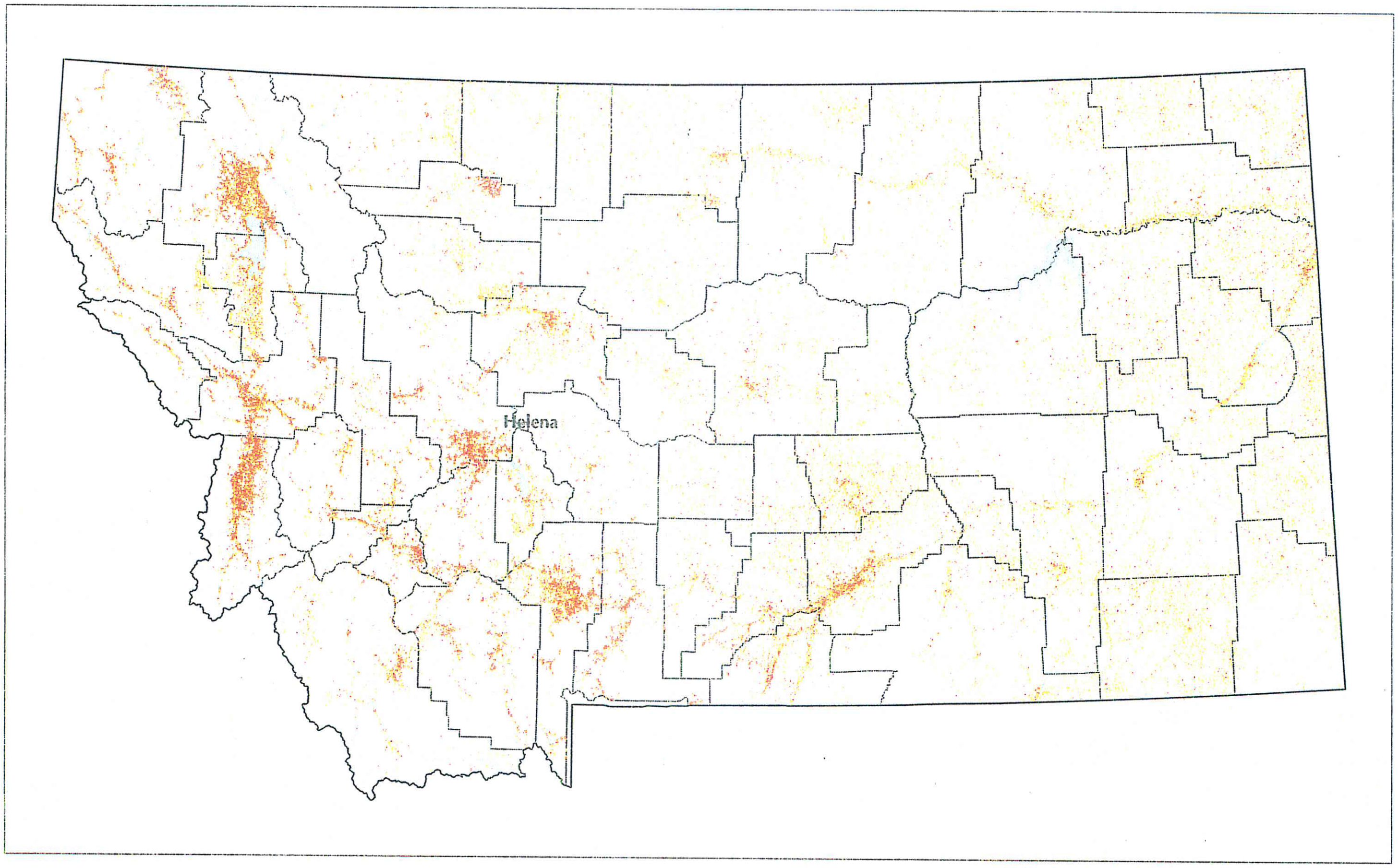
Montana Bureau of Mines and Geology



Well locations in Montana

Activities of the Montana Groundwater Assessment Program

State of Montana
Marc Racicot, *Governor*

Montana Tech of The University of Montana
Lindsay D. Norman, *Chancellor*

Montana Bureau of Mines and Geology
John C. Steinmetz, *Director and State Geologist*
Marvin R. Miller, *Assistant Director*

First Printing, 1997

Printed by The University of Montana Printing Services, Missoula, January 1997

Montana Bureau of Mines and Geology
Groundwater Assessment Open-File Report 3

Activities of the Montana Groundwater Assessment Program

Assessment Program Staff
Tom Patton
Dennis McKenna
Larry Smith
John LaFave
Luke Buckley

Contents

January 1997

The Legislative Response to Groundwater Information Needs

In response to concerns about groundwater quality management in Montana, the 1989 Legislature authorized the Environmental Quality Council to evaluate the state's groundwater programs. The EQC task force identified insufficient data and lack of a systematic data-collection effort as major problems in managing groundwater. The task force recommended long-term monitoring, systematic characterization of groundwater resources, and a computerized data base. Following these recommendations, the 1991 Legislature passed the Montana Groundwater Assessment Act (85-2-901 et seq., MCA) to improve the quality of groundwater management, protection, and development decisions within the public and private sectors. The Act established three programs at the Montana Bureau of Mines and Geology to address groundwater information needs in Montana:

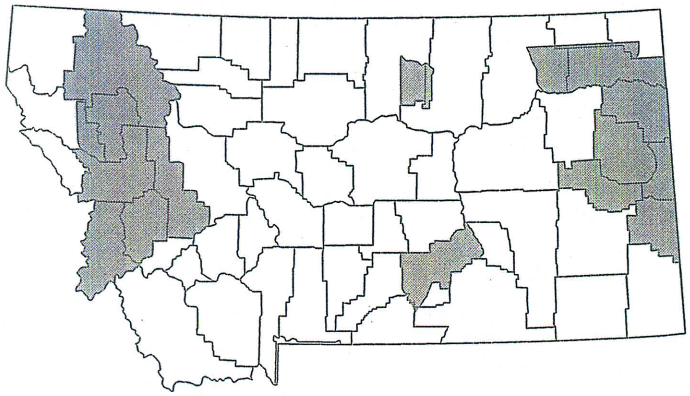
- the **groundwater monitoring program**, which provides long-term records of water quality and water levels for the state's major aquifers
- the **groundwater characterization program**, which maps the distribution and documents the water quality and water-yielding properties of individual aquifers in specific areas of the state
- the **groundwater information center (GWIC)**, which provides readily accessible information about groundwater to land users, well drillers, and local, state, and federal agencies

Coordination and Cooperation are Critical

The Montana Groundwater Assessment Steering Committee oversees implementation of the Assessment Program. The Steering Committee includes representatives from water agencies in state and federal government, as well as local governments and water user groups. The committee also coordinates groundwater management, protection, development, and research functions among units of state, federal, and local government.

Cooperation with many local groups, such as conservation districts and water-quality districts, and Tribal governments has greatly enhanced the efficiency of the Assessment Programs and their responsiveness to local needs and concerns. For example, the characterization program has had cooperative agreements with the conservation districts in Dawson, Fallon, and Richland counties and with the Confederated Salish and Kootenai tribes. The monitoring program is working cooperatively with the water-quality districts in Lewis and Clark and Missoula counties and with the Fort Belknap and Fort Peck Tribes. As the programs proceed into other areas of the state, more cooperative agreements will be developed.

The Groundwater Information Center (GWIC) is becoming increasingly recognized as the best source for groundwater information in Montana. The value of GWIC is measured not only by the number of users, but also by the number of agencies, such as the Departments of Natural Resources and Conservation (DNRC), the U.S. Geological Survey, and the Confederated Salish and Kootenai tribes, which share groundwater data with the center.



Shaded areas denote counties and Indian reservations where assessment programs are cooperating with local groups.

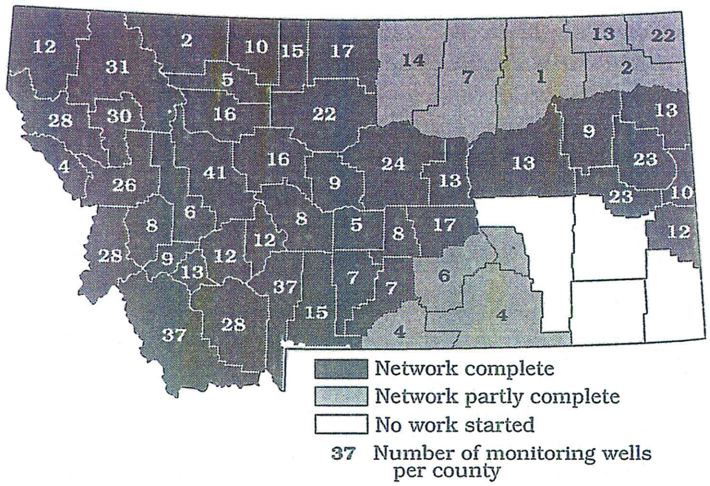
In the future, the Assessment Programs will provide increasing amounts of reliable and readily accessible information about groundwater resources for large areas of the state. Each year, the characterization program will publish a groundwater atlas containing detailed information about specific areas. Each year, the monitoring program will continue to acquire data on trends in water levels and water quality for the state's major aquifers. Each year, landowners and agencies will be able to make better decisions on how to protect, manage, and develop groundwater resources.

