Appendix G - Groundwater

Groundwater Section - Blue Earth County Water Management Plan

Water Contaminants

Groundwater Quantity and Use

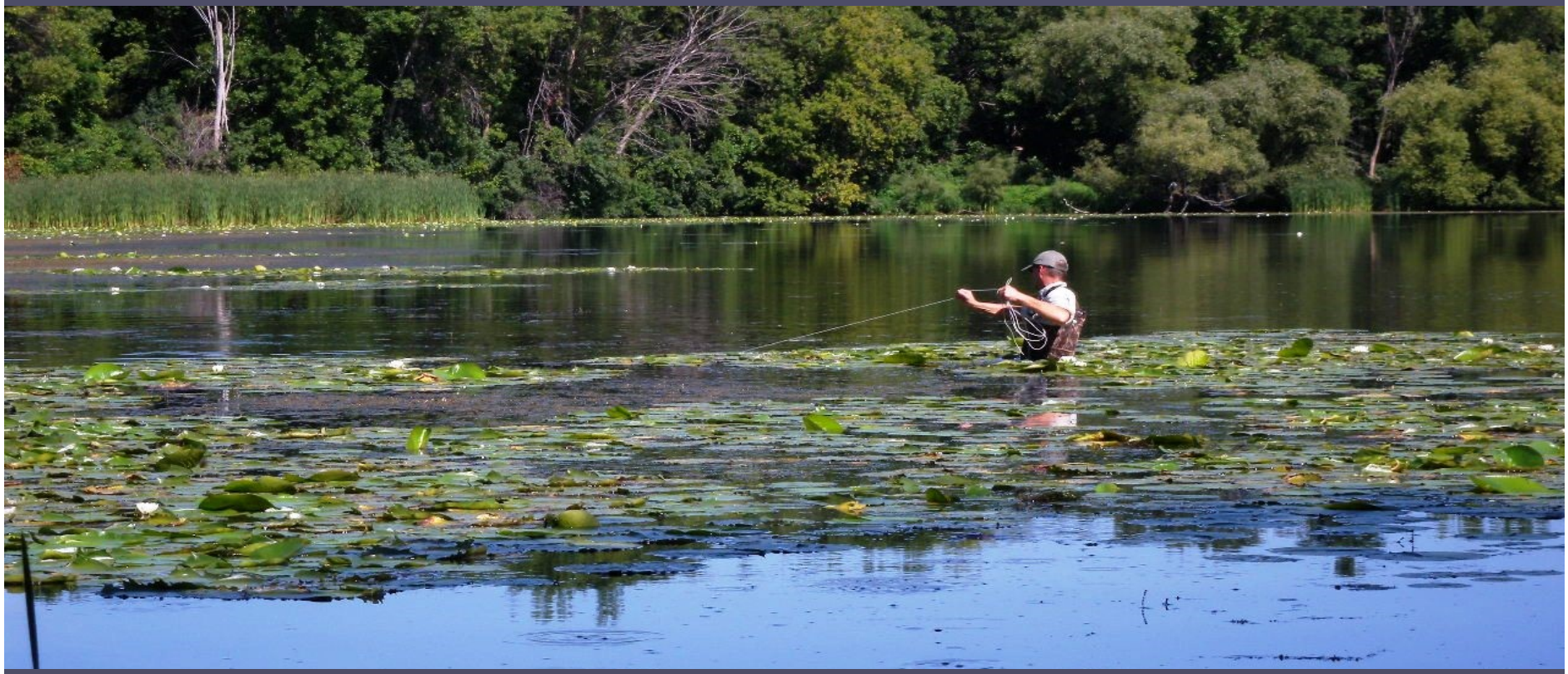
Ground and Drinking Water Quality

Private and Non-Community Wells

Public Water Supplies

Drinking Water and Groundwater Protection Goals

Blue Earth County Water Management Plan 2017-2026
Groundwater Section



Appendix G — Groundwater
Blue Earth County Land Use Plan

Priority Concern: Groundwater

Groundwater Contaminants

Water Contaminants

Common groundwater contaminants are bacteria, nitrate, hazardous substances such as petroleum, chemicals and naturally-occurring arsenic and magnesium.

Bacteria

Most of Minnesota's groundwater is free of disease-causing organisms, because water is filtered by upper layers of soil and rock as it soaks into the ground. To maintain this protection of groundwater, there must be:

- Proper well construction
- Proper well maintenance
- Prompt sealing of unused wells
- Regular water testing

Well Construction

Since 1974, Minnesota has regulated well related activities, including the construction of new wells. Wells must be separated from sources of contamination, such as sewers and septic systems. When wells are drilled, disinfectant chlorine must be added to the drilling fluid, and the well casing must consist of approved materials and assembled watertight. In addition, the space between the drill hole and the well casing must be grouted watertight with a bentonite slurry or cement. The top of the well must extend at least 12 inches above the ground surface, and be covered with an approved watertight well cap or seal.

Many old wells in Minnesota do not meet the current sanitary standard**s** for well construction and location, or they have deteriorated to the point where they can no longer keep surface contaminants out of the water. Examples of unsafe wells include old dug wells with leaking casing joints, rotten boards for covers, wells in well pits which are susceptible to flooding, wells with holes corroded through the casing, and wells too close to contamination sources such as municipal sewers or septic systems. These unsafe wells can present a very real health threat and can be a threat for safety. They need to be properly sealed by a licensed well contractor and replaced with a new, properly constructed well.

Maintenance

Modern, properly constructed wells require remarkably little regular maintenance. It is important, however, to protect the top of the casing from physical damage, especially from bumping by cars, snow plows, riding mowers, etc. The well cap should be securely fastened and the entry point for pump wiring properly sealed. Disinfection of the well with chlorine is required any time it is opened up for service. (To protect the well from chemical contamination, store paints; gasoline; and lawn, agricultural, and other household chemicals as far from the well as possible.)

Well Sealing

Unused wells provide an open channel for disease organisms and other contaminants to travel deep into the ground, by-passing the natural filtration which occurs when water moves through soil and rock. State law requires all unused wells to be either:

- sealed by a state licensed well contractor,
- restored to service, or
- maintained under a state issued annual maintenance permit.

Well Testing

New wells can operate for many years without showing signs of bacterial contamination, but there are no guarantees. The Minnesota Department of Health (MDH) recommends private wells should be

tested at least **once a year** for bacterial safety. It is also wise to test well water any time the water changes in taste, odor, or appearance.

Public Health and Nitrates

Too much nitrate in drinking water poses a risk to infants less than six months of age. If an infant is fed water or formula made with water that is high in nitrate, a condition called "blue baby syndrome" (or "methemoglobinemia") can develop. Bacteria which are present in an infant's stomach can convert nitrate to nitrite (NO_2), a chemical which can interfere with the ability of the infant's blood to carry oxygen.

The federal drinking water standard for nitrate is 10 mg/L of nitrate-nitrogen, which provides newborns with reasonable protection against blue baby syndrome. This level is mandatory for all public water systems, and recommended for private wells.

Natural levels of nitrate in Minnesota groundwater are usually quite low (less than 1 milligram per liter [mg/L] of nitrate-nitrogen). Nitrate is a nitrogen-oxygen compound that is found naturally in very low concentrations in ground and surface water but in much higher concentrations in areas affected by human activities.

Certain geologic settings, such as sand and gravel deposits and shallow limestone formations, are more prone to nitrate contamination of groundwater; in addition, certain types of wells (shallow wells, hand-dug wells, tile wells, and un-grouted or improperly grouted wells) are more vulnerable to nitrate contamination.

Nitrate in drinking water is a public health concern. Nitrate is also an environmental concern for aquatic organisms, and it contributes to hypoxia or the “dead zone” in the Gulf of Mexico. Nitrate is an essential plant nutrient critical for crop production; it can be present in fertilizers or produced by microorganisms in the soil from organic and inorganic nitrogen sources. It is also made by microorganisms as they break down sewage or manure.

Public water systems are monitored regularly for nitrate and other contaminants as part of the Safe Drinking Water Act. Any public supplier that exceeds the drinking water standard of 10 milligrams per liter (mg/L) must take corrective actions, which include notifying residents of the situation and possibly supplying them with a different source of water, such as bottled water. These systems must explore options and develop a way to reduce the nitrate levels in the water.

Private Wells

Wells most vulnerable to nitrate contamination include shallow wells, dug wells with casing which is not watertight, and wells with damaged, leaking casing or fittings.

Municipal Community Water Suppliers

All community water suppliers in the county consistently provide water to consumers that are below 10 milligrams per liter of nitrate-nitrogen as required by the Safe Drinking Water Act.

Impacts of Nitrate on Community Public Water Systems

A growing number of public water systems in Minnesota are concerned about increasing nitrate levels in their source water and are managing for nitrate using treatment and other options, including managing land use, taking a well out of service, drilling a new well, connecting to a nearby public water system, and blending high-nitrate water with lower-level nitrate water. (Source: Minnesota Department of Health)

Lead

Well water in Minnesota usually does not contain detectable levels of lead. The sources of lead in drinking water are the pipes and other components (such as faucets, valves, or fittings) in the household plumbing that may contain lead. If household plumbing does contain

lead, lead may dissolve into the water. The longer the water stands idle in the plumbing pipes and components, the more lead that can dissolve into the water. The most common cause for elevated lead levels in drinking water are:

- Lead pipes, which are typically the worst contributor to elevated lead levels.
- Lead solder, which was used in the past to join copper pipes, but has been illegal in Minnesota since 1985.
- Brass components such as faucets, coolers, and valves. Although brass usually contains low lead levels of 8 percent or less, it can still dissolve lead into the water, especially during the first few months of use.
- Wells drilled over 20 years ago may contain lead "packers" above the well screen. Some brands of submersible pumps manufactured before 1995 may contain leaded-brass components. Since January of 1995, all submersible pump manufacturers in America have agreed not to use leaded-brass components in submersible pumps.

Concerned about Lead?

Use Only Cold Water for Cooking and Drinking and
Let the water run for at least 60 seconds before using

Hot water dissolves lead more quickly than cold water. Water from hot-water faucet should not be used for cooking or drinking. It is especially important not to use the hot water for making baby formula.

Source: Minnesota Department of Health

Naturally Occurring Contaminants

Some chemicals present in water, such as arsenic and manganese, are naturally occurring but can potentially pose a human health risk.

Arsenic

Arsenic is a part of the earth's crust and occurs naturally in soil and rock. Arsenic from soil and rock can dissolve into groundwater, the primary source of drinking water for much of Minnesota. When arsenic occurs in well water, the source is almost always a natural source. According to the MDH, arsenic can occur in groundwater just about anywhere in Minnesota. Arsenic levels can vary from one well to the next, even within a very small area.

Arsenic in water has no taste or odor, so the only way to know if your well water contains arsenic is to have it tested. While well owners are not required to test existing private wells for arsenic, MDH recommends that every well be tested for arsenic at least once.

Beginning in 2008, State regulations now require licensed water well contractors (and anyone constructing a new well for his or her personal use) to have the water from each new drinking water well tested once for arsenic. The test result must be provided to the well owner before placing the well into service.

Human activities can sometimes contribute to arsenic in groundwater, as well as in soil and air. While arsenic is not in common use today, it was once an ingredient in some pesticides, and residues remain from past use and improper disposal. Until January 2004, arsenic-based wood preservatives were used to treat some wooden foundations, decks, and children's play structures. Arsenic from these sources does not usually move very far in the environment.

Manganese

Manganese (Mn) is considered a trace beneficial element, which means that low levels of manganese are a benefit to humans.

However, high exposures to Manganese can also harm the nervous system. At this time the State does not require manganese testing.

Manganese and Arsenic Testing

In preparing the *Geologic Atlas for Blue Earth County, Part B*, the MNDNR tested 93 wells throughout the county. The wells tested were in a wide range of aquifers to better understand groundwater movement and pollution sensitivity in the county. In addition to groundwater levels and movement, the MNDNR tested water samples for two naturally occurring contaminants: arsenic and manganese.

Arsenic water sampling results

Twenty-two of the groundwater samples (24 percent) exceeded the federal drinking water standard of 10 parts per billion (ppb) for arsenic (MDH, 2012). Elevated arsenic concentrations in deeper buried sand aquifers appear to be relatively rare. Only 4 of the 22 samples (19 percent) from aquifers associated with older glacial sediment exceeded the federal limit. Only 2 out of 37 bedrock water samples (5 percent) equaled or exceeded the federal limit of 10 ppb.

