
8. GROUNDWATER

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In October 2004, the Bureau of Drinking and Groundwater, in conjunction with several other state and federal agencies, produced a report titled: *Components of a Groundwater Monitoring Strategy for the State of Wisconsin (Groundwater Strategy)*. This report details programmatic goals, several components needed to meet those goals, and phases for implementation. Use of the strategy by local, state, and federal agencies and by researchers will allow for better data management and sharing, a common protocol for collecting high quality groundwater data and expansion of the fixed monitoring network. The basic framework of that strategy is included here with some subsequent refinements.

Status: Partially in Place

Some of the components detailed below that are needed to create a comprehensive groundwater monitoring program already exist and are maintained by state and federal agencies. These include a fixed network for groundwater level monitoring, a fixed network for surface water monitoring, and a water use reporting program. Other components, such as a fixed network for monitoring groundwater quality and a data management process, need to be implemented.

Monitoring Objectives

Implementation of the Clean Water Act (CWA), Wisconsin's Groundwater Law (Chapter 160 Wisconsin Statutes) and recently enacted Water Quantity legislation (2003 Act 310) all require an understanding of groundwater systems that involves monitoring. The CWA gives WDNR primary responsibility for protecting and restoring water quality including monitoring and assessing the state's waters and reporting on their quality.

Clean Water Act Objectives

- Establishing, reviewing and revising water quality standards
- Determining water quality standards attainment (standards have been in place since 1984)
- Identifying impaired groundwater
- Identifying causes and sources of water quality impairments
- Supporting the implementation of water management programs
- Supporting the evaluation of program effectiveness

Chapter 160 of the Wisconsin Statutes requires the WDNR to work with other agencies and the Groundwater Coordinating Council (GCC), to develop and operate a system for monitoring and sampling groundwater to determine whether harmful substances are present (s. 160.27, Wis. Stats.). Recently enacted groundwater quantity legislation (2003 Wisconsin Act 310) directs the WDNR to issue well approvals and track water use for high capacity wells. The objective of the monitoring strategy is to coordinate groundwater monitoring between all agencies interested in groundwater quality, quantity and use in Wisconsin.

In this light, the *Groundwater Strategy* defines three specific goals, described below.

Goal 1: Provide and maintain sufficient, high quality groundwater data to evaluate spatial and temporal trends in groundwater quality, quantity and use

Agencies need high quality data to make changes to groundwater management and protection policies in response to changing trends in groundwater quality, quantity and use. The components used to meet this goal must be flexible enough to accommodate new contaminants and threats as they are recognized. Examples of how the data will be used include:

- Evaluating groundwater protection programs;

- Evaluating public health protection programs;
- Documenting the presence of new pollutants;
- Assessing groundwater quality in WDNR basins;
- Tracking groundwater levels in groundwater management areas; and
- Evaluate water use and its impacts on groundwater levels.

Goal 2: Provide high quality data for a more complete understanding of groundwater systems

An understanding of hydrogeology drives state and local policy and management decisions that affect drinking water, fisheries and wildlife habitat. Research aimed at understanding flow systems at different scales, local and regional, helps local resource managers make decisions that protect all water resources.

Examples of how this data will be used include:

- Locating and preserving groundwater recharge areas to sustain groundwater quantity;
- Understanding the fate and transport of natural and human-induced contaminants;
- Understanding how land use practices affect groundwater quality and flow; and
- Developing and evaluating management alternatives.

Goal 3: Provide tools to make groundwater data accessible to citizens, policy makers and resource managers

The public's understanding of groundwater has greatly increased since the Groundwater Law was passed in 1984. The next step is to make local groundwater data easily accessible to citizens, policy makers, researchers, and resource managers so that all stakeholders have the information they need to increase protection of the resource and public health, whether on a local or statewide level. To attain this goal we will:

- Make groundwater data accessible to citizens, policy makers and resource managers via a website;
- Develop tools to help educate citizens about statewide and local groundwater quantity and quality problems; and
- Involve partners in groundwater monitoring to increase awareness of groundwater.

Monitoring Design

Five of the components listed in *Components of a Groundwater Monitoring Strategy for the State of Wisconsin* are outlined below (Components 2-6 of the *Groundwater Strategy*). The other components of the *Groundwater Strategy* are addressed here within the Data Management, Data Analysis, and Reporting sections. Following these components, a phased implementation outline is provided.

