is documented through a permitting process. Fishing tournaments and special events draw visitors to the lakes. And finally, the homeowners on the lake own an average of one dock/boat lift/boat per property. The purchase of an infested boat lift or other water related equipment has been the source of several documented new infestations in Minnesota. This use relationship coupled with transport of boats and water equipment from lake to lake, increases the probability of infestation. "Destination lakes" for popular fish species like walleyes and muskies along with popular recreation waters for boating and swimming are at increased risk for infestation.

Public access inspections data was reviewed for each lake, but difficulty in standardizing data across lakes challenges the reliability of the data to be used as part of public use data for the final risk assessment.

The numbers used represent boating units per summer. For parcels, an average of one boat per parcel was used in the calculation. For fishing tournaments, the total boats participating in the tournament was used.

For access parking and resort units, the numbers were multiplied by 15 weeks of summer between Memorial Day and Labor Day for an estimated total summer use. This number is likely underestimated, but the ratings still come out the same either way, showing that the calculations are very robust (Tables 3-4). In weighting the resorts and accesses by the 15 weeks of summer, they are weighted appropriately compared to the resident parcels.

Table 3. Public use rating calculations.

Lake	Parcels*	Access Parking*	Resort Units*	Fishing Tournaments*	Total*	Risk
Pelican	999	600	4065	70	5,734	High
Big Cormorant	643	360	3930	70	5,003	High
Detroit	608	240	3330	40	4,218	High
Melissa	397	300	720	0	1,417	Moderate
Middle Corm	198	270	495	0	963	Moderate
Sallie	236	495	75	0	806	Moderate
Floyd	380	225	0	0	605	Low
Lizzie	337	165	0	0	502	Low
Upper Corm	233	150	150	0	533	Low
Little Floyd	111	120	180	0	411	Low
Prairie	138	36	0	0	174	Low
Little Pelican	120	0	0	0	120	Low

**All numbers are the total number of boats for the 15 weeks of summer.*

Table 4. Use ratings and assigned risk for Zebra mussel infestation.

	Low Risk	Moderate Risk	High Risk
Total Boat Units (the sum of public access parking spaces, resort units, lake parcels and special events)	0-700	701-2,000	2,000+

Water Chemistry

Available water quality data was compiled and analyzed for each major lake and stretch of river in the Pelican River Watershed. The average was calculated for each available parameter. The values were then compared to the ranges in Table 5 to determine the potential for Zebra mussels to establish and reproduce in the water body. Calcium was considered first, based on its importance in shell formation (Mackie & Schloesser 1996); however calcium data were not available for all water bodies. Next, alkalinity, hardness and pH were considered (Mackie & Claudi 2010; Hincks & Mackie 1997). Lastly, Secchi depth, chlorophyll a and total phosphorus were considered, although they are not sufficient parameters alone to assess risk (Mackie & Claudi 2010).

Total phosphorus and chlorophyll a are useful for determining the lake's trophic state, which does affect suitability for Zebra mussels. Zebra mussels thrive best in mesotrophic lakes (Karatayev et al. 1998, Nelepa 1992). Eutrophic lakes have a lower suitability due to too much phosphorus and chlorophyll a, and usually softer substrates.

Table 5. Water column Zebra mussel suitability criteria (Mackie and Claudi 2010).

	Risk		
Parameter	**Low Little Potential for Larval Development**	**Moderate (survivable, but will not flourish)**	**High (favorable for optimal growth)**
Calcium (mg/l)	8-15	15-30	>30
pH	7.0-7.8 or 9.0-9.5	7.8-8.2 or 8.8-9.0	8.2-8.8
Hardness (mg/L)	30-35	55-100	100-280
Alkalinity (mg/L)	30-55	55-100	100-280
Conductivity (umhos)	30-60	60-110	>110
Secchi depth (m)	1-2 or 6-8	4-6	2-4
Chlorophyll a (ug/L)	2.0-2.5 or 20-25	8-20	2.5-8
Total Phosphorus	5-10 or 35-50	10-25	25-35

Substrate Suitability

One of the reasons Zebra mussels are such a nuisance is that they attach to hard substrates via their byssal threads. Zebra mussels prefer a hard substrate for attachment although they will attach to plants as well (Karatayev et al. 1998). In lakes, they have been documented to colonize on rocks, docks, boatlifts and water intake pipes. Lakes with mainly soft substrate and not many man-made structures may not be as supportive to Zebra mussel colonization. Plants have just moderate suitability because in Minnesota they die off at the end of each summer, meaning the Zebra mussels that are attached to them must crawl to other substrates or die off during winter (Karatayev et al. 1998). Comments are made for each water body, its dominant substrate, and its likelihood to support Zebra mussels. The substrate types were determined by the MNDNR (Table 6).

Table 6. Substrate descriptions and their suitability to Zebra mussel survival.

Substrate (MNDNR)	**Description**	**Suitability to Zebra mussels**
Muck	Decomposed organic material	Low
Marl	Calcareous material	Low
Silt	Fine material with little grittiness	Low
Sand	Diameter less than 1/8 inch	Low
Submerged macrophytes	Underwater rooted plants	Moderate
Gravel	Diameter 1/8 to 3 inches	High
Rubble	Diameter 3 to 10 inches	High
Boulder	Diameter over 10 inches	High

Temperature

Zebra mussels begin reproduction when water temperature is above 12 C, but ideal reproduction temperature occurs above 17-18 C (McMahon 1996). The upper thermal limit for North American Zebra mussels occurs somewhere around 30 C (McMahon 1996) The optimal temperature range for zebra mussel spawning in North America is estimated to between 18-26 C.

In Minnesota, lakes are usually ice-covered on average from November to March. During the ice-covered season, it is assumed that the water temperature is too cold for Zebra mussel spawning. However, the Zebra mussels do over-winter at the bottom of the lake (Mackie *et al.* 1989).

In summer, Minnesota lakes rarely exceed 30 C (86 F); therefore, it is likely that the Zebra mussels reproduce all summer once the water temperature reaches 17-18 C. This occurrence has been documented in Pelican Lake, where Zebra mussel veligers were first found at 18 C in 2012 and 19 C in 2013 (Rufer 2014).

The maximum temperature was reported for each lake and the risk was assigned based on if the lake exceeded 32 C in mid-summer or not (Table 7). The lake's mixing regime and period of hypolimnetic anoxia were also noted as research has found that few Zebra mussel veligers occur below the thermocline in temperate lakes (Mackie *et al.* 1989).

Table 7. Temperature values and their impact on Zebra mussel survival.

Survival Potential	Temperature Range	Risk Rating
Prevent zebra mussel establishment	> 32 C	Low
Little impact on mussel survival	8 – 31 C	High

Infestation Risk Rating

The two main vectors of spread for Zebra mussels are lake connectivity and public use. The risks from these two categories were combined for an overall risk of infestation rating for each lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 8).

Table 8. Combined infestation risk rating using public use and connectivity.

	Public Use Total Boat Units	Connectivity	Combined Risk Rating
Low Risk	0-700	0 = Headwaters Lake	0-1,000
Moderate Risk	701-2,000	2,500 = Chain of Lakes	1,000-6,000
High Risk	2,000+	5,000 = Infested or Infested lake upstream	6,000+

Zebra mussel Suitability Rating

The two main factors for zebra mussels thriving in a lake are suitable water chemistry and suitable substrate. The risks from these two categories were combined for an overall suitability rating for each lake. This suitability rating can be interpreted as the probability that Zebra mussels will thrive in the lake. A scoring system was used to weight each of these two categories, which resulted in three overall risk categories (Table 9).

Table 9. Combined Zebra mussel suitability rating using water chemistry and substrate.

	Water Quality	Substrate	Combined Risk Rating
Low Risk	0 = The majority of averages in green category.	0 = Sand, Silt, Muck	0 - Low
Moderate Risk	500 = The majority of averages in yellow category.	500=Submerged macrophytes	1000 - Moderate
High Risk	1,000 = The majority of averages in red category.	1,000 = Rocks, Gravel, Rubble	2000 - High

River Methods

Water chemistry data have been collected throughout the Pelican River by the Pelican River Watershed District and the International Water Institute (Figures 12-13). For this assessment, the Pelican River was split into two sections: Becker County and Otter Tail County (Table 10, Figure 11).

Table 10. Pelican River and tributary sections in this report.

Section	Stream
1	Pelican River Becker County: Floyd Lake to Pelican Lake
2	Pelican River Otter Tail County: Pelican Lake to Fergus Falls

Unlike lakes, rivers are not usually ideal habitat for Zebra mussels. Studies have shown that the turbulence in streams and rivers causes high Zebra mussel veliger mortality and assists in preventing the veligers from settling on hard substrates (Horvath & Lamberti 1999). Without an infested lake upstream continually supplying the stream with Zebra mussel veligers, the stream is unlikely to sustain a large population on its own. Although streams can be pathways for downstream infestations, the probability of Zebra mussel veliger survival decreases with distance downstream (Horvath & Lamberti 1999; Horvath *et al.* 1996).

For small streams (like the Pelican River), even the presence of an infested lake upstream supplying veligers will probably not allow the stream to support populations of Zebra mussel adults. Strayer (1991) found that in streams <10 meters wide (33 feet) there were no stable adult Zebra mussel populations. Zebra mussel adults seem to only survive in the largest rivers (>100 m wide) or large pools and stagnant backwaters.

