

Kentucky Interagency
Groundwater
Monitoring Network

Annual Report
July 2010–June 2011

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Lexington, Kentucky

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Kentucky Interagency Groundwater Monitoring Network Annual Report July 2010–June 2011 Executive Summary

Kentucky's citizens, businesses, industries, and ecosystems depend on adequate supplies of clean groundwater. Regional and temporal variations in groundwater quantity and quality are not adequately known, however. For this reason, the 1998 Kentucky General Assembly directed the Kentucky Geological Survey to establish a long-term groundwater monitoring network (KRS 151.620 and 151.625). The network collects groundwater data, characterizes groundwater quality, distributes groundwater information, improves coordination between agencies that use groundwater data, and facilitates data sharing. These activities are conducted in coordination with the Interagency Technical Advisory Committee (ITAC), composed of representatives from 15 State and Federal agencies and the University of Kentucky. The duties and responsibilities of this committee include developing a plan to coordinate agencies for overall characterization of the state's groundwater, reviewing the data-entry process to ensure that all groundwater data collected are placed into the Kentucky Groundwater Data Repository, establishing a long-term groundwater monitoring plan for the commonwealth, recommending priorities for the state's groundwater research needs, annually reviewing and evaluating groundwater data collection and analysis.

The Kentucky Geological Survey is also charged with annually reporting network activities to the governor's office and the Legislative Research Commission. This report summarizes activities during the 2010-11 State fiscal year.

From July 2010 through June 2011, 26 data-collection programs were under way, and eight major groundwater characterization reports were published. Groundwater information was communicated to the scientific and regulatory communities and to the public through 22 publications and

14 presentations, as well as postings on Web sites. Quarterly meetings of the Interagency Technical Advisory Committee provided an opportunity to coordinate groundwater-related efforts and share information among agencies. Exchange of groundwater data, including electronic transfer of analytical results between Division of Water and Kentucky Geological Survey databases, has proceeded through close cooperation between the Kentucky Division of Water and the Kentucky Geological Survey.

The Kentucky Interagency Groundwater Monitoring Network has been in existence for 13 years. During this time, significant progress has been made. Important work remains, however. Among the critical issues facing Kentucky are:

- Determining recharge areas for sampled wells and springs so water supplies can be protected
- Establishing monitoring sites in areas that are currently not monitored or where groundwater demand is expected to increase
- Optimizing the sampling frequency to account for natural variations in groundwater flow systems throughout the state
- Monitoring the rate of intrusion of nonpoint-source contaminants into groundwater systems so that effective prevention and remediation can be implemented
- Establishing standard procedures for assessing whether compromised well integrity is allowing surface contamination to reach groundwater supplies
- Standardizing reported information about sampling methods, field measurements, and sample-site descriptions to promote data sharing
- Developing a water-level monitoring network to track long-term land-use and climate effects on groundwater supplies

- Standardizing reporting procedures and database structures to facilitate electronic data sharing
- Providing increased public access to groundwater-quality data in order to increase awareness
- Determining sources and amounts of bacteria and other pathogens in both local and regional groundwater flow systems
- Investigating the amount of pharmaceutical and personal-care-product chemicals in water systems
- Evaluating amounts and effects of pesticide metabolites in groundwater
- Increasing the use of stable isotopes, caffeine, and other tracers to indicate contaminant sources and quantify groundwater ages and flow rates
- Quantifying how groundwater affects the quality and quantity of water in streams in terms of water-quality standards, total maximum daily loads, and designated uses.

The Kentucky Interagency Groundwater Monitoring Network will continue to address these issues. Progress has been hampered by staff and funding limitations, however, which are increasing. Recent advances have been the result of substantial agency commitment of State executive budget funds; one-time, competitive grants to the Kentucky Division of Water's Groundwater Section and the Kentucky Geological Survey; and voluntary cooperation between agencies. An effective groundwater monitoring network requires sustained, recurring funding to maintain the long-term effort.

Introduction

Groundwater is used extensively throughout Kentucky for domestic, agricultural, commercial, and industrial purposes. Because of its connection with rivers, lakes, and wetlands, groundwater is also essential to the health of surface-water ecosystems. Determining the quality of this resource and protecting it from contamination are important to the future of the commonwealth and its citizens. The Kentucky Interagency Groundwater Monitoring Network was established in 1998 by the Kentucky General Assembly to increase knowledge and awareness of groundwater resources. For 13 years, the network has met its obligation of collecting and interpreting data, communicating findings, sharing data, and promoting interagency cooperation. Previous annual reports for the network are posted at www.uky.edu/KGS/water/gnet.

Information provided by the Kentucky Division of Water indicates that more than 400,000 citizens rely on water from private wells and springs for drinking, cooking, and washing. Public water systems serving more than 1.25 million people also rely on groundwater as a source of drinking water. This dependence on groundwater resources will continue and may increase for economic reasons. Many public water-supply systems are consider-

ing switching from surface-water to groundwater sources because the required treatment and monitoring are less extensive and less expensive. Furthermore, many people who now rely on private wells or springs for domestic water supplies will remain dependent on groundwater because of the cost of extending public water-supply systems to rural areas and because groundwater supplies are more than sufficient in some areas of the commonwealth.

Significant quantities of groundwater are used for commercial and industrial applications, crop irrigation, livestock watering, mining, and thermoelectric power generation. Groundwater also sustains valuable ecosystems by providing base flow to streams, lakes, and wetlands. This is particularly important during moderate to severe droughts, such as those that occurred in 1999-2001, 2005-06, and 2007-08. In the absence of precipitation, groundwater base flow is the only source of water to maintain stream flow and lake levels, and to preserve riparian and wetland ecosystems.

The 1998 legislation also established the Interagency Technical Advisory Committee to assist the Survey in the development, coordination, and implementation of a groundwater monitoring network (KRS 151.629). The following agencies and or-

ganizations were asked to appoint a representative to the Interagency Technical Advisory Committee:

- Kentucky Department for Environmental Protection
- Kentucky Department for Natural Resources
- Kentucky Department for Surface Mining Reclamation and Enforcement
- Kentucky Department of Agriculture, Division of Pesticide Regulation
- Kentucky Department of Mines and Minerals
- Kentucky Division of Conservation
- Kentucky Division of Environmental Health and Community Safety
- Kentucky Division of Forestry
- Kentucky Division of Waste Management
- Kentucky Division of Water
- University of Kentucky, College of Agriculture
- University of Kentucky, Kentucky Geological Survey
- University of Kentucky, Kentucky Water Resources Research Institute
- U.S. Geological Survey, Kentucky Water Science Center.

