2022 ANOKA WATER ALMANAC

WATER RESOURCE CONDITIONS OF ANOKA COUNTY, MINNESOTA

ANOKA CONSERVATION DISTRICT

A REPORT OF WATERSHED ACTIVITIES FACILITATED BY THE ANOKA CONSERVATION DISTRICT

March 2023

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Executive Summary

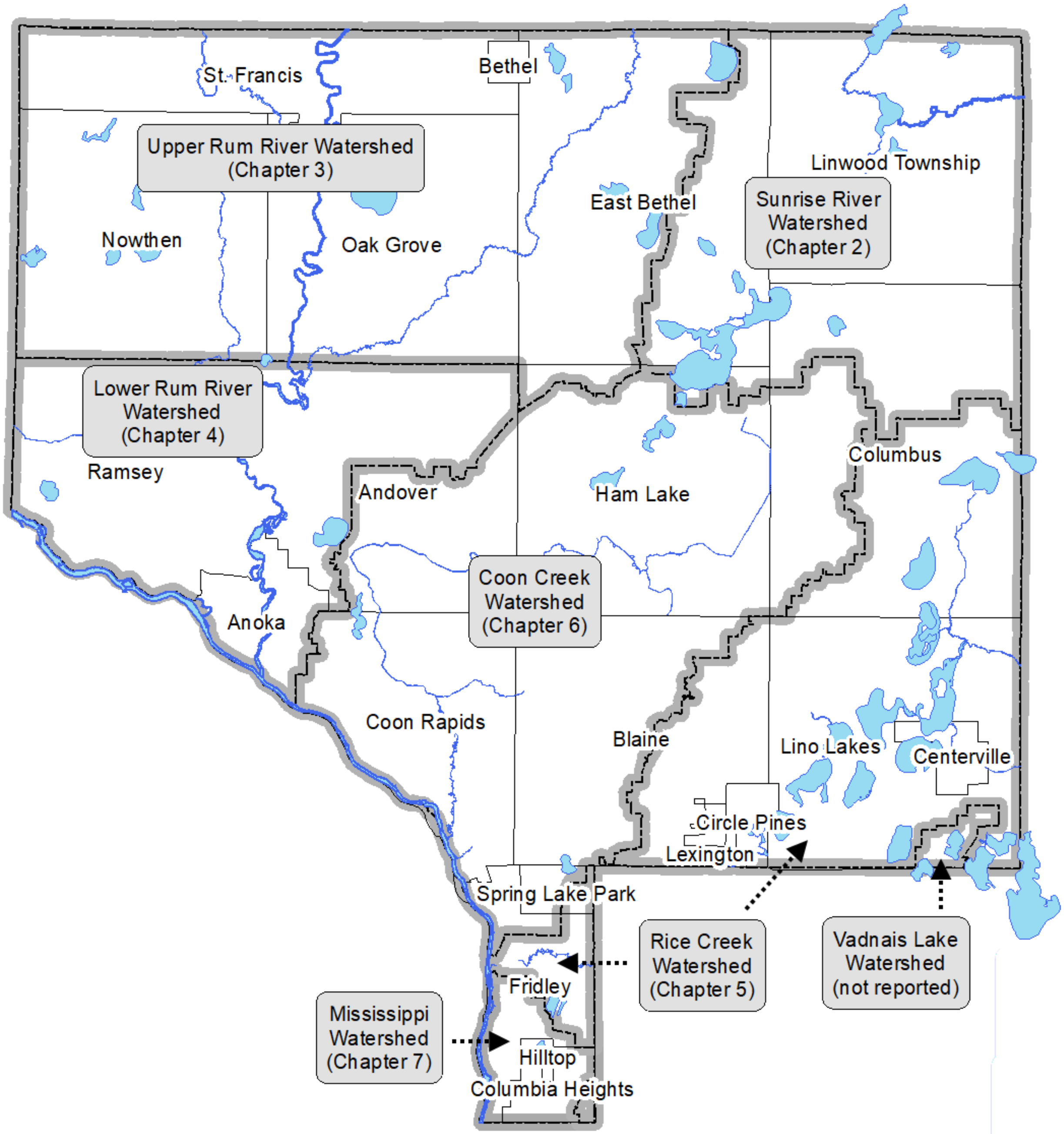
This report summarizes water resources management and monitoring activities done as a cooperative effort between the Anoka Conservation District (ACD), watershed districts, and watershed management organizations. Chapters include detailed information about lakes, stream, wetlands, precipitation, groundwater, outreach efforts, financials, and water quality improvement projects. The results of this work is presented on a watershed basis and serves as an annual report to each of the partnering watershed organizations. Readers who are interested in a certain lake, stream, or river should first determine which watershed it is located in, and then refer to the chapter corresponding to that watershed. The maps and countywide summaries in Chapter 1 will help the reader determine if the information they are seeking is available and which chapter to find it in. In addition to countywide summaries, Chapter 1 also provides methodologies used, explanations of terminology, and instruction of data interpretation.

The water resource management and monitoring work reported here include:

- Monitoring
  - precipitation
  - lake levels
  - lake water quality
  - stream hydrology
  - stream water quality
  - stream benthic macroinvertebrates
  - shallow groundwater levels in wetlands
  - groundwater levels in observation wells
- Water quality improvement projects
  - projects designed, installed, or planned are briefly discussed in this report
  - cost share grants for erosion correction, lakeshore restorations, and rain gardens
  - promotion of available grants for water quality improvement projects.
- Studies and analyses
  - stormwater retrofitting assessments,
  - upstream to downstream water quality analyses,
  - water quality trend analyses and
  - reference wetland multi-year summary analyses.
- Public education efforts
  - newsletters and mailings,
  - signage,
  - workshops,
  - web videos, and
  - websites.
- Other work done for watershed management organizations
  - reviews of local water plans,
  - grant searches and applications,
  - annual reports to the State, and other administrative tasks

While this report is perhaps the most comprehensive source of monitoring data on lakes, stream, rivers, groundwater, and wetlands for Anoka County, it is not the only source; nor is this report a summary of all work completed throughout the county in 2022. Rather, it is a summary of work related to water resources carried out by ACD in conjunction with watershed organizations within the county. Furthermore, only work conducted during 2022 is presented in this almanac (although trend and similar analysis also include previous years' data). For results of work completed in past years, readers should refer to previous Water Almanacs. All data collected in 2022 and prior is available in digital format from the Anoka Conservation District (https://maps.barr.com/Anoka/Home/Chart/). All applicable data is also submitted to state databases for wider availability; these include the MPCA's EQuIS water quality database, the DNR's lakefinder tool for lake levels, the DNR's Cooperative Groundwater Monitoring (CGM) tool for observation wells, and the State Climatology Office online precipitation database.

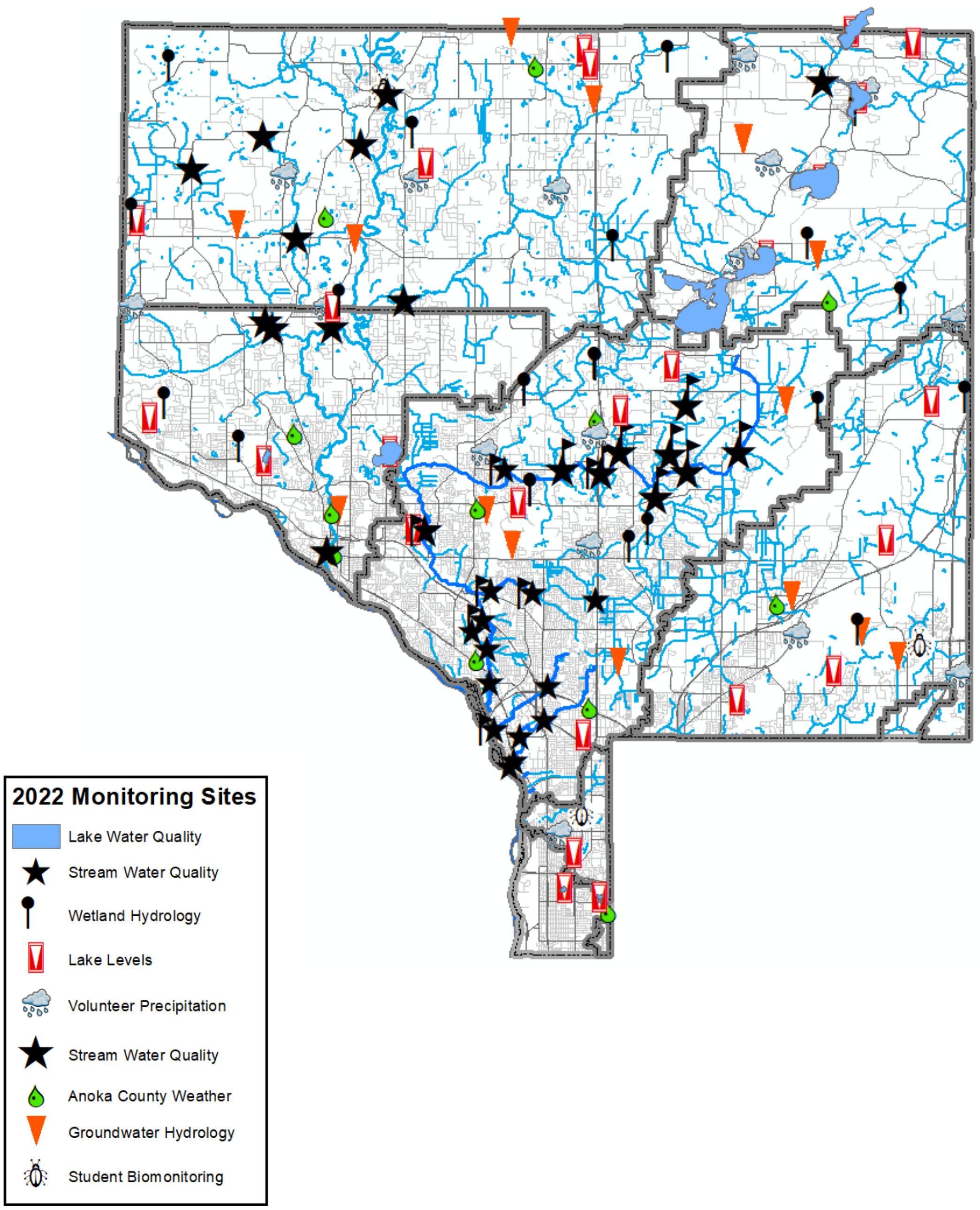
CHAPTER 1 – PRIMER



Water Resources Monitoring Primer

This report is an annual report to watershed organizations that helps fund water monitoring and management in cooperative efforts with ACD. It also includes other water-related work carried out by ACD without partners. This primer provides an overview of the monitoring activities reported in later chapters, the methodologies used, and information that will help the reader interpret information. Countywide precipitation and groundwater hydrology data is presented in Chapter 1. This report includes a variety of work aimed at managing water resources, including lakes, streams, rivers, wetlands, groundwater, and precipitation (see map below).

2022 Water Monitoring Sites



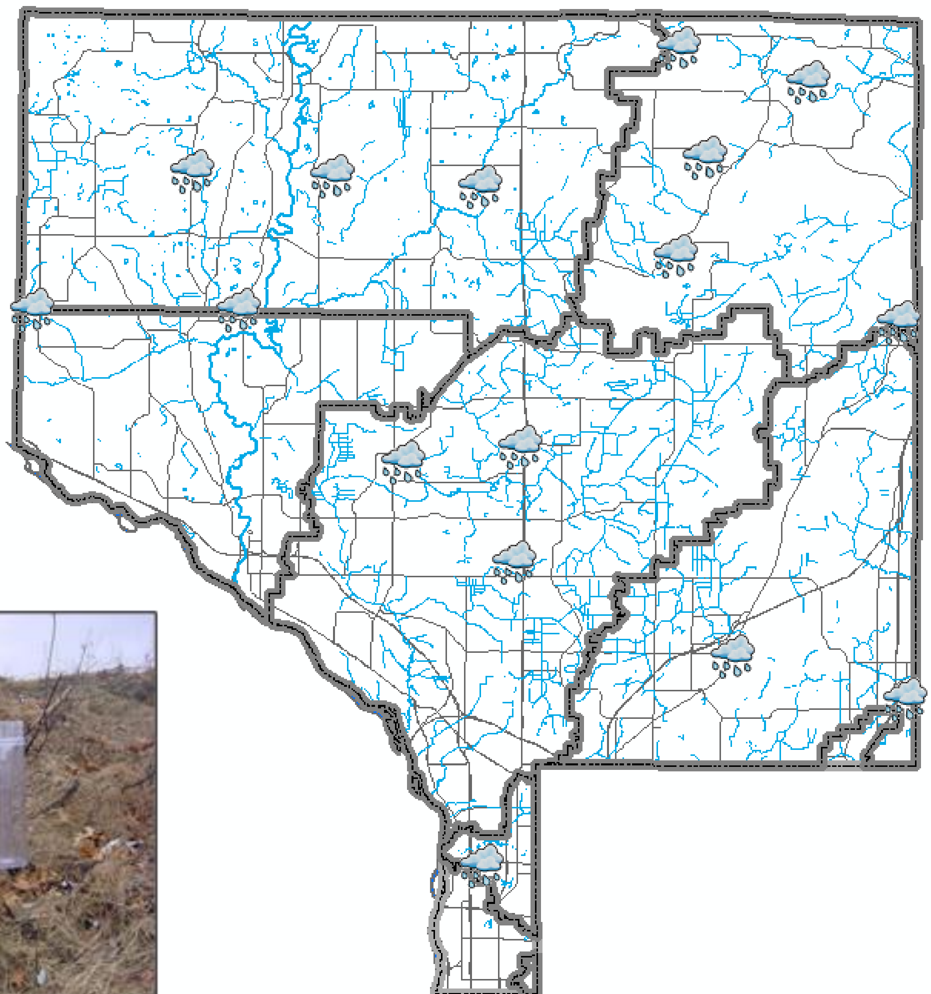
Precipitation

Precipitation data is useful for understanding the hydrology of water bodies, predicting flooding and groundwater limitations, and helps guide special regulations that protect property and the environment in times of high or low water. Rainfall can vary substantially, even within one city.

ACD coordinates a network of 13 rain gages countywide, which are monitored by volunteers, including one at the ACD office. The volunteer-operated stations are cylinder style rain gages located at the volunteer's home. Total rainfall is read daily. All data collected by volunteers is submitted to the Minnesota State Office of Climatology where it is available to the public through https://climateapps.dnr.state.mn.us/index.htm.

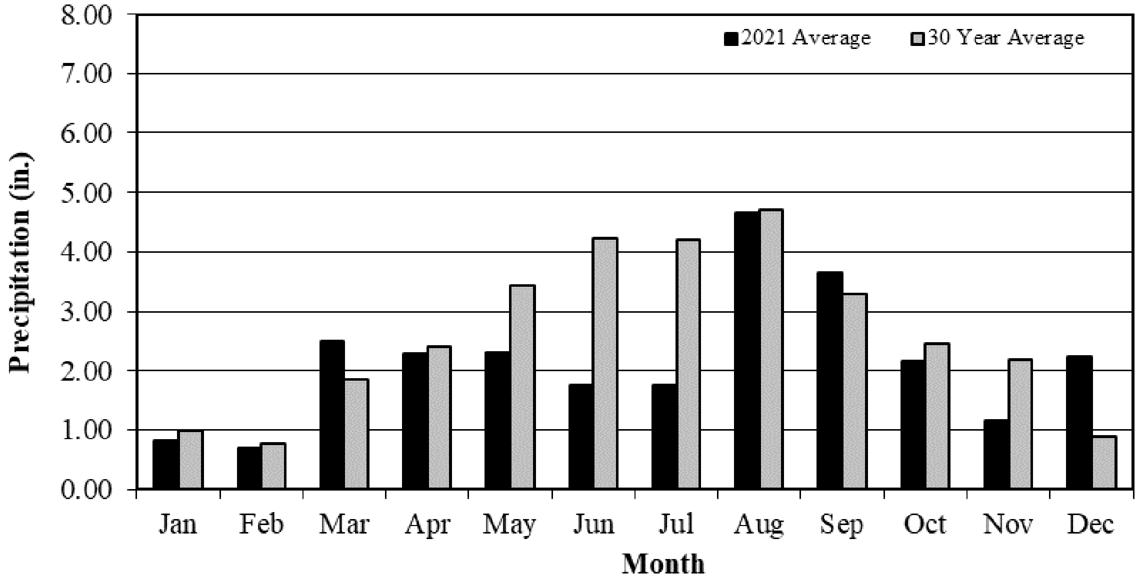
A summary of countywide data is provided on the following pages.