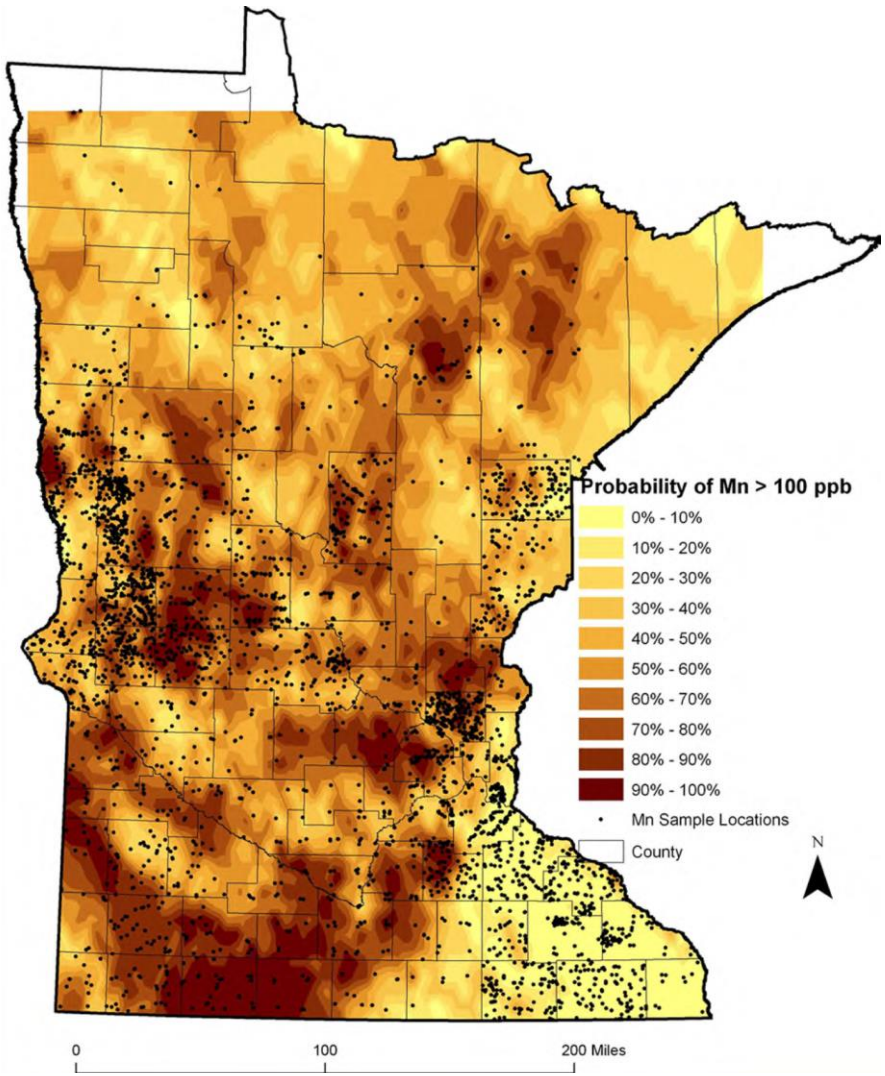
Manganese water sampling results

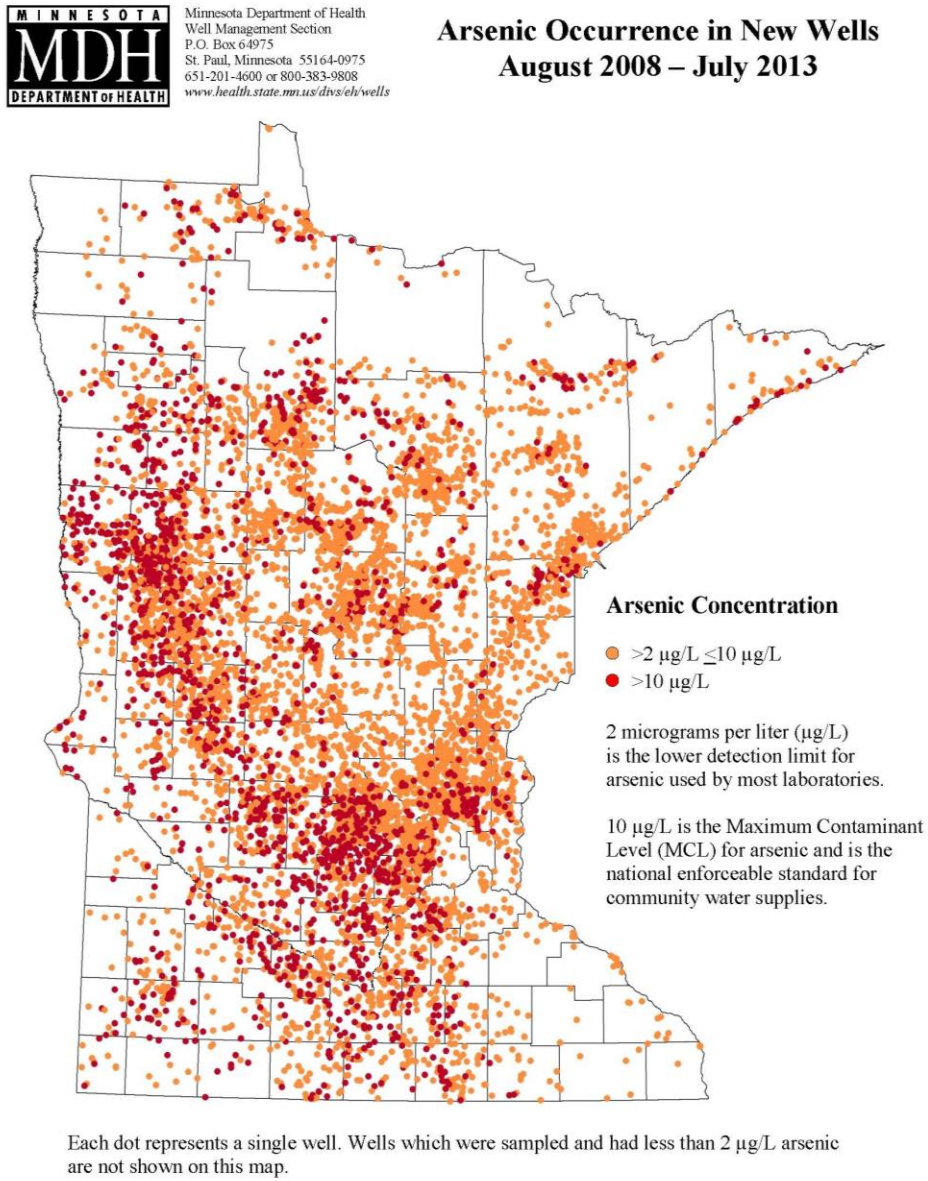
A large proportion of groundwater samples (74 samples, 80 percent) contained manganese concentrations that exceeded the lower proposed MDH Health Risk Limit (HRL) established for infants (100 ppb) indicating a natural water quality issue for the majority of well owners in the county. The standard for adults is 300 ppb. Low levels of manganese are a benefit to humans, but high exposures can harm the nervous system (MDH, 2012).

The following MDH maps show arsenic occurrence in new wells and the probability of manganese greater than 100 ug/L in Minnesota groundwater.

Probability of manganese greater than 100ug/L in Minnesota groundwater.

Probability of Manganese >100ug/L in Minnesota Groundwater.
Source: Minnesota Department of Health





Contaminants of Emerging Concern

Contaminants of emerging concern are substances that have been released to, found in, or have the potential to enter Minnesota waters (groundwater or surface water) and:

- do not have Minnesota human health-based guidance (how much of a substance is safe to drink);
- pose a real or perceived health threat; or
- have new or changing health or exposure information.

They can include pharmaceuticals, pesticides, and industrial effluents, personal care products that are washed down drains and processed by municipal wastewater treatment plants, SSTS, and others.

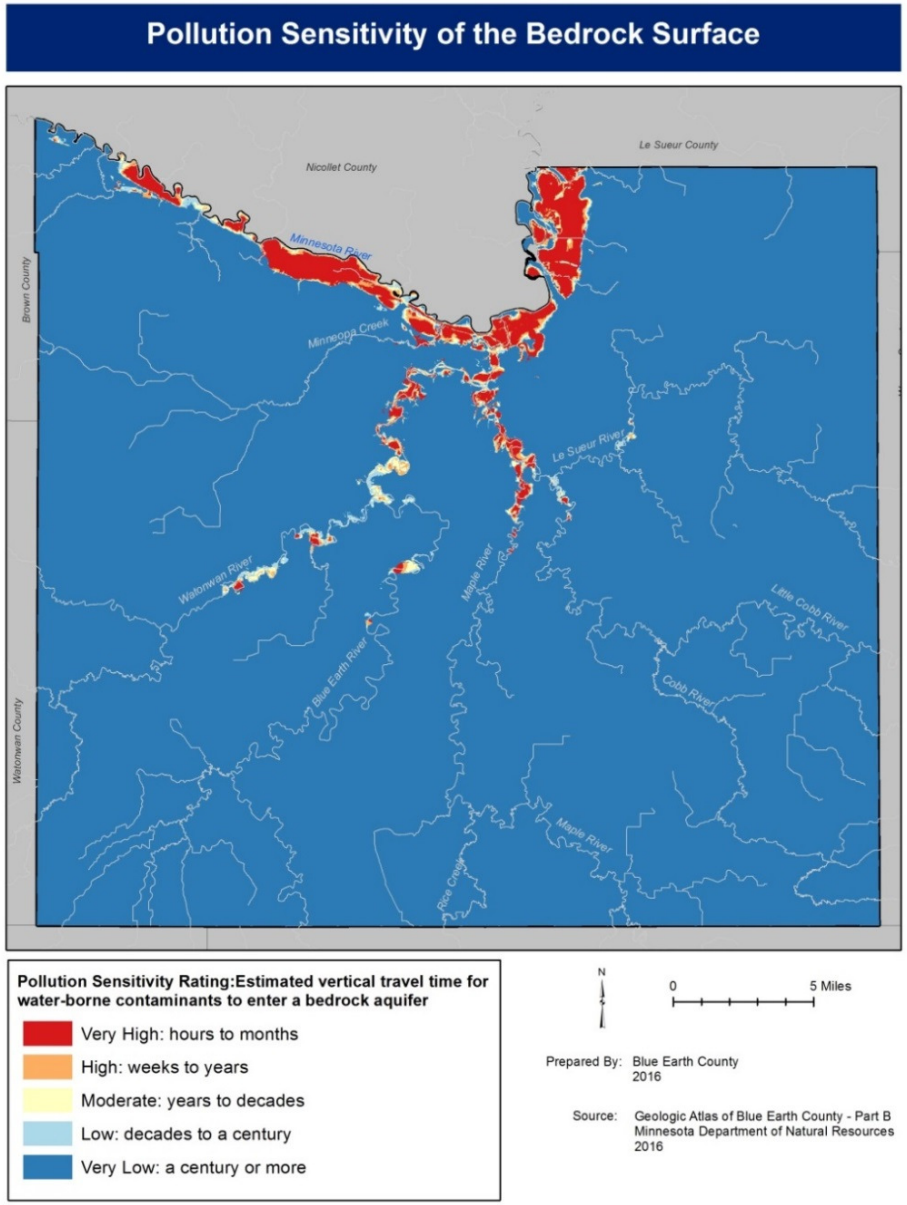
New contaminants are being found in Minnesota waters. This is due, in part, because:

- there are better methods for finding substances at lower levels;
- additional substances are being looked for;
- new substances are being used; and
- old substances are being used in new ways.

Petroleum Storage Tanks

Underground storage tank (UST) systems that contain petroleum or hazardous waste are a potential threat to water quality. The MPCA regulates the design and operating rules for UST systems including piping and dispensers. The County has no regulatory control over UST systems. According to the MPCA, the volume of contaminants leaking from failing tanks has been significantly reduced since the implementation of regulatory controls.

Above-ground storage tank (AST) systems that contain petroleum or hazardous waste are very safe when properly designed and operated.



However AST systems are subject to construction flaws, corrosion, cracking, weld and valve failures, spills during transfers, and occasionally tank rupture. When AST systems leak or spill, the stored substances may flow into lakes and rivers, migrate through the soil to the water table, or catch fire, thereby contaminating soil, groundwater, or surface water and creating hazards to aquatic life and human health.

AST systems which store liquid substances that may pollute the waters of the state are regulated by Minnesota Rules, part 7151, if site capacity is less than one million gallons. Larger facilities (facilities with a capacity of one million gallons or more) are regulated by permits negotiated with MPCA. The goal of regulating AST systems is to prevent spills and leaks by providing storage tank owners with various safeguard options.

Class V Injection Wells

Class V Injection Wells are regulated by the Federal government. The EPA has inspected many businesses in Blue Earth and other counties to determine if Class V floor drains were present. The EPA has ordered business owners to correct violations and the EPA has conducted follow up inspections to ensure the violations were resolved.

Dry wells, cesspools, and septic system leach fields taking floor drain wastes are examples of simple Class V wells. Because Class V floor drains often provides little or no pretreatment and fluids are injected directly into or above an underground source of drinking water, proper management is important. Most Class V wells are "low-tech" and depend on gravity to drain fluids directly below the land surface. (Source: EPA)

Examples of "low-tech" Class V injection wells that typically rely on gravity drainage include:

- **Motor vehicle disposal wells** include vehicle repair home businesses, new and used car dealers, boat yards, auto body shops, farm machinery dealers, where service floor drains or sinks lead to a septic system or otherwise discharged into the ground. Motor vehicle disposal wells are banned. Holding tanks or sanitary sewer systems are required.
- **Carwashes** where wastewater enters a floor drain that leads to a dry well or septic system

The County addresses potential Class V injection wells when issuing land use permits. Holding tanks are recommended for commercial garage floor drains.

Transportation of Hazardous Waste and Hazardous Waste Spills

Hazardous wastes are transported throughout the county by truck, rail and pipelines. The movement, loading, and off-loading of hazardous wastes pose potential threats of accidents, leaks, and spills. To reduce spill incidents and volume the Minnesota Legislature passed MN Chapter 115E, Oil and Hazardous Substance Discharge Preparedness. This requires hazardous waste transporters to prepare and train to respond to petroleum and chemical spills. Pipelines, trucking, and railroad businesses that transport more than 100,000 gallons of hazardous waste per month are mandated to develop spill prevention and preparedness plans.

When a spill does occur, State agencies and the party responsible for the spill are required to ensure environmental protection. Public safety is the responsibility of local first responders. All spills that have the potential to impact the environment must be reported to the State of Minnesota Office of Public Safety (Minnesota State Duty Officer) within 24 hours. The MPCA oversees the initial response and cleanup of non-agricultural spills, and the MDA oversees the clean-up of agricultural chemical spills.

Pipelines are regulated by the U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration. The MPCA is responsible for responding to pipeline release incidents and local first responders are responsible for public safety. The County does not have direct pipeline regulatory authority, but does have the opportunity to review permit applications and comment on what efforts should be made to protect groundwater.

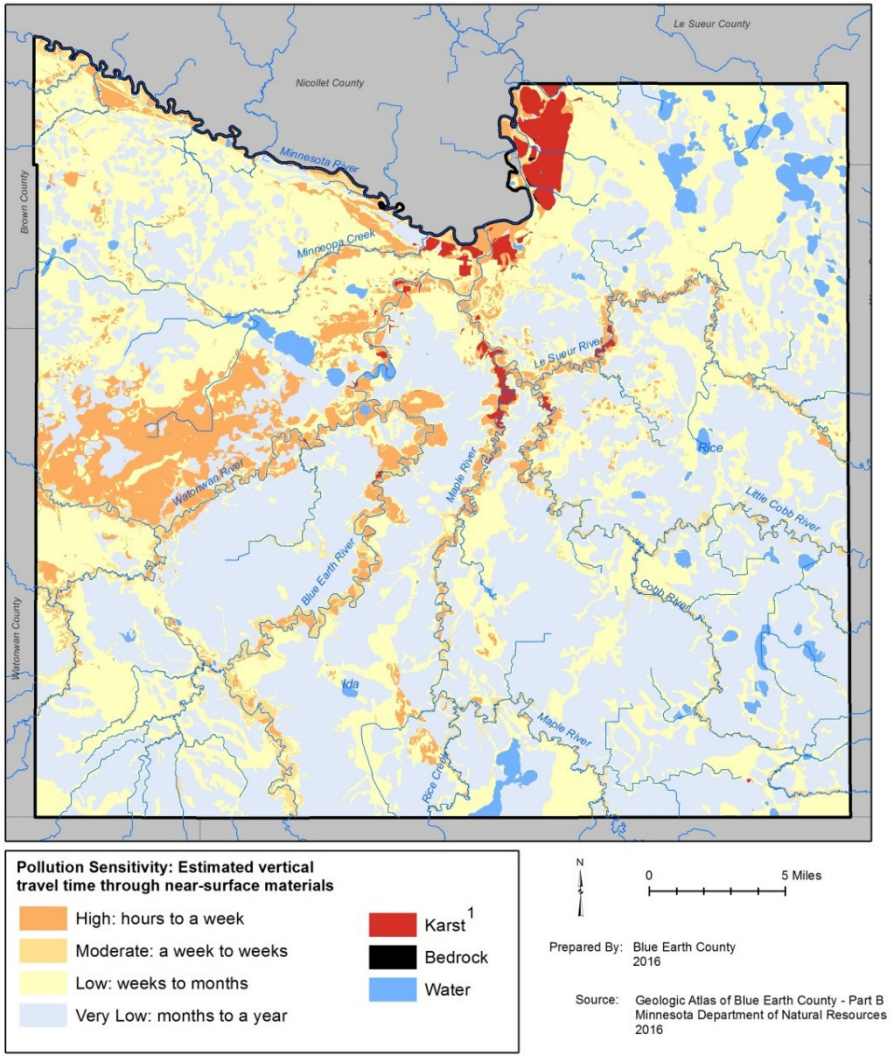
Blue Earth County Hazardous Waste Programs

Improperly handled hazardous waste has contaminated soil and groundwater in localized areas of Blue Earth County. The majority of hazardous waste releases that have contaminated groundwater occurred prior to the implementation of Federal and State regulations in the 1980s. Properly managed hazardous wastes should not pose a threat to groundwater.