2010-11 Activities and Accomplishments

Brief summaries of work performed by the ITAC agencies during the 2010-11 State fiscal year are presented herein to show how the major goals of the network are being addressed. Additional information regarding these projects can be obtained by contacting the responsible agency.

The Interagency Technical Advisory Committee met four times during the 2010-11 fiscal year (July 13, 2010, at the Kentucky Geological Survey in Lexington; October 12, 2010, at the Kentucky Division of Conservation in Frankfort; January 18, 2011, at the Kentucky Geological Survey; and April 12, 2011, at the Division of Mine Reclamation and Enforcement in Frankfort). These meetings served as opportunities for networking and information sharing. In addition, all committee members were invited to the Kentucky Water Resources Annual Symposium held on March 21, 2011, in Lexington. The conference included numerous presentations related to groundwater conditions in the commonwealth.

Statewide and regional ambient monitoring programs evaluated groundwater that is not affected by point-source contamination, and determined whether nonpoint-source chemicals such as sewage, pesticides, fertilizers, and volatile organic compounds have affected groundwater quality. These large-scale studies are conducted in basin management units (Fig. 1), which were established by the Kentucky Division of Water (1997) and include one or more major river watersheds. Site-specific studies were conducted in smaller watersheds or other, more restricted regions. These more specific studies were designed to evaluate the effects of particular land uses or unique hydrologic conditions on the quality of unregulated water supplies, such as roadside springs, used by the public.

Groundwater Data Collection

Drilling wells, collecting and analyzing water samples, measuring water levels in wells, and mapping recharge and discharge areas of karst systems provide the fundamental data needed to determine current groundwater quality, detect changes over time, and evaluate hydrogeologic hazards.

Kentucky Division of Water, Watershed Management Branch, Groundwater Section

The Groundwater Section of the Kentucky Division of Water's Watershed Management Branch maintains an active groundwater-sample collection and analysis program. The following projects have been active during the report period.

Ambient Groundwater Monitoring Network. Regularly scheduled sampling continued for the statewide Ambient Groundwater Monitoring Network. This fiscal year 121 samples were collected from 55 sites (wells and springs) across the state. Groundwater-quality data were provided to numerous persons through information requests. Data were also included in statistical analyses for regional and watershed-based groundwater assessments.

Pesticides Memorandum of Agreement Project (Pest MOA). The Pest MOA with the Department of Agriculture covers four permanent sampling sites (three springs and one well) in western Kentucky. Each site was sampled quarterly for a total

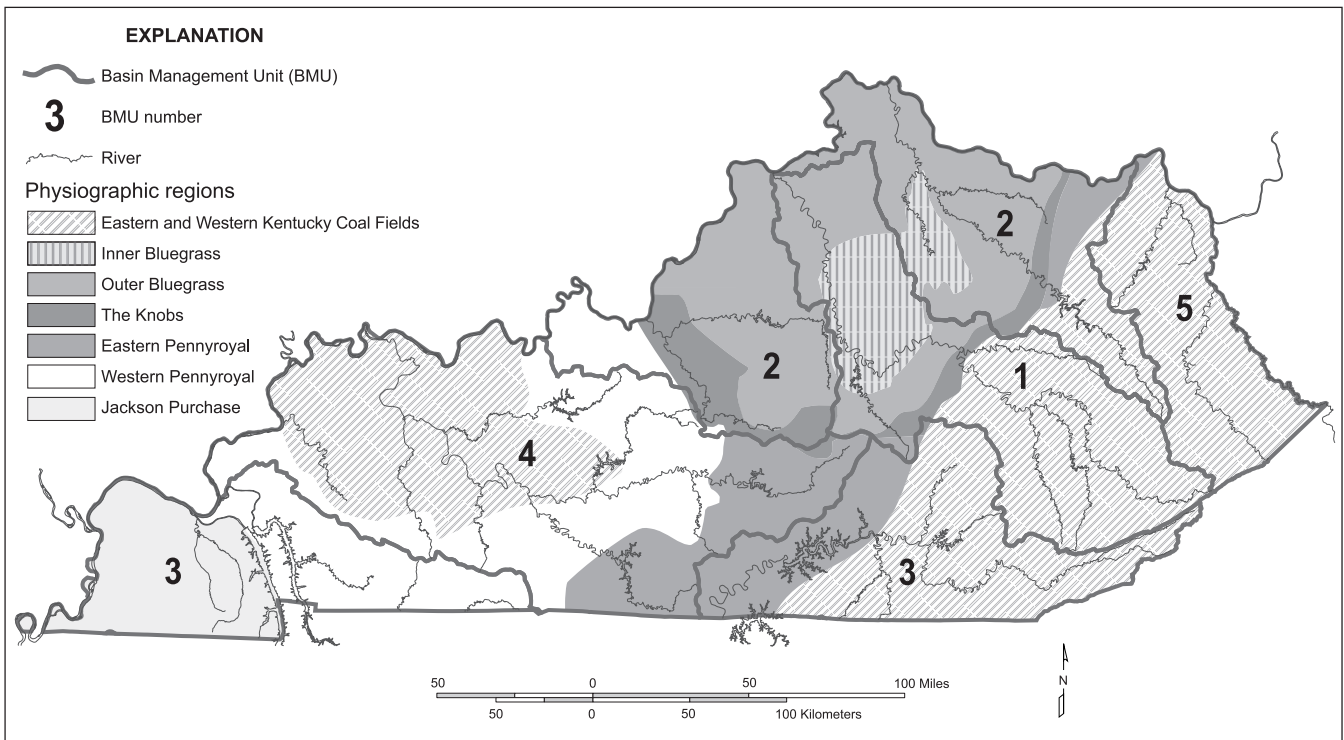


Figure 1. Major rivers, basin management units, and physiographic regions in Kentucky.

of 16 samples throughout the fiscal year. Pesticide data from these sites and the Ambient Groundwater Monitoring Network sites are submitted to the Department of Agriculture annually.

Complaint Sampling. The Division of Water responds to complaints about groundwater and investigates as requested by the general public. This fiscal year, the division collected 25 samples from 25 sites in response to complaints. The majority of these samples are collected by Groundwater Section personnel. Several other water-well and spring inspections were completed in response to citizen requests for technical assistance, but analytical samples were not collected.

