CARNELIAN-MARINE-ST. CROIX
WATERSHED MANAGEMENT PLAN

APPENDIX A

Land & Water Resource Inventory

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APPENDIX A: LAND AND NATURAL RESOURCE INVENTORY

This section summarizes the physical resources of the Carnelian-Marine-St Croix Watershed District including wetlands, lakes, streams, and groundwater. The summaries and figures in this section were completed with the most up-to-date regional data as of 2021.

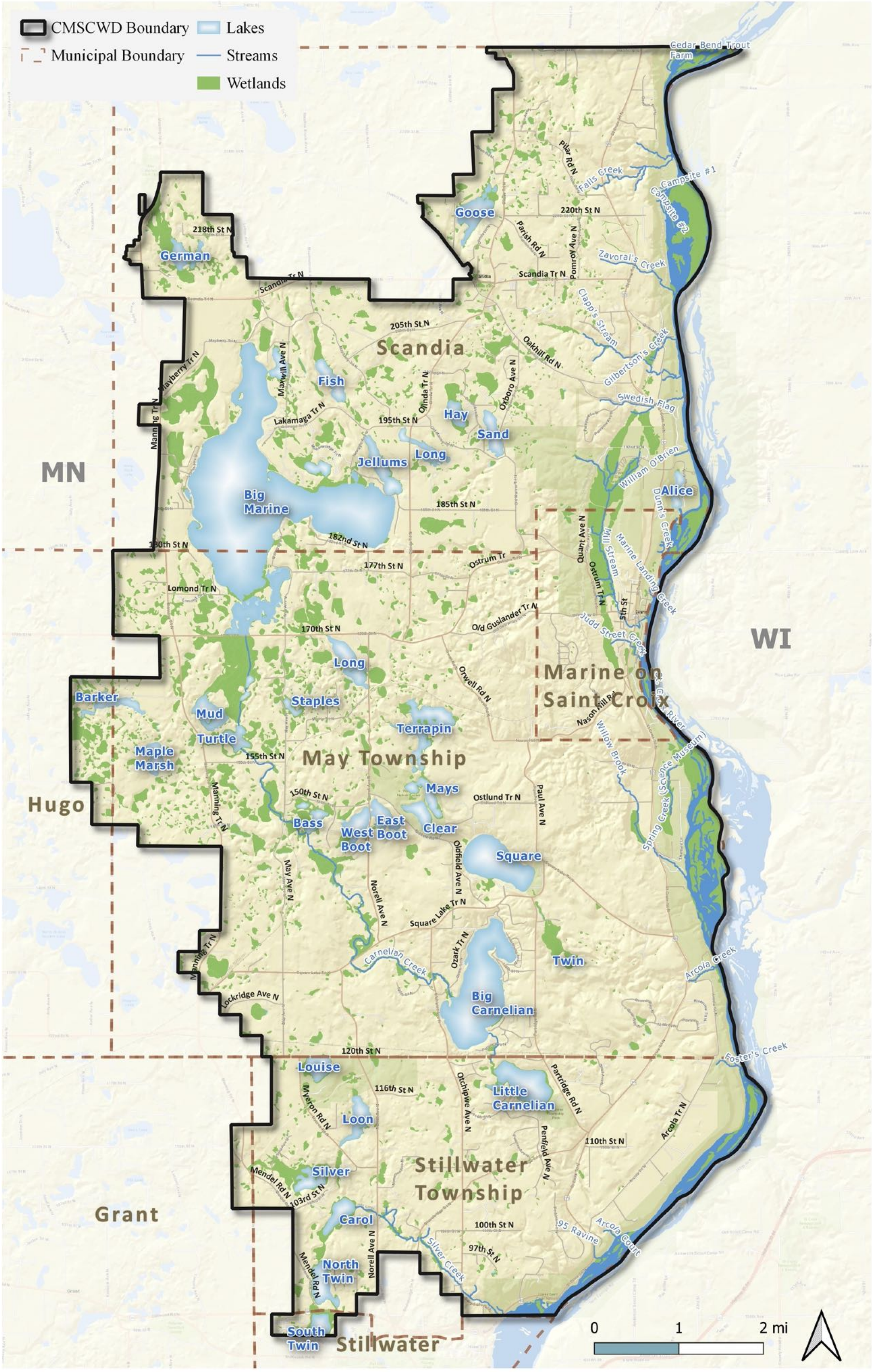
Location

The Carnelian Marine-St. Croix Watershed District (CMSCWD) is approximately 81.4 square miles in size and is located in Washington County, Minnesota. The Carnelian Marine Watershed District was formed on June 22, 1981, by order of the Minnesota Water Resources Board (now part of the Minnesota Board of Water and Soil Resources). In 2007, the Carnelian Marine Watershed District merged with the Marine Water Management Organization and became the CMSCWD. The merger also included part of Washington County that was not previously a part of a water management organization. Today the total area of CMSCWD encompasses portions of Grant, Hugo, Marine on St. Croix, May Township, Scandia, Stillwater, and Stillwater Township (Figure A-1). Table A-1 lists each city and township, its total population, and its contributing area to the District. These contributing areas were determined using the legal boundary of the District.

Table A-1. Cities and Townships located in the CMSCWD

City/Township	Total Population (2010 Census)	Area in CMSCWD [Acres]	Area in CMSCWD [Square Miles]	Percentage of Total CMSCWD Area [%]
Grant	4,096	157	0.25	0.3
Hugo	13,332	476	0.74	0.9
Marine on St. Croix	689	2,674	4.18	5.1
May Township	2,776	22,115	34.55	42.4
Scandia	3,936	17,487	27.32	33.6
Stillwater	18,225	136	0.21	0.3
Stillwater Township	2,366	9,072	14.18	17.4
Total	45,420	52,117	81.43	100

Figure A-1. CMSCWD and Municipality Boundaries



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Climate and Precipitation

The climate within the CMSCWD is similar to the overall seven county Metropolitan Area and exhibits typical characteristics of continental climates. Areas with continental climates have winters with at least one month below 32 ° F and at least three months of temperatures above 50 ° F. Regions with continental climates are characterized by winter temperatures cold enough to support snow cover from late fall to early spring, and relatively moderate precipitation that occurs mostly in the summer months.

30-year (1991-2020) average temperature and precipitation for Forest Lake, Minnesota (Station 212881) are summarized in Table A-2. This information is collected by the National Weather Service cooperative program and is available at the Minnesota Climatology Working Group web site: http://climate.umn.edu. The average annual temperature was 46.0 degrees F. Average annual precipitation was 32.9 inches.

Table A-2. Monthly Temperature and Precipitation Averages

Month	Temperature [°F]	Precipitation [Inches]
January	15.0	0.9
February	20.2	0.8
March	32.3	1.7
April	46.4	3.0
May	58.6	4.3
June	68.1	4.6
July	72.5	4.7
August	70.7	4.0
September	62.8	3.0
October	49.3	2.9
November	34.5	1.9
December	21.3	1.3
Annual Mean	46.3	32.9

Source: National Weather Service

Table A-3 illustrates the standard values assumed for the probability of a rainfall event occurring in any given year. The data provided is for a location in the center of the watershed (at Warner Nature Center). Due to the size of the watershed and the variability of precipitation, the recurrence intervals likely vary across the watershed. The recurrence interval is a measure of the probability of occurrence of a storm event. For example, a rainfall event of 5.9 inches has a 1% probability of occurring in any given year which is expressed as once in every 100 years; the 3.5-inch rainfall event has a 20% probability of occurring in any given year which is expressed as once in every 5 years.

Table A-3. Storm Events and Recurrence Intervals

Recurrence Interval [Years]	24-Hour Rainfall Amount [Inches]
1	2.43
2	2.80
5	3.50
10	4.16
25	5.19
50	6.08
100	7.05

Source: NOAA National Weather Service Atlas 14

The climate is expected to change over time, requiring new definitions of the condition viewed as “normal” for this area. Generally accepted updated information on design storms, temperature, and precipitation should be used as it is developed.

1.1. Climate Change

According to the report developed by the Union of Concerned Scientists, Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems (Kling et al, 2003) average annual temperatures in the State of Minnesota are increasing. By the end of the 21st century, temperatures are projected to rise 6-10 degrees Fahrenheit in the winter and 7-16 degrees Fahrenheit in the summer. In addition, periods of extreme heat will be more common, and the growing season could be three to six weeks longer than normal. It is projected that by the end of the century, the Minnesota summer climate will feel more like summer in current-day Kansas and the winter climate will feel more like current-day Wisconsin.

As the Earth warms, the intensity of precipitation increases in two ways: (1) the increasing temperature of the land and oceans causes water to evaporate faster; and (2) the increasing air temperature enables the atmosphere to hold more water vapor. These factors combine to make clouds richer with moisture, making heavy downpours or snowstorms more likely. The State of Minnesota is predicted to see a total increase in annual precipitation. Seasonal precipitation is estimated to change as follows: precipitation will increase in winter by 15-50 percent and decrease in summer by up to 15 percent. While the frequency of heavy rainstorms (both the 24-hour and the multi-day) will increase, droughts will be more common as the rainfall cannot compensate for the drying effects of a warmer climate. These trends have already been observed, a review of approximately 3,500 National Oceanic and Atmospheric Administration (NOAA) weather stations indicates that Minnesota has already seen a 24 percent increase in the frequency of extreme precipitation events from 1948 to 2006 (Madsen and Figdor, 2007). In the Twin Cities Metropolitan Area, this increase was as large as 47 percent. Other changes we can expect to see in the State of Minnesota include a shorter winter season with less snow, more ice and winter rains, earlier ice out dates and more rapid spring snowmelt events. Table A-4 summarizes the impacts we can expect to see in the State of Minnesota as a result of climate change.

Table A-4. Impacts to Minnesota water resources as a result of climate change

Impact to Water Resource	Description	Indicators
Increases in Water Pollution Problems	Warmer air temperatures result in warmer waters	Warmer waters hold less dissolved oxygen (DO) making instances of low DO and hypoxia more likely Increased frequency of algal blooms
	Increased flooding increases water-borne diseases and sediment transport	Increased stormwater runoff washes sediments (erosion) and other contaminants into waterbodies Overloading of stormwater and stormsewer systems transports contaminants into waterbodies
	Changes in snowfall patterns	More ice during the winter requires application of more chemicals Less lake ice coverage results in greater evaporation of surface waters during winter and lower surface water levels, concentrating pollutant loads
More Extreme Water-Related Events	Heavier precipitation during rainfall events	Increased risk of flooding Increased variability of streamflows Increased velocity of water during high flow periods Taxes existing infrastructure systems (e.g. levees, sewer pipes, wastewater treatment plans, etc.)
Changes to Availability of Drinking Water Supplies	Changing patterns of precipitation and snowmelt	Increased drought conditions place higher demands on drinking water supplies Increased water loss due to higher evaporation (as a result of warmer air temperatures)
	Warmer air temperature	Places higher demands on community water supplies Increased water needs for agriculture and industry Increased need for energy production (e.g. air conditioning)
Water Boundary Movement & Displacement	Size of wetlands & lakes will change	Changing water flow to lakes/streams Increased evaporation Changes in precipitation impacts wetland hydrology (bounce and duration)
	Increased stream channel instability	Increase in channel-forming flows (bank-full flows) leads to increased sediment transport potential and channel instability
	Decreased Groundwater Recharge	Rain from extreme events falls too quickly to be absorbed into the ground Reduced summer water levels diminish recharge of groundwater Earlier snow melt reduces ability of snow to recharge aquifers
	Increased Erosion	Due to altered buffer/shoreline areas

Table A-4. Impacts to Minnesota water resources as a result of climate change		
Impact to Water Resource	Description	Indicators
Changing Aquatic Biology	Warmer water temperatures	Loss of fisheries habitats as aquatic life is replaced by other species better adapted to warmer waters Interruption of breeding cycles Increase in invasive species

- Sources:
  1. National Water Program Strategy: Response to Climate Change. Office of Water U.S. Environmental Protection Agency. September 2008.
  2. Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands. U.S. Climate Change Science Program. Synthesis and Assessment Product 3.3. June 2008.
  3. When it Rains, It Pours: Global Warming and the Rising Frequency of Extreme Precipitation in the United States. Frontier Group and Environment America Research & Policy Center. December 2007.
  4. Confronting Climate Change in the Great Lakes Region: Impacts on Our Communities and Ecosystems. Union of Concerned Scientists. 2003.

Topography and Geomorphology

The following discussion of topography and geomorphology was adapted from the report Integrating Groundwater and Surface Water Management–Northern Washington County (EOR, 2003). The topography of the CMSCWD was formed by glacial and post glacial processes (Figure A-2). These processes deposited and eroded the landscape, resulting in geomorphic regions which contain similar characteristics. Geomorphology describes the landforms as they relate to glacial processes, landscape evolution, drainage and topography. The geomorphology of the CMSCWD can be broken down into four general categories including meltwater deposits, outwash plains, moraine deposits, lake plains and terrace deposits (Figure A-3).

<u>Meltwater Deposits</u>

Melt water deposits in the study area consist of outwash plains and eskers. Outwash plains are sandy features formed by broad glacial melt plains. Outwash plains are a result of glacial melting. They are characteristically composed of well sorted sand and gravel deposits. The topography is flat to gently rolling, containing few wetlands. There is typically a high connection between lakes and groundwater within the outwash deposits. Closed depressions are common throughout. Groundwater fed creeks are also common in the watershed within the outwash plain.

Eskers are formed as a result of glacial melt water deposits in ice contact situations. They are sandy and linear in nature, and are deposited along the direction of ice flow. There is one very large esker within the watershed. It extends from the eastern edge of Big Marine Lake northwest into Chisago County. Linear lakes and wetlands are common along its margins. Evidence of groundwater dependent resources has been found along the western margin of the esker, indicating connectivity with groundwater. There is also an unusual lack of till deposits within the esker formation.

<u>Moraine deposits</u>

Moraine deposits within the watershed were deposits laterally along the ice flow or at the furthest extent of glacial flow, perpendicular to ice flow. The moraine deposits are generally deposited diagonally between Hugo and Scandia and are commonly referred to as the St. Croix Moraine. The St. Croix Moraine consists of poorly graded sand, gravel, clay and silt deposits. The Moraine contains numerous small lakes and wetlands, having less connection with regional aquifers than other moraine deposits. The topography is hummocky.

<u>Lake deposits</u>

Lake deposits within the watershed consist of ice-walled lake plains. Ice walled lake plains are found sporadically within the watershed, with the most significant encompassing the area around Big Marine Lake. Ice-walled lakes form as depressions in the top of glacial ice which receive meltwater flowing from other parts of the glacier. Over time the lake fills with fine grained sediment, and the surrounding ice melts. The result is a large flat topped hill. Large lakes are commonly found within these deposits. They were often closed depressions, prior to artificial outlets being installed.

Terrace deposits

Terrace deposits are found along the St. Croix River. These deposits were formed as a result of glacial lake melting. Terrace deposits are a remnant of past higher water levels within the St. Croix River. Topography of the upper terraces is generally level. Deposits consist of coarse sand and gravel. The water table is seldom found in these deposits, as bedrock is near the surface. A steep bluff extends along the western margin of the St. Croix River. Topography is very steep and bedrock is commonly exposed along the bluff. Springs are commonly found along the bluff and emanating from the bedrock and terrace deposits.

Soils

A map identifying the soils of the CMSCWD is included as Figure A-4. As this map illustrates, the soils are classified into groups based upon the hydrologic characteristics of the soils. Soil hydrologic groups are used to estimate the amount of runoff generated for a given rainfall event. Vegetation, organic/mineral or physical composition and slope all contribute to the runoff potential of a soil. There are four hydrologic soil groups: A, B, C and D. Table A-5 presents a description for each of the hydrologic soil groups and identifies the predominant soil type in the watershed for each group.

Table A-5. Soil Classification

Hydrologic Group	Description
A	Soils having high infiltration rates when thoroughly wet (low runoff potential). Deep, well drained to excessively drained sand or gravelly sand.
B	Soils having a moderate infiltration rate when thoroughly wet. Moderately deep or deep, moderately well drained or well drained with moderate to moderately coarse texture.
C	Soils having a slow infiltration rate when thoroughly wet: soils have a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture.
D	Soils having very slow rates of infiltration when thoroughly wet (high runoff potential): soils consist of clays with high shrink-swell potential; soils have a high permanent water table; soils that have a claypan or clay layer at or near the surface and soils that are shallow over nearly impervious material.

Source: Soil Survey of Ramsey and Washington Counties, 1977

Figure A-2. CMSCWD Topography

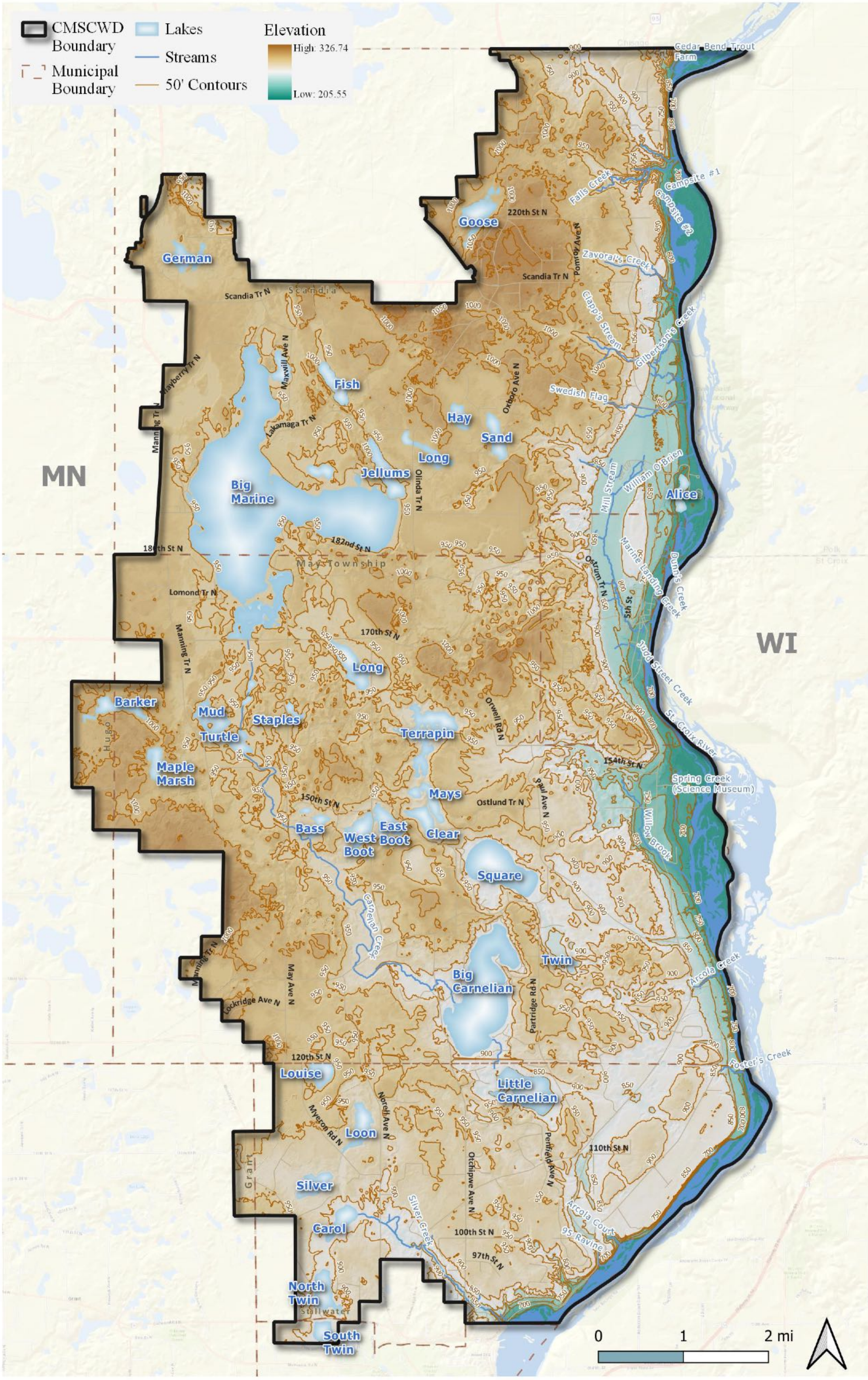

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Figure A-3. CMSCWD Geomorphology

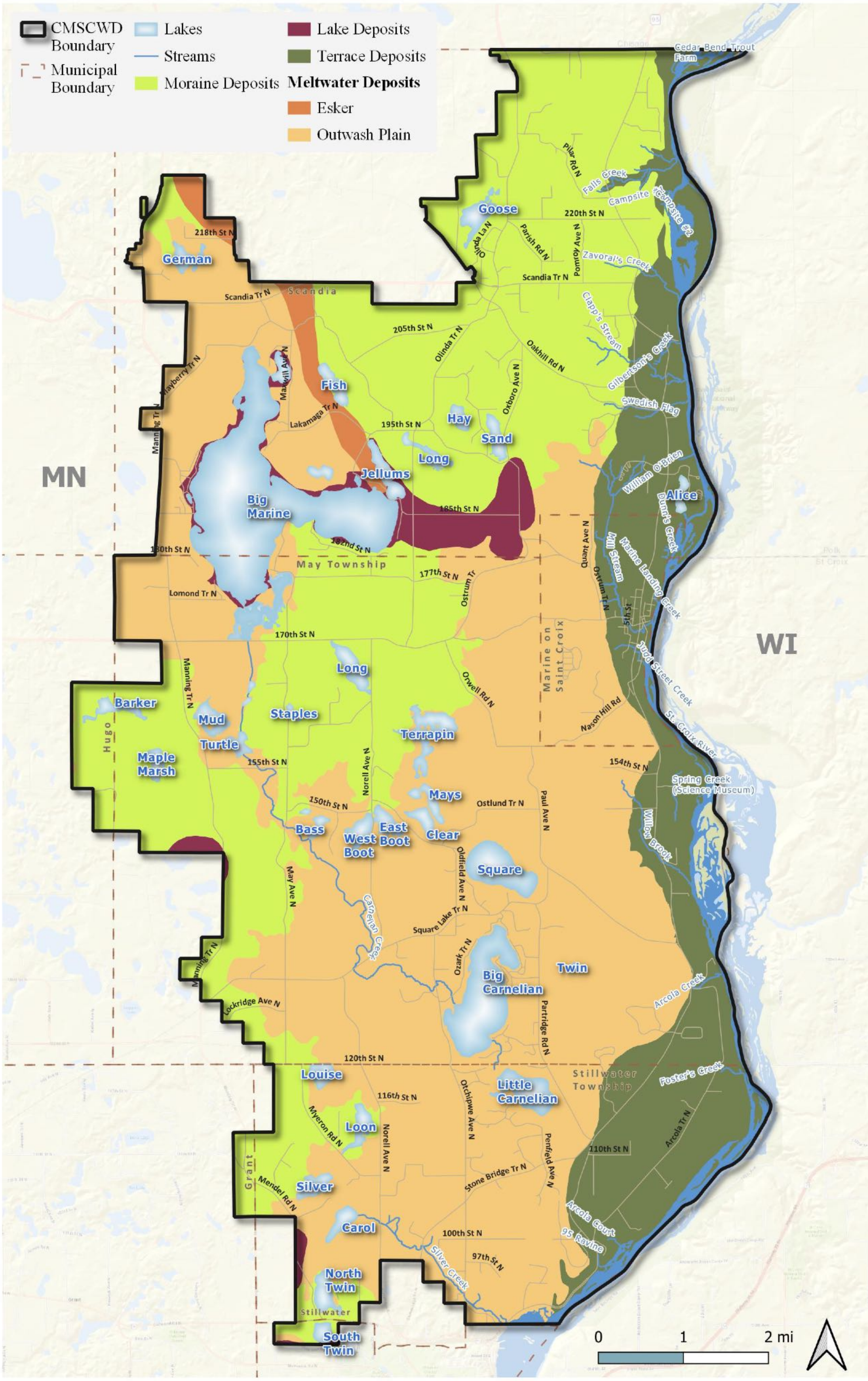

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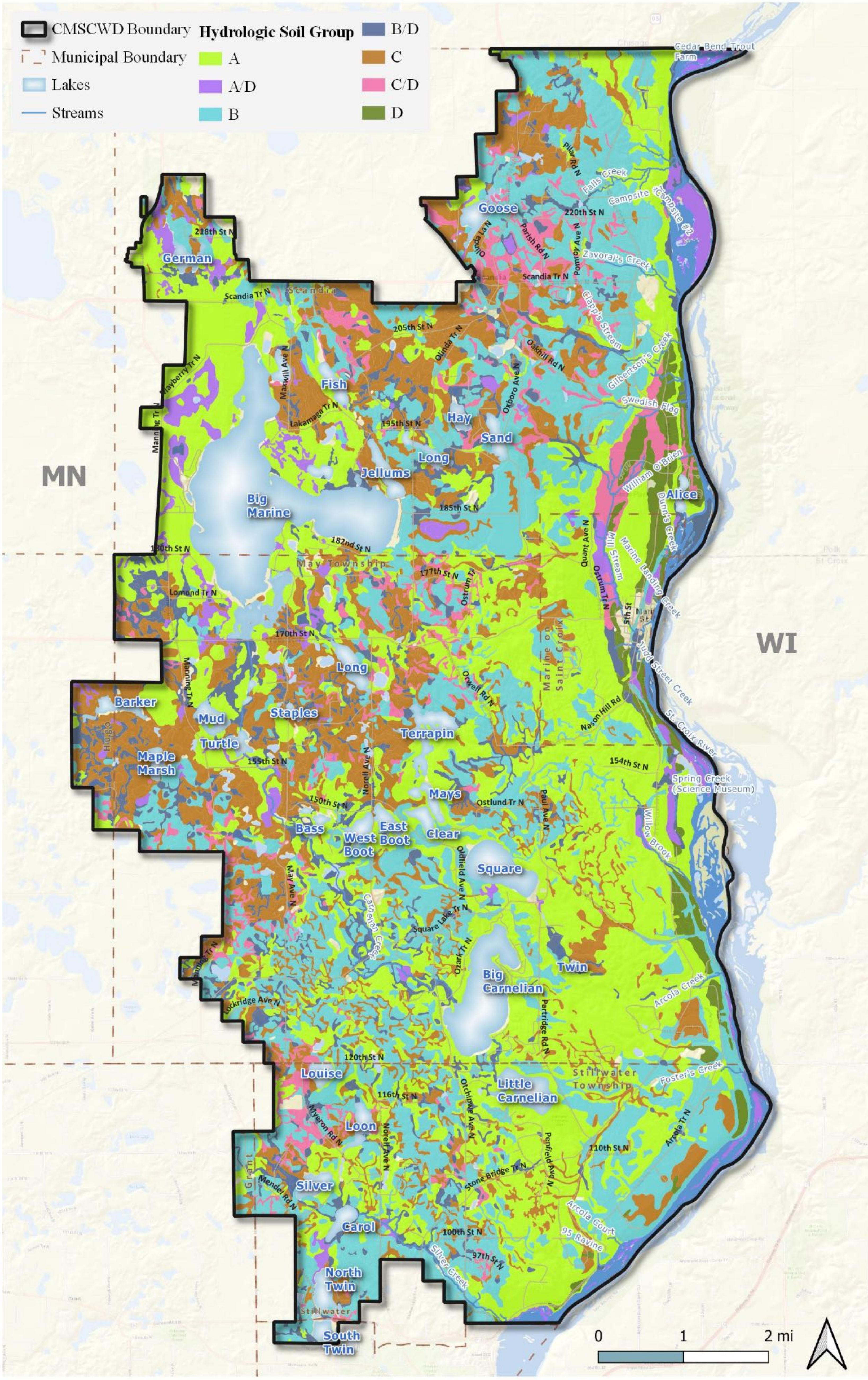
Figure A-4. CMSCWD Soils by Hydrologic Soil Group



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Geology

Surficial Geology

The surficial geology of the CMSCWD contains sediments that were deposited during glacial and post glacial times. The surficial geology is characterized by layers of glacial outwash and till ranging from 0 to greater than 350 feet thick overlaying bedrock. The surficial deposits are associated with the Des Moines Lobe (Grantsburg Sublobe) and Superior Lobe of the Wisconsin Glaciation. In the District, these consist mainly of moraine and meltwater deposits. Along the St. Croix River are stream deposits and river terraces. Many of the lakes in the District were formed when blocks of ice were deposited in outwash plains and meltwater deposits. As the ice melted, depressions were formed. Big Marine, Long, Terrapin, Mays, Square, Big Carnelian, and Little Carnelian formed this way (Patterson et al., 1009). Detailed description of each surficial deposit can be found on the Geologic Atlas of Washington County, Minnesota available online at http://www.geo.umn.edu/mgs.