Household Hazardous Waste

The County operates a Household Hazardous Waste (HHW) program and facility. The HHW facility provides a separate collection system for residents to dispose of common products such as paints, solvents, and petroleum wastes. The HHW program is important in reducing potential groundwater pollution by giving alternatives to residents who might otherwise dispose of hazardous waste down drains, septic systems, storm drains, ditches, alleys and in back yards.

Pollution Sensitivity of Near-Surface Materials



1 Karst allows a direct, very rapid exchange between surface water and groundwater and significantly increases groundwater contamination risk from surface pollutants.

This pollution sensitivity model assumes a 10-foot-deep water table and vertical travel of possible pollutants through unsaturated, near-surface materials.

Medicine Collection Program

The County started a Medicine Collection Program in December 2011. This program provides a method for the safe disposal of medication to keep these contaminants out of our groundwater. Between December 2011 and February 2016, 6,623.7 pounds of medicine have been collected for proper disposal to protect human health and the environment.

Locations

Blue Earth County Justice Center: A collection box is located in the lobby of the Sheriff's Department at the Blue Earth County Justice Center (401 Carver Road, Mankato, MN) open during business hours, 8:00 am to 5:00 pm, Monday – Friday.

Mankato Public Safety Center: A 24-hour collection box is located at the Mankato Public Safety Center (710 S. Front Street, Mankato, MN).

Very Small Quantity Generator Program

The County's Very Small Quantity Generator (VSQG) program helps businesses dispose of hazardous waste safely and affordably. Small quantity generators refers to the amount of hazardous waste generated, not the size of the company or institution. To be a VSQG, a business or organization must generate 660 pounds of hazardous waste or less per year. Wastes are accepted from businesses at the HHW facility only by appointment.

Farm Waste Drop Off

Farmers with old pesticides and herbicides may bring them to the Household Hazardous Waste Facility during regular hours for residential drop off.

Groundwater Quantity and Use

Water Use

Water use and ground water recharge have become a growing concern as general awareness of the value and limited availability of quality ground water increases. When compared with other natural resources needs and services, access to good quality drinking water is the number one priority for most people. Heavy water users, including for the production of ethanol recently, has raised concerns. Use of good quality ground water aquifers for snow making and lawn sprinkling is also criticized. A greater understanding of ground water supplies at the local, County and regional scale is needed to develop plans and policy to protect ground water.

Water Appropriations

The Minnesota Department of Natural Resources (MNDNR) is responsible for monitoring the utilization of both the ground and surface water. MNDNR water appropriation permits are required when either a designated public surface water is affected or the volume of groundwater exceeds either 10,000 gallons per day or 1 million gallons per year.

Minnesota's water appropriation law was first enacted in 1937. The purpose of the original act was to establish a water policy for the state and a permit system to regulate water users. The Water Appropriation Permit System is designed to control the use of the resource and to ensure that water use conflicts are avoided if possible. In 1973, the Minnesota Legislature established a priority system for water use to allocate water equitably to riparian owners when a water supply was limited. This priority system was revised in 1989 by the Legislature with the first priority being domestic water supplies and contingency power production as specified by law. The MNDNR

Minnesota Water Allocation Priorities
Minnesota Statute 103G.261

The commissioner shall adopt rules for allocation of waters based on the following priorities for the consumptive appropriation and use of water:

(1) first priority, domestic water supply, excluding industrial and commercial uses of municipal water supply, and use for power production that meets the contingency planning provisions of section 103G.285, subdivision 6;

(2) second priority, a use of water that involves consumption of less than 10,000 gallons of water per day;

(3) third priority, agricultural irrigation, and processing of agricultural products involving consumption in excess of 10,000 gallons per day;

(4) fourth priority, power production in excess of the use provided for in the contingency plan developed under section 103G.285, subdivision 6;

(5) fifth priority, uses, other than agricultural irrigation, processing of agricultural products, and power production, involving consumption in excess of 10,000 gallons per day; and

(6) sixth priority, nonessential uses.

Appropriation and use of surface water from lakes of less than 500 acres in surface area must be discouraged.

The treatment and reuse of water for nonconsumptive uses shall be encouraged.

recently implemented a preliminary assessment and approval prior to drilling a well which will require a water appropriation permit.

MNDNR Water Appropriation Permits in Blue Earth County

The MNDNR list of 2016 water appropriation permits in the county shows there are many large water users. The following is a list of types of users with water appropriation permits in the county in 2016.

Summary of 2016 MNDNR Water Appropriation Permits by Permit Use Type

Permit Use Type	Permits
Livestock Watering	24
Agricultural Crop Irrigation	22
Municipal/Public Water Supply	11
Golf Course Irrigation	4
Sand and Gravel Washing	3
Commercial/Institutional Water Supply	2
Private Water Supply	2
Sand/Gravel Pit Dewatering	2
Thermoelectric Power Cooling - Once Through	2
Agricultural/Food Processing	1
Aquaculture	1
Fire Protection Water Supply	1
Landscaping/Athletic Field Irrigation	1
Metal Processing	1
Mine Processing (excludes sand/gravel)	1
Quarry Dewatering	1
Snow/Ice Making	1
Sod Farm Irrigation	1
Total	**81**

Since 2007, the largest increase in water appropriation permits is for agricultural crop irrigation and livestock watering. In 2007 there were five water appropriation permits for crop irrigation, and there were 22 in 2016. The increase in MNDNR water appropriations for livestock watering is due to changes in MNDNR water appropriation permit requirements.

Water appropriation permit holders are required to report water use to the MNDNR annually. The *Geologic Atlas of Blue Earth County, Part B*, shows water use of aquifers as reported by water appropriation permit holders of various types. The table on the following page shows water use in the county in 2013 as reported to the MNDNR by permit holders.

Water Use Conflicts

There has been one water use conflict confirmed by the MNDNR. The water use conflict to be verified by the MNDNR was with Mount Kato snowmaking and a residential well more than 25 years ago.

2013 Water Appropriation Permit Use
Source: *Geologic Atlas of Blue Earth County, Part B*

	Aquifer Water Use – Million Gallons Per Year (MGY)				
Water Use Category	**Surficial Sand – Quaternary Water Table Aquifer**	**Buried Sand and Gravel Quaternary Artesian Aquifer**	**Bedrock**	**Total (MGY)**	**Percent**
Waterworks (municipal& private)	856	-	1,313	**2,169**	**56.9**
Industrial or commercial	-	-	1,396	**1,396**	**36.6**
Irrigation	-	160	32	**192**	**5**
Other*	-	10	47	**57**	**1.5**
Total (MGY)	**856**	**170**	**2,788**	**3,814**	
Total (Percent)	**22.4**	**4.5**	**73.1**		

Flowing Wells

Although not considered geologically sensitive areas by virtue of the soil cover, the unrestricted flow from old existing flowing wells is a waste of ground water resources. A flowing well with only 1.9 gallons of water per minute flow will waste nearly 1 million gallons of water in one year.

There are four general areas of the county where flowing wells present special circumstances relative to well construction and ground water conservation. These areas are generally located in the following areas:

Hungry Hollow: Hungry Hollow describes an area south of Mankato which is situated along the Le Sueur River in Sections 33 and 34 of Mankato Township (T108N-R26W) and Section 3 and 4 of Decoria Township (T107N-R26W). This river bottom is capable of producing 500 gallons per minute flows from five inch domestic wells. Double cased and grouted well construction must be employed to ensure the flow can be safely contained.

Big Cobb River: The Big Cobb River Valley, in the vicinity of the unincorporated community of Beauford has numerous small flowing wells that are developed in the glacial drift. While none have significant flows, it is an area requiring special well construction.

Maple River: A significant portion of the Maple River system that flows through Mapleton and Sterling Townships also has several small flow glacial drift wells. The situation is similar to those found in the Beauford area.

Judson and Cambria Township: Flowing wells are observed in the Minnesota River valley.

Flowing Well Description

Flowing groundwater is water that is found beneath the surface of the earth and has saturated the pore spaces in unconsolidated geologic materials and bedrock and in fractures in bedrock. Groundwater is usually recharged from water which has percolated through the soil from precipitation on the land surface or from bodies of water. Groundwater can flow from points of higher elevation or pressure to points of lower elevation or pressure.

An aquifer is a geologic formation, either unconsolidated material like sand and gravel or permeable bedrock, which readily transmits water and is tapped for supplying groundwater to water-supply wells. In some cases, the groundwater may be under pressure because the aquifer is overlain by a confining layer, such as clay or shale. The confining layer retards the movement of groundwater and pressure can then build up within the aquifer. This condition can occur when the aquifer is recharged at a point of higher elevation than the location where the aquifer is under pressure. When a well (or boring) taps the underlying aquifer, the water level will rise in the well to a level above the top of the aquifer. This type of well is an artesian well. If the water level rises in the well to an elevation above the land surface, the well will actually flow. This well is referred to as a flowing artesian well.

The figure at left from the MDH depicts the hydro-geologic conditions causing flowing artesian wells.

Problems with Flowing Wells

Pressures and flows in flowing wells can vary from slightly more than atmospheric pressure and flows less than one gallon per minute to tens of pounds of pressure and flows of hundreds or thousands of gallons per minute. Flowing artesian wells can present major problems for casing completion and sealing of wells and borings. Uncontrolled flows can cause land erosion and land subsidence, pose safety concerns, damage drilling equipment and structures, and waste groundwater. Un-grouted casings can allow water to migrate up the outside of the casing, causing bore hole erosion and uncontrolled flows. Once a flow becomes uncontrolled, it can be difficult or impossible to regain control.

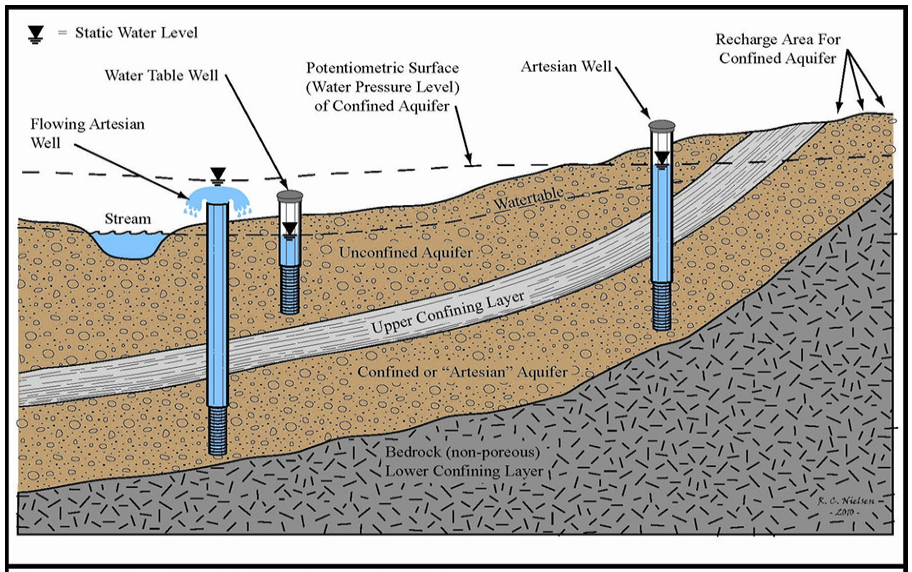


Figure 1. Terms Relating To Flowing Artesian Wells

Rules Pertaining to Flowing Wells and Borings

A well or boring with flows above the ground surface must be constructed to prevent erosion of the aquifer and the confining layer. The Minnesota Well Code requires casing be installed into the flowing aquifer to prevent water migrating up outside the casing.

The Minnesota Department of Health (MDH) has the authority to designate a Flowing Well and Boring Special Construction Area in a geographic area where high flow and high pressure conditions have been widely reported and flowing wells and borings have occurred.

Contractors installing a well or boring within the designated area must follow the construction requirements in Minnesota Rules, part 4725.3450.

Mount Simon Aquifer

All users of the Mount Simon Aquifer are required to participate in Mount Simon user group. The City of Mankato and local commercial/industrial users are part of the user group. A goal of the user group is to support monitoring the Mount Simon Aquifer as well as reduce water use from the aquifer. The MNDNR prepared two Mt. Simon reports. Excerpts from those reports are included to describe this aquifer and recharge areas.

South-Central Minnesota Groundwater Monitoring of the Mt. Simon Aquifer, MNDNR 2012

The deepest bedrock aquifer of south central/southeastern Minnesota, including the Minneapolis/St. Paul metro area, is the thick (50 to 200 feet) Cambrian sandstone Mt. Simon aquifer. It supplies all or some of the water used by over one million Minnesotans. The few water level measurements available from this aquifer in the Mankato and Minneapolis/St. Paul metro area indicate declining water levels in areas where water is being withdrawn for municipal and industrial use. To better understand the recharge dynamics of the Mt. Simon aquifer the western and northern edge of the Mt. Simon aquifer, where it is not overlain by relatively impermeable Paleozoic shale formations, was considered the most likely area for aquifer recharge. This edge of the Mt. Simon aquifer was investigated and characterized through observation well installations, water level monitoring, groundwater chemical analysis, and aquifer capacity testing to help determine recharge pathways and sustainable limits for this aquifer. Most data collected for this study are derived from the wells installed at 14 locations by contracted drilling companies.