A Fixed Network of Groundwater Level Monitoring Locations (meets goals 1 and 2)

Monitoring will include measurement of groundwater levels in all of Wisconsin's water-bearing formations reflecting both water table conditions and deep confined and unconfined aquifers. It should include areas of groundwater development such as urban and rural areas with large withdrawals and undeveloped areas such as forestland.

The USGS and Wisconsin Geological and Natural History Survey (WGNHS) have maintained a fixed network of approximately 100 monitoring wells since the 1940s. The network was designed to monitor water levels in the upper most aquifers. In 2000 the USGS evaluated the network for well location, condition and presence of geologic logs. They recommended that 48 wells be abandoned and replaced by wells in different locations. The cost estimate for improving the observation well network is shown in the table below.

Table 11. Estimated costs for observation well network improvements.

Well abandonment	\$500/well
Real time monitoring equipment	\$1500/well
Siting (professional time)	\$700/well
Drilling and well installation	\$2000/well

Costs may be lower if existing wells can be added to the network. This new, improved observation well network will monitor water levels in shallow, unconfined aquifers in each of Wisconsin's 23 basins and improve our understanding of groundwater flow systems in each basin. This information will allow us to look at groundwater quantity trends.

Monitoring the cone of depression in areas where the water table is declining will require additional monitoring wells. These wells will be installed in the deeper bedrock aquifers and may require casing. Approximately 10 new wells will be installed at a cost of about \$40,000 per well. The total estimated cost would be \$400,000.00. This cost may be less if existing wells can be used. The yearly combined cost for maintaining a fixed network of 115 water table wells and 10 deep wells to monitor cones of depression will be about \$120,000. This includes rehabilitating wells, training staff and replacing damaged wells.

This component meets goals 1 and 2 by providing high quality groundwater level data over a long period of time. Currently the USGS, WDNR and WGNHS maintain and monitor a fixed network. Improvements to the network have been proposed above and funding is being looked at by the different agencies.

Statewide Assessment of Groundwater Quality (meets goals 1 and 2)

Numerous efforts have been made to characterize groundwater quality on a statewide basis. These efforts include sampling of private, public and monitoring wells. An excellent example is described in the Department of Agriculture, Trade and Consumer Protection's report, *Agricultural Chemicals in Wisconsin Groundwater* (2002). DATCP used a statistical procedure for stratified random sampling of private wells to obtain a representative sample of all Wisconsin groundwater for pesticide analysis. The sampling protocol is statistically sound, and uses a sophisticated well selection procedure to determine the extent of monitoring within a sampling stratum. Sampling strata are defined as the geographic area of interest. Examples of strata include aquifers, watersheds, basins, or agricultural statistics districts.

Briefly, stratified random well selection works like this: parcels are randomly selected and the well nearest the center of the parcel is selected for sampling if permission is given by the well owner. If there is no well or the owner refuses to have the well sampled, another parcel is selected by spiraling out clockwise around the original parcel. If appropriate sampling strata are used, this approach can be used to select wells for sample collection and analysis for non-agricultural water quality parameters as well. The number of samples collected in each statistical stratum can be based on many things including prior detects, number of acres in a certain land use or number of acres in a watershed or basin. Frequency of sampling also varies based on the hydrogeology of the area and the nature of the contaminant.

The DATCP pesticide surveys of 1994, 1996 and 2001 used a fifty-percent rotation scheme in which half of the wells in the 1996 and 2001 surveys were part of the previous survey and half were new wells. This allowed detection of changes in pesticide levels over time.

The cost for sample collection and analysis will vary depending on the parameters analyzed for. As a rough estimate, it would cost about \$180,000 per year. Parameters may include major cations and anions, indicator parameters, and the contaminants of special interest. This component will meet goals 1 and 2 by providing a flexible means of looking at groundwater quality trends and better defining groundwater contaminant transfer in flow systems. The Monitoring and Data Management Subcommittee of the GCC will help better define how the data will be made accessible.

