

Kentucky Interagency Groundwater Monitoring Network

Annual Report
July 2016–June 2017



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Kentucky Geological Survey
University of Kentucky
Lexington, Kentucky

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On the cover: Left: David Jackson of the Kentucky Division of Water samples Auburn Municipal Spring, also known as the Auburn Bluehole, in Logan County (map number 39 on Figure 2); right: Pirtle Spring (map number 37 on Figure 2), located behind the Hardin County Water District No. 1 Pirtle Spring water treatment plant near Cecilia. Inset shows Scotty Robertson of the Kentucky Division of Water sampling Pirtle Spring from inside the water treatment plant.

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Kentucky Interagency Groundwater Monitoring Network Annual Report July 2016–June 2017

Introduction

Groundwater is vital to Kentucky and its citizens. This natural resource is used extensively across the state for domestic, public, 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 of paramount importance to the commonwealth. To this end, the Kentucky Interagency Groundwater Monitoring Network was established in 1998 by the Kentucky General Assembly through KRS 151.625 to provide a means to characterize and increase knowledge about the commonwealth's groundwater resources. In order to provide oversight for the groundwater monitoring network, the 1998 General Assembly also established an Interagency Technical Advisory Committee through KRS 151.629. This committee was tasked with assisting the Kentucky Geological Survey in the development, coordination, and implementation of the groundwater monitoring network. The following agencies and organizations were asked to appoint a representative to the Interagency Technical Advisory Committee:

- Kentucky Department for Environmental Protection
- Kentucky Department for Natural Resources
- Kentucky Department of Agriculture, Division of Environmental Services
- Kentucky Division of Conservation
- Kentucky Division of Forestry
- Kentucky Division of Public Health Protection and Safety
- Kentucky Division of Waste Management
- Kentucky Division of Water

- University of Kentucky, College of Agriculture, Food and Environment
- University of Kentucky, Kentucky Geological Survey
- University of Kentucky, Kentucky Water Resources Research Institute
- U.S. Geological Survey, Ohio-Kentucky-Indiana Water Science Center.

The participating Network agencies have continued to fulfill their obligation of collecting and providing groundwater-quality and other water-related data throughout the 19 years of the Network's existence. Annual reports summarizing these activities since 1999 are available on the Network website at www.uky.edu/KGS/water/gnet.

From July 2016 through June 2017, more than 33 groundwater investigations and data-collection activities were carried out by ITAC member agencies. Groundwater and related surface-water information was communicated to the scientific and regulatory communities and to the public through various publications and presentations, as well as through postings on websites. Exchange of groundwater data, including electronic transfer of analytical results between Division of Water and Kentucky Geological Survey databases, has continued on a regular basis through close cooperation between the Division of Water and the Kentucky Geological Survey.

2016-17 Activities and Accomplishments

Summaries of water-related projects performed by the ITAC agencies during the 2016-17 State fiscal year are presented below as an indication of how the Network goals are being addressed. Additional information regarding any of these projects can be obtained by contacting the reporting agency.

Groundwater Data Collection

Groundwater data are generated through many avenues. 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.

Below are summaries of projects related primarily to groundwater that were conducted by ITAC member agencies during the 2016-17 fiscal year. Surface-water projects are listed in the "Other Activities" section of this report.

Kentucky Division of Water, Watershed Management Branch, Groundwater Section

The Groundwater Section of the Kentucky Division of Water–Watershed Management Branch maintains an active groundwater sampling and analysis program, and conducts research to address issues related to groundwater quantity, quality, and use. These studies range in scope from statewide to basin management unit scale (Fig. 1).

Table 1 lists the number of sites by physiographic region and basin management unit and Figure 2 shows the locations of the sites within physiographic regions. Table 2 lists the AKGWA numbers (Assembled Kentucky Ground Water; Kentucky Division of Water identification numbers), map numbers, and sampling frequency of the network sites shown in Figure 2. The following program activities were conducted during fiscal year 2016-17.

Ambient Groundwater Monitoring Network. Regularly scheduled sampling continued for the statewide Ambient Groundwater Monitoring Network. This fiscal year, 138 samples were collected from 51 permanent sites (24 wells and 27 springs) across the state, of which 61 were from wells and 77 from springs. Nineteen of these sites are public water suppliers, of which 14 are wells and five are springs (Fig. 3). All groundwater-quality data are uploaded to the Kentucky Groundwater Data Repository and thus made available to the general public. Groundwater-quality data were also provided in response to numerous information requests and used in-house for statistical analysis for regional and watershed-based groundwater assessments.

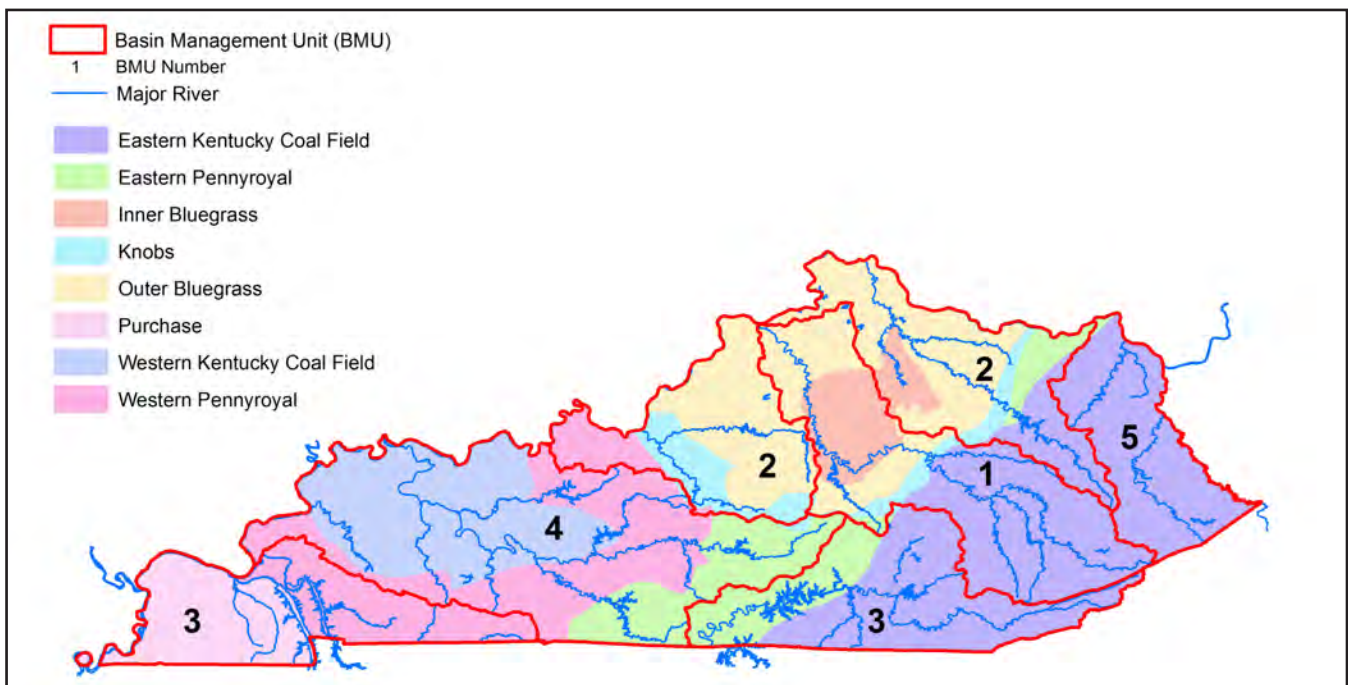


Figure 1. Major rivers, basin management units, and physiographic regions in Kentucky.

