NORTH DAKOTA

SOURCE WATER ASSESSMENT PROGRAM

STRATEGIC PLAN

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AFO	Animal Feeding Operation
BMP	Best Management Practices
CAFO	Concentrated Animal Feeding Operation
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
EPA	Environmental Protection Agency
ERAC	Environmental Review Advisory Council
GIS	Geographic Information System
GTS	Geographic Targeting System
MCL	Maximum Contaminant Level
Mg/L	Milligrams per Liter
NDAC	North Dakota Administrative Code
NDCC	North Dakota Century Code
NDDoH	North Dakota Department of Health
NDDEQ	North Dakota Department of Environmental Quality
NDSWC	North Dakota State Water Commission
NPS	Nonpoint Source
NTNC	Non-Transient Non-Community
PSC	Potential Source of Contamination
PWS	Public Water System
RCRA	Resource Conservation and Recovery Act
SDWA	Safe Drinking Water Act
SWAP	Source Water Assessment Program
TAC	Technical Advisory Committee
TDS	Total Dissolved Solids
TNC	Transient Non-Community
USGS	United States Geological Survey
WHP	Wellhead Protection

Introduction

In 1996, the United States Congress amended the federal Safe Drinking Water Act (SDWA) requiring states to take an active role in the identification and assessment of potential threats to the quality of public drinking water supplies. The amendments specifically found in PL. 104-182, Section 1428 and 1453, required states to fully implement a federally approved Source Water Assessment Program (SWAP) plan by the year 2003. It was the intent of Congress that completion of source water assessment activities would lead to the establishment of local water protection programs. In compliance with the federal SDWA amendments, the state of North Dakota developed a SWAP plan which identified the implementation strategy designed to complete a source water assessment for all public drinking water systems (PWSs). The initial North Dakota SWAP was submitted to the U. S. Environmental Protection Agency (EPA) on February 1, 1999. The EPA approved the North Dakota SWAP on October 25, 1999.

This document provides a description of the North Dakota SWAP plan and implementation strategy. The SWAP plan includes delineation methods of source water assessment areas, potential contaminant source inventories, and susceptibility determinations of public water systems.

This document combines the federal mandates addressed in the 1996 SDWA amendments with the natural, economic, social, and regulatory environments unique to North Dakota. The North Dakota SWAP plan contains the following chapters:

Chapter 1. Public Participation: Describes how North Dakota incorporates public involvement in developing a SWAP plan and the process by which source water assessments are made available to the public.

Chapter 2. Natural Environment and Existing Environmental Protection Programs: Summarizes the level of knowledge about natural resources in the state and the existing state environmental protection programs.

Chapter 3. Source Water Assessment and Completion Criteria: Outlines the North Dakota SWAP plan.

Chapter 4. SWAP Plan implementation: Describes how the SWAP plan is implemented in North Dakota.

Chapter 1. Public Participation

Section 1428(b) of the federal Safe Drinking Water Act required that each state establish procedures to encourage the public to participate in the development of a SWAP plan. The public participation process was intended to build public support, increase awareness of water quality protection issues, and result in the development of a plan that is responsive to the needs of the public.

To assist in developing the North Dakota SWAP plan, the North Dakota Department of Health (NDDoH) (changed to the North Dakota Department of Environmental Quality in 2019) solicited comment and active participation from a diverse group of stakeholders. Environmental organizations, industry representatives, water suppliers, academia, and the public were all encouraged to provide guidance and comment. Public access and input were solicited through public notification, news releases, and the activation of Technical and Citizens Advisory Committees. Although comments were submitted relating to the scope and direction of the North Dakota SWAP plan, no major issues or significant discussion points were identified by the public or advisory committees.

1.1 Public Participation: SWAP Plan Development

Section 1428(b) of the SDWA required each state establish procedures including, but not limited to, the creation of technical and citizens advisory committees to encourage the public to participate in developing the protection program for wellhead areas and source water areas under Section 1453. Such procedures shall include notice and opportunity for public hearing on the state program before it is submitted to the Administrator. The primary focus of the Technical Advisory Committee is to provide guidance and comment relating to the technical feasibility and effectiveness of a state SWAP approach. The Citizens Advisory Committee is intended to provide comment on the desirability and appropriateness of a state SWAP approach.

1.1.1 Technical Advisory Committee

To encourage public participation during the development of the North Dakota SWAP plan, a Technical Advisory Committee (TAC) was established. The goal of the TAC was to provide guidance and comment relating to the technical feasibility and effectiveness of a North Dakota SWAP plan. An existing state-sanctioned committee acted as the TAC. This committee has historically advised the NDDoH in development of programs for the prevention and control of pollution of waters in the state. The advisory board, referred to as the State Water Pollution Control Board (replaced with the Environmental Review Advisory Council in 2019) consisted of 13 members. Membership on the board included the State Health Officer, State Engineer, Director of the Game and Fish Department, State Geologist, and nine other members appointed by the Governor. The nine other members represented the following sections: Production Agriculture, Manufacturing and Processing, Solid Fuels Industry, Fluid and Gas Fuels Industry, Environmental Sciences, and County or Municipal Government.

Comments relating to the technical feasibility and effectiveness of a North Dakota SWAP plan were solicited from the State Water Pollution Control Board from June 1998 to January 1999. During this time, two meetings of the board were convened to discuss water quality pollution issues, including the development and implementation of the North Dakota SWAP plan. The meetings were convened on June 23, 1998 and November 23, 1998 at the Environmental Training Center in Bismarck, North Dakota.

1.1.2 Citizens Advisory Committee

To ensure that all interested parties had adequate opportunity to participate in the development of the proposed SWAP plan, input was solicited from the public through the formation of a Citizen (a.k.a. Community) Advisory Committee. The Citizen Advisory Committee's primary purpose was to provide comment and guidance as to the desirability and appropriateness of the proposed plan. The public notification and comment period was initiated in November 1998 and concluded at the end of January 1999. During this time, information was distributed through radio, newspaper, direct contact, and the NDDoH webpage.

During the notification and comment period, two meetings were convened to provide a public forum in which the proposed SWAP plan was presented and discussed. The Citizen Advisory Committee meetings were convened in Bismarck, North Dakota at the Environmental Training Center on December 21, 1998 and January 19, 1999. Attendees at both meetings were encouraged to provide comment on all aspects of the document, including the overall appropriateness of the proposed SWAP plan.

In addition to the comments received as a part of the Citizens Advisory Committee meetings, written comments were received from six different individuals or organizations. Comments were received from the North Dakota Oil and Gas Division, North Dakota State Water Commission (NDSWC), North Dakota Geological Survey, North Dakota Chapter of the Sierra Club, EPA, and the North Dakota Public Drinking Water Program.

1.2 Source Water Assessment Reports and Public Notification

Source water assessments provide the initial elements considered to be a precursor to voluntary local water protection programs. However, to realize the optimum benefit from each assessment report, they must be readily accessible to the public in a timely, accurate, and understandable format. To ensure adequate public access to each source water assessment report, several traditional and electronic media information distribution strategies have been implemented.

1.2.1 Source Water Assessment Report Format

Upon finalization of a PWS source water assessment, an official report is completed for distribution to the public. The amount of information in a report will depend upon the availability of site-specific information (i.e., local geology, hydrology, well construction, and use); the

complexity of the source water delineation; contaminant source inventory; and susceptibility analysis. The North Dakota source water assessment format will include the following sections:

- Discussion of the Source Water Assessment Delineation
- Source Water Assessment Delineation Map
- Geologic Cross Section Illustration (if applicable)
- Contaminant Source Inventory
- Susceptibility Determination

The source water assessment delineation map will be displayed utilizing Geographic Information System (GIS). This format is easily updated and readily available to the public through the North Dakota Geographic Information System Hub. Based upon availability, information such as lithologic logs, soil risk assessment, water quality analytical results, and location of water quality observation stations may be included in the report.

1.2.2 Source Water Assessment Report Distribution

The NDDEQ and individual public water systems are responsible for providing public notice of completed source water assessment reports. The NDDEQ provides source water assessments through direct mailings and online publication of reports. Public water system notification of reports is part of the Safe Drinking Water Act Consumer Confidence Reporting requirements.

Each community PWS source water assessment report is available to the owner or operator of the PWS, environmental agencies, and other parties expressing technical interest in the completed reports.

Reports are available to other federal, state, or local agencies, and other interested individuals upon request of the NDDEQ. Non-Community source water assessment reports will be transmitted to the owner of the facility and published online. The NDDEQ will provide paper copies of a report to interested parties upon request.

Pursuant to the requirements of the SDWA, each community PWS will notify the interested public of the availability of a source water assessment report as part of Consumer Confidence Reporting.

Chapter 2. Natural Environment and Protection Programs

Since the late 1960s and arguable prior to that time, the citizens of North Dakota have acknowledged the importance of a clean, plentiful supply of water for a variety of uses. Examples of this awareness can be found in reviewing state laws, especially North Dakota Century Code (NDCC) 61-28 entitled "Control, Prevention, and Abatement of Pollution of Surface Waters." In NDCC 61-38, the Statement of Policy declares:

> It is hereby declared to be the policy of the state of North Dakota to act in the public interest to protect, maintain and improve the quality of the waters in the state for

> continued use as public and private water supplies, propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, recreational and other legitimate beneficial uses, to require necessary and reasonable treatment of sewage, industrial, or other wastes and to cooperate with other agencies in the state, agencies of other states and the federal government in carrying out these objectives.

The EPA has promoted similar policies through federal mandates identified in the Clean Water and Safe Drinking Water Acts. The objective of this chapter is to identify the status of North Dakota's water resources and the programs designed to protect their quality. The natural environment and existing regulatory infrastructure are integral to the success of a comprehensive North Dakota SWAP plan. This chapter includes a description of:

- The status of surface and groundwater resources
- The existing quality of source waters
- The status of North Dakota PWSs
- The primary sources of water quality contamination
- The status of existing source water protection programs

2.1 Natural Environment and Source Water Description

Local geology, hydrology, and other features provide various levels of natural protection from manmade contamination. These factors play an important role in the development and implementation of a comprehensive SWAP strategy and allow for site-specific protection plans.

2.1.1 State Geography and Surficial Geology

North Dakota is within two provinces of the Interior Plains--the Great Plains and Central Lowlands provinces (Figure 1). The Missouri Escarpment that traverses the state is considered to mark the boundary of the Great Plains province to the west and the Central Lowlands province to the east. The separation of the physiographic provinces is based on the sharp land surface elevation increase accompanying the Missouri Escarpment toward the west to the Missouri Coteau. In some locations, the rise of the escarpment may be as great as 500 feet per mile, although a more gradual increase of 100 to 200 feet per mile is more common (Bluemle, 1991). The surface elevation of North Dakota generally decreases from the southwest corner to the northeast corner of the state. Elevations range from the highest point of 3,506 feet above sea level at White Butte in Slope County of southwestern North Dakota to the lowest point of 730 feet above sea level near Pembina in northeastern North Dakota.

The land surface elevation of the Great Plains province generally exceeds 2,000 feet above sea level. The Missouri Slope Upland and the Coteau Slope consist of rolling to hilly plains, except in the badlands area where relief is very steep. Surface drainage is well developed on the older, erosional landscapes of the province, including the Missouri Slope Upland that was unglaciated and the Coteau Slope that was covered by thin or discontinuous glacial deposits. By contrast, the Missouri Coteau section is characterized by a depositional landscape created by large-scale stagnation of thick glacial deposits consisting primarily of glacial till, but also including large areas of glaciofluvial sand and gravel deposits. The Missouri Coteau landscape is a hummocky, irregular plain. Drainage of the Missouri Coteau is nonintegrated or noncontributing, meaning that no streams flow through the area. Wetlands and small lakes, however, are common in the area and serve as collection and storage locations for local precipitation.

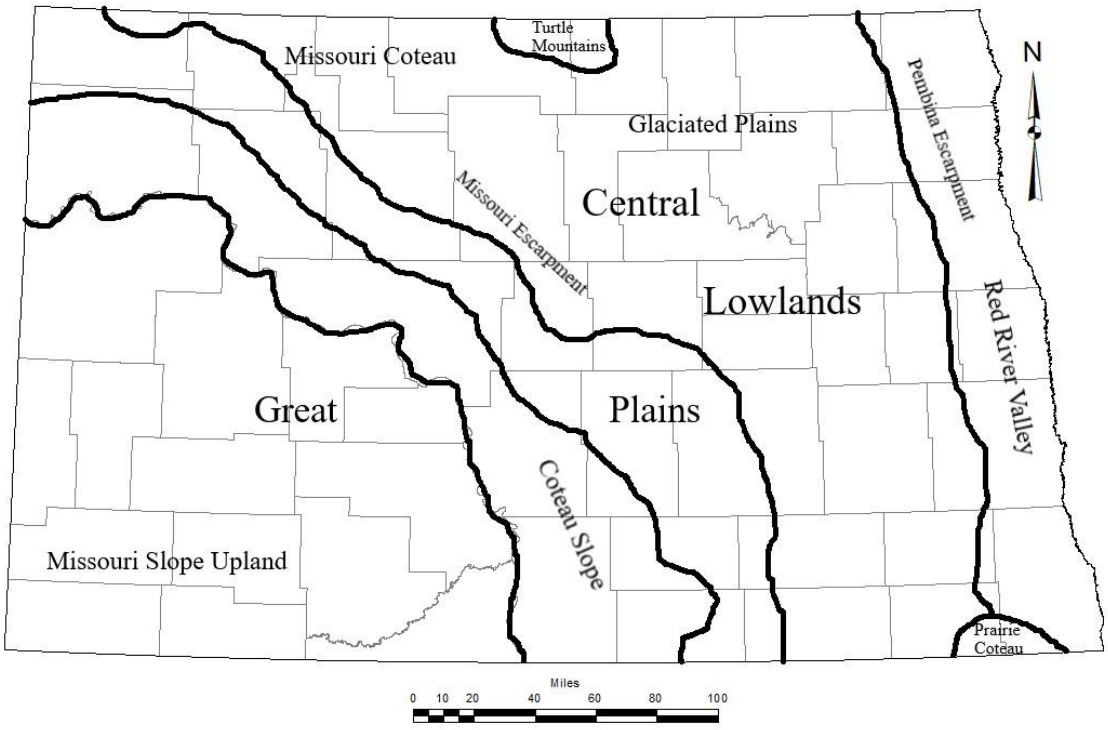

Figure 1. Geographic divisions of North Dakota (modified from Bluemle, 1991)

The Central Lowlands province is characterized primarily by depositional landscapes formed in thick glacial deposits. The province includes the Glaciated Plains and the Red River Valley physiographic regions (Figure 1). The Glaciated Plains region is a rolling, gently sloping landscape formed in glacial deposits consisting primarily of glacial till, but also including fine-grained glacial lake deposits and glaciofluvial sand and gravel deposits. Surface elevation of the Glaciated Plains averages 1,400 to 1,700 feet above sea level (Bluemle, 1991). Surface drainage of the Glaciated Plains is poorly integrated and includes closed basins.

The Red River Valley region is a flat, gently sloping plain formed as the result of deposition of silt and clay sediments on the floor of former glacial Lake Agassiz (Figure 1). The Pembina Escarpment marks the boundary between the Red River Valley and the Glaciated Plains. Surface elevation of the Red River Valley averages 800 to 1000 feet above sea level. Surface drainage of the Red River Valley is integrated by low-gradient streams that drain into the Red River of the North, which defines the eastern boundary of the state.

2.1.2 Precipitation

North Dakota's average annual precipitation ranges from about 13 inches in the northwest to about 20 inches at the state's eastern border. The precipitation is generally derived from air masses originating in the Gulf of Mexico. Summer rainfall is primarily from local thunderstorms, resulting in large variations in the space and time of precipitation events. About 60 percent of the annual precipitation occurs between April and July, with an estimated 75 percent of the annual precipitation occurring between April and September.

2.1.3 Surface Water Resources

Prior to glaciation, all streams in North Dakota flowed northeastward to the Hudson Bay Basin (Bluemle, 1991). Present-day North Dakota, however, is separated hydrologically by a continental divide running northwest through the central and southeastern part of the state. The two drainages created by the divide are the Missouri Drainage and the Hudson Bay Drainage.

The Missouri Drainage in North Dakota includes the Missouri River Basin and the James River Basin. Both drain south to the Gulf of Mexico (Figure 2). The Missouri River Basin alone covers about 34,600 square miles or 48 percent of the state.

The Hudson Bay Drainage includes the Red River of the North Basin, the Souris River Basin, and the Devils Lake Basin. This drainage region covers about 27,000 square miles or about 38 percent of the state (Bluemle, 1991). The Devils Lake Basin is a closed sub-basin. In response to Devils Lake's record-breaking rise in recent years, construction on an outlet from the West Bay of Devils Lake to the Sheyenne River began in 2002 and was completed in 2005. An additional outlet was constructed on the east side of Devils Lake in 2012 to increase operating capacity to 600 cubic feet per second, as needed. In addition to the outlets, a control structure was constructed in 2012 at Tolna Coulee (Devils Lake natural outlet) to control natural overflow.

The remaining 9,000 square miles (14 percent) of the state, including the Missouri Coteau section of the Great Plains province, is undrained or noncontributing. The Continental Divide follows the Missouri Coteau from the northwestern corner of the state to the center of the state, where it deviates from the Missouri Coteau to separate the James River Basin from the Red River of the North Basin (Figure 2).

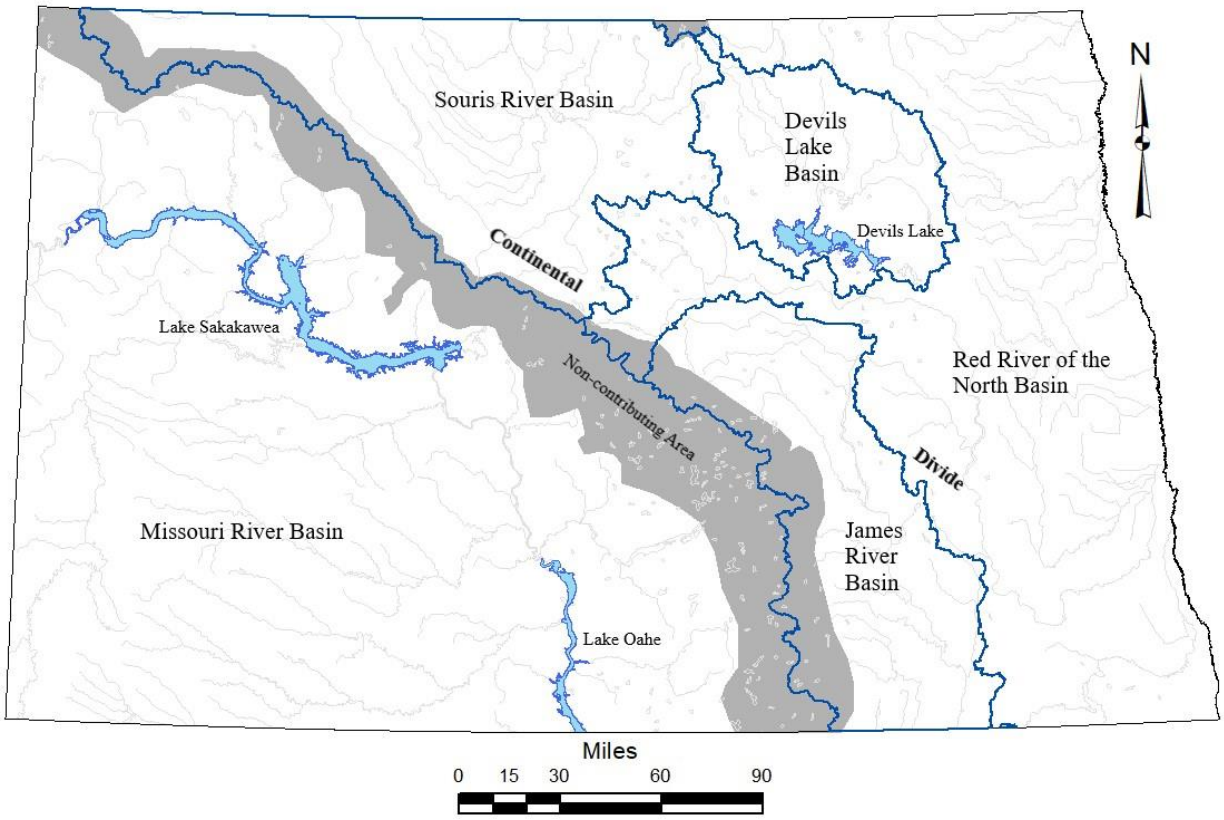

Figure 2. Drainage basins in North Dakota

2.1.3.1 Surface Water Quantity

Surface water is a vital resource to North Dakota cities, industry, and agriculture. About 50 percent of the state's population relies on surface water for domestic water supplies. Several of the largest cities in North Dakota, including Fargo, Bismarck, and Grand Forks, depend on surface water for public water supplies. In addition, surface water provides approximately 40 percent of the water used for irrigation.

The Missouri River discharges the largest quantity--and the best quality--of water of all rivers in North Dakota. The Missouri River discharges at least six times more water than the Red River, the second largest river in the state. The combined annual flow of the Red River at Fargo, the Sheyenne River at Valley City, the James River at Jamestown, and Souris River at Minot is less than 4 percent of the annual flow of the Missouri River at Bismarck.

Within the state, there are 56,644 total miles of rivers and streams: 12,164 miles in the Red River Basin; 3,890 miles in the Souris River Basin; 14,381 miles in the Upper Missouri (Lake Sakakawea) Basin; 23,141 miles in the Lower Missouri (Lake Oahe) Basin; and 3,013 miles in the

James River Basin. Of the total river miles in North Dakota, 427 are shared borders with other states or Canadian provinces.

