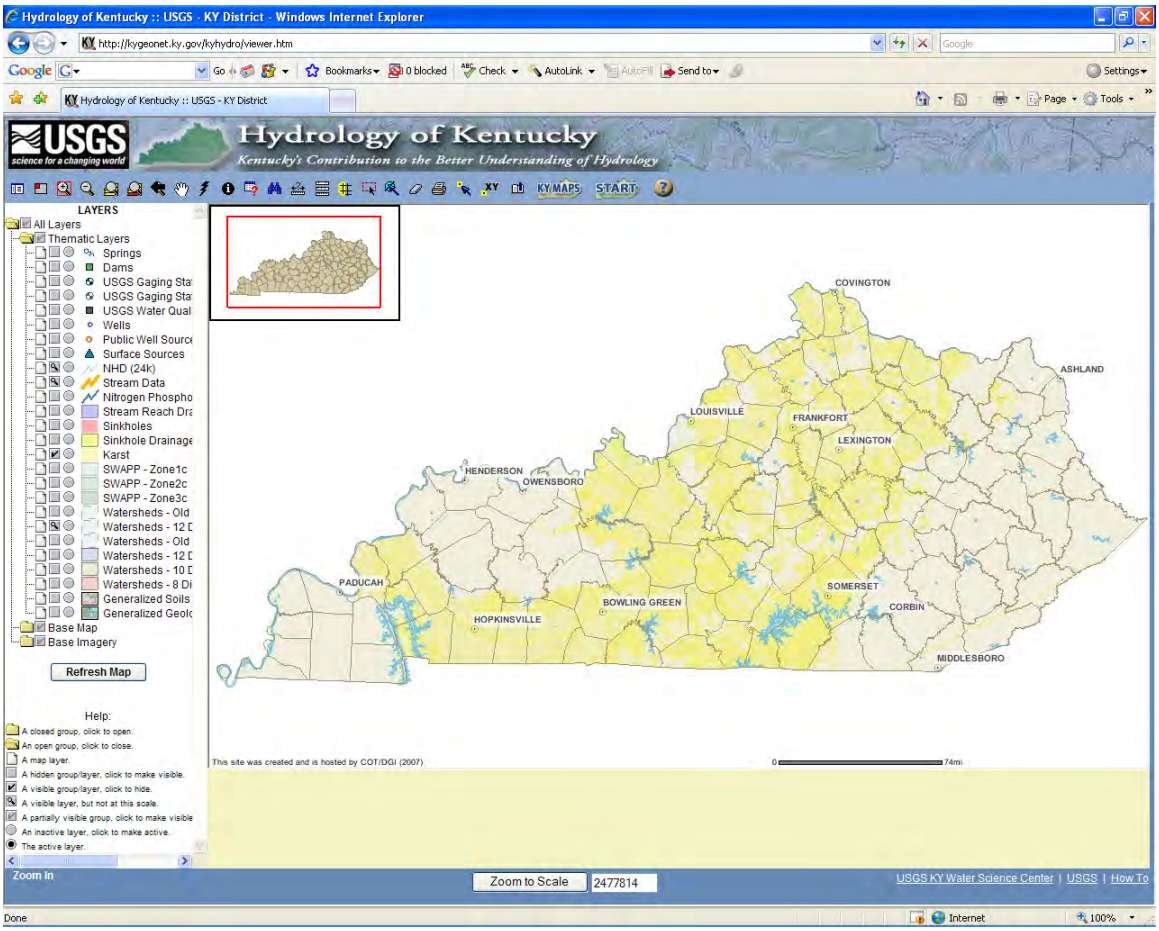



# Project Final Report: Interactive GIS Tool to Estimate Basin Characteristics, Streamflow Statistics, and Nutrient Loads

Grant Number: C9994861-04

Workplan Number: 04-09

MOA Number: M-04541128

Project Period: June 1, 2004 to February 15, 2008

Submitted by: Tanja Williamson Ph.D., Hugh Nelson, and Kenneth Odom Ph.D., P.E.

## Non-discrimination clause

The US Geological Survey (USGS) and the Kentucky Environmental and Public Protection Cabinet (EPPC) do not discriminate on the basis of race, color, national origin, sex, age, religion, or disability. The USGS and EPPC will provide, on request, reasonable accommodations including auxiliary aids and services necessary to afford an individual with a disability an equal opportunity to participate in all services, programs and activities. To request materials in an alternative format, contact the Kentucky Division of Water, 14 Reilly Road, Frankfort, KY 40601 or call (502) 564-3410, or contact the U.S. Geological Survey, 9818 Bluegrass Parkway, Louisville, KY 40299 or call (502) 493-1900.

Funding for this project was provided in part by a grant from the U.S. Environmental Protection Agency (USEPA) through the Kentucky Division of Water, Non-point Source Section, to USGS as authorized by the Clean Water Act Amendments of 1987, §319(h) Non-point Source Implementation Grant # C9994861-04. Mention of trade names or commercial products, if any, does not constitute endorsement. This document was printed on recycled paper.

## Acknowledgements

The project was a cooperative effort with the Kentucky Natural Resources and Environmental Protection Cabinet, Kentucky Division of Water (KDOW), Water Resources Branch through Nonpoint Source (319) Program funding. The authors are grateful to the national SPARROW model team, especially A. Hoos, R. Alexander, S. Preston, S. Terziotti, G. Schwarz, and R. Smith for their assistance. In addition, the authors appreciate the technical assistance of P. Finnell and J. Haagen from the U.S. Natural Resources and Conservation Service, and Ken Bates from Kentucky State University.

