Final Project Report:
Groundwater Education, Training, and Technology Transfer

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Executive Summary

This project was designed to provide easy public access to groundwater-quality data and to educate Kentucky's citizens about groundwater-quality issues.

The Kentucky Groundwater Data Repository, maintained by the Kentucky Geological Survey, contains a wealth of information regarding our groundwater resource. However, those data were not readily accessible or understandable until now. Work conducted for this project first focused on standardizing data reporting and placing analytical results in the context of natural and contaminant sources, geologically controlled regional variations, potential health consequences of long-term consumption, and ways to reduce or eliminate groundwater contamination. KGS then designed and developed user friendly on-line search capabilities that allow anyone to obtain and analyze groundwater-quality data for the entire state or any selected region.

The products are available from any computer with an internet connection. Starting at the KGS home page http://www.uky.edu/KGS/, select Search Databases and Publications, then select Groundwater Information. From there one can choose one of three types of search:
Search for Groundwater-Quality Data gives results in tabular format,
Graphical Groundwater-Quality Comparison provides graphical and statistical summaries, and
Groundwater-Quality Data Map Service gives results on geologic or geographic base maps.
All pages provide tutorials and information files to make the data understandable.

Introduction and Background

More than a million Kentuckians rely on wells and springs for drinking water supplies and general domestic use. Much of this groundwater comes from private wells serving a single residence; however, cities are increasingly supplementing surface-water supplies with groundwater. Throughout the Commonwealth, groundwater is also used for crop irrigation, livestock watering, industrial cooling, and manufacturing. In addition, groundwater provides base flow to support streams, lakes, and associated ecosystems that are essential to environmental quality and recreational facilities.

Despite groundwater's importance, it has historically been difficult for citizens, environmental-quality regulators, resource managers, or legislators to obtain information regarding groundwater quality, whether for the entire state or for smaller regions such as counties, watersheds, or major geologic regions. Similarly, information describing the multiple sources of dissolved chemicals in groundwater, how those chemicals can impact human health or restrict water usage, and how groundwater contamination can be avoided has not been readily available.

Purpose and Goal

In the past, both KGS and DOW have devoted a considerable amount of time and resources to answering public inquiries concerning groundwater availability and quality. These inquiries typically came by telephone or mail, and sometimes it was not possible to provide an immediate response. Developing an internet-based searchable database will allow anyone with internet access to immediately obtain the data of interest.

The purpose of this project was to respond to the need for readily available and understandable information describing the condition of Kentucky's groundwater resource. The goal of the project was to educate Kentucky citizens about groundwater, including the quality and importance of Kentucky's groundwater resource, nonpoint source (NPS) threats to groundwater quality, and management practices that can abate or prevent groundwater contamination.

Objectives

The Kentucky Geological Survey (KGS) proposed to accomplish this goal by updating the groundwater data repository and making groundwater quality data available via a Web site, together with information about groundwater use, NPS chemicals, and a description of best management practices (BMPs) that can be implemented to prevent NPS chemicals from entering the groundwater system. The availability of this information would be publicized and training workshops conducted to show people how to access the Web site and how to use the information. Watershed basin management teams, the Interagency Technical Advisory Committee on Groundwater Monitoring, and other technical and user groups would be consulted on the design of the data presentation. Users would be able to download data from the Web site so they can perform additional analyses. Other agencies, organizations, or individuals would be able to link their Web site to the interactive groundwater quality Web site. Links would be established between the Web site and the groundwater-quality database so that the most recent data would be presented on the Web site after KGS received and checked new groundwater-quality reports.

Five objectives were stated in the Memorandum of Agreement:

1. Prepare Web-based maps showing sample sites and concentrations of selected NPS chemicals; also provide a Web-based tutorial to facilitate use.

2. Prepare statistical summaries of the concentrations of each constituent.

3. Prepare information files for each mapped constituent.

4. Provide a list of BMPs that can prevent groundwater contamination by NPS chemicals.

5. Educate and train citizens in the use of these internet educational materials and publicize the availability of the Web site.

Materials and Methods

No special materials were used for this project. Objectives were met by developing web-based data-search and information-providing capabilities. Methods are described below for each of the Objectives.

Objective 1. Prepare Web-based maps showing sample sites and concentrations of selected NPS chemicals; also provide a Web-based tutorial to facilitate use.

KGS routinely publishes maps of natural and nonpoint-source chemical concentrations in groundwater as a series of Information Circulars. These maps have a background showing the major river watersheds and physiographic regions of Kentucky in a standard form so that all maps have a similar appearance. Concentrations of the chemicals of interest are grouped into high, medium, and low concentration ranges, with the range limits determined by EPA health standards, secondary drinking water standards, or other agency-based criteria. These reports are available as paper copy and can be viewed at the KGS Web site (www.uky.edu/kgs/water/gnet/gnet.htm). KGS also regularly responds to inquiries concerning groundwater quality throughout the state.

Data for these publications and responses are obtained from the Kentucky Groundwater Data Repository. The Repository was established in 1990 by Kentucky Revised Statute 151.035, which designated the Kentucky Geological Survey (KGS) to be the Commonwealth's official repository for all information relating to the occurrence and quality of groundwater. In response, KGS has archived all available groundwater quality data. Major sources of such data are the Kentucky Division of Water (DOW), KGS, U.S. Environmental Protection Agency (EPA), U. S. Geological Survey USGS), and the NURE (National Uranium Resource Evaluation) project. Other data sources include data collected for RCRA, CERCLA, and other regulatory programs, as well as data from private consultants. This variety of data sources has two major consequences: (1) the repository is the most complete source of groundwater quality data available, and (2) because chemicals (analytes) of interest have been reported in a variety of names, concentration units, and explanatory and descriptive modifiers, data in the repository is confusing to nonexperts. In order to allow public access to groundwater quality data from an interactive Web site, the various names, units, and modifiers in the repository first had to be standardized so results would be useful and understandable to the public.

This objective was completed by the following activities.

<u>Activity 1-1, Obtain the most recent set of groundwater quality data for the Groundwater Data Repository:</u>

KGS obtained the most recent digital data from agencies that collect and analyze groundwater samples and added their reports to the Groundwater Data Repository. The DOW Groundwater Branch routinely transfers groundwater quality to KGS; during the project, data transfers occurred in May and November 2005, September 2006, October 2007, and July 2008. The Environmental Protection Agency (EPA) and the U. S. Geological Survey (USGS), together with the KGS, are the other main sources of groundwater quality data. STORET data (EPA water quality records) were updated in February 2004 and March 2006; USGS data were updated in May 2006. KGS data are added to repository routinely as it is reported by the KGS analytical laboratory.

KGS incorporated the new data into the Groundwater Data Repository. DOW, EPA, USGS, and other sources of digital water-quality information each store the data in different systems with different database structures, none of which are directly compatible with the Groundwater Data Repository. Essentially, each data table received from an outside agency had to be taken apart and reassembled in the Groundwater Data Repository.

<u>Activity 1-2, Obtain groundwater-quality data from the Repository:</u>

KGS and DOW choose analytes of general interest and significance. The repository contains more than 1,200 different analyte names. Many of these are chemicals that were reported under more than one name, identification number, or other qualifying descriptor, others are relatively uncommon solutes that were analyzed for but not detected. Discussions with the DOW Groundwater Branch led to the conclusion that this project would focus on the following water properties and chemicals of general interest and NPS importance:

<u>Water properties</u>: pH, hardness, total dissolved solids, total suspended solids,

<u>Inorganic solutes</u>: arsenic, barium, chloride, fluoride, iron, manganese, mercury, sulfate,

<u>Nutrients</u>: ammonia, nitrate-nitrogen, nitrite-nitrogen, orthophosphate, total phosphorous,

<u>Pesticides</u>: alachlor, atrazine, cyanazine, metolachlor, simazine,

<u>Volatile organic compounds</u>: benzene, ethylbenzene, toluene, xylenes, MTBE.

<u>Bacteria and pathogens</u>: If properly sampled and analyzed data for bacteria and pathogens became available, they were to be included in this project. However, proper collection and analysis for bacteria and pathogens requires that stringent protocols for sample collection, preservation, and holding times be followed. This is beyond the scope of regular monitoring programs. No bacteria or pathogen data meeting these requirements were available for this project.

KGS added the following analytes because they are important for understanding water quality.

<u>Water properties</u>: alkalinity, conductivity,

<u>Inorganic solutes</u>: cadmium, calcium, chromium, copper, lead, magnesium, selenium,

sodium,

Pesticides: 2,4-D.

The repository was queried using Microsoft Access for all variations of the analyte names listed above. More than one name or identifier was found for all the analytes, and a wide variety of concentration units were reported (Table 1).

Table 1. List of analyte names, units, and remarks for analytes of interest.

Analyte name reported	units	Remarks
2,4-D	ug/L	2,4-D WHL SMPL UG/L
2,4-D by GC-ECD	MG/L	
2,4-D IMA	ug/L	Concentration
2,4-Dichlorophenol	MG/K	
2,4-Dichlorophenol	MG/L	
2,4-Dichlorophenol	MG/L	
2,4-Dichlorophenol	ug/L	2,4-Dichlorophenol, water, unfiltered, recoverable, micrograms per liter
2,4-Dichlorophenoxyacetic acid (2,4-D)	MG/L	
2,4-Dichlorophenoxyacetic acid (2,4-D)	UG/L	
2,4-D	MG/L	
2,4-D	UG/L	2,4-D, water, unfiltered, recoverable, micrograms per liter
Alachlor	MG/L	
Alachlor	MG/L	
Alachlor	UG/L	Alachlor, water, unfiltered, recoverable, micrograms per liter
ALACHLOR	ug/L	Concentration
Alachlor by Immunoassay	MG/L	
Alachlor by Immunoassay	UG/L	
ALACHLOR GC/ECD	ug/L	Concentration
ALACHLOR IMA	ug/L	Concentration
Alkalin Carb It	mg/L	ALKALIN. CARB.IT LAB MG/L
Alkalinity	mg/L	T ALK CACO3 MG/L
Alkalinity	mg/L as CaCo	FIELD
Alkalinity	MG/L	
Alkalinity	MG/L	
Co3 Alk CaCo3	mg/L	CO3 ALK CACO3 MG/L
HCo3 Alk CaCo3	mg/L	HCO3 ALK CACO3 MG/L
Ammonia	mg/L	Unionized as NH3 AMMONIA 7664-41-7
Ammonia	mg/L as NH4	Ammonia, water, unfiltered, milligrams per liter as NH4
NH3 - NH3	mg/L	UN-IONZD NH3-NH3 MG/L
Ammonia	MG/L	
Ammonia	mg/L as N	Ammonia, water, unfiltered, milligrams per liter as nitrogen
Ammonia (NH3-N)	MG/L	
Ammonia Nitrogen	mg/L	UN-IONZD NH3-N MG/L
Ammonia-Nitrogen	MG/L	

Table 1, continued

analyte name reported	units	Remarks
NH3 + NH4	mg/L	NH3+NH4- N TOTAL MG/L
Arsenic	MG/L	
Arsenic	ug/L	ARSENIC AS,TOT UG/L
Arsenic	ug/L	Arsenic, water, unfiltered, micrograms per liter
Arsenic , Dissolved by ICP	MG/L	
Arsenic, Dissolved by ICP	MG/L	
Arsenic, Dissolved by ICP	UG/L	
Arsenic	MG/L	
Arsenic	MG/KG	
ATRAZINE	ug/L	Concentration
Atrazine	MG/L	
ATRAZINE DEETHYL	ug/L	ATRAZINE DEETHYL WTR UG/L
ATRAZINE DEISPRPL	ug/L	ATRAZINE DEISPRPL WTR UG/L
Atrazine desethyl	MG/L	
ATRAZINE GC/ECD	ug/L	Concentration
ATRAZINE GC/NPD	ug/L	Concentration
Atrazine	UG/L	Atrazine, water, unfiltered, recoverable, micrograms per liter
Atrazine	MG/L	
Barium	MG/KG	
Barium	ug/L	BARIUM BA,TOT UG/L
Barium	mg/L	as Ba
Barium	ug/L	Barium, water, unfiltered, recoverable, micrograms per liter
Barium	MG/L	
Barium, Dissolved by ICP	MG/L	
Barium, Total by ICP	MG/L	
Bicarbonate	mg/L	Bicarbonate, water, unfiltered, fixed endpoint (pH 4.5) titration, field, millig
Bicarbonate	mg/L as HCo3	ION
HCo3 Ion	mg/L	HCO3 ION HCO3 MG/L
Cadmium	MG/L	
Cadmium	ug/L	Cadmium, water, unfiltered, recoverable, micrograms per liter
Cadmium Rec	ug/L	CADIUM T OT.REC. UG/L
Cadmium, Dissolved by ICP	MG/L	
Cadmium	MG/KG	
Calcium	mg/L	CALCIUM CACO3 MG/L
Calcium	mg/L as CaCo	Calcium, water, unfiltered, milligrams per liter as calcium carbonate
Calcium	mg/L	Calcium, water, filtered, milligrams per liter
Calcium, Total by ICP	MG/L	
Calcium	UG/L	
Calcium	MG/KG	
Carbonate	mg/L	Carbonate, water, unfiltered, fixed endpoint (pH 8.3) titration, field, milligra
Carbonate	mg/L as Co3	ION
Carbonate	mg/L as CaCo	Carbonate, water, unfiltered, milligrams per liter as calcium carbonate
Co3 Ion	mg/L	CO3 ION CO3 MG/L
Chloride	mg/L	IN WATER

Table 1, continued

analyte name reported	units	Remarks
Chloride	mg/L	CHLORIDE TOTAL MG/L
Chlorine	ppb	Elemental concentration of Chlorine
Chlorine	ug/L	ELEMENTAL,DISS, FILT WATER SAMPLE
Chromium	ug/L	Chromium, water, unfiltered, recoverable, micrograms per liter
Chromium	MG/L	
Hexavalent Chromium	MG/L	
Chromium	MG/KG	
Chromium	G/L G	
Chromium Rec	ug/L	CHRMIUM TOT.REC. UG/L
Chromium, Dissolved by GFAA	MG/L	
Chromium, Total by GFAA	UG/L	
Chromium, Total by GFAA	MG/L	
Conductance	MMHOS/CM	Specific Conductance - CNDUCTVY AT 25C MICROMHO
Conductance	USIEM	Specific Conductance in MicroSiemens/CM
Conductivity	UU/C	
Conductivity	uU/cm	
Conductivity	ÆMHO	
Conductivity	MG/L	
Conductivity	mmohs/cm	Laboratory-measured Conductivity in micromhos/centimeter
Conductivity	UU/CM	
Specific conductance	micro/cm 25C	Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degre
Specific conductance	Microsiemens	Specific conductance, water, unfiltered, laboratory, microsiemens per centimeter
Copper	MG/L	
Copper	ug/L	Copper, water, unfiltered, recoverable, micrograms per liter
Copper	MG/KG	
Copper Rec	ug/L	COPPER TOT.REC. UG/L
Copper, Dissolved by ICP	MG/L	
Copper, Dossolved by ICPCP	MG/L	
Cyanazin	ug/L	CYANAZIN WHL WAT UG/L
Cyanazine	UG\L	
Cyanazine	MG/L	
Cyanazine	UG/L	Cyanazine, water, unfiltered, recoverable, micrograms per liter
Cyanazine	MG/L	
CYANAZINE	ug/L	Concentration
Cyanazine (SemiQ) by GC/NPD	MG/L	
Cyanazine by GC/NPD	UG/L	
Cyanazine by GC/NPD	MG/L	
CYANAZINE GC/NPD	ug/L	Concentration
Fluoride	mg/L	Fluoride, water, unfiltered, milligrams per liter
Fluoride	mg/L	FLUORIDE F,TOTAL MG/L
Fluorine	ppb	Elemental concentration of Fluorine
Fluoride	G/L	
Fluorine	ug/L	ELEMENTAL,DISS, FILT WATER SAMPLE
Fluorine	MG/L	

Table 1, continued

analyte name reported	units	Remarks
CAL HARD CA MG	mg/L	CAL HARD CA MG MG/L
Hardness	mg/L	TOT HARD CACO3 MG/L
Hardness	mg/L as CaCo	Hardness, water, milligrams per liter as calcium carbonate
Hardness, total	MG/L	
NC Hardness	mg/L	NC HARD CACO3 MG/L
Noncarbonate Hardness	mg/L	as CaCo3
Noncarbonate hardness	mg/L as CaCo	Noncarbonate hardness, water, unfiltered, field, milligrams per liter as calcium
Hardness	MG/L	
Iron	MG/KG	
Iron	MG/L	
Iron	ug/L	Iron, water, unfiltered, recoverable, micrograms per liter
Iron	mg/L	IRON FE MG/L
Iron	ug/L	IRON FE,TOT UG/L
Iron, Total by ICP	MG/L	
Lead	MG/L	
Lead	ug/L	Lead, water, unfiltered, recoverable, micrograms per liter
Lead Rec	ug/L	LEAD(PB) TOT.REC. UG/L
Lead, Dissolved by GFAA	MG/L	
Lead, Dissolved by ICP	MG/L	
Lead, Dissolved by ICP	UG/L	
Lead	MG/KG	
Magnesium	mg/L	MGNSIUM MG,TOT MG/L
Magnesium	MG/KG	
Magnesium	mg/L	Magnesium, water, filtered, milligrams per liter
Magnesium	ppb	Elemental concentration of Magnesium
Magnesium, Dissolved by ICP	MG/L	
Magnesium, Total by ICP	MG/L	
Manganese	ppb	Elemental concentration of Manganese
Manganese	ug/L	Manganese, water, unfiltered, recoverable, micrograms per liter
Manganese	mg/L	as Mn MNICAP-D 7439965
Manganese	ug/L	MANGNESE MN,SUSP UG/L
Manganese Rec	ug/L	MNGANESE TOT.REC. UG/L
Manganese, Total by ICP	MG/L	
Manganese	MG/L	
Manganese	MG/KG	
Mercury	MG/L	
Mercury	ug/L	MERCURY HG,TOTAL UG/L
Mercury	ug/L	Mercury, water, unfiltered, recoverable, micrograms per liter
Mercury (AA)-Water	UG/L	
Mercury (AA)-Water	MG/K	
Mercury (AA)-Water	MG/L	
Metolachlor	MG/L	
METOLACHLOR	ug/L	Concentration
Metolachlor by GC/ECD	UG/L	

Table 1, continued

analyte name reported	units	Remarks
Metolachlor by GC/ECD	MG/L	
Metolachlor by Immunoassay	MG/L	
METOLACHLOR GC/ECD	ug/L	Concentration
METOLACHLOR IMA	ug/L	Concentration
Metolachlor	MG/L	
Metolachlor	UG/L	Metolachlor, water, unfiltered, recoverable, micrograms per liter
Molybdenum	ug/L	Molybdenum, water, unfiltered, recoverable, micrograms per liter
Molybdenum	MG/L	
Molybdenum	MG/KG	
Nitrate	mg/L	Nitrate, water, unfiltered, milligrams per liter
Nitrate	mg/L	NITRATE TOT-NO3 MG/L
Nitrate	MG/K	
Nitrogen	mg/L	TOTAL N AS NO3 MG/L
N N	mg/L	TOTAL N N MG/L
Nitrate	mg/L as N	Nitrate, water, unfiltered, milligrams per liter as nitrogen
Nitrate Nitrogen	mg/L	NO3-N DISS MG/L
Nitrate Nitrogen	mg/L as N	
Nitrate-N	MG/K	
Nitrate-N	MG/L	
Nitrate-N (NO3-N)	MG/L	
Nitrate-N (NO3-N)	UG/L	
No3 - N	mg/L	NO3-N TOTAL MG/L
Nitrite	mg/L	NITRITE TOT-NO2 MG/L
Nitrite	MG/L	Nitrite, water, filtered, milligrams per liter
Nitrite	mg/L as N	Nitrite, water, filtered, milligrams per liter as nitrogen
Nitrite Nitrogen	mg/L	NO2-N TOTAL MG/L
Nitrite Nitrogen, Total	MG/L	
Nitrite-N (NO2-N)	MG/L	
Orthophosphate	UU/C	
Orthophosphate	ÆMHO	
Orthophosphate	mg/L	ORTHOPO4 PO4 MG/L
Orthophosphate (PO4)	MG/L	
Phosphate	mg/L	T PO4 PO4 MG/L
Phosphate	mg/L	Phosphate, water, unfiltered, milligrams per liter
Phosphate-ortho	MG/L	
Phosphorus	mg/L as P	Phosphorus, water, unfiltered, milligrams per liter as phosphate
Phosphorus	mg/L	TOTAL P AS PO4 MG/L
Orthophosphate	UU/CM	
Orthophosphate	UU/C	
Orthophosphate	ÆMHO	
Orthophosphate	mg/L as P	Orthophosphate, water, filtered, milligrams per liter as phosphorus
Orthophosphate	MG/L	Orthophosphate, water, unfiltered, milligrams per liter as phosphorus
Orthophosphate-P (PO4-P)	MG/L	
PHOS-T ORTHO	mg/L	PHOS-T ORTHO MG/L P

Table 1, continued

analyte name reported	units	Remarks
Phosphorus - Ortho	mg/L	PHOS-DIS ORTHO MG/L P
pH	standard uni	pH, water, unfiltered, laboratory, standard units
pH	SU	
pH	pH Un	
pH	PH U	
pH	S.U.	
pH	Lab SU	
pH	SU	PH LAB SU
pH	PH UN	
pH	H	
pH	Std. U	in Standard Units
pH	S.U.	
pH	MG/L	
pH	PH U	
pH	H	
Selenium	MG/KG	
Selenium	ug/L	Selenium, water, unfiltered, micrograms per liter
Selenium	ug/L	SELENIUM SE,TOT UG/L
Selenium	MG/L	
Selenium	MG/L	
Selenium, Dissolved by ICP	MG/L	
Selenium, Total by ICP	MG/L	
SIMAZINE	ug/L	SIMAZINE WH.WATER (UG/L)
Simazine	MG/L	
Simazine by GC/ECD	MG/L	
Simazine by GC/NPD	MG/L	
Simazine by GC/NPD	UG/L	
SIMAZINE GC/ECD	ug/L	Concentration
SIMAZINE GC/NDP	ug/L	Concentration
Simazine	UG/L	Simazine, water, unfiltered, recoverable, micrograms per liter
Simazine	MG/L	
Sodium	mg/L	Sodium, water, unfiltered, recoverable, milligrams per liter
Sodium	%	Sodium, water, percent in equivalents of major cations
Sodium	ppb	Elemental concentration of Sodium
Sodium, Dissolved by ICP	MG/L	
Sodium, Total by ICP	MG/L	
Sodium	MG/KG	
Sulfate	mg/L	SULFATE SO4-TOT MG/L
Sulfate	mg/L	Sulfate, water, unfiltered, milligrams per liter
Toluene	MG/L	
Toluene		
TOLUENE	ug/L	TOLUENE TOT UG/L
Toluene	MG/L	
Toluene	UG/L	Toluene, water, unfiltered, recoverable, micrograms per liter

Table 1, continued

analyte name reported	units	Remarks
Toluene	MG/KG	
Toluene	MG/K	
Toluene	ML/L	
Toluene	ÆG/M	
Toluene-d8	%	Toluene-d8, surrogate, Schedule 2090, water, unfiltered, percent recovery
Dissolved Solids	mg/L	Residue on evaporation at 180 degrees C
Solids	Tons/Day	DISS SOL TONS/DAY
Solids	mg/L	DISS SOL SUM MG/L
Solids	Tons/Acr	DISS SOL TONS PER ACRE-FT
Total Dissolved Solids	MG/L	
Suspended Solids	mg/L	Suspended solids, dried at 110 degrees Celsius, water, milligrams per liter
Total Suspended Solids	MG/L	
Triazine	MG/L	
Triazines by Immunoassay	MG/L	
Triazines by Immunoassay	UG/L	
TRIAZINES IMA	ug/L	Concentration
1,2-Xylene	MG/KG	
1,2-Xylene	MG/L	
1,2-Xylene	ML/L	
1,2-Xylene	MG/K	
1,2-Xylene	UG/L	
1,2-Xylene	ÆG/M	
1,3-Xylene	UG/L	
1,3-Xylene	MG/L	
1,3-Xylene & 1,4-Xylene	MG/KG	
1,3-Xylene & 1,4-Xylene	MG/L	
1,3-Xylene & 1,4-Xylene	ÆG/M	
1,3-Xylene & 1,4-Xylene	ML/L	
1,3-Xylene & 1,4-Xylene	MG/K	
1,4-Xylene	UG/L	
1,4-Xylene	MG/L	
M-XYLENE	ug/L	Concentration
M-Xylene	mg/L	M-XYLENE TOT MG/L
m-Xylene plus p-xylene	ug/L	m-Xylene plus p-xylene, water, unfiltered, recoverable, micrograms per liter
Total Xylenes		
TOTAL XYLENES	ug/L	Concentration
Xylene	ug/L	XYLENE TOT UG/L
Xylene (all isomers)	ug/L	Xylene (all isomers), water, unfiltered, recoverable, micrograms per liter
Xylenes	MG/L	
Xylenes	UG/L	

It would be impossible for a non- expert user to obtain all the data for a constituent of interest because of non-standard reporting contained in the repository. Therefore, KGS standardized analyte names so that queries could return all results for an analyte of interest. Each combination of analyte name, concentration units, and remarks was examined to confirm that the analyte reported was in fact the analyte of interest. Analyte names that were variations of the same solute or compound were assigned a standard name.