About 24 million acre-feet of total normal storage is available in North Dakota reservoirs; much of this storage is within the Missouri River reservoirs of Lake Sakakawea and Lake Oahe (NDSWC, 2017). Table 1 presents a summary of characteristics of the five hydrologic basins and the major streams in North Dakota.

The NDDEQ recognizes only those lakes and reservoirs which are primarily publicly owned. Within the state, water quality assessments are ongoing for 295 lakes and reservoirs: 146 are manmade reservoirs and 149 are natural lakes. Reservoirs are defined as water bodies formed because of dams or dugouts constructed on natural or manmade drainages. Natural lakes are water bodies having natural lake basins; a natural lake can be enhanced with outlet control structures, diversions, or dredging. The 149 natural lakes cover 239,237 acres, with 102,376 attributed to Devils Lake. The remaining lakes average 924 acres in size, with approximately 40 percent smaller than 250 acres.

2.1.3.2 Surface Water Quality

The NDDEQ, as well as other state and federal agencies, have a history of evaluating the quality of North Dakota's surface water resources. This information has been utilized to characterize the potential of primary water bodies for beneficial uses such as domestic, agricultural, industrial, and recreational. Each of the major lakes and streams have been classified according to their potential to meet beneficial use criteria as identified in North Dakota Administrative Code (NDAC) 33-16-02 Standards of Quality for Waters of the State. The classifications for streams are defined in Table 2.

The classification of North Dakota lakes is different from the stream classification as it is based upon the type of fishery a lake may be capable of supporting. Class 1 is of the highest quality, with Class 5 lakes considered to be of the poorest quality. The classification for North Dakota lakes as defined in NDAC 33-16-02 is presented in Table 3.

Table 1. Summary of Characteristics for Major Hydrologic Basins (NDSWC, 2014)

	Missouri River Basin	James River Basin	Souris River Basin	Red River Basin	Devils Lake Sub-basin
Drainage Area (square miles)	34,544	6,493	8,734	17,100	3,842
Number of Communities	105	33	52	140	28
Normal Reservoir Storage (1,000 acre-feet)	24,200	230	352	200	3,775
Dominant Land Uses	54% Range 35% Crop	60% Crop 23% Range	56% Crop 28 % Range	70 % Crop 13% Range	60% Crop 12% Range
Average Discharge (cubic feet/sec)	22,000 Missouri River at Bismarck	212 James River at LaMoure	335 Souris River above Minot	4,899 Red River at Drayton	213 Devils Lake Outlets
Average Total Dissolved Solids (milligrams per liter or mg/L)	429 at Missouri River at Bismarck	457 at James River at Jamestown	1039 at Souris River north of Sawyer	418 at Red River near Drayton	1366 at Devils Lake near West Outlet

Table 2. Definition of Stream Classifications in North Dakota

Class	Characteristics
Class I	The quality of waters in this class shall be such as to permit the propagation of life, or both, of resident fish species and other aquatic biota and shall be suitable for boating, swimming, and other water recreation. The quality shall be such that after treatment consisting of coagulation, settling, filtration, and chlorination, or equivalent treatment processes, the treated water shall meet the bacteriological, physical, and chemical requirements of the NDDEQ for municipal use. The quality of water shall be such as to permit its use for irrigation, stock watering, and wildlife use without injurious effects.
Class IA	The quality of this class of waters shall be such that its uses shall be the same as those identified for Class I, except that treatment for municipal use may also require softening to meet the chemical requirements of the NDDEQ. The physical and chemical criteria shall be those for Class I.
Class II	The quality of this class of water shall be such that its uses shall be the same as those identified for Class I, except that additional treatment may be required over that noted in Class IA to meet the drinking water requirements of the NDDEQ. Streams in this classification may be intermittent in nature which would make some of these waters of questionable value for beneficial uses, such as irrigation, municipal water supplies, or fish life.
Class III	The quality of this class of waters shall be suitable for industrial and agricultural uses, i.e., cooling, washing, irrigation, and stock watering. These streams all have low average flows and generally prolonged periods of no flow; they are of marginal or seasonal value for immersion recreation and fish aquatic biota. The quality of the water must be maintained to protect recreation, fish, and aquatic biota. The physical and chemical criteria shall be those for Class II, with the following exceptions: Sulfate (total) - maximum limit 750 milligrams per liter (mg/L).

Table 3. Definition of Lake Classifications in North Dakota

Class	Characteristics
1	Cold water fishery. Waters capable of supporting growth of salmonoid fishes and associated aquatic biota.
2	Cool water fishery. Waters capable of supporting growth and propagation of nonsalmonoid fishes and marginal growth of salmonoid fishes and associated aquatic biota.
3	Warm water fishery. Waters capable of supporting growth and propagation of nonsalmonoid fishes and associated aquatic biota.
4	Marginal fishery. Waters capable of supporting fishery on a seasonal basis.
5	Not capable of supporting a fishery due to high salinity.

Based upon the information collected as part of the North Dakota water quality monitoring and assessment effort identified later in this section, each of the major surface water systems utilized as domestic drinking water supplies have been classified as identified in Table 4.

Table 4. Classification of Surface Water Used to Supply a Public Drinking Water System

Source Water	Standards Classification (*)
Missouri River	I
Red River	I
Sheyenne River	IA
Park River	II
Goose River	IA
Souris River	IA
Pembina River	IA
Lake Sakakawea	1**
Lake Oahe	1**
Mt. Carmel Dam	2**

* As identified in NDAC 33-16-02 Standards of Quality for Waters of the State
** Lake Classification

Prior to 1993, the NDDoH conducted surface water quality monitoring through established chemical monitoring stations. Many of these stations were located immediately below point source discharges or near the confluences of major streams. Typical water quality variables analyzed were temperature, dissolved oxygen, pH, major ions, nutrients, and fecal coliform bacteria. Trace elements were also analyzed at a few select sites. At its peak in 1993, the network included 61 ambient chemical monitoring sites on 31 rivers and streams.

This monitoring strategy was not effective in assessing trends in water quality across the state, nor did it provide the spatial resolution necessary to conduct beneficial use assessments for a significant portion of the river and stream miles in the state. The data was only indirectly related to beneficial use impairment. In 1993, the NDDoH changed the emphasis to biological monitoring in watersheds, and it started with the Red River Basin. This was implemented by reducing the number of chemical monitoring sites from 61 to 27 in 1994. Where practical, sites were co-located with USGS flow gauging stations, thereby facilitating the analysis of chemical data with stream hydrologic data. All 27 sites are located as basin or sub-basin integrator sites where the chemical data reflects water quality from a watershed. The program was expanded into the James River Basin in 1995, the Souris River Basin in 1997, and to the Upper Missouri and Lower Missouri basins in 1999. In addition, the USGS also operates and maintains several water quality monitoring sites which provide data used by the NDDEQ for assessment of beneficial use impairment.

There are approximately 56,644 miles of rivers and streams in the state of North Dakota, based on river and stream waterbodies indexed to the 1:100,000 National Hydrography Dataset (NHD plus), and they include ephemeral, intermittent, and perennial rivers and streams. These river and stream miles are evaluated for five categories of beneficial use impairment, representing varying levels of water quality standards attainment ranging from Category 1, where all a waterbody's designated uses are met, to Category 5, where a pollutant impairs a waterbody and a Total Maximum Daily Load (TMDL) is required. The Watershed Management Program, within the NDDEQ's Division of Water Quality, assesses these miles and publishes the North Dakota Integrated Section 305(b) Water Quality Assessment Report and Section 303(d) List of Waters Needing Total Maximum Daily Loads every two years.

Through 2016, drinking water supply use has been classified for 5,598 miles of rivers and streams. Of the 916 miles assessed, 151 miles were assessed as threatened for drinking water supply use. (NDDoH, 2017).

2.1.4 Groundwater Resources

Groundwater is one of North Dakota's most valuable resources. Half of the state's population relies on groundwater for drinking water supplies. Ninety-seven percent of the state's incorporated communities rely on groundwater, either from municipal systems, rural water systems, or private wells. In addition, groundwater is essentially the only source of water supply for farm families and their livestock, and residents of small communities that are not served by public water systems.

In recent years, the emphasis on value-added agriculture has resulted in increased demand for groundwater used for irrigation. Figure 3 depicts the major uses of groundwater in North Dakota.

Groundwater resources in North Dakota occur in two principal aquifer types: (1) unconsolidated glacial deposits and (2) sedimentary bedrock. The bedrock geology of North Dakota is dominated by the Williston Basin, a sedimentary basin centered southeast of Williston, North Dakota, where its maximum depth is approximately 15,000 feet deep.

There are four major bedrock aquifer units within the Williston Basin. Water quality varies considerably within the aquifer units, with the deeper units generally considered highly saline and the shallower units exhibiting saline to brackish to moderately low total dissolved solids (TDS). The best quality water in the bedrock aquifer units almost always occurs in the shallowest unit at any given location. In some near-surface bedrock aquifers in southwestern North Dakota, TDS may occasionally be as low as 1000 mg/L.

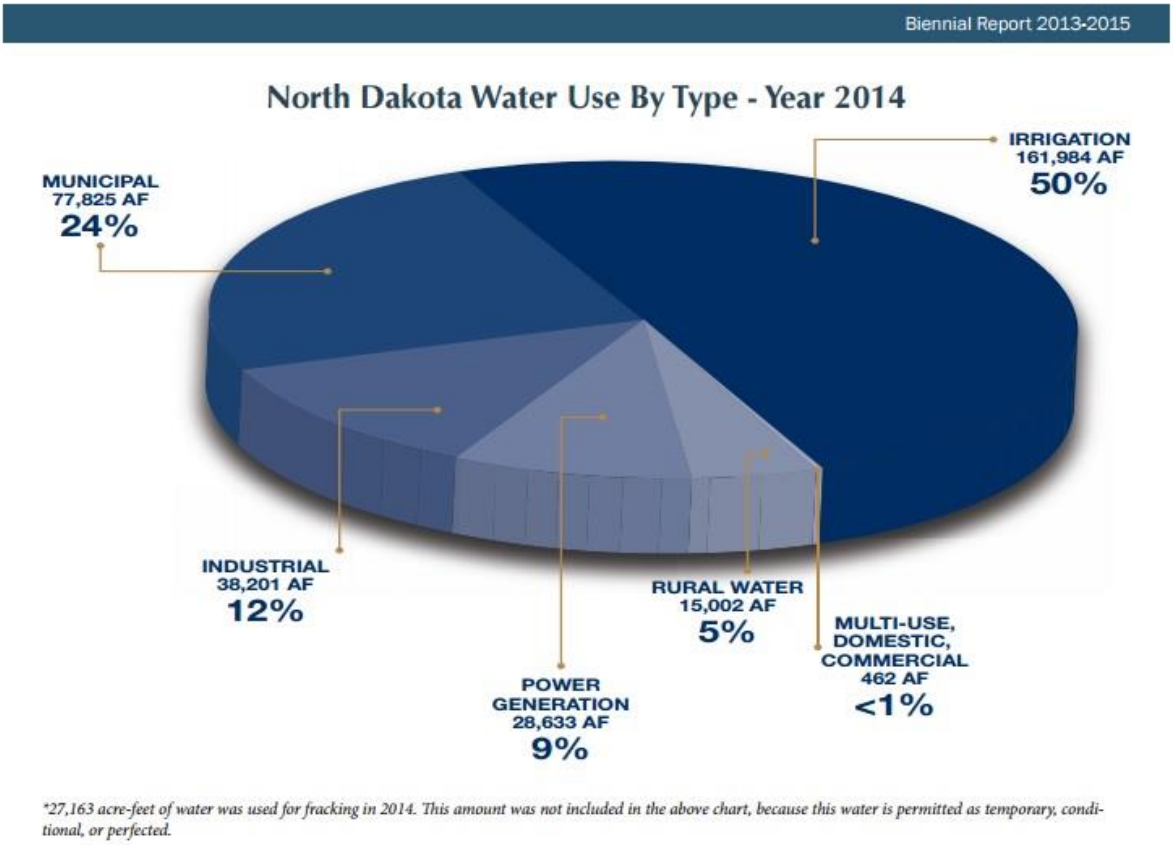

Figure 3. Major uses of groundwater in North Dakota (NDSWC)

The majority of high-quality groundwater (less than 2,000 mg/L TDS) in North Dakota is contained within glacial drift aquifers (Figure 4). These aquifers are generally composed of sand and/or gravel deposited by glacial activity. Most of the glacial drift aquifers are located at or near the surface, although some are buried by till deposits from subsequent glacial advances.

Groundwater quality in the glacial drift aquifers ranges from as low as 200 mg/L TDS to several thousand mg/L TDS. Some areas that discharge groundwater mainly through evapotranspiration processes may have TDS exceeding 10,000 mg/L.

The groundwater resources of North Dakota have been extensively studied and catalogued. Every county in the state has had a geology and groundwater resources study completed through a cooperative effort by the USGS, the North Dakota Geological Survey, and the NDSWC. More than 15,000 geological test holes were drilled for these studies, with almost 6,000 completed as observation wells. Several state agencies continue to characterize and survey the quality and quantity of North Dakota's water resources. The NDSWC now has an observation well network of more than 8,000 wells across the state, with more being drilled every year.

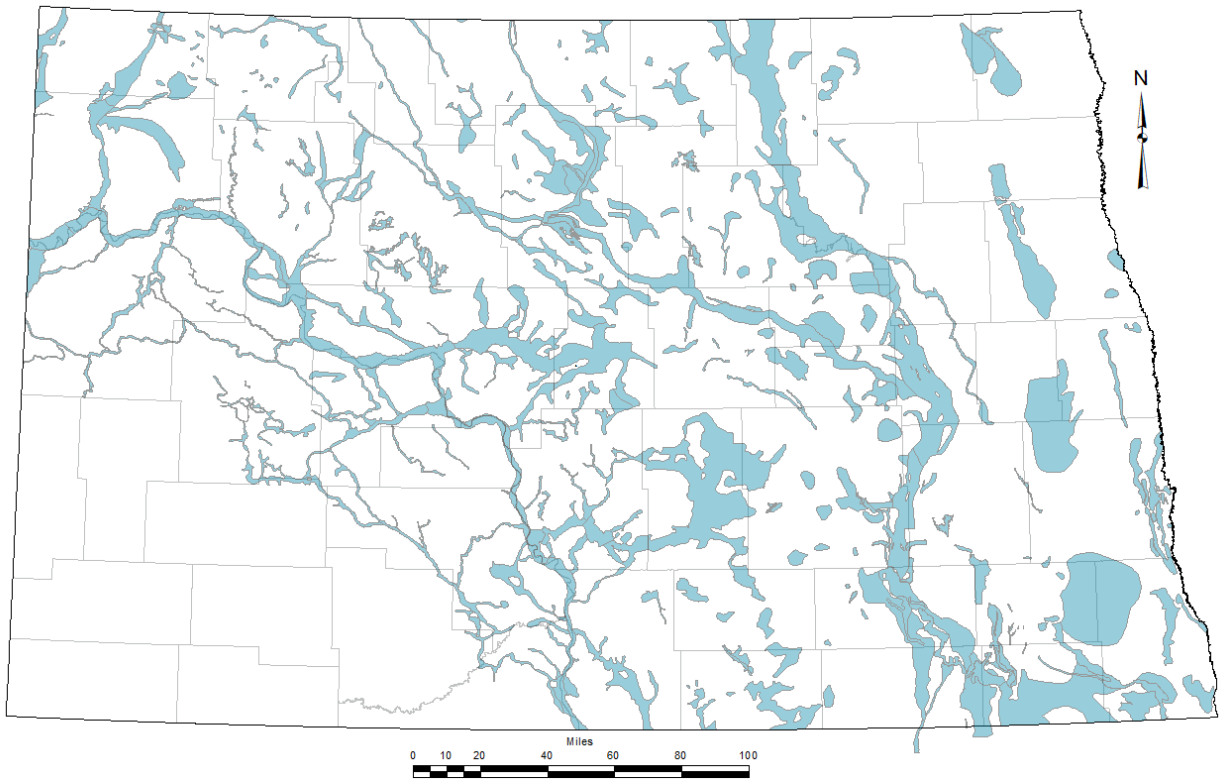

Figure 4. Major glacial drift aquifers of North Dakota

In 1991, the NDDoH developed an aquifer sensitivity prioritization system designed to identify areas in the state where groundwater resources are potentially more susceptible to contamination. Named the Geographic Targeting System (GTS), the method combines rating factors representing aquifer vulnerability, sensitivity, and risk.

Aquifer vulnerability is determined using the DRASTIC model, developed by the EPA to be a standardized system for evaluating groundwater pollution potential. The DRASTIC model incorporates consideration for several aquifer characteristics which include the Depth to water, net Recharge, Aquifer media, Soil media, Topography, Impact of the vadose zone, and hydraulic Conductivity. Sensitivity primarily relates to the usage of agricultural chemicals and fertilizers. The market value of agricultural production per acre, for both crops and livestock, is used as a beneficial use of the water or amount of harm which may result from aquifer contamination. The total volume of groundwater permitted for withdrawal from an aquifer for domestic irrigation and industrial use represents the aquifer's potential risk.

The outcome is a numeric score which ranges from a low priority rating of 3 to a high priority rating of 9. This systematic approach is used to prioritize monitoring activities associated with the NDDEQ Ambient Groundwater Monitoring Program. The overall aquifer sensitivity ratings are reviewed periodically and amended as needed to reflect changes in water and land use, as well as from results of water quality monitoring activities. Figure 5 is the 2017 GTS map of the glacial drift aquifers in North Dakota. A complete listing of each GTS aquifer rating is provided in Appendix B.

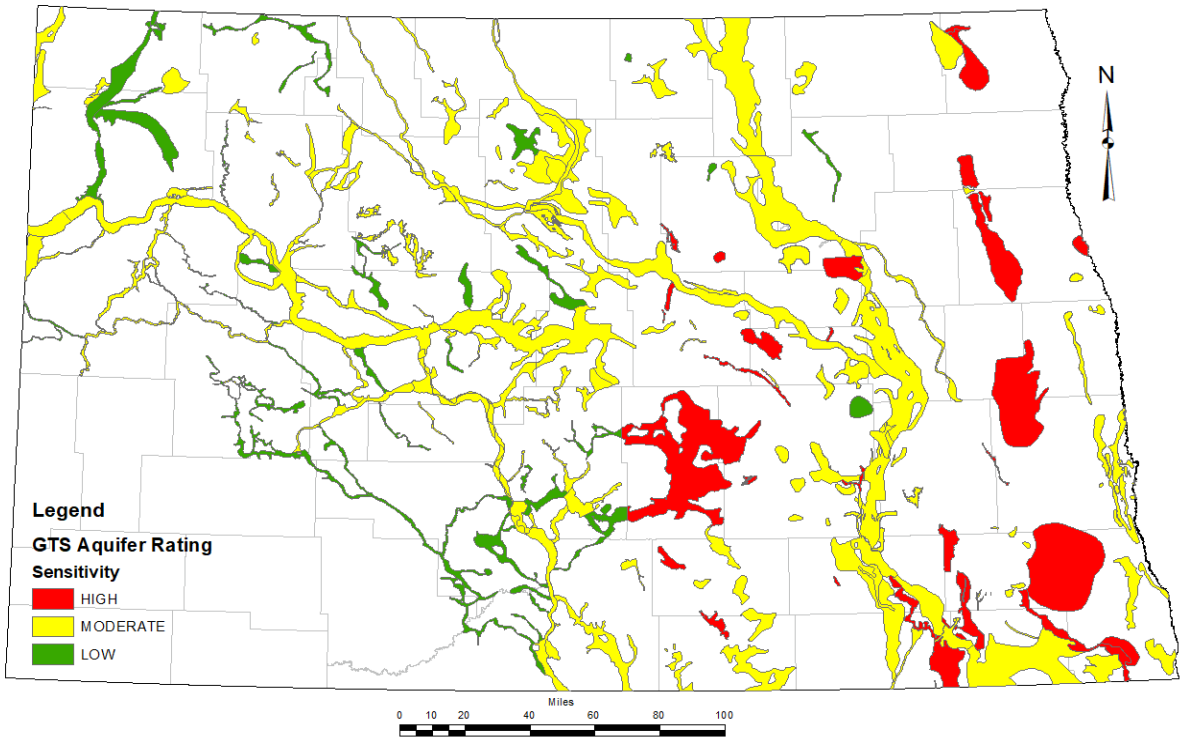

Figure 5. 2017 GTS aquifer map

In 1992, the NDDoH initiated routine monitoring of the 50 most susceptible aquifers identified by the GTS. Approximately 10 aquifers a year are monitored for general anion/cation chemistry and agricultural chemicals. The analytes of concern have been general anions and cations, total nitrate plus nitrite (N), 32 base-neutral pesticides, 10 chlorinated pesticides, and eight carbamate pesticides. The three pesticide groups include all parameters identified in the SDWA Phase II/V sampling requirements. Criteria used for sample site selection in each of the aquifers includes: (1) location and construction of wells, (2) one well sampled per section, and (3) accessibility. Private and public wells, in addition to NDSWC observation wells, are included. Each year the quantitative results are presented in a report identifying the analytical detection of pesticide compounds, discussing general water quality, and assessing possible sources of contamination. A 25-year summary report was completed in January 2018 (Peterson, 2018). Table 5 summarizes those investigations.

2.2 Public Water Supply System Definition and Status

A Public Water System (PWS) provides water via piping or other constructed conveyance for human consumption to at least 15 service connections or serves at least 25 people for at least 60 days each year. Acknowledging the fact that not all PWSs are operated for the same objective or require the same level of regulatory oversight, EPA has divided PWSs into two primary categories:

- Community Water Supply System: a PWS that pipes water for human consumption to at least 15 service connections used by year-round residents, or that regularly serves at least 25 year-round residents (e.g., municipality, subdivision, mobile home park)

- Non-Community Water Supply System: a PWS that pipes water for human consumption to at least 15 service connections used by individuals other than year-round residents for at least 60 days a year, or that serve 25 or more people at least 60 days a year (e.g., schools, factories, rest areas).