Bedrock Geology

Lying beneath the surficial sediment is marine sedimentary bedrock of Early Paleozoic age (525 to 400 million years old). Shallow seas covered southeastern Minnesota and parts of adjacent states during most of this period. Sand accumulated on near shore beaches and sand dunes, clay and silt accumulated in offshore deeper water areas, and carbonate (which forms limestone and dolomite) formed in banks and reefs just off shore. The seven bedrock groups which subcrop (are exposed in the subsurface directly below the Quaternary sediment) or outcrop (are exposed directly at the surface) are from youngest to oldest: Decorah Shale, Platteville and Glenwood Formations, St. Peter Sandstone, Prairie du Chien Group limestone and dolomite, Jordan Sandstone, St. Lawrence-Franconia Formations and Ironton-Galesville Sandstone.

A very deep (greater than 350 feet) buried bedrock valley runs from Square Lake south to the St. Croix River. A buried bedrock valley also follows Silver Creek west to Silver Lake.

Surface Water Resources

1.2. Watershed Hydrology

As identified previously, the entire watershed is approximately 81.4 square miles in size. The CMSCWD is home to thousands of acres of lakes and wetlands, many of which are connected via overland flow to the St. Croix River. However, there are two general types of drainage within the watershed. The first type of drainage system is characterized by numerous small ponds and lakes, many of which are landlocked. These landlocked basins are located primarily in the western and central portions of the watershed. Subwatersheds including known major landlocked basins are mapped in Figure A-5. For example, Long (May), Terrapin, and Mays Lakes form a chain of lakes interconnected by a defined drainage way that terminates at Clear Lake, which is landlocked. The same is true for Square Lake which overflows to a landlocked basin. These areas likely serve as important groundwater recharge areas. There are few well defined drainage systems in this area, indicating the permeable nature of the soils and the relatively flat relief of the terrain.

The second type of drainage system is characterized by steep terrain, river terraces and well defined water courses that, for the most part, drain to the St. Croix River. For example, Silver Creek drains a chain of lakes in the southern portion of the watershed to the St. Croix River including South and North Twin Lakes and Silver, Loon and Carol Lakes. Another example is perennial Mill Stream that drains Hay and Sand Lakes during times of high water. This type of drainage is found primarily along the eastern half of the watershed. This portion of the watershed has a well defined drainage system with few lakes. The numerous spring creeks that form along this area were the subject of a comprehensive study entitled St. Croix Spring

Creek Stewardship Plan. Many of the spring creeks are identified as trout streams by the DNR.

1.3. DNR Public Waters and Wetlands

The MN DNR public waters are the lakes, wetlands and watercourses shown in Figure A-6. Beginning in 1937 and based on Minnesota Statute 103G.005, Subdivision 15, the MN DNR has regulatory jurisdiction over these features. In particular, the MN DNR regulates development below the ordinary high water level (OHW) established for the public waters and wetlands.

Figure A-5. CMSCWD Major Landlocked Basins and Subwatersheds

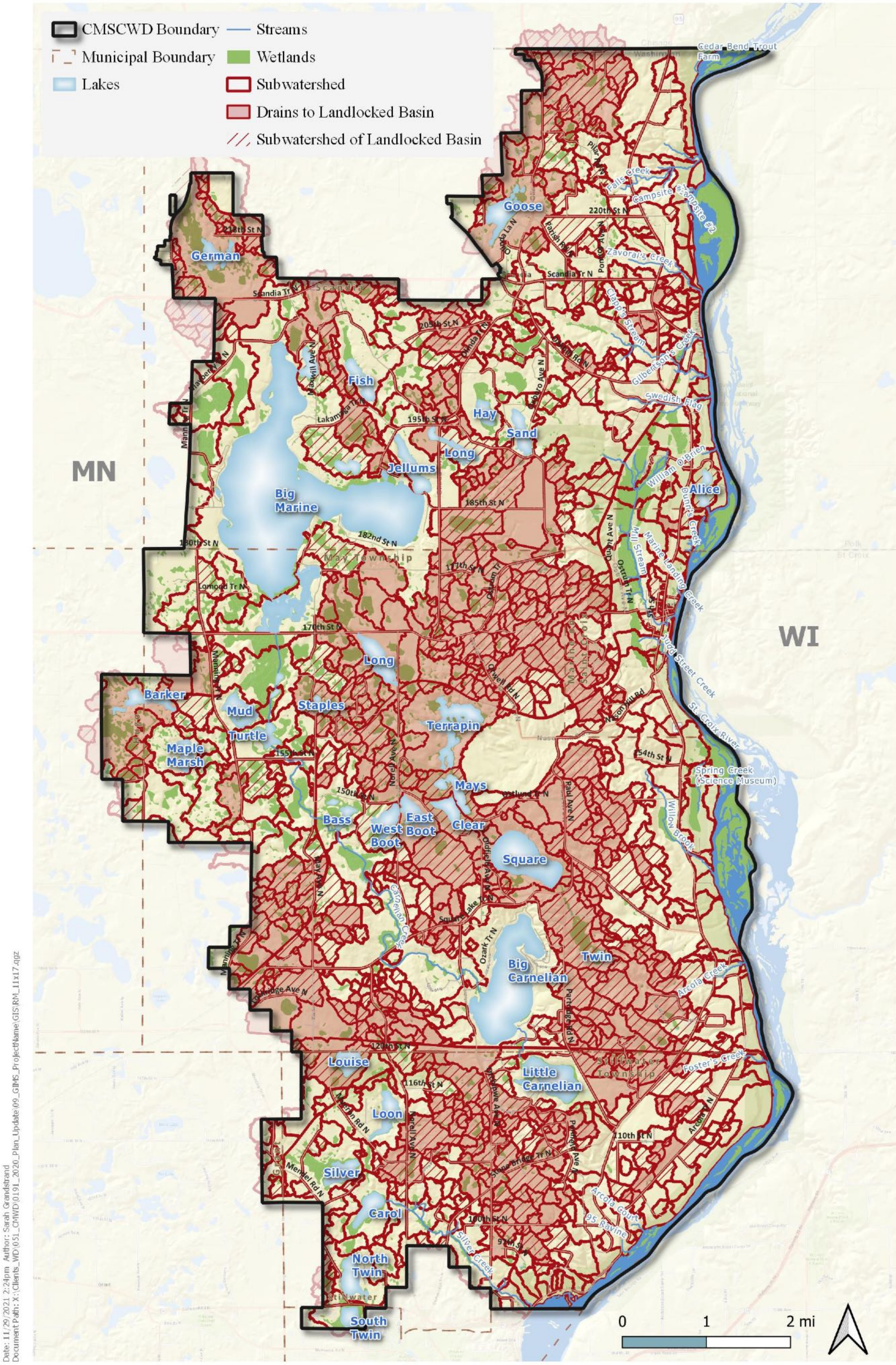
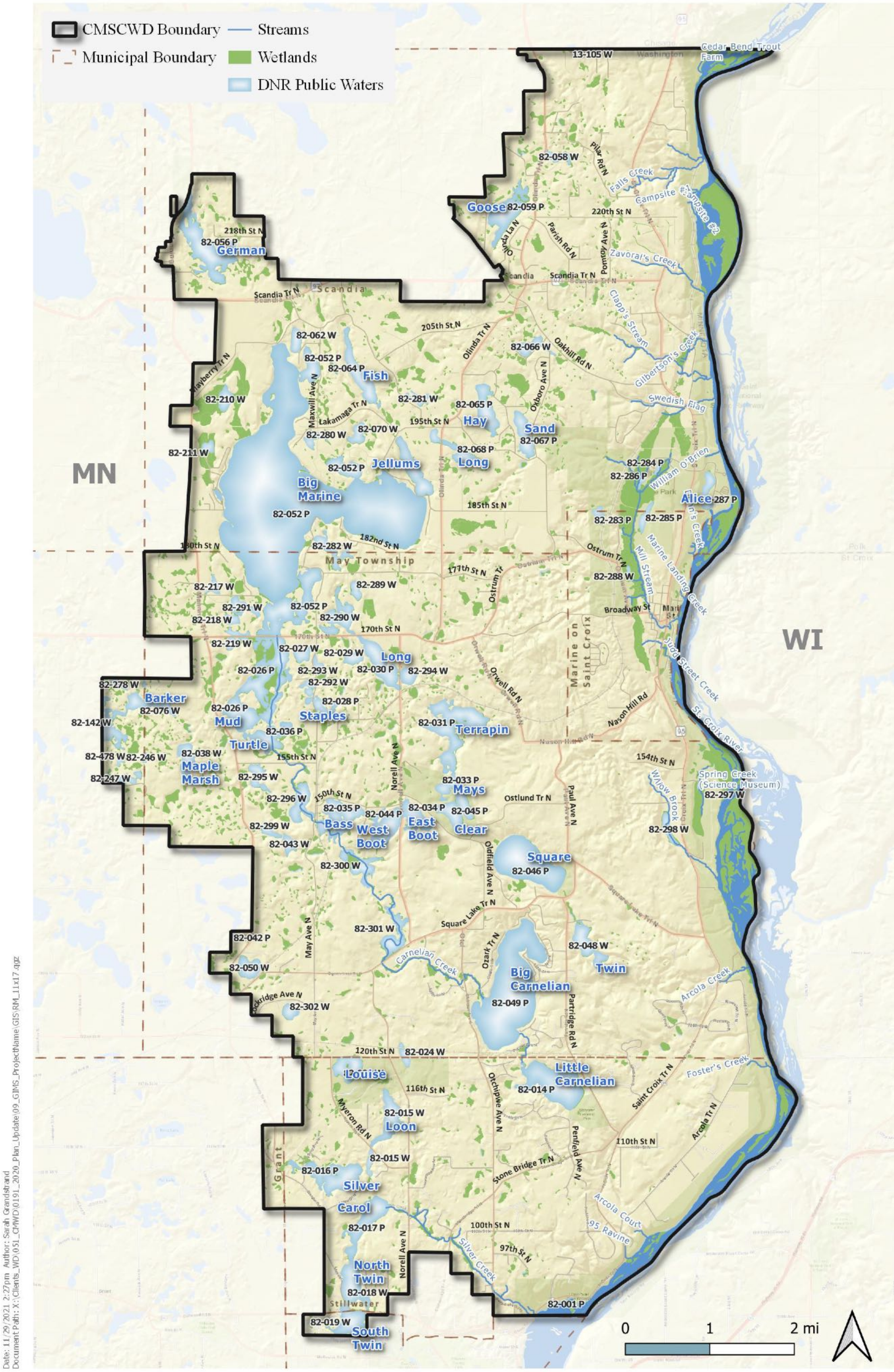


Figure A-6. DNR Public Waters



1.4. Surface Water Features

St. Croix River

The St. Croix River joins with the Mississippi River at Point Douglas, MN / Prescott, WI and then flows south to the Gulf of Mexico. The Lower St. Croix River was designated as a National Wild and Scenic Riverway by Congress in 1972. The portion of the river given the Wild and Scenic designation extends from its source in Wisconsin to its mouth at Point Douglas, MN/Prescott, WI. In 2000, a Cooperative Management Plan was developed for the Lower St. Croix by the Lower St. Croix Management Commission with the assistance of the Lower St. Croix Planning Task Force. The portion of the St. Croix River that forms the eastern boundary of the CMSCWD is listed on the MPCA Impaired Waters List per Section 303(d) of the federal Clean Water Act. This part of the River is identified as impaired for aquatic consumption by mercury and PCBs. Just downstream of the CMSCWD, the St. Croix River widens to form Lake St. Croix which extends to the confluence with the Mississippi River. Lake St. Croix is listed as impaired for aquatic recreation by excess nutrients.

The St. Croix River is currently classified by the State of Minnesota as an Outstanding Resource Value Water for its water quality, wildness and other benefits. By state statute, new or expanded discharges (changes in volume, quality, location or any other manner) to the St. Croix River must be controlled so as to prevent deterioration in the quality of the St. Croix River (MN Statute 7050.0180 Subp. 9).

Streams

Fall's Creek, Willow Brook, Mill Stream, Carnelian Creek and Silver Creek are the five most significant perennial streams in the watershed. Fall's Creek, Willow Brook, Gilbertson's Creek and Mill Stream are state-designated trout streams. Information related to these streams is available within the Lower St. Croix River Spring Creek Stewardship Plan (EOR, 2003c), and is summarized below.

Fall's Creek

Fall's Creek is considered to be the finest and most ecologically diverse natural area in Washington County and is of state-wide significance. Fall's Creek has a naturally reproducing population of Brook Trout (Salvelinus fontinalis). However, population size is limited by habitat. In-stream habitat is moderate due to sedimentation and lack of significant pools and in-stream cover. Three intolerant macroinvertebrate genera are found in abundance at this site indicating that water quality is excellent.

The Fall's Creek watershed is comprised of forested ravines, abandoned farm fields and S.H. 95 right-of-way. The lower portion of the watershed includes the Fall's Creek Scientific and Natural Area. In its upper reaches, Fall's Creek is an ephemeral stream with two major branches extending several miles west of S.H. 95. The last 0.8 miles of stream is a perennial, cool water stream.

Willow Brook

Willow Brook starts within a groundwater-dependent wetland complex west of Highway 95. East of Highway 95, Willow Brook flows through the Croixside Residential Development. Within this reach, Willow Brook is a moderate to high gradient stream. Just upstream of the St. Croix River, a series of small fish ponds were constructed behind concrete weirs. The headwaters of Willow Brook encompass an excellent quality shrub fen/rich fen wetland complex. This wetland complex provides the majority of base flow to Willow Brook and is therefore important to the long term protection of this stream. Willow Brook contains populations of naturally reproducing brook trout.

The 1,150 acre watershed of Willow Brook is relatively undeveloped west of Highway 95, where it is dominated by forest, woodland, conifer plantation and old fields. The watershed east of Highway 95 is dominated by residential development, with Willow Brook flowing through the back yard of many residential lots.

Mill Stream

Mill Stream runs through the center of the village of Marine-on-St. Croix. There are two lakes in the headwaters of the stream, Sand Lake and Hay Lake. During wet conditions, particularly frozen-ground, snowmelt-runoff periods, these two lakes may fill up with enough water to outlet to Mill Stream. Downstream of the ephemeral channel that outlets from Sand Lake, the perennial portion of Mill Stream begins. The headwaters of Mill Stream within William O'Brien State Park contains a large, groundwater-dependent wetland complex. This wetland complex has probably been ditched and altered from past grazing more than other wetlands in the area. However, some potions of this wetland complex do include good quality tamarack swamp, mixed hardwood seepage swamp and rich fen. From this northerly point, Mill Stream flows south for about 1.5 miles to the village of Marine-on-St. Croix. Within this 1.5 mile reach, flows increase significantly as groundwater discharges off the terrace slope located to the west of Mill Stream. Within the lower-most portion of this reach, MN DNR has restored wetland communities and approximately 1000 feet of tributary channel that historically flowed to Mill Stream from the numerous springs within this reach.

Downstream of the restoration site, Mill Stream is impounded (Upper Mill Pond) behind a concrete weir constructed across what was once a waterfall. Below the Upper Mill Pond, Mill Stream flows as a high gradient stream over bedrock within a deep valley for several hundred feet. Approximately 200 feet upstream of Highway 95, the gradient of Mill Stream lessens considerably as it flows across the middle terrace of the St. Croix River and through the center of Marine-on-St. Croix. Below State Highway 95, Mill Stream flows through an additional groundwater-fed wetland complex. This second wetland complex encompasses many of the same wetland types found near the headwaters, but and is generally of higher quality. Just above Judd Street, Mill Stream is again impounded behind a concrete weir, forming the Lower Mill Pond. Below the concrete weir, Mill Stream flows under the Brookside Bar and outlets over a second waterfall. Below the second waterfall, Mill Stream flows several hundred more feet through a floodplain forest where it discharges into the St. Croix River.

Brook Trout (Salvelinus fontinalis) are known to occur throughout the entire stream, including the recently restored tributaries. The best habitat, however, is within the lower sections of the creek below the Upper Mill Pond.

The watershed of Mill Stream is a diverse mixture of agricultural land, large-lot residential, forest, and woodland and grassland. The lower section of the stream flows though a relatively dense urban community with substantial direct drainage of impervious surfaces, mostly from a combination of residential streets, State Highway 95 and County Road 4, which all converge near the lower end of the creek and convey storm flows directly to Mill Stream.

Carnelian Creek

Carnelian Creek is an extensive waterway traversing almost 9 miles through three communities and connecting numerous wetlands along its path from Big Marine Lake through Turtle, Bass and Big Carnelian Lakes and finally on to Little Carnelian Lake. The former CMWD's *Natural Resource Inventory and Management Plan* identifies the resources found in the Carnelian Creek as ranking from moderate to high for ecological ranking, wildlife habitat rank and rare features potential. The natural watercourse of Carnelian Creek was modified by a major improvement project completed in July of 1985, referred to as the outlet project. The main purpose of the project was to alleviate flooding around Big Marine Lake, Big Carnelian Lake and along the entire watercourse. The outlet project consisted of a 15,000 ft gravity pipe from Little Carnelian Lake (outlet elevation 854.4) all the way to the St. Croix River. In addition to the outlet pipe, the project included control structures and some channel improvements along the flow route from Big

Marine Lake to Little Carnelian Lake. At the northern end of the project a drop inlet control structure was built to provide an outlet for Big Marine Lake. A control structure located at the outlet of Turtle Lake was built in order to help the CMWD maintain water in the wetland area in the vicinity of Mud and Turtle Lakes during dry years while still providing an outlet from the area during wet years. A control structure was also built at the existing outlet from Big Carnelian Lake. Improvements were also made to runout channels from Big Marine Lake through Big Carnelian Lake to Little Carnelian Lake.

Silver Creek

Silver Creek flows perennially from Carol Lake to the east approximately two miles to the St. Croix River near the St. Croix Boom Site. Four lakes drain into Carol Lake including three high quality wildlife lakes (Silver Lake, North Twin Lake and South Twin Lake) and one poor quality lake (Loon Lake) which form the headwaters of the Creek. The southern portion of the Silver Creek watershed, near South Twin Lake, extends to within ¼ mile of the Brown's Creek Corridor. Approximately ¼ mile before discharging to the St. Croix River, Silver Creek cascades over a 50-foot waterfall, Fairy Falls. The CMWD and the MWMO completed the St. Croix Spring Creek Stewardship Plan concurrently with the CMWD's Natural Resource Inventory (NRI). Both of these studies identified Silver Creek and its corridor as an important resource and a priority for management efforts. As a result, the Silver Creek Corridor was established with development and implementation of the Silver Creek Corridor Management Plan.

The upper portion of the corridor encompasses a system of five good quality shallow lakes with significant areas of riparian wetland habitat. The middle reaches of the corridor contain a number of unique groundwater-dependent plant communities including rich fen and mixed hardwood seepage swamp. The lower reaches of Silver Creek are an ecologically rich area with high quality plant communities and a high quality, groundwater-fed perennial stream. The Silver Creek Corridor provides an excellent link between the St. Croix River and upland areas to the west including the Brown's Creek corridor. Silver Creek and its associated riparian areas form a significant aesthetic resource for Stillwater Township residents. That said, neither Silver Creek nor Carnelian Creek are suitable for trout or utilized as a significant recreational resource. Historically, it has been the intention of the District to manage these two streams for the purpose of flood prevention, water quality protection and improvement, and natural corridor preservation.

Lakes

There are 31 named lakes in the watershed (Figure A-6). Attachment A (Table A-19) summarizes historic lake water quality data available for lakes in the CMSCWD (total phosphorus, chlorophyll-a and secchi disc readings). Several of the lakes fall within parkland or protected areas including Big Marine, Terrapin Lake, Mays Lake, Clear Lake, Lake Alice and portions of Square Lake. The remaining lakes are generally surrounded by predominantly large lot residential homes.

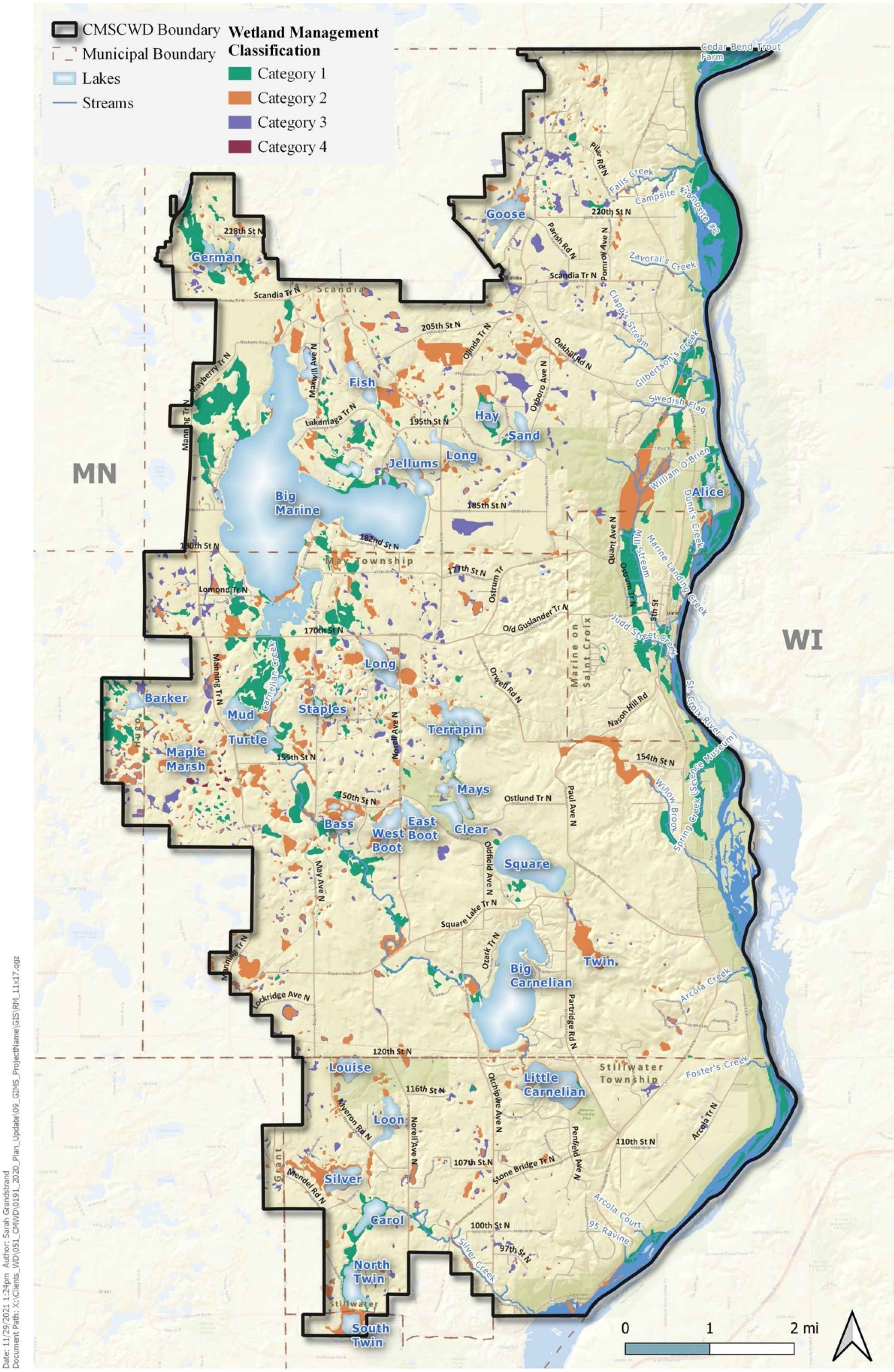
The Carnelian Creek chain of lakes consists of Big Marine, Turtle, Bass, Big Carnelian and Little Carnelian. Big Marine, Big Carnelian and Little Carnelian are some of the principle lakes in the District. Their respective sizes are roughly 1,800, 450 and 160 acres. All have exceptionally good water quality. These three lakes are part of the District's major watercourse that starts in Big Marine and eventually meanders through Big Carnelian and Little Carnelian where a gravity outlet discharge pipe to the St. Croix River exists.