2022 Precipitation Monitoring Sites



Cylinder rain gauge.

2022 Anoka County Average Monthly Precipitation (average of all sites)



2022 Anoka County Monthly Precipitation at Each Monitoring Site

		Month													Growing Season
Location or Volunteer	**City**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual Total**	**(May-Sept)**
BYRG, DNR, and NWS data															
30N 24W 3 DNR	Fridley	0.87	0.41	3.04	2.17	2.2	0.78	1.79	5.98	1.64	2.25	1.35		22.48	12.39
30 24 14 BYRG	Fridley	0.70	0.50	2.66										3.86	0.00
32 22 14 BYRG	Columbus	0.70	0.63	2.48	2.47	2.03	1.27	1.59	4.42	2.4	2.49			20.48	11.71
32 24 23 NWS	Andover	0.57	0.69	2.31	1.87	1.79	2.11	4.00	3.88	4.54	2.7	1.15		25.61	16.32
34N 23W 36 BYRG	East Bethel	0.91	0.88	2.86	2.34	2.71	2.98	1.57	3.53	6.46	1.97			26.21	17.25
Cylinder rain gauges (read daily)															
M. Ross	East Bethel											1.18	1.64	2.82	0.00
J. Rufsvold	Burns				2.17	3.07	0.49	1.76	4.96	4.60	1.58	0.91		19.54	14.88
J. Arzdorf	Blaine			1.72	2.94	2.19	1.44	1.37		2.10	2.72			14.48	7.10
P. Arzdorf	East Bethel				2.02	2.60	2.68	1.05	4.35	6.40	1.95			21.05	17.08
A. Mercil	East Bethel	0.56	0.22	1.94	1.65	0.87	2.28	2.05	4.69	3.45	1.37	0.97	1.22	21.27	13.34
K. Ackerman	Fridley	1.14	1.33	3.53	2.76	2.16	0.85	1.63	6.12	1.47	1.84	1.44	3.59	27.86	12.23
B. Myers	Linwood				2.52	1.86	2.73	1.47	5.01	4.49	2.39			20.47	15.56
W. Boese	Forest Lake											1.36	2.07	3.43	0.00
D. Bauer	Lino Lakes	1.14	0.83	2.88	2.73	2.38	1.44	1.45	5.16	1.92	2.47	1.12	3.34	26.86	12.35
ACD Office	Ham Lake			1.45	2.54	1.57	2.89	2.15	4.16	2.97	2.69	1.14		21.56	13.74
Y. Lyrenmann	Ramsey				2.03	3.71	0.35	0.80	4.24	4.11	2.17	0.89	1.50	19.80	13.21
T. Isaacson	Oak Grove				1.93	3.07	2.22	1.99	4.01	4.66	1.78			19.66	15.95
M. Hebaus	Lino Lakes				1.94									1.94	0.00
2021 Average	County-wide	0.82	0.69	2.49	2.27	2.30	1.75	1.76	4.65	3.66	2.17	1.15	2.23	25.94	14.13
30 Year Average	Cedar	0.99	0.76	1.84	2.40	3.43	4.22	4.21	4.70	3.29	2.44	2.18	0.90	31.36	19.85

Precipitation as snow is given in melted equivalents.

*Incomplete monthly data not included in averages

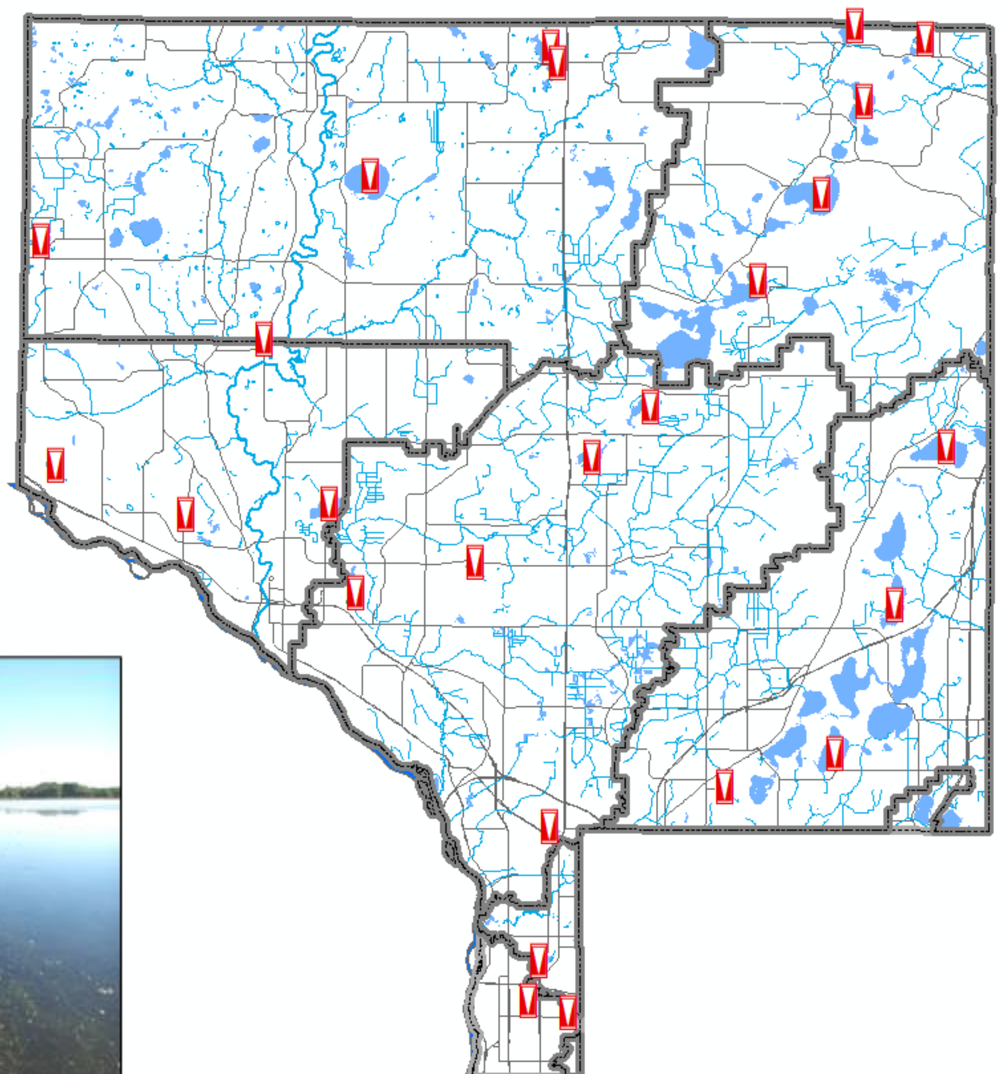
Lake Levels

Long-term lake level records are useful for regulatory decision-making, building/development decisions, lake hydrology manipulation decisions, and investigations of possible non-natural impacts on lake levels. ACD coordinates volunteers who monitor water levels on 25 lakes, with one additional lake monitored by continuous data logging equipment.

An enamel gage is installed in each lake and surveyed; this allows readings to coincide with sea level elevation. Each gage is read weekly. ACD reports all lake level data to the MN DNR, where it is made available on their website (https://www.dnr.state.mn.us/lakefind/index.html), along with other unique information for each lake.

Results of lake level monitoring are separated by watershed in the following chapters.

2022 Lake Level Monitoring Sites



Lake level gauge

Stream Hydrology

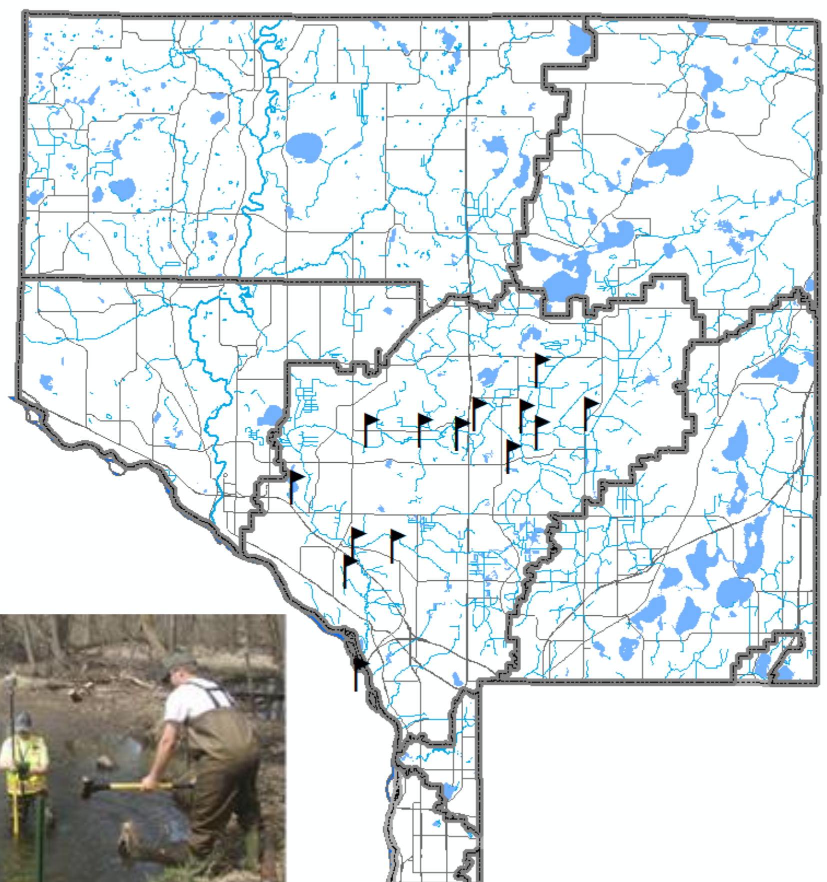
Hydrology is the study of water quantity and movement. Records of the quantity of water flowing in a stream helps engineers and natural resource managers better understand the effects of rain events, land development, and storm water management. This information is often paired with water quality monitoring and used to calculate pollutant loadings, which are used in computer models and water pollution regulatory determinations.

ACD monitored hydrology at seven stream sites in 2022. Each site is equipped with an electronic gage that records water levels ranging from every hour to every 15-minutes, depending on how fast the stream fluctuates. These gages are surveyed and calibrated so that stream water level is measured in feet above sea level.

Rating curves, a known mathematical relationship between water level and flow such that one can be calculated from the other, have been developed for these sites. ACD, watershed management organizations, watershed districts, townships, cities, and others use the information gained from the stream hydrology monitoring sites.

Results of stream hydrology monitoring are separated by watershed in the following chapters.

2022 Stream Hydrology Monitoring Sites



Stream gauge setup.

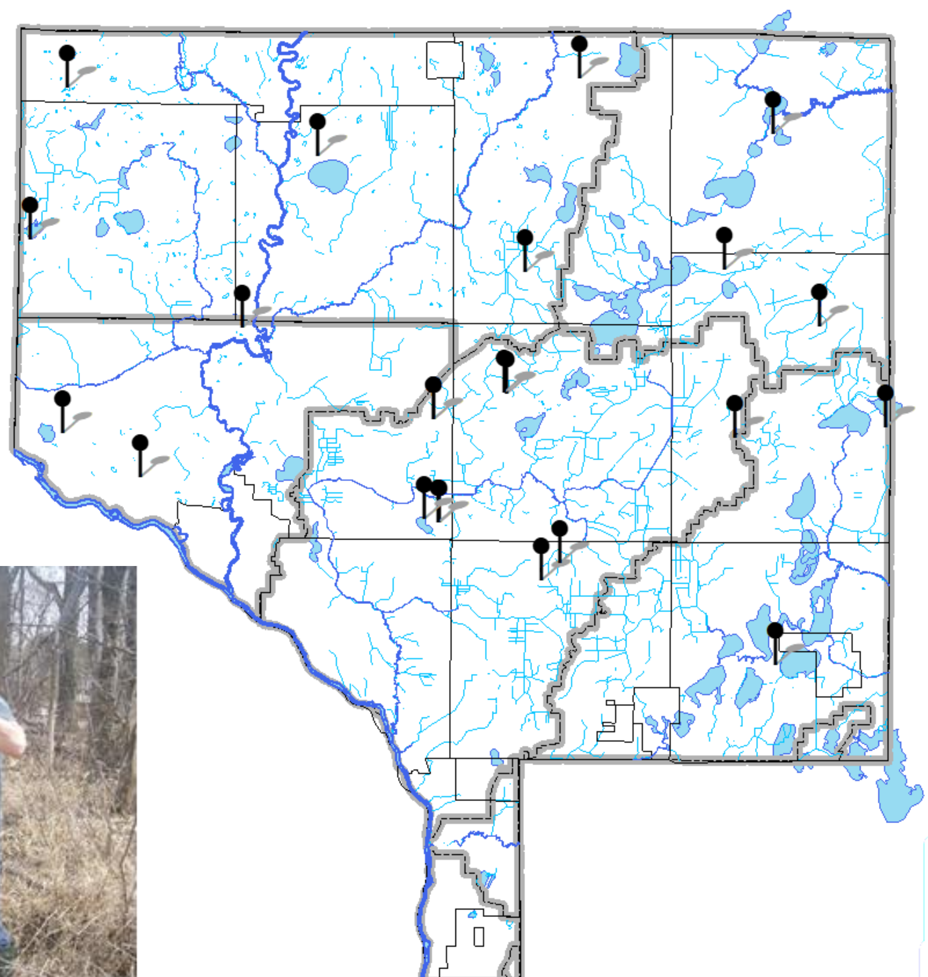
Wetland Hydrology

Wetland regulations are often focused upon determining whether an area is, or is not, a wetland. This is difficult at times because most wetland are not continually wet, especially at the surface. In order to facilitate fair, accurate wetland determinations, ACD monitors 19 wetlands throughout the county that serve as a reference of conditions countywide, and are thus called reference wetlands. Electronic dataloggers are used to measure subsurface water levels in wetlands every four hours. This hydrologic information, along with examination of the vegetation and soils, aids in the accurate wetland determinations and delineations. These reference wetlands represent several wetland types and most have been monitored for more than 18 years.

Reference wetland data provide insights into shallow groundwater hydrology trends. This can be useful for a variety of purpose from flood predictions indices of drought severity. There are concerns locally that shallow aquifers are being drawn down and wetland data can help speak to this.

Results of wetland hydrology monitoring are separated by watershed in the following chapters. The Coon Creek Watershed chapters includes a multi-year and most recent year analysis of all the wetlands.

2022 Reference Wetland Monitoring Sites



Wetland gauge deploy.