  Non-Community water supply systems are further categorized:

  - Non-Transient Non-Community (NTNC) Water System: a system that serves at least 25 of the same people more than six months per year (e.g., schools, factories, industrial parks, office buildings).

  - Transient Non-Community (TNC) Water System: a system that does not meet the definition of a NTNC water system (e.g., highway rest stops, restaurants, motels, golf courses, parks).

As of 2016, North Dakota had 324 community PWSs, 83 non-community PWSs, 12 non-transient non-community PWSs, and 95 transient non-community PWSs. A state status, designated nonpublic, defines state-regulated systems only and includes 161 systems in North Dakota. A complete list of the systems currently regulated in the state can be found in Appendix A.

Table 5. Ambient Groundwater Quality Monitoring Results in North Dakota

Rotation Period	Total Wells Sampled	Wells with Analyte Detection	Common Analyte Detects	Percent Detect By Analyte
1992-1996	756	62 of 756 or 8.2 % of wells	Picloram 2,4-D BHC(Beta) Bentazon Dicamba Trifluralin Atrazine Nitrate	4.93 % 1.07 % 0.77 % 0.68 % 0.67 % 0.66 % 0.53 % 5.00 %
1997-2001	1027	97 of 1027 or 9.4 % of wells	Picloram Pentachlorophenol Bentazon 2,4-D Dicamba Endrin DDT Nitrate	4.78 % 1.50 % 0.95 % 0.83 % 0.51 % 0.48 % 0.39 % 6.00 %
2002-2006	1044	62 of 1044 or 5.9 % of wells	Picloram Bentazon 2,4-D Chlorothalonil Nitrate	4.22 % 0.77 % 0.29 % 0.29 % 4.00 %
2007-2011	1007	64 of 1007 or 6.4 % of wells	Picloram Bentazon Atrazine Dicamba Trifluralin Metolachlor Nitrate	2.39 % 1.39 % 0.60 % 0.40 % 0.40 % 0.30 % 5.40 %
2012-2016	897	33 of 897 or 3.7 % of wells	Picloram Bentazon 2,4-D Dicamba Nitrate	2.39 % 0.80 % 0.23 % 0.23 % 5.13 %

Source: North Dakota Agricultural Ambient Groundwater Monitoring Program 1992-2016 (Peterson, 2018)

2.2.1 Surface Public Water Supply Systems

There are currently 14 PWSs in North Dakota which receive source water from surface water intakes. Seven community systems serve populations larger than 3,300 people. Three systems are rural water systems. Only one non-community system still maintains its own surface water intake. Table 6 identifies the PWSs in North Dakota which have independent surface water sources supplying all or a portion of their drinking water needs.

Table 6. Public Water Systems with Independent Surface Water Sources

PWS Name	PWS City	PWS Type	Source
Coal Creek Station	Underwood	NTNC	Missouri River
Drayton, City of	Drayton	Community	Red River
Fargo, City of	Fargo	Community	Red River
Fargo, City of	Fargo	Community	Sheyenne River
Garrison, City of	Garrison	Community	Lake Sakakawea
Grafton, City of	Grafton	Community	Park River
Grafton, City of	Grafton	Community	Red River
Grand Forks, City of	Grand Forks	Community	Red Lake River
Grand Forks, City of	Grand Forks	Community	Red River
Mandan, City of	Mandan	Community	Missouri River
OMND Water Treatment Plant	Rural Water System	Community	Lake Sakakawea
Riverdale, City of	Riverdale	Community	Lake Sakakawea
South Central RWD-Emmons	Rural Water System	Community	Lake Oahe
Southwest Water Authority	Rural Water System	Community	Lake Sakakawea
Valley City, City of	Valley City	Community	Sheyenne River
Washburn, City of	Washburn	Community	Missouri River
Williston, City of	Williston	Community	Missouri River

2.2.2 Groundwater Under the Direct Influence of Surface Water Supply Systems

There are currently two systems in North Dakota that are classified as groundwater under the direct influence of surface water (Table 7). "Under the direct influence of surface water" means the groundwater source is located close enough to a nearby surface water, such as a river or lake, to receive direct surface water recharge. Since a portion of the groundwater source's recharge is from surface water, the groundwater source is considered at risk from contamination from pathogens such as Giardia lamblia and viruses, which are not normally found in true groundwaters.

Table 7. Public Water Systems Designated Groundwater Under the Direct Influence of Surface Water

PWS Name	PWS City	PWS Type	Source
Bismarck, City of	Bismarck	Community	Radial Collector Well Bismarck Aquifer/Missouri River
South Central RWD-North Burleigh	Rural Water System	Community	Groundwater Wells Burnt Creek Aquifer/ Missouri River

All the systems identified in Tables 6 and 7 are in compliance with the requirements of the SDWA, including the Surface Water Treatment Rule (SWTR) promulgated by the EPA. The SWTR became effective on December 31, 1990. Under this rule, filtration and disinfection for surface water and groundwater systems under the direct influence (UDI) of surface water are required. One of the objectives of the SWTR is to provide water free from certain microbiological organisms for which no enforceable Maximum Contaminant Level (MCL) standards have been established. Systems may avoid this requirement provided specific source water quality and system operation criteria are met. These include compliance with established microbiological and turbidity criteria in the raw water source prior to any treatment. The water system must also operate in a way to minimize consumer risk from microbiological contamination. This can be accomplished by:

- The establishment and maintenance of a watershed control program
- Having no more than two monthly total coliform MCL violations in any consecutive two-month period
- Not exhibiting a history of waterborne disease outbreaks
- Compliance with total trihalomethane requirements for systems serving 10,000 or more people

Systems which filter source water must ensure that filtration and disinfection are effective as demonstrated by turbidity and disinfection criteria. As with unfiltered systems, effectiveness is demonstrated in part by the amount of disinfectant and the length of time it is in contact with the water before reaching the first customer.

2.2.3 Groundwater Public Water Supply Systems

North Dakota currently includes 190 independent groundwater PWSs in the Source Water Protection Program. Of these systems, 108 are community PWSs with 22 being rural water systems, and 82 are non-community systems with 32 on seasonal status. An additional 17 systems are classified as nonpublic, a state-designated status for state-regulated-only systems.

2.2.4 PWS Compliance Status

The EPA has established enforceable MCLs for specific inorganic, organic, and microbial contaminants in drinking water. The SDWA requires each PWS to routinely monitor the quality of the drinking water in distribution systems for compliance with each of the established MCLs. The compliance status of PWSs with the SDWA for year 2016 is shown in Table 8.

Table 8. PWS SDWA Compliance Status (2016)

Parameter	Total Number of PWSs	Compliance Percentage
Primary Inorganic		
Community	324	100
NTNC	12	100
TNC	95	98.9
Regulated Organics		
Community	324	100
NTNC	12	100
TNC	N/A	N/A
Radionuclide		
Community	324	99.69
NTNC	N/A	N/A
TNC	N/A	N/A
Total Coliform Rule		
Community	324	100
NTNC	12	100
TNC	95	97.9
Revised Total Coliform Rule		
Community	324	100
NTNC	12	100
TNC	95	100
Stage 2 Disinfectants/Disinfection By-products Rule		
Community	317	99.4
NTNC	5	100
TNC	N/A	N/A
Groundwater Rule		
Community	222	100
NTNC	10	100
TNC	85	100

N/A - not applicable

PWSs have historically achieved exceptional compliance with the SDWA MCL standards. This is attributed, in part, to effective operator training, routine sanitary surveys/ inspections, and an effective point source regulatory program. Of the systems that exhibited MCL violations, one system had one exceedance of total nitrate and nitrite. One system had an exceedance of radionuclide MCLs, and two systems had reports of nonacute total coliform violations.

2.3 Contaminant Source Overview

The degradation of waters of the state can result from a variety of sources involving both natural processes and manmade activities. Because natural impacts to water quality are usually widespread and occur over long periods of time, cost-effective remedies are usually limited. However, concerns arise when land use activities accelerate the natural degradation rate, overwhelm natural attenuation processes, or introduce contaminants not native to the environment resulting in adverse impacts.

North Dakota citizens, through the enactment of legislation, have mandated that contaminants of concern be regulated for the protection of public health and the environment, and to safeguard social, economic, and industrial development associated with the water resource. The sources of water contamination in North Dakota are associated with domestic, municipal, agricultural, surface mining, oil and gas extraction, and industrial sectors within the state, as well as naturally occurring nonpoint source (NPS) surface soil erosion and atmospheric deposition of chemical contaminants.

Through years of regulatory attention and environmental water quality monitoring, the NDDEQ has identified a list of activities that, if conducted improperly, can result in adverse impacts on the beneficial uses of the state's water resources. Table 8 identifies the major water quality contaminant sources and parameters of concern for surface and groundwater resources, as identified in the North Dakota 2016 Integrated Water Quality Assessment Report (NDDoH, 2016) and from ambient surface/groundwater monitoring activities.

It is important to note that this list does not include all contaminant sources occurring in North Dakota. Sections 2.3.1 through 2.3.6 provide additional insight as to the magnitude of the issues for some of the contaminants of concern in North Dakota.

Table 9. Major Sources of Water Quality Contamination in North Dakota

Contaminant Source	Factors Considered in Selecting a Contaminant Source	Typical Contaminants
Agricultural Chemical Facilities	-Human Health and Environmental Risk (Toxicity) -Number and/or Size of Contaminant Sources -Geographic Distribution/Occurrence	Pesticides Nitrates Ammonia
Animal Feedlots	-Human Health and Environmental Risk (Toxicity) -Number and/or Size of Contaminant Sources -Geographic Distribution/Occurrence	Nitrate/Ammonia Sulfate Bacteria Chloride Phosphorus
On-farm Agricultural Mixing and Loading Procedures	-Human Health and Environmental Risk (Toxicity) -State Findings	Pesticides Nitrate
Storage Tanks (Above Ground)	-Human Health and Environmental Risk (Toxicity) -Location of Sources Relative to Drinking Water Sources -Number and Size of Contaminant Sources -Documented from Mandatory Reporting	Petroleum Compounds Salinity/Brine Nitrate/Ammonia
Storage Tanks (Below Ground)	-Human Health and Environmental Risk (Toxicity) -Location of Sources Relative to Drinking Water Sources -Number and Size of Contaminant Sources -Documented from Mandatory Reporting	Petroleum Compounds Halogenated Solvents
Surface Impoundments	-Number and Size of Contaminant Sources	Nitrate Sulfate Total Dissolved Solids Chloride Nutrients
Large Industrial Facilities	-Human Health and Environmental Risk (Toxicity)	Petroleum Compounds Nitrate Sulfate Total Dissolved Solids Chloride
Accidental Spills	-Human Health and Environmental Risk (Toxicity) -Documented from Mandatory Reporting -Geographic Distribution/Occurrence	Pesticides Petroleum Compounds Nitrate Salinity/Brine
Urban Runoff/Storm Sewers	-Human Health and Environmental Risk (Toxicity) -Geographic Distribution/Occurrence	Petroleum Compounds Metals/Mercury Total Dissolved Solids Salinity
Agricultural Field Runoff	-Human Health and Environmental Risk (Toxicity) -Geographic Distribution/Occurrence	Total Dissolved Solids Nutrient Loading Bacteria
Industrial/Municipal Discharges	-Human Health and Environmental Risk (Toxicity) -Geographic Distribution/Occurrence -Documented from Mandatory Reporting	Nutrient Loading Bacteria

2.3.1 Industrial/Municipal Wastewater Discharge

Wastewater treatment is accomplished in North Dakota using two methods. The first is through lagoon systems or waste stabilization ponds. This is the most common form of wastewater treatment, especially for municipalities, due to the low cost of operation and maintenance and the availability of land to use. Waste stabilization ponds are usually operated in a series and are connected through valves which are kept closed unless water is being transferred. As water is transferred from one cell to the next, the attenuation processes continue to clean the wastewater. Lagoon systems are considered intermittent discharges and usually only discharge once or twice a year. Lagoon water quality is commonly indicated through 5-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS) analytical results. High concentrations of BOD_5 or TSS point to poor treatment. Prior to discharging, lagoon operators discuss analytical results with program representatives.

Mechanical treatment plants are the second method of treatment used to treat wastewater in North Dakota. Mechanical plants are machinery-based and use one or more physical, chemical, and/or biological process units to treat wastewater. Several municipalities and industries have chosen mechanical plants over lagoon systems. Although mechanical plants are more technical in nature, more labor-intensive, and more expensive to construct and operate than lagoon systems, they can treat a larger amount of wastewater more quickly than lagoon systems. These systems are generally continuous dischargers.

Toxic pollutants in wastewater discharges are controlled by the industrial pretreatment program administered in North Dakota by the EPA - Region VIII. This program regulates individual industries using municipal sewer systems. Whole effluent toxicity (WET) testing of treated wastewater discharged from all major permittees, including industries, is required.

2.3.2 Underground Storage Tanks

Underground storage tanks (USTs) are commonly used for storage and dispensing of motor fuels. The NDDEQ has maintained an inventory of active underground tanks since 1989. The inventory is limited to regulated tanks, which are defined as those having a capacity of greater than 1,100 gallons. The number of underground tanks has declined over the years from a high of 8,573 tanks to a current level of 2,340 tanks at 879 active fueling sites.

Releases of petroleum products associated with the operation of USTs can result in significant contamination of groundwater resources, some of which can go undetected for many years. Adverse impacts include required abandonment of wells and the development of explosive atmospheres in buildings and underground piping.

As of 2017, the NDDEQ had confirmed releases of petroleum products at 1,015 sites. Most sites have been remediated and/or closed. Remedial action activities are ongoing at only 41 sites. To assist in addressing contamination associated with USTs, the North Dakota Insurance Department administers the Petroleum Release Compensation Fund, which reimburses owners of registered

tanks for costs associated with remedial measures taken at sites of leaking tanks. To date, remedial actions at 27 sites have been elevated to federal Leaking Underground Storage Tank (LUST) Trust Fund projects.

2.3.3 Pesticide Usage

Much of the state's 45,716,480 land surface acres are rangeland, tilled cropland, federal parks, or set-aside lands under federal and private conservation programs. Approximately 78 percent of the acreage in North Dakota is treated with herbicides, insecticides, fungicides, desiccants, or some combination thereof. Furthermore, approximately 32 percent of the total acreage was planted with treated seed.

The North Dakota Department of Agriculture is responsible for registering pesticides and ensuring proper application of pesticides through education, applicator certification, and enforcement. In addition, the Department of Agriculture has operated Project Safe Send since 1992. Project Safe Send is a state program supported by pesticide registration fees; it collects and disposes of unusable or unwanted pesticides throughout North Dakota. The project has collected more than 4 million pounds of pesticides since its inception.

In response to federal concerns over pesticide use and application, the North Dakota Department of Agriculture prepared a State Management Plan in 1998 which outlines water quality protection strategies for pesticide applications. The State Management Plan identifies the roles of various federal and state agencies in protecting the state's water resources. It also establishes a Contaminant Response Task Group and describes the group's role in implementing voluntary and nonvoluntary remedial actions when contamination is identified.

Additional water quality monitoring is conducted annually by the Department of Agriculture in conjunction with the NDDEQ for pesticides in surface water. The NDDEQ also implements the Ambient Groundwater Quality Monitoring Program. The state-funded program was initiated in 1992 to determine the occurrence and concentration of pesticides in the most susceptible groundwater resources. The program now has more than 25 years of groundwater quality data.

2.3.4 Fertilizer Storage and Application

Natural or commercial fertilizer, when managed properly, is a valuable tool used to increase crop yields for the producer. However, when mismanaged, fertilizer compounds can adversely impact the quality of both surface and groundwater resources. Increased eutrophication of lakes or excessive ammonia/nitrate concentrations in groundwater can occur in areas of improper application or handling of fertilizer.

Approximately 450 fertilizer distribution or storage facilities are currently licensed in the state. These facilities range in size from retail department store outlets to the larger bulk dealerships. Fertilizer compounds include granular, liquid, and anhydrous ammonia compounds used in a variety of applications. To date, approximately 40 different water quality contaminant assessment

and remedial action activities have been initiated to address improper disposal, storage, or handling of fertilizer compounds. These remedial or cleanup activities range from removal of contaminated soil to the treatment of contaminated ground water. Documented cases of nitrate and ammonia contamination from fertilizers have identified water quality impacts which exceed EPA MCLs or Health Advisories.

2.3.5 Livestock Operations

Pursuant to NDAC 33-16-03.1, the NDDEQ requires that all defined concentrated animal feeding operations (CAFOs) apply for a permit and receive approval to operate. Requirements for appropriate waste storage and handling practices, coupled with compliance monitoring to minimize impacts to water and air quality, are addressed by the NDDEQ. As of May 2018, there were 100 permitted CAFOs and 778 permitted AFOs in the state. Most of the livestock operations are cattle wintering operations, hog operations, and dairy operations that are part of a larger farming unit. During the last few years, there has been an increase in large, confined animal feeding operations for turkeys, hogs, and dairy cattle. To address the increase in larger operations, the NDDEQ review process addresses potential environmental impacts from wastes generated by these large operations. The review process helps to ensure that operators are responsible for proper facility construction, operation, and waste handling to minimize adverse water and air quality impacts. In some cases, the NDDEQ has required groundwater monitoring and the development of spill contingency and nutrient management plans. Finally, the NDDEQ works with county commissions, local zoning boards, livestock producers, and concerned citizens to assist them in recognizing sensitive areas where livestock operations may impact waters of the state.

2.3.6 Accidental Contaminant Release and Emergency Response

The accidental release of compounds into the environment from operator error or equipment failure has the potential to cause severe and lasting impacts to water quality. Accidental releases from any public or private sector activity can contain both hazardous and nonhazardous compounds. The resulting environmental impact from a released compound depends upon the type and quantity of the compound released, natural protection (e.g., site-specific geology, depth to ground water), proximity to receptors, and the time required to initiate a reasonable response or cleanup action.

To minimize the adverse environmental impacts of an accidental release, North Dakota has established a contaminant release reporting requirement and a Spill Investigation Program. As part of the state statutory requirement identified in NDAC 33-16-02, Standards of Quality for Waters of the State, "... any spill or discharge of waste which causes or is likely to cause pollution of waters of the state must be reported immediately." The spill must be reported to the NDDEQ or the North Dakota Department of Emergency Services, which is accessible 24 hours a day. This ensures immediate response in cases of potential life-threatening or severe environmental impacts. Immediate reporting mobilizes the necessary local, state, and federal agencies after notification, resulting in expedited and appropriate prevention/cleanup action.

2.4 Pollution Prevention and Environmental Protection Programs

Over the years, the state of North Dakota has developed comprehensive environmental protection programs designed to address state-specific concerns and comply with federal mandates. The state and federal laws and regulations address a wide variety of point and NPS contaminant sources. The primary aim of each program is to promote antidegradation and beneficial use policies as they relate to the water resources of the state. This is accomplished through the implementation of rules which establish minimum design and operation standards, prohibition of specific activities, inspection and reporting, environmental impact monitoring, and appropriate penalties for noncompliance. The regulations have been developed with full public participation as required by state law.

Appendix C is a comprehensive listing of the water quality protection programs and regulations in North Dakota. The state agencies listed have established the fiscal and technical capacity to operate several federally mandated programs, and they have been granted federal primacy to implement those programs. Primacy programs include the SDWA; the Resource Conservation and Recovery Act; the Clean Water Act; and the Federal Insecticide, Fungicide, and Rodenticide Act. The NDDEQ also works closely with the EPA in the implementation of the Comprehensive Environmental Response, Compensation, and Liability Act (commonly called Superfund) and the Toxic Substances Control Act. Primacy is granted to states which have demonstrated their laws can achieve equivalent or better environmental protection than federal laws. Primacy also establishes a state's capacity to administer and implement laws.

2.4.1 Water Quality Assessment and Protection Programs

North Dakota has several programs which assess contaminant potential and/or provide protection of the state's water resources. These programs are integral components of the North Dakota SWAP.

The NDDEQ administers NDAC, Article 33-16-02, Standards of Quality for Waters of the State. Beneficial use, waterbody classifications, and narrative and numeric standards are defined to preserve the state's water resources.

Numeric criteria are provided for chemical, biological, and physical parameters. Many of these parameters are naturally occurring in surface waters. When concentrations for a parameter become elevated so as to impair a beneficial use, the parameter is defined as a pollutant.

Surface waters are classified into five categories: Class I, IA, II, III, and IV. The assignment of a waterbody to a classification is based on the quality of historical data, hydrology, and natural factors. Refer to Section 2.1.3.2 of this document for an additional description of the classification levels.

All rivers and streams and 180 lakes and reservoirs are designated a specific classification in the standards. The standards implement the beneficial use policy of the state pertaining to waters used

for the propagation of wildlife, fish, and aquatic life; domestic and municipal water; and recreation, agricultural, and industrial activities.

2.4.2 Section 305(b) Program

North Dakota's 305(b) Program fulfills the requirements of Section 305(b) of the federal Clean Water Act, which requires the monitoring and assessment of the quality of surface waters across the state. The NDDEQ, Division of Water Quality, implements this program and develops a report for public review every two years.

An ambient surface water quality monitoring network was initiated with five sites in November 1967 and expanded to 23 sites during 1968. Expansion of the number of sites continued until October 1993, when the NDDoH maintained 61 monitoring sites on 31 rivers and streams. Stream segments and lakes have been, and continue to be, assessed using ambient water quality data collected by the NDDEQ, the USGS, the U.S. Army Corps of Engineers, the EPA, and the state of Minnesota. This data is contained in EPA's Storage and Retrieval (STORET) data system.