A fixed network of water quality monitoring sites (meets goals 1 and 2)

Stratified random sampling of private wells may lead to selection of fixed monitoring sites for long term monitoring. Fixed sites chosen to consider the effect of different land use practices will be part of the fixed network. Existing research and monitoring project wells could also be incorporated into the fixed network as well as public water supply wells (e.g. sentinel wells). Each location may have more than one well to monitor specific parameters. This network may change somewhat with time. Costs at this time are difficult to estimate. This component meets goals 1 and 2 by providing groundwater quality data in areas of concern over time. More details on this component will need to be worked out by the GCC and its subcommittees.

Surface water monitoring stations (meets goals 1 and 2). These stations overlap with those used in the WDNR stream monitoring program. This monitoring is conducted by USGS and WDNR.

Surface water monitoring stations provide stream flow data used to:

- Calibrate groundwater flow models
- Assess basin water resources management decisions
- Model the effect of development on watersheds
- Determine the effect of groundwater use on stream flow and fisheries habitat.

The USGS has evaluated the current stream gaging network and determined that 25 additional monitoring stations are needed on medium-sized streams. The cost of adding 25 new stations and maintaining them is \$250,000. Proposed station locations are based on the need for stream flow data for WDNR Watershed and Fisheries Management programs. Funding for changes to the network is not currently available from the USGS or WDNR. To evaluate the environmental impact of high capacity wells under Wisconsin Act 310, stream flow measurements will be needed on smaller protected streams (trout streams, outstanding resource waters and exceptional resource waters). An assessment of how many monitoring stations are needed for this purpose has not been made. In addition to monitoring station costs, \$70,000 per year is needed to collect low flow measurements in small streams.

This component meets the needs of goals 1 and 2 by providing long term data on groundwater baseflow to surface water at fixed locations. The USGS and WDNR currently maintain a surface water monitoring network and will continue to do so. Other partners have access to the data on a website.

Water use reporting (meets goals 1 and 2)

The purpose of water use reporting is to manage groundwater at local and regional levels. Data are used to evaluate impacts of proposed wells, monitor well approval conditions, identify trends, as input for groundwater flow models, develop hydrologic budgets for watersheds and basins and improve water use estimates. We currently have good data for municipal water supply systems. In 2007 the reporting is being expanded to all high-capacity (>100,000 gal/day) wells including:

- Industrial and commercial users
- Irrigators
- Non-irrigation agricultural users

Costs for this reporting are covered by the funding generated by the 2003 Groundwater Protection Act.

This component meets goals 1 and 2 by providing groundwater use data to help determine water quantity trends and define groundwater/surface water interactions.

Implementation Outline

The following four phases illustrate how the monitoring network will be implemented and used. Results of phases one and two will assess groundwater systems and help determine fixed monitoring locations as described in phases three and four. Parts of phases one and two are completed or started for some basins or deep aquifers. Other parts will be implemented when funding is available. Some components of phases three and four will run concurrently with phases one and two.

Phase I: Baseline Assessment of shallow aquifer system by 23 major basins

Most groundwater management decisions made in Wisconsin are based on data collected for other purposes and published studies done in other states. As groundwater sustainability becomes more critical it is important to use more reliable and applicable data to make groundwater and land use decisions. Assessing the condition of shallow groundwater in each basin is the first step toward groundwater sustainability. Initially, a pilot basin will be assessed to determine the best way to do a groundwater assessment for each basin. An assessment of each of the 23 basins may include the following:

- Mining of data in existing databases to determine contaminants in the basin

- Evaluating potential contaminants present in the basin due to land use
- Determining water quality using a selection of wells (private, public, or monitoring wells) for major cations and anions and other contaminants of concern
- Modeling groundwater flow and surface water interactions
- Identifying fixed monitoring stations (surface water and groundwater) for water quality and quantity
- Evaluating water use
- Making the data and assessment public

Phase II: Baseline Assessment of Deep Aquifer Systems

The next step toward better management of Wisconsin's groundwater is evaluating the deeper aquifers. Because deeper aquifers are not impacted as quickly by land use and because deep groundwater divides usually differ from surface water divides, it is more appropriate to evaluate across basin lines by aquifer. An assessment of deeper aquifer systems will include the following:

- Mining of data in existing databases to determine contaminants in the aquifer
- Evaluating potential contaminants due to land use
- Evaluating pathways allowing contaminants to reach deeper aquifers
- Determining water quality using a selection of wells (private, public, or monitoring wells) for major cations and anions and other contaminants of concern
- Identifying fixed monitoring stations, including sentinel wells for water supply systems, for water quality and quantity
- Evaluating water use
- Delineating deep aquifer systems
- Making the data and assessment public