Region	Number of Sites	Basin Management Unit	Number of Sites
Bluegrass	11	1—Kentucky River	11
Eastern Kentucky Coal Field	8	2—Salt and Licking Rivers	7
Ohio River alluvium	10	3—Four Rivers, Upper and Lower Cumberland	22
Mississippian Plateau	23	4—Green and Tradewater Rivers	15
Western Kentucky Coal Field	2	5—Big and Little Sandy Rivers and Tygarts Creek	5
Jackson Purchase	6		

The Groundwater Section continues to work with the Kentucky Geological Survey to develop a water-level monitoring and flow-measurement network. Groundwater Section personnel coordinated a meeting with KGS and Hardin County District No. 1 to collect groundwater flow data from the Head of Rough Spring in Hardin County.

Pesticides Memorandum of Agreement. The Pesticide MOA with the Kentucky Department of Agriculture funds sampling at four permanent

sites (three springs and one well) in western Kentucky. Each site was sampled quarterly for a total of 16 samples during the fiscal year. Pesticide data from these sites are submitted to the Department of Agriculture annually.

Complaint and Technical Assistance Sampling. Groundwater Section personnel respond to complaints and requests for technical assistance about groundwater, and investigate as requested by the general public, industry, and other government

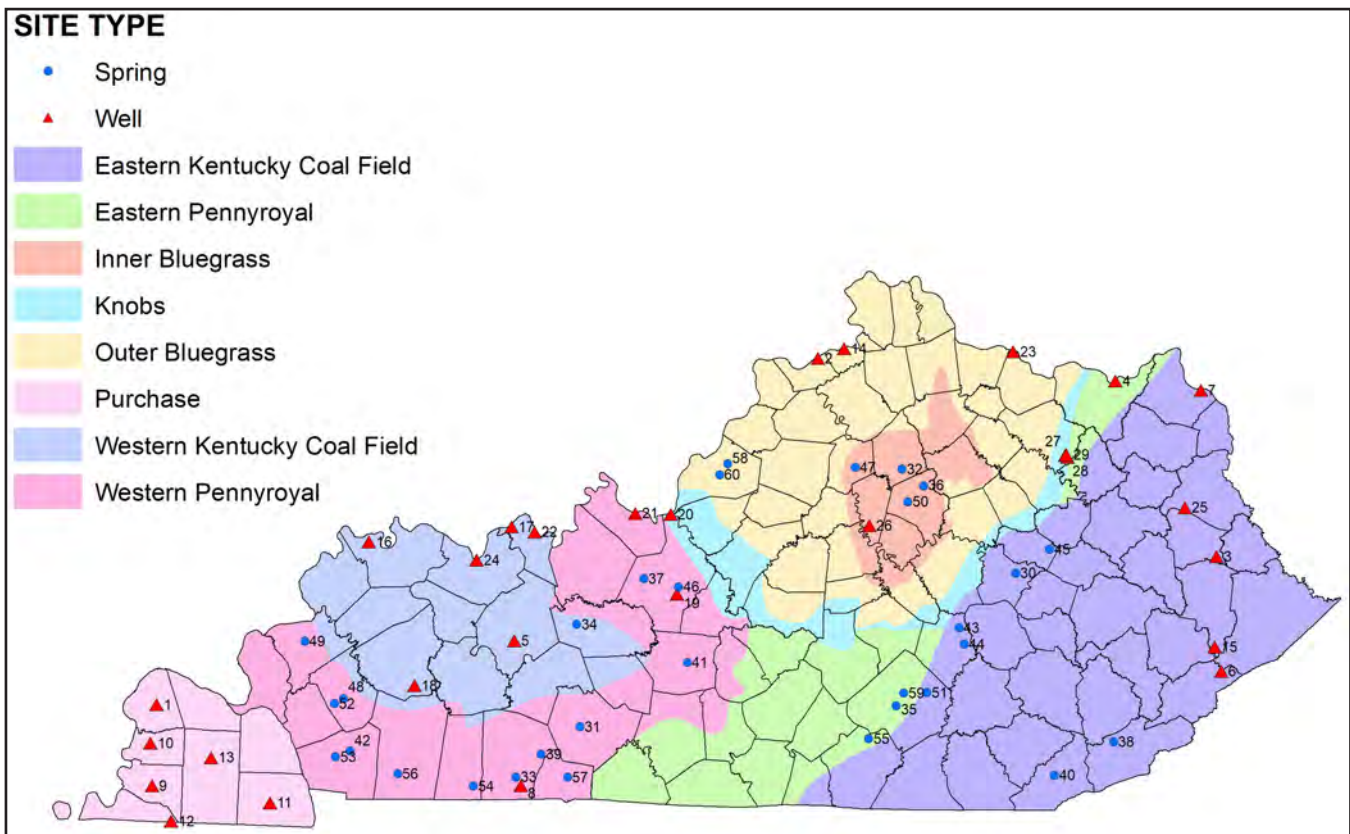


Figure 2. Interagency Groundwater Monitoring Network sites maintained by the Kentucky Division of Water. Table 2 gives map numbers, Division of Water’s AKGWA numbers, and sampling frequency for these sites.

Table 2. AKGWA numbers and sampling frequency for the network sites shown in Figure 2. AKGWA numbers can be located using the Kentucky Groundwater Data Repository website. Q=quarterly. M=monthly. 5Q=every fifth quarter. 2Q=every second quarter. Pest. MOA=Pesticides Memorandum of Agreement. AKGWA numbers starting with “0” are water wells, starting with “8” are monitoring wells, and starting with “9” are springs. Sample times vary.

Map No.	AKGWA No.	Sample Frequency	Map No.	AKGWA No.	Sample Frequency	Map No.	AKGWA No.	Sample Frequency
1	00000811	5Q	21	00061854	Q	41	90000798	M
2	00007133	5Q	22	00061858	Q	42	90000854	2Q
3	00012311	Q	23	00065002	Q	43	90001020	Q
4	00014293	2Q	24	00065149	Q	44	90001051	5Q
5	00019489	5Q	25	00068511	Q	45	90001134	Q
6	00028100	5Q	26	00069574	Q	46	90001137	Q
7	00029505	2Q	27	80046811	2Q	47	90001143	M
8	00029983	Pest. MOA	28	80046812	2Q	48	90001145	2Q
9	00033887	5Q	29	80046813	2Q	49	90001149	2Q
10	00033904	5Q	30	90000045	Q	50	90001161	Q
11	00033965	5Q	31	90000054	Q	51	90001254	5Q
12	00033972	5Q	32	90000055	M	52	90001343	2Q
13	00037330	5Q	33	90000315	Pest. MOA	53	90001344	2Q
14	00037376	5Q	34	90000456	5Q	54	90001475	Pest. MOA
15	00039374	5Q	35	90000544	5Q	55	90001822	Q
16	00040944	Q	36	90000552	Q	56	90001857	Q
17	00041471	Q	37	90000702	Q	57	90002823	Pest. MOA
18	00042984	Q	38	90000703	Q	58	90002934	Q
19	00043253	5Q	39	90000705	M	59	90003064	5Q
20	00049097	Q	40	90000710	5Q	60	90003355	Q



Figure 3. Kentucky Division of Water–Groundwater Section supervisor David Jackson samples in Auburn Spring as part of the Ambient Groundwater Monitoring Network project.

agencies. In fiscal year 2016-17, the Groundwater Section responded to 24 complaints and requests for technical assistance, resulting in 30 samples being collected from 14 wells and five springs. When samples are not collected, recipients are often provided with technical assistance and their domestic water source is inspected. The Groundwater Section also assisted several county health departments with 15 dye-trace studies to determine subsurface hydraulic connections to failing onsite septic systems.