## Table of Contents



## Figures



## Tables

## Appendices

## Conversion factors

| Multiply | By | To obtain |
|---|---|---|
| **Length** | | |
| foot (ft) | 0.3048 | meter (m) |
| **Area** | | |
| square mile ($mi^2$) | 2.590 | square kilometer ($km^2$) |
| **Flow rate** | | |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second ($m^3/s$) |

## Abbreviations

7Q2 – The streamflow that occurs over 7 consecutive days and has a 2-year recurrence interval period
7Q10 - The streamflow that occurs over 7 consecutive days and has a 10-year recurrence interval period
$A_s$ – Upslope contributing area (in square meters)
CFS – Cubic Feet per Second
CTI – Compound topographic index or wetness index
DEM – Digital Elevation Model
DOQ – Digital Orthophoto Quadrangle
DRG – Digital Raster Graphic
E2RF1 - Enhanced River Reach File 2.0
EPPC – Kentucky Environmental and Public Protection Cabinet
GIS – Geographic Information System
GUI – Graphical User Interface
KDOW – Kentucky Division of Water
kg - Kilogram
KGS – Kentucky Geologic Survey
KLS – Kentucky Landscape Snapshot data compilation
$km^2$ – Square kilometer
m – Meter
$mi^2$ – Square mile
NADP – National Atmospheric Deposition Program
NHD – National Hydrography Dataset
NLCD – National Land Cover Data
NRCS – United States Department of Agriculture Natural Resources Conservation Service
OFR – USGS Open-File Report series
Q2 – The streamflow that has a peak-flow recurrence interval of 2 years
Q5 – The streamflow that has a peak-flow recurrence interval of 5 years
Q10 – The streamflow that has a peak-flow recurrence interval of 10 years
Q25 – The streamflow that has a peak-flow recurrence interval of 25 years
Q50 – The streamflow that has a peak-flow recurrence interval of 50 years
Q100 – The streamflow that has a peak-flow recurrence interval of 100 years
Q200 – The streamflow that has a peak-flow recurrence interval of 200 years
Q500 – The streamflow that has a peak-flow recurrence interval of 500 years
$Q_a$ – Mean-annual flow statistic
SPARROW – SPAtially Referenced Regression On Watershed attributes model
STATSGO – State Soil Geographic Data Base
SSURGO – Soil Survey Geographic Data Base
SWAPP – Source Water Assessment and Protection Program
tan S – Local slope (in degrees)
USGS – United States Geological Survey
yr – Year

# Executive summary

The *Hydrology of Kentucky* KYGEONET tool (http://kygeonet.ky.gov/kyhydro/viewer.htm) was created by the U.S. Geological Survey (USGS) Kentucky Water Science Center in order to make Kentucky stream statistics readily available to the public. A graphical user interface (GUI) provides 'point-and-click' operation so users may easily select a location on a map and access data for watersheds as small as 0.1 $mi^2$ and increasing in increments of 0.01 $mi^2$. Underlying the GUI is an extensive geodatabase containing data derived from existing sources, historical and real-time streamflow and water-quality stations, published algorithms, and statistical modeling approaches.

The objectives of this study were to develop a GUI that would easily access an underlying geodatabase containing accurate basin characteristics, estimates of streamflow statistics, annual estimates of nitrogen and phosphorus loads, and historical and real-time data from USGS streamflow-gaging and water-quality stations. The result of these objectives is easy access to accurate, consistent, and relevant hydrologic data without the need for specialized computer equipment, programs, or training.

# Introduction and background

Planning and other activities associated with watershed and regulatory programs in Kentucky require reliable, accurate estimates of geographic information on drainage area, land use, and other basin characteristics, as well as estimates of streamflow and water quality characteristics. The overall goal of this project was to provide those involved in watershed planning, assessment, hydrologic-design, and permit-review with reliable and reproducable hydrologic information at user-selected stream sites in Kentucky, without requiring users to invest heavily in computer technology or have advanced knowledge of computer-based geographic or hydrologic analysis. This goal was achieved by development and implementation of an interactive, web-based geographic information system (GIS) tool (http://kygeonet.ky.gov/kyhydro/viewer.htm ) (fig. 1) and database that allows users to quickly and easily obtain basin characteristics, estimates of streamflow statistics, historical and real-time data from USGS streamflow-gaging and water-quality stations, and estimates of nutrient loads for Kentucky streams (fig. 2).

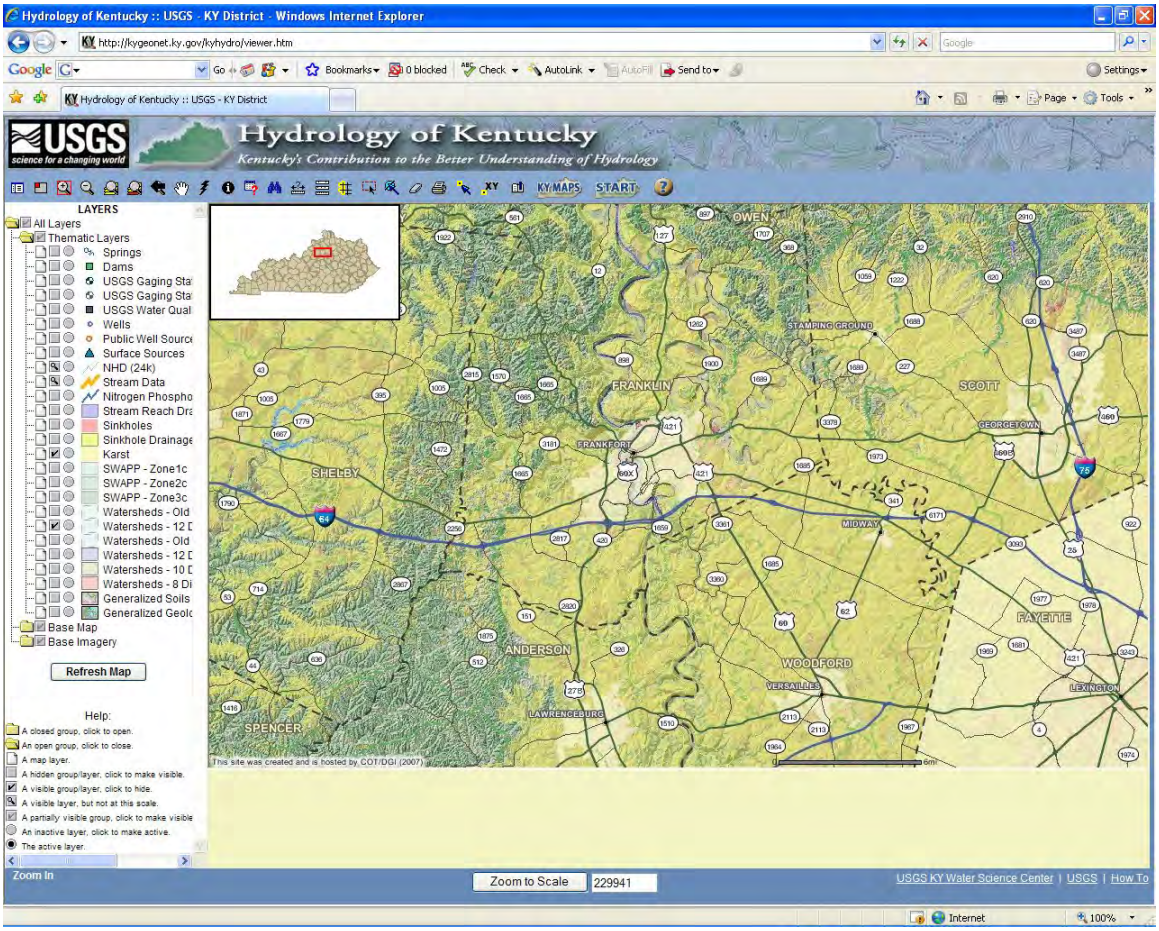



Figure 1. Screen capture of Hydrology of Kentucky KYGEONET web page showing interactive, web-based geographic-information system (GIS) tool.

