Kentucky Geological Survey: Water Resources Research and Data

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Outline of This Talk:

• A Brief Overview of KGS, and the Water Resources Section Mission

• Example WRS Project: Cane Run/Royal Spring karst basin investigation.

• The Kentucky Groundwater Data Repository: What’s Available

• KGS’s Current Effort to Improve Groundwater Monitoring: A New Statewide Groundwater Observation Network
“As a mandated research center of the University of Kentucky, our mission is to increase knowledge and understanding of the mineral, energy, water resources, geologic hazards, and geology of Kentucky for the benefit of the Commonwealth and the Nation.”
Statutory Mandates for KGS

- Mineral Resources Investigation
- Oil and Gas Well Data Repository
- Kentucky Seismic and Strong Motion Network
- Groundwater Data Repository
- Groundwater Monitoring Network
KGS Organization

Energy and Minerals

Geologic Mapping

Water Resources

Geologic Hazards

Geoscience Information Mgmt.
Is 5th largest repository of its type in the Nation.

- Over 22,000 sets of well samples from 120 KY counties.
- 3,000 sets of cores from 95 counties.
- 1,000 sets of auger holes from 11 counties.

Provides access to physical samples of:

- Bedrock and unconsolidated overburden strata of all types.
- Oil & gas reservoir rocks.
- Aquifer media (rocks and sediments).
Water lab provides for analysis of major/minor inorganics (incl. trace metals, nutrients).

Water Lab moved administratively to the WRS in 2014 to better accommodate KGS and UK research needs.

Lab also helps serve needs of others outside UK-KGS, for example, Kentucky Watershed Watch program groups.
KGS Maintains A Website that Provides Much Information about Research Activities and Access to Data

http://www.uky.edu/KGS/
Much of the Data KGS Collects Are Available Through Its User-Interactive Web Service

http://kgs.uky.edu/kgsmmap/kgsgeoserver/viewer.asp
Example Showing Mapped Sinkholes in Lexington, Louisville, and Elizabethtown Areas

http://kgs.uky.edu/kgsmap/kgsgeoserver/viewer.asp?gkarst=true
All Kinds of Other Geologic, Topographic, and Hydrologic Data Are Available to the Public
Many Published Reports and Maps Available Too: County Land-Use Planning Maps Are Popular Downloads

http://kgs.uky.edu/kgsweb/download/geology/landuse/lumaps.htm
Activities of the KGS Water Resources Section

Principle Areas of Research:

Groundwater Occurrence and Flow

Water Quality and Hydrogeochemistry

Karst Hydrogeology and Sinkhole Mapping

Hydrogeologic Applications of Geophysical Surveying

Groundwater Modeling and Model Applications
Kentucky Is A Topographically and Geologically Complex State

Aquifers and Groundwater Characteristics Vary Significantly from Place to Place.

Obtaining Data Needed for Proper Understanding and Assessment of Groundwater Resources Is Often Technically Difficult, and Requires Multidisciplinary Study Approaches.
An Example is Characterizing Groundwater Flow and Factors that Effect Groundwater Quality in the State’s Karst Areas

Where the Aquifer System Looks Something Like This:
One Such KGS-WRS Project:

Mass Flux of Potential Contaminants in the Cane Run-Royal Spring Karst Basin

A Collaborative Effort between KGS and UK College of Agriculture and College of Civil Engineering
Cane Run Creek Sinks Underground to Royal Spring Conduit Except During High Flows

Lexington 30X60 minute Karst Groundwater Basin Map
Water-Tracing Tests Have Been Conducted to Determine Time-of-Travel of Potential Contaminants to Royal Spring
A Monitoring Well Network Was Installed At the KY Horse Park to Sample Water in the Aquifer and Cave Stream Feeding Royal Spring.
Locating the Monitoring Wells Required Help Using Geophysical Survey Data:

Monitoring wells were drilled into identified low-resistivity target zones indicating fractured/karstic rock and possible groundwater flow zones.
Cartoon View of Drilled Wells and Intercepted Conduits

Northeast

Wells 20, 23, and 25

Southwest

0.85 meters +/-

5 meters +/-
Monitoring Wells at the KyHP Monitoring Site

- Well 1 drilled in 2007
- Stage Recorder
- Well 25: Velocity sonde
- Well 24: Stage Recorder
- Well 20: Pump
- Well 23: Water Quality Logger
- Wells 21 and 22 are off the plot to the southwest
- Well 18 is unusable

CAVE: height is 0.9 meters, width is 4+ meters

Flow

Barton Well
Hydrographs Showing Hydraulic Communication and Water Levels in KyHP Monitoring Wells:

Data courtesy of Jim Currens, KGS
Three years (2011-14) of collected groundwater-quality data have been compiled and are being analyzed.