Nonpoint-Source Groundwater Assessments. The Groundwater Section is currently participating in three nonpoint-source studies. These projects are in various stages, from review of the final report to area reconnaissance and site selection.

Statewide Pathogens Study. This study determines the occurrence of pathogens in groundwater, particularly in wells and springs providing domestic water supplies. A total of 210 sites – 202 wells and eight springs – across Kentucky were sampled for total coliform, *E. coli*, iron-related, sulfate-reducing, and slime-forming bacteria, as well as caffeine. Results indicate that the presence of bacteria correlates with the type of well construction and maintenance practices. A secondary goal of sample collection was to educate well owners about proper maintenance and disinfection practices. A report is under administrative review and is expected to be completed by Dec. 31, 2017.

South-Central Karst Study. This study has expanded karst groundwater mapping south of Lake Cumberland. The study area covers parts of Pulaski, Clinton, Wayne, and McCreary Counties. Current work is focused on groundwater dye tracing and delineation of karst basins. Thus far, 48 tracer tests have been recovered at 40 springs; 10 tracer tests were conducted in the 2016-17 fiscal year. Further delineation of spring basins is needed, after which large spring monitoring sites will be selected. The project will use an integrated approach for surface-water and groundwater assessment. Sixteen springs, mainly from the South-Central Karst Study area, were also inventoried during the 2016-17 fiscal year.

Onsite Sewage Disposal Systems and Their Potential Effects on Groundwater. This project will evaluate potential impacts of home septic systems on groundwater. The literature-review stage has been completed, and site selection and evaluation are continuing. Seven sites have already been evaluated, and some initial water-quality sampling has been conducted.

Special Projects. During fiscal year 2016-17, the Groundwater Section and Louisville Metropolitan Sewer District collaborated on an investigation to determine the source of contamination at a spring near Interstate 64. To date, the investigation has led to an old spent carbide landfill that is no longer in use (Fig. 4). Dye tracing was used to establish connections between the landfill and the I-64 spring. The site has been referred to the state Superfund Section for assessment and remedial action.

The Groundwater Section is partnering with the U.S. Environmental Protection Agency, U.S. Geological Survey, and Northern Kentucky Sanitation District to develop a pilot study for the injection of stormwater into the Ohio River alluvium near the cities of Bellevue, Covington, and Ludlow (Fig. 5). The study is in response to the sanitation district's consent decree to develop measures to reduce the number of sanitary sewer bypasses to the environment during storms. To date, test wells have been installed, pump and injection tests have been conducted, and the initial sampling and



Figure 4. Contamination from a spent carbide landfill near I-64 flowing into Beargrass Creek.



Figure 5. From left: Mike Unthank (U.S. Geological Survey), Craig Frye (Northern Kentucky Sanitation District), Scotty Robertson (Division of Water), Catherine Fargen (U.S. Geological Survey), and Brooke Shireman (Northern Kentucky Sanitation District) inspect the test well at the Bellevue site.

characterization of “first flush” stormwater has been completed.

Groundwater Protection Plan Program. The program’s focus continues to be on public outreach and education about activities that can threaten groundwater. Emphasis has been placed on offering onsite technical assistance to facilities and the public to identify best management practices needed to protect the groundwater from activities that could result in contamination. Many different activities conducted by individuals and companies throughout Kentucky require groundwater protection plans, but most inspections thus far have been limited to industrial sites that store large quantities of chemicals or fuel. Table 3 outlines protection plans that have been received, reviewed, and approved, and gives the number of field reviews completed by month for fiscal year 2016-17.

<i>Month and Year</i>	<i>Number Received</i>	<i>Number Reviewed</i>	<i>Number Approved</i>	<i>Field Reviews</i>
July 2016	4	8	4	0
Aug. 2016	12	8	3	11
Sept. 2016	5	4	3	11
Oct. 2016	3	11	4	6
Nov. 2016	6	5	2	0
Dec. 2016	7	6	4	8
Jan. 2017	10	4	0	3
Feb. 2017	8	7	5	0
March 2017	19	4	3	2
April 2017	10	8	2	9
May 2017	3	8	3	13
June 2017	15	21	16	0
Totals	102	94	49	63

Certified Well Drillers Program. The number of domestic wells in use in Kentucky remains consistent with previous years. The Eastern Kentucky Coal Field and Jackson Purchase Region continue to have the greatest percentage of households that rely on domestic wells as their primary source for drinking water. In the 2016-17 fiscal year, 469 wells were drilled and reported to the Division of Water. Plugging records were submitted for 963 decommissioned wells.

The Groundwater Section issued licenses to 177 certified well drillers: 40 water-well drillers, 78 monitoring-well drillers, and 59 dual-licensed drillers. This represents a 17 percent increase in the total number of licenses issued compared to the last fiscal year. The license renewal period continues beyond the end of the current reporting period, so this may not be a full accounting of the number of certified drillers licensed in Kentucky.

Groundwater Section personnel are an integral part of the Kentucky Groundwater Association’s Annual Drillers’ Tradeshow and Workshop in Louisville. Section personnel gave presentations on the need for groundwater protection plans, and also organized a roundtable discussion on the needs of certified well drillers licensed in Kentucky. Approximately 100 drillers received their required annual continuing education credits needed for licensure in Kentucky.

Section personnel instituted new procedures and protocols for installation and abandonment of dewatering wells that are part of the decommissioning of coal-combustion residual fly-ash impoundments. The new protocols developed variances to construction, installation, and abandonment procedures at the fly-ash impoundments, as required by Kentucky Administrative Regulation 401 KAR 6:350. The variance approval greatly streamlined the process of installing and abandoning more than 4,000 dewatering wells while maintaining protections to the groundwater.

The Groundwater Section continues to explore ways of increasing the public’s groundwater awareness and providing education on groundwater issues that may affect them. In fiscal year 2016-17, Section personnel collaborated with the University of Kentucky’s College of Agriculture, Food and Environment to produce a YouTube video, “Abandoned Wells – A Guide for Kentucky

Landowners.” The video may be seen on the Kentucky Well Education website (water.ca.uky.edu/downwell).

U.S. Geological Survey

USGS Climate Response Network. The U.S. Geological Survey, as directed by Congress, is establishing a national climate-response network of groundwater wells. Each climate division in the country is to have at least one real-time monitoring well in a climate-responsive aquifer that is not affected by groundwater withdrawals or interactions with nearby surface water. Kentucky has one climate-response network well in each of its four climate divisions. The wells are in Graves,



Figure 6. The air-lift method (using compressed air to surge the well water to clean out the well-casing screen) was used to redevelop the USGS Climate Response Network well in Graves County. A USGS video describing this procedure can be seen at www.usgs.gov/center-news/usgs-groundwater-monitoring-well-redevelopment-using-air-lift-method.

Larue, Fayette, and Bell Counties (Figs. 6–7). Data from these wells, compiled by the USGS’s Ohio-Kentucky-Indiana Water Science Center, describe the natural variability in groundwater levels attributable to weather and climate. These data are available to the public through websites operated by the USGS (waterdata.usgs.gov/ky/nwis/current/?type=gw) and the USGS Climate Response Network (groundwaterwatch.usgs.gov).

Monitoring of Groundwater Resources of the Northeast Portion of the Ohio River Alluvial Aquifer, Near Louisville, Jefferson County. The USGS, in cooperation with the Louisville Water Co., monitors groundwater levels in the northeastern part of the alluvial aquifer near Louisville, in Jefferson County (Fig. 8). Tasks and field activities are designed to improve understanding of the various aspects of groundwater and surface-water interaction, especially riverbank infiltration.



Figure 7. USGS Hydrologic Technician Jason Thomas interprets borehole camera imagery for landowners at a Climate Response Network well in Larue County.