Phase III: Ambient monitoring network by basin and aquifer system

Wells useful for monitoring groundwater quality and quantity trends will be identified in phases 1 and 2. In phase 3 these wells will be sampled periodically for parameters specific to each basin or aquifer system. In addition, the wells will be available for use by other interested parties. Surface water monitoring stations will be monitored to determine trends reflected in groundwater/surface water interaction. Groundwater flow models will be updated as needed. Water use information will be a critical piece of information in determining water quantity trends. The data will be maintained by WDNR and made available to the public.

Phase IV: Long term sustainability of monitoring network

The monitoring strategy must be flexible enough to reflect changes in water use, land use, and identified emerging contaminants. It is important to maintain fixed monitoring locations and to re-assess baseline evaluations periodically (every 5-10 years). The wells will be used to perform more detailed monitoring studies and serve as a basis for developing educational resources and reports. The data will be maintained in an accessible database.

Prioritization

Available funding will not allow immediate implementation of all components of this strategy. Therefore a process for allocating funding towards key areas is necessary. A Groundwater Monitoring Workgroup composed of the Groundwater staff and representatives from USGS, WGNHS, DATCP and UW met in 2005 and 2006 and will meet at least once each year to set priorities for each fiscal year. These priorities will be used by the Bureau of Drinking Water and Groundwater to determine which elements of the strategy should be funded each year as funding is available.

Core and Supplemental Water Quality and Quantity Indicators

- Groundwater levels
- Stream baseflow
- Water usage
- Major anions and cations
- Nitrate
- Chloride
- Arsenic
- Radon
- Pesticides
- VOCs

Quality Assurance

See the description of WDNR's Quality Management Plan (QMP) under the *Quality Assurance* section of the *Monitoring Program Logistics* Chapter in this document. Also see the Bureau of Drinking Water & Groundwater Quality Assurance Project Plan (QAPP).

Data Management

The Groundwater Retrieval Network (GRN) reports data from public and private drinking water supply wells, non-point source priority watershed projects, special groundwater studies, and the Bureau of Waste's Groundwater and Environmental Monitoring System (GEMS) landfill monitoring wells. Data covers the period from the early 1970s to present for the Public Water Supply data, 1988 to present for the Private Water Supply, priority watershed and special study data, and from the mid-1970s to present for the GEMS database. Not all programs that currently generate groundwater-related data are linked into the GRN system. Data from the Bureau of Remediation and Redevelopment (LUST, spills, or remediation sites) as well as data from the Bureau of Watershed Management (wastewater treatment facilities and land spreading sites) is not currently retrievable through the GRN system. [http://prodoasext.dnr.wi.gov/inter1/grn\\$.startup](http://prodoasext.dnr.wi.gov/inter1/grn$.startup)

The Drinking Water System (DWS) is also used for groundwater quality analysis. Its purpose is to enforce Safe Drinking Water Act regulations covering public water systems and it was created and is maintained by the WDNR's Bureau of Drinking Water and Groundwater. It contains the monitoring and reporting requirements for each public water system and their drinking water sampling results. It also includes violations for any missing requirements and exceedances of the maximum contaminant levels (MCLs). This system is used to report public water supply data to USEPA as required by the Safe Drinking Water Act. The DWS also contains information on public and private well construction and high-capacity well approvals. A subset of data is available on the Internet for public access at <http://www.dnr.state.wi.us/org/water/dwg/DWS.htm>.

A "Directory of Groundwater Databases" was completed by the GCC in 1998. This publication will be updated. It will form the foundation of a meta-database available on the Internet. Metadata refers to any data used to aid the identification, description and location of networked electronic resources. As the other components of the strategy are implemented, existing and new databases related to groundwater monitoring will be added to the meta-database.

One half of an FTE will collect and maintain the metadata base and be responsible for adding new databases as necessary. The Monitoring and Data Management subcommittee of the GCC will determine the minimum data elements and insure that data sharing occurs. The group recommends that the use of Wisconsin Unique Well Numbers be used as a means of tracking individual well data. The data will be available through a common portal, possibly located on the GCC website.