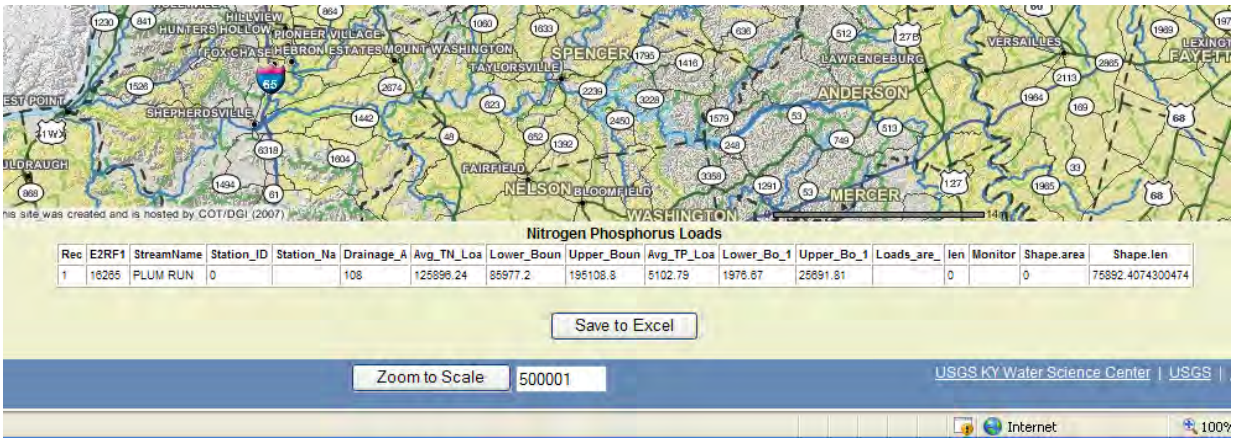



Figure 2. Screen capture of Hydrology of Kentucky KYGEONET web page showing table created by 'identify tool' for nitrogen and phosphorus loads on Plum Run in western Kentucky.

Minimizing the impacts of land-use on water resources often requires planning, design, permitting, implementation, and assessment of practices that control surface-water quantity and quality. These activities depend on reliable, accurate, and reproducable estimates of basin characteristics beyond those available for discrete streamflow-gaging and monitoring stations. The U. S. Geological Survey (USGS) has developed techniques for estimating selected flow statistics and loads at stream sites in Kentucky where no measured data are available. Regional regression equations have been published for estimating streamflow statistics as a function of known physical and climatic basin characteristics (Ruhl and Martin, 1991; Martin and Ruhl, 1993; Martin and others, 1997; Martin, 2002; Hodgkins and Martin, 2003). In addition, equations to estimate loads of nitrogen and phosphorus from individual watersheds are available through the national SPARROW (SPAtially Referenced Regression On Watershed attributes) model (http://water.usgs.gov/nawqa/sparrow/) (Smith and others, 1997) and the Kentucky SPARROW model (Williamson T.N., this report). This SPARROW model uses spatial differences in land use and land cover in order to depict relative differences in nonpoint pollution sources within and between watersheds.

# Materials and methods

This project encompassed the entire Commonwealth of Kentucky. Prior to this project, the USGS, working in cooperation with the Commonwealth of Kentucky, completed: (1) a DEM (digital elevation model) with grid points spaced 10 meters apart and (2) a 1:24,000-scale National Hydrography Dataset (NHD) stream coverage (U.S. Geological Survey and U.S. Enivronmental Protection Agency, 1999). High-resolution DEM and NHD coverages from bordering areas of Tennessee and Virginia that drain into Kentucky were also available and were incorporated into the drainage network. Development of the predefined subbasin boundaries was a major task in the first year of the project. Subbasin boundaries were delineated using ArcGIS 8.1 ™ in a basin-segmentation scheme suitable for measuring the basin characteristics and solving the regression equations. This delineation of subbasin boundaries incorporated current knowldege of Kentucky's vast karst areas, which alter surface hydrology from what would be expected based on topography.

Ancillary GIS coverages, such as transportation networks, civil boundaries, topographic maps (digital raster graphics or DRGs), detailed aerial photographs (digital orthophoto quadrangles or DOQs), and the Natural Resources Conservation Service (NRCS) STATSGO (State Soil Geographic Data Base) coverage are used by the *Hydrology of Kentucky KYGEONET tool* as backdrop information to help locate stream sites of interest. In addition, three generations of land use data are used for both context and in order to solve the regression equations for streamflow; these include: 1970's Geographic Information and Retrieval System (GIRAS) (US EPA, 1998); 1:250,000 aerial photograph national

coverage (U.S. Geological Survey, 1986); National Land Cover Data (NLCD) compilation of the early 1990s (U.S. Geological Survey, 1992); and Kentucky Landscape Snapshot (KLS) data compilation for circa 2000 (Kentucky Commonwealth Office of Technology, 2007).

Subsequent to compilation of supporting data and GIS coverages, drainage basin statistics, streamflow statistics, and annual nitrogen and phosphorus streamloads were estimated. Basin characteristics at user specified locations are now available based on data from 30-ft DEMs and in drainage areas as small as 0.1 $mi^2$ and increasing in increments of 0.01 $mi^2$. Previously published regional-regression equations for estimating streamflow statistics (low-flow and mean annual flow) as a function of known physical and climatic basin characteristics were also included after compilation of supporting GIS coverages. Finally, the Kentucky SPARROW model was used to generate estimates of annual nitrogen and phosphorus loads for stream reaches throughout Kentucky based on data from 40 monitoring stations located throughout Kentucky and parts of Tennessee. Approxiamtely 300 land-use, municipal, and natural-resource variables were evaluated in order to identify the significant contributing factors of nitrogen and phosphorus to streams.