Figure 8. U.S. Geological Survey hydrologist Mike Unthank uses a steel tape to measure the depth to groundwater in a well belonging to the Louisville Water Co.

Specifically, the program compiles groundwater-level data and infiltration rates for the water company's riverbank filtration system and compares them with previous years' data, monitors groundwater quality to ensure proper wellhead protection planning, evaluates groundwater-level data to estimate the contributing areas to the riverbank filtration system, and develops groundwater flow-modeling capabilities.

West Point Well Field Monitoring, Hardin and Meade Counties. Water treatment facilities at Fort Knox receive source water from drinking-water supply wells located along the Ohio River near West Point. The alluvial deposits in this area are typically 100 feet thick and are underlain by bedrock formations known to contain natural gas and high chloride concentrations. Previous investigations by the USGS and the U.S. Army have determined that improperly abandoned gas wells have provided a means for brines, under pressure within the underlying bedrock, to migrate upward and contaminate the groundwater in the alluvial deposits.

The USGS is collecting data in the well field to monitor groundwater conditions (Fig. 9). These activities include measurement of water levels and chloride concentrations in groundwater, surveillance of active and abandoned gas wells, periodic geophysical surveys to track the size and move-



Figure 9. A public water-supply well near the Ohio River in west-central Kentucky.

ment of chloride plumes, and computer simulations of groundwater flow for wellhead protection management strategies.

Groundwater Monitoring and Aquifer Testing of the Alluvial Deposits in Boone, Campbell, and Kenton Counties. The USGS continues to work in cooperation with the Northern Kentucky Sanitation District as the District evaluates the feasibility of injecting stormwater infiltration into the area's alluvial deposits. Three pilot sites (Ludlow, Bellevue, and Covington) were selected for evaluation. One test well was installed at each site for the purpose of gathering groundwater-level data and aquifer testing. The USGS conducted a series of pumping and injection tests at each pilot site to provide data that will be used to evaluate the injection capacity of the alluvial deposits, which will factor into the design of a proposed stormwater injection system.

The USGS maintains a network of four groundwater observation wells in the alluvial deposits in northern Kentucky near Covington. Data on groundwater levels and temperature are continuously collected in three of the wells, and water-level measurements are collected quarterly for the fourth well.

Identifying Groundwater/Surface-Water Interactions in Nolin River Lake, Bee Spring, Kentucky. In cooperation with the U.S. Army Corps of Engineers, the U.S. Geological Survey is investigating potential groundwater inflows to Nolin River Lake. Previous studies have indicated that these inflows

may be a substantial source of nutrients to the lake. Nutrients can fuel biological productivity, which can result in harmful algal blooms and limit some uses of the lake. Karst features and fault zones may provide preferential pathways for groundwater to reach the lake. This study is examining historic data and using integrated synoptic water-quality surveys to identify groundwater inflows. The integrated synoptic surveys include discrete-depth measurements of water-quality properties from a manned boat and from an autonomous underwater vehicle.

Establishing an Updated, Modern GIS-Based Web Mapping Application for Groundwater and Surface-Water Hazards and Spill-Response Mitigation in and Adjacent to Mammoth Cave National Park. The U.S. Geological Survey, in cooperation with the National Park Service, is developing a web-based mapping application to help emergency responders determine the flow path that a spill along Interstate 65, the Cumberland Parkway, or the CSX railroad might follow in the vicinity of Mammoth Cave National Park. Possible pathways for the spill include overland flow in the vicinity of those transportation corridors, underground karst conduits, and perennial streams. Multiple conduit pathways are possible and are identified by the tool. Roadway infrastructure, including drop boxes and culverts that alter natural drainage, are noted. Responders can identify the spill site by using a virtual pindrop feature on a map or by entering the latitude and longitude or UTM coordinate in the web application.

Monitoring Groundwater Levels for a U.S. Army Corps of Engineers Earthen Dam Restoration Project at Rough River Lake, Breckinridge and Grayson Counties. The Louisville District of the U.S. Army Corps of Engineers is rehabilitating a large-scale earthen dam at Rough River Lake in Breckinridge and Grayson Counties. As part of the effort to track the progress of the restoration, the USGS monitors groundwater levels in 46 piezometers equipped with continuously recording pressure transducers. Changes in pressures are also monitored with vibrating-wire transducers grouted in place at 60 sites throughout the dam (Fig. 10). The Corps uses these data to determine



Figure 10. Contractors for the U.S. Army Corps of Engineers install vibrating-wire transducers on the downstream side of the Rough River Dam. The USGS monitors the transducers in cooperation with the Corps.

priorities for repair and to monitor groundwater-level changes related to construction activities.

Kentucky Department of Agriculture

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

Kentucky Geological Survey, Water Resources Section

The Water Resources Section conducts research vital to the development, management, and protection of the commonwealth's groundwater and surface-water resources. Hydrogeologic information and other water-related data compiled

by KGS help meet the needs of State and federal public health and environmental protection agencies, public water suppliers, agriculture and industry, consulting geologists and engineers, and the general public. The Water Resources Section is charged by legislative mandate with managing the state's official repository for groundwater information (KRS 151.035) and overseeing establishment of a long-term groundwater monitoring network (KRS 151.625). Section staff also contribute to the educational mission of the University of Kentucky by interacting and collaborating with faculty and students.

During fiscal year 2016-17, the Water Resources Section investigated groundwater availability, characterized aquifers, monitored groundwater levels, assessed groundwater or surface-water quality, enhanced sinkhole mapping using high-resolution LiDAR data, and monitored discharges from karst springs.

Evaluation of Groundwater Availability at the University of Kentucky Research and Education Center Farm, Princeton. In February 2017, KGS began an investigation of groundwater availability at the University of Kentucky Research and Education Center in Princeton.

The objectives of the study are to identify the best potential locations for drilling one or more irrigation wells and to determine whether groundwater withdrawn from the local limestone aquifer will be capable of supplying enough water for planned agricultural research at the UK Grain and Forage Center of Excellence. Various investigative methods are being employed at the 255-acre row-crop field at the Center. KGS hydrogeologists performed aquifer tests on an unused domestic well (Fig. 11) and at three irrigation wells on the farm. Electrical-resistivity surveys were conducted along five transects to attempt to identify high-permeability or water-bearing zones in the bedrock. Three dye-trace tests were initiated from sinkholes on

the farm to determine local groundwater flow directions. Additional investigations, such as drilling a new test well, are planned and are likely to be conducted during the fall of 2017.

Hydrostratigraphy of the Claiborne Aquifer System. Work continued to improve the delineation and mapping of aquifers and confining zones in the Claiborne aquifer system in the Jackson Purchase Region. Detailed cross sections of these hydrostratigraphic units in Fulton, Hickman, Graves, Carlisle, and Ballard Counties have been constructed using geophysical logs from lignite boreholes collected by the Phillips Coal Co. in the mid-1970s and recent gamma-ray logs collected from selected water wells in the area. Hydrostratigraphic tops and bottoms—the upper and lower elevations of aquifer and confining zone boundaries derived for these cross sections—are being used by a graduate student in the University of Kentucky Department of Earth and Environmental Sciences to create a groundwater flow model for the Obion Creek and Bayou de Chien watersheds in Hickman and Fulton Counties. The student has worked with KGS personnel for more than a year collecting water-level



Figure 11. An aquifer test being conducted by KGS Water Resources Section scientists on an unused water well (located inside the concrete blockhouse) at the University of Kentucky Education and Research Center in Princeton.

measurements and other hydrologic data needed to calibrate the groundwater flow model.