The combinations of chemical residence time indictors, continuous water level data from nested well locations, and a general knowledge of the regional hydrostratigraphy, show an aquifer with a very slow recharge rate from a large source area located south of the Minnesota River and a smaller source area located in the northern portion of the study area. The younger ^{14}C residence time values of Mt. Simon groundwater (7,000-8,000 years) from this project roughly correspond to a time after the last ice sheet had receded from southern Minnesota suggesting groundwater in the Mt. Simon aquifer in this region began as precipitation that infiltrated during the post-glacial period. The stable isotope data of oxygen and hydrogen support this conclusion. A recharge estimate of the Mt. Simon aquifer south of the Minnesota River based on these minimum residence time data suggests a recharge rate of approximately 0.49 cm/yr. The resulting 1.2 billion gallons/year of recharge from the southern source area is less than the amount of groundwater used from the most recent year for which data are available (2009). The results of this project suggest that Mt. Simon aquifer groundwater use in the study area, for the most recent period (2009), may be more than the replacement rate along the Mt. Simon subcrop. Continued monitoring of the observation wells in this region should help determine if more water is used than is being replaced by recharge.

A major accomplishment of this project is the creation of a network of observation well nests along the western margin of this aquifer system. Long term water level data and geochemistry from these wells will enable future hydrologists to evaluate the local and regional effects of Mt. Simon groundwater pumping in the region.

South-Central Minnesota Groundwater Monitoring of the Mt. Simon Aquifer – Phase 2, MNDNR 2013

This project has shown that the most critical recharge area for the Mt. Simon-Hinckley aquifer and Minneapolis-St. Paul metropolitan area water supply includes portions of Wright, Sherburne, and Isanti counties. Protection of this region from water pollution should be a high priority for all levels of government. Continued monitoring of wells installed for this investigation will create a long term record that can be used to interpret changes in local and regional water supply due to water use or climate changes.

Observation Wells

According the *Geologic Atlas of Blue Earth County, Part B*, there is only one active observation well in the county near Lake Crystal. Because this well was only recently constructed, no data were available in 2015 when the atlas was written.

An objective in the *Blue Earth County Water Management Plan 2008-2016* was to support MNDNR establishing more observation wells in the county. The County continues to support the establishment of additional observation wells.

Ground and Drinking Water Quality
Private Wells and Non-community Wells

The most effective ways to protect groundwater and prevent well contamination are:

- Wise management, use, storage and disposal of hazardous substances
- Proper well construction
- Sealing of unused wells

Blue Earth County Delegated Well Program

Since 1987, the Commissioner of Minnesota Department of Health (MDH) has had the authority to delegate specific responsibilities for the regulation of water wells, monitoring wells and/or dewatering wells to local boards of health (Minnesota Statutes 2017, section 103I.111). In 2016 nine boards of health (covering eight counties and two cities) had responsibility for wells within their jurisdictions. These delegated programs provide local permitting and inspection of well construction and sealing.

Blue Earth County was delegated by the MDH to administer the Minnesota Well Code in Blue Earth County in 1989. The County oversees the construction and sealing of private wells and noncommunity wells. The MDH oversees community wells, monitoring wells and borings, dewatering wells, elevator shafts, and geothermal wells.

Minnesota Well Code

Well Construction and Well Sealing

Minnesota's rules governing well construction were first adopted in July 1974. (Minnesota Rules, part 4725, the "Well Code") The rules establish minimum standards for the location, construction, repair, and ultimate sealing (closure) of wells and borings in Minnesota, to protect public health and the state's invaluable groundwater.

In Minnesota, a person or contractor who provides services for the construction, repair, and sealing of wells and some borings (elevator borings, environmental bore holes, exploratory borings, and vertical heat exchangers) must be licensed by the Minnesota Department of Health (MDH).

Blue Earth County is delegated by the MDH to administer the well code. Blue Earth County Environmental Services staff handles all permitting and inspections of private and noncommunity wells in the county, ensures that new wells meet separation distances from contaminant sources, and ensures that the required water tests are conducted by the well driller.

Well Location – Isolation Distances

Observing minimum isolation distances (also known as setback or separation distances) from contamination sources and well construction standards required under the Minnesota Well Code help ensure the quality of the well water remains high.

The County reviews isolation distances in conjunction with permit review to help ensure existing and proposed wells meet setbacks. Landowners are responsible for ensuring isolation distances are maintained.

Water Testing

New wells

When a new well is constructed, Minnesota law requires that the water be tested for coliform bacteria, nitrate, and arsenic. Arsenic testing was required for new wells starting in 2008. The contractor who constructs the well is responsible for obtaining a water sample and having it tested by a certified laboratory. The well contractor must provide the owner with a copy of the water sample results and Well and Boring Construction Record.

A water test tells the owner only about the water quality at the time the sample was taken. Ongoing water testing is the responsibility of the well owner.

Well Owner Responsibilities

Water Well Testing

Private well owners are responsible for maintaining their drinking water quality. Private well owners need to be well informed and diligent in caring for their drinking water.

Drinking water should be tested any time a well system is serviced, or whenever there is a change in taste, color, or odor. Groundwater pumped from some wells, in particular shallow or old wells may vary in quality during the year, especially after heavy rainfall or melting of snow. More frequent testing of old wells or wells that are less than 50 feet deep is recommended. There are many old wells in the county but only a few wells less than 50 feet deep are used for drinking water supplies. At a minimum, private wells should be tested for coliform bacteria once a year and for nitrate every two years. If nitrate has been detected previously, the well should be tested for nitrate every year. The following table shows the MDH water testing recommendations.

Minnesota Department of Health
Water Testing Recommendations for Private Wells

Test for	Annually	Every 2 years	Once
Total Coliform Bacteria	X		
Nitrate*	X	X	
Arsenic			X
Lead			X

*Test nitrate annually or every two years and always test before giving to an infant.
* If nitrate has been detected previously, the well should be tested for nitrate every year.

Maintenance

When a well is properly located, constructed, and maintained it can provide a reliable safe source for drinking, food preparation, irrigation, or for any purpose be it for domestic, agricultural, or commercial uses.

Landowners are responsible for maintaining the well to prevent groundwater contamination by:

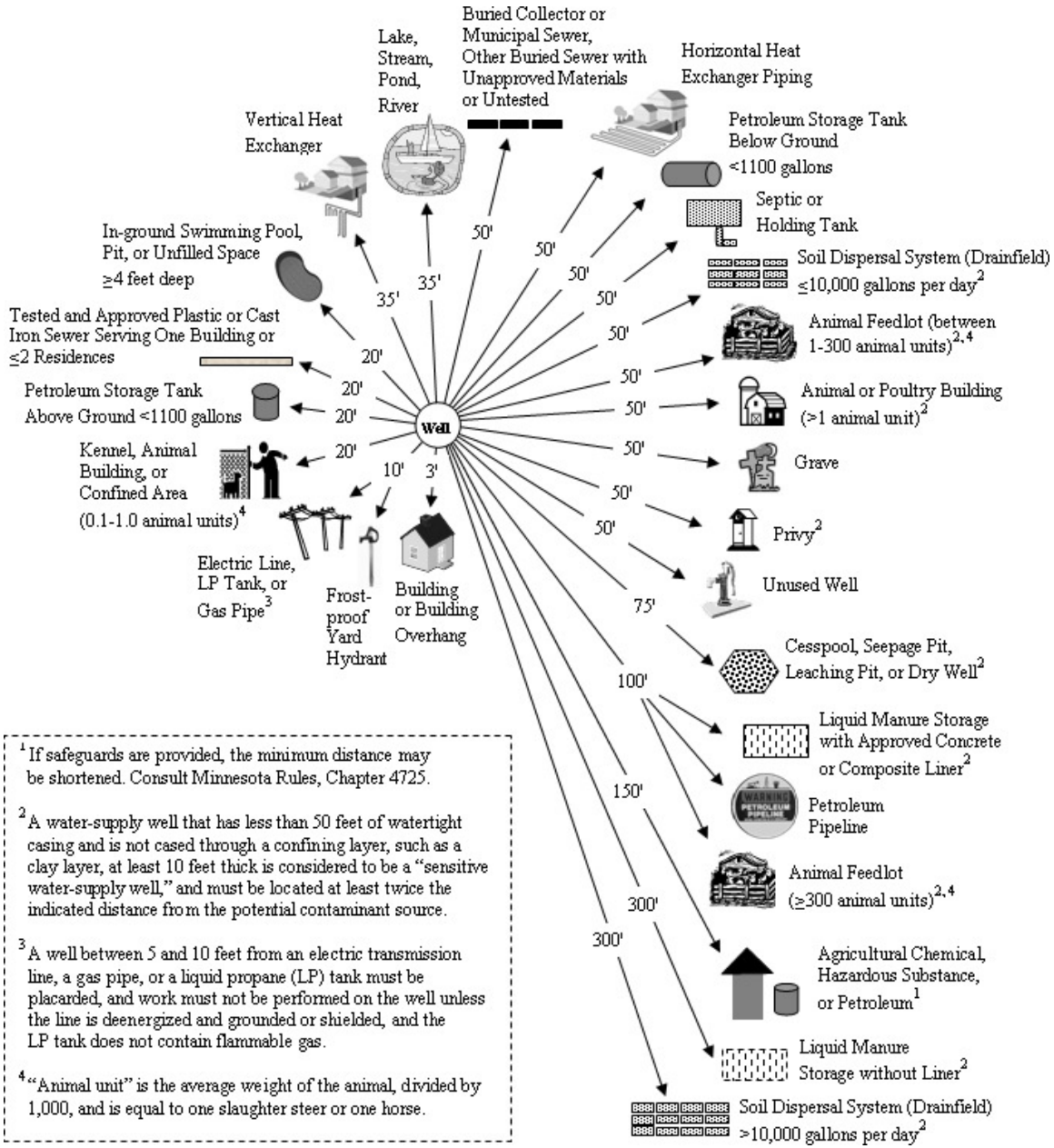
1. **Stopping Contaminants**
   - Keeping the top of the well at least 1 foot above the ground.
   - Not allowing runoff from the road, driveway, or rooftop to pond around the well.
   - Keeping the area around the well clear and free of debris, pet, and livestock wastes, hazardous chemicals, and any other potential pollutants.
   - Limit fertilizer and pesticide use in vicinity of wells.
   - Not disposing of wastes in dry wells or unused wells.

- Maintaining minimum setback or “isolation” distances from possible sources of contamination.

2. **Protecting the Wellhead**
   - Do not run into the well with lawn mowers, snowplows, or other equipment so as not to damage the wellhead or water distribution line. Mark the well location with a highly visible flag during winter.

3. **Routinely Inspect the Well**
   - Visually inspect the well for problems such as cracks, corrosion, loose wires, settling, or well casing damage.
   - Ensure the well cap is securely attached to the well casing, not broken or missing, and connections to the well are watertight.
   - Hire a licensed well contractor to inspect your well for defects every 10-15 years.

4. **Sealing Unused Wells**



Source: Minnesota Department of Health – (Minnesota Rules Chapter 4725 has a complete listing of Isolation Distances)

Unused and Abandoned Wells

Wells do not last forever. Abandoned wells are common in both developed, older areas of cities that are presently served by public water supplies and in older rural homesteads and farm fields. In cities and townsites, a well may have been a home or business's main water source before city water became available. Abandoned wells are also located in farm fields where wells were located to serve old farmsteads or previously pastured areas.

Unused or abandoned wells that have not been properly sealed can provide a direct pathway for contaminants to enter the groundwater aquifers, potentially threatening groundwater quality in other wells. Contaminants from surface water runoff, or sources, such as leaking sewers or septic system drainfields, can enter the well through casings that have deteriorated. Unused wells also pose a safety hazard, especially for children, pets, and livestock. In Minnesota it is illegal to dispose of wastes in an unused well, and it will result in additional costs to clean the well and possibly the groundwater before the well is sealed.

Well Sealing

According to Minnesota law, a well must be sealed in any of the following situations:

1) the well is contaminated and cannot be corrected;
2) the well has been improperly sealed in the past;
3) the well poses a threat to the health or safety of the public or to groundwater quality; or
4) the well is not in use and does not have a maintenance permit.

A water well is properly sealed when it is removed from service and is completely filled with grout (neat cement, bentonite or another MDH approved material). Only a licensed well contractor or a licensed well sealing contractor may seal a well. The contractor must seal the well in accordance with Minnesota law. Well owners cannot seal their own wells.

Legal Responsibilities - Well Disclosure Statement

When a home, farm, or other property is sold or transferred, Minnesota Statutes 2017, section 103I.235, requires that the seller of real estate to disclose the number and the status of all wells on the property and provide a sketch map showing the location of each well. The well disclosure statement indicates the location, number of wells, and if the well is being used or not used.

Well and boring sealing records are not available from the MDH County Well Index online.