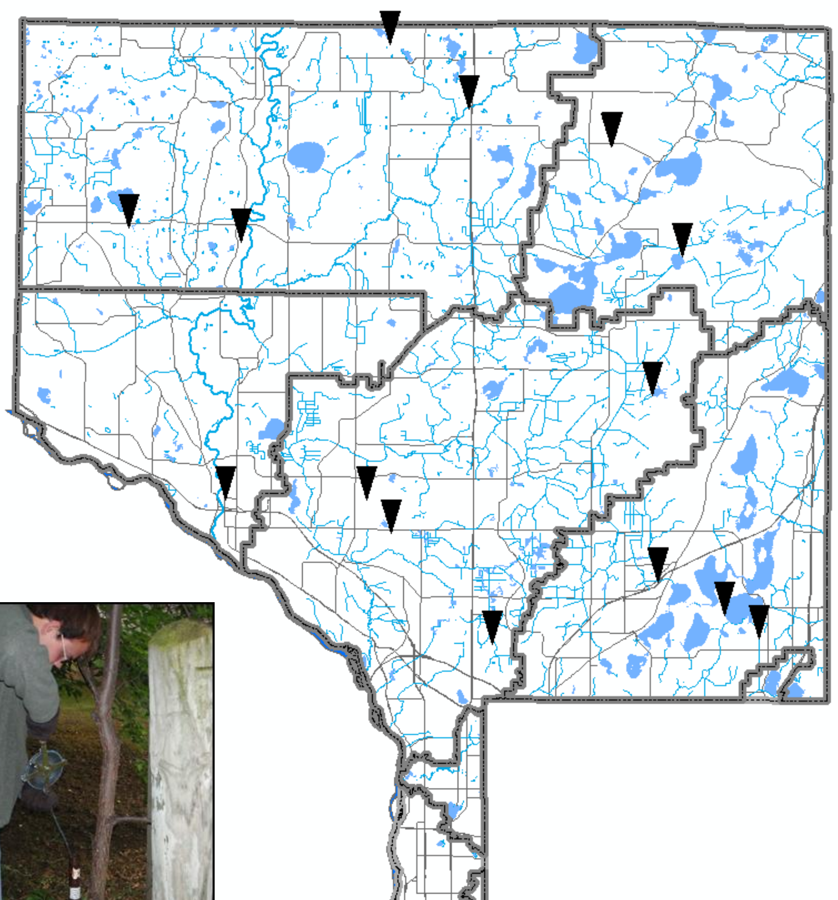
Groundwater Hydrology

The MNDNR and ACD are interested in understanding Minnesota's groundwater quantity and flow. These deep groundwater wells are not as sensitive to precipitation as other hydrologic systems such as wetland and streams, but rather respond to longer term trends. The MNDNR maintains a network of groundwater observation wells across the state.

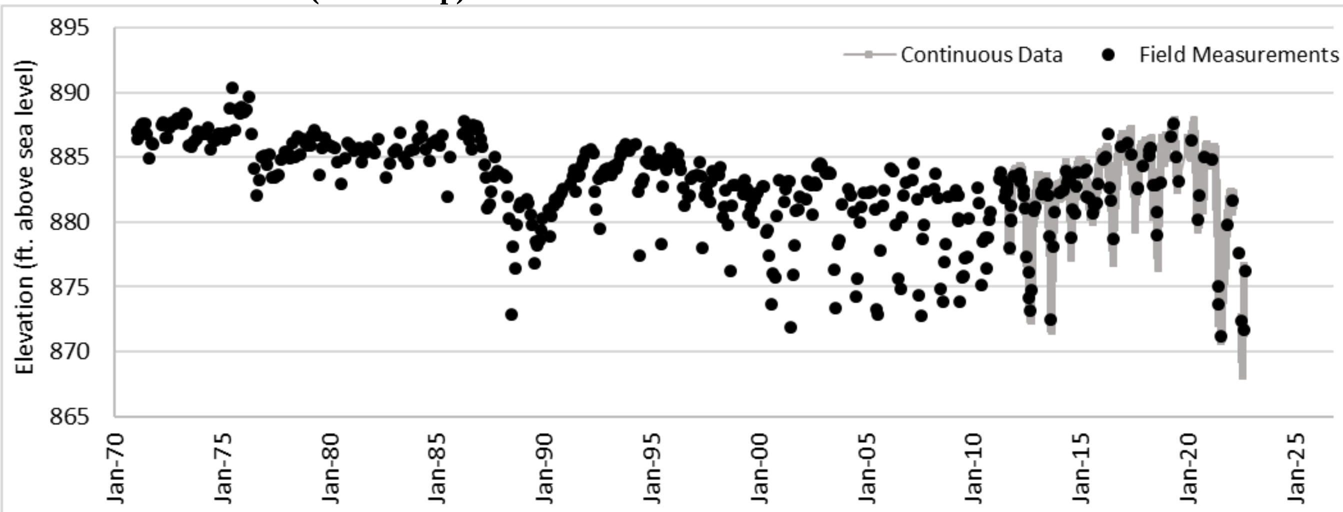
ACD is contracted to take water level readings at 24 wells in Anoka County and to download continuous data-loggers quarterly, submitting the findings to the MNDNR. At most sites, the MNDNR has automated devices taking continuous water level readings. ACD still hand measures wells with data loggers periodically to ensure accuracy. The MNDNR incorporates these data into statewide and national databases that aid in groundwater mapping. Raw data as well as continuous data from wells with data loggers installed are available for downloaded on their website (https://www.dnr.state.mn.us/waters/cgm/index.html).

The charts on the following pages show groundwater levels hand measured by ACD through 2022 for each well. These results are not presented elsewhere in this report.

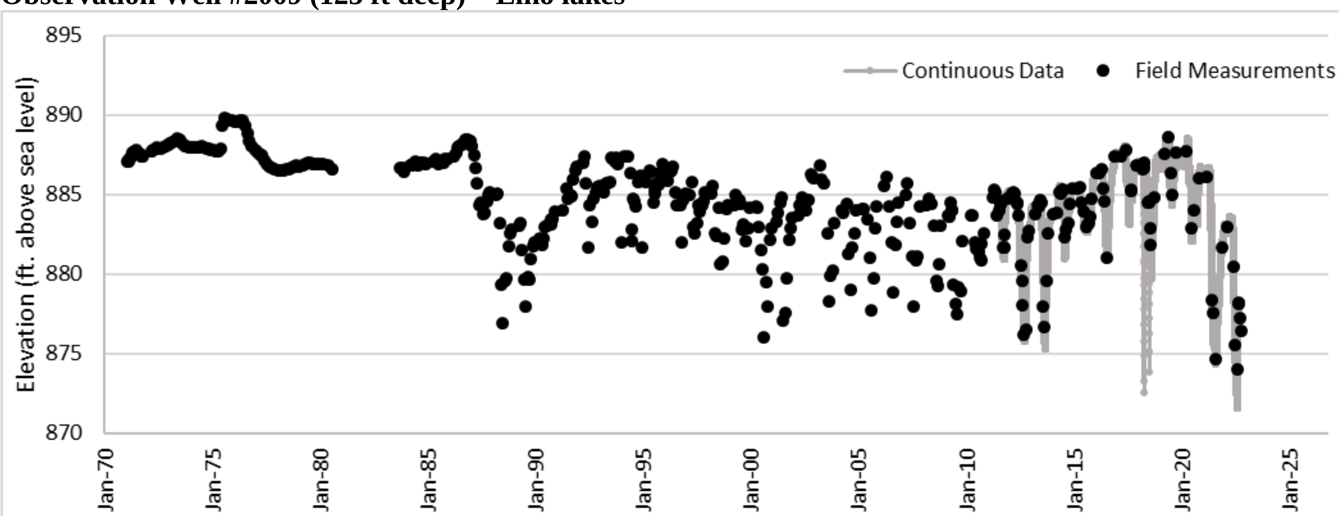
2022 Groundwater Observation Well Sites



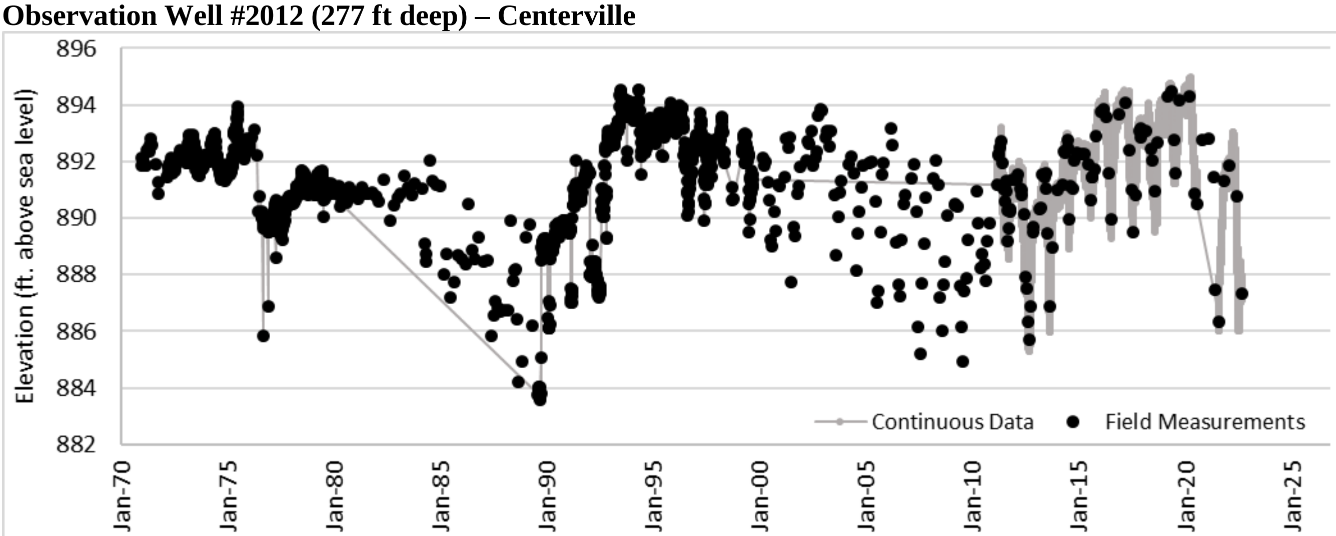
Observation Well #2007 (270 ft deep)—Lino Lakes



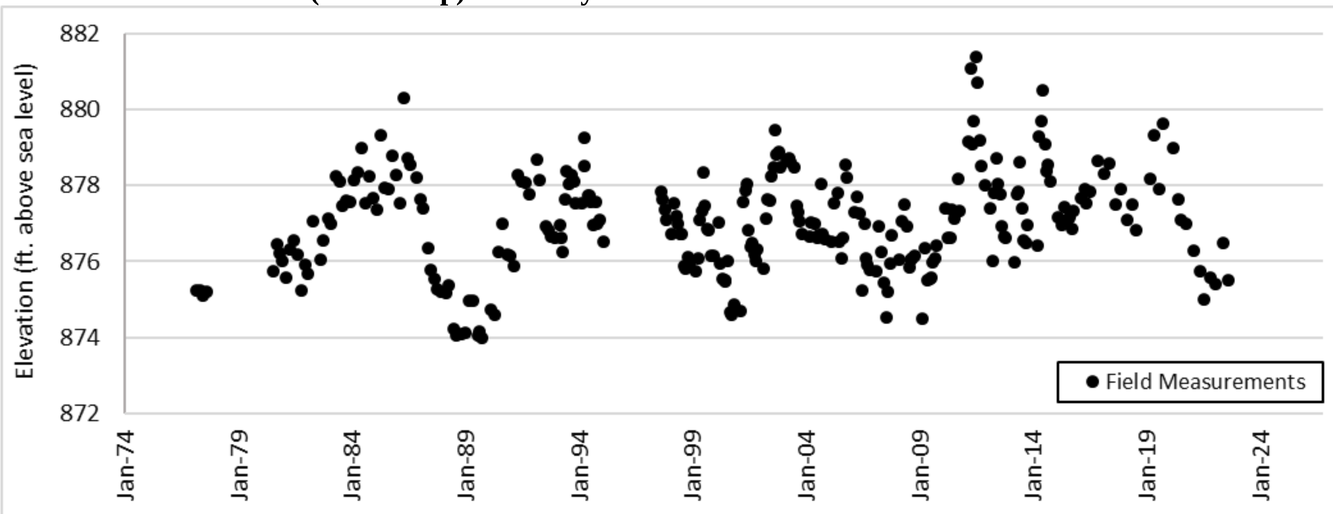
Observation Well #2009 (125 ft deep)—Lino lakes



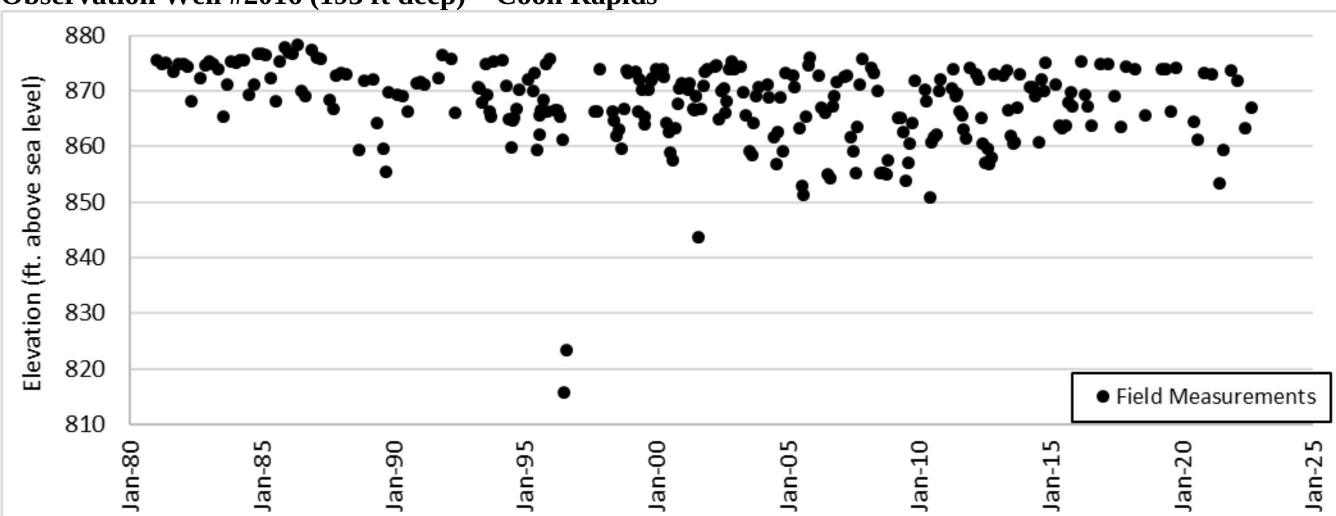
Observation Well #2012 (277 ft deep) – Centerville