Groundwater Quality Assessment in Sinking Creek and Beargrass Creek Watersheds (NPS0303). This project is currently in the report-writing phase. Groundwater-quality monitoring and tracer tests have been completed. Parts of the report have been completed, but data have not been completely summarized. Aspects of this project relating to groundwater infiltration of the sanitary sewer system in the Beargrass Creek Watershed, Jefferson County, have been presented at

water-resources conferences and to a community watershed group.

Integrated Surface-Water and Groundwater Assessment of Large Springs in the Green River Basin (NPS0503). The report for this project is under internal review. Groundwater-quality monitoring and tracer tests have been completed. An integrated approach was used to assess groundwater resources, according to surface-water protocols, in an attempt to better define the nexus between the two systems. Ten large springs in the Mississippian Plateau Region were monitored for one year. Data obtained were sufficient to assess these springs and to have them listed on the 2008 Integrated Report—305(b)/303(d).

The final report for this project will discuss each spring relative to the primary contact recreation and aquatic life use standards set forth in Kentucky Administrative Regulations 401 KAR 10:031. The report will also include findings for biological population assessments, and tracer tests conducted to delineate and refine these identified karst groundwater basins. Results of this study have been presented at water-resources conferences.

Basin Management Unit 5 Elkhorn Creek Sub-basin Groundwater Study (NPS0604). This project is focused on assessing groundwater quality of domestic-use wells along Elkhorn Creek in south-eastern Pike County and northeastern Letcher County. All chemical water-quality samples have been collected and analyzed. Each well used in this study will be sampled for total coliform and *E. coli* bacteria. Biological activity reaction tests will also be collected for each well, which will detect iron-related bacteria, sulfate-reducing bacteria, and slime-forming bacteria. Preliminary work on the draft report is currently in progress.

Western Pennyroyal Karst Study (NPS0704). Work on this project began in late fall of 2008. Tracer tests are currently being conducted throughout the study area. Following completion of the tracer tests and delineation of several karst groundwater basins, monitoring sites will be chosen. An integrated surface-water/groundwater assessment will be done.

Statewide Pathogens Study. This project will study the occurrence of pathogens in groundwater, focusing in particular on domestic water wells. Current plans are to sample approximately 200 domestic drinking-water wells across Kentucky for total coliform, *E. coli*, iron-related, sulfate-reducing, and slime-forming bacteria, as well as caffeine. Although this research will be statewide, priority will be given to areas with the highest domestic groundwater use, specifically the Eastern Kentucky Coal Field and Jackson Purchase Region.

Wellhead Protection Program. Two new staff members were hired in spring 2011, after both positions were vacant for several months. The priority is to complete the required 5-year updates to plans for groundwater systems around the state; current focus is on the Jackson Purchase Region. Wellhead protection plans are in progress for 16 of the 24 systems in that region that are past due for updating. Since February 2011, seven of the 5-year updates and two phase-one plans have been approved. In addition, five new wellhead protection areas have been delineated: Warsaw Water Works; Western Mason County Water District; Mayfield Electric, Water and Sewer System; La Center Municipal Water; and 4-Star Apartments and Catering. The

Wellhead Protection Program continues to work on educational materials to raise awareness about groundwater protection for public water supplies and the communities they serve. Questions about the Wellhead Protection Program can be directed to Jessica Moore at (502) 564-4310 or Jessica.Moore2@ky.gov.

Special Projects. The division conducted 34 tracer tests for karst mapping projects and groundwater technical assistance. Twelve county health departments, two Division of Water regional offices, the Division of Abandoned Mine Lands, Morehead State University, and the division's Environmental Response Team were assisted with dye traces for local contamination investigations.

Adding Karst Data to the National Hydrography Dataset. In conjunction with the Kentucky Geological Survey, the division has conducted a pilot study on the feasibility of adding karst data to the U.S. Geological Survey's National Hydrography Dataset. The dataset was designed to incorporate groundwater data, and data from a limited number of water wells and springs were included in the original dataset. The Survey and Division of Water have compiled and digitized karst flow data for more than half of the karst regions in Kentucky. Adding previously omitted subsurface flow data into the dataset provided several benefits, primarily: (1) demonstration of local deviation of karst drainage from topographic watershed divides, (2) establishment of a baseline for mapping karst features and groundwater flow paths, and (3) improvement of accuracy and applicability of information used for hydrologic modeling, research, and field investigation. The pilot study was a success, as tracer data for the West Fork of the Red River watershed were added to the database. The USGS is currently pursuing funding to expand the scope of this project. Results have been presented at professional conferences.

Complaint Response. The division has responded to at least 10 complaints about the presence of methane gas in water wells, allegedly from natural gas exploration or the deep mining of coal. Dissolved gases in water wells present a potentially hazardous environment in wells and homes. Methane (CH₄) and hydrogen sulfide (H₂S) gases are a com-

mon occurrence in wells in the Eastern Kentucky Coal Field. These gases are especially prevalent in coal seams and petroleum deposits. Iron and sulfur bacteria also commonly occur in wells throughout eastern Kentucky. These bacteria are not known to be harmful to health, but are a nuisance, causing red, orange, brown, or black stains to plumbing fixtures, along with sulfurous “rotten egg” odors (H_2S) and red or orange coloration of the water. The division has published a guide for well owners on managing such issues. This guide recommends and explains regular well maintenance, proper venting, and precautionary measures. The Division of Water recommends that a water-well driller holding a current license in Kentucky be used to make modifications to the wells.

Proposed Legislation. The Kentucky Water Well Certification Board has proposed two draft statutes for closed-loop geothermal drilling. The proposals, requested by members of the drilling community through the Kentucky Water Well Drillers’ Certification Board and the board of the Kentucky Groundwater Association, have been presented to membership for ratification. One version includes reporting, construction, and abandonment requirements, but no certification requirement. The other version calls for certification of drillers of closed-loop geothermal wells along with reporting, construction, and abandonment requirements. The board planned to meet in Lexington in September 2011 during the Midwest Groundwater Conference to review the results of the poll, the draft statutes, and to discuss plans and strategy to move forward on this issue.