Groundwater Monitoring Program

Long-Term records are Important

The Groundwater Monitoring Program provides long-term water-quality and static-water level data at selected locations across the state. Water-quality and static-water level data are similar to climatic data in that measurements over a period of years are necessary to determine if background conditions have changed or if changes are due to short-term fluctuations. For example, decisions regarding the severity of drought are not made by comparing present conditions to a single year's precipitation measurement, but to precipitation data collected over a long period of time. Questions about water-level response to climatic conditions, nearby development, or ditch losses also cannot be answered without collecting long-term data. Often periods of static-water level record exceeding 30 years are necessary to evaluate groundwater response. The Monitoring Program provides the following:

- long-term records of groundwater quality through collection of about 70 water samples annually
- long-term records of water levels in wells through quarterly measurements in at least 730 wells and operation of about 70 continuous water-level recorders



Monitoring network status—November 1996

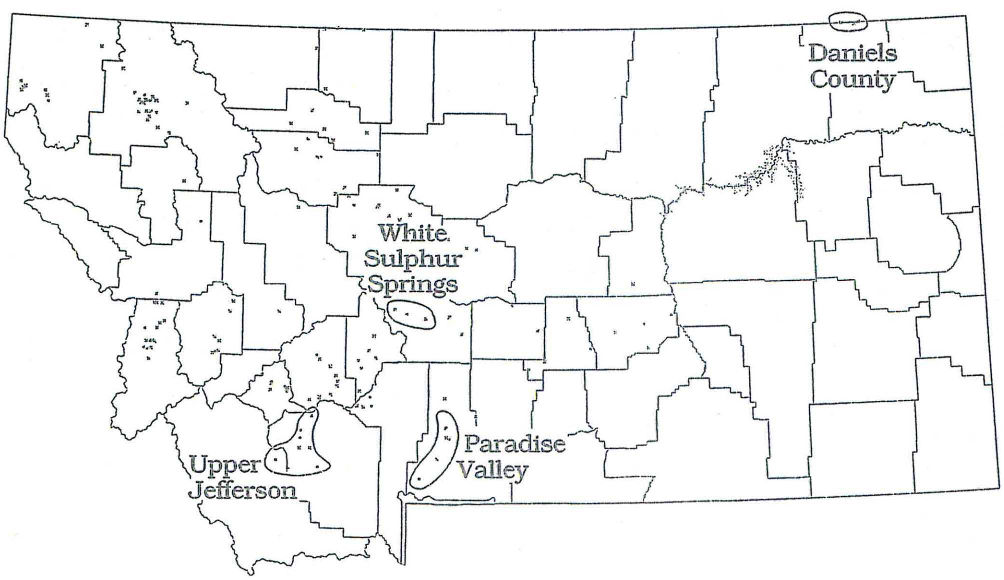
Monitoring Network nearing Completion

The monitoring network is approximately 80% complete. The monitoring network status map shows the number of wells and the level of network completeness in each county. Only existing wells have been used in the network and no new wells have been drilled by the program. Most of the network consists of privately owned wells and permission has been granted by their owners to gather data. The distribution of network wells is shown on page 5; included are hydrographs from selected wells.

In November 1996 there were 744 wells in the network. Although the Groundwater Assessment Steering Committee's initial plan called for about 730 wells, there now will be between 850 and 950 wells in the final network. Wells selected near each other and cooperative efforts have allowed inclusion of more wells than anticipated. For example, wells located near each other but completed in different aquifers can be measured during a single trip. The total also is increased by groups that monitor groundwater such as the Confederated Salish and Kootenai tribes who have allowed static-water level data from their monitoring networks to be included.

Building a Water-quality Record

Water-quality sampling in the Monitoring Program is designed to obtain initial water-quality data in areas that have no water-quality information, and to build a water-quality record in areas where there has been previous sampling. More than 200 water samples, including those taken for quality assurance and control, have been collected at 156 sites since July 1, 1992. The locations of the sampled wells are shown on the water-quality sampling site map. Initial samples were collected in areas such as the Paradise valley in Park County, the White Sulphur Springs valley in Meagher County, and the upper Jefferson River valley. About 30% of the samples were taken from previously sampled wells in other areas so that any changes in water quality could be observed. Each of these wells had been sampled more than five years ago.



Water-quality sampling sites

A cluster of wells in northern Daniels County has been sampled each year since July 1992. The sampling constitutes part of Montana's obligations under the International Joint Agreement with the government of Saskatchewan regarding coal-mine dewatering, power generation, and other operations at Coronach, Saskatchewan.

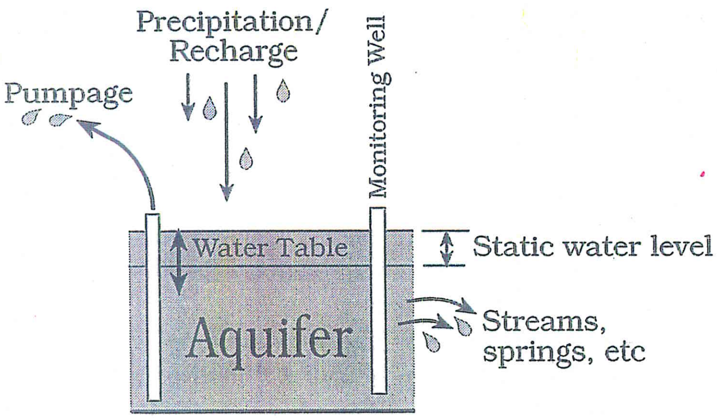
Static-water Levels Show Changes in Aquifer Storage

The static water level is the distance from the land surface to the water in a well casing when the well is not being pumped. Measurement of static-water levels in wells at different times documents change in aquifer storage near a well. The idea is illustrated in the water levels and aquifer storage sketch. In the sketch, the line marked by the double-headed arrow moves upward when aquifer storage increases, and downward when storage decreases. Water levels rise when aquifer recharge exceeds discharge and the volume of water stored in the aquifer increases. Water levels fall when discharge exceeds recharge.

Aquifers Respond to Different Conditions

The static water–level monitoring program has attempted to incorporate wells with pre-existing water-level data into the network. In using these records the long-term value of pre-existing data is enhanced, as is the value of new measurements. However, only about 40% (300 of 744) of the network wells have periods of record longer than five years. The hydrographs on the facing page illustrate how linkage of long-term water-level data with climatic, irrigation development, ditch loss, intensive development, and land use information can help interpret changes in aquifer storage. Interpretations of long-term water-level data decrease chances that poor management decisions might be made in response to specific questions about groundwater quantity.

The **Kalispell valley** hydrograph shows the perspective that can be gained from a long-term water-level record. Water levels from 1963 to about 1973 showed little upward or downward trend. In 1973 water levels began declining reaching a low point in about 1990. Since 1991 the trend has been generally upward. Previous interpretations of this record attributed the water-level decline to rapid development of the aquifer beginning in about 1973. Since 1973 more than 230 wells have been installed within two miles of the monitoring well. The upward trend since 1991 indicates that the decline may have been caused by other influences, such as climatic conditions.



Water levels and aquifer storage

The **Turner-Hogeland** hydrograph is interpreted as showing responses to climatic conditions. The upper line on the graph shows water levels in the well and the lower line precipitation at Turner, Montana. The water-level rise in 1986–1987 was in response to wet conditions in 1986. Precipitation declined to normal levels in 1988 and water levels (aquifer storage) decreased accordingly. The annual fluctuations are caused by irrigation wells about one mile away.

