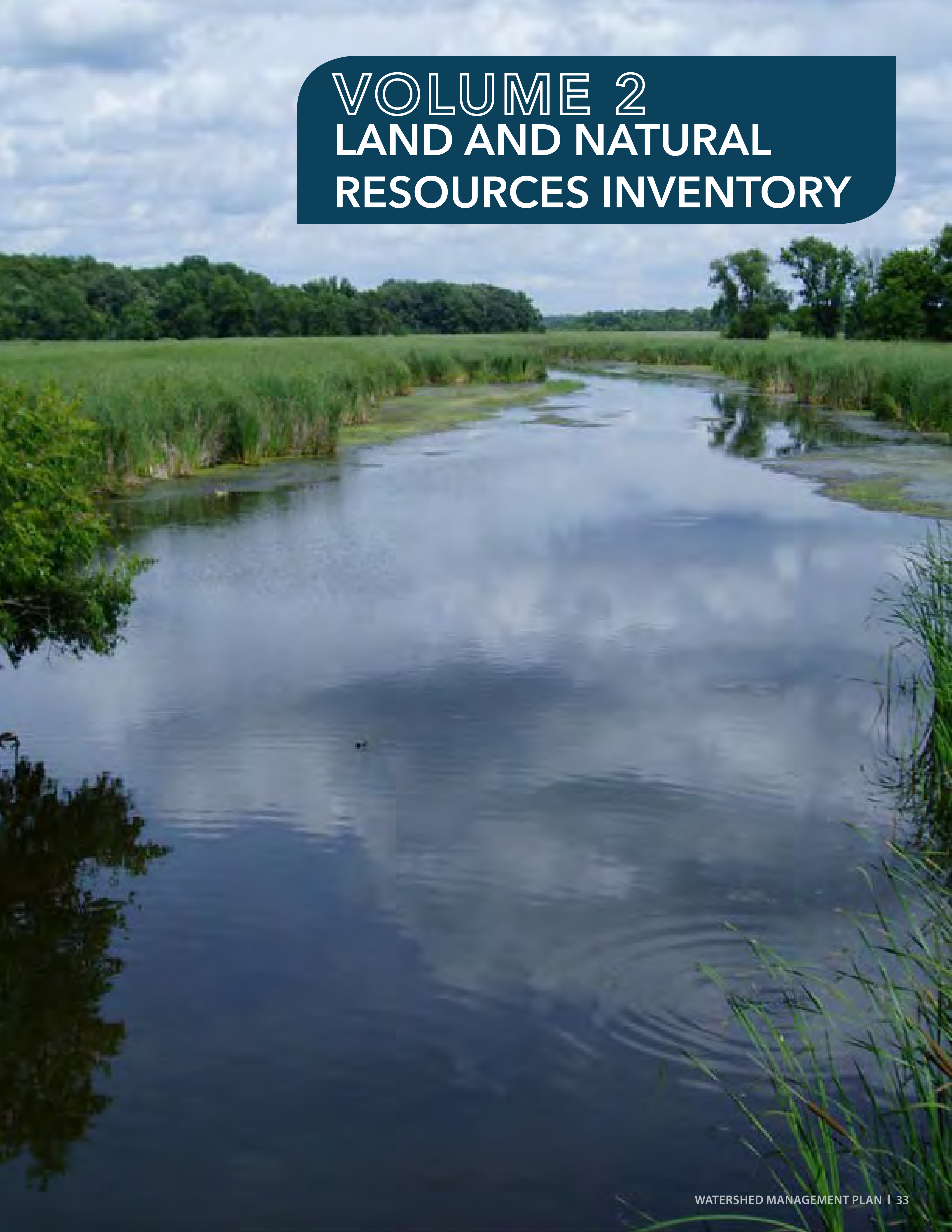
VOLUME 2
LAND AND NATURAL RESOURCES INVENTORY



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2.1 Introduction

This volume contains detailed information on the land and water resources within the Minnehaha Creek Watershed District (MCWD or District). These data are summarized and analyzed in this volume for ease of reference and to focus Volume 3 on implementation strategies. Section 2.2 of this volume looks at the geography of the watershed and includes information on climate, topography and drainage, water resources, geology and soils. Section 2.3 looks at the characteristics of the 11 individual subwatersheds and provides the data from studies and assessments conducted within each of the subwatersheds. This section can be referenced for the technical information used to develop the subwatershed implementation plans detailed in Volume 3. Section 2.4 provides a complete inventory of all available MCWD data and studies.

The data are presented following the four overarching strategic goals of the District:

- Water Quality
  - To preserve and improve the quality of surface and groundwater.
- Water Quantity
  - To manage the volume and flow of stormwater runoff to minimize the impacts of land use change on surface and groundwater.
- Ecological Integrity
  - To restore, maintain, and improve the health of ecological systems.
- Thriving Communities
  - To promote and enhance the value of water resources in creating successful, sustainable communities.

2.1.1 MCWD DATA SETS:

The District continues to maintain and develop a wealth of data to inform and guide implementation efforts within the watershed. Data available to characterize issues and inform watershed management can generally be broken into the following categories:

- Monitoring Program Data and E-grade Program
- Watershed Wide Studies
- Subwatershed Studies
- Waterbody Specific Studies or Total Maximum Daily Load Studies
- Project Feasibility or Small Area Plans

Most of these past data collection efforts included extensive public participation. This Plan integrates these data sets and public participation into a long-range strategic plan to guide implementation across the eleven subwatershed planning units.

2.1.2 MONITORING PROGRAM DATA:

The District maintains a Research and Monitoring Program to collect water quality, water quantity and ecological integrity data across the watershed. The program is a collaborative effort between the Three Rivers Park District (TRPD), the Minneapolis Park and Recreation Board (MPRB), the Minnesota Pollution Control Agency (MPCA), the United States Geological Survey (USGS), Metropolitan Council Environmental Services (MCES), the Citizen-Assisted Monitoring Program (CAMP), and the Minnesota Department of Natural Resources (DNR).

The program, which was initiated in 1968 and was expanded in 1997, 2004, and 2011 to provide a comprehensive view of water quality, is currently being expanded again to broaden its focus into ecosystem services. This expansion, characterized as E-Grade (summarized below), provides data regarding the physical, chemical and biological components of the District, divided into ecosystem services by lakes, streams, wetlands and upland systems.

District's Monitoring Priorities:

The primary objectives of the District's monitoring program are to:

- Diagnose issues and stressors to guide management strategies
- Broadly characterize ecological health through the E-Grade program
- Identify trends in water quality, water quantity, and ecological integrity
- Track the efficacy of implementation efforts across the watershed

E-Grade Program:

In 2014, the District began developing a new tool to evaluate and broadly characterize the health and function of the watershed. The Ecosystem Evaluation Program, or E-Grade for short, will provide a holistic assessment of ecosystem health.

Historically, water quality has been characterized by three measures: water clarity (i.e., Secchi depth measurements), chlorophyll-a, and total phosphorus concentrations. These measures are used to compute grades (ranging from A to F) on lakes. The public often uses the lake grades to assess which lakes to recreate upon, where to purchase lakefront property, and to request improvement of a waterbody from the District. However, the current grades are only a partial snapshot of a lake's health, because they exclude other indicators of a healthy ecosystem like flood control and habitat diversity. The current system does not differentiate between deep and shallow lakes, which function very differently. Furthermore, there are more types of waterbodies in the District than just lakes – such as wetlands and streams – yet the overall health and function of these waters has not been assessed to the same degree as lake systems, and the interaction amongst the many ecosystems has not been effectively studied and documented.

The E-Grade program will assess five landscape types: deep lakes, shallow lakes, streams, wetlands, and uplands. Each of the landscape types will be evaluated on six interdependent ecosystem services and the conditions that affect their performance. As it will more thoroughly assess waterbodies and uplands, E-Grade will lead to identification of more localized ecosystem issues and stressors, and better inform the management strategies of the District and its partners. As a result, project goals can be expanded beyond traditional metrics such as phosphorus reduction to include more complex metrics based on biological components. This science-based information will allow the District to better identify areas in highest need of improvement or protection, which in turn will inform priority-setting for District activities. The resulting E-Grade reports will also be a useful education tool for the public.

Program Design:

Ecosystem services are functions that natural systems perform to the benefit of the environment. Ecosystem services are key to sustainability, and how well services function affects the quality of ecosystems. Given this understanding, the United Nations (UN) Environment Programme began an integrated approach to ecosystem management that "focuses on sustaining ecosystems to meet both ecological and human needs" (*United Nations Environment* - web.unep.org/ecosystems/who-we-are/about-ecosystems). The UN's integrated ecosystem management approach identified about three dozen ecosystem services to manage.

The E-Grade Program is based on this integrated approach and is being developed as an integrated watershed management tool. For the District, six ecosystem services were selected to best characterize ecosystem quality. The E-Grade integrated watershed management tool will allow the District to preserve and improve water quality, water quantity, and ecological integrity while promoting and enhancing the value of water resources that will lead to thriving communities.

Development of E-Grade was performed by District staff and Wenck Associates, and included the participation of a Technical Advisory Committee (TAC). Members of the TAC included representatives of state, local, and regional agencies, as well as academics from the University of Minnesota. The TAC provided guidance and feedback on which ecosystem services to select as well as the metrics to be used in assessing ecosystem performance. The TAC also provided biological data collected by other agencies and schedules for collection of these data. Their effort fulfilled two goals – to maximize the use of existing data and to provide professional rigor to a scientific foundation for E-Grade.

Services, Functions and Measures:

As previously noted, E-Grade will assess six ecosystem services for each of the five landscape types. The E-Grades will be scaled from individual waterbodies and summarized up to the watershed level (Figure 2.1). The function and measures for each ecosystem service are listed in Table 2.1. The classification breakpoints for all the metrics is based on literature, widely accepted state agencies' standards, and/or recommendations by the TAC. The performance of the ecosystem services for each of the five landscape types will be graded using the terminology in Table 2.2.

Figure 2.1. Scale of E-Grade Assessment Tool.

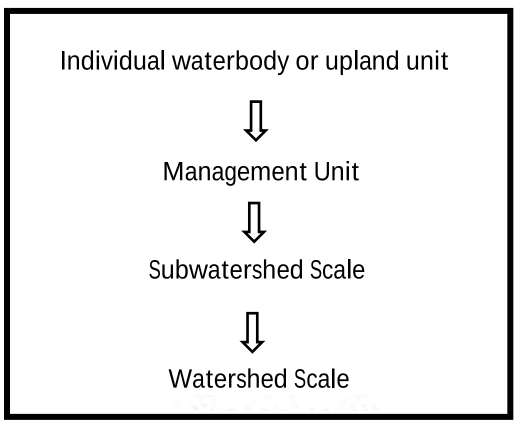

Table 2. 1. E-Grade Ecosystem Services, Functions and Measures.

Ecosystem Service	Functions	Measure	Landscape Types				
			Deep Lake	Shallow Lake	Stream	Wetland	Upland
Groundwater Supply	Groundwater Recharge	Groundwater Supply				X	X
Flood Control	Watershed Storage	Watershed Storage	X	X		X	
		Stormwater retention and detention					X
		Wetland Density				X	
	Floodplain Encroachment	Barriers in the Floodplain			X		
Biodiversity	Resilient Biological Community	Fish Community Quality	X		X		
		Aquatic Vegetation Quality	X	X		X	
		Macroinvertebrate Community Quality			X		
Habitat Diversity	Habitat for Fish, Macroinvertebrates, and Wildlife	Aquatic Vegetation Quality	X	X			
		Shoreline Quality	X	X			
		Stream Habitat Complexity			X		
		Connectivity			X	X	
		Stream Water Quality			X		
		Hydrology			X		
		Wetland Size				X	
Nutrient Cycling	Nutrient: Sink, Source, and/or Transformer	Eutrophication Indicators	X	X			
		Nutrient Concentrations in Stream			X		
		Wetland Soil Chemistry				X	
Recreation	Swimmability	Water Clarity	X	X	X		

Table 2. 2. E-Grade Technical Threshold Descriptions.

Technical Threshold Descriptions	
Exceptional	Community structure and species composition or ecosystem processes are near reference conditions. The most relatively pristine communities.
Good	Community structure and species composition or ecosystem processes are beginning to show signs of disturbance, but support the ecosystem service.
Poor	Community structure and species composition or ecosystem processes show obvious signs of disturbance.
Degraded	Community structure and species composition or ecosystem processes are showing high levels of disturbance.

Implementation Schedule:

As part of the development of the E-Grade program, from 2014-2016 the District collected data on the new E-Grade parameters in three "test" subwatersheds – Minnehaha Creek, Six Mile Creek, and Schutz Lake. The E-Grade reports for these three subwatersheds will be released in 2018. For the remaining eight subwatersheds, the District will produce preliminary E-Grade reports in 2019. These preliminary reports will be based on existing data compiled from the District and its partner agencies and may not include all E-Grade parameters. Additional parameters will be collected throughout the Plan cycle according to current District priorities and staff capacity. As additional data are collected, the reports will be updated with the new information.

Monitoring Locations, Frequency, and Parameters:

In 2017, the District updated its monitoring plan in order to meet the District's priorities and improve program efficiency. Some locations act as "anchor" stations that are monitored every year to assess long-term changes throughout the subwatershed. These stations are selected to be representative of the entire subwatershed and are typically major lakes or the furthest downstream station on the major streams. Other stations are monitored on a rotational basis through the E-Grade program as described in the previous section.

The following describes current monitoring locations, frequency, and parameters. These may be adjusted over the planning period to serve program purposes.

Anchor Stations Monitored By MCWD

Anchor Lakes

In 2017, the Research and Monitoring Program re-designated which lakes would be anchor stations (Table 2.3). Staff have chosen to have volunteers measure Secchi depth readings on additional upper watershed lakes to provide an effective warning system for detecting change (Table 2.4). If a significant negative change in the Secchi depth is noticed, Program staff can investigate further.

Sampling consists of three major procedures: measuring a lake's profile with multi-parameter sonde, Secchi disk depth (SD) measurements, and water sample collection. Temperature (temp), dissolved oxygen (DO), pH, and specific conductivity (cond) are measured at each lake station. Readings are collected from the water surface to the bottom of the lake at one meter increments. Water samples are analyzed for total phosphorus (TP), total suspended solids (TSS), and chlorides (Cl). Sampling season is from May-September. Deep lakes are monitored once a month, while shallow lakes plus Wassermann Lake, Halsted Bay, and Jennings Bay are monitored twice a month. Parameters sampled are listed in Table 2.5.

Table 2. 3. Lakes designated as anchor stations.

Subwatershed	Lake
Christmas Lake	Christmas Lake
Gleason Lake	Gleason Lake*
Lake Minnetonka	Carman Bay
	Crystal Bay
	Forest Lake
	Grays Bay
	Halsted Bay
	Jennings Bay
	Lower Lake South
	Stubbs Bay
Lake Virginia	Lake Virginia
Long Lake Creek	Long Lake
	Tanager Lake
Six Mile Creek	Parley Lake*
	Wassermann Lake

*Shallow lakes

Table 2. 4. Lakes with water clarity monitored by volunteers.

Subwatershed	Lake
Dutch Lake	Dutch Lake
Lake Virginia	Lake Minnewashta
Schutz Lake	Schutz Lake
Six Mile Creek	Piersons Lake

Table 2. 5. Lake parameters sampled.

	Temp	DO	Cond	pH	SD	Cl	Chl-a	TP	TSS**
Surface	Profile				X		X	X	X
Bottom*						X		X	

*2 year rotation, **Only at Grays Bay, Halsted Bay, Jennings Bay, Wassermann Lake and shallow lakes

Anchor Streams

Many of the streams within MCWD are intermittent, meaning the flow is irregular and often dependent on precipitation. The streams in the western part of the District have been ditched and/or flow through wetlands. Minnehaha Creek, in the eastern part of the District, is the only stream in the District designated for recreational use. Minnehaha Creek drains the upper watershed and Lake Minnetonka and eventually flows into the Mississippi River. In 2017, the Monitoring Program re-designated which stream stations would be anchor stations (Table 2.6).

Sampling consists of four major procedures: using a multi-parameter sonde to measure basic water characteristics, using a flow tracker to measure discharge, recording stage or water level, and water sample collection. Sampling season is year round. During the winter, sampling occurs once a month. Once ice is off the streams, sampling occurs twice a month. During the spring, 6 to 10 additional samplings may occur to capture storm events. Parameters sampled are listed in Table 2.7. Additionally, the Monitoring Program has an ISCO automated sampler set up at the Hiawatha Ave station on Minnehaha Creek to capture storm events.

Table 2. 6. Stream stations designated as anchor stations.

Subwatershed	Stream Station	Station #
Dutch Lake	Dutch Creek Outlet (CR 110)	CDU01
Langdon Lake	Langdon Lake Outlet (CR 110)	CLA01
Minnehaha Creek	Grays Bay Dam	CMH07
	McGinty Rd W./I-494 Ramps	CMH01
	34th Ave/Aquila Ln	CMH02
	Excelsior Blvd	CMH11
	W. 56th St	CMH04
	21st/Minnehaha Pkwy	CMH24
	Hiawatha Ave	CMH06
Painter Creek	West Branch Rd.	CPA01
Schutz Lake	Lake Minnetonka: Smithtown Bay Inlet (N. of HWY 7)	CSC02
Six Mile Creek	Inlet to East Auburn Lake (HWY 5)	CSI05
	Lundsten Lake N Outlet	CSI01
	Mud Lake Outlet (Highland Rd)	CSI02

Table 2. 7. Stream parameters sampled.

	Discharge	Temp	DO	Cond	pH	Cl	TP	TSS	*E. coli**	Elevation
Biweekly Sampling	X	X	X	X	X		X	X		X
Storm Events							X	X		
Monthly						X				
Weekly, April- Oct.									X	

**E. coli* bacteria sampled only at Minnehaha Creek and Painter Creek stations; Note - Minnehaha Creek: Hiawatha Ave Station is also analyzed for NO2, NH3, total dissolved phosphorus (TDP), and total suspended volatile solids (TSVS)

E-Grade Parameters Monitored By MCWD

An E-Grade Assessment will focus on a subwatershed for three years. Anchor and non-anchor lake and stream stations will be assessed for the following ecosystem services: nutrient cycling, habitat diversity, and biodiversity, flood control and recreation. Wetland stations will be assessed for all ecosystem services, except for recreation. The measures and parameters for uplands will be defined by 2018. The Monitoring Program will incorporate the data into the E-Grade for each subwatershed.

The following describes the E-Grade parameters. Table 2.8 lists the E-Grade measures, parameters, timeframe, and frequency.

Field Collection - Water Samples

The following are needed to complete an E-Grade assessment: field collection for water samples (TP, Chl-a, total nitrogen, total Kjeldahl nitrogen, NO_3, and TSS), Secchi depth and DO readings, and flow. The collection of these parameters will follow the same procedures as outlined above for monitoring at anchor lake and stream stations.

Fish Community Surveys

For characterizing ecological health of lakes, fish community surveys are conducted on lakes with surface areas larger than 100 acres. The MnDNR will be conducting the majority of the fish surveys within MCWD for their watershed assessment of fish communities. The fish community surveys are actually three types of surveys - trap net, gill net and near shore seining surveys. The data are computed through the Fish Index of Biological Integrity (IBI) assessment created by the MnDNR.

Lake Vegetation Community Surveys

For characterizing ecological health of lakes, lake vegetation community surveys are conducted. District staff conduct the lake vegetation community surveys. The data collected are computed through the floristic quality index (FQI) assessment created by the MnDNR.

Stream Habitat Assessments and Macroinvertebrate Community Surveys

For characterizing ecological health of streams, stream habitat assessment and macroinvertebrate community surveys are conducted at E-Grade stream stations. MCWD staff will conduct the surveys following assessment protocols created by the MPCA.

Wetland Vegetation Community Surveys and Soils Analysis

For characterizing ecological health of wetlands, surveys of the wetland vegetation communities and collection of soil samples are conducted in a percentage of wetlands within a subwatershed. The wetland vegetation community surveys will follow the MPCA's rapid floristic quality assessment protocol. These surveys are for emergent and submergent vegetation. In conjunction with the field surveys, relevant McRAM questions also will be answered for the E-Grade assessment. Two soil samples will also be collected per surveyed wetland.

Upland Monitoring

Protocol for characterizing ecological health of uplands is still in development and will be finalized in 2018.

GIS/Aerial Photos/Modeling Analyses

Protocol for the GIS/aerial photos/modeling analyses are still in development and will be finalized in 2018.

Table 2. 8. E-Grade parameters, timeframe and frequency for each landscape type.

Landscape Types	Measure	Parameters*	Timeframe	Frequency (During an E-Grade Assessment)†
Lakes	Aquatic Vegetation Quality	Aquatic Vegetation Survey	July - Sept	One/Lake
Lakes	Eutrophication Indicators	Field Collection - Water Samples	June - Sept	Once/Month
Lakes, Streams	Fish Community Quality	Fish Survey (Deep Lakes and Minnehaha Creek only)	July - Aug	One/Lake
Streams	Nutrient Concentrations in Streams	Field Collection - Flow & Water Samples	April - Sept	Twice/Month
Streams	Macroinvertebrate Community Quality	Macroinvertebrate Survey	Aug - Sept	One/Stream Station
	Stream Habitat Complexity	MN Stream Habitat Assessment		One/Stream Station
Wetlands	Aquatic Vegetation Quality and Connectivity	Rapid Floristic Quality Assessment and Select McRAM Questions - in the Field	Aug - Early Oct	Once/Wetland
	Wetland Soil Chemistry	Field Collection - Soil samples		Once/Wetland
Lakes, Streams, and Wetlands	Connectivity, Shoreline Quality, Wetland Density and Size	Field Verification of GIS Analysis	July - Sept (Field Verf.)	If needed, One/Station
Lakes, Streams, Wetlands and Uplands	Shoreline Quality, Connectivity, Hydrology, Wetland Density and Size, and Groundwater Supply	Review of GIS data and/or Aerial Photos	Oct - March	One/Station
	Hydrology, Groundwater Supply, Watershed Storage	Review Existing Data, Modeling and Analysis		

*Will be incorporating existing data sets from cities/other agencies, †E-Grade Assessment is 3 years.

Other Parameters Monitored by MCWD

AIS Early Detection Surveys

The District conducts early detection monitoring for new infestations of aquatic invasive species. Monitoring typically involves a weekly check of a zebra/quagga mussel sampler plate attached to public access docks, weekly checks of substrate around the boat access for zebra mussels, and rake tosses at the public access to look for new invasive plants. Snorkel searches are also performed on high use lakes as time allows during the season, and typically in partnership with other agencies. The District also coordinates with other local agencies that perform early detection monitoring at District lakes, sharing information and coordinating our search efforts. Data collected through the AIS volunteer monitoring program are also included in the early detection results.

Lake Elevation Monitoring

Lake elevation is monitored on Lake Minnetonka in Grays Bay, just west of the Grays Bay Dam. The Grays Bay Dam is operated by MCWD staff in accordance with the Headwaters Control Structure Management Policy and Operating Procedures and Minnesota Department of Natural Resources (DNR) Permit #76-6240. The operating plan was developed by MCWD and approved by local municipalities and the DNR.

The operating range for the control of discharges at the Grays Bay Dam is when the lake level is between 928.6 and 930.0. Elevation 928.6 marks the legal natural runout elevation for Lake Minnetonka, and elevation 930.0 is the crest of the 202-foot long fixed-elevation emergency spillway located north of the dam structure itself. The Dam discharge is reported on the MCWD website at minnehahacreek.org/data-center/faq-water-levels-lake-minnetonka-and-minnehaha-creek.

Prior to 2017, Monitoring Program staff monitored 19 lakes throughout the District. As of 2017, 17 of the 19 lakes gages are being read by volunteers. Program staff monitor Parley Lake and Lydiard Lake. The lake elevation data are sent to the MnDNR. Ordinary High Water Level (OHW) and lake elevation data are available on the MnDNR website at dnr.state.mn.us/lakefind/index.html.

Continuous Elevation Monitoring

Continuous water level monitoring is conducted at 15-minute intervals by pressure transducers (i.e., TROLLS) on stream and lake stations throughout the watershed (Table 2.9). One station on Six Mile Creek (Mud Lake Outlet) monitors water elevation using a SonTek IQ (velocity beams profiler) to measure flow and volume.

Table 2. 9. Continuous water elevation monitoring stations.

Subwatershed	Station	Station #	Lake/Stream
Gleason Lake	Gleason Lake	LGL01	Lake
Lake Minnetonka	Grays Bay Dam	CMH07Lk	Lake
	Halsted Bay (Boat Landing)	RLHL01	Lake
Long Lake Creek	Long Lake Outlet	CLO01	Stream
	Holy Name Trib Outlet	CLO08	Stream
	Wolsfeld Lake Outlet	CLO09	Stream
	School Lake Outlet	CLO12	Stream
Minnehaha Creek	McGinty/I-494	CMH01	Stream
	Mill Pond	CMH03Up	Stream
	Hiawatha Ave (USGS)	CMH06	Stream
Painter Creek	West Branch Rd	CPA01	Stream
Six Mile Creek	Lundsten Lake outlet	CSI01	Stream
	Kings Point Rd	CSI17	Stream
	Mud Lake outlet	CSI02	Stream

Parameters Monitored by Other Agencies

Lake Stations Monitored by Other Agencies

There are additional lakes within MCWD that are monitored by the Minneapolis Park and Recreation Board (MPRB), Three Rivers Park District (TRPD), and the Metropolitan Council Environmental Services' Citizen-Assisted Monitoring Program (CAMP) as shown in Table 2.10.

Table 2. 10. Lakes monitored by other agencies.

Subwatershed	Lake	Agency
Lake Minnetonka	Lake Minnetonka: Libbs Lake*	City of Minnetonka
	Shaver Lake*	
Lake Virginia	St. Joe Lake	CAMP
	Lake Minnewashta: South Bay	
Minnehaha Creek	Brownie Lake	MPRB
	Cedar Lake	
	Diamond Lake**	
	Grass Lake**	
	Lake Calhoun/Bde Maka Ska	
	Lake Harriet	
	Lake Hiawatha	
	Lake of the Isles	
	Lake Nokomis	
	Powderhorn Lake*	
	Cobblecrest Lake*	CAMP
	Twin Lakes*	
	South Oak Lakes*	
	Windsor Lake**	City of Minnetonka
Six Mile Creek	Steiger Lake	TRPD
	Stone Lake	
	West Auburn Lake	
	Zumbra-Sunny Lake	

*Shallow lake, **Wetland

Stream Stations Monitored by Other Agencies

In 2005, MCWD partnered with the USGS to install and manage a gaging station at the Minnehaha Creek: Hiawatha Ave stream station (CMH06). In response to the Minnehaha Creek's chloride impairment, a conductivity and temperature probe was installed in 2010 to collect continuous data in 15-minute real-time intervals year-round. In 2012, an ISCO automated sampler was installed to collect storm events that will be used for defining loads, tracking trends, and modeling for TMDLs for Minnehaha Creek and the Mississippi River.

In 2015, MCWD again partnered with the USGS to install and manage a second gaging station at Lake Minnetonka: Grays Bay Dam. Water elevations at both locations are posted on the MCWD website. In 2017, the District discontinued monitoring the Gleason Lake inlet stream station. The City of Plymouth plans to monitor that station from 2017-2019. The Metropolitan Council managed a watershed outlet monitoring program (WOMP) station at 34th Avenue S on Minnehaha Creek from 1999-2013. Also, MPRB periodically monitors a station at Xerxes Ave on Minnehaha Creek.

Lake *E. Coli* Monitoring

MCWD does not monitor for *E. coli* in lakes. Hennepin County, MPRB, and some cities monitor the beaches for *E. coli* and are responsible for closing a beach if *E. coli* levels are elevated.

Lake Elevation Monitoring

Resident volunteers monitor lake elevations on 17 lakes throughout the District. MPRB also has been monitoring water levels on the Chain of Lakes. The lake elevation data are sent to the MnDNR. Ordinary High Water Level (OHW) and lake elevation data are available on the MnDNR website at dnr.state.mn.us/lakefind/index.html.

AIS Early Detection Surveys

Carver County, Minneapolis Parks and Recreation Board, and Three Rivers Park District also conduct AIS early detection surveys on lakes within the watershed. Surveys involve zebra/quagga mussel sampling plates and boat launch checks.

Precipitation Monitoring

The last year for the Monitoring Program to operate the precipitation gaging stations throughout the District was in 2016. The District uses precipitation data from two established stations, one located at the Minneapolis-St. Paul Airport and a NOAA-NWS station located in Chanhassen, MN. The data can be accessed at dnr.state.mn.us/climate/twin_cities/index.html.

Groundwater Monitoring

The Prairie du Chien-Jordan formations serve as major sources of municipal water in the western suburbs and as a major industrial water source in Minneapolis. The MnDNR has monitored groundwater elevations at seven deep wells within the watershed (Table 2.11). The Golden Valley well was discontinued in May 2009. The data from wells can be accessed at dnr.state.mn.us/waters/cgm/index.html.

MPRB collects pieziometric well data. TRPD is working with the MnDNR to install groundwater monitoring wells at Carver Park Reserve.

Table 2. 11. Lakes monitored by other agencies.

MnDNR Well Number	Subwatershed	Location	Ground Elevation (AMSL)
27043	Lake Minnetonka	Mound	957 ft
27010	Lake Minnetonka	Orono	931 ft
27046	Lake Minnetonka	Minnetonka	938 ft
27012	Minnehaha Creek	Golden Valley	890 ft
27041	Minnehaha Creek	St. Louis Park	917 ft
27036	Minnehaha Creek	Minneapolis	830 ft
27044	Six Mile Marsh	St. Bonifacius	950 ft

2.1.3 WATERSHED-WIDE STUDIES:

The District has completed a number of watershed wide studies that inform the overall hydrology, water quality and ecological integrity of the District's natural resources. These studies are outlined throughout Volume 2 with a complete list included in Section 2.4. The studies will be made available and searchable on the District's website. Some of the key watershed wide studies include:

- Hydrologic, Hydraulic and Pollutant Loading Study (HHPLS)
- Functional Assessment of Wetlands
- Stream Assessments

Hydrologic, Hydraulic and Pollutant Loading Study (HHPLS):

In 2003, the District completed a two year effort to compile existing and new information on the water resources in the District, to identify existing water management issues, define the impact of future land use change on the system, and identify management strategies for the District and its partners. At the time, this effort represented one of the most ambitious watershed studies undertaken by a watershed District in Minnesota. The HHPLS study was initiated to:

- Document the nature of the physical, chemical, and biological characteristics of the watershed
- Quantify the amount of water moving through the watershed
- Gather public input to assist in problem identification and solution mapping
- Tailor implementation efforts on a subwatershed basis

Functional Assessment of Wetlands:

In 2003 the District completed a *Functional Assessment of Wetlands* (FAW), covering all wetlands in the District larger than one-quarter acre in size. This assessment used a variant of the Minnesota Routine Assessment Method, and was developed in partnership with the Hennepin Conservation District to assess the overall function and value of individual wetland systems.

The analysis has been consistently used by the District and its partners to guide land use decisions and natural resource management decisions by providing consistent, comprehensive wetland data.

Stream Assessments:

In 2003 the MCWD assessed the physical and biological condition of Minnehaha Creek, Long Lake Creek, Gleason Creek, Classen Creek, Painter Creek and Six Mile Creek. The assessments characterized the general condition of the streams and provided baseline information that assists the District and its partners in developing management strategies to improve and protect streams as a vital part of the watershed system.

In 2012 the District updated and expanded its stream assessment to include first and second order tributaries to mainstem streams. This assessment, coupled with the HHPLS, the FAW, and broad system monitoring, provides the MCWD with a thorough understanding of its lakes, streams, and wetland systems.

2.1.4 SUBWATERSHED STUDIES:

The District has also collected information and data at subwatershed scales which provide resource specific information regarding issues, the stressors driving those issues, and informs management strategies for the District and its partners. A complete list of subwatershed studies is included in Section 2.4 and will be made available and searchable on the District's website. Some of the notable studies conducted at a subwatershed scale include:

- Minnehaha Creek Visioning, 2005
- Baseflow Restoration in Minnehaha Creek Watershed with Stormwater Infiltration, 2014
- Six Mile Creek Diagnostic Study, 2013
- Painter Creek Feasibility Study, 2004
- Gleason Lake Management Plan, 2007

2.1.5 WATERBODY SPECIFIC STUDIES OR TMDLS:

The District has also collected information on specific waterbodies which provide resource specific information regarding issues and the stressors driving them, and informs management strategies for the District and its partners. Total Maximum Daily Load Studies (TMDLs) have also been conducted on specific impaired waters. Waterbody specific studies are summarized by subwatershed in Section 2.4 and will be made available and searchable on the District's website. Some of the studies conducted on specific waterbodies include:

- Preserving the Quality of Lake Minnetonka, 1971
- Blue Water Commission Report on Lake Nokomis and Lake Hiawatha, 1998
- MCWD Lakes TMDL – Lakes Nokomis, Parley, Virginia, and Wassermann, 2011
- Minnehaha Creek *E. Coli* Bacteria / Lake Hiawatha Nutrients TMDL, 2013
- Upper Minnehaha Creek Watershed Nutrient and Bacteria TMDL Study, 2014
- Effects of Curlyleaf Pondweed Control on Gleason Lake, 2015
- Twin Cities Metropolitan Area Chloride TMDL Study, 2016

2.2 Watershed Overview

The MCWD was established in 1967 and is responsible for managing and protecting the water resources of the Minnehaha Creek watershed drainage basin. The drainage basin extends for 178 square miles draining into the Minnehaha Creek and ultimately into the Mississippi River. The watershed district encompasses 11 subwatersheds which drain 12 creeks, 129 lakes, and thousands of wetlands throughout two counties, 27 cities, and two townships.

The watershed of Minnehaha Creek includes approximately 148 square miles in Hennepin County and 30 square miles in Carver County. The upper watershed includes Lake Minnetonka (est. 14,101 acres) and the land that drains into Lake Minnetonka. The lower watershed includes Minnehaha Creek (22 miles) and the land that drains into Minnehaha Creek east of Lake Minnetonka. The Lake Minnetonka outlet is located at Gray's Bay Dam, the headwaters of Minnehaha Creek. Each watershed feature provides unique recreational opportunities and aesthetic resources.

2.2.1 CITIES:

The Minnehaha Creek Watershed District encompasses all or parts of 27 cities, two townships, a portion of the unorganized area of Ft. Snelling, and a very small area within an unorganized area of Shorewood (Figure 2.2). Table 2.12 shows the cities and their area within the District's legal boundary.

Table 2. 12. Cities and townships in the Minnehaha Creek watershed.

City or Township	Area (sq mi)	% of MCWD	City or Township	Area (sq mi)	% of MCWD
Chanhassen	5.2	2.9%	Mound	3.6	2.0%
Deephaven	1.7	1.0%	Orono	25.1	14.2%
Edina	4.4	2.5%	Plymouth	5.8	3.3%
Excelsior	0.7	0.4%	Richfield	2.3	1.3%
Golden Valley	0.1	0.1%	Shorewood	12.1	6.8%
Greenwood	0.4	0.2%	Spring Park	0.4	0.2%
Hopkins	2.2	1.2%	St. Bonifacius	1.1	0.6%
Independence	4.8	2.7%	St. Louis Park	9.6	5.4%
Laketown Township	15.9	9.0%	Tonka Bay	1	0.5%
Long Lake	0.9	0.5%	Unorganized Territory of Fort Snelling Area	1.2	0.7%
Maple Plain	0.3	0.2%	Unorganized Territory of Shorewood	0	0.0%
Medina	10.2	5.7%	Victoria	8.5	4.8%
Minneapolis	20.8	11.7%	Watertown Township	0.2	0.1%
Minnetonka	13.8	7.7%	Wayzata	3.1	1.8%
Minnetonka Beach	0.5	0.3%	Woodland	0.6	0.3%
Minnetrista	21.1	11.9%	**TOTAL**	**177.5**	

2.2.2 CLIMATE:

Climate in the District is mid-continental. Both temperature and precipitation can vary widely and change abruptly. Table 2.13 shows the watershed's temperature averages for the last 30 years, at the National Weather Service's Chanhassen office.

Table 2. 13. Temperature averages in °F for the Minnehaha Creek watershed.

Twin Cities (1981-2010)													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Maximum	23.7	28.9	41.3	57.8	69.4	78.8	83.4	80.5	71.7	58.0	41.2	27.1	55.3
Minimum	7.5	12.8	24.3	37.2	48.9	58.8	64.1	61.8	52.4	39.7	26.2	12.3	37.3
Mean	15.6	20.8	32.8	47.5	59.1	68.8	73.8	71.2	62.0	48.9	33.7	19.7	46.3

Source: Minnesota State Climatology Office and National Climatic Data Center.

In a normal year, approximately 30 inches of precipitation falls on the watershed. Table 2.14 shows the watershed's precipitation averages. Winter snowfall averages about 55 inches, and generally stays on the ground from mid-December to early March. Snow and rainfall data for the watershed is obtained at the National Weather Service's Chanhassen office.

Table 2. 14. Precipitation averages in inches for the Minnehaha Creek watershed.

Twin Cities (1981-2010)													
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Precipitation	0.90	0.76	1.89	2.65	3.36	4.25	4.04	4.29	3.07	2.43	1.76	1.15	30.57
Snow	11.7	8.5	10.8	2.8	0	0	0	0	0	0.6	8.9	12.2	55.5

Source: National Oceanic and Atmospheric Administration (NOAA) National Weather Service.

2.2.3 TOPOGRAPHY, SOILS, AND DRAINAGE:

Topography and Soils:

The topography of the watershed was formed by glacial action and is characterized by five distinct geomorphic units, each with its characteristic patterns of glacial drift. Following the glacial ice's retreat, physical, chemical and biological processes turned the upper 2 to 4 feet of drift material into the soil layer that today covers the watershed. Because traits of the soil directly influence runoff, they affect total water volumes generated in the watershed. To estimate and help manage this runoff, the Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service) has indexed over 4,000 soil systems into four major hydrologic soil groups. This classification relies on two major processes: infiltration rate and transmission rate. Table 2.15 lists the four major hydrologic soil groups defined by the NRCS and Figure 2.3 illustrates their distribution across the watershed. These landforms and the geology underlying them are well described in the *2007 MCWD Comprehensive Water Resources Management Plan*.

Table 2. 15. Soil characteristics and infiltration rates by Hydrologic Soils Group (HSG).

HSG	Infiltration Rate/Hour	Texture	Unified Soil Classification System
A	1.63"	Gravel, sandy gravel and silt gravels	GW – well graded gravels, sandy gravels GPO – Gap-graded or uniform gravels, sandy gravels GM – Silty gravels, silty sandy gravels SW – Well-graded, gravelly sands
	0.8	Sand, loamy sand or sandy loam	SP – Gap-graded or uniform sands, gravelly sands
B	0.45	Silt loam	SM – Silty sands, silty gravelly sands
	0.3	Loam	MH – Micaceous silts, diatomaceous silts, volcanic ash
C	0.2	Sandy clay loam	ML – Silts, very fine sand, silty or clayey fine sands
D	0.06	Clay loam, silty clay loam, sandy clay, silty clay or clay	GC – Clayey gravels, clayey sandy gravels SC – Clayey sands, clayey gravelly sands CL – Low plasticity clays, sandy or silty clays OL – Organic silts and clays of low plasticity CH – Highly plastic clays and sandy clays OH – Organic silts and clays of high plasticity

Source: Minnesota Stormwater Manual.

Drainage:

The watershed is divided into eleven principal subwatersheds (Figure 2.4). The upper watershed (upstream of Gray's Bay dam) is divided into ten principal subwatersheds. Nine of the upper principal subwatersheds drain directly into Lake Minnetonka via streams, channels, and storm sewer. Lake Minnetonka and some small drainage areas comprise the tenth of the upper principal subwatersheds. The upper watershed discharges through a control structure, the Gray's Bay dam, into Minnehaha Creek. The dam is managed to discharge water from Lake Minnetonka into Minnehaha Creek when the DNR-established runout elevation of the lake is exceeded.

The lower watershed (downstream of Gray's Bay) drains to Minnehaha Creek and is comprised of one principal subwatershed. Some land area within the lower subwatershed does not drain directly or indirectly to Minnehaha Creek, but drains directly or indirectly to the Mississippi River. The central portion of the subwatershed drains to the Minneapolis Chain of Lakes, which in turn discharges to Minnehaha Creek.

2.2.4 WATER RESOURCES:

Lakes and Streams:

The lake inventory for the District includes 65 basins over 10 acres in size. Numerous streams drain the watershed. Minnehaha Creek, for which the watershed is named, is formed at the outlet of Gray's Bay of Lake Minnetonka and flows 22 miles east to the Mississippi River. In the upper watershed, the primary streams include Long Lake Creek, Gleason Creek, Classen Creek, Painter Creek, and Six Mile Creek, although there are many other small streams and channels, named and unnamed. Data on these lakes and streams, including physical descriptions, current water quality and water quality trends, are provided in detail by subwatershed in Section 2.3.

Minnesota Statutes §103F.48, the Buffer Law, allows Soil and Water Conservation Districts (SWCDs) to provide a summary of watercourses and associated recommendations that must be incorporated into the watershed management organization's plan. Both Carver County SWCD and Hennepin County acknowledged that adequate protection of watercourses is being provided through the District's regulations and other implementation efforts and did not provide any additional recommendations. For the summary of watercourses, Carver County SWCD referenced Figure 23 from the District's 2007 Comprehensive Water Resources Management Plan. Hennepin County did not provide any additional watercourses beyond what is included in the DNR Buffer Protection Map.

Public Drainage Systems:

Throughout many parts of Minnesota, including lands now within the Twin Cities metropolitan area, surface drainage systems were established in the early 1900's to promote agricultural activities on lands that were marginally productive because of wet conditions or to enable other uses. These ditch and tile systems were constructed pursuant to a set of laws referred to as the Minnesota drainage code that date to the late 1800's and continue in force today at Minnesota Statutes chapter 103E. Section 103E.005, subdivision 12, defines "drainage system" as:

> A system of ditch or tile, or both, to drain property, including laterals, improvements, and improvements of outlets, established and constructed by a drainage authority. "Drainage system" includes the improvement of a natural waterway used in the construction of a drainage system and any part of a flood control plan proposed by the United States or its agencies in the drainage system.

The type of drainage system referenced by this definition and governed by Chapter 103E is a "public" system that typically provides a conveyance and outlet for surface drainage from multiple tracts of land. Public systems are differentiated from private drainage that a property owner may install to a natural outlet or connect to a public drainage system.

The eight public ditches for which the District is responsible are:

1. Judicial Ditch 2 – Six Mile Creek (mainly open channel)
2. County Ditch 10 – Painter Creek (mainly open channel)
3. County Ditch 14 – from St. Louis Park into Lake Calhoun (storm sewer)
4. County Ditch 15 – into Gleason Lake (open channel/sewer)
5. County Ditch 17 – from Edina to Lake Calhoun (storm sewer)
6. County Ditch 27 – part of Long Lake Creek (mainly open channel)
7. County Ditch 29 – from St. Louis Park into Lake Calhoun (storm sewer)
8. County Ditch 32 – out of Gleason Lake in Wayzata (open channel/sewer)

Figure 2.5 shows the general locations of County/Judicial Ditches within the District.
Under the drainage code, public drainage systems principally are managed by counties; however, by resolution of a county board, this responsibility may be transferred to a watershed district. In 1971, the District petitioned Hennepin County to transfer this responsibility for those county systems within the watershed. The authority for the seven Hennepin County systems was transferred by Hennepin County Board resolution on March 28, 1972. The authority for Judicial Ditch 2 (Six-Mile Creek) was transferred to the District by court order on March 27, 1972 (a judicial ditch is located in more than one county and therefore, under the earlier drainage code, was managed through the district court).

In areas served by public drainage systems that have since become urbanized, drainage for agricultural productivity has greatly declined and many systems either convey urban stormwater or have been replaced with, or rendered superfluous by, municipal storm sewers. Often the storm sewers were constructed in different locations and alignment than that of the drainage system they replaced and the old channels were filled in. County Ditches 14, 17 and 29 lie entirely within the Cities of St. Louis Park, Edina and Minneapolis, and are of this nature.

County Ditches 15 and 32 lie entirely within the City of Plymouth. The first is a series of ponds connected by pipe, and the second lies within Gleason Creek. These two systems, a combination of open channel and subsurface pipe, no longer serve agricultural drainage purposes but provide drainage for residential development and associated roads.

Judicial Ditch 2, County Ditch 10 and County Ditch 27 are located in the less-developed western portion of the District and consist entirely or almost entirely of altered natural channels. These systems continue to provide drainage for agricultural purposes as well as the development that has occurred in those areas.

Wetlands:

Wetlands are defined for regulatory purposes by the United States Army Corps of Engineers Wetland Delineation Manual (January 1987). In the 1980s, the US Fish and Wildlife Service (FWS) compiled wetland maps from aerial photo interpretation as part of the National Wetland Inventory (NWI). Wetland scientists use two common classification schemes to identify wetland type – the FWS's "Circular 39" system, and a replacement system developed by Cowardin et al., commonly referred to as the Cowardin system. The Circular 39 system was originally developed to classify wetlands for waterfowl habitat purposes. Eight of the Circular 39 freshwater wetland types are found in Minnesota. The Cowardin scheme is a hierarchical classification based on landscape position, substrate, flooding regime, and vegetation. While the Cowardin scheme has been officially adopted by the FWS and other agencies, the Circular 39 system is still commonly used because of its simplicity and ease of use. In 2013, the DNR completed an update to the NWI across the state using remote sensing imagery; the East-Central region of Minnesota, including Hennepin and Carver Counties, was reevaluated using 2010 and 2011 imagery.

In 2001-2003 the District undertook a *Functional Assessment of Wetlands* (FAW) on all wetlands greater than one-quarter acre in size. This assessment used a variant of the Minnesota Routine Assessment Method (MnRAM). Using the results of this analysis, individual wetlands were assigned to one of four management classes – Preserve, and Manage 1, 2, or 3. Wetlands that were evaluated as Exceptional or High on certain ecological or hydrologic values were assigned to the Preserve class. The balance of evaluated wetlands were assigned to a category based on this assessment of current functions and values, with Manage 1 wetlands exhibiting higher values and Manage 2 and 3 moderate or lower values. These management classifications are used in the regulation of wetland impacts within the District, with the level of protection dependent on the class of wetland. Refer to the *Functional Assessment of Wetlands* (2003) for details of methodology, classification, and management recommendations. Wetlands by Circular 39 type are shown in detail by subwatershed in Section 2.3.

Public Waters:

The Department of Natural Resources' Public Waters Inventory identifies numerous basins within the Minnehaha Creek watershed under the jurisdiction of the DNR. By statute, public waters wetlands include all type 3, 4, and 5 wetlands that are 10 acres or more in size in unincorporated areas or 2.5 acres or more in size in incorporated areas. Public waters watercourses include natural and altered watercourses with a total drainage area greater than two square miles, Minnesota Statutes §103G.005 defines several other categories of basins and watercourses as public waters. For more information regarding the Public Waters Inventory in the watershed, please refer to *the 2007 MCWD Comprehensive Water Resources Management Plan* or the DNR website at dnr.state.mn.us/waters/watermgmt_section/pwi/maps.html.

Floodplain:

Land use regulations define the floodplain as the area that has a one percent chance of a flood occurring in a given year, also known as the 100-year flood. The floodplain is divided into two zoning districts: the floodway and flood fringe. The floodway or other watercourse includes the river channel and nearby land areas which must remain open to discharge the 100-year flood. The flood fringe, while in the floodplain, lies outside the floodway. Regulations usually allow development in the flood fringe but require flood-proofing or raising to the legal flood protection elevation.

In 1968, Congress created the National Flood Insurance Program (NFIP) to make flood insurance available to property owners at federally subsidized rates. The NFIP required communities to adopt local laws to protect lives and future development from flooding. The Federal Emergency Management Agency (FEMA) first must formally notify a community that it has special flood hazard areas (SFHA) before it can join the NFIP. FEMA notifies communities by issuing a Flood Hazard Boundary Map (FHBM). This map shows the approximate boundaries of the community's 100-year flood plain. Each participating community has a special conversion study or a Flood Insurance Study (FIS). The FIS includes a flood plain map depicting the community's flood hazard areas. Flood mapping was updated in 2016 for all communities in Hennepin County.

Floodplain maps are available at each City Hall or online at msc.fema.gov/portal. Information on the state floodplain management program can be found on the DNR website at dnr.state.mn.us/waters/watermgmt_section/floodplain/index.html.

In 2003, the District completed a *Hydrologic and Hydraulic and Pollutant Loading Study (HHPLS)* to develop an updated hydrologic and hydraulic model for the watershed and update flood elevations in Minnehaha Creek and five upper watershed streams. Watershed hydrology and hydraulics were modeled using the XP-SWMM model platform. This XP-SWMM model was submitted to FEMA to produce updated Flood Insurance Study (FIS) Flood Maps for Minnehaha Creek, and in 2013 FEMA modified the XP-SWMM model and subsequently used this modified version to produce flood maps. The District currently uses this modified XP-SWMM model to establish regulatory elevations for permitting development and redevelopment. Cities within the watershed are responsible for using the FIS maps to inform property owners about floodplain elevations for purposes of the National Flood Insurance Program and to regulate floodplain elevations within their zoning codes.

2.2.5 POTENTIAL ENVIRONMENTAL HAZARDS:

Groundwater connections, hazardous waste, leaking above- and below-ground storage tanks, and feedlots can be potential sources of surface and groundwater contamination. The MPCA maintains a current on-line mapping tool with information about air quality, hazardous waste, remediation, solid waste, tanks and leaks, and water quality. This tool is available at www.pca.state.mn.us/udgx680.

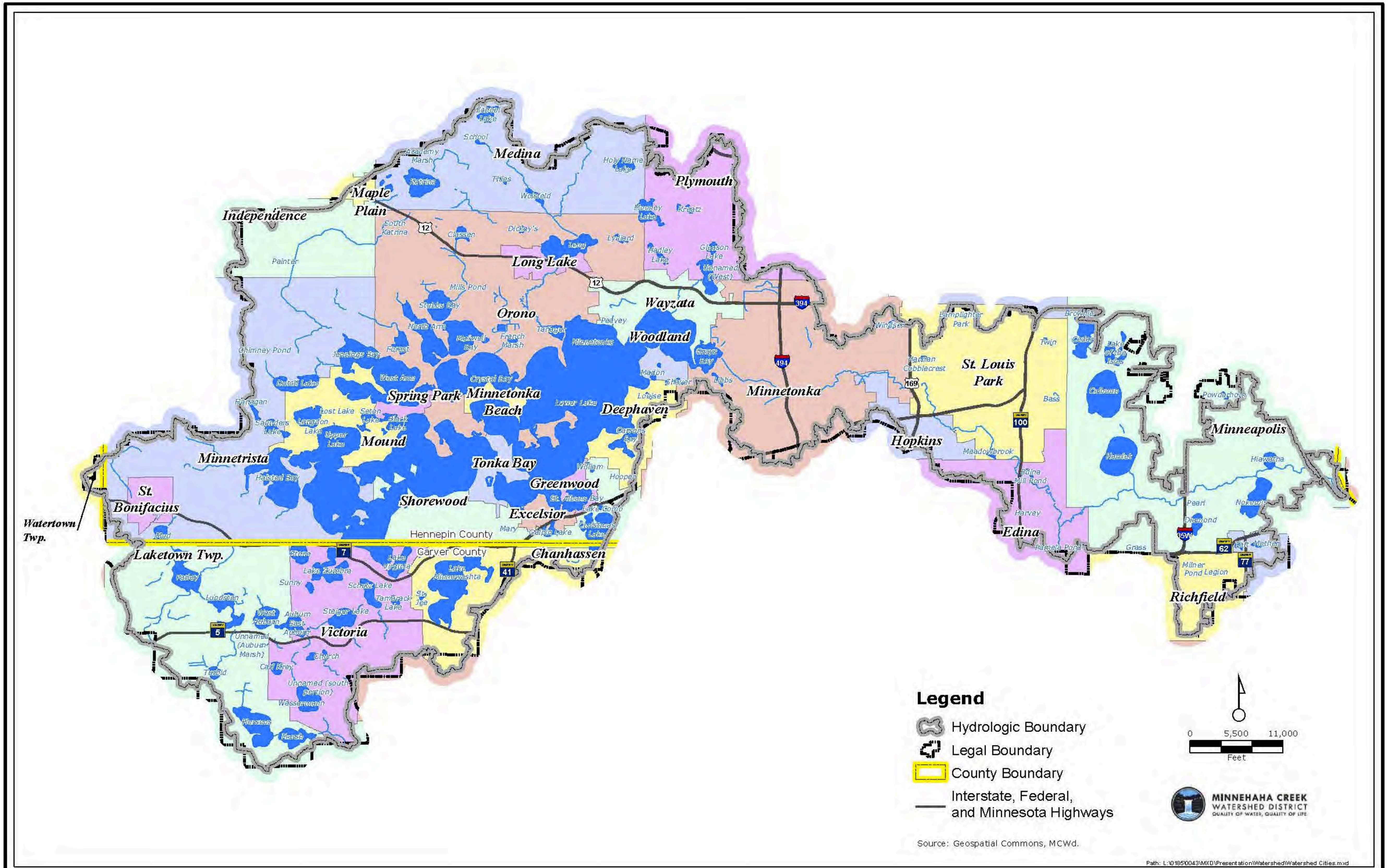

Figure 2. 2. The Minnehaha Creek Watershed District.

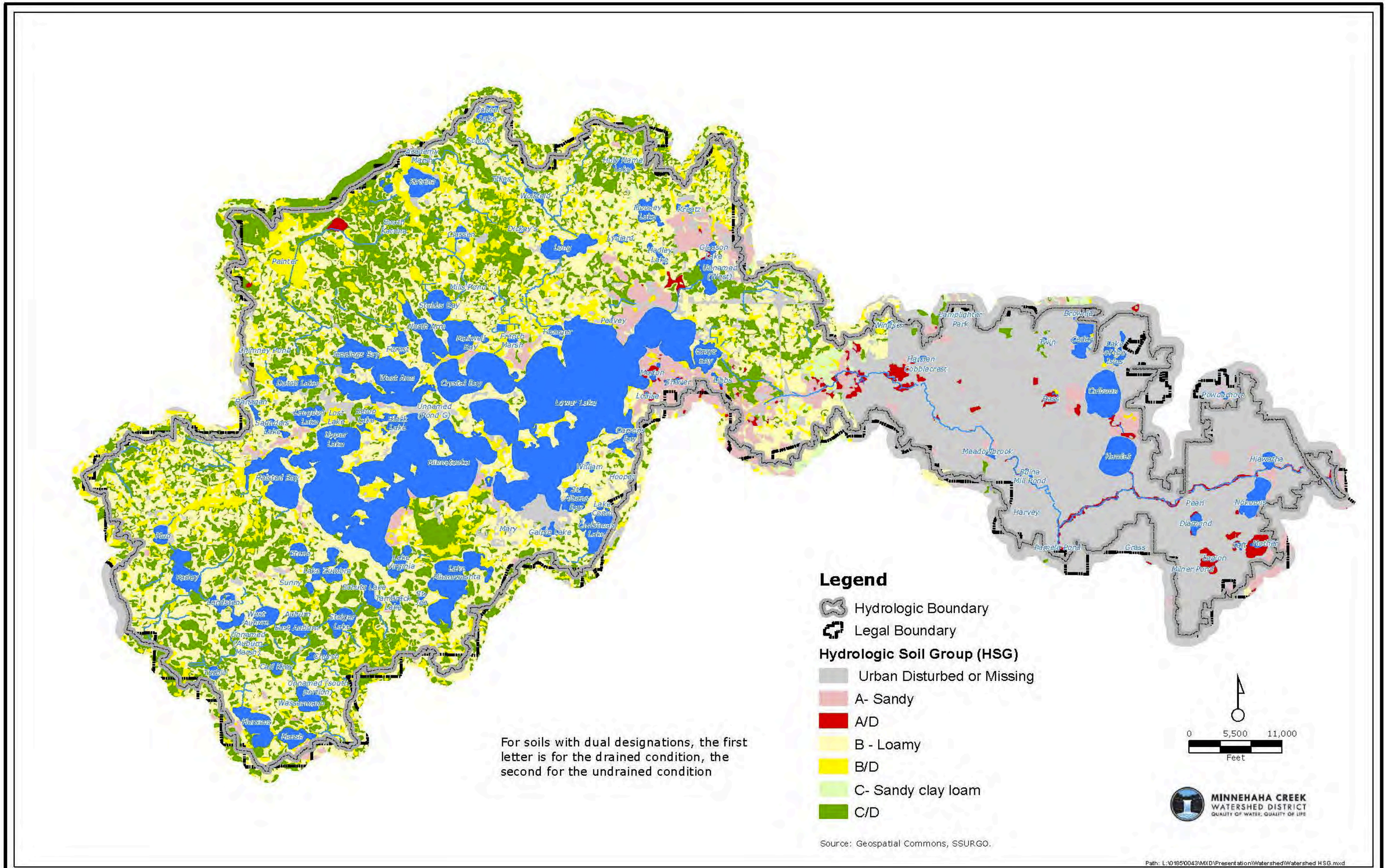

Figure 2. 3. Hydrologic Soil Groups in the Minnehaha Creek watershed.

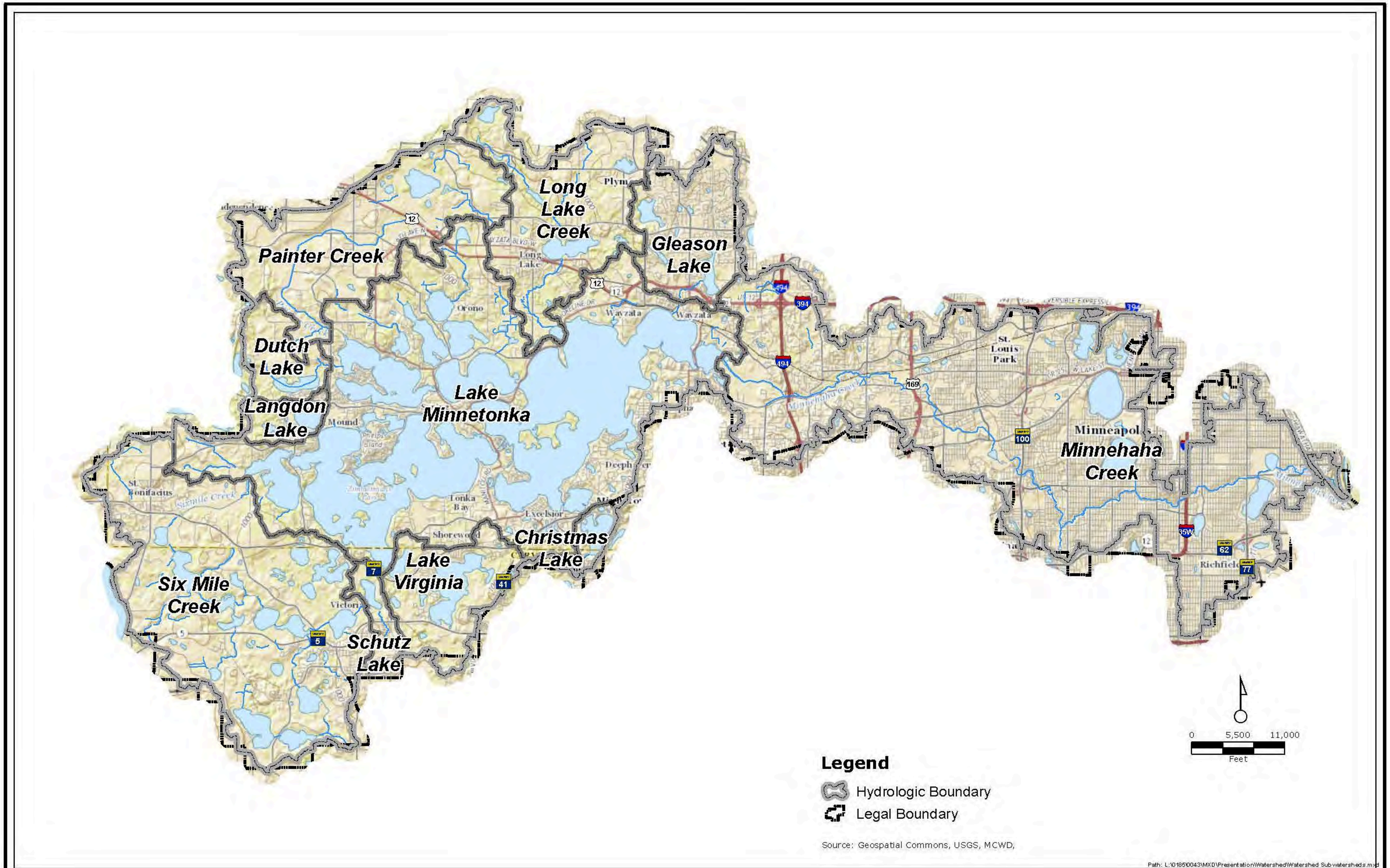

Figure 2. 4. Topography and subwatersheds within the Minnehaha Creek watershed.

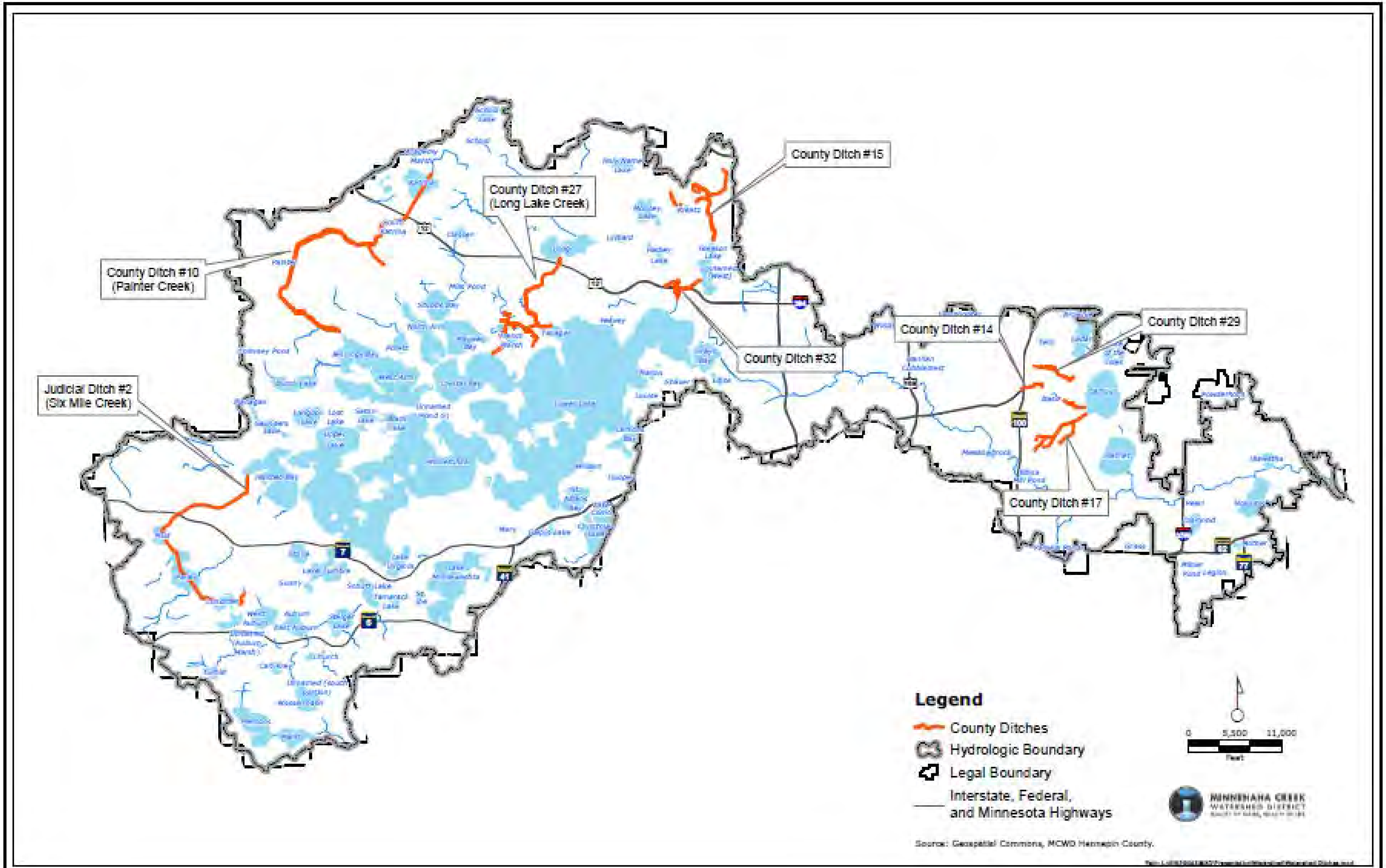

Figure 2. 5. County ditches in the Minnehaha Creek watershed.

2.3 Subwatershed Inventory

2.3.1 CHRISTMAS LAKE SUBWATERSHED

The Christmas Lake Subwatershed is the smallest in the watershed district. The subwatershed is dominated by a mix of residential/business and woodland/wetland land cover. The nutrient contribution to Lake Minnetonka is minimal due to the fact that Christmas Lake does not often flow into St. Albans Bay. There are four cities that lie within the Christmas Lake Subwatershed boundary. The area of the Christmas Lake subwatershed in acres by individual city, in total, and as a percentage of the total subwatershed is presented in Table 2.16 (Figure 2.6).

Table 2. 16. Cities in the Christmas Lake subwatershed.

City	Area (Acres)	% of Subwatershed
Chanhassen	253.0	34%
Excelsior	2.6	0.4%
Greenwood	0.2	<0.1%
Shorewood	486.5	65.5%
Total	742.5	100%

Source: MCWD.

Subwatershed Description and Hydrology:

The Christmas Lake subwatershed's topography is erratic surface relief and numerous depressed areas that form wetlands, small ponds and lakes. The eastern edge of the subwatershed is a highly sloped linear glacial formation that forms the bluffs on the east shore of Christmas Lake.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.7). Much of the subwatershed is developed to typical suburban densities with a low to medium degree of imperviousness. There are several small wetlands in the southern subwatershed, generally surrounded by small areas of woodland or grassland.

Soils within the watershed are predominantly classified as Natural Resources Conservation Service Hydrologic Soil Group B (loamy soils with moderate infiltration potential), with group D (clay soils with very low infiltration potential) soils found in low-lying areas and generally hydric, or showing indications of inundation.

Christmas Lake dominates the subwatershed. A small stream drains the upper part of the subwatershed and outlets into southwest Christmas Lake. The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS*) subdivided the Christmas Lake subwatershed into five subwatershed units, designated CL-1 through CL-5 (Figure 2.8).

Figure 2. 6. The Christmas Lake subwatershed.

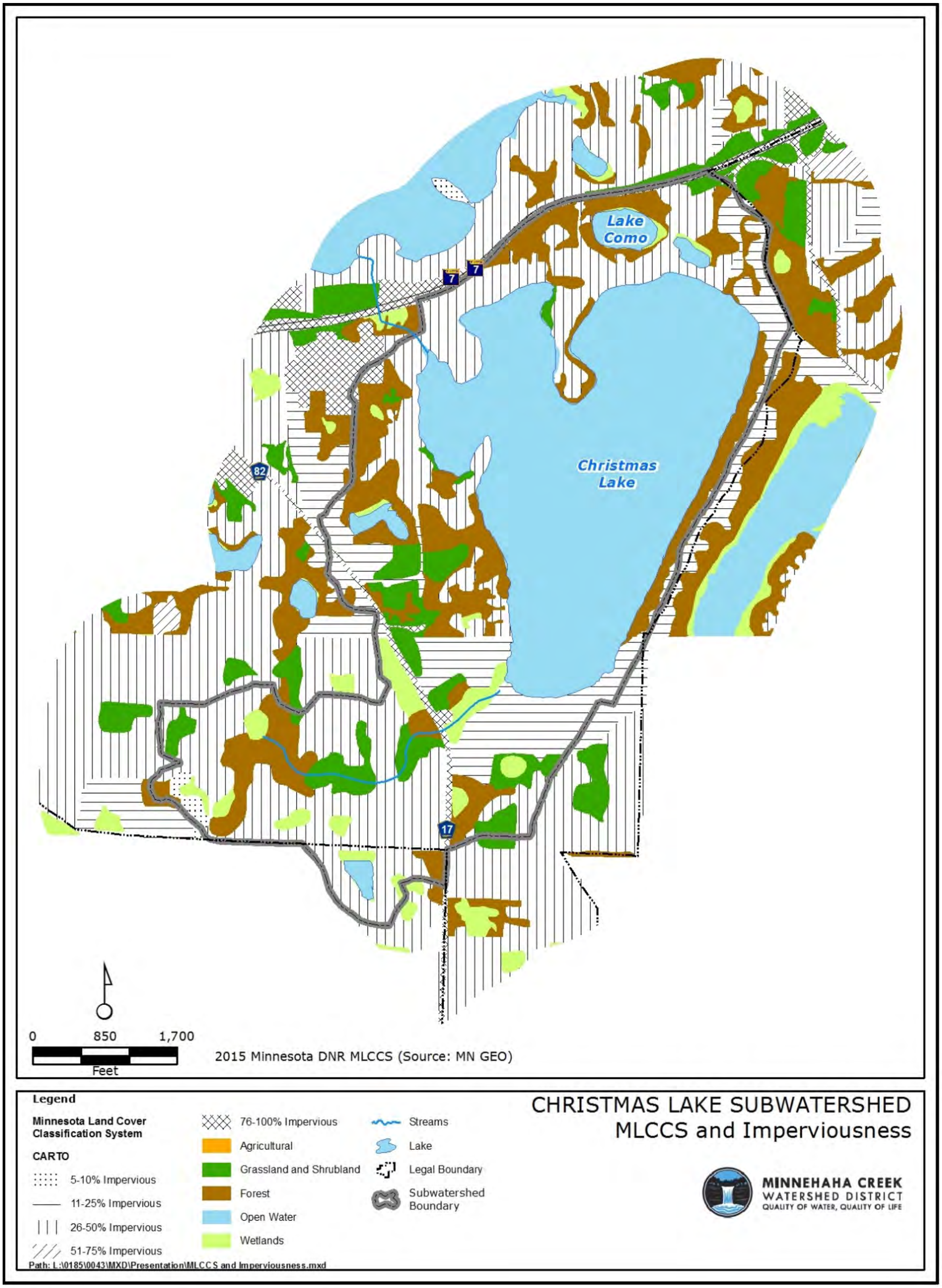

Figure 2. 7. Christmas Lake subwatershed MLCCS and imperviousness.

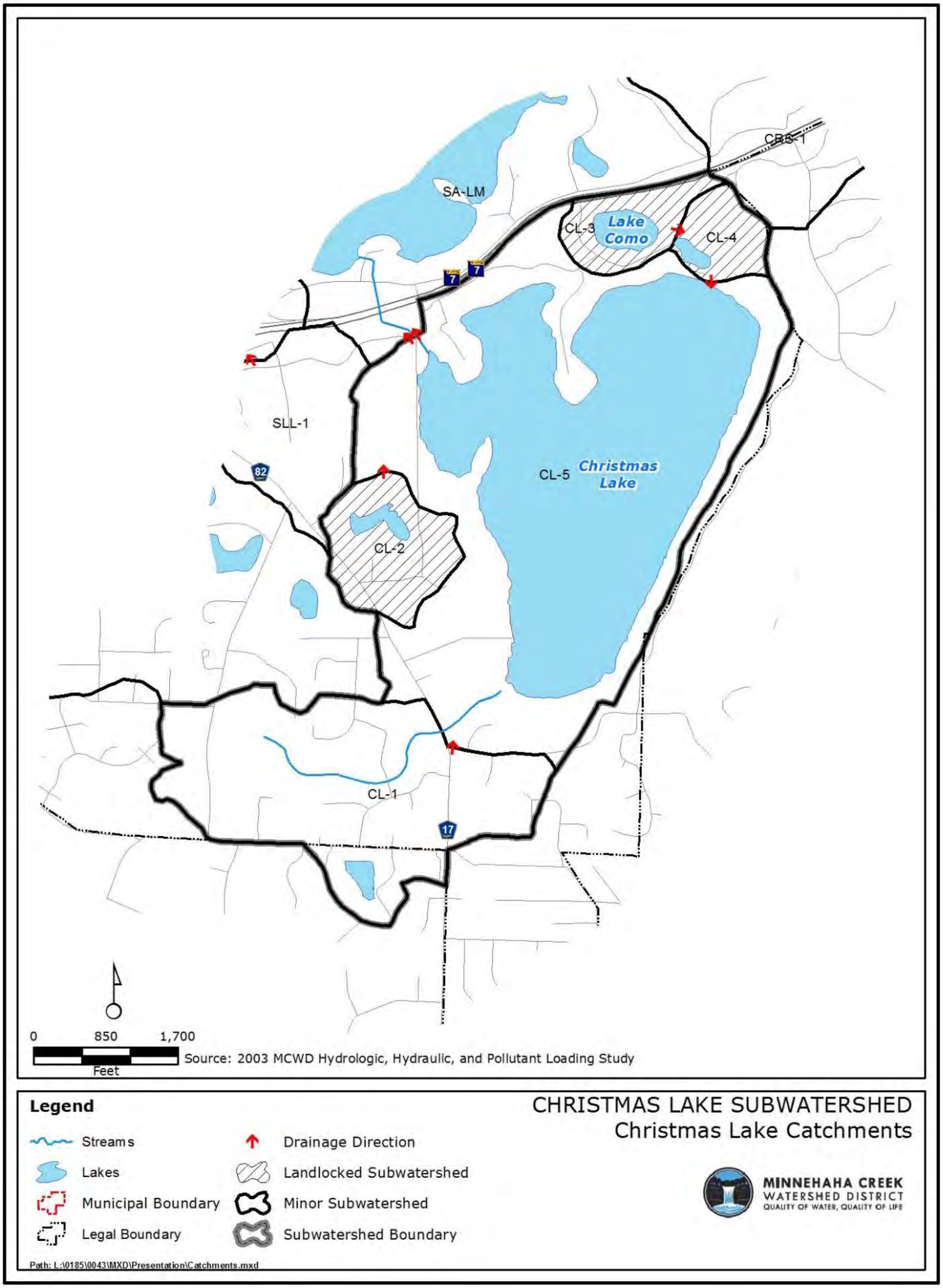

Figure 2. 8. Christmas Lake subwatershed catchments.

Water Quality:

The following are summaries of the characteristics and classifications of lakes, streams, and wetlands within the subwatershed including water quality goals and trends.

Lakes:

Christmas Lake is the primary receiving water within the subwatershed, and is classified by the DNR for shoreland management purposes as a Recreational Development lake (Table 2.17). Christmas Lake has the best water quality in the District and is one of the highest-quality lakes in the Metro area. The lake is listed by the MPCA on the draft 2016 303(d) list of Impaired Waters for excess mercury in fish tissue and is included in the statewide mercury TMDL. To assess long-term change in Christmas Lake, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth from 2001-2015. There were no statistically significant changes in water quality in Christmas Lake over this period (Table 2.18).

Tables 2.17 and 2.18 below detail the physical and water quality characteristics of Christmas Lake. For more information regarding water quality in the subwatershed, please refer to the District's Water Quality (Hydrodata) reports.

Table 2. 17. Physical characteristics of lakes in the Christmas Lake subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Christmas	267	87	3:1	Recreational Development

Source: Minnesota DNR.

Table 2. 18. Selected water quality goals and current conditions of lakes in the Christmas Lake subwatershed.

Lake	State TP Standard (µg/L)	2007 Plan Goal TP (µg/L)	Trend*	2001-2015 Average		
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Christmas	40	15	No trend	14	2	5.7

*Statistically significant at ≤ 0.05.
Source: MCWD.

Streams:

There is a channel that conveys drainage from the southern part of the subwatershed to the lake. This channel is experiencing some erosion, possibly conveying sediment to the lake. No information is available to assess the potential causes or extent of this erosion (Figure 2.9).

Tables 2.19 and 2.20 below detail the physical and water quality characteristics of streams and tributaries within the subwatershed. At this time no streams are listed as Impaired Waters, although the Christmas Lake Inlet (CCH02) TP data are high relative to the State's river eutrophication standards. The Christmas Lake Inlet has an average TSS concentration of 14 mg/L, and the Christmas Lake outlet an average TSS concentration of 4 mg/L; both below the 30 mg/L state standard for this ecoregion. However, those standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand that haven't been assessed in the stream. It is important to note that the number of samples collected for each parameter vary year to year depending on climate conditions.

To assess long-term change at the Christmas Lake outlet station, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2005-2015. There were no statistically significant changes in water quality in the Christmas Lake outlet during this period (Table 2.20). For more information regarding water quality in the subwatershed, please refer to the District's Water Quality reports.

Table 2. 19. Major streams in the Christmas Lake subwatershed.

Stream	Length (mi)
Christmas Lake – Christmas Lake Inlet	0.71
Christmas Lake – Christmas Lake Outlet	0.26

Table 2. 20. Current conditions of streams in the Christmas Lake subwatershed.
See Figure 2.9 for monitoring locations.