- Annual mass flux calculations for nitrogen, phosphorus, and total suspended sediments have been calculated.
KGS Groundwater Data Repository

Groundwater Monitoring Network
Groundwater Data Repository (GWDR)

All Groundwater Data Collected in Kentucky is Stored in the Kentucky Geological Survey’s Data Base and Can Be Accessed Via the Internet:

- The GWDR currently contains:
  - Over 92,000 water well records.
  - Approximately 5,100 spring records.
  - About 60,000 groundwater-quality analyses.
  - Compiles data contributed from: DOW, USGS (NWIS), EPA (Storet), KGS, Others
  - Largest single source of data are water-well construction records submitted by Kentucky Certified Drillers.

http://www.uky.edu/KGS/water/index.htm
http://kgs.uky.edu/kgsweb/DataSearching/watersearch.asp
Searching the Groundwater Data Repository (GWDR)

Menu-Driven Queries

User-interactive Map Search
Working in Cooperation with KDOW, Driller’s Well Construction Logs were Scanned and Made Available Online in 2014.

Benefits:

- They are currently the only way to find lithology for wells drilled in the past 10 years.
- Original logs can be used to double-check and correct data returned in searches (lat/lons, TDS, reported yield, etc.).
- Some wells have water-quality data in paper format never entered into the DOW database (primarily bacteria data)
- Drillers themselves appreciate having permanent digital archive of, and ready access to, their well logs.
### Groundwater-Quality Data Accessible In GWDR

#### Bulk
- pH
- Conductance
- Temperature

#### Major Ions
- Bicarbonate
- Carbonate
- Chloride
- Sulfate
- Potassium
- Magnesium
- Calcium

#### Nutrients
- Nitrate-Nitrogen
- Nitrite-Nitrogen
- Ammonia-Nitrogen
- Total Kjeldahl Nitrogen
- Total Organic Carbon
- Total Phosphorus
- Ortho-Phosphate

#### Pesticides
- 2,4-D
- Alachlor
- Atrazine
- Cyanazine
- Metolachlor
- Simazine

#### Inorganics
- Chlorine
- Fluorine

#### VOC’s
- Benzene
- Toluene
- Ethyl Benzene
- Xylene
- MTBE

#### Metals
- Lead
- Magnesium
- Manganese
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Sulfur
- Zinc

#### Organics
- Nitrogen/Phosphorus
- Chlorinated Pesticides
- Herbicides
- PCBs

#### Residues
- Total Dissolved Solids
- Total Suspended Solids
Range-of-Value Groundwater-Quality Maps Are Also Available On-Line for 32 Parameters (Most Updated in 2014)
Example Using Data Available in the GWDR:

*Groundwater Occurrence and Quality in the Berea Sandstone Unconventional Oil and Gas Play*

Bart Davidson and Junfeng Zhu, KGS WRS

Eastern Unconventional Oil and Gas Symposium
Lexington, KY
November 5-7, 2014
Berea Play area showing physiographic regions and types of water wells

Type of Well
- Domestic
- Public
- Industrial
- Monitoring
- Irrigation

Physiographic Region
- Eastern Coal Field
- Eastern Pennyroyal
- Knobs
- Outer Blue Grass

Domestic (Private): 6,753
Public: 1,348
Industrial: 55
Monitoring: 3,932
Agriculture (Irrigation or Livestock): 114
TOTAL: 12,202

Davidson and Zhu, 2014
Total depths for domestic wells (feet below land surface)

Total Depth (feet)
- 25 - 100
- 100 - 200
- 200 - 400
- 400 - 600
- 600 - 1,000
- 1,000 - 2,000

Davidson and Zhu, 2014
Groundwater Levels Reported in the Berea play area (feet above mean sea level)

Elevation – SWL = GW level (potentiometric map)

Davidson and Zhu, 2014
Total Dissolved Solids in Domestic Wells (mg/L)

TDS Secondary MCL = 500 mg/L
(All inorganic or organic substances contained in water)

Davidson and Zhu, 2014
Although much information is available by searching the KGS Websites and the GWDR, there is one critical data gap:

Kentucky lacks a statewide network of long-term groundwater observation (monitoring) wells.