**Drainage Basin Characteristics**

Drainage basin characteristics, including mean elevation (ft), mean slope (percent and degrees), and drainage area ($mi^2$) were calculated using 30-ft DEMs and ArcGIS ArcHydro tools. In addition, the wetness index (also known as the compound topographic index) was computed in order to provide a graphical display of the variability of moisture conditions throughout the basins. This index, given by the following equation,

$$CTI = \ln (A_s / \tan S) \qquad (1)$$

where

CTI – compound topographic index or wetness index,
$A_s$ – upslope contributing area ($m^2$)
tan S – local slope (degrees)

calculates the potential for water accumulation and its likelihood of moving down slope. Finally, impervious area (percent) was calculated from Multi-resolution land characteristics consortium (MRLC), National land cover database (NLCD), 2001 data, (MRLC, 2001), in order to provide an understanding of how imperviousness, or the converse of decreased water infiltration, varies throughout the state.

## Peak-flow, low-flow, and mean annual flow

Estimates of streamflow in cubic feet per second (CFS) for the Q2 (peak-flow with a 2-yr recurrence interval), Q5, Q10, Q25, Q100, Q200, Q500, 7Q2 (7-consecutive-day streamflow with a 2-yr recurrence interval), 7Q10, and mean annual ($Q_a$) flow statistics were estimated from published equations as documented in Ruhl and Martin (1991), Martin and Ruhl (1993), Martin (2002), Hodgkins and Martin (2003), and Martin and others (1997). Peak-flow, low-flow, and mean-annual equations are generally presented in the Hydrology of Kentucky KYGEONET tool for the estimation of streamflow statistics on ungaged, unregulated streams in rural, non-karst drainage basins. Limitations to the application of these equations are discussed in the 'Limitations of study' section at the end of this report.

Equations used to estimate streamflow statistics were derived from data collected at U.S. Geological Survey streamflow-gaging stations (both continuous and partial-record stations), and specific, significant ancillary data such as drainage area, basin slope, and basin development factors. Equations developed at a station were then regionalized, through regression techniques, utilizing explanatory statistics such as the streamflow variability index (the standard deviation of the logarithms of the 19 discharges at 5-percent class intervals from 5 to 95 percent on the flow duration curve; Searcy, 1959; Dempster, 1990).

## Nitrogen and phosphorus SPARROW model

The SPARROW model is a non-linear model that estimates the magnitude and significance of source and delivery variables for the downstream end of each stream segment (reach) based on measured data at monitored sites. The model then sums the nutrient load within each reach with those from the upstream reaches. The results presented in the final GIS coverage are from an adjusted model; this means that measured data for monitored reaches were included in the final model and used to adjust the model at each monitored reach and thereby improve the accuracy of the estimated nutrient concentrations. Consequently, the model is most accurate immediately downstream of a monitored reach. Conversely, the largest accumulated error is in reaches immediately upstream of a monitored reach.

Analysis of results from the SPARROW model yielded information on source identification for nutrient loads. For nitrogen, the sources were identified as wastewater (Hoos, USGS, written communication July 2007), agricultural land use (pasture plus cultivated land areas – USGS, 1992), and atmospheric deposition of ammonium and nitrate (National Atmospheric Deposition Program, 1992). Delivery of atmospheric deposition is controlled by how water moves through the soil (soil permeability is a component of the STATSGO soils-data coverage). In addition, the model estimates that there is depletion of stream nitrogen in the state's reservoirs. The SPARROW nitrogen model has a yield $R^2$ (accounting for the size of each drainage area) of 0.89. For phosphorus, the sources were identified as wastewater (Hoos, USGS, written communication July

2007), pasture lands (USGS 1992), and natural soil phosphorus (estimated from Karathanasis, 2006a and 2006b). Delivery of pasture land sources is by infiltration-excess overland flow (Wolock, 2003) This phosphorus model has a yield $R^2$ of 0.65. Limitations of the application of this model are discussed in the 'Limitations of study' section at the end of this report.

# Objectives

Objectives of this study are divided into three categories, primary objectives, ancillary objectives, and related publications and outreach. To meet the primary objectives of this study, numerous tasks had to be completed. Each of these tasks had value, and in some cases, this value was of equal importance to the primary objectives of this project. Each of these objectives and related products are detailed below.

**Primary Objectives**

1) Create a GUI that allows the user to view and select stream locations and access stream data. The *Hydrology of Kentucky KYGEONET tool* was constructed in order to provide users access to stream data. This GUI functions without the user needing their own GIS software, sophisticated computer equipment, or training. In order to facilitate location identification, several base, or thematic, layers are provided in addition to stream layers, topographic map, and commonwealth map. These base layers are given in table 1:

**Table 1.** Geographic information system base layers used to facilitate user orientation on Hydrology of Kentucky KYGEONET graphical user interface.

| Thematic Layer | Source |
|---|---|
| Springs | Kentucky Geological Survey |
| Dams | Kentucky Geological Survey |
| USGS Gaging Stations | US Geological Survey |
| USGS Water Quality Stations | US Geological Survey |
| Wells | Kentucky Geological Survey |
| Public Well Sources | Kentucky Department of Water |
| Surface Sources | Kentucky Department of Water |
| Sinkholes | Kentucky Speleological Society |
| Karst | US Geological Survey |
| SWAPP Zones | Kentucky Department of Water |
| Hydrologic Unit Codes | US Geological Survey |
| State Soil Geographic Data (STATSGO) | Natural Resources Conservation Service |
| 1:500,000 Geologic Map | Kentucky Geological Survey |

2) Provide a GIS database that contains the digital map data for measuring the basin characteristics. Basin characteristics in the *Hydrology of Kentucky KYGEONET tool* are based on 30-ft DEMs and imperviousness data (Kentucky

Commonwealth Office of Technology, 2007). Stream data, within the GIS database, are presented in two forms. First, the NHD data, derived from 1:24,000 topographic maps, represent perennial streams as blue lines. Second, stream channels derived from 30-ft DEMs are presented as an orange network; this stream network is usually coincident with the blue-line coverage, but frequently extends beyond it in order to show smaller streams.

3) Provide basin characteristics at user specified locations. Data from 30-ft DEMs were used to construct basin characteristics. For each stream segment and the total accumulated basin to that segment, basin attributes include:

- Mean elevation (ft).
- Mean slope (percent and degrees).
- Wetness (Compound Topographic) Index.
- Drainage area ($mi^2$).
- Impervious area (percent).