U.S. Geological Survey

Louisville Water Co., Ohio River Alluvial Aquifer, Jefferson County. The U.S. Geological Survey, in cooperation with the Louisville Water Co., maintains a network of 24 water-level observation wells in the northeastern part of the Ohio River alluvium in Jefferson County. Ten of the wells are equipped with continuously recording pressure transducers that measure depth to water and water temperature. Water-level measurements are taken at the other 14 observation wells on a quarterly basis. These data assist the Louisville Water Co.’s efforts to operate and maintain river-bank infiltration using a network of water-supply wells constructed

to draw and naturally filter river water through the sand and gravel aquifer near the Payne water-treatment plant.

Groundwater-Level Data Collection. The USGS collects real-time continuous water-level measurements from an observation well in Graves County that is included in the USGS National Groundwater Climate Response Network – a nationwide network of long-term observation wells intended to monitor the effects of droughts and other climate variability on the nation’s groundwater resources. The water-level data for this well can be accessed at groundwaterwatch.usgs.gov or ky.water.usgs.gov. Two additional long-term observation wells located in downtown Louisville are also maintained by the USGS and are used to collect continuous water-level data from the Ohio River alluvial aquifer. These data, historical water-level data from other observation wells, and additional information about the activities of the USGS–Kentucky Water Science Center are available at ky.water.usgs.gov.

Well-Integrity Survey of Abandoned Gas Wells near West Point. Abandoned and unrecorded natural-gas wells may act as conduits for oil and gas field brines and other pollutants to contaminate groundwater supplies. The casings of abandoned wells may eventually develop leaks, which, if not properly plugged, can allow pollutants to reach freshwater aquifers that supply drinking water. Such is the situation in the Fort Knox well field near West Point, Ky. Many of the drinking-water supply wells for Fort Knox have chloride concentrations in excess of secondary maximum contaminant levels of 250 mg/L; some are as high as 1,900 mg/L. The USGS, working in cooperation with the U.S. Army Corps of Engineers and the Army installation at Fort Knox, is presently conducting a geophysical and hydrogeologic investigation of the Ohio River alluvial aquifer at the Fort Knox well field to identify abandoned or improperly plugged oil and gas exploration wells that may be contributing brine contamination to the freshwater aquifer and to characterize the migration and dispersion of chlorides.

Kentucky Department of Agriculture

The Kentucky Department of Agriculture-Technical Support Branch continued to receive monitoring data from the Division of Water under its memorandum of agreement. The memorandum covers 16 samples yearly from four sites. It is supplemented by the Division of Water's Ambient Groundwater Monitoring Program.

Kentucky Geological Survey

Identifying Raw-Water Supplies. The Water Resources Section is helping small Kentucky communities look to groundwater sources for public water supplies. Work continued in eastern Kentucky with the city of Campton in Wolfe County and the Kentucky Division of Water during construction of a new water-treatment plant, which included bringing online a new supply well. In Letcher County, section personnel provided an initial appraisal of developing groundwater supplies from potential wellsites on Pine Mountain.

Cumberland Gap Tunnel. Research continues to determine the rate at which the roadbase aggregate is being dissolved by the groundwater flow system entering the bottom of the tunnel. Four borings in the pavement were completed with sampling devices to monitor the loss of limestone aggregate over the next several years.

Cane Run Watershed. The Lexington-Fayette Urban County Government is under a consent decree with the U.S. Environmental Protection Agency to improve the natural water quality within its jurisdiction. KGS is working in cooperation with the University of Kentucky's College of Agriculture to monitor the underground conduit through which the Cane Run watershed usually flows from Lexington to Royal Spring, the major water supply for Georgetown, in Scott County. This watershed is the focus of an EPA grant to mitigate poor water quality. Electrical-resistivity and spontaneous-potential geophysical logs were used to help pinpoint the location of the active conduit at the Kentucky Horse Park, where monitoring wells were drilled into the conduit. Equipment has been installed to monitor discharge and water quality through the conduit, and some initial samples have been taken. Water flow and water chemistry will be monitored at this site in the coming year. In addition, exploratory

drilling will be conducted on College of Agriculture farm lands in the vicinity of Berea Road and at North Farm in Lexington to locate the conduit at those locations for additional monitoring purposes.

Groundwater Contaminant Modeling at the Paducah Gaseous Diffusion Plant. Historic activities at the Paducah Gaseous Diffusion Plant have released hazardous, nonhazardous, and radioactive wastes to the environment, including PCB's, trichloroethene, uranium (multiple isotopes), and technetium-99. The plant is listed by the Environmental Protection Agency as a National Priority List Superfund site. Trichloroethene and technetium-99 are widespread groundwater contaminants associated with the plant. KGS conducted an independent review of the most recent version of a groundwater flow and contaminant transport model designed to assist in remediation efforts at the plant. KGS will continue to develop and operate the model to simulate potential groundwater and source-area remediation scenarios at the plant that are generally outside the scope of modeling activities for Department of Energy contractors. The next step in this project is to incorporate newly collected hydrostratigraphic data into the model.

Groundwater-Quality Data Associated with Domestic Well Sampling in Western Kentucky.

Groundwater-quality data collected from 668 water wells in 12 western Kentucky counties were checked for errors and formatted for entry into the Kentucky Groundwater Data Repository. Of the 668 wells, 650 are in the eight counties making up the Jackson Purchase Region. The remaining 18 wells are in four counties in the Western Kentucky Coal Field. Assessed parameters included field measurements (pH, electrical conductivity, temperature, dissolved oxygen, and Eh), nutrients, metals-cations, anions, alkalinity, herbicides, bacteria, nitrogen and oxygen isotopes, and caffeine. The number of analyses assessed and submitted for entry was 23,932. These data have been submitted to the Groundwater Section of the Kentucky Division of Water (Watershed Management Branch), and will be entered into the repository via the next upload to the repository.

Karst Activities. In cooperation with the Division of Water, KGS staff completed and published the

karst groundwater basin map for the Tell City 30 x 60 minute quadrangle. Work continued on developing maps of the probability of occurrence of cover-collapse sinkholes. Statistical analyses are being used to link geologic strata to the occurrence of sinkholes and the probability that sinkholes will occur in the future.

Significant amounts of time and effort were spent on various activities to locate the main-stem conduit for the Royal Spring karst aquifer in the vicinity of the Kentucky Horse Park. This included conducting specialty groundwater tracing experiments, electrical-resistivity experiments, and drilling 17 holes. The conduit was found from a combination of data from the electrical-resistivity logs, fundamental hydrogeologic techniques, and a conceptual model that explains the results of both the recent drilling and previous attempts to locate the conduit. Each hole drilled, regardless of what it found, was an essential piece of the puzzle.