Stream	Trend*	2005-2015 Summer Average**			
		TP (µg/L)	TN (mg/L)	TSS(mg/L)	Cl (mg/L)
Christmas Lake Inlet (CCH02)	n/a	236	1.99	12	55
Christmas Lake Outlet (CCH01)	No trend	43	0.54	4	26

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride.
*Statistically significant at ≤ 0.05, **Annual data not available for all years.
Source: MCWD.

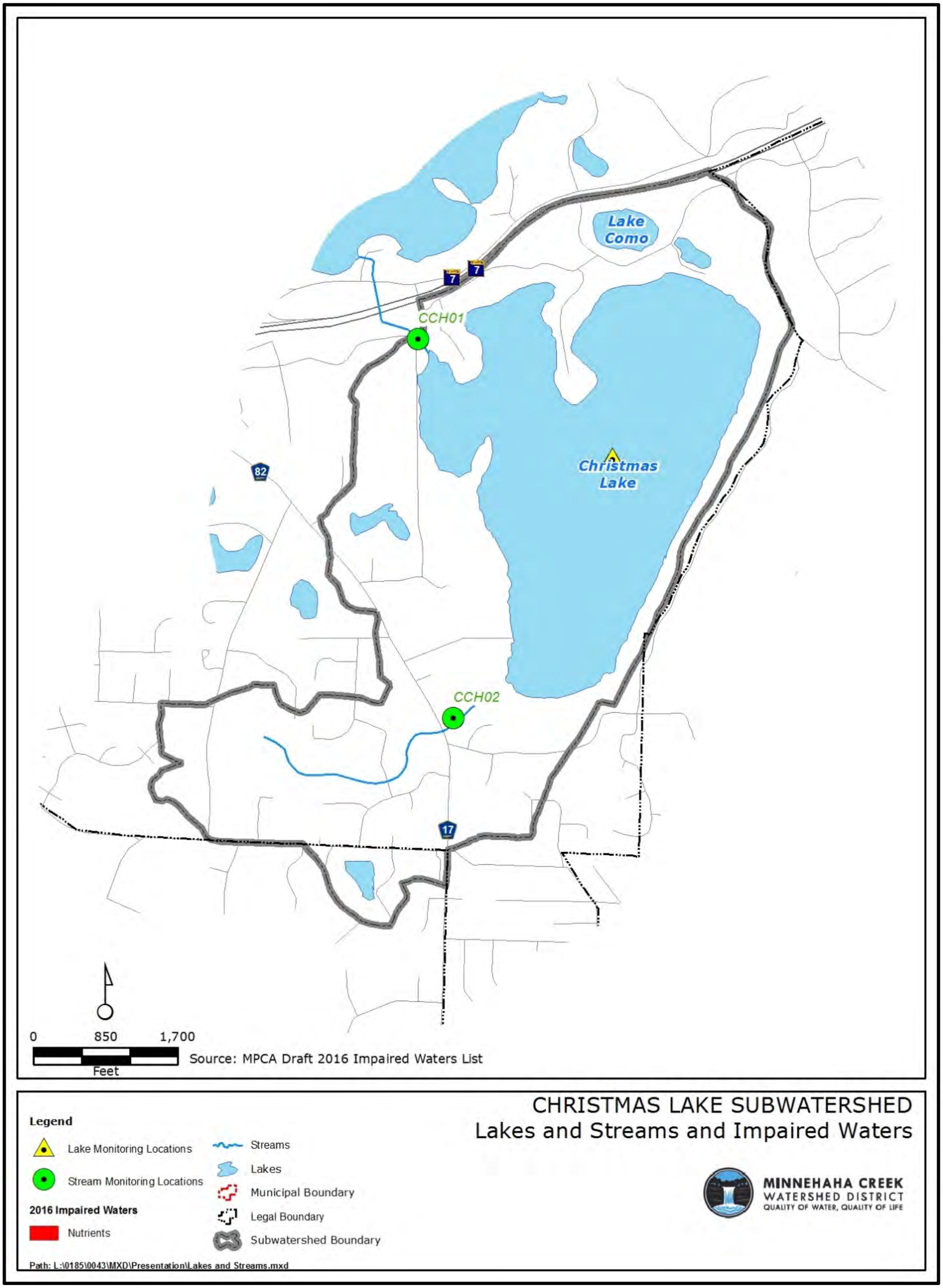

Figure 2. 9. Christmas Lake subwatershed lakes and streams and impaired waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover 11 percent of the subwatershed's surface (Figure 2.10 and Table 2.21). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands. Currently, no data are available.

Table 2. 21. Functional Assessment of Wetlands inventory of wetland types in the Christmas Lake subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	-	-
2 - Wet Meadow	3.7	0.75
3 - Shallow Marsh	21.6	4.37
4 - Deep Marsh	1.1	0.22
5 - Open Water	26.1	5.29
6 - Scrub Shrub	2.5	0.51
7 - Forested	0.8	0.16
8 - Bog	-	-
Riverine	-	-
Wetland Total	55.8	11.3
Upland	437.1	88.7
TOTAL	492.9	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

The infiltration potential of the upland areas within the subwatershed is described as moderate. Because of the organic or clayey nature of the soils in the wetland areas, the general infiltration potential there is low. The Carver *County Water Resource Management Plan* classifies the groundwater resources of the southern subwatershed area as being of medium to low sensitivity to pollution. The *Hennepin County Geologic Atlas* classifies the northern subwatershed as generally low sensitivity, except for a narrow band at the north end of Christmas Lake classified as medium sensitivity.

The entire subwatershed is within the Wellhead Protection Areas for Eden Prairie, Chanhassen, and Shorewood municipal drinking water wells. The Minnesota Department of Health classifies these Areas as Low Vulnerability for contamination. Figure 2.11 shows areas in the subwatershed with groundwater sensitivity and that are designated Wellhead Protection Areas.

Figure 2. 10. Christmas Lake subwatershed wetlands by type.

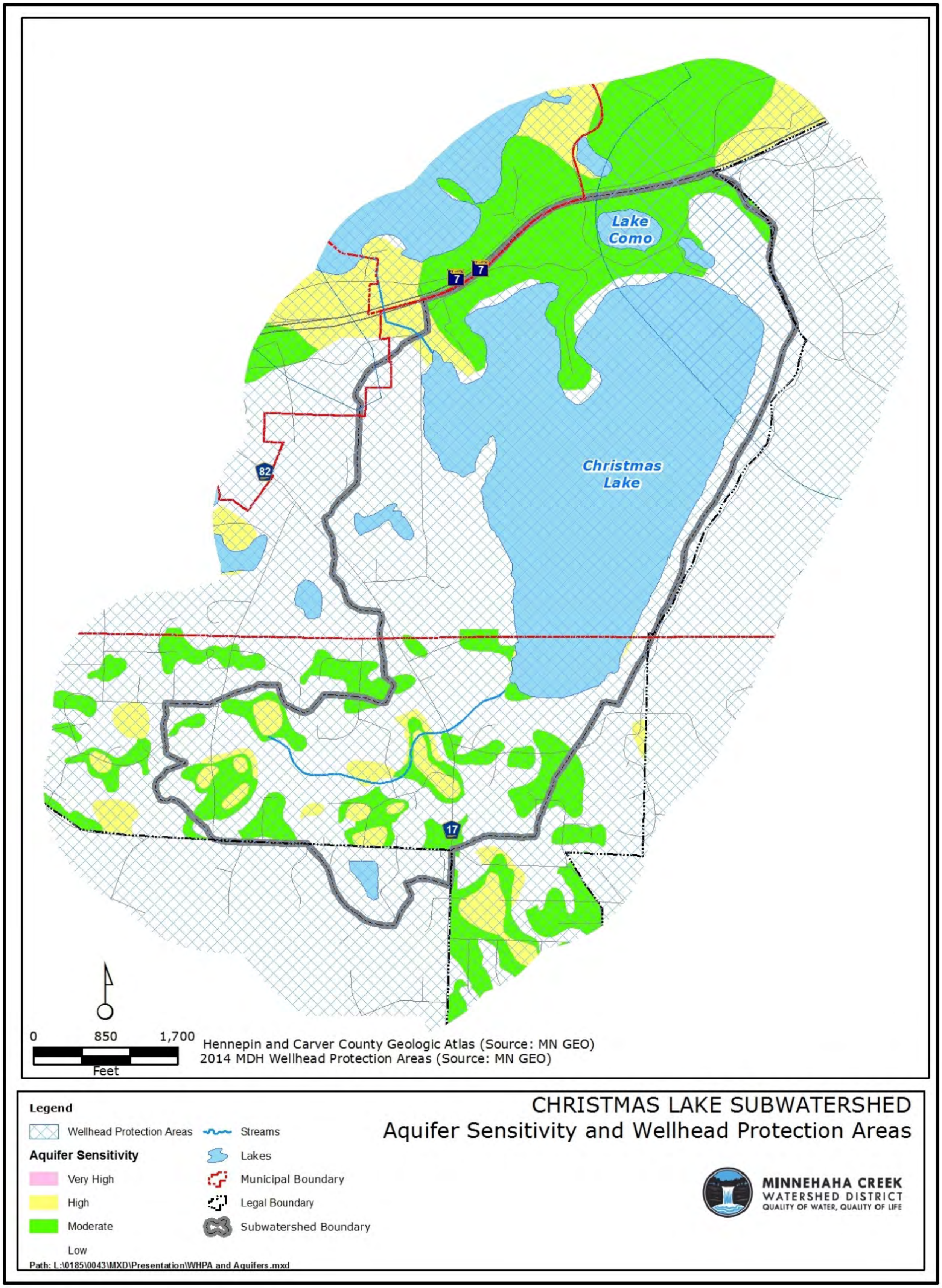

Figure 2. 11. Christmas Lake subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

As detailed in the HHPLS, the subwatershed discharges into an outlet under Highway 7 into St. Albans Bay of Lake Minnetonka. Surface flows in the Christmas Lake subwatershed are routed primarily through a system of culverts connecting small depressions. Flows are received by small pocket wetlands (some landlocked) and then to Christmas Lake before ultimately discharging into St. Albans Bay. Although Christmas Lake is not landlocked, these water elevations are frequently below the crest of the outlet control structure meaning the lake does not always discharge. Water elevations of Christmas Lake indicate that the lake is significantly influenced by evaporation and that there is likely a strong groundwater interaction.

There are several landlocked and semi-landlocked units and several small pocket wetland and depressions that do not typically contribute to Christmas Lake. Landlocked basins are particularly sensitive to stormwater volumes. Strong volume control standards are recommended in all areas draining to landlocked areas (Figure 2.8).

To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water yield data for the Christmas Lake outlet. Water yield from 2006-2015 showed no statistically significant trend.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity and habitat diversity and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Christmas Lake subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data where available.

Lakes:

<u>Biodiversity</u>

Fish Community. No fish IBI data are available for the lakes in this subwatershed. Christmas Lake is stocked with rainbow trout and was last surveyed by the DNR in 2007. The DNR describes Christmas Lake as unique, because it is one of a few lakes in the Metro area that can support a two-story fishery. This means sufficient oxygen levels and cool water temperatures in deeper portions of the lake allow the over-summer survival of cold-water species, while warm-water species inhabit the warmer water above the thermocline. Christmas Lake is under a Fish Consumption Advisory for mercury, and was added to the state's Impaired Waters in 1998 for that reason.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. The most recent survey was conducted in 2015 and 26 species were observed. Floristic Quality Index (FQI) data from the 2015 survey was 28.8, which is considered good and supporting the ecosystem service, but beginning to show signs of disturbance.

Aquatic Invasive Species. Since 1992, Eurasian watermilfoil has been confirmed in Christmas Lake. Curlyleaf Pondweed and Zerba mussels are also present.. Zebra mussels were discovered in Christmas Lake in 2014. Initial treatments showed success at controlling zebra mussels within the treatment area by the access. However, more zebra mussels were found on the opposite end of the lake in 2015; the population is now established lakewide.

<u>Habitat diversity</u>

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species or the extent to which it may be dominated by a few species. This has not been calculated yet but will be available once E-Grade is completed in the subwatershed.

Shoreline Health. Shoreline health is assessed by looking at shoreline vegetative cover and the relative human disturbance. The DNR uses the *Score the Shore* protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score The Shore data are available for the subwatershed; however, aerial photos show that most of the lake is developed with turf grass, beach, and seawall/riprap, lacking in woodland or wetland fringes which are beneficial for controlling runoff and supporting emergent vegetation at the shoreline.

Streams:

Biodiversity

Fish Community. No fish data are available for the two unnamed streams within the subwatershed.

Macroinvertebrate Community. No macroinvertebrate data are available for the streams within the subwatershed.

Aquatic Invasive Species. No AIS data are available for the two unnamed streams within the subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity for the two unnamed streams within the subwatershed.

Connectivity. Connectivity is defined by two metrics: 1) presence or absence of barriers, and 2) access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are three barriers to the two unnamed streams in this subwatershed: two culverts along the inlet to Christmas Lake as the stream passes under Bretton Way and Powers Boulevard, and a small control structure on the outlet of Christmas Lake.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to the Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. The quick rising and falling of a stream in response to rain events can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are not available for the two unnamed streams in this subwatershed, although they are likely best characterized as minimal flow.

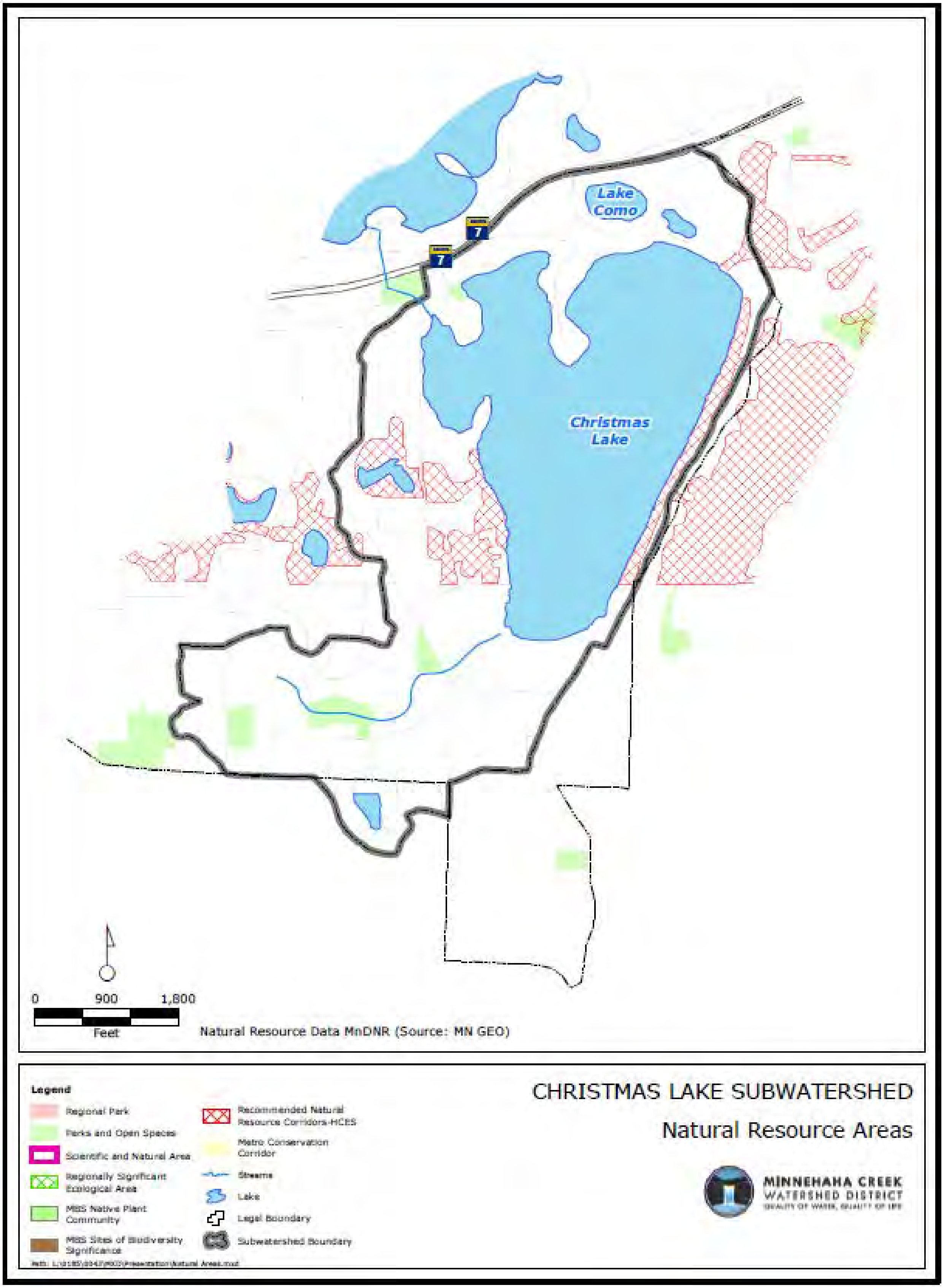

Figure 2. 12. Christmas Lake subwatershed natural resource areas.

Wetlands:

Biodiversity

Vegetation Community. No Rapid Floristic Quality Assessment (RFQA) data are available for the wetlands in this subwatershed. However the *Functional Assessment of Wetlands* identified one small wetland with exceptional vegetative diversity and another with high diversity. Three wetlands were classified as having exceptional aesthetic and fish habitat values.

Habitat diversity

Connectivity. There are limited opportunities to connect wetlands within this subwatershed.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species. There are few large wetlands within this subwatershed.

Shoreline Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. Wetlands are present on less than two percent of the shoreline, concentrated in one small, shallow bay on the west side of the lake.

Uplands:

The subwatershed is almost fully developed, there are only a few remaining patches of undeveloped landscape. Most of these areas are wetlands or are wooded portions of large residential lots. No area within the subwatershed has been identified by the DNR or the Minnesota Biological Survey (MBS) as being high-value or ecological areas (Figure 2.12).

Thriving Communities:

Land use:

Table 2.22 shows the land uses within the area of the Christmas Lake subwatershed in acres and as a percentage of the total subwatershed. The predominant land use in the subwatershed is single family residential with a small percentage of park and open space (Figure 2.13). Much of the subwatershed is identified as water, while the vacant or undetermined land use is characterized as wetland.

Table 2. 22. 2016 land use in the Christmas Lake subwatershed.

Land Use 2016	Acres	% of Subwatershed
Single - Family Residential	348.0	46.9
Water	273.0	36.8
Vacant or Undetermined	92.8	12.5
Parks and Open Space	14.6	2.0
Multi - Family Residential	6.2	0.8
Roads and Highways	5.0	0.7
Industrial	2.3	0.3
Institutional	0.4	0.1
Commercial	n/a	n/a
Agricultural	n/a	n/a

Source: Metropolitan Council.

Recreation:

Due to its clarity, Christmas Lake attracts snorkelers and SCUBA divers from across the Metro area. There are not any unique or scenic areas in this subwatershed. The Minnesota Historic features database lists three properties in the subwatershed: a former resort on Christmas Lake, and two farmhouses. There is a public boat launch on the north side of Christmas Lake (Figure 2.14). The water clarity of the Christmas Lake allows for swimming and other recreation activities.

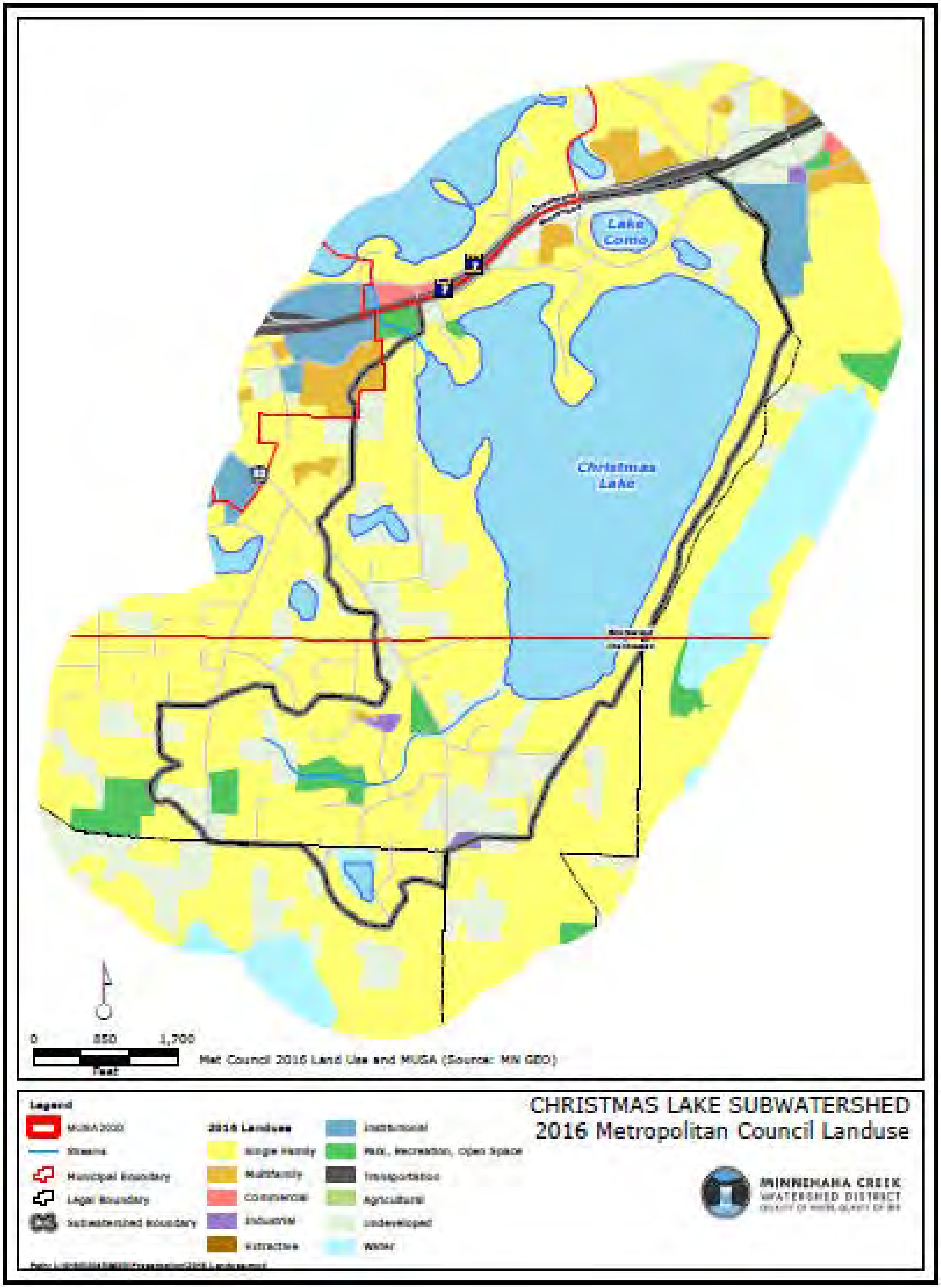

Figure 2. 13. Christmas Lake subwatershed 2016 Metropolitan Council land use.

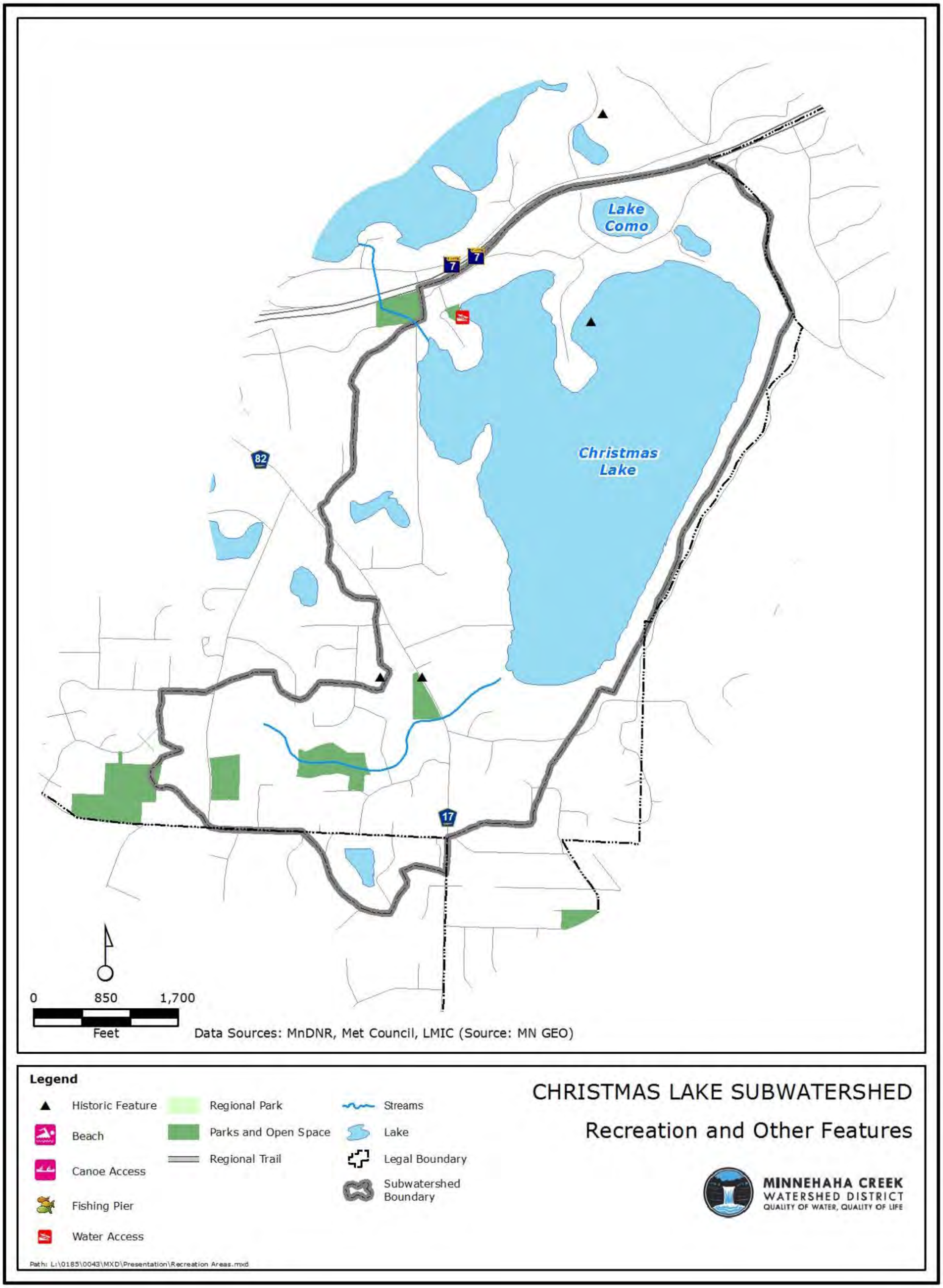

Figure 2. 14. Christmas Lake subwatershed recreational and other features.

2.3.2 DUTCH LAKE SUBWATERSHED

The Dutch Lake Subwatershed has a land cover mix of wetlands, woodlands, agriculture, horse farms and residential that surround Dutch Lake. Dutch Lake inlet (CDU02) drains the wetland to the north into Dutch Lake, and the lake outlet (CDU01) flows into Jennings Bay, Lake Minnetonka. There are ecological impacts from the Dutch Lake outlet loading nutrients into Jennings Bay. Below is the area of the Dutch Lake subwatershed in acres by individual city, in total, and as a percentage of the total subwatershed (Table 2.23, Figure 2.15).

Table 2. 23. Cities in the Dutch Lake subwatershed.

City	Area (Acres)	% of Subwatershed
Minnetrista	1,704.6	90%
Mound	183.8	10%
Total	1,888.4	100%

Source: MCWD

Subwatershed Description and Hydrology:

The Dutch Lake subwatershed is hummocky, rolling and hilly, with some steep slopes on the hillsides and along the southwestern shore of Dutch Lake and adjacent wetland.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.16). The subwatershed is primarily agriculture and open space in the north and grassland or turf with low to medium impervious surface typical of residential development in the south and east. The open space is dominated by wetland, forest and woodland.

Soils within the subwatershed are predominantly classified as Natural Resources Conservation Service Hydrologic Soil Group B (loamy soils with moderate infiltration potential) and D (clayey soils with very low infiltration potential. The Group D soils are found in low-lying areas and are generally hydric, or showing indications of inundation. For further information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan.*

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Dutch Lake subwatershed into seven subwatershed units, designated DL-1 through DL-7 (Figure 2.17). Dutch Lake is the primary receiving water within the subwatershed. There is one primary stream, Dutch Creek, which serves as the outlet of Dutch Lake and flows to Jennings Bay**.** The Dutch Lake subwatershed has two large wetland systems: a wetland complex dominates the western half of the subwatershed and another on the upper portion of the watershed that drains to a large wetland complex in the central watershed, which in turn drains south and then east to Dutch Lake.

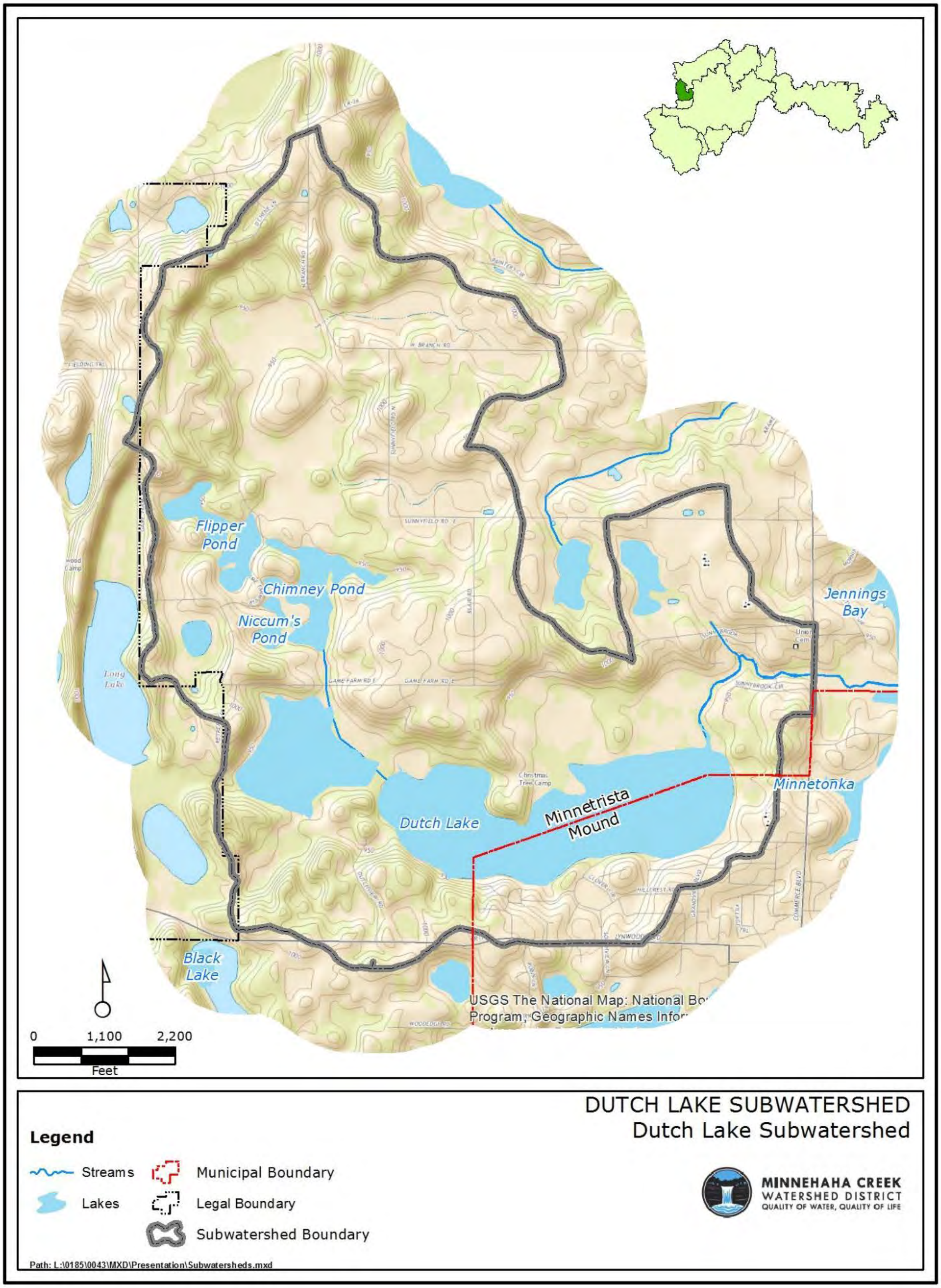

Figure 2. 15. The Dutch Lake subwatershed.

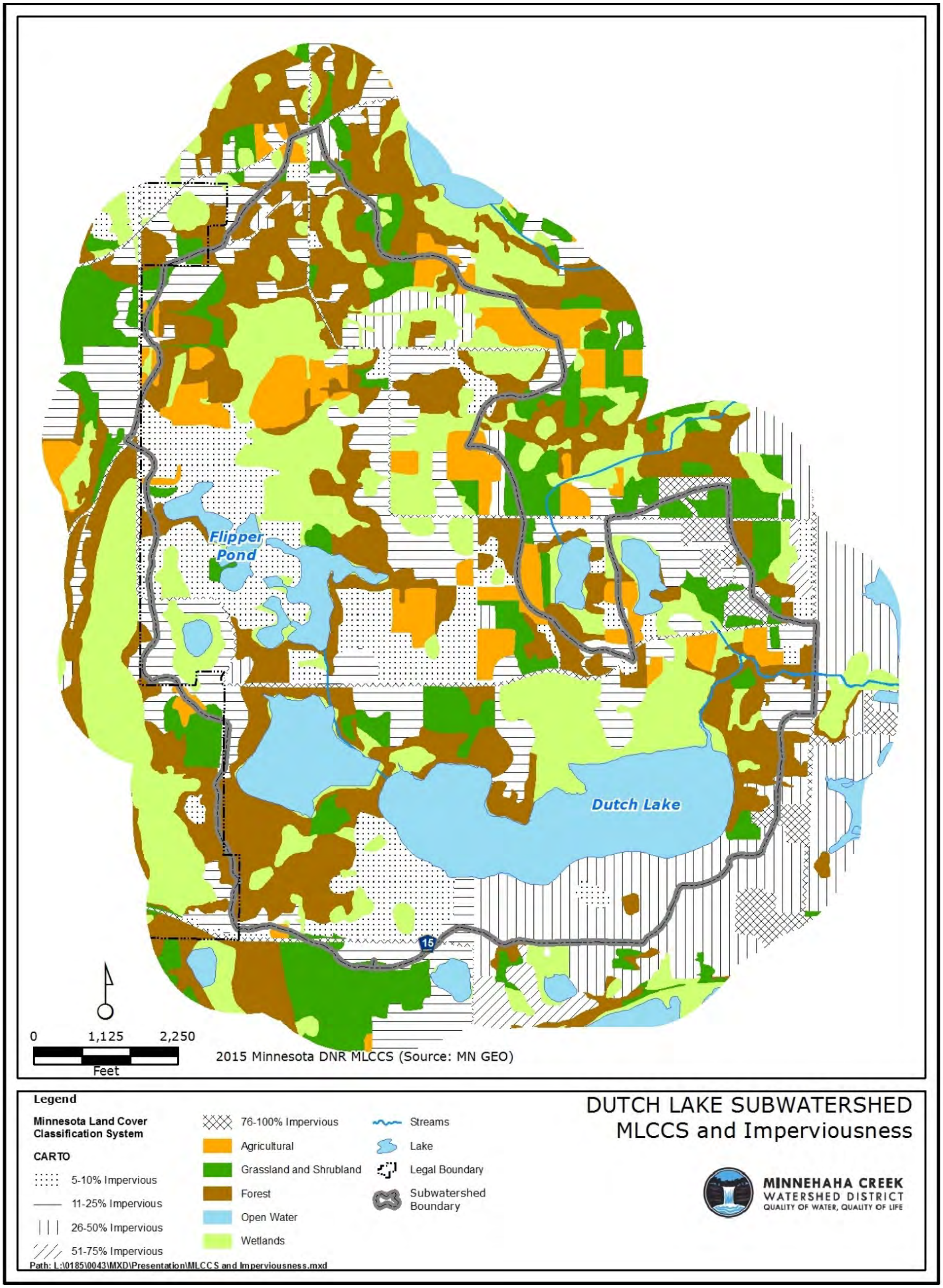

Figure 2. 16. Dutch Lake subwatershed MLCCS and imperviousness.

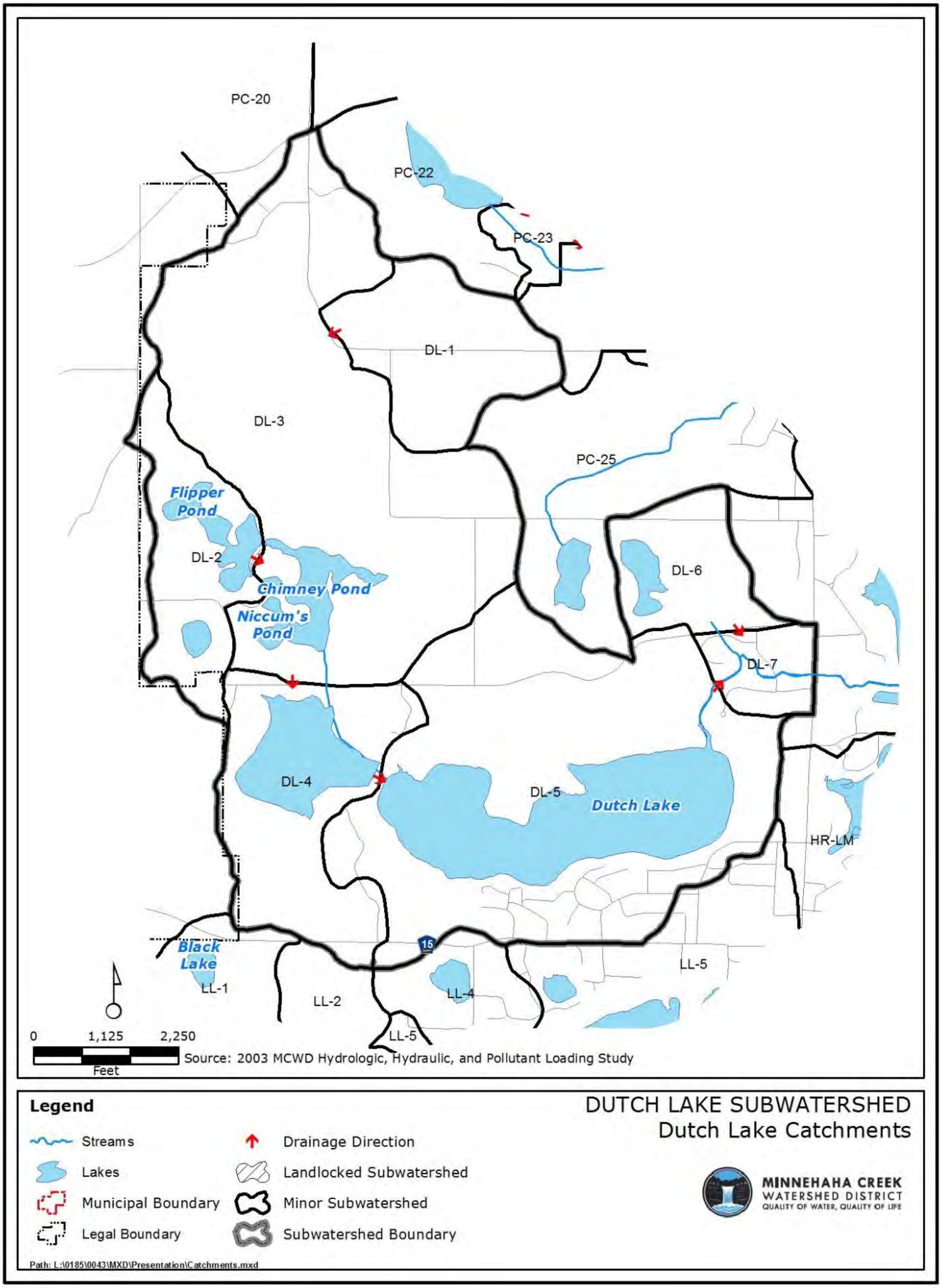

Figure 2. 17. Dutch Lake subwatershed catchments.

Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

Dutch Lake is the primary receiving water within the subwatershed, and is classified by the MnDNR for shoreland management purposes as a Recreational Development lake (Table 2.24). Tables 2.24 and 2.25 below detail the physical and water quality characteristics of Dutch Lake.

Dutch Lake is listed on the State's Impaired Waters list for nutrient/eutrophication biologic indicators. Average summer nutrient concentrations are greater than the state standard. Algal blooms and poor water quality makes recreational activities undesirable at certain times of the year. To assess long-term change in Dutch Lake, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth data from 2001-2015. There were no statistically significant changes in water quality in Dutch Lake over this period.

For more information regarding water quality in the subwatershed, please refer to the District's annual Water Quality Reports and the Upper Minnehaha Creek Watershed TMDL.

Table 2. 24. Physical characteristics of lakes in the Dutch Lake subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Dutch	173	45	10:1	Recreational Development

Source: Minnesota DNR.

Table 2. 25. Selected water quality goals and current conditions of lakes in the Dutch Lake subwatershed.

Lake	State TP Standard (µg/L)	2007 Plan Goal TP (µg/L)	Trend*	2001-2015 Average		
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Dutch	40	40	No trend	66	39	1.1

*Statistically significant at ≤ 0.05.
Source: MCWD and Minnesota DNR.

Streams:

There is one primary stream within the subwatershed; Dutch Creek, which serves as the outlet of Dutch Lake and flows to Jennings Bay. A small stream drains wetlands on the west side of Dutch Lake, which flows seasonally or intermittently. Flow in the stream is controlled by an outlet structure on Dutch Lake and is mainly runoff event-driven. Large events within the subwatershed can result in temporarily high flows into the Creek.

At this time no streams are listed as Impaired Waters; however, both streams have TP concentrations that are high relative to the state river eutrophication standards. However, those standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand that haven't been assessed in the Creek. Tables 2.26 and 2.27 below detail the physical and water quality characteristics of streams and tributaries within the subwatershed.

Table 2.26 shows the average TSS concentrations at sites of the two unnamed streams in the subwatershed, Dutch Lake Inlet and Dutch Lake Outlet. The streams have an average TSS of 6 and 9 mg/L respectively, which is well below the 30 mg/L state standard. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. Monitoring data show that both sites fall below the standard multiple times per year.

To assess long-term change in Dutch Lake Outlet station, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2005-2015. There was a statistically significant improvement in TSS at the Dutch Lake outlet during this period. For more information, please refer to the District's Water Quality (Hydrodata) reports.

Table 2. 26. Major streams in the Dutch Lake subwatershed.

Stream	Length (mi)
Dutch Lake Inlet (CDU02)	0.16
Dutch Lake Outlet (CDU01)	0.92

Table 2. 27. Current conditions of streams in the Dutch Lake subwatershed.
See Figure 2.18 for monitoring locations.

Stream	Trend*	2005-2015 Summer Average			
		TP (µg/L)	TN (mg/L)	TSS(mg/L)	Cl (mg/L)
Dutch Lake Inlet (CDU02)	n/a	240	1.01	6	26
Dutch Lake Outlet (CDU01)	Imp TSS	118	1.26	9	31

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride.
*Statistically significant at ≤ 0.05, Imp = improving, Deg = degrading.
Source: MCWD.

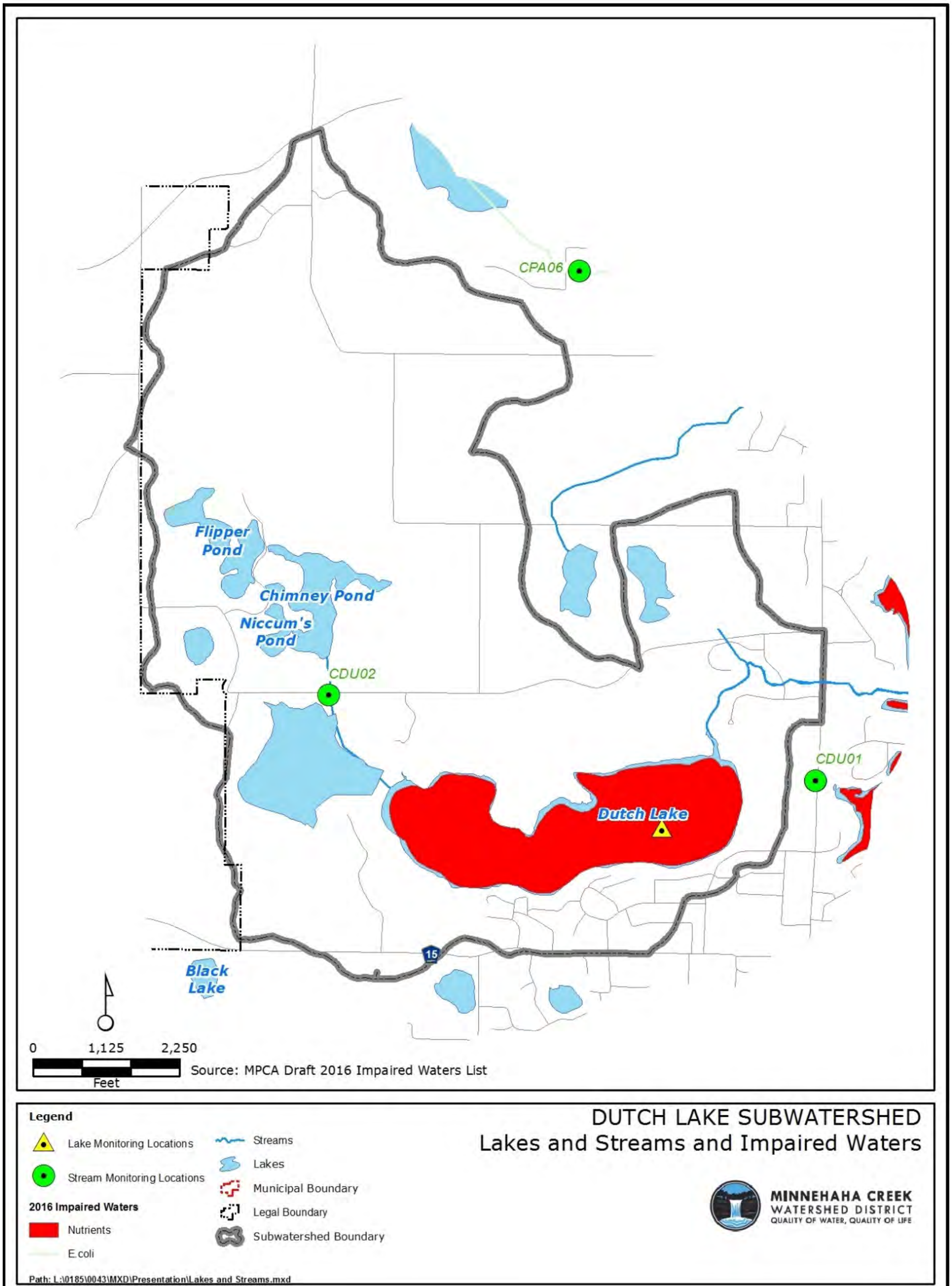

Figure 2. 18. Dutch Lake subwatershed lakes and streams and Impaired Waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover 20 percent of the watershed's surface (Figure 2.19 and Table 2.28). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients to and from the subwatershed. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2. 28. Functional Assessment of Wetlands inventory of wetland types in the Dutch Lake subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	3.4	0.21
2 - Wet Meadow	41	2.5
3 - Shallow Marsh	280.2	17.09
4 - Deep Marsh	2.8	0.17
5 - Open Water	-	-
6 - Scrub Shrub	0.4	0.02
7 - Forested	0.3	0.02
8 - Bog	-	-
Riverine	-	-
Wetland Total	328	20.0
Upland	1,313.1	80.0
TOTAL	1,641.1	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

The infiltration potential of the upland areas in the subwatershed are described as low to medium. Because of the organic nature of the soils in the central wetland area, infiltration potential there is variable. The *Hennepin County Geologic Atlas* classifies most of the upland areas as being of low sensitivity to pollution, and the central wetland area as highly sensitive.

Part of the Dutch Lake Subwatershed has been designated by the Minnesota Department of Health as a Drinking Water Supply Management Area (DWSMA) and a wellhead protection area for a City of Minnetrista public well. While the aquifer sensitivity is high, the MDH has designated this area to be of low risk and low vulnerability to contamination of the drinking water supply. Figure 2.20 shows areas in the subwatershed with groundwater sensitivity and that are designated wellhead protection areas.

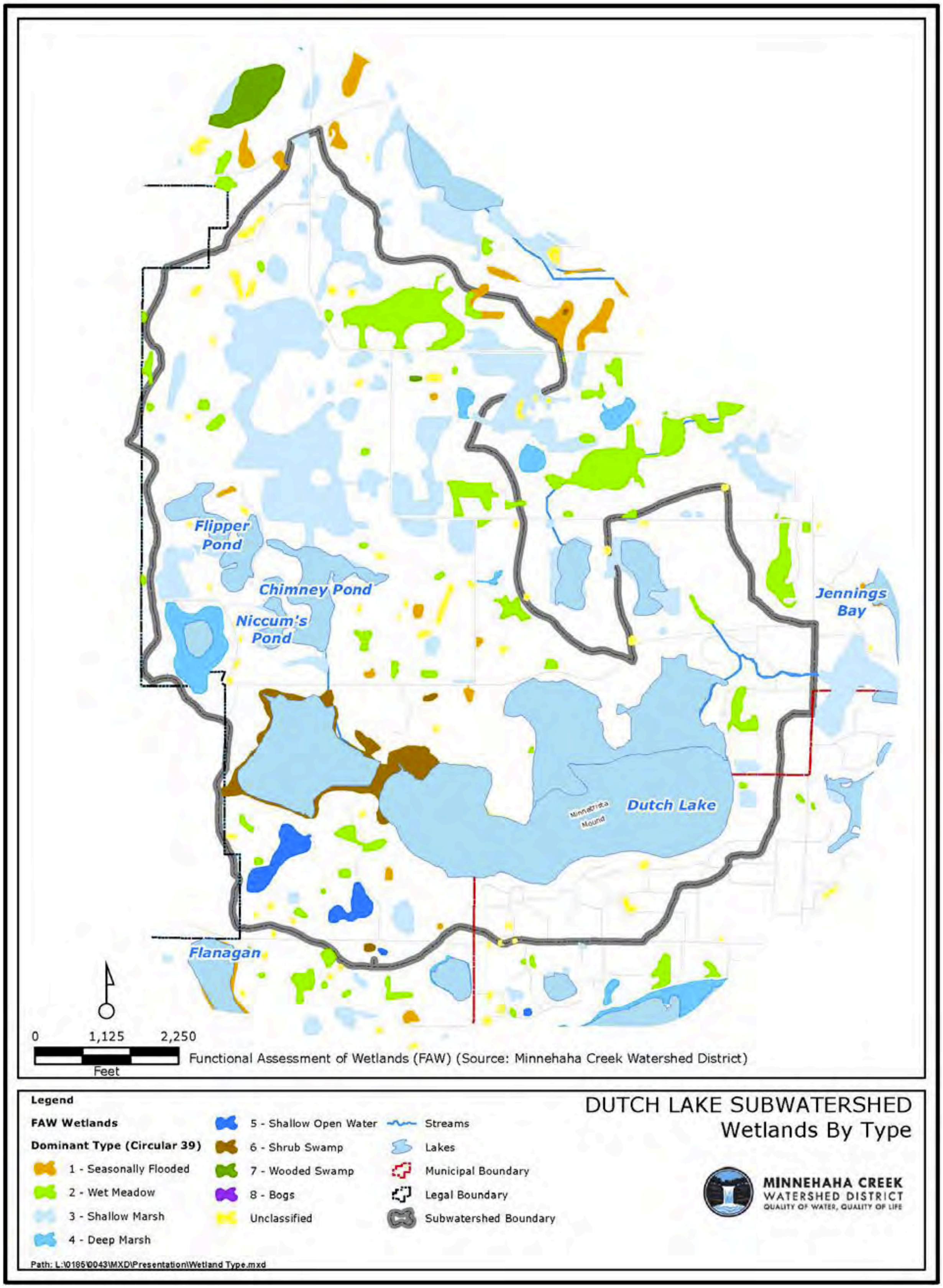

Figure 2. 19. Dutch Lake subwatershed wetlands by type.

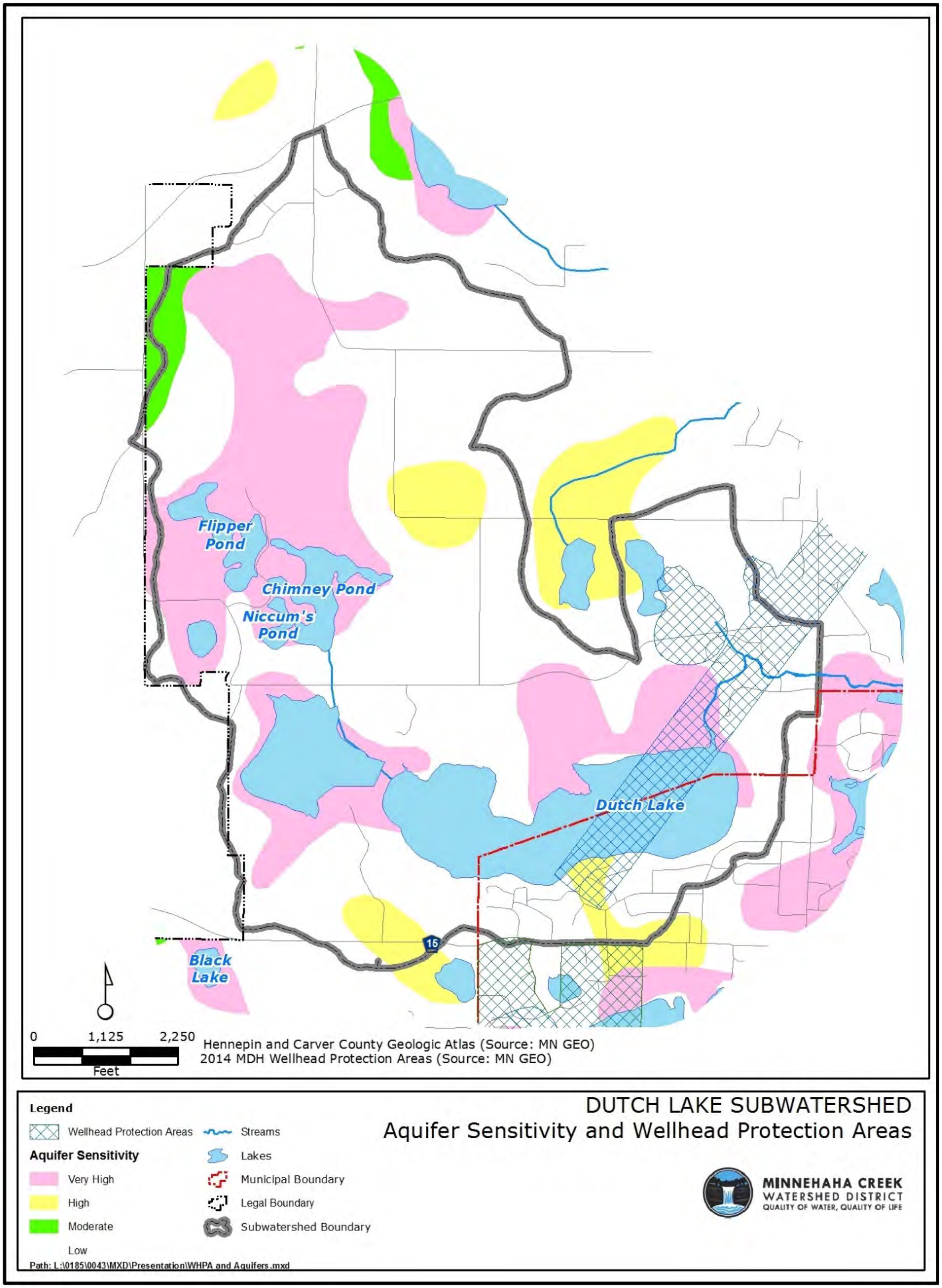

Figure 2. 20. Dutch Lake subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

A small stream drains wetlands on the west side of Dutch Lake, which flows seasonally or intermittently. The Dutch Lake subwatershed is characterized by a system of ditches and culverts conveying water into the main water bodies of the subwatershed.

To asses change in water yield, a Mann-Kendall statistical trend test was performed on data for the Dutch Lake outlet station. The period of record for the Dutch Lake outlet station was 2006-2015. Water yield did not exhibit any statistically significant trend upward or downward.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. The Dutch Lake subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data, where available (Figure 2.21).

Lakes:

Biodiversity

Fish Community. No fish IBI data are available for the lakes in this subwatershed. Dutch Lake was last stocked by the MnDNR in 2011 for bluegill and was last surveyed in 2014. At the time of that survey (late July) water clarity was 1.2 feet and the lake was strongly stratified with poor (<2 mg/l) dissolved oxygen below 8 feet. That survey found that Northern Pike abundance was relatively low compared to other similar lakes in the state; however, typical of lakes with low density, mean size was larger than average. The pan fish community appears healthy. Yellow Perch have never been abundant in Dutch Lake and have always been sampled at a rate below average.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. Floristic Quality Index data were collected in 1996. The FQI was 15.1, which is considered Poor. Dutch Lake is infested by Eurasian watermilfoil.

Aquatic Invasive Species. Eurasian watermilfoil has been confirmed in Dutch Lake.

Habitat diversity

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species or the extent to which it may be dominated by a few species. This has not been calculated yet, but will be once E-Grade is completed in the subwatershed.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score The Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score The Shore data are available; however, aerial photos show that much of the west, north and east side of Dutch lake as well as many of the wetlands in the subwatershed have significant woodland or wetland fringes, which are beneficial for controlling runoff and supporting emergent vegetation at the shoreline.

Streams:

Biodiversity

Fish Community. No fish IBI data are available for the streams in this subwatershed.

Macroinvertebrate Community. No macroinvertebrate data are available for the streams in this subwatershed.

Aquatic Invasive Species. No AIS data are available for the streams in this subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity on either the inlet and outlet streams of Dutch Lake.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are several barriers on the streams in this subwatershed, most of them culverts at road crossings. There are no stream cross-section data available for either the inlet or outlet streams.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are not available, but based on observation, the average flow of both the inlet and outlet streams is low, which would be indicative of the low DO levels mentioned above.

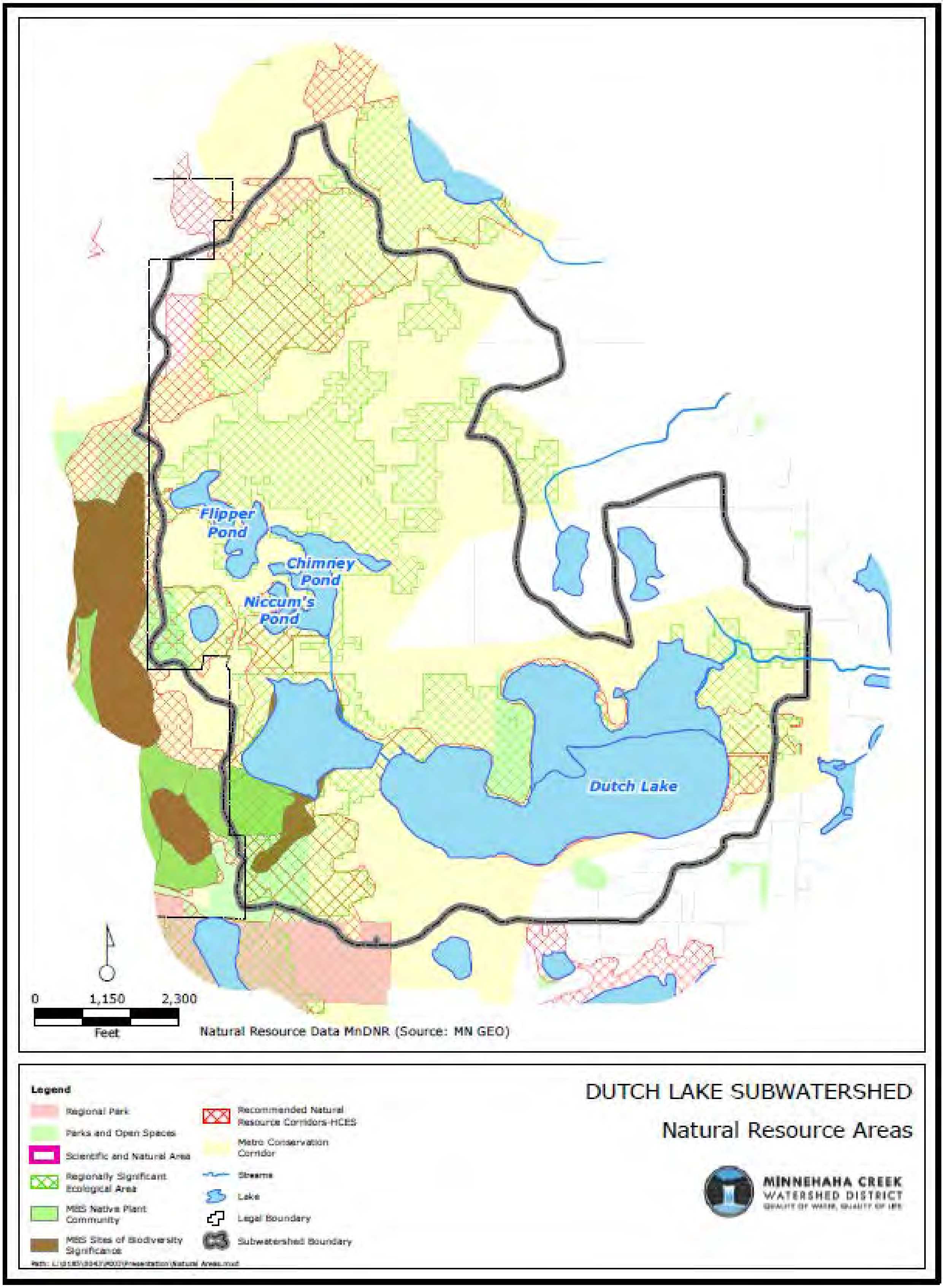

Figure 2. 21. Dutch Lake subwatershed natural resource areas.

Wetlands:

Biodiversity

Vegetation Community. No Rapid Floristic Quality Assessment data are available for the wetlands in this subwatershed. However the *Functional Assessment of Wetlands* scored two large riparian wetlands highly – on the north side and west side of the lake - on vegetative diversity, fish and wildlife habitat, or aesthetics. There is one wetland in the subwatershed with high restoration potential. Numerous other small wetlands or moderate restoration potential are located throughout the subwatershed.

Uplands:

Biodiversity

Existing data sources do not highlight any unique or scenic areas in this subwatershed. However, much of the subwatershed has been identified by the DNR as a Metropolitan Conservation Corridor and by the City of Minnetrista as a natural resources corridor due to the predominance and contiguity of wetlands (Figure 2.21).

Habitat diversity

Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. Much of the subwatershed has been identified by the MnDNR as a Metropolitan Conservation Corridor and by the City of Minnetrista as a natural resources corridor due to the predominance and contiguity of wetlands.

The Minnesota Biological Survey (MBS) has identified both terrestrial and aquatic locations in the watershed with intact native plant communities, and those with biodiversity significance (Figure 2.21). Native plant communities are a group of native plants that interact with each other and the surrounding environment in ways not greatly altered by humans or by introduced plant or animal species. On the west side of Dutch Lake are two native plant communities classified as Imperiled or Imperiled/Vulnerable. A 25-acre Tamarack Swamp and a 32 acre Sugar Maple-Basswood-Bitternut Hickory Forest are part of a native plant corridor between Dutch Lake and Long Lake/Little Long Lake, which are both outside the watershed.

Thriving Communities:

Land use:

Table 2.29 below shows the land uses within the area of the Dutch Lake subwatershed in acres and as a percentage of the total subwatershed. The predominant land use in the subwatershed is vacant land, mainly wetland and forest or woodland (Figure 2.22). There are scattered low density single family residential uses in the upper watershed, mainly isolated homes and farmsteads. The south and eastern portion of the subwatershed are dominated by single family residential. Mound Westonka High School is a large, institutional use in the eastern subwatershed.

Much of the watershed is outside of the MUSA 2020 boundary, and is not served by regional wastewater facilities.

Table 2. 29. 2016 land use in the Dutch Lake subwatershed.

Land Use 2016	Acres	% of Subwatershed
Vacant or Undetermined	935.4	49.5
Single - Family Residential	379.9	20.1
Agricultural	192.6	10.2
Water	181.1	9.6
Parks and Open Space	112.4	6.0
Institutional	77.5	4.1
Multi - Family Residential	8.9	0.5
Commercial	0.6	<0.1
Industrial	n/a	n/a
Roads and Highways	n/a	n/a

Source: Metropolitan Council.

Recreation:

Existing data sources do not highlight any unique or scenic areas in this subwatershed. The Minnesota Historic Features database notes one historic site in this subwatershed, a farmhouse. There is one public boat access on Dutch Lake off of Grandview Boulevard, adjacent to Grandview Middle School (Figure 2.23). The YMCA operates Camp Christmas Tree on the north shore of the lake, with a wide variety of swimming, fishing and boating activities available to campers.

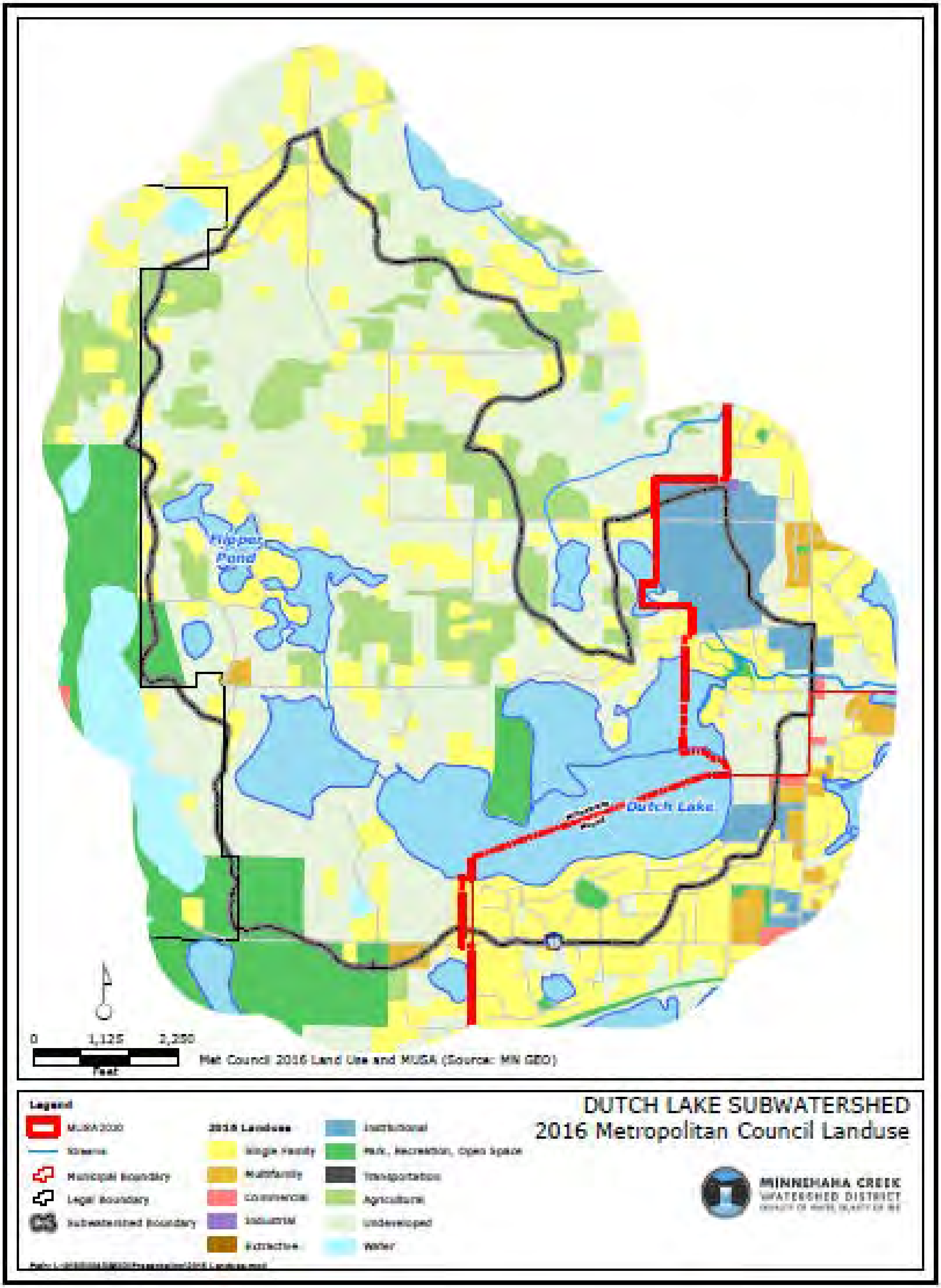

Figure 2. 22. Dutch Lake subwatershed 2016 Metropolitan Council land use.

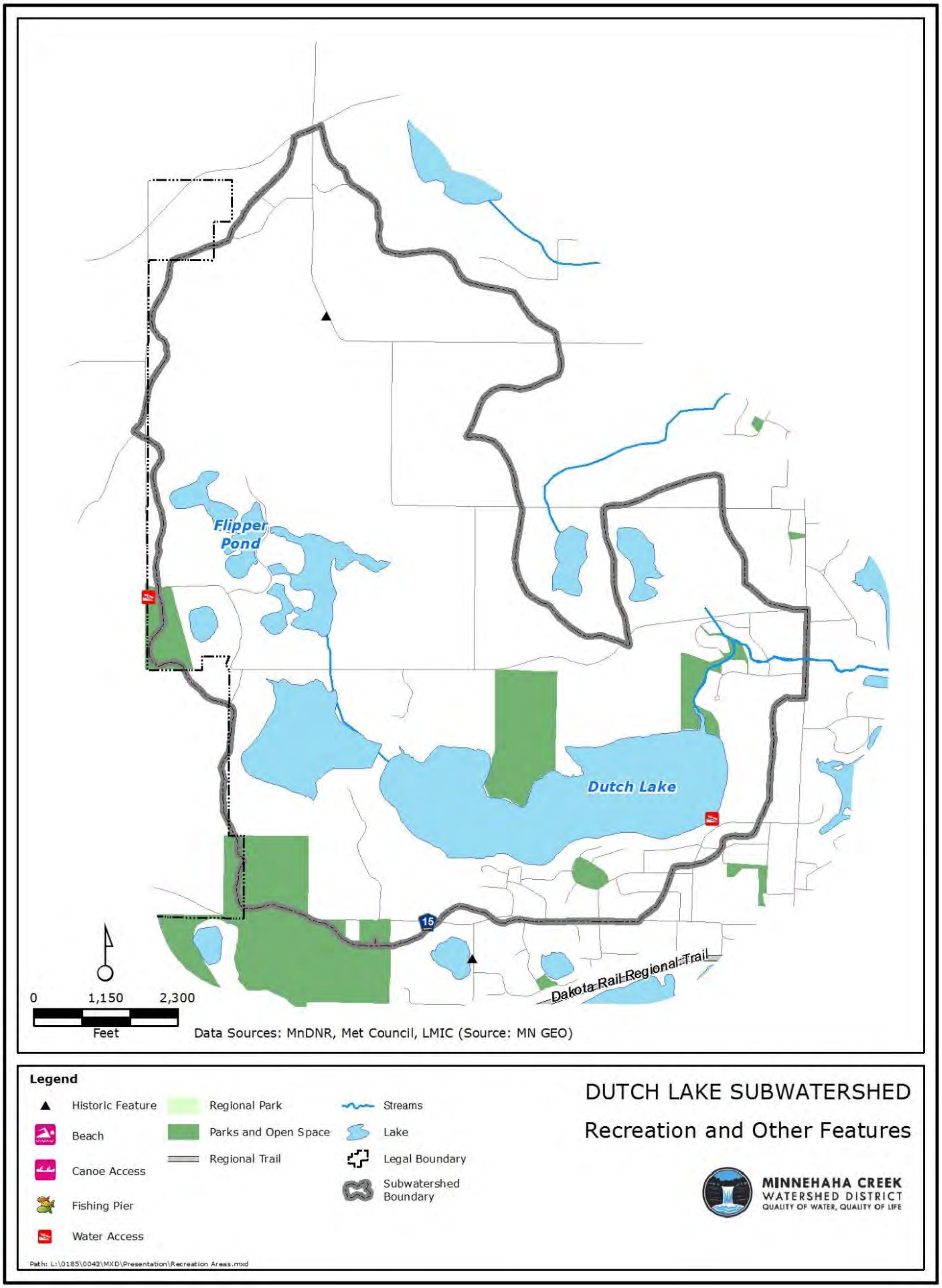

Figure 2. 23. Dutch Lake subwatershed recreation and other features.

2.3.3 GLEASON LAKE SUBWATERSHED

Gleason Lake Subwatershed is dominated by a mix of urban residential/business land cover with very little woodland and wetlands remaining. The subwatershed is drained in the west by Hadley Lake and in the east by Gleason Lake. All the water drains into Wayzata Bay, Lake Minnetonka. The nutrient loading into Wayzata Bay is not well understood. One of the outlets is piped and the other one drains into pond prior to discharging into Wayzata Bay. A 2013 Macroinvertebrate Assessment indicates poor water quality along the creek that discharges into Wayzata Bay. Table 2.30 shows the area of the Gleason Lake subwatershed in acres by individual city, in total and as a percentage of the total subwatershed (Figure 2.24).

Table 2. 30. Cities in the Gleason Lake subwatershed.

City	Area (Acres)	% of Subwatershed
Medina	130.8	3.0
Minnetonka	51.4	1.2
Orono	138.3	3.2
Plymouth	3,507.5	80.4
Wayzata	537.1	12.3
Total	4,365.2	100%

Source: MCWD

Subwatershed Description and Hydrology:

The Gleason Lake subwatershed is comprised of gentle rolling hills with an abundance of lakes and ponds. The eastern portion of the subwatershed drains through several wetlands including Kreatz and Snyder Lakes and then to County Ditch #15, which discharges into Gleason Lake. The western watershed drains through Hadley Lake and then south to Gleason Lake Creek, which outlets the south end of Gleason Lake and flows by channel and culvert to Glenbrook Pond. The Pond outlets to a storm sewer that discharges downstream to Wayzata Bay.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.25). The subwatershed is mostly developed areas with low to medium impervious surface typical of residential development. Pockets of wetlands and wooded areas (mainly park lands) are present.

Soils within the subwatershed are predominantly classified as Natural Resources Conservation Service Hydrologic Soil Group B (loamy soils with moderate infiltration potential) and D (clayey soils with very low infiltration potential). For further information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Gleason Lake subwatershed into 16 subwatershed units, designated GLC-1 through GLC-11, and HL-1 through HL-5 for that part of the subwatershed that is within the Hadley Lake drainage area (Figure 2.26).

Mooney Lake has no natural outlets; however, it is pumped out under certain agreed upon conditions to prevent flooding.