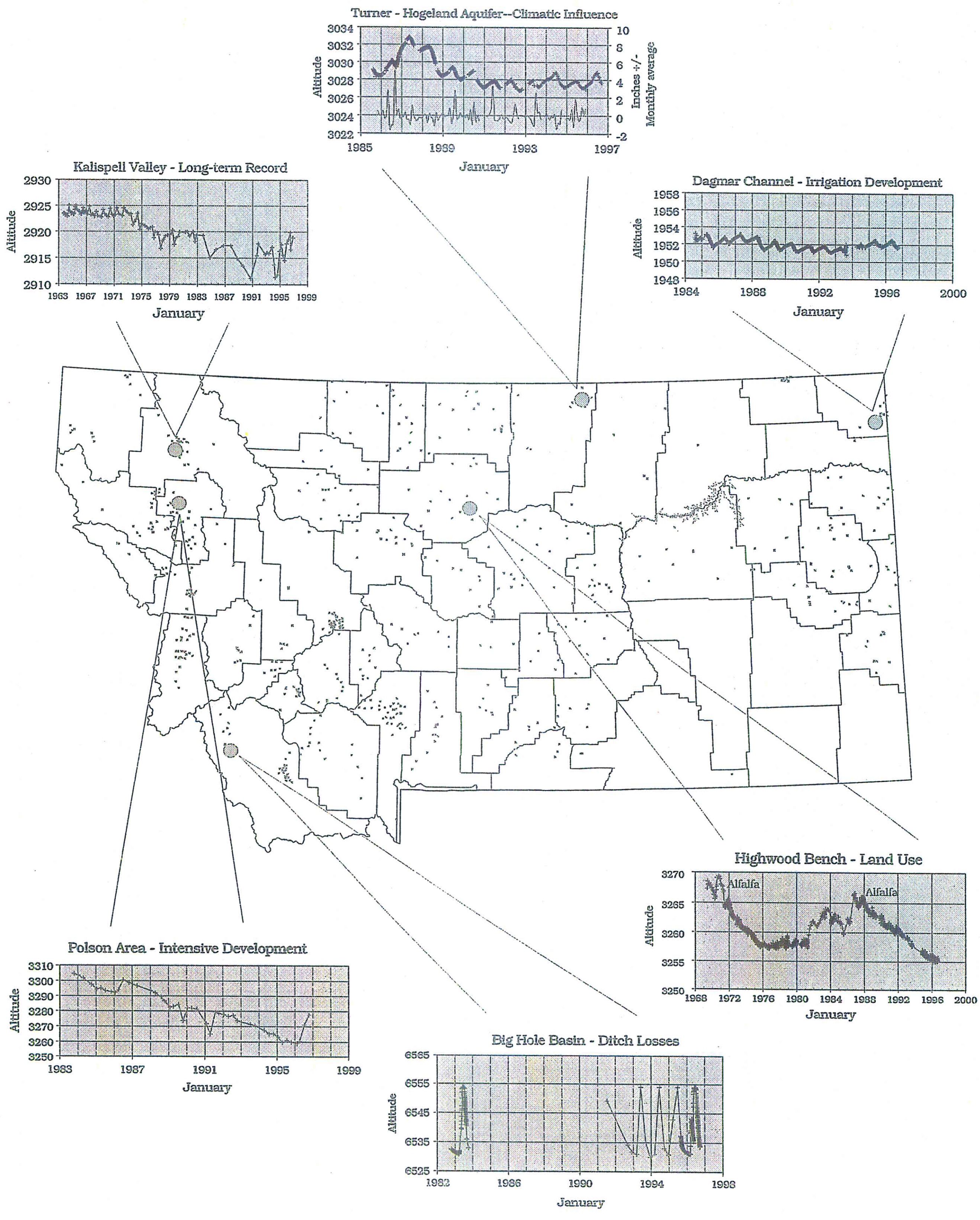
Water-level fluctuations on the **Dagmar Channel** hydrograph are interpreted as response to irrigation-well withdrawals in the Clear Lake aquifer in Sheridan County.

The **Bighole basin** hydrograph is from a well located about 20 feet from a leaky irrigation ditch. Within hours after water is put in the ditch each spring, water levels in the well begin rising (storage increases). When the ditch is shut off, groundwater levels fall to lower levels over periods of weeks to months.

The **Polson area** hydrograph shows impacts from intensive groundwater usage from an aquifer northwest of Polson. Water levels have dropped about 50 feet since 1983 but rose sharply in 1996; the cause and duration of the recent rise are unknown. The measurements are courtesy of the Confederated Salish and Kootenai tribes.

The **Highwood Bench** hydrograph shows the responses of shallow groundwater to land use. When the land was farmed using the crop-fallow system, water levels rose. However, when deeply rooted alfalfa was planted in 1971 and again in 1987, water levels fell.

Monitoring Well Locations and Selected Hydrographs



Monitoring well locations and selected hydrographs–November 1992

The Groundwater Characterization Program

Protect, Manage, and Develop Groundwater Resources

The Montana Groundwater Characterization Program is mapping the distribution and documenting the water quality and physical properties of the state's aquifers. The primary purpose of the program is to provide information to help the public and private sectors make decisions on how to protect, manage, and develop groundwater resources. Staff of the Montana Bureau of Mines and Geology work closely with representatives of local governments, agricultural and conservation groups, and planning and economic development agencies to identify important local issues related to ground water. The results of each characterization study will help answer questions, such as the following:

- If I drill a new well, how deep will I have to go? Will the water be suitable for drinking?
- Is there any chance of using groundwater as a new public water supply?
- Where is the best place to look for a landfill site?

Map and Evaluate Groundwater

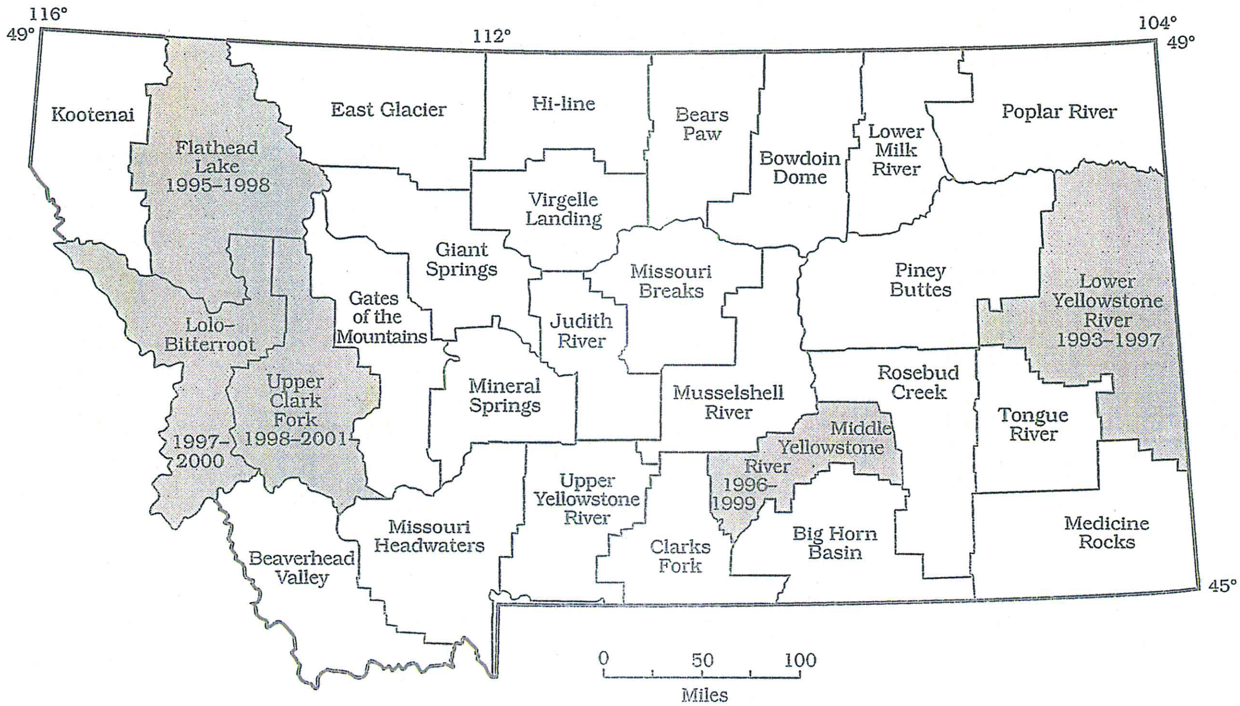
Bureau scientists, in cooperation with local, state, and federal agencies, are characterizing individual aquifers in 28 areas—one to five counties in size. Each investigation will take three years to complete. The Groundwater Assessment Steering Committee has developed a list of priority study areas based on various measures of groundwater use and vulnerability. But in selecting areas for study, the Committee also considers the level of local interest and whether other groundwater studies are ongoing in the area.

In each area Bureau scientists compile information on the geology and groundwater resources. By reviewing all available drillers' logs, they can more accurately map the geology and determine the number of wells withdrawing water from each aquifer. Technicians then visit hundreds of wells to measure water levels and basic water-quality parameters to accurately determine the distribution and properties of the aquifers. Staff also collect and analyze water samples to evaluate water quality and to better understand groundwater flow systems.