Edge-of-Field Water-Quality Monitoring and Monitoring Soil Moisture and Groundwater Conditions in Western Kentucky. A KGS hydrogeologist began a multiyear collaboration with the University of Kentucky Cooperative Extension Service and other researchers from the UK College of Agriculture, Food and Environment on an edge-of-field surface runoff water-quality project and a soil moisture under-irrigation project. The edge-of-field project has received partial funding from the Kentucky Soybean Board, and additional funding from the U.S. Department of Agriculture's Natural Resources Conservation Service is anticipated in the fall of 2017. Installation of field instruments and sampling of surface runoff should also begin at that time. The goal of the edge-of-field project is to determine the nutrient and sediment loss from active row-crop fields with different nitrogen application methods and cover crops. A new employee of the UK Department of Plant and Soil Sciences who is stationed at the KGS Western Office in Henderson will be assisting. The project should run through 2029.

Soil-moisture and groundwater-level measurements are being collected at an agricultural site in Hickman County to investigate the potential influence that withdrawals from an irrigation well have on local groundwater conditions during a typical agricultural season. Groundwater-level measurements began in January 2017, prior to planting, and should continue through 2017. Groundwater-withdrawal measurements began in May 2017 and should continue through the growing season. Soil-moisture sensors will be installed in the row-crop field, and soil-moisture data collection began in July and will continue through the growing season. The soil-moisture data will be used to evaluate the soil-moisture conditions of a fragipan soil (a hardened soil that acts as an impermeable barrier) under different slope positions and to develop recommendations for sensor placement for producers.

Karst Spring Investigation at The Homeplace on Green River Farm. During the fall of 2016, Water Resources staff began investigating the hydrogeology of a karst spring at The Homeplace

on Green River Farm, near Campbellsville. The project is the first phase of a larger planned effort entitled "Adapting Edge-of-Field Monitoring for Water-Quality and Soil-Health Assessments in Sinkhole-Dominated Crop Fields" and is funded by a Conservation Innovation Grant from the U.S. Department of Agriculture's Natural Resources Conservation Service. Water from the spring discharges from a cave at the head of a steep ravine (Fig. 12). A flume and stilling well were installed in June 2017 by Water Resources Section staff to begin continuous monitoring of the discharge from the spring. A multiparameter water-quality data sonde (stainless steel cylindrical monitoring device) has been purchased and will be installed in the fall of 2017 to continuously monitor changes in pH, specific conductance, temperature, and turbidity. A tipping-bucket rain gage was also installed at the farm. Additional work conducted at the ap-



Figure 12. This karst spring at The Homeplace on Green River, near Campbellsville, is the focus of a comprehensive investigation being conducted by staff of the Water Resources Section.

proximately 22-square-mile study area will map sinkholes, surface-runoff routes, and catchment boundaries using a high-resolution LiDAR database, and a series of electrical-resistivity surveys will be run in an attempt to identify the locations of subsurface conduits beneath the farm's primary cropped field (Fig. 13). Dye-trace tests will be conducted late in 2017 and in 2018 to delineate karst flow paths and to determine the approximate boundaries of the spring's recharge area. All of these methods will contribute information needed to understand the spring's surface and subsurface hydrology and enable better planning and execution of anticipated water-quality sampling.



Figure 13. Hydrogeologists from KGS lay out electrodes and cables needed to conduct an electrical-resistivity survey to search for underground conduits containing groundwater at the farm at The Homeplace on Green River, near Campbellsville.

Head of Rough Spring Discharge Monitoring. In December 2016, KGS began a collaboration with the Hardin County Water District to construct and maintain a station to continuously monitor discharge and water quality at Head of Rough Spring near Cecilia (Fig. 14). The project is funded by the Kentucky Division of Water through a Source Water Protection Assistance Program grant. Water-level measurements and water-quality data are being automatically collected at 30-minute intervals and uploaded to a cloud-based webserver by satellite telemetry every 4 hours; this will allow daily tracking of the variability in spring-flow and water-quality parameters such as turbidity



Figure 14. Water Resources Section hydrogeologist Steve Webb installs water-quality and water-level monitoring equipment at the Head of Rough Spring monitoring station in Hardin County.

and specific conductance (Fig. 15). Field data are also being collected to enable development of a preliminary stage-discharge-rating curve for the station, and to assess changes in total suspended solids concentrations.

Enhanced Sinkhole Mapping Using LiDAR Data. Water Resources personnel are using newly available LiDAR data to improve digital maps of sinkhole occurrence in selected parts of Kentucky (Fig. 16). During the summer of 2017, Water Resources staff and two student workers from the UK Department of Earth and Environmental Sciences were able to extend sinkhole mapping to Woodford, Boyle, and Jessamine Counties. At present, approximately 6,200 possible sinkholes have been identified in these three counties, and the team is reviewing the data and verifying results in the field. In addition, Water Resources staff are collaborating with Florida State University and UK Department

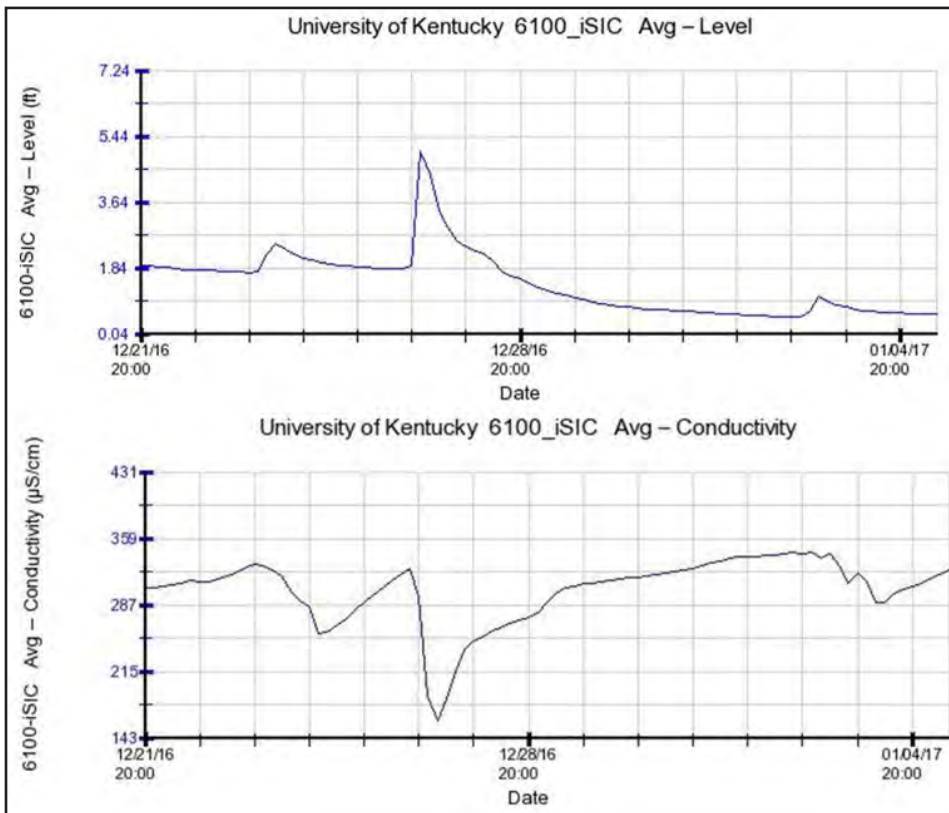


Figure 15. Example plots show variability in water level (top) and specific conductance (bottom) being monitored at Head of Rough Spring, in Hardin County.