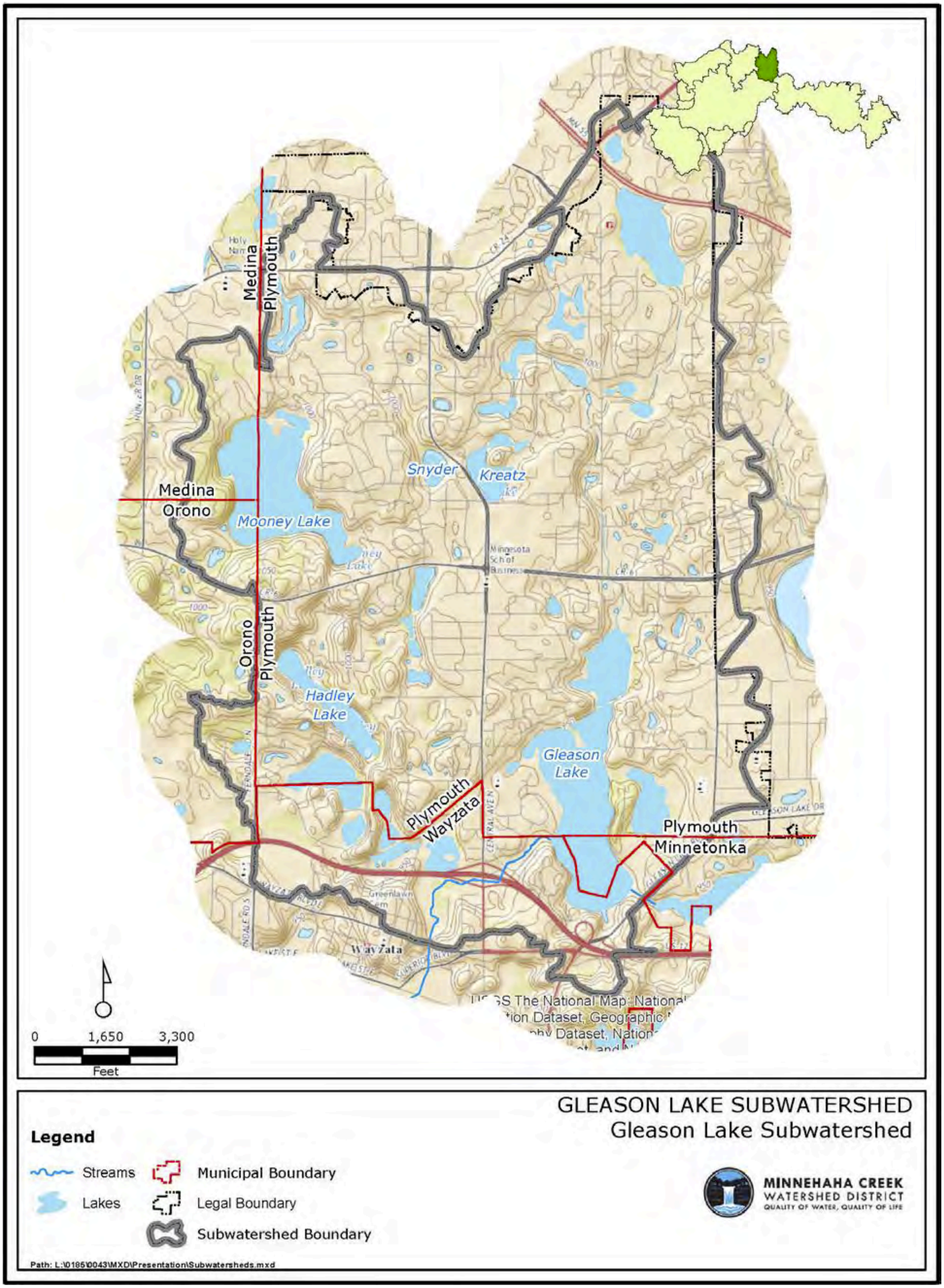

Figure 2. 24. The Gleason Lake subwatershed.

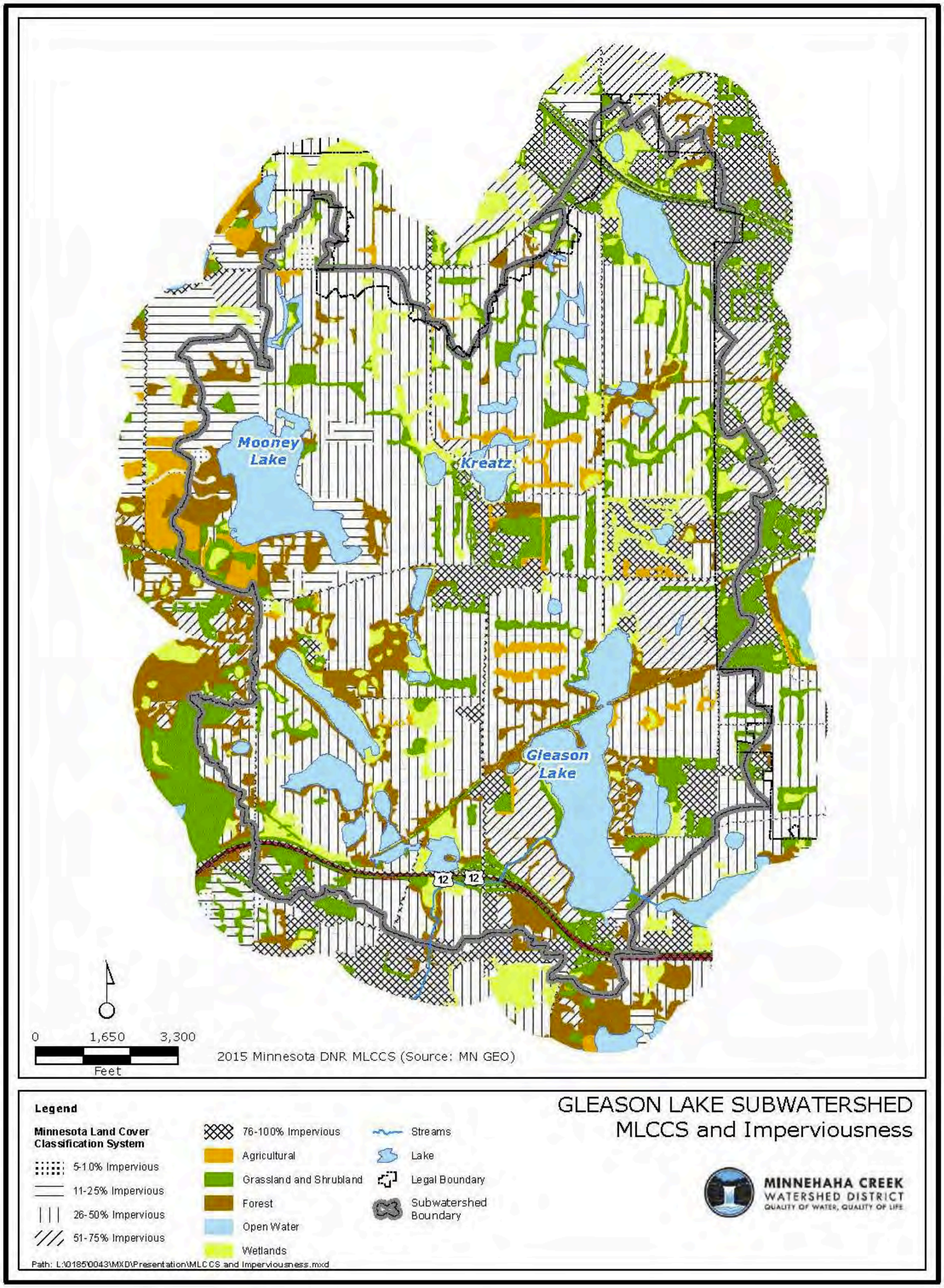

Figure 2. 25. Gleason Lake subwatershed MLCCS and imperviousness.

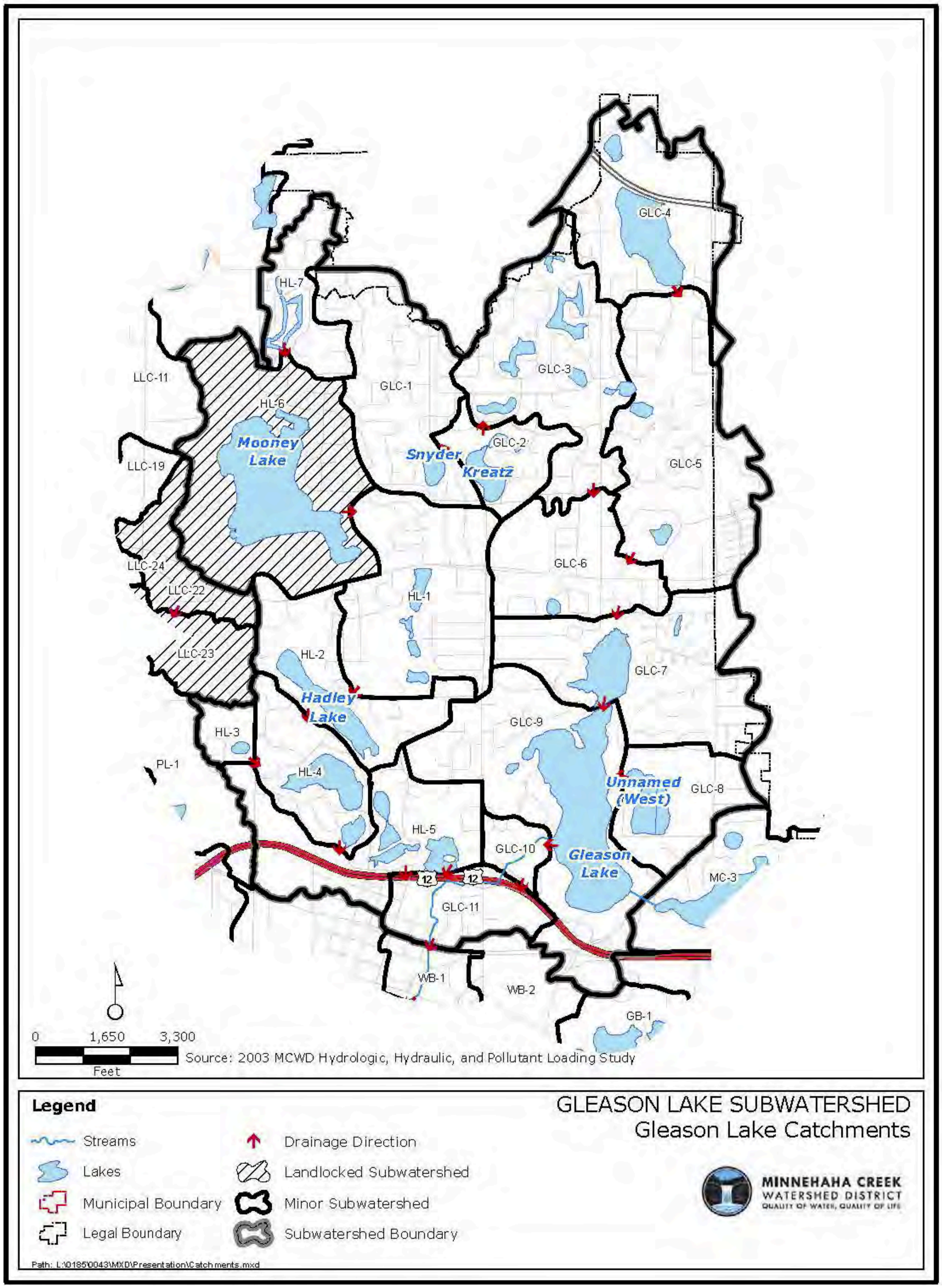

Figure 2. 26. Gleason Lake subwatershed catchments.

Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

Gleason Lake is the primary receiving water within the subwatershed, and is classified by the DNR for shoreland management purposes as a Recreational Development lake (Table 2.31). Other large water resources in the subwatershed are Hadley, Kreatz, Mooney and Snyder Lakes (Figure 2.27).

Four lakes in the subwatershed are listed on the State's Impaired Waters list, with average summer nutrient concentrations greater than the state standard: Gleason, Hadley, Mooney and Kreatz (Snyder) Lakes. There are discrepancies in the naming of Kreatz and Snyder lakes between the MCWD, DNR, and MPCA that are being resolved. The larger lake to the east is Kreatz but is listed as Snyder in the impaired waters list and the Upper Minnehaha Creek Watershed Lakes TMDL.

To assess long-term change in Gleason Lake, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth data from 2001-2015. There were no statistically significant changes in water quality in Gleason Lake during this period. Tables 2.31 and 2.32 below detail the physical and water quality characteristics of Gleason Lake and other lakes within the subwatershed. For more information regarding water quality in the subwatershed, please refer to the District's annual Water Quality Reports and the Upper Minnehaha Creek Watershed Lakes TMDL.

Table 2. 31. Physical characteristics of lakes in the Gleason Lake subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Gleason	164	16	16:1	Recreational Development
Hadley	22	n/a	24:1	Recreational Development
Snyder	9	12	42:1	Recreational Development
Kreatz	16	7	18:1	Recreational Development
Mooney	117	12	5:1	Recreational Development

Source: Minnesota DNR, MCWD

Table 2. 32. Selected water quality goals and current conditions of lakes in the Gleason Lake subwatershed.

Lake	State TP Standard (µg/L)	2007 Plan Goal TP (µg/L)	Trend**	2001-2015 Average		
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Gleason[1]	60	80	No trend	98	51	1.11
Hadley[2]	40	*	n/a	57	16	-
Kreatz[2]	60	*	n/a	72	41	1.0
Snyder	60	*	n/a	198	47	0.79
Mooney	60	n/a	n/a	78	51	1.0

*10% reduction from existing, provided it is greater than 25 µg/L; will require baseline data.

**Statistically significant at ≤ 0.05.

[1]Data are from 2005-2011, as shown in the Upper Watershed Lakes TMDL.

[2]Data are from 2006-2008, as shown in the Upper Watershed Lakes TMDL.

Source: MCWD, Upper Minnehaha Creek Watershed Lakes TMDL, MPCA.

Streams:

County Ditch #15 drains the upper watershed to Gleason Lake. Gleason Creek is the outlet of Gleason Lake and flows to Glenbrook Pond in Wayzata, which is discharged by storm sewer into Wayzata Bay of Lake Minnetonka. Part of the creek was channelized as County Ditch #32 at some unknown past date. Flow in the creek is controlled by an outlet weir on Gleason Lake and is mainly runoff event-driven. The creek flows through five culverts at the US Highway 12/TH 101 interchange (Figure 2.27).

At this time no streams are listed as Impaired Waters. Total phosphorus concentrations on CD #15 at the Gleason Lake inlet are high relative to the state river eutrophication standards. However, those standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand that haven't been assessed in CD #15.

Table 2.33 shows the average TSS concentrations in Gleason Creek and CD #15 to be well below the 30 mg/L state standard for this ecoregion. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. Monitoring data show that Gleason Creek can fall below this standard in summer during periods of no or low flows.

To assess long-term change in Gleason Lake Outlet station, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2005-2015. There were no statistically significant changes in water quality in Gleason Lake Outlet during this period (Table 2.34). Tables 2.33 and 2.34 below detail the physical and water quality characteristics of streams and tributaries within the subwatershed. For more information please refer to the District's Water Quality (Hydrodata) reports.

Table 2. 33. Major streams in the Gleason Lake subwatershed.

Stream	Length (mi)
Gleason Creek	0.87
County Ditch #15	2.47
County Ditch #32	1.01

Table 2. 34. Current conditions of streams in the Gleason Lake subwatershed.
See Figure 2.27 for monitoring locations.

Stream	Trend*	2005-2015 Summer Average			
		TP (µg/L)	TN (mg/L)	TSS(mg/L)	Cl (mg/L)
Gleason Creek (CGL01) – lake outlet	No trend	53	0.69	5	101**
CD #15 (CGL03) – lake inlet	n/a	150	0.891	12	130***

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride.
*Statistically significant at $\leq$ 0.05, **Data are from 2009-2015; ***Data are from 2008-2015.
Source: MCWD.

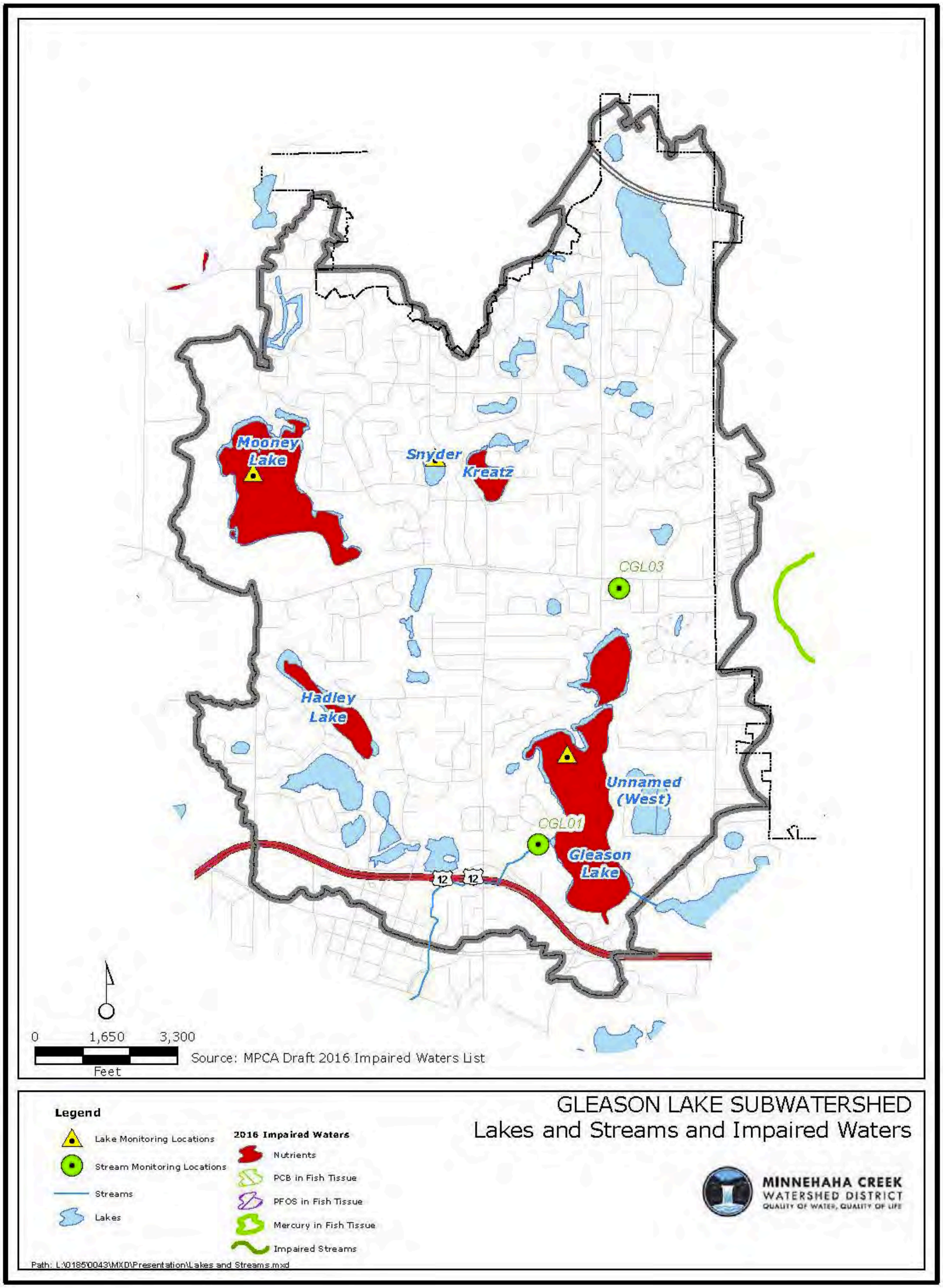

Figure 2. 27. Gleason Lake subwatershed lakes and streams and Impaired Waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover 13.9 percent of the watershed's surface (Figure 2.28 and Table 2.35). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients to and from the subwatershed. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2. 35. Functional Assessment of Wetlands inventory of wetland types in the Gleason Lake subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	12.8	0.34
2 - Wet Meadow	15.4	0.41
3 - Shallow Marsh	231.6	6.22
4 - Deep Marsh	18.1	0.49
5 - Open Water	153.0	4.11
6 - Scrub Shrub	9.8	0.26
7 - Forested	76.6	2.06
8 – Bog	-	-
Riverine	-	-
Wetland Total	517.3	13.9
Upland	3,198.8	86.1
TOTAL	3,716.1	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

The infiltration potential of the upland areas within the subwatershed is described as medium to low with some areas of variability where the soils are organic in nature. The *Hennepin County Geologic Atlas* classifies area to the north of Gleason Lake as high infiltration potential and also high aquifer sensitivity due to the outwash nature of the underlying soil deposits.

The entire Gleason Lake subwatershed has been designated by the Minnesota Department of Health as a Drinking Water Supply Management Area (DWSMA) and Wellhead Protection Area (WHPA) for City of Plymouth public wells. The MDH has designated areas within the DWSMA as high to moderate risk and vulnerability to contamination of the drinking water supply. Figure 2.29 shows areas in the subwatershed with groundwater sensitivity and that are designated as higher Drinking Water Sensitivity.

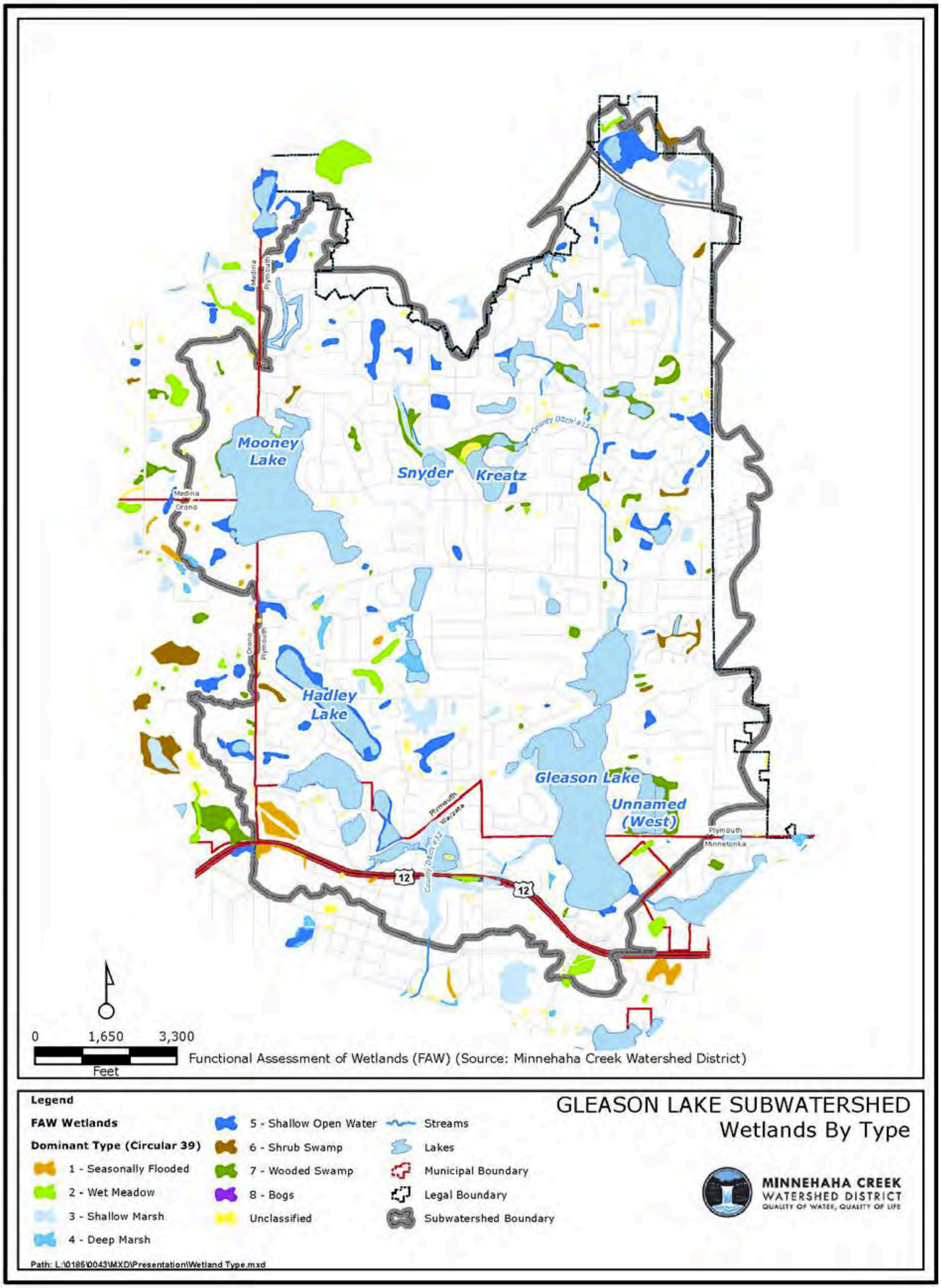

Figure 2. 28. Gleason Lake subwatershed wetlands by type.

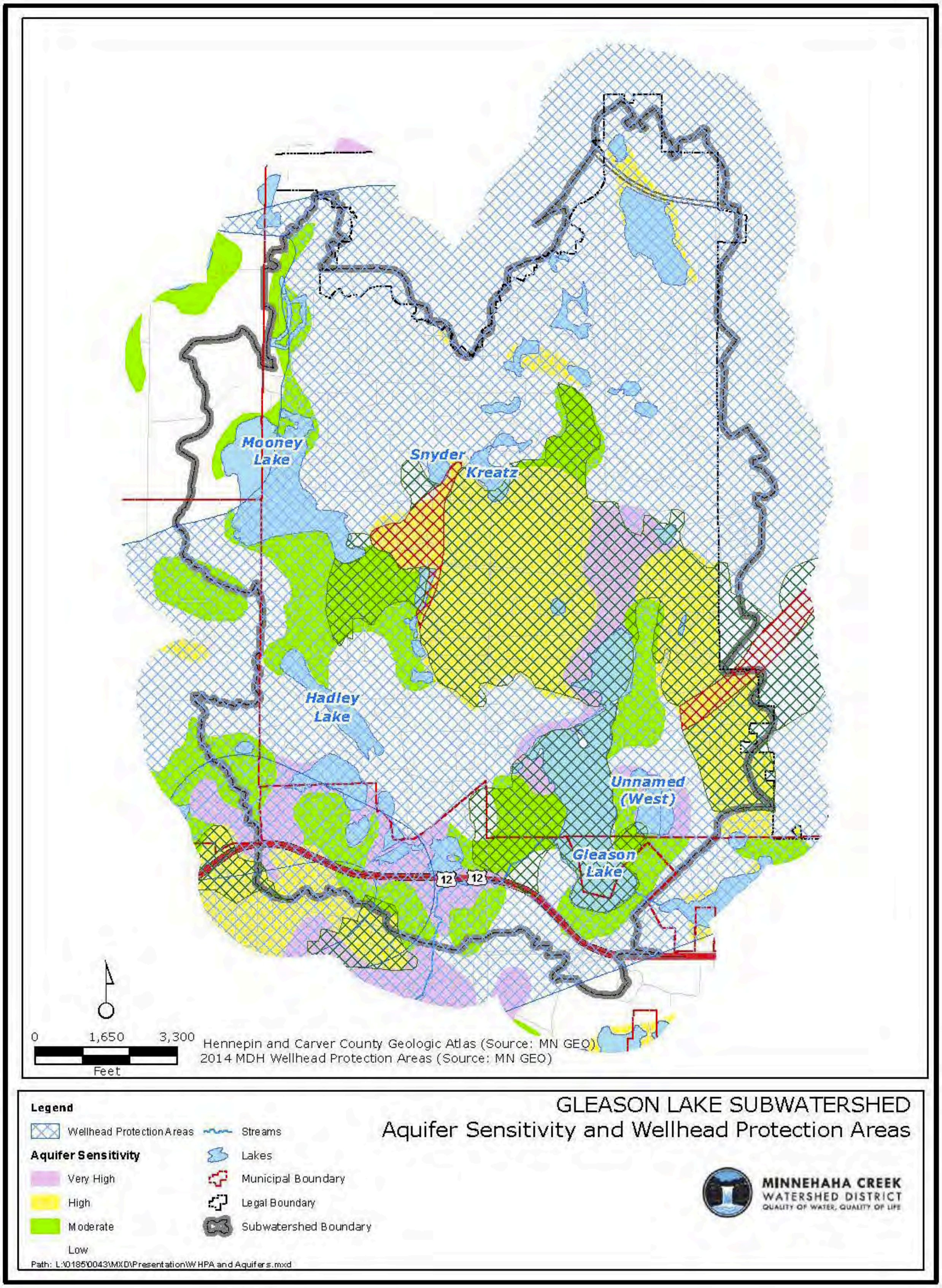

Figure 2. 29. Gleason Lake subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

Mooney Lake basin is landlocked and pumps water out of the basin once the lake reaches a certain elevation towards HL-1 (Figure 2.26). No statistical assessment on water-yield was computed for the Gleason Lake Subwatershed.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Gleason Lake subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data, where available (Figure 2.30).

Lakes:

Biodiversity

Fish Community. The most recent fish survey for Gleason Lake was conducted in 2011 for the City of Plymouth. It identified a fishery dominated by bluegills and yellow bullheads. Pumpkinseed sunfish and black crappies were also found in above-average numbers. In 2016, a fish survey indicated Mooney Lake has a healthy fish community. No fish survey data are available for the other lakes.

In 2007, the District completed fish and macroinvertebrate sampling on Gleason to assess the impact of whole-lake Curly leaf Pondweed treatments. Fish and invert IBI protocols were still in development at the time, so while IBI scores were computed they are similar to but not directly comparable to the current IBI protocols and metric scores used in the E-Grade program.

Fish sampling found bluegills to be the dominant species, with top predators underrepresented. Gleason Lake had a low IBI score based on the existing fish community. However the IBI score was within the expected range for lakes with similar trophic status and dominant watershed land use.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. No Floristic Quality Index data are available. An aquatic vegetation survey was completed in 2002 by Blue Water Science for the Gleason Lake Management Plan. Gleason Lake is almost entirely littoral (less than about 15 feet deep), with extensive aquatic vegetation dominated by coontail. Curly leaf pondweed was detected at one-third of the stations sampled in the lake at nuisance densities. A whole-lake treatment was applied to the lake in 2007, followed by spot treatments. Just prior to treatment curly leaf pondweed was found at 8 of the 27 sample stations in the small north basin and at 101 of the 127 sample stations in the main lake, at an average of 817 stems/m^2 before treatment, well above the nuisance threshold of 100 stems/m^2 . Following treatment, curly leaf pondweed was found at only 1 of 27 sample stations in the north basin and 1 of 127 stations in the main lake. Curly leaf has not been eradicated from the lake, but it has been substantially reduced. A more recent survey was performed in 2014, and a total of 6 species were found with coontail dominating the community.

Aquatic Invasive Species: Curlyleaf pondweed has been confirmed in Gleason Lake and Mooney Lake.

Habitat diversity

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species, or the extent to which it may be dominated by a few species. Gleason Lake is almost entirely littoral (less than about 15 feet deep), with extensive aquatic vegetation dominated by coontail. Whole-lake and spot herbicide treatments appear to have controlled the previously nuisance-level of curly leaf pondweed.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score The Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score The Shore data are available. Much of the shoreline around the lakes within this subwatershed is developed, with homes maintaining turf grass to the shoreline and scattered stands of emergent vegetation.

Macroinvertebrate Community. Macroinvertebrates were sampled in Gleason Lake in 2007 and 2012 using the MPCA's protocol for monitoring depression wetlands. At the time the MPCA's threshold of impairment was an IBI of 36 on a 100 point scale. The mean of four locations sampled on Gleason Lake was 47.5. In 2012, when sampling was repeated following whole-lake treatment of curly-leaf pondweed, the IBI threshold was 47. IBI scores at the four Gleason Lake locations ranged from a high of 50 to a low of 26, indicating impairment. It was hypothesized that following treatment the native plant community had not yet reestablished, and thus the lake lacked sufficient habitat to maintain a diverse invertebrate population.

Streams:

Biodiversity

Fish Community. No fish data are available for streams in the subwatershed.

Macroinvertebrate Community. Biological sampling on Gleason Creek was conducted as a part of the *2004 Upper Watershed Stream Assessment.* Two sites were sampled; only one yielded more than the 100 organisms typically needed to assure sample reliability. The H-IBI fell into the Poor category. Seven taxa of organisms were found, dominated by pollution-tolerant species. In 2013 the invertebrate sampling was replicated. The two sites scored 14 and 18 on a 100-point scale, falling well below the M-IBI impairment threshold of 43. The samples were dominated by pollution-tolerant species, and lacked representation from a broad range of functional feeding groups.

Aquatic Invasive Species: No AIS data are available for streams in the subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity. However, notes taken for the *2004 Upper Watershed Stream Assessment* were reviewed to better understand conditions in the in-stream zone and riparian zone, and to assess channel morphology. That survey divided the stream into 5 reaches. The survey found that the stream in some locations had moderately complex habitat and morphology, but in general the stream is less complex and more altered.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. That survey divided the stream into 5 reaches, with the predominance of barriers located within reach 4. There are several barriers on the streams in this subwatershed, most of them are storm sewer outfalls, and culverts at road or trail crossings and where the stream crosses under Highway 12/101 interchange. There are no stream cross-section data available, but notes taken for the 2004 Upper Watershed Stream Assessment indicate the stream generally has low banks and direct access to ponds and wetlands.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are not available, but based on observation, both Gleason Creek and CD #15 do run dry at times in the summer.

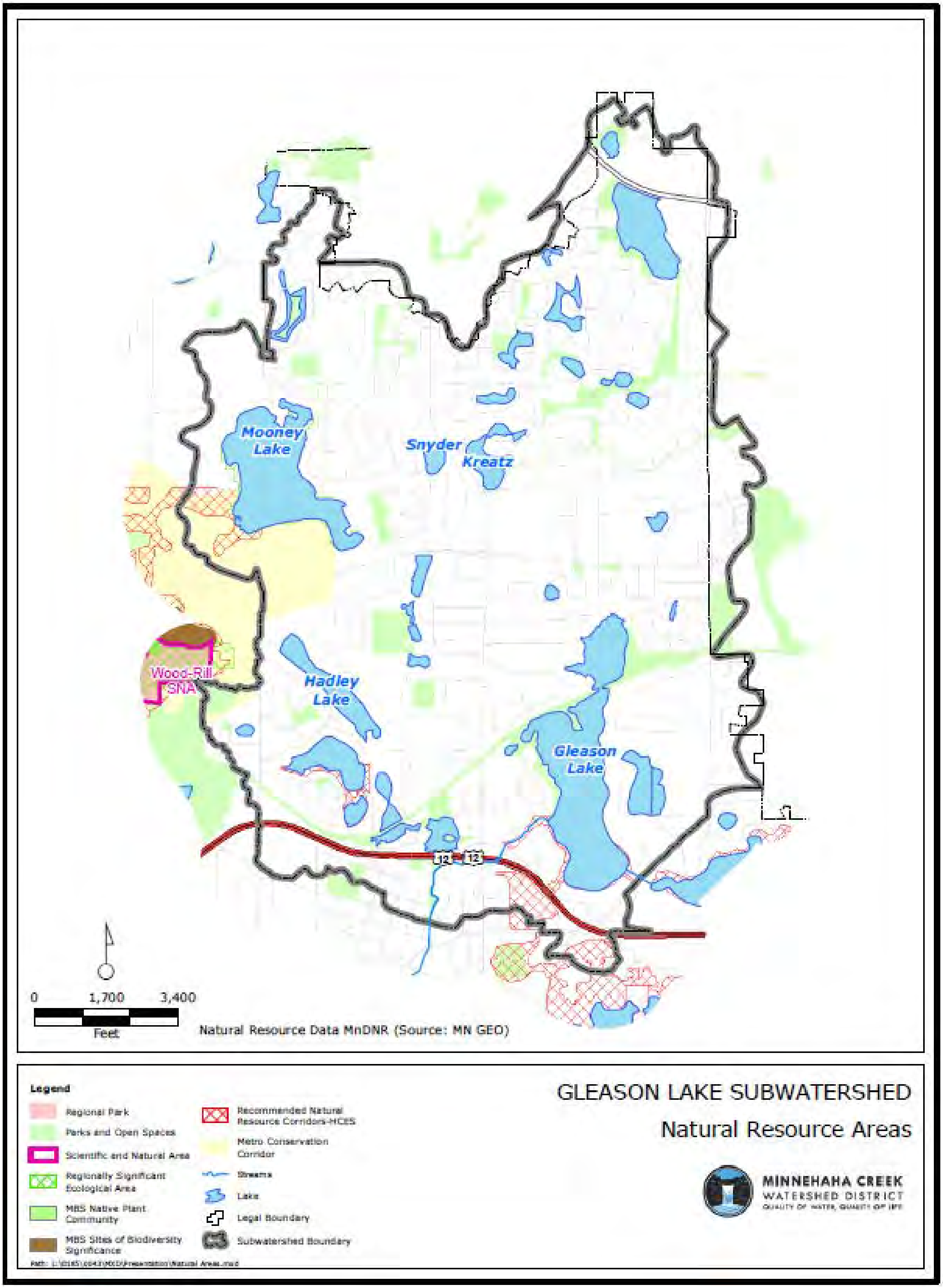

Figure 2. 30. Gleason Lake subwatershed natural resource areas.

Wetlands:

Biodiversity

Vegetation Community. No Floristic Quality Index data are available for the wetlands in this subwatershed. However some scattered wetlands were identified in the *Functional Assessment of Wetlands* as having high vegetative diversity and wildlife habitat potential as well as having high aesthetic values. Wetlands riparian to Gleason Lake were noted as important fish habitat.

Habitat diversity

Connectivity. Some scattered wetlands were identified in the 2003 MCWD *Functional Assessment of Wetlands* (FAW) as having high vegetative diversity and wildlife habitat potential as well as having high aesthetic values. Wetlands in this subwatershed have little to no connectivity.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species. There are a few large wetlands in the subwatershed, to the east and west of Gleason Lake and another south of TH 55.

Shoreline Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. Approximately half of the Gleason Lake shoreline is identified as probable wetlands under the National Wetland Inventory (NWI) however most of that area is residential development with a very narrow band of emergent vegetation at the shoreline.

Uplands:

Biodiversity

Existing data sources do not highlight any other unique or scenic areas in this subwatershed. The Gleason Lake Creek subwatershed is mostly developed, with few intact areas of minimal disturbance. The Minnesota Biological Survey (MBS) did not identify any landscape areas of biological significance in this subwatershed, although the Wood-Rill Scientific and Natural Area is just outside of this subwatershed in Orono. Some wooded and wetland areas around Hadley Lake and a few pocket wetlands and wooded areas elsewhere in the subwatershed provide the most significant areas of habitat and biological integrity (Figure 2.30).

Habitat diversity

Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. Most of the Gleason Lake subwatershed is fully developed with limited upland areas in a natural state. Some wooded and wetland areas around Hadley Lake and a few pocket wetlands and wooded areas elsewhere in the subwatershed provide the most significant areas of habitat and biological integrity.

Thriving Communities:

Land use:

Table 2.34 below shows the land uses within the area of the Gleason Lake subwatershed in acres and as a percentage of the total subwatershed. The predominant land use in the subwatershed is single-family residential (Figure 2.31). There is a commercial/industrial corridor along TH 55 and Vicksburg Lane in the upper subwatershed, and another commercial node at TH 101 and County Road 5. Some small pockets of undeveloped area remain, mainly large lots.

A small corner of the subwatershed in the City of Orono is outside the MUSA 2020 area.

Table 2. 36. 2016 land use in the Gleason Lake subwatershed.

Land Use 2016	Acres	% of Subwatershed
Single - Family Residential	2,525.5	57.9
Water	402.4	9.2
Parks and Open Space	341.6	7.8
Multi - Family Residential	326.9	7.5
Vacant or Undetermined	299.0	6.8
Institutional	193.5	4.4
Commercial	125.9	2.9
Roads and Highways	101.4	2.3
Industrial	24.9	0.6
Agricultural	24.2	0.6

Source: Metropolitan Council.

Recreation:

The Luce Line Regional Trail passes through this subwatershed, crossing the north end of Gleason Lake. Existing data sources do not highlight any other unique or scenic areas in this subwatershed. The Minnesota Historic Features database notes 15 historic features in this subwatershed, all farmhouses or residences (Figure 2.32). There is no public boat access, beach or parks on Gleason Lake other than the regional trail crossing and none on the other lakes in the subwatershed.

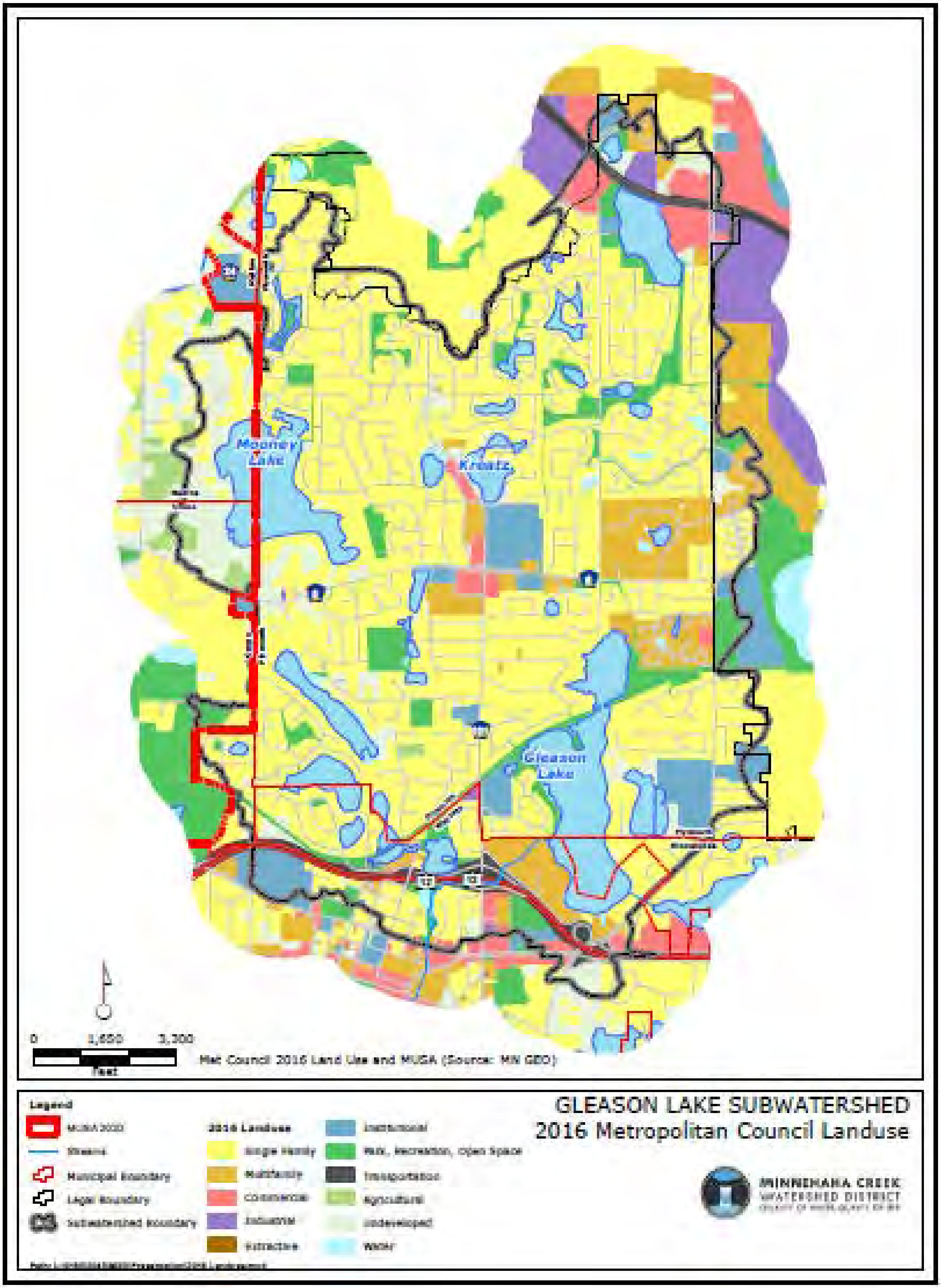

Figure 2. 31. Gleason Lake subwatershed 2016 Metropolitan Council land use.

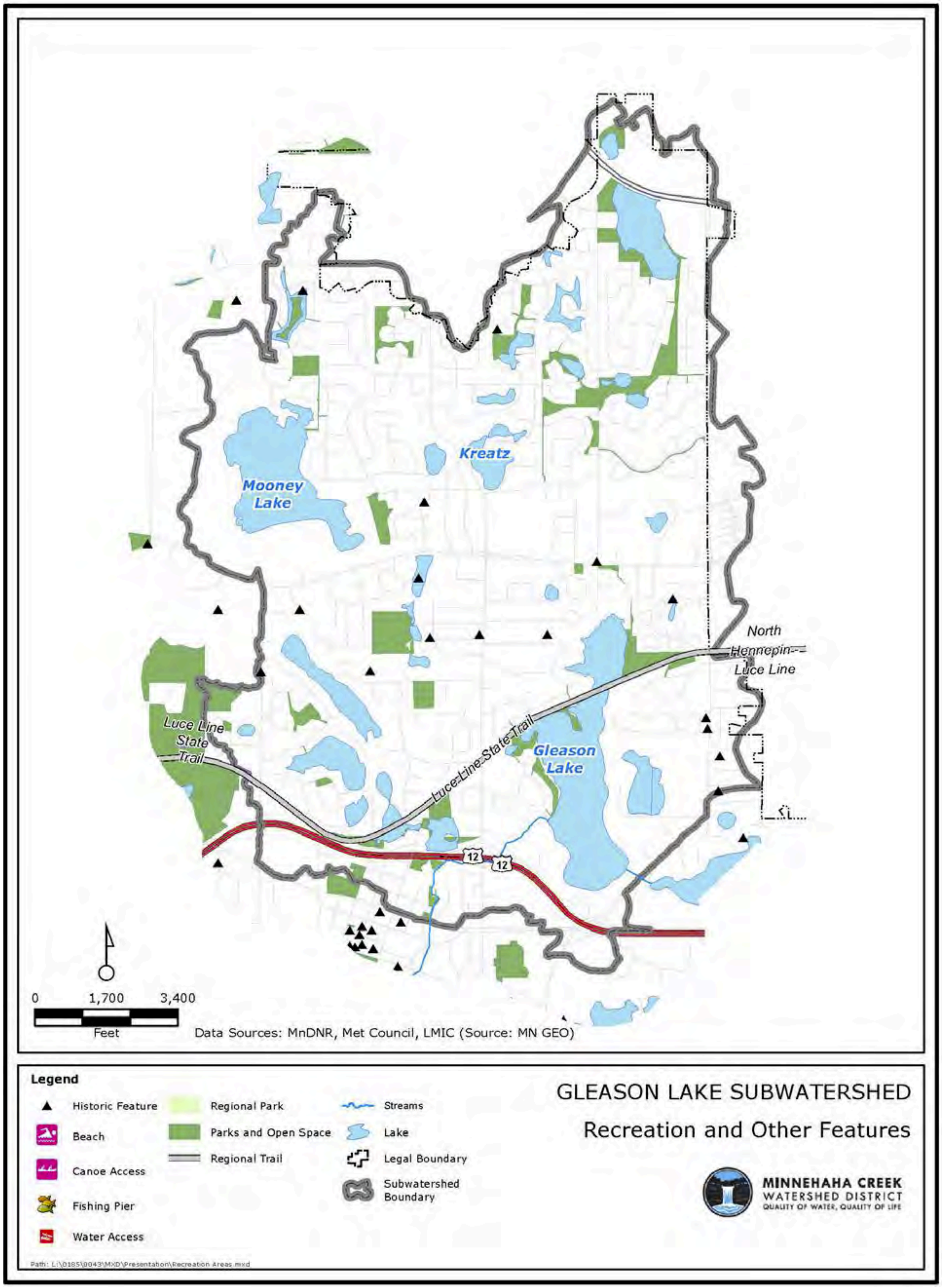

Figure 2. 32. Gleason Lake subwatershed recreation and other features.

2.3.4 LAKE MINNETONKA SUBWATERSHED

The land cover in the Lake Minnetonka Subwatershed is comprised of lakes, wetlands and scattered pockets of forest, woodlands and grasslands. Single-family residences, marinas, sailing schools, and restaurants are concentrated along the shorelines. Agricultural uses exist on the western boundary of the subwatershed in the vicinity of Halsted Bay, Jennings Bay, North Arm and Stubbs Bay.

Unlike the other subwatersheds in the MCWD, the Lake Minnetonka Subwatershed receives direct drainage from nine major sources. The health and function of Lake Minnetonka is not only affected by these creek inlets, but also affected by aquatic invasive species. Lake Minnetonka was one of the first lakes in the Watershed District to be infested with Eurasian watermilfoil and zebra mussels.

Table 2.37 shows the area of the Lake Minnetonka subwatershed in acres by individual city, in total, and as a percentage of the total subwatershed (Figure 2.33).

Table 2. 37. Cities in the Lake Minnetonka subwatershed.

City	Area (Acres)	% of Subwatershed
Chanhassen	146.8	0.4%
Deephaven	1,993.6	6.1%
Excelsior	551.5	1.6%
Greenwood	660.7	2.0%
Long Lake	4.5	<0.1%
Minnetonka	722.0	2.2%
Minnetonka Beach	981.4	3.0%
Minnetrista	5,153.8	15.8%
Mound	2,543.2	7.8%
Orono	10,740.1	33.0%
Shorewood	3,912.2	12.0%
Spring Park	387.2	1.1%
Tonka Bay	1,346.2	4.1%
Victoria	293.2	0.9%
Wayzata	2,336.4	7.1%
Woodland	741.8	2.2%
Total	32,515.6	

Source: MCWD.

Subwatershed Description and Hydrology:

Rugged hills or knobs and deep irregular depressions called "kettles" dominate this subwatershed. The many bays, points and islands of Lake Minnetonka are formed from submerged knobs and kettles formed by melted glacial ice. The northwestern subwatershed is identified by thinly spread glacial drift and circular, level-topped hills with low slopes, small streams and numerous lakes and peat bogs. The dominant water feature in this subwatershed is Lake Minnetonka.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.34). Most of the subwatershed is fully developed, although the upper subwatershed includes some large agricultural and forested areas. Wetlands are scattered throughout the subwatershed. For more information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Drainage is conveyed from the watershed to the lake through several streams, including Gleason Creek, Long Lake Creek, Classen Creek, Painter Creek, and Six Mile Creek, as well as through smaller channels or storm sewers. The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Lake Minnetonka subwatershed district into 26 subwatershed units and the minor subwatersheds into 19 drainage areas that include from one to six subwatershed units (Figure 2.35).

The subwatershed outlets through a control structure on Grays Bay into Minnehaha Creek. The dam is operated by the District in accordance with the limitations set forth in the Headwaters Control Structure Management Policy and Operating Procedures and Minnesota DNR Permit #76-6240.

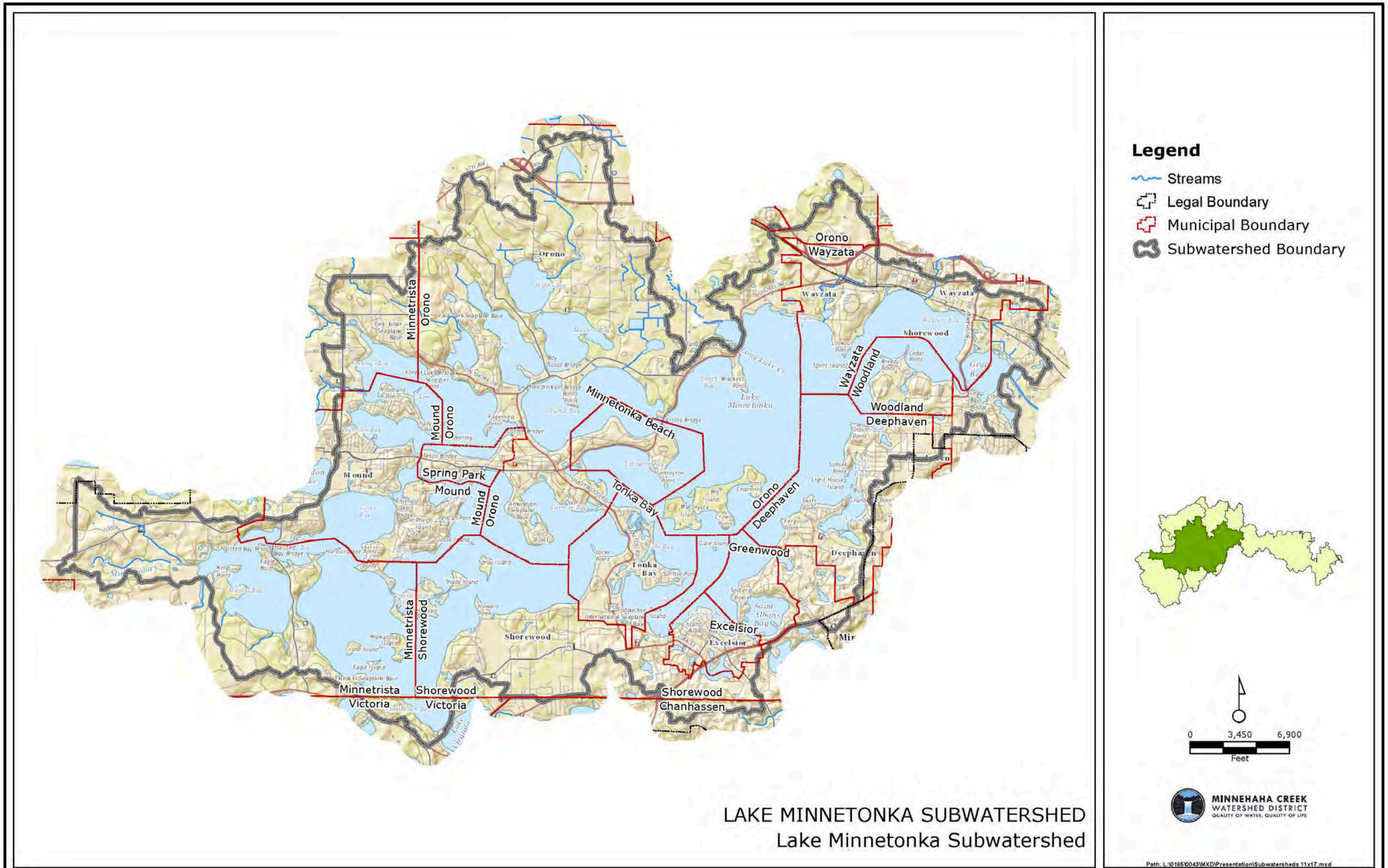

Figure 2. 33. The Lake Minnetonka subwatershed.

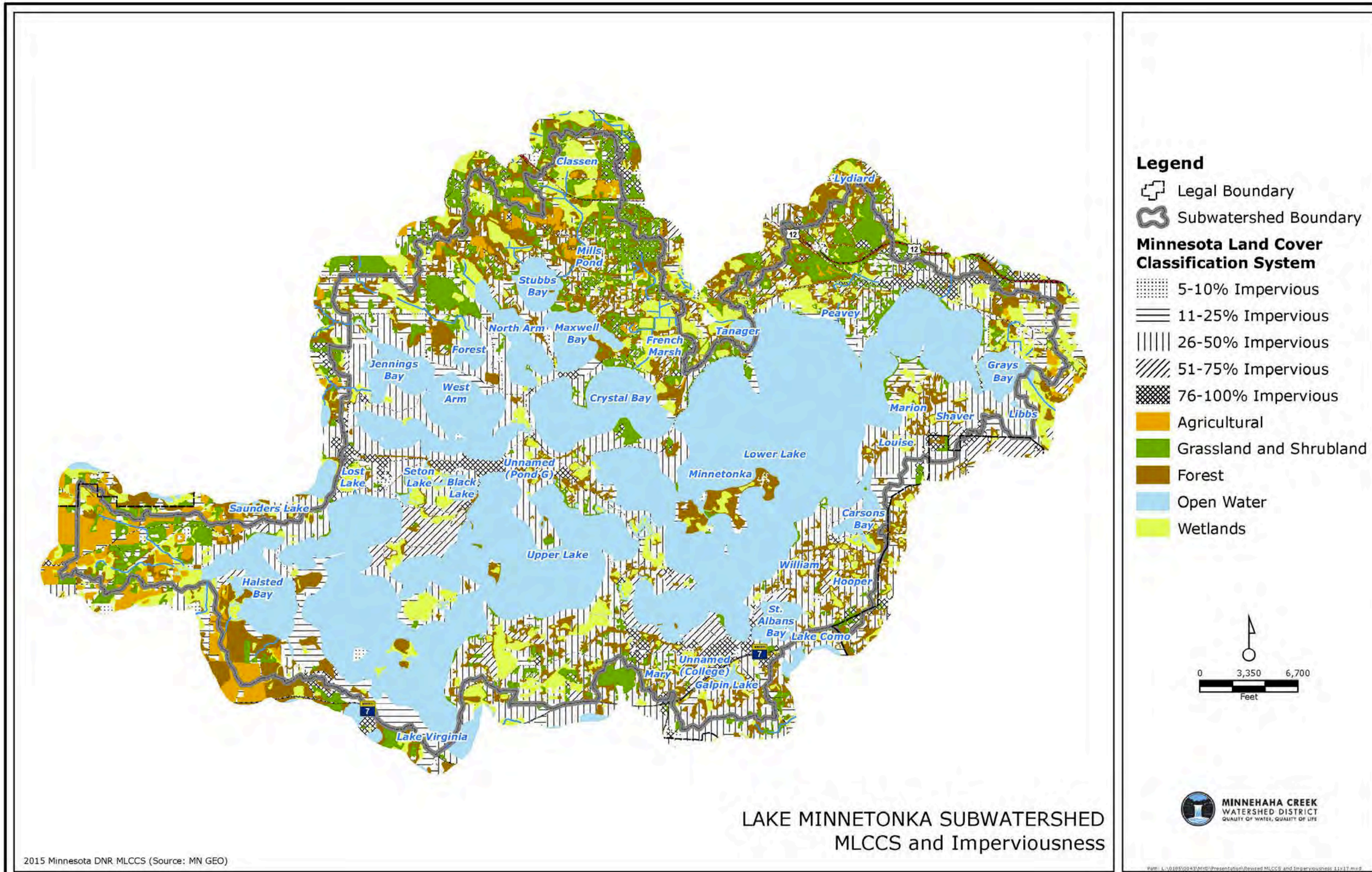

Figure 2. 34. Lake Minnetonka subwatershed MLCCS and imperviousness.

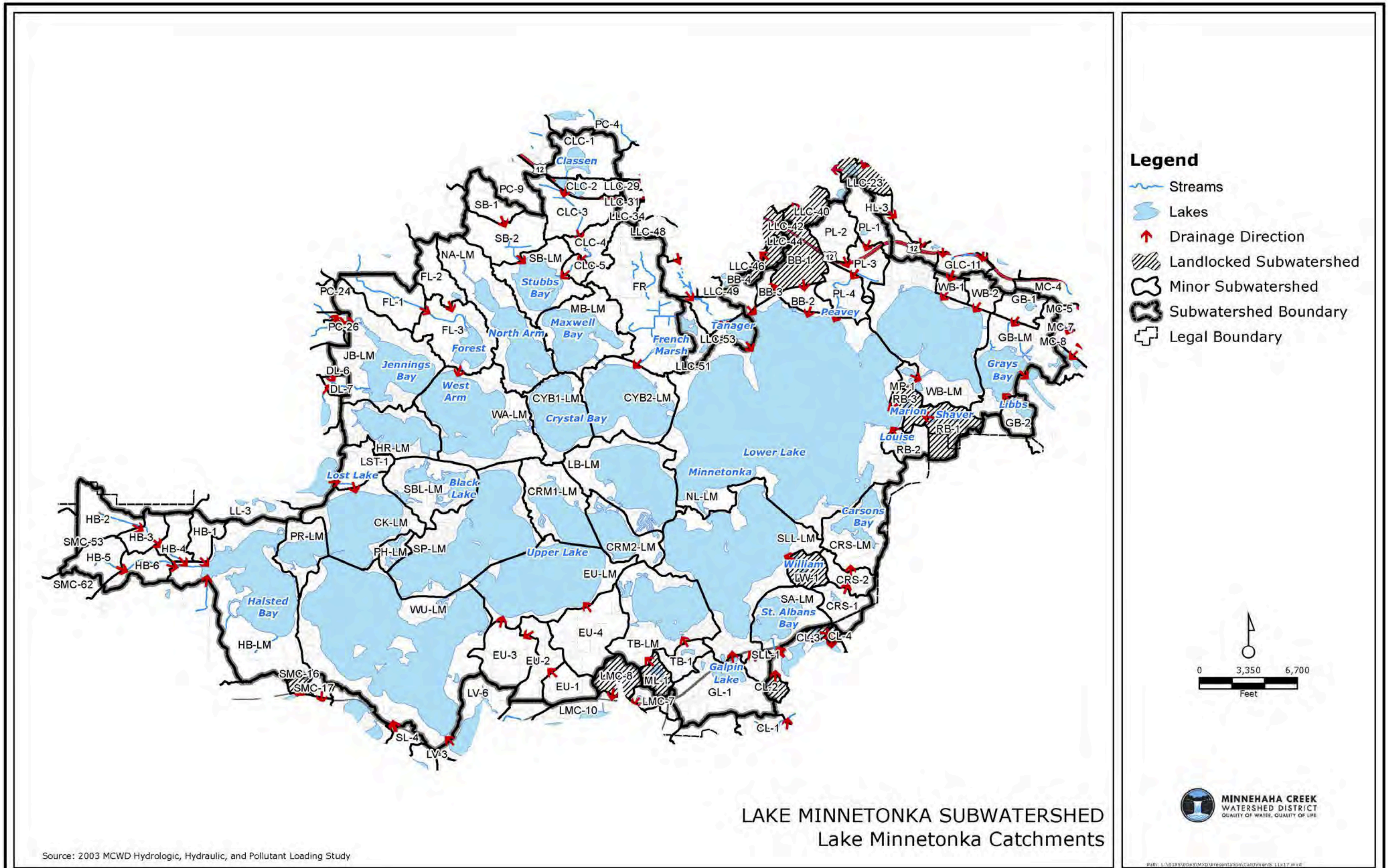

Figure 2. 35. Lake Minnetonka subwatershed catchments.

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Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

The subwatershed is dominated by Lake Minnetonka with its complex configuration of bays and channels. The lake is classified by the DNR for shoreland management purposes as a Recreational Development lake (Table 2.38). There are numerous other smaller lakes in the subwatershed. The District monitors Lake Minnetonka and some small lakes, while several of the small lakes are monitored by trained volunteers. Tables 2.38 and 2.39 below detail the physical and water quality characteristics of Lake Minnetonka and other lakes within the subwatershed.

Four Lake Minnetonka bays (Halsted, Jennings, Stubbs, and West Arm) and Forest Lake exceed the state standard for total phosphorus, and are listed on the State's Impaired Waters list for nutrient/eutrophication biologic indicators. A TMDL completed for those impairments identified a significant amount of excess nutrients discharged into those water bodies from the watershed, as well as load contributed from internal sources such as lake sediments. To assess long-term change, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth on lakes/bays that had 8 or more years of data. Statistically significant changes in water quality are listed in Table 2.39. For more information regarding water quality in the subwatershed, please refer to the District's annual Water Quality Reports and the Upper Minnehaha Creek Watershed Lakes TMDL.

Table 2. 38. Physical characteristics of lakes in the Lake Minnetonka subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Classen Lake	53	3	6:1	Natural Environment
Forest Lake	90	42	10:1	General Development
Lake Galpin	46	13	11:1	Recreational Development
Lake Marion	13	45	26:1	Recreational Development
Lake Minnetonka	14,004	113	5:1	General Development
Libbs Lake	22	8	5:1	Natural Environment
Peavey Pond	9	63	86:1	n/a
Shavers Lake	19	7	12:1	Recreational Development
Lake William	16	12	8:1	Recreational Development

Source: Minnesota DNR.

Table 2. 39. Selected water quality goals and current conditions of waterbodies in the Lake Minnetonka subwatershed.

Waterbody	State TP Standard (µg/L)	2007 Plan Goal TP (µg/L)	Trend**	2001-2015 Average			Years Monitored
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)	
Classen Lake	n/a	n/a	n/a	107	80	0.5	2009-2010
Forest Lake	40	n/a	No trend	63	49	0.9	1996-2015
French Marsh	n/a	n/a	n/a	48	11	0.9	2011-2012
Lake Galpin	60	60	n/a	n/a	n/a	1.4	2011
Hooper Lake	n/a	n/a	n/a	29	10	1.8	2010-2011
Lake Marion	n/a	*	n/a	14	3	3.6	2009-2012
Libbs Lake	60	30	n/a	22	5	1.5	2011-2012
Lake Louise	n/a	*	n/a	47	16	1.8	2006-2008
Peavey Pond	n/a	*	Deg Secchi, TP	89	20	1.9	1999-2015
Shavers Lake	60	*	n/a	42	8	1.2	2001-2015
Lake William	n/a	n/a	n/a	38	8	1.1	2009-2015
Lake Minnetonka Bays							
Black Lake	40	45	No trend	32	14	2.1	2006-2015
Browns	40	20	n/a	n/a	n/a	n/a	n/a
Carman	40	50	No trend	22	8	2.7	2004-2013
Carsons	40	50	Imp Secchi	22	4	3.5	2004-2015
Cooks	40	30	No trend	29	13	2.1	1997-2015
Crystal	40	25-30	Imp Secchi	26	10	2.6	1997-2015
Grays	40	20	Imp Secchi, TP	21	4	3.6	2004-2015
Halsted	40	50-60	No trend	104	62	0.9	1997-2015
Harrisons	40	50	No trend	58	48	0.9	2001-2013
Jennings	40	50-70	No trend	114	69	0.8	2005-2015
Lafayette	40	20	Imp Secchi, Chl-a	21	5.4	3.5	1997-2015
Lower Lake North	40	20	No trend	20	5	4	2005-2013
Lower Lake South	40	20	All Imp	19	5	3.7	1997-2015
Maxwell	40	40	No trend	32	14	1.9	1997-2015
North Arm	40	30	No trend	31	13	1.9	2001-2013
Phelps	40	20	n/a	24	7	3.3	2006-2013
Priests	40	30	Deg Chl-*a*	27	38	1.4	2006-2016
Robinsons	40	30	n/a	n/a	n/a	n/a	n/a
St. Albans	40	20	All Imp	20	4	4	1997-2015
St. Louis	40	50	n/a	n/a	n/a	n/a	n/a
Smithtown	40	n/a	No trend	22	8	2.5	2004-2013
Spring Park	40	20	Imp Secchi, TP	22	7	3.2	2006-2015
Stubbs	40	50-55	No trend	47	52	0.9	2006-2015
Wayzata	40	20	Imp Secchi	21	4	3.7	1997-2015
West Arm	40	50	No trend	72	54	1	1997-2015
West Upper	40	25	No trend	26	8.7	2.6	1997-2015

*10% reduction from existing, provided it is greater than 25 µg/L; will require baseline data
*Statistically significant at ≤ 0.05, Imp = improving, Deg = degrading.
Source: MCWD, MPCA, City of Minnetonka.

Streams:

There is one primary stream within the subwatershed: Classen Creek, which flows 1.9 miles from Classen Lake to Stubbs Bay. Two other small streams flow out of wetlands and into Stubbs Bay and Forest Lake. Several other small streams and channels provide drainage and local conveyance within the subwatershed.

At this time Classen Creek is not listed as an Impaired Water, but does exhibit TP concentrations that are high relative to the state river eutrophication standards. However, those standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand that haven't been assessed. CST01 and CFO01 are both short wetland outlet channels discharging into Stubbs Bay and Forest Lake, respectively, and would not likely be assessed by the MPCA for potential impairment. Each of these streams is likely contributing significant nutrients loads to their respective receiving waters. Table 2.40 below details the water quality characteristics of streams and tributaries within the subwatershed.

The average TSS concentrations at monitoring stations in the subwatershed are well below the 30 mg/L state standard. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. Monitoring data show that DO at the Classen Wetland and Forest Lake inlet stations both fall below the standard multiple times per year, as does the Classes Creek upstream station .

To assess long-term change, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2005-2015. There is a statistically significant increase in TP concentrations during this period at Classen Wetland Creek (CST01) that drains into Stubbs Bay. For more information, please refer to the District's Water Quality reports.

Table 2. 40. Current conditions of streams in the Lake Minnetonka subwatershed.
See Figure 2.36 for monitoring locations.

Stream	Trend*	2005-2015 Summer Average			
		TP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl (mg/L)**
Classen Creek (CCL04)	n/a	163	1.46	8	59
Classen Creek at Stubbs Bay Inlet (CCL01)	No trend	193	1.34	20	60
Classen Wetland Cr at Stubbs Bay Inlet (CST01)	Deg TP	277	1.47	7	48
Forest Lake Inlet (CFO01)	No trend	232	0.97	6	91

*Statistically significant at ≤ 0.05, Deg = degrading, **Data from 2008-2015
Source: MCWD.

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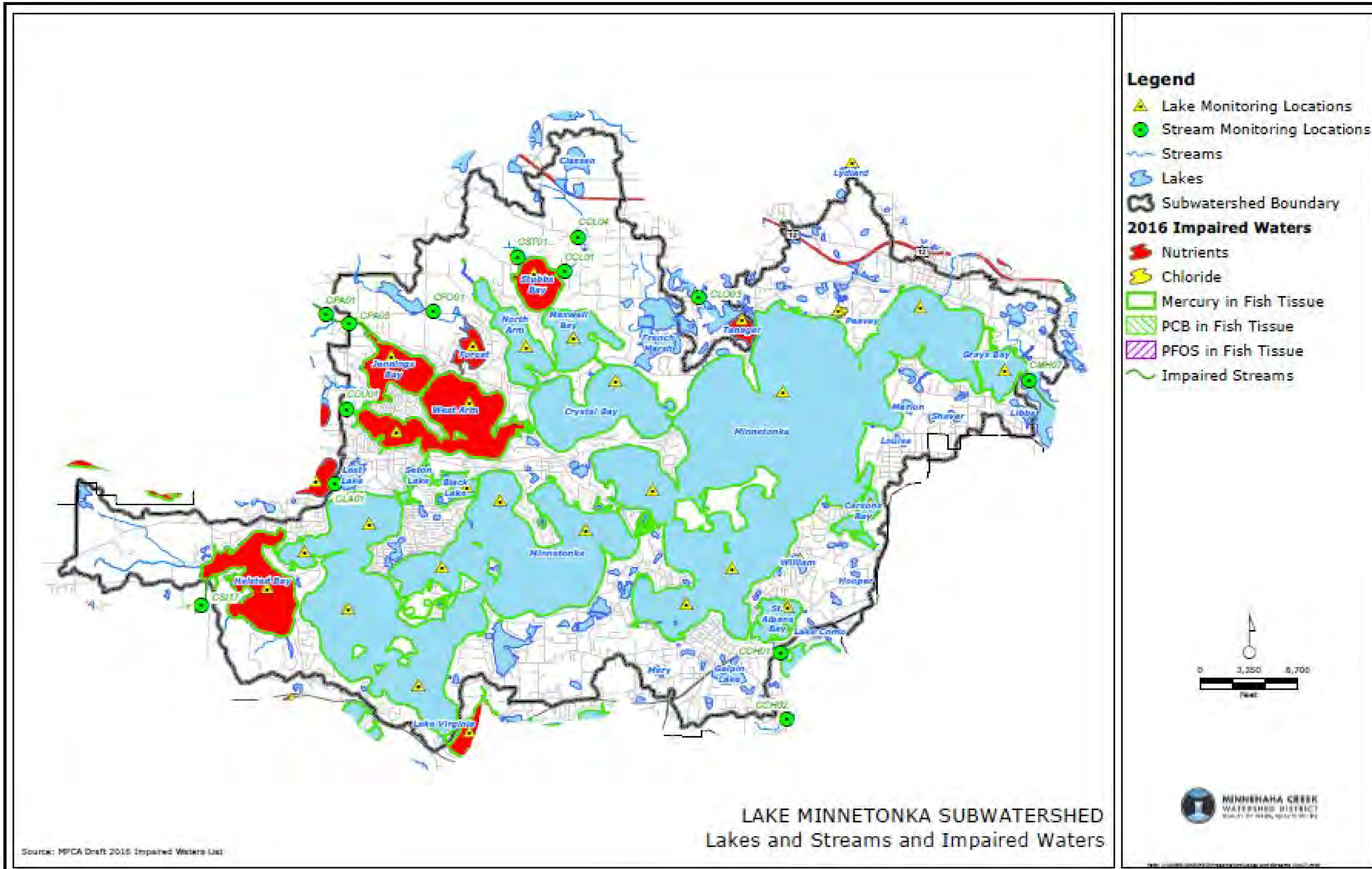

Figure 2. 36. Lake Minnetonka subwatershed lakes and streams and Impaired Waters.

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Wetlands:

According to the FAW, wetlands, including lakes, cover nearly 13.7 percent of the watershed's surface (Figure 2.37 and Table 2.41). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2. 41. Functional Assessment of Wetlands inventory of wetland types in the Lake Minnetonka subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 – Seasonal	71.9	0.40
2 - Wet Meadow	269.1	1.49
3 - Shallow Marsh	1,148.3	6.35
4 - Deep Marsh	562.6	3.11
5 - Open Water	181.3	1.00
6 - Scrub Shrub	163.2	0.90
7 – Forested	72.8	0.40
8 – Bog	2.5	0.01
Riverine	6.9	<0.1
Wetland Total	2,478.5	13.7
Upland	15,661.8	86.3
TOTAL	18,140.3	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

The infiltration potential of the upland areas in the subwatershed are described as low to medium. A large area of high infiltration potential in the eastern subwatershed is associated with an area of sandy till and glacial outwash deposits. The *Hennepin County Geologic Atlas* classifies that till and outwash area, which is most of the area south of Wayzata Bay and much of the city of Wayzata, as well as the south side of the lower lake as being highly or very highly sensitive to pollution. Most of the upland areas are of low sensitivity to pollution.

Parts of the subwatershed have been designated by the Minnesota Department of Health as Drinking Water Supply Management Areas (DWSMA) and Wellhead Protection Areas for various municipal wells. While there are areas of high aquifer sensitivity in these DWSMAs, the MDH has generally designated them to be of low risk and low vulnerability to contamination of the drinking water supply, with only a few areas designated as moderately vulnerable. Figure 2.38 shows areas in the subwatershed with groundwater sensitivity, designated Wellhead Protection Areas, and areas with moderate vulnerability.

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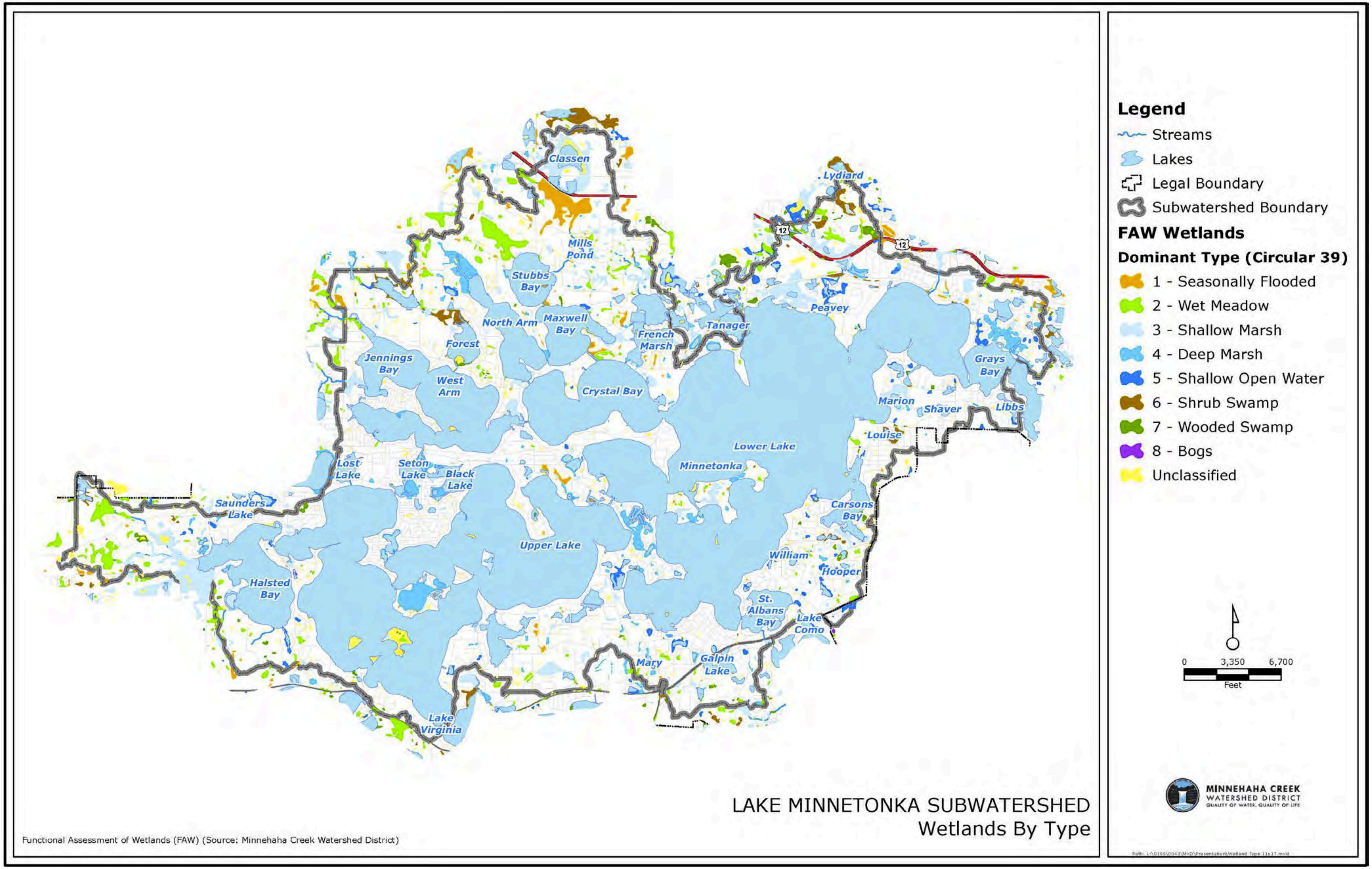

Figure 2. 37. Lake Minnetonka subwatershed wetlands by type.