Concentrations of each analyte of interest were reported in a variety of units in the repository (Table 1). These units had to be standardized so that all concentrations of a particular analyte were reported in identical concentration units. In most cases, concentrations were converted to milligrams per liter (mg/L) of the solute, or equivalent mg/l of nitrogen (N) for the nitrate (NO_3^-), nitrite (NO_2^-), and ammonium (NH_4^+) or equivalent mg/l of phosphorus (P) for orthophosphate (PO_4^{-3}) (Table 2). International conventions were followed for conductivity and pH units; standard practices were followed for alkalinity and hardness reporting.

Table 2. List of standard names and units.

standard_name	standard units
2,4-D	mg/L
Alachlor	mg/L
Alkalinity	mg/L as $CaCO_3$
Ammonia-Nitrogen	mg/L as N
Arsenic	mg/L
Atrazine	mg/L
Barium	mg/L
Cadmium	mg/L
Calcium	mg/L
Chloride	mg/L
Chromium	mg/L
Conductivity	Microsiemens/cm
Copper	mg/L
Cyanazine	mg/L
Fluoride	mg/L
Hardness	mg/L as $CaCO_3$
Iron	mg/L
Lead	mg/L
Magnesium	mg/L
Manganese	mg/L
Mercury	mg/L
Metolachlor	mg/L
Nitrate-Nitrogen	mg/L as N
Nitrite-Nitrogen	mg/L as N
Orthophosphate-Phosphorus	mg/L as P
pH	Standard Units
Selenium	mg/L

Table 2 continued

standard_name	standard units
Simazine	mg/L
Sodium	mg/L
Sulfate	mg/L
Toluene	mg/L
Total Dissolved Solids	mg/L
Total Suspended Solids	mg/L
Xylenes	mg/L

Activity 1-3, Examine data for erroneous entries:

Reports of exceptionally high concentrations were individually examined; results were deleted from the database only if there was clear evidence that the report was in error. Examples of such errors are transcription errors from paper copy to digital files, or cases where analyte names were paired with inappropriate concentration units. Otherwise, high concentrations were considered possibly real and were retained.

Activity 1-4, Export data for mapping:

Data tables were generated using Microsoft Access queries to the Groundwater Data Repository, and then exported to Microsoft Excel for examination and standardization. Excel files were then imported to ArcView and ArcGIS for mapping. Map symbols and concentration ranges were chosen to highlight sites where analyte concentrations approached or exceeded health standards or showed that NPS chemicals had entered the groundwater system (Table 3). EPA maximum contaminant levels (MCLs) or secondary maximum contaminant levels (SMCLs) were used to determine plot groupings if such levels were established; otherwise, standards set by Kentucky regulatory agencies were used. If no standards existed, concentration groupings for plotting were chosen to highlight natural variations.

Table 3. Concentration ranges used for plotting analyte concentrations.

Analyte	Concentration range
2,4-D	Greater than MCL (0.07 mg/L)
	Less than or equal to MCL
	Less than detection
Alachlor	Greater than MCL (0.002 mg/L)
	Less than or equal to MCL
	Less than detection

Table 3. Continued

Analyte	**Concentration range**
Alkalinity	Less than 500 mg/L
	501 to 1,000 mg/L
	Grater than 1000 mg/L
Ammonia-N	Greater than 0.110 mg/L (DEP)
	Less than or equal to 0.110 mg/L
	Less than detection
Arsenic	Greater than MCL (0.010 mg/L)
	Less than or equal to MCL
	Less than detection
Atrazine	Greater than MCL (0.003 mg/L)
	Less than or equal to MCL
	Less than detection
Barium	Greater than MCL (2.0 mg/L)
	Less than or equal to MCL
Barium	Less than detection
Benzene	Greater than MCL (0.005 mg/L)
	Less than or equal to MCL
	Less than detection
Chloride	Greater than SMCL (250 mg/L)
	Less than or equal to SMCL
Conductivity	Greater than 10,000 microsiemens/cm
	Less than or equal to 10,000 microsiemens/cm
Cyanazine	Greater than 0.001 mg/L (HAL)
	Less than or equal to 0.001 mg/L
	Less than detection
Ethylbenzene	Greater than MCL (0.7 mg/L)
	Less than or equal to MCL

Table 3. Continued

Analyte	**Concentration range**
	Less than detection
Fluoride	Greater than MCL (4.0 mg/L)
	2 to 4 mg/L
	Less than or equal to 2 mg/L
Hardness	Greater than 120
	Less than or equal to 120
Iron	Greater than SMCL (0.3 mg/L)
	Less than or equal to SMCL
Manganese	Greater than SMCL (0.05 mg/L)
	Less than or equal to SMCL
Mercury	Greater than MCL (0.002 mg/L)
	0.001 to 0.002 mg/L
	Less than detection
Metolachlor	Greater than 0.1 mg/L
Metolachlor	Less than or equal to 0.1 mg/L
	Less than detection
MTBE	Greater than 0.05 mg/L (DEP)
	Less than or equal to 0.05 mg/L
	Less than detection
Nitrate-N	Greater than MCL (10.0 mg/L)
	5 to 10 mg/L
	Less than or equal to 5 mg/L
Nitrite-N	Less than or equal to MCL (1 mg/L)
	Less than detection
Orthophosphate-P	Greater than 0.04 mg/L
	Less than or equal to 0.04 mg/L
	Less than detection
Phosphorus (total)	Greater than 0.1 mg/L

Table 3. Continued

Analyte	**Concentration range**
	Less than or equal to 0.1 mg/L
pH	Less than 6.5 standard units
	6.5 to 8.5 standard units
	Grater than 8.5 standard units
Simazine	Greater than MCL (0.004 mg/L)
	Less than or equal to MCL
	Less than detection
Sulfate	Greater than SMCL (250 mg/L)
	Less than or equal to 250 mg/L
Toluene	Greater than MCL (1.0 mg/L)
	Less than or equal to MCL
	Less than detection
Total dissolved solids	Brine: greater than 2,500 mg/L
	Medium saline: 1,001 to 2,500 mg/L
	Slight saline: 501 to 1,000 mg/L
Total dissolved solids	Potable: less than 500 mg/L
Total suspended solids	Greater than 35 mg/L (KPDES)
	Less than or equal to 35 mg/L
Xylenes (total)	Greater than MCL (10 mg/L)
	Less than or equal to MCL
	Less than detection

MCL: Maximum Contaminant Level (U.S. Environmental Protection Agency). Concentrations higher than the MCL may present health risks.

SMCL: Secondary Maximum Contaminant Level (U.S. Environmental Protection Agency); concentrations greater than the SMCL may degrade the sight, smell, or taste of water.

HAL: Health Advisory Level. Higher concentrations may impact human health.

KPDES: Kentucky Pollution Discharge Elimination System. Standard set for water-treatment facilities.

DEP: Kentucky Department for Environmental Protection risk-based concentration. Higher concentrations may present health risks.

Activity 1-5, Place maps and data on KGS Web site:

The groundwater quality data were plotted on base maps that show the major physiographic provinces and watersheds in Kentucky. These same base maps have been used previously for KGS maps and Information Circulars. These maps and associated data were made available via the KGS Web site. More importantly, KGS developed queries and applications that would permit any user to design and construct a map of analyte concentrations specific to their needs.

Activity 1-6, Prepare tutorial:

Recognizing that most users would need help generating groundwater quality maps and data tables, KGS prepared an on-line tutorial and placed it on the KGS web site.

Objective 2. Prepare statistical summaries of the concentrations of each constituent.

Tabular and graphical summaries are needed to characterize water quality parameters in specific regions or between regions. Previous groundwater quality evaluations conducted by KGS summarized analyte concentrations for major river watersheds and Kentucky Basin Management Units (refs). KGS and DOW agreed that the methods used previously should be used in this project as well.

Activity 2-1, Prepare summary statistics and plots:

Water-quality data are generally positively skewed, that is, concentrations are not symmetrically distributed about a mean value and there are some extremely high values. The combined effect of a non-normal (skewed) distribution and extreme outlier values is that parametric statistical measures such as mean and standard deviation do not adequately describe the data. Nonparametric statistical measures such as quartile values and interquartile range provide a better description of the data population (e.g. Helsel and Hirsch, 1992).

The quartile values are:

zero quartile: the minimum value; all other values are greater,
first quartile: the value which is greater than 25 percent of all values,
second quartile: the median value; greater than 50 percent of all values,
third quartile: the value which is greater than 75 percent of all value,
fourth quartile: the maximum value.

Graphical summaries included cumulative data (probability) plots and box-and-whisker plots.

Probability plots (Figure 1) show values sorted from smallest to largest plotted versus percent of the total number of analytical results. They provide an easy way read percentile values, to identify extreme (outlier) values, and to answer questions such as: what is the probability that a new sample in this region will exceed a particular value?

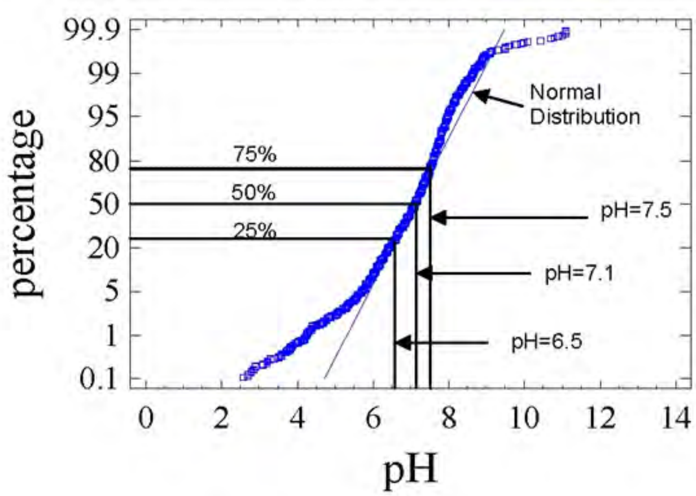


Figure 1. Example of a cumulative data plot, showing pH values in Kentucky groundwater.

Box and whisker plots (Figure 2) show the median value and interquartile range, and illustrate how clustered or scattered the data are. The box extends from the first quartile value to the third quartile value, including the central 50 percent of the data. A center line or notches within the box show the median value. Whiskers extend from each edge of the box a distance of 1.5 times the interquartile range. Values that are more than 1.5 times the interquartile range are shown as squares; values which are more than 3.0 times the interquartile range above the third quartile value or below the first quartile value are shown as squares with plus signs through them. The presence of far outside points indicates suspect values or a highly skewed distribution.

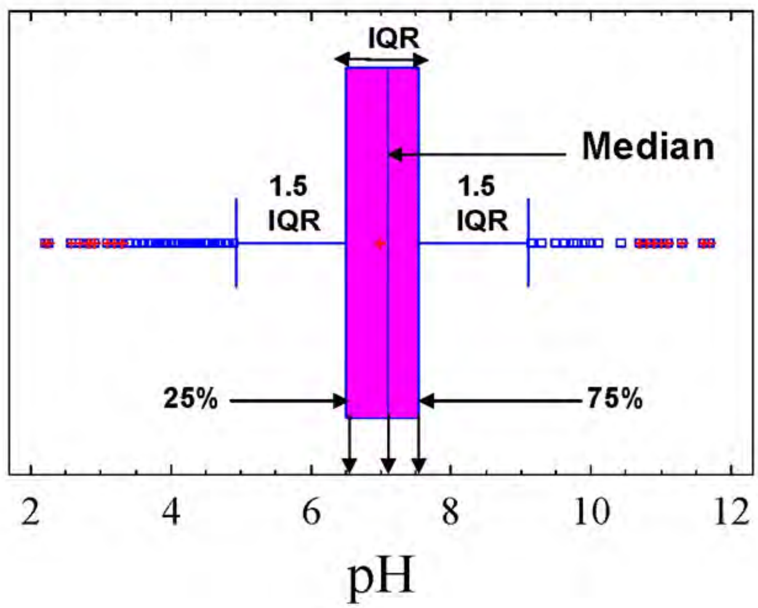


Figure 2. Example of a box and whisker plot showing pH measurements reported in Kentucky groundwater.

Rather than arbitrarily selecting data sets, generating static statistical summaries of the date and posting those on the Web site, KGS proposed to provide the means for the public to choose a data set of interest and generate statistical summaries on-line. Groundwater Branch personnel agreed that this was a much more versatile, useful capability. Calculating quartile values, interquartile ranges, and ranking data for cumulative plots requires only simple mathematics and is described in most statistics books (e.g. Helsel and Hirsch, 1992). KGS purchased the software package Flipper Graph ASP v. 2.8 (www.proworks.com) to generate plots on the web, and used this software package to display the results of statistical calculations.

Objective 3. Prepare information files for each mapped constituent.

KGS and DOW agreed that groundwater quality data would be most useful if educational information was provided at the same time water quality data were made available. This led to the following activities.

Activity 3-1, Summarize sources and potential health effects for each analyte:

Natural and anthropogenic sources and potential health effects of NPS constituents were summarized from information provided by the U. S. Environmental Protection Agency (EPA) and other reference documents. EPA Web sites used include:

http://epa.gov/safewater/standards.html: for drinking water standards,

http://epa.gov/safewater/contaminants/index.html: for list of potential contaminants,

http://epa.gov/safewater/regs.html: for EPA regulations and guidance, and

http://cfpub.epa.gov/safewater/sourcewater/: for source water protection.

The book "Study and Interpretation of the Chemical Characteristics of Natural Water (Hem, 1985) was used for natural sources of dissolved chemicals such as nutrients and solutes derived from groundwater reactions with aquifer materials.

Activity 3-2, Link information files to analyte maps:

Text files were made accessible from the KGS groundwater-quality Web search page.

Objective 4. Link to a list of BMPs that can prevent groundwater contamination by NPS chemicals.

As part of the educational aspect of this project, KGS wanted to provide information regarding ways to avoid groundwater contamination. BMPs (best management practices) are intended to reduce or prevent the transport of sediment or chemicals from land surface to surface waters and the groundwater system. BMPs may consist of physical barriers such as filter strips along crop fields, or methods such as nutrient and pesticide management procedures. BMPs address pollution from both point sources and non-point sources, and for activities ranging from transportation to forestry to agriculture. Although both point-source and nonpoint source chemicals can impact groundwater quality, the focus of this project was nonpoint-source contaminants, particularly from agriculture, silviculture, or on-site waste disposal systems, because these are the main threats to Kentucky groundwater quality.

Activity 4-1, Obtain a list of best management practices:

The Kentucky Division of Conservation, Kentucky Department of Agriculture, and the University of Kentucky, College of Agriculture provide detailed information regarding BMPs designed specifically for Kentucky agriculture and silvaculture. The Kentucky Transportation Cabinet has established BMPs to reduce runoff from construction and post-construction sites, as well as practices designed specifically for Kentucky's karst terrain. Information from these sources was collected and assembled as information files.

Activity 4-2, Summarize the list of BMPs as text files with citations:

Information provided by the sources listed above was summarized with citations.

Activity 4-3, Link the BMP summaries:

Text files with citations and links to sources from activities 4-1 and 4-2 were placed on the Web site and linked to the groundwater data search pages.

Objective 5. Educate and train citizens in the use of these internet educational materials and publicize the availability of the Web site.

Activity 5-1, Conduct training workshops and demonstrations

The availability and capabilities of the new Web site were advertised through professional contacts with members of the Kentucky Division of Water and the U. S. Geological Survey, and at meetings of the Kentucky Department of Agriculture Pesticide Work Group, the Interagency Technical Advisory Committee on Groundwater, the Kentucky Water Resources Research Institute Annual Symposium, and the Kentucky Geological Survey Annual Symposium. All requests for demonstrations were met.

Results and Discussion

Each Workplan objective resulted in one or more products, described below. These products are web-based services, not tangible objects. Their exact form will depend on the conditions specified by each user; that is the power and versatility of this work. To fully evaluate this project final report, the reviewer must be able to access the web sites listed and described.

Objective 1. Prepare Web-based maps showing sample sites and concentrations of selected chemicals; provide Web-based tutorial to facilitate use.

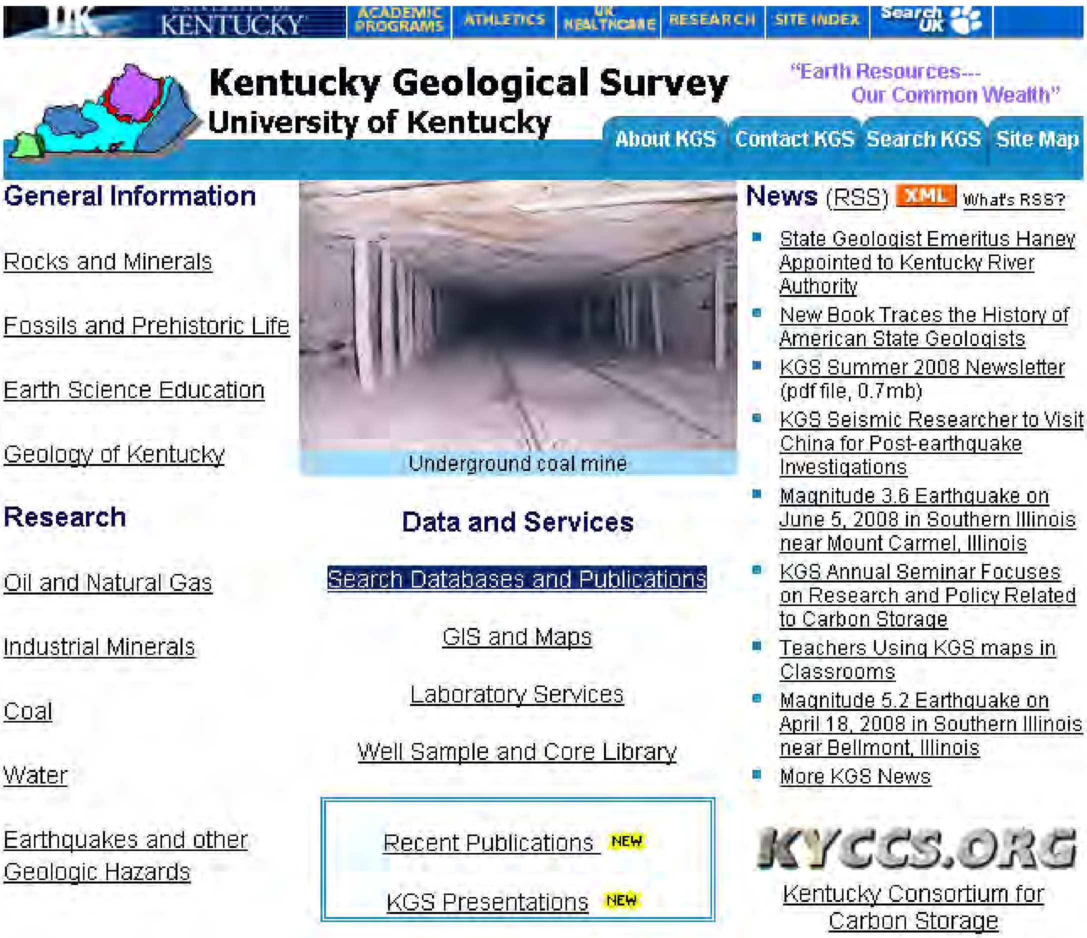
Product 1-1, Map of each analyte with associated metadata:

As described in the "Materials and Methods" section, analytical data reports in the Groundwater Data Repository had to be "cleaned" and standardized before concentrations could be mapped. Once the data were suitable for mapping, several additional useful functions could be offered online. KGS experience was that state regulatory agencies, scientists, and citizens wanted groundwater quality data in a particular area, and often wanted to download the data for other uses. KGS therefore generated two products under this Workplan: (1) a search capability that provides groundwater quality in tabular form, and (2) a search capability that maps groundwater quality. Each search capability includes a wide variety of options that can be selected by individual users to obtain specific data for their particular interests. Both search features include maps of analyte concentrations.

All products are web-based, therefore this final project report uses web page addresses and screen capture views to illustrate the products.

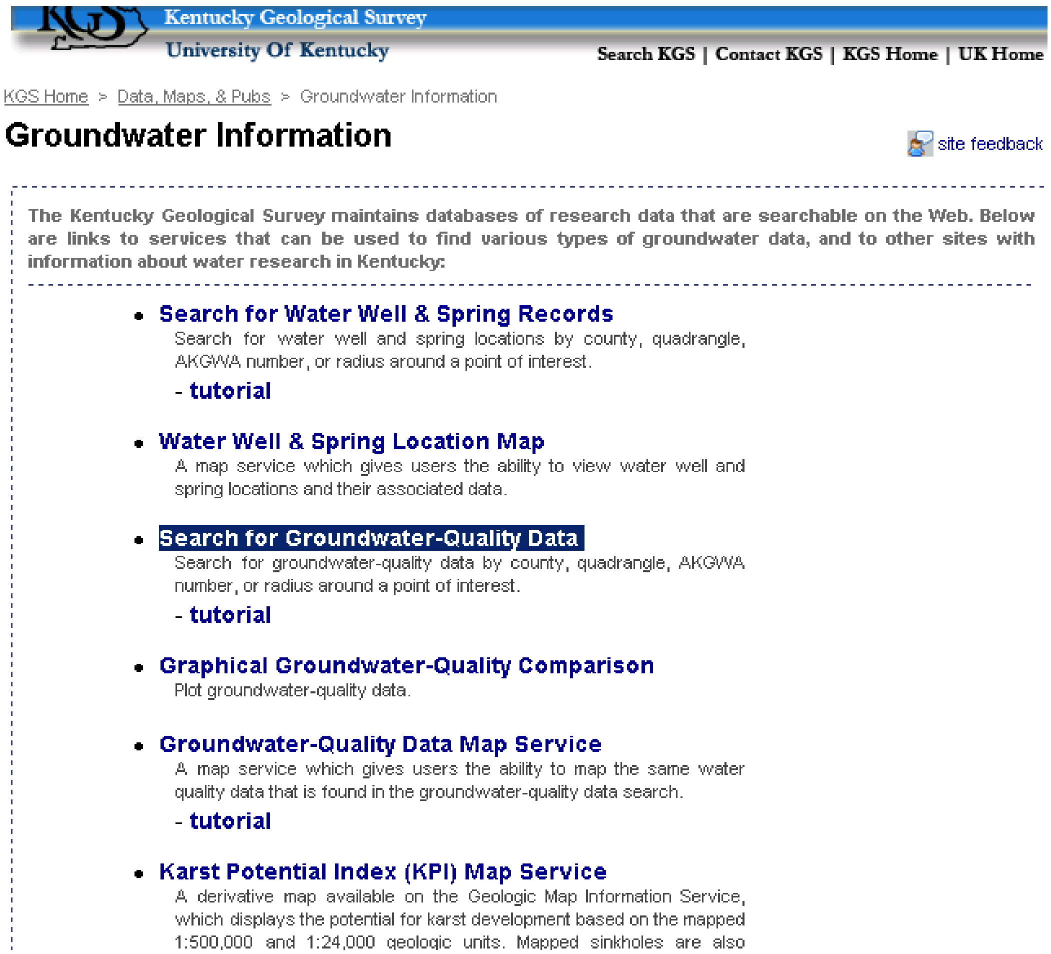
Product 1-1a. Tabular groundwater-quality search capability.