After 1994, the NDDoH revised the objectives for surface water quality monitoring to incorporate a basin-wide biological monitoring approach. The historic strategy of monitoring trends in water quality was ineffective, and it did not provide adequate spatial resolution for the beneficial use assessments of many stream and river miles in the state. For example, copper concentrations which exceed the state copper standard can have a toxic effect on the biological community. Therefore, the occurrence of copper levels higher than the state standard would be an indicator of aquatic life use impairment. In addition, historic monitoring ignored the effects of nutrients, sediment, and habitat alterations on aquatic life in surface waters.

The basin-wide biological monitoring approach began as a cooperative effort with the Minnesota Pollution Control Agency and the USGS's Red River National Water Quality Assessment Program in 1994. That year, data was obtained from approximately 100 sites on the Red River, and an Index of Biotic Integrity for fish in the Red River Basin was developed. The project continued during 1995, with the addition of 50 biological monitoring sites along the Upper Red River Basin, as well as the Sheyenne River and tributaries of the Sheyenne. The most recent assessment was completed in 2010. This basin approach allows more intense monitoring, includes biological indicators such as macroinvertebrate sampling, and does not rely exclusively on surrogate measures such as chemical concentration data.

2.4.3 Section 319 Program

In 1972, Congress passed the Clean Water Act to restore and maintain the quality of the nation's water resources. This Act was amended in 1987 to include Section 319, which emphasizes voluntary control of NPS pollution.

NPS pollution can be defined as contaminated precipitation runoff from city streets, construction sites, and agricultural areas. The runoff can contain sediments, nutrients, pesticides, and other contaminants which are deposited in receiving wetlands, streams, rivers, reservoirs, and lakes.

Under Section 319, the EPA is authorized to award grants to states or local entities on an annual basis. In North Dakota, the NDDEQ administers and implements the NPS Program. EPA provides 60 percent of the funding; the remaining 40 percent must come from local sources.

Three categories of projects are eligible for Section 319 funding: developmental, educational, and watershed. Watershed projects are usually preceded by developmental projects which (1) identify beneficial use impairments or threats and (2) determine the extent to which any impairments or threats are due to NPS pollution. Watershed projects are then designed to mitigate the documented NPS pollution impacts within the watershed. The goals of watershed projects are to: (1) reduce/prevent NPS pollution by promoting voluntary application of Best Management Practices (BMPs); (2) disseminate information on effective solutions to NPS impacts; and (3) evaluate the project's progress and benefits.

Across North Dakota, agriculture and its associated activities have been the primary focus of the state's NPS Program. Since 1990, a majority of the state's Section 319 funds have been awarded to locally sponsored projects promoting voluntary NPS pollution control on agricultural lands. The projects have implemented various information and educational activities and/or provided financial and technical help to landowners for implementation of BMPs on their farms. The BMPs typically installed include conservation tillage, grassed waterways, crop residue use, integrated crop management, or upgrading of livestock waste management facilities. In recent years, Section 319 funding has also been used to support local initiatives to evaluate water quality conditions and determine sources of NPS pollution within watersheds.

2.4.4 Wellhead Protection Program

A primary water protection activity for PWSs in North Dakota is the Wellhead Protection (WHP) Program. North Dakota currently has 177 public water systems, as of January 2018, utilizing groundwater as a primary water source. Approximately 40percent of North Dakota's population is served by groundwater-dependent community water systems.

North Dakota's WHP Program was approved by the EPA in December 1992. It consisted of seven essential elements: (1) community participation and commitment, (2) delineation of a wellhead protection area, (3) completion of a potential contaminant source inventory, (4) development of management strategies, (5) preparation of contingency plans, (6) siting of new wells, and (7) public education and involvement. The WHP was incorporated into the Source Water Protection Program in October of 1999.

2.5 Summary of Natural and Regulatory Water Quality Protection

The information provided in Sections 2.1 through 2.4 is summarized below.

- The majority of PWSs across the state draw source water from groundwater.
- The geographic region of the state is contained within five surface watersheds.
- The surface and subsurface hydrogeology across the state are not neatly coupled, which makes detailed delineation of source water a unique analysis for each PWS.
- The GTS method of prioritizing aquifers for water quality monitoring has delineated those aquifers in the eastern half of the state as having medium or high vulnerability to contamination and those aquifers in the western half as mostly low with some medium vulnerability.
- Existing water quality information has shown that the primary causes of surface water pollution and beneficial use impairment are related to NPS runoff from watersheds into streams and rivers.
- Existing water quality information has not identified hydrogeological conditions which merit more detail in source water assessments.
- The state currently implements pollution prevention and control programs addressing a wide variety of potential pollution sources.

The information provided in the preceding sections is considered essential for a comprehensive SWAP, specifically elements relating to the natural environment, assessment activities, and current regulatory/enforcement capacity.

Chapter 3. Source Water Assessment Program

3.1 Source Water Assessment Strategy and Completeness Criteria

Section 1453 of the SDWA Amendments of 1996 required states to establish a source water assessment program. EPA's *State Source Water Assessment and Protection Programs Guidance* has defined "complete" as the status achieved when the state fulfills all actions in a state-approved SWAP and meets all requirements of Sections 1453 and 1428(b) of the SDWA. To achieve monitoring flexibility under Section 1418(b), the state must also have an EPA-approved SWAP, and any PWS seeking such flexibility must have completed a source water assessment.

EPA's guidance indicates that a SWAP plan must describe how assessments will protect and benefit PWSs and the level of detail that "completed" assessments will achieve. A completed assessment must include three elements: (1) a delineation of the source water assessment area, (2) a contamination source inventory for that source water assessment area, and (3) a determination of the PWS's susceptibility to contamination by sources inventoried within the source water assessment area. The EPA guidance also indicates that states can propose alternatives to the guidance's mandates and recommendations for each of the three elements.

The NDDEQ SWAP plan provides unique considerations to achieve and maintain the beneficial use of all waters of the state as identified in state law (NDCC 61-28 and NDAC 33-16). For example, the first actions in achieving the goals of the SDWA Amendments of 1996 are pollution prevention and mitigation; these actions are consistent with beneficial use policy and existing regulatory structure in North Dakota.

3.1.1 Source Water Assessment Goals

EPA's SWAP guidance states that "source water assessments will generate information on significant potential contamination sources and on the susceptibility of public water systems to contamination by these sources that may help states target systems for additional or reduced monitoring, or for actions to assure compliance with drinking water standards…" In other words, the SWAP plan goals need to identify assessment areas where the public may implement water quality protection activities. The following goals are proposed to meet the expressed federal requirement for a state SWAP plan:

G1. Complete source water assessments for all PWSs, which include non-community water supply systems.

G2. Increase stakeholder involvement in the assessment and protection of the state's water resources.

G3. Use the SWAP to maintain the quality of the state's water resources, protect beneficial uses, and implement remedial action, as provided by state law.

3.1.2 Source Water Assessment Objectives

EPA's guidance acknowledges that a source water assessment for a PWS provides only the first three elements in a water quality protection program, and it notes that a complete prevention program would include "…monitoring source water quality, implementing management measures for sources of contamination, and contingency planning." The SDWA amendments of 1996 do not require these other actions, although they are elements of a fully implemented SWAP, and many are addressed through existing state regulatory and monitoring programs.

In program planning, objectives express tasks directed at achieving goals. The NDDEQ strives to complete the following objectives:

O1. Complete source water assessments for groundwater and surface water PWSs (G1).

O2. Educate the public on the benefits of establishing a local proactive water quality protection program (G2).

O3. Where feasible, adjust the strategies of programs which protect the water resources of the state to be compatible with the protection of the source waters of PWSs (G3).

3.2 Levels of Source Water Assessment

EPA has recognized that one level of detail may not be possible or appropriate in assessments for PWSs. Its guidance recommends different degrees of detail in source water assessment delineations, contamination source inventories, and susceptibility determinations for categories of PWSs. However, its guidance also indicates that a differential approach must have a coherent rationale for the protection and benefit of each PWS. Assessments can be completed on an area-wide basis to include more than one PWS. To provide a coherent assessment strategy, the NDDEQ performs:

- A defined methodological approach for each element of a source water assessment for PWSs which draw source water from groundwater.
- A defined methodological approach for each element of a source water assessment for PWSs which use surface water.
- A protective, yet less detailed, approach for non-community PWSs.

3.3 Delineation of Source Water Assessment Areas

The first element and foundation of the SWAP plan is the delineation of the water quality protection area. Section 1453(a)(2)(A) of the SDWA requires states to:

> …delineate the boundaries of the assessment areas in such state from which one or more public water systems in the state receive supplies of drinking water, using all reasonably available hydrogeologic information on the sources of the supply of drinking water in the state and the water flow, recharge and discharge and any other reliable information as the state deems necessary to adequately determine such areas.

A source water assessment area delineation may address either surface water or groundwater systems and can be defined as a surface or subsurface area over or through which contaminants are likely to move toward and reach a PWS. The delineation is intended to define an area where PWSs can best utilize public funds to concentrate water quality protection measures. The following paragraphs will define the various source water delineation methods for surface and groundwater resources in North Dakota.

3.3.1 Source Water from Groundwater

EPA's guidance defines the source water assessment area for a PWS dependent upon groundwater as that area delineated with methods accepted under an EPA-approved Wellhead Protection Program. Consideration must also be given to conjunctive delineation of source water assessment areas where the hydraulic connection between surface and groundwater may occur.

The North Dakota Wellhead Protection Program was approved by the EPA in December 1992. Since that time the NDDEQ, Division of Water Quality, has used four methods to delineate source water assessment areas for groundwater-dependent PWSs. These methods are approved for use in

source water assessment. The North Dakota Wellhead Protection User's Guide defines a wellhead protection area as:

> "…the surface and subsurface area surrounding a water well or well field, which supplies a public water system and through which contaminants are likely to move toward and reach such water well or well field."

The wellhead protection area coincides with the area from which a PWS well(s) receives groundwater. It should be noted that the delineation of recharge areas for confined aquifer systems is not addressed in the North Dakota SWAP plan. The primary justification for this approach relates to the fact that the most extensively used aquifers are unconfined with well-defined recharge areas, while confined aquifers are typically overlain by several hundred feet of dense geologic material providing natural protection from contamination. In addition, recharge areas for confined aquifer systems are ill defined and typically at a distance from the wellhead, making a meaningful assessment difficult.

The degree of detail in the delineation of the source water assessment area for groundwater depends upon several factors, including availability and accuracy of site-specific hydrogeologic data. The NDDEQ Wellhead Protection Users Guide describes four different wellhead protection area delineation methods. These methods provide a delineation protocol for systems with little or no available hydrogeological information, as well as for systems with extensive site-specific information. The four methods are briefly described in the following sections.

3.3.1.1 Arbitrary Fixed Radius

The simplest of the delineation methods is called the arbitrary fixed radius method (Figure 6). An arbitrary fixed radius protection area is defined as a circle (with a given radius) around a specific PWS wellhead. The minimum recommended radius is 1200 feet; however, the actual radius chosen may vary depending upon site-specific conditions. This method is typically utilized when the primary well is more than 100 feet deep and is known to be drawing from a confined aquifer recharged at a considerable distance from the wellhead. The arbitrary fixed radius approach can also be used in cases where the rapid delineation of a wellhead assessment area is desired, or if little or no site-specific hydrogeological information is available as is typical of many non-community PWSs.

3.3.1.2 Calculated Fixed Radius

The calculated fix radius method (Figure 7) utilizes site-specific information to calculate an appropriate radius. Information may include specific yield or porosity, well screen interval, aquifer thickness, volume of water pumped, and desired time of travel. The NDDEQ requires a minimum 10-year time of travel.

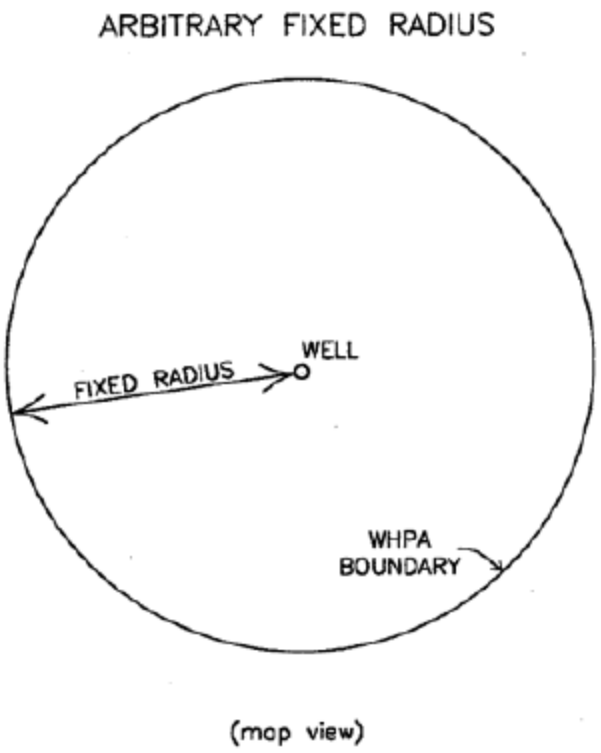

Figure 6. Arbitrary Fixed Radius Method

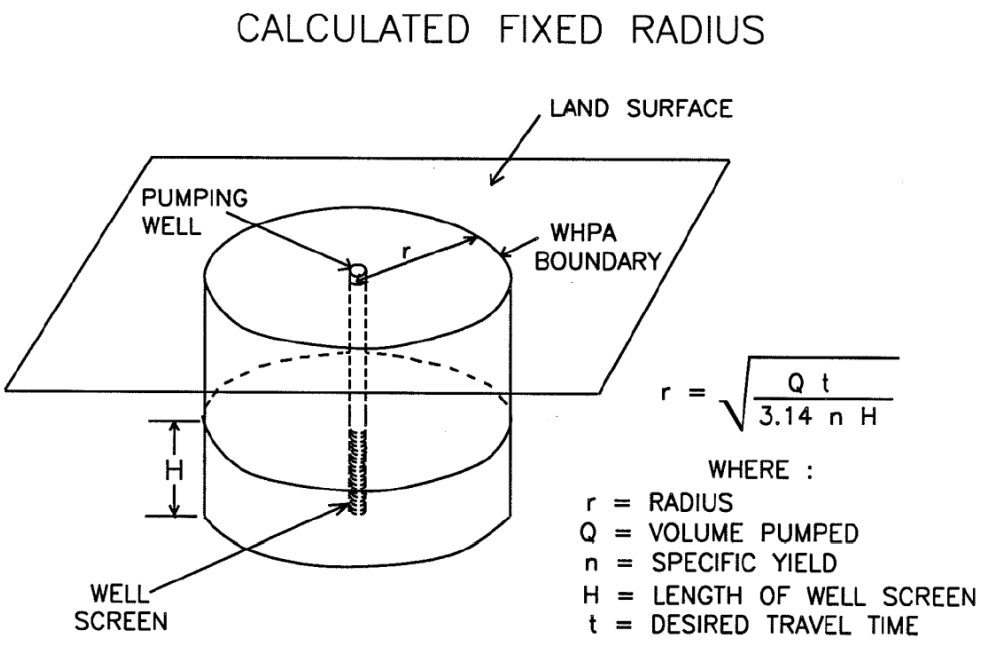

Figure 7. Calculated Fixed Radius Method

3.3.1.3 Zone of Contribution

The zone of contribution method is a uniform flow analytical method that results in the calculation of a zone of contribution (ZOC) as shown in Figure 8. The ZOC method attempts to approximate the actual aquifer area that contributes water to the well system during a specified amount of time. Data required to apply this method includes well pumping rates, specific yield or effective porosity, saturated thickness, hydraulic conductivity, and hydraulic gradient. The ZOC calculation theoretically allows the boundary to extend indefinitely in an upgradient position; therefore, an appropriate time-of-travel distance is needed to provide a realistic upgradient boundary. The time of travel is defined as the distance the water will travel through the aquifer in a given amount of time. For the North Dakota Wellhead Protection Program, a minimum of a 10-year time of travel is considered acceptable with increased time-of-travel values being selected for specific PWSs.

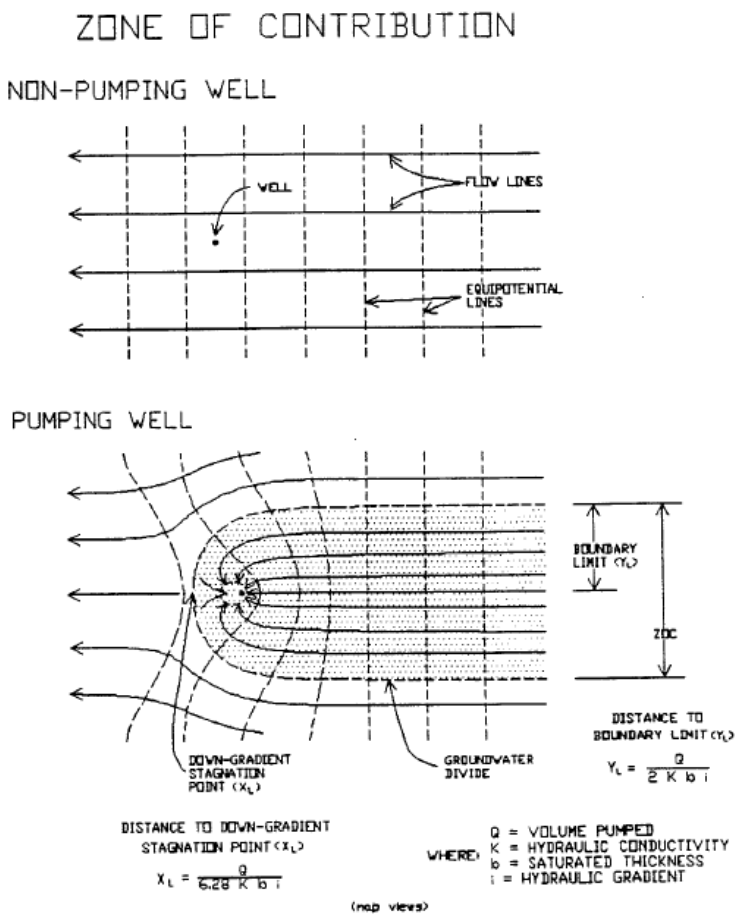

Figure 8. Zone of Contribution Method

3.3.1.4 Hydrogeologic Mapping

The hydrogeological mapping method utilizes the natural characteristics or man-induced changes to an aquifer flow system. Elements which can impact the flow of groundwater include rivers or

manmade artificial boundaries (e.g., pumping wells, holding ponds, injection wells) and low permeable soils. For example, if a river crosses through a calculated wellhead assessment area, the river may influence the flow of groundwater in the area resulting in a change in the size or configuration of the assessment area. Figure 9 depicts an example of hydrogeologic mapping.

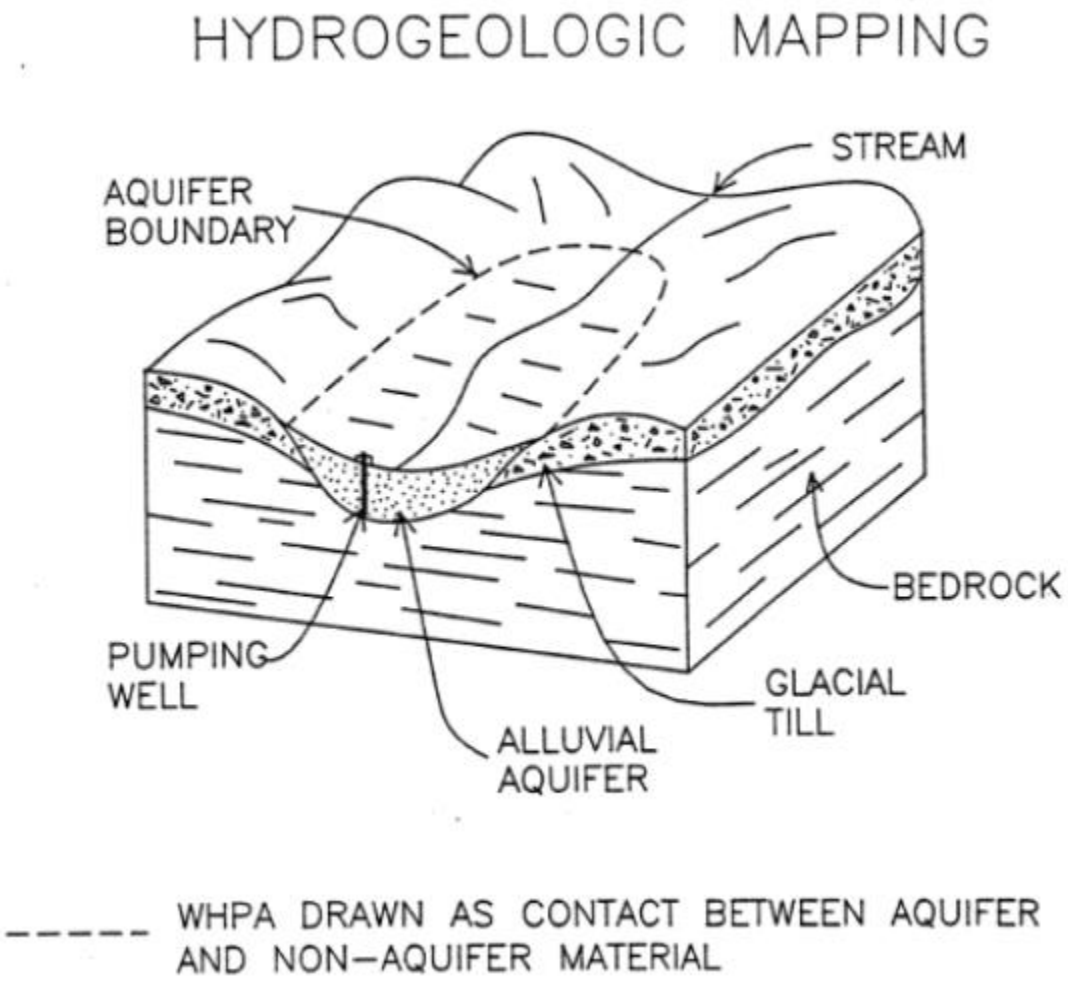

Figure 9. Hydrogeologic Mapping Method

The method(s) selected to define a groundwater-derived source water assessment area is a function of site-specific conditions and the availability of applicable hydrogeologic information. It should be noted that the final source water assessment area configuration for any PWS may be the result of the application of one or more delineation method(s). The final method(s) selected typically will be determined by the NDDEQ to provide reasonable and consistent representation of the water used by a PWS. However, a PWS may request that a more technical or extensive delineation method be implemented by the NDDEQ. The extent to which these requests will be accommodated will be based upon technical feasibility and availability of site-specific information.