Local Well Sealing

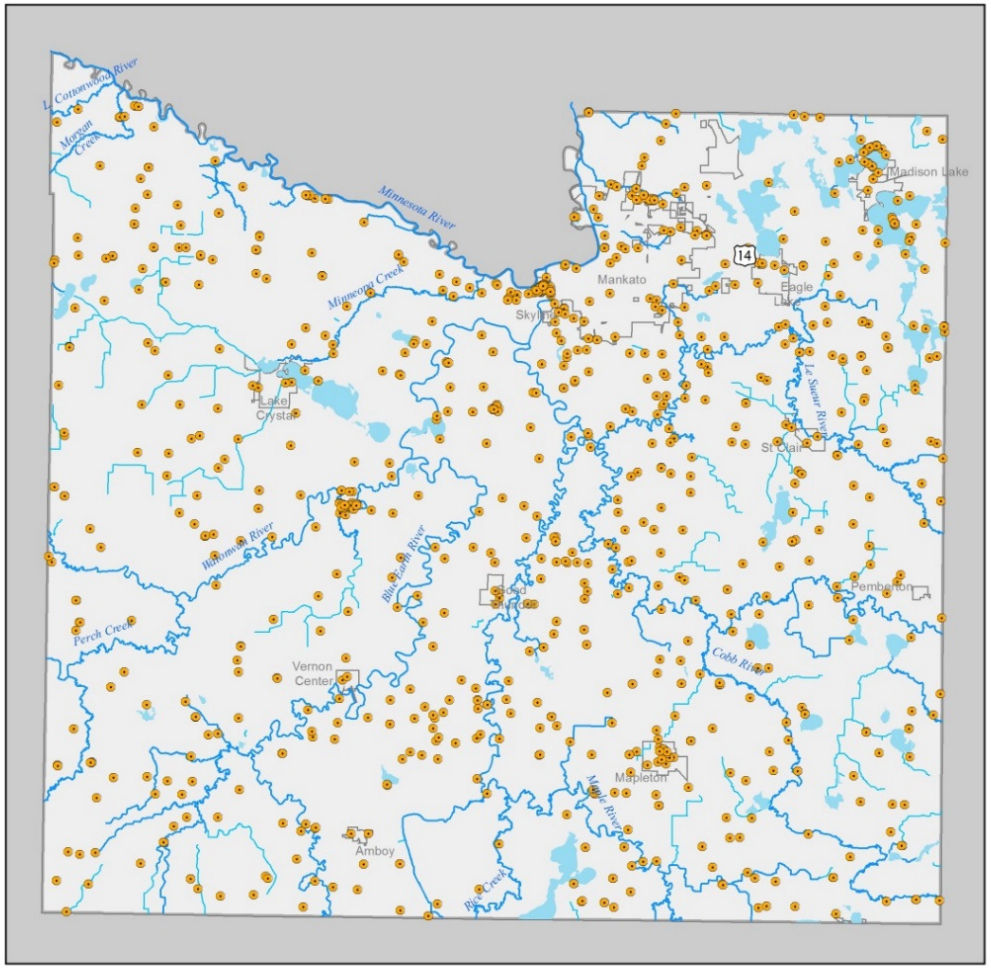
Blue Earth County is responsible for inspecting and permitting well sealing in all areas of the county. In conjunction with land use permit review, the County identifies potential abandoned and unused wells. The County also assists landowners and local government units with locating abandoned and unused wells.

Since 1989, more than 2,800 abandoned wells have been sealed in the county. The table on the following page summarizes well sealing and new well construction in the county from 1989 through 2016. A map of properly sealed wells that were field-located is also on the following page.

Summary of Sealed Wells and New Wells in Blue Earth County from 1989 to 2016

Year	Wells Sealed	New Wells
1989	95	99
1990	83	89
1991	203	71
1992	220	93
1993	141	94
1994	112	108
1995	104	95
1996	128	87
1997	117	92
1998	116	95
1999	148	81
2000	108	93
2001	109	93
2002	114	77
2003	106	79
2004	120	94
2005	78	82
2006	87	79
2007	94	67
2008	61	49
2009	57	43
2010	49	37
2011	58	39
2012	96	56
2013	88	49
2014	95	33
2015	88	35
2016	54	42
Total	**2,929**	**2,051**

Sealed Wells that have been Field Located



0 5 Miles

Sealed Well

City

Prepared By: Blue Earth County Environmental Services 2016

Source: Blue Earth County Sealed Well Database

Note: Map shows sealed wells that have been field located. Blue Earth County began field locating sealed wells with GPS units in 2008 so there are many sealed wells that are not shown on this map.

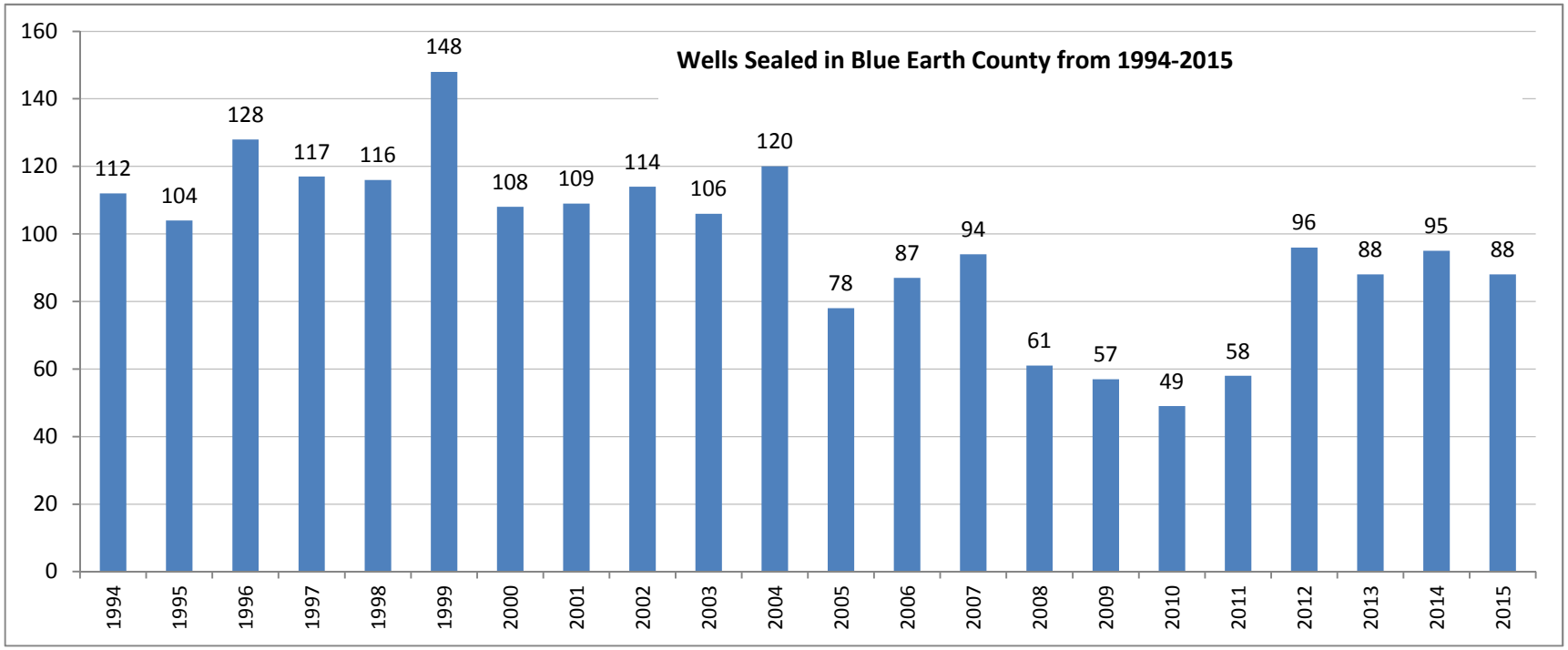
Well Sealing Cost-Share

The County started a locally-funded, abandoned well sealing cost-share program in 1989 and will continue funding this local program. Landowners are eligible for 50% cost share up to $1,000 which is enough to seal most wells. The local cost-share program has $9,000 to $10,000 available annually which in many years is not enough to meet all landowner requests for well sealing cost share. The County has also received a few grants to seal high priority wells and wells in high priority areas.

Community Wellhead Protection Plans

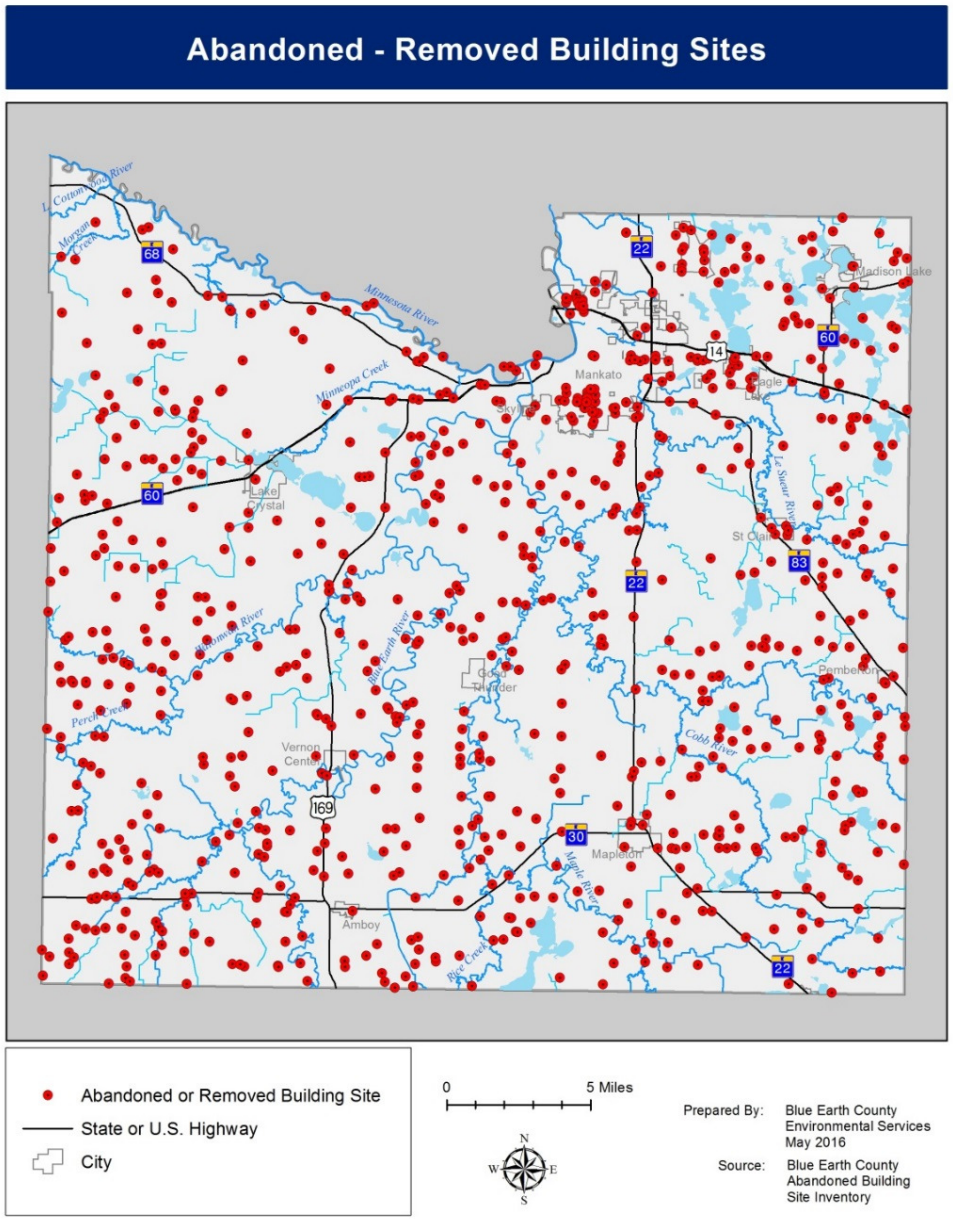
Community wellhead protection plans address the identification and sealing unused and abandoned wells in wellhead protection areas and Drinking Water Source Management Areas.

The MDH provides grants to municipalities for well sealing. Blue Earth County well sealing cost share can also be used in municipalities.



Abandoned-Removed Building Sites

The map on this page shows the location of building sites that were in existence in the late 1930's as shown on the 1938-1939 aerial photos but are no longer in existence or have been significantly reduced in size. More than 850 sites in the county were in the inventory. This inventory is used in the review of land use proposals to identify sites where there is likely at least one abandoned well.



Note: Abandoned building sites are building sites that were present as shown in 1938-39 aerial photos and have been removed, altered or significantly reduced in size as shown on 2005-2009 photos.

Special Well and Boring Construction Area

A Special Well and Boring Construction Area is also called a well advisory. It is a mechanism which provides for controls on the drilling or alteration of public and private water-supply wells, and monitoring wells in an area where groundwater contamination has, or may, result in risks to the public health. The purposes of a Special Well and Boring Construction Area are to inform the public of potential health risks in areas of groundwater contamination, provide for the construction of safe water supplies, and prevent the spread of contamination due to the improper drilling of wells or borings.

There is one Special Well and Boring Construction Area in Blue Earth County located in Le Hillier.

Le Hillier Special Well and Boring Construction Area

Le Hillier is a small community in Blue Earth County near the confluence of the Blue Earth and Minnesota Rivers. At the time of the advisory, there were no central water-supply or sewage systems serving the city. Most of the 200 homes in the area were supplied by individual drive-point wells driven to approximately 30 feet in depth. A few homes had wells cased to the St. Lawrence confining layer with open-hole construction into the Franconia or Ironton aquifer. Many of the individual sewage disposal systems consisted of septic tanks draining into leaching tanks or perforated 55-gallon steel barrels.

In 1981, following a tip on the Minnesota Pollution Control Agency (MPCA) "hotline" about dumping of hazardous wastes, groundwater contamination was verified. Major contaminants detected in the drift and alluvium and some bedrock wells were nitrates and volatile organic chemicals (VOCs), primarily trichloroethylene (TCE).

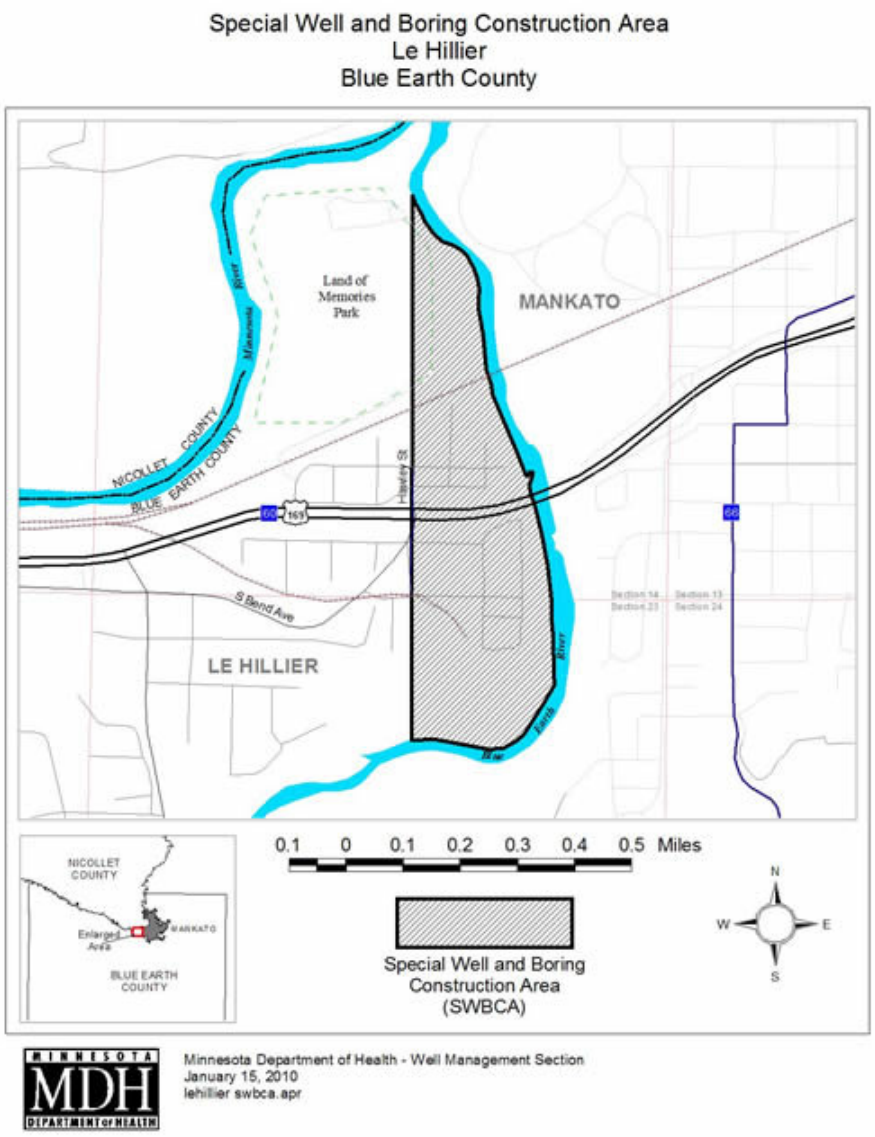
In September of 1981, an advisory was mailed to licensed well contractors working in the Mankato area. The advisory area is in parts of Sections 14 and 23, Township 108 North, Range 27 West, Blue Earth County, bounded by East Hawley on the west and the Blue Earth River on the east, north and south. The contractors were specifically told that residents with elevated levels of trichloroethylene had been advised to use alternate drinking water sources, and that the Health Department was not advising that contaminated wells be deepened or that new deeper wells be constructed until the source, extent, nature and hydraulics of the contamination was known.