Another notable hydrologic feature within the District is Square Lake. Square Lake is the most well researched lake in the watershed. Square Lake consistently has the best water quality of any lake in the seven county metro area with an average secchi disk reading of 18.7 feet (2010-2020). This lake maintains a groundwater base flow and continuously outlets through an artificial outlet to the south into a landlocked basin. The lake is stocked annually with rainbow trout by the DNR. The former MWMO conducted a comprehensive study on this lake entitled Square Lake Clean Water Partnership Project: Diagnostic Feasibility Study and Implementation Plan, May 2002.

Wetlands

A Wetland Management Plan was completed by CMSCWD in 2010. A complete inventory and functional assessment was performed for all the wetlands in the watershed. The Wetland Management Plan is meant to supplement existing state and federal regulations currently in control of CMSCWD's wetland resources, it is also meant to add additional protection and flexibility in managing the wetlands in the district. The overall goal of the wetland plan is at a minimum to protect the functions and diversity of the district's wetlands and lay the groundwork to improve these resources. Utmost emphasis is placed on maintaining and protecting the diverse array of high valued and high functioning wetlands within CMSCWD, with secondary focus on restoration. The wetland functional assessment was used to classify CMSCWD's wetlands into one of the four following management categories shown in Figure A-7.

Figure A-7. Wetland Functional Assessment



1.5. Impaired Waters

Section 303(d) of the Federal Clean Water Act requires that states establish total maximum daily loads of pollutants to water bodies that do not meet water quality standards. The loading limits are to be calculated such that, if achieved, the water body would meet the applicable water quality standard. To comply with the Clean Water Act, the Minnesota Pollution Control Agency (MPCA) assesses the state's waters, lists those water bodies that are impaired (i.e. do not meet water quality standards), and conducts studies to determine the pollutant loading limits for the impaired water bodies. These studies are known as total maximum daily load (TMDL) studies.

The MPCA sets target start and completion dates for individual TMDL studies. Each TMDL study describes the impairment, identifies the relevant pollutant(s), inventories the pollutant sources, calculates the assimilative capacity of the water body, allocates the allowable loads to the different sources, and prescribes an implementation strategy to restore the water body to meet water quality standards. Within a year of completing the TMDL study, the MPCA requires the completion of an implementation plan, which provides more specific management details than are provided in the initial TMDL study.

Table A- 6 summarizes District water bodies on Minnesota's 2020 303(d) list of impaired waters. Three of the lakes (Big Marine, Big Carnelian, and Square Lakes) and reach of the St. Croix River from Taylors Falls Dam to Lake St Croix are impaired for aquatic consumption due to mercury. The MPCA completed a Statewide Mercury TMDL, approved by the US EPA on March 27, 2007, which does not include any specific requirements for stormwater discharges and is therefore not applicable to the District. The TMDL focuses on reductions in mercury from air emissions and wastewater treatment plants.

The Watershed District completed a TMDL on ten lakes impaired for aquatic recreation as a result of nutrients/eutrophication, and biological

indicators (Table A-7). The CMSCWD Multi-Lakes TMDL was approved by the US EPA in 2012. Barker Lake (82-0076) was listed in 2012 as impaired for aquatic recreation as a result of nutrients/eutrophication, and biological indicators. Goose Lake (82-0059-) was listed as impaired for aquatic consumption due to mercury in 2012. The St. Croix River reach from Taylors Falls Dam to Lake St Croix was listed in o the CMSCWD is identified as impaired for aquatic consumption for PCBs and impaired for aquatic life dues to nutrients in 2006 and 2020 respectively. Currently there are not TMDLs planned for these four impairments.

Water Body	Year Listed	AUID	Affected Designate Use	Pollutant or Stressor	TMDL
St Croix River[1] Taylors Falls Dam to Lake St Croix (82-0001-00)	1998	07030005-784	Aquatic Consumption	Mercury in fish tissue	Statewide TMDL: Mercury Pollutant Reduction Plan
	2006	07030005-784	Aquatic Consumption	PCBs in fish tissue	NA
	2020	07030005-784	Aquatic Life	Nutrients	NA
Loon (Main Lake)	2004	82-0015-02	Aquatic Recreation	Nutrients	Carnelian Marine St. Croix 10 Lake TMDL: Excess Nutrients
South Twin	2006	82-0019-00	Aquatic Recreation	Nutrients	
Louise	2004	82-0025-00	Aquatic Recreation	Nutrients	
Mud (main lake)	2010	82-0026-02	Aquatic Recreation	Nutrients	
East Boot	2004	82-0034-00	Aquatic Recreation	Nutrients	
Big Marine (Jellums)	2004	82-0052-02	Aquatic Recreation	Nutrients	
Goose	2002	82-0059-00	Aquatic Recreation	Nutrients	
Fish	2004	82-0064-00	Aquatic Recreation	Nutrients	
Hay	2002	82-0065-00	Aquatic Recreation	Nutrients	
Long	2004	82-0068-00	Aquatic Recreation	Nutrients	
Square	2002	82-0046-00	Aquatic Consumption	Mercury in fish tissue	Statewide TMDL: Mercury Pollutant Reduction Plan
Big Carnelian	1998	82-0049-00	Aquatic Consumption	Mercury in fish tissue	
Big Marine (Main Lake)	1998	82-0052-04	Aquatic Consumption	Mercury in fish tissue	
Goose	2012	82-0059-00	Aquatic Consumption	Mercury in fish tissue	NA
Barker	2012	82-0076-00	Aquatic Recreation	Nutrients	NA

Table A- 6. District Water Bodies on Minnesota’s 2020 Impaired Waters List

Table A-7. Lakes included in the CMSCWD Multi-Lakes TMDL (2012) and annual phosphorus reduction goal		
Lake Name	Lake ID	Annual Reduction in Total Phosphorus to meet TMDL
East Boot	82-0034-00	8 lb/yr
Fish	82-0064-00	54 lb/yr r
Goose	82-0059-00	92 lb/yr
Hay	82-0065-00	36 lb/yr
Jellum's	82-0052-02	47 lb/yr
Long (Scandia)	82-0068-00	23 lb/yr
Loon	82-0015-02	82 lb/yr
Louise	82-0025-00	40 lb/yr
Mud	82-0026-02	13 lb/yr
South Twin	82-0019-00	1 lb/yr

1.6. Floodplain

Figure 8 shows floodplain boundaries derived from the Flood Insurance Rate Maps (FIRMs) published by the Federal Emergency Management Agency (FEMA). Floodplains are lowland areas adjacent to lakes, wetlands, and rivers that are susceptible to inundation of water during a flood. For regulatory purposes, the floodplain is defined as the area covered by the 100-year flood or the area that has a 1 percent chance of flooding every year. It is usually divided into districts called the floodway and flood fringe. The floodway includes the river channel and the portion of the floodplain outside of the river channel that carries the base flood. The flood fringe is the outer portion of the floodplain that lies between the floodway and the limit of flooding expected from the 1 percent change event. The 100-year flood elevation has been established for basins within the CMSCWD either by FEMA or the District (Figure A-7). Also shown in the table are the critical event resulting in the 100-year flood elevation.

Table A-8. 100-year Flood Elevations of Basin in the CMSCWD				
Basin Name	MN DNR ID	100-year Flood Elevation	Source	Event
Alice	82-0287 00			
Barker	82-0076 00	987.20	FEMA	
Barking Dog Pond	82-0499 00	869.01	District	10-day Snowmelt
Bass	82-0035 00	933.75	District	10-day Snowmelt
Big Carnelian	82-0049 00	864.80	FEMA	
Big Marine	82-0052 00	942.60	FEMA	
Big Marine (EC Bay)	82-0052 03	944.81	District	10-day Snowmelt
Big Marine (NE Bay)	82-0052 01	947.04	District	10-day Snowmelt
Big Marine (Ourlet Bay)	82-0052 05	945.13	District	100-year, 24-hour
Bjorndahl Pond	82-0064 02	952.81	District	10-day Snowmelt
Brown Pond (Survey 0655)	82-0513 00	927.99	District	100-year, 24-hour
Carol	82-0017 00	886.00	District	10-day Snowmelt

Table A-8. 100-year Flood Elevations of Basin in the CMSCWD				
Basin Name	MN DNR ID	100-year Flood Elevation	Source	Event
Clear	82-0045 00	907.61	District	10-day Snowmelt
Deaner	82-0509 00	970.49	District	10-day Snowmelt
Dwyer Pond	82-0511 00	898.36	District	10-day Snowmelt
East Boot	82-0034 00	919.60	FEMA	
Fish	82-0064 00	954.20	FEMA	
German	82-0056 00	959.00	FEMA	
Goose	82-0059 00	979.45	District	10-day Snowmelt
Haas Pond	82-0515 00	991.90	District	10-day Snowmelt
Hay	82-0065 00	973.50	District	10-day Snowmelt
Jamee Lee Slough	82-0289 00	950.16	District	100-year, 24-hour
Jellums	82-0052 02	944.65	District	10-day Snowmelt
Kelley Pond	82-0295 00	948.65	District	10-day Snowmelt
Kiesow	82-0299 00	967.38	District	100-year, 24-hour
Little Carnelian	82-0014 00	858.97	District	10-day Snowmelt
Little Keller Pond	82-0505 00	946.61	District	10-day Snowmelt
Long (May)	82-0030 00	932.74	District	100-year, 24-hour
Long (Scandia)	82-0068 00	965.09	District	10-day Snowmelt
Loon	82-0015 00	906.96	District	10-day Snowmelt
Loon (South Bay)	82-0015 01	903.26	District	100-year, 24-hour
Louise	82-0025 00	943.23	District	10-day Snowmelt
Maple Marsh	82-0038 00	974.50	FEMA	
Mays	82-0033 00	913.57	District	10-day Snowmelt
Mud - east basins	82-0026 00	943.00	FEMA	
Mud - wetland south of CSAH 4	82-0026 01	943.91	District	100-year, 24-hour
Mud - main lake	82-0026 02	941.36	District	10-day Snowmelt
North Deaner	82-0043 00	957.32	District	100-year, 24-hour
North Twin	82-0018 00	886.01	District	10-day Snowmelt
Pitzl Pond	82-0282 00	942.48	District	10-day Snowmelt
Rasmussen Pond	82-0070 00	947.10	FEMA	
Sand	82-0067 00	966.83	District	10-day Snowmelt
Silver	82-0016 00	909.70	District	10-day Snowmelt
South Twin	82-0019 00	889.74	District	100-year, 24-hour
Square	82-0046 00	869.97	District	100-year, 24-hour
Staples	82-0028 00	950.00	FEMA	
Terrapin	82-0031 00	913.69	District	10-day Snowmelt
Turtle	82-0036 00	943.00	FEMA	
Twin (May)	82-0048 00	855.60	District	10-day Snowmelt
Warikois Pond	82-0027 00	943.66	District	100-year, 24-hour

Table A-8. 100-year Flood Elevations of Basin in the CMSCWD				
Basin Name	MN DNR ID	100-year Flood Elevation	Source	Event
Warner Nature Pond	82-0032 00	962.56	District	10-day Snowmelt
West Boot	82-0044 00	919.60	FEMA	
Wojtowicz Pond	82-0058 00	984.02	District	10-day Snowmelt
	82-0024 00	930.10	District	10-day Snowmelt
	82-0029 00	941.88	District	100-year, 24-hour
	82-0050 00	974.88	District	10-day Snowmelt
	82-0062 00	947.01	District	10-day Snowmelt
	82-0066 00	992.09	District	100-year, 24-hour
	82-0142 00			
	82-0210 00	953.67	District	100-year, 24-hour
	82-0211 00	950.92	District	100-year, 24-hour
	82-0217 00	957.72	District	10-day Snowmelt
	82-0218 00	947.65	District	100-year, 24-hour
	82-0219 00			
	82-0246 00			
	82-0247 00	1,005.90	District	100-year, 24-hour
	82-0278 00			
	82-0280 00			
	82-0281 00	987.05	District	100-year, 24-hour
	82-0283 00	862.99	District	100-year, 24-hour
	82-0284 00	814.90	District	100-year, 24-hour
	82-0285 00	814.86	District	100-year, 24-hour
	82-0286 00	818.63	District	100-year, 24-hour
	82-0288 00			
	82-0290 00	941.48	District	100-year, 24-hour
	82-0291 00	947.65	District	100-year, 24-hour
	82-0292 00			
	82-0293 00	946.61	District	10-day Snowmelt
	82-0294 00	935.27	District	100-year, 24-hour
	82-0296 00	937.60	District	100-year, 24-hour
	82-0297 00			
	82-0298 00			
	82-0300 00			
	82-0301 00			
	82-0302 00	977.52	District	10-day Snowmelt
	82-0478 00			

Natural Communities

The CMSCWD contains a number of valuable resources. Natural communities are grouped by landscape units areas based on the results of the 1999 Mill Stream Natural Resources Inventory (NRI), the 2001 Marine-on-St. Croix Watershed Management Organization NRI, and the 2003 Carnelian-Marine Watershed District NRI. A map of the natural communities can be found on Figure A-9.

1.7. Summary of the CMSCWD Natural Resource Inventories

Before the Marine-on-St. Croix Watershed Management Organization (Marine WMO) and the Carnelian-Marine Watershed District (CMWD) merged, several Natural Resource Inventories (NRIs) were completed. The first NRI was completed for the Mill Stream Association in collaboration with the City of Marine-on-St. Croix and the Marine WMO who initiated the first phase of the project. The geographic scope of this first phase included areas within the hydrologic boundaries of Mill Stream Watershed, generally lying south of William O'Brien State Park. Phase I of the project, emphasized the riparian corridor of Mill Stream as well as the physical and biological instream features of the Mill Stream, was competed in 1999, and is shown in Figure A-10 as the "Millstream Landscape Unit."

The Marine WMO completed the second phase of the project in 2001. The geographic scope was expanded to include all portions of the Marine WMO not completed during the first phase of the project. The second phase does not include inventory of William O'Brien State Park or Warner Nature Center. The boundaries of the second phase of the project are shown in Figure A-10 as "Marine WMO Landscape Units." The results of both phases of the Marine WMO NRI are summarized in Table A-9.

The Carnelian-Marine Watershed District (CMWD) also completed a Natural Resource Inventory (CMWD) in 2003 (EOR, 2003a). The results of the CMWD NRI are also summarized in Table A-9 and shown in Figure A-10 as the "CMWD Landscape Units."

Figure A-8. Floodplain Map (FEMA, 2008)

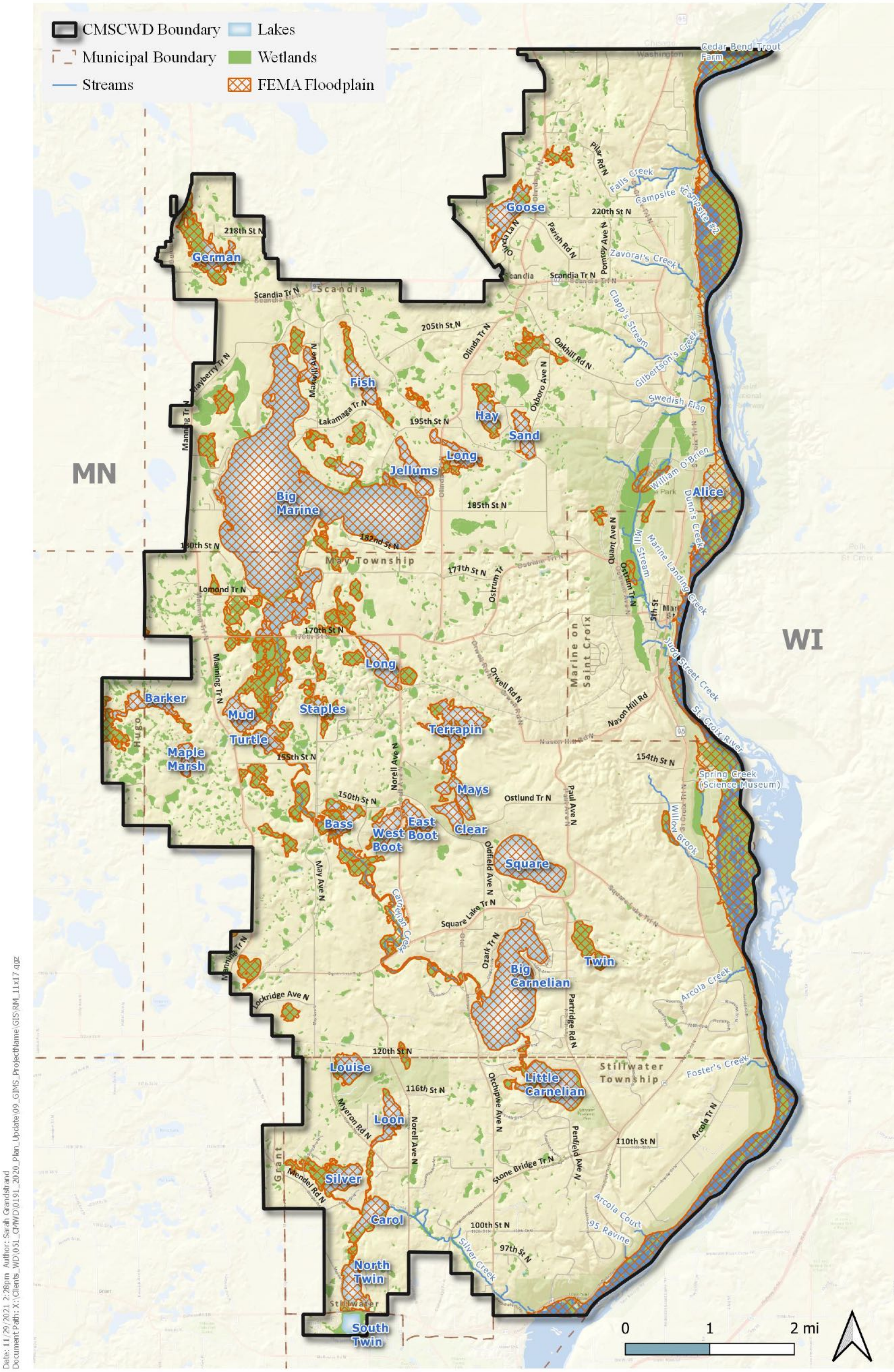


Figure A-9. CMSCWD Natural Communities

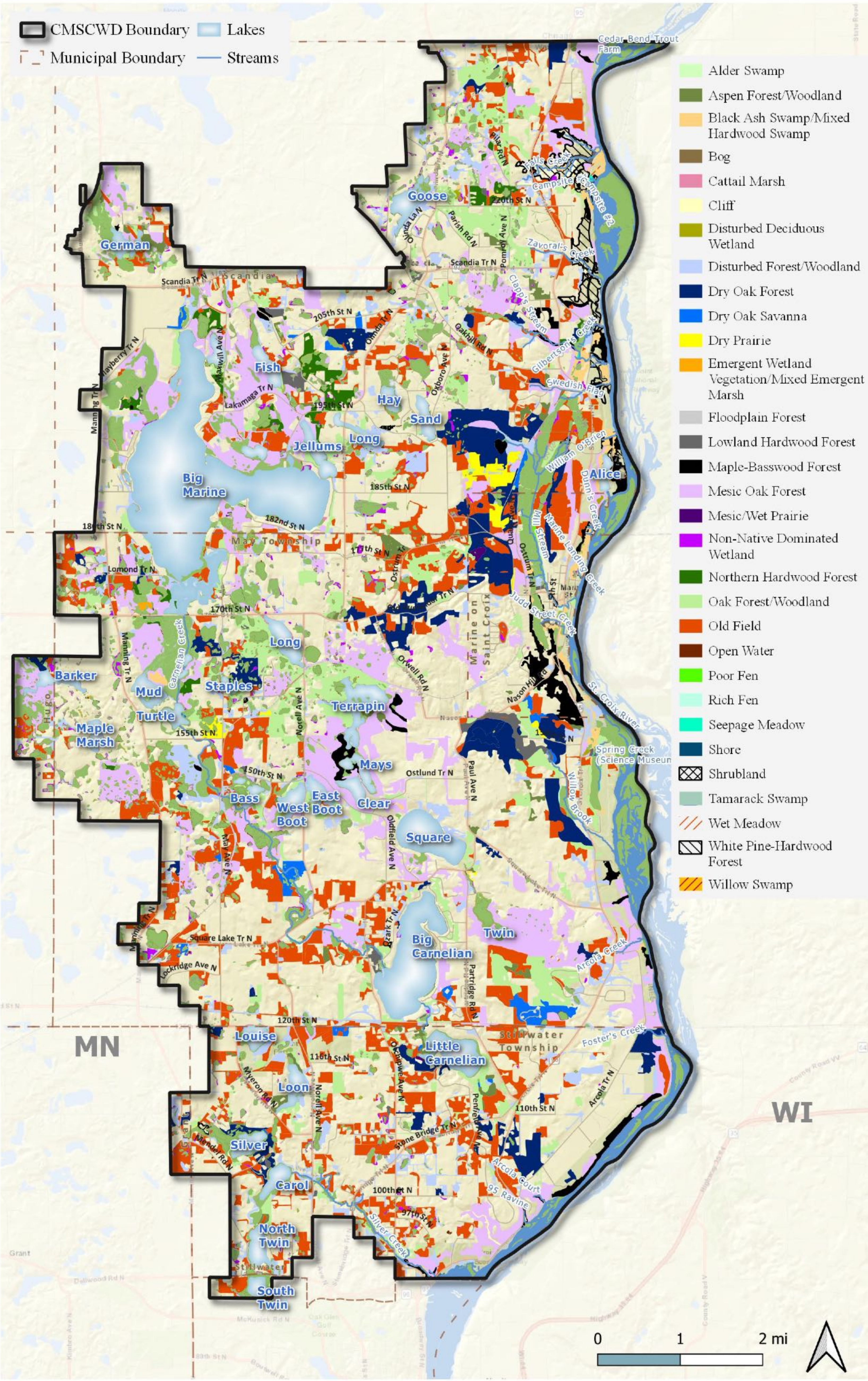


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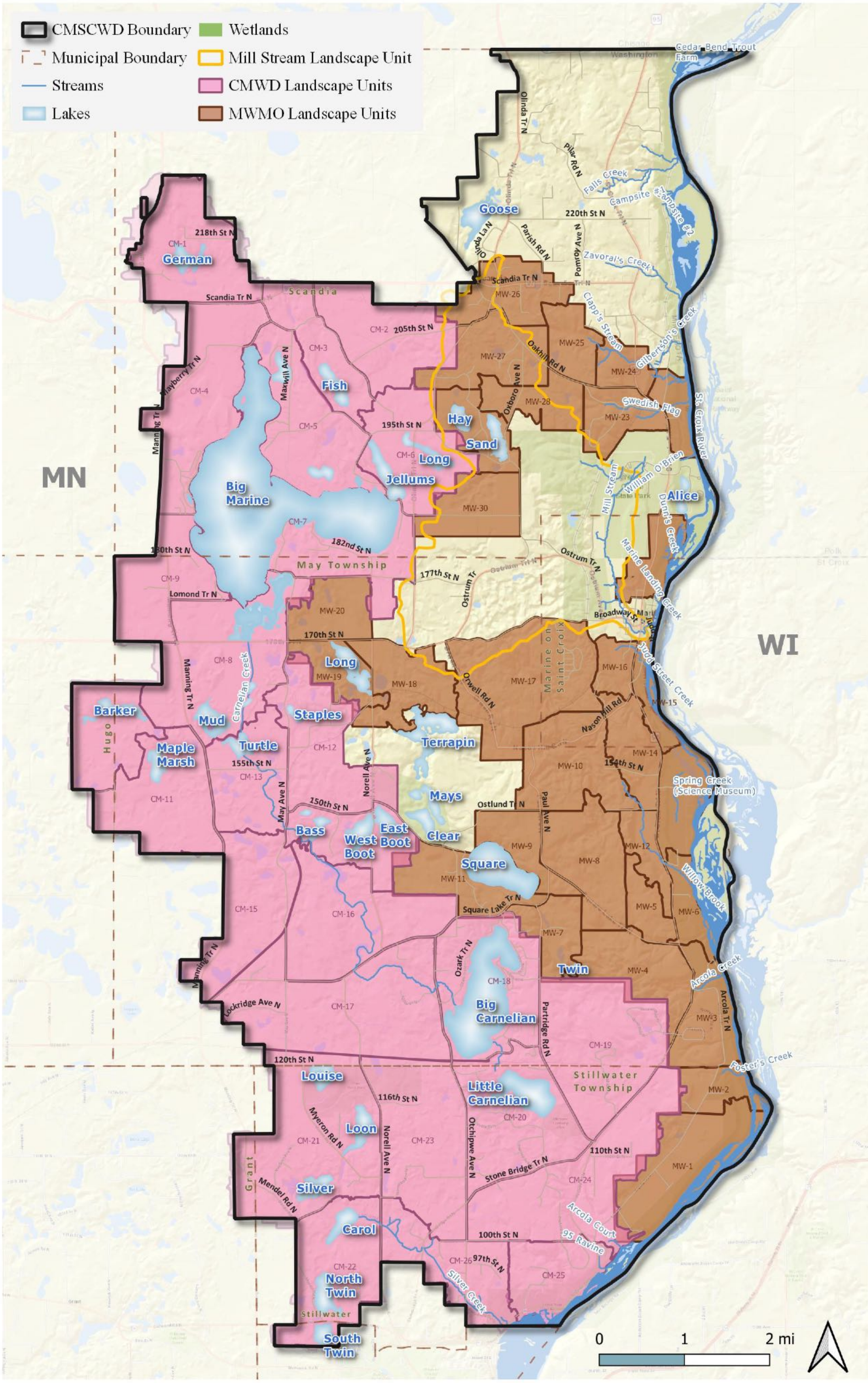
Figure A-10. Natural Resource Inventory Landscape Units