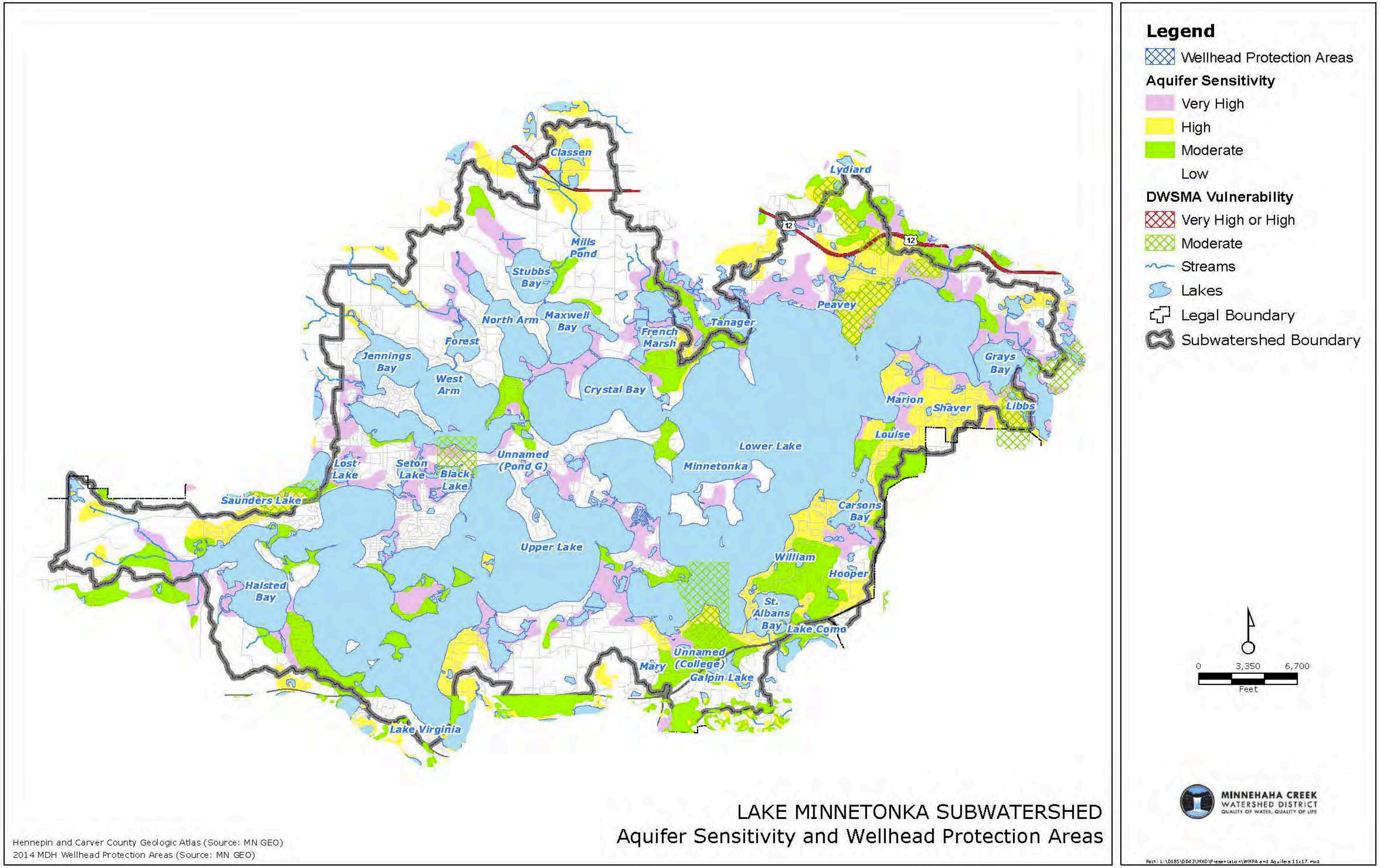

Figure 2. 38. Lake Minnetonka subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

The minor subwatersheds are drainage areas that are small relative to the 11 major subwatersheds, and do not contain lakes that were modeled for water quality purposes. Many of these minor subwatersheds include smaller lakes or ponds. There are several landlocked basins and subwatershed units, including Marion Lake, Mary Lake, Shavers Lake and William Lake.

No statistical assessment on water-yield was computed on the Classen and Forest systems in the Lake Minnetonka Subwatershed.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the water quality section. The Lake Minnetonka subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data, where available (Figure 2.39).

Lakes:

Biodiversity

Fish Community. The DNR conducts extensive fish surveys in Lake Minnetonka every other year, and has found a diverse fish community (14 species) dominated by northern pike, bluegill, and walleye. Several bass tournaments are held on Minnetonka each year and the lake has a reputation for quality fishing for largemouth bass and muskellunge. Walleye and muskellunge are stocked nearly annually. Forest Lake, Peavey Pond, and Libbs Lake were last surveyed by the DNR in 1992, which found them to be dominated by panfish and rough fish.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. Generally, aquatic vegetation is more abundant and diverse in the eastern bays of Lake Minnetonka, which tend to have better water clarity. The far western bays tend to be more algae dominated, poorer clarity, and less aquatic vegetation.

Aquatic Invasive Species. Zebra mussels, Eurasian Watermilfoil, Curlyleaf Pondweed, Flowering Rush and Common carp are all present in Lake Minnetonka. Eurasian Watermilfoil was first discovered in 1987, and can be found in varying densities across the lake. Zebra mussels were confirmed in Lake Minnetonka August 2010, are present in most of the bays, and have been found to be influencing water quality in several areas of the lake. Common carp are present throughout the lake, but over abundant populations can be found in many of the receiving bays of the lake, such as Halsted Bay, and contribute towards ecological degradation in those bays. Flowering rush is present, but not abundant, and is typically found around Big Island, Crystal Bay, Maxwell Bay, Lafayette Bay and Browns Bay.. Eurasian watermilfoil and zebra mussels are also present in Forest Lake, Peavey Lake and Libbs Lake. Eurasian Watermilfoil is present in Galpin Lake.

Habitat diversity

Aquatic Vegetation Community. Habitat and diversity is determined by the percent occurrence of species, or the extent to which they may be dominated by a few species. This has not yet been calculated for Lake Minnetonka, but will be available once E-Grade is completed in the subwatershed.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score The Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score The Shore data are available; however, aerial photos show that many of the smaller lakes in the subwatershed have emergent wetland fringes, which are beneficial for controlling runoff and supporting emergent vegetation at the shoreline. Much of the shoreline of Lake Minnetonka is developed and maintained as turf grass and with a riprap shoreline.

Streams:

Biodiversity

Fish Community. No fish IBI data are available for the streams in this subwatershed.

Macroinvertebrate Community. Two sites on Classen Creek were sampled for macroinvertebrates in 2013. The M-IBI scores were 16 and 17, well below the impairment threshold for its stream type. The community was dominated by pollution-tolerant species and lacking in some functional groups.

Aquatic Invasive Species. No AIS data are available for the streams in this subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity on Classen Creek. However, notes taken for the *2004 Upper Watershed Stream Assessment* were reviewed to better understand conditions in the in-stream zone and riparian zone, and to assess channel morphology. The survey found that the stream in some locations had moderately complex habitat and morphology, but in general the stream is less complex and more altered. There is a small impoundment created by a small earth dam and concrete weir. Several areas of significant streambank erosion were noted.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are several barriers on the streams in this subwatershed, culverts at road crossings as well as a small dam and weir creating an impoundment. There is some access to floodplain, but also segments where the banks are steep.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS increases turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A very flashy stream, that is, one that rises and falls very quickly, can be stressful to organisms. Streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are not available, but the average flow in all these streams is low, which would be indicative of low DO levels.

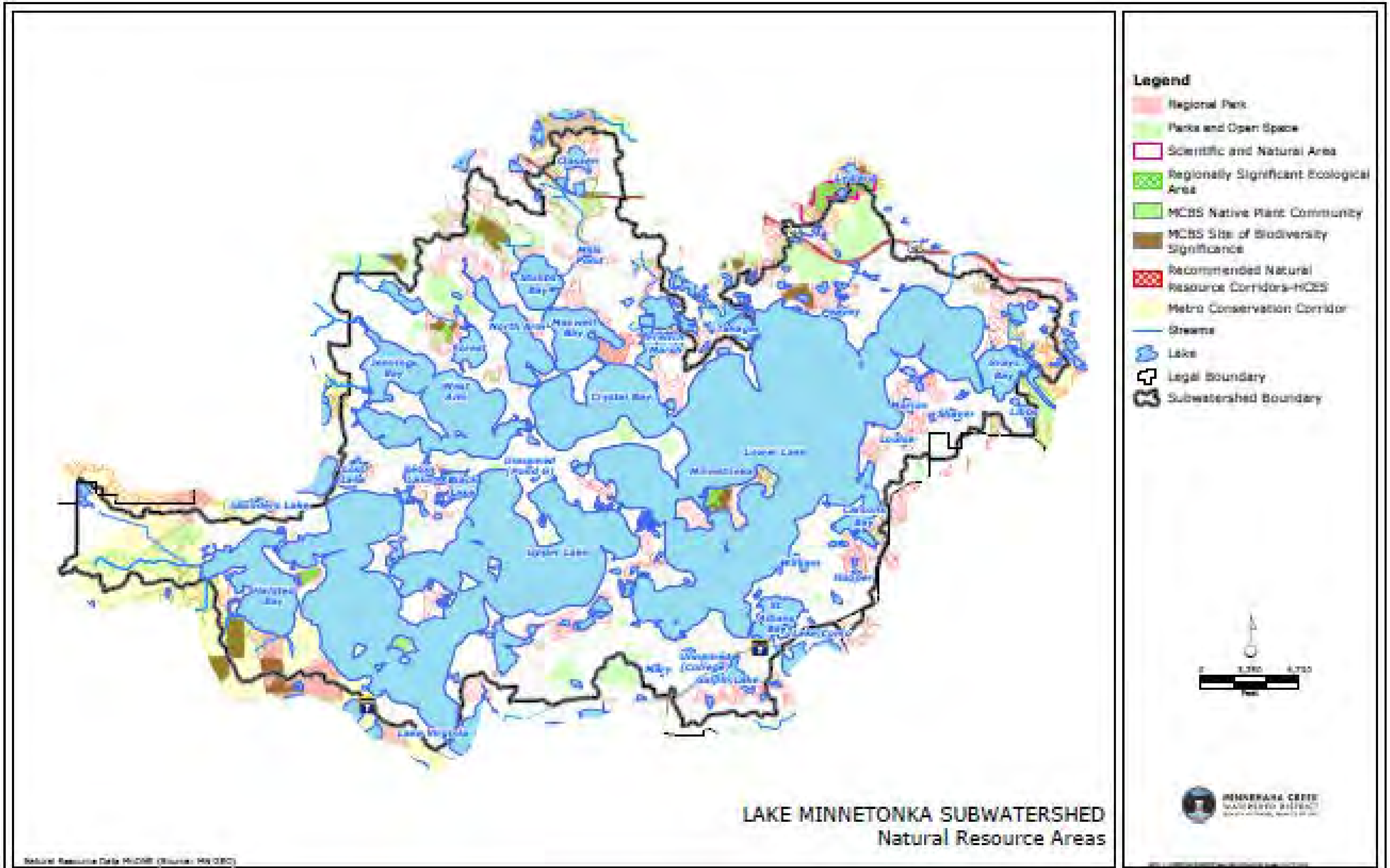

Figure 2. 39. Lake Minnetonka subwatershed natural resource areas.

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Wetlands:

Biodiversity

Vegetation Community. No Rapid Floristic Quality Assessment data are available for the wetlands in this subwatershed. The *Functional Assessment of Wetlands* score only a few scattered wetlands as having exceptional or high vegetative quality. The most notable is Classen Marsh on both sides of Highway 12, which was rated high on vegetative quality.

Habitat diversity

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Uplands:

Biodiversity

A native plant community is a group of native plants that interact with each other and with their environment and are minimally altered by modern human activity or by introduced organisms. The Minnesota Biological Survey has identified several native plant communities in the subwatershed (Figure 2.39), including patches of sugar maple forest, southern mesic maple-basswood forest, a sedge meadow on Big Island, and sedge meadows in the small corner of Wood-Rill Scientific and Natural Area that is within the subwatershed. The Minnesota Biological Survey also assesses sites for biodiversity significance. That rank is based on the presence of rare species populations, the size and condition of native plant communities within the site, and the landscape context of the site. The subwatershed includes areas of moderate significance, including Ferndale Marsh, Big Island, Hardscrabble Woods, and one of high significance – Lowry Woods, which is a wooded/wetland complex upstream of Stubbs Bay.

Habitat diversity

Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. They are rated by examining important ecological attributes of the ecological patches including size, shape, cover type diversity, and adjacent land use. Several locations within the subwatershed have been designed by the DNR as being of ecological significance in the Metro area (Figure 2.39). Many of these areas contain intact native plant communities and are within DNR Metro Conservation Corridors. Hennepin County has also designated areas within the subwatershed as Recommended Natural Resources Conservation Corridors.

Thriving Communities:

Land use:

Table 2.42 below shows the land uses within the area of the Lake Minnetonka subwatershed in acres and as a percentage of the total subwatershed. The subwatershed is nearly one-half covered with water. Single family residential is the predominant non-water land use, with vacant or undetermined and parks and open space are also significant land uses (Figure 2.40). Much of the vacant land is large wetland or woodland tracts or grass and shrubland. Some large agricultural uses and forested tracts are present in the western subwatershed.

Parts of the western and northern subwatershed are outside of the MUSA 2020 boundary, and are not served by regional wastewater facilities.

Table 2. 42. 2016 land use in the Lake Minnetonka subwatershed.

Land Use 2016	Acres	% of Subwatershed
Water	14,641.8	45.0
Single - Family Residential	9,540.0	29.3
Vacant or Undetermined	4,184.9	12.9
Parks and Open Space	2,011.4	6.2
Agricultural	572.7	1.8
Multi - Family Residential	492.5	1.5
Institutional	448.0	1.4
Commercial	378.2	1.2
Roads and Highways	178.1	0.5
Industrial	68.1	0.2

Source: Metropolitan Council.

Recreation:

Two Three Rivers Park District regional parks are located within the subwatershed: Noerenberg Memorial Gardens in Orono and Lake Minnetonka Regional Park. The Park District also owns property on Big Island, Wawatasso Island, and Goose Island. Several regional trails, including the Luce Line, the Southwest Hennepin LRT trail, and the Dakota Rail trail, cross the subwatershed.

The Minnesota Historic Features database notes about 460 historic features in this subwatershed, mostly residences, agricultural or commercial buildings, including over 300 buildings in historic Excelsior alone. The Crane Island Historic District in Minnetrista conserves 14 buildings that exemplify the type of seasonal residential lake cottages that served as retreats from city life in the early 20th century.

Lake Minnetonka offers a wide variety of opportunities for aquatic recreation (Figure 2.41), with numerous public and private boat accesses, beaches and fishing areas.

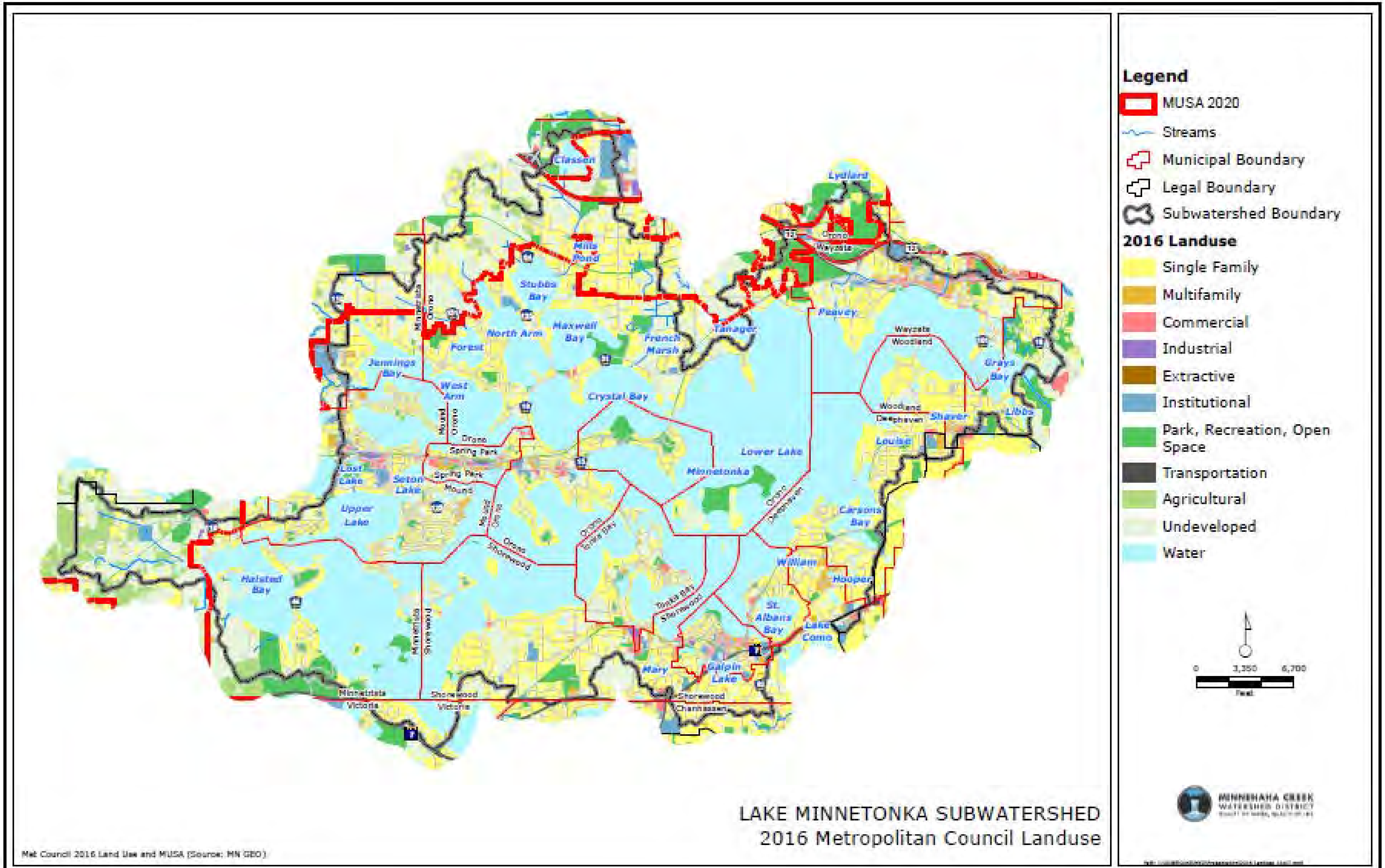

Figure 2. 40. Lake Minnetonka subwatershed 2016 Metropolitan Council land use.

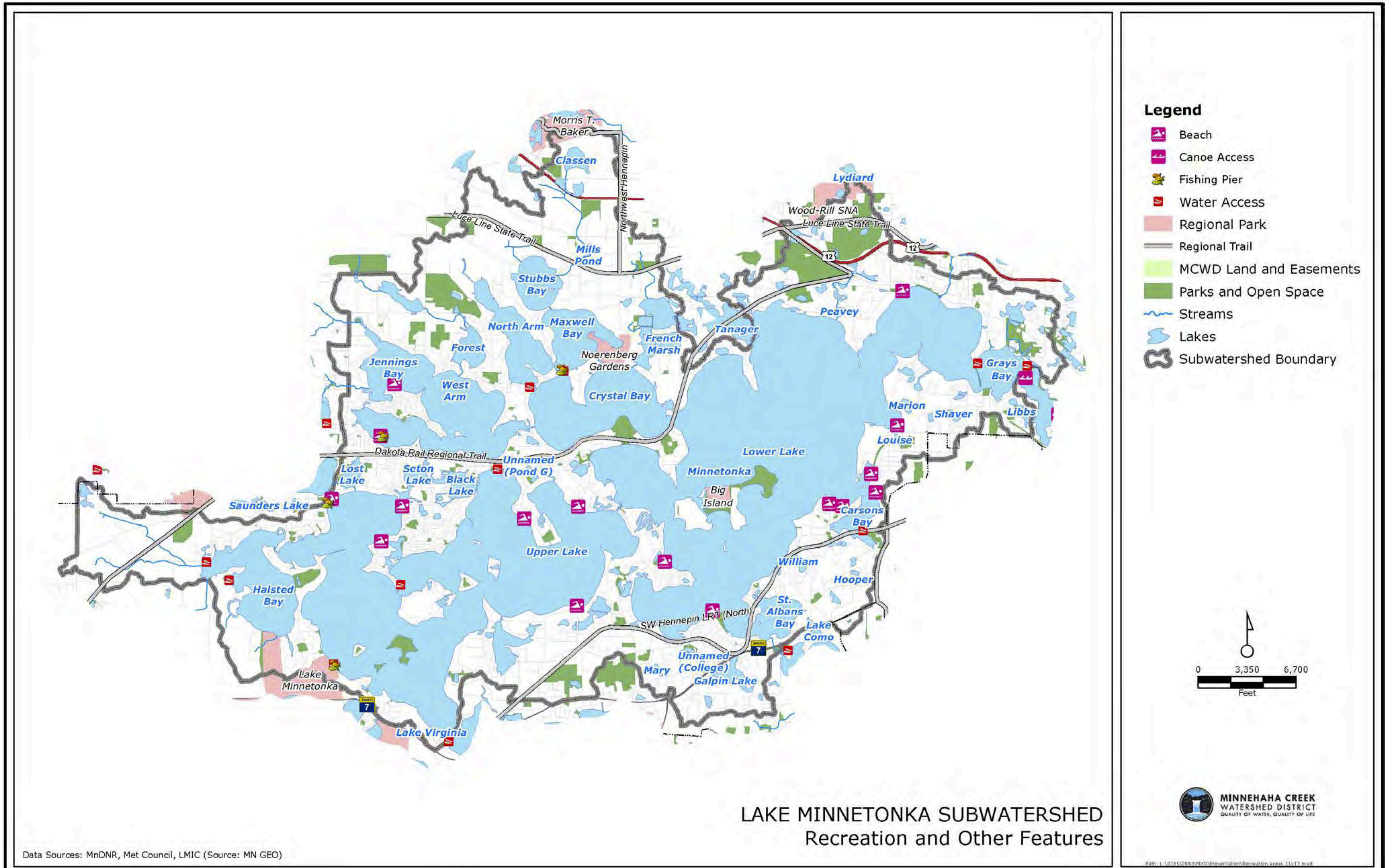

Figure 2. 41. Lake Minnetonka subwatershed recreation and other features.

2.3.5 LAKE VIRGINIA SUBWATERSHED

The Lake Virginia Subwatershed is dominated by four lakes and a mix of wetlands, agricultural, and residential land cover. The Lake Minnewashta Regional Park resides within this subwatershed and provides recreational access to Lake Minnewashta from the east. The park is dominated by forest, woodland, grassland and wetlands. The water drains into Lake Virginia from Lake Minnewashta and Tamarack Lake. The outlet of Lake Virginia is ditched, connecting the lake directly to Smithtown Bay, Lake Minnetonka. The outlet into Smithtown Bay is inaccessible, and therefore is not monitored. Table 2.43 shows the area of the Lake Virginia subwatershed in acres by individual city, in total and as a percentage of the total subwatershed (Figure 2.42).

Table 2. 43 Cities in the Lake Virginia subwatershed.

City	Area (Acres)	% of Subwatershed
Chanhassen	2,755.6	69%
Chaska	18.8	0.5%
Shorewood	344.1	8.6%
Victoria	872.4	21.8%
Total	3,991.2	

Source: MCWD.

Subwatershed Description and Hydrology:

The topography of the eastern subwatershed is rolling and hilly with areas of steep slopes along the eastern shore of Lake Minnewashta. The western subwatershed is distinguished by fewer steep slopes.
There are two major lakes within the subwatershed – Lake Minnewashta and Lake Virginia – and two other primary lakes – Lake St. Joe and Tamarack Lake. Lake Minnewashta is located in the upper subwatershed and discharges by Minnewashta Creek to Lake Virginia.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.43). Lake Minnewashta Regional Park is a dominant feature in the watershed. North of Highway 5, much of the watershed is developed to typical suburban densities with a low to medium degree of imperviousness. The Arboretum and Regional Park lands include wetland, wooded, and grassland cover, as well as some agricultural uses. The area around and between Lake St. Joe and Tamarack Lake includes a number of wetlands and wooded tracts.

Soils within the watershed are predominantly Natural Resources Conservation Service Hydrologic Soil Group B (loamy with moderate infiltration potential). Group C (loamy clay with low infiltration potential) and D (clayey with very low infiltration potential) soils are found in low-lying areas and are generally hydric, or showing indications of inundation. For further information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Lakes Minnewashta and Virginia are the primary receiving waters within the subwatershed. Tamarack Lake and Lake St. Joe are additional lakes in the subwatershed. There is a small stream that conveys discharge from Lake Minnewashta to Lake Virginia known as Minnewashta Creek. The Lake Virginia subwatershed discharges by a small channel in Smithtown Bay, Lake Minnetonka. The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Lake Virginia subwatershed into 16 subwatershed units, designated LMC-1 through LMC-10 in the Lake Minnewashta drainage area, and LV-1 to LV-6 in the downstream, Lake Virginia area (Figure 2.44).

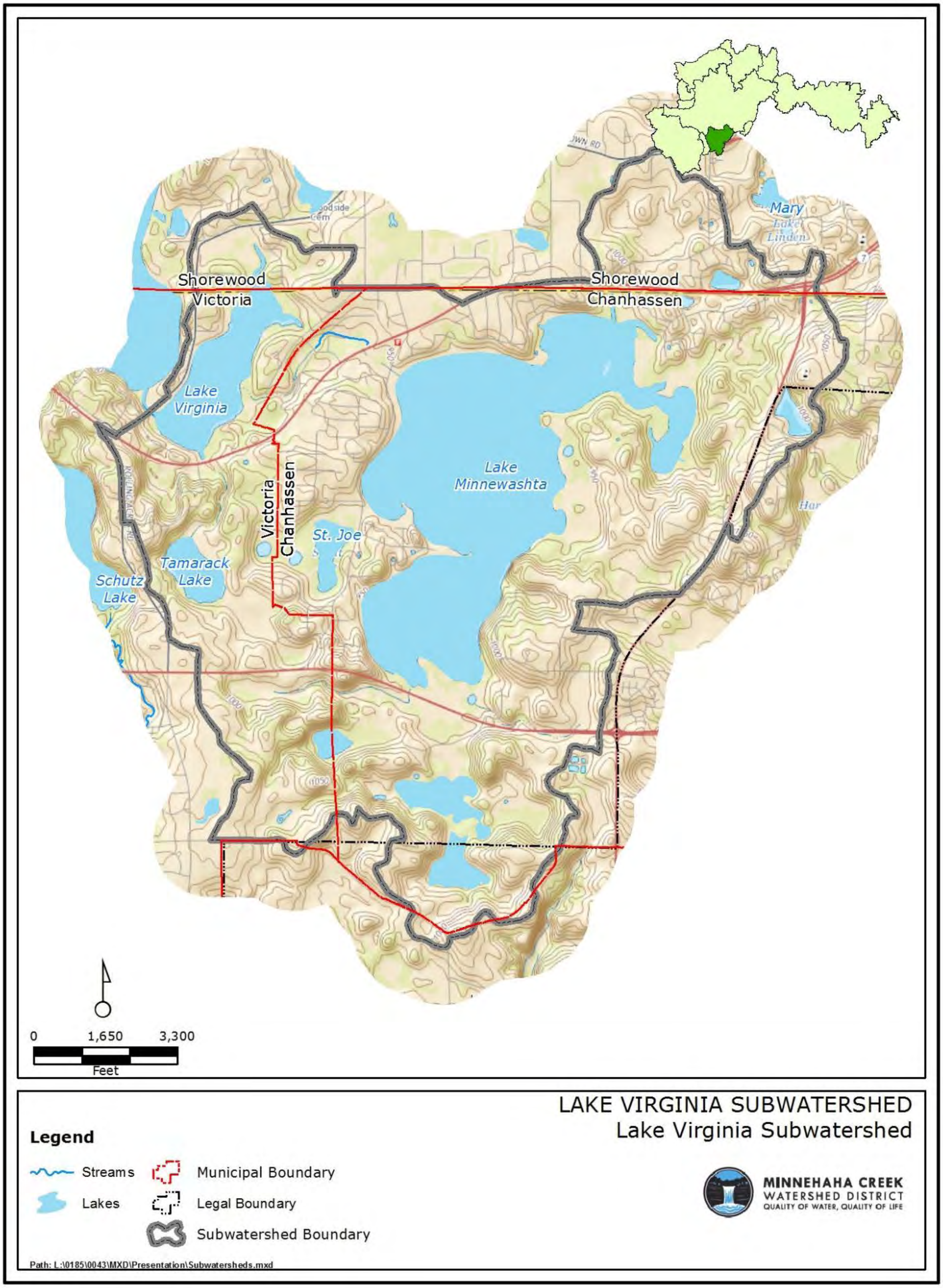

Figure 2. 42. The Lake Virginia subwatershed.

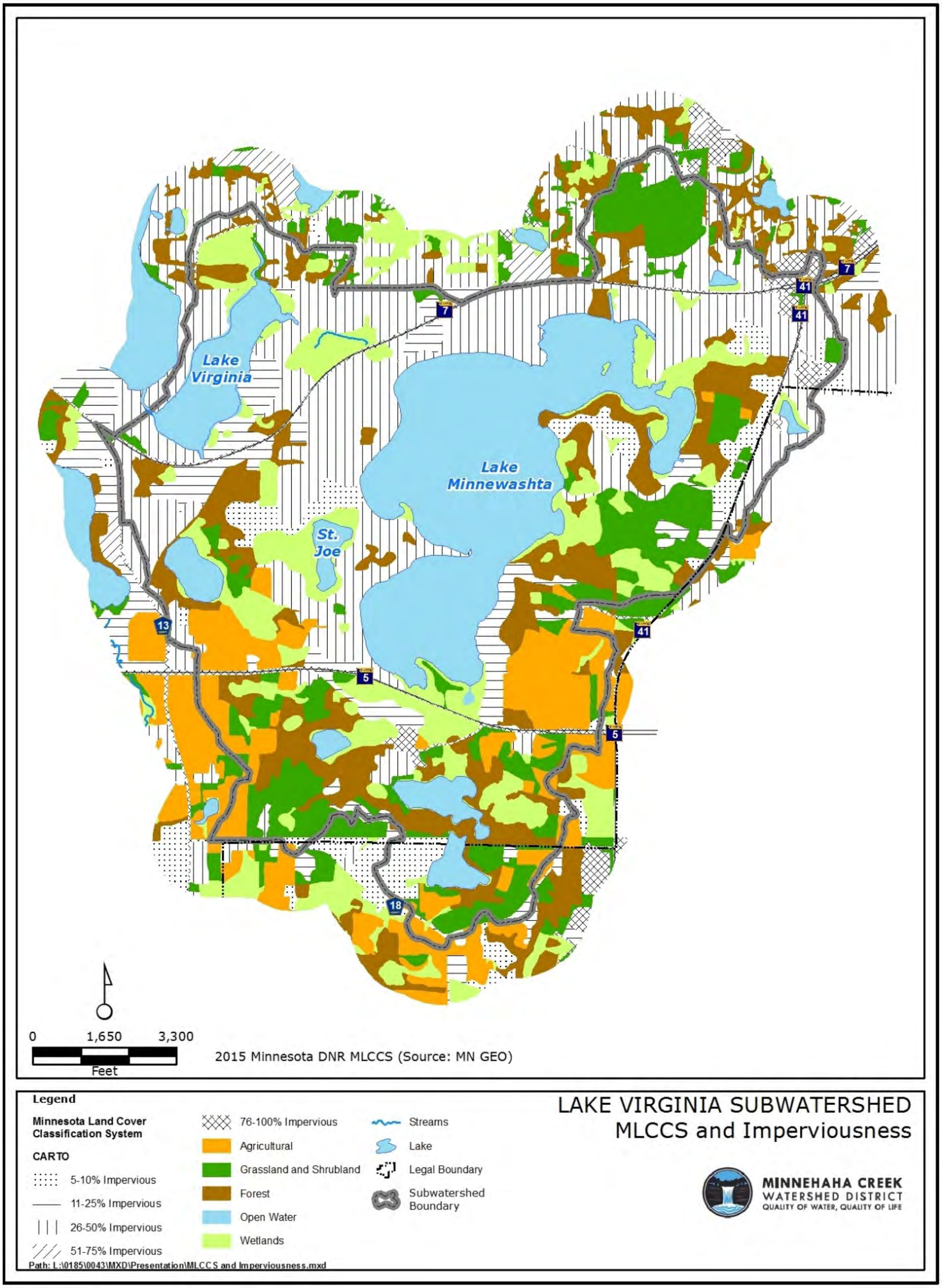

Figure 2. 43. Lake Virginia subwatershed MLCCS and imperviousness.

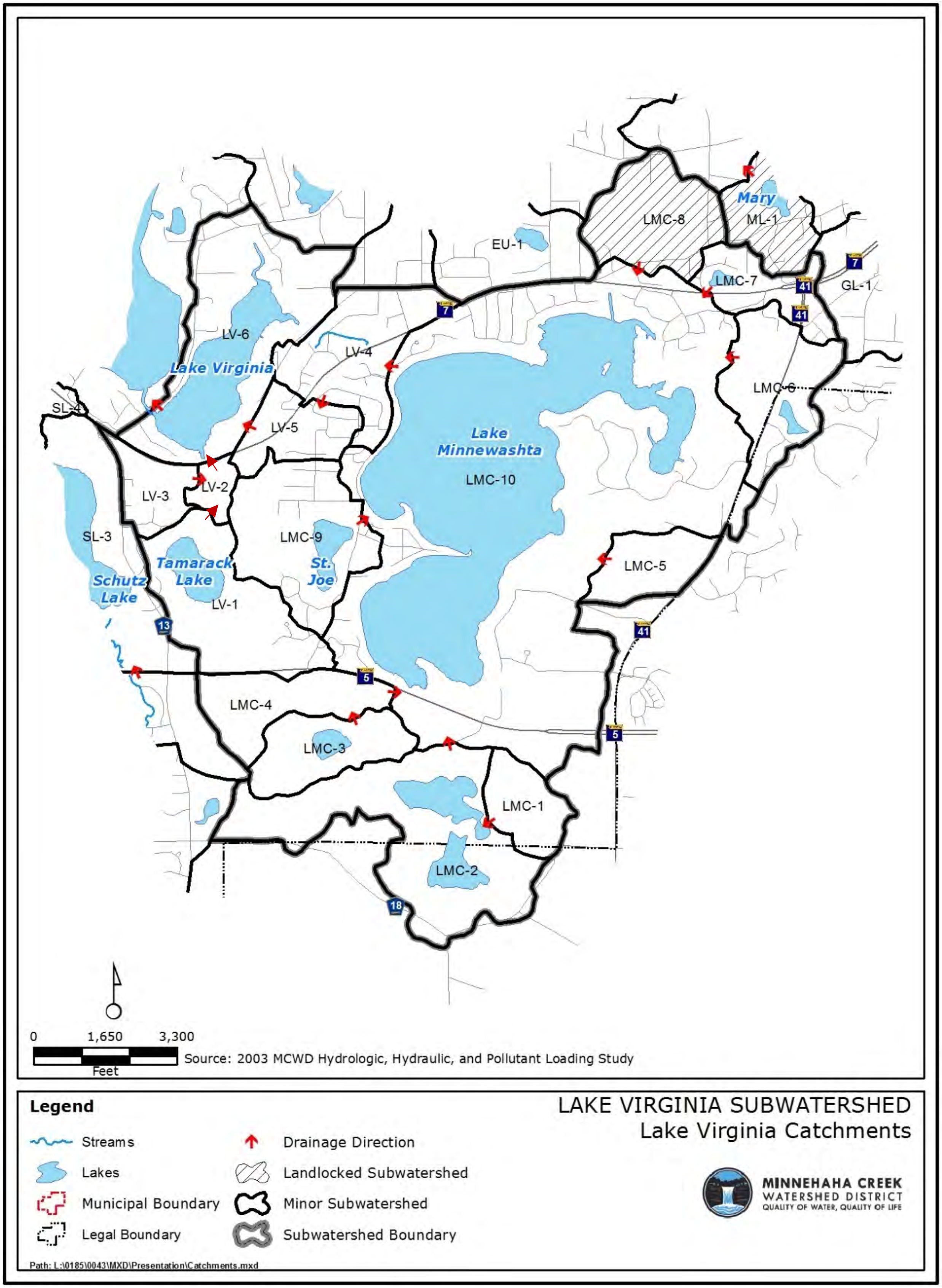

Figure 2. 44. Lake Virginia subwatershed catchments.

Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

Lakes Minnewashta and Virginia are the primary receiving waters within the subwatershed, and are classified by the DNR for shoreland management purposes as Recreational Development lakes. Tamarack Lake and Lake St. Joe are additional resources within the subwatershed, and are classified by the DNR as Natural Environment lakes (Table 2.44). Lake Virginia and Tamarack Lake are listed as Impaired Waters for excess nutrient concentrations; however, Tamarack Lake varies just above to just below the impairment threshold (Figure 2.45). Minnewashta and St. Joe Lakes enjoy excellent water quality, although St. Joe can experience algal blooms as evidenced by the somewhat elevated average chlorophyll-*a* concentrations.

The *Minnehaha Creek Watershed Lakes TMDL* prepared a TMDL for Lake Virginia while the *Upper Minnehaha Creek Watershed Lakes and Bacteria TDML Project*, prepared a TMDL for Tamarack Lake. Both Minnewashta and Virginia are listed as Impaired Waters for excess mercury in fish tissue, and the State of Minnesota has completed a statewide TMDL for those impairments. For more information, refer to the TMDL reports and the District's Water Quality (Hydrodata) reports.

Tables 2.44 and 2.45 show the physical and water quality characteristics of the major lakes in the subwatershed. To assess long-term change on the four lakes within the Lake Virginia Subwatershed, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth data from 2001-2015. There were no statistically significant changes in the water quality in the four lakes during this period.

Table 2. 44. Physical characteristics of lakes in the Lake Virginia subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Minnewashta	677	70	5:1	Recreational Development
St. Joe	19	52	11:1	Natural Environment
Tamarack	28	82	8:1	Natural Environment
Virginia	105	34	38:1	Recreational Development

Source: Minnesota DNR.

Table 2. 45. Selected water quality goals and current conditions of lakes in the Lake Virginia subwatershed.

Lake	State TP Standard (µg/L)	2007 Plan Goal TP (µg/)	Trend*	2001-2015 Summer Average TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Minnewashta[1]	40	20	No trend	22	9	2.4
St. Joe[2]	40	n/a	No trend	26	5	2.7
Tamarack[2]	40	n/a	No trend	37	15	2.3
Virginia[3]	40	40	No trend	55	36	1.3

**Statistically significant at ≤ 0.05.

[1] (1997-2015) from MCWD.

[2] (2004-2015 irregularly monitored) from Citizen Assisted Monitoring Program (CAMP).

[2] (2004-2015) from Citizen Assisted Monitoring Program (CAMP) and MCWD Volunteer Program.

[3] (2005-2015) from MCWD.

Source: MCWD, Upper Minnehaha Creek Watershed Lakes TMDL, MPCA.

Streams:

There is a small stream that conveys discharge from Lake Minnewashta to Lake Virginia known as Minnewashta Creek (Figure 2.45). As an outflow channel, water quality in Minnewashta Creek is highly influenced by water quality in Lake Minnewashta. Average TP concentration in the Creek is well below the state river eutrophication standard. Depending on flow and concentration, the Minnewashta Creek outlet historically has relative lower TP concentrations and loading, though loading does show an increase during higher flow years.

Tables 2.46 and 2.47 detail the physical and water quality characteristics of streams and tributaries within the subwatershed. The stream has an average TSS concentration of 4 mg/L, which is well below the 30 mg/L state standard. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. The most recent DO readings collected by the District were above the standard.

To assess long-term change in the Minnewashta Creek outlet, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2006-2015. There was a statistically significant increase in TSS concentrations in the Minnewashta Creek outlet over this period. For more information please refer to the District's Water Quality (Hydrodata) Reports.

Table 2. 46. Major streams in the Lake Virginia subwatershed.

Stream	Length (mi)
Minnewashta Creek (CMW02)	1.03

Table 2. 47. Current conditions of streams in the Lake Virginia subwatershed.
See Figure 2.45 for monitoring locations.

Stream	Trend*	2006-2015 Annual Average			
		TP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl (mg/L)
Minnewashta Creek (CMW02)	Deg TSS	36	0.58	4	29**

TP = total phosphorus, TN = total nitrogen, TSS = total suspended solids, Cl = chloride.
*Statistically significant at ≤ 0.05, Deg = degrading, **Cl data 2008-2014
Source: MCWD.

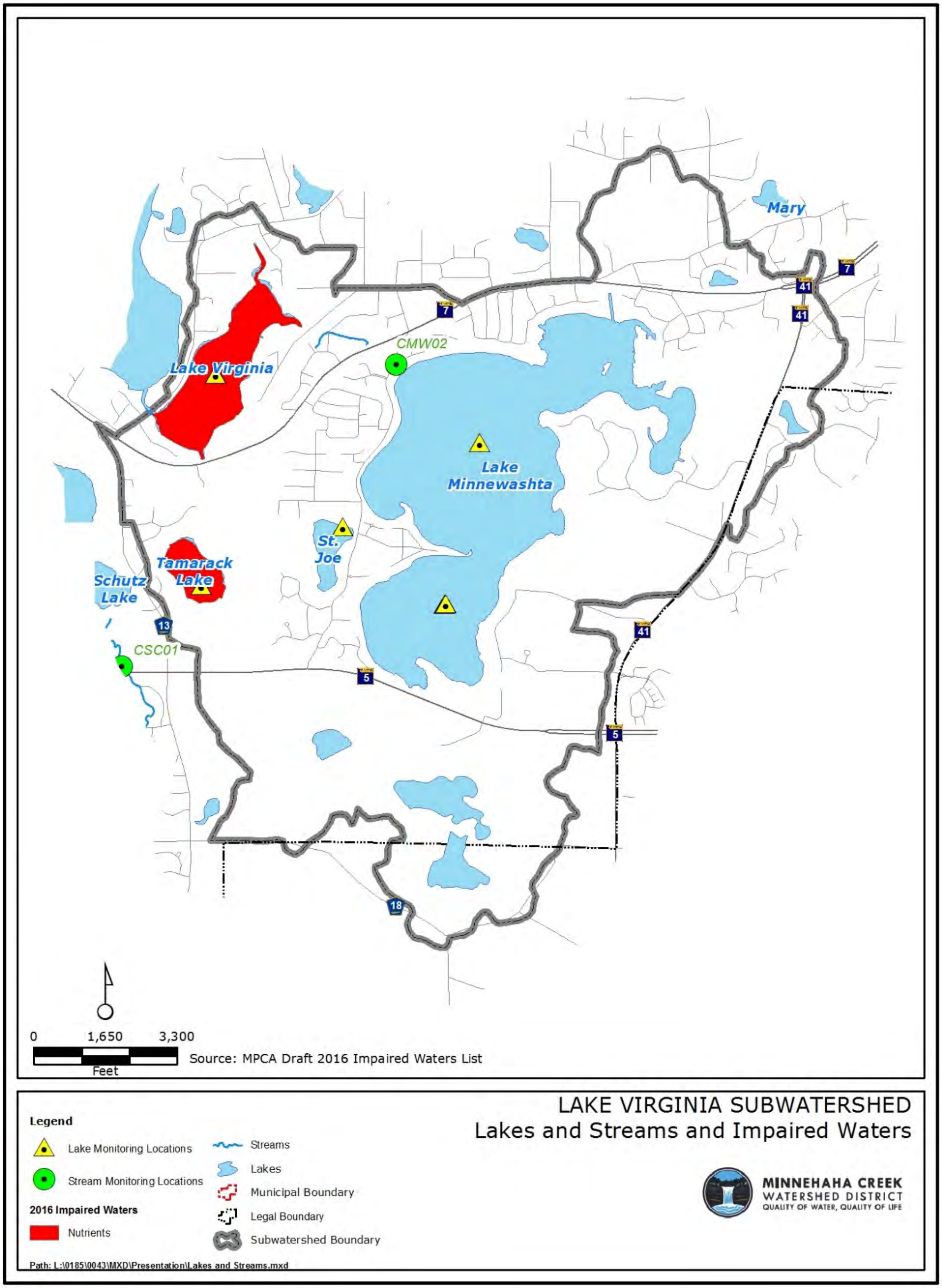

Figure 2. 45. Lake Virginia subwatershed lakes and streams and Impaired Waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover 21.8 percent of the subwatershed's surface (Figure 2.46 and Table 2.48). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients to and from the subwatershed. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2. 48. Functional Assessment of Wetlands inventory of wetland types in the Lake Virginia subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	32.7	0.98
2 - Wet Meadow	167.3	5.00
3 - Shallow Marsh	191.2	5.71
4 - Deep Marsh	64.8	1.94
5 - Open Water	112.2	3.35
6 - Scrub Shrub	105.0	3.14
7 - Forested	56.1	1.68
8 - Bog	-	
Riverine	-	
Wetland Total	729.4	21.8
Upland	2,621	78.2
TOTAL	3,350.4	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream base flow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

Infiltration potential of the upland areas within the subwatershed as generally medium, with a number of pockets of low potential clayey soils. Because of the organic nature of the soils in the wetland areas, in general infiltration potential there is variable. The *Carver County Water Resource Management Plan* and *Hennepin County Geologic Atlas* classifies those organic soil areas as highly sensitive to aquifer impacts, with the balance of the subwatershed as being of medium to low sensitivity to pollution, and the major wetland areas on the north and in the south as being highly sensitive.

Much of the northeastern part of the subwatershed as well as Lake Minnewashta itself has been designated a Drinking Water Supply Management Area (DWSMA).Two Wellhead Protection Areas (WHPA) surrounding Chanhassen and Shorewood water supply wells are partly within this subwatershed. Figure 2.47 shows areas in the subwatershed with groundwater sensitivity and that are designated Wellhead Protection Areas.

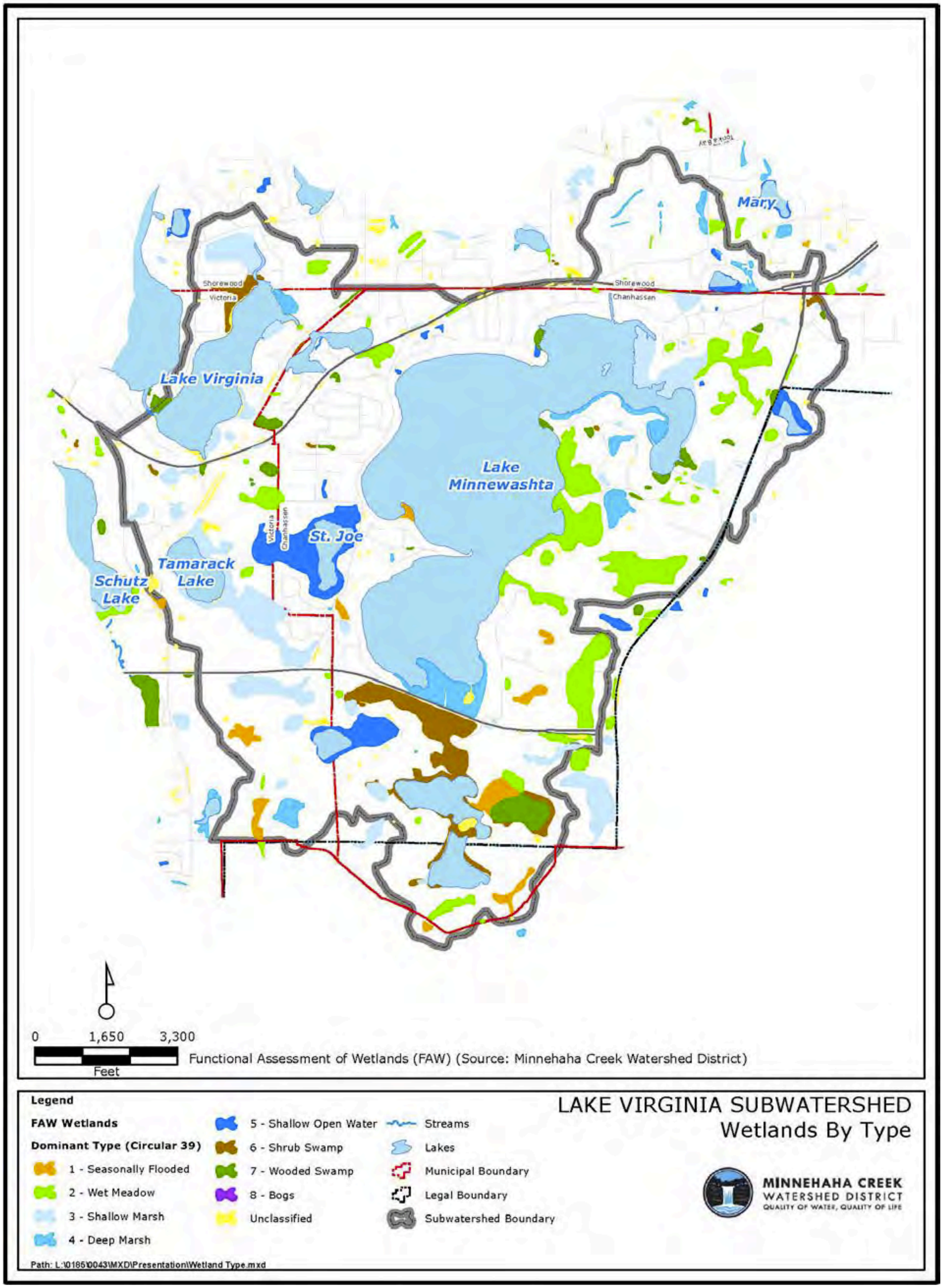

Figure 2. 46. Lake Virginia subwatershed wetlands by type.

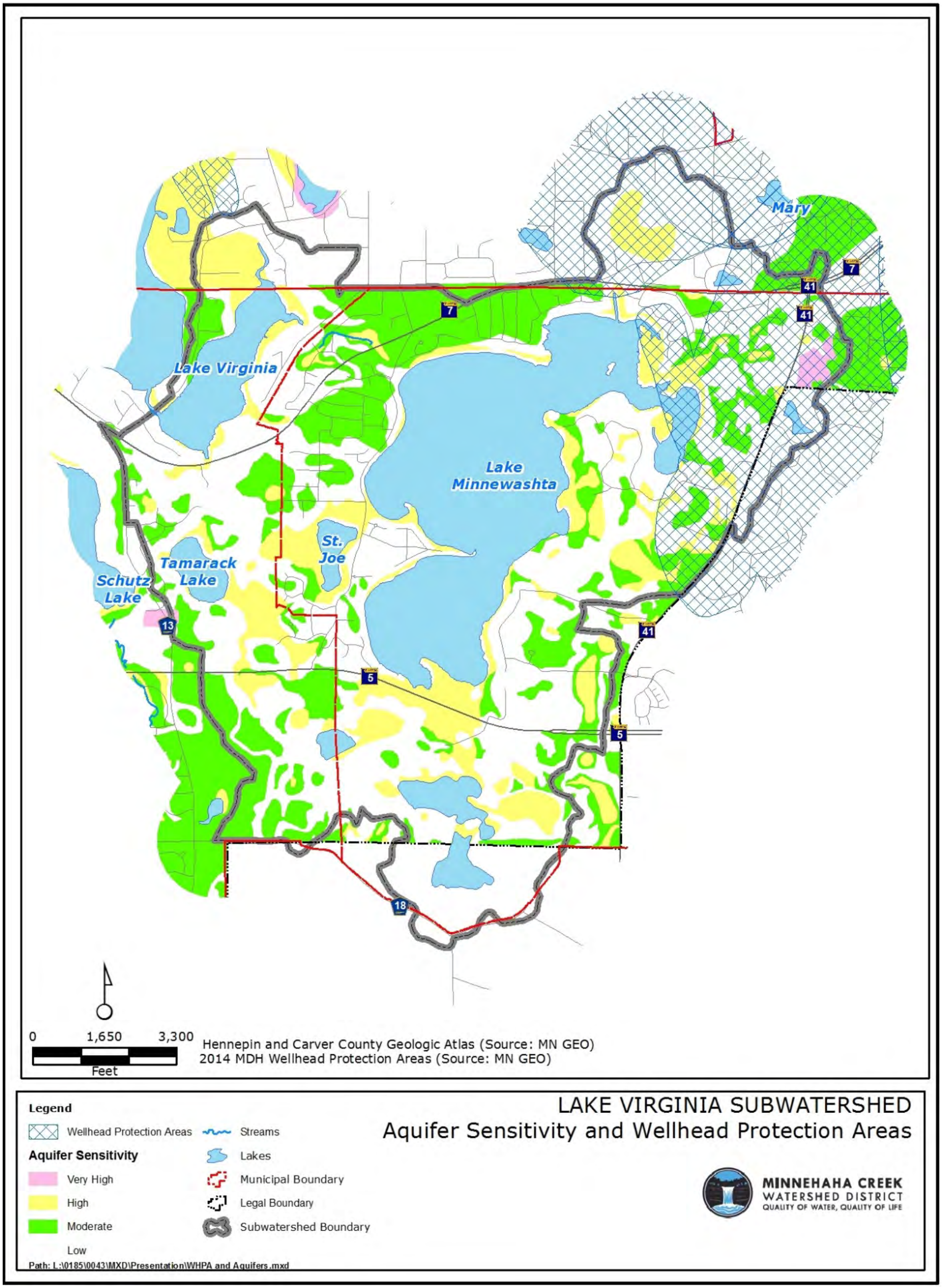

Figure 2. 47. Lake Virginia subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

As detailed in the *HHPLS*, two subwatershed units in the Lake Virginia subwatershed are landlocked (Figure 2.44).

To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water yield data for the monitoring station on Minnewashta Creek. Water yield for 2006-2015 did not exhibit any statistically significant trend upward or downward, indicating that there has not been a significant change in outflow over the past ten years.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Lake Virginia subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data, where available (Figure 2.48).

Lakes:

Biodiversity

Fish Community. No Fish IBI data are available for the lakes in the subwatershed. Lake Minnewashta is a popular bass/northern/panfish lake that was last surveyed by the DNR in 2011. A catch-and-release only regulation for largemouth bass is in effect. Lake Virginia maintains a bass/northern/panfish fishery with abundant bluegills. Dissolved oxygen levels in the deeper parts of the lake in late summer fall below the levels needed to sustain aquatic life, which may impact certain sensitive species. Common carp and other rough fish are abundant. Lake St. Joe has a fish population dominated by small black bullheads, northern pike and several species of panfish. Tamarack Lake has not been surveyed since 1994. The fish population at that time was primarily panfish, although there were fair numbers of northern pike.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. A Floristic Quality Index (FQI) is available for Lake Minnewashta, Tamarack and St. Joe lakes. Lake Minnewashta FQI score of 28.8 – Good. This grade indicates the lake has moderate species diversity and a mixed assemblage of tolerant and intolerant species, beginning to show signs of anthropogenic disturbance. Tamarack Lake and St. Joe, with a score of 14.1 and 18.09 respectively – both classified as Poor meaning the community in both lakes is showing obvious signs of anthropogenic disturbance, low species diversity often comprised of non-native and/or intolerant species. Eurasian watermilfoil and Curly leaf Pondweed are present in both Lakes Minnewashta and Lake Virginia.

Aquatic Invasive Species. Curlyleaf Pondweed is present in St. Joe Lake. Eurasian Watermilfoil, Curlyleaf Pondweed, and zebra mussels have been confirmed in both Lake Minnewashta and Lake Virginia. Zebra mussels were confirmed in 2014 for Lake Virginia and 2016 for Lake Minnewashta. A rapid response attempt to eradicate zebra mussels occurred on Lake Minnewashta in 2016. Monitoring and response continue as new zebra mussels were found at the public access in 2017. No zebra mussels have been found in the main body of the lake.

Habitat diversity

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species, or the extent to which it may be dominated by a few species. The vegetation community has not been assessed yet for habitat diversity.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score the Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score the Shore data are available for the lakes in this subwatershed. Aerial photos show that much of eastern shore of Minnewashta Lake has significant shoreland vegetation along Lake Minnewashta Regional Park. About 40 percent of the perimeter of Lake Minnewashta and 35 percent of Lake Virginia are protected by riparian wetlands. Both Lake St. Joe and Tamarack Lake have fully intact shoreland vegetation.

Streams:

Biodiversity

Fish Community. No fish IBI data are available for the streams in this subwatershed.

Macroinvertebrate Community. No macroinvertebrate data are available for the stream in this subwatershed.

Aquatic Invasive Species. No AIS data are available for the streams in this subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity for Minnewashta Creek. By observation, this stream is more like a channel between the two lakes.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are culverts that intersect Minnewashta Creek along its 1.03 mile course to Lake Virginia.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are not available, but instantaneous flow measured since 2006. Annual average flow for each year was computed first, and then all the years' averages were averaged together. Annual average flow at CMW02 was 3.54 cfs indicating generally low flow conditions at time of data collection.

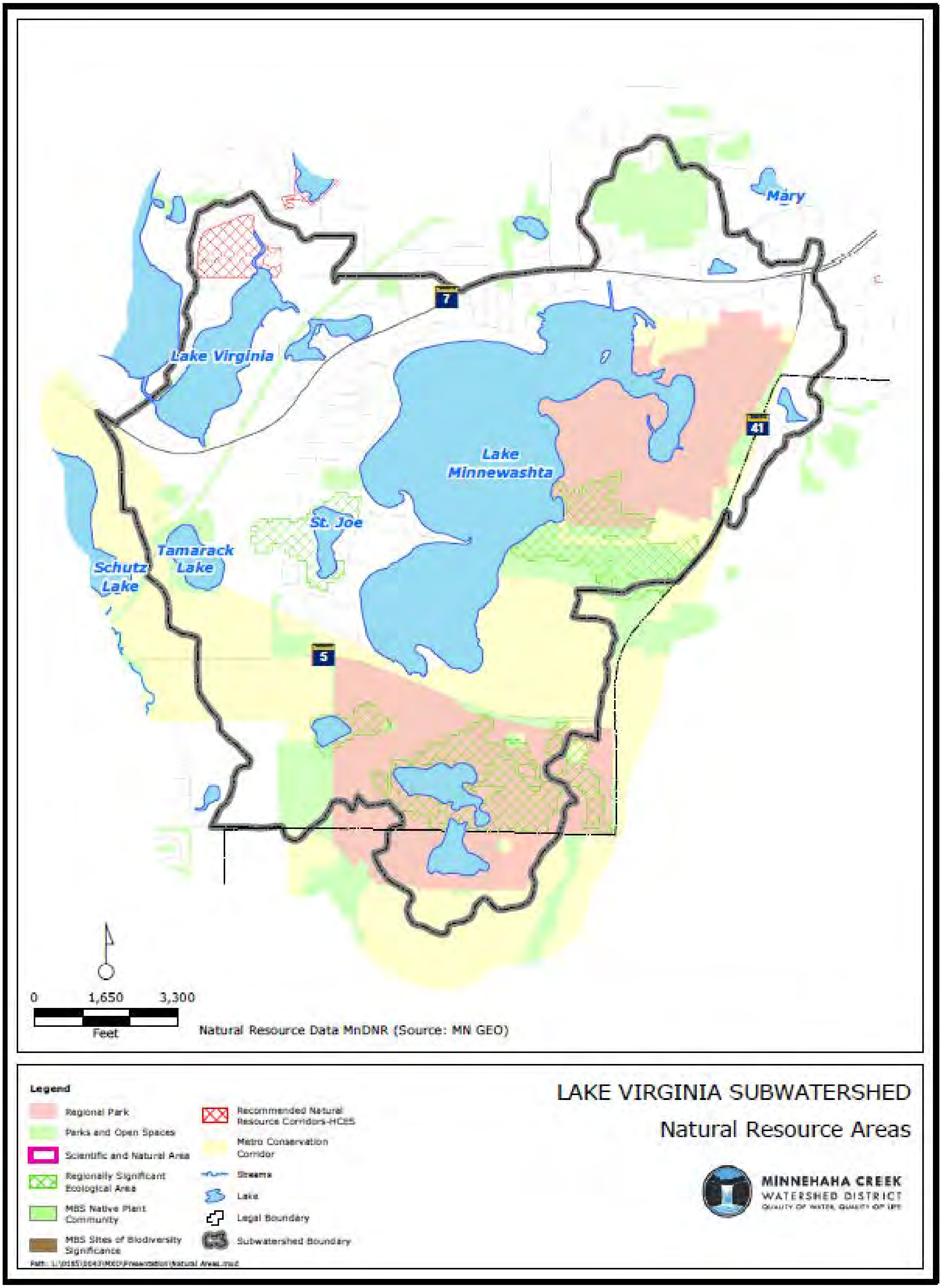

Figure 2. 48. Lake Virginia subwatershed natural resource areas.

Wetlands:

Biodiversity

Vegetation Community. No FQI data are available for the wetlands in this subwatershed. Over 39 percent of the wetlands in the subwatershed were classified as "preserve" due to their exceptional or high vegetative diversity, or fish or wildlife habitat value. Those wetlands described as exceptional are present on the east side of Lake Minnewashta, the northwest shore of Lake Virginia and all of Lake St. Joe.

Macroinvertebrate Community. No macroinvertebrate data are available for the wetlands in this subwatershed.

Habitat diversity

Connectivity. Connected wetland corridors are desirable as they provide a variety of habitats as well as protected areas for passage. Most of the connectivity between wetlands is already protected within the Lake Minnewashta Regional Park and/or the University of Minnesota Landscape Arboretum.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species. Much of eastern shore of Minnewashta Lake has large wetlands present within Lake Minnewashta Regional Park. Both Lake St. Joe and Tamarack Lake also have large wetlands around their respective perimeters.

Shoreline Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. About 40 percent of the perimeter of Lake Minnewashta and 35 percent of Lake Virginia is protected by riparian wetlands. Both Lake St. Joe and Tamarack Lake have fully intact shoreland vegetation.

Uplands:

Biodiversity

Much of the subwatershed has been identified by the DNR as a Metropolitan Conservation Corridor, including Lake Minnewashta Regional Park and the Minnesota Landscape Arboretum. Wetland and associated upland areas with high ecological value are present and should be conserved and connected to preserve their values, create larger areas of ecological value, and connect existing resources. The Minnesota Landscape Arboretum and Lake Minnewashta Regional Park lands include wetland, wooded and grassland cover as well as some agricultural uses.

Habitat diversity

Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. Figure 2.48 shows areas designated by the DNR as regionally significant within Lake Minnewashta Regional Park, the Landscape Arboretum, and riparian to Lake St. Joe. The Regional Park, University of Minnesota Horticultural Research Center, and Landscape Arboretum also preserve significant areas of lightly-disturbed woodlands and grasslands that provide significant habitat value to terrestrial and avian species in the subwatershed.

Thriving Communities:

Land use:

Table 2.49 shows the land uses within the area of the Lake Virginia subwatershed in acres and as a percentage of the total subwatershed. The principal land uses in the northern part of the subwatershed are parks and open space and single family residential (Figure 2.49). South of Highway 5 the subwatershed is mainly agriculture and vacant or undetermined area with some single family and the campus of southwest Metro Catholic High School.

Except for some very small areas in the south, the entire subwatershed is located within the 2020 Metropolitan Urban Services Areas (MUSA) boundary.

Table 2. 49. 2016 land use in the Lake Virginia subwatershed.

Land Use 2016	Acres	% of Subwatershed
Parks and Open Space	1,097.0	27.5
Single - Family Residential	1,054.3	26.4
Water	876.1	21.9
Vacant or Undetermined	485.5	12.2
Agricultural	297.1	7.4
Institutional	87.3	2.2
Roads and Highways	60.4	1.5
Commercial	21.5	0.5
Multi - Family Residential	9.0	0.2
Industrial	3.0	0.1

Source: Metropolitan Council.

Recreation:

Lake Minnewashta Regional Park encompasses most of the northeastern shore of Lake Minnewashta. Most of the subwatershed south of Highway 5 is part of the Minnesota Landscape Arboretum. The Southwest Hennepin LRT Regional Trail passes across the northwest corner of the subwatershed, to the east of Lake Virginia. The Minnesota Historic features database lists several properties in the subwatershed, including a home and farmhouse, and two clusters of buildings and sites associated with the Arboretum and its research activities.

There is one public boat launch in the Regional Park on Lake Minnewashta, and one on Lake Virginia (Figure 2.50). A canoe launch is available on Lake St. Joe. There is a beach and fishing pier on the east side of Lake Minnewashta in the Regional Park, and a beach on the west side of Lake Minnewashta in the City of Chanhassen’s Roundhouse Park.

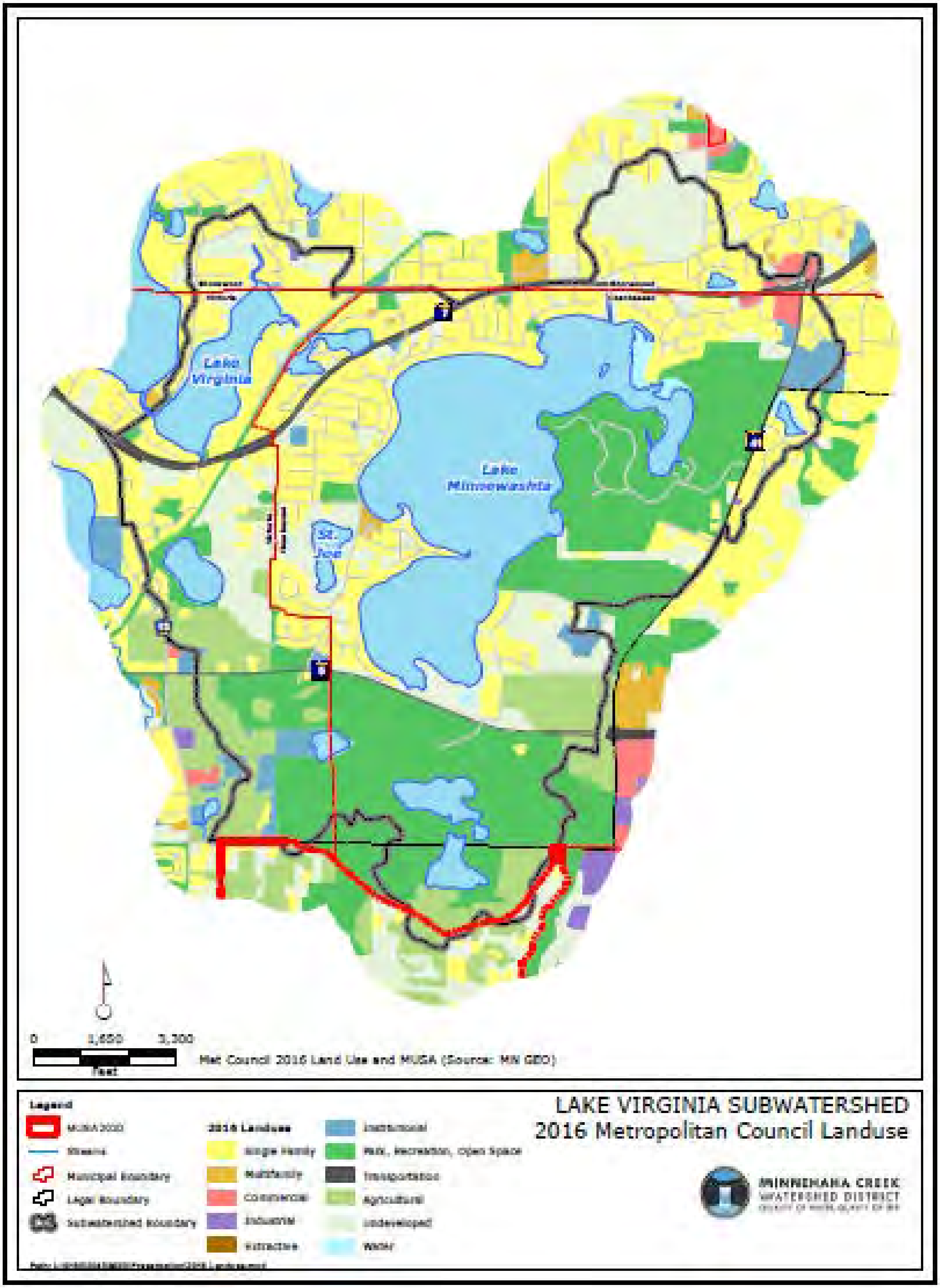

Figure 2. 49. Lake Virginia subwatershed 2016 land use.

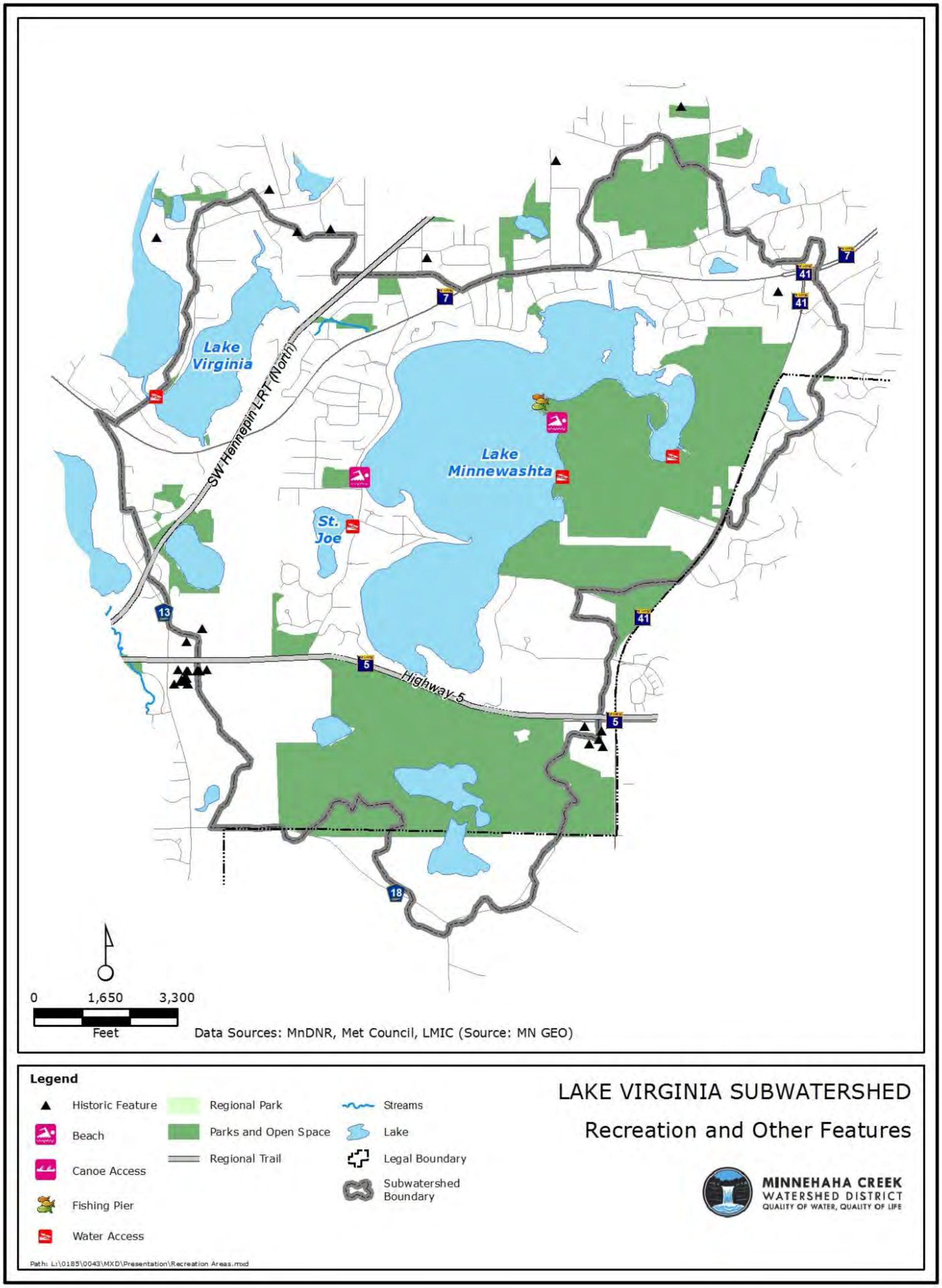

Figure 2. 50. Lake Virginia subwatershed recreation and other features.

2.3.6 LANGDON LAKE SUBWATERSHED

The land cover in the Langdon Lake Subwatershed is dramatically different between Minnetrista and Mound. In Minnetrista, the western portion of the subwatershed, there is a mix of woodlands, forests, grasslands, wetlands (Flanagan and Saunders), and agricultural land use. In Mound, the eastern portion of the subwatershed, there are wetlands adjacent to Langdon Lake with the remaining land cover dominated by residential and commercial/institutional use. The Dakota Rail line runs north of Saunders and Langdon lakes. Langdon Lake inlet (CLA02) drains the subdivisions around Saunders Lake and flows through a wetland before reaching Langdon Lake. The lake outlet (CLA01) flows into Lost Lake wetland complex and eventually into Cooks Bay, Lake Minnetonka. Table 2.50 below shows the area of the Langdon Lake subwatershed in acres by individual city, in total and as a percentage of the total subwatershed (Figure 2.51).

Table 2. 50. Cities in the Langdon Lake subwatershed.

City	Area (Acres)	% of Subwatershed
Minnetrista	539.3	51%
Mound	516.3	49%
Total	1,055.6	100%

Source: MCWD

Subwatershed Description and Hydrology:

The topography of the Langdon Lake subwatershed is rolling and hilly with steep slopes abutting Lake Flanagan and its associated wetlands and abutting the shores of Saunders Lake. The subwatershed is bisected by a railroad corridor, which influences its hydrology. The Langdon Lake subwatershed is notable for its ecological resources and large wetlands. The northwestern part of the subwatershed, which includes several areas of high-value woods, grassland, and wetland, has been acquired by the Three Rivers Park District and incorporated into Gale Woods Regional Park.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.52). The eastern subwatershed is mostly developed at typical suburban densities, and has varying degrees of imperviousness. The western half of the subwatershed is dominated by a mosaic of forest and woodland, wetland and open water, with some agriculture in the southwest and some scattered, large-lot residential development.

Soils within the watershed are predominantly well-drained Natural Resources Conservation Service Hydrologic Soil Group B (loamy soils with moderate infiltration potential), with pockets of poorly-drained soils of varying infiltration potential. Group D soils (clayey soils with very low infiltration potential) are found in low-lying areas and are generally hydric, or showing indications of inundation. For further information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Langdon Lake is the primary receiving water within the subwatershed. Two other receiving waters within the subwatershed carry the informal designation of a lake: Saunders Lake and Lake Flanagan (note: has been known as Black Lake), both of which are classified as wetlands. There is a small channel that conveys discharge from the outlet of Saunders Lake to Langdon Lake.

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Langdon Lake subwatershed into five subwatershed units, designated LL-1 through LL-5 (Figure 2.53).

Figure 2. 51. The Langdon Lake subwatershed.

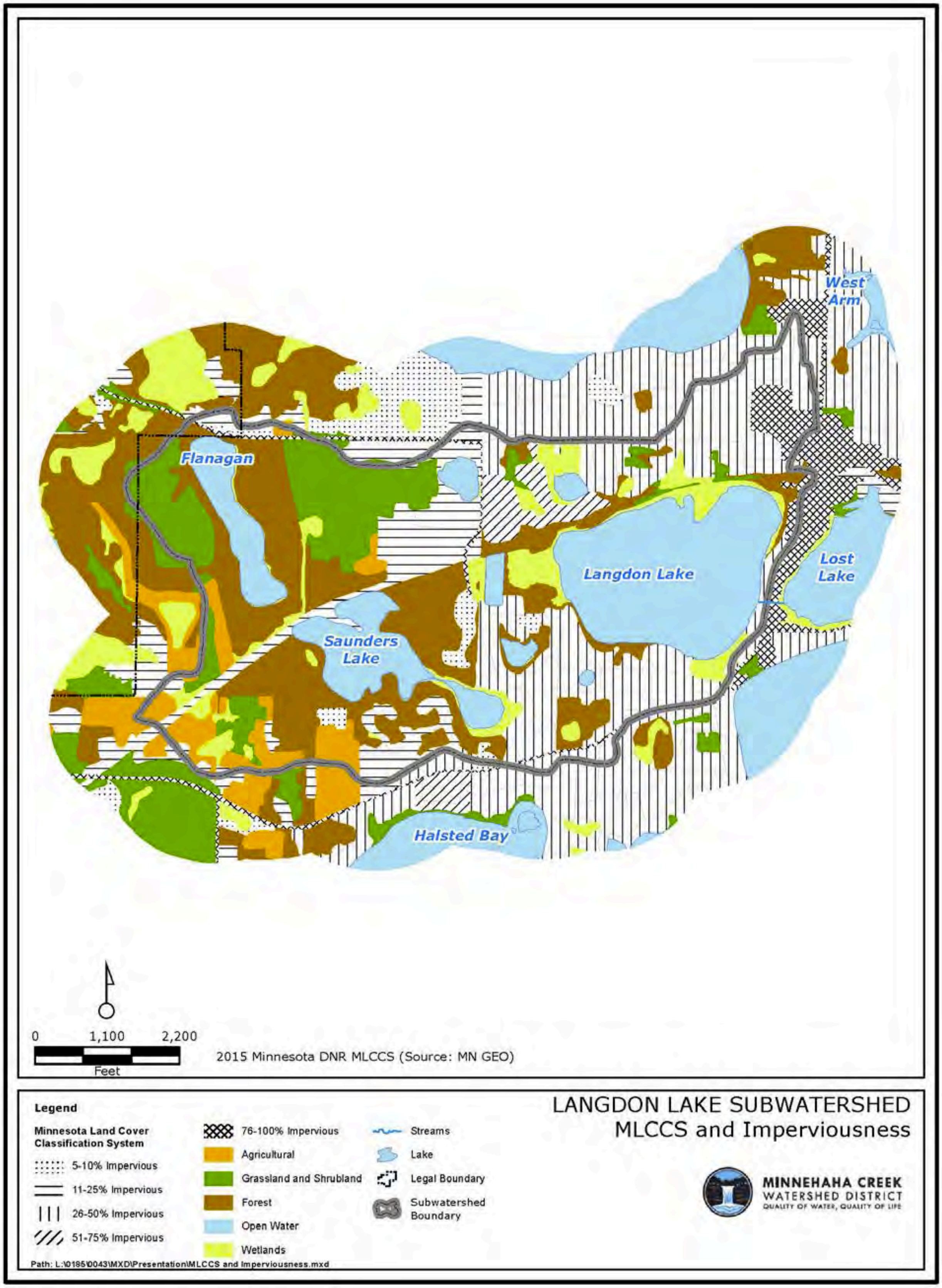

Figure 2. 52. Langdon Lake subwatershed MLCCS and imperviousness.