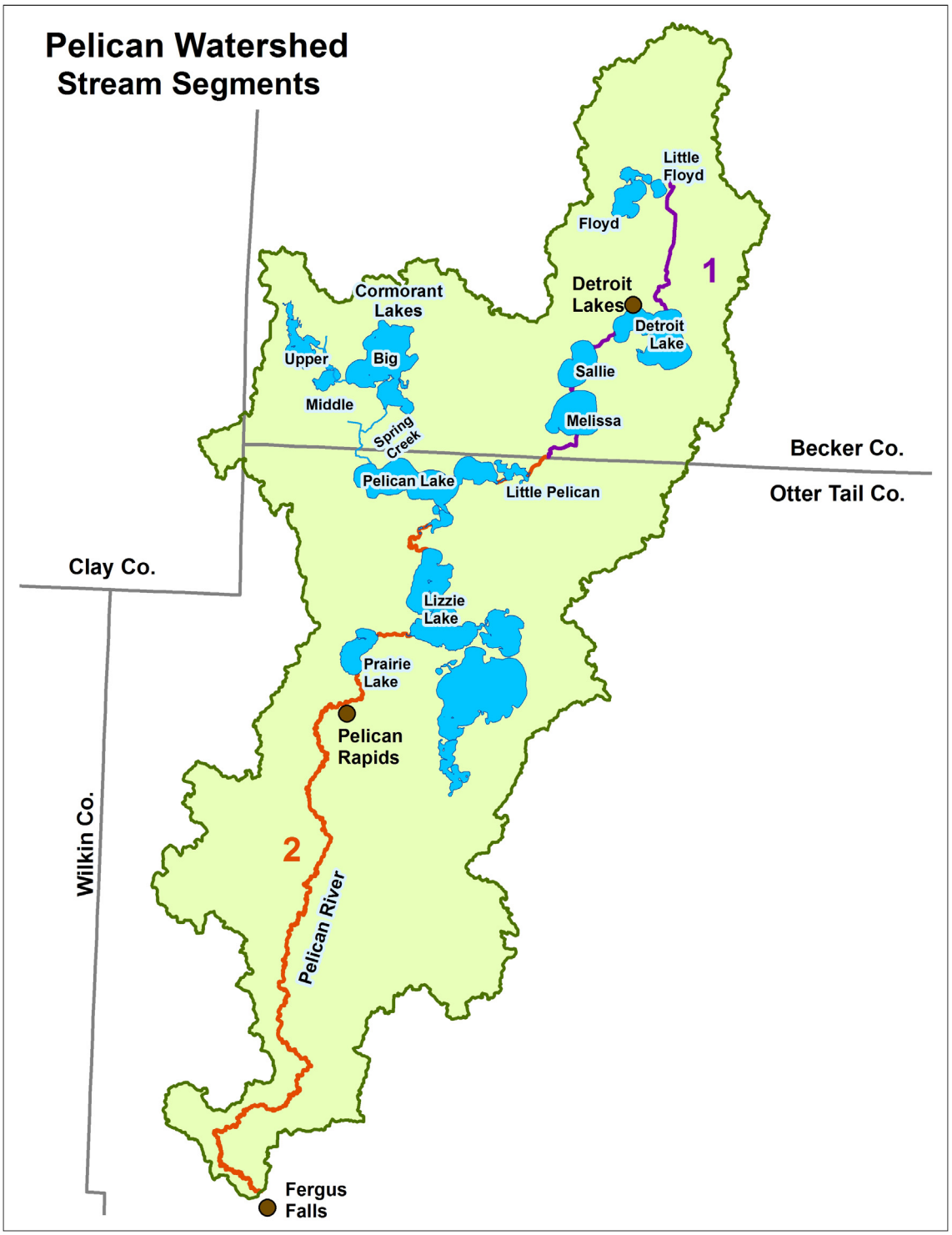


Figure 11. Pelican River stream segments used in this report.

Turbulence & Flow
Studies show that turbulence or shear may be the limiting factor for Zebra mussel survival in streams and rivers (Horvath & Lamberti 1999). Although specific flow rates are not determined, it appears that in streams and rivers, zebra mussels are only self-sustaining behind dams and stagnant backwaters. Therefore, for the purposes of this risk assessment, any stream sites are considered to have low risk due to the flow in the river, even if there is no flow data available.

Downstream Dispersal
Zebra mussel veliger abundance has been shown to decrease with distance in streams. Veligers have been found 10-18 km (6-11 miles) downstream of an infested lake in stream systems (Horvath *et al*.,1996). In heavily vegetated wetland stream systems, the dispersal distance has been found to be about 1 km (0.6 mile), which is much lower. There are a few possible factors affecting Zebra mussel veliger survival in wetlands streams, including aquatic vegetation, low water velocity, unsuitable water characteristics, limited substrate availability, and/or increased predation pressure (Bodamer & Brossenbroek 2008). These results show that protecting aquatic vegetation from removal, limiting stream dredging, and installing wetlands could help as a barrier for spreading Zebra mussels downstream.

The Pelican River has some submerged vegetation, usually lined with emergent vegetation, has sandy/rocky substrate and mostly clear water. Taking into account the literature and the condition and habitat of the river, for the purposes of the risk assessment for the Pelican River, 32 km (20 mi) is considered the longest a veliger could theoretically travel (Table 11). This distance of 32 km is very conservative, but until further research is conducted a better estimate is not available.

Water Quality
The water chemistry ranges from Mackie and Claudi 2010 (Table 5) can be applied to streams; however, more applicable water quality parameters to streams are turbidity and total suspended solids. Turbidity has been shown to limit Zebra mussel survival. Although acute exposures to high turbidity can negatively affect a Zebra mussel population, they are able to compensate for some high exposure (McMahon 1996). Chronic high turbidity has a greater negative effect on Zebra mussel survival, as it inhibits their filtering ability (McMahon 1996, Karatayev *et al.* 1998). Mackie and Claudi (2010) suggest upper limits for Zebra mussel survival for total suspended solids at 96 mg/L and turbidity at 80 NTU, if the turbidity is caused mainly from sediment suspension. The combination of high temperature and high turbidity seem to be most stressful to Zebra mussels (Alexander 1994). For the purposes of this study, the Mackie and Claudi (2010) numbers are used as guides, but further research is needed to be more decisive conclusions can be made.

Infestation Risk Rating
In the Pelican River Watershed, the lakes are fairly close in proximity to each other, and therefore the distance between lakes is possibly short enough to transport veligers to downstream lakes. Because a continual source of Zebra mussel veligers from a lake is needed to sustain a stream population of Zebra mussels, distance from the nearest lake is the limiting factor for an infested stream. In streams, public use is secondary, and a larger threat to downstream lakes than the stream itself (Table 11).

Table 11. Infestation Risk Rating for streams and rivers.

	Risk Rating Low	Moderate	High
Connectivity	No lakes connected	No upstream infested lakes	Upstream infested lakes
Distance from nearest upstream lake*	>32 km (20 mi)	10-32 km (6.2-20 mi)	0-10 km (0-6.2 mi)
Presence of aquatic vegetation/wetland conditions	Yes	Moderate	No
Public use	No public use	Fishing, ricing, bait harvest, waterfowl hunting, paddle sports	Motorboating, camping, fishing, bait harvest, waterfowl hunting, paddle sports
Overall rating	>32 km (20 mi) from nearest upstream lake	10-32 km (6.2-20 mi) from nearest upstream lake	0-10 km (0-6.2 mi) from nearest upstream lake

**possible limiting parameter for streams*

Suitability Risk Rating

Total suspended solids data were available from the Pelican River. Results show that it is well below the threshold of 96 mg/L (Figures 12-13). Therefore, the total suspended solids are most likely not limiting to Zebra mussels. It appears that flow is the main potential limiting factor to Zebra mussel establishment, so it was given the most weight when considering suitability (Table 12).

Table 12. Infestation Risk Rating for streams and rivers.

	Risk Rating Low	Moderate	High
Habitat suitability/substrate	Muddy water, silty mucky substrate	Clear to cloudy water, gravel and rocks	Clear water, rocky, very low flow
Flow rate*	High flow	Moderate flow	Low flow, dams and stagnant backwaters
Water chemistry*	Average turbidity and/or total suspended solids over the thresholds	Maximum turbidity and/or total suspended solids over the thresholds	Average and maximum turbidity and/or total suspended solids under the thresholds
Maximum temperature	>30 C	--	<30 C
Average dissolved oxygen	<7 mg/L	--	> 7 mg/L
Overall rating	High flow and high turbidity and/or total suspended solids	Moderate flow and low turbidity and/or total suspended solids; rocky substrate	Low flow, dams and backwaters and low turbidity and/or total suspended solids; rocky substrate

**possible limiting parameter for streams*

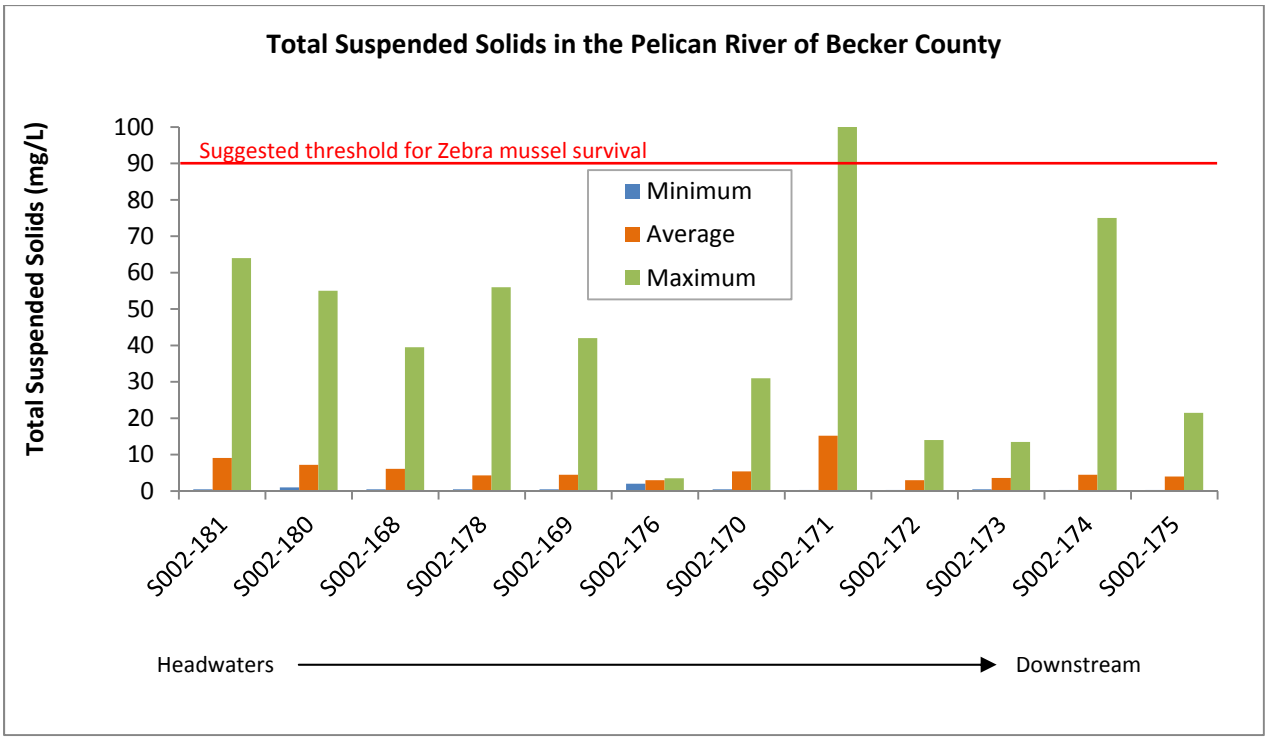


Figure 12. Total suspended solids results in the Pelican River of Becker County. Refer to site locations in Figure 12.