Much Field Work Completed

Currently, characterization studies are ongoing in the Lower Yellowstone River area in eastern Montana, the Flathead Lake area, and the Middle Yellowstone River area. In the **Lower Yellowstone River** area, program staff

- determined the source aquifer for 8,532 wells;
- prepared maps showing the location, depth, and thickness of the area's four principal aquifers;



Characterization studies are ongoing in the Lower Yellowstone River area, the Flathead Lake area, and the Middle Yellowstone River area. The Lolo-Bitterroot and Upper Clark Fork studies will begin in the next biennium.

- visited 1,471 wells to measure water levels and basic water-quality parameters;
- analyzed and evaluated 188 water-quality samples; and
- prepared maps showing the potentiometric surface and groundwater flow directions in the aquifers.

In the **Flathead Lake** area, staff

- determined the source aquifer for 14,036 wells;
- began preparation of maps showing the location, depth, and thickness of the principal aquifers;
- visited 954 wells to measure water levels and basic water-quality parameters; and
- collected and analyzed 193 water-quality samples.

The **Middle Yellowstone River** area study began in fall 1996. Program staff are

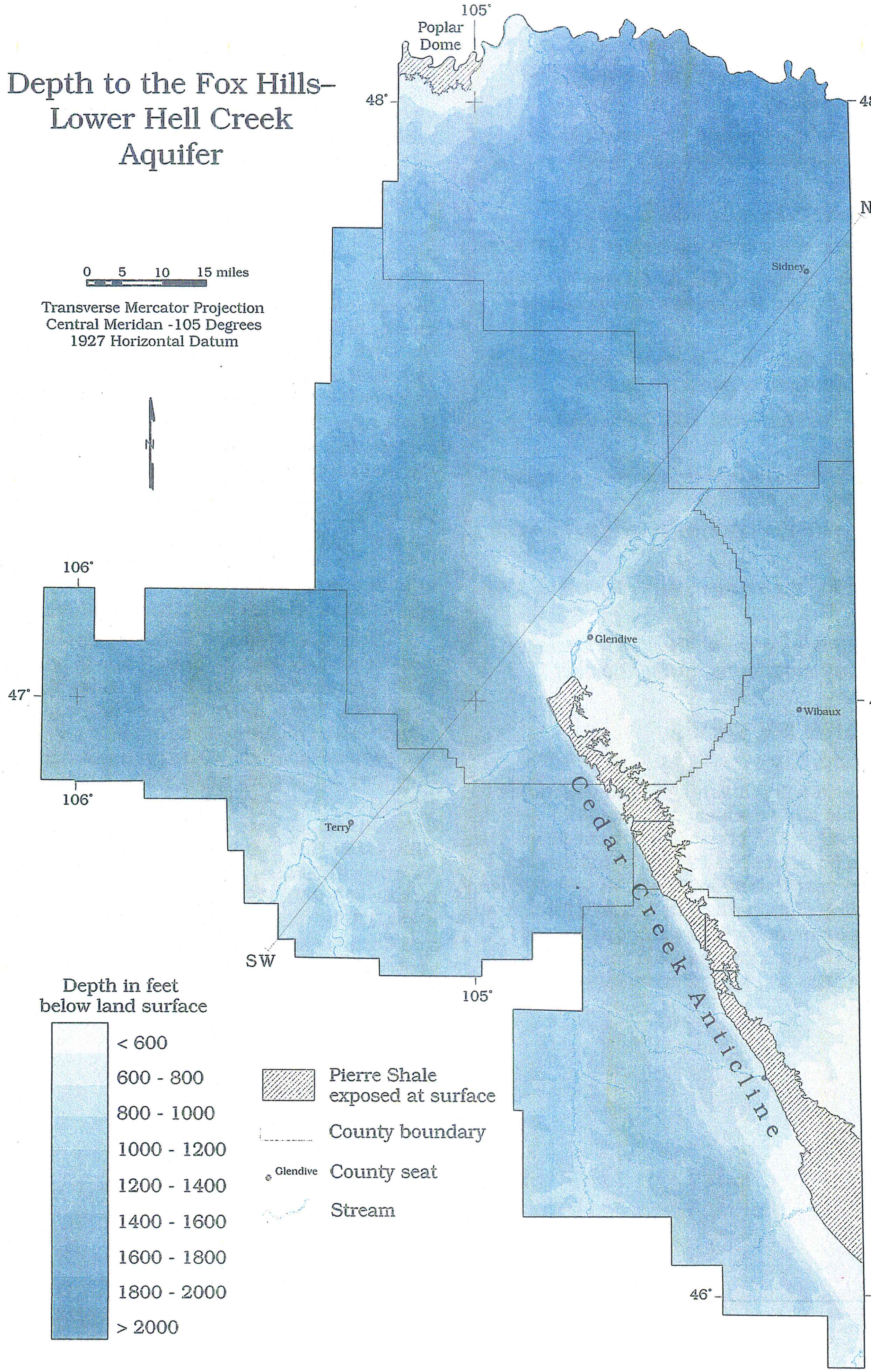
- meeting with local groups to identify important local issues;
- determining the source aquifer for about 8,000 wells; and
- establishing a network of wells for intensive water-level monitoring during the next 18 months.

Assess Availability, Quality, and Vulnerability

The bureau will publish a groundwater atlas for each area that will be widely distributed to agencies and landowners. The Lower Yellowstone River Area atlas will be completed in 1997 and successive atlases each year thereafter. The atlas will discuss the availability of groundwater, the potential for further development, overall water quality, and interactions between groundwater and surface water. Each atlas will also address issues related to groundwater management, protection, and development. The most important product of each study will be a series of maps showing the location, depth, and thickness of aquifers, groundwater flow directions, the principal recharge areas, and the relative vulnerability of aquifers to contamination. The aquifer vulnerability map will be important not only for use in identifying areas where groundwater is at risk but also for identifying areas where the potential for contamination of groundwater resources is low.

One of the mandates of the Groundwater Assessment Act is to assess the hydrogeology and quality of *individual aquifers in specific areas within the state.* The following pages are an example of an assessment of an individual aquifer—the Fox Hills–lower Hell Creek aquifer in the Lower Yellowstone River area. This aquifer, which underlies most of eastern Montana and parts of adjoining states, is the most reliable source of water in the study area. Although currently only about 12% of the wells in the five counties use the aquifer, it is used extensively in several areas. Whether the aquifer is being overused was one of the questions raised by local organizations in the study area and was a special focus of the characterization study.

The maps presented in this example are similar in scale and content to those that will be included in the groundwater atlas for the Lower Yellowstone River area. The primary purpose of the atlas is to help decision makers—local officials and landowners—to understand groundwater so that they may better manage, develop, and protect the resource. In order to help groundwater users make decisions about specific areas, the maps of the Fox Hills–lower Hell Creek aquifer and those prepared for other individual aquifers also will be released at a scale of 1:250,000 (1 in. = about 4 mi). These maps will be made available to local organizations and libraries and also will be available as geographic information system (GIS) coverages from the Bureau of Mines and Geology and the Natural Resources Information System (NRIS) at the Montana State Library.


Depth to the Fox Hills–Lower Hell Creek Aquifer
0 5 10 15 miles
Transverse Mercator Projection
Central Meridan -105 Degrees
1927 Horizontal Datum
N
Poplar Dome
105°
48°
48°
NE
Sidney
106°
47°
106°
Glendive
Wibaux
47°
Terry
Cedar Creek Anticline
SW
105°
46°
46°
Depth in feet below land surface
< 600
600 - 800
800 - 1000
1000 - 1200
1200 - 1400
1400 - 1600
1600 - 1800
1800 - 2000
> 2000
Pierre Shale exposed at surface
County boundary
Glendive County seat
Stream

Fox Hills–lower Hell Creek Aquifer: The Deepest and Most Extensive Aquifer in Eastern Montana

The term, Fox Hills–lower Hell Creek aquifer, refers to a body of rock composed predominantly of sandstone (aquifer material) and minor mudstone (non-aquifer material) in the lower part of the Hell Creek Formation and most of the Fox Hills Sandstone (see cross section). The aquifer ranges from 125 to 400 feet thick, where it is not eroded. Significant quantities of water can be produced from wells in the aquifer throughout the area, except near the Cedar Creek anticline and Poplar dome where it is thin (see map and cross section). The aquifer is underlain by the Pierre Shale, which is 2,000 feet thick and nearly impermeable to water. The Fox Hills–lower Hell Creek aquifer is the deepest usable aquifer in the area.