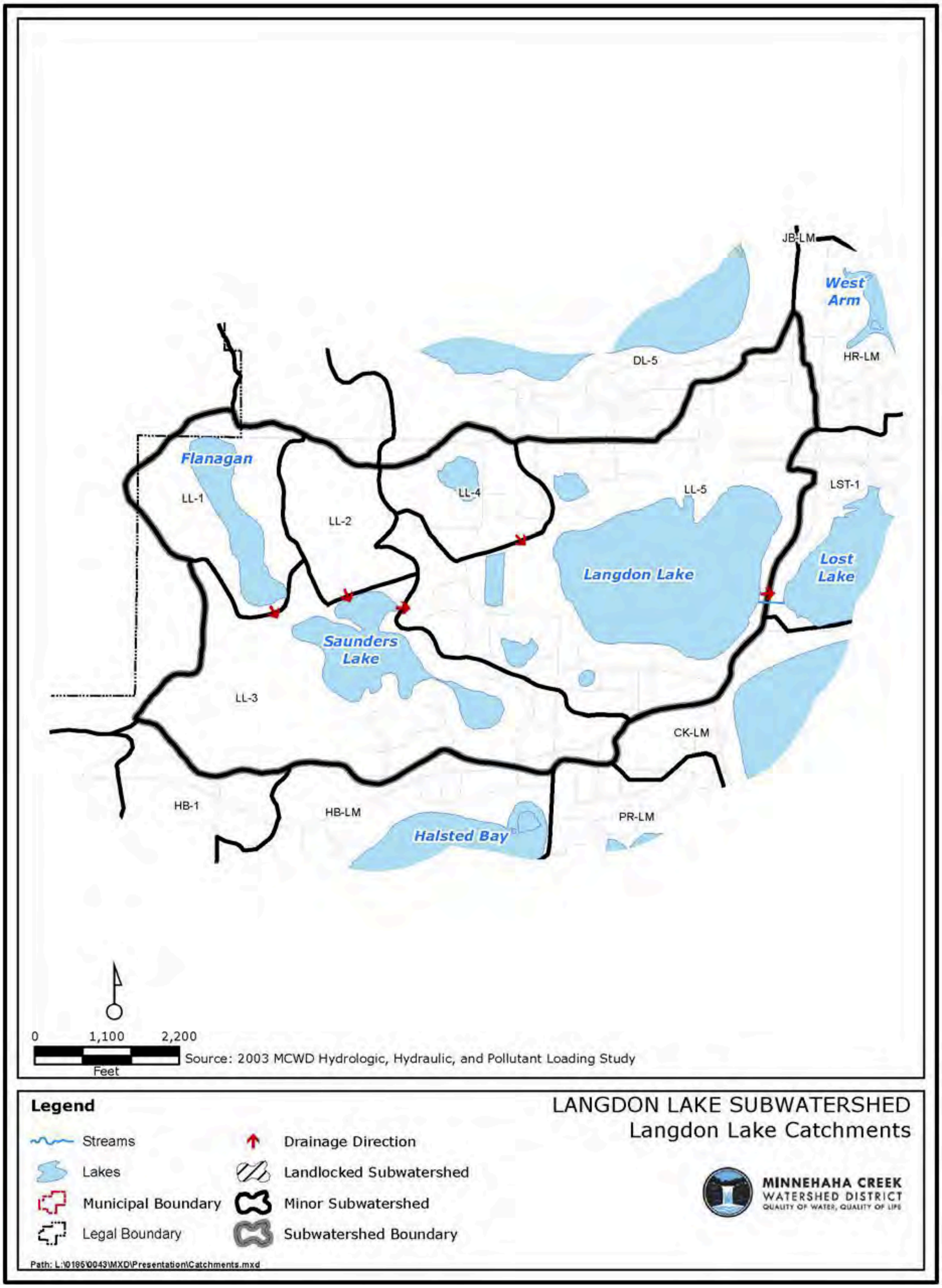

Figure 2. 53. Langdon Lake subwatershed catchments.

Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

Langdon Lake is the primary receiving water within the subwatershed, and is classified by the DNR for shoreland management purposes as a Recreational Development lake (Table 2.51). Two other receiving waters within the subwatershed carry the informal designation of lake: Saunders Lake and Flanagan Lake. Saunders Lake is a large, Type 5 wetland, classified as a Natural Environment lake while Flanagan Lake is a multi-type wetland with a small area of Type 5 open water.

Langdon Lake is listed on the State's Impaired Waters list, with average summer nutrient concentrations greater than the state standard. To assess long-term change, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth from 2001-2015. There were no statistically significant changes in water quality in Langdon Lake over this period. Tables 2.51 and 2.52 below detail the physical and water quality characteristics of Langdon Lake and other lakes within the subwatershed. For more information regarding water quality in the subwatershed, please refer to the District's Water Quality (Hydrodata) reports and the Upper Minnehaha Creek Watershed Lakes TMDL.

Table 2. 51. Physical characteristics of lakes in the Langdon Lake subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Langdon	144	39	8:1	Recreational Development

Source: Minnesota DNR.

Table 2. 52. Selected water quality goals and current conditions of waterbodies in the Langdon Lake subwatershed.

Waterbody	State TP Standard (µg/L)	2007 Plan Goal TP (µg/L)	Trend*	2001-2015 Summer Average		
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Flanagan[2]	n/a	n/a	n/a	17	3	3.5
Langdon[1]	40	40	No trend	99	57	0.7
Saunders[3]	n/a	n/a	n/a	27	5	1.2

*Statistically significant at ≤ 0.05.
[1]Data are from 2001-2015, from MCWD. [2]Data are from 2009-2010. [3]Data are from 2009-2012.
Source: MCWD, Upper Minnehaha Creek Watershed Lakes TMDL, MPCA.

Streams:

There is a small channel that conveys discharge from the outlet of Saunders Lake to Langdon Lake. No water quality or flow data are available for this channel. There is a small stream (Langdon Lake outlet) that conveys flow to Lost Lake: Lake Minnetonka (Figure 2.54). At this time no streams are listed as Impaired Waters. The Langdon Lake outlet stream is within the state river eutrophication standards. Tables 2.53 and 2.54 below detail the physical and water quality characteristics of streams and tributaries within the subwatershed.

Table 2.53 shows the average concentration of TSS at the one site on the Langdon Lake outlet stream to be 16 mg/L, below the 30 mg/L state standard for this ecoregion. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. Monitoring data show that the site on the Langdon Lake outlet stream has stayed at or above the standard the last few years for the vast majority of samples; however, it has dipped below the standard intermittently. It is assumed based on the time of year that low DO values were due to low flow and high summer temperatures.

To assess long-term change in Langdon Lake Outlet, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS. There were statistically significant improvements in both TP and TSS concentrations over time at the Langdon Lake Outlet (Table 2.54). For more information please refer to District's Water Quality (Hydrodata) reports.

Table 2. 53. Major streams in the Langdon Lake subwatershed.

Stream	Length (mi)
Langdon Lake Outlet (CLA01)	0.4

Table 2. 54. Current conditions of streams in the Langdon Lake subwatershed.
See Figure 2.54 for monitoring locations.

Stream	Trend*	2006-2015 Annual Average			
		TP (µg/L)	TN (mg/L)	TSS(mg/L)	Cl (mg/L)**
Langdon Lake Outlet (CLA01)	Imp TSS, TP	112	1.51	17	45
Langdon Lake Inlet (CLA02)	n/a	108	0.943	7	23

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride, Imp = Improving
*Statistically significant at ≤ 0.05, **Cl data from 2008-2015.
Source: MCWD.

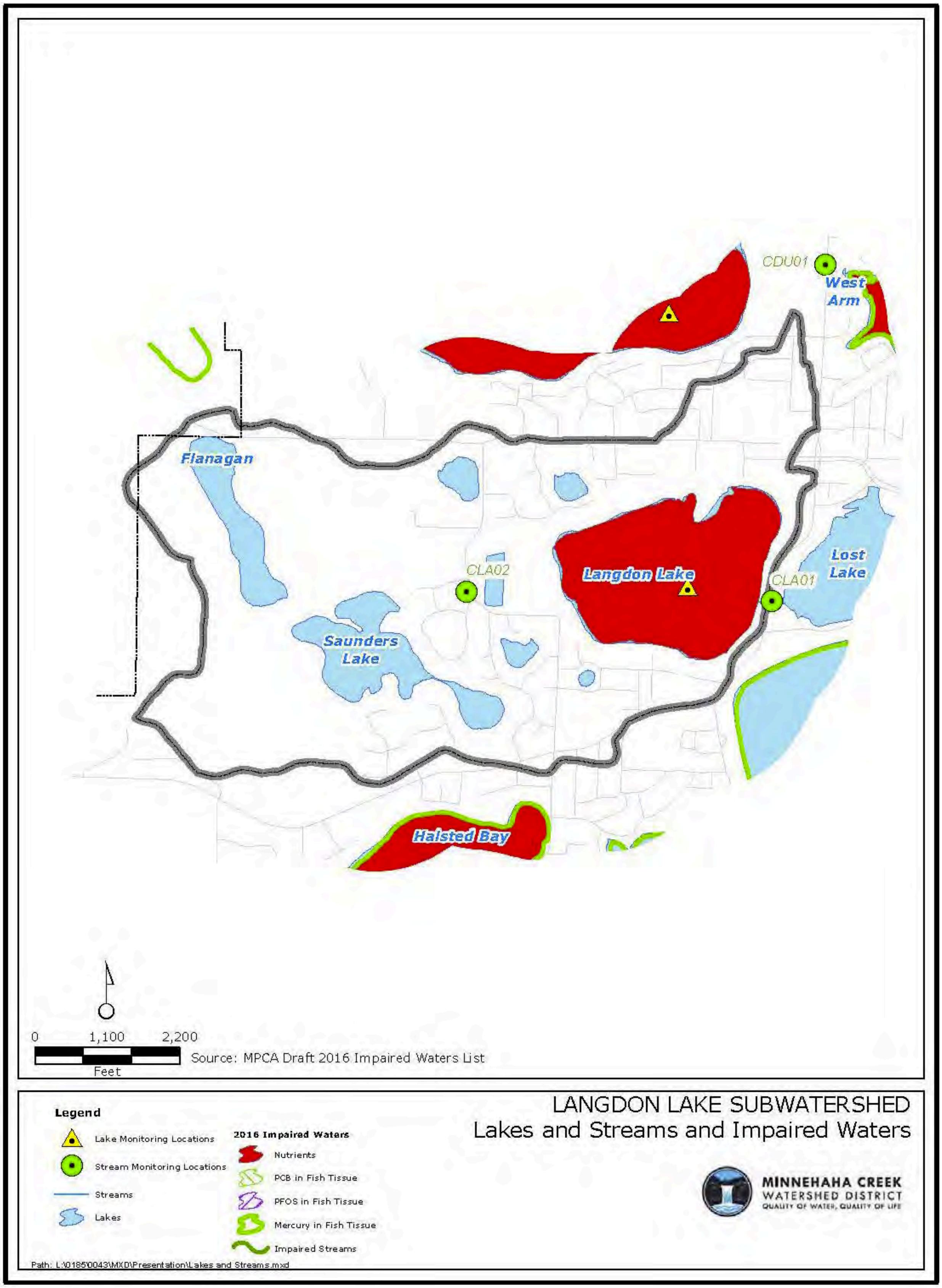

Figure 2. 54. Langdon Lake subwatershed lakes and streams and Impaired Waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover 10.7 percent of the subwatershed's surface (Figure 2.55 and Table 2.55). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2. 55. Functional Assessment of Wetlands inventory of wetland types in the Langdon Lake Creek subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	0.8	0.10
2 - Wet Meadow	6.2	0.75
3 - Shallow Marsh	16.7	2.02
4 - Deep Marsh	57.7	6.98
5 - Open Water	3.5	0.42
6 - Scrub Shrub	3.6	0.44
7 - Forested	-	
8 - Bog	-	-
Riverine	-	-
Wetland Total	88.4	10.7
Upland	735.3	89.3
TOTAL	823.7	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

Upland areas within the subwatershed have low to medium infiltration potential, with an area of high infiltration potential to the south and west of Langdon Lake in an area of ice-stratified sand and gravel till. The *Hennepin County Geologic Atlas* classifies most of the western subwatershed area as being of low sensitivity to pollution, while the area around Langdon Lake is variously medium to high to very highly sensitive, especially in the areas of gravel till deposits.

Part of the Langdon Lake subwatershed has been designated by the Minnesota Department of Health (MDH) as Drinking Water Supply Management Areas (DWSMA) and Wellhead Protection Areas (WHPA) City of Mound and City of Minnetrista municipal wells. The MDH has designated this area to be of low to moderate risk of contamination of the drinking water supply. Figure 2.56 shows areas in the subwatershed with groundwater sensitivity and that are designated Wellhead Protection Areas.

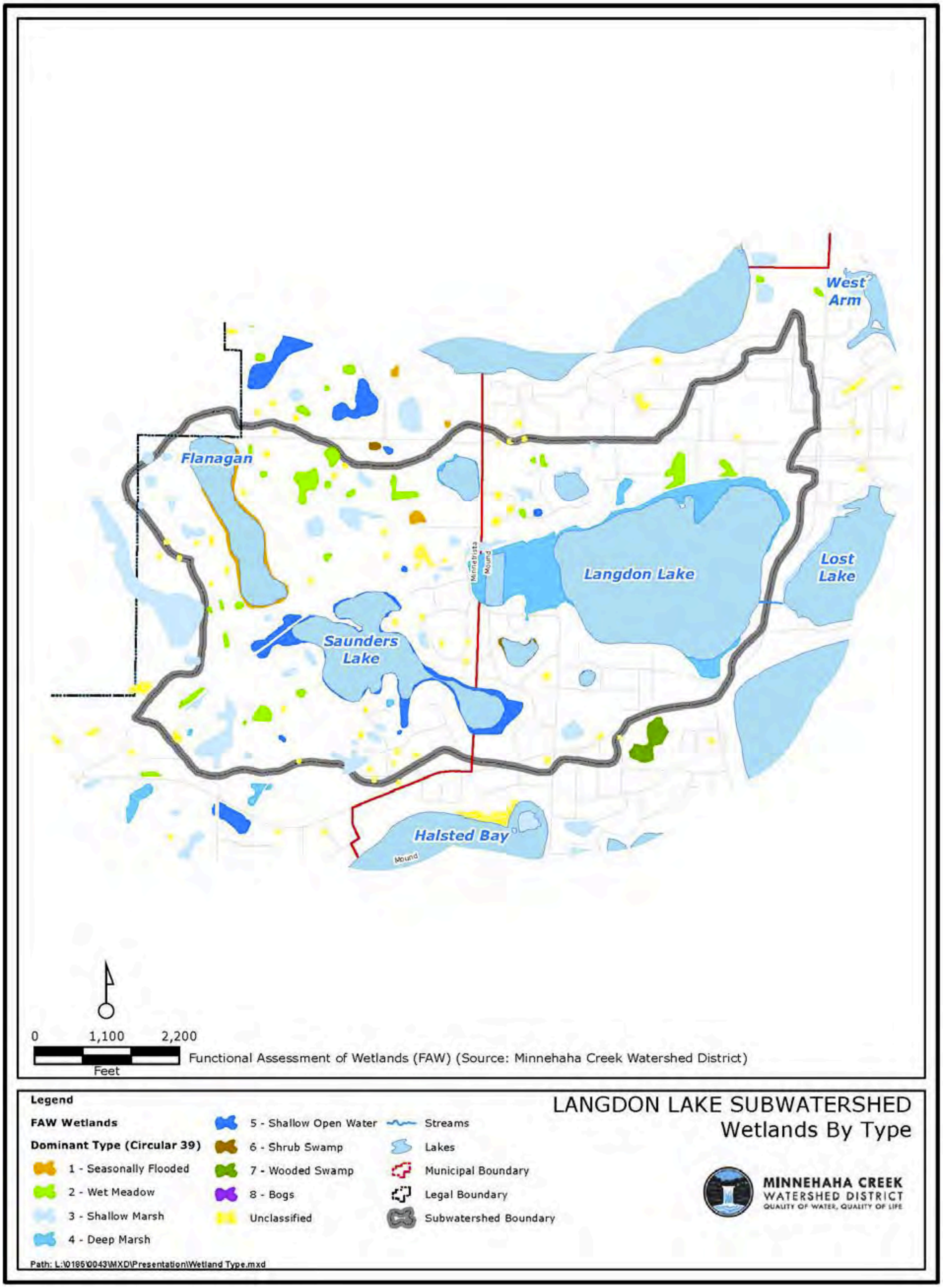

Figure 2. 55. Langdon Lake subwatershed wetlands by type.

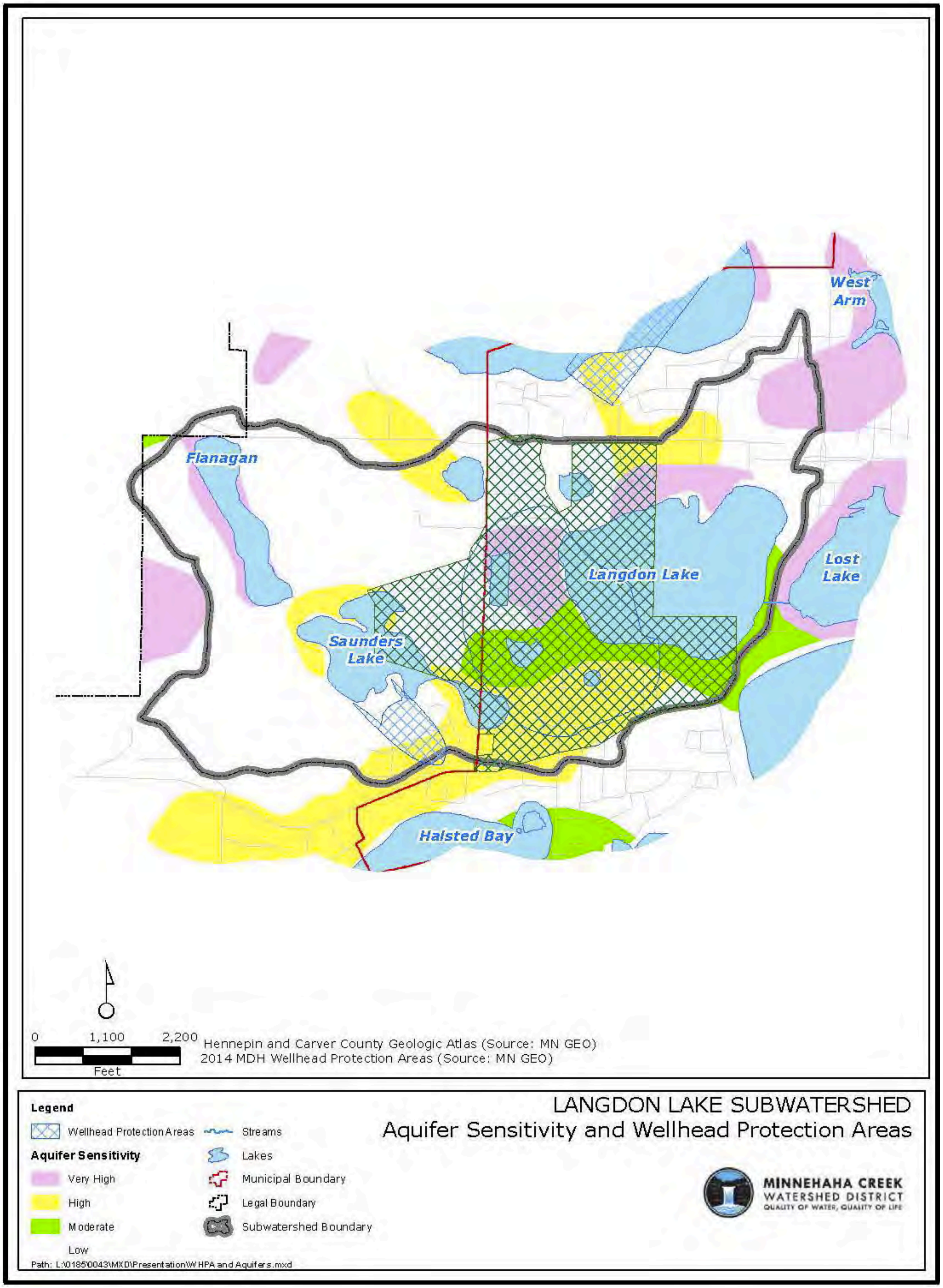

Figure 2. 56. Langdon Lake subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

LL-1 and LL-2 drain to Saunders Lake, a large wetland complex that is discharged through a small channel to Langdon Lake. Langdon Lake discharges through a culvert under Highway 110 into Lost Lake, which outlets into Cooks Bay: Lake Minnetonka. The subwatershed is bisected by a railroad corridor, which influences its hydrology (Figure 2.53).

To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water-yield data for the monitoring station at the outlet of Langdon Lake. Water yield for 2006-2015 did exhibit statistically significant ($p = 0.03$) increasing trend indicating that there has been a significant change in outflow over the past ten years.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Langdon Lake subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data, where available (Figure 2.57).

Lakes:

Biodiversity

Fish Community. No fish IBI data are available for the lakes in this subwatershed. The most recent DNR fish survey of Langdon Lake was conducted in 1993. At that time the fish population was dominated by black bullhead, a fish that is typical of turbid waters, and various species of sunfish.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. The most recent survey was conducted in 2015 with 6 species observed. The Floristic Quality Index (FQI) score from the 2015 survey was 12.7 – Degraded. The E-Grade indicates the aquatic vegetation community has very low species diversity with non-native and/or intolerant species, most disturbed communities present. By observation, the turbidity of the water limits the growth of aquatic macrophytes that in turn limits the fishery.

Aquatic Invasive Species. Curlyleaf Pondweed is confirmed in Langdon Lake. Eurasian watermilfoil is confirmed in Saunders Lake.

Habitat diversity

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species, or the extent to which it may be dominated by a few species. The vegetation community has not been assessed yet for habitat diversity.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score the Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score the Shore data are available; however, aerial photos show that around Saunders Lake the majority of the shoreline has wooded or wetland fringes as does the northern half of Langdon Lake. Flanagan Lake (a wetland) has a fully intact wooded or vegetated fringe. Fridge is beneficial for controlling runoff and supporting emergent vegetation at the shoreline.

Streams:

Biodiversity

Fish Community. There are no fish data for any of the streams in this subwatershed.

Macroinvertebrate Community. There are no macroinvertebrate data available for the streams in this subwatershed.

Aquatic Invasive Species. There are no AIS data for any of the streams in this subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity for the unnamed stream within the subwatershed. By observations, the creek is a straight ditch and is not deep or wide.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are no identified barriers along the unnamed stream within the subwatershed.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are not available, but instantaneous flow measured since 2006. Annual average flow for each year was computed first, and then all the years' averages were averaged together. Annual average flow at CLA01 was 1.18 cfs indicating generally low flow conditions at time of data collection.

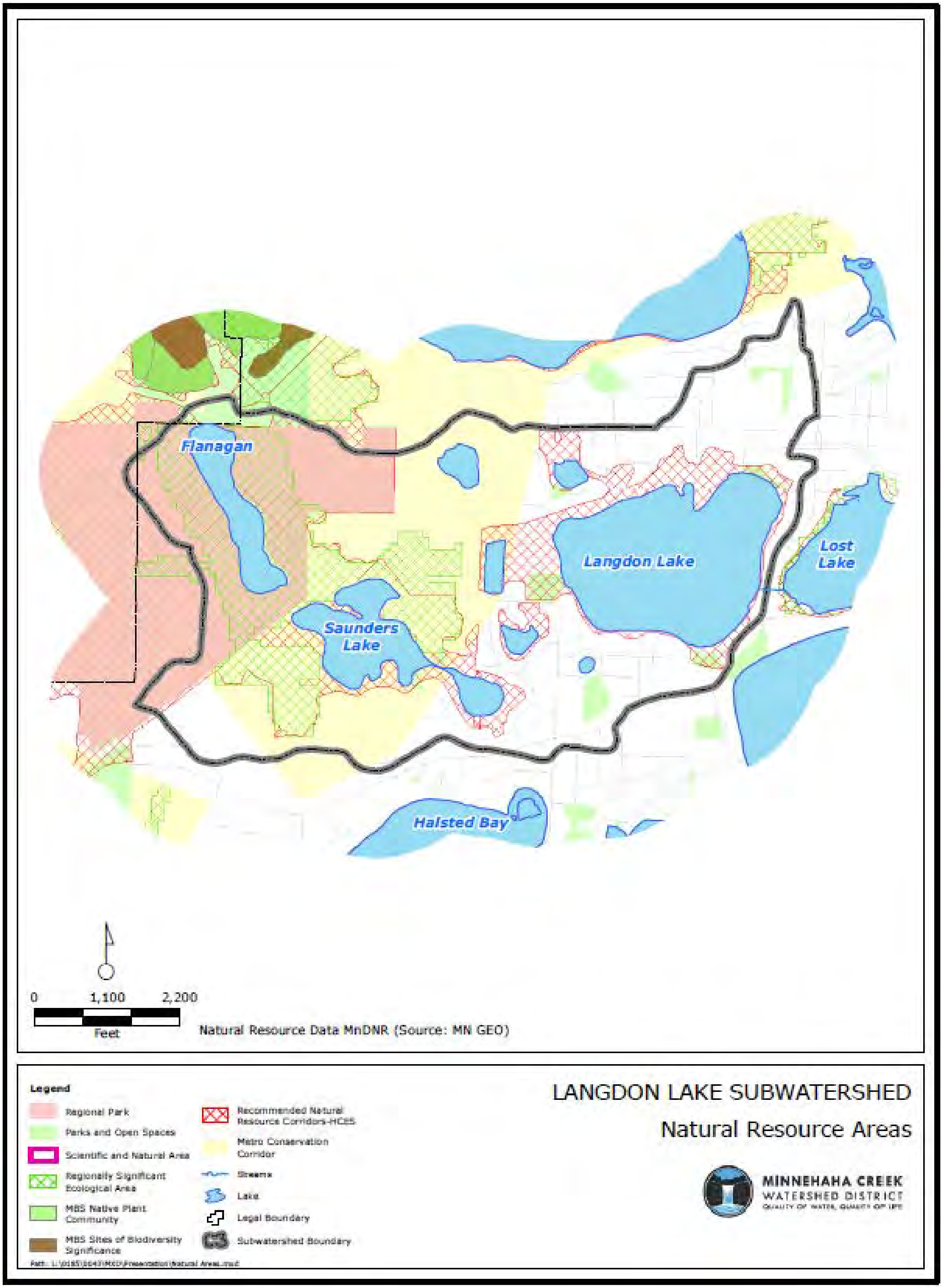

Figure 2. 57. Langdon Lake subwatershed natural resource areas.

Wetlands:

Biodiversity

Vegetation Community. No FQI data are available for the wetlands in this subwatershed. The *Functional Assessment of Wetlands* has classified several wetlands as having high vegetative diversity and wildlife habitat potential as well as having exceptional aesthetic and fish habitat values. The highest vegetative diversity was found in the wetland complex associated with Flanagan Lake within the Gale Woods Regional Park and the wetlands riparian to Saunders Lake. The wetlands riparian to Saunders and Langdon Lakes were evaluated as having high fish habitat values. There are four wetlands in the subwatershed that were identified as being of high restoration potential; three are located in Gale Woods Regional Park.

Macroinvertebrate Community. No macroinvertebrate data are available for the wetlands in this subwatershed.

Habitat diversity

Connectivity. While there are high quality wetlands within this subwatershed, the elevated Dakota Rail Regional Trail limits connectivity between the major wetlands.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species. There are several large wetland complexes in the subwatershed, including Flanagan Lake, a multi-type wetland with a small area of Type 5 open water, and Saunders Lake, a large Type 5 wetland.

Shoreline Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. Approximately 75 percent of the Langdon Lake shoreline is protected by wetlands, especially present in the west and north. About 60 percent of the shoreline around Saunders Lake, especially the southern eastern-most lobe is protected by wetlands, some of which front residential development. Lastly, Flanagan Lake itself is classified as a wetland.

Uplands:

Biodiversity

A portion of the western subwatershed is within Gale Woods Regional Park. The western half of the subwatershed is dominated by a mosaic of forest and woodland, wetland, and open water, with some agriculture in the southwest and some scattered, large-lot residential development. Existing data sources do not highlight any other unique or scenic areas in this subwatershed.

The Minnesota Biological Survey (MBS) did not identify any terrestrial or aquatic locations in the watershed with intact native plant communities, or those with biodiversity significance (Figure 2.57). However, the largely intact open space surrounding Flanagan Lake and the north and west sides of Saunders Lake are classified as a Regionally Significant Ecological Area.

Habitat diversity

Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. Nearly the entire western portion of the subwatershed has been identified as important conservation corridors worthy of protection by Hennepin County and the Metropolitan Council. The wide wetland areas along the western and northern areas of Langdon Lake have also been identified. The Dakota Rail Regional Trail may act as a barrier to wildlife migration between the north and south halves of the subwatershed.

Thriving Communities:

Land use:

Table 2.56 shows the land uses within the subwatershed in acres and as a percentage of the total subwatershed. The principal land use in the eastern part of the subwatershed is single family residential, with some vacant or undetermined land that is predominately wetland (Figure 2.58). The western watershed is dominated by Gale Woods Regional Park, Flanagan Lake and Saunders Lake and their associated wetlands, other wetlands, and some remaining agriculture and undeveloped land. The western subwatershed is outside the 2020 Metropolitan Urban Service Areas (MUSA).

Table 2. 56. 2016 land use in the Landon Lake subwatershed.

Land Use 2016	Acres	% of Subwatershed
Single - Family Residential	340.1	32.2
Water	234.8	22.2
Parks and Open Space	219.7	20.8
Vacant or Undetermined	188.9	17.9
Agricultural	18.8	1.8
Multi - Family Residential	15.8	1.5
Commercial	13.5	1.3
Industrial	12.2	1.2
Institutional	11.7	1.1

Source: Metropolitan Council.

Recreation:

The Langdon Lake subwatershed is notable for its ecological resources and large wetlands. The northwestern part of the subwatershed includes several areas of high-value woods, grassland, and wetland, and has been acquired by the Three Rivers Park District and incorporated into Gale Woods Regional Park. The Dakota Rail Regional Trail bisects the subwatershed, offering views of Langdon and Saunders Lakes.

There is no public boat access to Langdon Lake (Figure 2.59). There is City of Mound-owned open space on the west side of the lake, adjacent to a Metropolitan Council Environmental Services wastewater handling site, but there are no trails or other improvements. There are no public beaches on the lake; however, there is one small park. The City of Minnetrista operates Cusoke Park adjacent to Saunders Lake, a pedestrian trail and boardwalk which cross the "narrows" at the south end of the lake. Activities are limited to hiking/biking and viewing.

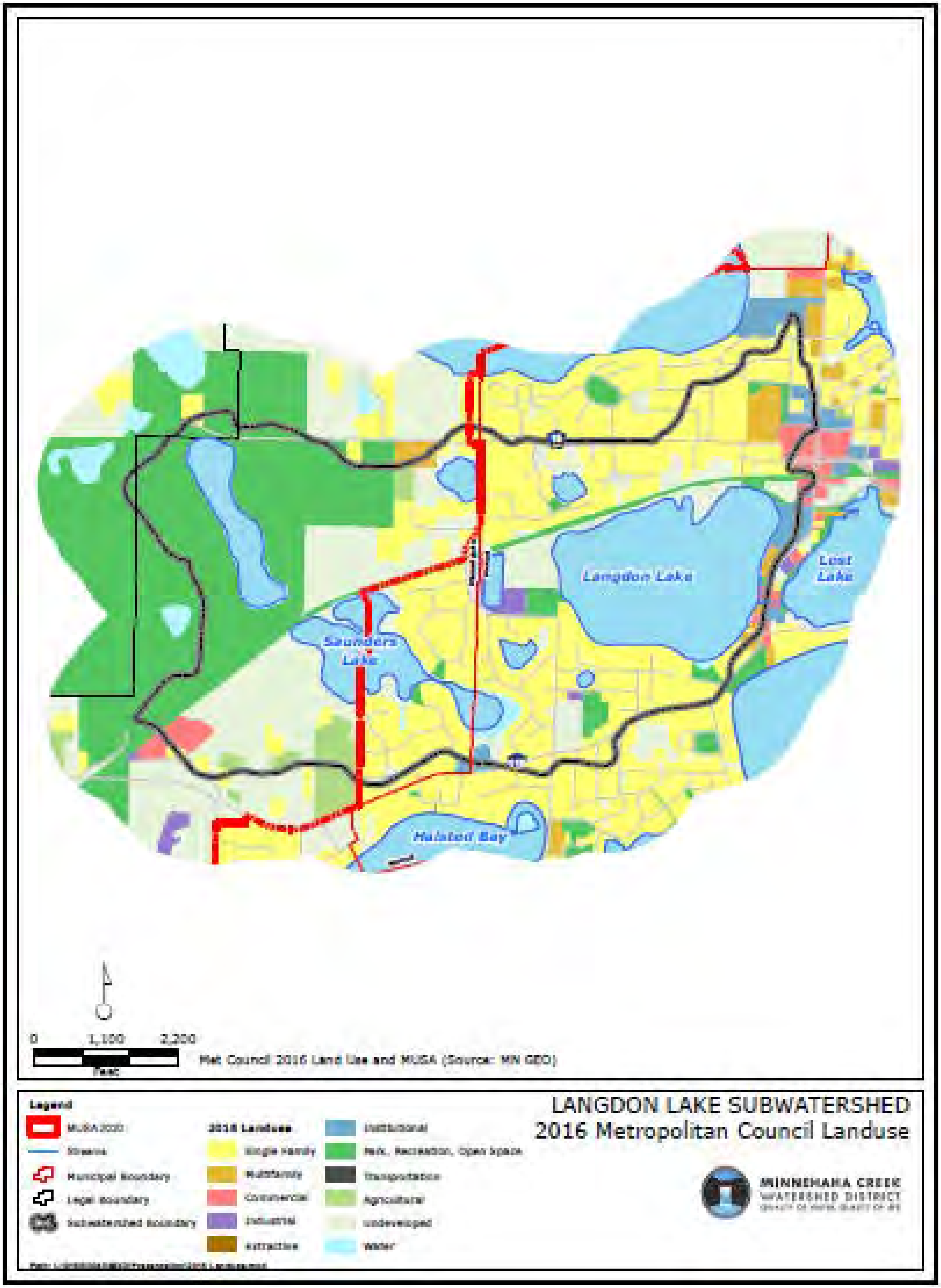

Figure 2. 58. Langdon Lake subwatershed 2016 Metropolitan Council land use.

Figure 2. 59. Langdon Lake subwatershed recreation and other features.

2.3.7 LONG LAKE CREEK SUBWATERSHED

The Long Lake Creek Subwatershed has a mix of land use with agricultural and open space and residential/business development in the south. The land cover is a mix of wetlands, forests, woodlands, grasslands and impervious cover. About 1600 acres drain into the primary inlet of Long Lake (CLO05). Long Lake drains south into wetland that discharges into Lake Minnetonka: Tanager Lake (CLO03). The creeks in the Long Lake Subwatershed are intermittent with loading influenced by precipitation and flow. Tanager Lake's inlet is also influenced by the water level of Lake Minnetonka, which produces backflow conditions. Table 2.57 below shows the area of the Long Lake Creek subwatershed in acres by individual city, in total and as a percentage of the total subwatershed (Figure 2.60).

Table 2. 57. Cities in the Long Lake Creek subwatershed.

City	Area (Acres)	% of Subwatershed
Long Lake	607.3	8.0
Medina	3,831.0	50.3
Orono	3,141.8	41.2
Plymouth	39.4	0.5
Total	7,619.4	100%

Source: MCWD

Subwatershed Description and Hydrology:

The eastern half of the subwatershed is gentle rolling hills with an abundance of lakes and ponds, reflected in the area's many wetlands. The western half is generally comprised of circular, level-topped hills.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.61). The subwatershed is mostly developed in the south with low to medium density impervious surface typical of residential development. The City of Long Lake is located along the southern shore of its namesake lake. The area north of Long Lake is much less densely developed, punctuated with agriculture – mostly pastures and orchards with some row crops - as well as large open areas of forest and wetlands.

Soils within the watershed are predominantly classified as Natural Resources Conservation Service Hydrologic Soil Group B (loamy soils with moderate infiltration potential) and D (clayey soils with very low infiltration potential). For further information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Upstream of Long Lake, a series of channels and wetlands drain the western part of the subwatershed from School Lake through Wolsfeld Lake to Long Lake. Similarly, the eastern part of the upper subwatershed drains via a channel from Holy Name Lake through wetlands, where it discharges into the western channel just north of County Road 6. Long Lake Creek flows out of Long Lake south to Tanager Lake, which is connected by a short channel to Lake Minnetonka.

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Long Lake Creek subwatershed into 53 subwatershed units, designated LLC-1 through LLC-53 (Figure 2.62).

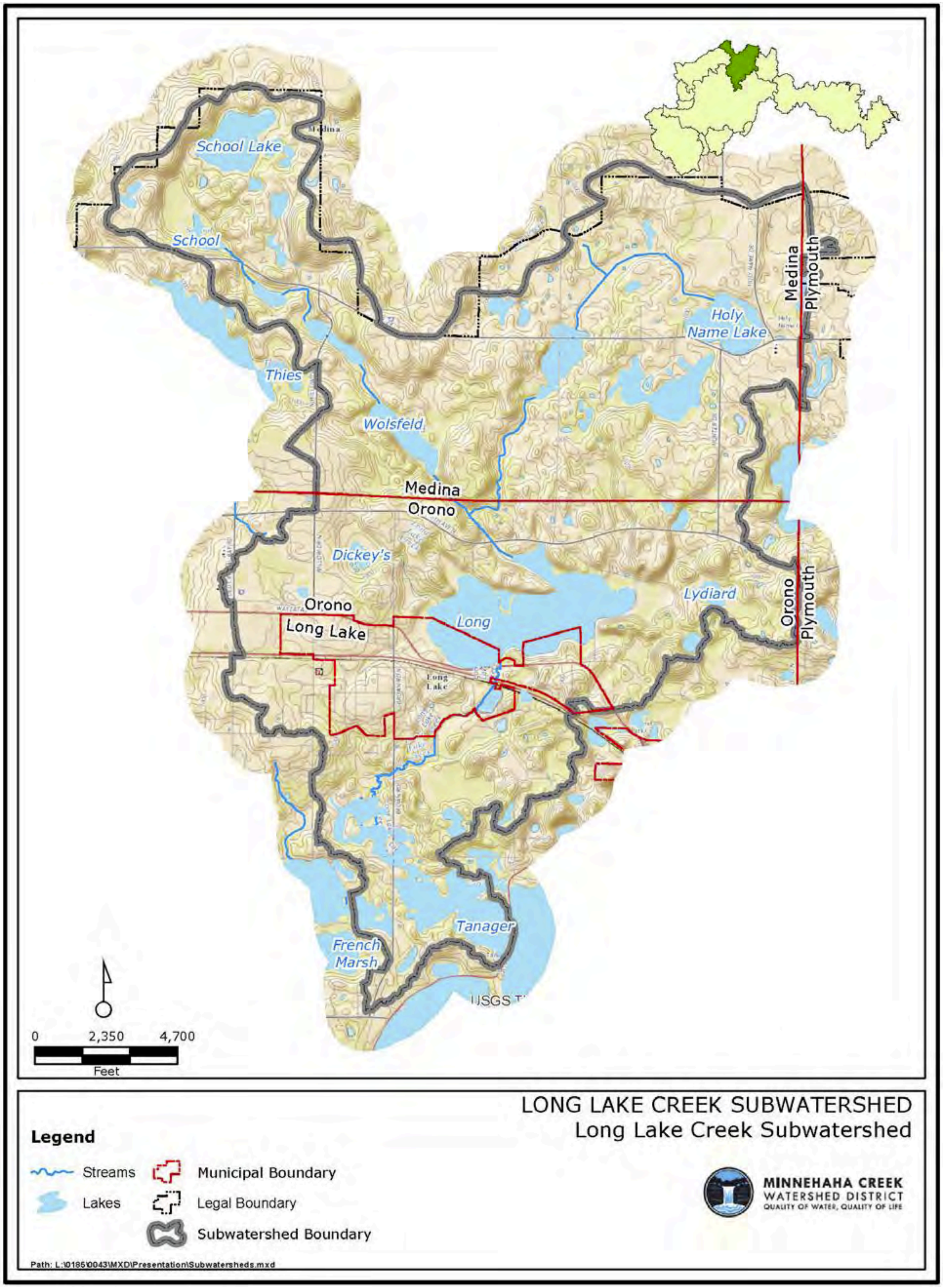

Figure 2. 60. The Long Lake Creek subwatershed.

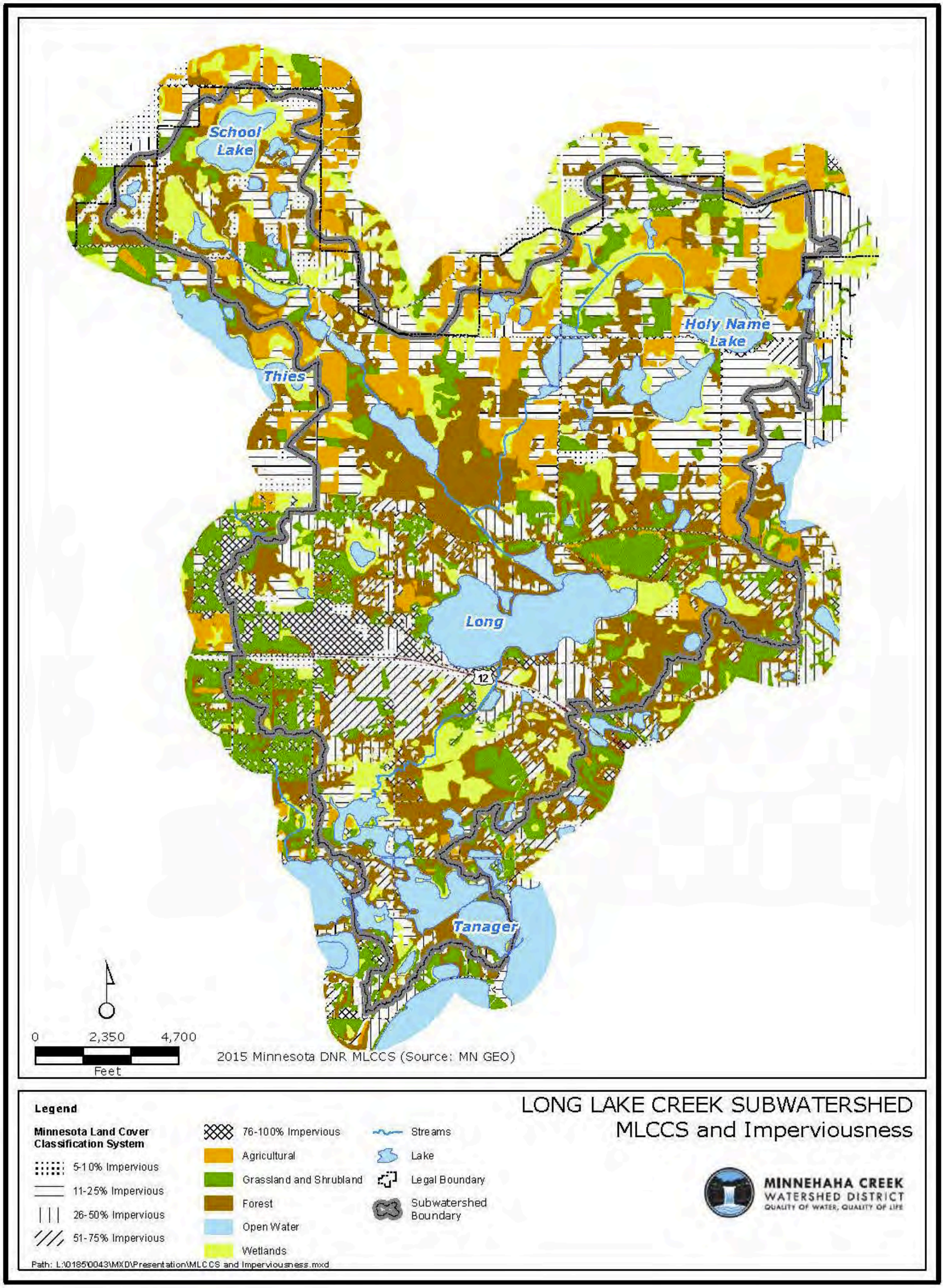

Figure 2. 61. Long Lake Creek subwatershed MLCCS and imperviousness.

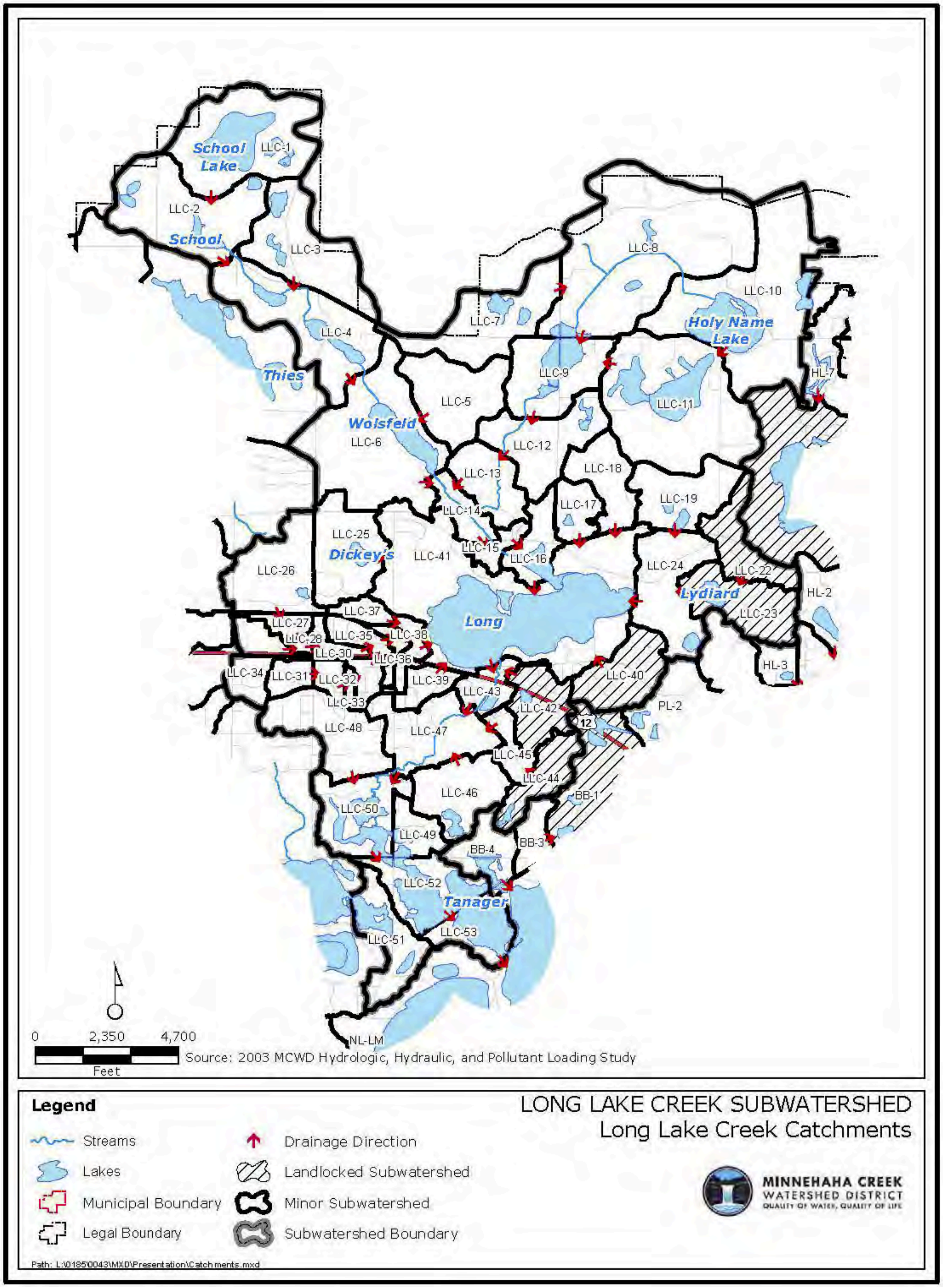

Figure 2. 62. Long Lake Creek subwatershed catchments.

Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

Long Lake is the primary receiving water within the subwatershed, and is classified by the DNR for shoreland management purposes as a Recreational Development lake (Table 2.56). Six lakes in the subwatershed are listed on the State's Impaired Waters list: School, Wolsfeld, Holy Name, Long, and Tanager Lakes. Average summer nutrient concentrations are greater than the state standard with excessive nutrients being conveyed to them from the watershed for these six lakes.

To assess long-term change in lakes within the Long Lake Subwatershed, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth from 2001-2015. There were statistically significant improvements in water clarity in Long Lake over this period, but the change is small. Tables 2.58 and 2.59 below detail the physical and water quality characteristics of Long Lake and other lakes within the subwatershed. For more information regarding water quality in the subwatershed, please refer to the District's Water Quality (Hydrodata) Reports and the Upper Minnehaha Creek Watershed Lakes TMDL.

Table 2. 58. Physical characteristics of lakes in the Long Lake Creek subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Dickey's	12	26	13:1	Natural Environment
Holy Name	68	7	7:1	Recreational Development
Long	285	33	23:1	Recreational Development
Lydiard	33	52	26:1	Natural Environment
School	11	21	51:1	Natural Environment
Tanager	54	23	151:1	Recreational Development
Wolsfeld	34	26	47:1	Natural Environment

Source: Minnesota DNR, MCWD.

Table 2. 59. Selected water quality goals and current conditions of lakes in the Long Lake Creek subwatershed.

Lake	State TP Standard (µg/L)	2007 Plan Goal TP (µg/L)	Trend*	2001-2015 Summer Average		
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)
Dickey's[1]	40	n/a	n/a	49	8.8	2.6
Holy Name[2]	60	n/a	n/a	94.82	54.2	0.9
Long	40	40-50	Imp Secchi	68	42	1.0
Lydiard[1]	40	n/a	n/a	19	4	3.0
School[3]	60	n/a	n/a	154	89	0.3
Tanager[4]	60	70	No trend	97	73	0.9
Wolsfeld[2]	40	n/a	n/a	90	59	0.7

*Statistically significant at ≤ 0.05, Imp = Improving

[1]Data are from 2009-2015. [2]Data are from 2006-2008, 2014-2015. [3]Data are from 2009-2010. [4]Data are from 2006-2015. [5]Data are from 2006-2008, 2011-2015.

Source: MCWD, Upper Minnehaha Creek Watershed Lakes TMDL, MPCA.

Streams:

There is one primary stream within the subwatershed: Long Lake Creek, which serves as the outlet of Long Lake and flows to Tanager Lake, when then discharges to Browns Bay of Lake Minnetonka. Part of the creek was channelized as County Ditch #27 in 1915. Flow to the creek is controlled by an outlet weir on Long Lake. Six storm sewer outfalls discharge into the creek. The creek flows through two large wetlands prior to discharging into Tanager Lake and then into Browns Bay (Figure 2.63).

Tables 2.60 and 2.61 below detail the physical and water quality characteristics of streams and tributaries within the subwatershed. No streams are listed as Impaired Waters, although Long Lake Creek TP is high relative to the state river eutrophication standards. However, those standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand that haven't been assessed in Long Lake Creek.

Table 2.61 shows the average TSS concentrations at three sites on Long Lake Creek to be less than 10 mg/L, below the 30 mg/L state standard for this ecoregion. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. Monitoring data show that the site above Long Lake and the site above Tanager Lake both fall below this standard at least several times per year.

To assess long-term change, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2005-2015. There were no statistically significant changes in water quality in Long Lake Outlet over this period. For more information, please refer to the District's Water Quality (Hydrodata) reports.

Table 2. 60. Major streams in the Long Lake Creek subwatershed.

Stream	Length (mi)
Holy Name Tributary	2.24
School Lake Tributary	3.55
Long Lake Creek	1.25

Table 2. 61. Current conditions of streams in the Long Lake Creek subwatershed.
See Figure 2.63 for monitoring locations.

Stream	Trend*	2005-2015 Annual Average			
		TP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl (mg/L)
Long Lake Cr –lake inlet (CLO05)	n/a	184	1.35	8	37
Long Lake Cr – lake outlet (CLO01)	n/a	85	1.40	8	49
Long Lake Cr – Tanager inlet (CLO03)	No trend	124	1.14	9	43

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride.
*Statistically significant at ≤ 0.05.
Source: MCWD.

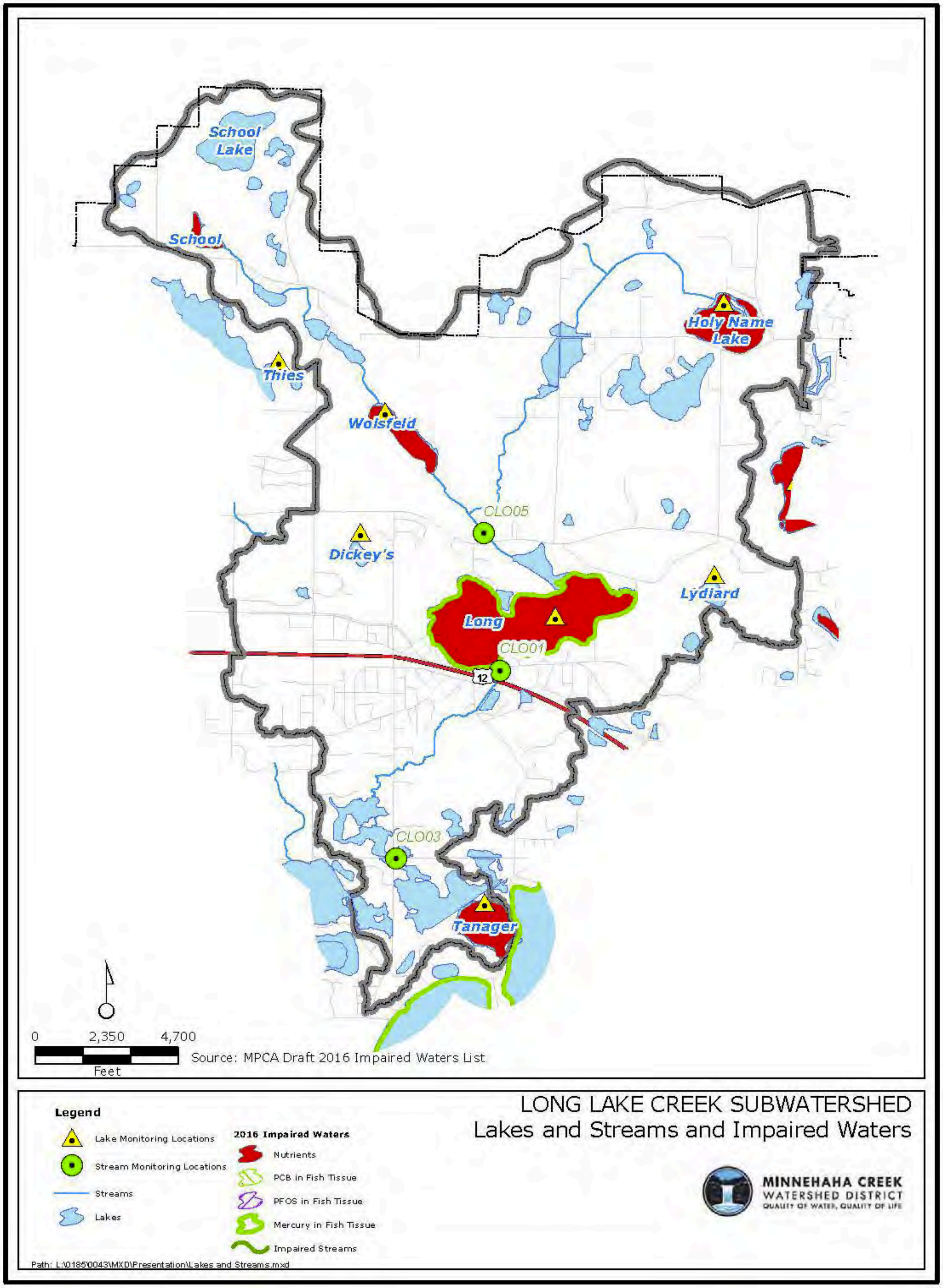

Figure 2. 63. Long Lake Creek subwatershed lakes and streams and Impaired Waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover over 20 percent of the watershed's surface (Figure 2.64 and Table 2.62). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients to and from the subwatershed. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2. 62. Functional Assessment of Wetlands inventory of wetland types in the Long Lake Creek subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	63.5	0.80
2 - Wet Meadow	308.3	3.89
3 - Shallow Marsh	484.6	6.12
4 - Deep Marsh	28.3	0.36
5 - Open Water	205.8	2.60
6 - Scrub Shrub	388.6	4.91
7 - Forested	168.0	2.12
8 - Bog	-	-
Riverine	2.6	<0.1
Wetland Total	1,649.7	20.8
Upland	6,294.7	79.2
TOTAL	7,944.4	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

Areas of moderate to high or very high aquifer sensitivity roughly follow the two tributary/wetland corridors in the upper subwatershed and the Long Lake Creek corridor to Browns Bay. Elsewhere the *Hennepin County Geologic Atlas* classifies most of the upland areas as being of low to moderate sensitivity to pollution.

Portions of the Long Lake subwatershed have been designated by the Minnesota Department of Health as a Drinking Water Supply Management Area (DWSMA) and Wellhead Protection Area for City of Plymouth and City of Long Lake public wells. The MDH has designated much of this area to be of low risk and vulnerability to contamination of the drinking water supply, with a small area located in a till deposit being of moderate risk and vulnerability. Figure 2.65 shows areas in the subwatershed with groundwater sensitivity and that are designated Wellhead Protection Areas.

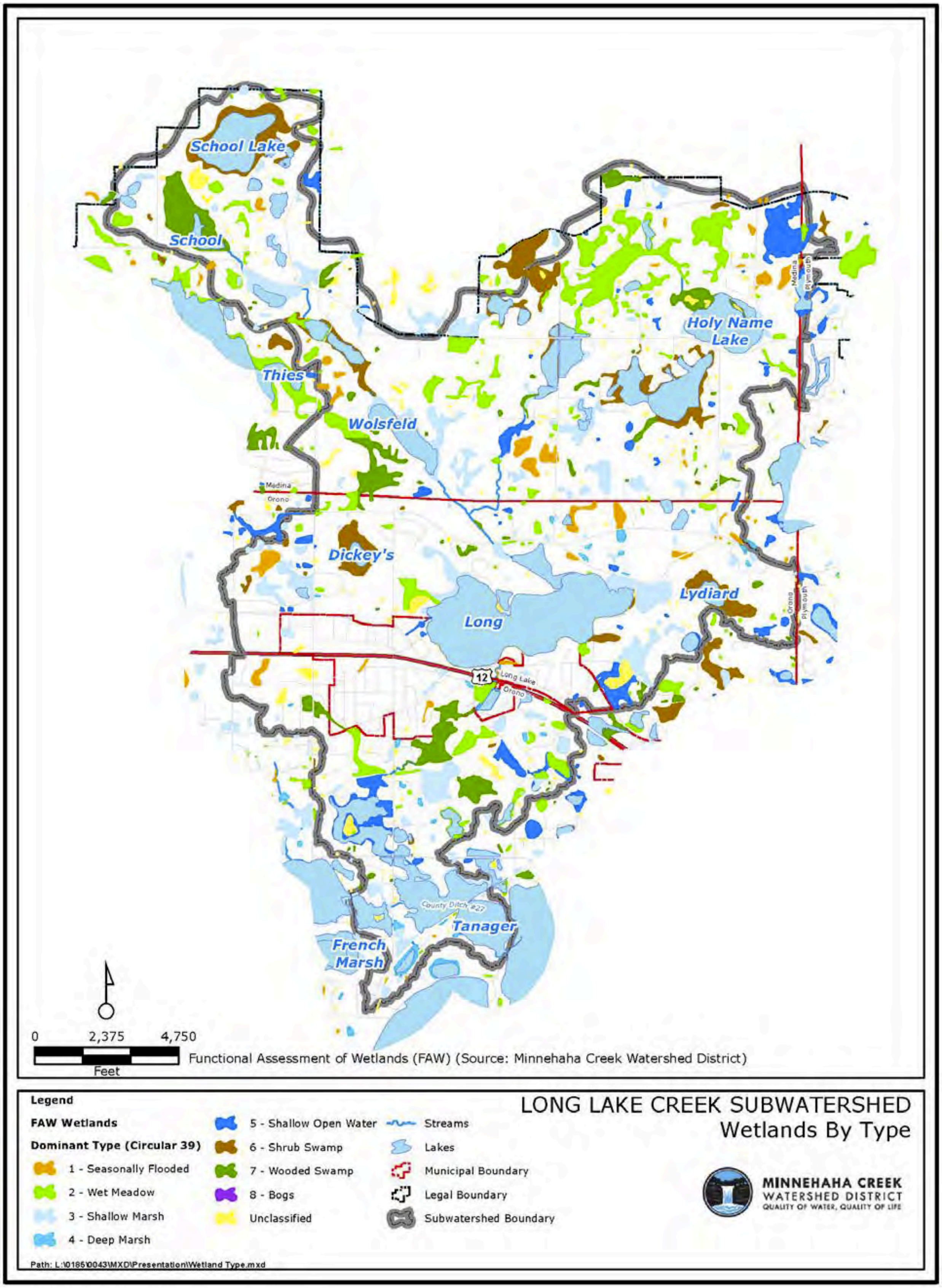

Figure 2. 64. Long Lake Creek subwatershed wetlands by type.

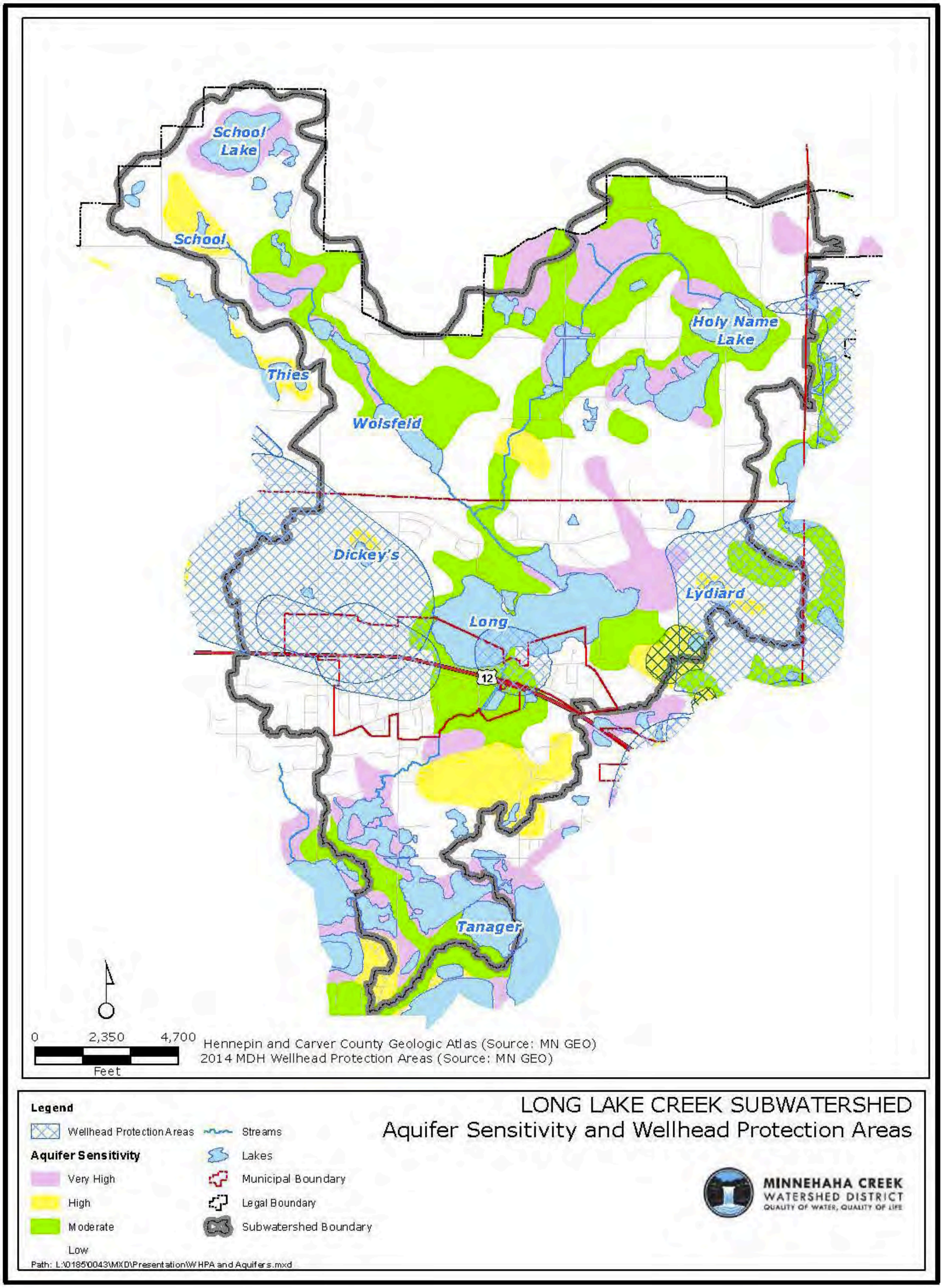

Figure 2. 65. Long Lake Creek subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

Two significant areas within the subwatershed are landlocked. The first is units LLC-22, and 23, which include Lydiard Lake, and have no natural outlet. Units LLC-40, 42, and 43 contain wetlands that have no or limited outlet (Figure 2.62).

To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water yield data for the monitoring station upstream of Long Lake. Water yield for 2006-2015 did not exhibit any statistically significant trend upward or downward.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Long Lake subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data, where available (Figure 2.66).

Lakes:

Biodiversity

Fish Community. No fish IBI data are available for the lakes in this subwatershed. Long Lake is stocked and maintained as a walleye fishery and was last surveyed by the DNR in 2013. That survey found that the walleye community was balanced, but the low dissolved oxygen and high summer temperatures were potentially limiting optimal growth and survival. The survey also found an abundant pike and panfish population. Limited fish survey data are available for the other lakes in the subwatershed.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. A survey was conducted on Long Lake in 2014, with 5 species observed. The Floristic Quality Index (FQI) score from the survey was 8.05 – Degraded indicating very low species diversity with non-native and/or intolerant species. The most disturbed communities present. Surveys have also been conducted on Dickey's, Lydiard and Wolsfeld. Dickey's and Wolsfeld have low biodiversity, less than 4 species observed, and an FQI score of less than 10, E-Grade = Degraded. Lydiard had 11 species observed, and a FQI score of 18.39, E-Grade = Poor, indicating obvious signs of anthropogenic disturbance. Lydiard has low species diversity often comprised of non-native and/or intolerant species.

Aquatic Invasive Species. Eurasian watermilfoil is present in Long Lake and Tanager Lake. Curlyleaf Pondweed is present in Holy Name Lake, Long Lake, and Tanager Lake. Zebra mussels are present in very low numbers in Tanager Lake. Common carp are believed to be an issue in this subwatershed, but no population data are available.

Habitat diversity

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species, or the extent to which it may be dominated by a few species. This has not been assessed yet.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score the Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score the Shore data are available; however, aerial photos show that many of the lakes in the subwatershed have significant woodland or wetland fringes, which are beneficial for controlling runoff and supporting emergent vegetation at the shoreline.

Streams:

Biodiversity

Fish Community. Limited fish data are available for Long Lake Creek. The DNR conducted a fish survey at one site in 2010. The fish IBI score for that survey was 40, which is on the border of Good and Poor. Fathead minnows were the most prevalent fish, a species that is tolerant of turbid, low oxygen conditions. A few lake species were also present.

Macroinvertebrate Community. Limited macroinvertebrate data are available for Long Lake Creek. The DNR conducted a survey in 2010; the IBI score for that survey was 41, which is just below the impairment threshold. The District conducted a survey at five locations on Long Lake Creek in 2013, and the IBI scores ranged from 9 to 12, well below the impairment threshold. Organisms found at these sites were very pollution-tolerant, and certain functional groups were not represented.

Aquatic Invasive Species. No AIS data are available for the any of the streams within this subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity, but notes taken for the 2003 *Upper Watershed Stream Assessment* were reviewed to better understand conditions in the in-stream zone and riparian zone, and to assess channel morphology. That survey found that the stream in some locations had moderately complex habitat and morphology, but there are reaches that are less complex and more altered.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are several barriers on the streams in this subwatershed, most of them culverts at road or trail crossings. There are no stream cross-section data available, but notes taken for the *2003 Upper Watershed Stream Assessment* indicate the stream generally has low banks and ready access to the floodplain.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are available at CLO01 station, and not available at CLO03 station. CLO01 station is the lake outlet, controlled by a weir, is often fast, but not flashy discharge. Instantaneous flow at CLO03 is not flashy and often has backflow, and since 2006, the CLO03 station has an average of discharge of 8.76 cfs. Note: Annual average flow for each year was computed first, and then all the years' averages were averaged together.

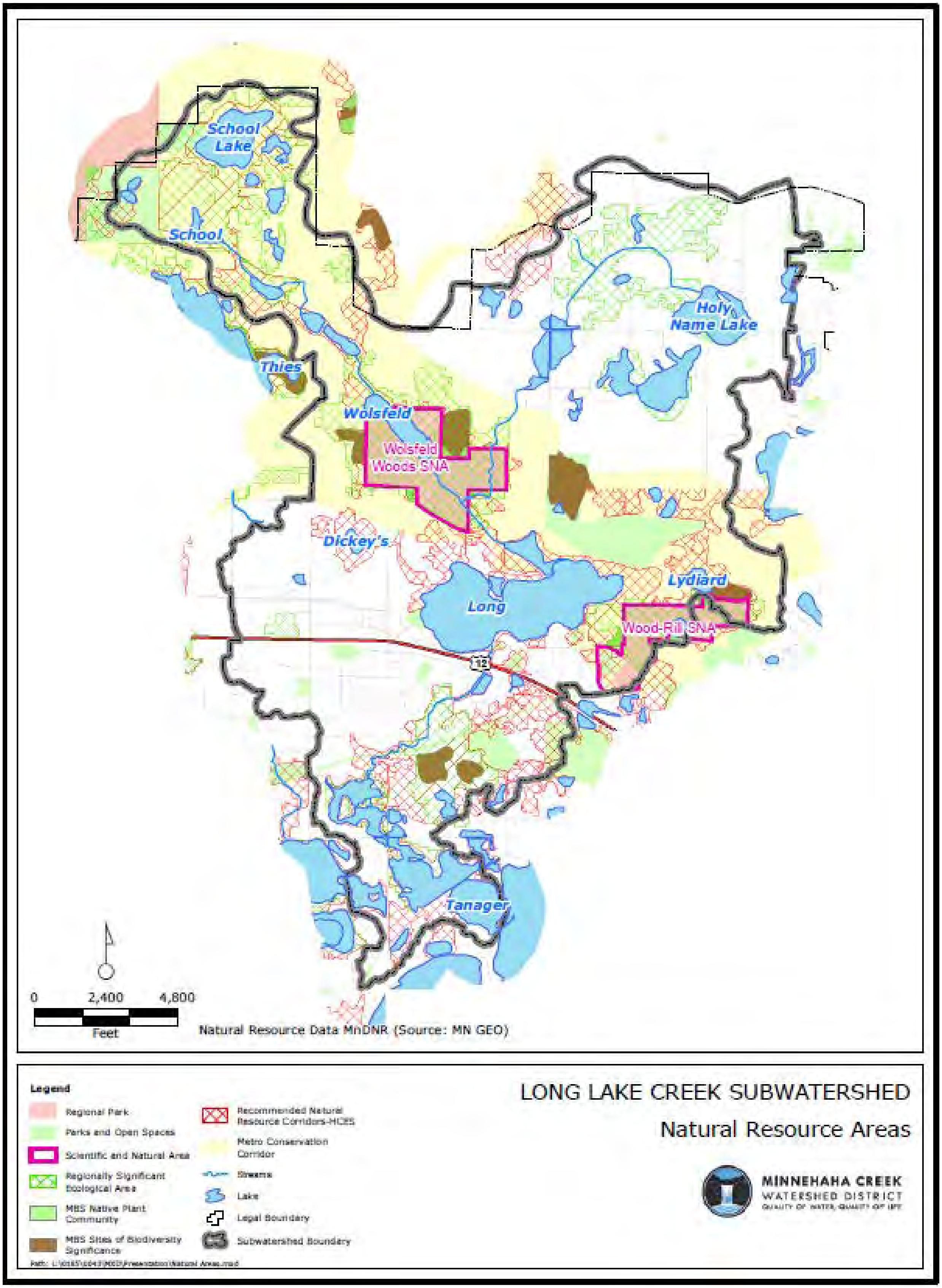

Figure 2. 66. Long Lake Creek subwatershed natural resource areas.

Wetlands:

Biodiversity

Vegetation Community. No Rapid Floristic Quality Assessment (RFQA) data are available for the wetlands in this subwatershed. However the *Functional Assessment of Wetlands* classified several large wetlands in the subwatershed as having exceptional vegetative diversity, including School Lake, wooded swamps in Wolsfeld Woods Scientific and Natural Area, and scrub shrub and wooded swamp wetlands in the Wood-Rill Scientific and Natural Area.

Macroinvertebrate Community. No macroinvertebrate data are available for the wetlands in this subwatershed.

Habitat diversity

Connectivity. There are several interconnected wetland corridors providing exceptional connectivity between wetlands of different type.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species. There are numerous large wetland complexes in the subwatershed, including wetlands along the two tributary corridors in the upper subwatershed and along Long Lake Creek.

Shoreline Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. About 22 percent of the Long Lake shoreline is protected by wetlands. About half the shoreline of Holy Name Lake and a third of Wolsfeld Lake is protected moderately well by fringing wetlands. School, Dickey's and Lydiard Lakes are ringed completely with wetlands and emergent vegetation.

Uplands:

Biodiversity

Two DNR Scientific and Natural Areas are present in the subwatershed: Wolsfeld Woods and Wood-Rill. Wolsfeld Woods is an example of the original "Big Woods" forest that once covered the south central part of the state. The large, mature stand of hardwoods covers gently rolling hills with a wide variety of tree species, including red oak, ironwood, butternut, maple, elm and basswood. Wolsfeld Lake is within this Scientific and Natural Area. Wood-Rill also preserves a remnant of the Big Woods, with land cover including maple-basswood forest, wetlands, ponds, and wet meadows. A moist lowland forest of red maple, black ash, hackberry, basswood, and green ash, grades into a small tamarack swamp at one end.

The Minnesota Biological Survey (MBS) has identified both terrestrial and aquatic locations in the watershed with intact native plant communities, and those with biodiversity significance (Figure 2.66). Native plant communities are a group of native plants that interact with each other and the surrounding environment in ways not greatly altered by humans or by introduced plant or animal species.

Habitat diversity

Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. These sites are numerous enough in the Long Lake Creek subwatershed that Hennepin County and the Metropolitan Council have identified several corridors within the subwatershed as important conservation corridors.