4) Provide estimated streamflow statistics by determination directly from USGS streamflow-gaging station data; estimation by means of regression analysis, linear interpolation of data from nearby USGS streamflow-gaging station(s), and(or) other statistical methods are discussed in Ruhl and Martin (1991); Martin and Ruhl (1993); Martin (2002); Hodgkins and Martin (2003) and Martin and others (1997). These values are estimated for the downstream end of the stream segment selected by the user. These streamflow values include:

- Peak-flow values (Q) over periods of 2, 5, 10, 25, 50, 100, and 500-years.
- Mean annual flow.
- Low-flow values for the 7-day 2-year (7Q2) and 7-day 10-year (7Q10) flow frequencies.

5) Provide annual estimates of nitrogen and phosphorus loads for stream reaches throughout Kentucky based on data from 40 monitored water-quality stations in Kentucky and Tennessee.

6) Provide a database of all previously published streamflow and water-quality information for sites in Kentucky. The USGS streamflow-gaging and monitoring stations provide links to historical data on streamflow and water quality for stream sites in Kentucky; active streamflow and water-quality monitoring sites are hyperlinked in the Hydrology of Kentucky KYGEONET map.

**Ancillary objectives**

In order to complete the main objectives outlined in the scope of this project, certain ancillary tasks, and their consequent products, were required to be completed. These ancillary products are noted as follows:

- Compiled an elevation and hydrography database.

- Developed a watershed-delineation tool.
- Designed and implemented a subbasin-delineation strategy.
- Compiled, evaluated, and reviewed existing land use, NRI, and soils data.
- Compiled available nutrient-load data and estimated nitrogen and phosphorus loads using the national SPARROW model. Available water-quality load data (Crain, 2001) was used to validate the national SPARROW-model estimates for Kentucky streams.
- Integrated all data into the interactive GIS tool.
- Submitted all iterations of the *Hydrology of Kentucky KYGEONET tool* to KDOW for review and approval.

**Related publications and outreach**

- Odom and Ayers, 2006, Simplification of access to hydrologic data through an online, interactive GIS tool. Kentucky Water Resources Research Institute Symposium, March 2006.
- Hydrologic Workshop, November 2005, at USGS Kentucky Water Science Center – internal presentation for KDOW personnel.
- A hands-on workshop on "Use of the Kentucky KYGEONET Hydrology Tool" was conducted on February 15, 2008 at Kentucky State University for employees of State and Federal agencies as well as local educators (fig. 3).


Figure 3**.** Workshop for "Use of the Kentucky KYGEONET Hydrology Tool" conducted on February 15, 2008 at Kentucky State University (photo by Ken Bates, Kentucky State University).

# Results and discussion

The result of the study was the creation of a tool that allows water-resource managers and other interested parties a way to quickly estimate basin characteristics, nutrient loads, and streamflow statistics without the need for advanced knowledge of hydrologic systems or sophisticated software. This type of analysis and tool is limited by the existing data and technology at the time of creation; as data, knowledge of hydrologic systems, and computer technology are made available and(or) improve, future upgrades to the utility of the tool will also become necessary.

### Conclusions

The Hydrology of Kentucky KYGEONET tool is online and active as part of the Kentucky Geography Network. Metadata for each of the layers is provided by the Geospatial Data Clearinghouse for the Commonwealth of Kentucky. Future direction includes improving the resolution of the Kentcuky SPARROW model, and, consequently, the precision of estimated annual nitrogen and phosphorus loads, through the use of the NHD stream coverage instead of the National Enhanced River Reach File 2.0 (E2RF1) stream coverage (which is limited in effective use to a 1:500,000 scale). A USGS Open-file report (OFR) will also be published documenting the Kentucky SPARROW model.

### Limitations of study

As with any regional analysis of streamflow data and(or) GIS application, limitations exist about which users must be aware and upgrades to newer versions of software and data are frequent. As computer technology and GIS applications evolve, many of these limitations will be ultimately resolved; however, immediate solutions to these problems are beyond the scope of this project. Existing, known limitations in the GIS application are noted as follows:

- The Hydrology of Kentucky web page is not linked to the main Kentucky Geography Network homepage.
- The USGS is not currently listed on the ‘list of publishers’ for the Kentucky Geography Network.
- The current presentation of the STATSGO soils data needs to be enhanced.
- Only active USGS streamflow-gaging station sites are hyperlinked to the USGS website. Discontinued streamflow-gaging stations or water-quality monitoring sites do not have a hyperlink.
- Variable titles in tables created with the ‘identify tool’ are an artifact of GIS programming.

- Some variables, including the shape numbers and KYGEONET codes are GIS program artifacts and not directly related to data (e.g. in the NHD layer).

Estimates of low-flow values are subject to certain limitations as discussed in Ruhl and Martin (1991).

- The estimating equations for 7Q2 and 7Q10 are applicable to ungaged, rural, unregulated stream sites with total drainage areas from 0.67 to 1,300 $mi^2$ for 7Q2 and 0.85 to 1,300 $mi^2$ for 7Q10. Caution is advised if total drainage area is outside the range of approximately 3.0 to 1,500 $mi^2$.
- Estimates of streamflow computed as 0.05 cfs or less should be considered zero. These values have been rounded to the nearest 0.10 cfs, so are reported as zero.
- Estimates of 7Q10 values at sites with drainage areas less than 3 $mi^2$ should be considered zero, except in streamflow variability index areas of 0.45, 0.50, or 0.55, which are karstic.
- Estimates of 7Q10 values at sites with drainage areas less than 600 $mi^2$ located entirely within streamflow variability index areas of 1.25 or 1.35 should be considered zero. These areas are in the Western Kentucky Coal Field region and most of the Outer Bluegrass region of Kentucky.
- The low-flow (7Q2 and 7Q10) equations are not applicable on stream reaches having “sinking-stream” karst discontinuities.
- The low-flow equations are not applicable on stream reaches affected by regulation or local diversion.

Estimates of annual nitrogen and phosphorus values are subject to the following limitations.

- The existing stream coverage is based on a coarse national stream coverage (Enhanced River Reach File 2.0 or E2RF1) and is not precise enough to be valid at any resolution smaller than 1:500,000. This E2RF1 stream coverage may be replaced by a higher-resolution NHD stream coverage allowing users the ability to ‘zoom in’ farther.
- Drainage areas are currently determined based on surface topographic features and are, therefore, only approximate estimators of true drainage areas in karst terrain. There are large uncertainties in the underground contributions to karstic watersheds; future and on-going work by the Kentucky Geologic Survey (KGS), KDOW, and USGS may be incorporated as it becomes available. Some caution must also be used when working in, and around, urban, mining, and other areas where significant land-surface disturbance has occurred.