The Aquifer is Deeply Buried in the Area

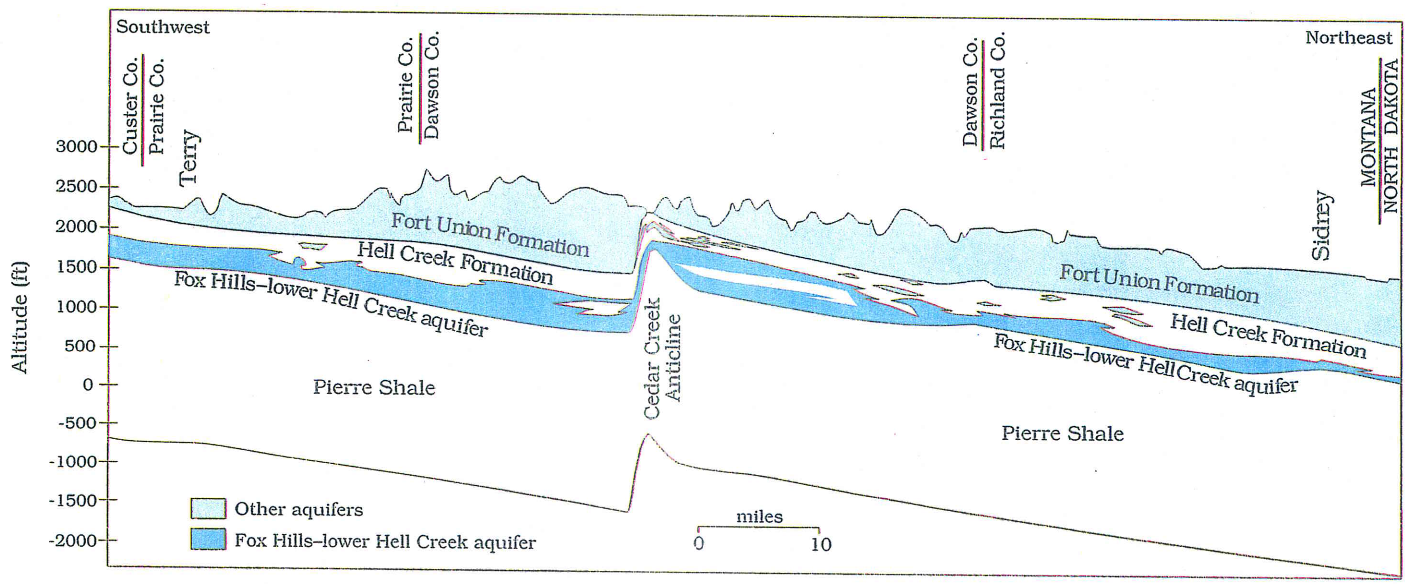
The depth to Fox Hills–lower Hell Creek aquifer map shows the depth to the top of the aquifer below the land surface. The aquifer is as much as 2,000 feet below land surface in central Dawson and northern Prairie counties. The cross section shows the aquifers and geologic units in a profile view from southwest (near Terry) to northeast (near Sidney). Regional tilting and folding of the rock units, erosion of the land surface, and changes in thickness of the aquifer cause the aquifer to be at different elevations across the region.

Most water wells are completed in the aquifer where it is within 1,000 feet of the surface. Because a sufficient quantity of water can usually be produced from wells that penetrate only a small part of the aquifer, most wells are drilled through less than 40% of its thickness.

Data Availability Affects Map Aaccuracy

The map was constructed by subtracting the elevation of the top of the aquifer from the ground-surface elevation. The elevation of the Fox Hills–lower Hell Creek aquifer was mapped using information from 488 wells drilled for oil, natural gas, and water. Data used to construct this map and a more detailed version of it will be published as a Groundwater Assessment Program open-file report by the Montana Bureau of Mines and Geology.

Map accuracy is affected by data availability, difficulties in correlating logs between widely spaced wells, and locational accuracy. Wells are distributed unevenly across the area. Thus, accuracy is variable across the map. Correlation errors and inconsistencies in interpreting well logs could produce discrepancies of 50 to 150 feet in where the top of the aquifer is picked from logs of neighboring wells. Well-location accuracy is typically within a quarter mile. Contouring may locally introduce depth errors of about 50–100 feet. Any error in depth on the map is estimated at less than 200 feet.



Cross section of aquifers and geologic units from near Terry to near Sidney.

The Groundwater is Confined and Under Pressure

Across most of the Lower Yellowstone River area the Fox Hills–lower Hell Creek is a confined aquifer. As shown on the previous cross section, the aquifer is composed of permeable sandstone sandwiched between low permeability shale and mudstone. Water flows relatively easily through the sandstone, but cannot easily move through the shale or mudstone. Thus, these units "confine" the water in the permeable sandstone. The sandstone that forms the Fox Hills–lower Hell Creek aquifer is completely saturated and the water is under "artesian pressure." Typically the water level in wells completed in the aquifer will rise above the top of the aquifer due to the artesian pressure, and in many low areas—such as the Yellowstone River valley—flowing wells are common.

The Groundwater Moves Slowly

Groundwater in the Fox Hills–lower Hell Creek aquifer moves from recharge areas to discharge areas at a rate of about six feet per year. A recharge area is that land-surface area where rain, snow, and stream runoff seep into the soil and replenish the underlying aquifer.

For the Fox Hills–lower Hell Creek aquifer most recharge occurs where the permeable sandstone is exposed at or near the land surface (see insert map at right). Recharge also occurs by slow leakage through the confining units from overlying aquifers. Leakage happens where the water pressure in the overlying aquifer is greater than the water pressure in the Fox Hills–lower Hell Creek aquifer.

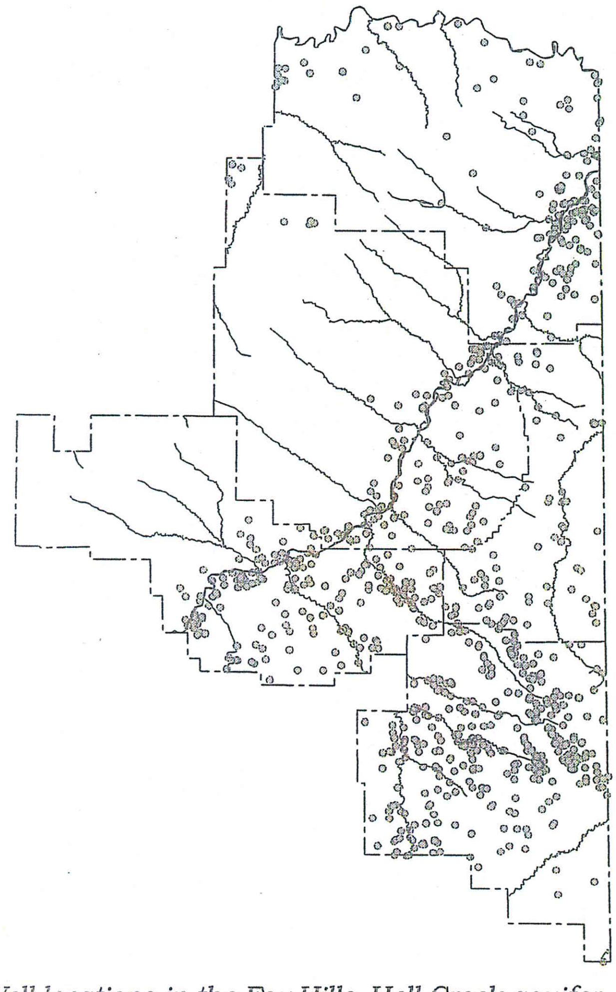
Discharge areas are places where groundwater in the aquifer is released to surface water, such as the Yellowstone River, or to overlying aquifers. Groundwater is also discharged from the aquifer by wells. Due to the slow rate of groundwater movement it can take tens of thousands of years for groundwater to travel from recharge to discharge areas.

Mapping the Groundwater Flow

The potentiometric surface is the elevation to which water will rise in wells penetrating an aquifer. The map of potentiometric surface (opposite page) is a graphical representation of groundwater levels in the Fox Hills–lower Hell Creek aquifer, and was prepared using groundwater elevations measured during the Groundwater Characterization Study in the Lower Yellowstone River area. Because groundwater flows from higher elevations to lower elevations, the map provides a general indication of groundwater flow directions, indicated by the arrows, and provides a basis for identifying the recharge and discharge areas. The insert map shows areas where the aquifer is at or near the land surface. These are the principal recharge areas for the aquifer. Most of the recharge areas are outside of the Lower Yellowstone River area.

In general, groundwater flows away from the recharge areas and toward the discharge areas. Across most of the study area groundwater in the Fox Hills–lower Hell Creek aquifer is flowing toward the Yellowstone River. The convergence of flow along the river indicates that groundwater discharges from the aquifer to the river.

Pumpage from wells in the river valley has accentuated the convergence of flow along the river by lowering water levels in the aquifer. The closed 2,100-foot contour near Glendive represents a pressure depression (lowering of the potentiometric surface) because of groundwater withdrawals in that area.