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<table>
<tr><th colspan="6">Table A-9. Overview of CMSCWD Landscape Units (LU)</th></tr>
<tr><th></th><th colspan="5">Landscape Unit Ranking</th></tr>
<tr><th>LU</th><th>Ecological Ranking</th><th>Wildlife Habitat Rank</th><th>Rare Features Potential</th><th>Surface Water Quality</th><th>Soil Erodibility Potential</th></tr>
<tr><td>MW-1</td><td>High</td><td>High</td><td>Mod.</td><td>High</td><td>High</td></tr>
<tr><td colspan="6">Long strip of very high quality maple-basswood forest along the St. Croix River Corridor. Landscape characterized by steep topography with cliff ridges and circumneutral seeps.</td></tr>
<tr><td>MW-2</td><td>Mod.</td><td>High</td><td>High</td><td>High</td><td>High</td></tr>
<tr><td colspan="6">Good diversity of maple basswood and floodplain forest along the St. Croix River corridor.</td></tr>
<tr><td>MW-3</td><td>High</td><td>High</td><td>High</td><td>High</td><td>High</td></tr>
<tr><td colspan="6">Includes Arcola Mills historic property, and some high quality maple-basswood forests along the St. Croix River Corridor with cliff ridges and several spring creeks with trout populations</td></tr>
<tr><td>MW-4</td><td>Mod.</td><td>Mod.</td><td>Low</td><td>High</td><td>High</td></tr>
<tr><td colspan="6">Extensive area of moderate quality mesic oak forest and woodland</td></tr>
<tr><td>MW-5</td><td>Low</td><td>Low</td><td>Low</td><td>High</td><td>Mod.</td></tr>
<tr><td colspan="6">Dominated by moderate quality conifer plantations and old fields</td></tr>
<tr><td>MW-6</td><td>High</td><td>High</td><td>High</td><td>High</td><td>High</td></tr>
<tr><td colspan="6">Large concentration of documented rare features including six mussel species, three plants, and one bird; plus five high quality forest communities, located along the St. Croix River Corridor including several spring creeks.</td></tr>
<tr><td>MW-7</td><td>High</td><td>High</td><td>High</td><td>Mod.</td><td>Mod.</td></tr>
<tr><td colspan="6">Includes Twin Lakes-excellent habitat for fish and shorebird species; an MCBS documented Sand Gravel Oak Savanna, and several high quality oak forests and woodlands</td></tr>
<tr><td>MW-8</td><td>Low</td><td>Low</td><td>Low</td><td>Low</td><td>Mod.</td></tr>
<tr><td colspan="6">Dominated by moderate quality woodlands, pastureland, and conifer plantations.</td></tr>
<tr><td>MW-9</td><td>Low</td><td>Mod.</td><td>Low</td><td>High</td><td>Mod.</td></tr>
<tr><td colspan="6">Dominated by moderate quality woodlands and conifer plantation; drains into Square Lake.</td></tr>
<tr><td>MW-10</td><td>High</td><td>High</td><td>High</td><td>High</td><td>Mod.</td></tr>
<tr><td colspan="6">Includes Tanglewood Preserve, an extensive area of high quality mesic oak forest, and three documented rare features.</td></tr>
<tr><td>MW-11</td><td>High</td><td>High</td><td>High</td><td>High</td><td>High</td></tr>
<tr><td colspan="6">Includes Square Lake - the clearest lake in the Twin Cities Metro area, an extensive area of high quality (yet fragmented) oak forest, a high quality shrub swamp, and four documented rare features.</td></tr>
<tr><td>MW-12</td><td>High</td><td>High</td><td>Mod.</td><td>High</td><td>High</td></tr>
<tr><td colspan="6">Encompasses the headwaters of a spring creek (out of Croixside), bluffs have dry cliff habitat. Four out of its five communities are high quality mesic oak forests, woodland, and a large shrub swamp/rich fen.</td></tr>
<tr><td>MW-13</td><td>High</td><td>High</td><td>High</td><td>High</td><td>Mod.</td></tr>
<tr><td colspan="6">Eleven documented rare features within seven high quality communities, including a rich complex of seepage swamps and fens, lowland hardwood forest, and older, visible conifer plantations. Provides high quality wildlife habitat along St. Croix River Corridor. Includes Science Museum of MN St. Croix Field Station.</td></tr>
<tr><td>MW-14</td><td>High</td><td>High</td><td>High</td><td>High</td><td>High</td></tr>
</table>

Table A-9. Overview of CMSCWD Landscape Units (LU)					
	Landscape Unit Ranking				
LU	Ecological Ranking	Wildlife Habitat Rank	Rare Features Potential	Surface Water Quality	Soil Erodibility Potential
Includes unique dry prairie habitat; extensive area of moderate to high quality oak and maple-basswood forests on steeply rolling terrain; provides excellent wildlife habitat along its middle terrace St. Croix River Corridor					
MW-15	High	High	Mod.	High	High
Located along the St. Croix River Corridor, includes Marine on St. Croix, and a mosaic of high quality natural communities (seepage swamps, river beach, maple basswood forest and old pine plantings).					
MW-16	Mod.	Mod.	Mod.	High	High
Comprised of moderate quality and diversity of lowland hardwood, oak, maple-basswood forests, and seepage swamps. High quality maple-basswood forest protected due to its extremely steep east-facing slope.					
MW-17	Mod.	Mod.	Mod.	Mod.	Mod.
Unique patches of native prairie, and extensive oak forest with some steep sloping topography and protected, mesic, north facing slopes.					
MW-18	High	High	High	High	Mod.
Includes Wilder Forest-Warner Nature Center, and extensive oak forests containing a mosaic of wetland communities. Two documented features in this area					
MW-19	High	High	High	High	Mod.
Contains Long Lake (May) that has excellent water quality, fish, and wildlife habitat. Also are eleven high quality natural communities including mesic oak and northern hardwood forests, tamarack swamp, other open water and wet meadow wetlands, and a unique ericaceous bog.					
MW-20	High	High	High	High	Mod.
Contains six high quality natural communities, such as oak and maple basswood forest, and wetlands such as an alder swamp and tamarack scrub swamp.					
MW-21	High	High	High	High	Mod.
Located along St. Croix River Corridor, is a mosaic of high quality natural areas of extremely high scenic value, includes “Greenburg Island” - a significant Strandline Beach/Floodplain Forest Community, and a unique spring creek flowing out of a black ash seepage swamp and over a rock outcrop. Six rare features documented in the river.					
MW-22	High	High	High	High	High
Located along St. Croix River Corridor, includes high quality lowland hardwood and floodplain forest along shoreline, plus several spring creeks. Also contains very high quality mixed white pine-hardwood forests.					
MW-23	High	Mod.	Mod.	High	High
Includes a high quality oak/maple-basswood forest					
MW-24	High	High	Mod.	High	High
Contains diversity of moderate quality oak, maple-basswood, and lowland hardwood forests with large sized trees.					
MW-25	Mod.	Mod.	Mod.	High	High
Mostly agricultural and old-field dominated, with patches of oak and lowland hardwood forest.					
MW-26	Mod.	Mod.	Mod.	Low	Mod.

Table A-9. Overview of CMSCWD Landscape Units (LU)					
	Landscape Unit Ranking				
LU	Ecological Ranking	Wildlife Habitat Rank	Rare Features Potential	Surface Water Quality	Soil Erodibility Potential
Mostly woodlands and disturbed forested communities surrounded by agricultural fields and residential areas. Contains a mesic brush prairie with restoration potential.					
MW-27	Mod. -High	High	Mod.	Mod.	Mod.
High quality complex of inland wetlands within a mosaic of moderate quality woodlands, surrounded by open fields, agricultural land, and residential areas.					
MW-28	Mod.	Mod.	Mod.	Mod.	Mod.
One high quality cattail marsh within a small complex of forest and wetlands, surrounded by open fields and agricultural land.					
MW-29	High	High	Mod.	High	Mod.
Includes Sand and Hay Lakes, and four very high quality natural communities including a mesic oak forest and some wetlands. The tamarack swamp in between Sand and Hay Lakes has a section of ericaceous vegetation such as leatherleaf, cranberries, and blueberries – not generally found in this area.					
MW-30	Mod.	Mod.	High	Mod.	Mod.
Contains some moderate quality oak woodlands and open water wetlands, with one higher quality cattail marsh, all surrounded by agricultural land. Blanding's turtle, a threatened species, was found in this area.					
CM-1	High	High	High		
German Lake and associated wetlands, some MCBS mapped Tamarack/Shrub Swamp along power line corridor Pristine floating tamarack bog within extensive high quality mesic oak forest					
CM-2	Mod.	Mod.	Mod.		
Oak Savanna restoration opportunities Contains a diversity of moderate to high quality wetland communities					
CM-3	High	High	Mod.		
Extensive Oak Forest along esker ridge Fish Lake and its associated wetland communities					
CM-4	High	High	High		
Many high quality, large wetland complexes (tamarack and hardwood seepage swamps) draining into Big Marine Lake Extensive mesic oak forest					
CM-5	High	High	High		
Extensive high quality Oak Forest along esker ridge also mapped by MCBS Unique rich fen and other high quality groundwater dependent wetland communities mapped by MCBS					
CM-6	Mod.	Mod.	Mod.		
• Jellum's Lake and Long Lake (Scandia) Extensive mesic oak forest above Jellum's Lake is among the highest quality in this watershed district.					
CM-7	High	High	Mod.		

Table A-9. Overview of CMSCWD Landscape Units (LU)

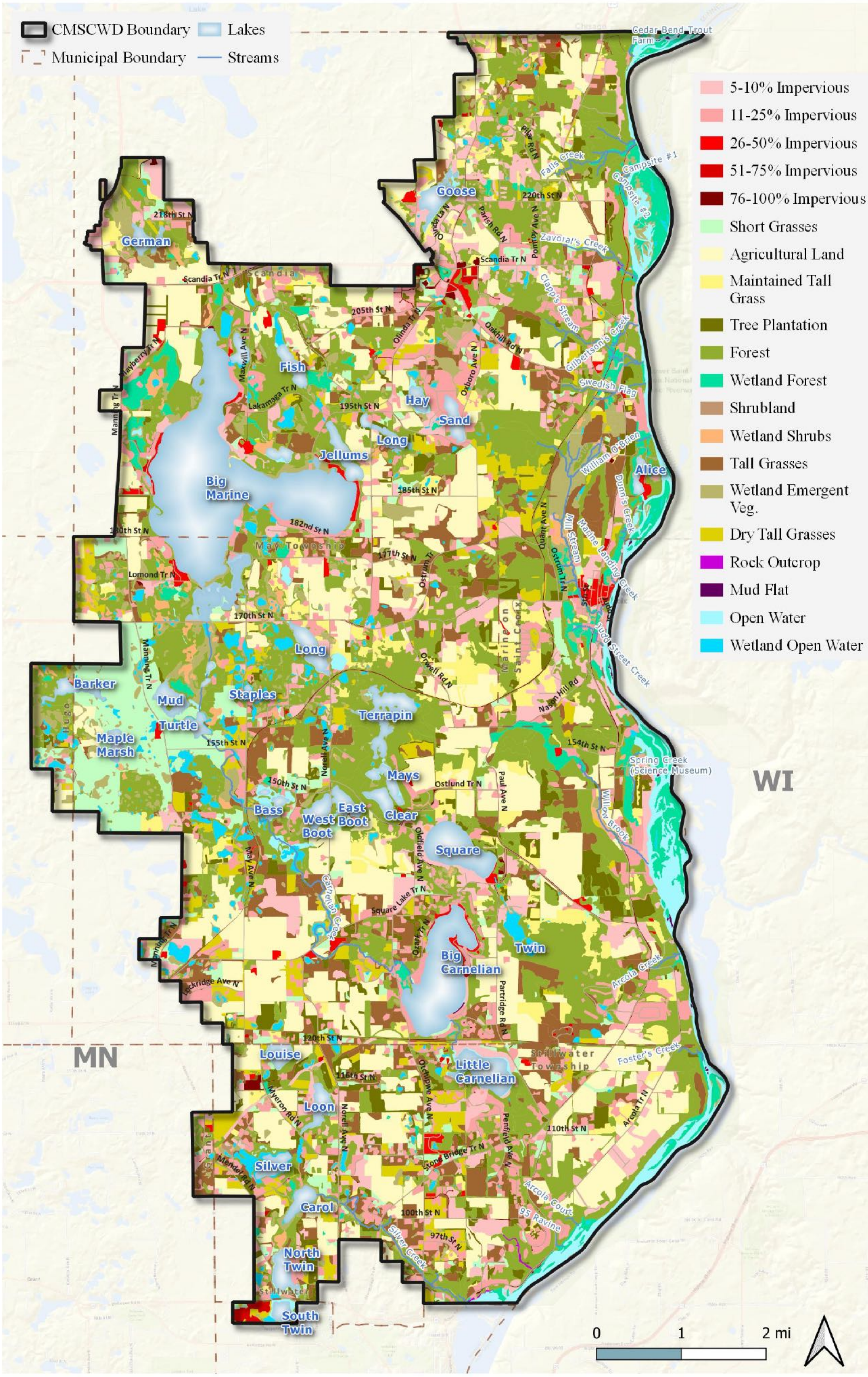
	Landscape Unit Ranking				
LU	Ecological Ranking	Wildlife Habitat Rank	Rare Features Potential	Surface Water Quality	Soil Erodibility Potential
Big Marine Lake, with excellent water quality, MCBS mapped Lake Bed, and Lake Beach is a highly valued resource Wet Prairie Seepage subtype and several other unique, high quality wetlands associated with Big Marine's East Arm					
CM-8	High	High	High		
Big Marine Park Reserve is a high quality wetland complex of emergent marsh, wet meadow, rich fens, and cattail marsh Much of this area has been mapped by MCBS; especially the large, high quality, groundwater dependent wetland systems Extensive oak forest protects much of this wetland complex					
CM-9	Mod.	Mod.	Mod.		
Contains several high quality, groundwater dependent wetland communities such as shrub swamp, tamarack swamp, and wet meadows draining northwest to Big Marine Lake					
CM-10	High	High	High		
Barker Lake and its surrounding, high quality mesic oak forest Diverse assemblage of wetland communities within mesic oak forest represent some of the highest quality floating tamarack bogs, sedge meadows, and poor fens in the watershed district.					
CM-11	Mod.	Mod.	Low		
• Maple Marsh surrounded by Kelley Cattle Farm Extensive oak forest surrounds numerous, small, wetland communities such as a very high quality tamarack swamp					
CM-12	High	High	High		
Contains part of Warner Nature Center and the highest quality poor fen in CMWD Northeastern section contains numerous, small floating tamarack bogs and high quality sedge meadows relatively undisturbed in their current state, surrounded by decent quality mesic oak forest					
CM-13	Mod.	Mod.	Low		
Turtle Lake, its associated creek and wetland communities Numerous small wetlands of moderate to high quality and an extensive deciduous woodland					
CM-14	Mod.	Mod.	Mod.		
East Boot Lake, West Boot Lake, and their adjacent mesic oak forests Rich Fen on the east facing slope to West Boot Lake Bass Lake and its associate wetland communities that feed into the Carnelian Creek Watercourse					
CM-15	Mod.	Low	Low		
Contains several high quality wetland communities including a unique floating tamarack bog					
CM-16	High	Mod.	Mod.		
Series of MCBS mapped Rich Fens along the Carnelian Creek Watercourse Several very high quality shallow lake systems also mapped by MCBS Native dry sand-gravel prairie remnants					
CM-17	Mod.	Mod.	Mod.		
Series of rich fens along Carnelian Creek Extensive oak forest mapped by MCBS along Carnelian Creek Corridor					

Table A-9. Overview of CMSCWD Landscape Units (LU)					
	Landscape Unit Ranking				
LU	Ecological Ranking	Wildlife Habitat Rank	Rare Features Potential	Surface Water Quality	Soil Erodibility Potential
CM-18	Mod.	High	High		
Big Carnelian Lake with exceptionally high water quality Carnelian Creek as it enters Big Carnelian Lake runs along an MCBS mapped Rich Fen Eagle's nest on western peninsula of Big Carnelian Lake					
CM-19	Mod.	Mod.	Mod.		
Native prairie and oak savanna remnants containing unique prairie plant species not found anywhere else in CMWD Extensive oak woodland comprises the northern portion					
CM-20	High	High	Mod.		
Little Carnelian Lake with very high water quality Carnelian Creek connecting Big to Little Carnelian Lake Native prairie remnants above Little Carnelian Lake Unique Paper Birch Forest on west side of the lake					
CM-21	Mod.	Mod.	Mod.		
Contains Pine Point Park with unique preservation and restoration opportunities Louise, Loon, and Silver Lakes and their associated wetland communities Silver Lake serves as the headwaters for Silver Creek					
CM-22	Mod.	Mod.	Mod.		
Contains Carol Lake (aka Lake McGuire) - a shallow, high quality lake system along the Silver Creek Watercourse North and Twin Lakes also draining into Silver Creek Unique and high quality shallow lake complex connecting and including Carol and North Twin Lakes					
CM-23	Low	Low	Low		
Provides excellent prairie and oak savanna establishment/restoration at a large scale					
CM-24	High	Moderate	High		
Moist Cliff site along the St. Croix River is the highest quality community in CMWD This feature supports several unique species of mosses and liverworts including some county and state records					
CM-25	High	High	High		
Contains many rare features including an extensive mesic oak forest, dry sand-gravel prairie, floodplain forest; and many threatened and endangered plants and animals along the St. Croix River Very unique slot canyon running along a ravine through the extensive mesic oak forest, exiting to the St. Croix River at the Historic Boom Site Landing					
CM-26	High	High	High		
Silver Creek Corridor contains many rare features, including maple-basswood forest, mesic oak forest, seepage meadow and dry sand-gravel prairie Many rare plants and animals documented along Fairy Falls Ravine Wall and along the St. Croix River Fairy Falls - a 50-foot waterfall along Silver Creek with dry and moist cliff along its walls					

1.8. Minnesota Land Cover Classification System Mapping

The Minnesota Land Cover Classification System (MLCCS) was developed by the MN DNR as a way to map all land cover types in the state; the hierarchical system can be applied at varying degrees of detail, depending on the level of specificity desired. Using this system provides compatibility between this report and similar planning efforts around the state and metro area, by establishing a uniform set of definitions and categories for cover types. The system encompasses the DNR Natural Heritage Program natural community classifications but differs in that it does not provide a qualitative assessment. It does, however, include non-native communities and human created cover types that are omitted from the Natural Heritage system. MLCCS mapping was completed to a level 5 for the entire CMSCWD. The MLCCS mapping is shown in Figure A-11.

Figure A-11. Minnesota Land Classification Mapping



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Fish & Wildlife

The CMSWD contains diverse and abundant fisheries throughout the District. Three very distinct types of fisheries exist within the District, consisting of natural lakes, spring creeks, and the St. Croix River.

There are 31 named lakes within the watershed. At least half of these lakes support naturally reproducing game fish populations. The lakes tend to contain fish species typical of the region such as largemouth bass, northern pike, black crappie, sunfish, perch and bullheads. Square Lake contains the same variety of natural reproducing game fish, however it is also managed by the DNR for cold water species due to the high quality spring fed nature of the lake. Rainbow Trout are stocked on an annual basis on Square Lake. Walleye are present in several of the lakes mostly due to ongoing stocking efforts. DNR lake reports show recent walleye stocking occurring in Big Marine, Big Carnelian and Alice. Fish, Long (Scandia), Louise, and Jellum's Bay have been used as walleye rearing ponds by the DNR. Further details on the lakes within the District can be found within the CMSCWD Individual Lake Plans in the Plan.

There are numerous spring creeks discharging groundwater along the eastern bluff areas of the district and flow down in to the St. Croix River. Based on the Lower St. Croix River Spring Creek Stewardship (EOR, 2003c), many of the spring creeks support brook trout populations. The DNR conducted a fish community survey within Mill Stream, Willow Brook, Falls Creek, Gilbertson Creek, Clapp's Steam and one unnamed tributary to the St. Croix (identified as Campsite #2 in the Spring Stewardship Plan). The surveys were done as part of an overall fish community survey conducted in 1999 in the Twin Cities (Schmidt and Talmage, 2001). Brook trout were numerous in most of the creeks. A few brown trout were found within Mill Stream and Gilbertson Creek. The presence of brown trout indicates the relatively undisturbed nature and high quality of these creeks. Groundwater seeps and springs along the creeks provide a source of cold water suitable for trout development. Other fish species identified include burbot in Fall's Creek and Clapp's Stream, rainbow darters in Gilbertson Creek and central mudminnows in Mill Stream.

The St. Croix River is an exceptional fishery with more than 60 documented fish species. The river contains everything from freshwater drum and redhorse to American eel. Walleye, sauger and smallmouth bass are the primary target of anglers fishing this stretch of river. A variety of other fish offer additional opportunities: sturgeon, muskellunge, northern pike, crappie, white bass and catfish are some of the other species targeted by anglers. The DNR stocks surplus muskellunge fingerlings in the river when available.

Public access to the fisheries varies significantly. The St. Croix River and larger lakes such as Big Marine, Big Carnelian, Square, and Goose Lake have designated public accesses with boat ramps. Some of the small lakes and creeks can be accessed through state or county parkland, while other areas are surrounded by private land limiting access to those that own property adjoining property.

Groundwater Resources

The groundwater system within the watershed is complicated and dynamic. Some creeks and lakes may serve as either recharge or discharge areas depending on local hydraulic conditions, recent climate conditions, and seasonal fluctuations. Basic information on the groundwater system within the CMSCWD is summarized in the following sections.

1.9. Aquifers

Numerous aquifers exist within the CMSCWD. The aquifers from youngest to oldest include: the Quaternary, St. Peter, Prairie du Chien, Jordan Sandstone, St. Lawrence, Franconia, and Ironton-Galesville Aquifers. The following discussion of topography and geomorphology was adapted from the report Integrating Groundwater and Surface Water Management–Northern Washington County (EOR, 2003).

The Quaternary Aquifer is the upper most layer formed through glacial processes including melt water deposits, moraine deposits, terrace deposits, and lake plains. This aquifer is often expressed as surface water features. This aquifer is not heavily used, as it's sensitivity to pollution is high. This aquifer is used near German Lake and in buried bedrock valleys where bedrock aquifers are very deep.

The St. Peter has been largely eroded within northern Washington County leaving small islands that are typically well connected to the Quaternary aquifer. Very few wells are completed in the St. Peter, mainly due to poor water quality. Drillers frequently bypass this sandstone unit and continue down into the Jordan or Franconia aquifers where less impacted water is available.

The Prairie du Chien has significant unconformity with the overlying St. Peter Sandstone. The Prairie du Chien is partially confined by both the shaley base of the St. Peter Sandstone and by glacial deposits. The presence of the Prairie du Chien's secondary porosity and conduits, and lack of a consistent confining layer allow for fast travel times of contaminants and make this aquifer susceptible to pollution. The Prairie du Chien has been completely eroded away in much of the CMSCWD; however, where it is present, it is typically used for water supply.

Below the Prairie du Chien is the Jordan Sandstone Aquifer. This is a regionally important aquifer capable of meeting municipal water demands. Although the Jordan Sandstone is a regionally important aquifer, it has no confining layer between it and the Prairie du Chien and can be susceptible to pollution. The Jordan is not a homogeneous aquifer. In particular, there are frequent shale lifts extending into the lower third of the aquifer. A good example of this can be seen along the St. Croix River, north of Stillwater to Copus. Along this reach, numerous springs and seeps emerge well above the Jordan - St. Lawrence contact. The Jordan is also frequently used as a water supply source.

The St. Lawrence Formation is not considered to be a significant regional aquifer. Some smaller wells are reported to be completed in the St. Lawrence, either in areas where the upper parts of the formation are fractured or as part of a multi-aquifer well.

Located stratigraphically below the St. Lawrence Formation, the Franconia aquifer is compromised of sandy and shaley facies and is commonly used as a water supply source for residents within the St. Croix Valley where the Jordan is not present.. The sandy facies are called the Mazomanie member and the shaley facies are called the Reno member. The Reno members, both the Reno Shale and Tomah Shale act as confining layers in the lower sections of the Franconia.