1. Start at the main KGS Web page http://www.uky.edu/KGS/:

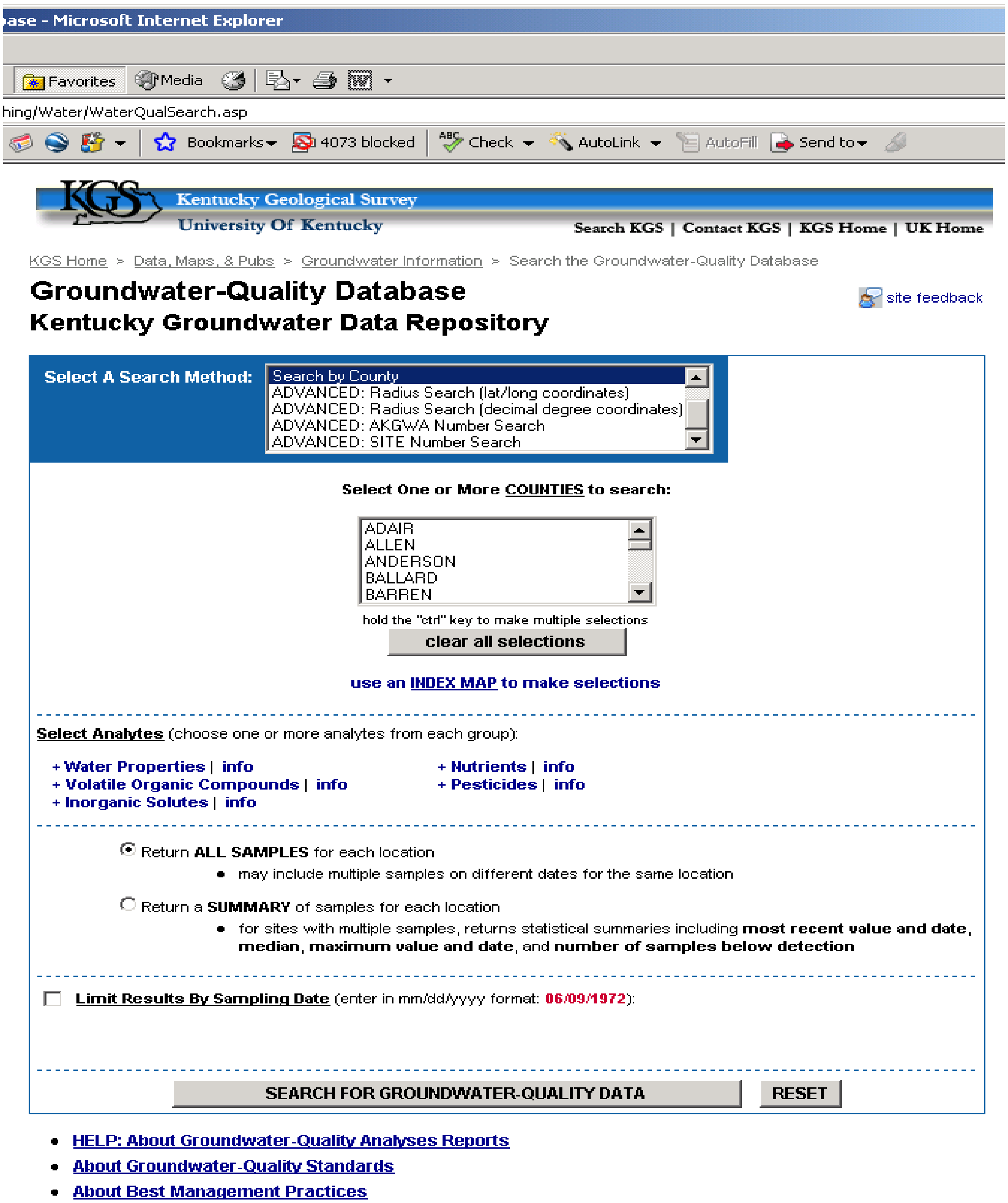


2. Select: Search Databases and Publications. The following page will appear.

3. Select Groundwater Information, the following page will appear. Note that a tutorial is offered beneath the description of the link.



4. Select Search for Groundwater-Quality Data, the following page will appear.



From this site, users can

(1) select a search method: all of Kentucky, one or more quadrangles, one or more counties, radius search about a geographic point, by AKGWA number, or by site number;

(2) select one or all analytes. Each analyte group expands to list individual chemicals; one or more can be selected from each group; note that an information file is shown adjacent to each analyte group name;

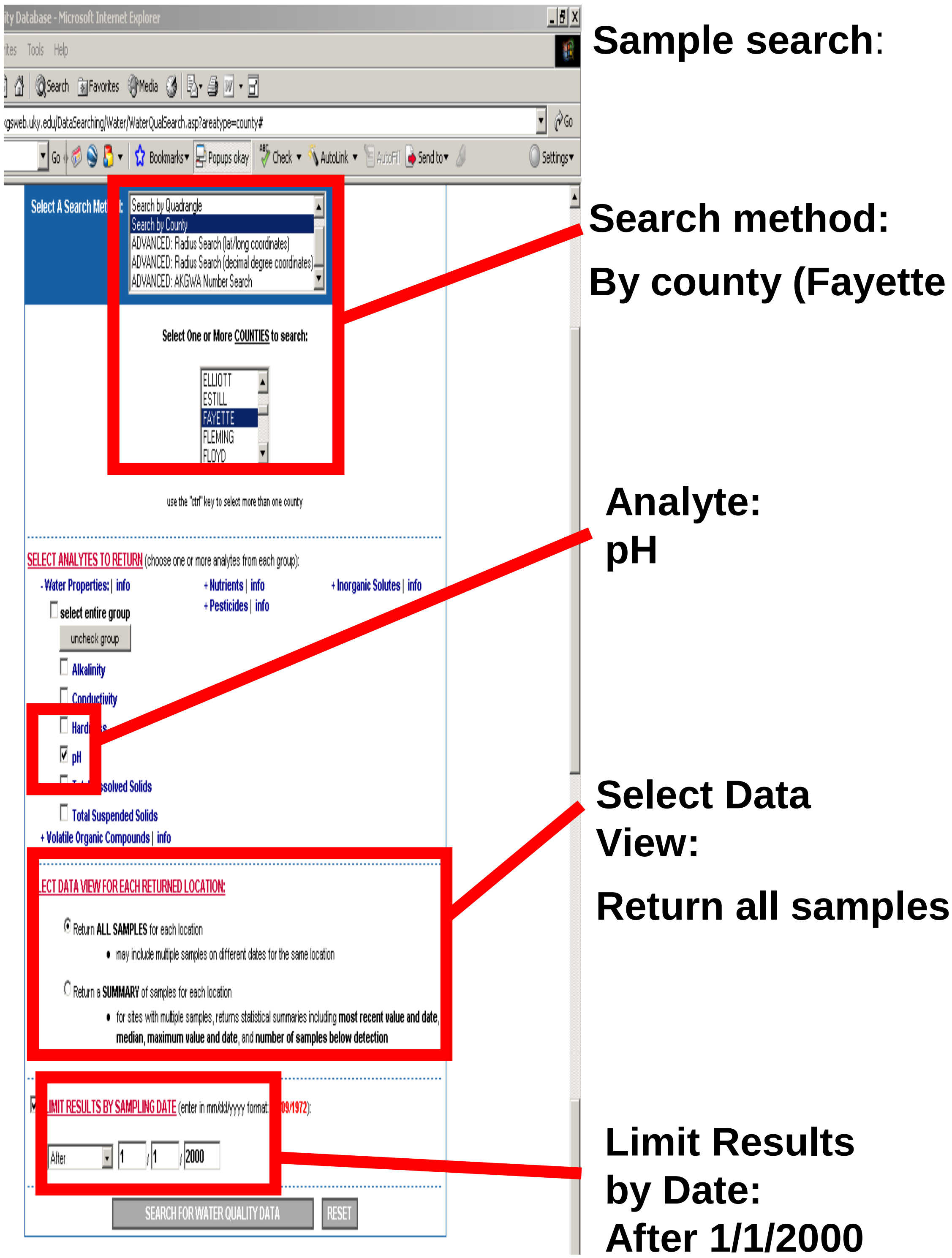
(3) choose to receive data for all samples from a particular well or spring or a summary of the data for each well or spring; and

(4) choose all results in the repository or only samples within a specified time interval (before a date, after a date, or between two dates).

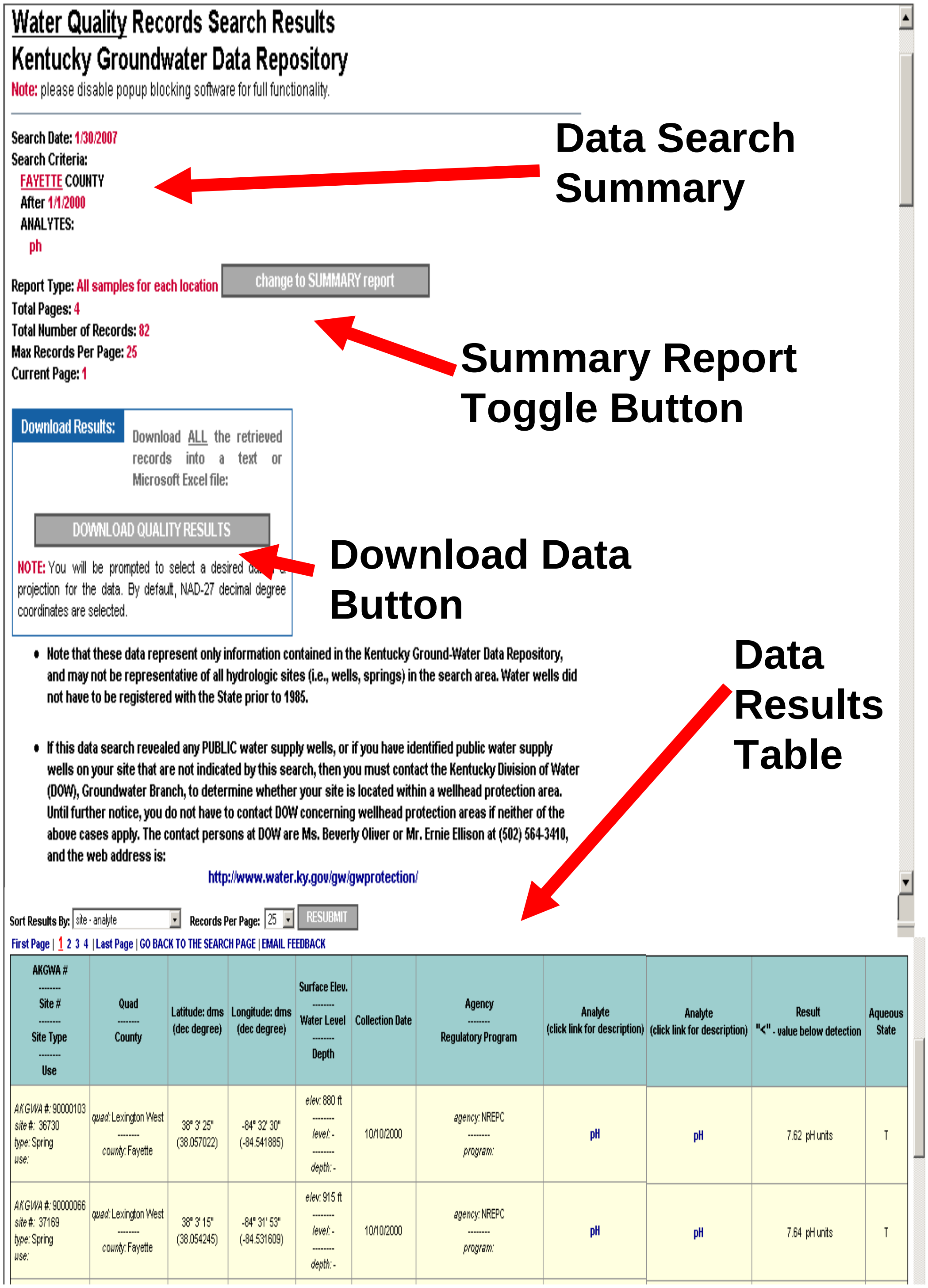
Note that at the bottom of the screen are links to help files about water quality reports, water quality standards, and best management practices..

Clicking on any of the five analyte groups will expand the list. Users can then select explanatory information or a statewide map of the analyte for guidance in their personalized search.

The following example shows the information returned for a particular data search.


Sample search:
Search method:
By county (Fayette
Analyte:
pH
Select Data
View:
Return all samples
Limit Results
by Date:
After 1/1/2000
Search by Quadrangle
Search by County
ADVANCED: Radius Search (lat/long coordinates)
ADVANCED: Radius Search (decimal degree coordinates)
ADVANCED: AKGWA Number Search
Select One or More COUNTIES to search:
ELLIOTT
ESTILL
FAYETTE
FLEMING
FLOYD
SELECT ANALYTES TO RETURN (choose one or more analytes from each group):
Water Properties: | info
Nutrients | info
Inorganic Solutes | info
Pesticides | info
select entire group
uncheck group
Alkalinity
Conductivity
pH
Total Suspended Solids
Volatile Organic Compounds | info
Return ALL SAMPLES for each location
may include multiple samples on different dates for the same location
Return a SUMMARY of samples for each location
After
SEARCH FOR WATER QUALITY DATA
RESET

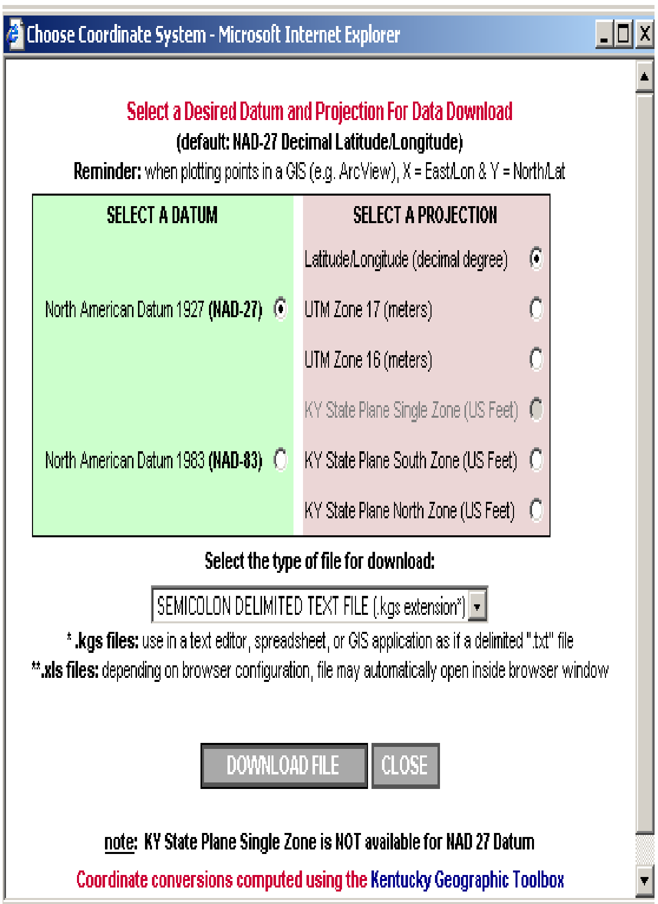
The search engine returns:



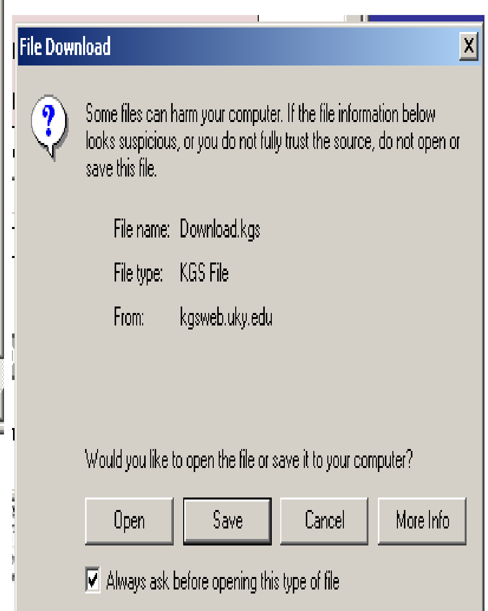
Note the toggle button , which allows switching to data summary mode.

The returned data can be viewed on screen or downloaded to a file. Using the Download Quality Results button produces the following screen which prompts for datum and projection selection and file type desired. This example used default options.

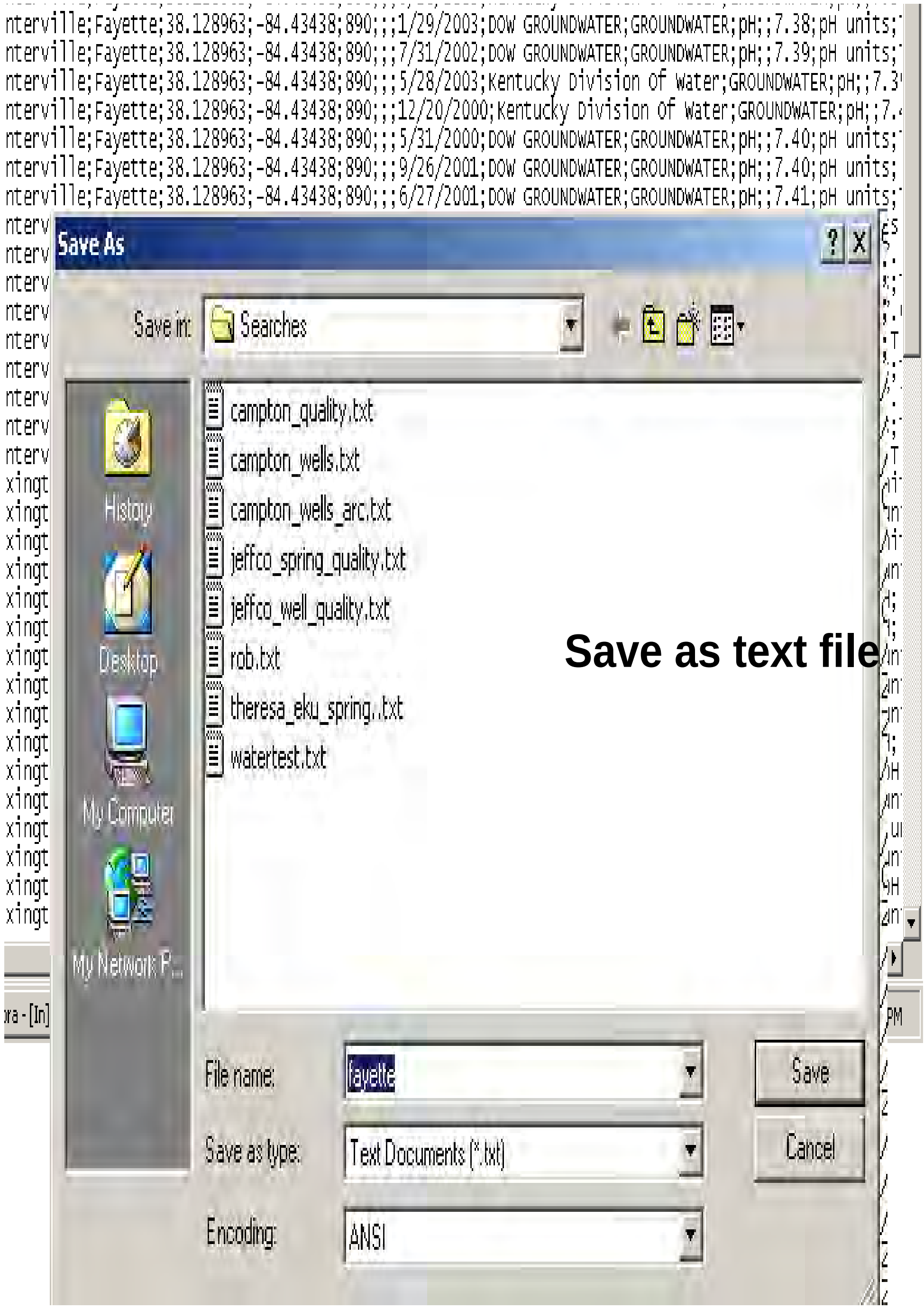
Select datum, projection and file type



Open now or save to ".kgs" file (must change to ".txt" in Explorer)

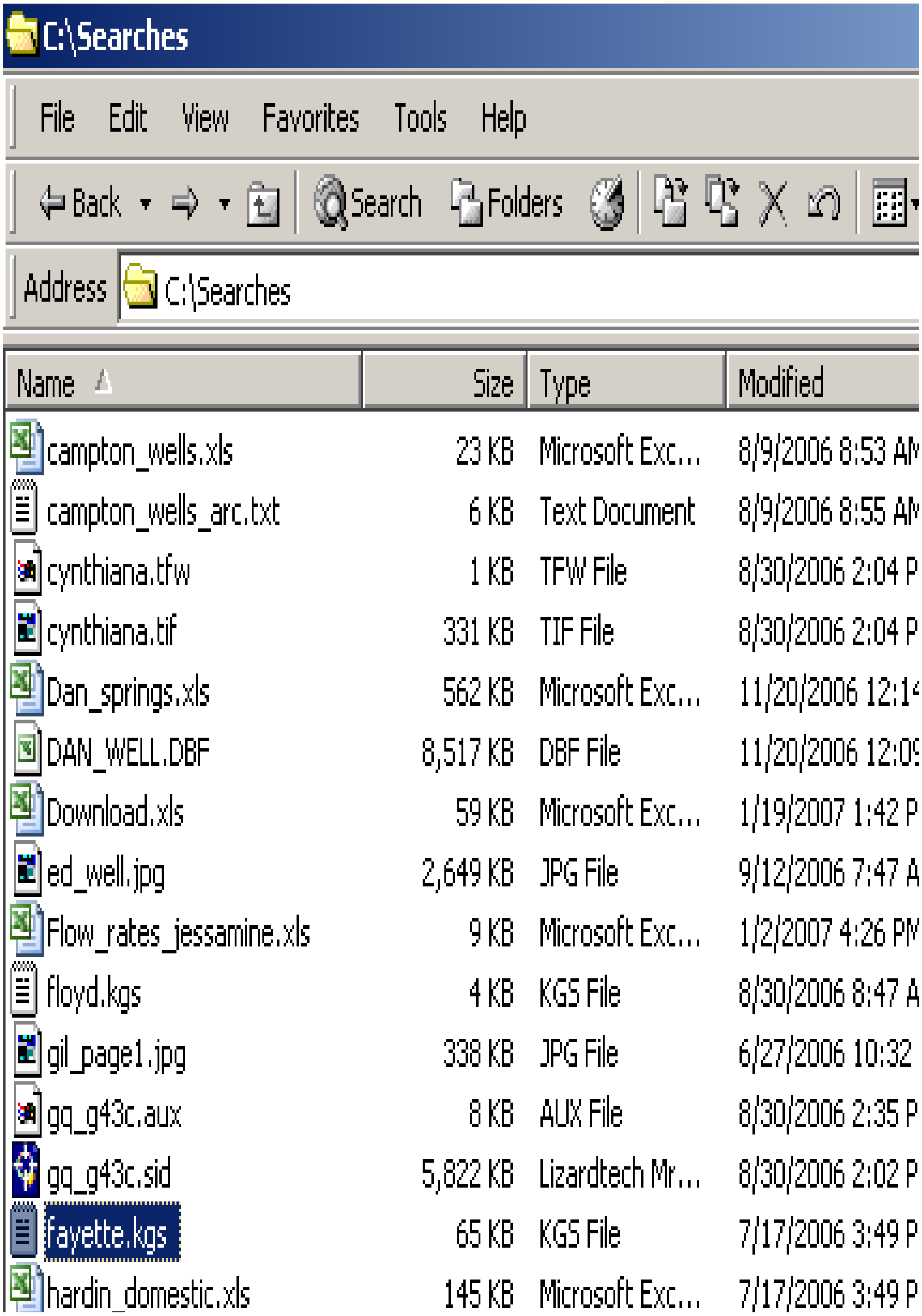


The resulting data file:

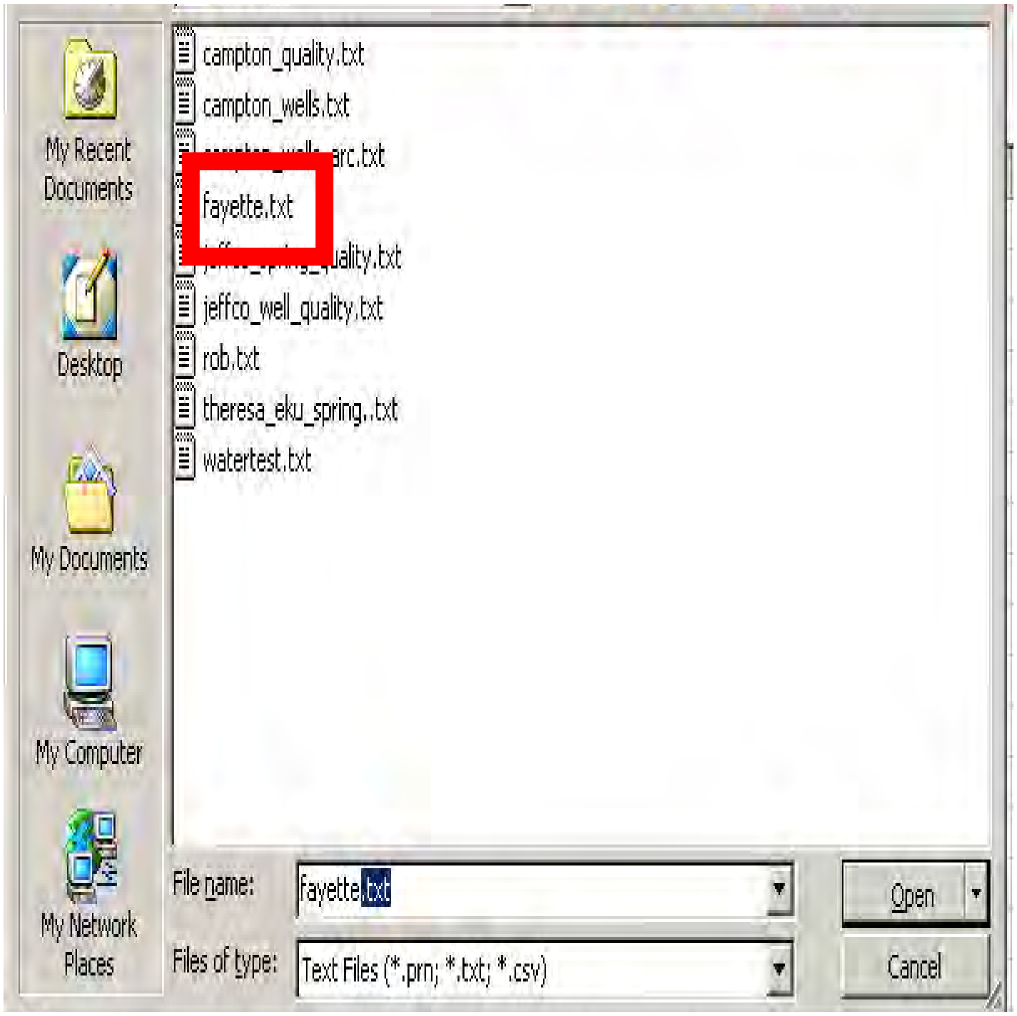


Data Down-load Page

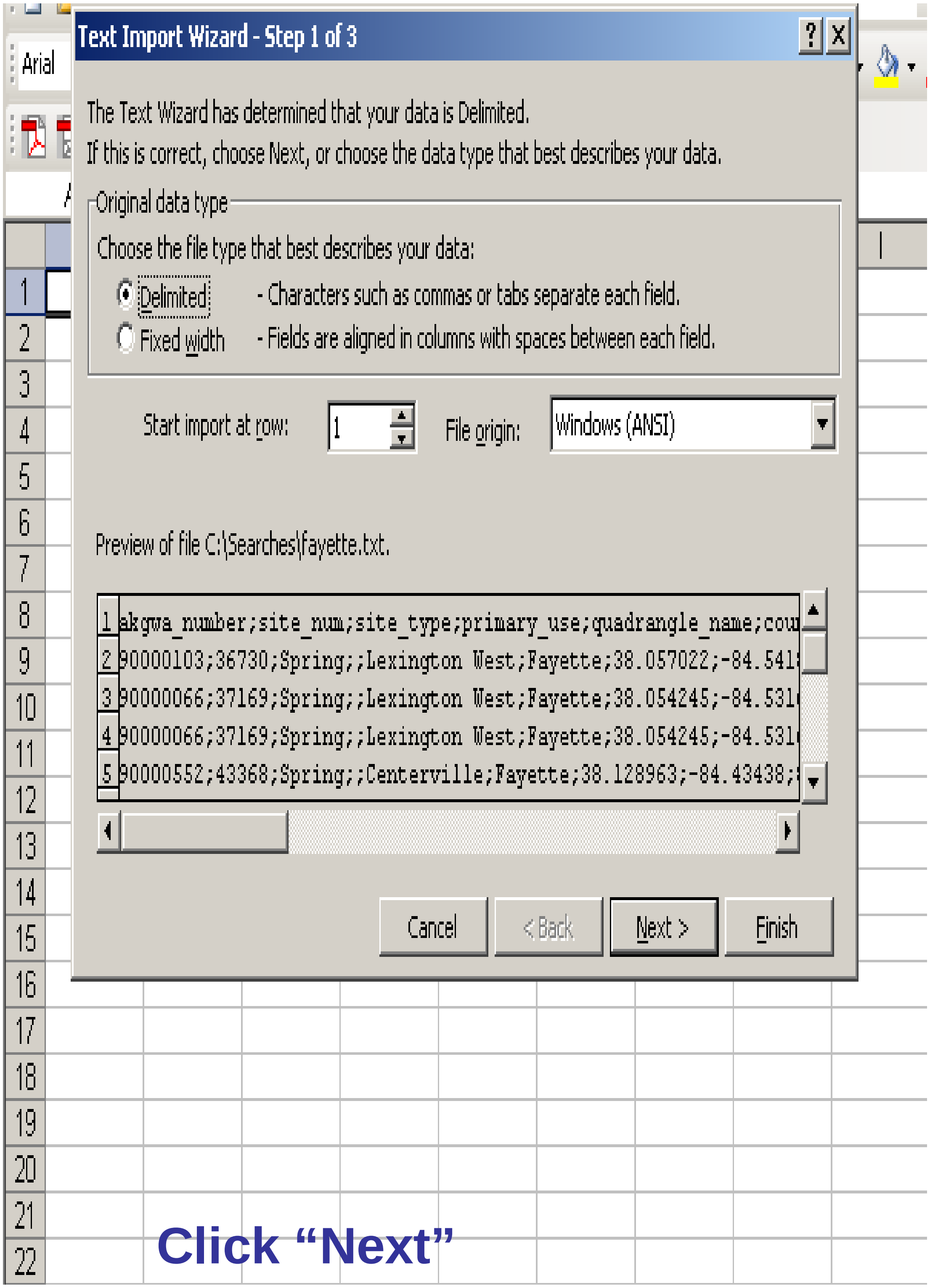
The file is returned with a .kgs extension.



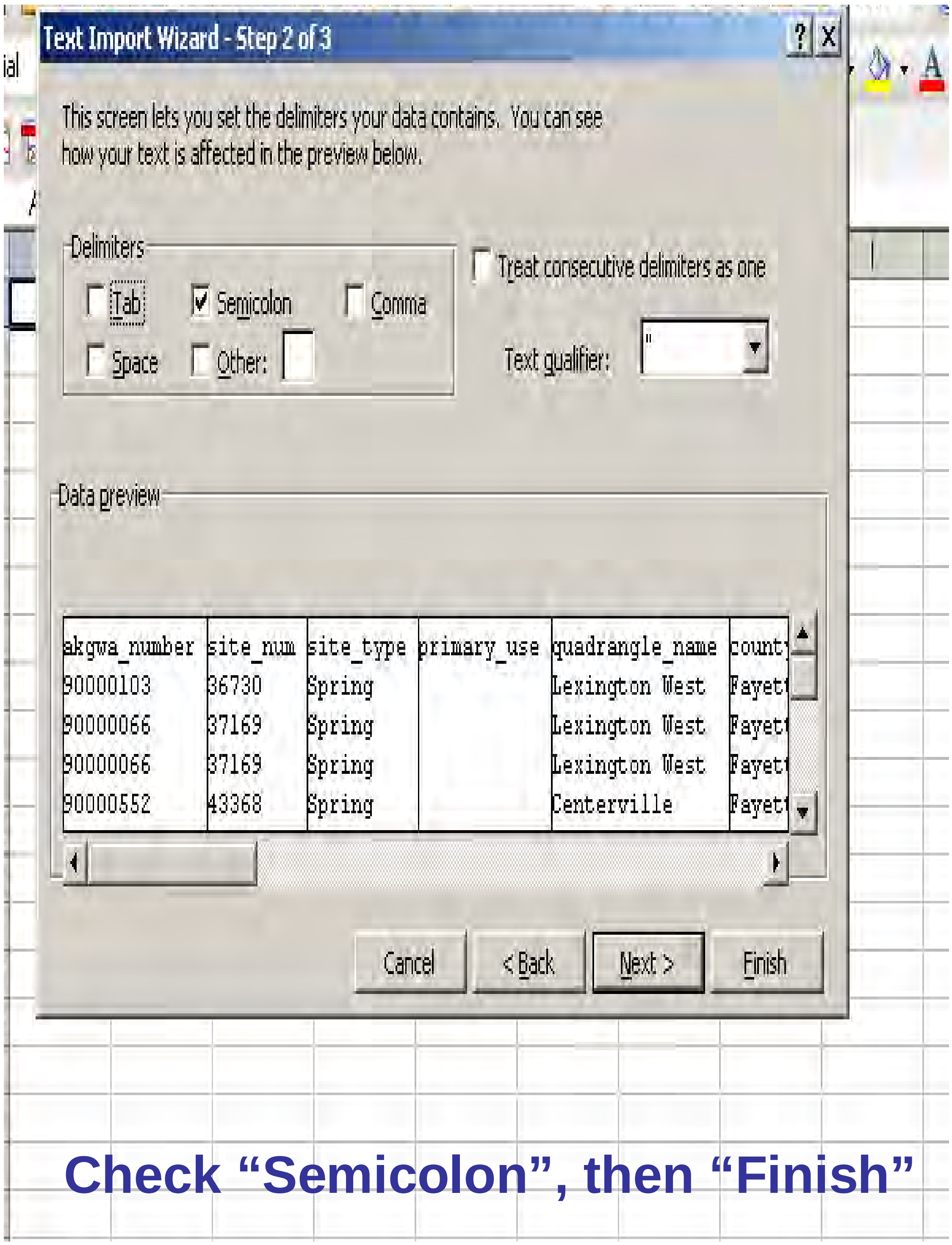
Change the file extension to .txt.



In Excel, open the Fayette.txt file and set file type to delimited.



Set to semicolon delimited.



The delimited data file is created, ready for further use:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	akgwa_nu	site_num	site_type	primary_us	quadrangle	county_na	lat27	lon27	surface_el	static_wat	total_deptl	collection_da	submit_ag	regulatory_	analyte
2	90000103	36730	Spring		Lexington '	Fayette	38.05702	-84.5419	880			10/10/2000	NREPC		pH
3	90000066	37169	Spring		Lexington '	Fayette	38.05425	-84.5316	915			10/10/2000	NREPC		pH
4	90000066	37169	Spring		Lexington '	Fayette	38.05425	-84.5316	915			12/11/2000	Kentucky Division Of '		pH
5	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			4/2/2003	DOW GRC	GROUNDV	pH
6	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			9/26/2001	DOW GRC	GROUNDV	pH
7	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			6/27/2001	DOW GRC	GROUNDV	pH
8	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			10/2/2002	DOW GRC	GROUNDV	pH
9	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			1/29/2003	DOW GRC	GROUNDV	pH
10	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			3/7/2001	DOW GRC	GROUNDV	pH
11	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			10/2/2002	DOW GRC	GROUNDV	pH
12	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			5/28/2003	Kentucky I	GROUNDV	pH
13	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			12/12/2001	DOW GRC	GROUNDV	pH
14	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			12/20/2000	Kentucky I	GROUNDV	pH
15	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			4/25/2000	DOW GRC	GROUNDV	pH
16	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			7/31/2002	DOW GRC	GROUNDV	pH
17	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			4/24/2002	DOW GRC	GROUNDV	pH
18	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			10/28/2002	Kentucky I	GROUNDV	pH
19	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			12/20/2000	Kentucky I	GROUNDV	pH
20	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			5/28/2003	Kentucky I	GROUNDV	pH
21	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			1/29/2003	DOW GRC	GROUNDV	pH
22	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			7/31/2002	DOW GRC	GROUNDV	pH
23	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			5/28/2003	Kentucky I	GROUNDV	pH
24	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			12/20/2000	Kentucky I	GROUNDV	pH
25	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			5/31/2000	DOW GRC	GROUNDV	pH
26	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			9/26/2001	DOW GRC	GROUNDV	pH
27	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			6/27/2001	DOW GRC	GROUNDV	pH
28	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			12/12/2001	DOW GRC	GROUNDV	pH
29	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			12/19/2000	Kentucky I	GROUNDV	pH
30	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			1/11/2000	DOW GRC	GROUNDV	pH
31	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			10/28/2002	Kentucky I	GROUNDV	pH
32	90000552	43368	Spring		Centerville	Fayette	38.12896	-84.4344	890			3/7/2001	DOW GRC	GROUNDV	pH

fayette

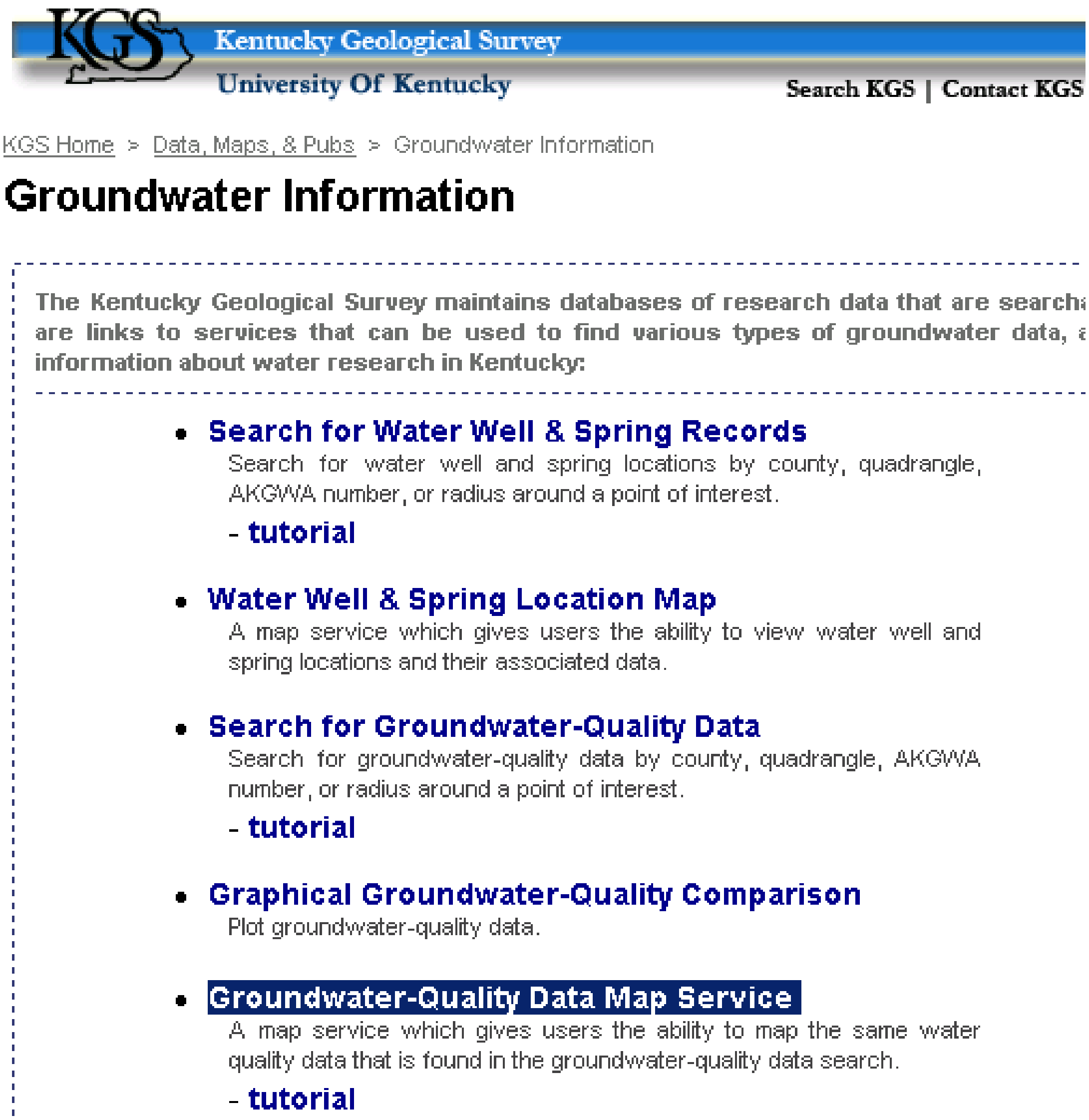
Product 1-1b. Groundwater-quality mapping capability.

The interactive Web-based groundwater quality data mapping service is accessed in the same way as the tabular data search.

1. Start at the main KGS Web page http://www.uky.edu/KGS/:

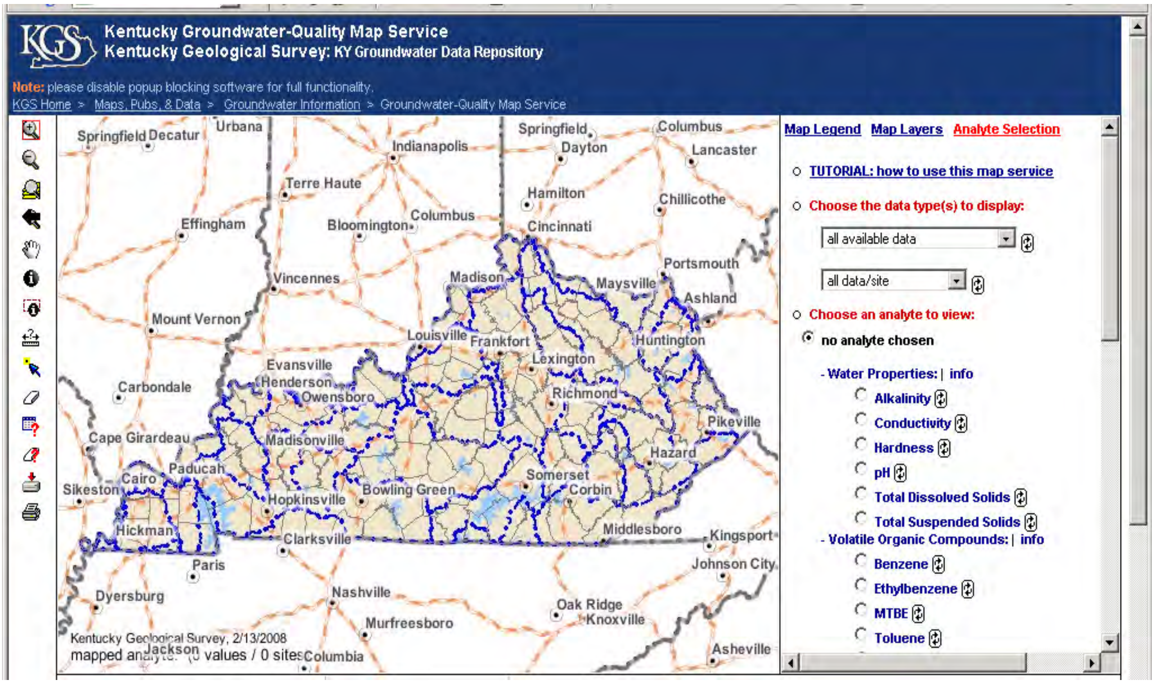
2. Select: Search Databases and Publications.

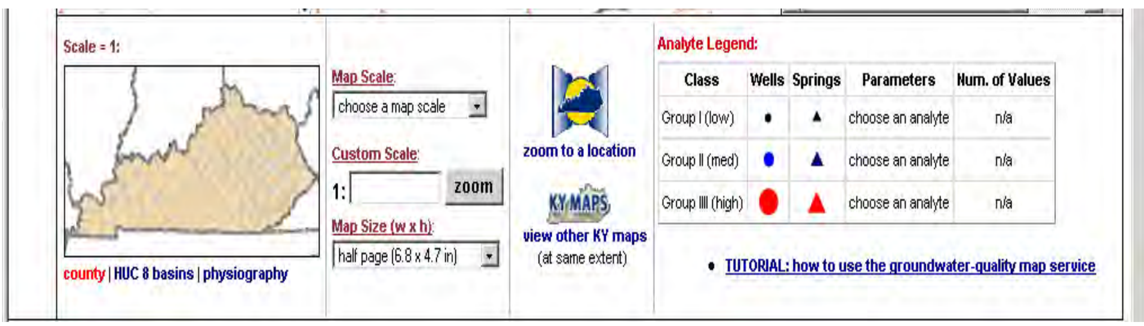
3. Select Groundwater-Quality Data Map Service:



Note that a tutorial is offered beneath the description of the link.

The following page is returned.





In the upper right are options to select map legend, map layers, and analytes, and a button to go to a tutorial. In this example, Analyte Selection has been chosen and highlighted. The map legend explains symbols on whatever base map is selected, whereas the map layers provide choices of base maps. On the left are a series of map tools that can be used to zoom in to areas of interest. At the bottom is a base map that can be switched between county, major watershed, or physiographic region boundaries; also shown is a legend that shows ranges of concentrations for each analyte, with different symbols to distinguish wells from springs.