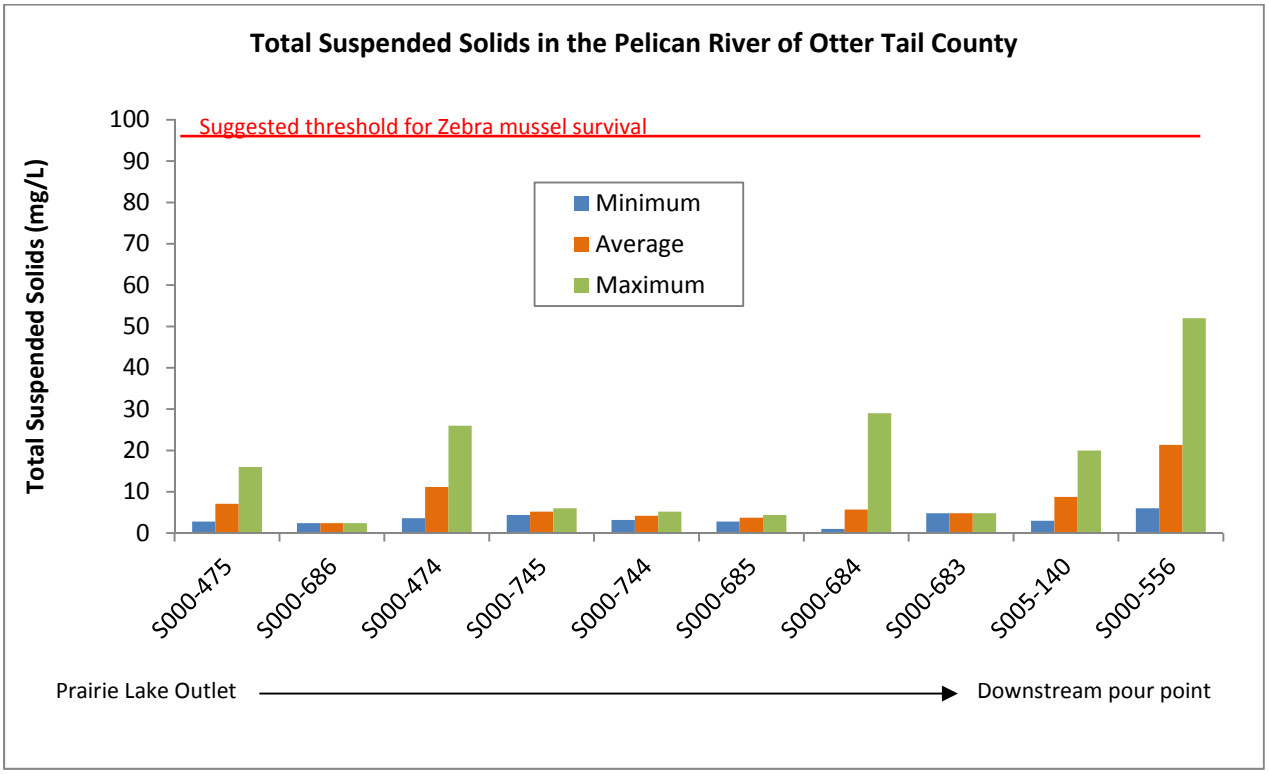


Figure 13. Total suspended solids results in the Pelican River of Otter Tail County. Refer to site locations in Figure 13.

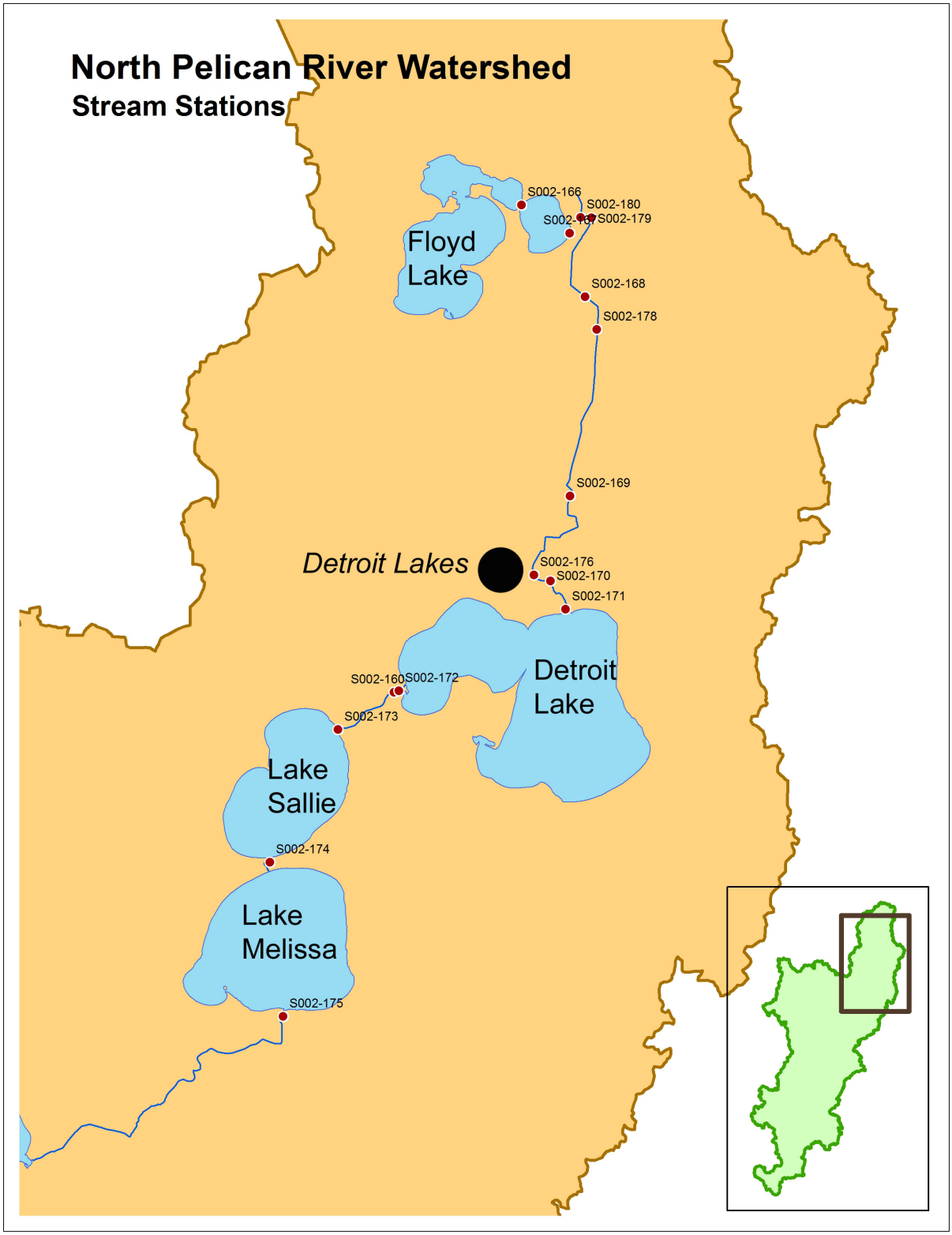


Figure 14. Stream monitoring sites in the Becker County portion of the Pelican River.

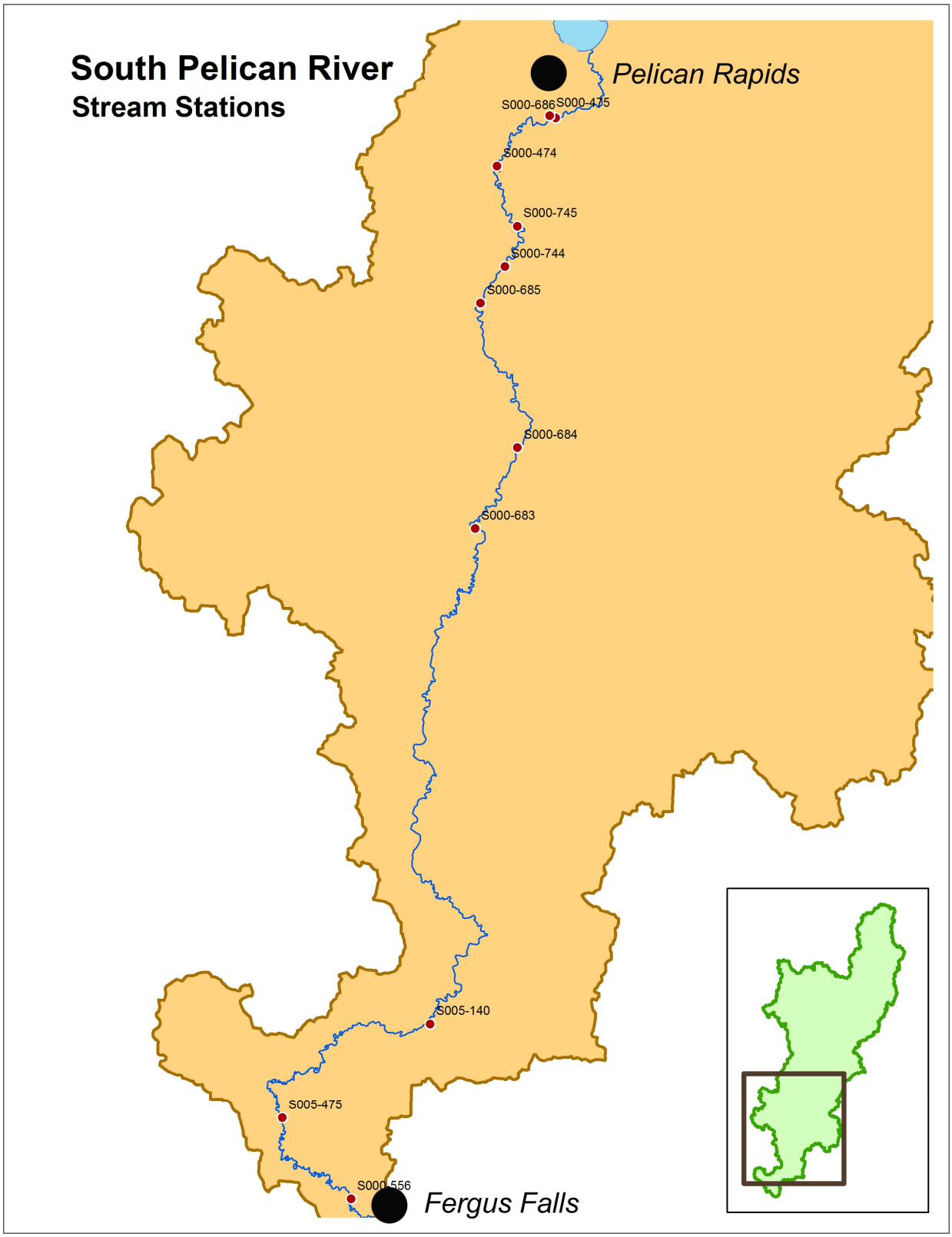


Figure 15. Pelican River stream sites in Otter Tail County.