Located stratigraphically below the Franconia aquifer, the Ironton-Galesville Aquifer (CIGL) is a thin layer of fine to coarse grained sands that is a potentially important aquifer for use in residential water demand. In some areas, the Franconia and Ironton Galesville form a single aquifer due to a lack of confining shaley layers.

1.10. Groundwater Flow

Groundwater flow in the watershed is characterized by Quaternary and bedrock aquifer systems. Both systems provide for movement of groundwater toward regional discharge areas. Groundwater flow is locally towards creeks and lakes and regionally towards the St. Croix River. A regional groundwater divide is present near the middle of North Washington County. Groundwater to the west of the divide flows to the Mississippi River; groundwater to the east of the divide flows to the St. Croix River.

A portion of the groundwater within the surficial and bedrock system discharges to surface water bodies supplying "base flow" to the surface water system. This base flow is important to the numerous spring creeks and other groundwater dependent natural resources that exist within CMSCWD as presented in Section 7.

Groundwater Recharge and Discharge

A large percentage of the watershed serves as a recharge area for groundwater aquifers (Figure A-12). Some rainfall will become runoff and flow toward local surface water bodies, and some rainfall will evaporate or be taken up by plants (evapotranspiration). A significant percentage will percolate through the soil profile and recharge the water table aquifer. In most parts of the CMSCWD the water table aquifer is the Quaternary aquifer. The Quaternary Aquifer is found within the surficial sediments above bedrock. Vertical flow out of the Quaternary aquifer recharges the lower bedrock aquifers.

Groundwater discharge occurs where aquifers intersects the ground surface or where water is pumped from wells. Figure A-12 shows the areas of natural groundwater discharge. Groundwater discharge maintains many of the high quality resources within the CMSCWD.

An infiltration management analysis was completed (EOR, 2003b) to identify those areas in the watershed with high, moderate and low potential to infiltrate runoff (Figure A-13). Infiltration potential simply defines the ability of the soils and underlying geology to accept infiltrating precipitation and runoff. The protection of areas with a naturally high infiltration capacity will serve to maintain the hydrologic and ecologic balance of a watershed and protect groundwater quality.

Figure A-12. Recharge and Discharge Areas

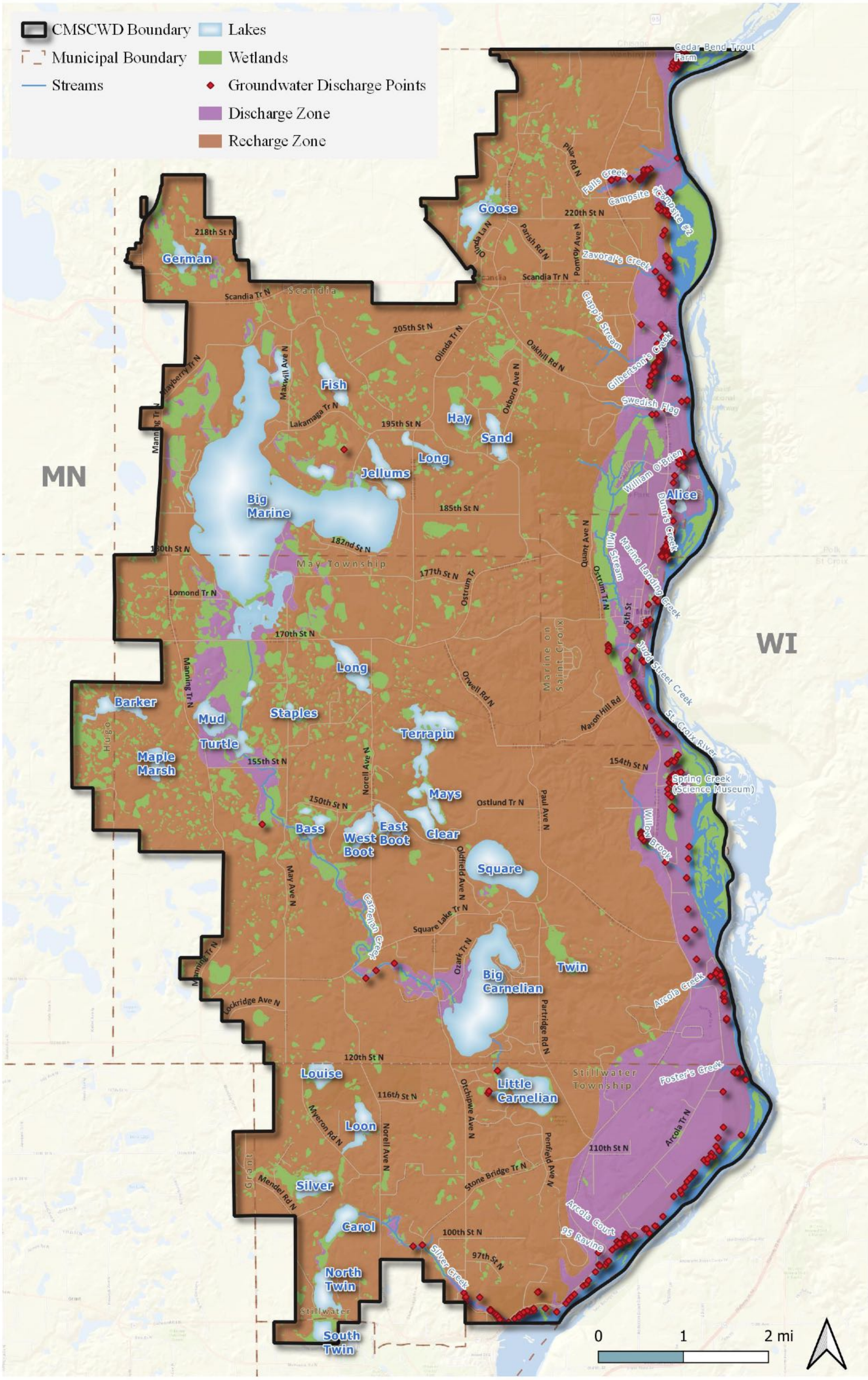

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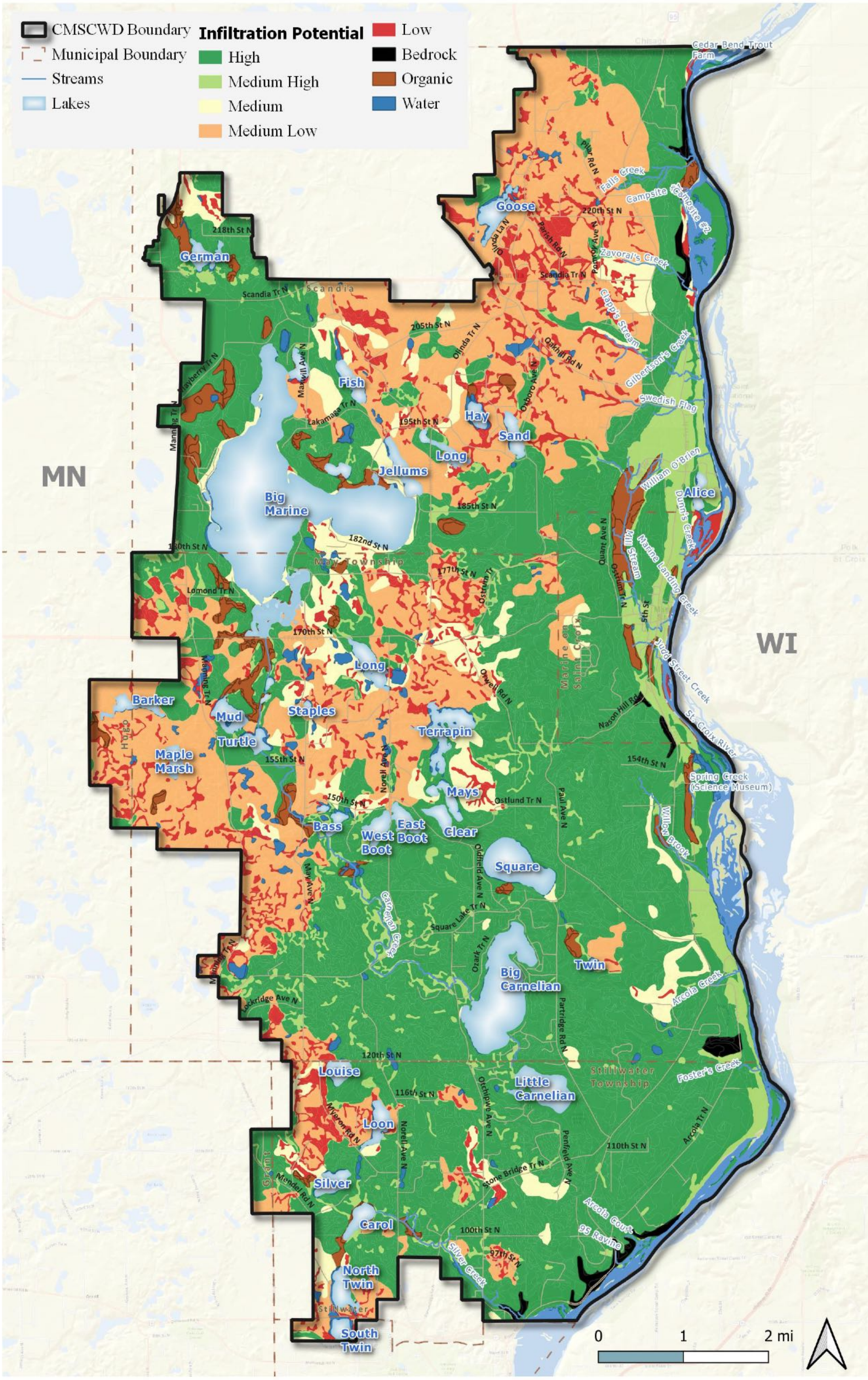
Figure A-13. Infiltration Potential



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1.11. Groundwater Appropriations and Water Supply

In order to manage water supply for domestic, agricultural, fish and wildlife, recreational, power, navigation and quality control purposes, MN DNR Waters regulates surface and groundwater appropriations based on daily and yearly withdrawal volumes. A permit through the Water Appropriation Permit Program is required for all users withdrawing more than 10,000 gallons per day or 1 million gallons per year. Exemptions apply to certain domestic users, test pumping, water reuse from a permitted municipal source and certain agricultural drainage systems. Minnesota law requires the DNR to limit appropriations during low flow conditions for the benefit of high priority downstream water users.

Figure A-14 shows the location and type of appropriations within the CMSCWD. Two of the five main water use categories are currently found within the CMSCWD: industrial processing and irrigation. Industrial processing in this case refers to sand and gravel washing at two pits in or near the watershed. There are two permitted surface water appropriations within the CMSCWD at Barker and Turtle Lake. These sites are permitted for major crop irrigation. The remaining appropriations are from groundwater resources.

There are several public water supply locations within the watershed including the City of Scandia wells and small community wells such as those that serve the Jackson Meadow development in Marine on St. Croix. Many of the wells have a source water assessment which is a study that provides basic information about the water used to provide drinking water and includes a mapped area where special protection may be warranted. The Minnesota Department of Health (MDH) develops source water assessments in compliance with the federal Safe Drinking Water Act. These assessments list the status of a public water system's source water protection plan, describe the water source used in the location, assess the susceptibility of the water source to contamination, and list contaminants of concern and potential contaminant sources of the water supply. Source water assessments are available online at: https://www.health.state.mn.us/communities/environment/water/swp/swa.html

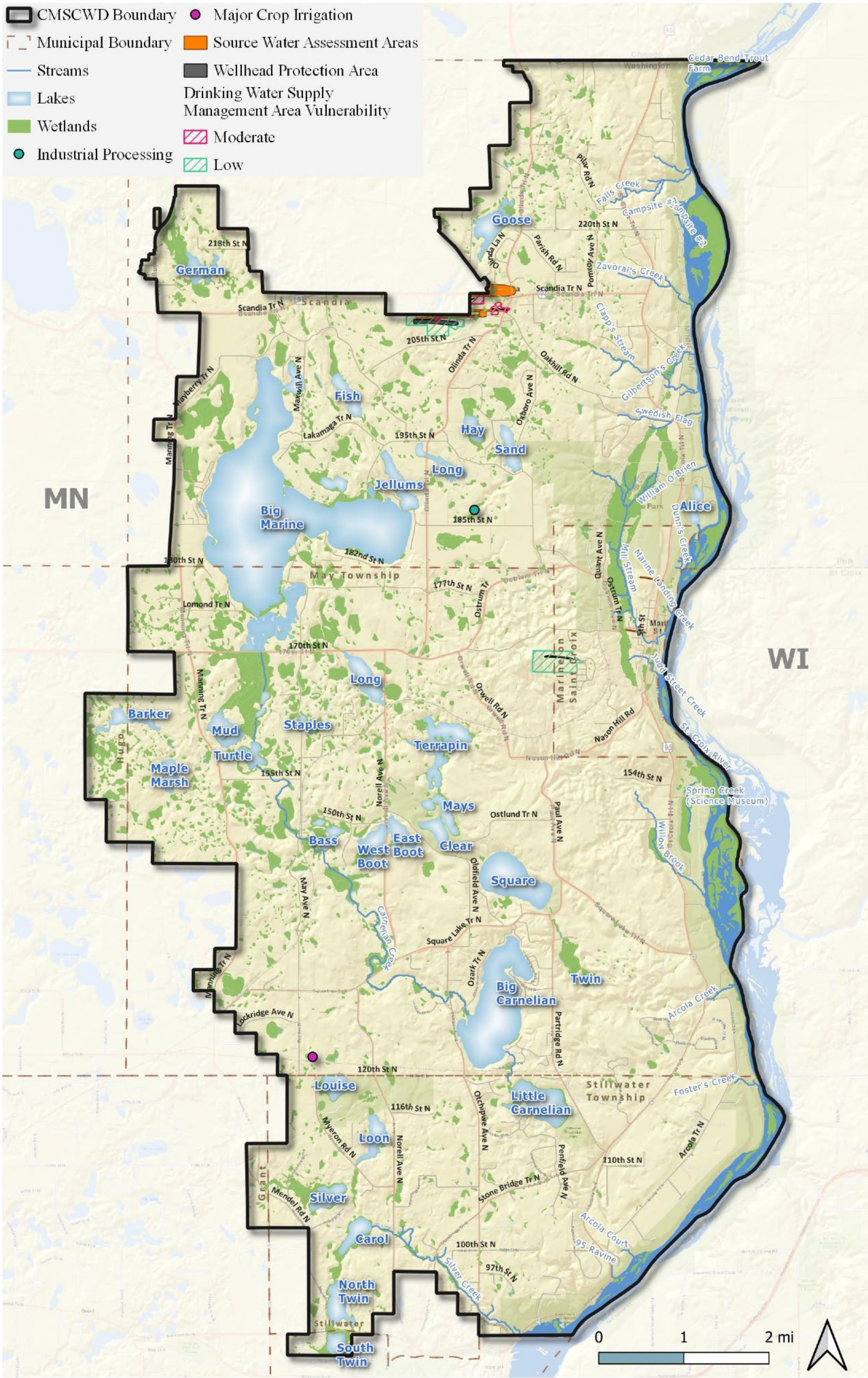
Source water assessment areas are identified on Figure A-14. Additional information on public water supplies can be obtained by contacting the community.

1.12. Groundwater Quality and Quantity

Groundwater quality in both the private and public wells is good to excellent. At present, groundwater quantity is sufficient to provide adequate volume to private and public sources and maintain base flow to local natural resources.

Unused wells that have not been properly sealed can be a source of groundwater contamination, potentially affecting nearby drinking water wells. Wells that are no longer in use are considered abandoned and state law requires that they be sealed by a licensed contractor. Existing wells, potentially contaminated sites and leaking underground storage tanks are all locations of interest related to pollutants entering the groundwater table. Additional information on these sites can be found in Section 13.

Figure A-14. Groundwater Appropriations and Water Supply



Mining Operations

Several gravel and sand mining operation exist within CMSCWD (Figure A-15). Direct connections to groundwater during mining and after reclamation that are often created within mining sites and increase the potential for contamination of the groundwater. In addition, dewatering that might occur with related mining operations has the potential to dewater nearby groundwater dependent resources.

Groundwater Monitoring

There are 12 DNR observation wells located within the CMSCWD. Only six of these wells are currently being maintained and monitored for water level data by the WCD for the DNR Observation Well Program. The period of record for the groundwater level data for these wells vary from well to well. The oldest data date back to 1969 for several wells located near Big Marine Lake. Water level data are available online at:

https://www.dnr.state.mn.us/waters/cgm/index.html

In addition, the CMSCWD has been monitoring nine residential wells since 2019 and is currently looking for opportunities to expand this monitoring effort.

1.13. Groundwater Dependent Natural Resources

Cold Water Trout Population

Several of the creeks discharging to the St. Croix River support cold water fisheries. The following creeks and streams have known brook trout populations: Falls Creek, Campsite #2 Creek, Zavoral's Creek, Gilbertson's Creek, Clapp's Stream, Old Mill Stream, Spring Creek, Willow Brook Creek, Arcola Creek, and Foster's Creek. Groundwater discharges from the bedrock aquifers maintain the base flow needed for these coldwater species. The majority of the larger springs feeding these trout streams are the result of discharges from the Franconia aquifer.

Groundwater Dependent Wetlands and Lakes

Data from the CMSCWD Natural Resource Inventory, the CMSCWD Wetland Management Plan, and from the report *Integrating Groundwater and Surface Water Management – Northern Washington County* (EOR, 2003b) were used to determine which wetlands and lakes within the District are groundwater dependent. Figure A-16 shows the identified groundwater dependent resources within the District. Also included in this figure are the Spring Creeks identified in the report *Lower St. Croix River Spring Creek Stewardship Plan* (EOR, 2003c).

Groundwater Dependent Wetlands and Lakes are those that meet the following criteria:

1. All those areas within CMSCWD that contain plant community types that are definitely groundwater dependent based on their sensitive plant species assemblages and known hydrology.

2. Wetlands identified in the field during the 2002 Natural Resource Inventory and the 2007 Wetland Management Plan as being definitely groundwater dependent.

3. Lakes classified as groundwater driven using the "Lake Data and Groundwater Function" table from the report *Integrating Groundwater and Surface Water Management – Northern Washington County*.

4. Wetlands adjacent to Groundwater Dependent Wetlands that have the potential for being groundwater dependent.

These wetlands have plant community types that can either be groundwater dependent or not. Because they exist adjacent to Groundwater Dependent Wetlands, they are assumed to be hydrologically connected and share the same dependence on groundwater.

Further field investigations could result in additional wetlands and lakes being classified as groundwater dependent. The types of wetlands classified in each category are identified in Table A-10.

Table A-10. Groundwater Dependent Wetland Types

Groundwater Dependent Wetlands	Groundwater and Surface Water Dependent Wetlands
Shrub fen	Lowland hardwood forest
Poor fen shrub subtype	Mixed hardwood swamp seepage subtype
Rich fen shrub subtype	Willow swamp - saturated soils
Shrub swamp seepage subtype	Wet meadow shrub subtype*
Wet meadow shrub subtype*	Willow swamp*
Willow swamp*	Mesic prairie
Wet prairie seepage subtype	Wet meadow*
Poor fen*	Cattail marsh
Poor fen sedge subtype	Poor fen*
Rich fen	Sedge meadow*
Rich fen sedge subtype	Seepage meadow*
Wet meadow*	Shallow emergent marsh*
Sedge meadow*	Mixed emergent marsh*
Seepage meadow*	Deep emergent marsh*
Shallow emergent marsh*	Shallow creeks*
Mixed emergent marsh*	Lake*
Deep emergent marsh*	Limnetic open water*
Trout stream	Shallow open water*
Lake*	Shallow open water with floating vascular vegetation*
Limnetic open water*	
Shallow open water*	
Shallow open water with floating vascular vegetation*	

*These wetland types can be either completely "Groundwater Dependent" or "Both" groundwater and surface water dependent and therefore are listed in both categories

Figure A-15. Mining Operations

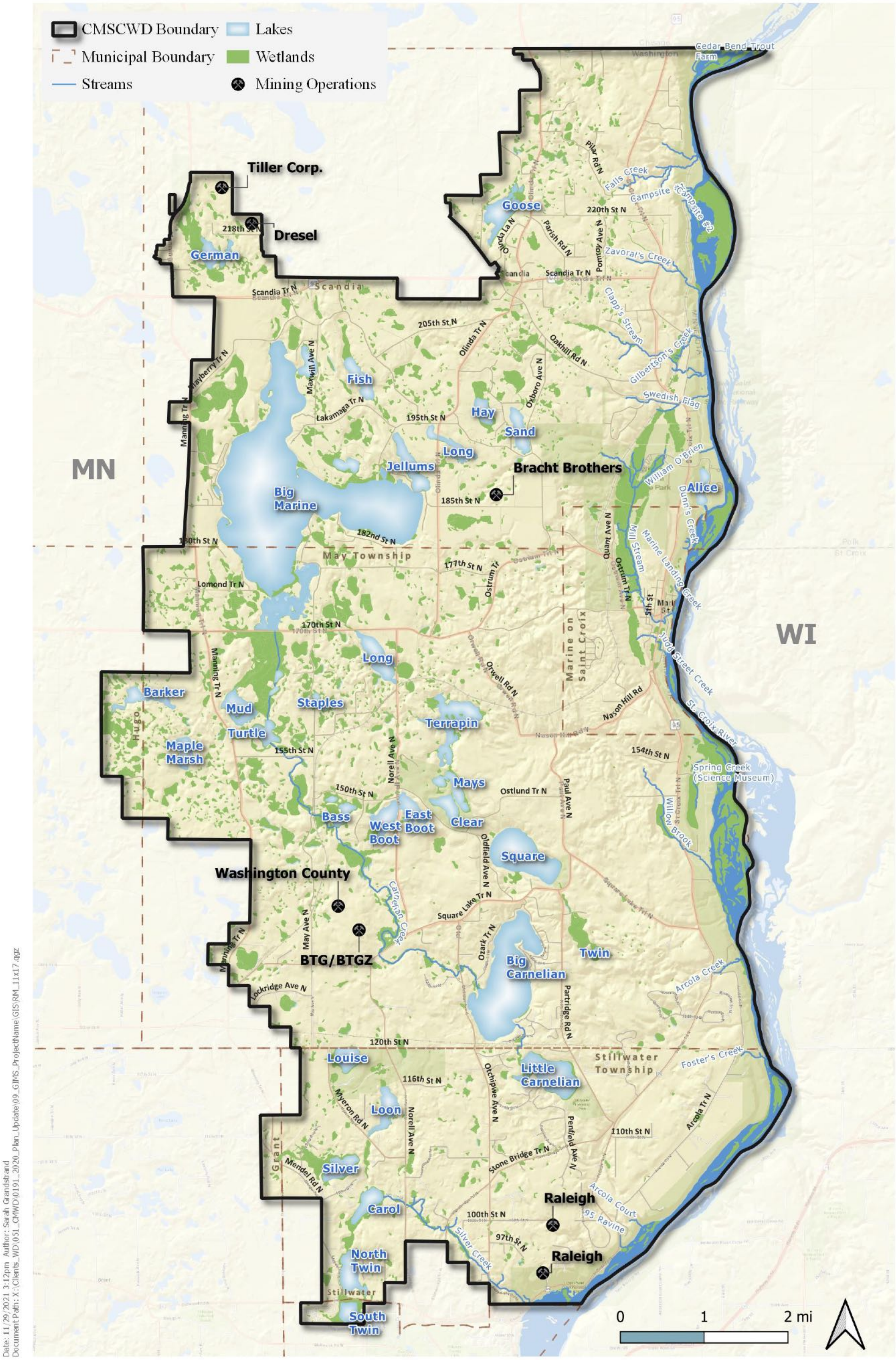
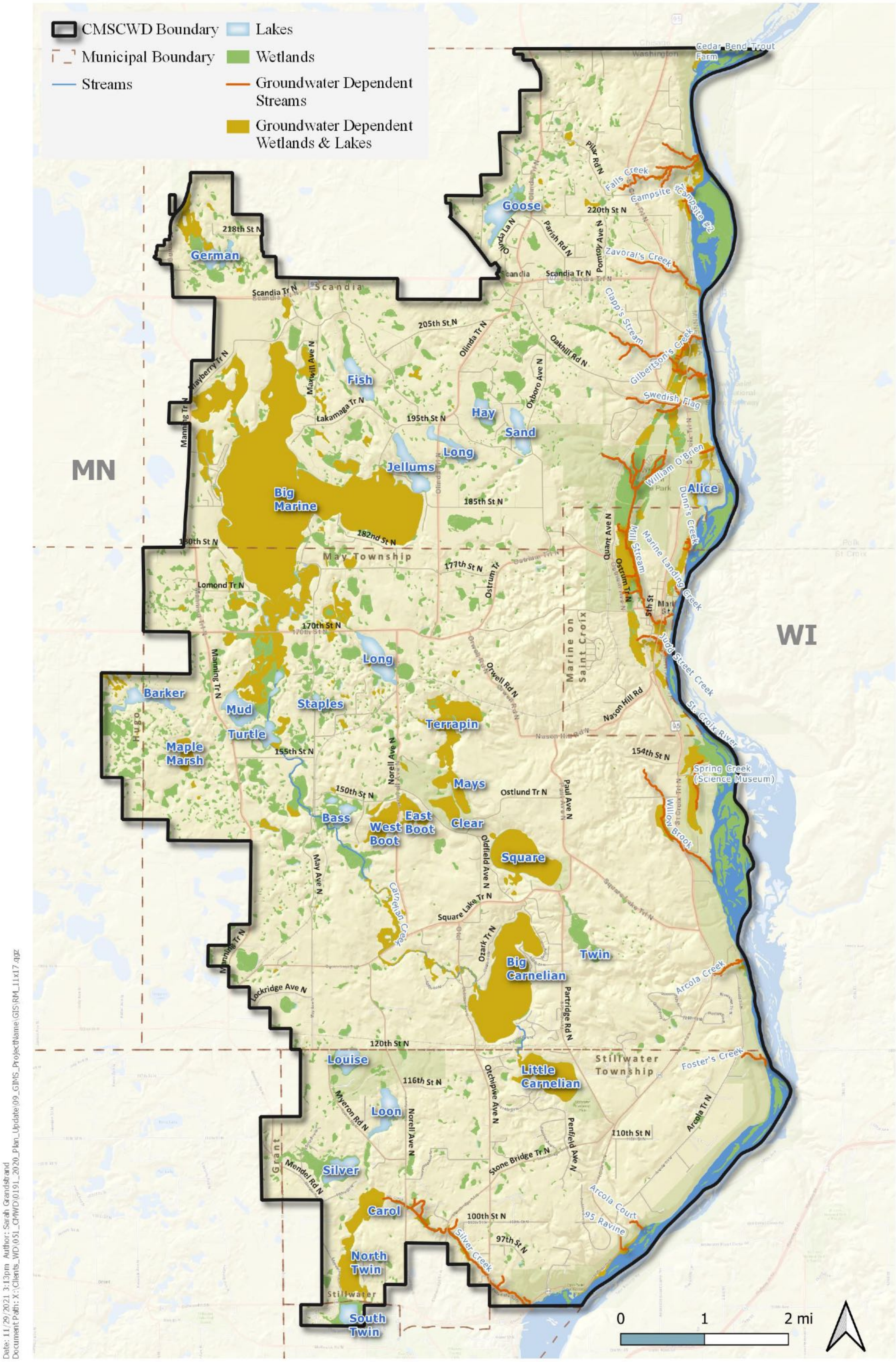


Figure A-16. Groundwater Dependent Wetlands and Lakes



1.14. Groundwater Studies

In 2016, the Metropolitan Council evaluated the potential to reuse stormwater or recharge groundwater aquifers in the DNR's North and East Metro Groundwater Management Area. The study identified areas suitable for aquifer recharge, along with the availability of stormwater runoff to serve as a source of water for non-potable activities including aquifer recharge. It also identified needs for further detailed analyses that can be taken to move toward implementation of identified approaches. The study can be found at: https://metrocouncil.org/Wastewater-Water/Publications-And-Resources/WATER-SUPPLY-PLANNING/Regional-Groundwater-Recharge-Stormwater-Capture.aspx

In the spring of 2004, the Washington County Water Consortium initiated the process of developing model groundwater rules for future adoption by the water management organizations located within the County. This effort addressed a number of the policies identified in the Washington County 2005 Groundwater Work Plan aimed at developing guidelines and standards to protect groundwater resources. The County's objective was to develop model standards and language that will serve to protect the wide variety of groundwater resources located in Washington County. The model groundwater rules include: Groundwater Appropriations, Volume Control, Groundwater Quality, and Groundwater Dependent Natural Resources. Through adoption of these standards by watershed districts and watershed management organizations, groundwater protection will become an integral part of future land use decisions at both the watershed district level and the municipal level.