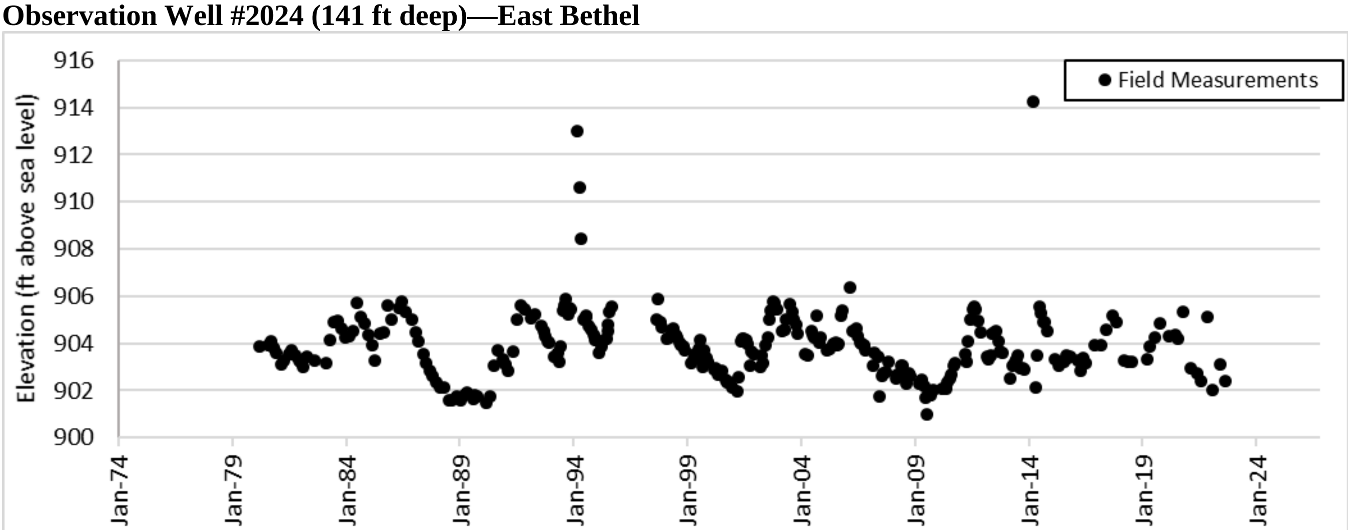
Observation Well #2015 (280 ft deep)—Ramsey



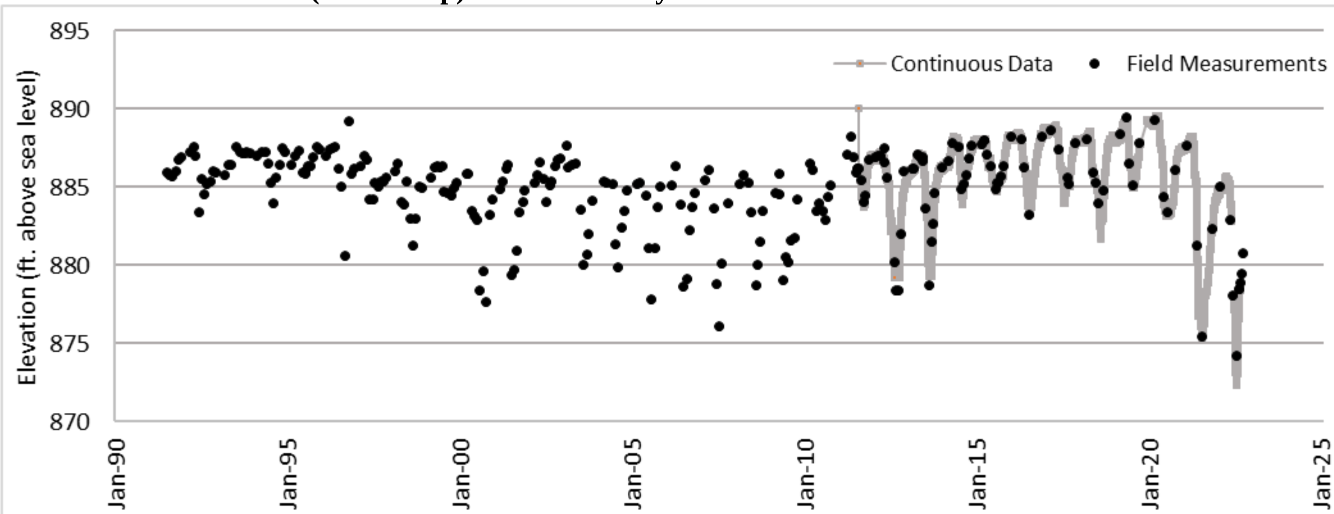
Observation Well #2016 (193 ft deep)—Coon Rapids



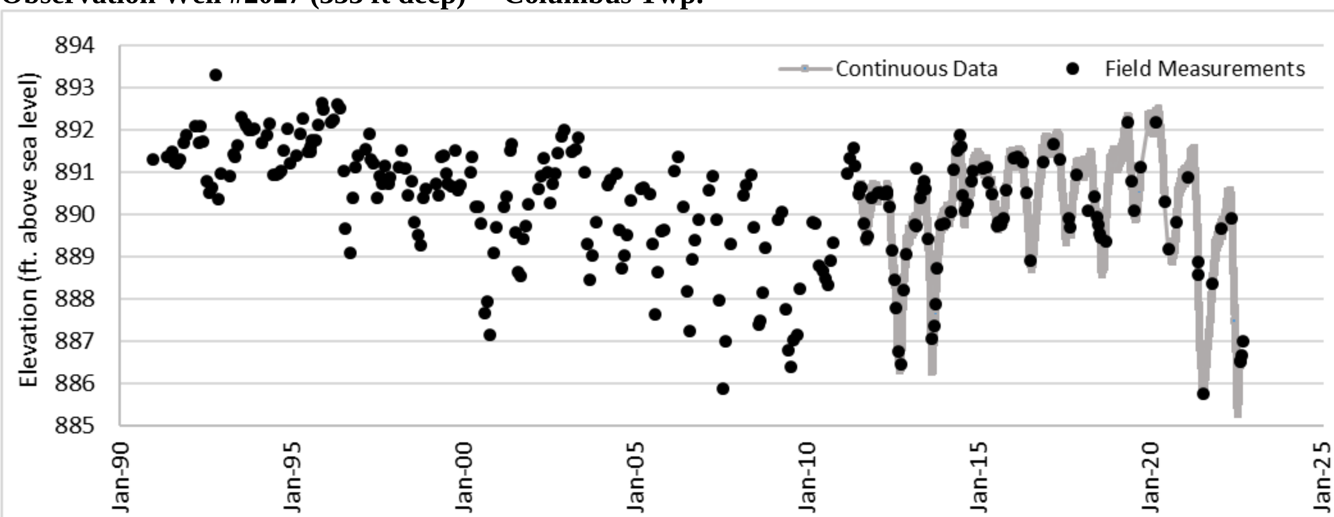
Observation Well #2024 (141 ft deep)—East Bethel



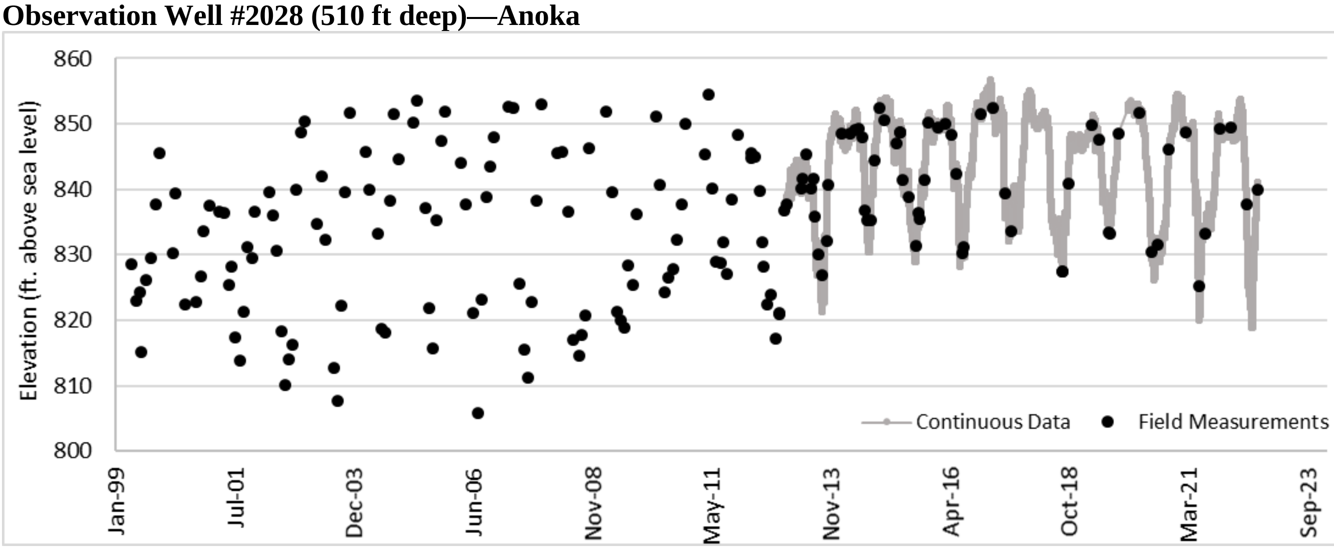
Observation Well #2026 (150 ft deep)— Carlos Avery #4



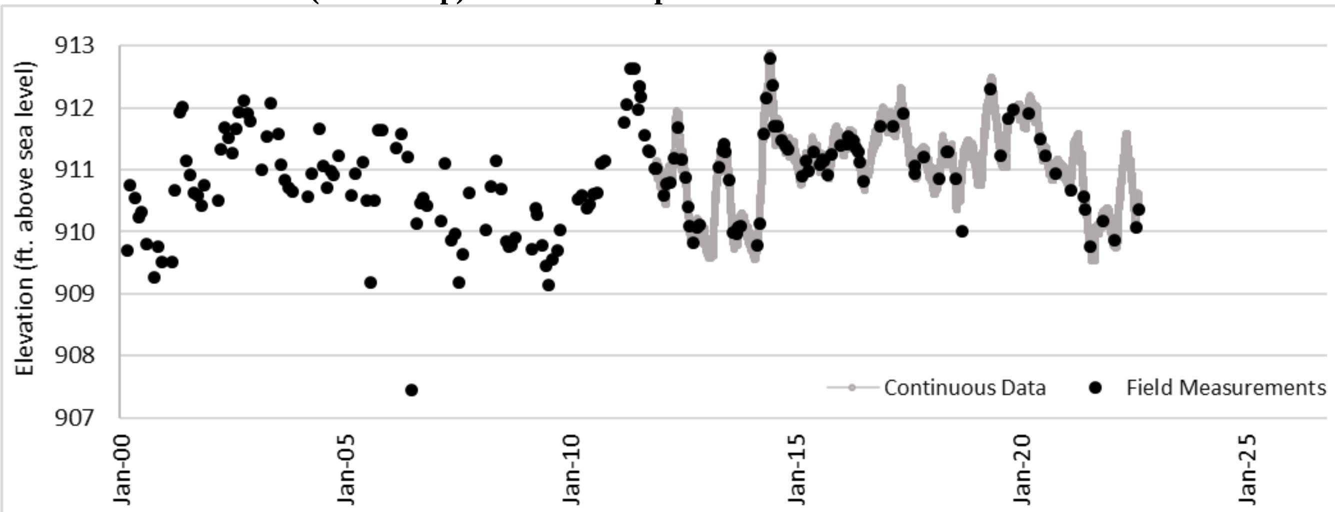
Observation Well #2027 (333 ft deep)— Columbus Twp.



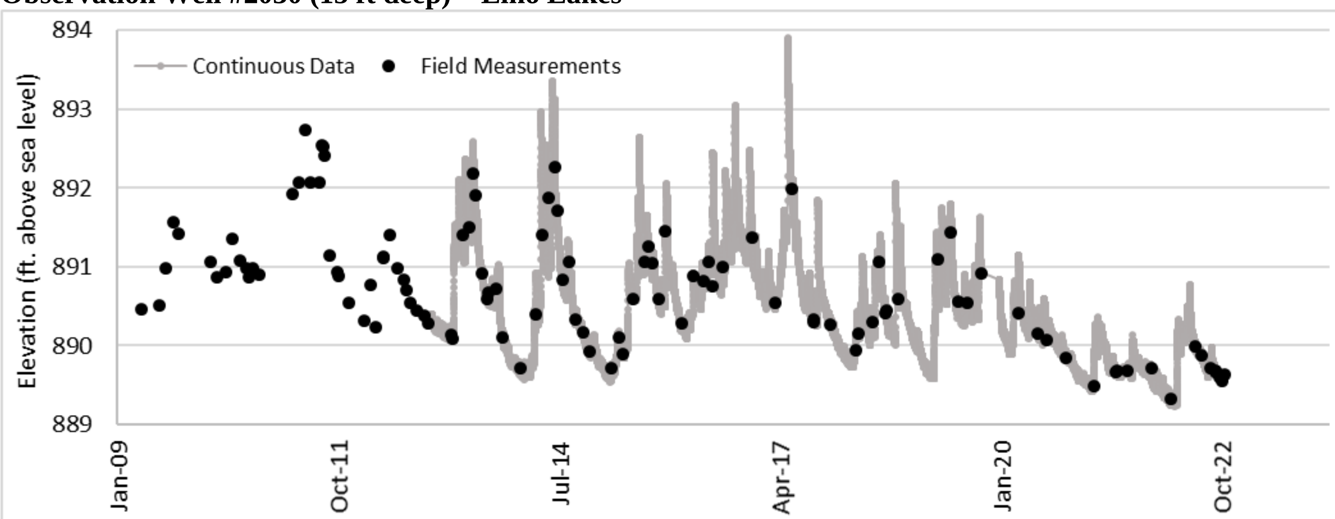
Observation Well #2028 (510 ft deep)—Anoka



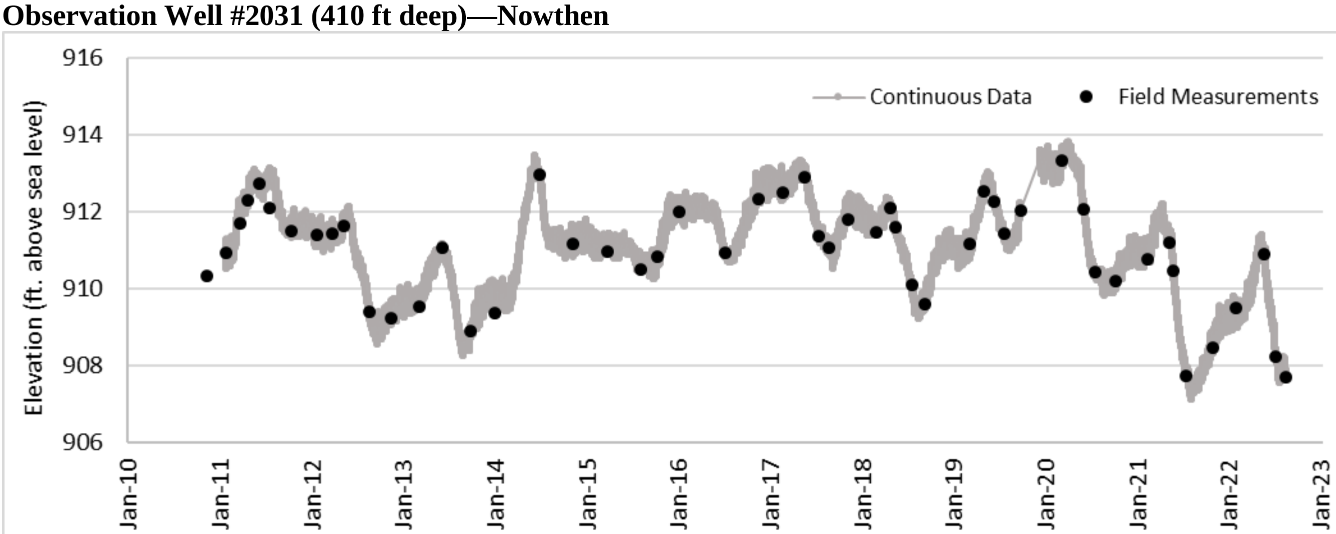
Observation Well #2029 (221 ft deep)—Linwood Twp.