# References cited


Alexander, R.B., Ludtke, A.S., Fitzgerald, K.K., Briel, L.I., and Schertz, T.L., 1996, Data from the U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN) on CD-ROM: U.S. Geological Survey Open-File Report 96-337 and Digital Data Series DDS-37.

Alexander, R.A., Smith, R.B., and Schwarz, G.E., 2000, Effect of stream channel size on the delivery of nitrogen to the Gulf of Mexico: Nature, v. 403. p. 758-761.

Crain, A.S., 2001, Estimated loads and yields of suspended soils and water-quality constituents in Kentucky streams, U.S. Geological Survey Water-Resources Investigations report 01-4075, 125 p.

Dempster, G.R., Jr., 1990, National water information user's manual, v.2, chapter 3; Automated data processing system: U.S. Geological Survey Open-File Report 90-116, 321 p.

DeWald, T., Horn, R. Greenspun, R., Taylor, P., Manning, L., and Montalbano, A., 1985, STORET Reach Retrieval Documentation: U.S. Environmental Protection Agency, Washington, D.C.

ESRI, 1992, Arc/Info users guide, cell-based modeling with GRID, 2nd ed., ESRI, Redlands, CA.

Hodgkins, G.A., and Martin, G.R., 2003, Estimating the magnitude of peak flows for streams in Kentucky for selected recurrence intervals, US Geological Survey Water-resources Investigations report 03-4180, 73 p.

Karathanasis, A.D., 2006a, Descriptions and Complete Laboratory Characterization Data for Some Soils in Kentucky. Special Report 100, UK Agr. Exp. Station, University of Kentucky, p. 106, January 2006. available at http://www.ca.uky.edu/agc/pubs/sr/sr100/sr100.pdf.

Karathanasis, A.D., 2006b, Descriptions and Reference Laboratory Characterization Data for Some Soils in Kentucky. Special Report 101, UK Agr. Exp. Station, University of Kentucky, p. 94, January 2006. available at http://www.ca.uky.edu/agc/pubs/sr/sr101/sr101.pdf.

Kentucky Commonwealth Office of Technology, 2007, Kentucky Landscape Snapshot DATA Viewing and Download; available at http://kls.ky.gov/klsdata.htm.

Martin G.R., and Ruhl, K.J., 1993, Regionalization of harmonic-mean streamflows in Kentucky, U.S. Geological Survey Water-resources Investigations report 92-7173, 47 p.

Martin, G. R., Ruhl, K. J., Moore, B. L., and Rose, M. F., 1997, Estimation of peak-discharge frequency of urban streams in Jefferson County, Kentucky, U.S. Geological Survey Water-resources Investigations report 97-4219, 40 p.

Martin, G.R., 2002, Estimating mean annual streamflow of rural streams in Kentucky, U.S. Geological Survey Water-resources Investigations report 02-4206, 35 p.

Multi-resolution land characteristics consortium (MRLC), National Land Cover Database (NLCD), 2001, MRLC Consotium, Naitonal land cover database (NLCD 2001) Multi-zone download site, available at http://www.mrlc.gov/scripts/mapserv.exe?map=d%3A%5CInetpub%5Cwwwroot%5Clccp%5Cmrlc2k%5Czones%5Czones.map

National Atmospheric Deposition Program, 1992, Grids of Inorganic Nitrogen atmospheric (wet) depostion for 1995 through 2001 available at water.usgs.gov/nawqa-only/nuts/data/inputs/#AtmGrids, source data from http://nadp.sws.uiuc.edu/.

Omerinik, J.M., 1987, Aquatic ecoregions of the conterminous United States, U.S. Geological Survey map, available at sagemap.wr.usgs.gov/ftp/regional/ecoregion.html.

Ruddy, B.C., and Hitt, K.J., 1990, Summary of selected characteristics of large reservoirs in the United States and Puerto Rico, 1988, US Geological Survey Open-file Report 90-163, 295 p.

Ruhl, K.J., and Martin, G.R., 1991, Low-flow characteristics of Kentucky streams, U.S. Geological Survey Water-resources Investigations report 91-4097, 50 p.

Searcy, J.K., 1959, Flow-duration curves: U.S.Geological Survey Water-Supply Paper, 1542-A, 33 p.

Smith, R.A., G.E. Schwarz, and R.B. Alexander, 1997, Regional interpretation of water-quality monitoring data, Water Resources Research, v. 33, no. 12, pp. 2781-2798

Snyder, J.P., 1987, Map Projections: A Working Manual, U.S. Geological Survey Professional Paper 1395, 385 p.

U.S. Environmental Protection Agency, 1996, USEPA Reach File Version 1.0 (RF1) for the Conterminous United States (CONUS), available at http://www.epa.gov/waters/doc/rf1_meta.html.

U.S. Department of Agriculture, Soil Conservation Service (now the Natural Resources Conservation Service), 1994, State Soil Geographic (STATSGO) data base, www.ncgc.nrcs.usda.gov/products/datasets/statsgo.

U.S. Department of Agriculture, Natural Resources Conservation Service, 2006-2007, Soil Survey Geographic (SSURGO) database for Kentucky (by county), available at SoilDataMart.nrcs.usda.gov.

U.S. Environmental Protection Agency, Office of Water and Office of Science and Technology, 1998, 1:250,000 scale quadrangle of landuse / land cover, Geographic Information and Retrieval System (GIRAS) spatial data of CONUS in BASINS, availble at http://www.epa.gov/waterscience/basins/b3webdwn.htm.

U.S. Geological Survey, 1986, Land Use Land Cover Digital Data from 1:250,000 and 1:100,000-Scale Maps, Data User Guide 4, U.S. Geological Survey, Reston, VA.

U.S. Geological Survey, 1992, National Land Cover Data 1992 (NLCD 92), EROS Data Center Distributed Active Archive Center (EDC DAAC), U.S. Geological Survey, EROS Data Center, available at http://eros.usgs.gov/products/landcover/nlcd.html.

U.S. Geological Survey, 1997a, Federal land features of the United States (linear), The National Atlas of the United States of America, parkwaysm, available at http://nationalatlas.gov/parkwaysm.html.

U.S. Geological Survey, 1997b, Federal land features of the United States (polygon), The National Atlas of the United States of America, fedlandsm, available at http://nationalatlas.gov/fedlandsm.html.