3.3.1.5 Conjunctive Delineation

The NDDEQ has completed conjunctive use determinations for all community PWSs and nearly all non-community PWSs. Conjunctive use is defined as groundwater under the influence of surface water. These determinations have been accomplished through an evaluation of site-specific well construction, geology, and hydrology. In some cases, microscopic particulate analyses have been used to identify the influence of surface water on groundwater.

The delineation of source water assessment areas for PWSs under the influence of surface water will be completed by: (1) delineation of an assessment area around each well utilizing the appropriate method (Sections 3.3.1.1 to 3.3.1.5); and (2) assuming the location of the furthest downstream well as the intake structure, identify the surface water assessment area by utilizing one of the delineation methods identified in Section 3.3.3.

3.3.2 Source Water from Groundwater Delineation Strategy

Based upon the status, use, diversity of available hydrogeologic information, and number of PWSs in North Dakota, groundwater-derived source water assessment areas in North Dakota are implemented by one of the following methods:

- Assessment areas for transient non-community PWSs are developed utilizing the fixed radius method with a minimum radius of 1200 feet around each well or well field. If appropriate site-specific information is available, other methods may be applied at the request of the well owner.
- For PWSs determined to be: (1) located in a low vulnerability region based upon results of the North Dakota Geographic Targeting System, or (2) determined to have more than 30 feet of low permeable geologic material between the surface and the aquifer, and (3) a recharge area located more than 1 mile from a wellhead, the fixed radius method using a minimum radius of 1200 feet is used. For wells which have sufficient site-specific use and hydrogeologic information, a calculated fixed radius method may be implemented.
- For all other PWS delineations, a case-by-case technical analysis is implemented, defining the hydrogeologic setting and zone of contribution utilizing site-specific data. A minimum of a 10-year contaminant time-of-travel value is used to define the assessment boundary.
- For groundwater-derived PWS systems determined to be under the influence of surface water, source water assessment delineations for each well or well field will include one of the four methods identified in Sections 3.3.1.1 to 3.3.1.4 and a surface water delineation method as defined in Section 3.3.3.

A listing of all PWSs with defined primary source water can be found in Appendix A.

3.3.3 Source Water from Surface Water

For PWSs which rely on surface water to supply a portion or all their drinking water needs, the EPA source water assessments guidance states:

> "…the state program submittal needs to adopt a policy that sets the delineation of the source water protection area to include the entire watershed area upstream of the PWS's intake structure, up to the boundaries of the state's borders."

The guidance also indicates that if water is diverted from another watershed into a surface water resource used by a PWS, the watershed upstream of each diversion structure would need to be delineated in a similar manner. Information outlining the aerial extent of each watershed from which a surface water-derived PWS system receives water will be provided to each PWS system as defined in Figure 10.

However, the delineation of the state into large source water assessment areas covering most of the state is considered to be unmanageable when attempting to complete meaningful susceptibility analyses and contaminant source inventories, or to implement water protection programs. It is the opinion of the NDDEQ that large source water assessment areas may not be necessary as they do not consider the positive natural cleansing impact of buffer zones, the natural attenuation/remediation of contaminants that occurs in surface water, or the environmental protection regulations currently implemented at the federal, state, and local level (Section 2.1.3.2 and 2.4). Acknowledging these issues, the EPA SWAP guidance states:

> "...for the purposes of undertaking an inventory for significant potential contamination sources and determining susceptibility of the public water supply, the state can choose to segment delineated watershed area(s) into units (e.g., stream segments, buffer zones, sub-watershed areas) for more cost-effective analysis."

Based upon the above-referenced explanation and unique differences in the surface water systems in the state, the NDDEQ proposes to delineate rivers/streams and lakes/reservoirs utilizing separate methods. Delineation methods used to define surface water assessment areas in North Dakota are explained in 3.3.3.1 through 3.3.3.3.

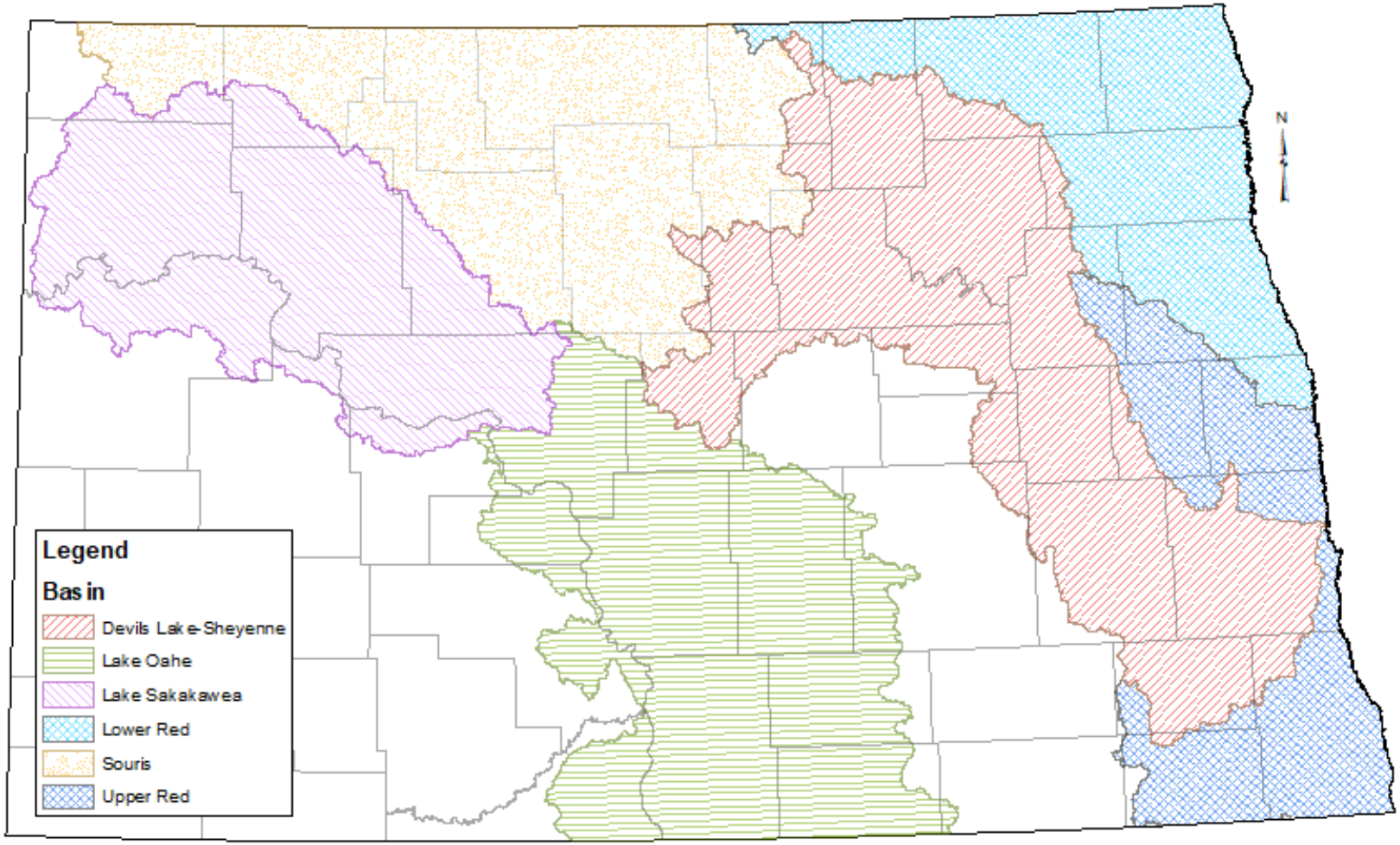

Figure 10. Watershed Delineation: Source Water Areas for the Entire State

3.3.3.1 Default Stream/River - Critical Zone Segments

The source water assessment primary delineation method for rivers and streams in North Dakota is referred to as the default stream/critical zone segment method. This method will be applied to stream/river systems from which limited or no applicable site-specific information is available. This method includes the identification of a stream stretch bounded on each side by a buffer or critical zone area. The assessment area for a stream segment using this method is defined as a fixed distance starting from the PWS intake and ending at a predetermined point upstream of the intake. For river/stream systems in North Dakota, this fixed distance will be a minimum delineated distance of 15 valley miles upstream of the intake structure. Other inputs into the main surface water supply, such as natural tributaries into the source water leading to the PWS intake structure or other points of diversion, will be delineated with a minimum distance of 15 valley miles as measured from the PWS intake structure.

Generally, assessment areas will be delineated using the 15 valley mile criteria as outlined in this chapter. However, if manmade or natural diversions result in a site-specific change in flow or residence time in a stream/river channel, the 15 valley mile criteria will be evaluated and modified, if necessary, to provide for the delineation of an appropriate source water assessment area.

The critical zone method is defined as a horizontal distance perpendicular from the bank full elevation stage. This horizontal distance will be a minimum of 1,000 feet on both sides of the river/stream. A distance less than 1,000 feet may be considered where the natural topography/geology, width of the alluvial aquifer system, or proximity of contaminants of concern justify a decreased critical zone size.

3.3.3.2 Time of Travel

This surface water delineation method for a stream/river system utilizes site-specific historical information for the stream/river. Data obtained from routine stream gaging completed by the USGS provides long-term information on stream/river flow for the major surface water systems in North Dakota. This information provides year-round flow or velocity data. With a given stream velocity and a given response time, an assessment area for a stream segment can be determined. To identify a source water delineation size, the NDDEQ will use a streamline flow data consistent with the bank full stage at a specific stream gaging station.

The defined stream/river segment will have a critical zone of 1,000 feet, measured from the bank full elevation, on both sides of the streams to the full length of the assessment area. A distance less than 1,000 feet will be considered where natural topography/geology, width of the alluvial aquifer system, or proximity of contaminants of concern justify a decreased critical zone.

The surface water-derived PWSs listed in Table 10 are delineated by these methods.

Table 10. Public Water Systems Drawing Source Water from River Surface Waters

PWS Name	PWS City	PWS Type	Source
Coal Creek Station	Underwood	NTNC	Missouri River
Drayton, City of	Drayton	Community	Red River
Fargo, City of	Fargo	Community	Red River
Fargo, City of	Fargo	Community	Sheyenne River
Grafton, City of	Grafton	Community	Park River
Grafton, City of	Grafton	Community	Red River
Grand Forks, City of	Grand Forks	Community	Red Lake River
Grand Forks, City of	Grand Forks	Community	Red River
Mandan, City of	Mandan	Community	Missouri River
Valley City, City of	Valley City	Community	Sheyenne River
Washburn City of	Washburn	Community	Missouri River
Williston, City of	Williston	Community	Missouri River

3.3.3.3 Surface Water from Natural Lakes or Manmade Reservoirs

PWSs which utilize natural lakes or manmade reservoirs in North Dakota are typically located in rural agricultural areas of the state. Due to the lack of point sources of contamination and the typically large volumes of water, a default critical zone of 1,000 feet will be included around the entire waterbody as measured from the highest recorded water elevation established by the USGS. Distances less than 1,000 feet will be considered where natural topography/geology, width of the alluvial aquifer system, or proximity of contaminants justify a decrease in the critical zone. Primary tributaries or streams which feed into these lakes have been identified by the NDDEQ NPS Program and will be included in the assessment.

An alternative delineation method will be implemented for Lake Sakakawea, which encompasses 382,000 acres and has 1,530 miles of shoreline. The large size of Lake Sakakawea makes the delineation of the entire lake unmanageable when attempting to implement source water assessment provisions. To address PWSs which utilize this water resource, a 1,000-foot critical zone as measured from the highest recorded lake elevation will be extended to a minimum distance of 3 miles on either side of the PWS intake structure. The defined assessment area is considered due to the natural size of the lake, dilution expected to occur in the case of a catastrophic release of a contaminant into the lake, and state law which requires immediate reporting and corrective action be implemented in the event of a release. Table 11 shows PWSs using these methods.

Table 11. Public Water Systems Drawing Source Water from Lake Surface Waters

PWS Name	PWS City	PWS Type	Source
Garrison, City of	Garrison	Community	Lake Sakakawea
OMND Water Treatment Plant	Rural Water System	Community	Lake Sakakawea
Riverdale, City of	Riverdale	Community	Lake Sakakawea
South Central RWD - Emmons	Rural Water System	Community	Lake Oahe
Southwest Water Authority	Rural Water System	Community	Lake Sakakawea

3.4 Contaminants of Concern

Section 1453(a)(2)(B) of the SDWA Amendments of 1996 required states to:

> "Identify for contaminants regulated under this title for which monitoring is required under this title (or any unregulated contaminants selected by the state, in its discretion, which the state, for purposes of this subsection, has determined may present a threat to public health), to the extent practical, the origins within each delineated area of such contaminants to determine the susceptibility of the public water systems in the delineated area to such contaminants."

EPA's guidance mandates that the list of contaminants of concern include all raw water contaminants regulated under the SDWA for which an MCL is specified, contaminants regulated under the surface water treatment rule, microorganisms, and radionuclides. Table 12 identifies SDWA MCLs, including those regulated under the SWTR. Also included in Table 12 are contaminants detected by the state ambient water quality monitoring programs (Section 2.1.4 and 2.1.3.2) and/or regulated under the State Management Plan for Pesticides (Section 2.3.3) or SDWA if contaminants could potentially impact a source water intake. The list of contaminants of concern will be evaluated every three years, with the objective to identify new contaminants of concern or delete existing compounds that no longer pose a threat to PWS systems, as documented by existing environmental use or monitoring data.

3.5 Contaminant Source Inventory

A contaminant source inventory identifies land use or facilities which have a significant potential to release a contaminant of concern. The EPA guidance defines a significant potential source of contamination as:

> "…any facility or activity that stores, uses, or produces, as a product or by-product, the contaminants of concern and has a sufficient likelihood of releasing such contaminants to the environment at levels that could contribute significantly to the concentration of these contaminants in the source waters of the public water supply(s)."

Table 12. Contaminants of Concern

INORGANIC CHEMICALS	ORGANIC CHEMICALS	PESTICIDES	MICROBIOLOGICAL
Antimony	Acrylamide	Alachlor	Cryptosporidium
Arsenic	Benzene	Atrazine	Giardia lamblia
Asbestos	Benzo(a)pyrene (PAHS)	Carbofuran	Heterotrophic plate count
Barium	Carbon tetrachloride	Chlordane	Legionella
Beryllium	o-Dichlorobenzene	Chlorobenzene	Total Coliforms (including fecal coliform and E. Coli)
Cadmium	p-Dichlorobenzene	2,4-D	Turbidity
Chromium	1,2-Dichloroethane	Dalapon	Viruses (enteric)
Copper	1,1-Dichloroethylene	1,2-Dibromo-3-chloropropane (DBCP)	
Cyanide	Cis-1,2-Dichloroethylene	Dinoseb	**DISINFECTION BYPRODUCTS**
Fluoride	Trans-1,2-Dichloroethylene	Diquat	Bromate
Lead	Dichloromethane	Endothall	Chlorite
Mercury	1,2-Dichloropropane	Endrin	Haloacetic acids (HAA5)
Nitrate	Di(2-ethylhexyl)adipate	Glyphosate	Total Trihalomethanes (TTHMS)
Nitrite	Di(2-ethylhexyl)phthalate	Heptachlor	
Selenium	Dioxin (2,3,7,8-TCDD)	Heptachlor epoxide	**DISINFECTANTS**
Thallium	Epichlorohydrin	Lindane	Chloramines
	Ethylbenzene	Methoxychlor	Chlorine
	Ethylene dibromide	Oxamyl(Vydate)	Chlorine Dioxide
	Hexachlorobenzene	Picloram	
	Hexachlorocyclopentadiene	Simazine	**RADIONUCLIDES**
	Polychlorinated byphenyls	Toxaphene	Alpha particles
	Pentachlorophenol	2,4,5-TP Silvex	Beta particles and photon emitters
	Styrene		Radium 226 and Radium 228 (combined)
	Tetrachloroethylene		Uranium
	Toluene		
	1,2,4-Trichlorobenzene		
	1,1,1-Tricholorethane		
	1,1,2-Trichloroehtane		
	Trichloroethylene		
	Vinyl chloride		
	Xylenes		

The NDDEQ has compiled a list of types of potential contaminant sources (Table 13). It is important to note that ambient water quality monitoring, remedial response, and implementation of state regulatory programs have identified contaminant sources that have shown increased likelihood to impact water quality in North Dakota (Table 9). The potential sources are classified in one of four categories: farm, commercial/industrial, residential, and other (generally municipal).

Table 13. Categories of Sources and Activities that may Impact Water Quality

Agricultural

Feedlots
Manure piles
Chemical application/storage
Fertilizer application/storage

Residential

Septic tanks/drainfields
Domestic wells
Storage tanks
Chemical storage
Abandoned wells
Pet waste

Public Water Systems

Storm sewer impoundment/discharge
Sanitary sewer
Lift stations
Water/wastewater treatment
Industrial waste disposal
Landfills (active and inactive)
Hazardous waste sites
Salts and piles
Snow cleanups
Urban runoffs
Golf courses/parks
Cemeteries
Animal burial
Roads
Railroads
Airports

Commercial/Industrial

Gas/service stations/auto repair
Truck terminals
Rust proofers
Small engine repair
Machine shops
Auto body shops
Auto/chemical supplies
Dry cleaners
Metal platers
Painters/finishers
Furniture strippers
Wood preservers
Heat treaters/smelters
Annealers/descalers
Laundromats
Car washes
Beauty salons
Medical/dental/veterinary
Mortuaries/funeral homes
Research laboratories
Herbicide wholesale/retail
Pesticide wholesale/retail
Fertilizer wholesale/retail
Junk/salvage yards
Grain elevators
Fuel oil distributors
Concrete/asphalt/tar plants
Coal gasification plant
Oil pipeline
Mines: coal/sand/gravel
Slaughterhouses
Food processors
Nurseries
Oil wells
Geothermal wells
Water supply wells
Exploration wells
Abandoned wells
Seismic shot holes
Monitoring wells
Printers
Photo processors
Painting supplies

EPA's definition for a significant potential source allows exclusion of any source which does not have "a sufficient likelihood…" of impacting the water source. EPA's guidance translates this source-exclusion flexibility into thresholds for factors such as: (1) amount produced, stored or used; (2) likelihood of release at the source, including source mitigation plans; (3) source location with respect to the PWS's intake structure; and (4) site-specific others.

Each threshold represents a risk that a release of a contaminant of concern could exceed a drinking water standard in the source water.

A source water assessment contaminant inventory will:

- Generally, exclude potential domestic sources from consideration as significant sources, assuming contaminants of concern are not kept for commercial purposes.
- Include other sources within defined source water assessment areas where (1) indicator contaminants of concern are detected without application of any other thresholds such as amount stored or used, and (2) where contaminants are released to soil or water.
- Outside the defined source water assessment area, but within the delineated boundary of the local watershed, only major point sources (i.e., RCRA facilities, power plants, large feedlots) which are considered significant potential sources of contamination (PSCs), will be identified.

An indicator contaminant of concern is defined as a chemical compound(s) detected as part of an ambient water quality or other state-approved monitoring program. Industries or other activities which utilize an indicator contaminant will be identified in the contaminant source inventory. As an example, the detection of benzene in an ambient monitoring program would result in the inclusion of all commercial or industrial sources of benzene as part of the potential contaminant source inventory. This may include gasoline storage facilities, automotive garages, accidental spill sites, or other activities which have a history of utilizing benzene-containing compounds. Typical household or domestic uses of an indicator contaminant of concern will be excluded from the inventory, unless it can be documented that special conditions (e.g., high density of household use) exists. These activities would be included regardless of their past regulatory compliance or permit record.

3.6 Contaminant Source Inventory Strategy

Completion of a contaminant source inventory for each PWS system in North Dakota requires the identification of significant water quality contaminant sources within each source water assessment area. To facilitate the completion of contaminant source inventories in a timely and consistent manner, the NDDEQ adheres to the following strategy.

An initial contaminant source inventory is completed utilizing available computer data files which identify land use of facilities under state regulation. The data search identifies the location and

type of facilities, or land use classification, within the delineated surface and groundwater source water assessment areas. A site visit to the delineated source water protection area is conducted by NDDEQ personnel to assess potential contaminant sources within the designated area. This inventory information will be provided to PWS owners to encourage future source water assessment efforts.

After the NDDEQ completes a contaminant source inventory, each community and non-community PWS can voluntarily complete a more detailed inventory. All PWS systems are encouraged to augment their contaminant source inventory by:

- Identifying all PSCs as identified in Table 13. Contaminant source inventory forms are provided by the NDDEQ to assist in the proper classification and location of PSCs.
- Providing this information to the NDDEQ for inclusion into the PWS system source water assessment file.