Thriving Communities:

Land use:

Table 2.63 shows the land uses within the area of the Long Lake Creek subwatershed in acres and as a percentage of the total subwatershed. The predominant land use in the subwatershed is vacant or undetermined use, mainly large wetland or woodland tracts (Figure 2.67). Single family residential dominates the central and eastern subwatershed. There is a commercial and industrial corridor along US Highway 12, in the City of Long Lake. Some large agricultural parcels remain in the upper subwatershed, mainly row crops and hobby farms.

Table 2. 63. 2016 land use in the Long Lake Creek subwatershed.

Land Use 2016	Acres	% of Subwatershed
Vacant or Undetermined	2,833.0	37.2
Single - Family Residential	2,148.3	28.2
Parks and Open Space	762.2	10.0
Agricultural	750.0	9.8
Water	672.7	8.8
Institutional	140.5	1.8
Commercial	93.6	1.2
Roads and Highways	85.2	1.1
Industrial	83.4	1.1
Multi - Family Residential	50.5	0.7

Source: Metropolitan Council.

Recreation:

The Luce Line Regional Trail passes through this subwatershed, as will the proposed Southwest Hennepin Regional Trail. The Minnesota Historic features database notes 22 historic features in this subwatershed, most are residences or farmhouses or agricultural buildings (Figure 2.68). The listing includes a school and a cemetery as well as three bridges, including a Luce Line bridge.

There is one public boat access, fishing pier and two public beaches on Long Lake. There is public boat (i.e., canoe) access to Holy Name Lake at Holy Name Park in Medina.

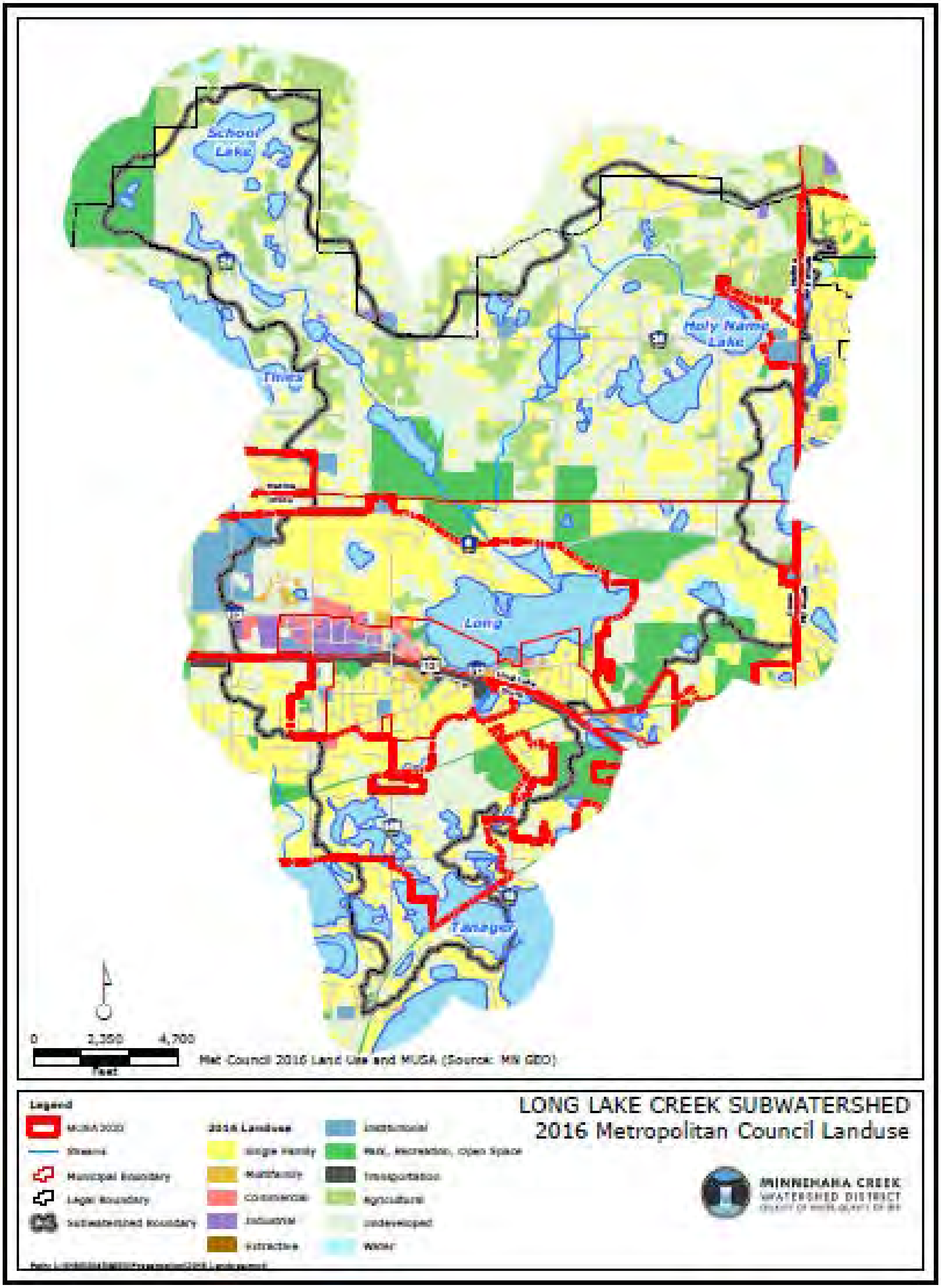

Figure 2. 67. Long Lake Creek subwatershed 2016 Metropolitan Council land use.

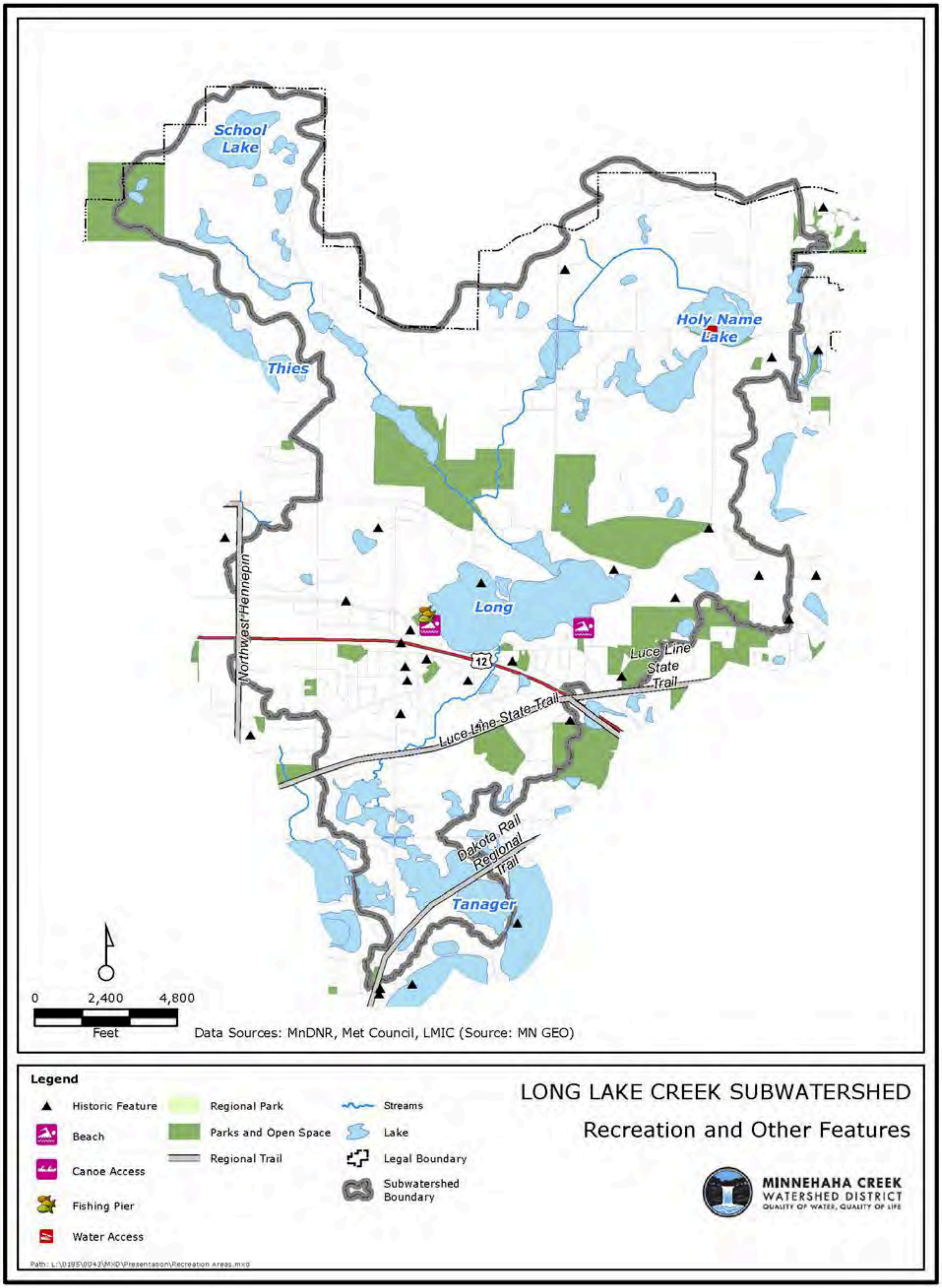

Figure 2. 68. Long Lake Creek subwatershed recreation and other features.

2.3.8 MINNEHAHA CREEK SUBWATERSHED

Minnehaha Creek Subwatershed is the only subwatershed east of the Lake Minnetonka. The land use is dominated by residential, business and industrial developments. The impervious cover on the land is higher in this subwatershed compared to the other ten subwatersheds. Land designated for parks and recreational areas are scattered throughout the subwatershed; many are adjacent to the lakes and the creek, as are the majority of the remaining wetlands and woodlands. Table 2.64 below shows the area of the Minnehaha Creek subwatershed in acres by individual city, in total and as a percentage of the total subwatershed. An additional 437.8 acres is included from Fort Snelling (Figure 2.69).

Table 2.64. Cities in the Minnehaha Creek subwatershed.

City	Area (Acres)	% of Subwatershed
Edina	2,634.3	8.7%
Fort Snelling	437.8	1.4%
Golden Valley	79.4	0.2%
Hopkins	1,193.7	3.9%
Minneapolis	11,096.3	36.6%
Minnetonka	7,068.0	23.3%
Plymouth	207.5	0.6%
Richfield	1321.1	4.3%
St. Louis Park	6,143.3	20.2%
Wayzata	119.3	0.3%
Total	30,301.1	

Source: MCWD.

Subwatershed Description and Hydrology:

The lower portion of this subwatershed generally east of the city of Hopkins is typified by gently rolling terraces and bottom lands punctuated by small lakes formed from melted blocks of glacial ice. The upper portion of this subwatershed is characterized by gently rolling to steep hilly landscapes with numerous lakes formed in deep irregular depressions called kettles. Soils within the watershed are predominantly urban disturbed soils that have not been classified. Where the soils have been classified, they are mainly Group B (loamy soils with moderate infiltration potential) and D (clayey soils with very low infiltration potential). For more information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan.*

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.70). Urban areas with moderate to high densities of impervious surface characterize the subwatershed which is entirely developed. There are some sizable areas of wetland and forest/woodland in the City of Minnetonka and in some locations along the creek corridor. An extensive, but narrow park system surrounds the Minneapolis lakes and Minnehaha Creek and along the Mississippi River.

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Minnehaha Creek subwatershed into 184 subwatershed units, designated MC-1 through MC-184 (Figure 2.71). Minnehaha Creek is formed at the outlet of Grays Bay and flows 22 miles to the Mississippi River. A significant area of the central portion of the subwatershed drains to the Chain of Lakes (Brownie, Cedar, Isles, Calhoun, and Harriet) in the City of Minneapolis, which outlets by a channel to Minnehaha Creek. Lake Nokomis is separated from Minnehaha Creek by a weir to reduce the influence of the creek on the lake's water quality and prevent the introduction of invasive species. Lake Hiawatha, however, is located in-line to Minnehaha Creek and is heavily influenced by it.

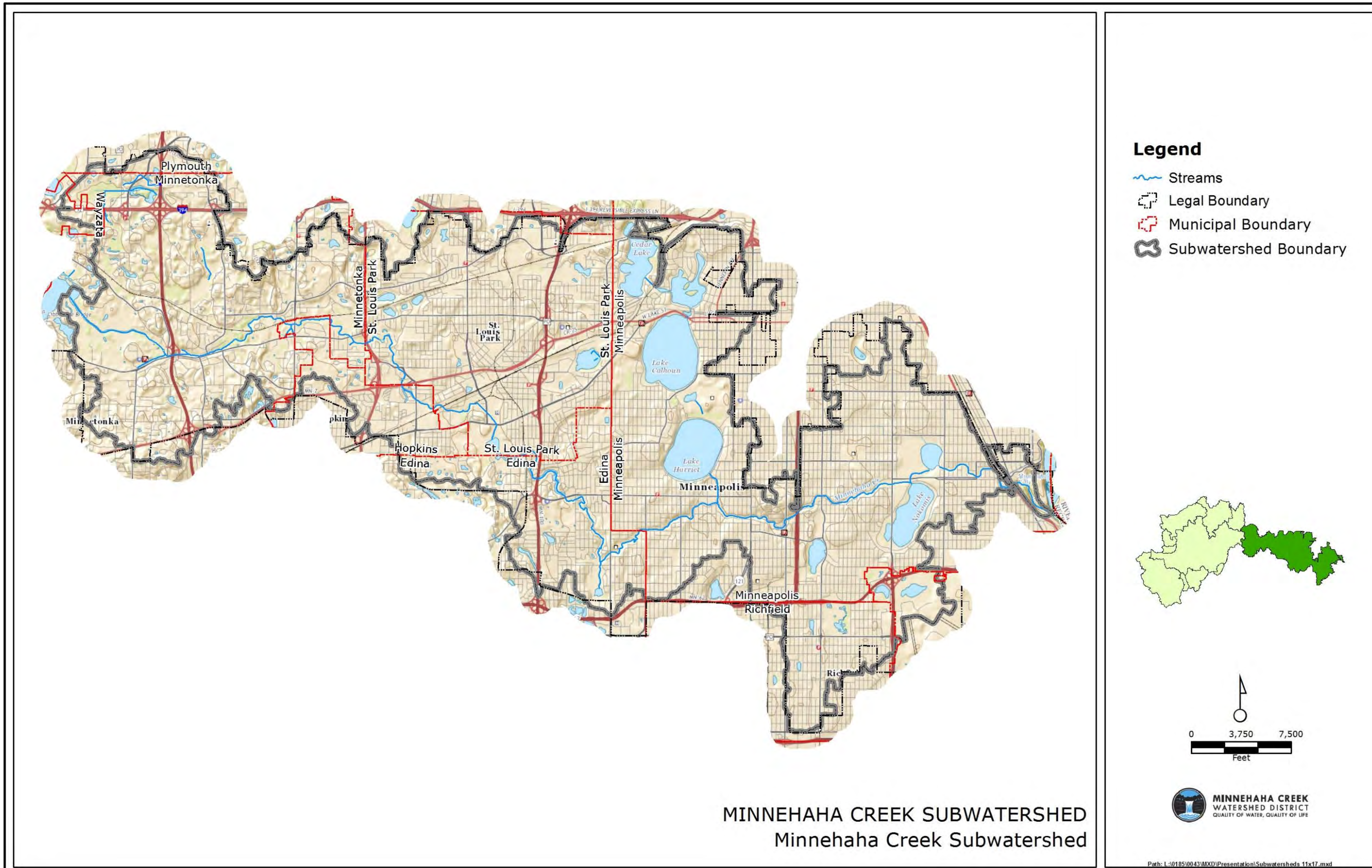

Figure 2.69. The Minnehaha Creek subwatershed.

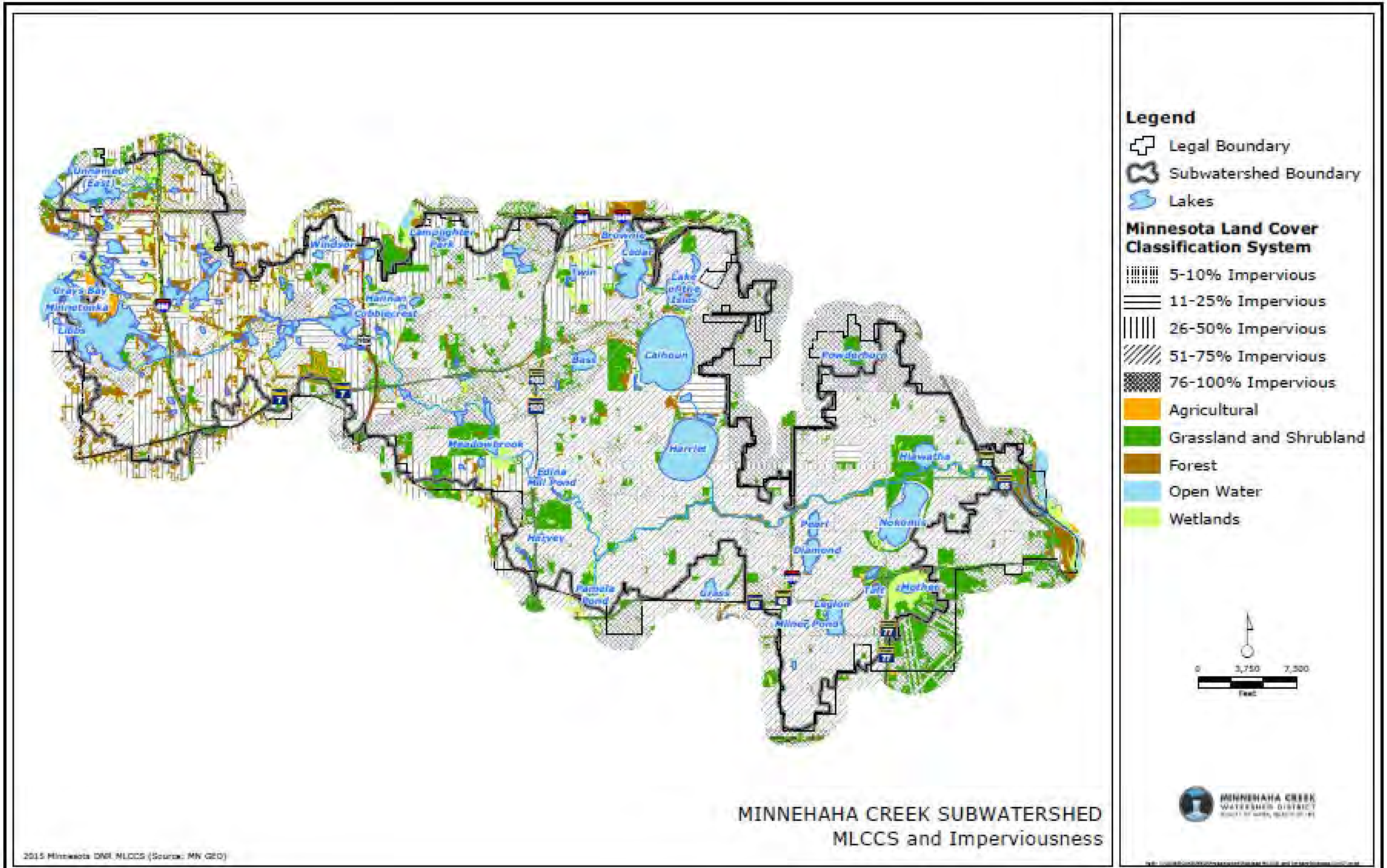

Figure 2.70. Minnehaha Creek subwatershed MLCCS and imperviousness.

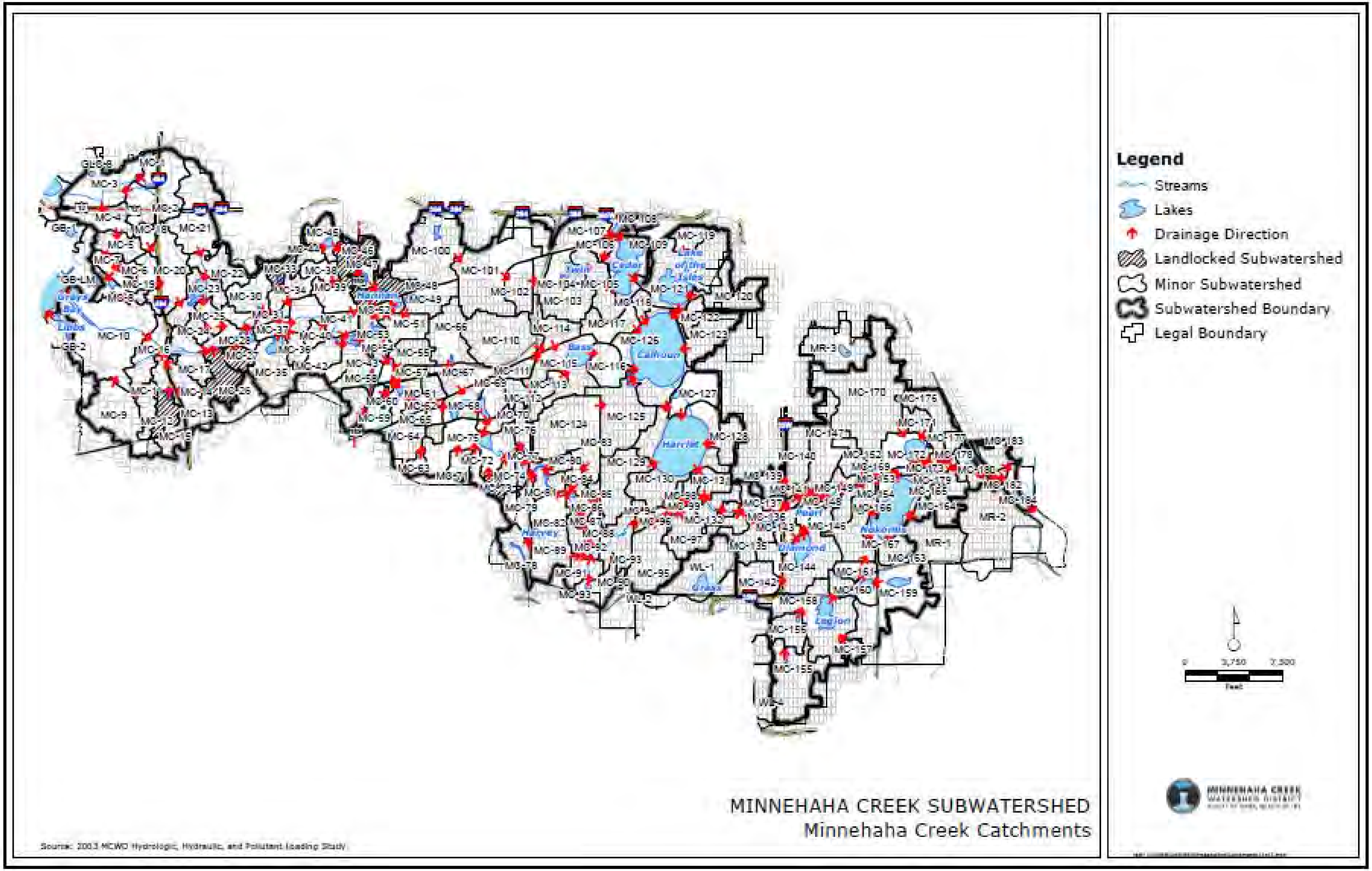

Figure 2.71. Minnehaha Creek subwatershed catchments.

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Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

The Minnehaha Creek subwatershed includes the Chain of Lakes in Minneapolis and several other smaller lakes (Figure 2.72). Powderhorn Lake in Minneapolis does not drain to the creek, but rather is pumped to the Mississippi River. Tables 2.65 and 2.66 below detail the physical and water quality characteristics of the major lakes within the subwatershed and Table 2.65 includes the DNR shoreland management classification.

The District, the Minneapolis Park and Recreation Board (MPRB), and trained volunteers monitor many of the lakes in the subwatershed. Five lakes in the subwatershed are listed on the State's Impaired Waters list for exceeding the state standard for total phosphorus, with excessive nutrients being conveyed to them from the watershed. TMDLs have been completed for two of those lakes: Hiawatha and Nokomis. Powderhorn and Brownie had been listed previously, but meet standards and were delisted in 2012 and 2010, respectively. However, the water quality in Powderhorn Lake, from 2011-2016, is indicating that lake could once again be evaluated for re-listing.

Several lakes are also impaired for excess mercury and PFOS or PCBs in fish tissue. Two lakes – Powderhorn and Brownie - are impaired by excess chloride, likely from road salt. Diamond Lake and Grass Lake have been classified by the MPCA as a wetlands, so the lake eutrophication standards do not apply. Diamond Lake; however, is listed as impaired for chloride in the TCMA Chloride TMDL.

To assess long-term change, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth data from 2001-2015. Statistically significant changes in water quality are listed in Table 2.66. For more information regarding water quality in the subwatershed, please refer to the District's Water Quality (Hydrodata) Reports.

Table 2.65. Physical characteristics of lakes in the Minnehaha Creek subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Brownie	10	50	22:1	Natural Environment
Calhoun	419	82	13:1	Recreational Development
Cedar	164	51	16:1	Recreational Development
Hannan	14	6	14:1	Natural Environment
Harriet	341	87	26:1	Recreational Development
Hiawatha	53	33	546:1	Natural Environment
Isles	112	31	32:1	Recreational Development
Meadowbrook	28	7	406:1	Natural Environment
Nokomis	201	33	12:1	Natural Environment
Powderhorn	11	24	28:1	Natural Environment
Taft	14	45	131:1	Natural Environment
Twin	13	7	132:1	Natural Environment

Source: Minnesota DNR, MCWD.

Table 2. 66. Selected water quality goals and current conditions of waterbodies in the Minnehaha Creek subwatershed.

Waterbody	State TP Standard (µg/L)	2007 Plan Goal TP (µg/L)	Trend*	2001-2015 Summer Averages		
				TP (µg/L)	Chl-*a* (µg/L)	Secchi (m)
Brownie	60	35	n/a	44	12	1.3
Calhoun	40	25	No trend	17	4	3.7
Cedar	40	25	Deg Secchi	25	9	2.0
Cobblecrest[1]	n/a	n/a	n/a	119	83	0.44
Diamond	n/a	n/a	n/a	149	46	0.5
Grass	n/a	n/a	n/a	116	46	n/a
Hannan[2]	60	n/a	n/a	67	23	0.82
Harriet	40	20	Deg TP	21	5	3.0
Hiawatha	50**	50	No trend	70	18	1.4
Isles	40	40	No trend	44	28	1.3
Meadowbrook[3]	60	n/a	n/a	49	11	2.1
Nokomis	50**	50	Imp Chl-*a*, TP	52	22	1.2
Powderhorn	60	120	No trend	114	28	1.0
Taft[4]	40	n/a	n/a	75	40	1.1
Twin	60	n/a	Imp TP	165	65	0.6
Windsor[5]	n/a	n/a	n/a	143	43	0.47

*Statistically significant at ≤ 0.05., Imp = improving, Deg = degrading.
**Both Nokomis and Hiawatha were granted a site-specific standard by the MPCA due to unique conditions.
[1]Data are from 2002-2015. [2]Data are from 2010-2015. [3]Data are from 2013-2015. [4]Data are from 2010-2015. [5]Data are from 2011-2015.
Source: MCWD, MPCA.

Streams:

Minnehaha Creek is the primary stream within the subwatershed. It is formed at the outlet of Grays Bay in Lake Minnetonka and flows 22 miles to the Mississippi River. Lake Hiawatha is in-line to the creek and heavily influenced by it. As an outlet for Lake Minnetonka and the upper watershed, Minnehaha Creek must discharge large volumes of water during spring snowmelt runoff, summer and fall. During a typical year, 4-6 inches of runoff from the 122 square-mile upper watershed are discharged to Minnehaha Creek. The typical average flow in the creek due to this runoff is 60 to 90 cfs. Tables 2.67 and 2.68 below detail the physical and water quality characteristics of streams and tributaries within the subwatershed.

Total phosphorus concentrations on Minnehaha Creek are less than the state river eutrophication standards. The state river eutrophication standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand, which have not been assessed on the Creek. The primary nutrient cycling concern for Minnehaha Creek is that it conveys phosphorus load to Lake Hiawatha. Minnehaha Creek is included in the State's Impaired Waters List due to excess chloride, fecal coliform concentrations, and low dissolved oxygen as well as impaired fish and macroinvertebrate communities. A small, unnamed channel (CGL04) that outlets the wetland on the southeast corner of Gleason Lake is also listed as impaired for chloride.

Table 2.67 shows the average TSS concentrations in Minnehaha Creek to be well below the 30 mg/L state standard for this ecoregion. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. Monitoring data show that Minnehaha Creek upstream of the Browndale Dam can fall below this standard in summer, but the reaches below the dam have not been observed to do so. The upstream reaches are influenced by through-flow and riparian wetlands, which may increase sediment oxygen demand. To assess long-term change in water quality in Minnehaha Creek,

a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2005-2015. Statistically significant changes in water quality in Minnehaha Creek are listed in Table 2.67.
Minnehaha Creek was studied in-depth in 2003 and 2012 as part of the District's *Minnehaha Creek Stream Assessment*, which included a physical inventory, erosion survey, and a fluvial geomorphic assessment to determine channel stability. For more information regarding these parameters, please refer to the *Minnehaha Creek Stream Assessments*. For more information regarding water quality in the subwatershed, please refer to the District's Water Quality (Hydrodata) Reports and the Minnehaha Creek-Lake Hiawatha TMDL.

Table 2. 67. Current conditions of streams in the Minnehaha Creek subwatershed.
See Figure 2.72 for monitoring locations.

Stream	Trend*	2005-2015 Annual Average			
		TP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl (mg/L)
Unnamed Gleason Channel (CGL04)	n/a	156	0.97	6	312
Gray's Bay Dam (CMH07)	n/a	20	0.66	2	47
I-494 (CMH01)**	Imp TP	38	0.64	3	62
W. 34th Street (CMH02)	Imp TP	52	0.80	7	76
Excelsior Blvd (CMH11)	Imp TP	65	0.85	12	79
Browndale Dam (CMH03)	Imp TSS, TP	62	0.87	5	80
W. 56th Street (CMH04)	n/a	59	0.78	7	79
Xerxes Avenue (CMH15)	Imp TSS, TP	68	0.80	9	85
21st Avenue (CMH24)	n/a	71	0.86	17	88
28th Avenue (CMH18)	n/a	71	0.93	6	90
Hiawatha Avenue (CMH06)	Imp TP	75	1.0	9	97

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride, Imp = Improving
*Statistically significant at ≤ 0.05.
**Station used to be named CMH19, but due to historic data findings, the station was renamed CMH01.
Source: MCWD.

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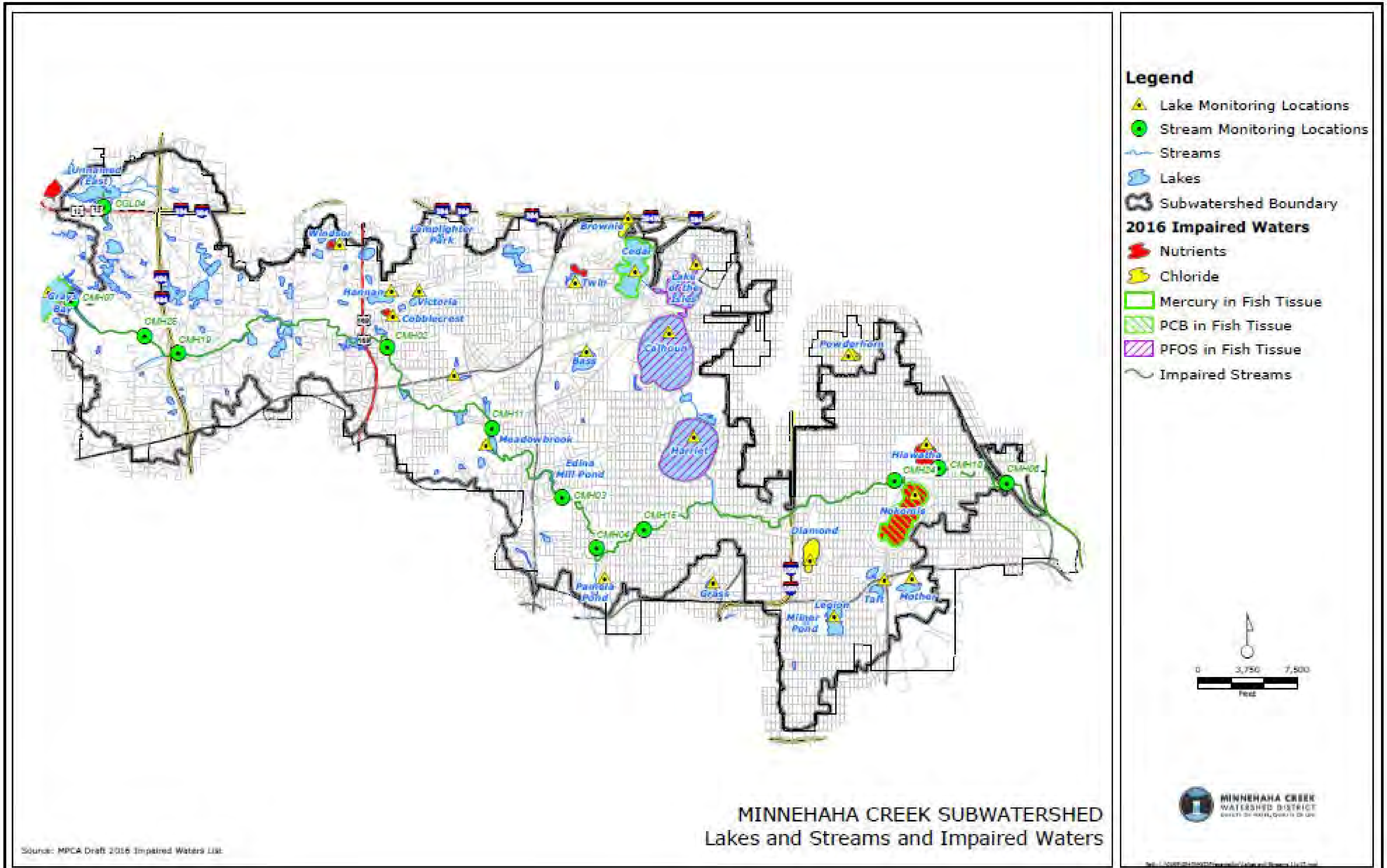

Figure 2.72. Minnehaha Creek subwatershed lakes and streams and Impaired Waters. *Note: CMH19 has been renamed as CMH01.

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Wetlands:

According to the FAW, wetlands, including lakes, cover just over 9 percent of the subwatershed's surface (Figure 2.73 and Table 2.68). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients to and from the subwatershed. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2.68. Functional Assessment of Wetlands inventory of wetland types in the Minnehaha Creek subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	105.9	0.36
2 - Wet Meadow	214.9	0.73
3 - Shallow Marsh	835.4	2.85
4 - Deep Marsh	33.0	0.11
5 - Open Water	591.7	2.02
6 - Scrub Shrub	435.6	1.48
7 - Forested	420.4	1.43
8 - Bog	3.0	0.01
Riverine	146.8	0.50
Wetland Total	2,786.7	9.5
Upland	26,585.1	90.5
TOTAL	29,371.8	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

The *HHPLS* identified the infiltration potential of the upland areas within the subwatershed as high to medium with some areas of variability where the soils are organic in nature. Most of the lower subwatershed is classified by the Hennepin County Geologic Atlas as being of high to very high aquifer sensitivity, reflecting the glacial outwash deposits that underlay the soils and the shallow depth to bedrock. The upper subwatershed, an area of loamy till, is classified as being generally of low to moderate sensitivity to pollution except along the Creek and in the large Grays Bay wetland complex.

There are a number of springs and seeps in the Mississippi River gorge area, including Camp Coldwater Spring, the largest limestone bedrock spring in the Metro area. The 2014 Baseflow Study by the University of Minnesota found that there is significant interaction between the creek and shallow groundwater, with some sections primarily gaining water from groundwater inputs while other sections primarily lose water through infiltration.

Much of the subwatershed has been designated by the Minnesota Department of Health as Drinking Water Supply Management Area (DWSMA) and Wellhead Protection Area (WHPA) for various municipal public wells. The MDH has designated areas within the DWSMAs as very high to moderate risk and vulnerability to contamination of the drinking water supply. Figure 2.74 shows areas in the subwatershed with groundwater sensitivity and that are designated as higher Drinking Water Sensitivity.

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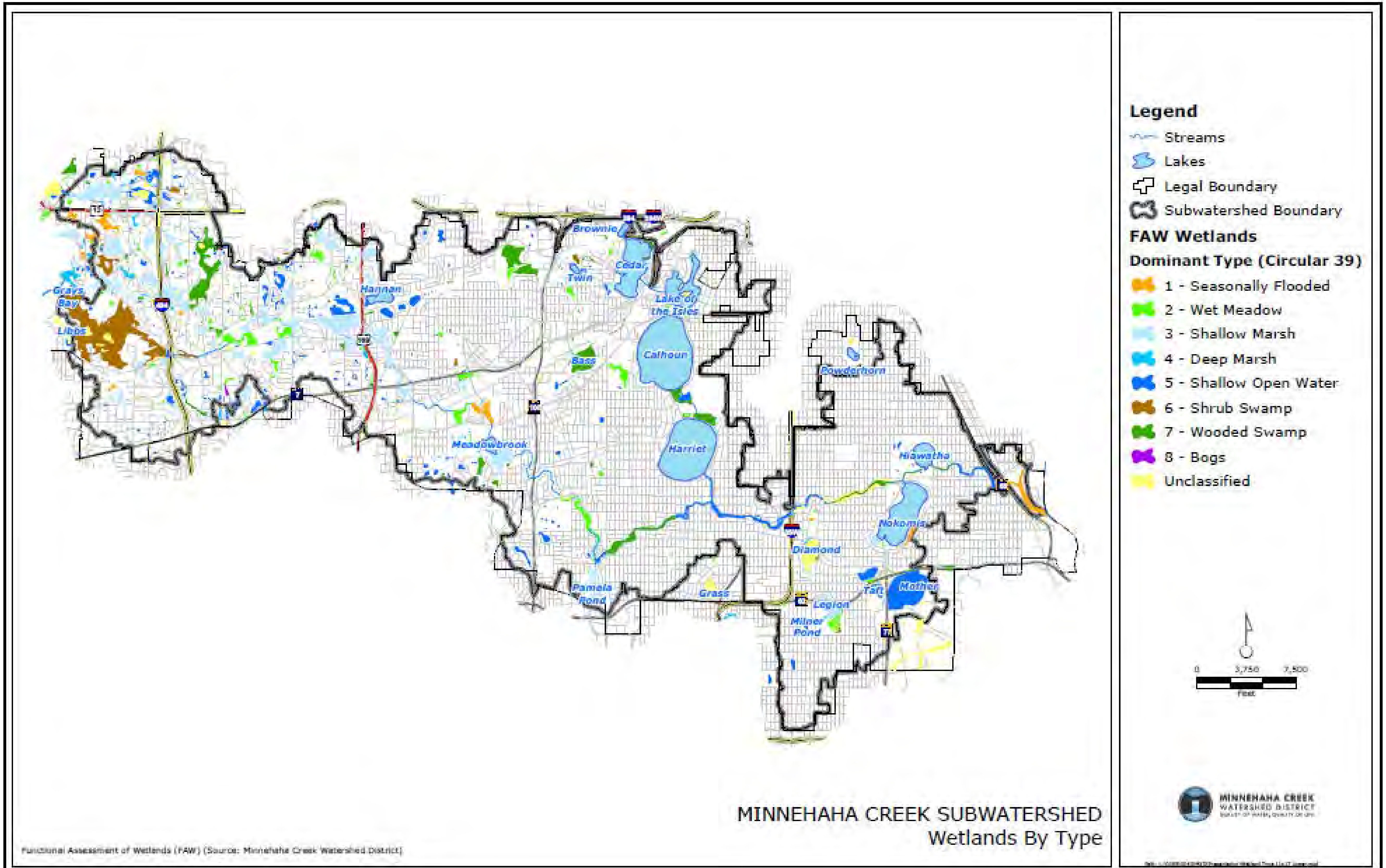

Figure 2. 73. Minnehaha Creek subwatershed wetlands by type.

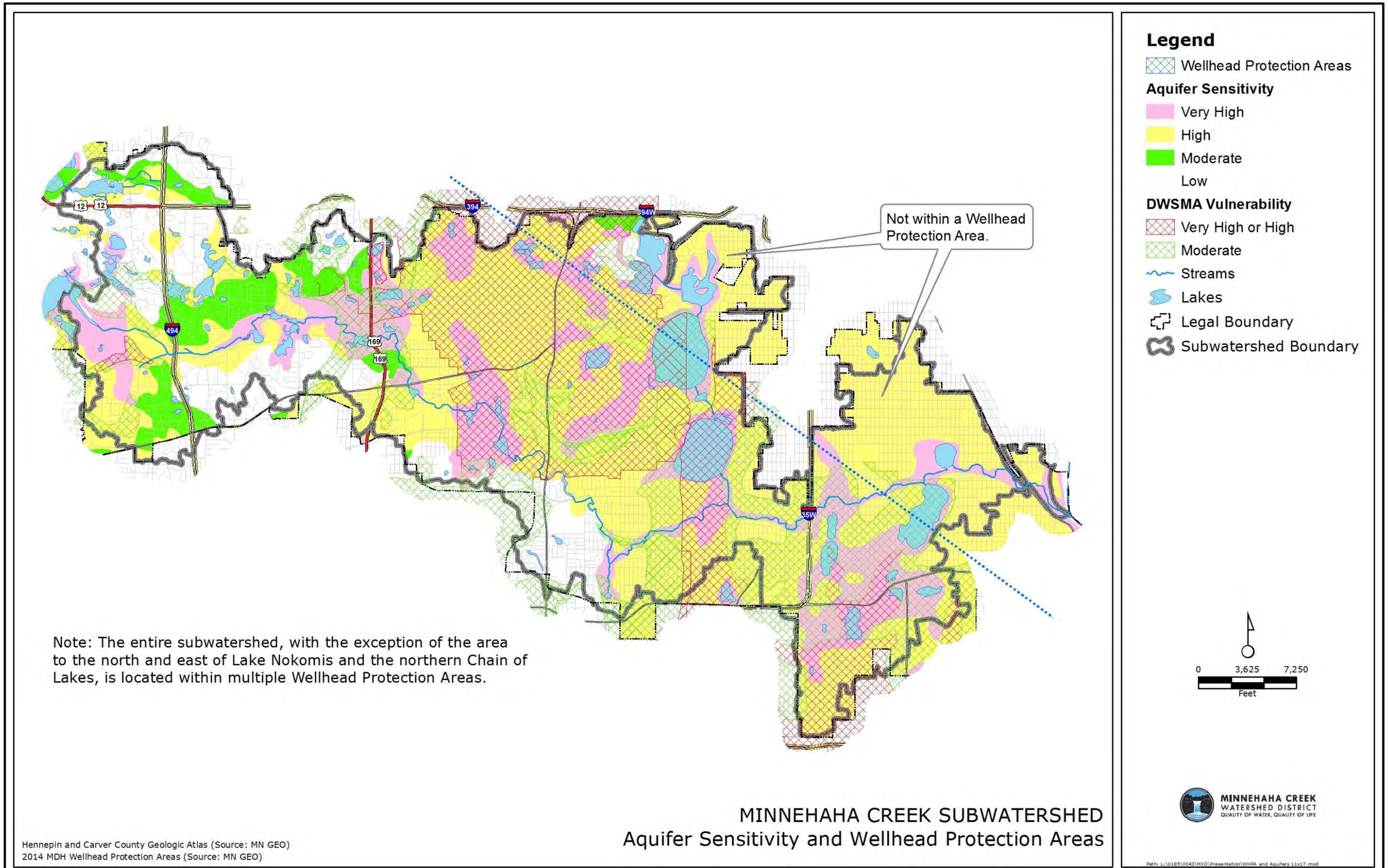

Figure 2.74. Minnehaha Creek subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

An operating plan was established for Grays Bay dam headwaters control structure when it was put into service in 1980. The plan was intended to emulate the historical discharge hydrograph produced by previous controls and the natural outlet of Lake Minnetonka. In drier periods, Lake Minnetonka typically does not discharge water, and portions of the Creek may experience low or even no flow.

Several landlocked basins and many smaller landlocked pocket wetlands exist in the upper reaches of the Minnehaha Creek drainage area including large areas within the City of Minnetonka and portions of Hopkins, Edina and St. Louis Park (Figure 2.71). As noted in the previous section, the District partnered with the University of Minnesota and the Mississippi Watershed Management Organization (MWMO) to complete a baseflow and stormwater infiltration study of Minnehaha Creek in 2014 that found that there is significant interaction between the creek and shallow groundwater.

To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water yield data for the monitoring stations downstream of the Grays Bay dam. The water yields for 2006-2015 did not exhibit any statistically significant trend.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Minnehaha Creek subwatershed has been evaluated by the E-Grade program in 2015-2017. At this time, only some of the E-Grade metrics have been assessed. The final E-Grade report for this subwatershed will not be available until 2018. This section summarizes ecological integrity using E-Grade and other existing data, where available (Figure 2.75).

Lakes:

Biodiversity

Fish Community. Biodiversity is measured using the Index of Biotic Integrity (IBI) for fish developed by the DNR. Fish IBI data are available for five of the lakes in the subwatershed. Cedar Lake and Lake of the Isles are classified as Good and meet state ecological integrity requirements. Lakes Calhoun, Harriet, and Nokomis are classified as Poor, meaning the biodiversity has been disturbed and the IBI is below the state threshold.
Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. Aquatic vegetation surveys are available on many of the lakes in the subwatershed and led to FQI scores for E-Grade. Brownie, Calhoun, and Cedar were classified as Good, meaning they had a good variety of species, including sensitive species. Lakes Harriet, Hiawatha, Nokomis, and Isles were classified as Degraded, due to low species diversity.

Aquatic Invasive Species. Biodiversity can be negatively impacted by the presence of aquatic invasive species (AIS). The most common AIS in the lakes in this subwatershed include Curlyleaf Pondweed and Eurasian watermilfoil. Common carp are known to be over abundant in Lake Nokomis. Population data in other lakes are limited. Zebra mussels have been found in Lake Hiawatha and Meadowbrook Lake, which are both connected to the zebra mussel infested Minnehaha Creek. Lake Nokomis is listed as infested for zebra mussels due to its connectivity to Minnehaha Creek via a weir, but zebra mussels have yet to be found in the lake. One lone zebra mussel was found in Lake Harriet in 2017, further searching has found no other zebra mussels at this time.

Habitat diversity

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species, or the extent to which it may be dominated by a few species. The vegetation community has not been assessed for habitat diversity yet.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score the Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. The protocol subdivides the riparian area into three zones: aquatic, shoreline and shoreland and evaluates various metrics such as vegetative cover, land use, human disturbance, and emergent vegetation. Brownie Lake's shoreline health was classified as Exceptional. Cedar Lake and some of the smaller shallow lakes were classified as Good, while most the lakes in the lower subwatershed were classified as Poor. In lakes classified as Poor, suitable shoreland and shoreline vegetation is lacking and has disturbances such as seawalls or riprap shorelines.

Streams:

Biodiversity

Fish Community. The DNR periodically assesses the fish community in Minnehaha Creek. Fish IBI data are available at six locations along the Creek. Five of the sites were last surveyed in 2010, while the sixth has not been updated since 2000. The monitoring site just upstream of 34th Avenue in southeast Minneapolis was classified as Degraded, scoring well below the state's fish IBI standard. The site in Big Willow Park in Minnetonka was also classified as Degraded, although those data are from 2000. The other four sites on the Creek were classified as Poor, showing signs of disturbance and falling below the IBI threshold.

Macroinvertebrate Community. The District collected macroinvertebrate samples at 23 sites on Minnehaha Creek in 2013 and 2015. The DNR also collected macroinvertebrate samples at five sites as part of its fish sampling. Macroinvertebrates are more sensitive to the stream conditions in their immediate vicinity, so the IBI scores can vary from site to site, even those in close proximity. A majority of the sites were classified as Degraded, meaning they were highly disturbed, with low species diversity and dominated by pollution-tolerant species. However, other sites were classified as Poor, with slightly better diversity and supporting some pollution-intolerant species.

Aquatic Invasive Species. Zebra mussels, Curlyleaf Pondweed, Eurasian watermilfoil, Common Carp and Flowering Rush are present in Minnehaha Creek.

Habitat diversity

Habitat Complexity. Minnesota Stream Habitat Assessment data are available to assess habitat complexity, which is evaluated in three zones: instream, riparian, and channel shape. Complexity is highly variable along the length of the stream due to decades of human disturbance. However, the lower reaches of the stream are located within and protected by a parkway, which helps limit the impacts of urbanization. Generally, the reaches in the stream above the Browndale Dam have greater habitat complexity than the lower reaches and are classified as Good. The lower reaches, where the channel form or morphology is more likely to have been disturbed, are classified as either Good or Poor, with a few locations classified as Degraded in one or more of the three zones.

Minnehaha Creek was studied in-depth in 2003 and 2012 as part of the District's *Minnehaha Creek Stream Assessment*, which included a physical inventory, erosion survey, and a fluvial geomorphic assessment to determine channel stability. For more information regarding these parameters, please refer to the *Minnehaha Creek Stream Assessments*.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are several barriers on Minnehaha Creek, the most significant being Minnehaha Falls, which disconnects the Creek from the Mississippi River. There are also three dams (Highway 55, 54th Street, and Browndale) and at least one significant culvert at McGinty Road. Access to floodplain is variable, and greatest in the upper subwatershed where there are riparian wetlands and low streambanks.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are available, and will be assessed and included in the Minnehaha Creek E-Grade report (2018). However, by observation, Minnehaha Creek is an urban stream with numerous storm sewer outfalls, and it can rise quickly during rain events. Instantaneous flow is also available along the Creek. Annual average flow for each year was computed first, and then all the years' averages were averaged together. The low, average and high discharge for the major stations in Minnehaha Creek are listed in Table 2.67.

Table 2.69. Average discharge for stations in the Minnehaha Creek subwatershed.
See Figure 2.72 for monitoring locations.

Stream	2006-2015		
	Low Discharge (cfs)	**Annual Average Discharge (cfs)**	**High Discharge (cfs)**
Gray's Bay Dam (CMH07)	0	87	420
I-494 (CMH01)	0	53	421
W. 34th Street (CMH02)	0	54	441
Excelsior Blvd (CMS11)	0	49	368
Browndale Dam (CMH03)	0	69	495
W. 56th Street (CMH04)	0.2	64	441
Xerxes Avenue (CMH15)	0	66	518
21st Avenue (CMH24)	0	57	442
28th Avenue (CMH18)	0	68	511
Hiawatha Avenue (CMH06)	0	73	530

Source: MCWD.

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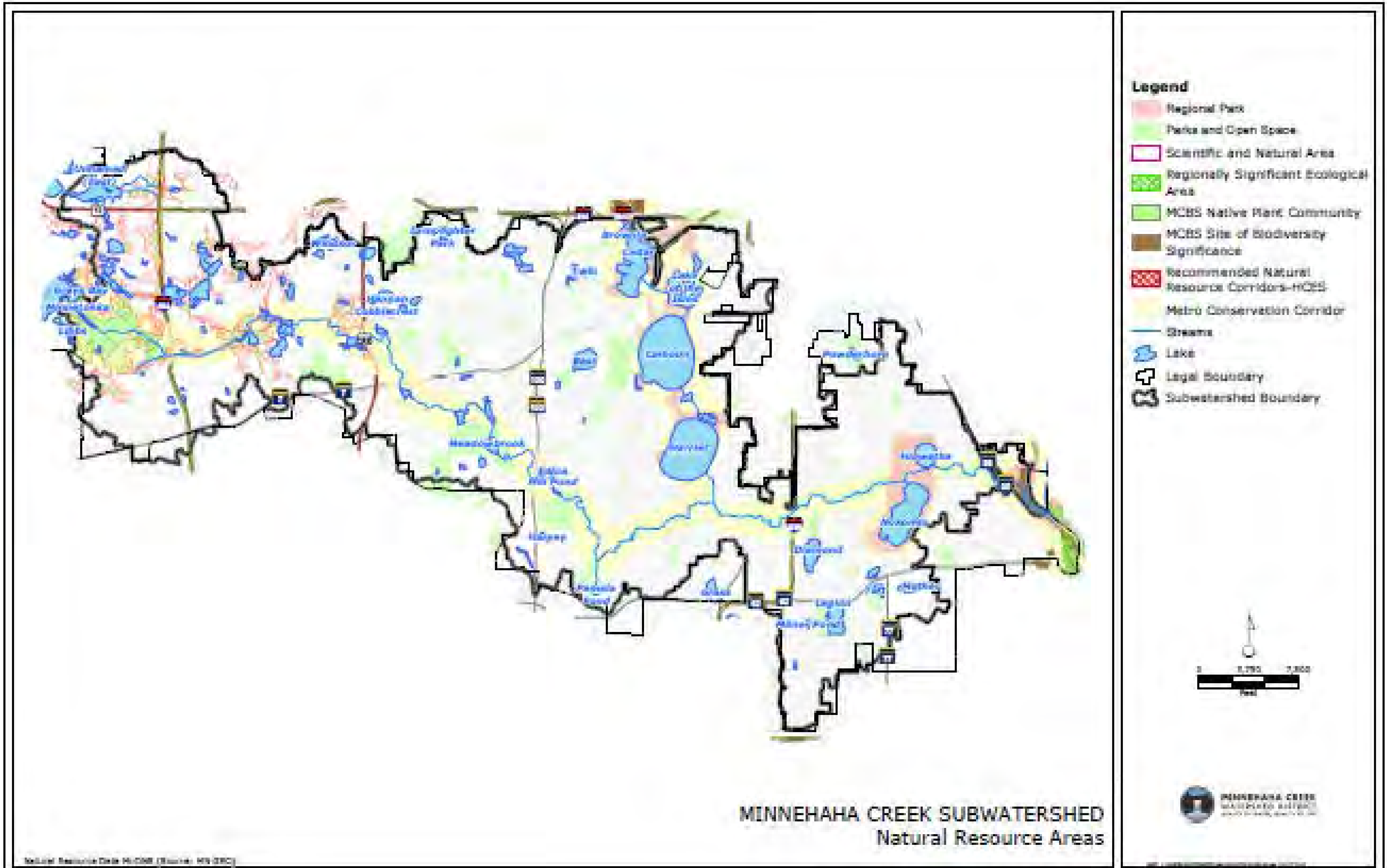

Figure 2.75. Minnehaha Creek subwatershed natural resource areas.

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Wetlands:

Biodiversity

Vegetation Community. The FQI developed by the DNR can be used to evaluate the biodiversity of vegetation in wetlands. A cross-section of 26 wetlands in the subwatershed were assessed for their vegetation condition, twelve in the upper subwatershed and fourteen in the lower subwatershed. Three of the twelve assessed in the upper subwatershed were classified as Degraded while nine were classified as Poor. Six of fourteen assessed in the lower subwatershed were classified as Degraded, and eight were classified as Poor. Wetlands ranked degraded tend to have fewer communities, primarily fresh meadow and/or floodplain forest. Buckthorn and reed canary grass tend to dominate in these communities. Some of the seasonally flooded basins are maintained as mowed turf.

Macroinvertebrate Community. These data are not currently being collected in E-Grade. For more information regarding macroinvertebrate community in the subwatershed, please refer to wetland health evaluation program (WHEP) program.

Habitat diversity

Connectivity. Hennepin County has identified the large wetland complex at the headwaters of Minnehaha Creek, and some wetlands and uplands connected to it, as Recommended Natural Resource Corridors. Minnehaha Creek itself and associated riverine and riparian wetlands is an important connected corridor, linking Lake Minnetonka, the Chain of Lakes, and the Mississippi River. Other smaller wetlands in the subwatershed are primarily isolated with limited opportunities for connectivity.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species. Most of the larger wetlands are in the upper subwatershed, to the west of TH 169. In the lower subwatershed, wetlands are smaller and isolated, and less likely to support a diversity of wildlife.

Shoreline Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. There are numerous riverine or riparian wetlands on Minnehaha Creek helping to stabilize the streambanks. However, there are few riparian wetlands protecting lakeshore. Cedar and Diamond Lakes have some moderate coverage, but most of the lakes do not.

Uplands:

Biodiversity

The Minnesota Biological Survey (MBS) did not identify any areas of biodiversity significance in the uplands of this subwatershed. (Figure 2.75).

Habitat diversity

The lower subwatershed – generally the area east of TH 169 – is developed with minimal areas of ecological significance. Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. The only such area in this subwatershed is the large wetland complex at the outflow from Gray's Bay, which is the headwaters of Minnehaha Creek, and some wetlands and uplands connecting that complex to other larger wetlands in the upper subwatershed.

Thriving Communities:

Land use:

Table 2.70 shows the land uses within the area of the Minnehaha Creek subwatershed in acres and as a percentage of the total subwatershed. The predominant land use in the subwatershed is single family residential, followed by parks and open space (Figure 2.76). The subwatershed is fully developed at typical urban and suburban densities and land uses. Redevelopment and infill development have increased since the last plan update, notably with an increase in multi-family residential. Most of the remaining vacant or undetermined land is large wetland or woodland tracts. The entire subwatershed is within the MUSA 2020 area.

Table 2.70. 2016 land use in the Minnehaha Creek subwatershed.

Land Use 2016	Acres	% of Subwatershed
Single - Family Residential	15,598.6	51.5
Parks and Open Space	4,409.5	14.6
Multi - Family Residential	2,338.5	7.7
Water	1,674.9	5.5
Commercial	1,483.1	4.9
Institutional	1,436.8	4.7
Roads and Highways	1,365.1	4.5
Vacant or Undetermined	1,227.7	4.1
Industrial	763.9	2.5
Agricultural	3.1	0.0

Source: Metropolitan Council.

Recreation:

The subwatershed contains numerous regional recreational facilities (Figure 2.77). The National Parks Service oversees the Mississippi River and Recreational Area, which includes the Mississippi River gorge area within the subwatershed, including Minnehaha Falls. The Falls area includes a number of structures constructed by the Works Progress Administration (WPA), including retaining walls along the creek. The Minneapolis Park and Recreation Board (MPRB) operates a popular park and trail system around the Chain of Lakes and along Minnehaha Creek east of Lake Harriet. The North and South branches of the Three Rivers Park District's Southwest LRT Regional Trail connects the Chain of Lakes with the western subwatershed.

Camp Coldwater Spring, a site with significance to Native American communities and the location of the first white settlement in Minnesota, is located in the extreme southeast part of the subwatershed. The Minnesota Historic Features database notes over 1300 historic features in this subwatershed, mostly residences or commercial buildings. Three Historic Districts are listed on the National Register of Historic Places: the Minnehaha District in the vicinity of Minnehaha Falls; the Nokomis Knolls District, a residential district at the southwest corner of Lake Nokomis; and the Country Club District in Edina, an area of over 500 historic residences, commercial buildings, and other properties, including the Minnehaha Grange. More detail regarding the Camp Coldwater Springs and other locations significant to the watershed's early history can be found in the *2007 MCWD Comprehensive Water Resources Management Plan*.

There are numerous boat accesses and beaches on the lakes in the subwatershed. There are seventeen canoe launches on Minnehaha Creek, and this popular urban canoe trail winds through numerous parks and open spaces. Most of these launches have parking available, and several have picnic areas and restrooms.

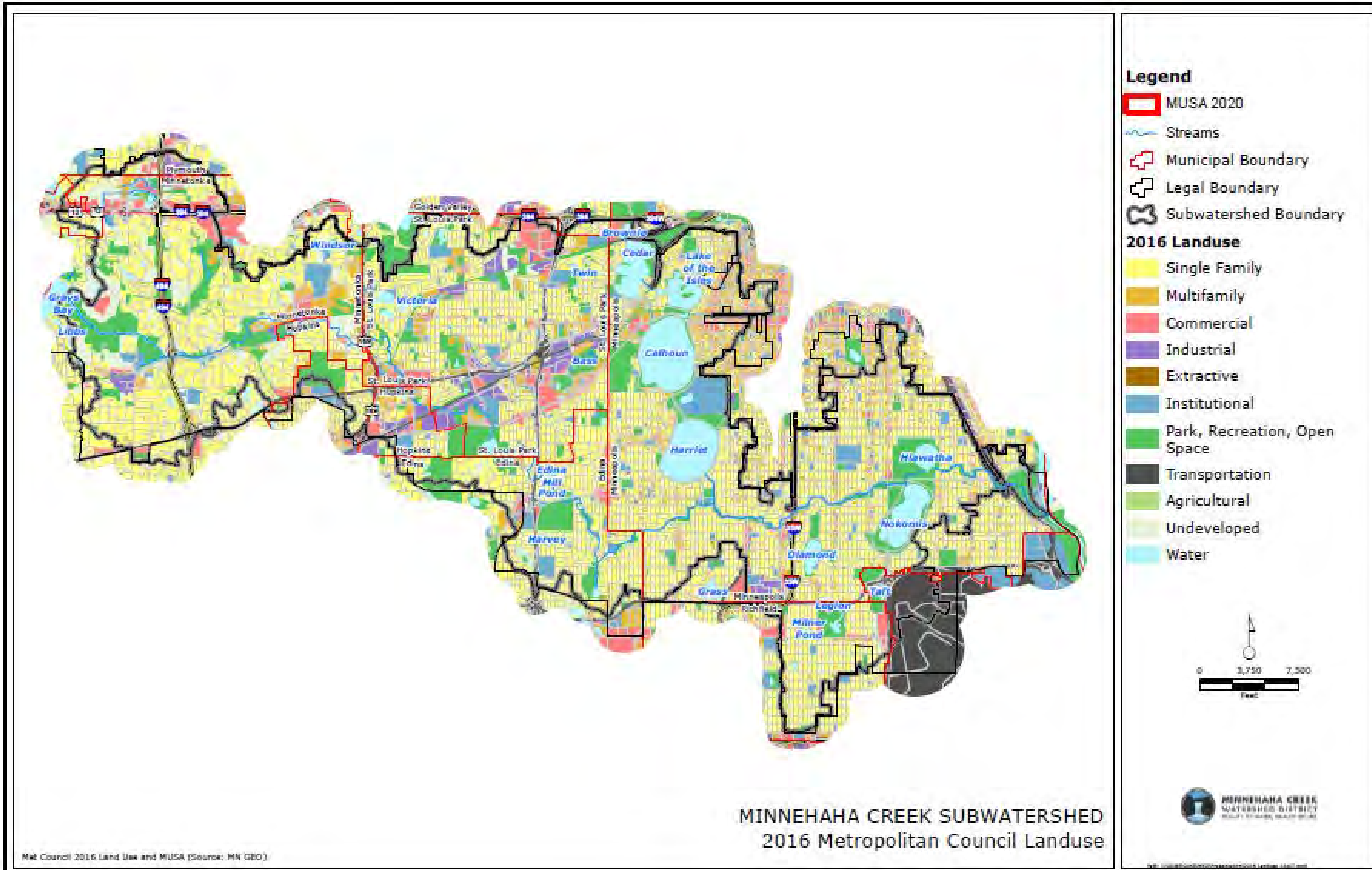

Figure 2.76. Minnehaha Creek subwatershed 2016 Metropolitan Council land use.

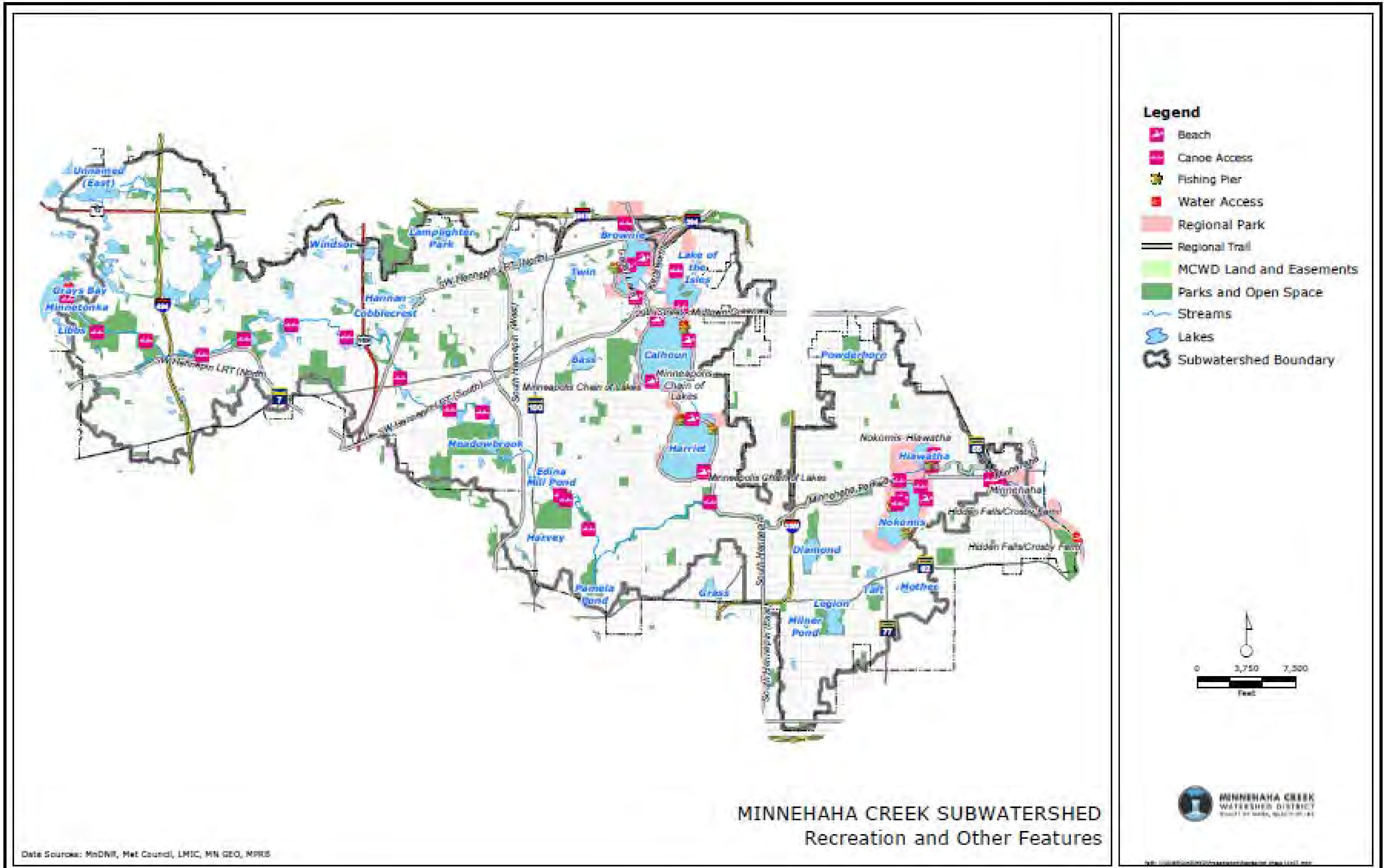

Figure 2.77. Minnehaha Creek subwatershed recreation and other features.

2.3.9 PAINTER CREEK SUBWATERSHED

Painter Creek Subwatershed drains the land and wetlands into Painter Creek, and eventually drains into Lake Minnetonka: Jennings Bay. The largest lake, Lake Katrina, was recently recommended by MPCA to be classified as a wetland. Wetlands make up over 25% of the land cover in the subwatershed, while the remaining 75% is a mix of agriculture, forests and woodlands, grasslands, and impervious cover. Painter Creek flows in and out of Katrina and flows through woodlands and through Painter Marsh before curving towards Lake Minnetonka. Most of Painter Creek is classified as ditched due to efforts to drain the landscape. Table 2.71 below shows the area of the Painter Creek subwatershed in acres by individual city, in total and as a percentage of the total subwatershed (Figure 2.78).

Table 2. 71. Cities in the Painter Creek subwatershed.

City	Area (Acres)	% of Subwatershed
Independence	3,069.1	35.4%
Maple Plain	202.8	2.3%
Medina	2,498.9	28.8%
Minnetrista	1,562.7	18.0%
Orono	1,336.0	15.4%
Total	8,669.7	

Source: MCWD.

Subwatershed Description and Hydrology:

Topography in the subwatershed is gently rolling, with circular, level-topped hills and numerous large wetlands. Soils within the watershed are predominantly classified as Natural Resources Conservation Service Hydrologic Soil Group B (loamy soils with moderate infiltration potential) and D (clay soils with very low infiltration potential). For more information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.79). There is a wide variety of land cover types in the subwatershed. Wetland and forest/woodland cover dominate the central subwatershed along the Painter Creek corridor, while low-density development is dispersed throughout the subwatershed. There is a small area of higher density development in the City of Maple Plain. Large areas in agricultural use are present in the lower watershed.

The upper subwatershed drains through streams and channels to Lake Katrina in the Baker Park Reserve. Painter Creek is the outlet of Lake Katrina, flowing 6.2 miles south and east from the lake to Jennings Bay: Lake Minnetonka. Painter Creek was channelized as County Ditch #10 in 1905, connecting and outletting wetlands to support agriculture in the subwatershed.

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Painter Creek subwatershed into 26 subwatershed units, designated PC-1 through PC-26 (Figure 2.80).

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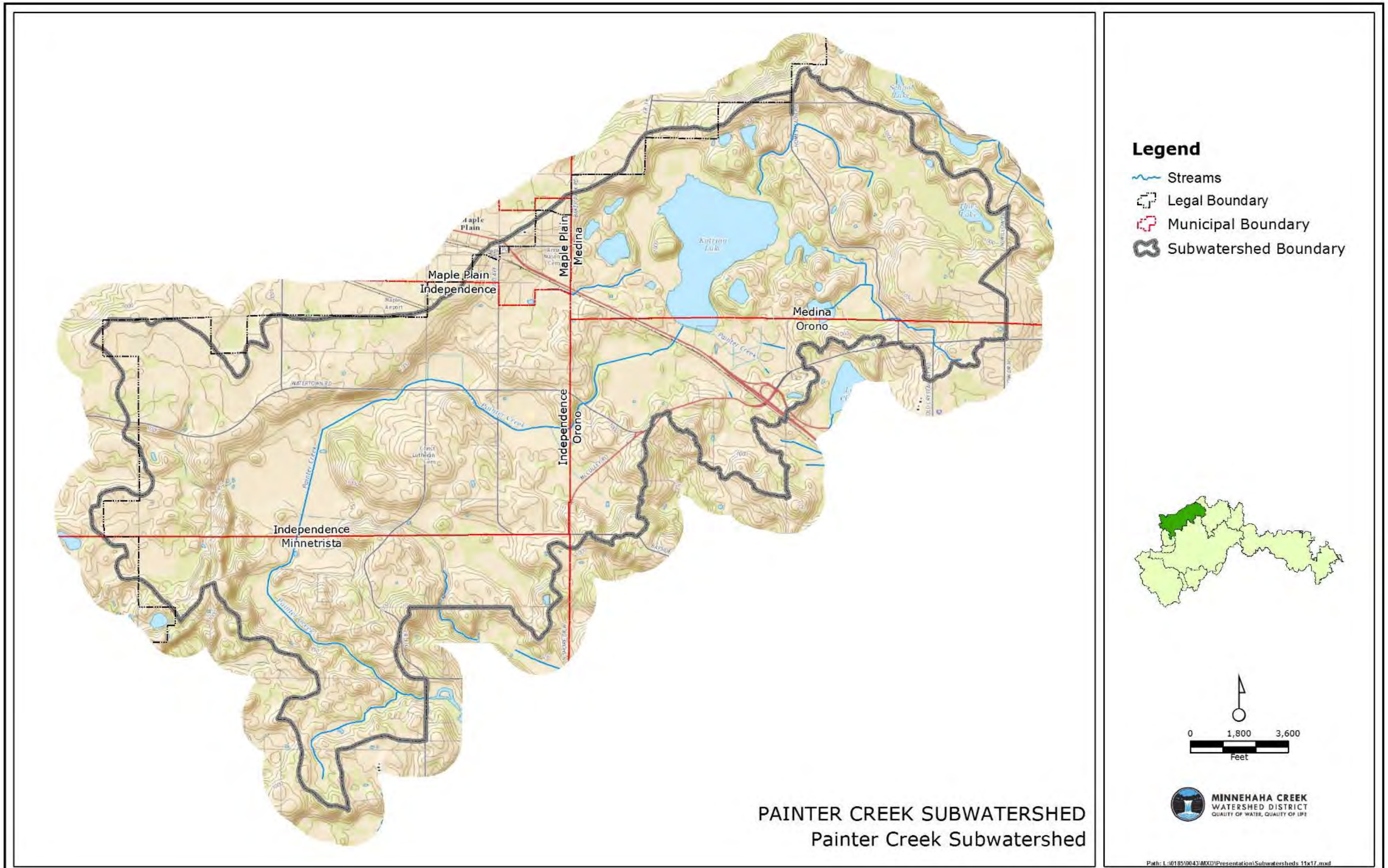

Figure 2. 78. The Painter Creek Subwatershed.

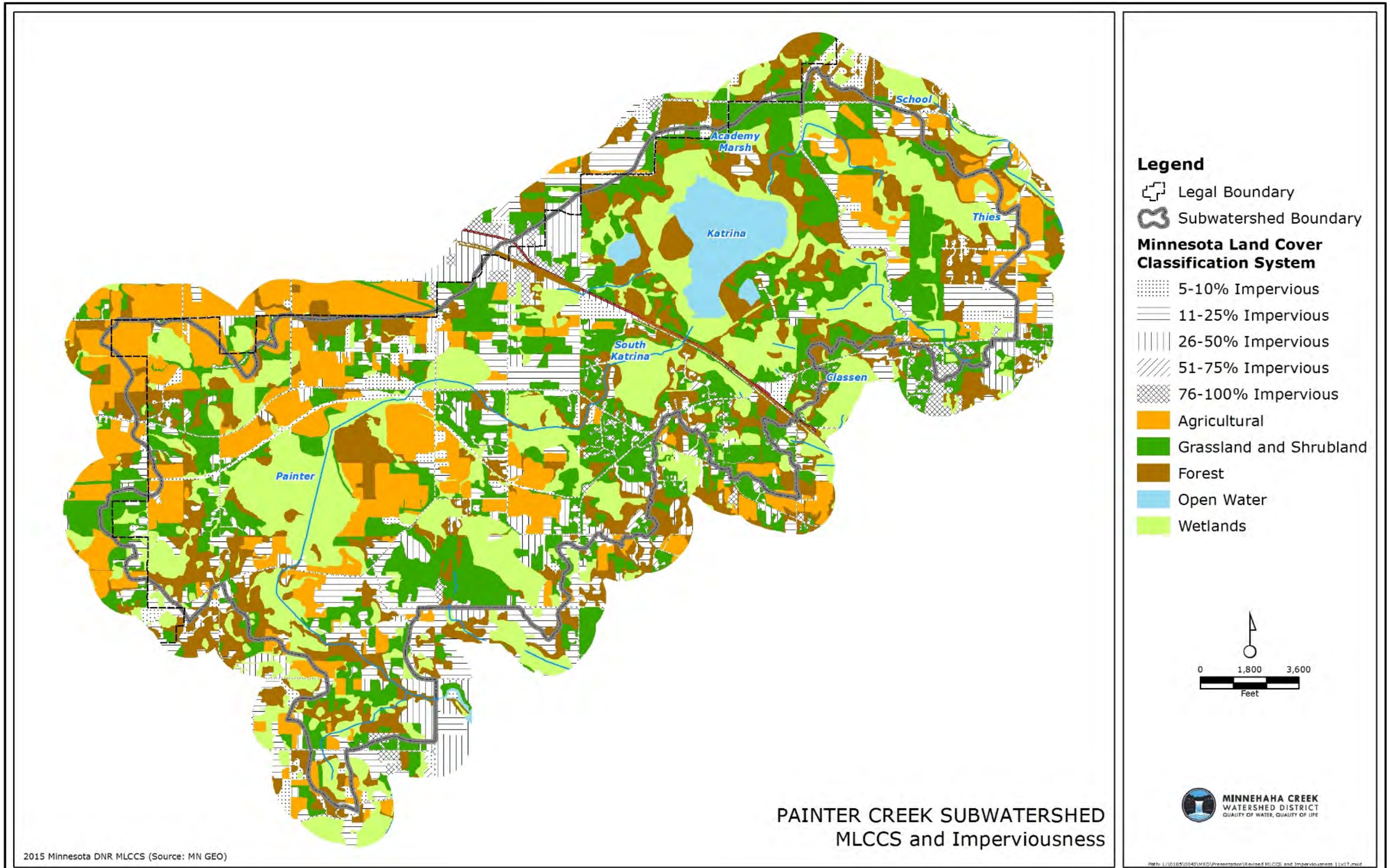

Figure 2. 79. Painter Creek subwatershed MLCCS and imperviousness.