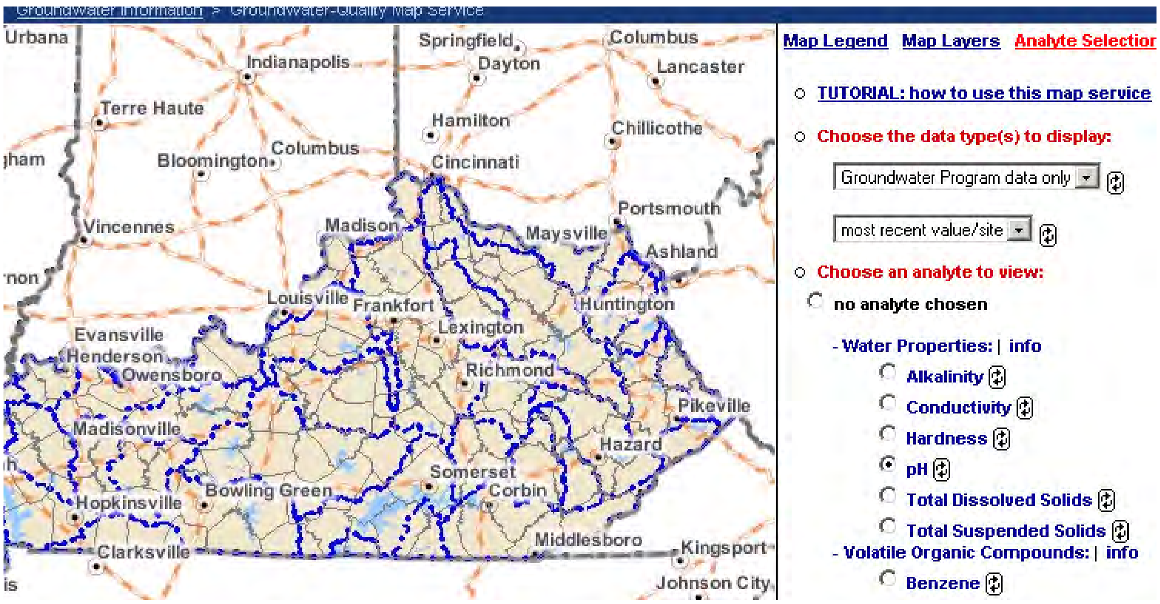
Options for data type are either all data in the repository, or only those results from the Division of Water Groundwater Monitoring Program.

Beneath that, the users can choose all data from each site, the median value from each site, the maximum value from each site, or the most recent value from each site.

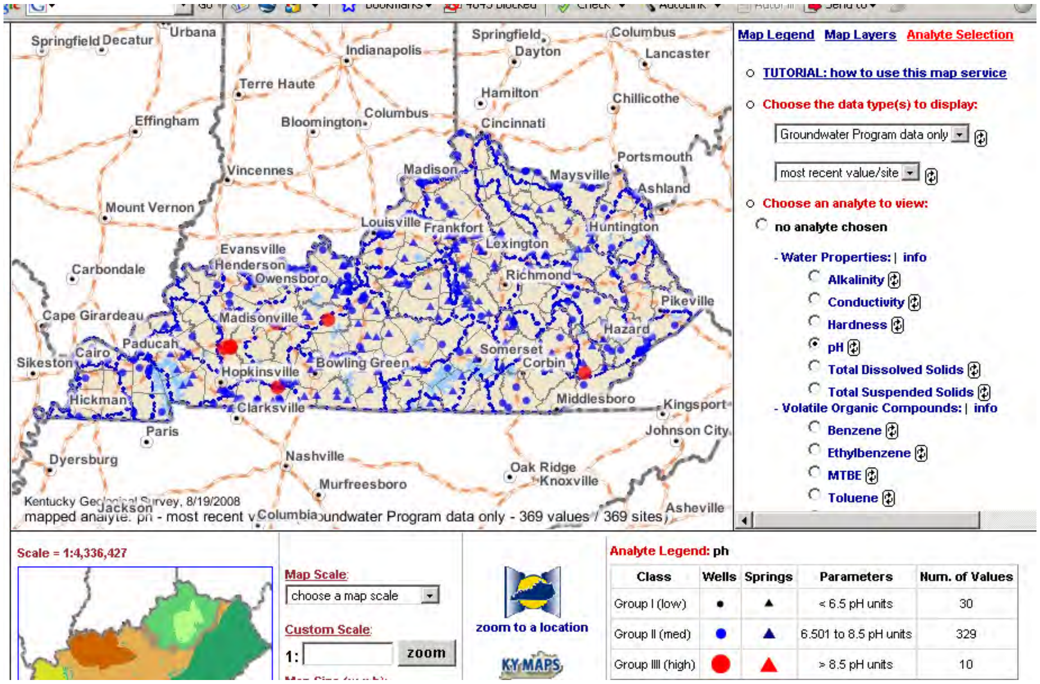
Analytes are listed within major groups; an information file is available for each group of properties or chemicals. Because the results are to be mapped, only one analyte can be selected at a time.

Clicking on any analyte name will open a file with explanatory information and a statewide map of the constituent to help users select and area of interest.

An example of mapping pH values illustrates the capability. We chose the most recent value from samples collected for the Groundwater Monitoring Program.

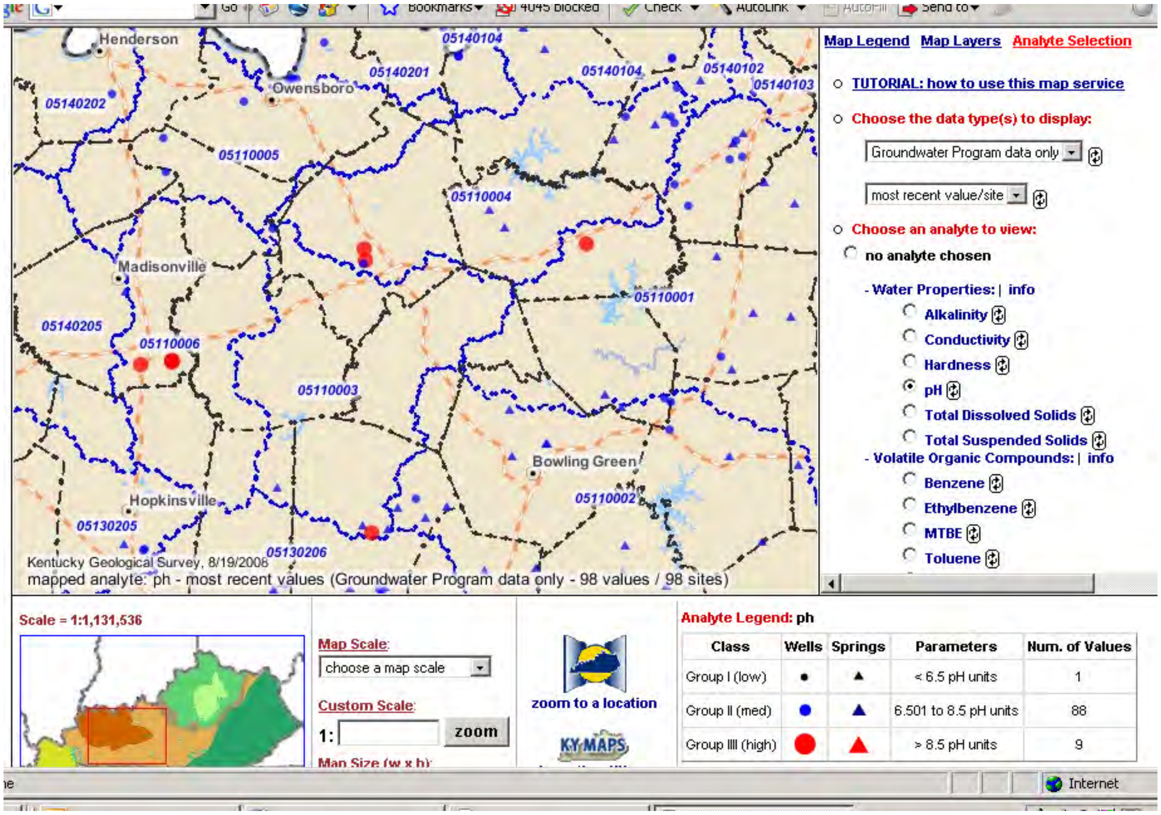


The following page is returned.

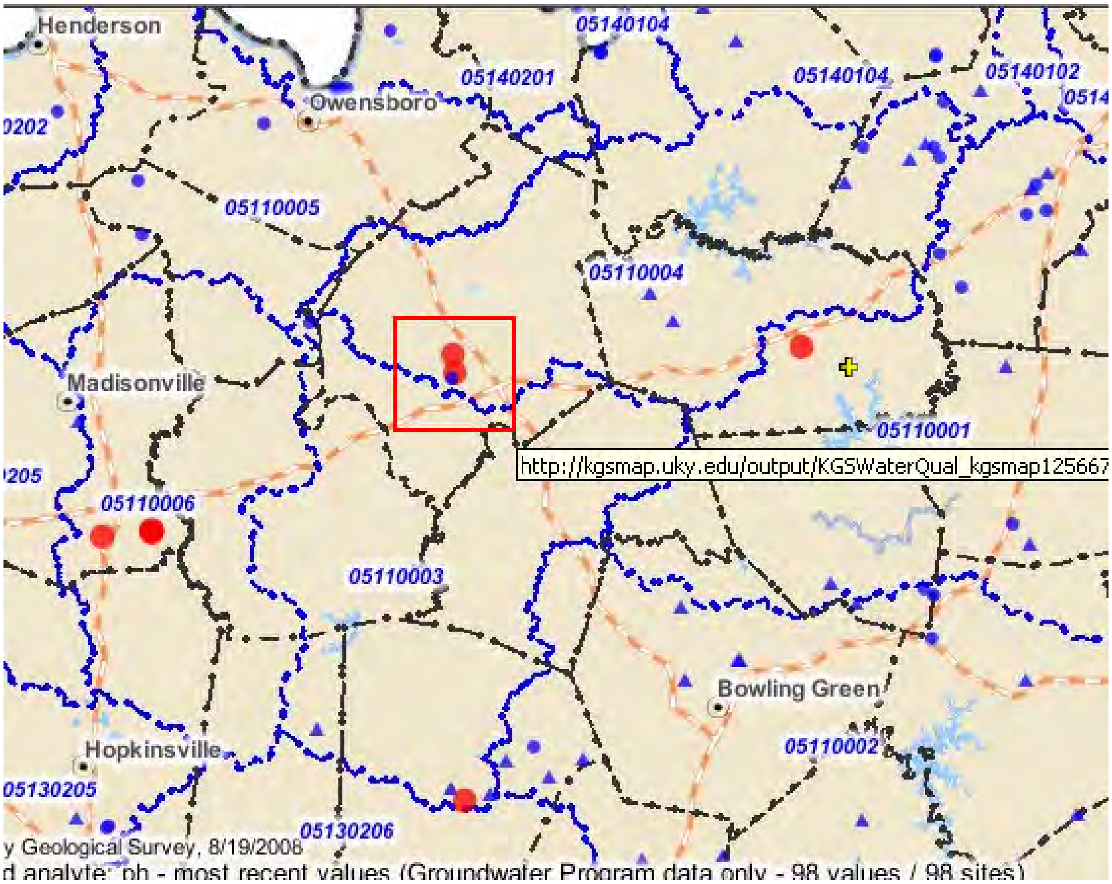


Values are coded according to whether they are below, within, or above the EPA SMCL of 6.5 to 8.5 standard pH units, and whether they are from wells or springs. The legend also shows the number of values in each class.

The mapping tool can be used to zoom into a particular area. Note that the number of samples in each class is automatically updated and additional information such as 8-digit HUC watershed identifiers are now displayed.



The identifier tool can be used to request information for one or more sites. For example, selecting a group of three symbols



returns the following information:

KGS Groundwater Quality Map Service - ID Features - Microsoft Internet Explorer

text search: [ ] find | highlight text | clear highlight

Kentucky Geological Survey
Groundwater-Quality Map Service
Identification of Features

- Print This Page

ID Area Info (center location):
KY Single Zone (north,east): 3671944.3832791 , 4594465.1270831
NAD-83 Decimal Degree (lat,lon): 37.402057, -86.875049
State: Kentucky
County: Ohio
Quadrangle (tile code): Hartford (O22)

Database Features:
(these are the Groundwater Analyses and "Point overlay" features)

- **Groundwater-Quality Information (Summary for All Analyses in ID Area):**

Analyte (click link for description)	No. of Samples -------- No. Below Detection	Max Value -------- Date "<" - value below detection	Most Recent Value -------- Date "<" - value below detection	Median Value
pH	*no. samples:* 56 -------- *no. below:* 0	*max:* 8.73 pH units -------- 3/29/2000	*rec:* 8.41 pH units -------- 2/5/2003	*med:* 8.35 pH units (only values above detection used)

+ **Groundwater-Quality Information (Summary for Analyses per Site)**

+ **Groundwater-Quality Information (All Analyses)**

Map Layer Features:

Watershed Info:

HUC 14 Basin Name	HUC 14 Code	HUC 11 Code	HUC 8 Code
Halls Creek	05110004150010	05110004150	05110004
No Creek	05110004130210	05110004130	05110004
Morrison Run	05110004130140	05110004130	05110004
Rough River	05110004130170	05110004130	05110004
Mill Run	05110004130160	05110004130	05110004

Many other combinations of options can be selected, according to the user's interest.

Product 1-2, On-line tutorial to assist navigating the Web site:

On-line tutorials are available for both the tabular and mapping data servers.

The tutorial for Search for Groundwater-Quality Data is shown below.

Kentucky Groundwater-Quality Data Search at KGS

Online groundwater-quality data searches for Kentucky are now available free of charge on the KGS Web site. Instructions on how to run the online search are provided below. The results of each search can be downloaded to a delimited text file with user-defined geographic coordinates in a desired datum and projection, which can then be inserted into spreadsheets or GIS systems. Search results can also be viewed on an interactive topographic map or aerial photograph by clicking on "Map View" in the results table.

HOW TO FIND THE ONLINE GROUNDWATER-QUALITY DATA SEARCH

1. Navigate to the KGS Web site (www.uky.edu/kgs), then click on the "Search Databases and Publications" link under the "**Data and Services**" heading.
2. Click on "Search for Groundwater Information" in the right-hand box.
3. Seven (7) options are available here, including the water well and spring record search, the water well and spring location map service, the groundwater-quality data search, the graphical groundwater-quality comparison service, the groundwater-quality data map service, the karst potential index map service, and the KGS water research home page. For groundwater-quality data, click on "Search for Groundwater-Quality Data."

HOW TO USE THE ONLINE GROUNDWATER-QUALITY DATA SEARCH

1. **Limit the geographic area for the search.** The default search is set to search for groundwater-quality data by county. To search by quadrangle, by using a radius from a specified latitude and longitude, or by the Kentucky Division of Water "AKGWA" number (if available), click on the "**Select a Search Method**" drop-down window, then select the type of search desired.
2. **Select analytes to return (required step).** There are five major categories of analytes to choose from (water properties, volatile organic compounds, nutrients, pesticides, and inorganic solutes), and 38 individual analytes within those categories. Click on the category to expand it and see all the analytes in that group, or on "Info" to view detailed descriptions of the analytes, including possible health effects. Either the entire group can be checked, or the individual analytes.
3. **Select how the data results will be viewed**. After selecting the analyte(s) to be searched, the display method for showing the results must be selected. If a site has more than one analysis, every record can be displayed (the default choice), or a statistical summary of records can be shown for sites with multiple sample dates.
4. **Limit results by sampling date.** The user can select the period of record for the data being searched. There are four options, using the qualifiers "equals", "between", "before" or "after". If the "**Limit Results by Sampling Date**" box is not checked, all available records will be returned.
5. **Run the search.** Click the "**Search for Groundwater-Quality Data**" button to complete the search. For additional information about the groundwater data reports and groundwater-quality standards, click on the appropriate links at the bottom of the search page. On the search results page, use the "**Download Quality Results**" button to download the data into either a delimited text file with a "kgs" extension (this must be changed to "txt" before using in other applications) or a Microsoft Excel Format file (with an ".xls" extension).

The tutorial for Groundwater-Quality Data Map Service is shown below.

Kentucky Groundwater-Quality Data Map Service at KGS

Displaying groundwater-quality data for Kentucky on interactive maps is a new feature on the KGS web site. Instructions on how to run the online map service are provided below. Users can specify one analyte at a time to be mapped, and choose from a list of 32 layers to display including geology, watershed boundaries, roads, orthophotography and sinkholes. The web site of this new service is http://kgsmap.uky.edu/website/KGSWaterQual/viewer.asp

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HOW TO FIND THE KGS INTERACTIVE GROUNDWATER-QUALITY DATA MAP SERVICE

1. Navigate to the KGS Web site (www.uky.edu/kgs), then click on the "Search Databases and Publications" link under the "**Data and Services**" heading.
2. Click on "Search for Groundwater Information" in the right-hand box.
3. Seven (7) options are available here, including the water well and spring record search, the water well and spring location map service, the groundwater-quality data search, the graphical groundwater-quality comparison service, the groundwater-quality data map service, the karst potential index map service, and the KGS water research home page. For groundwater-quality data, click on "Groundwater-Quality Data Map Service."

HOW TO USE THE KGS INTERACTIVE GROUNDWATER-QUALITY DATA MAP SERVICE

1. Click the **"Analyte Selection"** tab in the upper right corner, if you have not already done so (should be automatically displayed when the map service is first entered).
2. **Specify the data types to display.** Two required choices are shown at the top of the right-hand side bar, in drop-down boxes. The first drop-down box requires the user to select either all available data to be mapped, or only the most recent and complete data ("high-quality data set"). The second choice is regarding sites with multiple samples, and allows the user to specify all data to be displayed for every site, or the median, maximum, or most recent values only.
3. **Select the analyte to be mapped.** This map service can only map one analyte at a time. There are five major categories of analytes to choose from (water properties, volatile organic compounds, nutrients, pesticides, and inorganic solutes), and 38 individual analytes within those categories. The default value is "No analyte chosen", therefore no points appear on the map. Check the desired analyte, and note that the Analyte Legend below will change to the appropriate analyte.
4. **View the map data**
   - **View data for the current map area.** Click the "refresh" button beside the analyte you selected, and the map will refresh and display the available data for the analyte you selected, for the area you are currently viewing (which could be statewide - **load times can be very slow at this scale**).
   - **View data for a specified area or location.** You can choose to zoom to an area of interest either by using the zooming or panning map tools on the left-hand toolbar or by using the "**zoom to a location**" link at the bottom of the page (where you have the option of zooming to over 20 location types including coordinates, counties, HUC basins, and streams). When either the zoom/pan tool or the "zoom to a location" tool is used, the map will refresh and then display the available data for the analyte you selected at the location you selected. **NOTE**: it may take a few minutes for the map to update.
5. **Using the Map Tools on the left-hand toolbar.** A description of the map tools on the left-hand side-bar can be viewed by holding the cursor over each icon for a second or two. Included are zooming and panning tools, point identification tools, and map printing functions.
6. **Displaying map layers and legends.** By clicking on "Map Layers" at the top of the right-hand side-bar, users can select from over 30 layers to add to the interactive map. If the layer name is dimmed, that indicates that the layer cannot be viewed at the current scale, and the user must zoom in for the layer to become active. To display a legend for any map, click on "Map Legend".

Both tutorials are available from the main search page: http://kgsweb.uky.edu/DataSearching/watersearch.asp. The mapping tutorial is also available from the main mapping page: http://kgsmap.uky.edu/website/KGSWaterQual/viewer.asp.

Objective 2. Prepare statistical summaries of concentrations of each constituent.

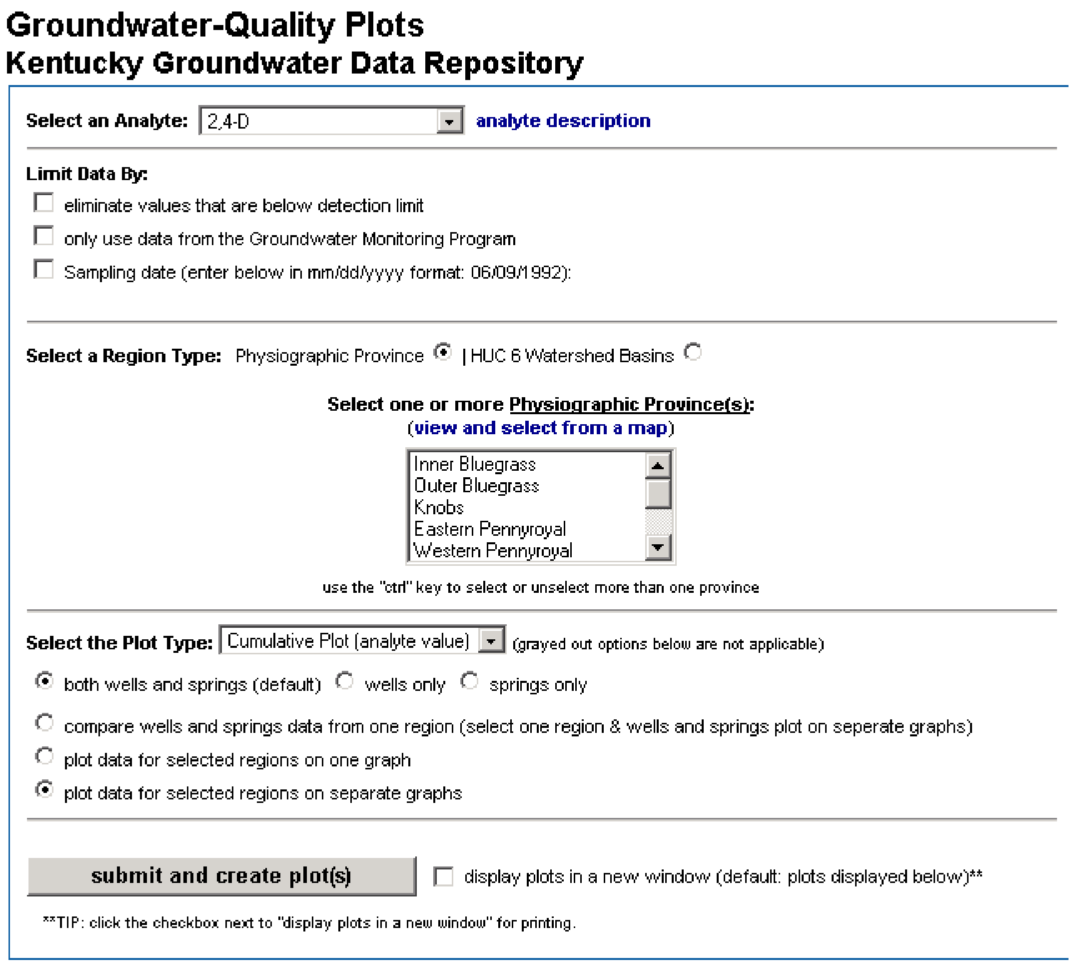
Product 2-1. Summary data tables and plots:

The tabular data search described in Objective 1, Product 1, returns statistical data for analyte concentrations in individual wells or springs that have been sampled repeatedly. With the summary report selected, the following information is returned for each well or spring: site number, AKGWA number, site type, primary use, latitude, longitude, surface elevation, water level, depth, analyte name, number of samples, number of samples below detection, maximum value with sample date, most recent value with sample date, and median value.

An additional capability returns statistical summaries and data plots for concentrations in a major watershed or physiographic region. These regions were chosen because they contain sufficient number of samples to make statistical parameters and plots significant; smaller geographic areas contain too few samples for meaningful statistical comparisons.

Starting from the KGS groundwater information page http://kgsweb.uky.edu/DataSearching/watersearch.asp, select Graphical Groundwater-Quality Comparison.

The following page appears.