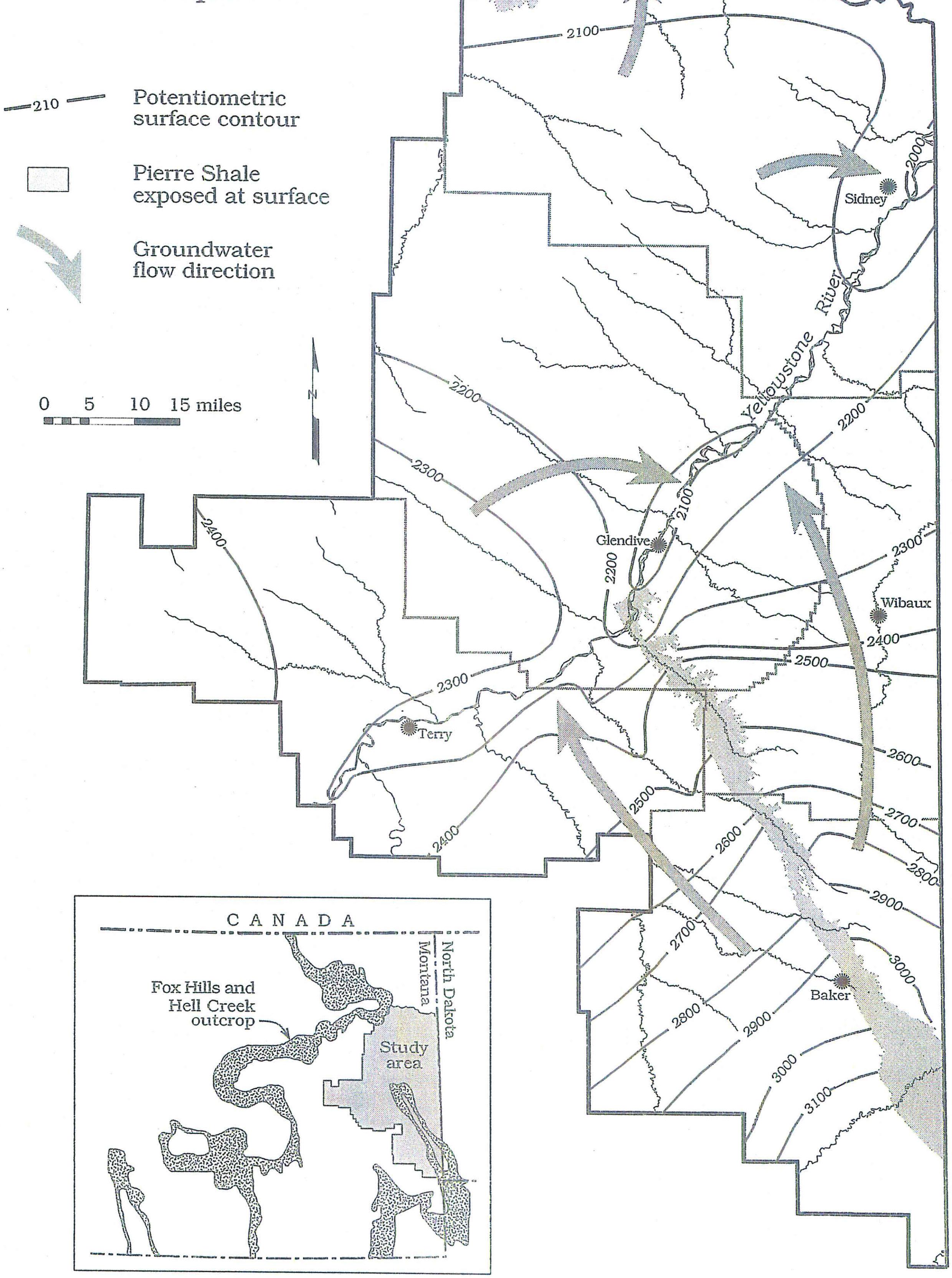


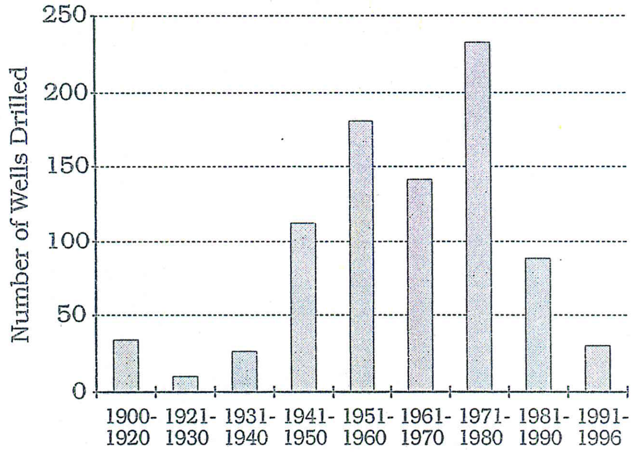
Well locations in the Fox Hills–Hell Creek aquifer.

The Water is Used for Domestic, Stock, and Municipal Purposes

Groundwater from the Fox Hills–lower Hell Creek aquifer is used primarily for domestic purposes, and stock watering. However, the cities of Baker, Lambert, and Richey also rely on it for municipal water supply. In the Lower Yellowstone

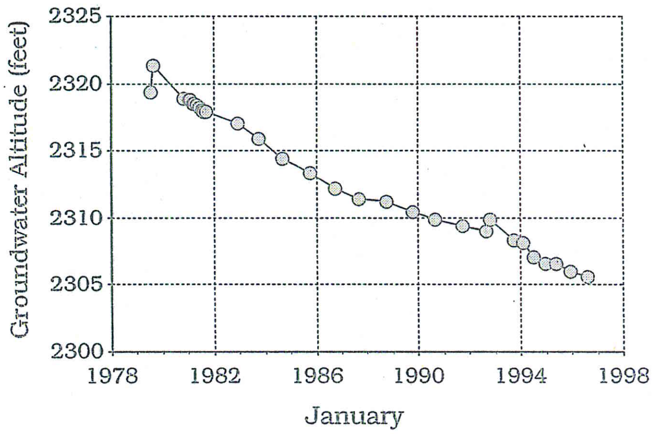
Potentiometric Surface Map Fox Hills–Lower Hell Creek Aquifer





Wells completed in the Fox Hills–lower Hell Creek aquifer.

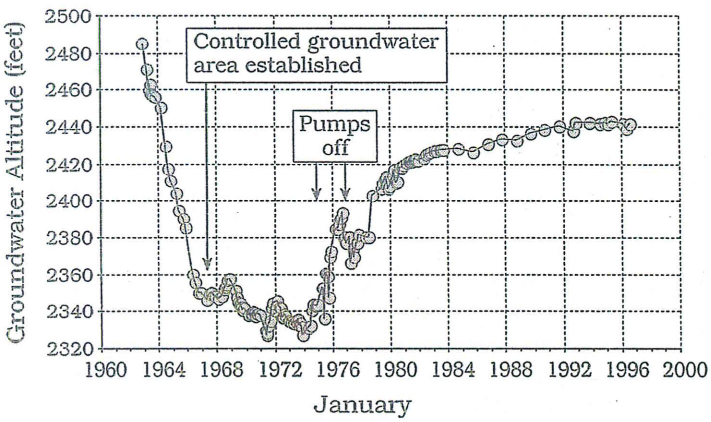
River Area there are about 1,000 wells completed in the aquifer; most are in the Yellowstone River valley or south of the river. There are fewer wells north of the Yellowstone River because the aquifer is typically more than 1,000 feet below land surface, and water levels are lower; thus well installation and pumping costs are higher. Wells in the Fox Hills–lower Hell Creek aquifer average a yield of about 20 gallons per minute (gpm). Although the development rate of the aquifer has slowed, water levels are declining in some areas. The hydrograph from an observation well near Terry shows declining water levels there—about 15 feet during the last 17 years. Long-term declines occur when more water is removed from the aquifer than is recharged. At some point these declines can create undesirable effects such as increased lift costs, decreased yields, and flowing wells ceasing to flow.



Water level decline north of Terry.

The Effects of Overuse

A dramatic example of the effects from over pumping an aquifer occurred in the Fox Hills–lower Hell Creek aquifer and resulted in the first controlled groundwater area in Montana. In the early 1960s at the South Pine oil field, between Glendive and Baker, a group of wells was used to pump groundwater from the aquifer at a combined rate of about 450 gpm for secondary oil recovery operations. The large groundwater withdrawals resulted in water-level declines that affected many surrounding stock and domestic wells. In response to landowner complaints, the South Pine Controlled Groundwater Area was created in 1967 to limit the pumping from the aquifer and, hopefully, slow the rate of water-level decline. Between 1975 and 1977 the industrial wells used for the oil recovery operations were phased out of production, and water levels in the aquifer began to recover.