This component meets goals 1 and 2 by providing a mechanism for data sharing between agencies for groundwater characterizations and goal 3 by providing data to the public on groundwater in the state. We suggest that 0.5 FTE be funded within WDNR to create and maintain the meta-database.

Data Analysis/Assessment

A comprehensive look at existing data for parameters of concern is a starting point for implementing each phase of the groundwater monitoring strategy. Existing databases (Groundwater Retrieval Network, DATCP, Wisconsin Groundwater Center and others) can be mined for parameters such as major anions and

cations, nitrate, chloride, arsenic and radon. Public, private and monitoring well data and their databases will be assessed. This component could be done with the assistance of partners who currently maintain existing databases. The GCC joint solicitation is a possible funding source.

This component meets goals 1 and 2 by providing baseline data for groundwater trend analysis and system research. We suggest funding a 0.5 FTE for the initial assessment and subsequent data mining.

Reporting

Data and maps generated from monitoring data should be accessible. The Education Subcommittee of the GCC will determine how materials will be made available to all agencies and the public, and will act as a clearinghouse for educational materials posted on the GCC website. Creation and maintenance of maps and monitoring reports will require 0.5 FTE.

Programmatic Evaluation

The groundwater monitoring strategy was designed to be flexible. Wells sampled and what samples are analyzed for will change with changing priorities. The strategy allows for sampling of newly identified contaminants; abandonment, rehabilitation and installation of new monitoring wells if needed; and sampling of private wells for contaminants that state agencies are concerned about in a specific location. The data collected will be used to evaluate how well groundwater protection programs administered by different agencies are working. The data collected by the various agencies will be shared to make the most of funding available for groundwater monitoring.

General Support and Infrastructure Planning

The estimated cost for the new groundwater monitoring strategy is summarized in Table 12.

Various groundwater monitoring programs are currently supported by state and federal agencies (see the Non-DNR Monitoring Programs section later in this document). Some of this data are suitable for inclusion in a common meta-database. An example would be DOT salt monitoring along highways. County health departments also currently sample private wells and that data may be included if appropriate. University research projects will be funded by grants with data made accessible through the GCC website.

Funding for the fixed networks would logically come from the programs they benefit. For example, federal Clean Water Act (106) and Nonpoint Source (319) grant money is allocated for monitoring. Fees collected, as part of the new Groundwater Quantity legislation will support money for water use data collection. Money allocated to the Groundwater Fund of the Environmental Fund will help fund some of the stratified random sampling programs as will money allocated to DATCP for pesticide monitoring. Safe Drinking Water funds could possibly be used to look at water quality and quantity trends at fixed stations placed to determine impacts to municipal wells. New funding sources may have to be found for the data mining, database development and maintenance and educational materials components.

Potential Partners

Potential partners include federal, state, and local governments, universities and other entities involved in groundwater management and research. In addition, volunteers (citizens, schools and others) will have opportunities for monitoring groundwater. Universities, high schools and private individuals might collect well samples. The WGNHS or USGS would provide well installation and training. This type of monitoring has been used in other states and meets both fixed monitoring and educational objectives.

Table 12. Estimated cost of Groundwater Monitoring Strategy components.

Components	One Time Cost	Yearly Cost
Water Level Monitoring	\$600,000	\$120,000
Water Quality Monitoring (public, private and monitoring wells)		\$180,000
Medium-Sized Stream Flow Monitoring	\$250,000 (approximate - number of monitoring stations to be determined)*	
Small-Sized Stream Flow Monitoring		\$70,000
Modeling groundwater flow and surface water interactions		\$90,000**
Data Management and Communication		0.5 FTE=\$32,500
Data Analysis/Assessment		0.5 FTE=\$32,000
Reporting		0.5 FTE=\$32,500
Total	\$850,000+	\$487,500+

*The cost of adding one surface water-monitoring station to the existing network is approximately \$10,000.00 per station.

**This is based on a proposed cost of \$90,000 for a 2-year project to model the Rock (Upper and Lower) Basin and assumes projects in two basins would be running concurrently. Project basins would be selected based on hydrogeologic and groundwater use factors. Not all basins would necessarily be modeled. It would take 5-10 years for coverage of all appropriate areas of the State.

References

Components of a Groundwater Monitoring Strategy for the State of Wisconsin. Wisconsin Department of Natural Resources. October 2004.