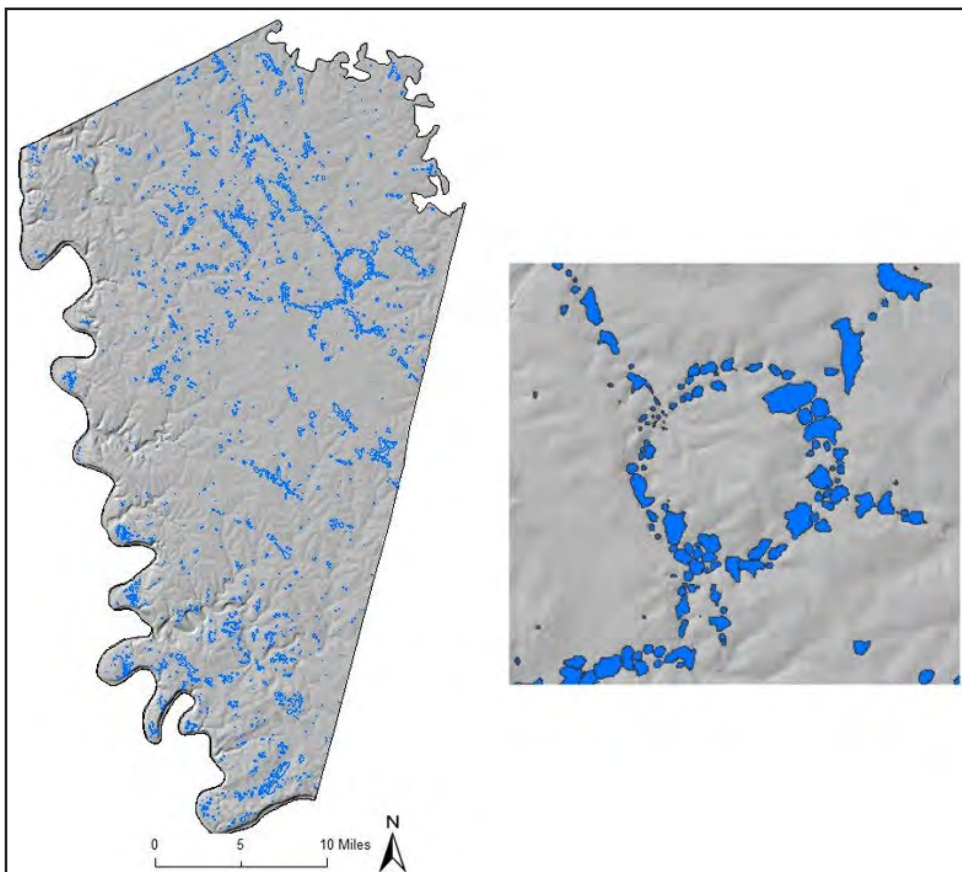


Figure 16. Probable sinkholes digitally mapped in Woodford County by KGS Water Resources Section staff using high-resolution LiDAR data. Inset shows how sinkholes delineate the shape and geographic extent of the Versailles cryptoexplosive structure, commonly interpreted to be the site of a meteorite impact.

of Computer Science personnel to develop and test a variety of machine-learning methods to improve computer-automated methods of sinkhole identification and mapping.

Drinking-Water Corrosivity Study. Working in collaboration with UK Department of Earth and Environmental Sciences staff and students, a Water Resources hydrogeologist is studying the quality of the Lexington-Fayette County public water supply to assess potential corrosion. This study is in response to the highly publicized water crisis in Flint, Mich., and is supported by the U.S. Geological Survey through the Kentucky Water Resources Research Institute at UK. In March 2017, 12 tap-water and source-water samples from throughout Lexington were collected and analyzed. A second round of sampling was conducted in September 2017. The objectives of the project are to collect baseline information about tap-water quality in Lexington, and assess the water's potential for corrosion and its relation to concentrations of metals. The study should also provide insight into whether the concentration of dissolved metals such as iron and copper increases in tap water with increased pipe distance.

Assessing Methane in Shallow Groundwater for the Berea Sandstone and Rogersville Shale Play Area, Eastern Kentucky. In early 2016, the Water Resources Section worked on a project funded by the U.S. Department of Energy in collaboration with GSI Environmental of Austin, Texas, to collect and analyze samples from 51 domestic water wells in Greenup, Carter, Boyd, Lawrence, Johnson, and Elliott Counties. Samples were analyzed for major cations and anions, metals, and dissolved light hydrocarbon gases including methane. A detailed analysis of these data conducted during fiscal year 2016-17 determined that groundwater from 26 of the wells (approximately 50 percent) contained methane in concentrations greater than 1 milligram per liter. Samples from these wells were further analyzed for carbon and hydrogen isotopes to identify potential sources of the methane. The isotope data indicate that the methane in all but two of the wells is derived from microbial activity in the shallow groundwater and not from upward migration of oil or natural gas from deeper source rocks. A peer-reviewed paper that summarizes

this research has been prepared and accepted for publication in the journal *Groundwater* in late 2017.

Collaboration With Kentucky Division of Water Groundwater Sampling Program. The Kentucky Division of Water is responsible for sampling about 60 sites (both wells and springs) across Kentucky that comprise the Interagency Groundwater Monitoring Network (www.uky.edu/KGS/water/gnet). Most samples are collected quarterly or twice a year by Division of Water personnel on 12 different sampling runs across the state. KGS assists the Division of Water in sampling three sites that are part of the north-central sampling run: McConnell Spring and Russell Cave Spring in Fayette County, and Royal Spring in Scott County. The Environmental Services Branch Laboratory in Frankfort analyzes the samples, and the resulting groundwater-quality data are uploaded into the Kentucky Groundwater Data Repository.

Kentucky Groundwater Observation Network. Water Resources staff are working to establish an observation-well network to monitor groundwater levels in the commonwealth's critical aquifers and help assess groundwater availability throughout the state. At present, 10 wells are equipped with automated equipment that measures water level at 15- to 30-minute intervals. These wells include two at the Kentucky Horse Park in Scott County, one at Mammoth Cave National Park in Edmonson County, and one well each in Calloway, Henderson, Hickman, and Marshall Counties. One new observation well, an unused domestic well on the University of Kentucky Research and Education Center property at Princeton, was added to the network in January 2017. A second observation well at Mammoth Cave National Park should be added to the network in late 2017, and the suitability of additional wells in parts of south-central and eastern Kentucky for long-term monitoring is being evaluated. Water-level data collected continuously from these wells will help KGS assess seasonal changes in groundwater availability and identify the onset and severity of hydrologic droughts and their potential impacts to groundwater and surface-water resources. A webpage being designed to provide public access to Network well hydrographs and other data should be accessible in the fall of 2017.

Kentucky Groundwater Data Repository. The Repository contains well-construction and water-quality sampling data for more than 103,000 sites across Kentucky. Included are data from more than 57,000 domestic, public, industrial, and agricultural wells; nearly 41,000 monitoring wells; and more than 5,300 springs. Hundreds to thousands of reported analytical sampling results are available for many of these wells and springs. Since the Repository's inception in 1990, data have been compiled from more than 15 agencies, including the Kentucky Geological Survey. The largest annual contributions come from the Kentucky Division of Water, and data compiled by the Division's Certified Well Drillers Program and the Interagency Groundwater Monitoring Network are transferred to KGS for uploading to the Repository approximately once every quarter. Scanned copies of water-well drillers' logs are uploaded approximately every 6 months. All available data for wells and springs are publicly accessible from the Repository webpage (www.uky.edu/KGS/water/research/gwreposit.htm) and can be searched, downloaded, and displayed online using various base maps. Users can generate comprehensive hydrologic site assessments for multiple applications, including groundwater resource exploration, environmental monitoring and remediation, land-use development, recreation, and agricultural planning, by pairing the Repository data with digital geologic information.