South Pine controlled groundwater area water levels.

The hydrograph from an observation well in the controlled groundwater area tells the story. Between 1962 and 1967 pumping caused the water level in the well to drop more than 130 feet. After the controlled groundwater area was established, the industrial pumping was reduced and the rate of water-level decline slowed considerably. Between 1967 and 1974 the water level dropped only 20 feet. After the industrial wells were shut down the water level in the observation well rose about 110 feet. However, the water level is still about 40 feet lower than the 1962 level, probably because of the same overdrafts that created the declines observed near Terry.

The Water Quality is Suitable for Domestic and Stock Uses

Water from the Fox Hills–lower Hell Creek aquifer is suitable for most domestic and stock uses. In the Lower Yellowstone River area, the total dissolved solids (TDS) content (concentration of minerals dissolved in water) of groundwater in the aquifer is generally between 750 and 1,500 milligrams per liter (mg/L). Although these concentrations exceed the federal aesthetic drinking water standard for TDS of 500 mg/L, water generally does not become too salty to drink until TDS concentrations reach about 2,000 mg/L. Animals can tolerate even higher concentrations than humans. TDS concentrations less than 3,000 mg/L are suitable for most livestock.

The chemical composition of groundwater in the aquifer is remarkably consistent. Typically, sodium and bicarbonate account for more than 75% of the ions dissolved in the water, making the water soft and alkaline. The water is unsuitable for irrigation purposes due to the high sodium content. In places, fluoride is present in the water at concentrations slightly above the federal health standard of 4 mg/L. Fluoride concentrations were measured in 31 wells as part of the groundwater characterization study. Concentrations ranged from less than 1 mg/L to 5 mg/L, only two samples had concentrations above 4 mg/L. Although small amounts of fluoride (less than 2.5 mg/L) in drinking water are desirable for the prevention of tooth decay, chronic exposure to elevated concentrations (more than 4.0 mg/L) may cause mottling of tooth enamel or skeletal damage.

Summary

The Fox Hills–lower Hell Creek aquifer is an important resource for eastern Montana. It provides reliable quantities of water of acceptable quality for most domestic and stock needs. North of the Yellowstone River the aquifer is relatively untapped due to the excessive depth (generally greater than 1,000 feet below land surface), but it may be a reliable source of water in this area. Where the aquifer is used, along and south of the Yellowstone River valley, it is threatened from overdraft. Long-term declines in water levels suggest that more water is being removed from the aquifer than is being recharged—a harbinger of future problems. This situation is aggravated by unrestricted discharge from flowing artesian wells, a process that bleeds pressure from the aquifer and results in lowered water levels. Conservation measures such as restricting or controlling freely flowing wells will help stem the rate of water-level decline in the aquifer. Without these and perhaps other mitigating measures, failures of wells can be expected as water-level declines continue.

Groundwater Information Center Data Base (GWIC)

Many People Need and Use Groundwater Data

Water well drillers, government and academic researchers, consultants, mining companies, the public, and many others have widely varying interests in groundwater ranging from development to protection. People interested in groundwater may meet their groundwater data needs by collecting their own data but almost always use data gathered by others as a starting point. A central repository for groundwater data serves all who need these data by making information readily and economically accessible.

The Montana Bureau of Mines and Geology manages the GWIC data base as part of the Montana Groundwater Assessment Program. Data

The GWIC data base serves the needs of many people whose interests in groundwater range from development to protection.

generated by the characterization and monitoring programs are stored in GWIC so that they become available before other Assessment Program products. Other state and federal groundwater data collection programs also use GWIC to store water data. As shown in the GWIC drawing, the data base serves as a central data source for people who need information about groundwater.

In November 1996, the GWIC data base contained about 145,000 well locations, more than 65,000 lithologic logs, water-level measurements at about 3,900 sites for periods as long as 40 years, and the results of 14,400 water-quality analyses at about 9,400 sites. Data are retrievable by any item in the data base, but geographic area, county, and project are most commonly used.

Most people contact GWIC by phone or mail and receive information ranging from a few well logs as paper copy to data for many wells shipped in electronic format. GWIC is directly accessible using the Internet to users in government and the university system.

Currently more than 30 agencies use this service. Our plans include electronic access for the public. Ever-increasing use of technology to transfer the data helps keep GWIC service costs low. To obtain information about GWIC, call the Montana Bureau of Mines and Geology at 406/496-4336. You also may send e-mail to the center at GWIC@mbmgsun.mtech.edu.

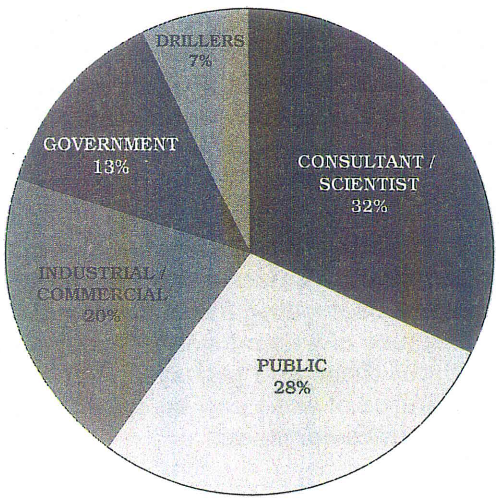
Inquiry locations

GWIC Serves Many Users

The pie chart below illustrates the distribution of GWIC users. Of the more than 2,400 inquiries for data received since July 1995, 85% were from non-government data users. The inquiry location map shows that these requests came from all areas of Montana. Most requests were for the heavily populated areas in western Montana, fewer requests were for eastern Montana. Considering population differences between western and eastern areas, east/west request rates were about the same. Information for about 49,000 wells was provided to the people requesting data.

Water well **drillers** often require site specific information. Most drillers use GWIC data to evaluate a proposed or active drilling location and they often require an interpretation regarding the chance of successful well completion. Individual retrievals for the **public** range from providing a single well log to providing data about many wells in an area. The **consultant/scientist, industrial/commercial**, and **government** user groups often require retrievals ranging from tens to thousands of wells. Generally, these user groups request uninterpreted information and receive large amounts of data shipped on diskette or delivered via the Internet.

Requests for groundwater information continue to increase as the public becomes more aware of the resource. The well logs and inquiries chart shows that requests have increased steadily from near 50 in 1992 to about 150 each month now. The common need among all groups using GWIC is easy access to groundwater information in useful formats. Storage of basic groundwater data such as well construction, static water levels, and water quality in a central repository is essential to cost-effective availability of these data.

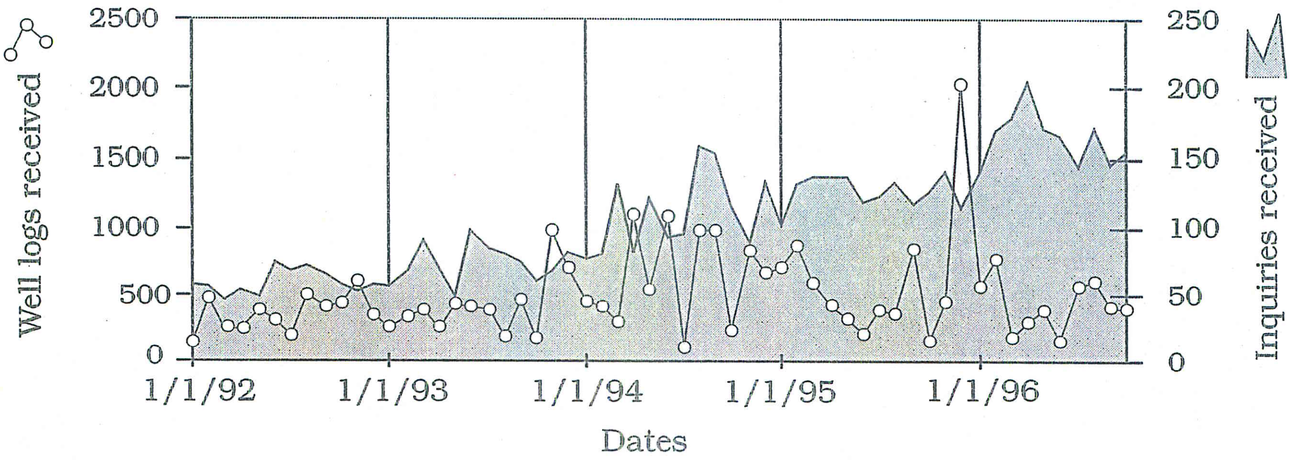


GWIC user groups: July 1995– November 1996

New Groundwater Data Added and Verified

Providing information to various user groups is about 25% of the GWIC effort. The remainder supports entry of information from new well logs into the data base and the completion of data entry for well logs older than January 1, 1990. Although most well logs at GWIC are represented by a database record, only about 50% (70,000) of the electronic records have been verified with the original paper documents. The verification process is ongoing and closely tied to activities of the Characterization Program.