A major revision of the Somerset karst groundwater basin map has recently been completed and is undergoing final review before publication.

Assessment of CO₂ Injection on Local Groundwater Quality. Glynn Beck and other Water Resources Section staff monitored shallow groundwater at two carbon storage projects overseen by the Energy and Minerals Section. One project, in Hancock County, investigated the feasibility of injecting CO₂ into deep saline aquifers. The second project, in Hopkins County, researched the feasibility of injecting CO₂ into an oil-producing formation to enhance oil recovery while also storing the carbon dioxide. The shallow groundwater was sampled to characterize the local water quality and assess any changes in quality that may be associated with CO₂ injection. Groundwater sampling in Hancock County will continue through 2012. Groundwater sampling in Hopkins County ended in June 2011; no changes in groundwater quality were found.

Analysis of Formation-Water Chemistry in the Appalachian and Illinois Basins of Kentucky. Marty Parris and Kathryn Takacs of the KGS Energy and Minerals Section, along with Glynn Beck, continue to evaluate archived formation-water chemistry data from deeper reservoirs in the Appalachian and Illinois Basins of Kentucky. The data come primarily from oil wells. To date, 1,271 mea-

surements from 107 counties have been examined and entered into a database. Most of the analyzed waters are brines and therefore nonpotable; salinities ranged up to 300,000 mg/L of total dissolved solids. Samples were collected from Precambrian through Pennsylvanian reservoirs spanning a depth range of 2,000 to 8,000 ft (sea-level reference). Most of the archived measurements included major cations (Na, Ca, Mg, K), major anions (Cl, SO₄, HCO₃), and water properties (pH, conductivity, total dissolved solids). Important administrative data, such as well location and sampled depth and stratigraphic interval, were also collected. About half of the data has been checked for quality assurance using charge-balance analysis. The distribution of solutes in a stratigraphic and depth context is being used to analyze basin hydrostratigraphy. The chemistry data are also used as inputs for CO₂ solubility models for carbon-sequestration studies.

In addition to the archived data, new formation water samples collected in 2010-11 include Silurian samples from the Laurel Dolomite (n=1) in Green County, Keefer Sandstone (n=3) in Lee County, and Lockport Dolomite (n=1) in Wolfe County. Silurian reservoirs in Kentucky contain NaCl brines that have the highest salinities in the state. The chemistry of the Silurian brines is being assessed because the brines can contain high concentrations of lithium suitable for industrial use.

From May 2009 to June 2011, KGS was the lead organization collecting formation-water samples from the Mississippian Jackson Sandstone reservoir at Sugar Creek Oil Field in Hopkins County. The work at Sugar Creek is part of the Midwest Geologic Sequestration Consortium enhanced oil-recovery and sequestration pilot program. The overall goal of sampling was to monitor movement of CO₂, which was injected into the Jackson reservoir at a depth of 1,850 ft below land surface from May 2009 to May 2010, and to document interactions among formation fluids, reservoir minerals, and CO₂. Over the course of the project, monthly measurements were made at nine oil wells and a tank battery for a total of approximately 250 measurements. They included field determination of water properties (pH, conductivity, dissolved oxygen, Eh) and collection of samples for bulk and isotopic chemistry. In addition, samples were collected and analyzed from shallower Pennsylvanian aquifers 200 to 900 ft be-

low surface from seven wells in and outside of the field. Collection was on a quarterly basis for a total of 62 measurements. The Pennsylvanian aquifers, which contain potable water, were monitored to ensure that CO₂ did not leak into them.

Unregulated Drinking-Water Initiative. The Water Resources Section completed a joint project with the Centers for Disease Control and Prevention in Atlanta., along with six other states. The CDC has initiated a nationwide project to identify and characterize unregulated drinking-water sources that are not covered by the Safe Drinking Water Act. These sources consist primarily of wells and springs. The pilot project contacted State, Federal, and local agencies that collect or maintain groundwater data in order to estimate the cost to digitize the paper records and enter them into the Kentucky Groundwater Data Repository. Twenty agencies were contacted and eight datasets were located that would be useful for inclusion into the repository. Funding has been applied for with the CDC that, if granted, will focus on digitizing and entering four of these datasets into the repository during the 2011-12 fiscal year.

New Groundwater Resource Maps for Kentucky. The U.S. Geological Survey Hydrologic Atlas maps for Kentucky have been used extensively over the years to facilitate the search for groundwater. Twenty-four atlases cover the entire state, and each atlas includes an "Availability of Groundwater" map indicating the most likely areas in which to obtain groundwater. The atlases also include flow rates and general water-quality information. Completed in the 1950's and early 1960's, these maps were created using extremely limited water-well and geologic mapping data.

KGS personnel recently used GIS techniques to overlay current digital geology and water-well data onto the groundwater availability maps, revealing inaccuracies in locating groundwater. The availability of digital 1:24,000-scale geologic data and current water-well data has made possible a new series of detailed groundwater resource maps for Kentucky.

Hydrologic factors such as well yield, well depth, static water level, and groundwater quality are now being mapped and analyzed to characterize the quantity and quality of groundwater

resources in Kentucky. Median values for each of these factors have been calculated for every major geologic formation and physiographic region. Resulting data are displayed both in map and graphical format. GIS technology allows several of these factors to be analyzed in a single map.

Groundwater resource maps are also being generated using groundwater-quality parameters such as alkalinity, sulfate, manganese, iron, pH, conductivity, hardness, chloride, and total dissolved solids. These maps will help users determine the likelihood of obtaining groundwater from any point in the state, and provide basic information on the quantity and quality of water available.

Distribution of Groundwater Information

One of the most important functions of the Groundwater Monitoring Network is translating analytical data from water-level measurements and groundwater analyses into readily available, useful information and presenting it to the public. During the 2010-11 fiscal year, groundwater information was communicated via short reports, oral and poster presentations at meetings and conferences, and posting on Web sites. Major reports and presentations are listed below.