KGS Laboratory Activities. The KGS laboratory supports geologic and scientific research for KGS and University of Kentucky researchers. The lab does this in several ways: Water, coal, and mineral samples are analyzed and characterized, and analysis techniques and instrumentation are taught to students and faculty from many UK departments. The KGS laboratory also houses and maintains a University-shared X-ray diffraction instrument.

Among the recent and ongoing projects utilizing the laboratory to analyze water samples are the Head of Rough and The Homeplace karst-spring monitoring projects, the Lexington Drinking-Water Corrosivity Study, several hydrogeology thesis projects by students from the UK Department of Earth and Environmental Sciences, and a study of nutrients and carbon loads in the Cane Run basin

by a doctoral student from the UK Department of Civil Engineering. The laboratory analyzes samples collected periodically from the Kentucky River as part of the Kentucky River Watershed Watch program, as well as samples submitted occasionally for student research projects sponsored by the Tracy Farmer Institute for Sustainability and the Kentucky Water Resources Research Institute.

Kentucky Division of Mine Reclamation and Enforcement

The Field Support Section of the Division of Mine Reclamation and Enforcement investigates groundwater at the request of citizens of the commonwealth. The investigations may be a result of diminished quality or quantity of water. In addition, the Division investigates surface water in connection with diminished quality, stream loss, or flooding. Investigations are also conducted as a result of landslides, methane migration, or other problems related to coal mining in the Eastern and Western Kentucky Coal Fields.

Distribution of Groundwater Information

One of the most important functions of the Interagency Technical Advisory Committee and 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 2016-17 fiscal year, groundwater information was communicated via short reports, oral and poster presentations at meetings and conferences, and posting on websites. Publications and presentations generated by ITAC agency members or affiliated personnel are listed below.

Publications

Robertson, S.E., 2017, Report of survey conducted at roundtable discussion held at Kentucky Groundwater Association Annual Tradeshow and Workshop: Kentucky Division of Water, 34 p.

Davidson, B., comp., 2016, Kentucky Interagency Groundwater Monitoring Network annual report, July 2015–June 2016: Kentucky Geological Survey, 15 p.

Zhu, J., Parris, T., Taylor, C., Webb, S., Davidson, B., Smath, R., Richardson, S., Molofsky, L., Kromann, J., and Smith, A., 2017, Assessing methane in shallow groundwater in unconventional oil and gas play areas, eastern Kentucky: Groundwater, doi:10.1111/gwat.12583.

Presentations

- Beck, E.G., 2016, Applying a synergistic approach to groundwater monitoring: Examples from the Jackson Purchase area: Kentucky Agriculture Science and Monitoring Committee executive meeting, Bowling Green, Ky., Oct. 27, 2016.
- Beck, E.G., 2017, Groundwater used for irrigation in western Kentucky: On-farm ag water tools for conservation: National Resources Conservation Service Technical Committee meeting, Lexington, Ky., March 30, 2017.
- Beck, E.G., 2017, Hydrogeologic research in the Jackson Purchase: Status report: Kentucky Geological Survey Advisory Board meeting, Lexington, Ky., April 21, 2017.
- Beck, E.G., 2017, Hydrogeological research in the Jackson Purchase: Great Rivers Sierra Club meeting, Murray, Ky., June 7, 2017.
- Beck, E.G., 2017, Improved hydrostratigraphic mapping of the Claiborne aquifer system in the southwestern portion of the Jackson Purchase: Kentucky Geological Survey annual seminar, Lexington, Ky., May 19, 2017.
- Beck, E.G., 2017, Kentucky Geological Survey, high-yield agricultural irrigation wells, and western Kentucky hydrogeology: Kentucky Rural Water Association, Water and Wastewater Operator Training, Henderson, Ky., Jan. 25, 2017.
- Beck, E.G., Zhu, J., Currens, J.C., Williams, D., Webb, S., Bleichroth-King, A., and Taylor, C., 2017, Investigation of groundwater availability for irrigation at the UK Research and Education Center at Princeton, Kentucky: Kentucky Geological Survey annual seminar, Lexington, Ky., May 19, 2017.
- Blair, R., 2017, Kentucky's Source Water Protection Program: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Currens, J.C., 2017, The Pleasant Grove Spring nonpoint source pollution study: An under-used data set: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Currens, J.C., 2017, Potential mechanism contributing to the development of cover collapse in Kentucky: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Davidson, B., Webb, S., Smath, R., and Zhu, J., 2017, Overview of groundwater sampling conducted in an unconventional oil and gas play area of eastern Kentucky [poster]: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Husic, A., Fox, J., Ford, W., Agouridis, C., Currens, J.C., and Taylor, C.J., 2017, Sediment nitrogen and nitrate dynamics of a fluviokarst system in the Bluegrass Region: Isotopic and numerical modeling investigation: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Lee, B., and Beck, E.G., 2016, Addressing clientele needs: Recent increased installation of irrigation wells in western Kentucky: 71st Soil and Water Conservation Society International annual conference, Louisville, Ky., July 24–27, 2016.
- Malette, S.L., 2017, Introduction to groundwater protection plans for water well drillers: Kentucky Groundwater Association Annual Drillers' Tradeshow and Workshop, Louisville, Ky., March 2, 2017.
- Merrick, J., Beck, E.G., and Fryar, A., 2017, Numerical modeling of anthropogenic impacts on groundwater availability in an agricultural landscape, Jackson Purchase Region, Kentucky: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Norris, L., and Shingleton, A., 2017, Assistance program for source water protection; success in Kentucky: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Roghani, A., and Pennell, K., 2017, Alternative pathways for subsurface groundwater vapors to enter buildings: Modeling approach: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.
- Unthank, M.D., and Unthank, K.G., 2017, Preliminary assessment of the geothermal potential of the alluvial aquifer beneath Louisville,

Kentucky created by rising groundwater levels and temperatures: Kentucky Water Resources annual symposium, Lexington, Ky., March 20, 2017.

Website Information

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

The Kentucky Geological Survey also maintains a website for the 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 websites of the ITAC agencies and organizations.

The Kentucky Water-Well and Spring search engine was accessed by the public 12,433 times during fiscal year 2016-17, resulting in 478 downloads. This search engine remains the second most popular on the KGS website, after the one for oil and gas records. Users can search for wells or springs by county, 7.5-minute quadrangle, or a radius from a latitude/longitude location. Resulting data can be displayed on maps or downloaded for use in GIS packages. This website also contains PDF and Word documents scanned by the Kentucky Division of Water, and these were downloaded 11,277 times. The associated Water Wells and Springs map service was accessed 5,045 times during the fiscal year, and the Karst Potential Map layout on the KGS Geologic Map Service was accessed 2,585 times.

The Kentucky Groundwater-Quality Data search engine was accessed by the public more than 730 times during fiscal year 2016-17, resulting in 105 downloads. Users can select from hundreds of parameters in 14 major categories, some of which are herbicides, pesticides, inorganics, metals, nutrients, volatile organic compounds, and petroleum hydrocarbons. Resulting data can be downloaded, displayed on maps, or used to generate graphs comparing groundwater-quality data by physiographic region or watershed basin.

The water-quality map was accessed 429 times, and the groundwater-quality data plotting service was accessed 65 times.

In addition to the Repository data, information about hydrology, geology, topography, water supply, and water quality has been compiled from maps, reports, and data collected from 1940 to the present at www.uky.edu/kgs/water. 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 Interagency Technical Advisory Committee on Groundwater provides a forum for participating organizations to meet 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 Cooperative Extension Service agents and Area Development District personnel throughout the commonwealth to promote awareness of hydrogeologic issues. Some ITAC agencies are also members of the Kentucky Agriculture Water Quality Authority or cooperate with the Authority and participate in its 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 data set 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 jointly report on groundwater quality throughout the state. During 2016-17, electronic files of water-well, spring, and groundwater-quality data were transferred from the Division of Water to the Kentucky Geological Survey quarterly, and scanned drillers' logs twice a year. These data were uploaded to the Kentucky Groundwater Data Repository, allowing end-users to access the most recent well and spring data available.