The Minnesota Pollution Control Agency initiated several superfund studies for identifying the source of the contamination and furnishing the residents of the area a safe water supply. Le Hillier received a grant and constructed a rural water-supply system. Mankato required assurances that the contamination would be cleaned up and that the discharge of sewage into the ground up-gradient from their Ranney well would be discontinued. A wastewater collection system was constructed in Le Hiller and their wastewater is treated at the City of Mankato's wastewater treatment plant. A program was implemented to seal the private drinking water wells in the contamination plume in order to prevent contamination of the Franconia-Ironton-Galesville aquifer.

A remedial study was completed utilizing numerous monitoring wells and the U.S. Corp of Engineers dike flood control wells to pump out contaminated water. From 1989 to 1997, this contaminated water was treated through an air stripper before being discharged to the Blue Earth River. In 2006 and 2007 six of the pumping wells and monitoring wells were sealed. The MPCA has determined that no further remedial action was required at this site. The MPCA continues to monitor this site and the well construction advisory remains in effect.

One of the provisions of the Remedial Investigation/Feasibility Study Record of Decision for Le Hillier released in September 1985 was to: "Ensure private wells in Le Hillier are properly closed/capped under the provisions of Minnesota Department of Health Well Code."

Between October and December 1988 an effort was conducted to seal 83 private water wells within the main trichloroethylene (TCE) contamination plume generally covering the east half of Le Hillier. Between 1989 and 2012 Blue Earth County continued to inspect the proper sealing of wells, mostly located in the west half of Le Hillier. These wells have been identified through well disclosure and the County building permit review processes. Unfortunately, many properties are being sold in Le Hillier without proper well disclosure. Starting in 2013 the County has targeted the remaining wells in Le Hillier suspected of having possible unsealed wells issues and provided grant program incentives to property owners. Through this targeted well sealing initiative, an additional 52 wells were properly sealed in Le Hillier.



Public Water Supplies

Public Water Systems

The Federal Safe Drinking Water Act (SDWA) is the principal regulation governing public water systems in Minnesota. It defines what a public water system is, sets drinking water quality standards, institutes water sampling and survey schedules, and establishes requirements for source water protection and operator certification, and more.

The SDWA affects all water systems that serve water to the public (in general, to more than 25 people on a regular basis). The SDWA does not apply to private wells or bottled water, although bottlers in Minnesota who have their own source of water are regulated as noncommunity public water systems.

Minnesota Rules, part 4720 adopts the SDWA by reference with some amendments and also includes sections on Wellhead Protection. There are many significant Minnesota Rules that apply to public water systems:

Federal Safe Drinking Water Act
Minnesota Safe Drinking Water Rules
Minnesota Well Code
Minnesota Plumbing Code
Minnesota Operator Certification Rule

Public Drinking Water Supply Systems

According to 2016 MDH data, there are 78 entities in the county that own 100 public water supply wells. The well owners include municipalities, rural subdivisions, commercial businesses, churches, parks, campgrounds, bar/restaurants, and golf courses. A high percentage of public water supply wells (62 wells) are in sensitive aquifers, and 22 wells are sensitive to groundwater contamination because the well does not meet current construction standards or there is no information about the well available. Most of these are transient noncommunity public water suppliers. Most municipal wells in the county are not in sensitive aquifers.

Public Water System Categories

Public Water System is a water system with 15 or more service connections or regularly serves at least 25 people 60 or more days a year. A system that serves water 60 or mores day a year is considered to "regularly serve" water. Public water systems can be publicly or privately owned. Public water systems are subdivided into two categories: community and noncommunity water systems. This division is based on the type of consumer served and the frequency the consumer uses the water.

Noncommunity Water Supply System is a public water system that pipes water for human consumption to at least 15 service connections used by individuals other than year-round residents for 60 days a year, or serves 25 or more people at least 60 days a year.

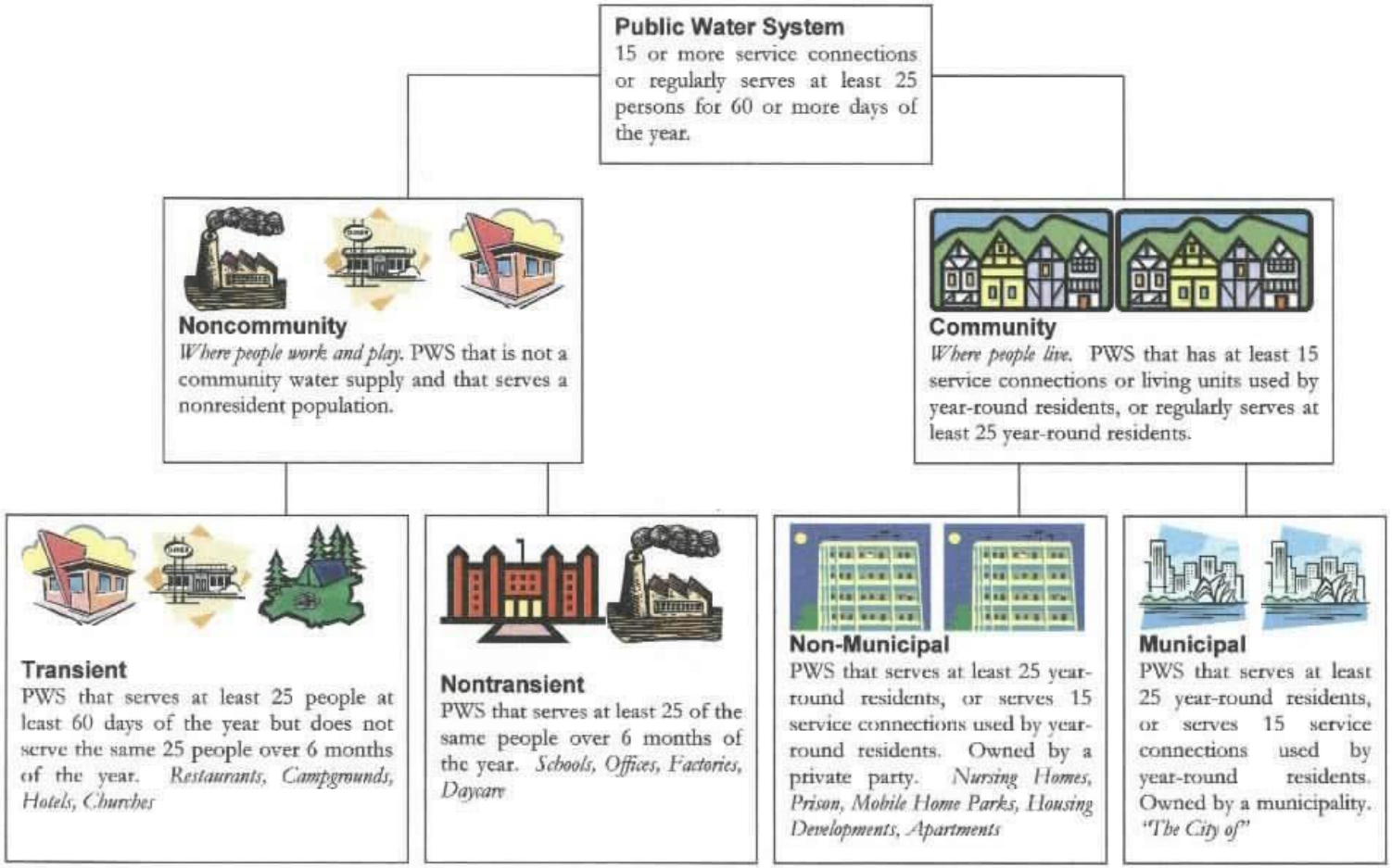
Nontransient Noncommunity Water Supply System is a noncommunity water system that serves at least 25 of the same persons over six months per year. Examples include schools, universities, colleges, factories, office parks or buildings, large-sized resorts and hotels, child care centers, and businesses.

Transient Noncommunity Water Supply System is a noncommunity water system that does not meet the definition of a non-transient noncommunity water system. Generally, these systems serve a

transient population such as parks, wayside rests, small-sized resorts and hotels, restaurants, bars, and campgrounds.

Like community water systems, noncommunity systems are required to meet the standards of the federal Safe Drinking Water Act. Should there be any issues with water quality, the owner of the system is responsible for identifying, correcting, and paying for corrective actions. For nitrate problems, these actions can include drilling a new well, installing a treatment system, or connecting to another public water system.

The following figure by the EPA shows the categories and definitions of public water supplies.


Public Water System
15 or more service connections or regularly serves at least 25 persons for 60 or more days of the year.
Noncommunity
Where people work and play. PWS that is not a community water supply and that serves a nonresident population.
Community
Where people live. PWS that has at least 15 service connections or living units used by year-round residents, or regularly serves at least 25 year-round residents.
Transient
PWS that serves at least 25 people at least 60 days of the year but does not serve the same 25 people over 6 months of the year. Restaurants, Campgrounds, Hotels, Churches
Nontransient
PWS that serves at least 25 of the same people over 6 months of the year. Schools, Offices, Factories, Daycare
Non-Municipal
PWS that serves at least 25 year-round residents, or serves 15 service connections used by year-round residents. Owned by a private party. Nursing Homes, Prison, Mobile Home Parks, Housing Developments, Apartments
Municipal
PWS that serves at least 25 year-round residents, or serves 15 service connections used by year-round residents. Owned by a municipality. "The City of"

Source: EPA

Community Public Water Supplies

All community water suppliers in the county provide water to consumers that meet Federal Drinking Water Act standards. Most community water wells are in bedrock aquifers.

Community public water supplies serve at least 26 persons or 15 service connections year-round. They include municipalities, manufactured mobile home parks, etc. These systems are required to provide a safe and adequate supply of water under the federal Safe Drinking Water Act (SDWA).

The Minnesota Department of Health (MDH) Community Water Supply Unit is responsible for assuring the compliance of community water supply systems with the SDWA. At least one certified water operator is required at each community public water supply system. That operator must hold a certificate that is at least the same class as the system (e.g., a Class B system requires a Class B certificate).

The MDH conducts on-site reviews of the adequacy of the water source, facilities, equipment, operation and maintenance of a public water supply system for producing and distributing safe drinking water at least every 18 months. All community water supplies are tested for contaminants such as pesticides, solvents, and metals.

If any of the samples collected from a community public water supply system show the presence of a contaminant above its health-based standard (called a maximum contaminant level or MCL), MDH will work with the system in resolving the contamination. Additional samples may be required to confirm the presence of the contaminant. If contamination is confirmed, the system is required to notify its users of the problem and it must take steps to correct the problem. Corrective actions may include repairs to the water system, disinfection of the water system, installation of treatment, or drilling a new well.

Primary Standards – Source EPA

The EPA has established National Primary Drinking Water Regulations (NPDWRs) that set mandatory water quality standards for drinking water contaminants. These are enforceable standards called "maximum contaminant level" (MCL). An MCL is the maximum allowable amount of a contaminant in drinking water which is delivered to the consumer. MCLs are established to protect the public against consumption of drinking water contaminants that present a risk to human health. The MCL Primary Standards include:

- Microorganisms
- Disinfectants
- Disinfection Byproducts
- Inorganic Chemicals
- Organic Chemicals
- Radionuclides

For microbiological contaminants, nitrate, and nitrite, the potential health effects can be immediate; for the others, the contaminant would have to be consumed at elevated levels over a long period of time for there to be any chance of adverse health effects. The federal standard for most contaminants is listed as a Maximum Contaminant Level (MCL), the lowest concentration at which that particular contaminant is believed to represent a potential health concern.

Because of technological limitations or other factors, it is not possible to test for some contaminants in a reliable fashion. Instead, public water systems are required to use specific Treatment Techniques (TT) that are designed to remove these particular contaminants from the water. In addition to the contaminants listed, monitoring is done for additional inorganic chemicals for which MCLs have not been established. If unacceptable levels are found of these “unregulated” contaminants—based on established state health standards and an assessment of the risks they pose—the response is the same as if an

MCL has been exceeded: the public water system must notify of those served by the system.

Secondary Contaminants – Source EPA

In addition, EPA has established National Secondary Drinking Water Regulations (NSDWRs) that set non-mandatory water quality standards for 15 contaminants. These contaminants are not considered to present a risk to human health. EPA does not enforce these "secondary maximum contaminant levels" (SMCLs). They are established only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, odor, staining and corrosion.

Wellhead Protection Plans

Wellhead Protection is a way to prevent drinking water from becoming polluted by managing potential sources of contamination in the area which supplies water to a public well. Much can be done to prevent pollution, such as the wise use of land and use of hazardous substances and sealing wells. Wellhead protection can protect public health and expense of treating polluted water or drilling new wells is avoided though wellhead protection efforts.

The MDH is responsible for overseeing wellhead protection plans. The MDH is phasing in wellhead protection plans in existing community and noncommunity systems based on the vulnerability of their water supply wells.