Publications

- Beck, E.G., 2010, Sources and occurrences of nonpoint-source chemicals in groundwater, Jackson Purchase Region, Kentucky: Data report: Kentucky Geological Survey, ser. 12, Information Circular 21, kgs.uky.edu/kgsweb/olops/pub/kgs/water/IC21_12 [accessed 09/28/2011].
- Beck, E.G., Boellstorff, D., Fielder, K., Smith, J., Dennis, S., Lee, B., and Dozier, M., 2011, Southern Region Down-Well Camera Team [abs.]: U.S. Department of Agriculture-National Institute of Food and Agriculture Land Grant and Sea Grant National Water Quality Conference, Washington, D.C., January 31-February 1, 2011, Proceedings and Abstracts, www.usa.waterquality.org/conferences/2011/regional/southern/S_Down_well_camera_team.pdf [accessed 09/30/2011].
- Beck, E.G., Boellstorff, D.E., Smith, J.W., Dozier, M., Fielder, K., Dennis, S., and Lee, B., 2011,

- Southern Region Down-Well Camera Project [abs.]: Kentucky Water Resources Annual Symposium, Lexington, Ky., March 21, 2011, Abstracts with Programs, p. 73.
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Web Site Information

The Kentucky Geological Survey provides online access to information about water wells and springs at kgs.uky.edu/kgsweb/DataSearching/Water/WaterWellSearch.asp. These data are useful to the public, well drillers, consultants, and researchers. KGS also maintains a Web site for the Kentucky Interagency Groundwater Monitoring Network (www.uky.edu/kgs/water/gnet), which contains links to current and previous annual reports of the network and to the Web sites of the ITAC agencies and organizations.

KGS has compiled information about hydrology, geology, topography, water supply, and water quality from maps, reports, and data collected from 1940 to the present at www.uky.edu/kgs/water.

Statewide groundwater data in the Kentucky Groundwater Data Repository can be accessed at kgs.uky.edu/kgsweb/DataSearching/watersearch.asp. The two main search engines cover water wells and springs and groundwater-quality data. Several alternatives are available for viewing groundwater information on both interactive and static maps, and for creating graphical representations of groundwater-quality data.

The Kentucky water-well and spring search engine was accessed by the public 6,022 times during fiscal year 2010-11 (a 25 percent increase over the previous year), and 696 downloads were made. It remains the second most popular search engine on the KGS Web site after that for oil and gas records. Users can search for wells or springs by county, 7.5-minute quadrangle, or a radius from a user-provided latitude/longitude location. Resulting data can be displayed on maps or downloaded for use in GIS packages.

The Kentucky groundwater-quality data search engine was accessed by the public more than 1,093 times during fiscal year 2010-11, and 386 downloads were made. Users can select from 38 parameters of interest in five major categories: water properties, volatile organic compounds, nutrients, pesticides, and inorganic solutes. Resulting data can be downloaded, displayed on maps, or used to generate graphs comparing groundwater-quality data by physiographic region or watershed basin.

For more information on groundwater-quality or water-well and spring data, contact the Survey at (859) 323-0524.

Interagency Coordination

Cooperation among agencies and research organizations that collect, analyze, and use groundwater data reduces monitoring costs, improves program efficiency, and promotes data sharing. The Kentucky Interagency Technical Advisory Committee on Groundwater provides a forum for organizations that participate in ITAC to meet quarterly and discuss groundwater issues.

Many programs benefit from the Division of Water's willingness to collect and analyze groundwater samples to support various projects. The Division of Water also samples groundwater and surface water for nonpoint-source constituents in support of projects for the Division of Pesticide

Regulation. The Division of Water and the Kentucky Geological Survey regularly answer inquiries from the public and communicate with staff of the Kentucky Rural Water Association. KGS staff have been meeting with County Extension Service agents and Area Development District staff throughout the commonwealth to promote awareness of hydrogeologic issues. Many of the ITAC agencies are also members of the Kentucky Agricultural Water Quality Authority or cooperate with the authority and participate in their meetings. Members of both the Division of Water and the Kentucky Geological Survey regularly participate in meetings of State and Federal agencies and citizens' groups that have interests in groundwater resources.

Groundwater Data Sharing

Sharing data is an essential function of the Interagency Groundwater Monitoring Network. Data transfers between agencies provide each group access to a larger database than any agency could develop independently, thereby improving evaluations of groundwater quality and suitability for various uses, threats to groundwater quality, and the effects of mining, logging, agricultural practices, urbanization, waste disposal, and oil and gas production. Sharing data also reduces the overall expense and increases the efficiency of monitoring efforts.

Data have been transferred electronically between the Division of Water groundwater database and the Kentucky Groundwater Data Repository and between the Kentucky Geological Survey analytical laboratory and the Division of Water's Groundwater Section since 1992. There has also been a high level of collaboration and data sharing between KGS and the Groundwater Section during the reporting period, as the agencies are jointly reporting on groundwater quality throughout the state. During 2010-11, electronic data files of water-well, spring, and groundwater-quality data were transferred from the Division of Water to the Kentucky Geological Survey, and have been uploaded to the Kentucky Groundwater Data Repository. Uploads from the Division of Water occur on a monthly basis, allowing end-users to access the most recent well and spring data available.

Other Activities

ITAC agencies are involved in many activities primarily concerning surface-water quality and public education about water resources. Although these projects do not directly address issues raised by the 1998 Kentucky General Assembly, they are important contributions because of the close interconnection of groundwater and surface-water systems in Kentucky.

University of Kentucky Environmental and Natural Resource Issues Task Force The Kentucky Well Education Web Site. The Kentucky Well Education Web site (www.ca.uky.edu/downwell) is a joint project between the Environmental and Natural Resource Issues Task Force and the Kentucky Geological Survey. The Web site contains information on well types and construction, along with simplified descriptions of Kentucky Division of Water regulations about general well construction and specific types of wells. The Web site provides video and photographic examples of problems that may occur in wells and gives advice on solutions. This site is maintained by the Environmental and Natural Resource Issues Task Force.

Home and Environment Extension Bulletin Series. The Home and Environment Extension Bulletin Series (HENV) is a newly established series of bulletins that provides homeowners with science-based information about their homes and home environment. Extension bulletins, radio scripts, PowerPoint presentations, and facilitators' guides have been developed for the topics listed below to be used by Extension agents and educators throughout Kentucky.