U.S. Geological Survey and U.S. Environmental Protection Agency, 1999, National Hydrography Dataset, available at http://nhd.usgs.gov.

Verdin, K.L., and Greenlee, S.K., 1996, HYDRO 1K Elevation Derivative Database, EROS Data Center Distributed Active Archive Center (EDC DAAC), U.S. Geological Survey, EROS Data Center, available at http://edcdaac.usgs.gov/gtopo30/hydro/.

Verdin, K.L., and Jenson, S.K., 1996, Development of continental scale digital elevation models and extraction of hydrographic features. In: Proceedings, Third International Conference/Workshop on Integrating GIS and Environmental Modeling, Santa Fe, New Mexico, January 21-26, 1996, National Center for Geographic Information and Analysis, Santa Barbara, California.

Wolock, D.M., 2003, Infiltration-excess overland flow estimated by TOPMODEL for the conterminous United States: U.S. Geological Survey Open-File Report 03–310, digital data set, available at http://water.usgs.gov/lookup/getspatial?ieof48.

# Appendices

Note: Appendices B, C, and D include metadata for the three layers of new data produced for this project. This metadata is presented herein as it appears to the user of the Hydrology of Kentucky KYGEONET tool.

Appendix A. Administrative and financial closeout.

Appendix B. Metadata for nitrogen and phosphorus loads GIS layer as published in the Hydrology of Kentucky KYGEONET tool.

Appendix C. Metadata for estimated streamflow statistics GIS layer as published in the Hydrology of Kentucky KYGEONET tool.

Appendix D. Metadata for Kentucky stream-reach drainage polygons GIS layer as published in the Hydrology of Kentucky KYGEONET tool.

Appendix E. Training manual used in instruction of “Use of the Kentucky GEONET Hydrology Tool” as presented on February 15, 2008 at Kentucky State University.

# Appendix A. Administrative and financial closeout

## 1. Milestones and discussion of outputs

The Kentucky Streamstats project (Grant No. C9994861-04) consisted of the following milestones. These milestones were met as described briefly below (dated where applicable) and are described in detail in the text above:

1. Sign agreement with KDOW
   Agreement signed August 1, 2004
2. Compile elevation and hydrography data and build watershed delineation tool.
   a. 30-ft DEM elevation data compiled
   b. 1:24,000 NHD hydrography data compiled.
   c. Watershed delineation tool completed as of February, 2005
3. Define and implement sub basin delineation strategy.
   Sub basin delineation strategy implemented at approximately 0.1-$mi^2$ using ArcHYDRO tools. Complete as of May, 2005.
4. Compile, evaluate, and review existing land use, NRI, and soils data.
   All data compiled, evaluated, and reviewed and incorporated into calculations for peak-flow (stream data), mean annual flow, and low-flow layers. Additionally, generalized soils data and geology maps were included with the KYGEONET base maps. Complete as of December, 2006.
5. Compile available nutrient load data and evaluate SPARROW model.
   Available nutrient-load data were compiled and a Kentucky SPARROW model was evaluated. Unique approach discovered, in cooperation with research staff from USGS Tennessee and National (Reston, Virginia) Water Science Centers to model the soil contribution of phosphorus to stream loads. Complete as of June, 2007.
6. Begin process with non-Federal match partners to document activities related to tool and data needs.
   On-going discussions occurred throughout the project.
7. Prepare quarterly progress review reports.
   Completed.
8. Prepare quarterly non-federal match reports.
   Responsibility of KDOW.
9. Integrate all data into the interactive GIS tool.
   All data has been integrated into GIS tool and is currently available for public access at: http://kygeonet.ky.gov/kyhydro/viewer.htm.
10. Submit annual report.
    Quarterly reports fulfilled this requirement.

11. Prepare a talk for annual NPS or KWRRI conference.
    a. Presented SPARROW model at USGS open house in November, 2005
    b. Presented applications March, 2006 at Kentucky Water Resources Research Institute.
    c. Presented applications November, 2006 to Salt River Basin Team.
12. Convene meetings with partners to discuss design, data, sharing, and format for workshop and training sessions.
    Multiple meetings held to discuss design, data, sharing, and format for workshop and training sessions.
13. Convene workshop and training sessions.
    Workshop and training session held February 15, 2008 at Kentucky State University.
14. Presentation and feedback from KDOW WRB and WMB.
    All materials updated based on feedback from KDOW personnel.
15. Final and close-out report submitted to KDOW.
    Final and closeout report submitted March, 2008.
16. Archive information and transfer database to KDOW and other agencies.
    Completed March, 2008.
17. Submit all draft materials (including GUI) of final products to KDOW for review and approval.
    All drafts submitted to Margi Jones (KDOW) for review.
18. Distribute final web-based report.
    Distributed March, 2008.

## 2. Budget Summary

**Grant No. C9994861-04**
**Kentucky Streamstats**

**a**. Original Detailed Budget

| Budget Categories | 2004 | 2005 | 2006 | 2007 | Total |
|---|---|---|---|---|---|
| Personnel | $40,892 | $95,847 | $57,191 | $43,731 | $237,661 |
| Office supplies | $0 | $0 | $101 | $0 | $101 |
| Travel | $0 | $1,154 | $316 | $1,483 | $2,953 |
| Freight | $27 | $4 | $40 | $15 | $86 |
| Vehicle | $0 | $0 | $238 | $196 | $434 |
| Operating Costs | $22,470 | $59,060 | $34,462 | $27,616 | $143,608 |
| Training | $0 | $215 | $857 | $365 | $1437 |
| **Subtotal** | **$63,389** | **$156,280** | **$93,205** | **$73,406** | **$386,280** |
| | | | | | |
| Funding sources | | | | | |
| 319 Funding (KDOW) | $37,389 | $75,000 | $68,205 | $47,406 | $228,000 |
| USGS Non-Federal matching funds | $26,000 | $75,000 | $25,000 | $26,000 | $152,000 |
| USGS Federal special-initiative funding | $0 | $6,280 | $0 | $0 | $6,280 |
| **Subtotal** | **$63,389** | **$156,280** | **$93,205** | **$73,406** | **$386,280** |

US Geological Survey (USGS) was reimbursed $228,000. All dollars were spent; there were no excess project funds to reallocate.

This project did provide non-Federal matching funds. This overmatch was not posted to the grant.

The USGS also provided additional funding in FY2005 in the amount of $6280.

## 3. Equipment Summary

No equipment was purchased for this project.