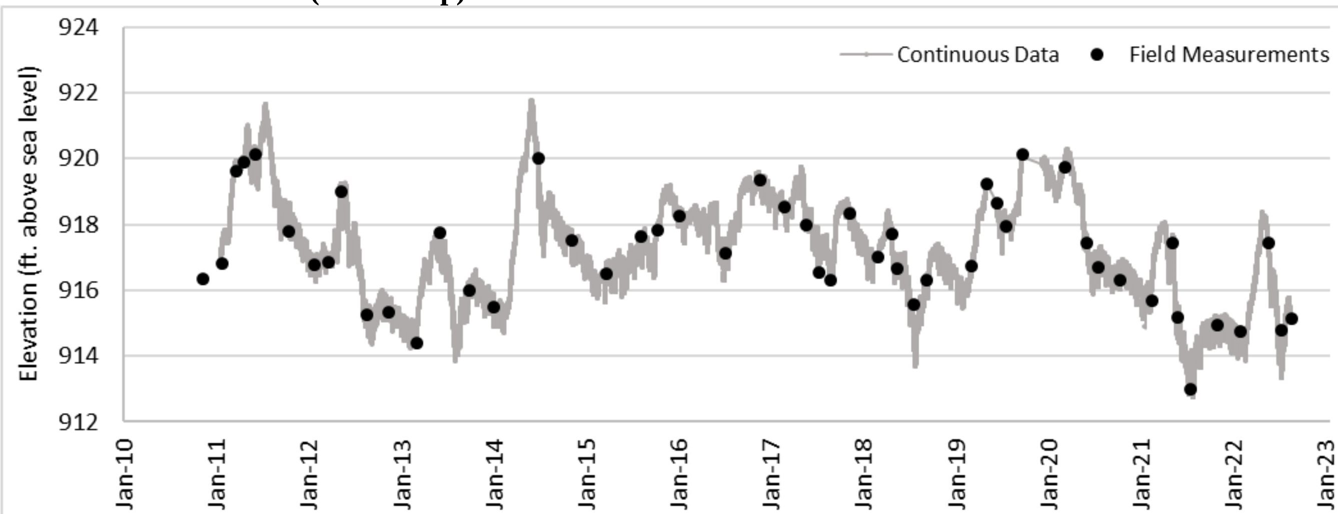
Observation Well #2030 (15 ft deep)—Lino Lakes



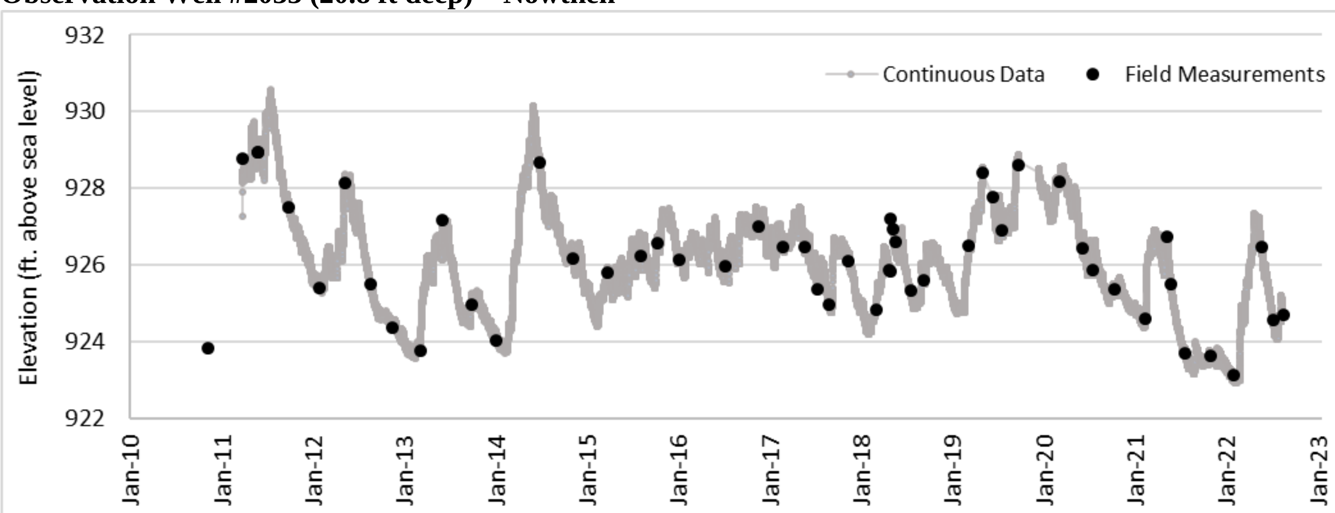
Observation Well #2031 (410 ft deep)—Nowthen



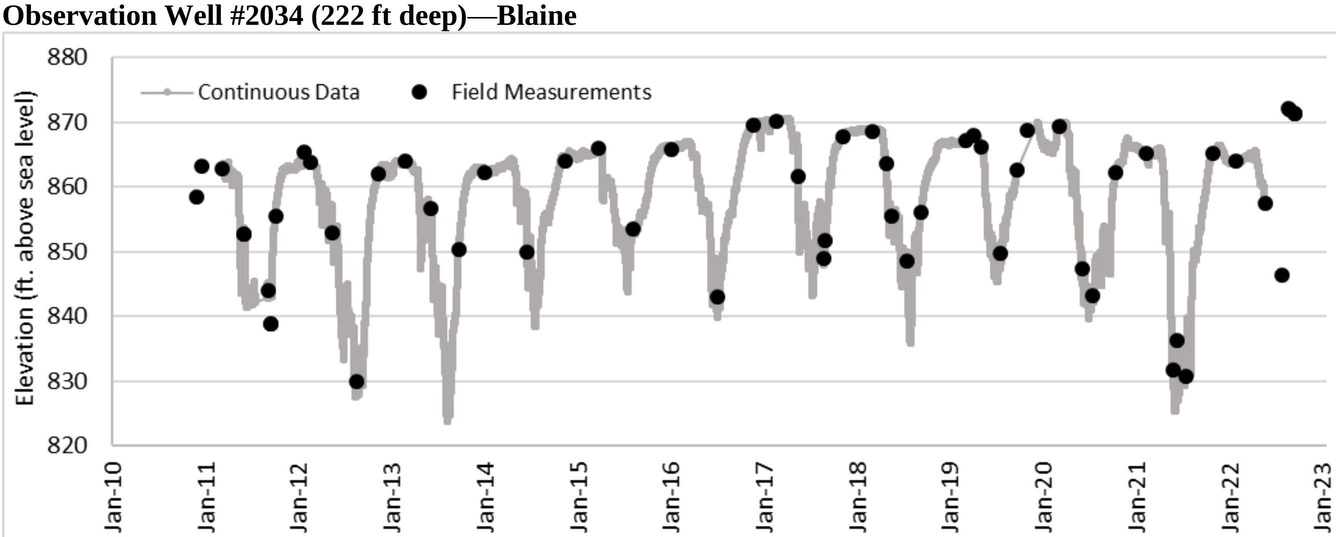
Observation Well #2032 (195 ft deep)—Nowthen



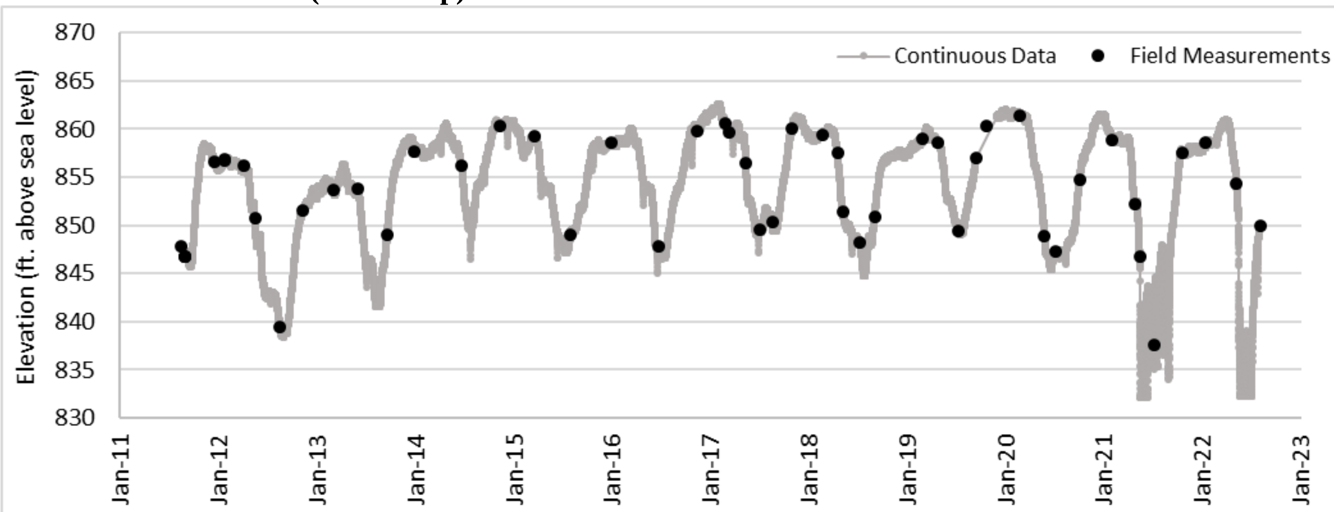
Observation Well #2033 (20.8 ft deep)—Nowthen



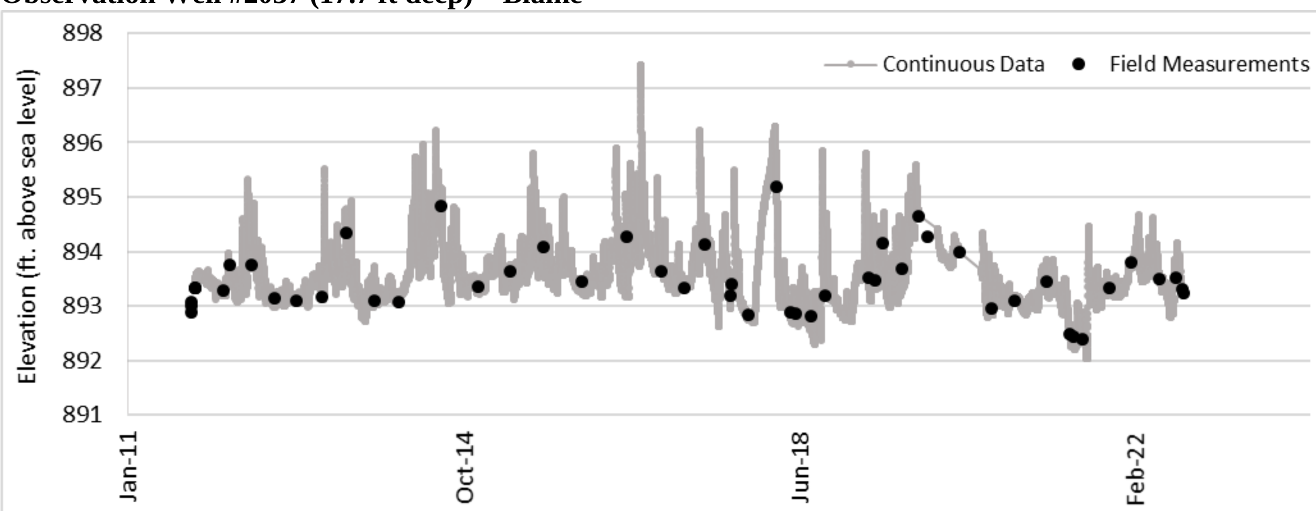
Observation Well #2034 (222 ft deep)—Blaine



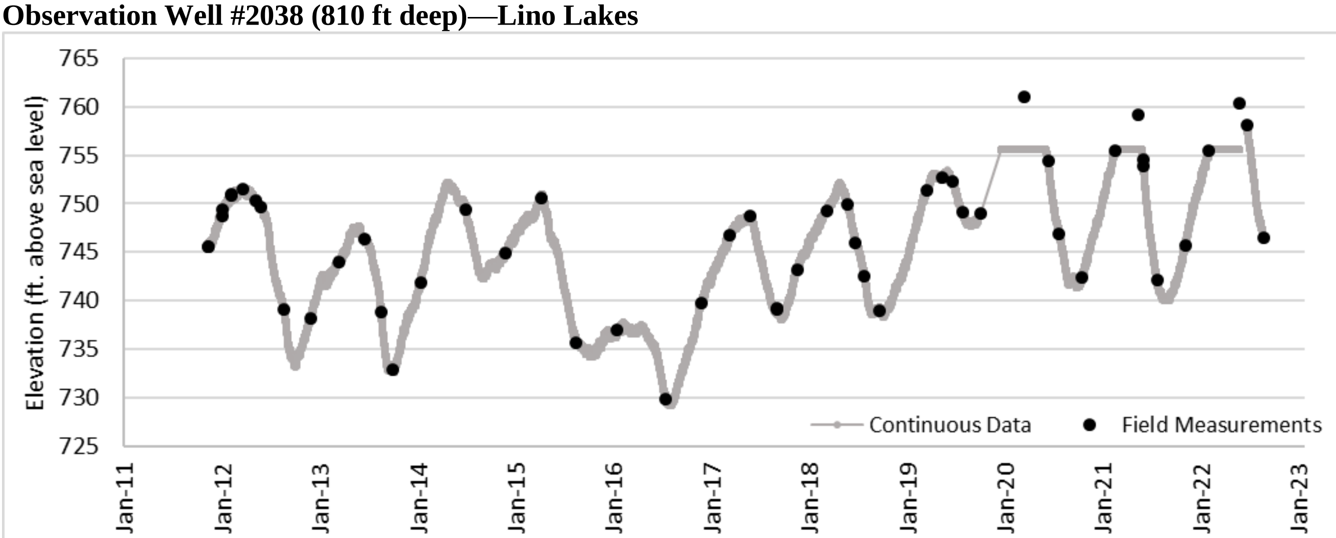
Observation Well #2036 (494 ft deep)—Andover



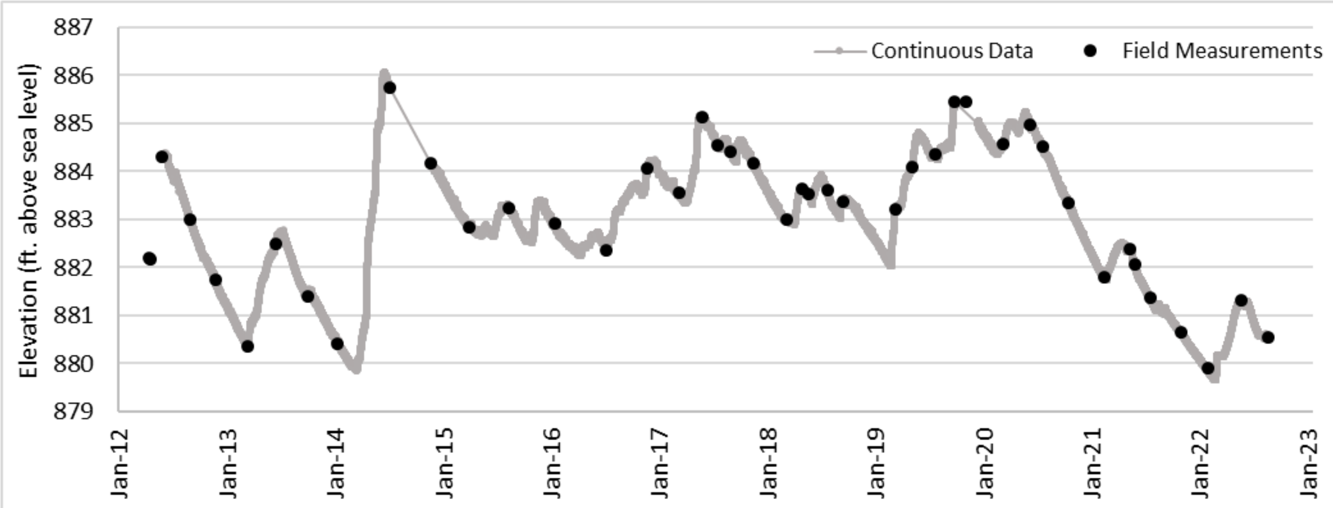
Observation Well #2037 (17.7 ft deep)—Blaine