Lake Risk Assessment Summary: Floyd Lake

Infestation Risk Rating: Low
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Otter Tail
Location: North of Detroit Lakes
Surface Area: 1,177 acres
Percent Littoral: 73%
Max Depth: 34 ft
Inlet: Campbell Creek

Summary

The only probable vector of spread for Floyd Lake is by humans and their boats/equipment since it is a headwaters lake. If Zebra mussels were introduced into Floyd Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (380)	605	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (225)		
Substrate Suitability (mean abundance, DNR)		Sand, Silt	56.3%, 33.3%	Low

Water Chemistry Risk

Parameter	Unit	Average	Sample Size	Suitable Range
Calcium*	Mg/L	NA	0	>30
pH*		8.6	63	8.2-8.8
Alkalinity*	mg/L	197	8	100-280
Conductivity*	uS/cm	380	53	>110
Secchi Depth	ft	9.6	82	6.56-13.12
Chlorophyll a	ug/L	3.8	19	2.5-8
Total Phosphorus	ug/L	17.6	35	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk

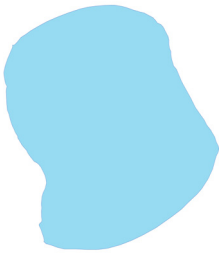
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 C (218 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Little Floyd Lake

Infestation Risk Rating: Low
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Otter Tail
Location: North of Detroit Lakes
Surface Area: 214 acres
Percent Littoral: 44%
Max Depth: 34 ft
Inlet: Pelican River



Summary

The only probable vector of spread for Little Floyd Lake is by humans and their boats/equipment since its only upstream lake is Floyd Lake (a headwaters lake.) If Zebra mussels were introduced into Little Floyd Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	One upstream headwaters lake	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (111)	411	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (300)		
Substrate Suitability (mean abundance, DNR)		Sand, silt, muck	45%, 32 %, 27%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Count	Suitable Range
Calcium*	mg/L	NA	0	>30
pH*		8.3	471	8.2-8.8
Alkalinity*	mg/L	NA	0	100-280
Conductivity	umhos	407.1	394	>110
Secchi Depth	ft	8.6	306	6.56-13.12
Chlorophyll a	ug/L	8.8	94	2.5-8
Total Phosphorus	ug/L	29.2	255	25-35

**primary parameters for zebra mussel Suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

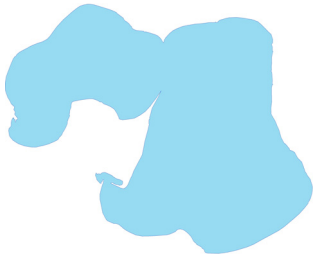
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.9 °C (316 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Detroit Lake

Infestation Risk Rating: High
1. Connectivity: Low Risk
2. Public Use: High Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Otter Tail
Location: Detroit Lakes
Surface Area: 3,067 acres
Percent Littoral: 62%
Max Depth: 89 ft
Inlet: Pelican River



Summary

Detroit Lake has a low probability of infestation from upstream since there is only one main lake upstream, and no current Zebra mussel infestations upstream of the lake. Due to its location within the City of Detroit Lakes, the lake has very high public use, which is high risk. If Zebra mussels were introduced into Detroit Lake they would most likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	One upstream lake	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (608)	4,218	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (3610)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel	47%, 13%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.1	737	8.2 - 8.8
Alkalinity*	mg/L	186.4	14	100 - 280
Conductivity*	uS/cm	410.4	587	>110
Secchi	ft	10.2	355	6.56-13.12
Chlorophyll a	ug/L	8.3	41	2.5 - 8
Total Phosphorus	ug/L	25.4	43	25 - 35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk

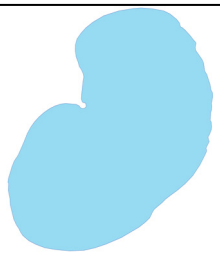
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 C (309 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Sallie

Infestation Risk Rating: Moderate
1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 1272.88 acres
Percent Littoral: 45%
Max Depth: 50 ft
Inlet: Pelican River



Summary

Lake Sallie is in the middle of a chain of lakes, which is a moderate infestation risk. If any upstream lakes become infested, it will spread to Lake Sallie. Lake Melissa, which is immediately downstream from Lake Sallie is infested. If Zebra mussels were introduced into Lake Sallie they would most likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 immediate downstream infested lake	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (236)	806	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (570)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	80%, 14%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	486	8.2-8.8
Alakalinity*	mg/L	190.0	5	100-280
Conductivity*	uS/cm	413.5	437	>110
Secchi Depth	ft	7.5	411	6.56-13.12
Chlorophyll a	ug/L	18.3	88	2.5-8
Total Phosphorus	ug/L	37.0	346	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.7 °C (287 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Melissa

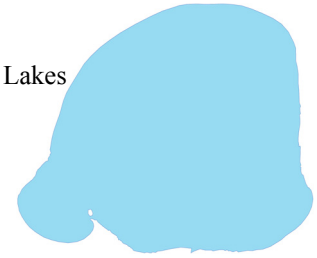
Overall Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 1,850 acres
Percent Littoral: 51%
Max Depth: 37 ft
Inlet: Pelican River



Summary

Lake Melissa is currently infested with Zebra mussels. Due to suitable water chemistry and substrate, Zebra mussels are likely to thrive in Lake Melissa.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	4 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (397)	1,417	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (1,020)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	82%, 10%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	304	8.2-8.8
Alkalinity*	mg/L	200	1	100-280
Conductivity*	uS/cm	392.8	271	>110
Secchi Depth	ft	8.8	246	6.56-13.12
Chlorophyll a	ug/L	11.3	11	2.5-8
Total Phosphorus	ug/L	23.0	18	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	29.3 °C (357 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Upper Cormorant

Overall Risk Rating: Low
1. Connectivity: Low Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Ottertail
Location: West of Detroit Lakes
Surface Area: 926.83 acres
Percent Littoral: 51%
Max Depth: 29 ft
Inlet: From Bijou Lake

Summary

The only probable vector of spread for Upper Cormorant Lake is by humans and their boats/equipment since it is a headwaters lake. If Zebra mussels were introduced into Upper Cormorant Lake they would likely infest the lake, but may not thrive in large numbers due to the lack of hard substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Headwaters	0 upstream lakes	Low
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (233)	533	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (300)		
Substrate Suitability (mean abundance)		Sand, silt, muck	25%, 39%, 35%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		NA	0	8.2-8.8
Alakalinity*	mg/L	NA	0	100-280
Conductivity*	uS/cm	NA	0	>110
Secchi	ft	7.4	91	6.56-13.12
Chlorophyll a	ug/L	13.4	44	2.5-8
Total Phosphorus	ug/L	31.1	44	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28.4 °C (19 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Middle Cormorant

Infestation Risk Rating: Moderate
1. Connectivity: Moderate Risk
2. Public Use: Moderate Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: West of Detroit Lakes
Surface Area: 408.72 acres
Percent Littoral: 35%
Max Depth: 40 ft
Inlet: Upper Cormorant Lake

Summary

Middle Cormorant Lake is in the middle of a chain of lakes, which is a moderate infestation risk. If any upstream lakes become infested, it will spread to Middle Cormorant Lake. If Zebra mussels were introduced into Middle Cormorant Lake they would most likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Uninfested Chain of Lakes	3 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (198)	963	Moderate
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (765)		
Substrate Suitability (mean abundance, DNR)		Sand, gravel	73%, 42%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.9	4	8.2-8.8
Alkalinity*	mg/L	194	5	100-280
Conductivity*	uS/cm	342	5	>110
Secchi Depth	ft	11.4	416	6.56-13.12
Chlorophyll a	ug/L	5	17	2.5-8
Total Phosphorus	ug/L	16.2	17	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	28 °C (15 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Big Cormorant

Overall Risk Rating: High
1. Connectivity: Moderate Risk
2. Public Use: High Risk

Suitability Risk Rating: High
1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: West of Detroit Lakes
Surface Area: 3657.06 acres
Percent Littoral: 22%
Max Depth: 75 ft
Inlet: Middle Cormorant Lake

Summary

Big Cormorant Lake has a moderate probability of infestation from upstream since it is in a chain of lakes. Due to its location and size, the lake has very high public use, which is high risk. If Zebra mussels were introduced into Big Cormorant Lake they would most likely thrive due to suitable water chemistry and substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Uninfested Chain of Lakes	4 upstream lakes	Moderate
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (643)	5,003	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (4,360)		
Substrate Suitability (mean abundance, DNR)		Sand, Rubble, Gravel	55%, 30%, 33%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Range for Zebra Mussels
Calcium*	mg/L	NA	0	>30
pH*		8.7	10	8.2-8.8
Alkalinity*	mg/L	250	11	100-280
Conductivity*	uS/cm	460	8	>110
Secchi	ft	18.9	178	6.56-13.12
Chlorophyll a	ug/L	4.0	78	2.5-8
Total Phosphorus	ug/L	25.2	89	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.9 °C (23 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Pelican Lake

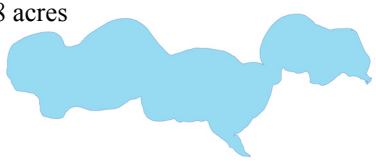
Overall Risk Rating: INFESTED

1. Connectivity: High Risk
2. Public Use: High Risk

Suitability Risk Rating: High

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 3962.88 acres
Percent Littoral: 41%
Max Depth: 55 ft
Inlet: Pelican River



Summary

Pelican Lake is currently an infested lake (listed in 2009). Its substrate and water chemistry is suitable for Zebra mussel establishment and growth.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of infested lakes	2 infested lakes upstream	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (999)	5,734	High
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (4,735)		
Substrate Suitability (mean abundance, DNR)		Sand, Gravel	78.8%, 18.3%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	35	55	>30
pH*		8.4	75	8.2-8.8
Alkalinity*	mg/L	192.5	12	100-280
Conductivity *	uS/cm	394.8	75	>110
Secchi	ft	12.8	192	6.56-13.12
Chlorophyll a	ug/L	4.8	116	2.5-8
Total Phosphorus	ug/L	14.6	116	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