The status of Wellhead Protection Plans in Blue Earth County communities in 2016 according to the MDH is shown to the right.

Non-Vulnerable/Protected aquifer:
Amboy
Eagle Lake
Good Thunder
Lake Crystal
Mapleton
Vernon Center
Mankato deep wells

Vulnerable/susceptible to contamination:
Madison Lake (Wellhead Protection Plan in progress)
Mankato shallow wells

Wellhead Protection Plans not yet started:
Pemberton
Skyline
South Bend Township
St. Clair

Wellhead Protection Area

Wellhead Protection Area (WHPA) is the surface and subsurface area surrounding a well or well field that supplies a public water system through which contaminants are likely to move toward and reach the well or well field.

Drinking Water Supply Management Area (DWSMA) is the area delineated using identifiable land marks that reflects the scientifically calculated wellhead protection area boundaries as closely as possible. The boundaries of the DWSMA can be 1) the center lines of highways, streets, roads, or railroad right-of ways; 2) section, half-section quarter-section, quarter-quarter section, or other fractional section lines of the United State public land survey; or 3) property lines.

Inner Wellhead Management Zone (IWMZ) is the area within 200 feet of a public water supply well.

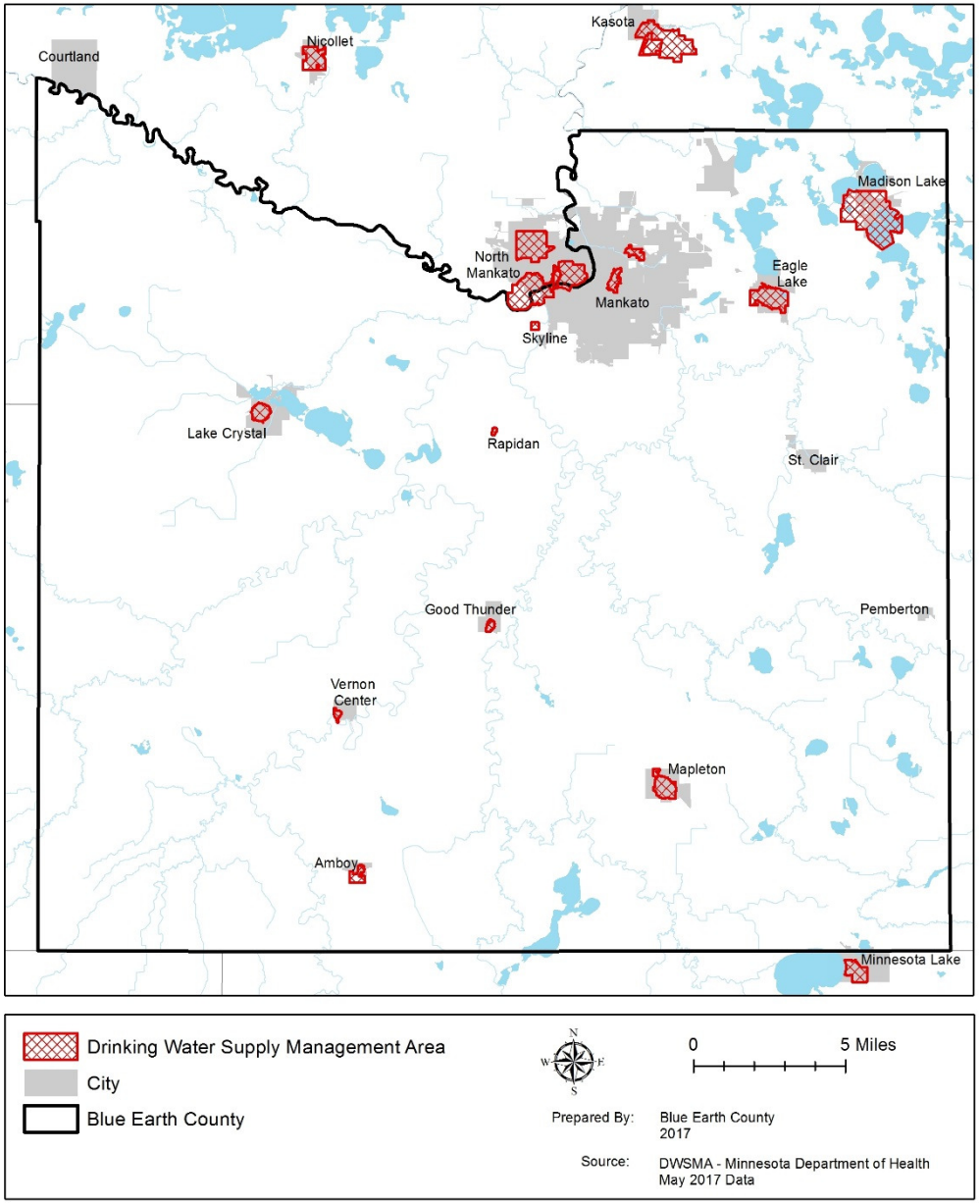
Criteria for Determining Wellhead Protection Area

The WHPA provides the focus for implementing a strategy to protect a public water supply well from contamination. A number of factors must be considered when delineating the WHPA to ensure that it actually reflects groundwater movement to the well. The following criteria must be used to delineate the WHPA:

- **Daily volume of water pumped** is derived from the maximum annual amount of water pumped over a five-year period and is needed to reflect the pumping stress the well has on the aquifer.

- **Aquifer transmissivity** defines the ability of the aquifer to yield water to a pumping well and strongly affects the size and shape of the calculated WHPA.

Drinking Water Supply Management Areas (DWSMA)



- **Groundwater flow field** defines the direction of groundwater flow and hydraulic gradient within the aquifer and is needed to "point" the WHPA in the proper direction and help determine the lateral extent of the WHPA. Groundwater moves preferentially toward a pumping well from the up gradient or "upstream" direction of groundwater flow. Most of the areal extent of a WHPA occurs up gradient of the well.

- **Flow boundaries** consist of features such as rivers, streams, lakes, wetlands, changes in the geologic composition of the aquifer and surrounding formations, and nearby wells which may impact the rate at which groundwater moves toward the public water supply well.

- **Time of travel or TOT** defines the time period over which groundwater moves through the aquifer to supply the public water supply well. The minimum TOT required is ten years although the public water supplier can select a longer time period.

Specific Requirements for Wellhead Protection

Specific wellhead protection requirements vary for the different classifications of public water systems in Minnesota (transient non-community, non-transient non-community, and community). The requirements for each type of system are described below:

Transient Noncommunity Public Water Systems (such as resorts, restaurants, and churches) are required to delineate a 200-foot radius around the well, known as an inner wellhead management zone, and then inventory and manage potential contaminant sources within the inner wellhead management zone.

Community and Nontransient Noncommunity Public Water Systems are required to delineate, inventory, and manage an inner wellhead management zone. Additionally, they must also create a formal wellhead protection plan. The wellhead protection planning process involves:

1. Delineation of the wellhead protection area and drinking water supply management area, as well as an assessment of the well(s) vulnerability.
2. Creation of the wellhead protection plan itself, including goals, objectives, plan of action, evaluation program, and contingency plan.

Wellhead Protection Grants

The MDH provides competitive grants to assist community public water suppliers implement Wellhead Protection Plans. For 2016 MDH grant programs, the following actions are eligible:

- Seal a well
- Construct a new well
- Install a monitoring well
- Well inspection (video log, gamma log)
- Educate public about drinking water protection
- Update well inventory
- Update contaminant source inventory
- Upgrade membrane filters
- Manage fuel storage tanks
- Clean up illicit dumping near well
- Support property owners to manage nitrogen
- Spill prevention and response

City of Mankato Public Water Supply Wells

The City monitors all drinking water supplies daily and consistently provides quality drinking water meeting all Federal and State drinking water standards. As required by Federal and State rules, the City prepares an annual drinking water safety report for its citizens every year.

The City of Mankato also operates a special water conservation facility as part of the wastewater treatment plant. This project is described in the Wastewater Section of the Water Management Plan and more information is available from the City of Mankato.

The City of Mankato operates water wells in shallow and bedrock aquifers.

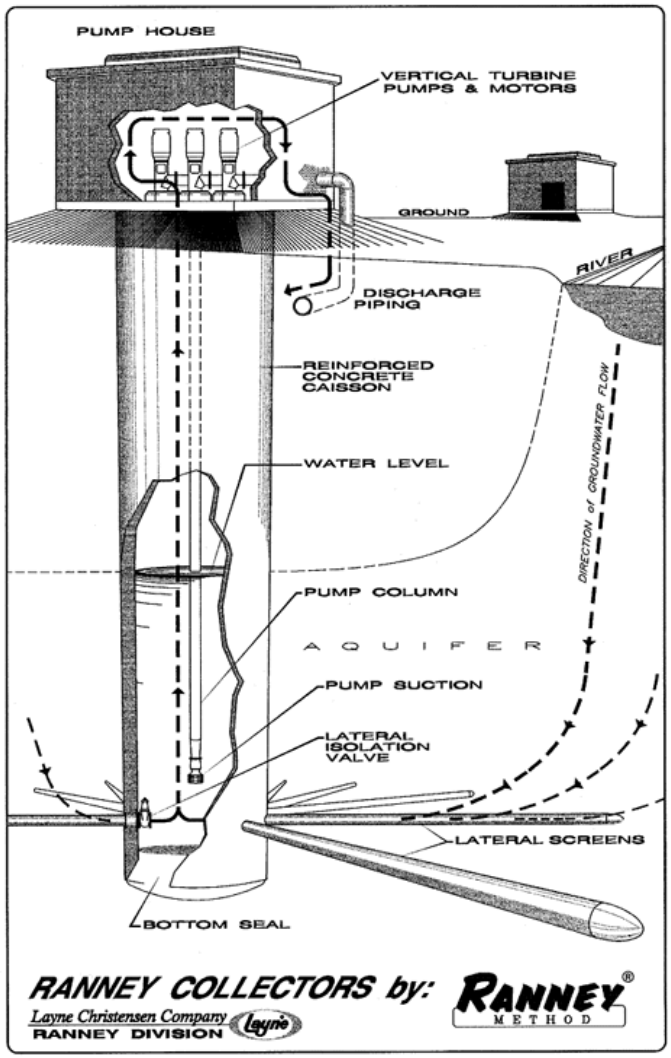
Bedrock Aquifer Wells

The City operates four deep wells drawing water from bedrock sources. The DWSMAs for these wells are relatively small and similar to other municipalities in the county.

Shallow Wells – Surficial Sands Aquifer

The City operates two shallow wells located in surficial sands aquifers near the Blue Earth and Minnesota River. The two shallow wells provide 61% of the total water volume for the City. These unique wells are called Ranney® collector wells. Ranney® wells are not surface water wells; however, the Blue Earth and Minnesota Rivers do influence the shallow aquifers below the rivers and their banks.

Ranney® wells consist of a large diameter, concrete caisson 16 feet in diameter and 50 to 60 feet in depth from which multiple well screens (laterals) are projected horizontally into the aquifer from near the base of the caisson. The Mankato Ranney® well laterals extend 95 to 220 feet along and below the Blue Earth and Minnesota Rivers providing a dependable source of water. The surficial sands provide



Ranney® Collector Well Example Schematic
Source: Layne Christianson Company

natural filtering. This natural filtration simplifies treatment needs and ensures high quality and high capacity water production.

Mankato's Ranney® wells conserve deep aquifer resources and require less energy to operate compared with deeper bedrock aquifer wells. The Mankato Ranney® Wells provide more than 850 million gallons per year. These wells use 39% of all the municipal groundwater appropriations reported to the MNDNR in 2013 by water appropriation permit holders in the county, according to the *Geologic Atlas of Blue Earth Count, Part B.*

Ranney® collector wells are a trademarked design invented in 1920. The Mankato Ranney® well near the Blue Earth River was constructed in 1974, and the Ranney® well near the Minnesota River was constructed in 2007.

Mankato Ranney® Well Source Water Assessment

The Minnesota Department of Health is responsible for preparing source water protection plans for public water supplies influenced by surface water sources, like Mankato. The City worked with the MDH in preparation of a source water protection plan in 2003. According to the MDH *City of Mankato Source Water Assessment*, the MDH determined three source water protection areas with two main source water priority areas. These include:

Inner Emergency Response Area is designed to help the City address contaminant releases which present an immediate health concern to users. This area was determined by the time required for the Mankato Water Department to shut off the Ranney® Well and a buffer time limit needed to accommodate unanticipated delays in notification and shut down.

The inner-emergency response area is about 57 square miles and includes the lower reaches of the Blue Earth, Le Sueur and Watonwan Rivers located entirely within Blue Earth County and part of the Minnesota River upstream of the Blue Earth River located in Blue Earth and Nicollet County.

Outer Source Water Management Area is designed to protect water users from long term effects related to low levels of chemical contamination or the periodic presence of contaminants at low levels in surface waters. This area should protect users from contaminants which may be usually present at treatable levels or occasionally present an acute health concern under certain conditions such as low stage of the Blue Earth River.

The outer-source water management area is about 120 square miles and is described as the minor watersheds that either flow directly into the four rivers upstream of the inner-emergency response area or are adjacent to the inner emergency response area. The outer-source water management area is located entirely within Blue Earth County and Nicollet County.

Watershed: The entire Greater Blue Earth River watershed and portions of the Minnesota River are also identified with a broad perspective in which to prioritize management efforts toward specific land uses that may impact the Ranney® Well. Maps displaying the source water protection area for the Blue Earth River Ranney® Well are available from the City of Mankato or the MDH.

Potential Pollutants

The main pollutants of concern include suspended solids, nitrate-nitrogen, pathogenic microorganisms and pesticides. The sources of contaminants are diverse. The MDH *City of Mankato Source Water Assessment* identified 348 potential contaminant sources including pipeline, highway, railroad river crossings and parallels; above- and below ground petroleum storage tanks; agriculture chemical facilities; animal feedlots; and hazardous waste storage facilities.

Nitrates

Nitrates in the Ranney® wells' shallow surficial sands aquifers are the City's primary management concern. To ensure the City water supply continuously meets Federal and State drinking water standards, the Ranney® well intakes have been monitored daily for decades. When nitrate levels are a potential concern, the City blends water from their deep aquifer wells with the Ranney® wells to obtain the desired nitrate level. At times when nitrate levels are very high, the City shuts off some or all the Ranney® wells' laterals.