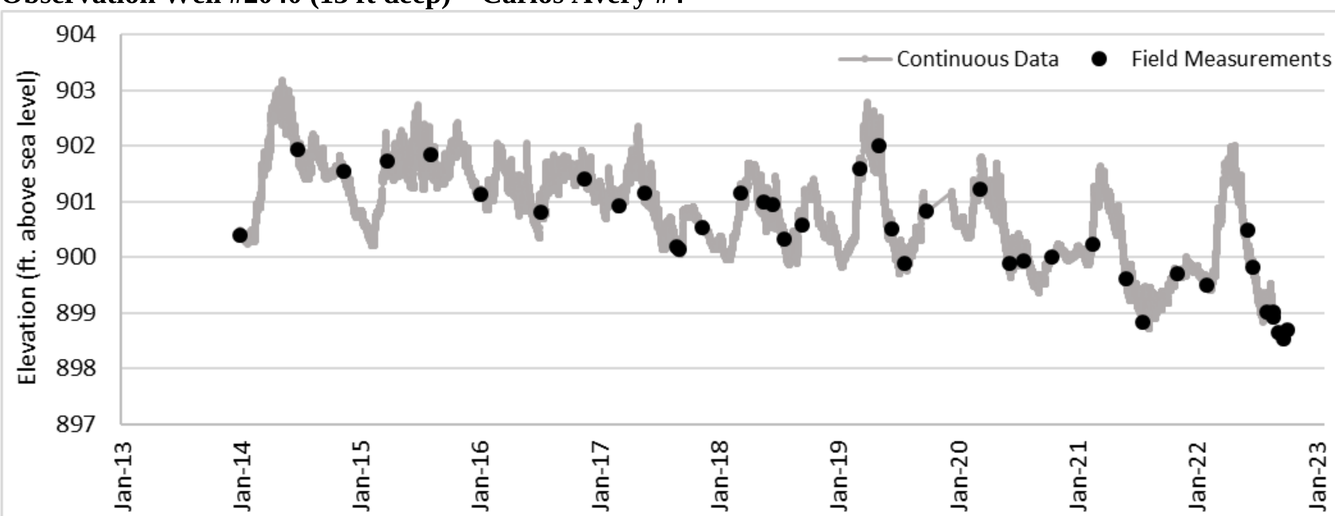
Observation Well #2038 (810 ft deep)—Lino Lakes



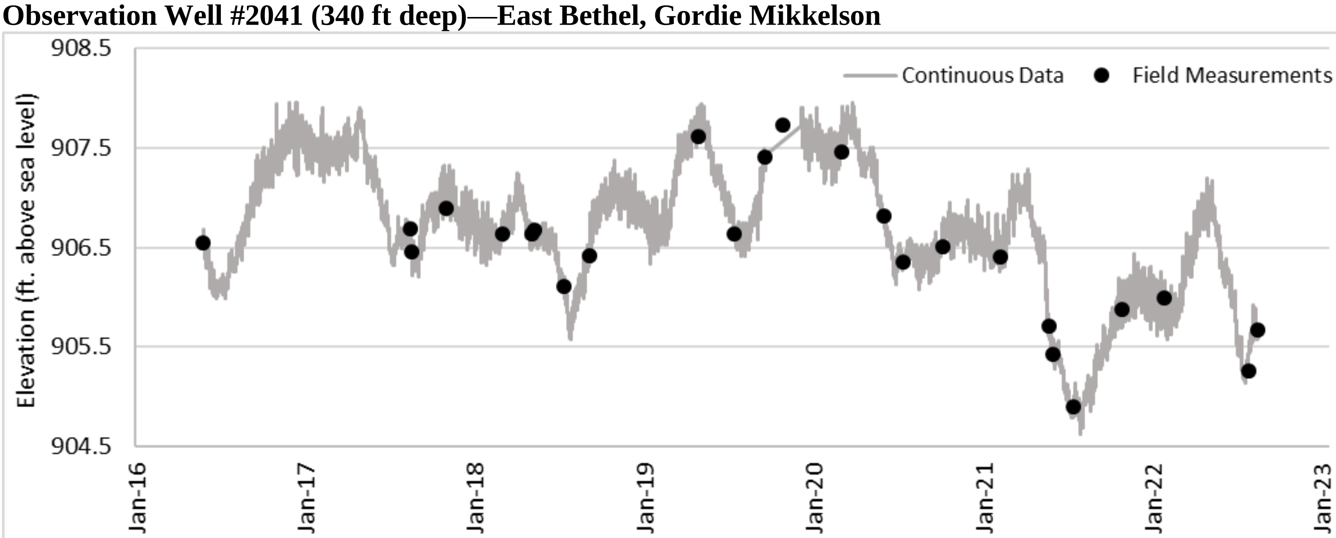
Observation Well #2039 (27.5 ft deep)—Andover



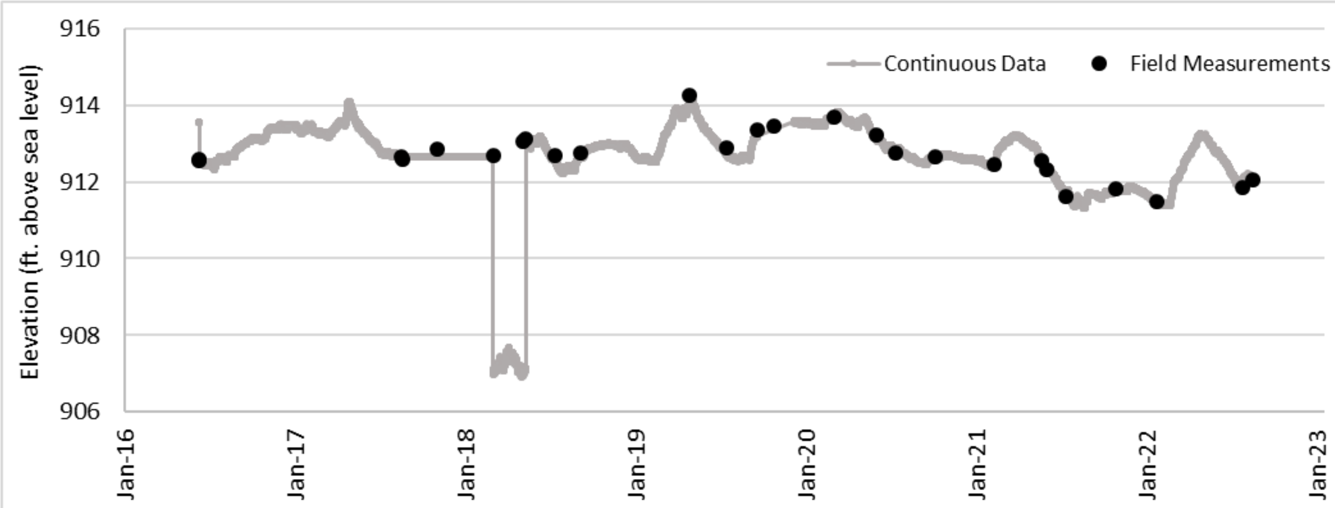
Observation Well #2040 (13 ft deep)—Carlos Avery #4



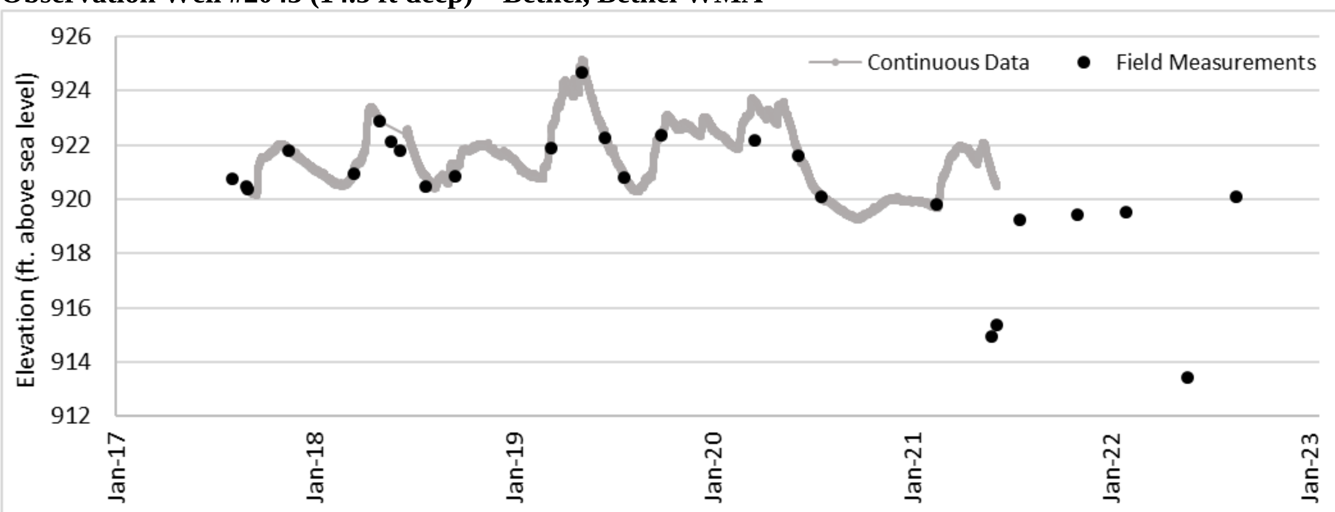
Observation Well #2041 (340 ft deep)—East Bethel, Gordie Mikkelson



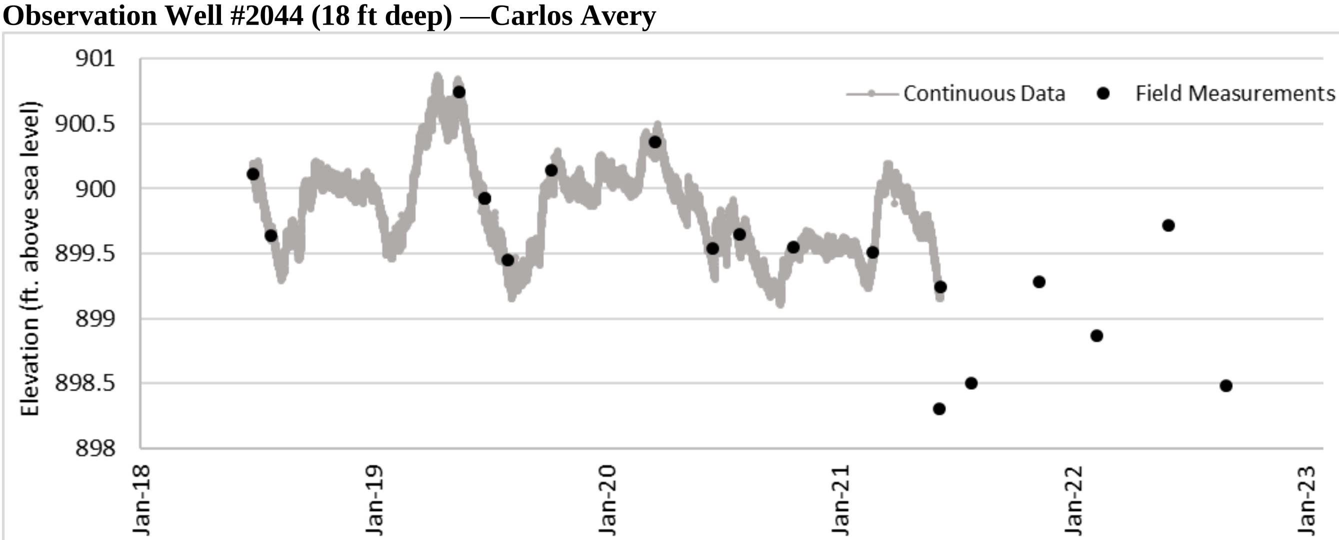
Observation Well #2042 (33.1 ft deep)—East Bethel, Gordie Mikkelson



Observation Well #2043 (14.5 ft deep)—Bethel, Bethel WMA



Observation Well #2044 (18 ft deep) —Carlos Avery



Lake Water Quality

The purpose of lake water quality monitoring is to detect and diagnose water quality problems that may affect suitability for recreation or that may adversely affect people or wildlife. The monitoring regime is designated to ensure major recreational lakes are monitored every 2-3 years. Some lakes are monitored more frequently if problems are suspected or problems are occurring that could affect lake water quality. Lakes with stable conditions, no suspected new problems, and robust datasets are monitored less often. Monitoring efforts of the MPCA or Metropolitan Council are not duplicated, and are not presented in this report.

In addition to this report, there are several sources of lake water quality data. For lakes monitored by ACD, Met Council, or MPCA prior to the current year, see the letter grade table on page 23. Detailed analyses for the lakes shown in that table are in each respective year's Water Almanac. All data collected by ACD is available on their online database (https://maps.barr.com/Anoka/Home/Chart/) and data from most other agencies can be retrieved through the MPCA's website Electronic Data Access tool, which draws data from their EQuIS database.

2022 Lake Water Quality Monitoring Sites

Lake water quality sample collection.

LAKE WATER QUALITY MONITORING METHODS

Each lake has data collected for the following parameters:

- Dissolved Oxygen (DO)
- Turbidity
- Conductance
- Temperature
- Salinity
- Total Phosphorous (TP)
- Transparency (Secchi Disk)
- Chlorophyll-a (Cl-a)
- pH

Lakes are sampled approximately every two-weeks May - September. Monitoring is conducted by boat or canoe at the deepest area of the lake. These sites are located using a GPS. Conductance, pH, turbidity, salinity, dissolved oxygen (DO), and temperature are measured using the HACH Quanta multi-parameter sonde at a depth of one meter. Water samples are collected with a Kemmerer sampler from a depth of one meter, to be analyzed by an independent laboratory for Total Phosphorous and Chlorophyll-a.

Sample bottles are provided by the laboratory. Total Phosphorous sample bottles contain the preservative sulfuric acid (H_2SO_4), while bottles for Chlorophyll-a analysis do not require preservative. Brown bottles are used for Chlorophyll-a to prevent light from entering the bottles. Water samples are kept cool and delivered to the laboratory within 48 hours of collection.

Transparency is measured using a Secchi disk. The disk is lowered over the shaded side of the boat until it disappears and is then pulled up to the point where it reappears again. The midpoint between these two depths is the Secchi disk measurement.

To evaluate the lake, results are compared to past data collected at the lake and other lakes in the region. Comparisons to other lakes are based on the Carlson's Trophic State Index and the Metropolitan Council's lake quality grading system for the North Central Hardwood Forest ecoregion. Historical data for each lake can be obtained from the U.S. EPA's national water quality database, EQuIS, via the Minnesota Pollution Control Agency.

LAKE WATER QUALITY QUESTIONS AND ANSWERS

This section is intended to answer basic questions about the ACD's methodology for monitoring lake water quality and interpreting the data.

