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Session 1B

Kentucky Water Resources Research Institute, University of Kentucky

FLOWING ONWARD: MAPPING NEW PROGRAM DIRECTIONS FOR THE KENTUCKY GEOLOGICAL SURVEY'S WATER RESOURCES SECTION

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In the spring of 2012, Dr. Jim Dinger retired as head of the Water Resources Section (WRS) of the KGS after 31 years of service. During that interval, the WRS underwent dramatic changes and growth in the areas of hydrogeologic data collection, analysis, storage, and reporting to help meet the needs of Kentuckians with regard to this vital resource—groundwater. One important accomplishment during this period was the construction and implementation of the state's official Groundwater Data Repository, a unique web-based groundwater information resource that serves the varied needs of government, scientists and environmental consultants, water well drillers, educators, and the general public. Working in collaboration with other state and federal partners, the WRS conducted a variety of other projects designed to better characterize groundwater availability and quality, map karst flow systems, assist public and private efforts to develop and properly manage groundwater resources, and enhance groundwater data accessibility.

Currently, the WRS is in the process of planning and implementing new program directions in order to continue to move forward with meeting present and future needs of Kentucky with regard to water resources. New investigative projects are anticipated in the areas of water availability and sustainability, water quality and emerging contaminants assessment, and watershed hydrology. In the state's extensive karst terrains, groundwater and surface water are highly interconnected and constitute a single dynamic system; therefore a greater emphasis will be placed on characterizing groundwater-surface water interaction. Greater attention will also be given to the collection and reporting of groundwater-level data, and to the establishment of a long-term observation well network.

Since the Capilouto administration began at UK in May of 2011, the role of KGS has become increasingly more integrated into the land grant mission of the University, especially with regard to improving people's lives through excellence in research. More direct communication and collaboration is now underway between the WRS and UK faculty and students involved in water resources research and education. Collectively, these new collaborative efforts and program directions are intended to advance the science and public service missions of both the KGS and WRS, and provide longstanding benefits to proper development, management, and protection of the Commonwealth's water resources.

NOTES

THE PRESENCE OF 17-β ESTRADIOL AND FLUOROQUINOLONES IN KENTUCKY'S SURFACE WATERS

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Over the past decade, surface water sampling conducted by the U.S. Geological Survey (USGS) and others (Hedgespeth and others, 2012) has shown the presence of pharmaceuticals and personal care products (PPCPs) in the environment. In 1999 and 2000, the USGS sampled 139 streams in 30 states for 95 pharmaceutical and personal care product chemicals. One or more of the chemicals analyzed were found in 80 percent of the streams sampled (Barnes and others, 2002; Buxton and Kolpin, 2002; Kolpin and others, 2002a; Kolpin and others, 2002b). In 2008, the USGS, in cooperation with the Kentucky Division of Water, sampled 9 selected watersheds for PPCPs. Surface water samples analyzed from 7 of the 9 watersheds contained 1 or more pharmaceuticals and antibiotics (Angie Crain, USGS Kentucky Water Science Center, personal communication).

In an effort to further increase our knowledge of the presence of PPCPs in Kentucky's surface waters, six watersheds were sampled in June and July of 2012 (round 1) for 17-β Estradiol (steroid hormone) and Fluoroquinolones (antimicrobials). Fifty six grab samples were collected from the Bayou de Chein, Clarks River, Floyds Fork, South Elkhorn Creek, Banklick Creek, and Licking River watersheds. Five of the six watersheds are designated as priority watersheds by the Kentucky Division of Water.

Of the 56 surface water samples collected, 15 (27 percent) contained 17-β Estradiol at a concentration greater than the method detection limit of 3.0 parts per trillion, whereas only 5 samples (9 percent) contained Fluoroquinolones at a concentration greater than the method detection limit of 0.025 parts per billion. Five samples containing 17-β Estradiol and 4 samples containing Fluoroquinolones were collected downstream, within 200 ft, of a known waste water treatment plant outfall.

In order to obtain more statistically significant data, 20 sites within four of the original six watersheds were resampled four times during November and December of 2012 (rounds 2-5). Two sampling sites were within the Bayou de Chein, four within the Clarks River, six within the Floyds Fork, and eight within the South Elkhorn Creek watersheds.

17-β Estradiol and Fluoroquinolones concentrations for sampling rounds 2 through 5 ranged from < 3.0 to 14.0 parts per trillion and < 0.025 to 0.456 parts per billion, respectively. The highest concentrations of both chemicals occurred at sampling sites downstream of waste water treatment plant outfalls. Currently, analytical data for rounds 1 through 5 are being analyzed statistically. Statistical results will be presented at the Symposium.