Each PWS is encouraged to update its contaminant source inventory annually, identifying changes in land use or potential contaminant sources. Significant changes to a PWS contaminant source inventory or detection of an indicator contaminant will result in a reevaluation of the susceptibility analysis.

3.7 Determination of PWS Susceptibility

The third element of a source water assessment is to determine source water susceptibility to a contaminant of concern at a groundwater well or surface water intake structure. For purposes of this document, susceptibility is defined as:

> The likelihood of a drinking water contaminant occurring or being detected at the water intake structure.

The EPA guidance indicates that Congress intended that source water assessments should include an analysis of potential threats to PWSs from inventoried sources of contamination. It also mandates that a SWAP plan describe how susceptibility determinations will be: (1) an absolute measure of the potential for contamination of the PWS, (2) a relative comparison between sources within the source water assessment area of the PWS, or (3) some other method that provides for the protection and benefit of PWSs.

Certain physical events must occur in such a sequence that the source water of a PWS contains levels of a contaminant that would pose a concern for PWS operators and the public. First, a release of the contaminant of concern must occur. Second, the contaminant must follow a pathway between the place of release and the source water intake of the PWS. Third, the concentration of the contaminant in the source water at the PWS intake depends upon the quantity released, ability to be attenuated, and the dilution and depletion of the contaminant along the pathway.

To provide a consistent analysis of potential contaminant threats to a PWS from inventoried sources, a site-specific susceptibility determination is completed. The North Dakota susceptibility determination process considers the following elements:

- The structural integrity of the source water intake
- The environment governing the transport of contaminants to the intake structure
- The results of the contaminant source inventory

3.7.1 Source Water from Groundwater Susceptibility Determination

The susceptibility determinations for groundwater are completed for all community and non-community PWSs after an appropriate delineation and contaminant source inventory has been completed. Each water intake structure is evaluated for its relative potential to be adversely impacted by a contaminant of concern.

The groundwater susceptibility determination includes a two-tiered approach. Tier I assesses well intake integrity and the natural environment. Tier II assesses the PSCs and their relationship to the susceptibility determination from Tier I.

Well integrity is determined by evaluating water well construction logs, results from sanitary surveys conducted by the NDDEQ, and routine bacteriological analysis. Table 14 identifies a water well integrity matrix designed to determine the general integrity of the well. Low integrity wells are identified if a YES answer follows one or more of the questions identified in the table. A high integrity well is determined if a NO answer follows all questions in Table 14.

Table 14. Well Integrity Identification Matrix

	YES	NO
Chronic bacteriological violations*		
Constructed prior to 1971 or does not meet the construction requirements of NDAC 33-18**		
Identification of well structural or operational problems during sanitary survey conducted by state or local health agencies		

*A chronic bacteriological violation is defined as a confirmed bacteriological detection for a community or non-community system as defined by the monitoring requirements of the SDWA and which require the implementation of remedial measures (e.g., chlorination).

**North Dakota Water Well Construction and Water Well Pump Installation Article 33-18: Water well and pump installation rules are established by the state to ensure the integrity of the well and protection of the public health.

Aquifer vulnerability and well integrity determinations are incorporated into a Tier I matrix to determine the potential susceptibility of the well intake structure in Table 15.

Table 15. Groundwater Potential Vulnerability - Tier I Classification

Well Integrity	High/Moderate Aquifer Vulnerability	Low Aquifer Vulnerability
Low Integrity Well	High Potential Vulnerability	Moderate Potential Vulnerability
High Integrity Well	Moderate Potential Vulnerability	Low Potential Vulnerability

A detection of a contaminant of concern at a groundwater well will result in a default determination of a high potential vulnerability for the specific well.

The Tier II assessments include the vulnerability determinations identified in the Tier I assessment and the sources of concern identified in the contaminant source inventory. The NDDEQ will designate a PWS as vulnerable when a contaminant of concern has been released within a source water protection area resulting in the contamination of the water resource. This is determined by reviewing: (1) regulated activities for compliance with applicable permit and operational standards, (2) emergency response or contaminant release files, and (3) monitoring reports.

High-risk-concern potential contaminants are defined as compounds: (1) with a documented unauthorized or accidental release, (2) for which storage or handling do not comply with applicable state/federal permits or regulations, or (3) which have been detected in the source water supply during routine monitoring within a source water assessment area. Low-risk-concern potential contaminants are defined as compounds (1) which are present within a source water assessment area but have not been released to the environment, (2) for which the storage or handling comply with applicable requirements, or (3) which have not been detected in the source water.

Table 16. Groundwater Resource Probable Vulnerability - Tier II Classification

Potential Vulnerability Ranking	Potential Contaminant Concern - High Risk	Potential Contaminant Concern - Low Risk
High Potential Vulnerability	Susceptible	Susceptible
Moderate Potential Vulnerability	Susceptible	Moderately Susceptible
Low Potential Vulnerability	Moderately Susceptible	Not Likely Susceptible

3.7.2 Source Water from Surface Water Susceptibility Determination

NDAC Chapter 33-16-02 defines drinking water as "waters that are suitable for use as a source of water supply for drinking and culinary purposes, after treatment to a level approved by the Department."

Under the auspices of the SDWA and 305(b) Program of the federal Clean Water Act, the NDDEQ assesses the beneficial use of surface waters for drinking water. The NDDEQ uses chemical monitoring data when available, as well as citizen complaints on taste and odor. Assessments are conducted by comparing chemical concentration data to North Dakota's water quality human health criteria for Class I, IA, and II rivers and streams. The water quality human health criteria include two means of exposure: (1) ingestion of aquatic organisms, and (2) ingestion of drinking water.

Specifically, the beneficial use of drinking water is classified as follows:

> Fully Supporting - For each human health contaminant, more than 50 percent of the samples had concentrations lower than the water quality standard, and there are no drinking water complaints on record.
>
> Fully Supporting but Threatened - For each contaminant, more than 50 percent of the samples had concentrations lower than the water quality standard; however, taste and odor or treatment costs have been associated with pollutants.
>
> Partially Supporting - For at least one contaminant, more than 50 percent of the samples exceed the human health standard, and/or frequent taste and odor complaints are on record.
>
> Not Supporting - Drinking water supply closure has occurred within the last five years.

An indication of the degree to which a surface water system is susceptible to contamination in North Dakota will be based upon the ongoing surface water quality assessments identified in the 305(b) *North Dakota Water Quality Assessment Report* and individual contaminant source inventories (i.e., sanitary survey and routine water quality monitoring). It is important to note that the 305(b) water quality classifications identified above are indicators of anthropomorphic and natural water quality impacts on a surface water system. The assessments provide an indication of the hydrologic sensitivity to such factors as land use, NPS and point sources of contamination, and the natural variations in water quality associated with northern climates.

Table 17. Surface Water Susceptibility - Classification

305(b) Class Determination	High Concern PSCs	Low Concern PSCs
Fully Supporting	Moderately Susceptible	Moderately Susceptible
Fully Supporting but Threatened	Moderately Susceptible	Moderately Susceptible
Partially Supporting	Susceptible	Moderately Susceptible
Not Supporting	Susceptible	Susceptible

High concern PSCs are defined as compounds (1) with a documented unauthorized or accidental release, (2) for which storage or handling do not comply with applicable state/federal permits or regulations, or (3) which have been detected in the source water supply during routine monitoring within a source water assessment area. Low concern PSCs are defined as compounds (1) which are present within a source water assessment area but have not been released to the environment, (2) for which the storage or handling comply with applicable requirements, or (3) which have not been detected in the source water.

Future susceptibility assessments may be conducted if additional contaminant sources are identified within a source water assessment area or if the original 305(b) classifications used to determine a susceptibility classification are changed.

Note that detection of a contaminant of concern at the surface water intake or the identification of a low integrity surface water intake during a sanitary survey can result in a default classification of susceptible.

Chapter 4. SWAP Plan Implementation

The successful implementation of the North Dakota SWAP plan is contingent upon many factors, including the commitment and coordination of federal, state, and local organizations to utilize assessments when considering future water protection strategies. This chapter discusses how the SWAP plan is implemented and promoted.

4.1 SWAP Plan Implementation Schedule

The NDDoH (now NDDEQ) received approval for the North Dakota Source Water Assessment Program from the EPA in October of 1999. Full implementation of the program was completed by May of 2003.

4.2 Lead State Agency Role and Stakeholder Coordination

The NDDEQ is the lead state agency responsible for the completion of all elements of PWS source water assessments. Source water delineations, contaminant source inventories, and susceptibility analyses are completed as described in the North Dakota SWAP plan. The NDDEQ strives to go beyond the initial completion of each source water assessment by encouraging public involvement and development of protection programs.

The role of the NDDEQ in the SWAP plan implementation is as follows:

- Initial completion of all the elements of the approved SWAP plan for each PWS in the state
- Notification of all interested parties, including federal, state, and local agencies, of the availability of completed source water assessments
- Promotion of the development of each source water assessment into a water protection program

4.2.1 Role of Supporting Federal, State, and Local Organizations

The role of supporting federal, state, and local organizations is to assist in SWAP plan implementation through collection of environmental data, review, and local program involvement. These activities are typically conducted through the completion of each organization's legislatively assigned duties and responsibilities. Program support comes primarily from but is not limited to: NDSWC, North Dakota Rural Water Association, state environmental regulatory programs, Natural Resources Conservation Service, and EPA. Organizations and agencies are encouraged

to utilize or comment on each source water assessment. The NDDEQ acknowledges that support is provided voluntarily as a benefit to the implementation of the SWAP plan.

4.3 Project Implementation Resource Requirements

To implement the North Dakota SWAP, the NDDEQ used the expertise developed through the implementation of the North Dakota Wellhead Protection Program. The implementation of the SWAP plan is divided into three areas.

4.3.1 Human Resources

The NDDEQ maintains a trained professional staff dedicated to the completion of PWS Source Water Assessments.

4.3.2 Technical Capacity

The NDDEQ maintains a professional staff trained in the use of modeling software and industry-accepted GIS software packages. This technical expertise is coupled with the widespread knowledge and availability of data relating to the state's water resources.

4.3.3 Financial Capacity

The NDDEQ relies on existing federal (e.g., Clean Water Act and SDWA) and state general funding to complete the SWAP plans.

4.4 SWAP Plan Reporting

Complete status of SWAP plan activities in North Dakota are reported to the EPA through reporting requirements that include:

- Annual end-of-year water quality program status reports to EPA Region VIII
- Identification of SWAP plan activities in 305(b) Water Quality Report to Congress

Additional reporting of SWAP activities are considered at the request of EPA and other governing agencies.

4.5 SWAP Plan Updates

The need to update each source water assessment is routinely evaluated by the NDDEQ and/or local PWS. Evaluation of source water assessments is completed once every five years after the initial completion of the source water assessment or more frequently if:

- Water quality monitoring, as part of the SDWA or ambient monitoring program, identifies a new contaminant of concern; or
- Identification of a new activity in the contaminant source inventory has the potential to impact water quality; or

- A change occurs in the PWS configuration (e.g., new well or intake structure or new water source); or
- The PWS requests an evaluation of the existing source water assessment for accuracy and completeness.

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Appendix A

Public Water Systems as of July 2018

PWS Number	PWS System Name	System Type	County	Source
ND3900001	ABERCROMBIE CITY OF	C	RICHLAND	GW
ND0511551	A-FRAME BAR & GRILL	NC	BOTTINEAU	GW
ND1801056	AGASSIZ WATER USERS DISTRICT	C	GRAND FORKS	GW
ND2700006	ALEXANDER CITY OF	C	MCKENZIE	GW
ND2711221	ALEXANDER WATER SPRING	NC	MCKENZIE	GW
ND0501057	ALL SEASONS WD-SYSTEM I	C	BOTTINEAU	GW
ND4001153	ALL SEASONS WD-SYSTEM IV	C	ROLETTE	GW
ND5311699	ALLSTATE PETERBILT	NC	WILLIAMS	GW
ND2711711	AMBER HILLS LODGE	NC	MCKENZIE	GW
ND1211226	AMBROSE COMMUNITY WELL	NC	DIVIDE	GW
ND5311747	AR-KOTA RV PARK	NC	WILLIAMS	GW
ND2710034	ARNEGARD CITY PARK	NC - Seasonal	MCKENZIE	GW
ND2701606	ARNEGARD DIAMOND ESTATES	C	MCKENZIE	GW
ND2600038	ASHLEY CITY OF	C	MCINTOSH	GW
ND2701003	BADLANDS DEVELOPMENT LONG X TC	C	MCKENZIE	GW
ND0201058	BARNES RURAL WATER DISTRICT	C	BARNES	GW
ND1511578	BAYSIDE OAHE RESORT	NC	EMMONS	GW
ND2911495	BEULAH BAY REC AREA #2	NC - Seasonal	MERCER	GW
ND2911297	BEULAH BAY REC AREA	NC - Seasonal	MERCER	GW
ND2900074	BEULAH CITY OF	C	MERCER	GW
ND5311718	BIG COUNTRY RV PARK	NC	WILLIAMS	GW
ND0510048	BIRCHWOOD INC	NC	BOTTINEAU	GW
ND0800080	BISMARCK CITY OF	C	BURLEIGH	GU
ND2711702	BLUE SKY LODGING	NC	MCKENZIE	GW
ND0511340	BOAT RAMP 74	NC - Seasonal	BOTTINEAU	GW
ND4011639	BORDER LOUNGE	NC	ROLETTE	GW
ND0500099	BOTTINEAU CITY OF	C	BOTTINEAU	GW
ND0511294	BOTTINEAU WINTER PARK SKI AREA	NC	BOTTINEAU	GW
ND0600119	BOWMAN CITY OF	C	BOWMAN	GW
ND0901184	BROOKTREE WELLS INC	C	CASS	GW
ND5100138	BURLINGTON CITY OF	C	WARD	GW
ND0411415	BURNING HILLS AMPHITHEATER	NC - Seasonal	BILLINGS	GW
ND1600159	CARRINGTON CITY OF	C	FOSTER	GW
ND0901060	CASS RURAL WATER DISTRICT-PHASE I	C	CASS	GW

C-Community, NC-Non-Community, NTNC-Non-Transient Non-Community
SW-Surface Water, GW-Groundwater, GU-Groundwater under the influence of Surface Water

PWS Number	PWS System Name	System Type	County	Source
ND0901124	CASS RURAL WATER DISTRICT-PHASE II	C	CASS	GW
ND0901131	CASS RURAL WATER DISTRICT-PHASE III	C	CASS	GW
ND5200169	CATHAY CITY OF	C	WELLS	GW
ND0910998	CENTRAL LIVESTOCK	NC	CASS	GW
ND5201309	CENTRAL PLAINS WATER DISTRICT	C	WELLS	GW
ND2810954	COAL CREEK STATION	NTNC	MCLEAN	SW
ND2000203	COOPERSTOWN CITY OF	C	GRIGGS	GW
ND0410678	COTTONWOOD CAMPGROUND 6	NC - Seasonal	BILLINGS	GW
ND5100663	COUNTRY ACRES MHP	C	WARD	GW
ND0901449	COUNTRY ACRES WATER CO	C	CASS	GW
ND4711364	CRYSTAL SPRINGS BAPTIST CAMP	NC - Seasonal	STUTSMAN	GW
ND2001061	DAKOTA RURAL WATER DISTRICT NORTH	C	GRIGGS	GW
ND2001121	DAKOTA RURAL WATER DISTRICT SOUTH	C	GRIGGS	GW
ND3711774	DEAD COLT CREEK RECREATION AREA	NC - Seasonal	RANSOM	GW
ND3600231	DEVILS LAKE CITY OF	C	RAMSEY	GW
ND2611267	DOYLE MEMORIAL STATE PARK	NC - Seasonal	MCINTOSH	GW
ND2500266	DRAKE CITY OF	C	MCHENRY	GW
ND3400269	DRAYTON CITY OF	C	PEMBINA	SW
ND4011778	DUNSEITH CENEX C-STORE	NC	ROLETTE	GW
ND4000277	DUNSEITH CITY OF	C	ROLETTE	GW
ND1801062	EAST CENTRAL REGIONAL WD-GF	C	GRAND FORKS	GW
ND4901071	EAST CENTRAL REGIONAL WD-TRAILL	C	TRAILL	GW
ND3700314	ENDERLIN CITY OF	C	RANSOM	GW
ND3900333	FAIRMOUNT CITY OF	C	RICHLAND	GW
ND2300544	FAIRVIEW COLONY	C	LAMOURE	GW
ND4011780	FAMILY DOLLAR	NC	ROLETTE	GW
ND0900336	FARGO CITY OF	C	CASS	SW
ND0700344	FLAXTON CITY OF	C	BURKE	GW
ND5010352	FORDVILLE PUBLIC SCHOOL	NTNC	WALSH	GW
ND1801456	FOREST RIVER COLONY	C	GRAND FORKS	GW
ND4100357	FORMAN CITY OF	C	SARGENT	GW
ND0901410	FRADETS ORCHARD WATER	C	CASS	GW

C-Community, NC-Non-Community, NTNC-Non-Transient Non-Community
SW-Surface Water, GW-Groundwater, GU-Groundwater under the influence of Surface Water

PWS Number	PWS System Name	System Type	County	Source
	SYSTEM			
ND2800389	GARRISON CITY OF	C	MCLEAN	SW
ND4200404	GOODRICH CITY OF	C	SHERIDAN	GW
ND5000408	GRAFTON CITY OF	C	WALSH	SW
ND1800410	GRAND FORKS CITY OF	C	GRAND FORKS	SW
ND3601424	GREATER RAMSEY WATER DISTRICT	C	RAMSEY	GW
ND5300425	GRENORA CITY OF	C	WILLIAMS	GW
ND0511343	GROUP CAMP COMPLEX 71	NC	BOTTINEAU	GW
ND4100428	GWINNER CITY OF	C	SARGENT	GW
ND0511396	HAHNS BAY RECREATION AREA	NC - Seasonal	BOTTINEAU	GW
ND2000446	HANNAFORD CITY OF	C	GRIGGS	GW
ND2711693	HAPPY VALLEY EMPLOYEE HOUSING	NC	MCKENZIE	GW
ND5200458	HARVEY CITY OF	C	WELLS	GW
ND0900460	HARWOOD CITY OF	C	CASS	GW
ND1500469	HAZELTON CITY OF	C	EMMONS	GW
ND2911480	HAZEN BAY RECREATION AREA	NC - Seasonal	MERCER	GW
ND1911236	HEART BUTTE F U CAMP	NC - Seasonal	GRANT	GW
ND4900482	HILLSBORO CITY OF	C	TRAILL	GW
ND0900488	HORACE CITY OF	C	CASS	GW
ND2810146	HUNTERS LODGE	NC	MCLEAN	GW
ND4001136	INTERNATIONAL PEACE GARDEN	NC	ROLETTE	GW
ND4711217	JAMESTOWN CAMPGROUND	NC - Seasonal	STUTSMAN	GW
ND4700498	JAMESTOWN CITY OF	C	STUTSMAN	GW
ND2710909	JUNIPER CAMPGROUND	NC - Seasonal	MCKENZIE	GW
ND0911393	K & K CONSTRUCTION AND REPAIR, INC.	NTNC	CASS	GW
ND2500509	KARLSRUHE CITY OF	C	MCHENRY	GW
ND4010280	KELVIN KLINIC BAR	NC	ROLETTE	GW
ND1311732	KILLDEER LODGE	NC	DUNN	GW
ND0910480	KNICKERBOCKER LIQUOR LOCKER	NC	CASS	GW
ND3200536	LAKOTA CITY OF	C	NELSON	GW
ND2310414	LAMOURE COUNTY MEMORIAL PARK	NC - Seasonal	LAMOURE	GW
ND1800550	LARIMORE CITY OF	C	GRAND FORKS	GW
ND1811323	LARSONS DRIVE INN	NC - Seasonal	GRAND FORKS	GW

C-Community, NC-Non-Community, NTNC-Non-Transient Non-Community
SW-Surface Water, GW-Groundwater, GU-Groundwater under the influence of Surface Water

PWS Number	PWS System Name	System Type	County	Source
ND0300553	LEEDS CITY OF	C	BENSON	GW
ND2600556	LEHR CITY OF	C	MCINTOSH	GW
ND0700569	LIGNITE CITY OF	C	BURKE	GW
ND3700574	LISBON CITY OF	C	RANSOM	GW
ND5311497	LITTLE BEAVER BAY REC AREA	NC - Seasonal	WILLIAMS	GW
ND2701631	M&M PARK	C	MCKENZIE	GW
ND0300587	MADDOCK CITY OF	C	BENSON	GW
ND0511341	MAID O MOON SHINE CAMPGROUND	NC - Seasonal	BOTTINEAU	GW
ND5100593	MAKOTI CITY OF	C	WARD	GW
ND3000596	MANDAN CITY OF	C	MORTON	SW
ND1101481	MAPLE RIVER HUTTERIAN ASSOCIATION	C	DICKEY	GW
ND4400615	MARMARTH CITY OF	C	SLOPE	GW
ND0500620	MAXBASS CITY OF	C	BOTTINEAU	GW
ND2801400	MCLEAN-SHERIDAN WATER DISTRICT-SYSTEM 1	C	MCLEAN	GW
ND3200636	MCVILLE CITY OF	C	NELSON	GW
ND3211493	MCVILLE FARMERS UNION	NC	NELSON	GW
ND1311473	MEDICINE HOLE GOLF COURSE	NC - Seasonal	DUNN	GW
ND4700637	MEDINA CITY OF	C	STUTSMAN	GW
ND0811773	MENARDS-BIDC	NTNC	BURLEIGH	GW
ND0511249	METIGOSHE DRIVE INN	NC - Seasonal	BOTTINEAU	GW
ND0510106	METIGOSHE MINISTRIES-CENTER SITE	NC	BOTTINEAU	GW
ND0511305	METIGOSHE MINISTRIES-PELICAN LAKE	NC - Seasonal	BOTTINEAU	GW
ND3200653	MICHIGAN CITY OF	C	NELSON	GW
ND3310177	MILTON R YOUNG STATION WELL - MPC	NTNC	OLIVER	GW
ND0300659	MINNEWAUKAN CITY OF	C	BENSON	GW
ND5100660	MINOT CITY OF	C	WARD	GW
ND5311471	MISSOURI-YELLOWSTONE INTERPRETIVE CENTER	NC	WILLIAMS	GW
ND2400715	NAPOLEON CITY OF	C	LOGAN	GW
ND2711664	ND INDOOR RV PARK	NC	MCKENZIE	GW
ND1400732	NEW ROCKFORD CITY OF	C	EDDY	GW
ND1210766	NOONAN CITY WELL 1 (COFFEE)	NC	DIVIDE	GW
ND5101065	NORTH PRAIRIE RWD-SYSTEM III	C	WARD	GW
ND3401128	NORTHEAST RWD- NORTH	C	PEMBINA	GW