Other Activities

ITAC agencies are involved in many activities 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. Some of these activities are listed below.

University of Kentucky Environmental and Natural Resource Issues Task Force "No P on My Lawn!": Residential Program on Lawn Nutrient Management. Nutrient pollution is one of America's most challenging environmental problems. In urban environments, nutrients are carried to surface-water bodies via stormwater runoff. Excess nutrients cause algae overgrowths or algal blooms that may be toxic to humans and pets and reduce water-oxygen levels for fish and other aquatic organisms. Leading the list of contaminants are nitrogen and phosphorus, common constituents of lawn and garden fertilizers

and natural amendments. In Kentucky, 25 years (1990–2014) of soils data show that most home lawns and gardens exceed the maximum recommendations for phosphorus fertilizer applications, and levels are increasing. Overfertilization and improperly timed nutrient applications increase nutrient loads to stormwater runoff, which leads to impaired water quality.

In response to the abundance of phosphorus in Kentucky home lawns, the University of Kentucky's Cooperative Extension Service is teaming with neighborhood associations, Master Gardeners, and other community organizations to implement a public education program—"No P on My Lawn!"—to educate homeowners on proper nutrient management in their landscapes (Fig. 17). The educational elements emphasize the environmental and aesthetic ramifications of overfertilization, demonstrate the benefit and method of soil testing, explain how to interpret soil tests, and identify appropriate plant nutrients utilizing the 5R approach to nutrient management: right source, right time, right rate, right place, and right price. Although the program focuses on phosphorus, the proposed management strategies will result in reduced nitrogen load as well.

The program is funded through the Lexington-Fayette Urban County Government Stormwater Quality Projects Incentive Grant Program, with matching funds from UK's College of Agriculture, Food and Environment. As a Phase I Municipal Separate Stormwater Sewer System (MS4) community, Lexington must meet minimum



Figure 17. Rick Durham leads a "No P on My Lawn!" workshop at the University of Kentucky Arboretum in Lexington.

stormwater control measures established by the Environmental Protection Agency. The “No P on My Lawn!” program will assist the city in meeting two of these measures: public education and public involvement. Participants will be engaged through community workshops, assist in soil testing of their lawn, and be assessed for current practices and behavioral change as a result of the workshop participation. Aggregated survey results, number of attendees, and total number of soil tests will be provided to the Urban County Government for its annual reporting. Initially, the program will be offered to Fayette County residents. Upon completion of the grant, the program will be refined as a model framework for distribution to other MS4 communities.

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.

Reducing forest cover increases water yield, whereas establishing forest cover decreases water yield. Water yield is the amount of surface water and groundwater leaving a watershed. On average, removing 10 percent of forest cover increases water yield by 40 millimeters in conifers, 25 millimeters in deciduous hardwoods, and 10 millimeters in brush and grasslands. Although simply removing forest increases the water yield, placing an impervious 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, revealed that water quality/quantity was the second most important concern about forests of the citizens of the commonwealth, highlighted in a statewide survey of the most important issues affecting the state’s forest resources. The Division, also using stakeholder input, delineated seven major forest priority areas across the commonwealth in which to focus a collaborative strategy to maintain sustainable forests and as a basis for improving water quality and quantity (Fig. 18).

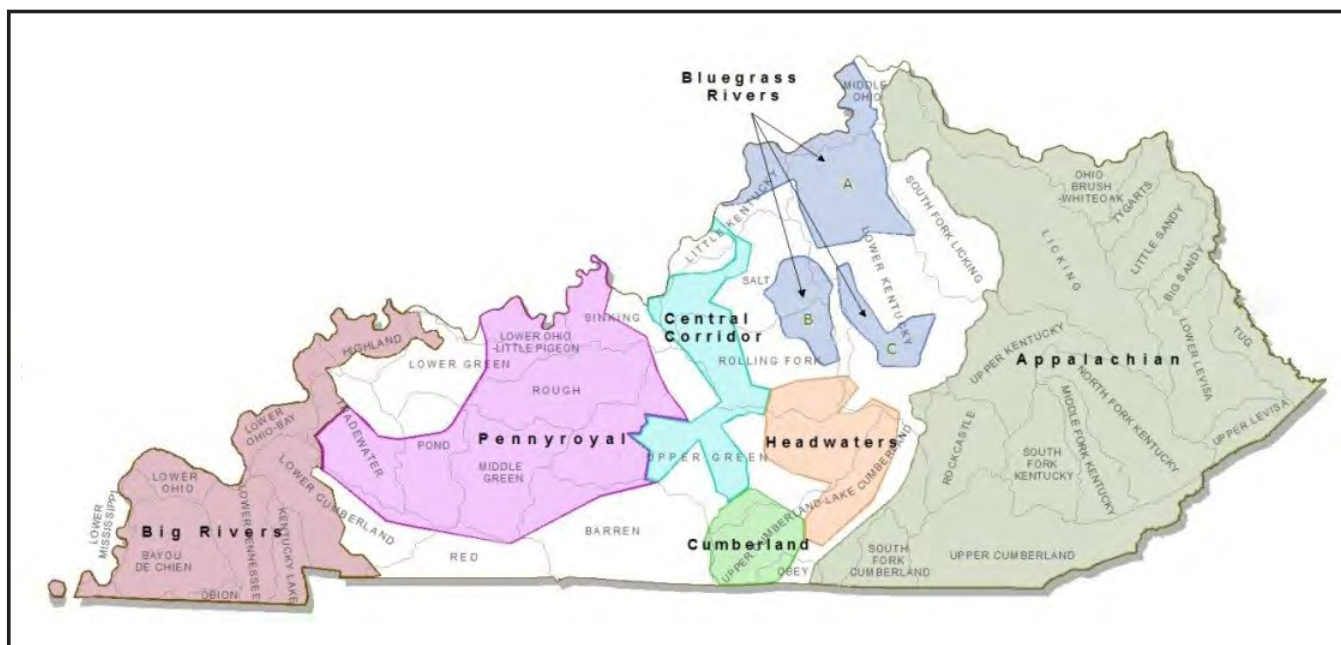


Figure 18. Forest priority areas and watersheds in Kentucky.

The primary objective of the Division's Timber Harvest Compliance Program 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 BMPs mandated by the Kentucky Agriculture Water Quality Plan.

For the 2016-17 fiscal year, 3,714 harvest inspections were performed, resulting in 447 enforcement actions.

The Division's Forestry Stewardship Program proactively mitigates 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.

The Division also addresses water quality by promoting the agroforestry concept of strategically incorporating trees into the agricultural landscape in order to protect water resources and meet landowner objectives. This integrated watershed approach is very effective in promoting good water quality, many times proving 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 educate 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 and foresters at the Division in fiscal year 2016-17 were involved in Lexington's Reforest the Bluegrass, in which more than 600 citizen volunteers planted more than 6,000 tree seedlings at Hisle Park. The Reforest Northern Kentucky event took place in Big Bone Lick State Park, and more than 300 volunteers planted more than 1,500 seedlings. Reforest Frankfort was another great success: 477 volunteers planted 2,000 seedlings at Cove Spring Park. Kentucky Division of Forestry personnel assisted with planning these events, and served as crew leaders.

County judge/executives from 110 counties signed Arbor Day proclamations for their respective counties, designating a specific day to celebrate Arbor Day. The Division sold or gave away 200,000 tree seedlings for use in a variety of Arbor Day activities.