HENV Series Numbering System:

- 100's—reduce, reuse, recycle, hazardous waste, compost, etc.
- 200's—stormwater (rain barrels, rain gardens, artificial drains, wetlands, etc.)
- 300's—chemical issues at home (radon, lead, arsenic, chromium, mercury, etc.)
- 400's—landscaping issues (tree throw, soil compaction, lawn management, etc.)
- 500's—rural wastewater issues (septic systems, cluster systems)

- 600's—drinking water (wells to water softeners)
- 700's—energy (green living, CFL's, appliances)

The following publications were developed during the reporting period:

- *Building a Rain Barrel* (HENV-201) Publication and radio script
- *Saving Water Saves Money: Tips for Conserving Water at Home* (HENV-704) Publication, facilitator's guide, and PowerPoint presentation

40 Gallon Challenge. The ENRI Task Force received funding from the Southern Region Water Program to administer the 40 Gallon Challenge Water Conservation Program (www.40gallonchallenge.org) in Kentucky, and host three in-service trainings in August 2011 on rain garden design and installation for homeowners.

In addition, the ENRI Task Force, in collaboration with the Rowan County Agriculture and Natural Resource agent, North Carolina Extension, and Morehead State University installed a rain garden at the Rowan County Middle School in April 2011 as part of the 40 Gallon Challenge.

ENRI Web Site. The ENRI Web site (www.ca.uky.edu/enri) contains information on groundwater (e.g., publications, radio scripts, activities). In addition, the site has information on watersheds, stormwater, nutrient management, the Kentucky Agriculture Water Quality Act, and the Kentucky Water Awareness Month packet. Also included on the site is an Upcoming Events page that provides information on current events such as Groundwater Awareness Week and Kentucky Water Awareness Month. The site is maintained by Ashley Osborne, ENRI Extension associate.

ENRI Quarterly Newsletter. The ENRI Newsletter (www.ca.uky.edu/enri/newsletter.php) is distributed to County Extension agents and other natural-resource professionals throughout Kentucky. Newsletters contain information about current research, resources (e.g., new publications, training, etc.), and events. Newsletters are coordinated by Ashley Osborne, ENRI Extension associate.

Consumer Radio Tips. The following 60-second radio scripts were recorded by the University of Kentucky Agricultural Communications Service:

- Building a Streamside Buffer Zone

- Conserving Water
- Creating a Rain Garden
- Kentucky Water Awareness Month
- Learning About Karst Topography
- Maintaining a Healthy Stream
- Protecting the Groundwater Supply
- Reporting on Water Quality
- Understanding What a Watershed Is

These scripts were developed and recorded by Amanda Gumbert, UK water-quality liaison, and Ashley Osborne, ENRI Extension associate.

"See Blue Go Green" Web Site. The "See Blue Go Green" Web site (www.ca.uky.edu/gogreen) contains information for all Kentuckians regarding topics such as drinking water, stormwater, wastewater, water quality, etc. The site includes publications, fact sheets, radio scripts, displays, lesson plans, activities, and links. It is maintained by Ashley Osborne, ENRI Extension associate.

Kentucky Water Awareness Month Packet. Each May, citizens across Kentucky celebrate Water Awareness Month. This program first began in 1996 as an educational tool of the University of Kentucky Cooperative Extension Service to promote water awareness. Program materials are developed by a committee at the state level, and distributed (via listserv) to each of the 120 County Extension offices. Counties across the commonwealth participate in activities such as after-school programs, environmental day camps, and homemaker club meetings. The 2011 Kentucky Water Awareness Month materials are available online at www.ca.uky.edu/enri/kwam2011.php and include a calendar, flyer, and several fact sheets, radio scripts, exclusives, and activities. The packet is coordinated by Ashley Osborne, ENRI Extension associate.

4-H₂O Ambassador Program. Kentucky partnered with several states in EPA Regions 4 and 6 to develop the 4-H₂O Ambassador Program. This program addresses concepts related to watershed education. The program committee has developed curriculum units, each of which focuses on a specific question related to water quality and watersheds. Each unit includes hands-on activities (e.g., chemical, physical, and biological water analysis). These curriculum units were piloted in fall 2009, spring

2010, and summer 2010 in Kentucky and Georgia. The following curriculum materials were finalized in winter 2010-11 and are available online:

- The Southern Region 4-H₂O Ambassador Program: Unit 1, What Is a Watershed? (4DE-01po)
- The Southern Region 4-H₂O Ambassador Program: Unit 2, What Is Water Quality? (4DE-02po)
- The Southern Region 4-H₂O Ambassador Program: Unit 3, What Impacts the Water Quality in My Watershed? (4DE-03po)
- The Southern Region 4-H₂O Ambassador Program: Unit 4, Improving My Watershed (4DE-04po)

Information about the program, including curriculum materials, is available online at www.ca.uky.edu/enri/4H2O.htm. The program is coordinated by Ashley Osborne, ENRI Extension associate.

Cane Run Watershed Project. The University of Kentucky has led watershed-based planning, monitoring, and educational efforts as part of the Cane Run Watershed Assessment and Restoration Project. This project is coordinated by Steve Higgins and Amanda Gumbert.

Activities in the Cane Run watershed include:

- Continued facilitation of the Cane Run watershed council
- Participation in stream cleanups with The Paddock Apartments
- Removal of invasive species in Lexmark's Shady Brook Park with student volunteers
- Creation of social media outlets to promote the Cane Run watershed (YouTube and Facebook)
- Tours of the Cane Run watershed for the UK Natural Resources Conservation and Management program courses, watershed professional development training for teachers and State/Federal/local agencies
- Coordination with Kentucky Water Resources Research Institute's Water Pioneers program to conduct an educational case study on Cane Run
- Implementation of a watershed-based plan, including the installation of a stream buffer, at the Kentucky Horse Park

- Cooperation with development of the Legacy Trail to install education signs about the Cane Run watershed and related issues
- Acquisition of additional funding for stream-buffer and water-quality research in the Cane Run watershed
- Sponsorship of a watershed festival for community outreach and education

Major Presentations

- 40 Gallon Challenge news segment on Lexington ABC television station WTVQ
- 4-H₂O Ambassador Program, Kentucky Association of Environmental Educators annual conference, September 2010
- 4-H₂O Ambassador Program, National Water Conference, January 2011
- 4-H₂O Ambassador Program, "Water Conservation: Half-Empty or Half-Full?" Regional Webinar Series hosted by Southern Regional Water Program and University of Florida, February 2011

Kentucky Division of Forestry

Forested land provides important benefits to both groundwater and surface water in rural and urban landscapes. Forests absorb rain, trap and filter pollutants, recharge groundwater, slow storm runoff, sustain late-season flows, reduce flooding, maintain watershed stability and resilience, and provide critical habitat for fish and wildlife. Studies show that the percentage of forested land in a source-water area is one of the most important factors in determining water quality. The more forested land in a source area, the better the water quality and lower the treatment costs. Watersheds with less forested land have higher water temperatures and also higher levels of fecal coliform bacteria, turbidity, and nutrients.