Percent contribution of the TN delivered to the Mississippi River in Keokuk, Iowa, from each Minnesota Watershed which ultimately drains to the Mississippi River

Load ranking	Watershed name	% load contribution
1	Lower Minnesota River	7.3
2	Minnesota River - Mankato	6.7
3	Blue Earth River	6.4
4	Le Sueur River	5.7
5	Minnesota River - Yellow Medicine River	5.6
6	Cannon River	5.2
7	Root River	5.2
8	Zumbro River	4.9
9	South Fork Crow River	4.7
10	Cedar River	4.4
11	Cottonwood River	4.3
12	Mississippi River - Twin Cities	3.7
13	Watonwan River	3.4
14	Des Moines River - Headwaters	3.2
15	Chippewa River	3.1
16	North Fork Crow River	2.4
17	Sauk River	1.7
18	Redwood River	1.6
19	Mississippi - Winona	1.5
20	Mississippi - Sartell	1.4
21	Mississippi – Lake Pepin	1.4

Source: *MPCA Nitrogen in Minnesota Surface Waters*, June 2013

In addition to monitoring the Ranney® well intake, the City monitors the water depth of the Minnesota River during the months of the year when the river is not frozen. Monitoring results show a strong correlation of nitrate in the Ranney® wells corresponding to the river depth. Nitrates are consistently highest in the spring and during periods of high flow and lowest in winter and during dry periods of the year when river water depths are low. In recent years there has been a trend of increasing nitrates in the Ranney® wells observed during all times of the year.

Reducing nitrates in the Blue Earth River is a priority concern for protecting the surficial sands aquifer at the confluence of the Blue Earth and Minnesota River, managing the City's water supply wells as well as Minnesota surface waters.

The Blue Earth and Le Sueur Watersheds are among the highest contributors of total nitrogen to the Minnesota and Mississippi River. The following table from the *Nitrogen in Minnesota Surface Waters: Conditions, trends, sources, and reductions, MPCA 2013* shows the top watersheds ranked for percent of the total load of nitrogen delivered to the Mississippi River in Iowa. Local watersheds are highlighted.

Nitrate Monitoring

The City of Mankato's nitrate trend observations are consistent with the MPCA report *Nitrogen in Minnesota Surface Waters: Conditions, trends, sources, and reductions, MPCA 2013.* According to the report, previous studies show that total nitrogen loads as well as nitrate loads have increased in the Minnesota River Basin. What the report lacks is any data on the Blue Earth River below the Rapidan Dam. This lack of nitrate data in this reach of the Blue Earth is explained in Appendix B5-2, *Nitrogen Transport and Transformation in Surface Waters of Minnesota:*

> "Monitoring transport along a stream network is expensive, and existing water-quality monitoring programs are often not designed to specifically estimate fate and transport of N. Thus, available monitoring data is often used to calibrate models to estimate N transport over greater temporal and spatial scales than the original monitoring covered. Even though models are never perfect, they can be useful for estimating the impact of a stream network on the downstream movement of N."

Appendix B5-2 of *Nitrogen in Minnesota Surface Waters Conditions, trends, sources, and reductions, MPCA 2013* states "that more complicated models need to be developed over the next decade to address multiple pathways of N transport in river networks (Figure 3). Improved models will include approaches to terrestrial-aquatic linkages including hydrologic exchanges between the channel, floodplain/riparian complex, and subsurface waters, and interactions between coupled biogeochemical cycles."

The diagram on the following page is from Appendix B5-2, "Nitrogen Transport and Transformation in Surface Waters of Minnesota"

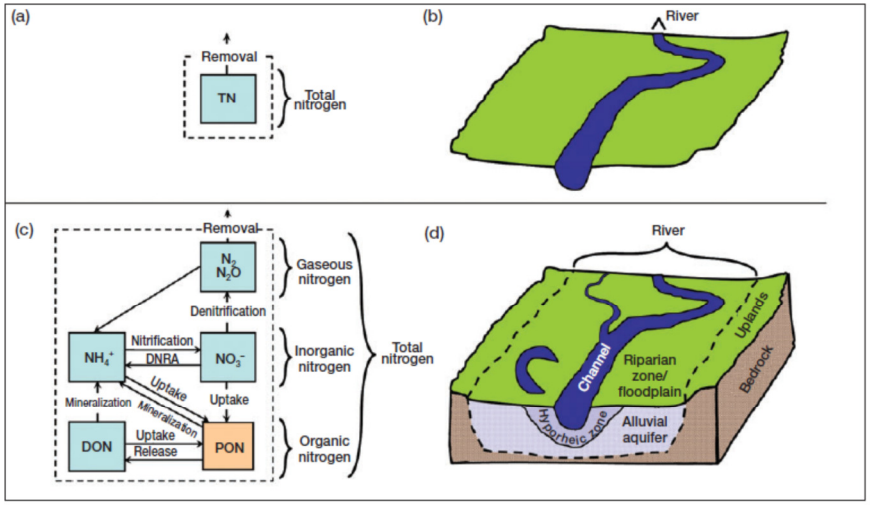


Figure 5. River-network models typically describe (a) one-way total nitrogen flux from (b) river channels. A more holistic conceptual model of nitrogen cycling in river ecosystems recognizes (c) multiple forms of nitrogen that undergo numerous transformations and (d) the role of non-channel river ecosystem components in nitrogen dynamics, including the hyporheic zone, alluvial aquifer, and floodplain/riparian complex. DON = dissolved organic nitrogen; PON = particulate organic nitrogen; NH_4^+ = ammonium; NO_3^- = nitrate; N_2 = dinitrogen gas; N_2O = nitrous oxide; DNRA = dissimilatory nitrate reduction to ammonium.

Existing river- network models typically describe one-way TN flux (a) from simple river channels (b). Future models will include more complicated N cycling (c) in both channel and off-channel ecosystem components (d). DON= dissolved organic N, PON = particulate organic N. Reprinted from Helton et al. (2011) Source: Figure 3 from *Nitrogen in Minnesota Surface Waters: Conditions, trends, sources, and reductions, MPCA 2013.*

Wetlands

Appendix B5-2 of *Nitrogen in Minnesota Surface Waters* describes wetlands ability to reduce nitrogen.

> "Wetlands are generally considered as aquatic systems with a high capacity to assimilate and ultimately denitrify N inputs. Wetlands have several characteristics that allow for TN removal including abundant labile organic carbon, anoxic sediments, generally long residence times and small watersheds. Mitsch and Day (2006) proposed the creation and restoration of wetlands throughout Mississippi-Ohio-Missouri Basin to intercept field drainage along with diversion wetlands fed by flooding river waters as a means to mitigate eutrophication in the Gulf of Mexico. They based this recommendation on an extensive review of field studies that demonstrated 33% to 95% NO_X-N retention in wetlands. Flow-through and riparian wetlands must be strategically positioned within a watershed to have the most impact on N transport. Many of the principles discussed in the lake and riverine backwater sections of this chapter also apply to wetlands. For instance, a large wetland receiving a modest load of TN from a small watershed would generally remove more N than a small wetland receiving a large load of TN from a large watershed."

Blue Earth County has identified potentially restorable basins that could be considered and further analyzed for nutrient treatment based on the above criteria. A description and map of these areas is in the priority areas for protection and restoration section of the *Blue Earth County Water Management Plan 2017-2026*.

Drinking Water and Groundwater Protection Goals

Goal: Protect the quantity and quality of groundwater resources to ensure long term sustainability of groundwater supplies.

Land Use Management Strategies

Land use planning and management have an in important role in protecting groundwater resources. Groundwater protection strategies will be incorporated in local comprehensive land use plans, zoning, water and wastewater ordinances, programs and policies to protect groundwater resources. Land development should be managed in areas with high to moderate pollution sensitivity and karst, when siting home occupations, commercial and industrial development using hazardous substances and wastewater treatment in areas without publicly-owned wastewater treatment.

COUNTY-WIDE STRATEGY: LAND USE PLANNING AND REGULATIONS.
Action: Conduct education and training with local officials and staff using the *Geologic Atlas of Blue Earth County, Part B*, to support development and implementation of groundwater protection in local plans, ordinances and policies.

Action: The County will ensure groundwater protection is an integral part of local land use plans and ordinances.

Action: All jurisdictions will review development proposals to ensure required well isolation distances (setbacks) from existing and future wells will be maintained.

Action: Ensure land development proposals address storage, use and disposal of potentially hazardous substances and hazardous waste.

Action: Review development proposals and well disclosures to ensure abandoned wells are identified and properly sealed.

Action: Utilize the *Geologic Atlas of Blue Earth County, Part B*, to identify areas with high to moderate pollution sensitivity to ensure land use in those areas protect groundwater.

Action: Review development proposals in areas not served with publicly owned wastewater treatment systems to ensure there are no Class V injection wells for any type of wastewater or stormwater management in existing and proposed uses.

Action: The County will review feedlot permits in areas with moderate to high pollution sensitivity to ensure compliance with local and state regulations.

Action: The County will continue to assist the MDH and MNDNR with water appropriation permitting and the regulation of unrestricted flowing wells.

Well Construction and Well Use Strategies

ONGOING STRATEGY: DELEGATED WELL PROGRAM.
Action: The County will continue to administer the Minnesota Well Code, issue permits, inspect the construction of new domestic wells

and non-community water supply wells, inspect the sealing of abandoned well, and ensure wells are maintained in accordance with the Minnesota Department of Health delegation agreement.

ONGOING COUNTY-WIDE STRATEGY: WELL SEALING.
Abandoned and improperly sealed wells are one of the most significant threats to groundwater quality in the county. State Law requires well owners to either repair abandoned wells and place them in service, or have them permanently sealed by a licensed well contractor. Abandoned wells are common in both rural areas and in municipalities and townsites that are presently served by public water supplies. Abandoned well identification and sealing efforts will help prevent contamination of groundwater.

Action: The County will continue to locate, permit and inspect well sealing throughout the county.

Action: The County will continue a minimum $10,000 locally-funded annual well sealing cost share program and will assess the adequacy and use of program to determine local needs and increase the cost-share funds available as needed.

Action: The County, Municipal Water Suppliers and other partners will identify priority areas and priority wells for sealing, such as DWSMAs, Source Water Protection Areas, floodplains, areas with moderate or high pollution sensitivity, areas of known contamination and other determined to be a priority based on land use, groundwater pollution sensitivity and well characteristics.

Public Water Supplier Strategies

STRATEGY: WELLHEAD PROTECTION.
Action: Support Public Water Suppliers' development and implementation of Wellhead Protection Plans required by the Minnesota Department of Health and Water Supply Plans required by the Minnesota Department of Natural Resources.

Action: The County will assist municipalities and the MDH with preparing wellhead protection plans and Water Supply Plans required by the MNDNR when requested by the municipality.

Action: Support municipalities implementing Wellhead Protection Plans, including activities such as:

- Well sealing
- Constructing a new well
- Installing a monitoring well
- Well inspection (video log, gamma log)
- Educating the public about drinking water protection
- Updating well inventories
- Updating contaminant source inventory
- Upgrading membrane filters
- Managing fuel storage tanks
- Cleaning up illicit dumping near well
- Support property owners to manage nitrogen
- Spill prevention and emergency response plan
- Water conservation and reuse projects

Waste Management Strategies

STRATEGY: HAZARDOUS WASTE MANAGEMENT.
Policy: Ensure hazardous substances, hazardous materials and hazardous wastes are managed at the site level to reduce the potential for groundwater contamination.

Action: Seek outside funding to address sites with contaminated soil with the potential to contaminate groundwater in areas with moderate and high pollution sensitivity as shown in the *Geologic Atlas for Blue Earth County, Part B*, and other areas with pollution sensitivity.

Ongoing Strategy: Hazardous waste disposal.
Action: The County will continue to operate the Household Hazardous Waste Collection Program, Small Quantity Generator Program and Medicine Collection Program.

Well Testing Strategies

Strategy: Private well testing.
Action: The County will continue education programs and encourage private well water testing for contaminants, such as bacteria, nitrates and arsenic, and will coordinate with a MDH certified lab to provide water testing services to residents for a fee.

Action: The County Environmental Services will work with the County Public Health, local medical clinics and other appropriate partners in the community to promote the need for private well testing.

Strategy: Public Water Supply Testing.
Action: Public water suppliers will continue water testing programs as required by the MDH and the Safe Drinking Water Act.

Strategy: Observation Wells.
Action: Support expansion of the MNDNR observation well network in Blue Earth County.

Groundwater Recharge Strategies

Goal: Reduce nitrate nitrogen in rivers recharging surficial sands aquifers used for drinking water.

The Blue Earth River recharges surficial sands aquifers. Use of this aquifer preserves the quantity of groundwater supplies in deeper bedrock aquifers like the Mount Simon.

Strategy: Reduce nitrate nitrogen in the Blue Earth River.
Action: Identify, prioritize and implement best management and treatment practices that reduce nitrogen in the Blue Earth River watershed.

Action: Local partners will work with landowners to restore wetlands to provide nutrient treatment functions as identified in this plan and other local, state or watershed plans that identify nitrogen treatment best practices.

Action: Local partners will work with counties and SWCDs in the Blue Earth, Le Sueur and Watonwan River watersheds to ensure nitrogen reduction is addressed in these watersheds during the MPCA watershed assessments and intensive monitoring programs, during development of MPCA Watershed Protection and Management Strategies and One Watershed One Plan.

Strategy: Nitrate Nitrogen Monitoring.
Action: The City of Mankato will continue its well and river monitoring programs.

Action: The City of Mankato and the County will work with the SWCD, MDH, USGS, MPCA, MDA, University of Minnesota and other appropriate local, state and federal agencies to develop and

implement a coordinated, expanded monitoring plan to improve understanding of nitrates in surficial sands aquifers at the confluence of the Blue Earth and Minnesota Rivers.

Goal: Recharge buried sands and bedrock aquifers.

STRATEGY: GROUNDWATER RECHARGE.

Action: Establish practices that recharge buried sands and bedrock aquifers.

Action: Protect, enhance and restore wetlands and similar conservation practices in areas where there is groundwater recharge potential as shown in the *Blue Earth County Water Management Plan*, high pollution sensitivity of buried sands aquifers as shown in the *Geologic Atlas of Blue Earth County, Part B,* or as shown in future plans and studies of groundwater recharge potential.

STRATEGY: LOW FLOW AUGMENTATION.

Action: Establish conservation easements in river corridors.

Action: Protect and restore wetlands in river corridors and former sand, gravel and rock mining sites.

STRATEGY: FLOWING WELLS.

Action: The County will identify flowing wells and ensure flowing wells are sealed as required by State law.

STRATEGY: MOUNT SIMON AQUIFER.

Action: Participate in Mount Simon Aquifer user group.

Action: Support reduced use of the Mount Simon Aquifer to the extent practicable.