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MAPPING KARST SINKHOLES USING LIDAR – A PILOT STUDY IN FLOYDS FORK WATERSHED, CENTRAL KENTUCKY

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Sinkholes are naturally occurring depressions in karst terrains and 50% of Kentucky's land surface has the potential for karst. Sinkholes are an important hydrologic feature because they collect surface runoff and facilitate its drainage to subsurface conduits. In addition, potential flooding and subsidence related hazards created by sinkholes cause damages to property and civil structures. Land-use and watershed planning should, therefore, include detailed mapping of sinkhole locations. The existing digital sinkhole coverage for Kentucky is based on low-resolution topography maps created more than 50 years ago. LiDAR (Light Detecting and Ranging) is a new technique that rapidly and accurately measures micro-topographic features. Therefore, high resolution digital elevation models (DEMs) can be generated from LiDAR and used to map sinkholes in more detail with high accuracy. Bare-earth elevation data can also be extracted from LiDAR, which helps with identifying sinkholes in forests and in urban areas.

The Floyds Fork watershed is located in north-central Kentucky and drains portions of Bullitt, Henry, Jefferson, Oldham, Shelby, and Spencer counties. The watershed is currently impaired by a variety of contaminants, including nutrients, organic enrichment, dissolved oxygen, fecal coliform, sedimentation, and aquatic plants. The U.S. Environmental Protection Agency is constructing a numerical water flow and quality model for calculating Total Maximum Daily Loads for nutrients in the watershed. About 90% of the watershed is underlain by carbonate rocks and 18% is classified as karst major area.

To help provide additional information about sinkholes in the Floyds Fork watershed and to test the feasibility of LiDAR in mapping sinkholes, we developed a sinkhole extraction procedure and selected the Bullitt County portion of the watershed as our first study area. The procedure consists of five steps: 1) creating DEMs from LiDAR point clouds, 2) extracting surface depression features from the DEMs, 3) inspecting the depression features for probable sinkholes, 4) delineating drainage areas for the probable sinkholes, and 5) verifying the probable sinkholes in the field. For the study area, we used LiDAR data collected in 2009 by the Louisville/Jefferson County Information Consortium. Besides LiDAR data, we also used 6-inch resolution aerial imagery from Kentucky Division of Geographic Information, Bing Maps, and Google Earth historical imagery in step 3. In the study area, we have finished depression feature extraction and are working on inspecting these features for probable sinkholes and delineating the drainage areas.

The next step is to examine the probable sinkholes in the field to assess the reliability of the LiDAR sinkhole identification method. We will use the reliability assessment to improve the method. And, if the method proves reliable, one long-term goal is to produce a high-resolution digital map of sinkholes in all karst areas in Kentucky where LiDAR data are available.

CHANGES IN THE KENTUCKY GROUNDWATER DATA REPOSITORY SEARCH ENGINES

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Recent changes made to the Kentucky Groundwater Data Repository (KGDR) Web pages enhance ease of use, search options, and data accessibility. Online water well, spring, and groundwater-quality data searches are now integrated with digital geologic mapping services, and include access to more analytical parameters than were previously available. This presentation will review the online process of searching for Kentucky groundwater data, options for displaying data on various base maps including digital geology, shaded-relief topographic maps, and aerial photography, and options for downloading data reports.

The KGDR, initiated in 1990 by the Kentucky Geological Survey (KGS) under mandate from the Kentucky legislature (KRS 151:035), was established to compile, store, and disseminate groundwater data collected throughout the Commonwealth by state and federal agencies, environmental consultants, private industry, and universities or independent researchers. The KGDR Web site is located at kgs.uky.edu/kgsweb/DataSearching/watersearch.asp. Users can search for and retrieve (1) water well and spring records, (2) groundwater-quality data, and (3) other water information, including karst potential index maps and surface water-quality data provided through a partnership between KGS and KY Watershed Watch. The KGDR database currently contains information for over 92,000 water wells, 5,100 springs, and 58,000 suites of water-quality analyses (millions of individual analyte results).

In 2010, KGS reformatted the Repository database structure to parallel that of the Kentucky Division of Water's (DOW) database, thereby making future data uploads virtually seamless to the end-user with no disruption of service. DOW continues to be the largest Repository data contributor. Because of this data framework change, users will notice several differences from the old search engines. Analyte categories have increased from 5 to 14. Also, users must now select either laboratory-derived or field-derived data prior to running a search. Search results can be limited by selecting the regulatory program under which data were collected (if applicable), or by a user-defined range of sampling dates.

Users are encouraged to submit any suggestions, questions, or concerns regarding the KGDR to the Survey via the contact information listed above.

NOTES

GROUNDWATER DISCHARGE
AT THE KENTUCKY HORSE PARK KWIS STATION

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The KWIS (Karst Water Instrumentation System) site is located at the Kentucky Horse Park in the Royal Spring springshed. The springshed has a drainage area of ~6,070 ha and extends to the east-central part of Lexington. The KWIS is situated at a critical location in the springshed because the surface and underground flow diverge at this point. The discharge in the central conduit monitored by 16 cm diameter drilled holes at a depth of 18 meters drilled in July of 2010. Although discharge data are essential to monitoring the flux of contaminants, the cross section of the cave, the velocity distribution, and the discharge are difficult to determine directly. We imaged the cave with a submersible borehole video camera that was modified to tilt to horizontal. The cave height was obtained by direct measurement but the distance to the walls was difficult to measure because the lighting was inadequate. In 2012 we obtained a submersible LED, 12-volt, marine navigation light which as significantly brighter and enabled us to not only see the walls but from Well 20 we could make out the casing through the cave in Well 23, 3 meters away. Doppler sonar observations to both delineate the walls and measure the velocity were not initially successful but we have had some recent success. Because of the uncertainty of the video and sonar we decided to conduct the dye tracing to determine the velocity and the discharge at the KWIS. Seven quantitative groundwater tracer experiments have been conducted at the KWIS as of December 2012 (Table 1).