For many parts of the state, groundwater-level data are lacking or more than 20–30 years out-of-date.
Is This A Cause For Concern for Kentucky?

If so, We Need to Address This Critical Data Gap Soon.

Long-Term Records of Water-Level Measurements (>5 yrs.) Are Needed To Be Able to Identify Statistical Trends
Comparison of Historical Trends in Kentucky’s Groundwater Data Collection Activities
Presently Active Groundwater Monitoring Sites

KDOV-ITAC Groundwater-Quality Sites

USGS real-time water-level well
(Fed. funded Natl. Climate Response GW Network)

KGS research project well
(number of wells in box)

Map Courtesy of Rob Blair, KDOV, 2014
KGS Initiation of A New Statewide Groundwater Observation Network

- Set up 14 new or revived observation well sites: Capitalization using $145K one-time funding; to collect continuous water-level measurements and quarterly groundwater-quality samples.

- “…in areas of demonstrated need.” (KRS 151.625)

- Wells serve as fixed monitoring sites representative of specific aquifers or aquifer types (e.g. karst, fractured sedimentary rock, etc.).

- “…support research efforts that develop models for groundwater systems…”, and “…to determine and monitor trends…”.

- Also 4 karst spring monitoring sites: “Livestream” NEA-LexArts project contributing $75K in private donations to equipment; continuous WQ and stage-discharge flow monitoring.
The observation wells to be located in areas of state where groundwater withdrawals are great and/or are expected to increase.

- Geographic distribution is a consideration,
- Also areas having significant agricultural or energy resource-extraction activities.
- Shallow, mostly unconfined aquifers responsive to precipitation recharge.
- Plan on drilling approx. 7 new wells in areas of critical need.
- Also, approx. 6 wells equipped with telemetry.

Annual O&M costs (est. $30K) to be covered by KGS for first 3 years:

- Unanticipated cost increases, funding cuts, or resource reallocation/research program decisions could potentially affect this.

- Long-term maintenance, expansion or enhancement of network and data-collection activities, will require additional outside funding/partnerships.
Proposed New KY Groundwater Observation Network

KDOV (ITAC GWQ network) sites

USGS real-time water-level monitoring well

Existing KGS research wells

Proposed general location for new KGS-KGON observation well site

Proposed KGS "Livestream" spring monitoring site
Other Planned Activities to Support the Network Include:

- Additional Well Inventory and Logging Work
- Periodic Water-Level Mapping in Selected Areas of Interest
- Conduct Aquifer Tests to Better Assess Groundwater Availability
- Create New Webpages Needed to Store and Display Water-Level Hydrograph Data
For Example KGS Is Presently Conducting a Well Inventory and Gamma-ray Logging of Selected Wells in the Jackson Purchase Area:

The Intent Here is to Better Understand Local Stratigraphic Variability in the Aquifers that May Effect GW Monitoring
Questions about the Local Aquifer Boundaries and the Extent of the JPA Confining Units Have Important Implications for Observation Well Placement and Construction.

Also for Interpretation of Groundwater Monitoring Data and Groundwater and Surface Water Resources Management in the Area.
KGS Proposed Network and Groundwater Investigation Plans Have Been Incorporated into the Draft KASMC 3-Year Work Plan

Plan was reviewed during the KASMC Annual Executive Level Meeting held on December 9, 2014.

Goal Is to Build Support for Groundwater Research and Data-Collection Efforts Needed to Support Agriculture.
Summary

KGS Water Resources Section is active on a variety of fronts to fulfill its legislative mandates to characterize the water resources of the Commonwealth, to maintain the State Groundwater Data Repository, and to establish a Statewide Groundwater Observation Network.

Although we are research unit within UK, we are also a public service agency, devoted to meeting the needs of state and federal agencies, and the general public for geologic and hydrologic data and information.

The WRS principally focuses on groundwater and hydrogeology research, but is also very involved in conducting applied research pertaining to water quality issues, sinkhole and karst hazards, and other water-related science and environmental issues.

In 2015-2016, the WRS will start up the new statewide Kentucky Groundwater Observation Network (KGON), consisting initially of fourteen long-term water-level monitoring wells and four karst springs.

The goal of the network is to provide groundwater data needed to better assess groundwater availability, recharge, aquifer characteristics, and interaction with surface streams for the benefit of all Kentuckians, including the agricultural community.
Questions and Discussion?