Q: Which parameters did you test and what do they mean?
A: The table on the following page outlines technical information about the parameters measured, which include:

pH: This test measures whether the lake water is basic or acidic. A pH reading of greater than 7 signifies that the lake is basic and a reading of less than 7 means the lake is acidic. Many fish and other aquatic organisms need a pH in the range of 6.5 to 9.0 in order to remain viable. Eutrophic lakes are often basic. The pH of a lake will fluctuate daily and seasonally due to algal photosynthesis, runoff, and other factors.

Specific Conductance: This measures the degree to which the water can conduct electricity. It is caused by dissolved minerals in the lake. Although every lake has a certain amount of dissolved matter, high conductance readings may indicate additional inputs from sources such as storm water (i.e. road salt), agricultural runoff, or failing septic systems.

Salinity: This is a measurement of the quantity of salts dissolved in the water. Dissolved salts in a lake are not naturally occurring in Anoka County. High salinity measurements may be the result of inputs from other sources such as failing septic systems, spring runoff from salted roads, and farm field runoff.

Dissolved Oxygen (DO): Sources of dissolved oxygen include the atmosphere, aeration from stream inflow, and photosynthesis by algae and submerged plants in the lake. Dissolved oxygen is consumed by organisms in the lake and by the decomposition process.

Dissolved oxygen is essential to the metabolism of all aquatic organisms, and low dissolved oxygen is often the reason for fish kills. Extremely low DO concentrations at the lake bottom can also trigger a chemical reaction that causes phosphorus to be released from the sediment into the water column.

Temperature: Fish species are sensitive to water temperature. For example, lake trout and salmon prefer temperatures between 46-56°F, while bass and pan fish will withstand temperatures of 76°F or greater. Temperature also affects the amount of dissolved oxygen that the water can hold in solution. At warmer temperatures, oxygen is readily released to the atmosphere and dissolved oxygen concentrations fall.

Secchi Transparency: Transparency is directly related to the amount of algae and suspended solids in the water column. A Secchi disk is a white disk attached to the end of a measuring tape that is marked at 0.1-foot intervals. The disk is lowered over the shaded side of the boat until it disappears and is then pulled up to the point where it reappears again. The midpoint between these two points is the Secchi transparency. Shallow measurements indicate abundant algae and/or suspended solids.

Total Phosphorus: Algal growth is commonly limited by phosphorus. High phosphorus in a lake can result in abundant algal growth. This in turn, affects a variety of chemical and ecological factors including the lake's recreational suitability, fisheries, plants, and dissolved oxygen. A single pound of phosphorus can result in 500 pounds of algal growth. Minnesota Pollution Control Agency standards designate a lake in our ecoregion as "impaired" if average summertime phosphorus is >40 µg/L for deep lakes or >60 µg/L for shallow lakes.

Sources of phosphorus include runoff from agricultural land, fertilizer runoff from lakeshore properties, failing septic systems, pet waste, and stormwater runoff. The lake itself can also be a source of phosphorus. High levels of phosphorus contained in the bottom sediments of lakes can be released when the sediment is disturbed through recreation or animal activity, or when dissolved oxygen levels are low.

Chlorophyll-a (Cl-a): Chlorophyll-a is the inorganic portion of all green plants that absorb the light needed for photosynthesis. Chlorophyll-a measurements are used to indicate the concentration of algae in the water column. It does not provide an indication of large plant (macrophytes) or filamentous algae abundance.

Turbidity: This is a measure of the diffraction of light from solid material suspended in the water column due to "muddiness" or algae.

Parameter	Units	Reporting Limit	Accuracy	Average Summer Range for North Central Hardwood Forest
pH		0.01	± .05	8.6 - 8.8
Conductivity	mS/cm	0.01	± 1%	0.3 - 0.4
Turbidity	NTU	0.1	± 3%	1-2
D.O.	mg/L	0.01	± 0.1	N/A
Temperature	°C	0.1	± 0.17 °	N/A
Salinity	%	0.01	± 0.1%	N/A
T.P.	µg/L	1	NA	23 – 50
Cl-a	µg/L	1	NA	5 – 27
Secchi Depth	ft m	NA	NA	4.9 - 10.5 1.49 – 3.2

Q: Lakes are often compared to the "ecoregion", what does that mean?

A: We compare our lakes to other lakes in the same ecoregion. The U.S. Environmental Protection Agency mapped regions of the U.S. based on soils, landform, potential natural vegetation, and land use. These regions are referred to as ecoregions. Minnesota has seven ecoregions. Anoka County is in the North Central Hardwood Forest ecoregion. Reference lakes, deemed to be representative and minimally impacted by man (e.g., no point source wastewater discharges, no large urban area in the watershed, etc.), were sampled in each ecoregion to establish a standard range for water quality that should be expected in each ecoregion.

The average summer range of water quality values in the table on the previous page are the inter-quartile range (25^{th} to 75^{th} percentile) of the reference lakes for the North Central Hardwood Forest ecoregion. This provides a range of values that represent the central tendency of the reference lakes' water quality.

Q: What is the lake quality letter grading system?

A: The Metropolitan Council developed the lake water quality report card in 1989 (see table below). Each lake receives a letter grade that is based on average summertime (May-Sept) Chlorophyll-a, Total Phosphorus, and Secchi Transparency. In the same way that a teacher would grade students on a "curve", the lake grading system compares each lake only to other lakes in the region. Thus, a lake that gets an "A: in the Twin Cities Metro might only get a "C" in northern Minnesota. The goal of this grading system is to provide a single, easily understandable description of lake water quality.

Grade	Percentile	TP (µg/L)	Cl-a (µg/L)	Secchi Disk (m)
A	< 10	<23	<10	>3.0
B	10 - 30	23 – 32	10 - 20	2.2 - 3.0
C	30 – 70	32 – 68	20 – 48	1.2 – 2.2
D	70 – 90	68 – 152	48 – 77	0.7 – 1.2
F	> 90	> 152	> 77	< 0.7

Q: What do the lake physical condition and recreational suitability numbers mean?

A: The Minnesota Pollution Control Agency has established a subjective ranking system that ACD staff use during each lake visit (see table below). Rankings are based purely upon the observer's perceptions. These physical and recreational rankings are designed to give a narrative description of algae levels (physical condition) and recreational suitability of each lake. While the physical condition is straightforward, the recreational suitability may be complicated by the impacts of both water quality and dense aquatic vegetation (the influence of these two factors is not separated in the ranking).

	Rank	Interpretation
Physical Condition	1	crystal clear
	2	some algae
	3	definite algae
	4	high algae
	5	severe bloom
Recreational Suitability	1	beautiful
	2	minimal problems, excellent swimming and boating
	3	slightly swimming impaired
	4	no swimming / boating ok
	5	no swimming or boating

Q: At what concentrations do Total Phosphorus and Chlorophyll-a become a problem in lake water?

A: Lakes in the North Central Hardwood Forests have a certain criteria set for both Total Phosphorus and Chlorophyll-a. For Total Phosphorous, the concentrations for primary contact, recreation, and aesthetics is set at <40 µg/L in deep lakes and <60 µg/L in shallow lakes. For Chlorophyll-a, the average concentrations range from 5 to 22 µg/L, with maximums ranging from 7 to 37 µg/L. Once these set limits have been reached or exceeded, excessive algae growth will be observed.

Q: How do we determine if there is a trend of improving or worsening lake water quality?

A: Because of inherent natural variation, lake water quality is not the same each year. Sorting out this natural variation from true trends is best accomplished with statistical tests that analyze the data objectively. When there is at least five years of monitoring data present, ACD staff test for lake trends using a multivariate Analysis of Variance (MANOVA). MANOVA tests the vector response of correlated response variables (Secchi depth, Total Phosphorus, and Chlorophyll-a) while maintaining the probability of making a type I error (rejecting the null hypothesis) at $\alpha= 0.05$. In other words, we are simultaneously testing the three most important measurements of lake water quality. Testing each response variable separately would increase the chance of making a type I error.

Q: How do lakes change throughout the year and how does this affect water quality?

A: Water temperature is very important to the function of lakes. Lakes undergo seasonal changes that can influence water quality conditions. Because many Anoka County lake are shallow (<15 ft. or where 80% or more of the lake is littoral), some of the seasonal changes that are typical for deep lakes do not occur. The following discussion does not apply to these shallow lakes.

In the summer, after the lake has warmed, deep lakes will be divided (stratified) into three layers based on the water's temperature and density, the well-mixed upper layer (epilimnion); the middle transition layer (metalimnion); and the cool, deep bottom layer (hypolimnion). The hypolimnion is depleted of oxygen because of decomposition of organic matter, the lack of photosynthesis, and because there is no contact with the surface, where gas exchange with air can occur. Nutrients attached to sediment or decomposing organic material also fall into the hypolimnion where they are temporarily or permanently lost from the system. This is one reason deep lakes are usually less nutrient rich and do not experience algae problems.

In the autumn, the water near the surface eventually cools to the same temperature as the water at the bottom of the lake. When the water is of uniform temperature from top to bottom, it is easily mixed by the wind. This mixes nutrients that were formerly trapped at the bottom and may cause an autumn algal bloom. If the algal bloom is too severe, it could be detrimental to the lake during the winter when it is covered with ice. These algae will decay consuming dissolved oxygen, already decreased due to ice over, which may lead to a winter fish kill. This situation is typically observed in shallow eutrophic and/or hypereutrophic lakes.

In winter, an inverse thermal stratification sets up. Ice is less dense than water and therefore floats. The coldest water is nearest the surface. Water has a maximum density at 4^{o} C, and that water is found at the bottom. The reversal of the temperature layers in spring and fall is called "turning over."

In spring, the lake "turns over" with the warmer water rising to the top and the colder sinking to the bottom. When this occurs, nutrients needed for plant growth (total phosphorus and nitrogen) are distributed throughout the lake from the bottom. As solar radiation slowly warms the deeper lakes during the spring and summer, the lake starts to stratify into the three layers again, this time with the warmest water on top.

Q: What does the "trophic state" of a lake mean?

A: Lakes fall into four categories, or trophic states, based on lake productivity and clarity.

1. Oligotrophic - In these lakes, nutrients (total phosphorus and nitrogen) are low. Oligotrophic lakes are the deepest and clearest of all lakes, but the least productive (i.e. lowest biomass of plants and fish due to lack of nutrients).

2. Mesotrophic - In these lakes, plant nutrients are available in limited quantities allowing for some, but not excessive plant growth. These lakes are still considered relatively clear. Northern Minnesota walleye and lake trout lakes are usually mesotrophic.

3. Eutrophic - In these lakes, the water is nutrient-rich. Productivity is high for both plants and fish. Abundant plant life, especially algae, results in poorer water clarity and can reduce the dissolved oxygen content when it decays. Algae blooms in the "dog days of summer" are commonplace. Bass and panfish are usually large components of the fish community, but rough fish can become problematic.

4. Hypereutrophic - In these lakes, nutrients are extremely abundant. Algae are grossly abundant, starving all other plants of light. The poor conditions often favor rough fish over game fish. These lakes have the poorest recreational potential.

Q: What is Carlson's Trophic State Index?

A: Carlson's Trophic State Index (see figure below) uses a number calculated with the lakes Secchi transparency, phosphorus, and chlorophyll-a readings to describe a lake's stage of eutrophication (nutrient level, or amount of algae). The index ranges from oligotrophic (clear, nutrient overloaded lakes). The index values generally range between 0 and 100 with increasing values indicating more eutrophic conditions. Unlike the lake letter grading system, the Carlson's Trophic State Index does not compare lakes only within the same ecoregion; it is a scale used worldwide.

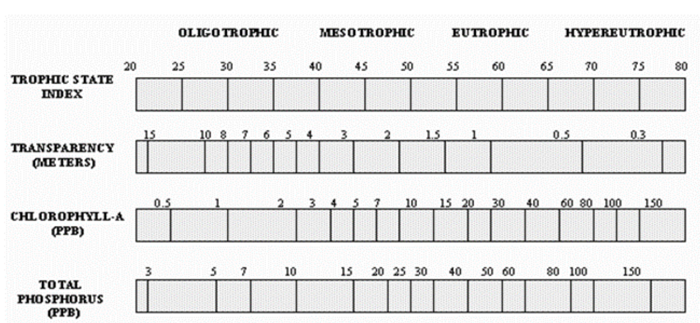
There are four trophic state index values: one each for phosphorus, chlorophyll-a, and transparency, plus an overall trophic state index value which is a composite of the others. The indices are abbreviated as follows:

TSI- Overall Trophic State Index.
TSIP- Trophic State Index for Phosphorus.
TSIS- Trophic State Index for Secchi transparency.
TSIC- Trophic State Index for the inorganic part of algae, Chlorophyll-a.

At the conclusion of each monitoring season, the summertime (May to September) average for each trophic state index is calculated.

CARLSON'S TROPHIC STATE INDEX

TSI < 30	Classic Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion, salmonid fisheries in deep lakes.
TSI 30-40	Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.
TSI 40-50	Water moderately clear, but increasing probability of anoxia in hypolimnion during the summer.
TSI 50-60	Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnion during the summer, submerged plant growth problems evident, warm-water fisheries only.
TSI 60-70	Dominance of blue-green algae, algal scum probable, extensive submerged plant problems.
TSI 70-80	Heavy algal blooms possible throughout the summer, dense submerged plant beds, but extent limited by light penetration. Often classified as hypereutrophic.
TSI >80	Algal scum, summer fish kills, few submerged plants due to restricted light penetration.