Groundwater-Quality Plots
Kentucky Groundwater Data Repository

Select an Analyte: 2,4-D analyte description

Limit Data By:
eliminate values that are below detection limit
only use data from the Groundwater Monitoring Program
Sampling date (enter below in mm/dd/yyyy format: 06/09/1992):

Select a Region Type: Physiographic Province | HUC 6 Watershed Basins

Select one or more Physiographic Province(s):
(view and select from a map)
Inner Bluegrass
Outer Bluegrass
Knobs
Eastern Pennyroyal
Western Pennyroyal
use the "ctrl" key to select or unselect more than one province

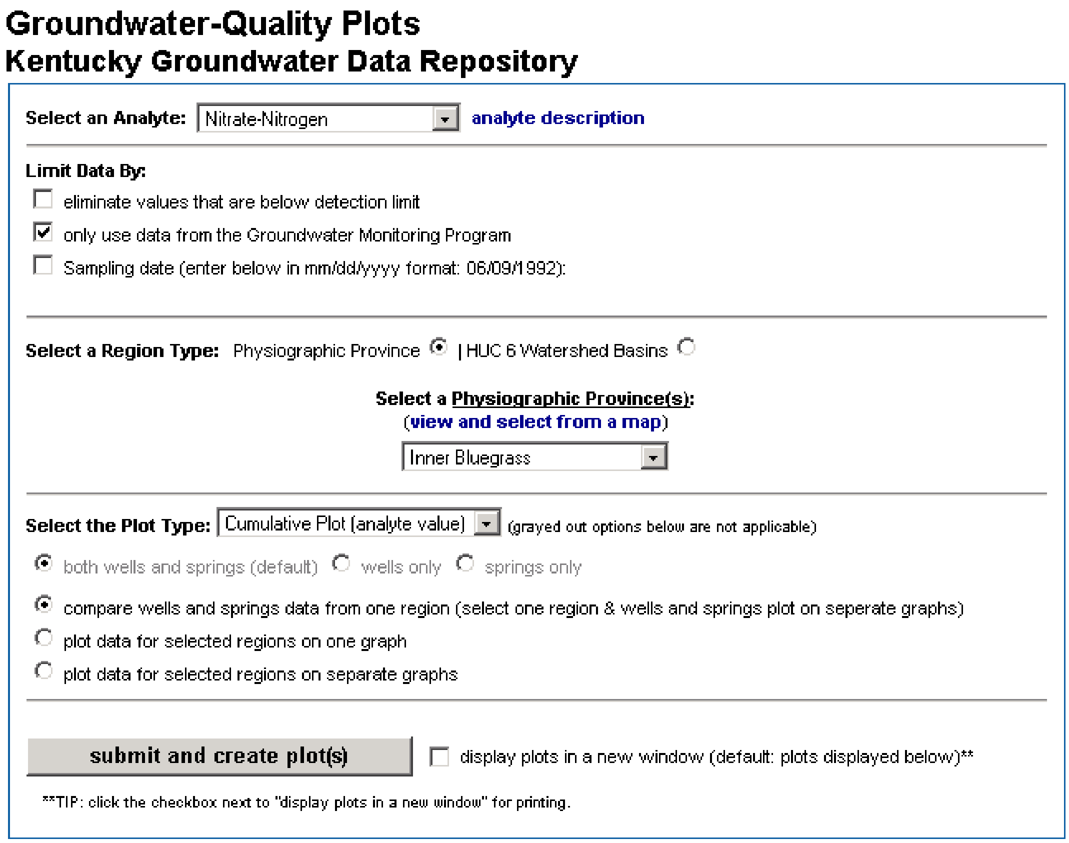
Select the Plot Type: Cumulative Plot (analyte value) (grayed out options below are not applicable)
both wells and springs (default) wells only springs only
compare wells and springs data from one region (select one region & wells and springs plot on seperate graphs)
plot data for selected regions on one graph
plot data for selected regions on separate graphs

submit and create plot(s) display plots in a new window (default: plots displayed below)**
**TIP: click the checkbox next to "display plots in a new window" for printing.

Users can select any one of the 38 analytes; limit the data by dates; select either a physiographic region or a HUC 6 watershed; select plot type (cumulative plot, concentration versus depth, or box-and-whisker plot); choose wells, springs, or both; and choose how the graphs are displayed.

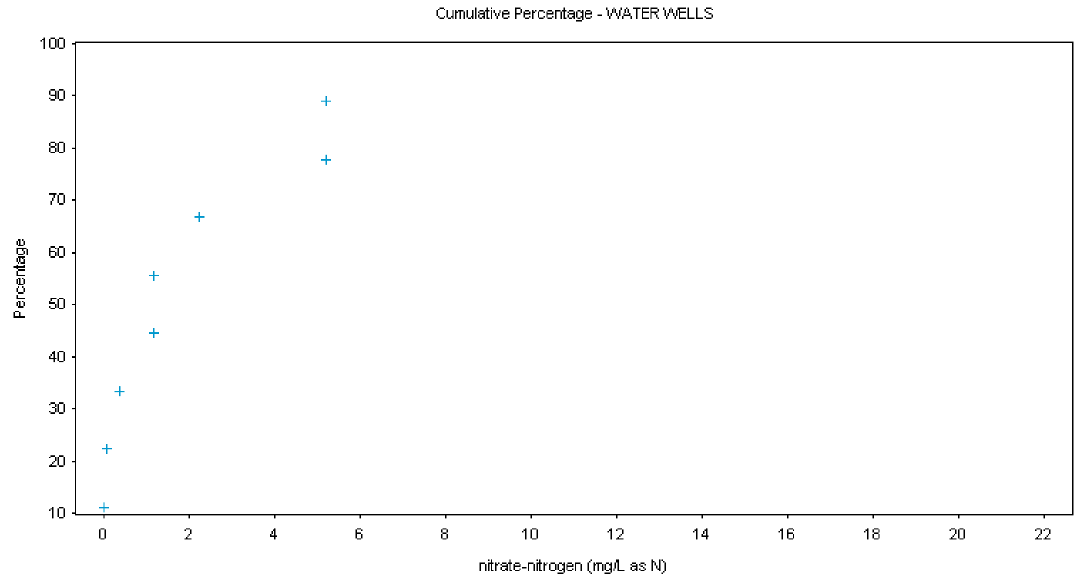
Information about each analyte and a statewide map of concentrations is available by clicking on analyte description in the "Select an Analyte" box. Users who area uncertain of the boundaries of physiographic regions or HUC 6 watersheds can click on "(view and select from a map)" to see index maps.

For example, the following selections

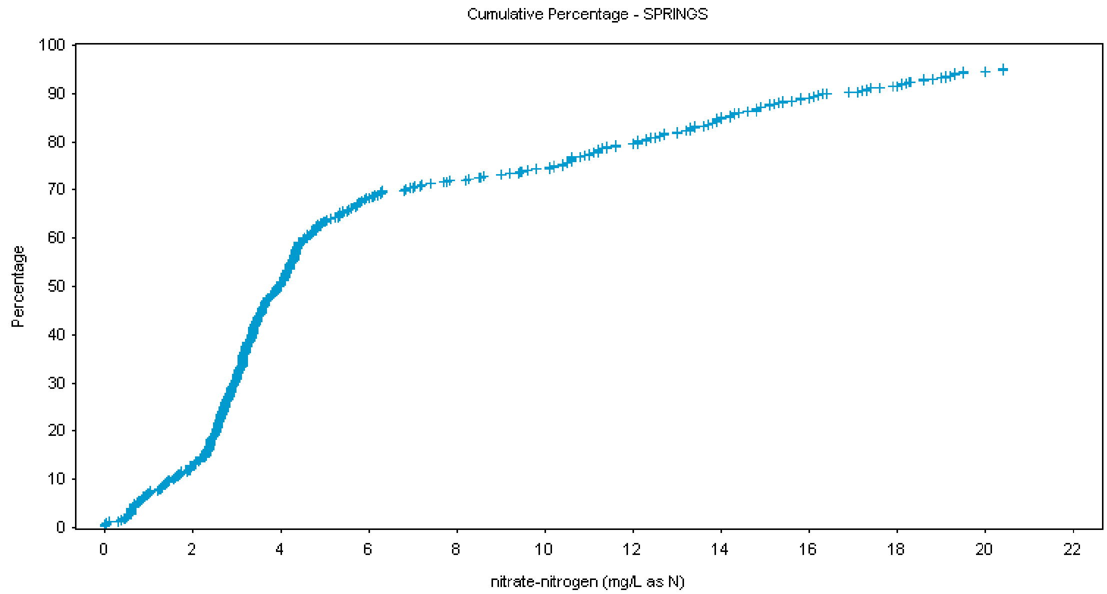


return the data and plots shown below. In addition to the plots for wells and the plot of data for springs, the statistical parameters number of samples, number of sites, minimum value, 25th percentile value (1st quartile), median value (2nd quartile), 75th percentile (3rd quartile) value, and maximum value for both wells and springs are given, presenting both a numerical and a visual comparison of analyte concentrations.

Analyte: nitrate-nitrogen
Groundwater Monitoring program data only



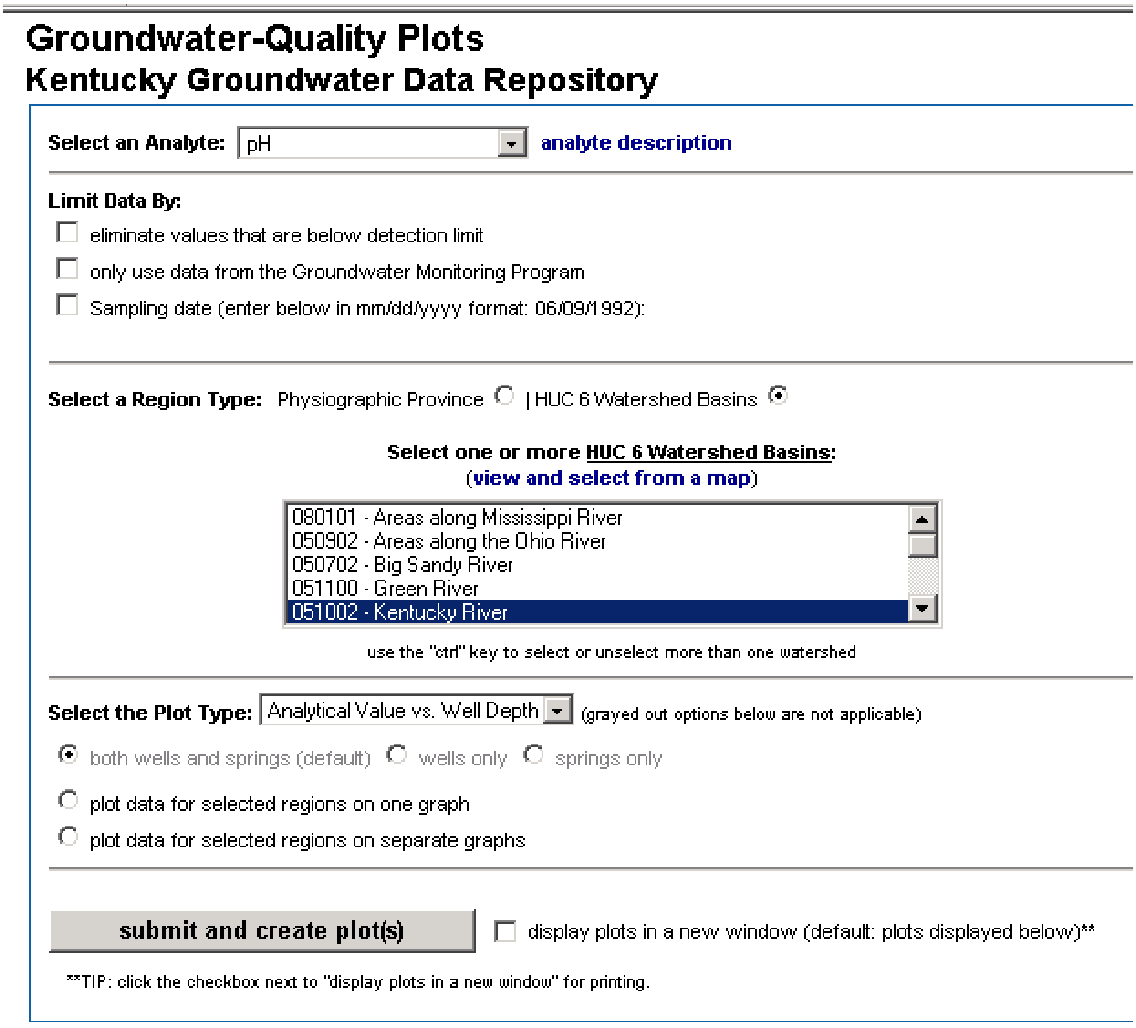
WATER WELLS Plot Data (top 95% and lower 0.1% of data not plotted):
number of samples = 9
number of sites = 6
min value (all samples) = 0.007
25th percentile = 0.353
median value = 1.180
75th percentile = 10.000
max value (all samples) = 10

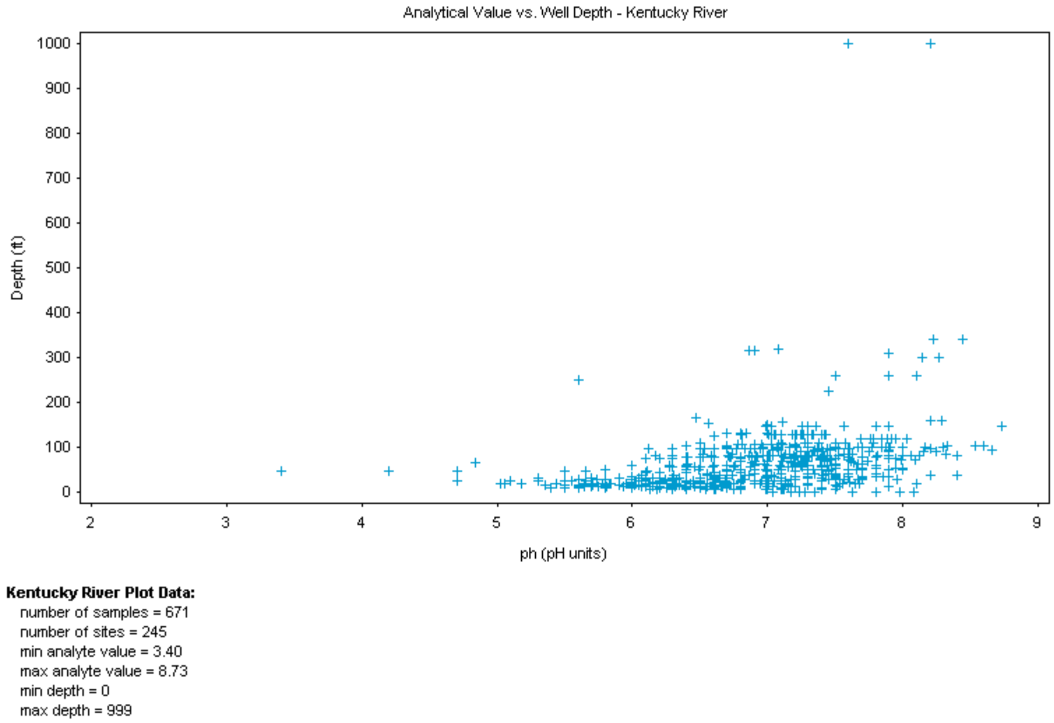


SPRINGS Plot Data (top 95% and lower 0.1% of data not plotted):
number of samples = 559
number of sites = 399
min value (all samples) = 0.011
25th percentile = 2.730
median value = 3.980
75th percentile = 10.400
max value (all samples) = 80.9

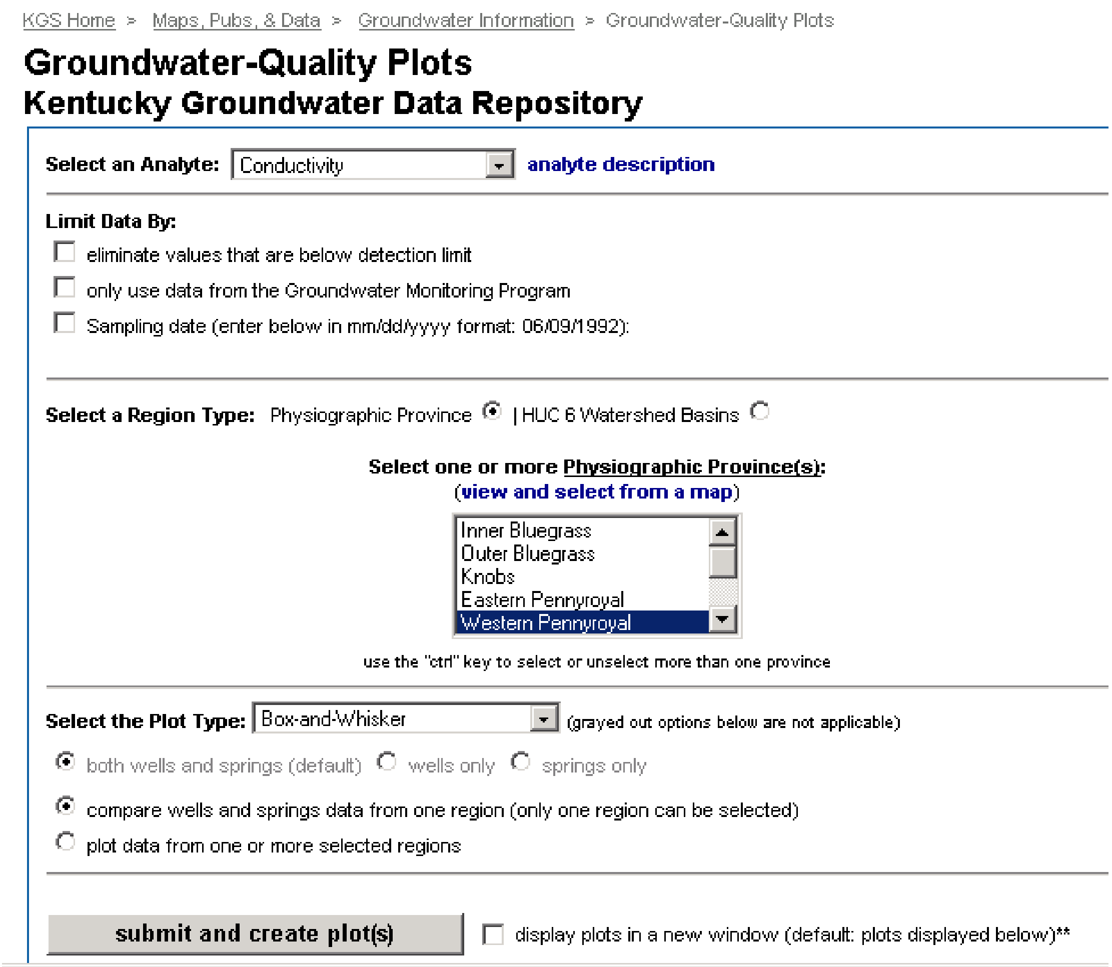
Other plotting options are illustrated below.

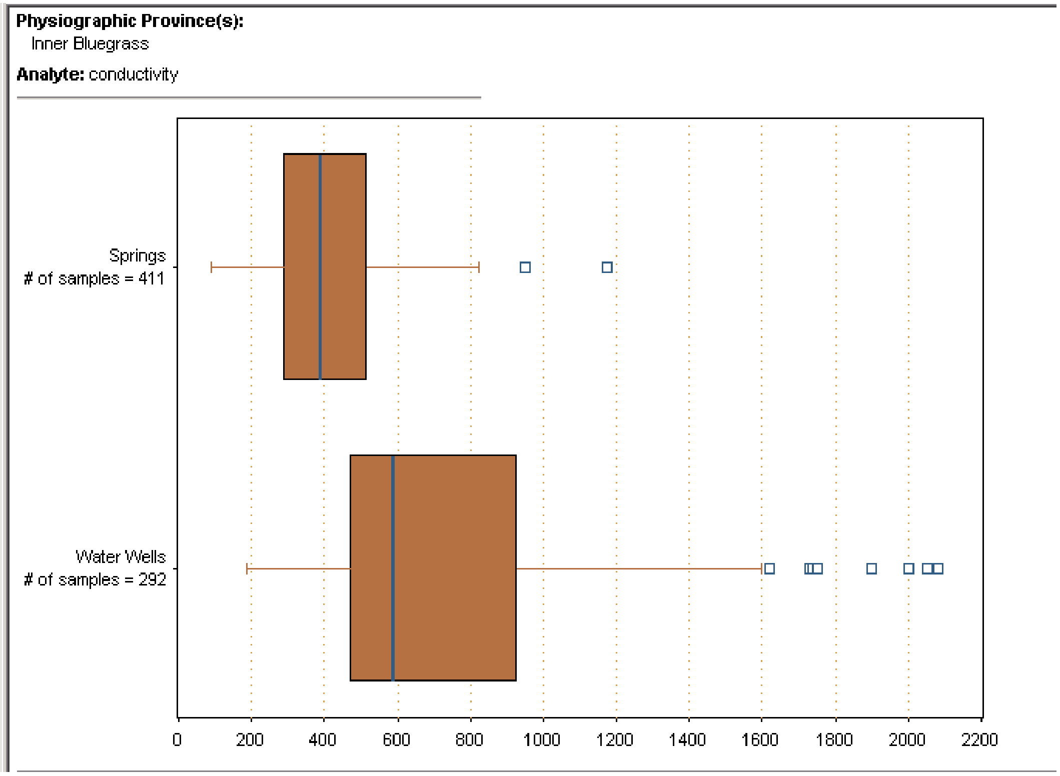
A plot of pH values versus well depth for samples from the Kentucky River watershed:





A comparison of conductivity values from wells versus springs for samples from the Eastern Pennyroyal physiographic province:


KGS Home > Maps, Pubs, & Data > Groundwater Information > Groundwater-Quality Plots
Groundwater-Quality Plots
Kentucky Groundwater Data Repository
Select an Analyte: Conductivity
analyte description
Limit Data By:
eliminate values that are below detection limit
only use data from the Groundwater Monitoring Program
Sampling date (enter below in mm/dd/yyyy format: 06/09/1992):
Select a Region Type: Physiographic Province | HUC 6 Watershed Basins
Select one or more Physiographic Province(s):
(view and select from a map)
Inner Bluegrass
Outer Bluegrass
Knobs
Eastern Pennyroyal
Western Pennyroyal
use the "ctrl" key to select or unselect more than one province
Select the Plot Type: Box-and-Whisker
(grayed out options below are not applicable)
both wells and springs (default)
wells only
springs only
compare wells and springs data from one region (only one region can be selected)
plot data from one or more selected regions
submit and create plot(s)
display plots in a new window (default: plots displayed below)**



Water Wells:
number of samples = 292
number of sites = 273
min value (all samples) = 188
-1.5 IQR = 188
25th percentile = 471.00
median value = 590.00
75th percentile = 924.50
1.5 IQR = 1600
max value (all samples) = 34400

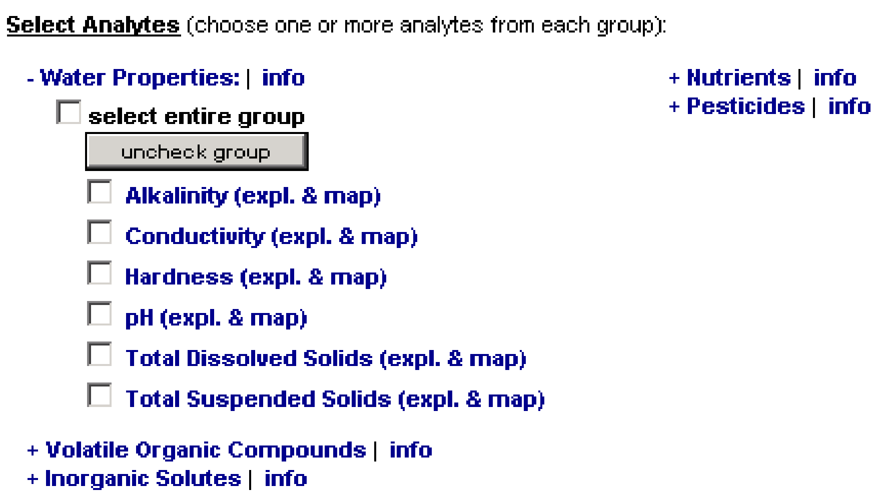
Springs:
number of samples = 411
number of sites = 383
min value (all samples) = 90
-1.5 IQR = 90
25th percentile = 290.00
median value = 391.00
75th percentile = 514.00
1.5 IQR = 822
max value (all samples) = 8390

Objective 3. Prepare information files for each mapped constituent.