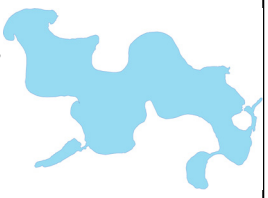
	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.5 °C (37 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Little Pelican Lake

Overall Risk Rating: INFESTED
1. Connectivity: High Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate
1. Water Chemistry: High Risk
2. Substrate: Low

Characteristics
Major Basin: Ottertail
Location: South of Detroit Lakes
Surface Area: 345 acres
Percent Littoral: 74%
Max Depth: 25 ft
Inlet: Pelican River



Summary

Little Pelican is currently an infested lake due to its connection with Pelican Lake; however, very few Zebra mussels have been found. It has a moderate suitability rating due to its substrate and eutrophic status.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	Connected to infested lake	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (120)	120	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (0)		
Substrate Suitability (mean abundance)		Silt, Muck	NA	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	34	55	>30
pH*		NA	0	8.2-8.8
Alkalinity*	mg/L	180	10	100-280
Conductivity *	uS/cm	412	12	>110
Secchi Depth	ft	8.5	87	6.56-13.12
Chlorophyll a	ug/L	9.8	87	2.5-8
Total Phosphorus	ug/L	23.9	87	25-35

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	26.5 °C (38 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Lake Risk Assessment Summary: Lake Lizzie

Overall Risk Rating: INFESTED

1. Connectivity: High Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: High Risk

Characteristics
Major Basin: Ottertail
Location: North of Pelican Rapids
Surface Area: 1,900acres
Percent Littoral: 43%
Max Depth: 66 ft
Inlet: Pelican River

Summary

Lake Lizzie is infested with Zebra mussels (listed in 2009). Its substrate and water chemistry is suitable for Zebra mussel establishment and growth.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	1 upstream infested lake	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (337)	502	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (165)		
Substrate Suitability (mean abundance)		Sand, Rubble, Gravel	42%, 33%, 25%	High

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.4	3	8.2-8.8
Alkalinity*	mg/L	193.3	3	100-280
Conductivity *	uS/cm	NA	0	>110
Secchi Depth	ft	12.7	61	6.56-13.12
Chlorophyll a	ug/L	5.3	62	2.5-8
Total Phosphorus	ug/L	16.1	62	25-35
Turbidity	mg/L	1.2	3	<96

**primary parameters for zebra mussel suitability*

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	25.6 °C (27 observations)	>32 C	High
Dissolved oxygen	Dimictic	<7 mg/L	High

Lake Risk Assessment Summary: Prairie Lake

Overall Risk Rating: INFESTED

1. Connectivity: High Risk
2. Public Use: Low Risk

Suitability Risk Rating: Moderate

1. Water Chemistry: High Risk
2. Substrate: Low Risk

Characteristics
Major Basin: Ottertail
Location: Pelican Rapids
Surface Area: 1,002 acres
Percent Littoral: 80%
Max Depth: 22 ft
Inlet: Pelican River

Summary

Prairie Lake is infested with Zebra mussels (listed in 2011). Its water chemistry is suitable for Zebra mussel establishment and growth, but spread may be limited by the substrate.

Attribute		Description	Number	Infestation Risk
Water Connectivity		Chain of lakes	3 upstream infested lakes	High
Public Use	Resident Watercraft/Boat Lift Impact	Number of parcels (138)	174	Low
	Non-resident Watercraft Impact	Total number of resort units, public access parking spots and special events for summer (36)		
Substrate Suitability (mean abundance)		Sand, Silt	72.1%, 15.4%	Low

Water Chemistry Risk Summary

Parameter	Unit	Average	Sample Size	Suitable Ranges
Calcium*	mg/L	NA	0	>30
pH*		8.5	1	8.2-8.8
Alkalinity*	mg/L	180	1	100-280
Conductivity*	uS/cm	380	1	>110
Secchi Depth	ft	9.8	44	6.56-13.12
Chlorophyll a	ug/L	5.8	43	2.5-8
Total Phosphorus	ug/L	20.6	44	25-35

Seasonal Temperature and Dissolved Oxygen Risk Summary

	Description	Lethal Limit	Suitability Rating
Summer maximum temperature	27.8 °C (27 observations)	>32 C	High
Dissolved oxygen	Polymictic	<7 mg/L	High

Stream Risk Assessment Summary: Pelican River, Becker County

Infestation Risk Rating: Moderate

1. Connectivity: Moderate Risk
2. Distance from lakes: High Risk
3. Public Use: Moderate Risk
4. Vegetation: Low Risk

Suitability Risk Rating: Low

1. Flow Rate: Low Risk
2. Water Chemistry: Moderate Risk
3. Substrate: High Risk
4. Dissolved Oxygen: High Risk

Characteristics

Major Basin: Otter Tail

County: Becker

Location: Floyd Lake to Lake Melissa

Length: 20 miles

Summary

The Pelican River in Becker County is uninfested with Zebra mussels upstream from Lake Melissa. Due to its connectivity to lakes, it is at a high risk for infestation. The stream flow would likely be the limiting factor for Zebra mussel survival within the stream itself. In order for Zebra mussels to be present in the stream, a source would be needed to continually introduce veligers to the stream.

Attribute	Description	Infestation Risk
Water Connectivity	Uninfested chain of lakes	Moderate
Distance from nearest upstream lake	<6 miles between lakes	High
Presence of aquatic vegetation/wetland conditions	Yes	Low
Public Use	Fishing, bait harvest, paddle sports	Moderate
Habitat Suitability	Sand, Gravel, Rocks	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	42 (2,016)	Unknown	Low
Maximum Flow (cfs)	153 (2,016)	Unknown	Low
Summer maximum temperature (C)	27.5 (108)	>32 C	High
Dissolved oxygen average (mg/L)	7.7 (114)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	NA	NA	0	>30
Hardness	Mg/L	NA	NA	0	100-280
Specific Conductance	uS/cm	NA	NA	0	>110
Total Suspended Solids	mg/L	5.7	2,054	2,068	<96
Turbidity	NTU	NA	NA	0	<80

Stream Risk Assessment Summary: Pelican River, Otter Tail County

Infestation Risk Rating: INFESTED

1. Connectivity: High Risk
2. Distance from lakes: Low Risk
3. Vegetation: Moderate Risk
4. Public Use: Moderate Risk

Suitability Risk Rating: Moderate

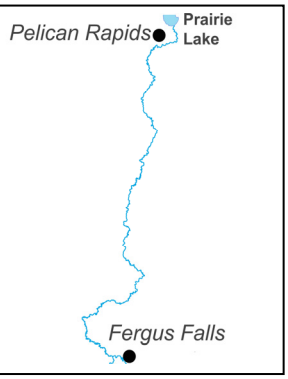
1. Flow Rate: Low Risk
2. Water Chemistry: High Risk
3. Temperature: High Risk
4. Dissolved Oxygen: High Risk

Characteristics

Major Basin: Otter Tail

Location: Pelican Lake to Otter Tail River (Pelican Rapids to Fergus Falls)

Length: 64 miles



Summary

The Pelican River is infested with Zebra mussels downstream from Pelican Lake to its pour point at the Otter Tail River near Fergus Falls, MN. The stream flow is likely the limiting factor for Zebra mussel survival within the stream itself, although there are many Zebra mussel source lakes along the stream that continually introduce veligers to the stream.

Attribute	Description	Infestation Risk
Water Connectivity	Infested	High
Distance from nearest upstream lake	64 miles	Low
Presence of aquatic vegetation/wetland conditions	Moderate	Moderate
Public Use	Fishing, bait harvest	Moderate
Habitat Suitability	Sand, Gravel, Rocks	High

Physical Parameters Risk

Item	Result (Sample Size)	Lethal Limit	Suitability Rating
Mean Flow* (cfs)	33 (6)	Unknown	Low
Maximum Flow (cfs)	83 (6)	Unknown	Low
Summer maximum temperature (C)	27.5 (108)	>32 C	High
Dissolved oxygen average (mg/L)	7.7 (114)	<7 mg/L	High

**possible limiting parameter for streams*

Water Chemistry Risk

Parameter	Unit	Average	Maximum	Sample Size	Suitable Range
Calcium	mg/L	102	139	10	>30
Hardness	Mg/L	244	284	10	100-280
Specific Conductance	uS/cm	410	470	83	>110
Total Suspended Solids	mg/L	10	52	80	<96
Turbidity	NTU	6	22	128	<80

Results and Discussion

Results

The lakes in the Pelican River Watershed resulted in differing infestation and suitability risk ratings (Table 13). In general terms, the headwaters lakes came out with the lowest infestation risk ratings because they have no water bodies upstream. The headwaters lakes in the Pelican River Watershed include Floyd, Little Floyd, and Upper Cormorant. Lakes that had moderate infestation risk ratings were Sallie, Melissa, and Middle Cormorant. These lakes came out as moderate because of the combination of moderate public use and being in the middle of a chain of lakes (Figure 17).

Lakes with high infestation risk ratings include Pelican, Big Cormorant and Detroit (Figure 17). These lakes are all part of chains of lakes, so have risk from connectivity. The highest risk to these three lakes; however, is their public use (Figure 16). They have the most resort units, public accesses, and property owners of any lakes in the watershed. Public use risks come from both lake visitors via boats and lake property owners via boats, boat lifts, docks and other water-related equipment. Pelican Lake was the first lake in the watershed to become infested with Zebra mussels, and it also had the highest public use rating of all the lakes in the watershed (Table 3).

Most of the lakes in the Pelican River Watershed resulted in a high Zebra mussel suitability rating (Figure 18). The lakes in northwest Minnesota are considered hardwater lakes from glacial deposits of calcium carbonate (limestone) (Wetzel 2001). All of the lakes in this study had suitable water chemistry, including calcium, for Zebra mussel growth and development.

The limiting factor that resulted in some lakes receiving a moderate suitability rating was substrate. Zebra mussels are not able to attach silt, muck, and sand directly. In areas with these substrates, the Zebra mussels will attach to plants, native mussels, and pieces of wood or stones (Karatayev et al. 1998). Therefore, lakes that have predominantly silt, muck and sand have a low substrate suitability rating. These lakes also tend to be more eutrophic, and Zebra mussels do not thrive in eutrophic lakes like they do in mesotrophic lakes (Karatayev et al. 1998, Nelepa 1992). The lakes with moderate suitability ratings included Prairie, Little Pelican, Floyd, Little Floyd, and Upper Cormorant (Table 13).

The Pelican River itself is a pathway for the spread of Zebra mussels downstream. Zebra mussel establishment in streams is limited by turbulence and flow, therefore the river itself is likely not a major source of zebra mussels. The northern half of the Pelican River in Becker County is uninfested, and therefore received a moderate infestation rating. The southern half of the Pelican River in Otter Tail County flows through infested lakes, and therefore received a high infestation rating.