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SW-Surface Water, GW-Groundwater, GU-Groundwater under the influence of Surface Water

PWS Number	PWS System Name	System Type	County	Source
	VALLEY BRANCH			
ND1100758	OAKES CITY OF	C	DICKEY	GW
ND1110760	OAKES GOLF CLUB	NC - Seasonal	DICKEY	GW
ND0300762	OBERON CITY OF	C	BENSON	GW
ND2901491	OMND WATER TREATMENT PLANT	C	MERCER	SW
ND0901363	OXBOW CITY OF	C	CASS	GW
ND5000773	PARK RIVER CITY OF	C	WALSH	GW
ND2710033	PDQ CLUB	NC	MCKENZIE	GW
ND0511413	PELICAN LAKE CAMPGROUND	NC - Seasonal	BOTTINEAU	GW
ND0811391	PIONEER PARK	NC - Seasonal	BURLEIGH	GW
ND0700800	PORTAL CITY OF	C	BURKE	GW
ND0700804	POWERS LAKE CITY OF	C	BURKE	GW
ND5301555	R & R TRAILER COURT	C	WILLIAMS	GW
ND2711676	RAKKEN ARROW RV PARK	NC	MCKENZIE	GW
ND2011162	RED WILLOW LAKE RESORT	NC - Seasonal	GRIGGS	GW
ND2701623	RIDGEVIEW PARK	NTNC	MCKENZIE	GW
ND0910560	RINGNECK BAR & GRILL	NC	CASS	GW
ND2800825	RIVERDALE CITY OF	C	MCLEAN	SW
ND0901365	RIVERDALE SUBDIVISION	C	CASS	GW
ND2200827	ROBINSON CITY OF	C	KIDDER	GW
ND4000833	ROLETTE CITY OF	C	ROLETTE	GW
ND4000834	ROLLA CITY OF	C	ROLETTE	GW
ND3500842	RUGBY CITY OF	C	PIERCE	GW
ND2711725	SANDSTONE DEVELOPMENT	NC	MCKENZIE	GW
ND4300871	SELFRIDGE CITY OF	C	SIOUX	GW
ND3501069	SELZ WATER USERS ASSOCIATION	C	PIERCE	GW
ND1400879	SHEYENNE CITY OF	C	EDDY	GW
ND2711599	SHORT STOP CONVENIENCE STORE	NC	MCKENZIE	GW
ND5010350	SIDETRACK BAR & DAM CAFE	NC	WALSH	GW
ND3711683	SILVER PRAIRIE SALOON	NC	RANSOM	GW
ND0900490	SLEEPY HOLLOW WATER COMPANY	C	CASS	GW
ND0500887	SOURIS CITY OF	C	BOTTINEAU	GW
ND0801502	SOUTH CENTRAL RWD NORTH BURLEIGH	C	BURLEIGH	GU
ND1501653	SOUTH CENTRAL RWD-EMMONS	C	EMMONS	SW
ND3901068	SOUTHEAST WUD (EAST)	C	RICHLAND	GW

C-Community, NC-Non-Community, NTNC-Non-Transient Non-Community
SW-Surface Water, GW-Groundwater, GU-Groundwater under the influence of Surface Water

PWS Number	PWS System Name	System Type	County	Source
ND1101442	SOUTHEAST WUD (WEST)	C	DICKEY	GW
ND0311637	SOUTHEND R & R	NC - Seasonal	BENSON	GW
ND4501434	SOUTHWEST WATER AUTHORITY	C	STARK	SW
ND4000854	ST JOHN CITY OF	C	ROLETTE	GW
ND2200913	STEELE CITY OF	C	KIDDER	GW
ND2711715	STONEGATE RESIDENCE SUITES & STORAGE	NC	MCKENZIE	GW
ND0510149	STRAWBERRY LAKE CAMPGROUND	NC - Seasonal	BOTTINEAU	GW
ND4700922	STREETER CITY OF	C	STUTSMAN	GW
ND4701303	STUTSMAN RURAL WATER DISTRICT	C	STUTSMAN	GW
ND0311302	SULLYS HILL NATL GAME PRESERVE	NC	BENSON	GW
ND4101452	SUNDALE HUTTERIAN ASSOCIATION	C	SARGENT	GW
ND2711720	SWEET CRUDE TRAVEL CENTER	NC	MCKENZIE	GW
ND2710994	T ROOSEVELT NATL PK-NORTH	NC	MCKENZIE	GW
ND2210933	TAPPEN PUBLIC SCHOOL	NTNC	KIDDER	GW
ND2711707	TELLURIDE LODGE	NC	MCKENZIE	GW
ND2711694	THE DAKOTAN MOTEL	NC	MCKENZIE	GW
ND0711443	THE FOOD BARN	NC	BURKE	GW
ND2711299	TOBACCO GARDEN RECREATION AREA	NC	MCKENZIE	GW
ND2500946	TOWNER CITY OF	C	MCHENRY	GW
ND2511433	TOWNER STATE NURSERY	NC - Seasonal	MCHENRY	GW
ND3201072	TRI-COUNTY WATER DISTRICT	C	NELSON	GW
ND2200951	TUTTLE CITY OF	C	KIDDER	GW
ND0510107	TWIN OAKS RESORT	NC - Seasonal	BOTTINEAU	GW
ND5101074	UPPER SOURIS WUA-SYSTEM I	C	WARD	GW
ND0200958	VALLEY CITY CITY OF	C	BARNES	SW
ND2500964	VELVA CITY OF	C	MCHENRY	GW
ND2711688	VESTA WATFORD ESTATES	NC	MCKENZIE	GW
ND3900973	WAHPETON CITY OF	C	RICHLAND	GW
ND0300987	WARWICK CITY OF	C	BENSON	GW
ND2800989	WASHBURN CITY OF	C	MCLEAN	SW
ND0511342	WASHEGUM CAMPGROUND 72	NC - Seasonal	BOTTINEAU	GW
ND2711771	WATFORD CITY STAR MOTEL	NC	MCKENZIE	GW

C-Community, NC-Non-Community, NTNC-Non-Transient Non-Community
SW-Surface Water, GW-Groundwater, GU-Groundwater under the influence of Surface Water

PWS Number	PWS System Name	System Type	County	Source
ND2701701	WATFORD RESIDENCE SUITES	C	MCKENZIE	GW
ND0311757	WEST BAY HEIGHTS	NC - Seasonal	BENSON	GW
ND0501001	WESTHOPE CITY OF	C	BOTTINEAU	GW
ND3111582	WHITING OIL & GAS	NTNC	MOUNTRAIL	GW
ND5301012	WILLISTON CITY OF	C	WILLIAMS	SW
ND2301467	WILLOWBANK COLONY	C	LAMOURE	GW
ND0801036	WING CITY OF	C	BURLEIGH	GW
ND2601037	WISHEK CITY OF	C	MCINTOSH	GW

C-Community, NC-Non-Community, NTNC-Non-Transient Non-Community
SW-Surface Water, GW-Groundwater, GU-Groundwater under the influence of Surface Water

Appendix B

North Dakota Geographic Targeting System 2017 Results

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
Adrian	151	168	3	HIGH	395.89	3	HIGH	0.00	1	LOW	7	MODERATE
Antelope Creek	85	103	1	LOW	152.40	1	LOW	40.79	3	HIGH	5	MODERATE
Apple Creek	103	125	1	LOW	188.94	1	LOW	19.12	2	MODERATE	4	LOW
Bantel	115	139	2	MODERATE	413.95	3	HIGH	0.00	1	LOW	6	MODERATE
Battle Creek	95	109	1	LOW	109.50	1	LOW	0.00	1	LOW	3	LOW
Beaver Creek N	114	122	1	LOW	110.04	1	LOW	0.00	1	LOW	3	LOW
Beaver Creek S	120	140	2	MODERATE	265.67	2	MODERATE	0.00	1	LOW	5	MODERATE
Beaver Lake	128	143	2	MODERATE	301.31	2	MODERATE	0.00	1	LOW	5	MODERATE
Belmont	80	103	1	LOW	563.96	3	HIGH	1.97	2	MODERATE	6	MODERATE
Bennie Peer	96	108	1	LOW	107.28	1	LOW	0.00	1	LOW	3	LOW
Big Bend	145	166	3	HIGH	357.54	3	HIGH	0.00	1	LOW	7	MODERATE
Bismarck	126	145	2	MODERATE	188.92	1	LOW	43.84	3	HIGH	6	MODERATE
Braddock	133	149	2	MODERATE	265.71	2	MODERATE	0.00	1	LOW	5	MODERATE
Brightwood	128	147	2	MODERATE	616.58	3	HIGH	0.00	1	LOW	6	MODERATE
Buffalo Creek	160	181	3	HIGH	263.65	2	MODERATE	0.00	1	LOW	6	MODERATE
Burnt Creek	143	166	3	HIGH	188.92	1	LOW	168.95	3	HIGH	7	MODERATE
Butte	82	108	1	LOW	203.89	2	MODERATE	0.00	1	LOW	4	LOW
Carrington	108	132	2	MODERATE	439.49	3	HIGH	192.13	3	HIGH	8	HIGH
Central Dakota	157	183	3	HIGH	213.21	2	MODERATE	112.81	3	HIGH	8	HIGH
Charbonneau	110	124	1	LOW	107.30	1	LOW	757.72	3	HIGH	5	MODERATE
Cherry Creek	128	138	2	MODERATE	107.37	1	LOW	87.52	3	HIGH	6	MODERATE
Cherry Lake	163	168	3	HIGH	265.75	2	MODERATE	0.08	1	LOW	6	MODERATE
Colfax	78	109	1	LOW	616.54	3	HIGH	2.07	2	MODERATE	6	MODERATE
Columbus	92	116	1	LOW	192.62	1	LOW	20.62	2	MODERATE	4	LOW
Cottonwood Creek	173	197	3	HIGH	167.67	1	LOW	0.00	1	LOW	5	MODERATE
Courtenay	96	122	1	LOW	356.91	2	MODERATE	0.00	1	LOW	4	LOW
Crete	139	162	3	HIGH	474.98	3	HIGH	0.00	1	LOW	7	MODERATE
Crosby	85	113	1	LOW	165.74	1	LOW	5.25	2	MODERATE	4	LOW
Cut Bank Creek N	179	201	3	HIGH	296.40	2	MODERATE	1.06	1	LOW	6	MODERATE

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
Cut Bank Creek S	120	158	2	MODERATE	186.85	1	LOW	1.06	1	LOW	4	LOW
Dead Colt	129	152	2	MODERATE	357.55	3	HIGH	0.00	1	LOW	6	MODERATE
Deer Lake	112	136	2	MODERATE	356.92	3	HIGH	0.00	1	LOW	6	MODERATE
Denbigh	163	185	3	HIGH	186.86	1	LOW	84.09	3	HIGH	7	MODERATE
Des Lacs River	128	150	2	MODERATE	262.87	2	MODERATE	0.00	1	LOW	5	MODERATE
Douglas	138	154	2	MODERATE	256.99	2	MODERATE	24.47	2	MODERATE	6	MODERATE
Dry Fork Creek	139	162	3	HIGH	167.85	1	LOW	0.00	1	LOW	5	MODERATE
Dunseith	113	138	2	MODERATE	202.13	1	LOW	0.00	1	LOW	4	LOW
East Fork Shell Creek	141	160	2	MODERATE	160.62	1	LOW	33.79	3	HIGH	6	MODERATE
Eastman	87	113	1	LOW	444.84	3	HIGH	4.55	2	MODERATE	6	MODERATE
Edgeley	164	181	3	HIGH	403.19	3	HIGH	319.41	3	HIGH	9	HIGH
Elk Valley	165	184	3	HIGH	525.42	3	HIGH	159.91	3	HIGH	9	HIGH
Ellendale	96	122	1	LOW	409.16	3	HIGH	1.57	2	MODERATE	6	MODERATE
Elliot	85	113	1	LOW	357.58	3	HIGH	237.68	3	HIGH	7	MODERATE
Elm Creek	88	95	1	LOW	176.54	1	LOW	7.73	2	MODERATE	4	LOW
Enderlin	122	149	2	MODERATE	416.06	3	HIGH	0.00	1	LOW	6	MODERATE
Englevale	133	158	2	MODERATE	423.74	3	HIGH	328.90	3	HIGH	8	HIGH
Esmond	143	166	3	HIGH	300.23	2	MODERATE	167.52	3	HIGH	8	HIGH
Estevan	100	128	1	LOW	165.75	1	LOW	0.00	1	LOW	3	LOW
Fairmount	65	91	1	LOW	616.46	3	HIGH	7.99	2	MODERATE	6	MODERATE
Fordville	157	168	3	HIGH	528.80	3	HIGH	122.65	3	HIGH	9	HIGH
Fort Mandan	140	151	2	MODERATE	262.32	2	MODERATE	0.00	1	LOW	5	MODERATE
Fox Haven	132	155	2	MODERATE	188.93	1	LOW	0.00	1	LOW	4	LOW
Garrison	119	142	2	MODERATE	263.70	2	MODERATE	258.24	3	HIGH	7	MODERATE
Glenburn	82	108	1	LOW	293.76	2	MODERATE	2.15	2	MODERATE	5	MODERATE
Glencoe Channel	139	160	2	MODERATE	195.48	1	LOW	92.07	3	HIGH	6	MODERATE
Glenview	123	148	2	MODERATE	188.99	1	LOW	43.47	3	HIGH	6	MODERATE
Goodman Creek	103	117	1	LOW	142.52	1	LOW	22.96	2	MODERATE	4	LOW
Grand Forks	124	142	2	MODERATE	525.29	3	HIGH	41.06	3	HIGH	8	HIGH

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
Grenora	97	111	1	LOW	166.38	1	LOW	52.18	3	HIGH	5	MODERATE
Guelph	112	136	2	MODERATE	298.96	2	MODERATE	111.57	3	HIGH	7	MODERATE
Gwinner	76	98	1	LOW	475.43	3	HIGH	50.85	3	HIGH	7	MODERATE
Hankinson	167	204	3	HIGH	616.56	3	HIGH	181.52	3	HIGH	9	HIGH
Heart River	121	124	1	LOW	184.66	1	LOW	6.32	2	MODERATE	4	LOW
Heimdal	160	181	3	HIGH	368.74	3	HIGH	0.00	1	LOW	7	MODERATE
Hiddenwood Lake	91	117	1	LOW	257.47	2	MODERATE	0.00	1	LOW	4	LOW
Hillsboro	96	118	1	LOW	560.68	3	HIGH	25.48	2	MODERATE	6	MODERATE
Hillsburg	150	161	3	HIGH	301.32	2	MODERATE	0.00	1	LOW	6	MODERATE
Hofflund	107	127	1	LOW	167.85	1	LOW	1303.09	3	HIGH	5	MODERATE
Homer	92	116	1	LOW	356.92	3	HIGH	0.00	1	LOW	5	MODERATE
Horse Nose Butte	83	98	1	LOW	120.89	1	LOW	7.68	2	MODERATE	4	LOW
Horseshoe Valley	146	155	2	MODERATE	263.77	2	MODERATE	187.97	3	HIGH	7	MODERATE
Icelandic	164	202	3	HIGH	586.90	3	HIGH	21.04	2	MODERATE	8	HIGH
Inkster	169	191	3	HIGH	525.43	3	HIGH	189.43	3	HIGH	9	HIGH
James River	160	181	3	HIGH	407.29	3	HIGH	1.24	1	LOW	7	MODERATE
Jamestown	155	174	3	HIGH	356.92	2	MODERATE	1715.06	3	HIGH	8	HIGH
Juanita Lake	170	189	3	HIGH	453.36	3	HIGH	247.17	3	HIGH	9	HIGH
Karlsruhe	149	170	3	HIGH	186.86	1	LOW	86.28	3	HIGH	7	MODERATE
Keene	111	136	2	MODERATE	107.40	1	LOW	17.10	2	MODERATE	5	MODERATE
Kenmare	84	110	1	LOW	176.56	1	LOW	0.00	1	LOW	3	LOW
Kilgore	151	188	3	HIGH	226.17	2	MODERATE	0.00	1	LOW	6	MODERATE
Killdeer	109	122	1	LOW	150.68	1	LOW	20.35	2	MODERATE	4	LOW
Knife River	141	157	2	MODERATE	148.54	1	LOW	139.37	3	HIGH	6	MODERATE
Koble	135	163	3	HIGH	356.92	3	HIGH	37.15	3	HIGH	9	HIGH
Lake Ilo	110	141	2	MODERATE	120.86	1	LOW	575.36	3	HIGH	6	MODERATE
Lake Nettie	158	163	3	HIGH	233.86	2	MODERATE	32.44	2	MODERATE	7	MODERATE
Lake Souris	185	205	3	HIGH	187.07	1	LOW	28.78	2	MODERATE	6	MODERATE
LaMoure	143	166	3	HIGH	409.71	3	HIGH	227.16	3	HIGH	9	HIGH

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
LaMoure North	152	185	3	HIGH	403.17	3	HIGH	235.03	3	HIGH	9	HIGH
Landa	122	146	2	MODERATE	282.52	2	MODERATE	0.00	1	LOW	5	MODERATE
Leeds	79	109	1	LOW	300.24	2	MODERATE	0.00	1	LOW	4	LOW
Lignite City	120	141	2	MODERATE	176.52	1	LOW	47.66	3	HIGH	6	MODERATE
Little Heart	103	110	1	LOW	183.39	1	LOW	11.35	2	MODERATE	4	LOW
Little Knife River Valley	148	156	2	MODERATE	160.59	1	LOW	9.31	2	MODERATE	5	MODERATE
Little Missouri River	119	138	2	MODERATE	114.52	1	LOW	6.76	2	MODERATE	5	MODERATE
Little Muddy	131	150	2	MODERATE	167.75	1	LOW	173.43	3	HIGH	6	MODERATE
Long Lake	79	92	1	LOW	202.05	1	LOW	13.39	2	MODERATE	4	LOW
Lost Lake	101	123	1	LOW	263.79	2	MODERATE	5.19	2	MODERATE	5	MODERATE
Maddock	145	166	3	HIGH	300.24	2	MODERATE	42.91	3	HIGH	8	HIGH
Manfred	143	168	3	HIGH	368.72	3	HIGH	21.63	2	MODERATE	8	HIGH
Martin	135	154	2	MODERATE	216.48	2	MODERATE	2.20	2	MODERATE	6	MODERATE
McIntosh	115	144	2	MODERATE	252.70	2	MODERATE	0.00	1	LOW	5	MODERATE
McKenzie	89	112	1	LOW	188.97	1	LOW	41.03	3	HIGH	5	MODERATE
McVille	107	134	2	MODERATE	319.70	2	MODERATE	53.82	3	HIGH	7	MODERATE
Medford	167	193	3	HIGH	526.40	3	HIGH	0.00	1	LOW	7	MODERATE
Medina North	170	185	3	HIGH	356.92	3	HIGH	591.13	3	HIGH	9	HIGH
Medina South	170	185	3	HIGH	356.92	3	HIGH	531.56	3	HIGH	9	HIGH
Middle James	128	151	2	MODERATE	382.57	3	HIGH	579.41	3	HIGH	8	HIGH
Midway	123	145	2	MODERATE	356.92	3	HIGH	5.24	2	MODERATE	7	MODERATE
Milnor Channel	135	158	2	MODERATE	535.57	3	HIGH	161.14	3	HIGH	8	HIGH
Missouri River	143	175	3	HIGH	190.69	1	LOW	21.61	2	MODERATE	6	MODERATE
Missouri River - Lake Sakakawea	120	141	2	MODERATE	201.79	1	LOW	21.73	2	MODERATE	5	MODERATE
Missouri River-Oahe	118	143	2	MODERATE	179.01	1	LOW	21.75	2	MODERATE	5	MODERATE
Montpelier	93	117	1	LOW	367.62	3	HIGH	0.00	1	LOW	5	MODERATE
Munich	106	132	2	MODERATE	356.04	2	MODERATE	0.00	1	LOW	5	MODERATE
Napolean	144	161	3	HIGH	301.29	2	MODERATE	42.75	3	HIGH	8	HIGH
New Rockford	103	125	1	LOW	303.13	2	MODERATE	27.68	2	MODERATE	5	MODERATE