Reduction of forest cover increases water yield whereas establishment of forest cover decreases water yield. Water yield is the amount of surface water and groundwater leaving a watershed. On average, removal of 10 percent of forest cover increases water yield by 40 mm in conifers, 25 mm in deciduous hardwoods, and 10 mm in brush and grasslands. Although simply removing forest increases the water yield, placing an impervi-

ous barrier such as pavement, roofing, or exposed rocks from mining further increases these yields.

The Kentucky Statewide Assessment of Forest Resources and Strategy, known as the Kentucky Forest Action Plan, released in June 2010 by the Kentucky Division of Forestry, also revealed that water quality and quantity was the second most important concern of the citizens of the commonwealth, highlighted in a statewide survey of the most important issues facing the state’s forest resources. The division, along with stakeholder input, delineated seven major Forest Priority Areas across the commonwealth in which to focus a collaborative strategy to maintain sustainable forests and improve water quality and quantity (Fig. 2).

The division’s Timber Harvest Compliance Program’s primary objective is to ensure that commercial timber harvesting operations use best management practices to protect water quality from nonpoint-source pollution. This program enforces the minimum performance standards of BMP’s mandated by the Kentucky Agriculture Water Quality Plan.

The division’s Forestry Stewardship Program is also proactively involved with mitigating water-quality concerns by providing technical assistance in practice plans for riparian buffer development under the auspices of the U.S. Department of Agriculture–Natural Resources Conservation Service’s Conservation Reserve Program. Statewide, 32 of

the program’s practice plans were completed, encompassing 850 acres for the fiscal year.

The division is also addressing water quality by promoting the agroforestry concept of strategically incorporating trees into the agricultural landscape, to protect water resources and meet landowner objectives. This integrated watershed approach is very effective in promoting water quality and many times proves economical to the landowner when implemented.

Mitigating stormwater issues is a component of the division’s Urban Forestry Program. The division’s urban forestry specialists are educating community leaders about the many benefits of trees in the urban setting, one of which is phytoremediation or the use of trees to decontaminate soils or water. Urban forestry specialists within the division are also involved in the Cane Run and Wolf Run Watershed Councils, addressing water-quality concerns for those two important urban drainages of the Bluegrass Region.

Four of the five Kentucky Division of Water focus watersheds have division personnel assigned to them, to work collaboratively with local groups in watershed management of the area.

Division of Mine Reclamation and Enforcement

Water samples are collected during the investigation of possible mining-related impacts to groundwater in both the Eastern and Western

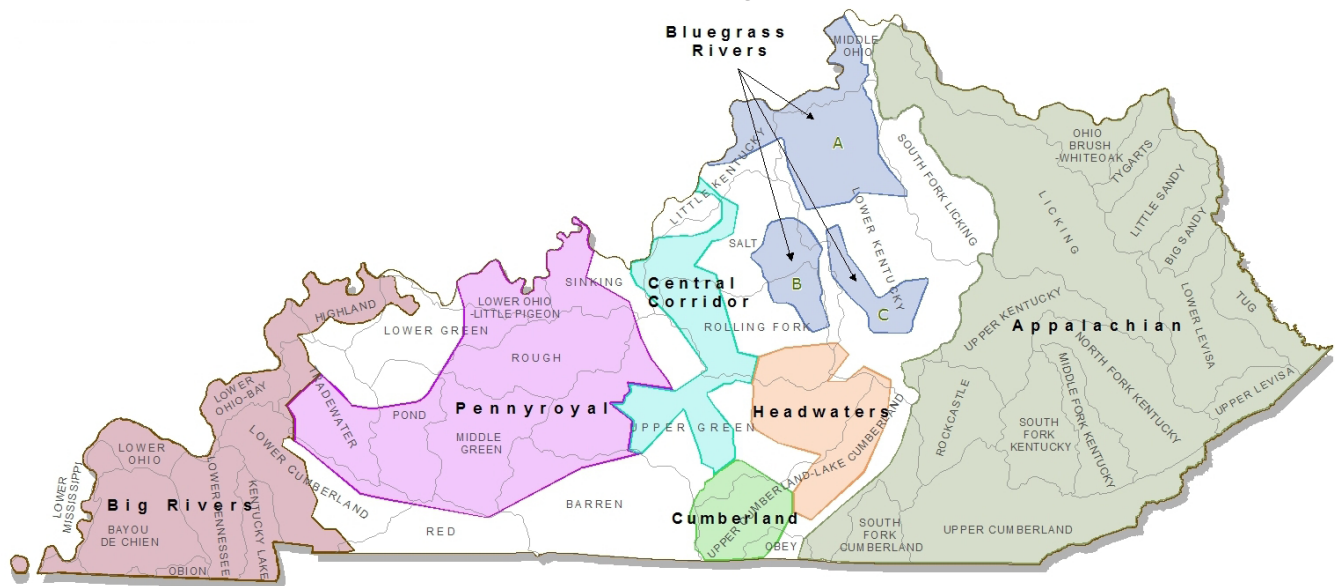


Figure 2. Kentucky forest priority areas and watersheds.

Kentucky Coal Fields. This fiscal year was relatively normal for the Technical Support Section of the Division of Mine Reclamation and Enforcement in terms of the number of investigations conducted. The division received 79 requests for inspection related to mining and water issues, and 89 investigations were closed during the year. Of the investigations closed, 20 were related to diminished quality and nine were related to diminished quantity. In addition, 10 investigations involved groundwater seepage or slide-related issues, and four involved fugitive methane contaminating water wells. The remaining 46 investigations were not related to groundwater.

Five investigations found that groundwater quality or quantity had been adversely affected by mining operations and another five investigations found that mining operations had affected the hydrologic balance, causing seeps or landslides of

varying magnitudes. In addition, four investigations found that mining activities had caused fugitive methane to contaminate water wells, leaving them unusable.

Funding

Most of the activities during the reporting period were investigations of identified or suspected groundwater-quality problems and were possible only because the agencies involved were able to obtain funding from outside sources. As noted in previous annual reports, the availability of these funds is decreasing. A stable source of recurring funding is essential if groundwater issues are to be addressed proactively, which will best serve the needs of citizens, resource managers, and environmental regulators.