Table 13. Summary of risk ratings and prioritized recommendations taking into account the risk.

Lake Name	Lake ID	Public Use Risk	Infestation Risk	Suitability Risk	Infestation Status as of 9/9/2014	AIS Program Prioritized Recommendations
Upper Cormorant	03-0588-00	Low	Low	Moderate		1. Education
Middle Cormorant	03-0602-00	Moderate	Moderate	High		1. Education
Big Cormorant	03-0576-00	High	High	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Big Floyd	03-0387-02	Low	Low	Moderate		1. Education
Little Floyd	03-0386-00	Low	Low	Moderate		1. Education
Detroit	03-0381-00	High	High	High		1. Public Access Inspections 2. Education 3. Early Detection Monitoring
Sallie	03-0359-00	Moderate	Moderate	High		1. Education 2. Early Detection Monitoring
Melissa	03-0475-00	Moderate	High	High	Infested with Zebra mussels	1. Decontamination station 2. Education
Little Pelican	56-0761-00	Low	High	Moderate	Infested with Zebra mussels	1. Decontamination station 2. Education
Pelican	56-0786-00	High	High	High	Infested with Zebra mussels	1. Decontamination station 2. Education
Lizzie	56-0760-00	Low	High	High	Infested with Zebra mussels	1. Decontamination station 2. Education
Prairie	56-0915-00	Low	High	Moderate	Infested with Zebra mussels	1. Decontamination station 2. Education

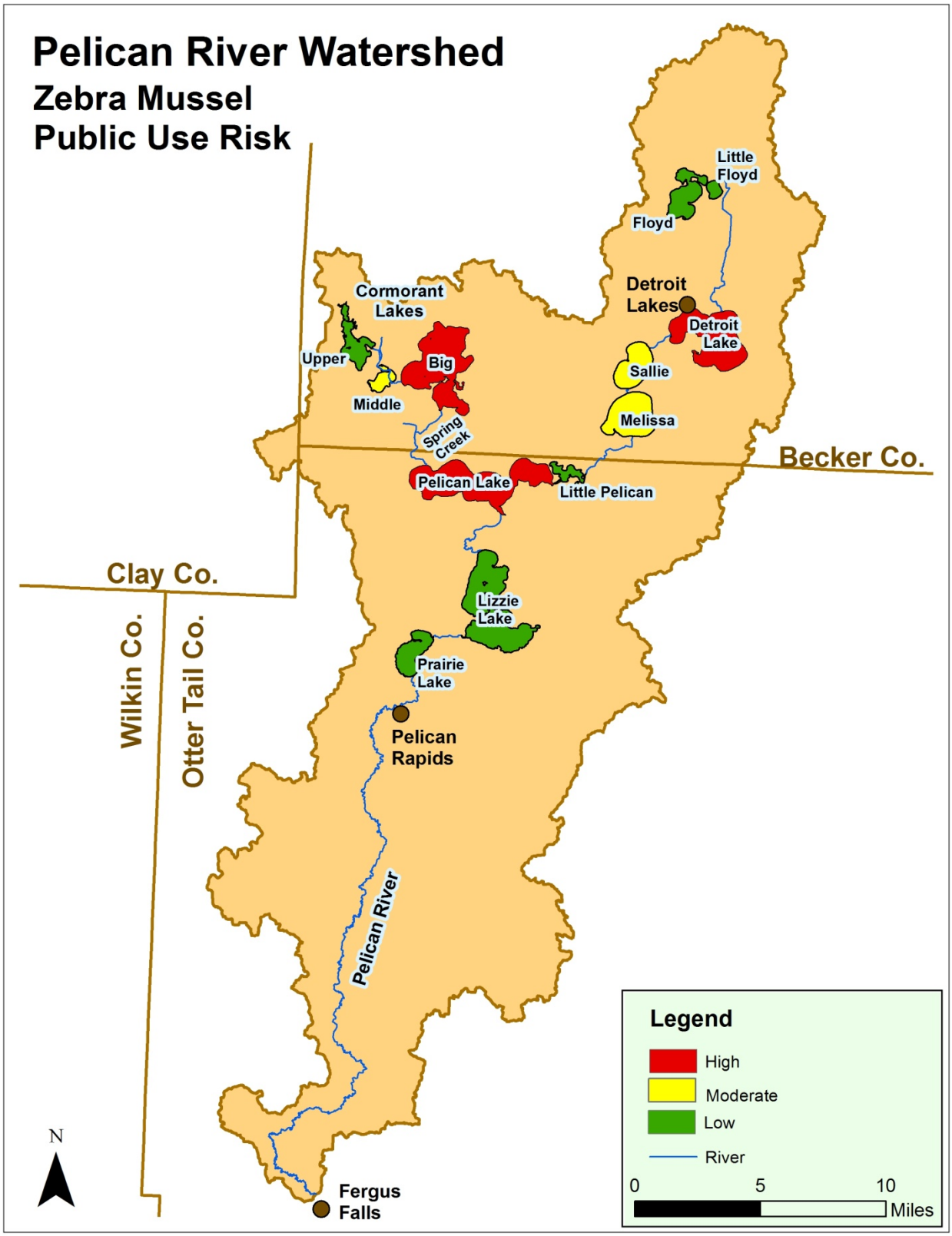


Figure 16. Public use risk rating for lakes in the Pelican River Watershed District.

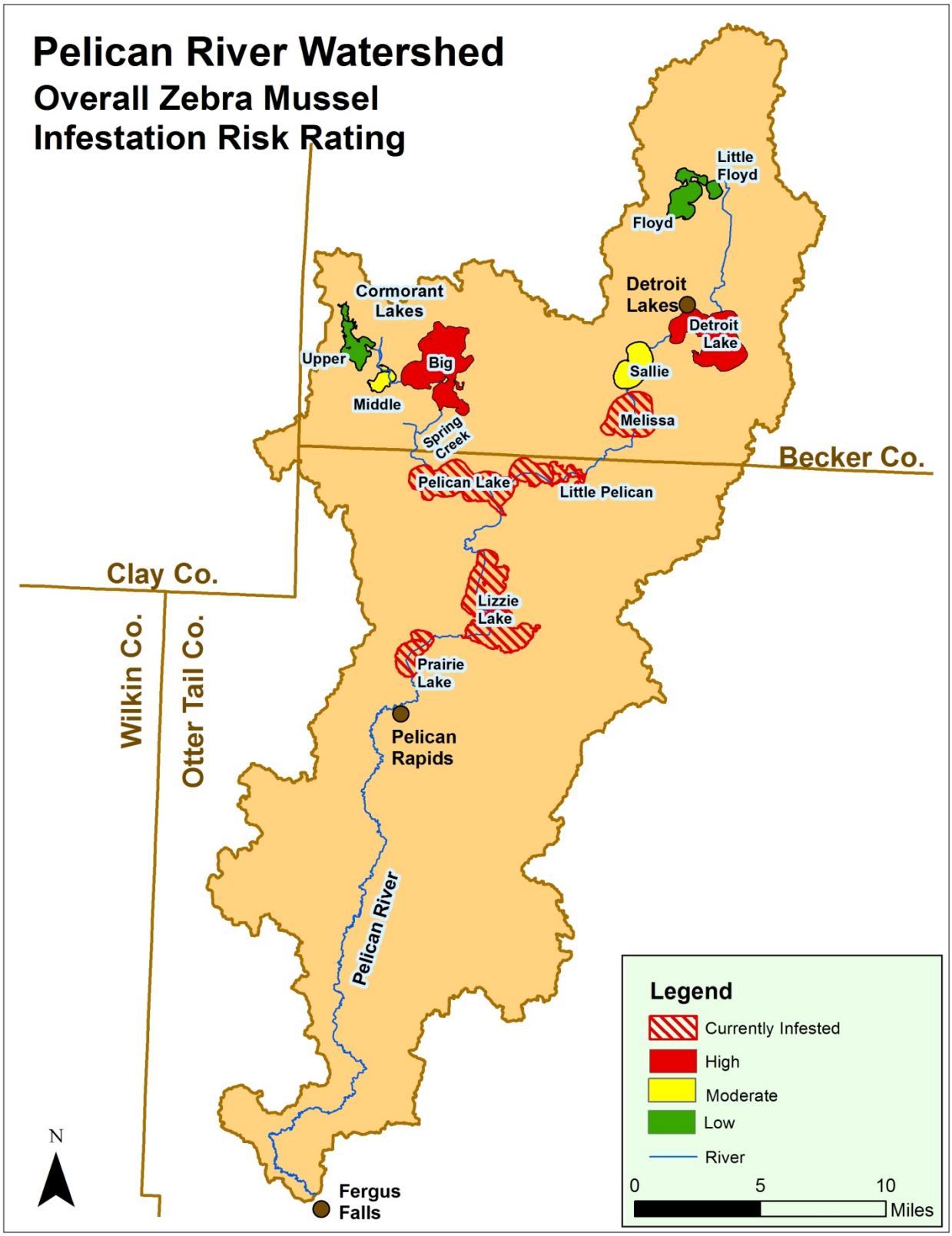


Figure 17. Overall Zebra mussel infestation risk rating in the Pelican River Watershed.