Washington County Department of Public Health & Environment with input from the Groundwater Advisory and Technical Advisory Committees and the Washington County Board of Commissioners developed the *Washington County Groundwater Plan 2014-2024*. The plan was approved by the Minnesota Board of Water and Soil Resources on August 28, 2014 and adopted by the Washington County Board of Commissioners on September 23, 2014. The intent of the plan was to "outline the physical nature of groundwater resources, discuss the issues that threaten groundwater, and provide direction and strategies on how to protect groundwater for future generations." The plan can be viewed at

https://www.co.washington.mn.us/DocumentCenter/View/794/Groundwater-Plan-2014-2024?bidId=

The plan is designed to serve as a serve as a framework to develop annual work plans for the county and its stakeholders that give specific implementation actions to address the groundwater issues in Washington County.

The 2003 *Lower St. Croix River Spring Creek Stewardship Plan* was funded by the Board of Water and Soil Resources, Marine on St. Croix Watershed Management Organization, Carnelian Marine Watershed District, and New Scandia Township (now City of Scandia). The two primary reasons for the project were to describe and evaluate spring creeks and associated groundwater dependent resources, and, based on this increased understanding of these unique resources, to define stewardship strategies towards their long-term protection. The purpose of the plan was to both inform and provide the necessary framework for local governmental units, watershed management organizations and citizens to carry on the task of resource management in the St. Croix Basin.

The 2001 report *The Influence of Ground Water on the Quality of Lakes in the Carnelian-Marine Watershed District* recognized that groundwater is a significant factor in managing lake water quality. With the support of the Watershed District, the Minnesota Geological Survey and staff of the Department of Geology at the University of Minnesota investigated the source, magnitude, and quality of ground-water input to lakes within the District.

Monitoring

The following monitoring summary is for data collected between 2001 and 2020. Detailed annual monitoring reports are available from the District Office. Available stream data are variable, with some years containing more information than in others. These data include total loading, discharge, and physical and chemical water quality sampling.

In the District's lakes, water surface elevations are measured and water quality is monitored on up to 33 lakes. The type and frequency of collected data varies from year to year and may include temperature and dissolved oxygen profiles, secchi disk measurements, and water quality sampling for total phosphorus, chlorophyll-a, and total Kjeldahl nitrogen.

Table A-11, Table A-12, and Table A-13 provide a summary of the monitoring activities that have taken place in the District. Table A- 14 summarize long and short term trends in total phosphorus and secchi depth for District Lakes. Note that at this time, there is not sufficient monitoring data on District streams to adequately conduct any trend analysis. Table A-19, Attachment A summarizes annual monitoring results. Figure A-17 depicts the locations of all lakes and streams monitored.

Table A-11. Summary of Precipitation Monitoring Efforts

Precipitation Monitoring Site	Type of Monitoring	Frequency per Year	Lead Agency	Years Monitored
Carnelian Creek at May Avenue	Automated Precipitation Gage	April-October	WCD	2002-2007
Carnelian Creek at Ozark Trail	Automated Precipitation Gage	April-October	WCD	2000-2012
Little Carnelian Lake Outlet	Automated Precipitation Gage	April-October	WCD	2001-2011
Swedish Flag Creek at St. Croix Trail	Automated Precipitation Gage	April-October	WCD	2008-2012

Table A-12. Summary of Existing Stream Monitoring Efforts			
Stream Monitoring Site	Type of Monitoring	Frequency per Year	Years Monitored
Carnelian Creek at May Avenue	Automated Flow, Temperature & Samples*	April-October	2002-2007
Carnelian Creek at Ozark Trail	Automated Flow, Temperature & Samples*	April-October	2000-2012
Carnelian Creek at Big Carnelian Outlet	Automated Flow, Temperature & Samples*	April-October	2001-2007
Carnelian Creek at Little Carnelian Outlet	Automated Flow, Temperature & Samples*	April-October	2001-2008
Silver Creek at Highway 95	Automated Flow, Temperature & Samples*	April-October	2002-present
Silver Creek at County Road 11	Flow, Temperature & Grab Samples*	April-October	1999-2001, 2007
Gilbertson Creek at Quinnel Ave	Automated Flow, Temperature & Samples*	April-October	2003, 2008-2012
Swedish Flag Creek at St. Croix Trail	Automated Flow, Temperature & Samples*	April-October	2003, 2008-2012
Mill Stream at Judd St.	Automated Flow, Temperature & Samples*	April-October	2002-2006, 2008-2012
Willow Brook at Croixside	Automated Flow, Temperature & Samples*	April-October	2008-2010, 2013-019
Zavoral's Creek	Automated Flow, Temperature & Samples*	April-October	2010-2016
Arcola Creek	Automated Flow, Temperature & Samples*	April-October	2009-2011
Long Lake North Inlet (82-0030)	Automated Flow, Temperature & Samples*	April-October	2010
Falls Creek	Samples*	April-October	2011-2012
Oldfield North Goose Lake Tributary at St. Sauver	Automated Flow, Temperature & Samples*	April-October	2017

* Samples = Water sample analysis variable and may include Total Suspended Solids (mg/L), Volatile Suspended Solids (mg/L), Total Kjeldahl Nitrogen (mg/L), Total Phosphorus (mg/L), Fecal Coliform (#/100 mL), Chemical Oxygen Demand (mg/L), Alkalinity (mg/L), Hardness (mg/L), Copper (mg/L), Nickel (mg/L), Lead (mg/L), Zinc (mg/L), Cadmium (mg/L), Chromium (mg/L), Chloride (mg/L), Nitrite N (mg/L), Nitrate N (mg/L), Ammonia Nitrogen (mg/L), Turbidity (NTU), Total Organic Carbon (mg/L), Total Biochemical Oxygen Demand (mg/L), Sulfate (mg/L), Ortho Phosphorus (mg/L).

Table A-13. Summary of Existing Lake Monitoring Efforts		
Lake Monitoring Site	Lead Agency	Years Monitored
Alice (DNR ID#82-287)	WCD	2014-2017, 2019
Barker Lake (DNR ID # 82-76)	WCD	1997-2009, 2013-2014, 2017-present
Bass Lake (DNR ID # 82-35)	WCD	1991-2009, 2012-2014, 2017-2019
Big Carnelian Lake (DNR ID # 82-49)	WCD	1991-2010, 2012-present

Big Marine Lake (DNR ID # 82-5200)	WCD	1990-1994, 1996-2010, 2013-present
Big Marine Lake (Jellums) (DNR ID # 82-5202)	WCD	1996-2011, 2015-2017, 2019-present
Carol Lake (DNR ID #82-17)	WCD	1996-2009, 2012-2013, 2016-2018, 2020
Clear Lake (Mays) (DNR ID # 82-45)	WCD/Volunteer	2008-2015, 2018-present
County Road 7 Wetland (DNR # 82-0301W)	WCD	2004-2007
East Boot Lake (DNR ID # 82-34)	WCD	1996-2015, 2017-2019
Fish Lake (DNR ID # 82-64)	WCD	1998-2011, 2015-2017, 2019-present
German Lake (DNR ID # 82-56)	WCD	2002-2009, 2012, 2014-2017, 2019
Goose Lake (DNR ID # 82-59)	WCD	2005-present
Hay Lake (DNR ID # 82-65)	WCD	2000-2001, 2003-2011, 2013-present
Little Carnelian Lake (DNR ID # 82-14)	WCD	1991-2010, 2013-present
Long Lake (May) (DNR ID # 82-30)	WCD	2000-2011, 2013-2015, 2018-present
Long Lake (Scandia) (DNR ID # 82-68)	WCD	1998-2011, 2015-2017, 2019-present
Loon Lake (DNR ID # 82-15)	WCD	1996-2010, 2012, 2016-2018, 2020
Loon Wetland (DNR ID # 82-15W)	WCD	2004-2007
Louise Lake (DNR ID # 82-25)	WCD	1996-2011, 2016-2018, 2020
Maple Marsh (DNR ID # 82-38)	WCD	1997-2007
Mays Lake (DNR ID # 82-33)	WCD/Volunteer	2008-2015, 2018-present
Mud Lake (DNR ID # 82-26)	WCD	1995-2007, 2010-2011, 2017-present
North Twin Lake (DNR ID # 82-18)	WCD	1996-2010, 2012-2013, 2016-2018, 2020
Sand Lake (DNR ID # 82-67)	WCD	2002-2011, 2013-present
Silver Lake (DNR ID # 82-16)	WCD	1996-2010, 2016-2018, 2020
South Twin Lake (DNR ID # 82-19)	WCD	1996-2011, 2016-2018, 2020
Square Lake (DNR ID # 82-46)	WCD	2000-present
Staples Lake (DNR ID # 82-28)	WCD	1997-2009, 2013-2015, 2018-present
Terrapin Lake (DNR ID # 82-31)	WCD	2004-2015, 2018-present
Turtle Lake(DNR ID # 82-36)	WCD	1991-2010, 2012-2014, 2017, 2019-present
Twin Lake (DNR ID # 82-48)	WCD	2008-2015, 2019
West Boot Lake (DNR ID # 82-44)	WCD	1996-2010, 2012-2015, 2019
205th Street Wetland (DNR ID # 82-62W)	WCD	2004-2007

TP = Total Phosphorus
CLA = Chlorophyll-A
TKN = Total Kjeldahl Nitrogen

Table A- 14. Long and Short Term Trends in TP and Secchi Depth

Lake	Long Term Trend*** All Years Through 2019		Short Term (10 yr) Trend*** 2010-2019	
	TP	Secchi	TP	Secchi

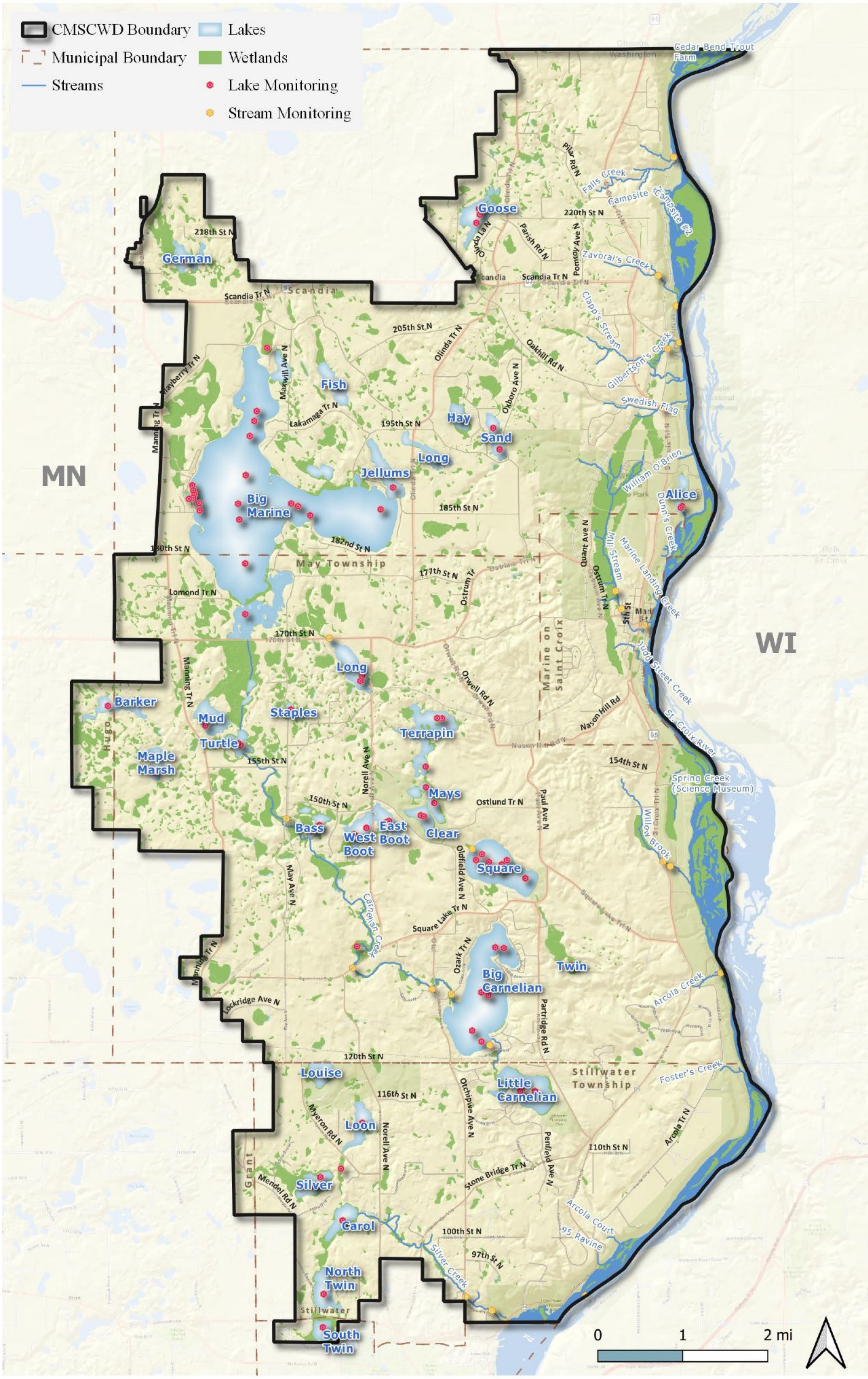
Table A- 14. Long and Short Term Trends in TP and Secchi Depth

Lake	Long Term Trend*** All Years Through 2019		Short Term (10 yr) Trend*** 2010-2019	
	TP	Secchi	TP	Secchi
Alice	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Barker Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Bass Lake	Insufficient Data	Minimally Worsening	Insufficient Data	Insufficient Data
Big Carnelian Lake	Insufficient Data	Strongly Improving	Strongly Worsening	Strongly Worsening
Big Marine Lake	Insufficient Data	Strongly Improving	Minimally Improving	Minimally Improving
Carol Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Clear Lake	Insufficient Data	Strongly Worsening	Insufficient Data	Strongly Worsening
East Boot Lake	Strongly Improving	Strongly Improving	Minimally Improving	Minimally Worsening
Fish Lake	Strongly Improving	Strongly Improving	Insufficient Data	Insufficient Data
German Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Goose Lake	Strongly Improving	Minimally Worsening	Minimally Improving	Minimally Improving
Hay Lake	Strongly Improving	Minimally Improving	Strongly Improving	Minimally Worsening
Jellum's Lake	Minimally Improving	Strongly Improving	Insufficient Data	Insufficient Data
Little Carnelian Lake	Minimally Improving	Minimally Improving	Insufficient Data	Minimally Worsening
Long Lake (May Twp)	Strongly Improving	Minimally Improving	Insufficient Data	Insufficient Data
Long Lake (Scandia)	Minimally Improving	Minimally Improving	Insufficient Data	Insufficient Data
Loon Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Louise Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Maple Marsh	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Mays Lake	Insufficient Data	Minimally Worsening	Insufficient Data	Minimally Worsening
Mud Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
North Twin Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Sand Lake	Insufficient Data	Minimally Worsening	Minimally Improving	Minimally Worsening
Silver Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
South Twin Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Square Lake	Minimally Improving	Strongly Worsening	Minimally Improving	Minimally Improving

Table A- 14. Long and Short Term Trends in TP and Secchi Depth				
Lake	Long Term Trend*** All Years Through 2019		Short Term (10 yr) Trend*** 2010-2019	
	TP	Secchi	TP	Secchi
Staples Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Terrapin Lake	Insufficient Data	Minimally Worsening	Insufficient Data	Insufficient Data
Turtle Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Twin Lake (May Twp)	Insufficient Data	Insufficient Data	Insufficient Data	Minimally Worsening
West Boot Lake	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data

*** Trends based on Pre-whitened Kendall Tau with Sen-Theil Slope with a 10% level of significance

Figure A-17. Location of CMSCWD Monitoring Sites



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Land Cover and Public Utilities

The CMSCWD currently consists of several land uses (Figure A-19 and Table A-15). The major land uses in the watershed are hay/pasture (26.8%) and deciduous forest (26.6%). Parks, recreation and preserves make up 11.1% of the watershed. Residential uses are concentrated around the watershed's many lakes.

Table A-15. Present Land Cover (NLCD 2016)

Land Cover	Acres	% of Watershed
Open Water	5,178	9.9%
Developed-Open Space	1,579	3.0%
Developed-Low Intensity	727	1.4%
Developed- Medium Intensity	101	0.2%
Developed-High Intensity	12	0.0%
Deciduous Forest	13,874	26.6%
Evergreen Forest	2,504	4.8%
Mixed Forest	213	0.4%
Shrub/Scrub	1,326	2.5%
Herbaceous	4,279	8.2%
Hay/Pasture	13,979	26.8%
Cultivated Crops	6,013	11.5%
Woody Wetlands	268	0.5%
Emergent Herbaceous Wetlands	2,069	4.0%
Totals	52117.4	100.0%

Source: National Land Cover Database, 2016

Currently, only that portion of the City of Stillwater that was annexed in 2008 from Stillwater Township near South Twin Lake is included in the Metropolitan Urban Service Area (MUSA). The MUSA is the outer edge of the metropolitan urban area, that part of the region which local and regional services are committed, and which have urban levels of regional sewer and transportation service. No further expansion of the MUSA into the District is anticipated through 2040.

Each of the municipalities within the district have developed a 2040 comprehensive plan (see Section 15) which identifies planned land uses within the jurisdiction. Figure A- 18 depicts the 2040 land uses within the district. None of the municipalities within the district identified specific tracts of land that were anticipated to be developed.

Figure A- 18. Future Land Use (2014)

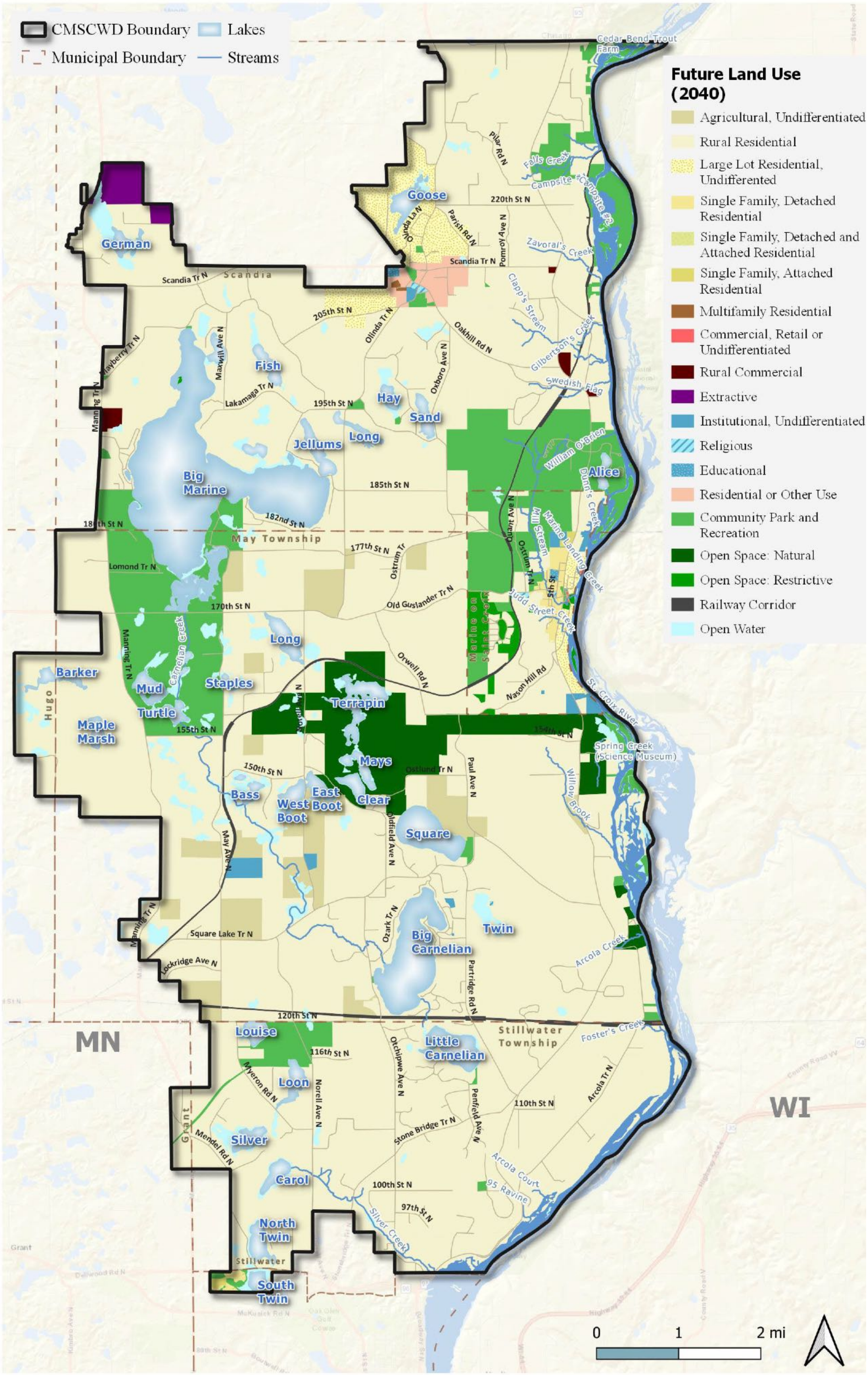
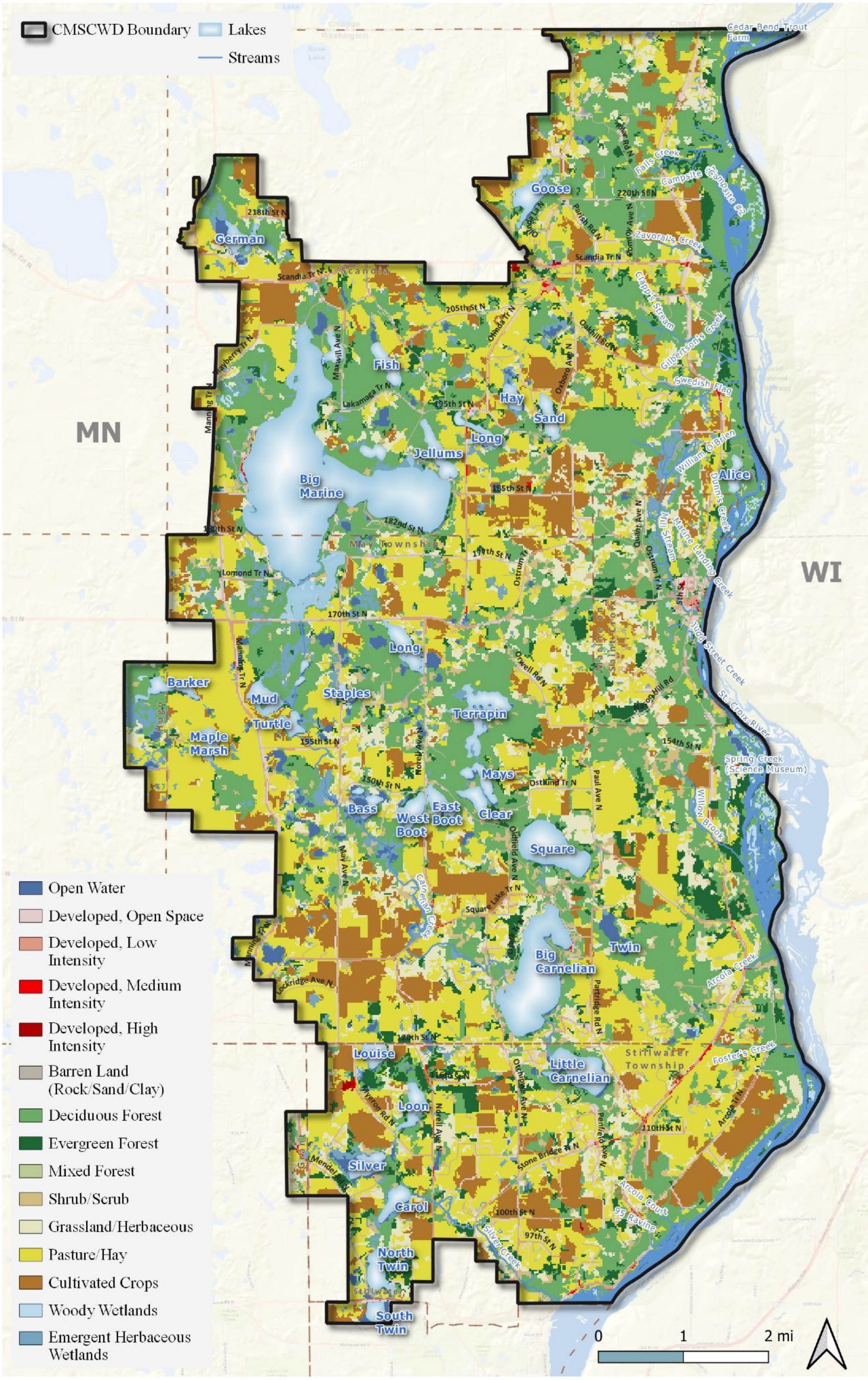


Figure A-19. 2016 Land Cover



Unique Features and Scenic Areas

The Carnelian-Marine-St. Croix Watershed District contains a number of unique features and scenic areas that contribute to the overall quality of life within the watershed. These features include parks and open spaces, rare species, unique habitats, and a river of regional significance.