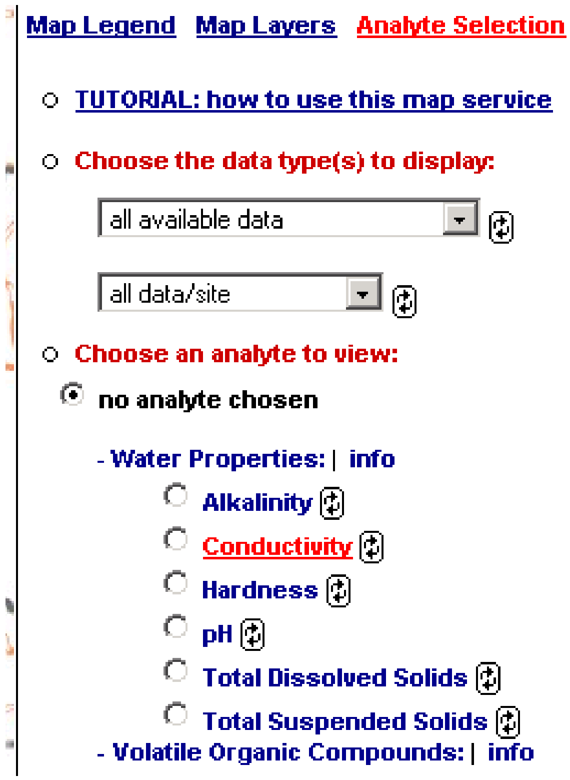
Product 3-1, Information files summarizing sources and hazards of each chemical

Information files summarizing natural and contaminant sources of each chemical, potential threats to human health, and limits to water use resulting from water quality are important educational materials provided by this work. Information files are available at several sites on the web pages for convenient access.

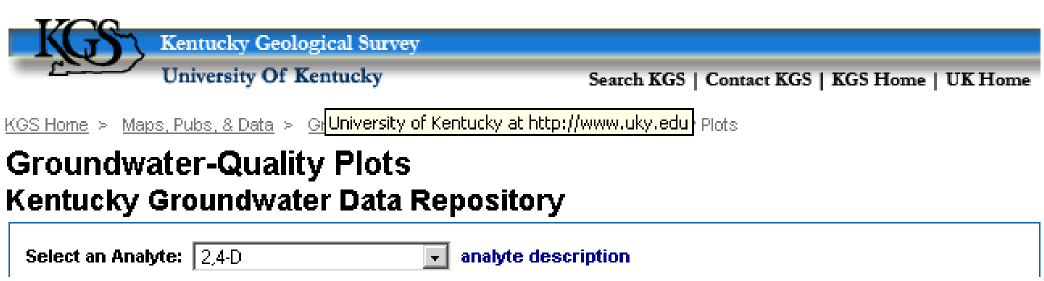
From the tabular data search page http://kgsweb.uky.edu/datasearching/Water/WaterQualSearch.asp, selecting the info tab for any analyte group will open an information file for each analyte in that group, whereas selecting any analyte will open a file containing information about that chemical or parameter and a statewide map of concentrations.



Similarly, from the map search page http://kgsmap.uky.edu/website/KGSWaterQual/viewer.asp, selecting the info tab for any analyte group will open an information file for each analyte in that group, whereas selecting any analyte will open a file containing information about that chemical or parameter and a statewide map of concentrations.



From the groundwater-quality comparison page http://kgsmap.uky.edu/website/KGSWaterPlot/WaterQualityPlot.asp#, selecting an analyte and clicking on "analyte description" will open the information file.



The information files for each analyte group are shown below.

[Groundwater-Quality Analyte Descriptions]

Water Properties
Water properties do not directly represent concentrations of individual dissolved chemicals and are not subject to federal regulations in public water-supply systems because they do not have direct effects on human health. They do, however, influence water suitability for domestic, irrigation, stock watering, or industrial uses. In cases where water properties cause cosmetic or aesthetic effects, EPA has established [Secondary Maximum Contaminant Levels].

Alkalinity ([map image])
Alkalinity refers to the capacity of water to neutralize acid. In uncontaminated water, alkalinity is primarily a measure

of dissolved bicarbonate and carbonate; concentrations of other acid- consuming solutes such as hydroxide, silicate, borate, and dissolved organic compounds are usually small compared to the amount of bicarbonate and carbonate. Alkalinity is reported as the equivalent amount of calcium carbonate in mg/L.

The primary source of natural alkalinity is carbon dioxide in the atmosphere and in soil gases that dissolves in rain, surface water, and groundwater. Bicarbonate released through dissolution of carbonate minerals also contributes to alkalinity. Major contaminant sources of alkalinity include landfills and other sites where alkaline or basic chemicals have been dumped. High levels of alkalinity may be accompanied by objectionable taste, or precipitation of scale in pipes and containers.

Conductivity (map image)
Conductivity measures the ability of water to transmit an electric current. Pure water is a poor electrical conductor. However, the ability of water to transmit electricity increases as the amount of dissolved solutes increases. Water with high conductivity may have objectionable taste, cause staining, and precipitate scale in pipes and containers. Conductivity is reported in micromhos per centimeter at 25º C, or the equivalent microsiemens per centimeter in the International System of Units.

Hardness (map image)
Hardness describes the capacity of water to precipitate an insoluble residue when soap is used. Hard water reduces the ability of soap to clean clothes; leaves a sticky film on skin, clothes, and hair; and deposits scale in water heaters, boilers, and industrial equipment.

Calcium and magnesium are largely responsible for the behavior of soap in water; therefore hardness is defined as the concentrations of dissolved calcium and magnesium expressed as an equivalent amount of calcium carbonate.

A frequently used classification of hardness in water supplies is:

Hardness Category	**Concentration (mg/L)**
Soft	0 to 17
Slightly Hard	18 to 60
Moderately Hard	61 to 120
Hard	121 to 180
Very Hard	more than 180

pH (map image)
The parameter pH (negative base-10 logarithm of hydrogen ion activity) is a fundamental water- quality parameter. It is readily measured on-site, indicates whether water will be corrosive, determines the solubility and mobility of many dissolved metals, and provides an indication of the types of gases and minerals groundwater has reacted with as it flows from recharge region to sample site.

The neutral pH of pure water at room temperature is 7.0. Rain that has equilibrated with atmospheric carbon dioxide has a pH value of about 5.6. Streams and lakes in wet climates such as Kentucky typically have pH values between 6.5 and 8.0. Soil water in contact with decaying organic material can have pH values as low as 4.0, and the pH of water that has reacted with iron sulfide minerals in coal or shale can be even lower. In the absence of coal or iron sulfide minerals, the pH of groundwater typically ranges from about 6.0 to 8.5, depending on the type of soil and rock contacted. Reactions between groundwater and sandstones result in pH values between about 6.5 and 7.5, whereas groundwater flowing through limestone strata can have values as high as 8.5.

There are no health-based drinking-water standards for pH. However, pH values that are not near neutral can lead to high concentrations of metals for which there are drinking-water standards and associated health effects. Water with pH higher than 8.5 or lower than 6.5 can produce staining, etching, or scaling. For this reason, EPA has established a Secondary Maximum Contaminant Level of 6.5 to 8.5.

Total Dissolved Solids (map image)
Total dissolved solids is the sum of all dissolved chemicals in water, expressed as mg/L. It can be calculated by adding all the solute concentrations from a complete chemical analysis, or measured as the weight of residue remaining after water has been evaporated to dryness. Total dissolved solids values typically increase with sample depth or the distance that groundwater has traveled from recharge area to sample site.

Total dissolved solids values are a general indicator of the suitability of groundwater for various uses. A common classification for total dissolved solids is

- Potable water: suitable for domestic use: up to 500 mg/L TDS
- Slightly saline water: adequate for drinking and irrigation: 500 to 1,000 mg/L TDS
- Medium saline water: potable only in cases of need, may be used for some crops and aquiculture: 1,000 to 2,500 mg/L TDS
- Saline water: adequate for aquiculture and industrial use: 2,500 to 5,000 mg/L TDS
- Brackish water: 5,000 to 35,000 mg/L TDS (the salinity of seawater)
- Brine: TDS greater than 35,000 mg/L

EPA has set a Secondary Maximum Contaminant Level of 500 mg/L for total dissolved solids. Water having a value greater than this has an unpleasant taste and may stain containers or precipitate scale in pipes and faucets.

Total Suspended Solids (map image)
Total suspended solids refers to particulate material in water. Total suspended solids values are typically higher where there is rapid water flow (karst springs, wells that intercept a fracture or karst conduit) and in water from uncased wells that has been stirred during purging prior to sample collection, and lower where groundwater flows slowly through porous media such as sand or sandstones. Total suspended solids values may also include any solids that formed in the sample bottle after collection and prior to analysis.

There are no health standards or cosmetic limits for total suspended solids in water. Some metals and pesticides are readily bound to suspended material, so water high in total suspended solids may also contain important amounts of metals or synthetic organic chemicals which may have health or safety implications. High amounts of suspended material can clog plumbing systems and stain clothing and water containers.

Inorganic Solutes
Most of the dissolved material in uncontaminated water consists of inorganic ions or complexes dissolved from soil and rock the water has passed through. The most abundant of these (calcium, magnesium, sodium, bicarbonate, chloride, and sulfate) provide nutrients for plants and animals. Other inorganic solutes may be essential for life in small amounts, but harmful if concentrations exceed certain limits. These chemicals have Maximum Contaminant Levels set by the U. S. Environmental Protection Agency and regulated in public water-supply systems. Other dissolved chemicals have Secondary Maximum Contaminant Levels set by the EPA because at higher concentrations they cause objectionable taste, odor, color, staining, or other esthetic effects. For more information, see epa.gov/safewater/mcl.html.

Arsenic (map image)
Arsenic is a metalloid that occurs naturally at low concentrations in rocks, soils, plants, and animals. In Kentucky, arsenic is commonly found in sulfide minerals associated with coal and black shales. It is released when these sulfides oxidize during weathering. Once released, arsenic is readily sorbed onto iron oxides and oxyhydroxides. This sorption can limit dissolved arsenic concentrations in groundwater, but can produce high total arsenic concentrations in unfiltered groundwater samples that contain suspended particulate material. Arsenic can undergo biochemical processes to form complex ions that are not readily removed from solution by sorption onto soils or the aquifer matrix.

Arsenic is used as a wood preservative and in paints, dyes, metals, drugs, soaps, semiconductors, animal feed additives, and pesticides. From 1860 through 1910, arsenic was heavily used in embalming fluids. It was banned in 1910 because it interfered with investigations into suspected poisoning deaths, but old graveyards may still contribute arsenic to groundwater. Waste-disposal sites and landfills may be sources of arsenic contamination because of the materials placed there, coal burning can release arsenic, and agricultural drainage can carry arsenic from pesticides into the groundwater. Hydrocarbons from leaking underground storage tanks can dissolve iron oxide minerals in soils, thus releasing naturally occurring arsenic to the environment.

Long-term exposure to arsenic in drinking water has been linked to cancer of the skin, bladder, lungs, kidneys, nasal passages, liver, and prostate. Arsenic has also been linked to damage of the cardiovascular, pulmonary, immunological, neurological, and endocrine systems. Because of these health effects, EPA set the Maximum Contaminant Level for arsenic in drinking water at 0.050 mg/L in 1974. In 2001 EPA announced that this would be lowered to 0.010 mg/L, effective January 2006.

Barium (map image)
Barium is an alkaline earth element that occurs naturally as the mineral barite (barium sulfate) in sandstone and limestone. Barite deposits have been mined throughout Kentucky, primarily in the Inner and Outer Bluegrass Regions. In groundwater, barium concentrations are generally low, because of the very low solubility of barite and the common presence of dissolved sulfate. Where dissolved sulfate concentrations are very low, barium concentrations may be as high as several mg/L. Barium is used in electronic components, metal alloys, bleaches, dyes, fireworks, ceramics, and glass, and as an additive to drilling fluids used in oil and gas wells. Barium may be released to soil and water from the discharge of drilling wastes or from leaking landfills in which barium- containing materials were discarded.

EPA has set the Maximum Contaminant Level for barium at 2 mg/L. Short-term exposure to higher concentrations can cause gastrointestinal distress and muscular weakness, whereas long- term exposure can cause high blood pressure.

Cadmium (map image)
Cadmium is a metallic element that occurs naturally with zinc ores and in the mineral sphalerite. It is rare in most Kentucky soils and bedrock. Cadmium is a byproduct of the metal industry, especially in zinc-, lead-, and copper refining. Industrial uses include metal electroplating and coating processes, nickel-cadmium and solar batteries, paint pigments, printing inks, stabilizers in plastics, and electrical batteries. It can be released to groundwater from buried wastes containing these materials, and by coal combustion.

Cadmium can be ingested by eating plants grown in contaminated soil, eating fish or seafood from contaminated water, or by drinking water that contains cadmium. Cadmium is a probable carcinogen. Acute exposure can cause nausea, vomiting, diarrhea, muscle cramps, liver injury, convulsions, and kidney failure. EPA indicates that long-term exposure to cadmium in drinking water has been linked to health problems such as liver, kidney, bone and blood damage. Because of these adverse health effects, the Maximum Contaminant Level for cadmium in drinking water is 0.005 mg/L.

Calcium (map image)
Calcium is a naturally abundant alkaline earth element and is common in Kentucky rocks and soils. It is generally the most abundant cation in uncontaminated groundwater systems, particularly those in contact with limestone, dolomite, gypsum, or sandstones that contain calcium carbonate cement. Calcium is found in many urban and industrial wastes, and in sewage effluents.

Calcium is a necessary nutrient to ensure strong bones and teeth. There are no health effects of calcium in drinking water; however, it is a primary cause of hardness in water and results in the formation of scale in plumbing and water containers. Calcium concentrations do not limit groundwater use for irrigation or stock water.

The EPA has not set limits on calcium in drinking water, but most water suppliers try to maintain concentrations below about 30 mg/L.

Chloride (map image)
Chloride is one of the most common anions in uncontaminated groundwater. Most soils, rocks, and minerals contain small amounts of chloride, as does saline water from salt licks or discharges from deep groundwater-flow systems. Other potential sources include agricultural or urban runoff, wastewater from industry, oil well wastes, effluents from wastewater treatment plants, and road salt. Chloride is very mobile in groundwater and is not readily removed by inorganic or biological processes.

Small amounts of chloride are needed for normal cell functioning in plants and animals. Higher concentrations can corrode metal pipes and valves, increase metals concentrations in water, and affect the taste of foods. No significant health threats are associated with moderate chloride concentrations in drinking water. EPA has set the Secondary Maximum Contaminant Level for chloride at 250 mg/L because higher concentrations give water an unpleasant taste.

Chromium (map image)
Chromium is a naturally occurring metal that is generally found at very low concentrations in soils and rocks. Its greatest uses are in metal alloys such as stainless steel, protective coatings on metals to impart specific properties, magnetic tapes, and as pigments for paints and other materials. It also has been used extensively for wood preservatives and for pressure-treated lumber. Chromium is rare in groundwater that is not affected by point-source contamination. Chromium compounds are readily sorbed onto soil particles, which limit its mobility.

The largest sources of chromium emissions are the chemical manufacturing industry and combustion of natural gas, oil, and coal. It may also be released from landfills or other solid- waste disposal sites.

EPA has set the Maximum Contaminant Level at 0.1 mg/L in drinking water. Short-term exposure to chromium concentrations above this can result in skin irritation or ulceration, whereas long-term exposure can damage the liver and kidneys.

Copper (map image)
Copper is a metal that occurs naturally in ore deposits, but only at very low concentrations in most soils and rocks. Copper is an essential element in plant and animal metabolism. Copper is used extensively in plumbing pipes and fixtures, and may be dissolved from water pipes if the pH of the water is less than 7. Copper salts are sometimes added to water-supply reservoirs to suppress algal growth, and copper compounds have been used extensively in agricultural pesticide sprays.

Short-term exposure to copper in drinking water can lead to gastrointestinal distress; long-term exposure can lead to liver or kidney damage. Copper contamination of drinking-water supplies generally occurs from corrosion of household copper pipes; therefore copper cannot be directly controlled or removed from the water-supply system by treatment facilities. EPA has established a Maximum Contaminant Level Goal of 1.3 mg/L. EPA requires water systems to control the corrosiveness of water provided to homes if copper concentrations exceed 1.3 mg/L in more than 10 percent of samples.

Flouride (map image)
Fluoride is a minor anion, usually present at less than about 1 mg/L in groundwater. Natural sources of fluoride include the mineral fluorite, which is common in carbonate rocks. The major contaminant sources are discharges from fertilizer- and aluminum-production facilities.

Because of the proven value of fluoride in maintaining healthy teeth and bones, it is added to most public water supplies to maintain a concentration of approximately 1 mg/L in the finished water. Although fluoride has a beneficial effect at low concentrations, at higher concentrations it may cause pain and weakness of the bones and staining or mottling of teeth. For these reasons, EPA has established a Maximum Contaminant Level of 4 mg/L in public drinking water, and a Secondary Maximum Contaminant Level of 2 mg/L.

Iron (map image)
Iron is a naturally occurring metal that is widely present in soils, rocks, and groundwater. Dissolved iron can exists in either an oxidized (ferric) or reduced (ferrous) state. At normal groundwater pH values, ferric iron is rapidly precipitated as an iron oxide, iron hydroxide, iron oxyhydroxide (rust), or poorly crystalline to amorphous material. Under reduced conditions, ferrous iron is stable and will remain dissolved in groundwater. When pH is low, such as in the case of acid mine drainage, substantial amounts of iron can occur in water.

Iron is commonly associated with acid mine drainage, and is a secondary cause of hardness in water. At concentrations of more than 0.3 mg/L, iron can stain plumbing fixtures and clothing. Iron imparts an objectionable taste to water at concentrations more than 1 mg/L, and is a problem for many industrial uses, such as food processing, paper manufacturing, and brewing at such concentrations.

Iron is an essential element for metabolism in animals and plants, and is vital for transporting oxygen in the blood. There is no EPA primary drinking water standard for iron in water supplies because it presents no serious health threats. There is, however, a Secondary Maximum Contaminant Level of 0.3 mg/L because higher concentrations produce objectionable odor, taste, color, staining, corrosion, and scaling.

Lead (map image)
Lead is a metal found widely disseminated at very low concentrations in soils and bedrock and concentrated in natural ore deposits. In Kentucky, lead has been mined in all regions except the Jackson Purchase, but particularly from the Western Kentucky Fluorspar District in Crittenden and Livingston Counties. Lead is used extensively in plumbing equipment, water service lines, and electrical storage batteries; lesser amounts are used in solder, leaded glass, and radiation shielding. Until recently, lead was added to paint as a pigment and to speed drying, increase durability, retain a fresh appearance, and resist moisture. Lead was also used as an additive to promote efficient gasoline combustion.

Lead can enter the groundwater system from leaking landfills, aerial fallout of exhaust from combustion engines, and coal burning. Lead is strongly sorbed onto soils, which limits its mobility in the natural environment. The most significant source of lead in drinking water is from leaching of lead or lead-based solder in water-supply lines. The capacity of water to leach lead from plumbing equipment is strongly dependent of factors such as the pH, alkalinity, and hardness of the water, as well as the amount of dissolved organic matter and calcium.

Lead can cause a variety of adverse health effects when people are exposed to it for relatively short periods. These effects may include interference with red blood-cell chemistry; delays in normal physical and mental development in babies and young children; deficits in attention span, hearing, and learning abilities of children; and increases in the blood pressure of adults. Long- term exposure to lead has the potential to cause stroke, kidney disease, and cancer. EPA has set a Maximum Contaminant Level Goal for lead in drinking water of zero. Because lead contamination usually occurs from corrosion of household lead pipes, it cannot be removed by the water-supply treatment system. EPA requires public water systems to control the corrosiveness of their water if the level of lead at home taps exceeds 0.015 mg/L. EPA believes this is the lowest level to which water systems can reasonably be required to control lead should it occur in drinking water at their customers' homes.

Magnesium (map image)
Magnesium is an alkaline earth metal that is generally one of the most abundant cations in groundwater. It is common in sedimentary rocks, particularly limestones, as well as in soils, and is essential in plant and animal nutrition. Dietary magnesium is also important to human health.

There are no EPA limits of acceptable levels of magnesium in drinking water for either health or aesthetic reasons. However, magnesium contributes to water hardness; so high magnesium concentrations may make groundwater unacceptable for some domestic uses.

Manganese (map image)
Manganese is a naturally occurring cation that is widely present in rocks, soils, and groundwater. Small amounts of manganese are typically present in limestone and dolomite, and in the waters that contact those rocks. Manganese and iron behave similarly geochemically, so high manganese concentrations can be expected from wells and springs that

produce water with high iron concentrations. In waters derived from acid mine drainage, it is common for both iron and manganese to be in solution near the mine, but with distance acid is neutralized, iron precipitates, and high manganese concentrations persist.

Manganese is an essential element in plant metabolism. There is no EPA primary standard for manganese in water supplies because there are no identified, serious health threats posed by it. There is, however, a Secondary Maximum Contaminant Level of 0.05 mg/L for manganese because higher concentrations produce objectionable odor, taste, color, corrosion, and staining.

Mercury (map image)
Mercury is a naturally occurring metal. Elemental mercury is a liquid that occurs in some ore deposits; it may also be concentrated around hot springs.

Currently, about 50 percent of mercury use is for electrical products such as dry-cell batteries, fluorescent lights, switches, and other control equipment. Mercury is also used in the electrolytic preparation of chlorine gas and caustic soda, in paint manufacture, and in pesticide production. In the past, large amounts of mercury were used in thermometers and pressure gauges. Forest fires, combustion of fossil fuels, sewage discharge, metal-refining operations, cement manufacture, municipal landfills, and chemical industries are major sources of mercury in the environment.

The health hazards of mercury exposure depend on the form of mercury to which an individual is exposed. Elemental mercury is relatively inert, although it gives off hazardous fumes at room temperature that can be adsorbed through the skin. If swallowed, however, it is not readily absorbed by the stomach, and will usually pass through the body without harm. Inorganic mercury compounds such as mercuric chloride can be inhaled or adsorbed through the skin, and can cause severe kidney damage. Inorganic mercury compounds can also be ingested through consumption of food grown in mercury-contaminated soils.

The greatest health hazards result when anaerobic bacteria mediate the conversion of inorganic mercury to organic methylmercury, which is highly soluble in water and is concentrated in fish and shellfish. People are exposed to mercury primarily by eating fish that have been contaminated as a result of improper disposal of industrial waste and chemicals. Chronic mercury poisoning can result in mood swings and severe nervous disorders. Both short-term and long-term exposure to high mercury levels has been found to cause kidney damage. These health effects have caused EPA to set the Maximum Contaminant Level for mercury in drinking water at 0.002 mg/L.

Selenium (map image)
Selenium is a naturally occurring element that is found at trace levels in many soils and rocks, particularly marine sedimentary rocks. Selenium compounds are commonly used in electronic components, photocopiers, metal alloys, rubber paint pigments, glass-making, and photographic emulsions. Selenium is also used in vitamins, dandruff shampoo, and as a dietary supplement for livestock.

Selenium is an essential trace nutrient which acts as an antioxidant by reducing free radicals that damage cell membranes. However, too much selenium can be harmful. EPA has set a Maximum Contaminant Level of 0.05 mg/L for selenium in drinking water because short-term exposure above this level may cause damage to hair and fingernails, damage to the peripheral nervous system, fatigue, and irritability. Long-term exposure to selenium concentrations above the MCL can result in hair and fingernail loss, and damage to the kidneys, liver, and the nervous and circulatory systems. Studies in animals have shown that elevated selenium concentrations can affect reproductive systems, particularly in fish and birds that feed on aquatic animals. For this reason, the aquatic wildlife standard for selenium in surface water has been set at 0.005 mg/L.

Sodium (map image)
Sodium is one of the most common inorganic solutes in surface water and groundwater. It is abundant in soils and rocks, and highly mobile in aqueous systems. Natural sources of sodium in Kentucky groundwater include saline waters found at depth throughout the state and beneath stream valleys in the Eastern Kentucky Coal Field, and salty seeps found throughout the state. The principal contaminant sources are improperly completed oil and gas wells,

leaking on-site sewage disposal systems, and road salt. Evaporation of irrigation water can also produce high sodium concentrations that may reach the water table.