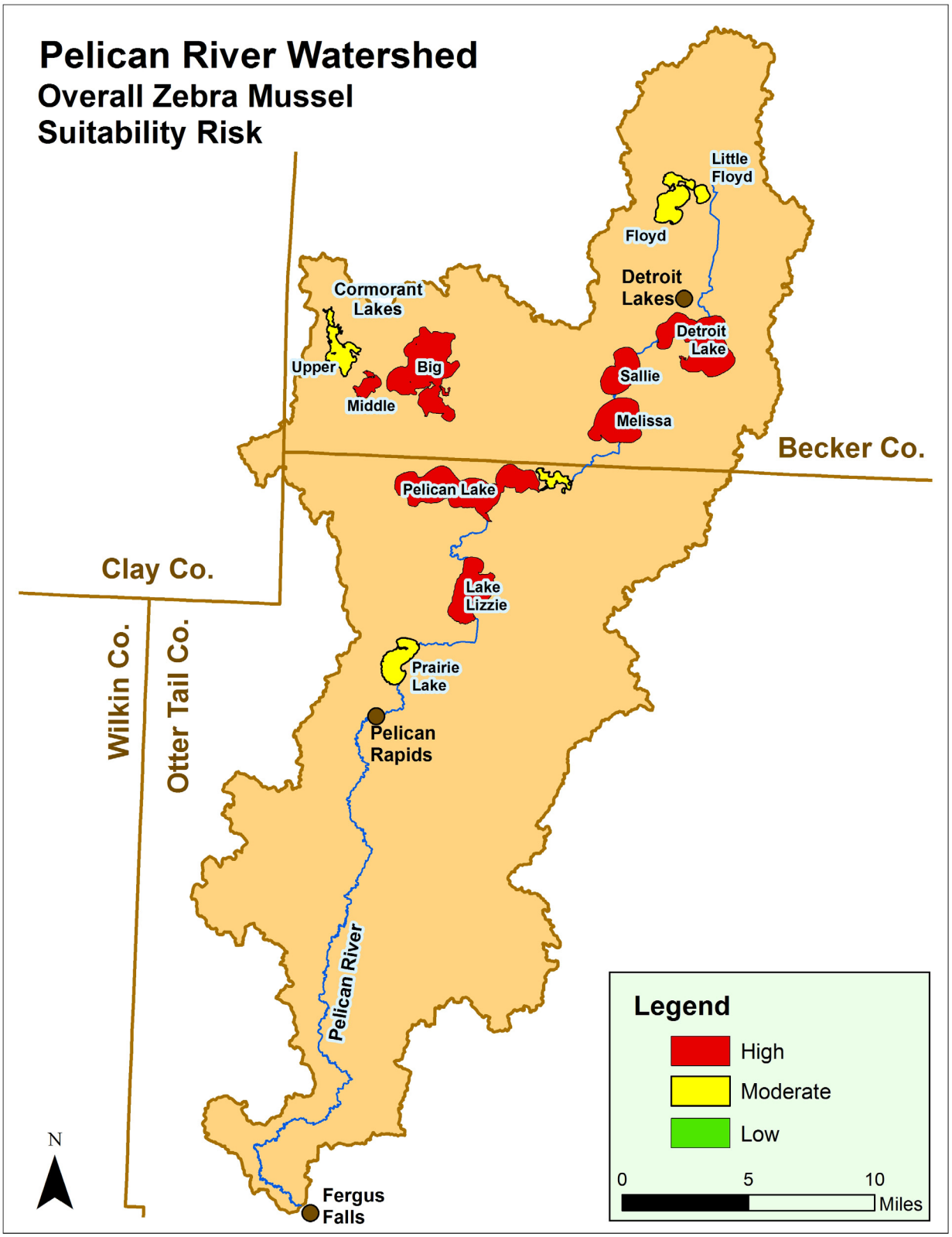


Figure 18. Overall Zebra mussel suitability risk rating in the Pelican River Watershed.

Data Gaps

This study identified some data gaps in the Pelican River Watershed. Calcium is the most important water chemistry parameter when evaluating Zebra mussel habitat suitability. Many lakes did not have any historical calcium data. Since they are hardwater lakes, it can be presumed that their calcium is high enough for Zebra mussel survival, but it is better to have the actual data numbers for evaluation. It is recommended that this data be collected to assist with overall verification of water chemistry. Lakes and streams with populations of freshwater mussels offer an additional level of habitat suitability to also support non-native mussel species. The data gaps are indicated on the lake report cards. See the table below for a summary of parameters needed for each lake (Table 14).

Table 14. Summary of data gaps for water bodies in the Pelican River Watershed.

Lake Name	Lake ID	Parameters Needed
Upper Cormorant	03-0588-00	Calcium, pH, Alkalinity, Specific Conductance
Middle Cormorant	03-0602-00	Calcium
Big Cormorant	03-0576-00	Calcium
Big Floyd	03-0387-02	Calcium
Little Floyd	03-0386-00	Calcium, Alkalinity
Detroit	03-0381-00	Calcium
Sallie	03-0359-00	Calcium
Melissa	03-0475-00	Calcium
Pelican	56-0786-00	None
Little Pelican	56-0761-00	pH
Lizzie	56-0760-00	Calcium, Specific Conductance
Prairie	56-0915-00	Calcium
Pelican River, Becker County		Calcium, Hardness, Specific Conductance, Turbidity
Pelican River, Otter Tail County		None

Vectors of Spread – Infestation Routes

In order to have a watershed strategy for AIS program management, the vectors of spread for each lake needs to be determined. This risk assessment process also identifies the vectors of spread for the lakes in the watershed. For headwaters lakes there is no risk of infestation from upstream, so any new infestation would come from lake users (boats, boat lifts, docks, etc). For lakes in a river chain, both lake users and upstream lakes need to be considered as potential vectors of spread.

Zebra mussels can be transferred from infested waters through several different pathways. Below are the pathways prioritized as to highest risk. These pathways are highly dependent upon the time of year and the stage in the Zebra mussel life cycle. The risk pathway ratings for time of year are shown in Table 15.

1. Connectivity via a river or stream.
   An upstream infested lake is almost certain to infest downstream lakes if the stream distance between lakes is short enough.

2. Transfer of equipment from lake to lake.
   The transfer of a large breeding adult Zebra mussel population from one lake to another on an infested boat lift, dock, swim raft or other water-related equipment has a very high probability of infesting a lake.

3. Transfer of mussels hitchhiking on vegetation or mud on boat and trailers.
   The risk of hitchhiking mussels depends somewhat on the time of year. When vegetation dies off in the fall, the Zebra mussels fall off into the sediments. Therefore, Zebra mussels are only attached to plants from approximately June to September. Zebra mussels can't be transferred alone in mud because they do not thrive in soft substrates; they need to be attached to a hard surface.

4. Transfer of veligers or mussels from live wells, bilges, and any area of the boat that holds water.
   The risk of veliger transfer depends greatly on the time of year. In infested lakes in northwest Minnesota, it has been documented that Zebra mussel veligers are at peak concentrations in early July (Rufer 2015). *Therefore, July is the month of the year where veliger transfer from lake to lake has the highest risk for infestation. Research has shown that veligers are non-existent during the ice-covered season, so there is essentially no risk of veliger transfer in the winter* (Rufer 2014).

5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.
   The risk of mussel transfer on boats is highest in July through September, because that is when the mussels are reproducing and settling on new hard surfaces.

6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.
   The risk of veliger transfer on gear depends somewhat on the time of year. July and August would be the times of highest risk throughout the year. Overall, this pathway is considered to be very low risk potential because the amount of water transferred is so small.

Risk – Time of Year

The risk of Zebra mussel infestation varies by the time of year. Data sources show that in Minnesota, the time of year that has the highest concentration of Zebra mussel veligers matches up with the highest use time for the public (Pesch & Bussiere 2014, Rufer 2015). The implications of these data indicate that additional prevention measures should be implemented during July to prevent Zebra mussel spread.

In Pesch and Busierre's (2014) survey of 2nd Homeowners in Central and West Central Minnesota, the highest use time of year was July, at an average of 16 days during that month (Figure 14, Pesch & Bussiere 2014). Rufer's monitoring of Zebra mussel veligers in Pelican Lake, a Zebra mussel infested lake in Otter Tail County, shows the peak density for Zebra mussels is in July (Figure 15, Rufer 2015).

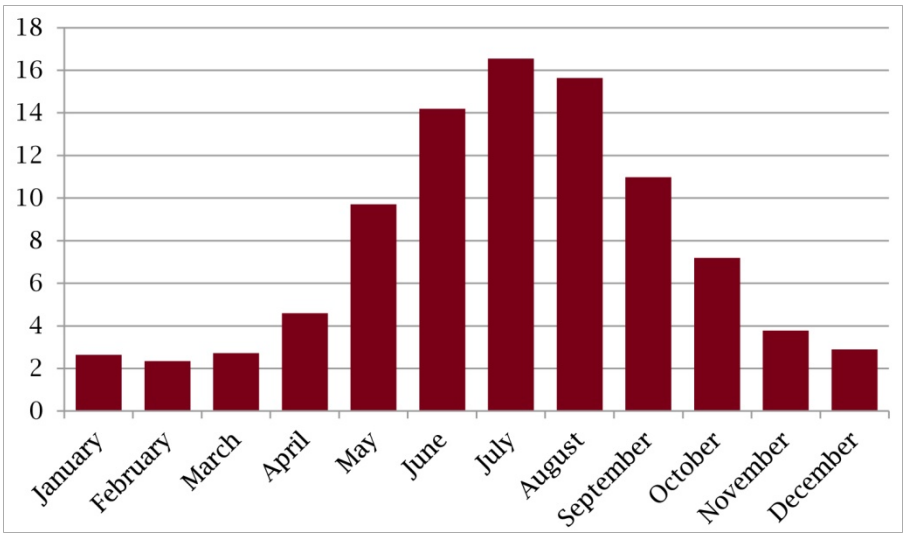


Figure 19. Average number of days occupied per month (n=552) from Pesch & Bussiere 2014.

The full report can be downloaded from this link:
http://www.extension.umn.edu/community/research/reports/docs/2014-2nd-Homeowners.pdf

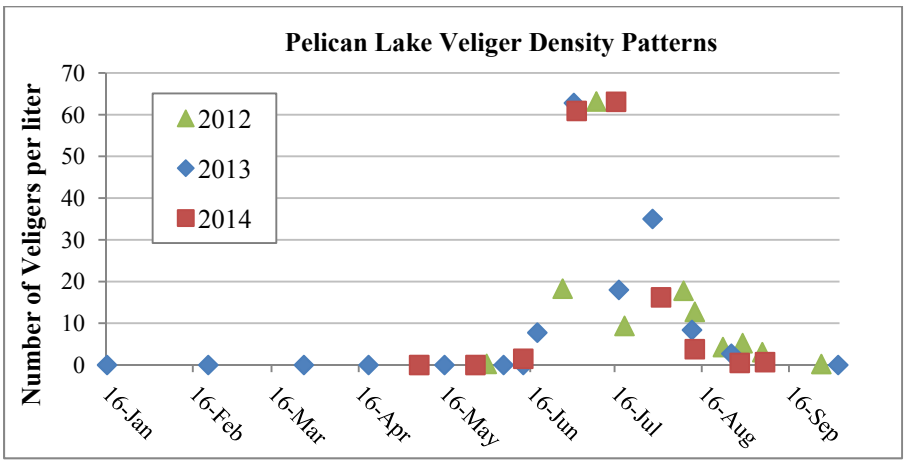


Figure 20. Veliger densities in Pelican Lake, 2012-2014 from Rufer 2015.

The full report can be downloaded from this link:
http://pgolid.org/wp-content/uploads/2014/01/PGOLID-Veliger-Report-2012-2014.pdf

Table 15. Summary of risk pathways depending on the time of year. The Zebra mussel life stage for the pathway is indicated in italics.