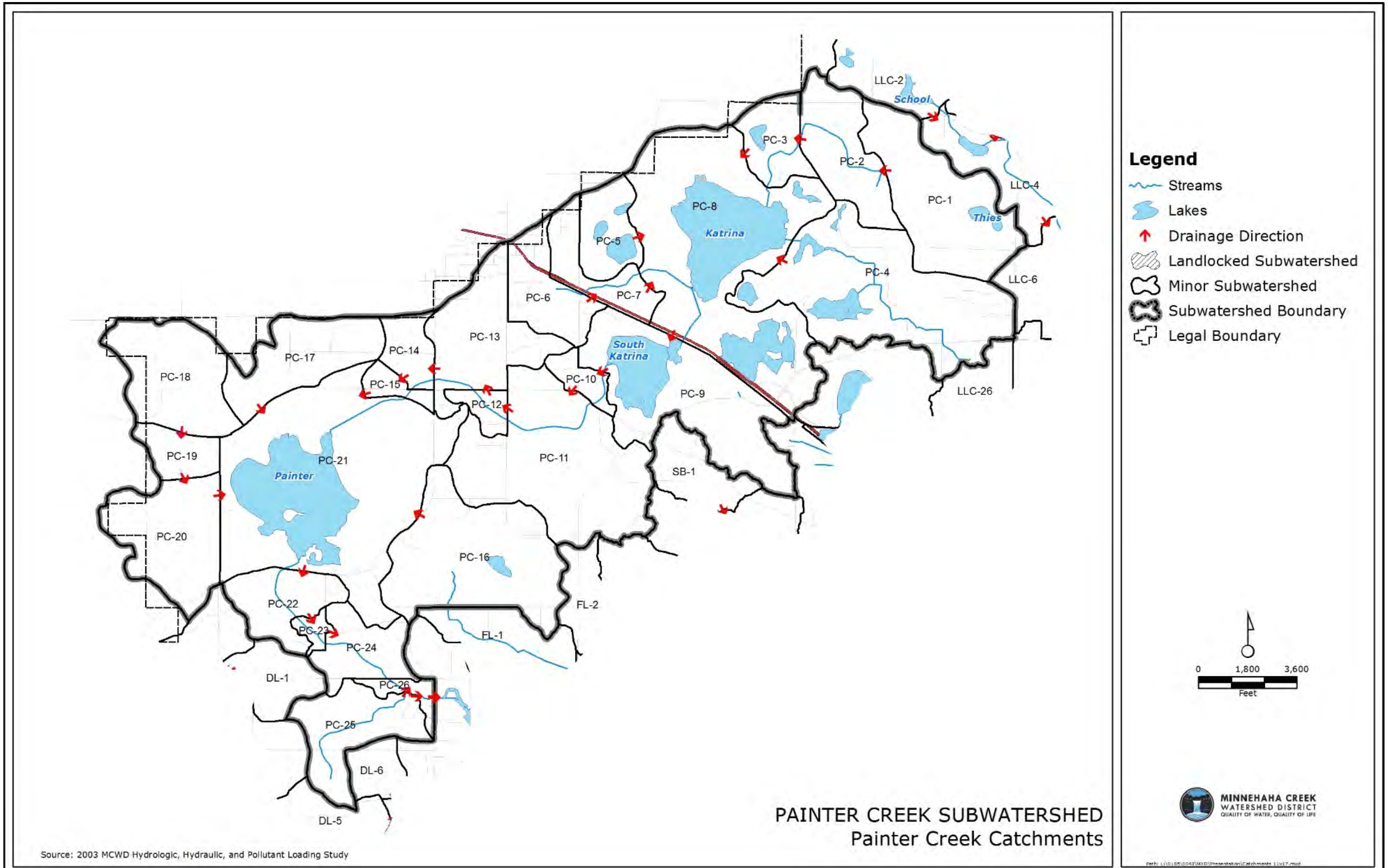

Figure 2. 80. Painter Creek subwatershed catchments.

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Water Quality:

The following are summaries of the characteristics and classifications of lakes, streams and wetlands within the subwatershed including water quality goals and trends.

Lakes:

Lake Katrina carries the informal designation of lake as the primary waterbody within the subwatershed, and is the headwaters for Painter Creek. Thies Lake is a small lake located in northeast portion of subwatershed (Figure 2.81). Lake Katrina is periodically monitored by the Three Rivers Park District and was monitored for three years by MCWD, while Thies Lake is monitored by trained volunteers. Tables 2.72 and 2.73 below detail the physical and water quality characteristics of the lakes within the Painter Creek subwatershed, and includes the DNR shoreland management classification.

Lake Katrina has been classified by the MPCA as a wetland; therefore, the lake eutrophication standard does not apply. Thies Lake exceeds the state standard for deep lakes (Table 2.73). For more information, refer to District's Water Quality (Hydrodata) Reports and the Upper Minnehaha Creek Watershed TMDL.

Table 2. 72. Physical characteristics of lakes in the Painter Creek subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Thies	11	29	42:1	Natural Environment

Source: Minnesota DNR.

Table 2. 73. Selected water quality goals and current conditions of waterbodies in the Painter Creek subwatershed.

Waterbody	State TP Standard (µg/L)	2007 Plan Goal TP (µ/L)	Trend	2006-2015 Summer Average		
				TP (µg/L)	Chl-*a* (µg/L)	Secchi (m)
Katrina	n/a	n/a	n/a	158	72	0.7
Thies	40	n/a	n/a	54	24	1.3

TP = Total phosphorus concentration. *Katrina data are from 2006-2014; Thies data are from 2009-2015.
Source: MCWD, MPCA.

Streams:

Painter Creek outlets Lake Katrina, flowing 6.2 miles to Jennings Bay. It is comprised mainly of ditches through large wetlands connected by relatively short reaches of channel. Flow is controlled by weirs at the outlets of Katrina Lake, South Katrina Marsh, Painter Marsh and Pond 937. The creek was channelized as County Ditch #10 in 1905. Several small streams and channels provide local conveyance (Figure 2.81). It was also studied in-depth in 2003 as part of the District's *Upper Watershed Stream Assessment* and the *Painter Creek Feasibility Study.*

Table 2.74 below details Painter Creek's water quality characteristics. Monitoring sites along the Painter Creek find TP concentrations high relative to the state river eutrophication standards. However, those standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand that have not been assessed in the Creek.

Painter Creek has low TSS concentrations, as shown on Table 2.74. Maintaining sufficient DO is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. District monitoring data show that all the monitoring sites on the creek fall below the standard multiple times per year.

Painter Creek downstream of Painter Marsh is designated an Impaired Water due to elevated levels of *E. coli* bacteria and has an approved TMDL. The state standard requires that the geometric mean of the aggregated monthly *E. coli* concentrations for one or more months must not exceed 126 organisms per 100 mL. A waterbody is also considered impaired if more than 10% of the individual samples within a month exceed 1,260 organisms per 100 mL. Data from 2001 to 2011 show that *E. coli* concentrations in Painter Creek exceed the monthly standard July to October, and the acute, individual standard 25% of the time in September and October.

To assess long-term change in Painter Creek, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2005-2015. There was a statistically significant change in TP concentrations at W. Branch Rd stream station in Painter Creek with TP concentrations increasing over time (Table 2.74). For more information, refer to District's Water Quality (Hydrodata) Reports.

Table 2. 74. Current Painter Creek conditions.
See Figure 2.81 for monitoring locations.

Stream	Trend*	2005-2015 Annual Average			
		TP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl (mg/L)
Jennings Bay Inlet (CPA05)	n/a	281	1.45	15	40
W Branch Road (CPA01)	Deg TP	280	1.50	11	47
Painter Creek Drive (CPA06)	n/a	277	1.38	5	46
Painter Marsh Outlet (CPA04)	n/a	272	1.21	3	43
Katrina Wetland Outlet (CPA03)	n/a	201	1.31	4	52

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride, Deg = degrading.
*Statistically significant at ≤ 0.05.
Source: MCWD.

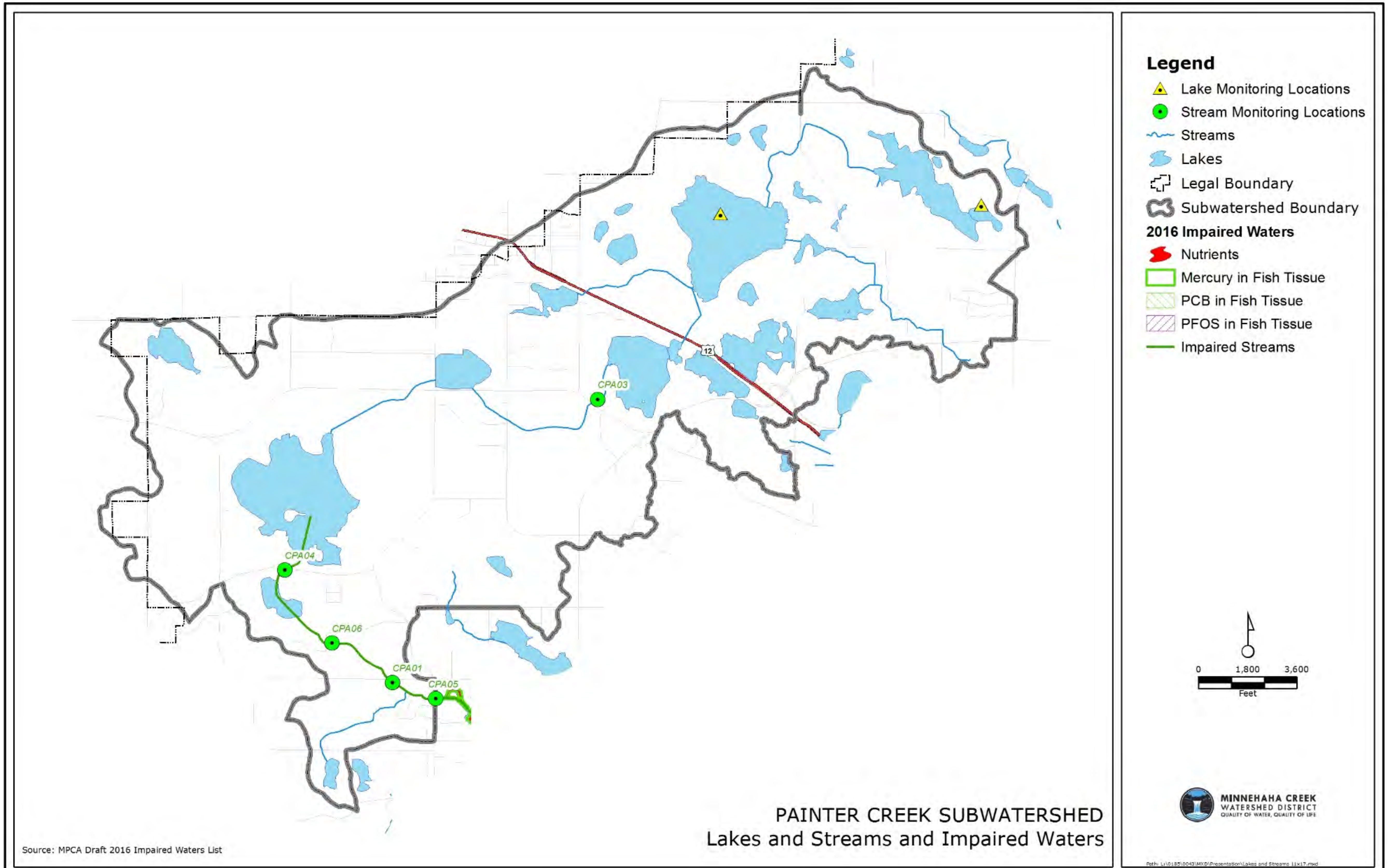

Figure 2. 81. Painter Creek subwatershed lakes and streams and Impaired Waters.

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Wetlands:

According to the FAW, wetlands, including lakes, cover almost 29 percent of the watershed's surface (Figure 2.82 and Table 2.75).

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients to and from the subwatershed. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Table 2. 75. Functional Assessment of Wetlands inventory of wetland types in the Painter Creek subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	337.4	3.99
2 - Wet Meadow	538.6	6.38
3 - Shallow Marsh	1,155.7	13.68
4 - Deep Marsh	30.5	0.36
5 - Open Water	43.2	0.51
6 - Scrub Shrub	97.9	1.16
7 - Forested	48.6	0.58
8 - Bog	-	-
Riverine	12.1	0.14
Wetland Total	2,264.0	26.8
Upland	6,172.7	73.2
TOTAL	8,436.7	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream baseflow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

The HHPLS identified the infiltration potential of the upland areas within the subwatershed as medium to low with some areas of variability where the soils are organic in nature. Areas of moderate to high or very high aquifer sensitivity roughly follow the Painter Creek corridor to Jennings Bay. Elsewhere the Hennepin County Geologic Atlas classifies most of the upland areas as being of low to moderate sensitivity to pollution.

Two small areas of the Painter Creek subwatershed have been designated by the Minnesota Department of Health as Drinking Water Supply Management Areas (DWSMA) for a City of Orono well and a City of Medina well. The MDH has designated these areas to be of low risk and vulnerability to contamination of the drinking water supply. Figure 2.83 shows areas in the subwatershed with groundwater sensitivity and that are designated Wellhead Protection Areas.

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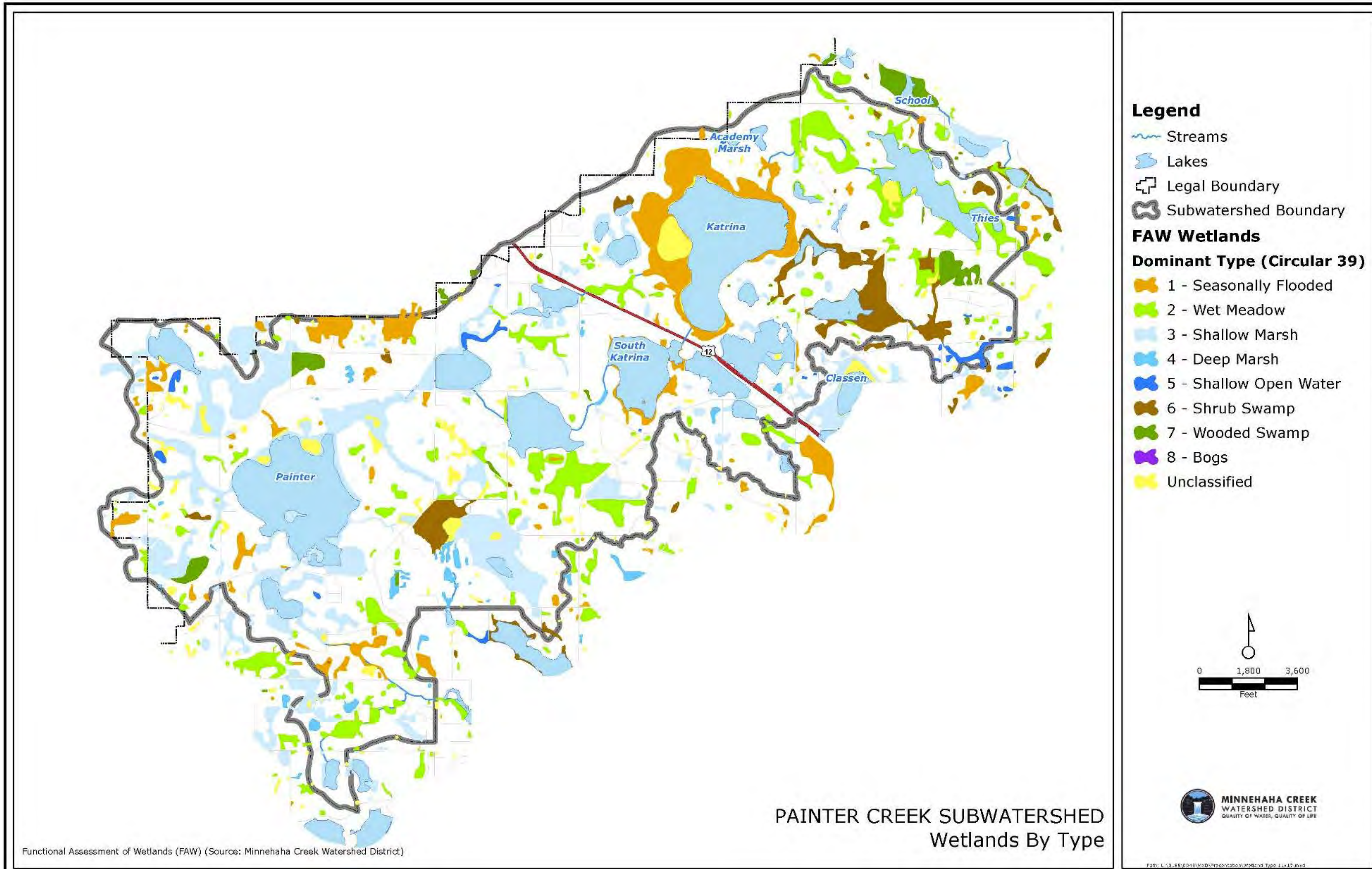

Figure 2. 82. Painter Creek subwatershed wetlands by type.

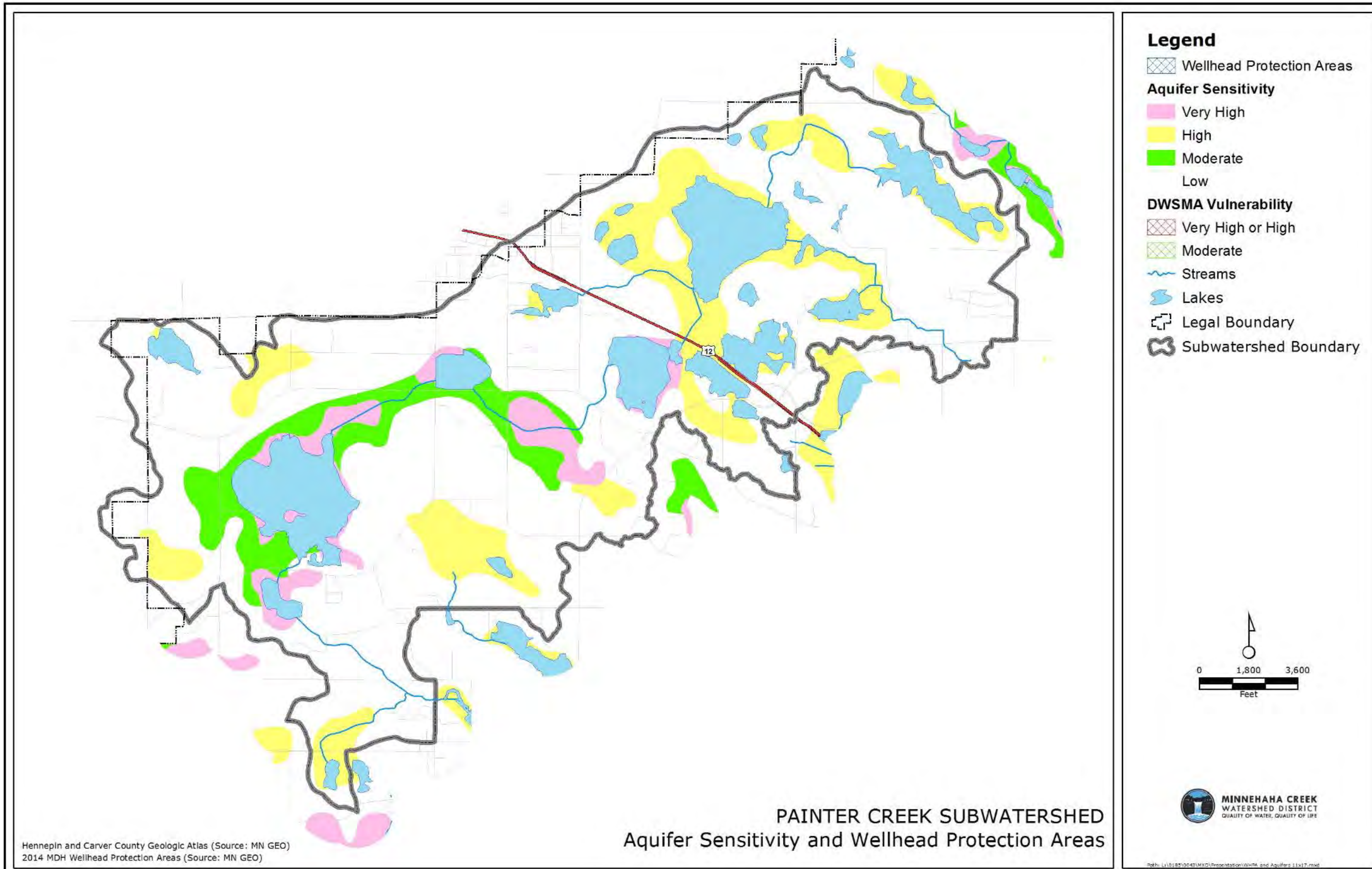

Figure 2. 83. Painter Creek subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

There are no landlocked basins in this subwatershed (Figure 2.80). To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water yield data for the monitoring station at West Branch Rd. The period of record for the station was 2006-2015. Water yield did not exhibit any statistically significant trend.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Painter Creek subwatershed has not yet been evaluated by the E-Grade program. This section summarizes ecological integrity using existing data, where available (Figure 2.84).

Lakes:

Biodiversity

Fish Community. No fish IBI or survey data are available for the lakes in this subwatershed.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. No aquatic vegetation survey or Floristic Quality Index (FQI) data are available for the lakes in this subwatershed.

Aquatic Invasive Species. No AIS data are available for the lakes in this subwatershed.

Habitat diversity

Aquatic Vegetation Community. No Floristic Quality Index (FQI) data are available for the lakes in the subwatershed.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score the Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. No Score the Shore data are available; however, aerial photos show that the lakes and larger wetlands with open water are bordered with riparian wetland or woodland.

Streams:

Biodiversity

Fish Community. The DNR conducted a fish survey on Painter Creek in 2010. The fish IBI score was 67, above the state's threshold. The survey found a variety of species and a good abundance of fish, including blackchin shiners and Iowa darters, both of which are intolerant species. The fish community in Painter Creek downstream of Painter Marsh, where this survey was completed, is likely colonized from Jennings Bay: Lake Minnetonka. Largemouth bass, bluegill, several sunfish species, and common carp were also present.

Macroinvertebrate Community. The DNR conducted a macroinvertebrate survey twice in 2010, and the District surveyed several sites along the creek in 2013. The DNR's M-IBI scores were 5 and 8 out of 100, well below the state's threshold. Scores from the District's surveys ranged from 3 to 20. Species were very pollution-tolerant, and there was low species diversity.

Aquatic Invasive Species. No AIS data are available for the stream stations in this subwatershed.

Habitat diversity

Habitat Complexity. No Minnesota Stream Habitat Assessment data are available to assess habitat complexity, but notes taken for the 2004 *Upper Watershed Stream Assessment* were reviewed to better understand conditions in the in-stream zone and riparian zone, and to assess channel morphology. That survey found that the stream has been channelized and straightened, with altered and limited habitat and morphology.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. There are several barriers on the streams in this subwatershed, most of them culverts at road crossings, or outlet structures on the larger of the flow-through wetlands.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are available for CPA01 and CPA03. Instantaneous flow at CPA01 can be flashy following storm events, and since 2006, the CPA01 station has an average of discharge of 8.35 cfs. Note: Annual average flow for each year was computed first, and then all the years' averages were averaged together.

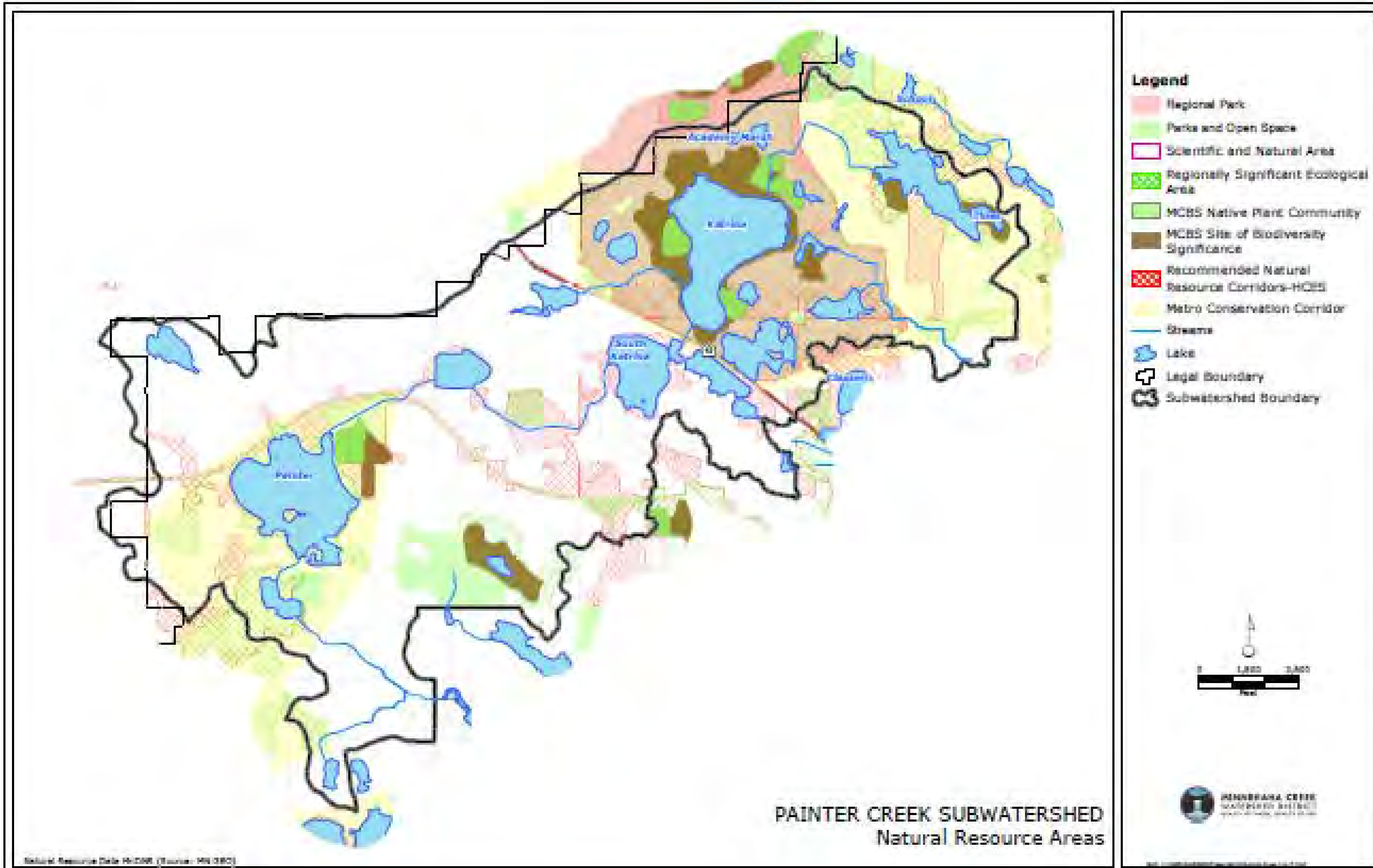

Figure 2. 84. Painter Creek subwatershed natural resource areas.

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Wetlands:

Biodiversity

Vegetation Community. No Rapid Floristic Quality Assessment (RFQA) data are available for the wetlands in this subwatershed. However, the *Functional Assessment of Wetlands* assessed two large riparian wetlands – around Lake Katrina and Thies Lake, which scored highly on vegetative diversity, fish and wildlife habitat, or aesthetics. Most of these high function and value wetlands are located within Baker Park Reserve.

Macroinvertebrate Community. No macroinvertebrate data are available for the wetlands in this subwatershed.

Uplands:

Biodiversity

Regionally Significant Ecological Areas are places where larger tracts of minimally disrupted land provide habitat complexity. Large areas of undisturbed or minimally disturbed forest and wetland in the subwatershed, including the Baker Park Reserve and Painter Marsh, have been designated Regionally Significant Ecological Areas by the DNR. The Minnesota Biological Survey (MBS) determined that several areas in the subwatershed were of moderate or high biodiversity significance, including a tamarack swamp complex; the wetland and upland areas surrounding Lake Katrina; and patches of maple-basswood and oak forest that are ranked as imperiled and vulnerable to extirpation (Figure 2.84).

Habitat diversity

The Baker Park Reserve and a large area in the lower subwatershed surrounding and including Painter Marsh are part of a DNR-designated Metro Conservation Corridor. The lower subwatershed conservation corridor area is part of a much larger corridor that extends south into the Dutch Lake and Langdon Lake subwatersheds, eventually connecting with the Gale Woods Regional Park in Minnetrista.

Thriving Communities:

Land use:

Table 2.76 shows the land uses within the area of the Painter Creek subwatershed in acres and as a percentage of the total subwatershed. The predominant land use in the subwatershed is vacant or undetermined use, followed by parks and open space and agriculture (Figure 2.85). The percentage of single-family residential has increased since the last plan update. Some large tracts of agricultural uses remain in the lower subwatershed, while the upper watershed is dominated by Baker Park Reserve. Much of the watershed is outside of the MUSA 2020 boundary, and is not served by regional wastewater facilities.

Table 2. 76. 2016 land use in the Painter Creek subwatershed.

Land Use 2016	Acres	% of Subwatershed
Vacant or Undetermined	3,163.8	36.5
Agricultural	1,643.0	19.0
Parks and Open Space	1,633.9	18.8
Single - Family Residential	1,600.9	18.5
Water	395.7	4.6
Roads and Highways	71.6	0.8
Institutional	69.0	0.8
Industrial	40.6	0.5
Commercial	34.5	0.4
Multi - Family Residential	16.9	0.2

Source: Metropolitan Council.

Recreation:

The Three Rivers Park District's Baker Park Reserve covers much of the upper subwatershed. The park includes numerous wetlands and Lake Katrina, and bicycle/hiking trails provide access to many natural features. The Luce Line Regional Trail passes across this subwatershed. There are no boat accesses or beaches on the lakes in the subwatershed, nor on Painter Creek.

The Minnesota Historic Features database notes 14 historic features in the subwatershed, most being residences, farmhouses or agricultural buildings. The listing includes a church, a post office as well as two commercial buildings in Maple Plain (Figure 2.86).

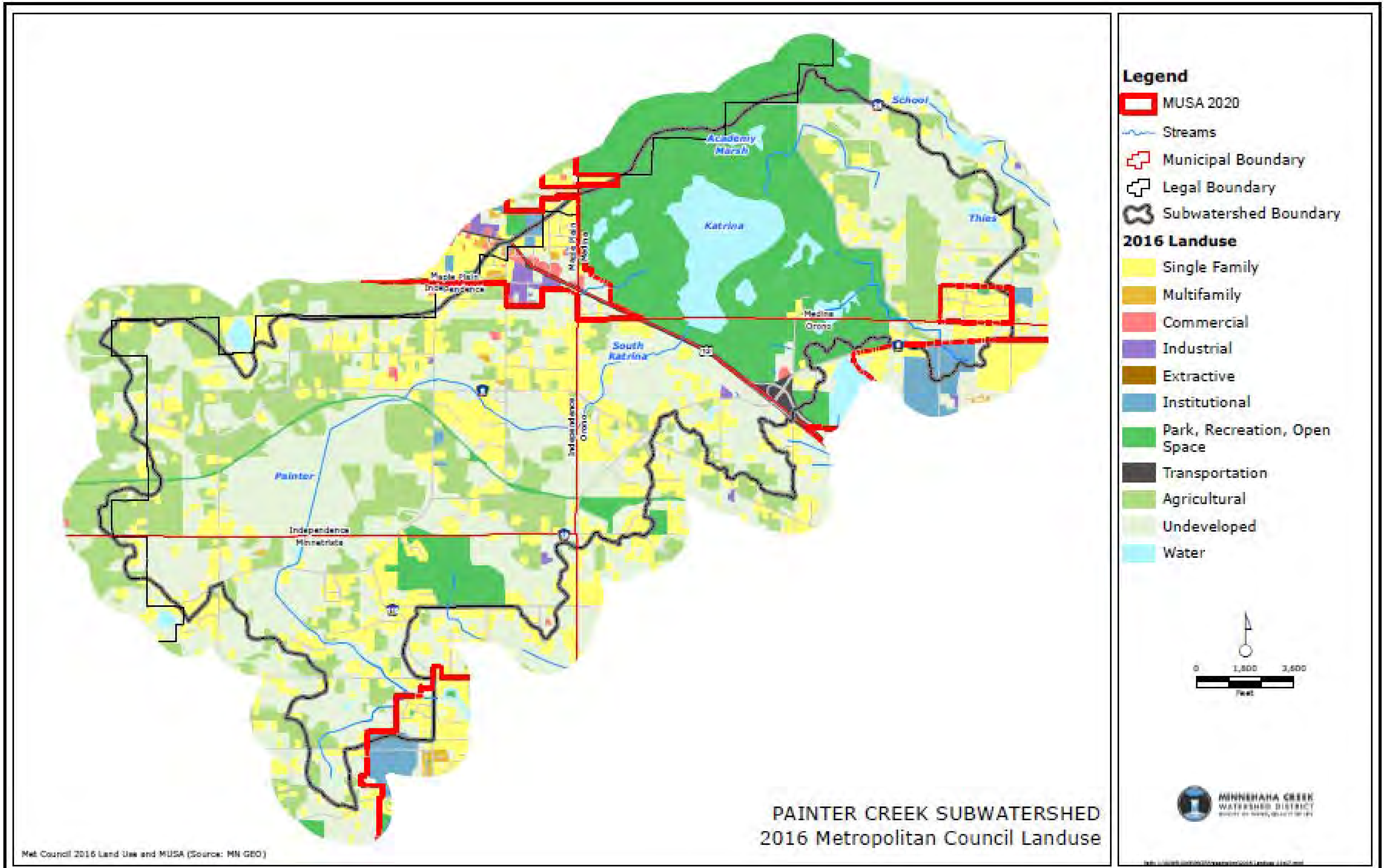

Figure 2. 85. Painter Creek subwatershed 2016 Metropolitan Council land use.

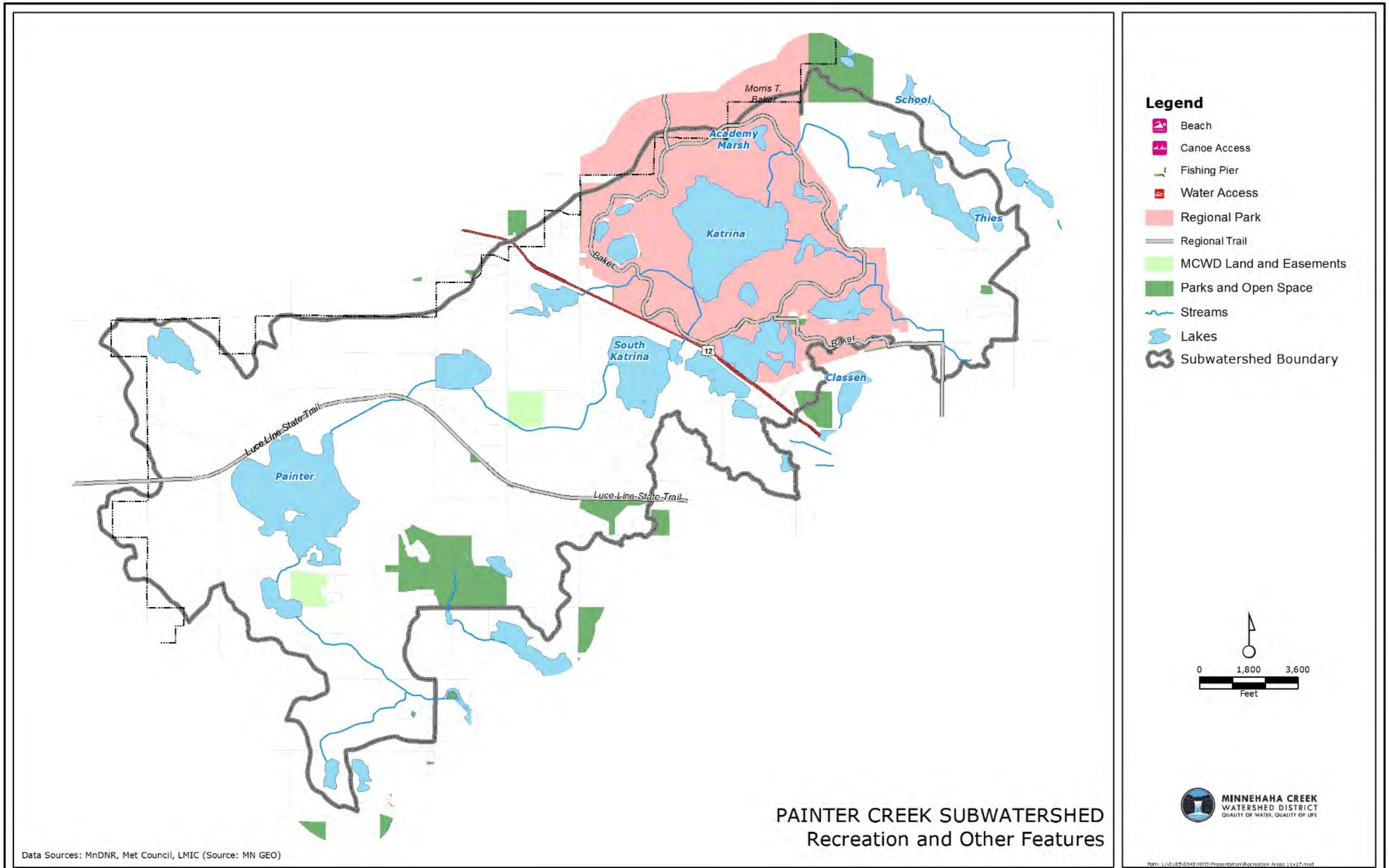

Figure 2. 86. Painter Creek subwatershed recreation and other features.

2.3.10 SCHUTZ LAKE SUBWATERSHED

Schutz Lake Subwatershed is one of the smaller subwatersheds throughout MCWD. It has a mixed land use - open space in Carver Park Reserve in the north, residential use in the east and agricultural use in the south. Wetlands, forests and woodlands are patchy throughout the subwatershed, but mostly concentrated around Schutz Lake. The subwatershed drains into Schutz Lake and then the lake drains into Lake Minnetonka: Smithtown Bay. The nutrient contribution to Lake Minnetonka from the Schutz Lake Subwatershed is not well understood. Table 2.77 below shows the area of the Schutz Lake subwatershed in acres by individual city, in total and as a percentage of the total subwatershed (Figure 2.87).

Table 2. 77. Cities in the Schutz Lake subwatershed.

City	Area (Acres)	% of Subwatershed
Victoria	969.2	100%
Total	969.2	100%

Source: MCWD

Subwatershed Description and Hydrology:

The Schutz Lake subwatershed is rolling and hilly with steep slopes abutting Schutz Lake and the wetlands to the north. A portion of the northwestern subwatershed is located within the Carver Regional Park Reserve, while the southern subwatershed contains lands that are part of the University of Minnesota Horticultural Research Center and Landscape Arboretum. The southern subwatershed contains agriculture and scattered residential development and drains through Schutz Creek north under Highway 5 to Schutz Lake. The lake dominates the northern subwatershed, with some residential development on its east side. Schutz Lake outlets into a large wetland that discharges to an outlet under Highway 7 into Smithtown Bay: Lake Minnetonka. For information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.88). The subwatershed is bisected by Highway 5. The lake dominates the north, with the forest, woodland and grasslands of the Carver Park Reserve to the west and residential areas with low to medium impervious surface to the east. The southern half of the subwatershed is maintained or natural grassland and agriculture with scattered residential development.

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Schutz Lake subwatershed into four units, designated SL-1 through SL-4 (Figure 2.89).

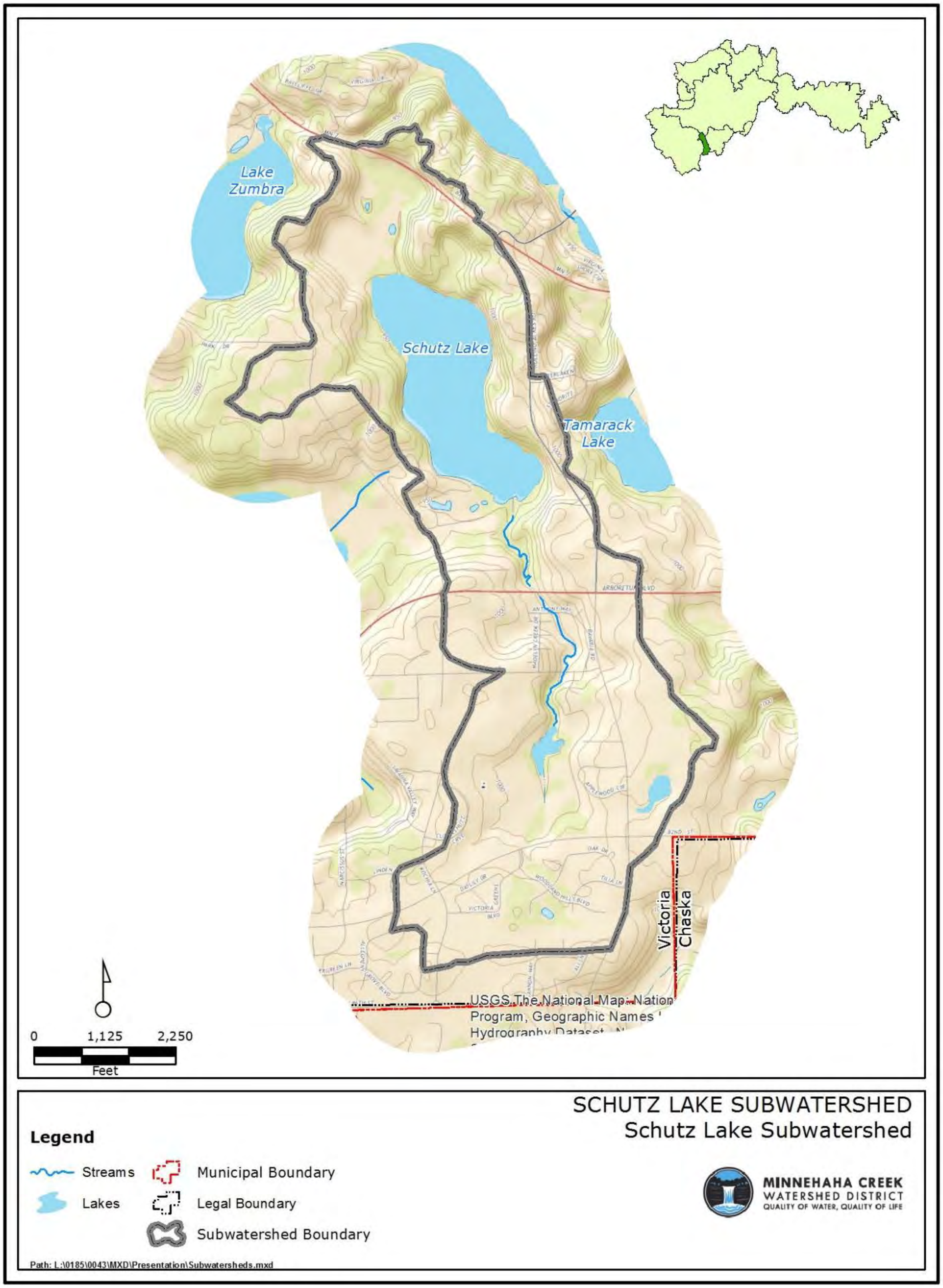

Figure 2. 87. The Schutz Lake subwatershed.

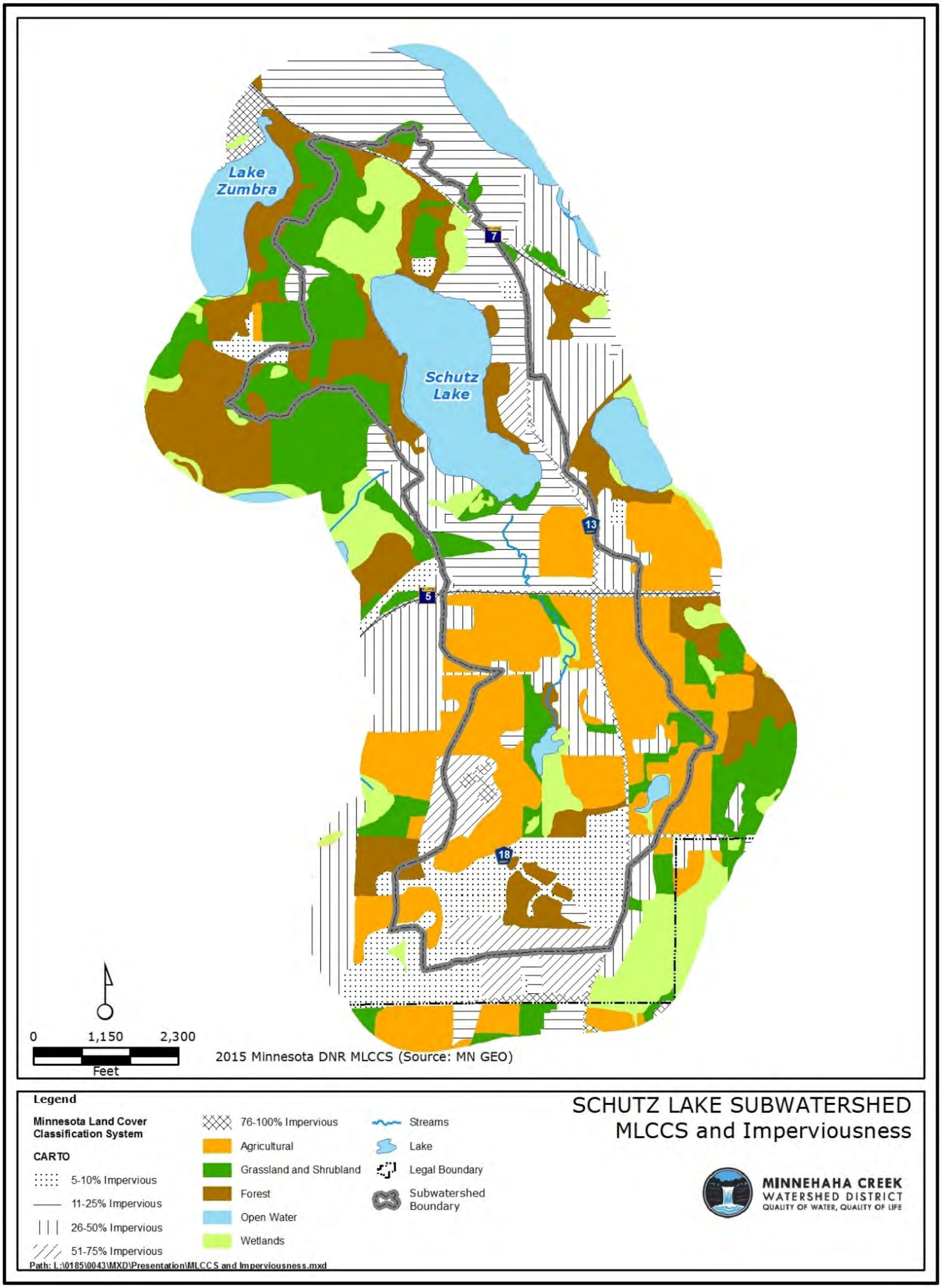

Figure 2. 88. Schutz Lake subwatershed MLCCS and imperviousness.

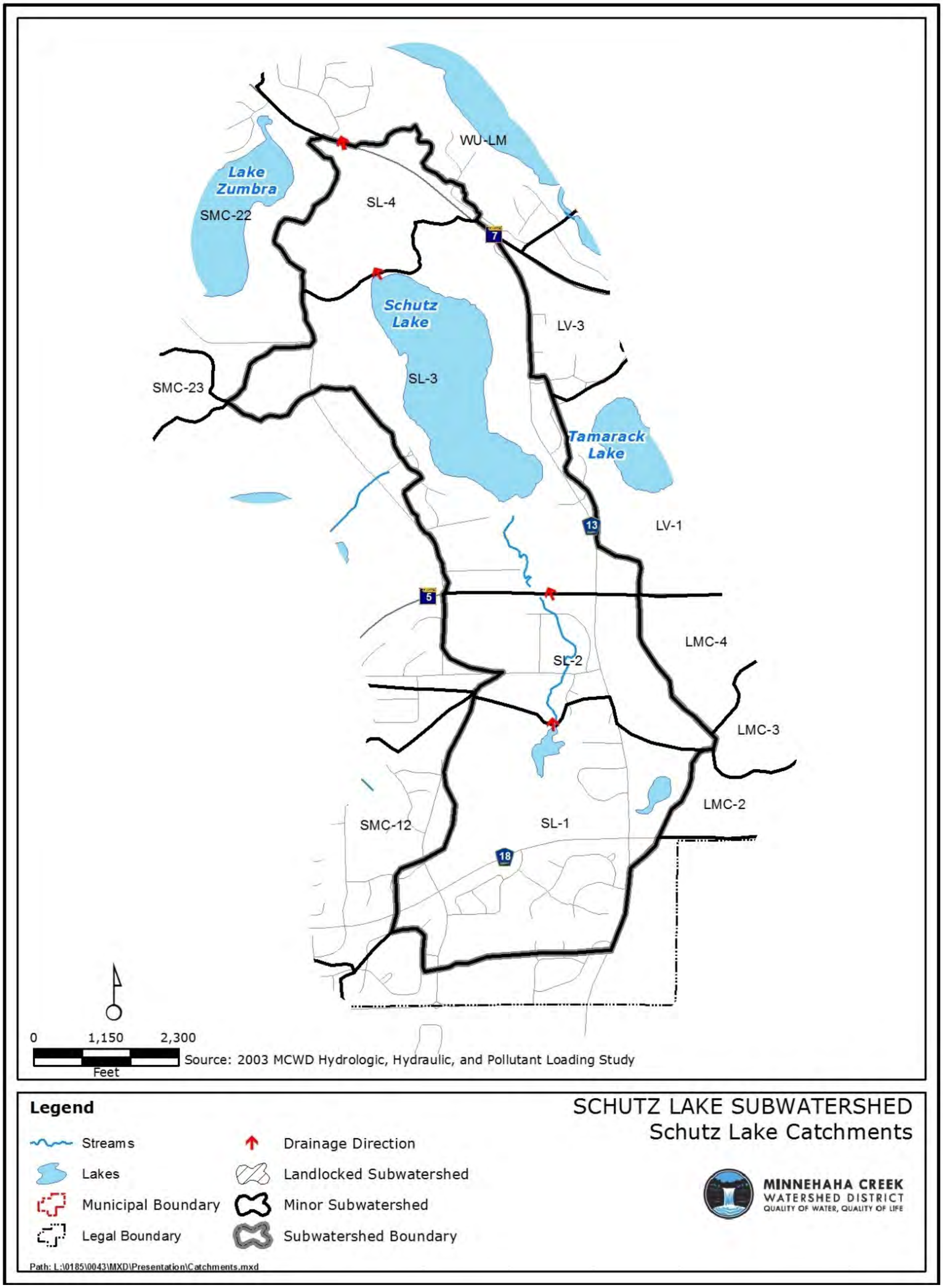

Figure 2. 89. Schutz Lake catchments.

Water Quality:

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

Schutz Lake is the primary receiving water within the subwatershed, and is classified by the DNR for shoreland management purposes as a Recreational Development lake (Table 2.78). Schutz Lake is not on the State's Impaired Waters list. However, the lake is eutrophic, with observations of greenish-brown water (an indication of algae). Tables 2.78 and 2.79 below detail the physical and water quality characteristics of Schutz Lake.

To assess long-term change in Schutz Lake, a Mann-Kendall trend analysis was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth data for the period 2002-2015. This analysis showed no trend in TP concentration or Secchi depth, but showed a statistically significant ($p<0.05$) degrading trend in chlorophyll-a, which is a measure of algal growth. For more information please refer to the District's Water Quality (Hydrodata) reports.

Table 2. 78. Physical characteristics of lakes in the Schutz Lake subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Schutz	106	49	8:1	Recreational Development

Source: Minnesota DNR.

Table 2. 79. Selected water quality goals and current conditions of lakes in the Schutz Lake subwatershed.

Lake	State TP Standard (µg/L)	2007 Plan Goal TP (µg/)	Trend*	2002-2015 Summer Average		
				TP (µg/L)	Chl-*a* (µg/L)	Secchi (m)
Schutz	40	40	Deg Chl-*a*	39	22	1.6

*Statistically significant at ≤ 0.05, Deg = degrading.
Source: MCWD.

Streams:

Schutz Creek conveys discharge through the upper subwatershed north under Highway 5 and empties into Schutz Lake (Figure 2.90). It is not listed as an Impaired Water; however, summer average total phosphorus concentration is greater than the nutrient component of the state's river eutrophication standard. Elevated levels of total phosphorus suggest that: 1) excess nutrients may be conveyed from the watershed to Schutz Lake through Schutz Creek, and/or 2) riparian wetlands in the watershed may be discharging phosphorus to the stream, indicating wetland disturbance.

Tables 2.80 and 2.81 below detail the physical and water quality characteristics of streams and tributaries within the subwatershed. To assess long-term change in Schutz Lake Inlet, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS data from 2006-2015. There were no statistically significant changes in water quality during this period.

Table 2.81 shows the average concentrations at the monitoring site of the Schutz Lake Creek outlet. The stream has an average TSS concentration of 12 mg/L, which is well below the 30 mg/L state standard. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. The most recent DO readings available by the District were above the standard. For more information, refer to District's Water Quality (Hydrodata) reports.

Table 2. 80. Major streams in the Schutz Lake subwatershed.

Stream	Length (mi)
Schutz Lake Creek Inlet (CSC01)	1.14

Table 2. 81. Current conditions of streams in the Schutz Lake subwatershed.
See Figure 2.90 for monitoring locations.

Stream	Trend*	2006-2015 Annual Average			
		TP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl (mg/L)
Schutz Lake Creek Inlet (CSC01)	No trend	182	1.23	12	54**

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride.
*Statistically significant at ≤ 0.05, **Cl data 2008-2015
Source: MCWD.

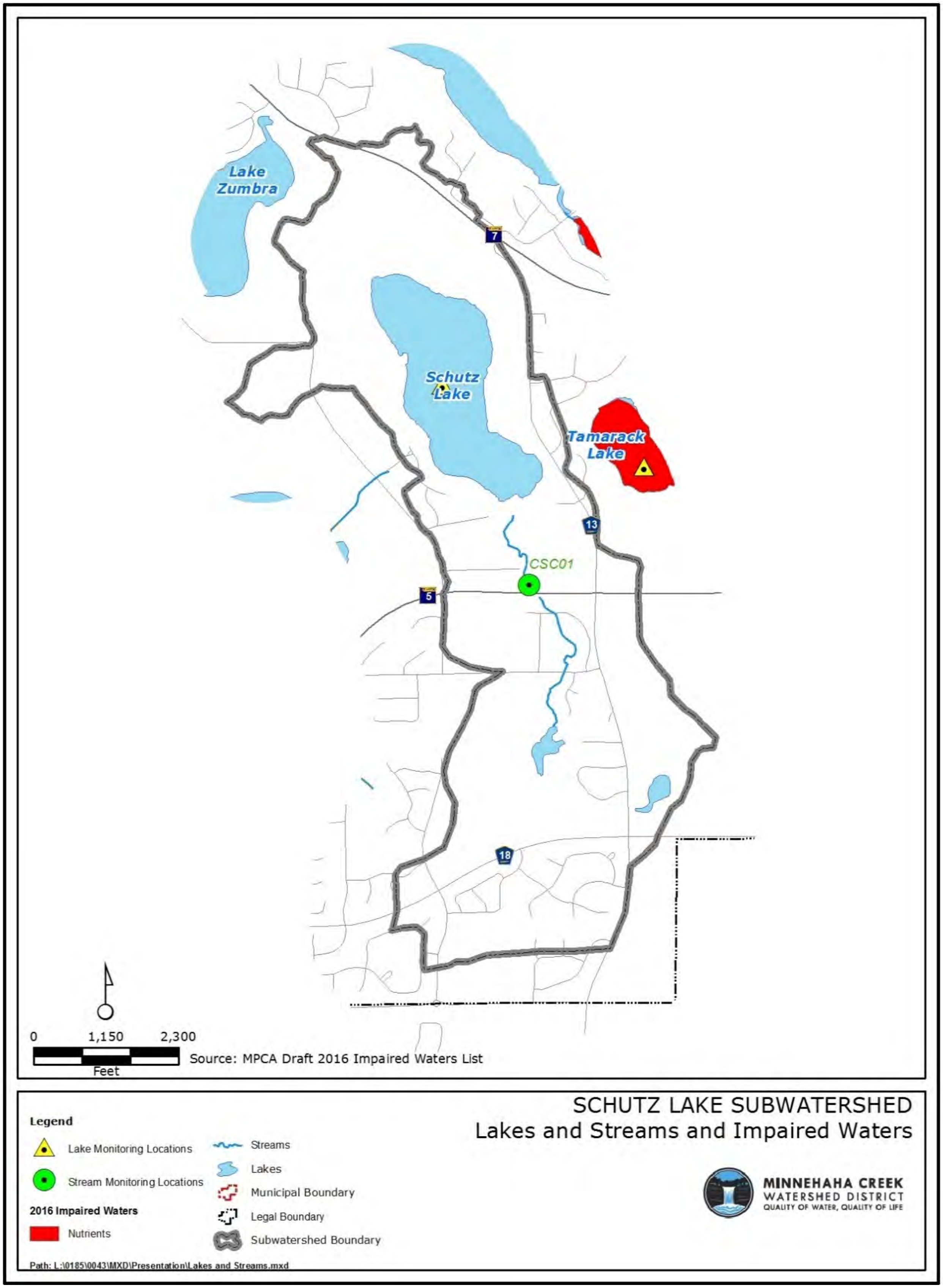

Figure 2. 90. Schutz Lake subwatershed lakes and streams and Impaired Waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover over 20 percent of the watershed's surface (Figure 2.91 and Table 2.82). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

No data are available yet to evaluate the ability of the wetlands in the subwatershed to cycle nutrients to and from the subwatershed. E-Grade will assess wetland soil chemistry, overall vegetative conditions, presence or absence of algal blooms, and condition of the buffer and area within 500 feet of the wetlands.

Table 2. 82. Functional Assessment of Wetlands inventory of wetland types in the Schutz Lake subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	6.5	0.71
2 - Wet Meadow	66.5	7.29
3 - Shallow Marsh	14.4	1.58
4 - Deep Marsh	36.6	4.01
5 - Open Water	3.2	0.35
6 - Scrub Shrub	0.3	0.03
7 - Forested	13.9	1.52
8 - Bog	-	-
Riverine	-	-
Wetland Total	141.4	15.5
Upland	770.2	84.5
TOTAL	911.6	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream base flow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

Infiltration potential of the upland areas within the subwatershed is generally medium, with the areas of loamy clay soils classified as low potential. Because of the organic nature of the soils in the wetland areas, generally, the infiltration potential there is variable. The *Carver County Water Resource Management Plan* classifies the groundwater resources of most of the western subwatershed area as being of medium to low sensitivity to pollution, and the major wetland areas on the north and in the south as being highly sensitive.

The western edge of the subwatershed has been designated by the Minnesota Department of Health as a Drinking Water Supply Management Area (DWSMA) and Wellhead Protection Area for the City of Victoria. Figure 2.92 shows areas in the subwatershed with groundwater sensitivity and that are designated Wellhead Protection Areas.

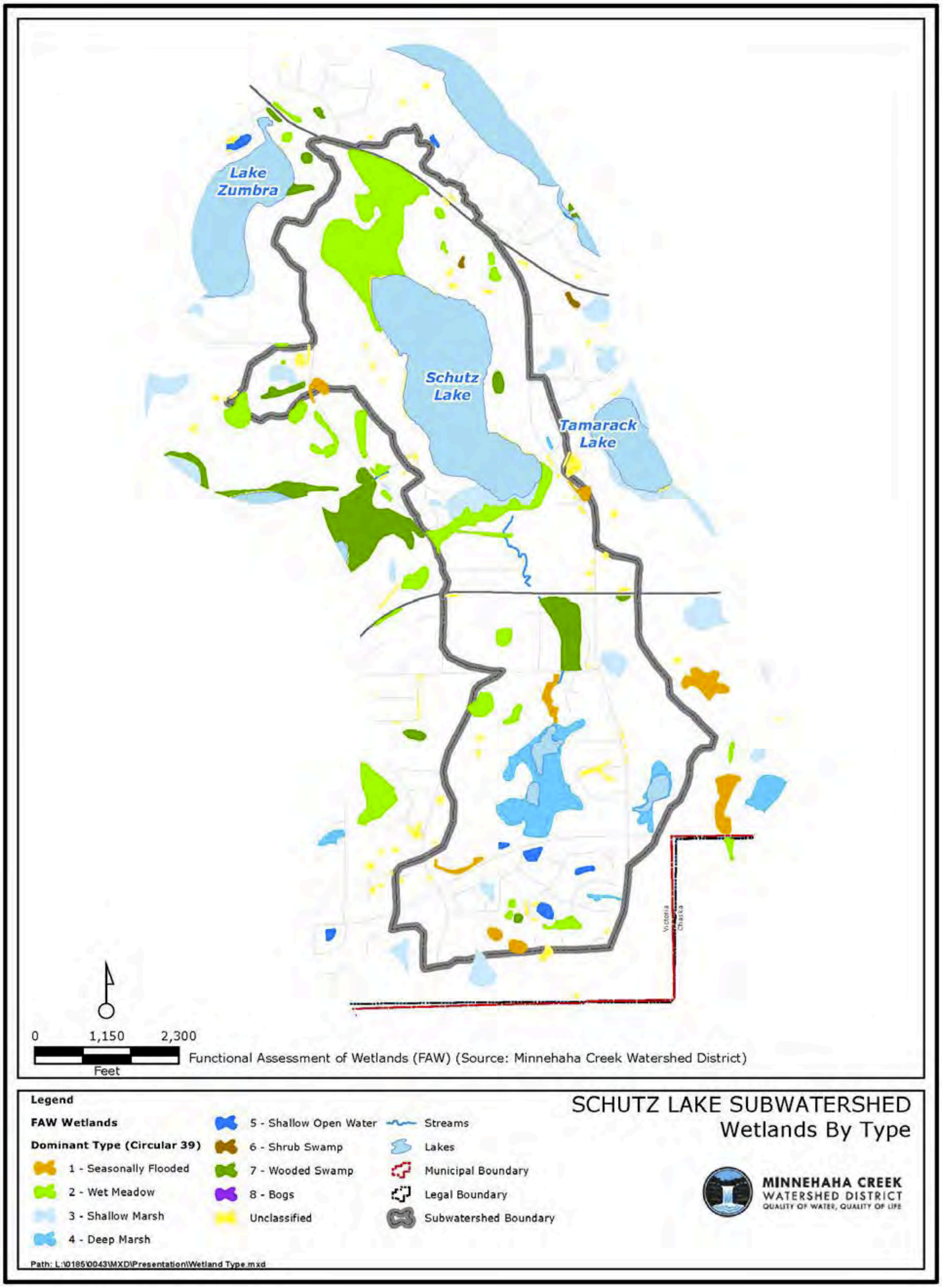

Figure 2. 91. Schutz Lake subwatershed wetlands by type.

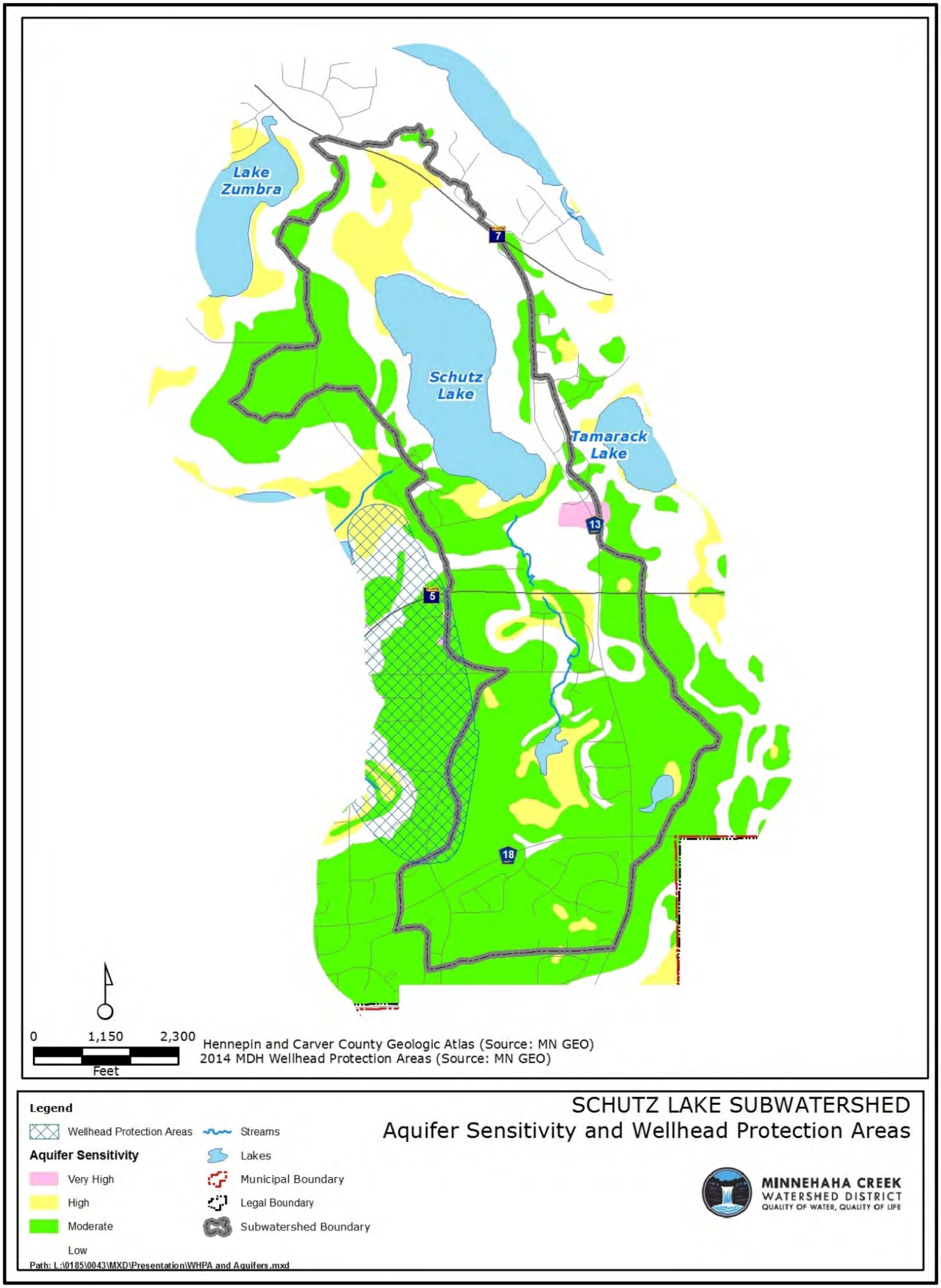

Figure 2. 92. Schutz Lake subwatershed aquifer sensitivity and Wellhead Protection Areas.

Water Quantity:

There are no landlocked basins in this subwatershed. To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water yield data for the monitoring station downstream of Highway 5. Water yield from 2006-2015 showed a statistically significant ($p=0.04$) increasing trend. There has been some development in the upper subwatershed during that period.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Schutz Lake subwatershed is being evaluated by the E-Grade program in 2015-2017. At this time, only some of the E-Grade metrics have been assessed. The final E-Grade report for this subwatershed will not be available until 2018. This section summarizes ecological integrity using E-Grade and other data, where available (Figure 2.93).

Lakes:

Biodiversity

Fish Community. Biodiversity is measured using the Index of Biotic Integrity (IBI) for fish developed by the DNR. MCWD surveyed Schutz Lake in 2015 for E-Grade. Schutz Lake's Fish IBI score is 22.8, which is classified as Poor, with the community showing obvious signs of anthropogenic disturbance compared to other similar lakes. Schutz Lake was last surveyed by the DNR in 1991. At that time the fish population was dominated by bluegill, black crappie, and largemouth bass in above average numbers.

Aquatic Vegetation Community. Biodiversity is determined by the number and variety of species, or richness. A Floristic Quality Index (FQI) assessment was completed for the Schutz Lake aquatic vegetation community. The FQI score was 9.4, which is classified as Degraded, with very low species richness and with a community comprised of non-native and/or intolerant species.

Aquatic Invasive Species. Schutz Lake is infested by Eurasian watermilfoil and Curlyleaf Pondweed.

Habitat diversity

Aquatic Vegetation Community. Habitat diversity is determined by the percent occurrence of species, or the extent to which it may be dominated by a few species. The habitat diversity of the vegetation community has not been assessed yet.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score the Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. Score the Shore data are available, but has not been assessed yet through E-Grade. Aerial photos, however, show that much of Schutz Lake has significant woodland or wetland fringes, which are beneficial for controlling runoff and supporting emergent vegetation at the shoreline.

Streams:

Biodiversity

Fish Community. No fish IBI data are available for the streams in this subwatershed.

Macroinvertebrate Community. Macroinvertebrate samples were collected in 2013 and 2015 in Schutz Creek. The M-IBI scores were 19 and 28, below the M-IBI threshold of 37 for a Southern Streams riffle/run stream. The community lacked species richness and was missing certain classes of organisms, which is indicative of poor water quality or habitat alteration.

Aquatic Invasive Species. No AIS data are available for the streams in this subwatershed.

Habitat diversity

Habitat Complexity. E-Grade uses the Minnesota Stream Habitat Assessment tool to assess habitat complexity in Schutz Creek. Habitat Complexity is determined by evaluating three zones: in-stream, riparian or near-stream, and channel morphology, or channel form. Schutz Creek scored 27 of 46 points for conditions in-stream, which is classified as Good. The stream bed was a good mix of cobble, gravel and sand, there were riffles and pools present, and multiple types of cover, although in low quantities. The riparian zone was scored 10 of 14, also Good. The riparian zone is moderately wide, the banks exhibit little erosion, and riparian tree cover provides adequate shading. Channel morphology was scored 28 out of 35, classified Exceptional. The channel was very sinuous, was well developed with variable depths, pools, and riffles, and minimal modifications.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. Schutz Creek is classified as Poor by the presence of culverts at Highway 5 and at the trail crossing.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are not available, but instantaneous flow has been measured since 2006. Annual average flow for each year was computed first, and then all the years' averages were averaged together. Annual average flow at CSC01 was 1.44 cfs indicating generally low flow conditions at time of data collection.

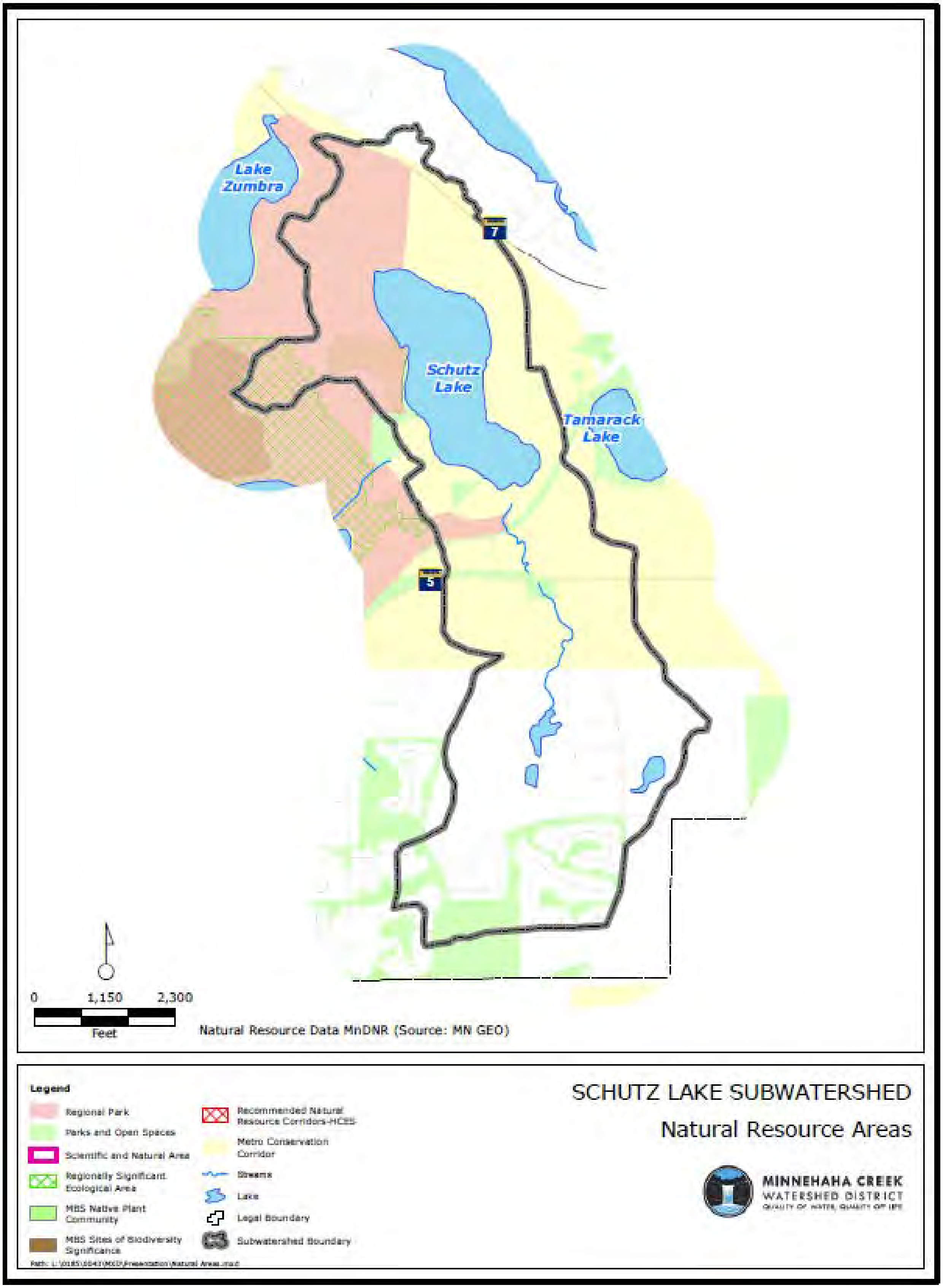

Figure 2. 93. Schutz Lake subwatershed natural resource areas.

Wetlands:

Biodiversity

Vegetation Community. Floristic Quality Index (FQI) data are available for seven wetlands in this subwatershed. One small wetland to the west of Mt. Olivet Church on Rolling Acres Road was classified as Good floristic quality. Four wetlands, including the large wetland at the headwaters of Schutz Creek to the northeast of Holy Family Catholic High School, were classified as Poor. Two small wetlands in the residential area to the north of Schutz Lake were classified as Degraded. Both were heavily infested with buckthorn, reed canary grass, and Canadian wood-nettle.

Habitat diversity

Connectivity. Few wetlands are present in the subwatershed, therefore there is limited opportunity to provide connectivity.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species. There are several large wetlands present in the west of the watershed, along the headwaters of Schutz Creek to Schutz Lake as well as on the north side of Schutz Lake.

Shoreline Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. About 30 percent of the Schutz Lake shoreline is protected by wetland.

Uplands:

Biodiversity

Within the Carver Park Reserve on the west side of the lake is a large patch of maple-basswood forest that has been designated on the Minnesota Biological Survey (MBS) as being a high-value native plant community. The larger area within Carver Park Reserve has been designated by the DNR as a regionally significant ecological area within the Metro area. (Figure 2.93).

Habitat diversity

Regionally significant ecological areas are places where larger tracts of minimally disrupted land provide habitat complexity. A portion of the northwestern subwatershed is located within the Carver Regional Park Reserve, while the southern subwatershed contains lands that are part of the University of Minnesota Horticultural Research Center and Landscape Arboretum.

Thriving Communities:

Land use:

Table 2.83 below shows the land uses within the area of the Schutz Lake subwatershed in acres and as a percentage of the total subwatershed. The principal land uses in the northern part of the subwatershed are single-family residential and parks and open space (Figure 2.94).

Table 2. 83. 2016 land use in the Schutz Lake subwatershed.

Land Use 2016	Acres	% of Subwatershed
Parks and Open Space	240.7	24.8
Single - Family Residential	228.4	23.6
Agricultural	140.9	14.5
Institutional	117.4	12.1
Water	109.8	11.3
Vacant or Undetermined	71.9	7.4
Multi - Family Residential	35.5	3.7
Roads and Highways	11.6	1.2
Commercial	8.1	0.8
Industrial	5.0	0.5

Source: Metropolitan Council.

Recreation:

There are no public beaches or accesses to the lake; however, there is a private access that the property owner has granted permission for a fee to anglers and monitoring agencies. The Carver Park Reserve abuts the northwesterly portion of the lake. A park trail loops through the area but does not access the lake. The Southwest Hennepin LRT Regional Trail crosses the subwatershed and portions of the southern subwatershed are part of the University of Minnesota Horticultural Research Center and Landscape Arboretum (Figure 2.95).