Sodium is included on the EPA Drinking Water Contaminant Candidate List as a solute that is not subject to national primary drinking-water regulations but may pose some health concerns because high levels may be associated with high blood pressure in some people. Sodium is an essential nutrient for humans, however, and EPA also found that sodium concentrations in most public water-supply systems are not likely to contribute to adverse health effects.

Sulfate (map image)
Sulfate is a major anion in most groundwaters. The most common natural sources of sulfate in Kentucky are oxidation of iron sulfide minerals in coal or shale, and dissolution gypsum or anhydrite in carbonate strata.

There is no primary drinking-water standard for sulfate. EPA has set a Secondary Maximum Contaminant Level of 250 mg/L because water containing higher concentrations has an unpleasant taste that makes it unsuitable for domestic use. Water having sulfate concentrations greater than about 500 mg/L is a mild laxative.

Nutrients
Nitrogen and phosphorus are the most common naturally occurring nutrients in uncontaminated water. Although both are essential for plant and animal growth, excessive amounts of either can have serious environmental and health impacts. Both nutrients occur as different compounds, depending on the availability of oxygen and bacterial activity.

Nitrogen Nutrients Nitrogen may be introduced to groundwater systems from urban and agricultural fertilizer applications, livestock or human wastes, and defective waste-disposal systems. Caves in karst terrain that house large bat colonies may accumulate large amounts of guano that can contribute nitrogen to groundwater. Nitrogen can be present in groundwater as ammonia, nitrate, and nitrite.

Ammonia (map image)
As reported by most laboratories, ammonia includes both the uncharged ammonia and positively charged ammonium forms of reduced nitrogen. Ammonia in groundwater can originate from natural processes such as decay of organic matter; however, concentrations greater than about 0.2 mg/L are almost always the result of contamination by animal or human waste, or from fertilizer applied to agricultural or urban environments.

Ammonia in drinking water does not present a direct health threat; therefore, there are no health- based limits for its presence. Above-normal ammonium concentrations can be toxic to fish, which may be a concern in karst systems.

Nitrate and Nitrite
(map image (nitrate) | map image (nitrite))
Nitrate is the most common form of nitrogen in groundwater. Nitrite is a reduced form of nitrogen that is unstable in oxygenated environments and is much less common than nitrate in uncontaminated groundwater.

High nitrate or nitrite concentrations in drinking water can cause methemoglobinemia (Blue Baby Syndrome), in which the ability of blood to transport oxygen is impaired. Elevated nitrate levels generally do not adversely affect older children or adults, but may be fatal to infants. High concentrations of nitrate or nitrite also suggest that other serious agricultural or residential contaminants such as pesticides or bacteria may be present.

EPA has set the Maximum Contaminant Level at 10 mg/L for nitrate-nitrogen and 0.1 mg/L for nitrite-nitrogen because higher concentrations are potentially fatal to infants.

Phosphorus Nutrients

Phosphorus is a common element in the earth's crust, and is an important constituent of the carbonate rocks that make up Kentucky's Bluegrass Region. Most phosphorus compounds and minerals have low solubility, which limits natural concentrations in waters. High phosphorus levels in groundwater usually indicate contamination from fertilizer, sewage systems, or confined animal-feeding operations. Phosphorus in groundwater may be reported as orthophosphate-phosphorus or as total phosphorus.

Orthophosphate (map image)

Orthophosphate is the form of phosphorus in water that is used by plants and animals. Prior to the 1960's, it was added to detergents, but this practice was ended because it promoted excessive algae growth, consumption of dissolved oxygen, and death of aquatic animals when sewage- disposal facilities released the water to streams and lakes. High orthophosphate levels in groundwater generally indicate contamination from fertilizer, sewage systems, or confined feedlot operations.

There are no health-based water-quality standards for orthophosphate in water. The Kentucky Division of Water recommends that orthophosphate-phosphorus concentrations be less than 0.04 mg/L to prevent excessive algae growth.

Total Phosphorus (map image)

Total phosphorus refers to the sum of all dissolved and particulate forms of phosphorus in an unfiltered water sample. This measurement includes orthophosphate as well as any phosphorus incorporated with organic or inorganic suspended sediment in the water sample. Excessive phosphorus can lead to algal blooms and the resulting depletion of dissolved oxygen in surface- water and karst groundwater systems.

There are no health-based water-quality standards for total phosphorus in water. The Kentucky Division of Water recommends that total phosphorus be less than 0.1 mg/L to prevent algae growth.

Pesticides

A large number of synthetic organic pesticides have been developed and applied in agricultural and urban settings. Some, such as the organochlorine insecticide DDT, were banned decades ago but still persist in soils and sediments and can still be found in groundwater. Most recently developed pesticides are less persistent in natural environments; however, they may still have undesirable impacts on human health and groundwater-quality.

According to recent agriculture sales data, atrazine, glyphosate, metolachlor, simazine, and 2,4-D are the top five pesticides sold in Kentucky. Alachlor and cyanazine have also been used extensively in the past. Toxicological information for pesticides was obtained from the Extension Toxicology Network (ace.orst.edu/info/extoxnet/pips/) and the EPA Integrated Risk Information System (epa.gov/iris).

2,4-D (map image)

2,4-D belongs to the chemical class of phenoxy compounds. Predominant uses are as a systemic herbicide used to control broadleaf weeds in cultivated agriculture, pasture and range land, forest management, home and garden settings, and to control aquatic vegetation.

2,4-D has a low persistence in soils with a half-life less than 7 days, and is readily degraded by microorganisms in aquatic environments. EPA has established a Maximum Contaminant Level of 0.07 mg/L for 2,4-D because the nervous system can be damaged from exposure to higher levels.

Alachlor (map image)
Alachlor is used to kill crabgrass and broadleaf plants that occur among various agricultural crops, including peanuts, sorghum, beans, and tobacco. The three primary breakdown products of alachlor (ethanesulfonic acid, alachlor oxanlic acid, and 2,6-diethylanaline) may be found in groundwater and surface water at higher levels than the alachlor itself; however, their health effects are not well established.

Alachlor has not been shown to cause cancer in humans, but can cause cancer in laboratory animals. EPA has set the Maximum Contaminant Level for alachlor at 0.002 mg/L.

Atrazine (map image)
Atrazine is used as both an agricultural and domestic herbicide for broadleaf and grassy weeds. Atrazine was used extensively in the 1980's for corn and soybean crops. It is a widely used pesticide throughout Kentucky.

Short-term health effects for exposure to atrazine include congestion of heart, lungs, and kidneys; low blood pressure; muscle spasms; weight loss, and damage to the adrenal glands. Long-term exposure can result in cancer, weight loss, cardiovascular damage, retinal and some muscle degeneration. Because of these health effects, EPA has set the Maximum Contaminant Level for atrazine at 0.003 mg/L.

Cyanazine (map image)
Cyanazine belongs to the chemical class of triazines. It is used mainly to control annual grasses and broadleaf weeds in corn. It has low to moderate persistence in soils and is rapidly degraded by microbial activity. Cyanazine has a half-life of 2 to 14 weeks, depending on soil type, and is stable in water. There is no Maximum Contaminant Level for cyanazine; however the Kentucky Division of Water has set a health advisory limit of 0.001 mg/L.

Metolachlor (map image)
Metolachlor belongs to the chemical class of amides. It is mainly used to control broadleaf and grassy weeds in field corn, soybeans, peanuts, grain sorghum, potatoes, pod crops, cotton, safflower, stone fruits, and nut trees, highway rights-of-way, and woody ornamentals. It is moderately persistent in soils with a half-life of 15 to 70 days, and is highly persistent in water. There is no Maximum Contaminant Level for metolachlor; the Kentucky Division of Water has set a health advisory limit of 0.1 mg/L.

Simazine (map image)
Simazine belongs to the chemical class of triazines. It is predominantly used to control broadleaf weeds and annual grasses in fields where berry fruits, nuts, vegetables, and ornamental crops are grown, and on turfgrass. It is moderately persistent in soils, with a half-life of about 60 days, and is moderately persistent in water, with a half-life that depends on the amount of algae present. The Maximum Contaminant Level for simazine is 0.004 mg/L. At higher levels, long-term exposure can cause tremors; damage to testes, kidneys, liver, and thyroid; and gene mutations. There is some evidence that simazine may have the potential to cause cancer from a lifetime exposure at levels above the MCL.

Volatile Organic Compounds
The volatile organic compounds benzene, ethylbenzene, toluene, and xylene are characterized by a pale to colorless appearance, sweet odor, and high volatilization. They are used as solvents and in the production of plastics, rubber, and resins. They are also components of gasoline and are most commonly introduced to the environment through spills from leaking gasoline-storage tanks, fumes and exhaust from gas-power engines, and runoff from gasoline- or oil-contaminated surfaces such as highways and parking lots. Local groundwater contamination from these compounds can also result from improper disposal of used oil. MTBE (methyl tertiary-butyl ether) is an oxygenate additive used to promote fuel combustion and reduce carbon monoxide and ozone emissions from vehicles. Releases to the environment are most commonly the result of leaking underground storage tanks and pipelines, other spills, and, to a lesser extent, from air deposition around refineries or urban areas.

The following summaries of potential sources and health effects of the selected volatile organic compounds were taken from the EPA Web pages “Current Drinking Water Standards” (epa.gov/safewater/mcl/html) and "Integrated Risk Information System" (epa.gov/iris).

Benzene (map image)
Benzene is a clear, colorless, aromatic organic compound that is highly flammable. It is used in the manufacture of gasoline, plastics, rubber, resins, and synthetic fabrics. It is also used as a solvent in printing, paints, and dry cleaning.

The most common sources of benzene in groundwater are leaks from underground gasoline- storage tanks and landfills. Benzene is released to the air by fumes and vehicle exhaust. Industrial discharges and losses during fuel spills can release benzene to soils and water supplies. Runoff from roads or parking lots, and improper disposal of gasoline and oil products around the home, can also contribute benzene to the groundwater system. Benzene does not degrade by reaction with water, but can be degraded by microbes in soil and water.

Short-term health effects of benzene exposure include anemia, immune-system depression, and temporary nervous-system disorders. Long-term effects include chromosome abnormalities and increased risk of cancer. For these reasons, EPA has set the Maximum Contaminant Level for benzene at 0.005 mg/L.

Ethylbenzene (map image)
Ethylbenzene is a clear, colorless, organic liquid that smells like gasoline. It is used primarily in the manufacture of styrene (a constituent of plastics), and is a component of gasoline. Ethylbenzene is also used in making plastic wrap and rubber, and is a solvent for coatings.

Common sources of ethylbenzene are discharges from petroleum refineries and leaking underground gasoline-storage tanks. Runoff from roads or parking lots, and improper disposal of gasoline and oil products around the home, can also contribute ethylbenzene to the groundwater system.

Short-term exposure to ethylbenzene can result in fatigue, drowsiness, headaches, eye irritation, and respiratory-system irritation. Long-term exposure over a lifetime can induce liver and kidney damage, as well as damage to the central nervous system and eyes. For these reasons, EPA has set the Maximum Contaminant Level for ethylbenzene at 0.7 mg/L.

MTBE (map image)
MTBE (methyl-tertiary-butyl ether) is a gasoline additive used to promote combustion and reduce emissions. The primary sources of MTBE in groundwater are leaks from gasoline-storage tanks or gasoline spills; atmospheric fallout of exhaust gases is also a potential source. Runoff from roads or parking lots, and improper disposal of gasoline and oil products around the home, can also contribute MTBE to the groundwater system.

Potential health effects of MTBE in water have not been established; however, the Kentucky Division of Water has set a risk-based water-quality standard of 0.050 mg/L.

Toluene (map image)
Toluene is a clear, colorless, organic liquid that smells like gasoline. It is used primarily in making benzene, a component of gasoline. Toluene is also used in making urethane, a solvent and coating. Toluene evaporates quickly when released to soils, and within a few hours when released to water. It is not as easily broken down by microbes as are other volatile organic compounds. The largest releases of toluene occur at petroleum-refining operations.

Common sources of toluene in groundwater are discharge from petroleum refineries and leaking underground gasoline-storage tanks. Runoff from roads or parking lots, and improper disposal of gasoline and oil products around the home, can also contribute toluene to the groundwater system.

Short-term exposure to ethylbenzene can result in nervous system disorders such as fatigue, nausea, and confusion. Long-term exposure over a lifetime can result in serious medical problems such as spasms, hearing impairments, memory loss, and kidney and liver damage. Therefore, the EPA has set the Maximum Contaminant Level for ethylbenzene at 1.0 mg/L.

Xylenes (map image)
Xylenes are a group of compounds that are clear liquids with a sweet odor. They are used as solvents and in the manufacture of plastics, and are a component of gasoline.

Xylenes in groundwater are usually the result of discharge from petroleum refineries or chemical factories, or leaking underground gasoline-storage tanks. Runoff from roads or parking lots, and improper disposal of gasoline and oil products around the home, can also contribute xylenes to the groundwater system.

The primary health effect of xylenes in drinking water is damage to the nervous system. The Maximum Contaminant Level is 10 mg/L for the sum of O-Xylene, P-Xylene, and M-Xylene.

Two other help files are available from the main page. The first provides explanations and definitions of terms used in the data reports:

KGS Online Groundwater-Quality Data Reports

Groundwater-quality data and sample-site information were obtained from the Kentucky Groundwater Data Repository, a database that KSG maintains to collect and preserve groundwater information throughout the state. The data have been gathered from numerous sources. The samples were collected at various times and analyzed by different laboratories for a variety of projects and purposes. There was no uniformity of reporting methods. KGS has standardized analyte names and analysis units in order to make the data more accessible to the public. No warranty is expressed or implied by KGS as to their accuracy or completeness. KGS staff cannot check every record, and we rely on our customers and end-users to help us correct errors and omissions. Please notify KGS of any errors or problems that you encounter using these data at 859-257-5500 x 162, or by e-mail at bdavidson@uky.edu.

Explanations and Definitions

AKGWA Number and Site Number: The AKGWA number is a unique site identification number assigned by the Kentucky Division of Water. However, not all sites represented in the Kentucky Groundwater Data Repository have AKGWA numbers; therefore Site Numbers are used to identify locations where groundwater samples have been collected.

Surface Elevation, Water Level, and Depth: Surface elevation is reported as feet above mean sea level. Water level and depth are reported as feet below top of casing. Note that depth refers to total well depth, not necessarily the depth to the water-producing zone.

Collection Date: Many wells and springs have been sampled repeatedly over time. If your project is time-sensitive, be sure to limit the results of your search to the appropriate time interval.

Regulatory Program: Samples collected for regulatory programs such as RCRA, CERCLA, State CERCLA, Solid Waste, or UST may be anomalous. Analytical results from these samples should not be used to infer ambient groundwater-quality. Samples collected for the Groundwater Program are part of the Kentucky Division of Water's groundwater monitoring program; these site locations were specifically chosen to avoid known sources of contamination.

Values below detection: A "<" sign indicates the analyte concentration was less than the analytical detection limit. For example, a result of "<0.003" mg/L indicates that the concentration was below a detection limit of 0.003 mg/L. Detection limits change over time as analytical methods improve. Some older analyses may have detection limits that are greater than current health-based water-quality standards.

Aqueous State: The aqueous state of a sample refers to whether it was filtered or not. T (Total) indicates that the sample not filtered, and therefore the analyte concentration includes both material in true aqueous solution and material associated with suspended solids. D (Dissolved) indicates that the sample was filtered, and the analysis reports only material in true aqueous solution.

Median Value: The median concentration at a site is calculated using only values that are above analytical detection limits.

The second provides information and links to sources regarding water quality standards:

Water Quality Standards

Groundwater-quality records the condition of the environment and indicates what type of contamination is entering the groundwater system. It also restricts potential uses of the resource, such as irrigation, animal watering, industrial applications, commercial processing, or domestic water supply. For further information on groundwater quality standards and related issues, please refer to the following Web sites.

For drinking water standards: http://epa.gov/safewater/standards.html

For contaminant and health information: http://epa.gov/safewater/mcl.html

For general groundwater information: http://water.usgs.gov/owq/

For information about groundwater in Kentucky: http://www.uky.edu/KGS/water/index.htm, http://www.water.ky.gov/gw/ as well as the KGS Web page

Objective 4, Link to a list of BMPs that can prevent groundwater contamination by NPS chemicals.

Product 4-1: Information files regarding best management practices that can reduce and prevent groundwater contamination:

A link to information regarding best management practices is located at http://kgsweb.uky.edu/DataSearching/Water/WaterQualSearch.asp. The information is shown below.

Best Management Practices

Best Management Practices (BMPs) are defined as the most effective, practical, and economical means of reducing and preventing water pollution by the Kentucky Agriculture Water Quality Act. Under this act, the Kentucky Division of Conservation developed an Agricultural Water Quality Plan which includes a listing of BMPs. These practices are designed to reduce or eliminate physical (e.g. sediment, manure, solid waste) and chemical (e.g. fertilizer, pesticide) contamination of surface water and groundwater. The Agricultural Water Quality Plan contains 56 BMPs for silviculture, pesticides and fertilizers, farmsteads, crops, livestock, and streams and other waters. More information is provided by the following sources:

Kentucky Division of Conservation Homepage, Kentucky Agriculture Water Quality Act:
www.conservation.ky.gov/programs/kawqa/

The 2008 revised Kentucky Agriculture Water Quality Plan:
www.conservation.ky.gov/NR/rdonlyres/56757AE1-3752-443F-88AF-A0E8DAFA4AFD/0/KAWQPlanRevised2008.doc.

To develop an Agriculture Water Quality Plan:
www.ca.uky.edu/enri/awqa/index.htm.

For information about Agriculture Water Quality Plans:
www.ca.uky.edu/enri/awqa/kawqpadditionalinfo.htm.

The Kentucky Department of Agriculture also provides information about BMPs.
www.kyagr.com/consumer/envsv/technical/bmp.thm

The Kentucky Transportation Cabinet has established BMPs to protect water quality during road construction and post-construction.

Division of Environmental Analysis:
http://transportation.ky.gov/EnvAnalysis/.

Highway design:
http://transportation.ky.gov/design/drainage/drainage.html.

Objective 5. Educate and train citizens in the use of these internet educational materials and publicize the availability of the Web site.

Product 5-1, Educational/training workshops: KGS staff notified state agency personnel, Kentucky citizens, and others interested in groundwater resources about the availability of the groundwater-quality search capabilities through personnel contacts, presentations at meetings and symposia, and Web-based notices. All requests for demonstrations were met. KGS staff will continue to provide demonstrations and training upon request.

The following training demonstrations were presented.

Feb. 16, 2007: Demonstration to KY Division of Waste Management in Frankfort.

Mar. 26, 2007: Demonstration of tabular data search at Kentucky Water Resources Research Institute Annual Symposium, Lexington, Ky.

Mar. 26, 2007: Demonstration of mapping data search at Kentucky Water Resources Research Institute Annual Symposium, Lexington, Ky.

Apr. 20, 2007: Demonstration of tabular and mapping searches at Kentucky Geological Survey Annual Meeting, Lexington, Ky.

Dec. 18, 2007: Demonstration to Interagency Technical Advisory Committee on Groundwater, Frankfort, Ky.

Mar. 31, 2008: Demonstration of tabular and mapping searches to the Pesticide Workgroup, KY Department of Agriculture, Frankfort Ky.

Conclusions

The Kentucky Groundwater Data Repository is the most complete and up-to-date source of information regarding water wells and springs, and groundwater quality. Those data were not readily accessible or understandable until now. Work conducted for this project standardized names and concentration units, and created information files that explain natural and contaminant sources of chemicals in groundwater, geologically controlled regional variations in concentrations, potential health consequences of long-term consumption of groundwater that contains various chemicals, and ways to reduce or eliminate groundwater contamination. KGS also designed user friendly on-line search capabilities that allow anyone to obtain and analyze groundwater-quality data for the entire state or any selected region.

The products are available from any computer with an internet connection. Starting at the KGS home page http://www.uky.edu/KGS/, select Search Databases and Publications, then select Groundwater Information. From there one can choose one of three types of search:
Search for Groundwater-Quality Data gives results in tabular format,
Graphical Groundwater-Quality Comparison provides graphical and statistical summaries, and
Groundwater-Quality Data Map Service gives results on geologic or geographic base maps.

All pages provide tutorials and information files to make the data understandable.

References Cited

Helsel, D. R., and Hirsch, R. M., 1992, Statistical Methods in Water Resources, Elsevier, New York, 529 p.

Hem, J. D., 1985, Study and Interpretation of the Chemical Characteristics of Natural Water: U.S. Geological Survey Water-Supply Paper 2254, 263

Appendix A. Financial and Administrative Closeout

Workplan Outputs

Milestone	Expected Begin Date	Expected End Date	Actual Begin Date	Actual End Date
1. Submit all draft materials to the Cabinet for review and approval prior to final development.	Jul 2003	Jun 2010	Jul 2003	Aug. 2008
2. Submit advanced written notice on all workshops and demonstrations to the Cabinet.	Jul 2003	Jun 2010	Jul 2003	Aug. 2008
3. Coordinate electronic transfers of data from DOW and other sources	Jul 2003	Jun 2010	Jul 2003	Jul 2008
4. Retrieve, examine, and clean-up data tables	Jul 2003	Jun 2010	Jul 2006	Jan 2007
5. Meet with DOW-NPS Technical Point of Contact quarterly to discuss project design and review project progress	Jul 2003	Jun 2010	Jul 2003	Aug. 2008
6. Prepare Web site tutorial to assist users	Jan 2004	Jun 2008	Jan 2006	Mar 2007
7. Prepare maps of sites, concentrations, and sample metadata	Jan 2004	Jun 2008	Jun 2004	Mar 2007
8. Prepare statistical summaries and plots to show data distributions, means, and quartile values	Jan 2004	Jun 2008	Mar 2005	Mar 2007
9. Prepare information files to describe sources, hazards, and limits to use caused by constituents	Jan 2004	Jun 2008	Apr 2004	Mar 2007
10. Prepare information files that summarize BMPs that can prevent groundwater contamination	Jan 2004	Jun 2008	Jan 2006	Mar 2007
11. Transfer all files to Web site and link files	Jan 2004	Jun 2008	Feb 2007	Mar 2007
12. Advertise educational training workshops and availability of the Web site	Apr 2006	Jun 2008	Feb 2007	Aug. 2008
13. Conduct educational training workshops	Jul 2006	Jun 2008	Dec 2006	Aug. 2008
14. Upon request of the Division of Water, submit Annual Report and/or participate in the Cabinet sponsored biennial NPS Conference.	Jul 2003	Jun 2010	Jul 2003	Aug. 2008
15. Prepare Final Report	Jun 2006	May 2010	May 2008	Aug. 2008
16. Submit three copies of the Final Report and submit three copies of all products produced by this project.	Jun 2010	Jun 2010	Aug. 2008	Sep. 2008

Budget Summary

The Detailed Budget from the Workplan is shown in Table A-1. Columns labeled "Budget Categories", "Section 319(h) Funds", "Non-Federal Match", and "Total" were copied from the budget in the Project Workplan. Dollar amounts for the column titled "Final Expenditures" in Table A-1 were taken from University of Kentucky invoices #067459001A (March 19, 2004), #068065007A (August 17, 2006) and #080248002A (June 11, 2008). No budget revisions were requested for this project.

Table A1. Detailed Budget Summary.

Budget Categories	Section 319	Non-Federal Match	TOTAL	Final Expenditures
Personnel	$371,500	$134,425	$505,925	486,579.02
Supplies	$3,000		$3,000	2,096.50
Equipment				0.00
Travel	$500		$500	0.00
Contractual				0.00
Operating Costs				0.00
Other	$75,000	$165,575	$240,575	225,373.99
TOTAL	$450,000	$300,000	$750,000	714,049.51
	60%	40%	100%	

Total expenditures were $449,913.88. The University of Kentucky Research Foundation and the Kentucky Geological Survey were reimbursed a total of $421,744.78. A balance of $28,169.10 is still due to UK; $85.40 was not spent and is not need for completion of this project.

Equipment Summary

No equipment was purchased for this project.

Special Grant Conditions

No special grant conditions were placed on this project.