Parks and open spaces include William O'Brien State Park, Big Marine Nature Preserve, Square Lake Regional Park, Wilder Forest, Rustrum Wildlife Management Area, Warner Nature Center and Falls Creek Scientific and Natural Area (Figure A-20).

Rare biological features were surveyed by the DNR through the Minnesota County Biological Survey (MCBS) for Washington County (Almendinger and Epp, 1990). The goal of the MCBS is to identify significant natural areas and to collect and interpret information on the distribution and ecology of rare plant species, animals, and native plant habitats. Among the products of this program is a map for each county assessing the status and distribution of the state's native plant communities mapped by the MCBS (Figure A-21). The CMSCWD contains many categories of natural communities and rare species mapped by the MCBS including: vascular plants, birds, amphibians and reptiles, colonial waterbirds, butterflies, mammals, bat caves, and mussels as documented by the Natural Heritage Information System database. These rare species are predominantly found along the St. Croix River and its smaller tributary streams as well as within large natural areas. Additionally, unique biological features were identified in Natural Resource Inventories (NRIs) as summarized in Section 7 of this Appendix. Natural Heritage Information System database information was incorporated into the NRIs. The District's NRIs are available through the District office. The DNR can be contacted for obtaining Natural Heritage Information System database information.

The bluffs of the St. Croix River provide for scenic views and offer several recreational opportunities. Outdoor recreational opportunities include fishing, camping, picnicking, swimming and bird watching. The *St. Croix River* is one of America's protected Wild and Scenic Waterways. The beautiful character of the St. Croix has earned the river its status as Minnesota's first stream in the national wild and scenic rivers system. Administered by the National Park Service, the St. Croix National Scenic Riverway was designated in 1968 to preserve the scenic qualities of the river and to provide adequate access for recreational users. The Lower 52 miles were added to the designated Riverway in 1972.

Figure A-20. Open Spaces and Recreational Areas

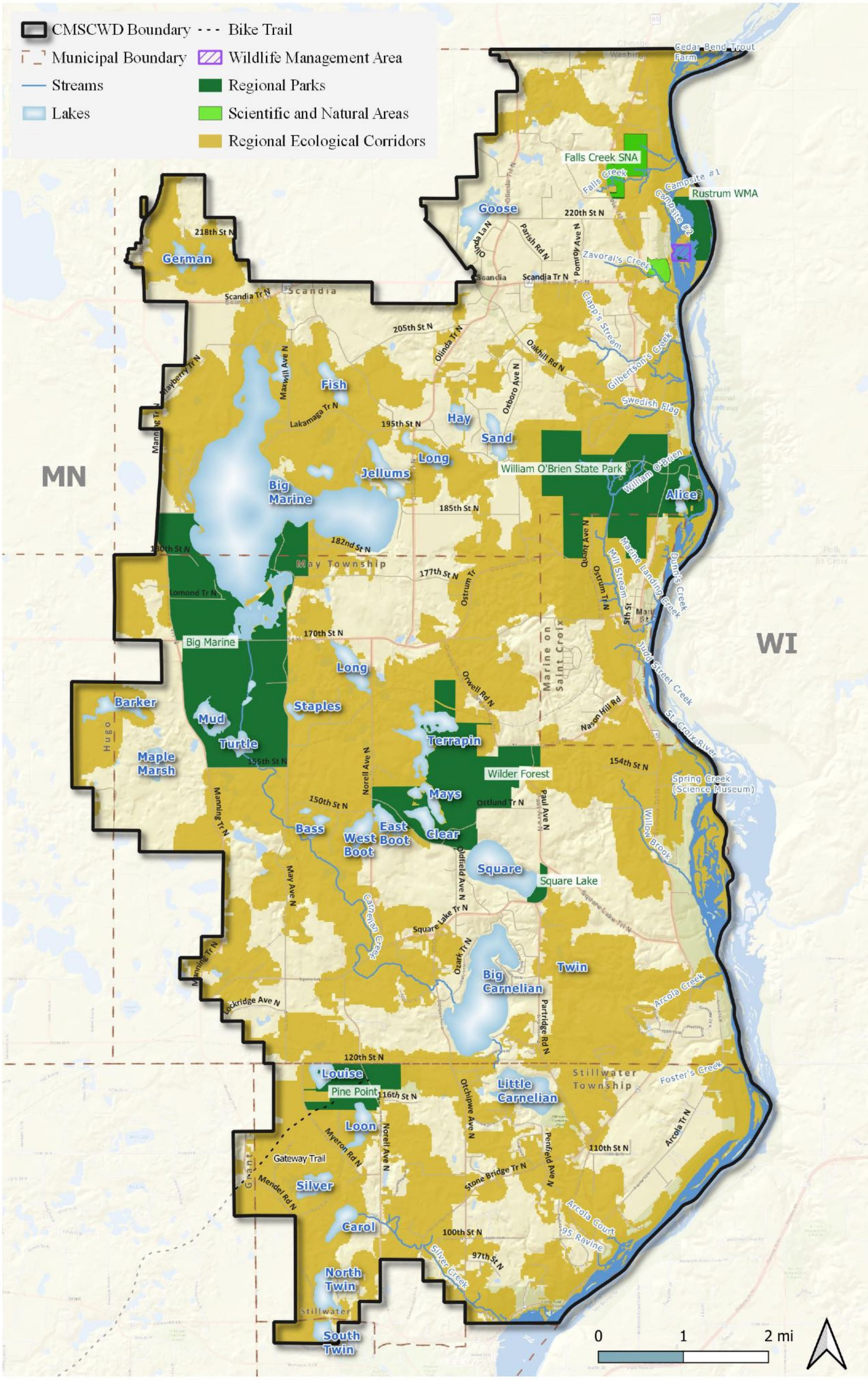


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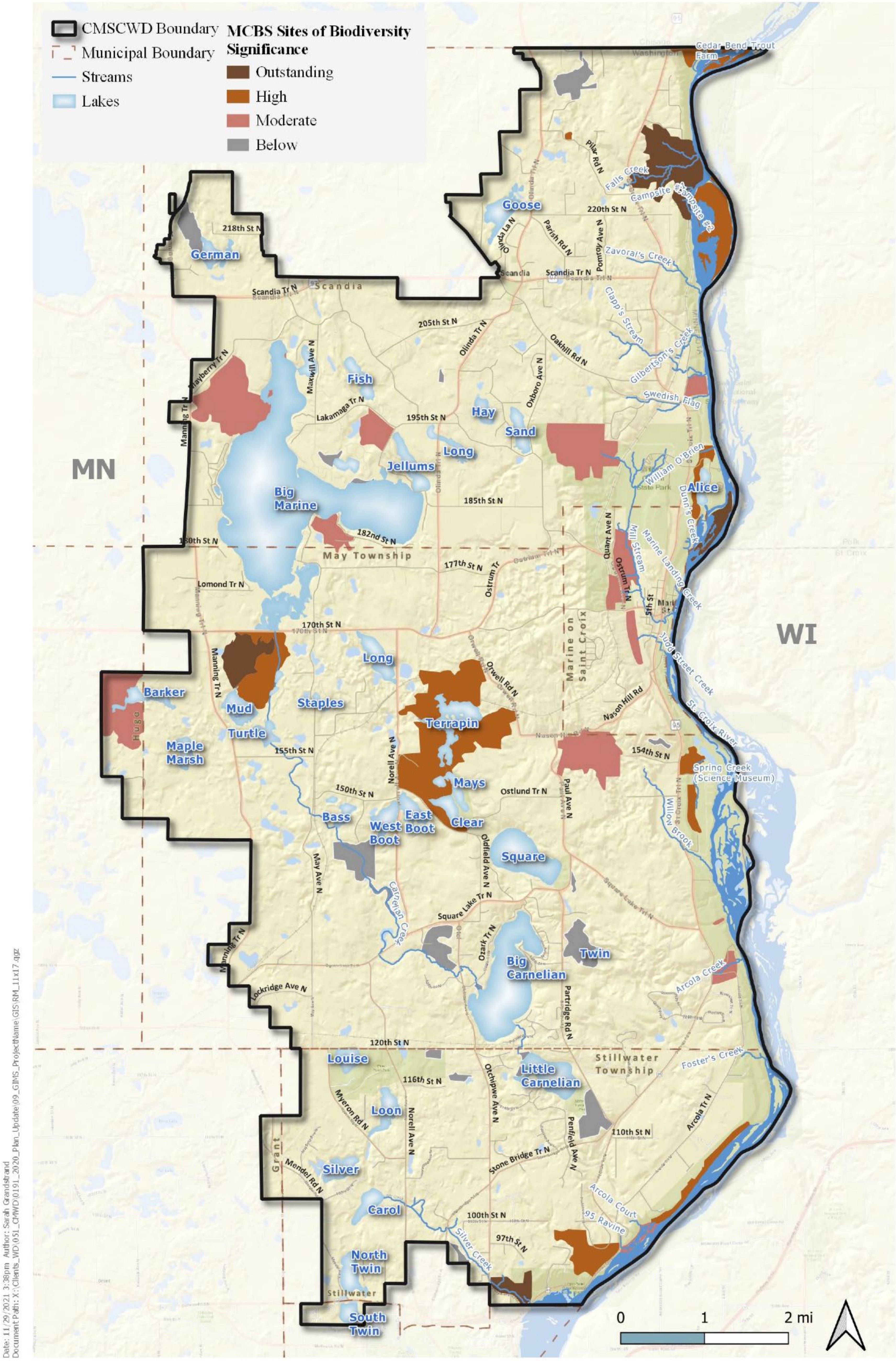
Figure A-21. Minnesota County Biological Survey Sites



Pollutant Sources

This section discusses the potential pollutant sources within the watershed, including all permitted point sources, potentially contaminated sites, leaking above- and below-ground storage tanks, unsealed wells; and soil treatment systems. Other potential hazards are likely to exist and are not discussed in this section, including non-point source pollution, urban runoff, and nutrients in surface water and groundwater.

A detailed inventory of pollutant sources and potential environmental hazards can be found in an interactive web-mapping tool at: https://mpca.maps.arcgis.com/apps/webappviewer/index.html?id=9d45793c75644e05bac197525f633f87

1.15. Permitted Discharges

Municipal Separate Storm Sewer System (MS4) Stormwater

Municipal Separate Storm Sewer Systems (MS4s) are defined by the Minnesota Pollution Control Agency (MPCA) as conveyance systems owned or operated by an entity such as a state, city, town, county, district, or other public body having jurisdiction over disposal of stormwater or other wastes. A conveyance system includes ditches, roads, storm sewers, stormwater ponds, etc. The goal of the MS4 Stormwater Program is to "reduce the amount of sediment and pollution that enters surface and groundwater from storm sewer systems to the maximum extent practicable". The MS4 stormwater discharges are regulated by National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permits administered by the MPCA.

Small MS4s outside of urbanized areas, with populations greater than 10,000 (or greater than 5,000 if they are located within 0.5 mile of an outstanding value resource or impaired water) are classified as small designated MS4s. As a requirement of the NPDES permit, MS4s must develop a stormwater pollution prevention program (SWPPP) which outlines a plan to reduce pollutant discharge, protect water quality, and satisfy water quality requirements in the Clean Water Act. The MS4s within CMSCWD are listed in Table A-16.

Table A-16. Municipal Separate Stormwater Sewer Systems within CMSCWD

Permit Holder	MS4 Permit Number
City of Grant	MS400091
City of Stillwater	MS400259
City of Hugo	MS400094
Washington County	MS400160

Construction Stormwater

Construction sites can contribute substantial amounts of sediment to stormwater runoff. The NPDES/SDS Construction Stormwater Permit administered by the MPCA requires that all construction activity disturbing areas equal to or greater than one acre of land must obtain a permit and create a Stormwater Prevention Pollution Plan (SWPPP) that outlines how runoff pollution from the construction site will be minimized during and after construction. Construction stormwater permits cover construction sites throughout the duration of the construction activities through final stabilization of the site. The MPCA Data Desk (datadesk.mpca@state.mn.us) can be contacted to obtain an updated list with location information on all permitted construction sites in the District.

Industrial Stormwater

There is one site within the CMSCWD that is permitted under the state Industrial Stormwater Permit: MJ Raleigh Trucking, Inc site in Stillwater Township. The NPDES/SDS Industrial Stormwater Permit applies to facilities with Standard Industrial Classification Codes in ten categories of industrial activity with significant materials and activities exposed to stormwater. Significant materials include any material handled, used, processed, or generated that when exposed to stormwater may leak, leach, or decompose and are carried offsite. The permit requires that the industrial facility create a Stormwater Prevention Pollution Plan (SWPPP) for the site outlining the structural and/or non-structural best management practices used to manage stormwater and the site's Spill Prevention Control and Countermeasure Plan. Figure A-22 shows the industrial stormwater permit site within the watershed district.

Feedlots

There are 21 MPCA registered feedlots within the CMSCWD, however none of the feedlots are required to have an NPDES/SDS permit (Figure A-22). The feedlots identified on Figure A-22 do not include all sites in the District where animals are located. The primary goal of the state feedlot program is to ensure that surface waters are not contaminated by the runoff from feedlots, manure storage or stockpiles, and cropland with improperly applied manure.

Industrial Wastewater

Eight facilities within the District are permitted by the MPCA to discharge wastewater; two of these are industrial discharges: one landfill located southeast of Long Lake in May Township and a sand and gravel mining pit located east of Big Marine Lake. The other six facilities are community wastewater treatment systems as discussed in the next section. For any discharge to a surface water, ground surface or subsurface, an NPDES and/or an SDS permit is required and administered by the MPCA. Figure A-22 shows all of the wastewater permitted sites within the watershed.

Private/Municipal Wastewater Treatment

The private wastewater needs of the CMSCWD residents are met through individual or community soil treatment systems. The watershed is not served by regional wastewater plants, with the exception of the City of Stillwater south of Highway 96. Six community wastewater treatment systems are permitted by the MPCA and identified as wastewater discharge sites on Figure A-22 (the facility in eastern May Township has three adjacent locations). In addition, the County regulates 7 wastewater collector systems including Jackson Meadows, Ti Gavo, Marine of St. Croix Downtown, Downtown Scandia, Carnelian Hills, Bliss, and Anderson Erickson. Communities are required by Minnesota Rules Chapter 7080 to adhere to the minimum standards set forth by the MPCA for the proper location, design, installation, use, and maintenance of Soil Treatment Systems (STS). Communities comply with MPCA standards by adopting a state approved STS ordinance. Washington County has a state approved ordinance that is more stringent than state standards. More information regarding the county ordinance is available at the following website:

http://www.co.washington.mn.us/client_files/documents/ORD/ORD-0128.pdf.

The regulation and permitting for this ordinance is performed by Washington County within these communities.

1.16. Potential Environmental Hazards

Contaminated Sites

Potentially contaminated sites within the watershed are shown on Figure A-23. The MPCA has maintained a database of potentially contaminated properties since the early 1980s. The database includes properties that have already been investigated and cleaned up, properties currently enrolled in MPCA cleanup programs, and properties that were suspected to be contaminated, but after investigation turned out to be clean. The types of potentially contaminated sites included in the database are operating and abandoned landfills, dumps, and solid waste sites, among others. Discharges at these sites may contain harmful substances that have the potential to contaminate both groundwater and surface water.

Leaking Above- & Below-ground Storage Tanks

The MPCA investigates and cleans up releases from petroleum tanks. Approximately 35 leaking above- and below-ground storage tanks (active, investigation, and cleanup) have been report in the watershed; their locations are shown in Figure A-23.

Wells

Residents of the CMSCWD obtain all of their drinking water from groundwater resources with the majority coming from private wells. Wells found within the CMSCWD are shown in Figure A-23 (CWI, 2008). Wells can serve as a connection between different aquifers and can serve as a pathway for groundwater contamination. Some of the wells included in the index may have been properly sealed when abandoned, but those still in use and those abandoned but not properly sealed may provide a pathway for contamination to spread between aquifers.

Figure A-22. Permitted Pollution Sources

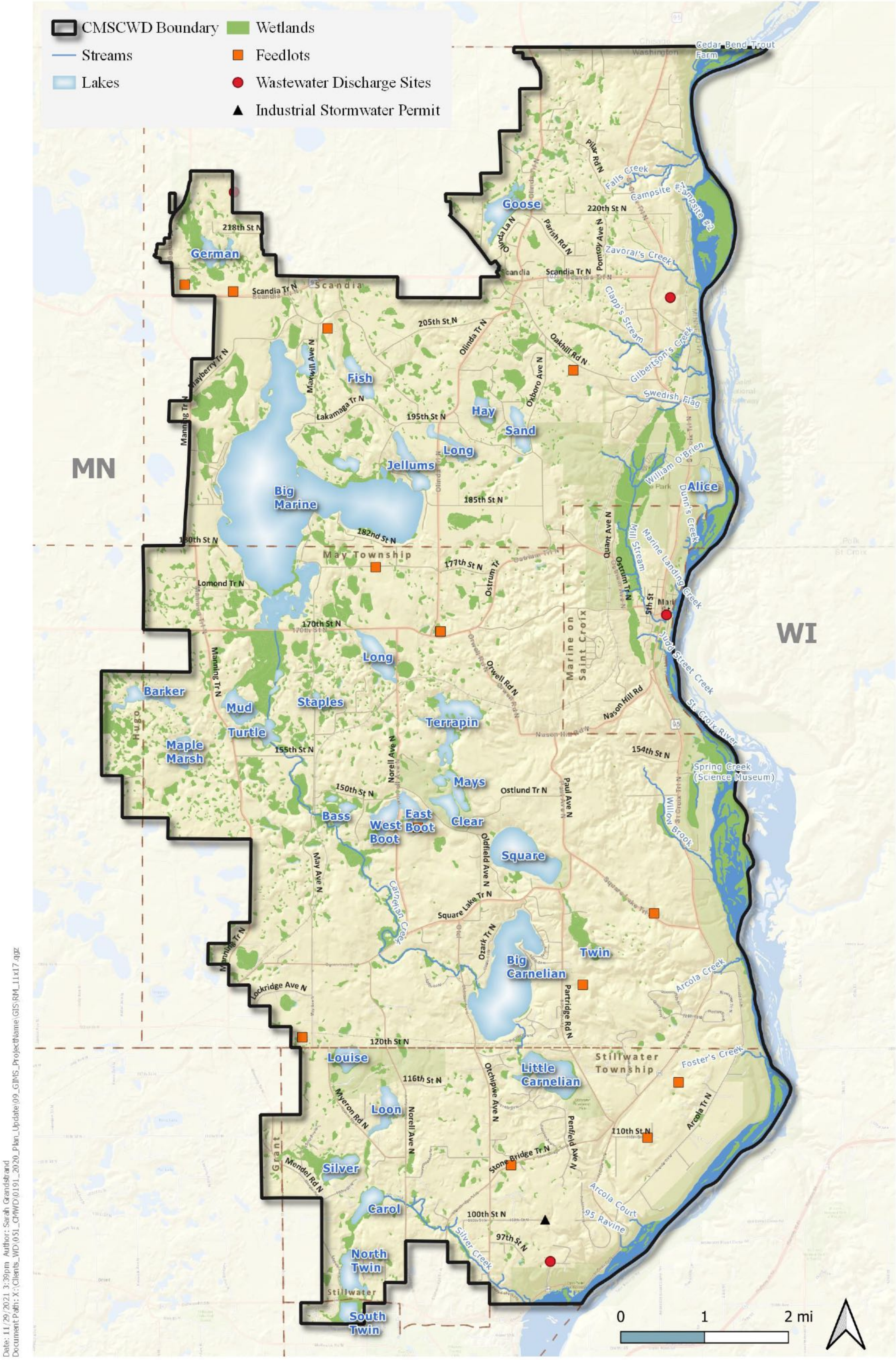
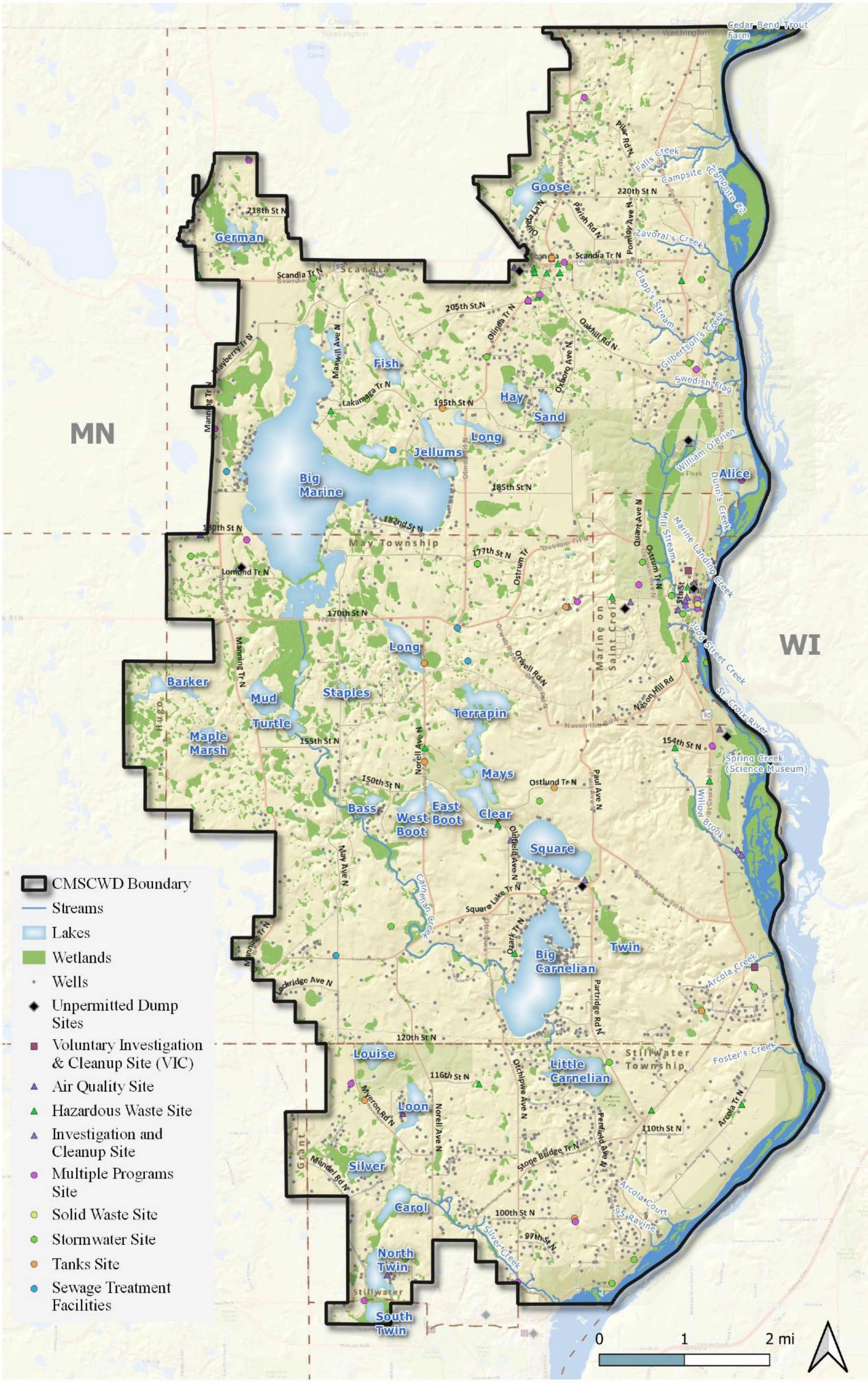


Figure A-23. Potential Environmental Hazards



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District Study Inventory

The CMSCWD has completed a number of studies since completion of the 2010 Plan. The major projects and studies including those completed by the former MWMO are summarized below. In addition, member communities and other organizations have completed relevant studies and project. These projects are included below.