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
New Town	103	120	1	LOW	163.71	1	LOW	58.35	3	HIGH	5	MODERATE
North Burleigh	134	145	2	MODERATE	200.02	1	LOW	12.64	2	MODERATE	5	MODERATE
Northwest Buried Channel	120	137	2	MODERATE	255.74	2	MODERATE	14.66	2	MODERATE	6	MODERATE
Oakes	151	172	3	HIGH	395.90	3	HIGH	199.14	3	HIGH	9	HIGH
Otter Creek	101	119	1	LOW	216.10	2	MODERATE	0.00	1	LOW	4	LOW
Page	135	153	2	MODERATE	514.08	3	HIGH	82.40	3	HIGH	8	HIGH
Painted Woods Creek	164	181	3	HIGH	203.83	2	MODERATE	0.00	1	LOW	6	MODERATE
Painted Woods Lake	124	150	2	MODERATE	263.21	2	MODERATE	136.42	3	HIGH	7	MODERATE
Pembina Delta	100	125	1	LOW	517.64	3	HIGH	0.00	1	LOW	5	MODERATE
Pembina River	120	140	2	MODERATE	586.92	3	HIGH	105.12	3	HIGH	8	HIGH
Pipestem Creek	155	176	3	HIGH	390.95	3	HIGH	28.27	2	MODERATE	8	HIGH
Pleasant Lake	109	125	1	LOW	251.51	2	MODERATE	89.82	3	HIGH	6	MODERATE
Pony Gulch	128	150	2	MODERATE	368.71	3	HIGH	0.00	1	LOW	6	MODERATE
Random Creek	150	163	3	HIGH	188.97	1	LOW	0.00	1	LOW	5	MODERATE
Ray	96	115	1	LOW	167.81	1	LOW	24.30	2	MODERATE	4	LOW
Renner	97	121	1	LOW	152.40	1	LOW	10.72	2	MODERATE	4	LOW
Riverdale	152	161	3	HIGH	253.37	2	MODERATE	0.00	1	LOW	6	MODERATE
Rocky Run	164	185	3	HIGH	368.73	3	HIGH	0.00	1	LOW	7	MODERATE
Rolla	110	138	2	MODERATE	221.53	2	MODERATE	10.83	2	MODERATE	6	MODERATE
Rosefield	90	120	1	LOW	368.74	3	HIGH	0.00	1	LOW	5	MODERATE
Rugby Aquifer	113	127	1	LOW	237.62	2	MODERATE	100.28	3	HIGH	6	MODERATE
Rusland	151	177	3	HIGH	368.71	3	HIGH	316.18	3	HIGH	9	HIGH
Russell Lake	155	174	3	HIGH	440.35	3	HIGH	0.00	1	LOW	7	MODERATE
Ryder	116	142	2	MODERATE	255.68	2	MODERATE	6.12	2	MODERATE	6	MODERATE
Ryder Ridge	97	120	1	LOW	255.66	2	MODERATE	0.00	1	LOW	4	LOW
Sand Prairie	153	176	3	HIGH	367.87	3	HIGH	53.09	3	HIGH	9	HIGH
Sanish	102	122	1	LOW	162.79	1	LOW	0.00	1	LOW	3	LOW
Seven Mile Coulee	149	170	3	HIGH	356.92	2	MODERATE	104.26	3	HIGH	8	HIGH
Sheldon	151	175	3	HIGH	357.54	3	HIGH	0.00	1	LOW	7	MODERATE

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
Shell Creek-Central	113	134	2	MODERATE	160.63	1	LOW	7.12	2	MODERATE	5	MODERATE
Shell Creek-East Branch	116	135	2	MODERATE	208.51	2	MODERATE	7.12	2	MODERATE	6	MODERATE
Shell Creek-White Lake	148	162	3	HIGH	164.66	1	LOW	7.11	2	MODERATE	6	MODERATE
Shell Valley	137	158	2	MODERATE	202.14	1	LOW	154.65	3	HIGH	6	MODERATE
Sheyenne Delta	151	172	3	HIGH	497.31	3	HIGH	49.75	3	HIGH	9	HIGH
Shields	81	92	1	LOW	134.26	1	LOW	3.59	2	MODERATE	4	LOW
Skjermo Lake	138	162	3	HIGH	165.60	1	LOW	109.21	3	HIGH	7	MODERATE
Smoky Butte	141	160	2	MODERATE	166.16	1	LOW	103.16	3	HIGH	6	MODERATE
Snake Creek	101	123	1	LOW	262.94	2	MODERATE	0.00	1	LOW	4	LOW
Soo Channel	122	145	2	MODERATE	188.94	1	LOW	216.29	3	HIGH	6	MODERATE
Souris River	110	138	2	MODERATE	235.15	2	MODERATE	0.96	1	LOW	5	MODERATE
South Branch Beaver Creek	121	143	2	MODERATE	237.18	2	MODERATE	0.00	1	LOW	5	MODERATE
South Fessenden	149	172	3	HIGH	368.73	3	HIGH	0.00	1	LOW	7	MODERATE
Spiritwood N	161	182	3	HIGH	403.18	3	HIGH	33.50	2	MODERATE	8	HIGH
Spiritwood S	139	160	2	MODERATE	319.89	2	MODERATE	33.50	2	MODERATE	6	MODERATE
Spiritwood-Berlin	91	117	1	LOW	402.93	3	HIGH	33.50	2	MODERATE	6	MODERATE
Spiritwood-Devils Lake	142	150	2	MODERATE	313.35	2	MODERATE	33.50	2	MODERATE	6	MODERATE
Spiritwood-Grand Rapids	110	121	1	LOW	408.98	3	HIGH	33.49	2	MODERATE	6	MODERATE
Spiritwood-Griggs	143	159	2	MODERATE	453.39	3	HIGH	33.50	2	MODERATE	7	MODERATE
Spiritwood-LaMoure SE	148	167	3	HIGH	402.05	3	HIGH	33.50	2	MODERATE	8	HIGH
Spiritwood-Oakes	147	165	3	HIGH	260.80	2	MODERATE	33.49	2	MODERATE	7	MODERATE
Spiritwood-Rogers	125	150	2	MODERATE	374.79	3	HIGH	33.47	2	MODERATE	7	MODERATE
Spiritwood-Sheyenne River	129	152	2	MODERATE	300.18	2	MODERATE	33.48	2	MODERATE	6	MODERATE
Spiritwood-Stutsman	139	160	2	MODERATE	305.17	2	MODERATE	33.50	2	MODERATE	6	MODERATE
Spiritwood-Warwick	127	145	2	MODERATE	479.98	3	HIGH	33.51	2	MODERATE	7	MODERATE
Spring Creek	120	159	2	MODERATE	237.26	2	MODERATE	6.38	2	MODERATE	6	MODERATE
Square Butte Creek	128	136	2	MODERATE	208.41	2	MODERATE	39.07	3	HIGH	7	MODERATE
Squaw Creek	85	109	1	LOW	115.32	1	LOW	0.00	1	LOW	3	LOW
St. James	97	113	1	LOW	154.84	1	LOW	0.00	1	LOW	3	LOW

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
Starkweather	88	116	1	LOW	338.29	2	MODERATE	0.00	1	LOW	4	LOW
Stoney Creek	159	180	3	HIGH	402.03	3	HIGH	0.00	1	LOW	7	MODERATE
Strasburg	165	184	3	HIGH	265.70	2	MODERATE	20.30	2	MODERATE	7	MODERATE
Strawberry Lake	105	115	1	LOW	259.43	2	MODERATE	19.31	2	MODERATE	5	MODERATE
Streeter	102	126	1	LOW	283.63	2	MODERATE	122.47	3	HIGH	6	MODERATE
Sundre	119	138	2	MODERATE	253.29	2	MODERATE	273.36	3	HIGH	7	MODERATE
Sydney	90	116	1	LOW	356.92	3	HIGH	0.00	1	LOW	5	MODERATE
Thompson	66	90	1	LOW	525.30	3	HIGH	0.00	1	LOW	5	MODERATE
Tobacco Garden	118	140	2	MODERATE	107.36	1	LOW	56.31	3	HIGH	6	MODERATE
Tokio	150	159	2	MODERATE	299.57	2	MODERATE	15.85	2	MODERATE	6	MODERATE
Tolgen	138	153	2	MODERATE	255.65	2	MODERATE	0.00	1	LOW	5	MODERATE
Tower City	159	180	3	HIGH	443.11	3	HIGH	11.73	2	MODERATE	8	HIGH
Trappers Coulee	161	180	3	HIGH	299.79	2	MODERATE	292.61	3	HIGH	8	HIGH
Trenton	100	121	1	LOW	148.42	1	LOW	41.39	3	HIGH	5	MODERATE
Turtle Lake	119	146	2	MODERATE	263.76	2	MODERATE	0.00	1	LOW	5	MODERATE
Upper Apple Creek	154	165	3	HIGH	188.96	1	LOW	1.56	2	MODERATE	6	MODERATE
Upper Buffalo Creek	120	148	2	MODERATE	356.92	3	HIGH	0.00	1	LOW	6	MODERATE
Vang	160	169	3	HIGH	255.56	2	MODERATE	7.39	2	MODERATE	7	MODERATE
Voltaire	155	176	3	HIGH	186.85	1	LOW	52.64	3	HIGH	7	MODERATE
Wagonsport	159	180	3	HIGH	189.65	1	LOW	10.75	2	MODERATE	6	MODERATE
Wahpeton Buried Valley	78	108	1	LOW	616.48	3	HIGH	374.17	3	HIGH	7	MODERATE
Warwick Aquifer	169	202	3	HIGH	286.06	2	MODERATE	130.06	3	HIGH	8	HIGH
Weller Slough	82	108	1	LOW	263.73	2	MODERATE	0.00	1	LOW	4	LOW
West Fargo	78	98	1	LOW	519.67	3	HIGH	18.49	2	MODERATE	6	MODERATE
West Wildrose	87	101	1	LOW	167.43	1	LOW	16.34	2	MODERATE	4	LOW
White Earth	154	153	2	MODERATE	160.54	1	LOW	0.00	1	LOW	4	LOW
White Shield	92	132	2	MODERATE	263.61	2	MODERATE	89.95	3	HIGH	7	MODERATE
Wildrose	127	148	2	MODERATE	165.86	1	LOW	2.70	2	MODERATE	5	MODERATE
Wimbledon	135	156	2	MODERATE	398.54	3	HIGH	0.00	1	LOW	6	MODERATE

Aquifer	Drastic Score	Pesticide Drastic Score	Vulnerability Score	Vulnerability Rating	Sensitivity Value (dollars/farmed acre)	Sensitivity Score	Sensitivity Ranking	Risk Value (acre-feet/mi^2)	Risk Score	Risk Rating	Total Monitoring Score	Total Monitoring Rating
Windsor	87	101	1	LOW	356.92	3	HIGH	15.04	2	MODERATE	6	MODERATE
Wing Channel	75	93	1	LOW	188.97	1	LOW	3.11	2	MODERATE	4	LOW
Winona	77	86	1	LOW	265.66	2	MODERATE	229.46	3	HIGH	6	MODERATE
Wishek	154	173	3	HIGH	244.55	2	MODERATE	45.35	3	HIGH	8	HIGH
Wolf Creek	116	142	2	MODERATE	263.73	2	MODERATE	0.00	1	LOW	5	MODERATE
Yellowstone	138	174	3	HIGH	107.24	1	LOW	9.55	2	MODERATE	6	MODERATE
Yellowstone River Channel	91	113	1	LOW	166.85	1	LOW	26.77	2	MODERATE	4	LOW
Ypsilanti	164	181	3	HIGH	357.05	3	HIGH	0.00	1	LOW	7	MODERATE
Zap	109	135	2	MODERATE	152.38	1	LOW	0.00	1	LOW	4	LOW
Zeeland	93	111	1	LOW	237.19	2	MODERATE	3.10	2	MODERATE	5	MODERATE

Appendix C

North Dakota Law and Source Water Protection

Sources of Water Quality Contamination	Statutes Governing Sources of Contamination (NDCC)	Rules Established Under Statute (NDAC)	Governing Agency	Brief Description of Regulatory Authority and Guidelines
I. Waste Impoundments A. Industrial B. Municipal	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Waters	Chapter 33-16-01 North Dakota Pollutant Discharge Elimination System	WQ	The statute requires plans and specifications for all industrial and municipal impoundments be submitted to the NDDEQ for approval. The rules establish water quality standards for surface discharges and construction design standards to reduce groundwater quality impacts.
C. Livestock		Chapter 33-16-03.1 Control of Pollution from Animal Feeding Operations	WQ	The rule requires defined concentrated animal feeding operations be permitted by the NDDEQ. Permit requirements may include compliance with design standards to address impoundment and waste handling as well as groundwater quality monitoring.
D. Hazardous Waste	Chapter 23.1-04 Hazardous Waste Management	Article 33-24 Hazardous Waste Management	WM	Chapter 33-24-05 (118-128) Surface impoundments requirements set standards for design, operation, monitoring, and inspection of hazardous waste impoundments.
II. Solid Waste Disposal A. Sanitary Landfills B. Special Use Landfills 1. Fly Ash 2. Drilling Fluid 3. Lime Sludge 4. Construction Waste	Chapter 23.1-08 Solid Waste Management and Land Protection	Article 33-20 Solid Waste Management and Land Protection	WM	The rules prescribe minimum standards for the storage, collection, transportation and disposal of solid wastes. Construction and operation requirements have been developed to protect ground and surface water from contamination. All locations are geologically sited to protect groundwater. Groundwater monitoring may be required.
C. Hazardous Waste Disposal Sites	Chapter 23.1-04 Hazardous Waste Management	Article 33-24 Hazardous Waste Management	WM	Chapter 33-24-05 Sets standards for the treatment, storage, and disposal of hazardous waste. Chapter 33-24-05 (47-58) Groundwater protection requirements set minimum standards for groundwater protection, including monitoring and corrective action programs.

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III. Injection Wells A. Oil and Gas	Chapter 38-08 Control of Oil and Gas Resources	Chapter 43-05-05 Underground Injection Control	OGD	The rules for all underground injection control programs require permits for all injection wells and establish construction, operating, monitoring, and reporting requirements to protect surface and groundwater. The rules address Class I, II, III, IV, V and VI underground injection well categories.
B. Mining	Chapter 38-12 Regulation, Development, and Production of Subsurface Minerals	Chapter 43-02-01.1 Underground Injection Control Program	NDGS	
C. Municipal	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Waters	Chapter 33-25-01 Underground Injection Control Program	WQ	
IV. Well Construction A. Improper Well Construction B. Abandoned Wells	Chapter 43-35 State Board of Water Well Contractors	Article 33-18-01 Water Well Construction and Water Well Pump Installation	SWC/MF/WQ	The statue requires all firms engaged in water well construction to be certified and establishes a state board of water well contractors. The rules establish location and construction requirements for water wells, irrigation wells, monitoring wells, abandoned wells, and geothermal return wells. Section 33-18-01-05 Protection of Ground Water Sources requires specific grouting and construction features to ensure the protection of groundwater.
C. Seismic Holes	Chapter 38-08.1 Geophysical Exploration Requirements	Chapter 43-02-12 Geophysical Exploration Requirements	OGD	The rules set requirements for permitting geophysical exploration, including requirements for plugging and abandoning drilled holes.
D. Monitoring Well Construction	Chapter 43-35 State Board of Water Well Contractors	Article 33-18-02 Ground Water Monitoring Well Construction Requirements	SWC/WQ	The statues require all firms engaged in the construction of groundwater monitoring wells to be certified. The rules establish

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				construction, siting, protection, and abandonment requirements.
E. Geothermal Energy Recovery Wells	Chapter 38-19 Geothermal Resource Development Regulation	Article 43-02-07 Geothermal Energy Production	NDGS	Establishes construction, installation, and permitting requirements for private and industrial geothermal recovery wells. Refers to Article 33-18 Water Well Construction and Water Well Pump Installation for some construction requirements.
V. Subsurface Sewage Disposal A. Drain Field Systems B. Mound Systems	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Waters	10 States Standards (GLUMRB) Chapter 62-03.1-03 Private Sewage Disposal Systems	WQ/MF	The statue requires the submission of plans and specifications for public subsurface disposal systems. Individual systems are approved by local health units. The NDDEQ has established guidelines for the construction, operation, and maintenance of subsurface disposal systems.
C. Septage	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Water	Chapter 33-1-02 Servicing of Septic or Holding Tanks, Privies, or Portable Restrooms	WQ/MF	The statue requires all septic tank pumpers to obtain a license. The rules require pumpers dispose of waste in a manner which will not endanger surface or groundwater.
VI. Land Application of Wastes A. Wastewater Irrigation	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Waters	Guidelines Chapter 33-1-02 Servicing of Septic or Holding Tanks, Privies, or Portable Restrooms	WQ/MF	All wastewater irrigation projects, including plans and specifications, are reviewed and approved by the NDDEQ. Groundwater monitoring is required on a case-by-case basis.
B. Land Application of Sludges	Chapter 23.1-08 Solid Waste Management and Land Protection	Chapter 33-20-09 Land Treatment Provisions	WM	The rules establish permitting requirements for sludge disposal.
C. Land Treatment of Contaminated Soils	Chapter 23-.1-08 Solid Waste Management and Land Protection	Guidelines	WM	Provides guidance on the site selection, sampling requirements, management, and notification requirements for land treatment areas for petroleum contaminated soils.

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VII. Accidental Spills A. Hydrocarbons B. Chemicals C. Salt Water D. Hazardous Material	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Waters Chapter 23.1-04 Hazardous Waste Management	Chapter 33-16-02.1 Standards of Quality for Waters of the State Environmental Incident Reporting Guidance Documents Article 33-24-02 Standards for Transporters	WQ/MF SHP WM	The NDDEQ has a Spill Investigation Program specifically to address released contaminants. The patrol utilizes the Pollution Control Contingency Plan or Oil and Hazardous Materials when accidental spills occur. The rules specify the type of immediate action to be taken and cleanup responsibilities in the event of a spill.
VIII. Mining A. Mine Development B. Reclamation	Chapter 38-14.1 Surface Mining and Reclamation Options Chapter 38-12.1 Coal Exploration	Article 69-05.2 Surface Coal Mining and Reclamation Operations Article 43-02 Mineral Exploration and Development	PSC NDGS	General requirements include surface and groundwater protection and monitoring requirements for mine development and reclamation. Article 69-05.2-25 Performance Standard Operations in Alluvial Valley Floors. Protects groundwater systems surrounding a mine area and ensures reestablishment of groundwater systems. The rules address water issues as they relate to mining exploration.
IX. Oil and Gas Development A. Blowouts B. Evaporation Ponds C. Communication Between Water-Bearing Strata D. Abandoned Wells	Chapter 38-08 Control of Gas and Oil Reserves	Article 43-02-03 General Rules Oil and Gas Development	OGD	Section 43-02-03-23 Blowout Prevention-Requires installation and maintenance of blowout prevention equipment. Section 43-02-03-53 Saltwater Handling Facilities-prohibits evaporation ponds Section 43-02-03-(20-21) Sealing of Strata-All oil, gas, and water formations above the production zone must be sealed. Section 43-02-03-(33-36) Abandonment and Plugging of Wells-requires plugging of abandoned wells.

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X. Storage Tanks A. Regulated Underground Storage Tanks 1. Petroleum 2. Hazardous Substances as Defined in Section 101(14) of CERCLA	Chapter 23-20.3 Hazardous Waste Management	Article 33-24-08 Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)	WM	The underground storage tank rules specify the technical standards, corrective action, and financial responsibility requirements that apply to owners and operators of underground storage tanks.
B. Above Ground Storage Tanks and Unregulated Underground Storage Tanks 1. Petroleum	Chapter 18-01 Fire Marshall Department Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Waters	Article 10-07-01 Fire Marshall	FM WQ	Rules specify National Fire Protection Association Standards for storage and handling of hydrocarbons.
XI. Agriculture A. Fertilizer	Chapter 4.1-40 Fertilizer and Soil Condition Law		NDDA	This statute requires fertilizers be registered and retailers who sell fertilizers be licensed.
B. Pesticide	Chapter 4.1-33 Pesticide Control		NDDA	The rules regulate the labeling and use of pesticides and establishes a pesticide control board.
	Chapter 23-33 Ground Water Protection Act		WQ/NDDA/SWC	The statute directs the NDDEQ to conduct groundwater quality monitoring activities, in cooperation with the SWC. The statute also requires chemical use data from product registrants, develops groundwater protection education programs, and allows the Department of Agriculture to develop pollution prevention criteria.

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	Chapter 4.1-34 Pesticide Registration		NDDA	The statute requires all pesticides which are sold within the state to be registered.
C. Leaching of Salts and Pesticides	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Water		WQ	The SWC and NDDEQ can reduce or discontinue an irrigation project if they feel it may cause groundwater or surface water contamination. This decision may be based on monitoring results or applied research.
	Chapter 61-04 Appropriation of Water		SWC	The SWC issues permits for all irrigation projects and monitors both quality and quantity of the water resources. The statue also requires specific well construction and backflow prevention equipment in the irrigation permit to prevent ground water contamination.
XII. Road Salt Application	Chapter 61-28 Control, Prevention, and Abatement of Pollution of Surface Water		WQ	Sand or other inert materials, rather than salt, are being increasingly used on North Dakota highways. Therefore, the state has not experienced problems associated with de-icing of highways.
XIII. Other	Chapter 61-28-1	Article 33-16-02.1 Standards of Quality for Waters of the State	WQ	Water quality standards apply to both surface and groundwater resources.

North Dakota Governing Agencies

- FM Fire Marshall
- MF North Dakota Department of Environmental Quality-Division of Municipal Facilities
- NDDA North Dakota Department of Agriculture
- NDGS North Dakota Geological Survey
- OGD Industrial Commission-Oil and Gas Division
- PSC Public Service Commission
- SHP State Highway Patrol
- SWC North Dakota State Water Commission
- WM North Dakota Department of Environmental Quality-Division of Waste Management
- WQ North Dakota Department of Environmental Quality-Division of Water Quality