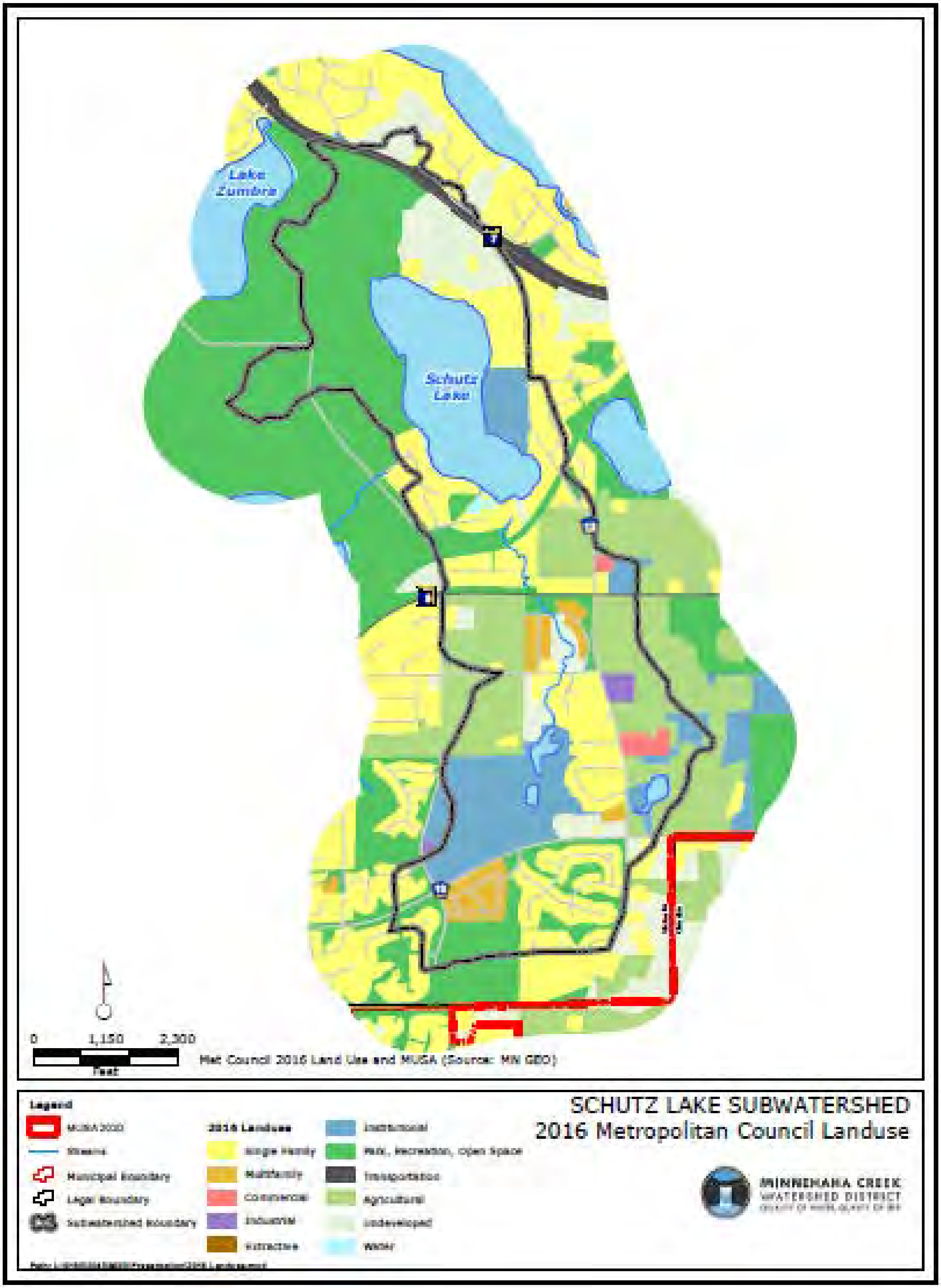

Figure 2. 94. Schutz Lake subwatershed 2016 Metropolitan Council land use.

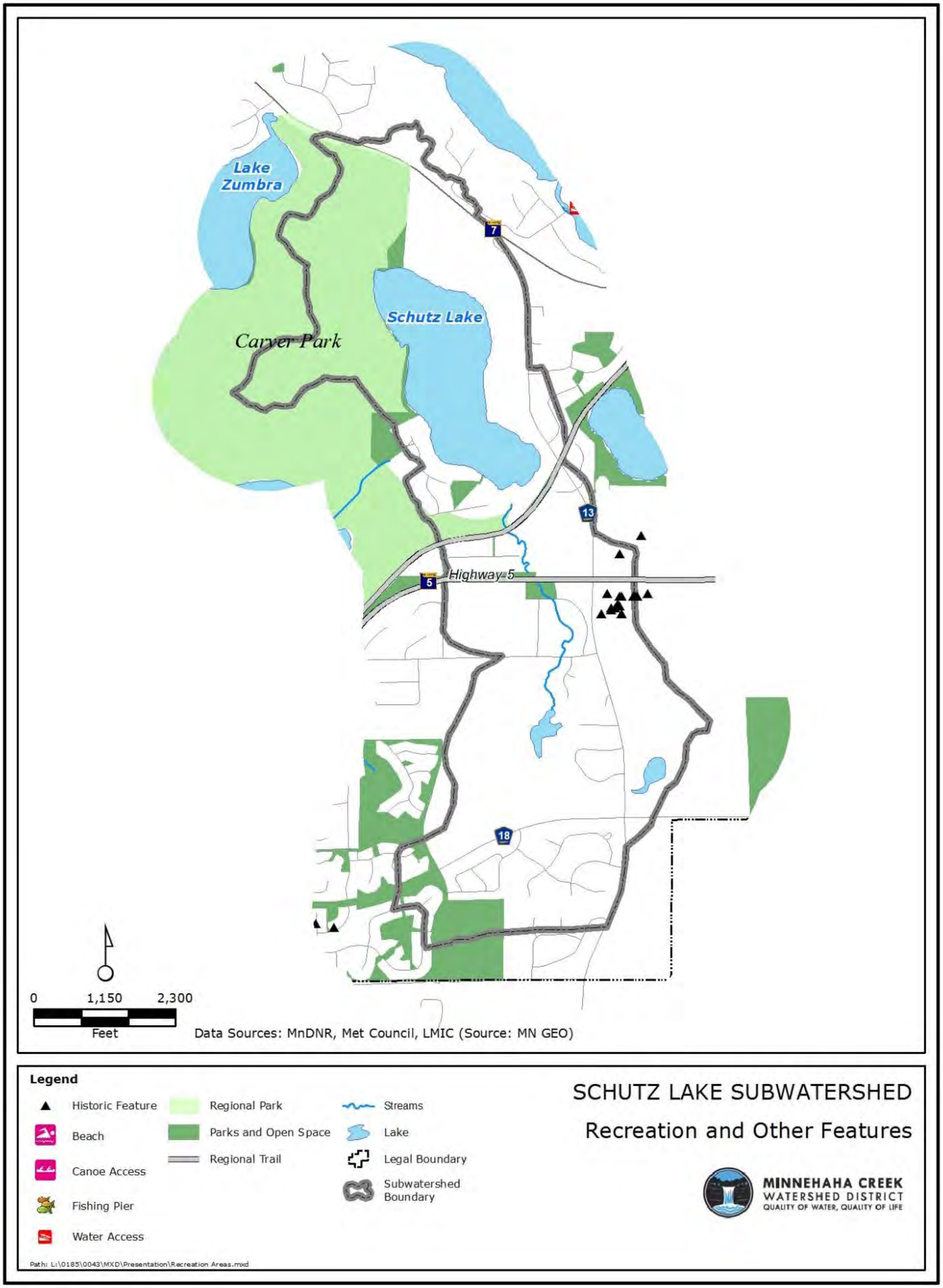

Figure 2. 95. Schutz Lake subwatershed recreation and other features.

2.3.11 SIX MILE CREEK SUBWATERSHED

Six Mile Creek Subwatershed is the third largest subwatershed within Minnehaha Creek Watershed. The land use is primarily agricultural, but residential and commercial development is on the rise as cities and townships within the subwatershed grow. Natural, open areas reside within the Carver Park Reserve, which is managed by Three Rivers Park District. The land cover within Carver Park Reserve is grassland, woodlands, forest and wetlands that surrounds the following lakes: Steiger, Lundsten, Auburn and portions of Zumbra. These lakes are part of a larger series of lakes within the subwatershed nicknamed the "western chain of lakes." Six Mile Creek, which is actually 11 miles long, flows through the "western chain of lakes," beginning with Piersons Lake and passes through Mud Lake wetland before discharging into Lake Minnetonka: Halsted Bay. Table 2.84 below shows the area of the Six Mile Creek subwatershed in acres by individual city, in total and as a percentage of the total subwatershed (Figure 2.96).

Table 2. 84. Cities and Townships in the Six Mile Creek subwatershed.

City	Area (Acres)	% of Subwatershed
Minnetrista	3,572.2	20.9%
St. Bonifacius	662.2	3.8
Victoria	4,476.2	26.2
Laketown Township	8,154.0	47.8
Watertown Township	167.9	0.9
Total	17,032.8	100%

Source: MCWD

Subwatershed Description and Hydrology:

The Six Mile Creek subwatershed has a rolling landscape with low slopes, small streams, numerous lakes and peat bogs. The subwatershed is drained by Six Mile Creek, which flows 11 miles from Piersons Lake to Halsted Bay: Lake Minnetonka. Many of the subwatershed's lakes are located in the Carver Regional Park Reserve.

Land cover is classified by the Minnesota Land Cover Classification System (MLCCS) (Figure 2.97). The subwatershed is dominated by agriculture in the southwest and northwest, while forest and woodland along with grass and shrubland is predominant through the central section. Smaller areas of lower density development are present in the southeast corner of the subwatershed. Wetlands are scattered throughout the subwatershed.

For more information regarding geology and soils in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

The *2003 MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS)* subdivided the Six Mile Creek subwatershed into 66 subwatershed units, designated SMC-1 through SMC-66 (Figure 2.98). More detailed information about the hydrology of the subwatershed can be found in the *Six Mile Creek Diagnostic Study* (Wenck 2013). That study divided the subwatershed into five Watershed Management Units (MUs): including Piersons-Marsh-Wassermann, Carver Park Reserve, Turbid-South Lundsten, Auburn-North Lundsten, and Parley-Mud.

Figure 2. 96. The Six Mile Creek subwatershed.

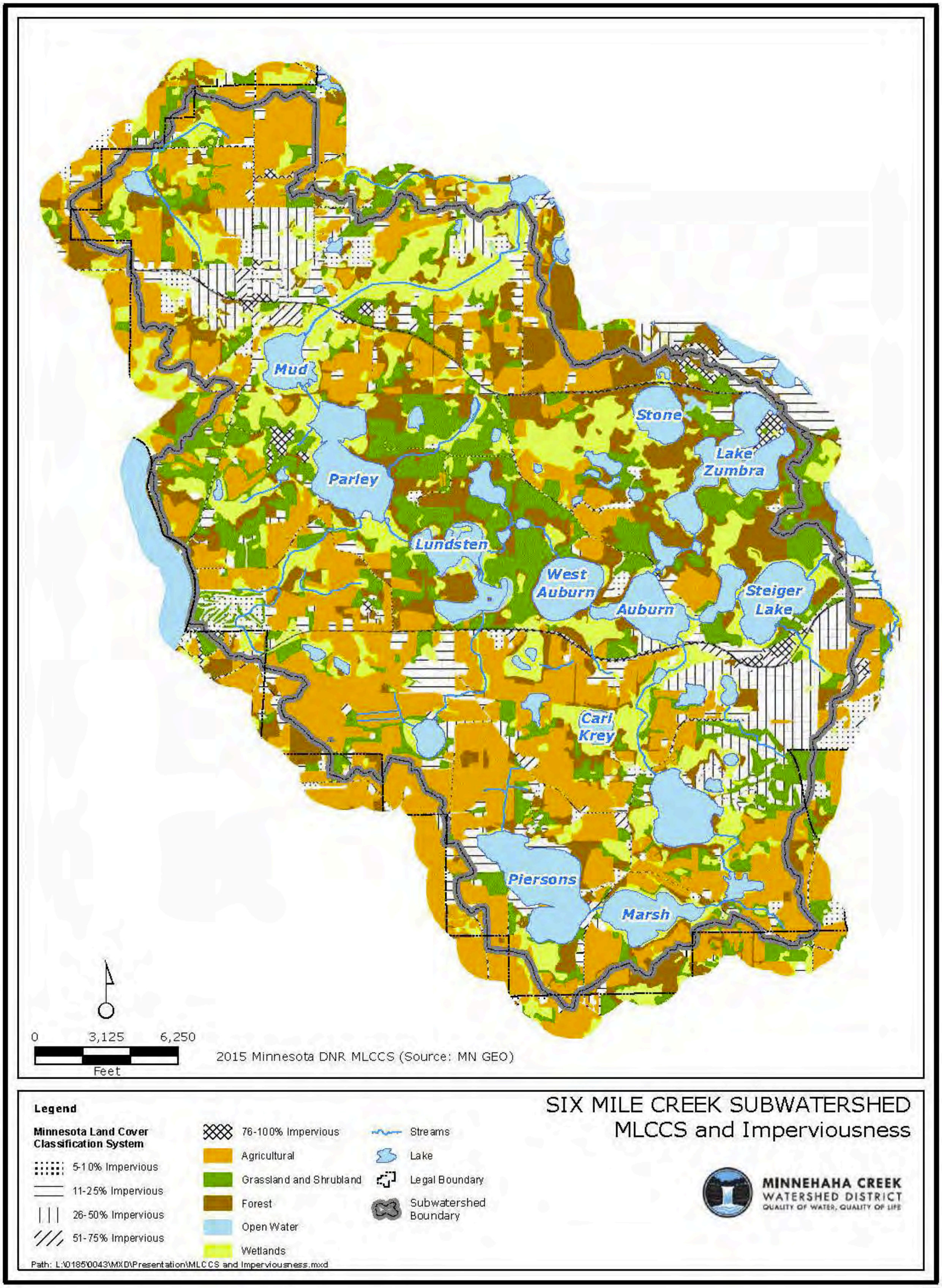

Figure 2. 97. Six Mile Creek subwatershed MLCCS and imperviousness.

Figure 2. 98. Six Mile Creek subwatershed catchments.

Water Quality

The following are summaries of the characteristics and classifications of lakes and streams within the subwatershed including water quality goals and trends.

Lakes:

The subwatershed includes several lakes through which Six Mile Creek flows, as well as other lakes not associated with that stream. Many of the lakes are located within the Carver Park Reserve (Figure 2.99). Most of the lakes are monitored either as part of the District's monitoring program or by Three Rivers Park District. Little or no water quality data are available for smaller lakes scattered throughout the subwatershed. Tables 2.85 and 2.86 below detail the physical and water quality characteristics of the lakes and DNR shoreland classification within the subwatershed.

The following lakes in the Six Mile Creek subwatershed are on the State's Impaired Waters List for excessive phosphorus: West Auburn, Parley, Stone, and Wassermann. Mud Lake has been classified by the MPCA as a wetland rather than a lake, so the lake standard does not apply. *Six Mile Creek Diagnosis Study* and the *Upper Minnehaha Creek Watershed Lakes TMDL* highlight whether external, internal or both are the sources contributing excessive nutrients to these lakes. Lakes Zumbra-Sunny, Steiger, and Wassermann are on the State's Impaired Waters List for Mercury in Fish Tissue, and is included in the statewide mercury TMDL.

To assess long-term change, a Mann-Kendall statistical trend test was performed on total phosphorus (TP), chlorophyll-a (Chl-a), and Secchi depth data from 2001-2015. Statistically significant changes in water quality in the lakes in the Six Mile Creek Subwatershed are listed in Table 2.86. For more information regarding water quality in the subwatershed, please refer to the District's Water Quality (Hydrodata) Reports and the *Six Mile Creek Diagnostic Study*.

Table 2. 85. Physical characteristics of lakes in the Six Mile Creek subwatershed.

Lake	Surface Area (acres)	Maximum Depth (ft)	Watershed to Lake Area Ratio	DNR Classification
Auburn East	148	40	52:1	Recreational Development
Auburn West	145	80	54:1	Recreational Development
Carl Krey	44	15	8:1	Natural Environment
Church	12	54	28:1	Recreational Development
Lundsten N	114	7	53:1	Natural Environment
Lundsten S	77	10	7:1	Natural Environment
Marsh	143	4	10:1	Natural Environment
Parley	257	19	48:1	Recreational Development
Piersons	267	119	5:1	Recreational Development
Stone	96	30	9:1	Natural Environment
Steiger	166	37	5:1	Recreational Development
Sunny (Zumbra-Sunny)	78	18	38:1	Natural Environment
Turbid	39	37	14:1	Natural Environment
Wassermann	170	41	17:1	Recreational Development
Zumbra (Zumbra-Sunny)	271	58	2:1	Recreational Development

Source: Minnesota DNR.

Table 2. 86. Selected water quality goals and current conditions of waterbodies in the Six Mile Creek subwatershed.

Waterbody	State TP Standard (µg/L)	2007 Plan Goal TP (µ/L)	Trend*	2001-2015 Summer Average			Years Monitored
				TP (µg/L)	Chl-a (µg/L)	Secchi (m)	
Auburn East	40	50	No trend	47	31	1.3	2006-2015
Auburn West	40	27	No trend	31	12	2.4	2002-2015
Carl Krey	60	n/a	No trend	28	7	2.2	2006-2015
Church	40	n/a	Deg Secchi	101	27	2.1	2006-2015
Lundsten N	60	70	n/a	61	17	1.4	2006-2015
Lundsten S	60	70	n/a	273	118	0.8	2012-2015
Marsh	60	n/a	n/a	29	7	0.9	2010-2015
Mud	n/a	n/a	n/a	227	126	0.4	2006-2015
Parley	60	50	No trend	95	69	0.7	1999-2015
Piersons	40	27	No trend	26	9	2.4	1997-2015
Stone	40	36	Imp Chl-a	40	13	2.4	2007-2015
Steiger	40	30	Imp Secchi, TP	35	14	2.2	2002-2015
Sunny	60	n/a	n/a	57	15	1.8	2013-2015
Turbid	40	n/a	n/a	68	28	1.4	2006-2016
Wassermann	40	50	No trend	78	51	0.9	1997-2015
Zumbra	40	25	All Imp	25	8	3	1994-2015

*Statistically significant at $\leq$ 0.05, Imp = improving, Deg = degrading.
Source: MCWD, MPCA.

Streams:

There is one primary stream within the subwatershed: Six Mile Creek, which flows to Halsted Bay. Several other small streams and channels provide drainage and local conveyance within the subwatershed. The creek was channelized as Judicial Ditch #2 in 1903 and is comprised of a series of small channels connecting flow-through lakes and wetlands. There are no known storm sewer outfalls to the creek, mainly due to minimal near-stream development. There are 5 bridge crossings, and some culvert crossings, which are mainly park trail, and path crossings. Table 2.85 below details the water quality characteristics of Six Mile Creek. Due to its nature as short channels connecting lakes, water quality in the stream is highly influenced by outflow from those lakes.

A majority of the Six Mile Creek stations are less than the State's river eutrophication standards for total phosphorus, except for Highland Rd (Mud Lake outlet (CSI02)). The state river eutrophication standards also look at other indicators such as chlorophyll-a, diel oxygen flux, and biological oxygen demand, for which chlorophyll-*a* has been assessed at the Highland Rd (CSI02) station. Chlorophyll-a concentrations are above the State's river eutrophication standards for the response (stressor) variable. The primary nutrient cycling concern for Six Mile Creek is that it conveys phosphorus load to Halsted Bay: Lake Minnetonka.
Table 2.87 shows the average TSS concentrations in Six Mile Creek to be below the 30 mg/L state standard for this ecoregion. Maintaining sufficient dissolved oxygen (DO) is necessary to support aquatic life. The DO state standard requires the stream to never fall below 5 mg/L DO. Monitoring data show that stations along Six Mile Creek often fall below this standard in summer. Stations (i.e., CSI14, and CSI10) that have DO above 5 mg/L earlier in the season, can run dry by mid-late summer. Six Mile Creek flows between lakes and wetlands. Stretches of the creek that are influenced by riparian wetlands may have increased sediment oxygen demand.

To assess long-term change in Six Mile Creek, a Mann-Kendall statistical trend test was performed on flow-corrected TP and TSS concentrations for the Highland Rd (CSI02) station from 2005-2015. There was a statistically significant improvement in TSS concentrations during this period (Table 2.87). For more information on Six Mile Creek and tributaries, please refer the District's Water Quality (Hydrodata) Reports, District's 2003 *Upper Watershed Stream Assessment*, and *Six Mile Creek Diagnostic Study.*

Table 2. 87. Current conditions of streams in the Six Mile Creek subwatershed.
See Figure 2.99 for monitoring locations.

Stream	Trend*	2005-2015 Annual Average				
		TP (µg/L)	TN (mg/L)	TSS (mg/L)	Cl (mg/L) [1]	Chl-a (µg/L) [2]
Highland Rd (CSI02)	Imp TSS	152	1.86	21	30	50
Lundsten Lake Outlet (CSI01)	n/a	73	1.07	8	21	n/a
Auburn Lake Outlet (CSI09)	n/a	38	0.99	3	30	n/a
Auburn Lake Inlet (CSI05)	n/a	106	0.94	4	23	n/a
Wassermann Outlet (CSI12)	n/a	87	1.36	9	22	n/a
Marsh Lake Outlet (CSI11)	n/a	63	0.79	11	22	n/a
Piersons Lake Outlet (CSI14) [3]	n/a	27	0.81	9	24	n/a

TP = total phosphorus, TN =total nitrogen, TSS = total suspended solids, Cl = chloride,
*Statistically significant at ≤ 0.05, Imp = Improving
[1]Cl data 2008-2015; [2]Chl-a data June-Sept 2013-2015; [3]All data 2010-2015
Source: MCWD.

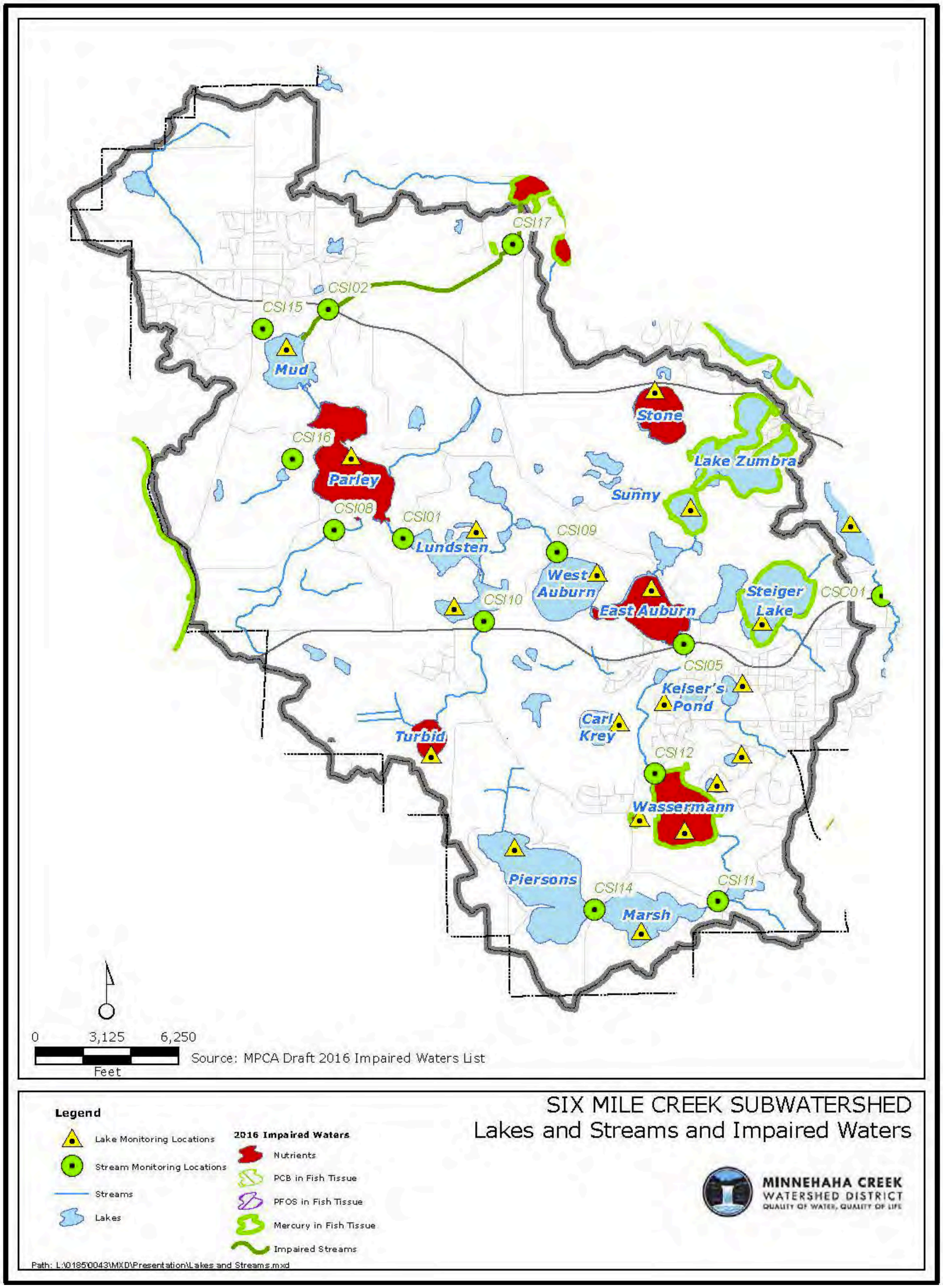

Figure 2. 99. Six Mile Creek subwatershed lakes and streams and Impaired Waters.

Wetlands:

According to the FAW, wetlands, including lakes, cover over 30 percent of the subwatershed's surface (Figure 2.100 and Table 2.88). A delineation of wetland boundaries is required to be completed any time development or other impacts may occur near or in a wetland. For more information regarding wetlands in the subwatershed, please refer to the *2007 MCWD Comprehensive Water Resources Management Plan*.

Table 2. 88. Functional Assessment of Wetlands inventory of wetland types in the Six Mile Creek subwatershed.

FAW Circular 39 Wetland Type	Area (acres)	Percent
1 - Seasonal	404.4	2.51
2 - Wet Meadow	480.3	2.98
3 - Shallow Marsh	1,678.1	10.42
4 - Deep Marsh	279.4	1.74
5 - Open Water	776.3	4.82
6 - Scrub Shrub	94.5	0.59
7 - Forested	279.4	1.74
8 - Bog	207.0	1.29
Riverine	19.4	0.12
Wetland Total	4,219.0	26.2
Upland	11,905.4	73.8
TOTAL	16,124.4	

Source: MCWD Functional Assessment of Wetlands.

Groundwater:

The District's roles in managing groundwater are to 1) promote surficial groundwater recharge to protect wetland hydrology and stream base flow, and 2) assist in protecting deeper aquifers used for drinking water by limiting infiltration in sensitive recharge areas.

Infiltration potential of the upland areas within the subwatershed is generally medium. Because of the organic nature of the soils in the wetland areas, in general infiltration potential there is variable. Groundwater sensitivity is low to medium in the uplands and high to very high in the wetlands.

Parts of the subwatershed have been designated by the Minnesota Department of Health as Drinking Water Supply Management Areas (DWSMAs) and Wellhead Protection Areas for the Cities of Victoria, Minnetrista, and St. Bonifacius. Figure 2.101 shows areas in the subwatershed with groundwater sensitivity and that are designated Wellhead Protection Areas.

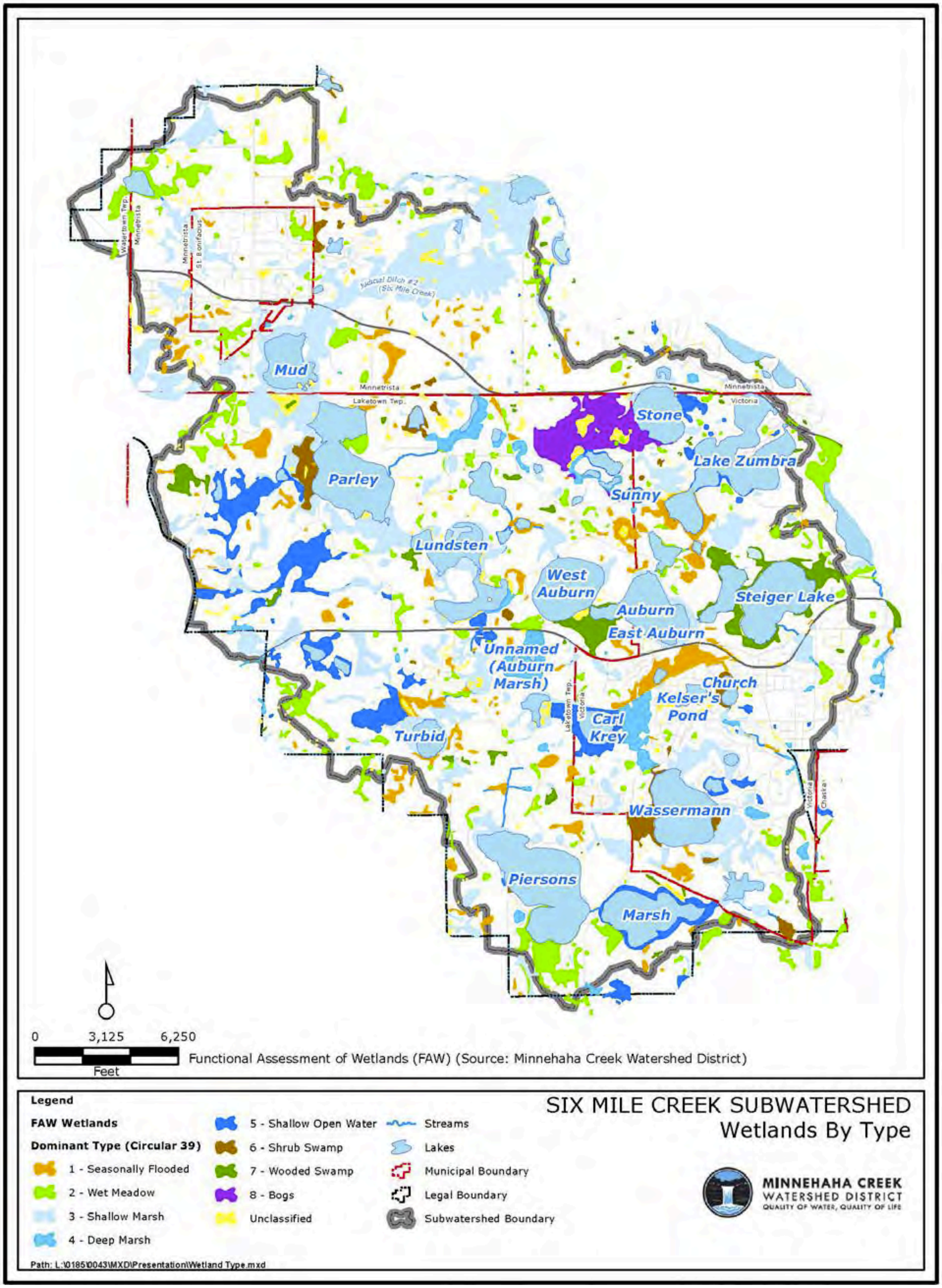

Figure 2. 100. Six Mile Creek subwatershed wetlands by type.

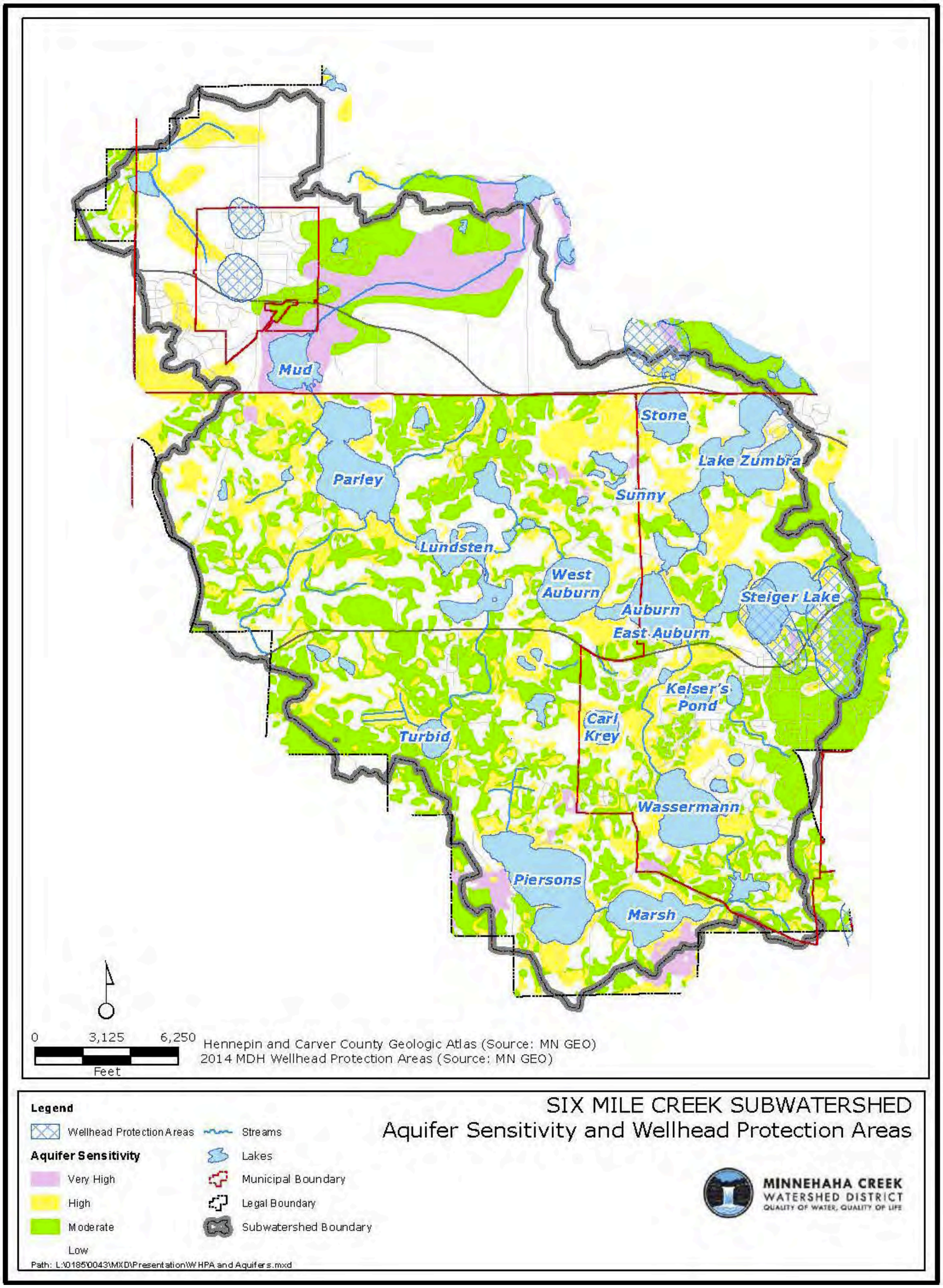

Figure 2. 101. Six Mile Creek aquifer sensitivity and wellhead Protection Areas.

Water Quantity:

There are four landlocked basins in the Six Mile Creek subwatershed (Figure 2.98). To assess change in water yield, a Mann-Kendall statistical trend test was performed on annual water yield data from 2006-2015 for the three monitoring stations along Six Mile Creek – East Auburn inlet, Lundsten Lake outlet, and Highland Rd. Water yield did not exhibit any statistically significant trend upward or downward.

Ecological Integrity:

The E-Grade program defines watershed ecological integrity as the degree to which the watershed provides three key ecosystem services: biodiversity, habitat diversity, and nutrient cycling. Nutrient cycling is described in the Water Quality section. The Six Mile Creek subwatershed is being evaluated by the E-Grade program in 2015-2017. At this time, not all of the E-Grade metrics have been assessed. The final E-Grade report for this subwatershed will not be available until 2018. This section summarizes ecological integrity using E-Grade and other data, where available (Figure 2.102).

Lakes:

Biodiversity

Fish Community.

Piersons-Marsh-Wassermann MU: E-Grade data that are available indicate F-IBI scores for Piersons and Wassermann lakes and Kelser's Pond are classified as Poor. This score means the biodiversity has been disturbed and the IBI is below the state threshold. For more information, refer to *Six Mile Creek Diagnostic Study* and *Six Mile Carp Assessment*.

Carver Park Reserve MU: E-Grade data that are available indicate F-IBI scores for Stieger and Zumbra lakes are classified as Poor. This score means the biodiversity has been disturbed and the IBI is below the state threshold. For more information, refer to *Six Mile Creek Diagnostic Study* and *Six Mile Carp Assessment*.

Auburn-North Lundsten MU: E-Grade data that are available indicate F-IBI scores for East and West Auburn lakes are classified as Degraded. This score means there is very low species diversity, there has been great disturbance to the fish community. The F-IBI is very below the state threshold. For more information, refer to *Six Mile Creek Diagnostic Study* and *Six Mile Carp Assessment*.

Turbid-South Lundsten MU: There is no F-IBI scoring available for Turbid and South Lundsten due to the small acreage of the lakes. The most recent fish survey for Turbid Lake is from 1992, more than 20 years ago. At that time, the fish population was dominated by rough fish, mostly black bullheads. No carp were captured during this sampling event. Overall, the lake had a very poor fish community. For more information, refer to *Six Mile Creek Diagnostic Study* and *Six Mile Carp Assessment*.

Parley-Mud MU: E-Grade data that are available indicate the F-IBI score for Parley Lake is classified as Good, meaning it has a good variety of species, including sensitive species. For more information, refer to *Six Mile Creek Diagnostic Study* and *Six Mile Carp Assessment.*

Aquatic Vegetation Community.

Piersons-Marsh-Wassermann MU: Floristic quality index (FQI) score was available for the following lakes in the Management Unit including Piersons, Marsh, Wassermann, Church, Kelser's Pond, and Carl Krey Lake. Piersons Lake is classified as Good, meaning moderate species diversity with mixed assemblage of tolerant and intolerant species. Kelser's Pond and Carl Krey are classified as Poor. Obvious signs of anthropogenic disturbance are present and low species diversity as non-native and/or intolerant species are present in these lakes. Wassermann and Church lakes are classified as Degraded. This score means there is very low species diversity, and there has been great disturbance to the vegetation community. For more information, refer to *Six Mile Creek Diagnostic Study.*

<u>Carver Park Reserve MU</u>: Steiger, Zumbra and Stone have FQI data for deep lakes, and Sunny has FQI data available for shallow lakes. Zumbra Lake is classified as Good, meaning the vegetation community is beginning to show signs of anthropogenic disturbance and there is moderate species diversity. Sunny, the adjacent bay to Zumbra, and Steiger are classified as Poor. Obvious signs of anthropogenic disturbance are present and low species diversity as non-native and/or intolerant species are present in these lakes. Stone is classified as Degraded. This score means there is very low species diversity, and there has been great disturbance to the vegetation community. For more information, refer to *Six Mile Creek Diagnostic Study.*

<u>Auburn-North Lundsten MU</u>: East and West Auburn lakes and North Lundsten lake have FQI scores that classifies the vegetation community as Poor. Obvious signs of anthropogenic disturbance are present and low species diversity as non-native and/or intolerant species are present in these lakes. For more information, refer to *Six Mile Creek Diagnostic Study.*

<u>Turbid-South Lundsten MU</u>: South Lundsten has a FQI score that classifies the vegetation community as Poor. Obvious signs of anthropogenic disturbance are present and low species diversity as non-native and/or intolerant species are present. The FQI score for Turbid Lake classifies the vegetation community as Degraded, meaning there is very low species diversity, and there has been great disturbance to the vegetation community. For more information, refer to *Six Mile Creek Diagnostic Study.*

<u>Parley-Mud MU</u>: Both Parley and Mud lakes have FQI scores that classifies the vegetation communities as Degraded. This score means that there is very low species diversity with non-native and/or intolerant species. There has been great disturbance to the vegetation community in both of these lakes. For more information, refer to *Six Mile Creek Diagnostic Study.*

Aquatic Invasive Species:

<u>Piersons-Marsh-Wassermann MU</u>: Pierson, Marsh, and Wassermann lakes have Eurasian watermilfoil and Curlyleaf Pondweed present with Pierson Lake demonstrating the densest populations. Church Lake only has Curlylead Pondweed. Common carp are known to be overabundant in Wassermann Lake, as described in the *Six Mile Creek Carp Assessment Report.*

<u>Carver Park Reserve MU</u>: Zumbra. Steiger and Stone lakes have Eurasian watermilfoil and curly-leaf pondweed with Steiger being heavily infested with Eurasian watermilfoil. Sunny Lake just has Eurasian watermilfoil. Common carp are overabundant in Zumbra, Steiger and Sunny, as described in the *Six Mile Creek Carp Assessment Report.*

<u>Auburn-North Lundsten MU</u>: East and West Auburn lakes are dominated by Eurasian watermilfoil and Curlyleaf Pondweed, while North Lundsten just has Curlyleaf Pondweed. Common carp are overabundant in both waterbodies, as described in the *Six Mile Creek Carp Assessment Report.*

<u>Turbid-South Lundsten MU</u>: South Lundsten and Turbid lakes have Curlyleaf Pondweed. Common carp are overabundant in both waterbodies, as described in the *Six Mile Creek Carp Assessment Report.*

<u>Parley-Mud MU</u>: Big SOB Lake, Mud Lake, and Parley Lake have Curlyleaf Pondweed. Parley Lake also has Eurasian watermilfoil. Common carp are overabundant in both waterbodies, as described in the *Six Mile Creek Carp Assessment Report.*

Habitat diversity

Aquatic Vegetation community. Habitat diversity is determined by the percent occurrence of species, or the extent to which it may be dominated by a few species. The vegetation community has not been assessed yet habitat diversity.

Shoreline Health. Shoreline health is assessed looking at shoreline vegetative cover and the relative human disturbance. The MnDNR is using the Score the Shore protocol to relate shoreline conditions to fish community structure using the fish IBI metric. Score the Shore data are available, but have not been assessed yet through E-Grade.

Streams:

Biodiversity

Fish Community. No fish IBI data are available for the streams in this subwatershed.

Macroinvertebrate Community. Macroinvertebrate samples were collected in 2003, 2013 and 2015 in Six Mile Creek For the 2013 assessment, Six Mile Creek showed the best biological community of the Upper Watershed streams, but it is still impacted by urbanization. The M-IBI scores were 22-47. The station with M-IBI score of 47 was above the threshold for glide/pool streams. The rest of the stations were below the M-IBI threshold. Two stations that were classified as riffle/run habitat were at the M-IBI threshold for modified use. Species richness ranged from 17 to 34 taxa. Five of the six stations sampled showed good overall diversity and good POET diversity.

The 2003 assessment had M-IBI scores for most of the sites below the M-IBI threshold. However, the M-IBI does not allow discrimination between low scores due to poor water quality or low scores due to lack of habitat. Six Mile Creek showed the most diversity of the upper watershed streams, with thirteen aquatic invertebrate taxa representing thirteen families. Most of the taxa found were those that are tolerant of poor water quality, although some taxa that are less tolerant were identified in some reaches. Six Mile Creek is mainly a wetland stream, and lacks the habitat complexity necessary to sustain a varied macroinvertebrate community.

Aquatic Invasive Species. No AIS data are available for the streams in this subwatershed.

Habitat diversity

Habitat Complexity. E-Grade uses the Minnesota Stream Habitat Assessment tool to assess habitat complexity in Six Mile Creek. Habitat complexity is determined by evaluating three zones: in-stream, riparian or near-stream, and channel morphology, or channel form.

Connectivity. Connectivity is defined by two metrics: presence or absence of barriers, and access to floodplain. Barriers such as dams, weirs, and culverts limit or prevent organisms from moving freely in the stream. Six Mile Creek has many culverts and water control structure at Lundsten Lake outlet.

Water Quality. Water quality factors impacting stream habitat diversity include concentrations of TSS and DO. Higher TSS concentrations increase turbidity, which can interfere with aquatic predators seeking their prey and which can limit growth of aquatic vegetation. Refer to Water Quality section for data.

Hydrology Indicators. Stream hydrology is an important factor in habitat diversity. A stream that is very flashy, that is, one that rises and falls very quickly in response to rain events, can be stressful to organisms. In addition, streams that periodically are dry or have minimal flow are hostile to aquatic life. Continuous streamflow data are available at Highland Rd (CSI02), Parley Lake inlet (CSI08), Lundsten Lake North outlet (CSI01), and instantaneous flow has been measured at all other stations since 2006. Instantaneous flow at CSI01 can be flashy following a clean out of the water control structure that is often obstructed by beavers, but the stream is buffered by wetlands downstream. Instantaneous flow at CSI02 is often slow with backflow conditions in the summer. Following storm events, CSI02 does receive higher flows, but the rise is gradual, not flashy. Annual average flow for each year was computed first, and then all the years' averages were averaged together. The annual average discharge at CSI02 is 16.52 cfs.

Wetlands:

Biodiversity

Vegetation Community. A high density of wetlands is present in the subwatershed. A number of them were identified in the 2003 MCWD *Functional Assessment of Wetlands* (FAW) as having exceptional to high vegetative diversity and wildlife habitat potential as well as having high aesthetic values. Tamarack swamp is present in the Carver Park Reserve and contains mostly invasive or non-native vegetation. The riparian wetlands adjacent to much of Six Mile Creek include cattails and some reed canary grasses.

Habitat diversity

Connectivity. There are numerous wetlands in this subwatershed; therefore, opportunities for connectivity is possible.

Size. Larger wetlands are more likely to support a notable on-site diversity and/or abundance of wildlife species.

Shoreland Protection. Riparian wetlands can provide significant shoreline protection and support emergent vegetation at the shoreline. The *Functional Assessment of Wetlands* evaluated riparian wetlands for their ability to protect lake or stream shoreline. Much of the riparian area along Six Mile Creek is wetland.

Uplands:

Biodiversity

The Minnesota County Biological Survey (MCBS) identified several areas of moderate or high biodiversity significance both within and outside of the regional park, including a large area of maple-basswood forest and tamarack swamp surrounding and west of Stone, Steiger and Zumbra Lakes. Areas of (Figure 2.102).

The Minnesota Natural Heritage Information System lists several rare natural features in this subwatershed. These include bald eagle, a federally-listed threatened species; trumpeter swans, a state-listed threatened species; and cerulean warbler, a bird of state species special concern; and the least darter, a fish of state species of special concern.

Habitat diversity

There are small patches of forest and woodland as well as larger, more extensive grasslands in the upland areas of the Carver Park Reserve. The forest and wetland in the subwatershed have been designated Regionally Significant Ecological Areas by the DNR, including nearly all of the Carver Park Reserve.

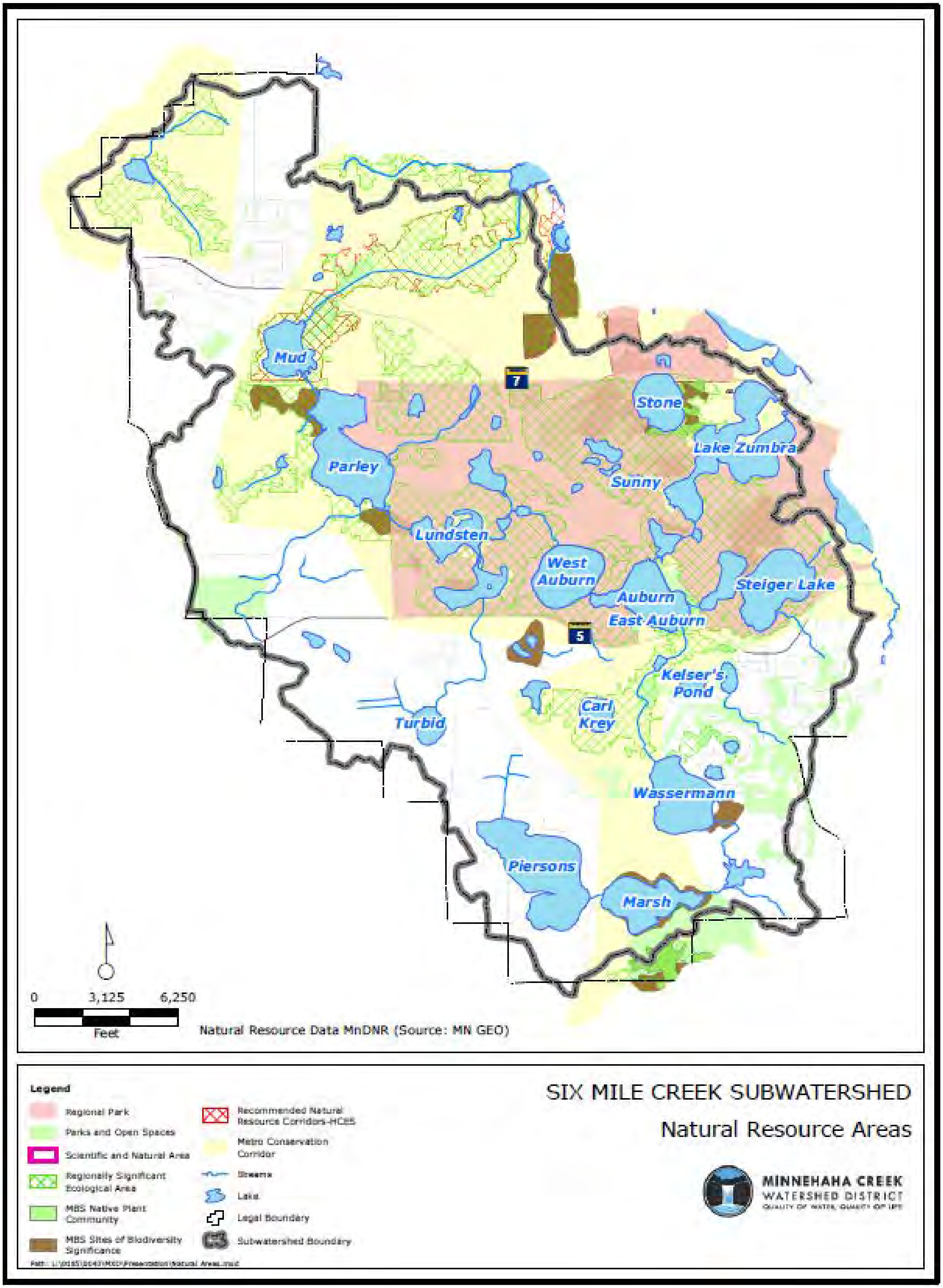

Figure 2. 102. Six Mile Creek subwatershed natural resource areas.

Thriving Communities:

Land use:

Table 2.89 below shows the land uses within the area of the Six Mile Creek subwatershed in acres and as a percentage of the total subwatershed. The predominant land use in the subwatershed is parks and open space , followed by agricultural and vacant or undetermined (Figure 2.103). Much of the vacant land is either large wetland or woodland tracts or grass and shrubland. Some large agricultural uses are present in Laketown Township, Victoria and St. Bonifacius. There are also other areas scattered throughout the west central and north central and northwest parts of the subwatershed.

Table 2. 89. 2016 land use in the Six Mile Creek subwatershed.

Land Use 2016	Acres	% of Subwatershed
Parks and Open Space	4,188.7	24.6
Agricultural	4,008.2	23.5
Vacant or Undetermined	3,687.6	21.7
Water	2,400.9	14.1
Single - Family Residential	2,091.0	12.3
Institutional	312.6	1.8
Roads and Highways	112.4	0.7
Multi - Family Residential	91.4	0.5
Commercial	84.9	0.5
Industrial	55.1	0.3

Source: Metropolitan Council.

Recreation:

The Three Rivers Park District's Carver Park Reserve covers much of the central subwatershed. The park includes numerous wetland and several lakes, and bicycling/hiking trails provide access to many natural features. The Minnesota Historic Features database notes about 50 historic features in this subwatershed, mostly residences or farmhouses or agricultural buildings. The listing also includes 5 churches and several commercial buildings in Victoria and St. Bonifacius. Part of the Three Rivers Park District's Lake Minnetonka Regional Park is located in the subwatershed.

The Carver County Park Reserve offers numerous opportunities for aquatic recreation in the Six Mile Creek subwatershed (Figure 2.104). Three fishing piers are available, with one located on the east southeast side of Steiger Lake and two on West Lake Auburn. Public water access can be found at Parley Lake, Piersons Lake, Wassermann Lake, Steiger Lake, Lake Auburn and Lake Zumbra. There are no access points directly to Six Mile Creek.

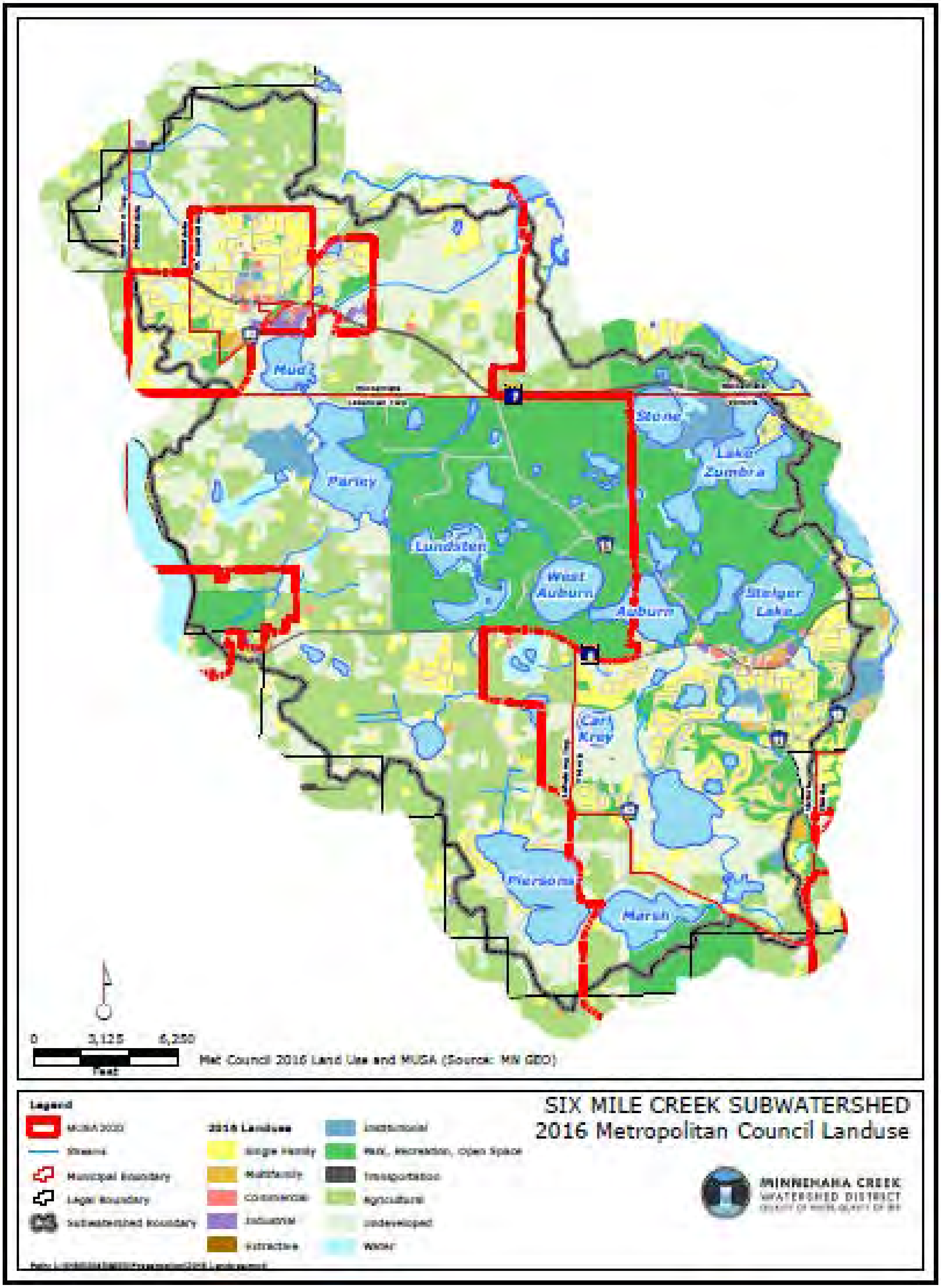

Figure 2. 103. Six Mile Creek subwatershed 2016 land use.

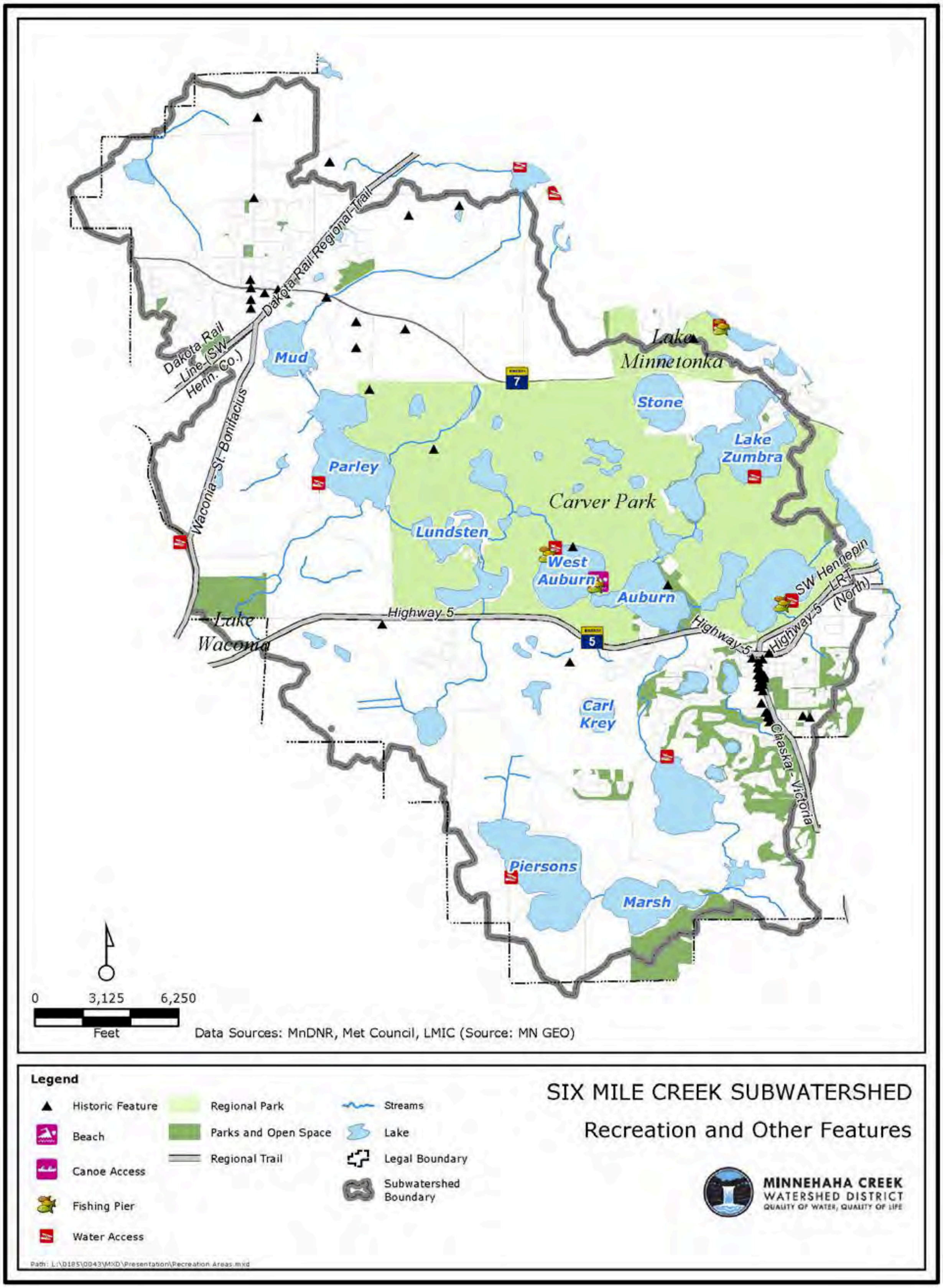

Figure 2. 104. Six Mile Creek subwatershed recreation and other features.

2.4 Inventory of Studies

District-Wide

- 1997-1998 Water Quality, Physical Habitat, and Fish Community Composition in Streams in the Twin Cities Metropolitan Area, USGS 1999
- Assessment of Effects of Whole Lake Treatments to Control Nuisance Aquatic Plants, University of Minnesota 2007
- Benefits of Wetland Buffers: A Study of Functions, Values and Size, EOR 2001
- Contamination of Stormwater Pond Sediments by PAHs in Minnesota, MPCA 2010
- Diatom Inferred TP in MCWD Lakes Report, Science Museum of MN & St. Croix Watershed Research Station 2006
- Diatom Inferred TP in MCWD Lakes Report Phase II, Science Museum of MN & St. Croix Watershed Research Station 2009
- Economic Aspects of Aquatic Invasive Species, University of Minnesota 2014
- Environmental Quality Report, Hennepin County 2007
- Extending Satellite Remote Sensing to Local Scales, University of Minnesota 2003
- Evaluating and Monitoring BMPs with Networked Wireless Sensors, University of Minnesota 2012
- Historical Water Clarity Assessment of Lakes in MCWD using Landsat Satellite Imagery, University of Minnesota 2006
- MCWD 1st Order Drainage Assessment, Fluvial Geomorphic Assessment Update Report, Inter-Fluve Inc. 2013
- MCWD 2003 Stream Stability and Habitat Assessment Report, Wenck 2004
- MCWD 2013 Macroinvertebrate Assessment, RMB 2014
- MCWD 2014 Flood Report, Wenck 2015
- MCWD 2015 Macroinvertebrate Assessment, RMB 2016
- MCWD: 30 Years of Water Resources Management 1967-1997, MCWD 1998
- MCWD Comprehensive Water Resources Management Plan, Wenck 2007
- MCWD Ditch Records and Policy Considerations Report, Wenck 2003
- MCWD Functional Assessment of Wetlands, Wenck 2003
- MCWD Hydrologic, Hydraulic, and Pollutant Loading Study (HHPLS), EOR 2003
- MCWD Lake Data Statistical Analysis I Report, HDR 2013
- MCWD Lake Data Statistical Analysis II Report, HDR 2014
- MCWD Period of Record Hydrographs, EOR 2005
- MCWD Stream Assessment Data Report, Wenck 2004
- MCWD Stream Data Statistical Analysis Report, HDR 2015
- MCWD Water Quality (Hydrodata) Reports, 1968-1988, 1992-2015
- Measuring Water Clarity and Quality in MN Lakes and Rivers: A Census-Based Approach Using Remote-Sensing Techniques, University of Minnesota 2007
- Minnehaha Creek *E. Coli* Bacteria / Lake Hiawatha Nutrients Total Maximum Daily Load, Tetra Tech. 2013
- Minnehaha Creek Watershed SWMM5 Model Data Analysis and Future Recommendations, US Army Corps of Engineers 2013
- Minnesota Statewide Mercury TMDL, MPCA, 2007
- Predicting Water Clarity of Lakes via Remote Sensing, University of Minnesota 2006
- Study of the Water Quality of Metropolitan Area Lakes, Metropolitan Council 1989, 1994, 1998, 2010, 2015
- Summary of MCWD Plans, Studies and Reports, US Army Corps of Engineers 2004

- Twin Cities Metropolitan Area Chloride Total Maximum Daily Load Study and Chloride Management Plan, MPCA and LimnoTech 2016
- Water Quality Reconstruction from Fossil Diatoms, MPCA and University of Minnesota 2002
- Weather: Extreme Trends, NOAA and Syntectic International, LLC 2014
- Upper Minnehaha Creek Watershed Lakes and Bacteria TMDL Project, MPCA and Wenck 2014

Christmas Lake Subwatershed

- Assessment of milfoil weevil populations for potential for control of Eurasian watermilfoil in selected lakes of the MCWD, University of Minnesota 2014
- Occurrence and Distribution of Eurasian, Northern and Hybrid Watermilfoil in Lake Minnetonka and Christmas Lake: Genetic Analysis, Montana State University, University of Minnesota and MCWD 2016
- Occurrence and Distribution of Eurasian, Northern and Hybrid Watermilfoil in Lake Minnetonka and Christmas Lake: Genetic Analysis Phase II, Montana State University, University of Minnesota and MCWD 2017

Dutch Lake Subwatershed

- Dutch Lake Infiltration (DL-5) Feasibility Study, Wenck 2010
- Dutch Lake Wetland Restoration Feasibility Study, HR Green and Applied Ecological Services 2009
- Technical Memo: Dutch Lake Outlet (DL-7) – SRP Loading to Jennings Bay, Wenck 2012

Gleason Lake Subwatershed

- Effects of Curly leaf Pondweed Control on Gleason Lake, Blue Water Science and MCWD 2015
- Gleason Lake/ CR 6 Pond Project Feasibility Study, Houston Engineering 2009
- Gleason Lake Fish Survey, Blue Water Science 2011
- Gleason Lake Regional Infiltration (GL-4) Feasibility Study, Mead & Hunt 2008
- Mooney Lake Aquatic Plant Survey, Blue Water Science 2011
- Mooney Lake Fish Survey, Blue Water Science 2011
- Mooney Lake Fish Survey, Blue Water Science 2016
- Mooney Lake Outlet Structure (Wetland Restoration#1) Feasibility Study, 2007
- Upper Minnehaha Creek Watershed Lakes TMDL, Wenck 2014

Lake Minnetonka Subwatershed

- 1995-1999 Water Quality of Lake Minnetonka, TRPD 1995-2000
- 1995-1999 Water Quality of Lake Minnetonka, TRPD 1995-2000
- 2014 Pilot Study: Spring Phenology of Submersed Aquatic Plants, Freshwater Scientific Services, LLC 2015
- A Preliminary Geotechnical Evaluation Report: Street and Utility Reconstruction Projects in Excelsior, MN, WSB 2011
- A Program for Preserving the Quality of Lake Minnetonka, MPCA 1971
- Assessment of 2008-2011 Coordinated Herbicide Treatments on Carmans, Grays, and Phelps Bay Summary Report, LMCD 2012
- Bathymetric Analysis of Lake Minnetonka, MCWD 2008
- Benthic Monitoring Study of Lake Minnetonka, MCWD 2000
- Big Island Wetland Restoration Feasibility Study, EOR 2008
- Boating Trends on Lake Minnetonka (1984-2004), MnDNR 2005
- Common Carp Assessment in Six Mile Creek, University of Minnesota 2016
- Distribution and Abundance of Milfoil Weevils in Lake Minnetonka, Inglis 2004
- Effects of Harvesting on Plant Communities Dominated By Eurasian Watermilfoil in Lake Minnetonka, University of Minnesota and MnDNR 1994
- Efficacy of Spray-Dried Zequanox for Controlling ZMs within Lake Minnetonka Enclosures, USGS 2016

- Evaluation and Application of a 3D Water Quality Model in a Shallow Lake with Complex Morphometry, University of Minnesota 2010
- Evaluation of the June 2009 Aquatic Herbicide Treatments on Grays Bay and Phelps Bay, Lake Minnetonka, US Army Corps of Engineers 2010
- Field evaluation of toxicity of low-dose molluscicide treatments for zebra mussel veliger larvae – potential applications in lake management, Minnesota AIS Research Center 2016
- Filling and Dredging in the Lake Minnetonka Area: Effects on Aquatic Habitats and Impacts on Fish and Wildlife, Kucera 1978
- Flowering Rush Hand Removal Study on Lake Minnetonka, MCWD & Blue Water Science & Waterfront Restoration 2011-2015
- Grays Bay Headwaters Projects Feasibility Study, 2003
- Technical Memos: Bushaway Road-Jennings Bay Wetland & Floodplain Restoration Project, Wenck 2014
- Halsted Bay Internal Load Management Feasibility Study, 2013
- Halsted Bay Wetland Restoration Project, HR Green 2008
- Lake Minnetonka Area Cities Land Cover Classification and Natural Resource Inventory, Bonestroo 2005
- Lake Minnetonka Boat Use Study, LMCD 2001
- Lake Minnetonka Comprehensive Study: Interim Report, MPCA 1970
- Lake Minnetonka Coordinated Herbicide Treatment Study on Carmans, Grays & Phelps, LMCD 2008-2011
- Lake Minnetonka Direct Infiltration (GB-LM) Feasibility Study, 2011
- Lake Minnetonka Direct Infiltration (CLC-2) Feasibility Study, 2012
- Lake Minnetonka Fisheries Special Assessment, MnDNR 2010
- Lake Minnetonka Habitat Suitability Assessment for Invasive Zebra Mussels, Blue Water Science 2010
- Lake Minnetonka Investigation, Hickok & Associates 1969-1970
- Lake Minnetonka Shoreline Restoration Feasibility Study, 2008
- Nutrient Removal System Feasibility Study, WSB 2013
- Occurrence and Distribution of Eurasian, Northern and Hybrid Watermilfoil in Lake Minnetonka and Christmas Lake – Genetic Analysis, MCWD & University of Minnesota & Montana State University 2015-2016
- Phytoplankton, Photosynthesis, and Phosphorus in Lake Minnetonka, University of Minnesota 1972
- Soil Bioengineering Technology for the Causeway and Headwaters Area in Grays Bay on Lake Minnetonka Feasibility Study, Robbin B. Sotir & Associates 2001
- Stubbs Bay- Lake Minnetonka Diagnostic Study, Wenck 2003
- Stubbs Bay Feasibility Study, BARR 2004
- Summary of Biological Survey of Lake Minnetonka, Hickok & Associates 1971
- Supplementing Mound Downtown Redevelopment with Innovative Stormwater Management, EOR 2004
- Technical Memo: MCWD Managers Request to Inventory Rip Rap Shoreline, Wenck 2010Technical Report: Stubbs Bay Feasibility Study, Wenck 2006

Lake Virginia Subwatershed

- Lake Virginia Regional Infiltration (LV-5) Feasibility Study, 2012
- MCWD Lakes TMDL – Lake Nokomis, Parley Lake, Lake Virginia, and Wassermann Lake, EOR & MPCA 2011
- Memo: Report from Curlyleaf Pondweed Harvesting Case Study, MCWD 2014
- Rapid Response to Zebra Mussels Infestation in Lake Minnewashta, MCWD 2016

Langdon Lake Subwatershed

- Environmental Testing Report MCES L38 Lagoon Sampling, MCES 2008
- Internal Phosphorus Loading and Sediment Phosphorus Fractionation Analysis for Langdon Lake, ERDC Eau Galle Aquatic Ecology Laboratory 2010

- Langdon Lake Infiltration (LL-2) Feasibility Study, 2008
- Langdon Lake Infiltration (LL-3) Feasibility Study, 2010
- Technical Memo: Langdon Lake Feasibility Study, Lake Sediment Analysis: Total Phosphorus Release Rates, Wenck 2010

Long Lake Creek Subwatershed

- Comprehensive Long Lake Creek Feasibility Study, EOR 2011
- Environmental Assessment Worksheet: Long Lake Creek Improvement Project, MCWD 2013
- Long Lake Improvement Projects: Deer Hill Road Pond 1997 Monitoring Report, Wenck 1998
- Long Lake Improvement Projects: Deer Hill Road Pond and CR 6 Pond 1998 Performance Monitoring Report, Wenck 1999
- Long Lake Regional Infiltration: LLC-8 Feasibility Study, HR Green 2012
- Long Lake Water Quality Improvement Project: Conceptual Downtown Redevelopment Stormwater Design, HR Green 2006
- Long Lake Wetland Restoration Project#2 Feasibility Study, BARR 2009
- Technical Memo: Effectiveness of Alum on Long Lake Water Quality, Wenck 2004

Minnehaha Creek Subwatershed

- Baseflow Restoration in Minnehaha Creek Watershed with Stormwater Infiltration, University of Minnesota and MWMO 2014
- Blue Water Commission Report, Metro Area Agencies 1998
- Comprehensive Water Quality Assessment of Select Metropolitan Area Streams: Minnehaha Creek, Metropolitan Council 2014
- Contribution of PAHs from Coal-Tar Pavement Sealcoat and Other Sources to 40 US Lakes, USGS 2010
- Cottageville Park Feasibility Study, Cuningham Group Architecture Inc. and WSB & Associates 2013
- Diamond Lake Watershed Monitoring and Modeling Report, MnDOT 2009
- Effects of Barley Straw on Water Clarity in Powderhorn Lake, MPRB and Blue Water Science 2008
- Evaluating and Monitoring BMPs with Network Wireless Sensors, University of Minnesota and MWMO 2012
- City Lakes Improvement Project Feasibility Report, Wenck 1994
- Fish Survey for 3 Pools in Minnehaha Creek and Lake Hiawatha, Blue Water Science 2010
- Grass Lake Hydrologic Study, Wenck 1996
- Knollwood Mall Stormwater Management, Wenck 2013
- Lake Hiawatha Stormwater Management Feasibility Study, City of Minneapolis and Houston Engineering 2014
- Technical Memo: Lake Nokomis Alum Dosing Study, HDR 2004
- Lake Nokomis Water Quality Improvements: Lake Nokomis Biomanipulation Study, Blue Water Science 2017
- Lakes Nokomis and Hiawatha Diagnostic-Feasibility Study, Wenck 1998
- MCWD Lakes TMDL – Lakes Nokomis, Parley, Virginia, and Wassermann, EOR 2011
- Minneapolis Chain of Lakes Clean Water Partnership Project: Stormwater Monitoring Study, BARR 1992
- Minnehaha Creek *E. coli* Bacteria/ Lake Hiawatha Nutrients, MPCA and Tetra Tech Inc. 2013
- Minnehaha Creek Fish and Habitat Assessment, MnDNR 2003
- Minnehaha Creek Meander Study, Inter-Fluve Inc 2012
- Minnehaha Creek Restoration Project: Methodist Hospital Campus Site Design Report, Inter-Fluve Inc. and HR Green 2008
- Minnehaha Glen Feasibility Study, Wenck and Kestrel Design Group 2007
- Minnehaha Creek Reach 7-Channel Restoration and Reconstruction Feasibility Study, Inter-Fluve Inc. 2010

- Minnehaha Creek Reach 14-Channel Restoration and Reconstruction Feasibility Study, Inter-Fluve Inc. 2011
- Minnehaha Creek Reach 20-= Restoration Project Feasibility Study, Inter-Fluve Inc. and HR Green 2011
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- Pamela Park Wetland Restoration, 1999
- Stormwater Harvesting and Reuse Report, University of Minnesota and MWMO 2013
- Surface Water Pathogen Study, Wenck 2003
- Taft-Legion Lakes Watershed Water Quality Improvement Project Feasibility Study, WSB & Associates 2010
- Technical Memo: Habitat Improvements alternatives from 54th St to Browndale Dam, Inter-Fluve Inc 2014
- Technical Memo: Comparison of 1997-1998 Results for Minnehaha Creek, Wenck 1999
- Technical Memo: 1997 Minnehaha Creek Phosphorus Loads, Wenck 1999
- Technical Memo: Calculation of In-Lake Phosphorus Reductions in Calhoun and Lake of Isles Following Alum Dosing, MPRB 1996
- Technical Memo: Lake Calhoun Alum Treatment, Wenck 2000
- Technical Memo: Reach 8-Channel Restoration and Reconstruction Concept Design Report, 2007
- Trends in Hydrophobic Organic Contaminants in Urban and Reference Lake Sediments Across the US, USGS 2005
- Twin Lakes Improvement Study, City of St. Louis Park and Hickok and Associates 1984

Painter Creek Subwatershed

- An Assessment of the Phosphorus Retention Capacity of Wetlands in the Painter Creek Watershed, Bruland & Richardson 2005
- Painter Creek (PC-2, 6 and 7) Volume and Load Reduction Feasibility Study, Wenck 2012
- Painter Creek Feasibility Study, HDR and EOR 2004
- Painter Creek Section 206 Feasibility Study, US Army Corps of Engineers, 2010

Schutz Lake Subwatershed

- No subwatershed-specific studies

Six Mile Creek Subwatershed

- Common Carp Assessment in Six Mile Creek Report, University of Minnesota 2016
- Evaluation and Application of a 3D Water Quality Model in a Shallow Lake with Complex Morphometry, University of Minnesota 2010
- Halsted Bay Wetland Restoration Project, HR Green 2008
- MCWD Lakes TMDL – Lakes Nokomis, Parley, Virginia, and Wassermann, MPCA and EOR 2011
- Marsh-Wassermann Corridor Plan, Cross River Consulting 2009
- Nutrient Removal System Feasibility Study, WSB 2013
- Parley Lake Internal Nutrient Load Diagnostic Study, Wenck 2011
- Parley Lake Wetland Restoration Feasibility Study, EOR 2007
- Six Mile Creek Diagnostic Study, Wenck 2013
- Steiger Lake Wet Detention Pond Feasibility Study, SRF Consulting Group, Inc. 2010Turbid-Lundsten Corridor Restoration Phase II, MCWD 2011
- Technical Memo: Lake Zumbra High Water Level Investigation, Wenck 2015
- Technical Memo: Pierson Lake Delta Sediment Investigation, Wenck 2014
- Turbid-Lundsten Wetland Restoration Feasibility Study, Wenck 2010
- Wassermann Lake Wetland Restoration Project, HR Green and Inter-Fluve 2007
- Wassermann Lake Wetland Restoration Project Phase II, Barr 2010