The well logs and inquiries chart shows that new well logs received at GWIC ranged from about 100 to more than 2,000 per month but averaged about 450. Newly received logs are compared to existing GWIC records to eliminate duplicates. Student workers then enter the data from them into the data base. After data entry is complete, the data are verified against the original log. After any corrections are made, the log is filed and becomes the backup to the GWIC data record.



GWIC well logs and inquiries

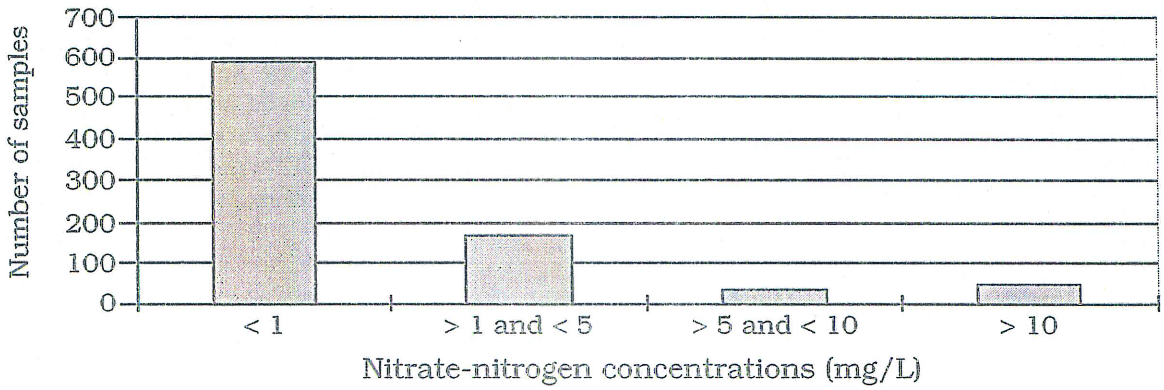
Dates

Multiple Uses of Groundwater Data

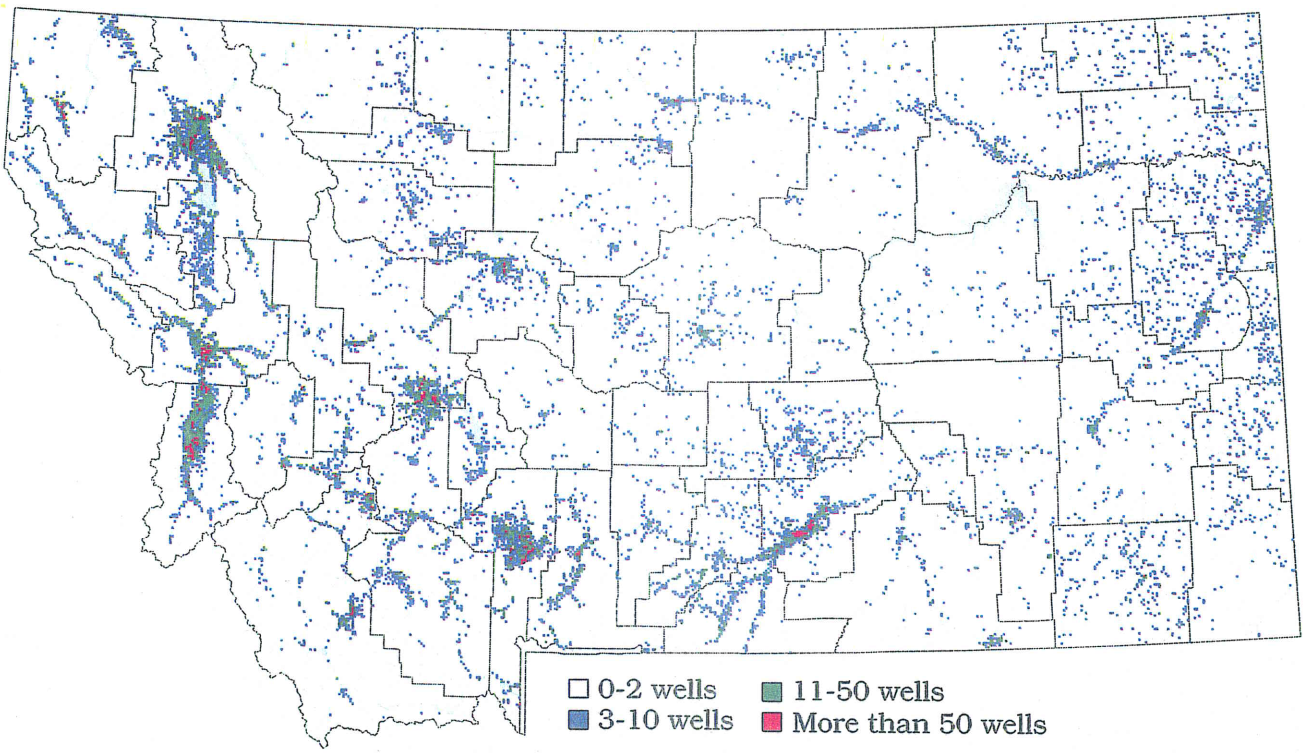
The hydrographs in earlier sections and the maps showing hydrologic and geologic characteristics of the Fox Hills–Lower Hell Creek aquifer in the Lower Yellowstone River area are some examples of how GWIC data can be used. GWIC also can provide data useful in evaluating water-quality and growth issues.

Low Nitrate Concentrations

GWIC contains water-quality data including data on nitrate concentrations. Since July 1993, the results of more than 770 analyses for nitrate have been recorded in GWIC. Only about 6% of the samples contained nitrate concentrations that exceed the maximum contaminant level of 10 mg/L (as nitrogen). Nitrate concentrations in 75% of the analyses were less than 1 mg/L.



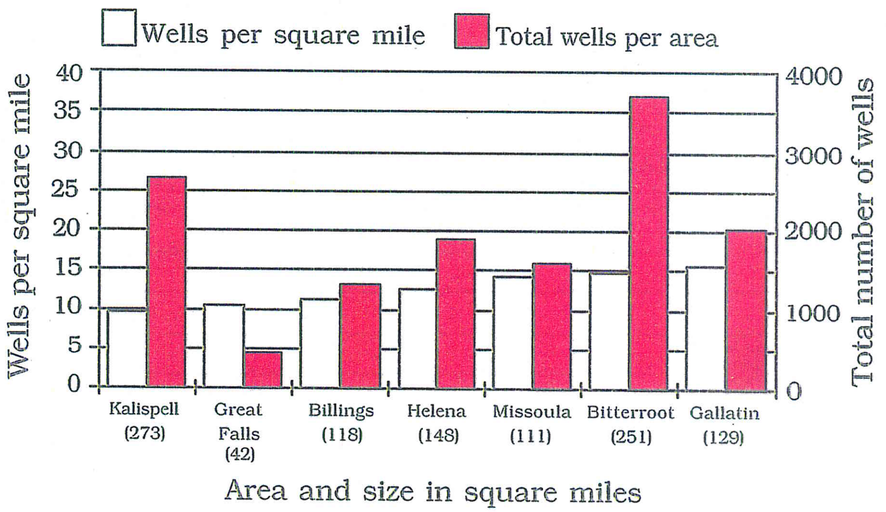
Nitrate concentrations in samples



Well Locations and Densities Show Growth

The front cover shows all GWIC well locations; those reported since 1985 are orange. The tightly packed well locations in the western valleys raise questions about how closely and how often wells are being drilled in these areas. The location data are shown as densities (wells drilled per square mile) on the map above. Highest well densities occur in the Great Falls and Billings areas and in the Helena, Kalispell, Missoula, Bitterroot, and Gallatin valleys. The most heavily drilled square mile is a section near Hamilton in Ravalli County where nearly 280 wells (1 well for every 2.3 acres) have been drilled.

The chart shows for the period 1985–1995 the total number of wells and the average number of wells drilled per square mile within these highly developed areas. Only those square miles that contain more than 11 wells (one well per 58 acres) were tabulated.



Total wells and wells per square mile

For the 1985–1995 period, the Bitterroot Valley ranked first with almost 4,000 new wells. The Kalispell valley was second with more than 2,500 new wells. If the size of each area in which wells are being drilled is considered, a different view appears. The developed area in the Gallatin valley contains about 130 square miles and the Bitterroot valley about 270 square miles. On this basis, the chart shows that between 1985 and 1995 the Gallatin valley ranked first, averaging greater than 15 new wells per square mile per year. Slightly fewer than 15 new wells per square mile per year were drilled in the Bitterroot valley.