Hydraulic/Hydrologic Studies and Models

The District has developed hydrologic models for the Carnelian Creek Drainage Area and the Silver Creek Drainage Area for internal use in evaluating potential projects and to estimate basin flood elevations for where no flood elevation information was available. These elevations are then used to establish a minimum low floor elevation for proposed developments that is acceptable to the District. Drainage structure information for creek crossings was based on As-built drawing information when available. When information was not available field surveys were conducted to obtain information for critical structures. Remaining topographic data input information was estimated from District and County 2-ft contour mapping of the area. Use of models to evaluate specific projects typically requires collection of more detailed topographic and structure information for the detailed study area. Estimated flood information was used by Washington County to update County Floodplain Maps.

Square Lake Diagnostic Study and Implementation Plan, 1998-2000

The Square Lake Diagnostic Study and Implementation Plan (WCD, 2000) consisted of a lake diagnostic and feasibility study. The goal of the project was to evaluate external and internal water quality and quantity inputs into Square Lake and to develop strategies for maintaining and improving the water quality of Square Lake. The project included an assessment of the groundwater inputs into the lake and an in-lake monitoring program. Parameters examined as part of the in-lake study included water quality data; zooplankton, phytoplankton and fish surveys; aquatic macrophyte surveys; and lake elevations. The study found that the lake receives significant amounts of groundwater and very limited amounts of surface runoff. The study also found that the lake has exceptional water quality in part due to the abundance & size of planktivorous zooplankton.

Mill Stream Natural Resource Inventory, 1998-1999

Completed in 1999, the Mill Stream Natural Resource Inventory (EOR, 1999) inventoried natural communities and water resources in the Mill Stream watershed. Plant communities and land cover were mapped using the MLCCS and provided as a final product along with stewardship recommendations.

MWMO Natural Resource Inventory, 1999-2000

Following the completion of the Mill Stream Natural Resource Inventory (EOR, 1999), the study area was expanded to include the whole of the MWMO. The project inventoried natural communities and water resources throughout the watershed. Plant communities and land cover were mapped using the MLCCS and provided as a final product along with stewardship recommendations.

The Influence of Ground Water on the Quality of Lakes in the CMWD, 2001.

In 2001, the Minnesota Geological Survey completed a study to determine to the source, magnitude, and quality of groundwater inputs to lakes in the district. The study investigated three major factors to identify groundwater inputs: 1) the distribution of bedrock and glacially-derived sediments within the watershed, 2) the shape and direction of the water table, and 3) direct detection of groundwater flow in the shoreline zone. Together, these three factors were used to explain the relationship of the lakes to the groundwater system and determine the relative importance of groundwater in each lake.

Integrating Groundwater and Surface Water Management– Northern Washington County, 2000-2003

The Integrating Groundwater and Surface Water Management – Northern Washington County study was initiated to provide local decision makers with planning-level information on groundwater resources in their area and data to support management strategies and policies protecting groundwater resources. The study area includes the northern portion of the County, from State Highway 36 north to the County line.

Lower St. Croix River Spring Creek Stewardship Plan, 2000-2003

The primary reasons for undertaking this project were to describe and evaluate spring creeks and associated groundwater-dependent resources, and based on this increased understanding of these unique resources, to define stewardship strategies towards their long-term protection. The report is a companion to Integrating Groundwater and Surface Water Management in Northern Washington County, which evaluated groundwater-surface water interaction and prescribed management recommendations for groundwater resources. The plan assesses twenty of the major creeks that flow into the St. Croix River from the north boundary of the City of Stillwater to the northern boundary of Washington County along the Minnesota side of the river. Each of the twenty streams was evaluated seasonally for two years. Parameters assessed include: hydrology, geomorphology, water quality and chemistry, macroinvertebrates, fisheries and riparian plant communities. Groundwater discharge areas supporting ground-water dependent plant communities were identified, evaluated and mapped. Using this data, streams were classified into one of four stream comparison domains:

1. Surface water-fed streams
2. Groundwater-fed streams with large watersheds
3. Groundwater-fed streams with small watersheds
4. Groundwater-fed streams, urban land uses

Results of two years of monitoring and data collection show that the spring creeks and associated groundwater-dependent natural resources are among the most diverse and unique ecosystems in the Twin Cities region. Over half the streams evaluated contain self-sustaining populations of Brook Trout and several contain new or undocumented (for Minnesota) taxa of macro invertebrates.

The report contains a fact sheet for each stream. The fact sheets are intended for use by local government units, watershed management organizations and citizens to carry on the task of resource management in the St. Croix basin. The fact sheets describe each creek's watershed, significant features, findings of the technical work, and make key management recommendations for natural resource management. The full report is available on the CMSCWD website https://www.cmscwd.org/documents

Phosphorus Sensitivity Analysis, 2000

The District in partnership with the Washington Conservation District completed a phosphorus sensitivity analysis for twenty lakes to develop well defined goals for each of the lakes within the Carnelian Marine Watershed District. The approach utilized Reckhow-Simpson and Minnesota Lake Eutrophication Analysis Procedure models to determine management strategies for each lake. The complete study is available on the CMSCWD website https://www.cmscwd.org/documents.

Carnelian Marine Watershed District Natural Resource Inventory and Management Plan, 2002-2003

Completed in 2003, the CMWD Resource Inventory (EOR, 2003) inventoried natural communities and water resources in the entire District. Plant communities and land cover were mapped using the MLCCS and provided as a final product along with management recommendations.

Silver Creek Corridor Management Plan, 2004

The CMWD identifies the Silver Creek Corridor as having significant moderate to high value resources associated with it. The District established a protective corridor over the creek and developed a management plan for this valued resource. The full study is available on the CMSCWD website. https://www.cmscwd.org/silver-creek

Washington County Floodplain Evaluation 2004

Washington County established 100-year high water levels for all DNR protected water bodies in the CMWD and requested that the District review all of their basin elevations for consistency with the District's modeling and all other information pertaining to water body elevations known by the District. The CMWD reviewed high water levels and the determination methodology for the DNR protected water bodies against the results of the CMWD Hydraulic Model. Results were submitted to Washington County in 2004 for use in the FEMA Washington County Flood Insurance Restudy.

A Paleolimnological Investigation of Trophic Change in Lakes of the Carnelian-Marine Watershed District, 2001

In 2001, the District completed a paleolimnological investigation of trophic changes in four lakes in the watershed: Big Carnelian Lake, Big Marine Lake, East Boot Lake, and Loon Lake. The purpose of the investigation was to establish the baseline trophic conditions existing in the lake prior to European settlement in the mid-1800s. Sediment cores of 1-2 meters in length were collected from deep areas of each lake and dated using ^{210}Pb methods. Water column total phosphorus concentrations were quantitatively reconstructed from fossil diatom assemblages using diatom-based transfer function developed from a set of 55 Minnesota lakes. Results of this study indicated that prior to European settlement, Big Carnelian and East Boot Lakes had very good water quality, with diatom inferred total phosphorus concentrations of 16 and 20 micrograms/liter, respectively. Several problems were encountered with the Loon Lake and Big Marine core data. The bottom of the core collected in Loon Lake was dated back to approximately 1915, indicating significant sedimentation in the lake or in the location of the core. The models used to infer historical TP concentrations do not apply well to Loon Lake due to the hypereutrophic state of the lake, and therefore understanding the pre-settlement condition of the lake was not possible. Big Marine had a poorly preserved diatom profile which made interpreting pre-settlement TP concentrations uncertain, although values were reported in the range between 22 and 33 micrograms/liter. The full study is available on the CMSCWD website https://www.cmscwd.org/documents

German Lake Area and Management Plan, 2003-2004

The District was enlarged in 2002 to include the German Lake Area which previously had not been included in a water management organization. During 2003 and 2004 the District completed resource inventories of the area and developed a lake management plan for German Lake.

Jellum's Bay Water Quality Management, 2002-2004

In 2002, the District completed the "Water Quality Report and Lake Management Plan for Jellum's Bay." The goal of the report was to develop a detailed plan for improving Jellum's Bay. The report found that the poor water quality in Jellum's Bay is primarily due to the shallow nature of the lake; frequent mixing during the growing season causes nutrients to be redistributed throughout the water column. The report identifies several possible projects to address internal nutrient loading in the lake, including dredging, alum treatment, aeration with hypolimnetic withdrawal, barley straw application, aquatic macrophyte restoration, and rough fish removal. To address external nutrient loading, the report suggests riparian restoration, overflow improvements, and proper fertilizer management and septic system maintenance education. In 2003 and 2004, the District and the Washington Conservation District conducted a barley straw treatment of Jellum's Bay in an effort to reduce the internal source of phosphorus in the lake.

SONAR for Groundwater Dependent Natural Resources, 2006

In 2006 the District participated in the Brown's Creek Watershed District (BCWD) effort to prepare a SONAR (Statement of Need and Reasonableness) for a volume control standard and a groundwater dependent natural resources standard. The objective of the volume control standard is to control the rate and volume of stormwater runoff so that surface water and groundwater quantity and quality are protected, soil erosion is minimized, flooding potential is reduced and thermal impacts are reduced. In addition, it is designed to address the preservation of natural infiltration and the recharge of groundwater to ensure that subsurface flows are maintained for groundwater dependent natural resources such as lakes, streams, wetlands, plant communities and drinking water supplies. The objective of the groundwater dependent natural resources standard is to protect the unique and sensitive resources found in Washington County. While there is some overlap in this standard with the others (volume control and groundwater quality), it addresses groundwater protection by providing specific criteria for vegetative buffers, stormwater management, water quality, and wetland bounce and duration.

Carnelian Marine St. Croix Wetland Management Plan, 2007-2008

The District 2000 Overall Plan identified a need to identify, map and preserve the District's pristine and high value wetlands. The District completed the wetland management plan in 2007. In 2008 the District completed the additional data collection and analysis required to include wetlands in the former MWMO Area. The plan sets management standards based on the function and value of each wetland. The wetland management mapping and management requirements are being provided to the Local Governments for inclusion in their 2030 Comprehensive Plan Updates.

Goose Lake Management Plan

The Town of New Scandia (now City of Scandia) developed a management plan for Goose Lake in 2005 initiated by the Goose Lake Association in response to concerns regarding water quality, water levels, and lake use. The Plan includes issues, lake goals and objectives, and a comprehensive management plan to achieve the goals. The Plan suggests that internal loading is a significant factor in water quality of Goose Lake.

2013 Review of the 2000 Phosphorus Sensitivity Analysis

The CMSCWD requested Jim Almendinger, Ph D. with the St. Croix Research Station to review the methodology and findings of the 2000 Phosphorus Sensitivity Analysis. Dr. Almendinger found the benefits of the modeling approach outweighed the problems associated with the uncertainty in its results. The full summary of the review is available on the CMSCWD website https://www.cmscwd.org/documents

Groundwater Management Summary, 2019

The CMSCWD initiated a compilation of existing data and reports on groundwater resources and groundwater management efforts to prevent duplication and highlight areas where CMSCWD should focus groundwater management efforts. The full report is available on the CMSCWD website https://www.cmscwd.org/documents

Summary of Pollutant Delivery Assessment Methodology and Results 2019

A detailed summary of the methodology to estimate both sediment and total phosphorus delivery from any point in the watershed to specific resources of interest. In contrast to previous work that was performed to estimate pollutant loads, the pollutant delivery estimates this approach took into account more complex phenomena, including both the travel time along a flow path and the extent of upstream to downstream disconnectedness due to the presence of landlocked and semi-landlocked basins to identify potential pollutant loading hot spots. The full technical memo is available on the CMSCWD website https://www.cmscwd.org/documents. The full data layer developed from this study is available by selecting the "Pollutant Hotspots" layer on the CMSCWD Interactive Watershed Map located on the CMSCWD website https://www.cmscwd.org/watershed-map

PCSWMM Model Update 2021

Updates to the CMSCWD hydrologic and hydraulic (H&H) model have been ongoing since 2017. This memo summarizes updates completed in 2018, 2019, and 2020 and includes the results of model calibration and recommended high water elevations for District basins. The full technical memo is available on the CMSCWD website at https://www.cmscwd.org/documents

Restorable Wetland Analysis, 2021

Washington Conservation District conducted a GIS desktop analysis to determine the lack or presence of restorable wetlands in Carnelian Marine St. Croix Watershed District. Restorable wetlands were defined as wetlands that have may have been partially drained or filled as a result of agricultural practices, development, or other human activities. The results of the analysis were compared to a model developed by the Natural Resources Research Institute (NRRI). The analysis indicated little evidence of excessive draining of wetlands for agricultural activities or excessively drained or filled for lawns, grazing, or sod farms. The full report is available on the CMSCWD website at https://www.cmscwd.org/documents

Status of Local Comprehensive Plans

The Metropolitan Land Planning Act requires local governments within the seven-county metropolitan area to prepare comprehensive plans. These local plans contain information including existing and future land use, growth forecasts, housing, surface water management, transportation, aviation, sewers, parks, water supply, etc. The plan must contain a local water resources plan approved by the District per Minnesota Statues 103B.235 (Minnesota Statutes Section 473.859, Subdivision 2.) The Metropolitan Council reviews these plans to determine their conformity with metropolitan system plans, consistency with other adopted plans of the Council, and compatibility with the plans of other local jurisdictions in the Metropolitan Area (MN Stat. §473.175, Subd, 1). Table A-17 identifies the status of Local Water Plans in the CMSCWD.

Table A-17. Status of Local Water Plans		
City/Township	Date of Local Water Plan Approval by CMSCWD	Notes
Grant	February 2, 2009	Comments on May 2019 Draft provided District on May 9, 2019
Hugo	January 10, 2018	Resolution 1-10-2018-3
Marine on St. Croix	March 20, 2019	March 20, 2019 Minutes
May Township	March 20, 2019	March 20, 2019 Minutes
Scandia	March 20, 2019	March 20, 2019 Minutes
Stillwater	January 10, 2018	Resolution 1-10-2018-2
Stillwater Township	January 10, 2018	Resolution 1-10-2018-1

1.17. Shoreland and Floodplain Ordinances

In the Metro Area, communities that are notified by the MN DNR must adopt a shoreland ordinance that is consistent with the MN State Rules. For those communities in the unincorporated areas that do not receive notification from the DNR, Washington County administers the shoreland ordinance for that community (e.g. townships). Table A-18 indicates the status of shoreland and floodplain ordinances within each city and township in the CMSCWD.

Table A-18. Status of Floodplain and Shoreland Ordinances				
City / Township	Floodplain Ordinance	Shoreland Ordinance Required	State Approved Shoreline Ordinance	Comments
Grant	Yes	Yes	No	Administered by County - County shoreland ordinances approved by the State.
Hugo	Yes	Yes	Yes	Adopted State approved ordinance.
Marine on St. Croix	Yes	No	Yes	Adopted the Lower St. Croix Bluffland and Shoreland Management Ordinance
May Township	Yes	N/A	N/A	Administered by County - County shoreland ordinances approved by the State.
Scandia	Yes	Yes	Yes	Approved 12/4/2007
Stillwater	Yes	No	No	
Stillwater Township	Yes	N/A	N/A	Administered by County - County shoreland ordinances approved by the State.

Washington County has adopted the Lower St. Croix River Bluffland and Shoreland Management Ordinance. Definitions within the ordinance include minimum setbacks and ISTS and floodway requirements. Additional information is available online at http://www.co.washington.mn.us/infor_for_residents/board_of_commissioners/ordinances/.

The intent and purpose of the Washington County Shoreland Management Ordinance includes the designation of suitable shoreland land use, the conservation of natural resources, the improvement of surface water quality, reduction of erosion and flooding, and the preservation of fish and wildlife habitat. Additional information regarding the county shoreland ordinance is available by contacting the county.

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Attachment A

Table A-19. Water Quality Data															
Name	Lake #	Para-meter Means	No. of Years Sampled	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average Mean	Average Grade
Alice	82028700	TP [ug/l]	5					20	25	24	14		23		21	A
		chl-a [ug/l]	5					7	11	5	2		4		6	A
		Secchi [m]	5					1.83	1.52	1.43	1.71		1.86		1.67	C
Barker (Kenny)	82007600	TP [ug/l]	6				73	71			60	51	57	59	62	C
		chl-a [ug/l]	6				43	39			42	46	41	47	43	C
		Secchi [m]	6				1.13	1.13			1.19	1.22	1.13	0.98	1.13	D
Barking Dog Pond	82049900	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Bass	82003500	TP [ug/l]	6			31	25	30			22	30	25		27	B
		chl-a [ug/l]	6			8	6	9			4	6	6		7	A
		Secchi [m]	6			3.02	2.35	2.19			2.41	2.35	2.19		2.42	B
Big Carnelian	82004900	TP [ug/l]	10	13		20	10	11	10	21	31	17	24	21	18	A
		chl-a [ug/l]	10	3		4	3	4	4	4	4	4	4	5	4	A
		Secchi [m]	10	3.6		4.91	5.3	5.03	5.3	5.3	4.91	4.82	4.85	4.97	4.90	A
Big Marine	82005200	TP [ug/l]	8				20	15	15	17	20	12	11	16	16	A
		chl-a [ug/l]	8				6	4	7	6	6	4	4	4	5	A
		Secchi [m]	9	3.57			3.51	3.66	3.72	3.84	3.69	4.48	5.21	3.99	3.96	A
Big Marine	82005201	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Big Marine	82005203	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Big Marine (Jellums)	82005202	TP [ug/l]	7	77	91				36	53	35		42	45	54	C
		chl-a [ug/l]	7	41	34				12	17	11		13	23	22	C
		Secchi [m]	7	1.19	1.4				1.52	1.86	1.49		1.62	1.13	1.46	C
Bjorndahl Pond	82006402	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Carol (McGuire)	82001700	TP [ug/l]	6			40	27			35	31	36		36	34	C
		chl-a [ug/l]	6			6	6			9	6	7		10	7	A
		Secchi [m]	6			1.13	0.98			0.85	0.91	0.82		0.79	0.91	D
Clear (Mays)	82004500	TP [ug/l]	5	14				12	11			14	16		13	
		chl-a [ug/l]	5	2				3	3			5	6		4	
		Secchi [m]	9	5.73	5.79	5.24	5.39	4.51	4.39			3.29	3.11	3.41	4.54	

Table A-19. Water Quality Data															
Name	Lake #	Para-meter Means	No. of Years Sampled	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average Mean	Average Grade
Deaner	82050900	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Dwyer Pond	82051100	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
East Boot	82003400	TP [ug/l]	10	32	33	40	25	19	17	42	18	21	30		28	B
		chl-a [ug/l]	9	7	8	8	5	4	5		3	6	5		6	A
		Secchi [m]	9	3.17	3.35	3.72	3.93	4.15	3.14		3.69	3.51	3.66		3.59	A
Fish	82006400	TP [ug/l]	6	104	63				40		76		72	39	66	C
		chl-a [ug/l]	7	47	45				15	7	29		27	14	26	C
		Secchi [m]	7	0.79	1.34				1.43	1.86	1.4		1.34	1.8	1.42	C
German	82005600	TP [ug/l]	6			28		18	18	15	19		23		20	A
		chl-a [ug/l]	6			2		4	7	5	5		5		5	A
		Secchi [m]	6			1.83		2.29	1.89	2.04	2.41		2.29		2.13	C
Goose	82005900	TP [ug/l]	11	38	54	60	47	30	43	34	32	34	70	48	45	C
		chl-a [ug/l]	11	26	47	23	33	17	43	27	25	25	27	21	29	C
		Secchi [m]	11	1.55	1.58	1.37	1.28	2.26	1.68	1.43	1.8	1.86	1.89	2.29	1.73	C
Hay	82006500	TP [ug/l]	10	42	54		36	49	44	39	31	27	28	35	39	C
		chl-a [ug/l]	10	20	25		10	22	16	11	11	7	6	10	14	B
		Secchi [m]	10	1.58	1.65		1.55	1.58	1.16	1.65	1.58	1.46	1.46	1.43	1.51	C
Jamee Lee Slough	82028900	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Little Carnelian	82001400	TP [ug/l]	8				7	12	9	15	11	10	12	10	11	A
		chl-a [ug/l]	8				2	3	3	3	3	3	2	2	3	A
		Secchi [m]	9	5.76			6.49	5.49	5.21	5.79	5.49	5.55	5.49	5.67	5.66	A
Little Keller Pond	82050500	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Long	82006800	TP [ug/l]	7	73	92				58	73	60		60	64	69	D
		chl-a [ug/l]	7	33	48				59	48	16		29	61	42	C
		Secchi [m]	7	1.01	1.07				0.46	1.04	1.19		1.01	0.55	0.90	D
Long	82003000	TP [ug/l]	7	33	35			47	29			26	34	45	36	C
		chl-a [ug/l]	7	11	5			12	11			4	5	10	8	A
		Secchi [m]	8	2.74	2.83		2.9	1.86	1.83			2.38	2.32	1.68	2.32	B
Loon	82001500	TP [ug/l]	6	86		70				100	87	71		67	80	D

Table A-19. Water Quality Data

Name	Lake #	Para-meter Means	No. of Years Sampled	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average Mean	Average Grade
		chl-a [ug/l]	6	91		40				69	61	42		50	59	D
		Secchi [m]	6	0.37		0.52				0.4	0.37	0.82		0.52	0.50	F
Louise	82002500	TP [ug/l]	6	119	124					62	64	60		49	80	D
		chl-a [ug/l]	6	44	32					13	28	22		16	26	C
		Secchi [m]	6	0.76	2.01					1.52	1.55	2.13		1.55	1.59	C
Mays	82003300	TP [ug/l]	5	18				30	14			16	16		19	A
		chl-a [ug/l]	5	2				3	4			4	4		3	A
		Secchi [m]	9	6.19	6.4	5.7	5.61	3.11	2.53			3.41	3.44	3.57	4.44	A
Mud	82002600	TP [ug/l]	6	79	138						71	84	73	61	84	D
		chl-a [ug/l]	6	35	97						50	59	46	41	55	D
		Secchi [m]	6	0.21	0.46						0.3	0.37	0.43	0.3	0.35	F
Mud (main lake)	82002602	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
North Twin	82001800	TP [ug/l]	6			40	18			31	20	20		24	26	B
		chl-a [ug/l]	6			5	3			7	3	2		3	4	A
		Secchi [m]	7	1.04		0.76	1.01			1.04	1.19	0.79		0.67	0.93	D
Pitzl Pond	82028200	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Rasmussen Pond	82007000	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Sand	82006700	TP [ug/l]	9	40	62			40	41	36	28	28	53	34	40	C
		chl-a [ug/l]	9	19	75			26	25	18	14	17	31	27	28	C
		Secchi [m]	10	1.68	1.92		1.68	1.55	1.13	1.37	1.58	1.65	1.01	1.46	1.50	C
Silver	82001600	TP [ug/l]	4							27	21	19		37	26	B
		chl-a [ug/l]	4							6	3	4		12	6	A
		Secchi [m]	5	1.65						1.68	1.8	1.62		1.58	1.67	C
South Twin	82001900	TP [ug/l]	6	39	75					35	32	29		18	38	C
		chl-a [ug/l]	6	8	26					13	12	7		25	15	B
		Secchi [m]	5	2.29						1.74	1.92	2.19		2.13	2.05	C
Square	82004600	TP [ug/l]	11	14	10	10	7	8	10	18	13	10	8	11	11	A
		chl-a [ug/l]	11	4	4	3	3	3	3	3	3	3	3	3	3	A
		Secchi [m]	11	5.06	5.39	5.61	5.09	4.79	5.21	4.85	5.61	5.12	5.64	4.45	5.17	A
St. Croix River-Taylors F	13016900	TP [ug/l]														
		chl-a [ug/l]														

Table A-19. Water Quality Data

Name	Lake #	Para-meter Means	No. of Years Sampled	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average Mean	Average Grade
		Secchi [m]														
St. Croix River-Taylors(WI)	13016900	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
Staples	82002800	TP [ug/l]	6				25	24	20			20	22	27	23	B
		chl-a [ug/l]	6				15	11	6			4	5	6	8	A
		Secchi [m]	7		1.77		2.41	2.68	2.47			2.9	3.02	2.59	2.55	B
Terrapin	82003100	TP [ug/l]	5	19				19	16			19	20		19	A
		chl-a [ug/l]	5	5				4	5			3	3		4	A
		Secchi [m]	9	3.2	3.99	3.6	3.69	3.26	2.29			2.5	3	3.05	3.18	A
Turtle	82003600	TP [ug/l]	6			60	130	83			41		58	50	70	D
		chl-a [ug/l]	6			10	9	31			6		7	7	12	B
		Secchi [m]	7	1.52		1.22	0.91	0.79			0.91		0.85	0.73	0.99	D
Twin	82004800	TP [ug/l]	4				13	12	12				13		13	A
		chl-a [ug/l]	4				3	5	3				3		4	A
		Secchi [m]	7	3.99	4.91	4.72	5	4.08	4.27				4.24		4.46	A
Warner Nature Pond	82003200	TP [ug/l]														
		chl-a [ug/l]														
		Secchi [m]														
West Boot	82004400	TP [ug/l]	5			20	30	17	14				15		19	A
		chl-a [ug/l]	5			3	4	4	4				3		4	A
		Secchi [m]	6	4.3		4.54	3.9	3.41	3.05				3.35		3.76	A