	Typical Minnesota Open Water Season							Typical Minnesota Ice-covered season				
Risk Pathway	**April**	**May**	**June**	**July**	**August**	**Sept**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**March**
1. Connectivity via a river or stream.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
2. Transfer of equipment from lake to lake.	insignificant	insignificant	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
3. Transfer of mussels hitchhiking on vegetation or mud on boats, trailers and gear.	Low *Adults & juveniles*	Low *Adults & juveniles*	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Moderate *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant
4. Transfer of veligers via water in boats (live wells, bilges, etc) and float planes.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant
5. Transfer of juvenile mussels on boats not thoroughly cleaned after being tied up on infested waters for an extended period of time.	insignificant	insignificant	Moderate *Adults & juveniles*	High *Adults & juveniles*	High *Adults & juveniles*	Moderate *Adults & juveniles*	Low *Adults & juveniles*	insignificant	insignificant	insignificant	insignificant	insignificant
6. Transfer of veligers and juvenile mussels on swimwear, SCUBA equipment, waders or other gear used in water.	insignificant	insignificant	Low *Veligers*	High *Veligers*	Moderate *Veligers*	Low *Veligers*	insignificant	insignificant	insignificant	insignificant	insignificant	insignificant

Sources: Zebra mussel veliger time-of-year risk was taken from Rufer 2015.
Zebra mussel adult and juvenile time-of-year risk was taken from Mackie & Claudi 201, Mackie 1996, McMahon 1996.

AIS Program Management Recommendations

In an ideal world, all Aquatic Invasive Species (AIS) prevention programs would be applied to all lakes. In reality, budgets are always limited, so prioritization of programs due to risk ratings is necessary. Due to the differing risk ratings, programs can be individualized to fit each lake's risk category (Table 13). Lakes with high public use ratings should be at the highest priority for boat inspections at public accesses. Lakes that are already infested should have boat-washing stations nearby for decontamination. All lakes should be targeted with a watershed-wide education program.

The assessments in this report result combine the report cards with the risk of time of year (Figure 15) in the following specific Aquatic Invasive Species Program Management Recommendations (Table 16). This portion of the report can be inserted directly into the county's AIS Plan, and guide the use of the county's AIS funds in the most efficient and effective way possible.

Table. 16. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Watercraft Inspections	Priority 1: • Detroit • Big Cormorant Priority 2: • Floyd • Upper Cormorant Priority 3: All	Priority 1: July Priority 2: August	County	TBD	This activity depends on available funding. If limited funding is available, focus inspections on Detroit and Big Cormorant in July as the best use of funds.
Early Detection Monitoring: *Adult Zebra mussels*	Priority 1: • Detroit • Big Cormorant Priority 2: All	Priority 1: September Priority 2: Every other week from late June to mid-September	Volunteers	$0	a. In September, conduct a lake-wide inspection of docks and boat lifts as they are removed from the lake. b. Place a cinder block in 5-8 feet of water near the public access and any other heavily used areas of the lake, and have the volunteers check the block (pull it up or snorkel) every other week from late June to mid-September. Record results on the MN DNR's website: http://www.dnr.state.mn.us/volunteering/zebramussel_monitoring/report.html.
Early Detection Monitoring: *Zebra mussel veligers*	Detroit Big Cormorant	July	County, Watershed District, or Lake Associations	$360	Collect plankton tow samples in early and late July for veliger analysis. Early detection allows for possible treatment.

Table 16 continued on the next page.

Table. 16 continued. Framework for the watershed's AIS plan.

Activity	Target Lakes	Target Time of Year	Who	Cost	Narrative
Water Quality Monitoring	See Table 14 for data gaps.	May – September	Lake Associations, COLA	TBD	Monitor lakes for missing parameters shown in Table 14. Priority parameters for each lake would be Calcium, Alkalinity, pH and Specific Conductance as they have the most effect on Zebra mussel suitability.
Monitoring: Invasive Plants	Priority 1: • Detroit • Big Cormorant Priority 2: • Floyd • Upper Cormorant Priority 3: All	Mid to late June	County, Watershed District, or Lake Associations	TBD	Conduct plant surveys to look for aquatic invasive plants. Mid to late June will catch Curly-leaf pondweed, Flowering rush, and Eurasian watermilfoil. Floyd and Upper Cormorant are listed as second priority because they are at the top of the watershed.
Education and Outreach	All	Priority 1: 4th of July week Priority 2: Memorial day to labor day Priority 3: Year round	County and watershed	TBD	Conduct a consistent watershed-wide education program to schools and the general public. In high tourism areas such as Detroit Lakes, focus *additional* education around 4th of July since that is the highest risk time of the year for spread.
Decontamination	Melissa Pelican Lizzie Prairie	Priority 1: July Priority 2: August	County, DNR, or private business	TBD	Provide decontamination opportunities for boats leaving infested lakes. Inform boaters on where the decontamination station is located.
Rapid Response Plan	All	Year round	County or watershed	TBD	Put together a plan of the chain of contacts if a new infestation is found and the steps to determine if treatment is possible. Having a plan in place allows for quick action if there is a new infestation.

Table 16 can be used as a framework for the best way to use available funding, as it shows when is the priority time of year and what are the priority lakes for each activity. For example, if funding is limited for watercraft inspections at public accesses, the funding should first be used to cover Detroit and Big Cormorant lakes in July. After that, if more funding is available, Detroit and Big Cormorant lakes should have inspectors available in August. After that, if more funding is available, provide inspectors at Floyd and Upper Cormorant Lakes in July, and so forth.

For monitoring, ideally all lakes would be monitored for adults because if trained volunteers are used there is no monetary cost, but there is a large benefit.

For education, because the highest risk time of the summer and one of the highest tourism times of the summer intersect on 4th of July week, focus *additional* targeted education and outreach during this time of year.

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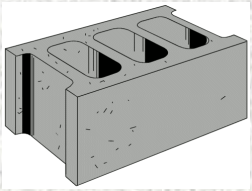
"Two Buck Block"

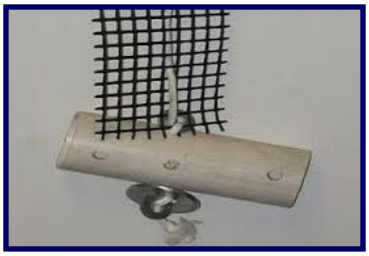
Early Detection



Zebra Mussel Monitoring Project!

Zebra mussels are spreading to lakes and rivers in Minnesota. These small invasive mussels attach to hard surfaces in lakes and rivers killing native mussels, limiting recreational activities, clogging water supply pipes, and competing with larval fish for food. You can provide important help tracking their distribution in Minnesota by spending a few minutes monitoring the lake or river where you live without any specialized equipment. Early detection for zebra mussels is important in protecting your property and Minnesota's water resources.

Make your own monitoring device. Hang a PVC pipe , brick or **cinder block** in 3– 8 feet of water under a shady spot of your dock (zebra mussels tend to avoid direct sunlight) and away from high traffic areas in the summer to monitor for zebra mussels. Suspend the object as deep as possible and tie to dock. Adult Zebra mussels have the ability to crawl to seek out places to attach so some portion of monitoring devise should have contact with the lake or stream bottom to allow for adult s who may be seeking a place to attach.



Monitoring un-infested lakes for Zebra mussels allows for early detection. If a lake becomes infested, early detection can prevent spread to other water bodies. There are two types of monitoring for early detection of Zebra mussels in lakes: veliger monitoring and adult/juvenile monitoring. When zebra mussels first establish in a lake, they can be at very low densities, so it is not always possible to detect them right away. A monitoring device placed by local lake property owners, can help with early detection and rapid response management planning.

Join in the Volunteer Zebra Mussel Monitoring Program and report your efforts each year. Examine the monitoring object, and add these observations to the Volunteer Monitor Report Form.

General Characteristics

- Zebra mussels look like small clams with a yellowish or brownish "D"-shaped shell, usually with dark and light-colored stripes (hence the name "zebra")
- They can be up to two inches long, but most are under one inch. Zebra mussels usually grow in clusters containing numerous individuals and are generally found in shallow (6-30 feet), algae-rich water
- Zebra mussels are the only freshwater mollusk that can firmly attach itself to solid objects – submerged rocks, dock pilings, boat hulls, water intake pipes, etc.
- On smooth surfaces, young zebra mussels feel like fine sandpaper.
- Juveniles are about the size of peppercorns.

Means of spread: Mussels attach to boats, nets, docks, swim platforms, boat lifts, and can be moved on any of these objects. They also can attach to aquatic plants, making it critical to remove all aquatic vegetation before leaving a lake. Microscopic larvae may be carried in water contained in bait buckets, bilges or any other water moved from an infested lake or river.

Where to look: Examine boat hulls, swimming platforms, docks, aquatic plants, wood, rocks and other objects in the water along shorelines of lakes and rivers.

Join in the Volunteer Zebra Mussel Monitoring Program and report your efforts each year.

Impacts: Zebra mussels can cause problems for lakeshore residents and recreationists. Homeowners that take lake water to water lawns can have their intakes clogged. Mussels may attach to motors and possibly clog cooling water areas. Shells can cause cuts and scrapes if they grow large enough on rocks, swim rafts and ladders. Anglers may lose tackle as the shells can cut fishing line. Zebra mussels can also attach to native mussels, killing them. Zebra mussels filter plankton from the surrounding water. This filtering can increase water clarity, which might cause more aquatic vegetation to grow at deeper depths and more dense stands. If a lake has high numbers of mussels over large areas, this filter feeding could impact the food chain, reducing food for larval fish.

What You Can Do?

- **Learn** to recognize zebra mussels.
- **Inspect** and **remove** aquatic plants, animals, and mud from boat, motor, and trailer.
- **Drain** water from boat, motor, live well, bilge, and bait containers.
- **Dispose** of unwanted live bait and worms in the trash.
- **Rinse** boat and equipment with high-pressure and/or hot water (minimum 120° F for 2 minutes or 140°F for 10 seconds), especially if moored for over a day, **OR**
- **Dry** everything for at least 5 days.
- **Never** introduce fish, plants, crayfish, snails or clams from one body of water to another.
- **Report** new sightings - note exact location; place specimens in a sealed plastic bag or store in rubbing (isopropyl) alcohol; if in Minnesota, call the MN DNR NW Region (218) 739-7575 ext. 254 Minnesota Sea Grant Program in Duluth, (218) 726-8712; the Minnesota DNR in St. Paul, 1-888-MINNDNR, or (651) 259-5100; or a local DNR fishery office.

***Information Courtesy of MN DNR Zebra Mussel Monitoring Program**.

http://dnr.state.mn.us/volunteering/zebramussel_monitoring/index.html

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