Historical Water Quality Grades for Anoka County Lakes (including monitoring by ACD and Met Council's CAMP program, post 1980)

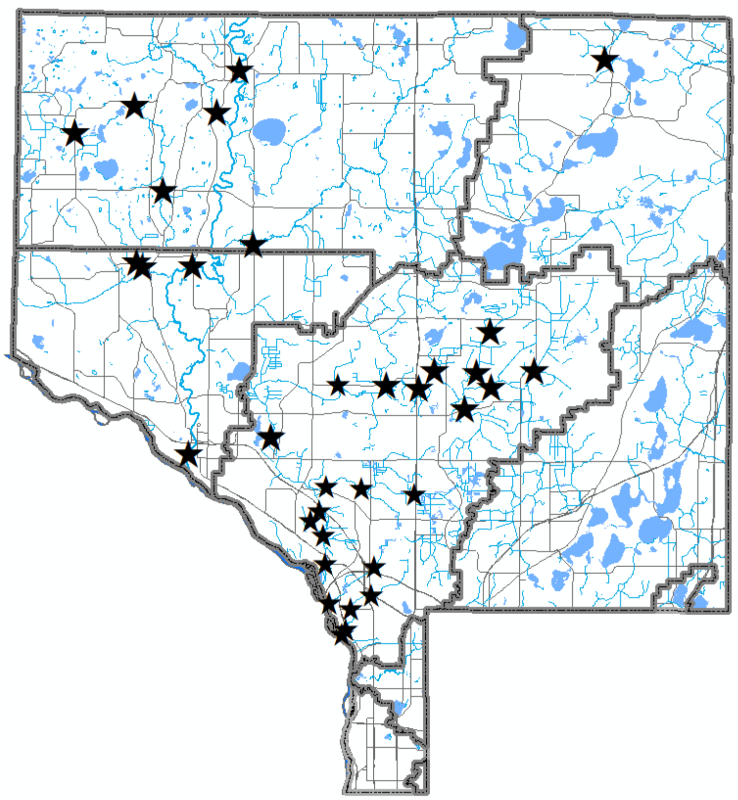
YEAR →	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Boot																																							C+	A		B
Cenaiko																		B	A	A	A	B	A	A	A	A	A	A	B	B	B	B	B						A-			
Centerville		C		C					D												C	C		C	C	A																
Coon	C				C					C					C			C	B	A	B	C			C		C		C													
Coon (East Bay)					C					C	C	C		C	C	C		B	B	A	B	C	B		C	C	C	B	A	B	B	B	B	B+	A		B		A			
Coon (West Bay)																															A		A		B		A-		A-			
Crooked				C		C				C					B	C	B	B	B		B		B	B		B	B-		B	B		B	A-		A	A		B	A-			
East Twin	A	B		C						B						B		A	B	A	A		A			A			A			A		A				A				A
Fawn									B									A	B	A	A	A			A		A		A		A		A			A			A			
Fish																																							A			
George	A	A	A		A					A								A	B	A	A		A			B			B			B		B	B	A	A	B	A	A	A	A
George Watch		F	D	D		D		D	D	F	D	F					F	D	F	D	D	F	D	D	F	D	F	F	D	D	D	D	F	F		D	F	D				
Golden						D	C	D	F	F	F	F		D			C	D	C	C	C	D	D	D	D	C	C	C	C	C	C											
Ham					C									A	B		A	A	B		C	C			B	B		B	A		B	B		A	A		B	B				
Highland																				D	D	D	F	F	F	F	F	F									F					
Howard										F	F	F							F	D	D																					
Island				C																				B	B	C	C	B	B	C	C	C	C									
Itasca																			A	B	B																					
Laddie	D													A	B	B			B	B	B	B	B	B	B	B			B			B					A	B				
Linwood	B	C		C						C					C			C	C	C	C	C		C		C		C	C	C			C			C			C			
Lochness																												A	B		B	C	C					C				
Martin				D														D	D	C	D	D		D		D		D	D	D			D		C	C	C	C	C	D	C	C
Minard																																		A	A							
E. Moore	C	C	C	C	C	B	C	C							C				C	B	B	C	C	C		C																
W. Moore	C	C	F	C	B	C	F	C												B	B	C	C	C		C																
Mud														B						B	C																					
Netta																		B	C	A		B		A	A		B+	B+		B	A-		A-	A		A	A		A	A		
Peltier				D										D	F	D	D	D	D	D	D	F	F	D	D	D	F	D														
Pickerel																B		A	A	B	C										A	C		B	A							
Reshanau																											D	D	D	D	D	D	D									
Rogers																			C		C			B			D		B	B												
Round																			B	A	B			A		B		C		C	C		A		A		A					
Sullivan (Sandy)														D	D	D		D	D	D	D	D	F	D	D	D								D			D					
Sunfish/Grass																																	B	B			B	A	B			B+
Sunrise																																							B-	C		
Typo														F	F	F		F	F	F	F	F		F		F		F		F			F		D	F	F	F	F	D	F	D

Stream Water Quality – Chemical Monitoring

Stream water quality monitoring is conducted to detect and diagnose water quality problems impacting the ecological integrity of waterways, recreation, or human health. Since many streams systems are connected to lakes, water quality in streams is often studied as part of lake management.

The methodologies for chemical stream water quality monitoring and information on data interpretation can be found on the following pages. Monitoring results are separated by watershed in individual chapters.

2022 Chemical Stream Water Quality Monitoring Sites.



Stream water quality sample collection.

STREAM WATER QUALITY MONITORING METHODS

Stream water was monitored during base flow conditions and immediately following storm events between the months of April and October (some special studies have different samplings regimes). Grab samples are a single sample of water collected to represent water quality for a given moment of stream condition. A composite sample, conversely, consists of collecting several small samples over a period of time and mixing them. Stream sampling is performed using a HACH Quanta multi-parameter sonde in the stream and concurrently collecting grab samples for laboratory analysis.

Each stream sample was tested for the following parameters:

- pH
- Dissolved Oxygen (DO)
- Turbidity
- Specific Conductance
- Temperature
- Salinity
- Total Phosphorus (TP)
- Total Suspended Solids (TSS)
- Secchi Tube Transparency
- E. Coli

Conductance, pH, turbidity, salinity, dissolved oxygen (DO), and temperature are measured in the field using a HACH Quanta multi-parameter sonde. E. coli samples are analyzed by the independent laboratory. Samples of E. coli are delivered to the laboratory no later than 7 hours after being collected. Total phosphorus and total suspended solids are analyzed by an independent laboratory. Sample bottles are provided by the laboratory, along with necessary preservations. Water samples are kept on ice and picked up by the laboratory within 24 hours of collection. Stream water level is noted when the sample is collected.

STREAM WATER QUALITY MONITORING QUESTIONS AND ANSWERS

This section is intended to answer basic questions about ACD's methodology for monitoring stream water quality and interpreting the data.

Q: Which parameters did you test and what do they mean?

A: The table on the following page outlines technical information about the parameters measured, which include:

pH: This test measures whether the lake water is basic or acidic. A pH reading of greater than 7 signifies that the lake is basic and a reading of less than 7 means the lake is acidic. Many fish and other aquatic organisms need a pH in the range of 6.5 to 9.0 in order to remain viable.

Specific Conductance: This measures the degree to which the water can conduct electricity. It is caused by dissolved minerals in the stream. Although every stream has a certain amount of dissolved matter, high conductance readings may indicate additional inputs from sources such as storm water (i.e. road salt), agricultural runoff, or failing septic systems.

Salinity: This is a measurement of the quantity of salts dissolved in the water. Dissolved salts in a stream are not naturally occurring in Anoka County. High salinity measurements may be the result of inputs from other sources such as failing septic systems, spring runoff from roads, and farm field runoff.

Dissolved Oxygen (DO): Dissolved oxygen is essential to the metabolism of all aquatic organisms. Sources of dissolved oxygen include the atmosphere, aeration from other stream inflow, and photosynthesis by algae and submerged plants in the stream. Dissolved oxygen is consumed by organisms in the stream and by the decomposition process.

Temperature: Fish species are sensitive to water temperature. For example, lake trout and salmon prefer temperatures between 46-56°F, while bass and pan fish will withstand temperatures of 76°F or greater. Temperature also affects the amount of dissolved oxygen that the water can hold in solution. At warmer temperatures, oxygen is readily released to the atmosphere and dissolved oxygen concentrations fall.

Secchi Tube Transparency: Transparency is directly related to the amount of algae and suspended solids in the water column. A Secchi tube is a 1 m long tube marked at 1 cm intervals with a white and black disk on a string within it. The tube is filled with water and the disk is drawn upward until it is just visible than lowered until it just disappears. The midpoint between these points is the Secchi transparency

Total Phosphorus: Algal growth is commonly limited by phosphorus. High phosphorus in a stream can result in abundant algal growth. This in turn, affects a variety of chemical and ecological factors including the stream's recreational suitability, fisheries, plants, and dissolved oxygen. A single pound of phosphorus can result in 500 pounds of algal growth. Minnesota Pollution Control Agency standards designate a stream as impaired if it has >100 µg/L average summertime phosphorous.

Sources of phosphorus include runoff from agricultural land, runoff-carrying fertilizer from lakeshore properties, failing septic systems, pet waste, and stormwater runoff. The lake itself can also be a source of phosphorus. High levels of phosphorus contained in the bottom can be released when the sediment is disturbed through recreation or animal activity, or when dissolved oxygen levels are low.

Turbidity: This is a measure of the diffraction of light from solid material suspended in the water column due to "muddiness" or algae

Analytical Limits for Stream Water Quality Parameters

Parameter	Unit of Measurement	Method Detection Limit	Reporting Limit	Analysis or Instrument Used
pH	pH units	0.01	0.01	Hydrolab Quanta
Conductivity	mS/cm	0.001	0.001	Hydrolab Quanta
Turbidity	NTU	0.1	0.1	Hydrolab Quanta
Dissolved Oxygen	mg/L	0.01	0.01	Hydrolab Quanta
Temperature	°C	0.1	0.1	Hydrolab Quanta
Salinity	%	0.01	0.01	Hydrolab Quanta
Total Phosphorus	µg/L	0.3	1.0	EPA 365.4
Total Suspended Solids	mg/L	5.0	5.0	EPA 160.2
Chloride	mg/L	0.005	0.01	EPA 325.1
E. *coli*	MPN/100 mL	1.0	1.0	SM9223 B-97

Q: How do you rate the quality of a stream's water?

A: We make up to three comparisons. First with published water quality values for the North Central Hardwood Forest (NCHF) ecoregion. Mean values for our ecoregion, and for minimally impacted streams in our ecoregion are in the table below.

Secondly, we compare each stream to other streams ACD has monitored throughout the county. The county includes urban, suburban, and rural areas so this comparison incorporates water quality expectations in all these land uses. Third, we compare levels of a pollutant observed to State water quality standards. These standards exist for some, but not all pollutants.

Typical Stream Water Quality Values for the North Central Hardwood Forest (NCHF) Ecoregion and Anoka County

Parameter	Units	NCHF Ecoregion Mean[1]	NCHF Ecoregion Minimally Impacted Stream[1]	Median of Anoka County Streams
pH	pH units		8.1	7.56
Conductivity	mS/cm	0.389	0.298	0.420
Turbidity	NTU		7.1	11.39
Dissolved Oxygen	mg/L	-	-	7.54
Temperature	°F		71.6	
Salinity	%		0	0.01
Total Phosphorus	µg/L	220	130	119
Total Suspended Solids	mg/L		13.7	14.37
Chloride	mg/L		8	13.3

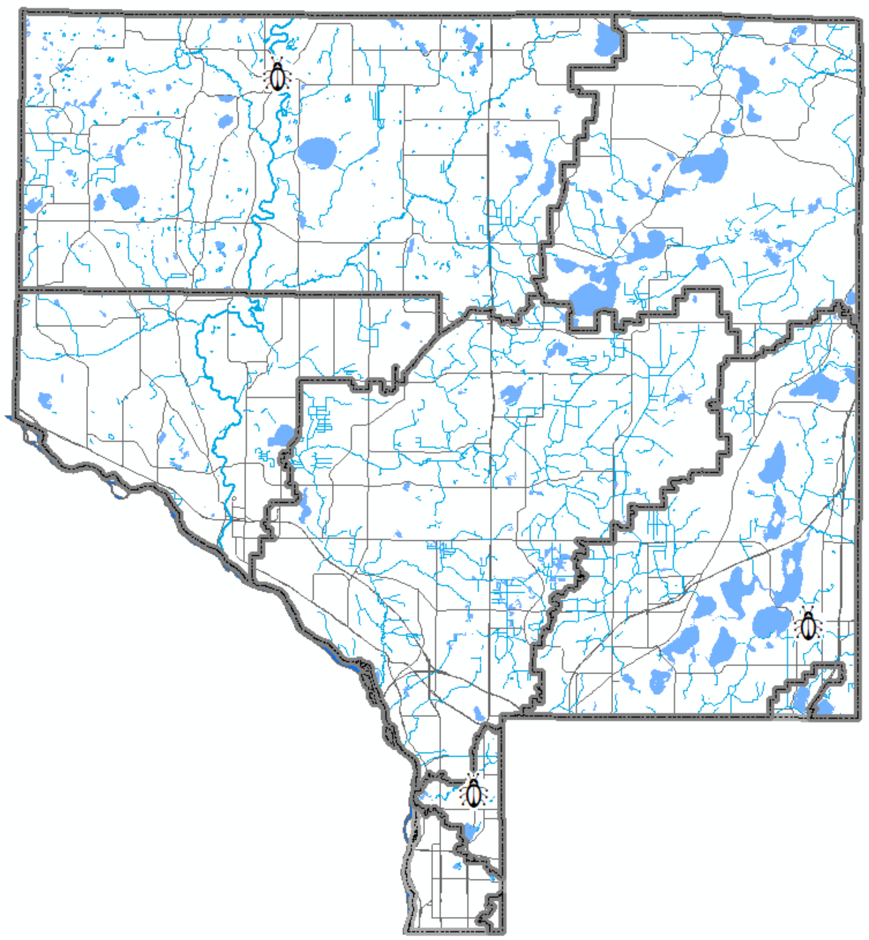
Stream Water Quality – Biological Monitoring

The stream biological monitoring program, often called biomonitoring, is both a stream health assessment and educational program. This biomonitoring program uses benthic (bottom dwelling) macroinvertebrates to determine stream health. Macroinvertebrates are animals without a backbone and large enough to see without a microscope, such as aquatic insects, snails, leeches, clams, and crayfish. Certain macroinvertebrates, such as stoneflies, require high quality streams, while others thrive in poor quality streams. Because of their extended exposure to stream conditions and sensitivity to habitat and water quality, benthic macroinvertebrates serve as good indicators of stream health.

ACD adds an educational component to the program by involving students in the biomonitoring at many of the sites. High school science classes are the primary volunteers. In 2022, approximately 300 students from four high schools monitored four stream sites. Since 2000, over 5,500 students have participated. The experience affords students an opportunity to learn scientific methodologies and become involved in local natural resource management.

Results of this monitoring are separated by watershed in individual chapters.

2022 Biological Stream Water Quality Monitoring Sites



Biomonitoring Methods

Student biomonitoring is loosely based on the EPA's multi-habitat protocol for low-gradient streams. Students doing the sampling determine how much of the stream is occupied by the types of micro-habitat: vegetated bank margins, snags and logs, aquatic vegetation beds and decaying organic matter, and silt/sand/gravel substrate. Sampling is by "jabs" or sweeps with a D-frame net. The students, making at least 20 jabs, sample each habitat type. All macroinvertebrates are preserved and identified to the family level in the classroom. The identified invertebrates are preserved in labeled vials. From the identifications, biomonitoring indices are calculated to rank stream health. Anoka Conservation District (ACD) staff oversee fieldwork and check student identifications before any analysis is done.

Biomonitoring Indices

Indices are mathematical calculations that summarize tallies of identified macroinvertebrates and known values of their pollution tolerance into a single number that serves as a gauge of stream health. The indices listed below are used in the biomonitoring program, but are not the only indices available. No single index is a complete measure of stream health. Multiple indices should be considered in concert.

Taxa Richness and Composition Measures

Number of Families: This is a count of the number of taxa (families) found in the sample. A high richness or variety is good.

EPT: This is a measure of the number of families in each of three generally pollution-sensitive orders: Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies). A high number of these families is good.

Tolerance and Intolerance Metrics

Family Biotic Index (FBI): The Family Biotic Index summarizes the various pollution tolerance values of all families in the sample. FBI ranges from 0 to 10, with LOWER values reflecting HIGHER water quality. Each macroinvertebrate family has a unique pollution tolerance value

Key to interpreting the Family Biotic Index (FBI)

Family Biotic Index (FBI)	Water Quality Evaluation	Degree of Organic Pollution
0.00 - 3.75	Excellent	Organic pollution unlikely
3.76 - 4.25	Very Good	Possible slight organic pollution
4.26 - 5.00	Good	Some organic pollution probable
5.01 - 5.75	Fair	Fairly substantial pollution likely
5.76 - 6.50	Fairly Poor	Substantial pollution likely
6.51 - 7.25	Poor	Very substantial pollution likely

Population Attributes Metrics

% EPT: This measure compares the number of organisms in the EPT orders (Ephemeroptera - mayflies: Plecoptera - stoneflies: Trichoptera - caddisflies) to the total number of organisms in the sample. A high percent of EPT is good.

% Dominant Family: This measures the percentage of individuals in the sample that are in the sample's most abundant family. A high percentage indicates low evenness (one or a few families dominate, and all others are rare).

2022 Monitoring groups and locations

Monitoring Group	Stream
Forest Lake Area Learning Center	Clearwater Creek
Totino Grace High School	Rice Creek
St. Francis High School	Rum River (North)
Anoka High School	Rum River (South)