Table 1: Results of quantitative traces at the Kentucky Horse Park (Eclipse Karst Window to KYHP KWIS.)

No.	Date Time	Stage Well 24, m above 800 ft.	MMcB* Velocity m/sec	Q-dye m^3/sec	Velocity dye, m/sec	Cross-section Q-dye/V-dye, m^2	Cross-section Area, Q Dye/V MMcB m^2.
1	7/7/11 13:00	0.60	0.06	0.07	0.04	1.8	~~1.17~~
2	11/15/11 13:00	0.98	0.06	0.3	0.06	5.0	5.00
3	11/28/11 14:00	8.51	0.29	NA	0.26	NA	~~NA~~
4	12/6/2011	6.58	0.32	1.82	0.07	26.0	5.69
5	3/1/2012 12:00	3.97	0.26	1.72	0.07	24.6	6.62
6	10/2/2012 15:00	2.47	0.08	NA	NA	NA	5.07
7	12/10/12 11:53	4.2	0.35	1.04	0.08	7.92	2.96
	Mean cross-section						5.07

The dye tracers are injected in the small karst window at the junction of Walt Robinson Road and Eclipse Road. The hydrologic system consists of the karst widow, a tributary from it to the main stem of the cave, a short section (less than 600 meters) of the main stem, and the tracer recovery point at the KWIS. The mass of tracer (Rhodamine WT) is chosen to minimize visibility at Royal Spring. The Rhodamine WT tracer is diluted in 120 liters of water so that the dye injection can be kept constant and extended over 1 ½ hours. The maximum rate of the pump is measured prior to beginning injection and the pump runs continuously until the diluted dye is exhausted. Although the concentration of tracer in the tub has been calculated, sampling the dye and measuring the injection rate a second injection flux can be measured. Samples are collected on 10-minute intervals at the KWIS site beginning two hours after the injection is started. The bottles are replaced at four hours during low flow, but all of the dye clears the station within four hours under higher flow conditions. At the mid-point a grab sample of the tracer is collected and a spike of fluorescein is injected. The fluorescein spike is used to measure the travel time of the dye. The velocity by dye travel time (Table 1) is significantly different from the Marsh McBirney velocity for some experiments due to back flooding conditions.

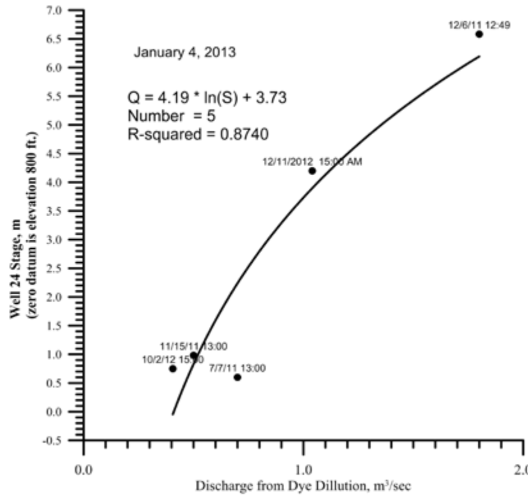

Figure 1 Stage/discharge rating curve for the Kentucky Horse Park monitoring station.

A stage/discharge rating curve is being constructed from the results of the quantitative tracer experiments. Two traces had been conducted with USGS support (Table 1, line 6 and 7). Drought beginning in the spring of 2012 made it impossible to obtain the flow conditions needed to complete the stage-discharge rating curve (Fig. 1). The values needed are in the mid-range of the graph, between 0.5 and 1.5 cubic meters a second. When a sufficient number of experiments have been conducted, the paired stage data and discharge from dye dilution will allow us to create a rating curve and derive the equation of the line regression. The rating equation is then used to convert the continuous stage data to continuous discharge.

Unfortunately the Marsh-McBirney point velocity record is frequently interrupted for long time periods and has a much noisier signal than the stage record. We are in the process of determining the relationship of the Marsh-McBirney point velocity to the mean velocity by evaluating simultaneously collected Dopplar sonar velocity data. The discharge calculated from the dye trace determined cross-section and the adjusted Marsh-McBirney point velocity can then be paired with the stage data to make a stage/discharge rating curve. This would be very useful in that the stage data is stable and complete and the line of regression and rating equation would be very robust because of thousands of data pairs to correlate.