# Appendix B. Metadata for nitrogen and phosphorus loads GIS layer as published in the Hydrology of Kentucky KYGEONET tool

**Nitrogen and Phosphorus Loads in Kentucky Streams at 1:500,000 Scale**

Description | Spatial | Attributes

### Keywords

**Theme:** stream, river, network, SPARROW, reach, RF1, water quality, reservoir, inland Waters, nitrogen, phosphorus
**Place:** Kentucky

### Description

#### Abstract

The Kentucky SPARROW (SPAtially Referenced Regressions On Watershed Attributes) model estimates annual nitrogen and phosphorus loads (concentrations) for stream reaches throughout the state based on data from 40 monitored stations in Kentucky and Tennessee. Approximately 300 land-use, municipal, and natural-resource variables were evaluated in order to identify the significant contributing factors of nitrogen and phosphorus to streams.
The SPARROW model is a non-linear model that estimates the magnitude and significance of source and delivery variables for the downstream end of each stream segment (reach) based on measured data at monitored sites. The model then sums the nutrient load within each reach with those from the upstream reaches. The results presented here are from an adjusted model - this means that measured data for monitored reaches were included in the final model and used to adjust the model at each monitored reach and thereby improve the accuracy of the estimated nutrient concentrations. Consequently, the model is most accurate immediately downstream of a monitored reach. Conversely, the largest accumulated error is in reaches immediately upstream of a monitored reach.
For nitrogen, the sources were identified as agricultural land use (pasture plus cultivated land areas - NLCD 1992), atmospheric deposition of ammonium and nitrate (NADP), and wastewater (Hoos, USGS, written communication July 2007). Delivery of these sources is controlled by how water moves through the soil (soil permeability - STATSGO). In addition, there is depletion of stream nitrogen in the state's reservoirs (as estimated by the model). This nitrogen model has a yield R2 (accounting for the size of each drainage area) of 0.89.
For phosphorus, the sources were identified as pasture and forested lands (NLCD), together with wastewater (Hoos, USGS, written communication July 2007). Delivery of these sources is by infiltration excess overland flow (Wolock, 2003) and soil erosion (estimated by the length-slope factor calculated from SSURGO); phosphorus

delivery to streams is decreased in areas where soils are naturally high in phosphorus (estimated from Karathanasis, 2006a and 2006b). This phosphorus model has a yield R2 of 0.73.

Questions? tnwillia@usgs.gov

## Purpose

The HYDROLOGY OF KENTUCKY tool was created by the Kentucky Water Science Center - USGS in order to make Kentucky stream statistics readily available to the public. Equations to estimate loads of nitrogen and phosphorus from individual watersheds are available through the national SPARROW model (http://water.usgs.gov/nawqa/sparrow/). However, a local model was developed in order to account for regional differences in land use and natural resources.

Acknowledgements
We'd like to thank the national SPARROW model team, especially A. Hoos, R. Alexander, S. Preston, S. Terziotti, G. Schwarz, and R. Smith for their assistance. In addition, we appreciate the technical assistance of P. Finnell and J. Haagen from the NRCS and H. Nelson from the USGS.

## Supplementary Information

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this Federal Geographic Data Committee-compliant metadata file is intended to document the data set in nonproprietary form, as well as in ArcInfo format, this metadata file may include some ArcInfo-specific terminology.

---

## Status of the data

## Time period for which the data is relevant

## Publication Information

---

## Data storage and access information

## Details about this document

**Nitrogen and Phosphorus Loads in Kentucky Streams at 1:500,000 Scale**

Description | Spatial | Attributes

**Horizontal coordinate system**

**Details**

---

**Bounding coordinates**

**Horizontal**

**In decimal degrees**

*West:* -89.184977

*East:* -81.250225

*North:* 39.095366

*South:* 35.240246

---

**Lineage**

**FGDC lineage**

**Process step 1**

**Process step 2**

**Process step 3**

**Process step 4**

**Process step 5**

**Process step 6**

**Process step 7**

**Process step 8**

**Process step 9**

**Process step 10**

**Process step 11**

**Process step 12**

**Process step 13**

**Process step 14**

**Process step 15**

**Process step 16**

**Sources**

**Source 1: ERF1-- Enhanced River Reach File 1.2 ((none))**

**Source 2: Data from Selected U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN) (Alexander and others, 1996)**

**Source 3: The effect of stream channel size on the delivery of nitrogen to the Gulf of Mexico (Alexander and others, 2000)**
**Source 4: STORET Reach Retrieval Documentation (DeWald and others, 1985)**
**Source 5: Arc/Info Users Guide, Cell-based Modeling with GRID, 2nd Edition (none)**
**Source 6: USEPA Reach File Version 1.0 (RF1) for the conterminous United States (CONUS) as enhanced for NOAA's Environmental Assessment Division (NOAA, 1997)**
**Source 7: Aquatic ecoregions of the conterminous United States (Omernik, 1987)**
**Source 8: Summary of selected characteristics of large reservoirs in the United States and Puerto Rico (Ruddy and Hitt, 1990)**
**Source 9: Hydrologic unit maps (none)**
**Source 10: Regional Interpretation of water-quality monitoring data (Smith and others, 1997)**
**Source 11: Map projections - A working manual (Snyder, 1987)**
**Source 12: The USEPA Reach File version 1.0 (RF1) for the conterminous United States (CONUS) (USEPA, 1996)**
**Source 13: Federal land features of the United States (linear) (USGS, 1997a)**
**Source 14: Federal land features of the United States (polygon) (USGS, 1997b)**
**Source 15: HYDRO1K elevation derivative database (Verdin and Greenlee, 1996)**
**Source 16: Development of continental scale digital elevation models and extraction of hydrographic features (Verdin and Jenson, 1996)**

---

**Spatial data quality**
**Horizontal positional accuracy**

---

**Spatial data description**
**Vector data information**
**SDTS description**

# Nitrogen and Phosphorus Loads in Kentucky Streams at 1:500,000 Scale

Description | Spatial | Attributes

**Details for Nitrogen and Phosphorus Loads in Kentucky Streams**

**Attributes**

**OBJECTID**

**Shape**

E2RF1
StreamName
Station_ID
StationNam

**Shape_Length**

Nitrogen_Mean_Annual_Load_kg_per_yr
Total_Drainage_Area_km2
CI_Lower_Bound_Nitrogen_Annual_Load_kg_per_yr
CI_Upper_Bound_Nitrogen_Annual_Load_kg_per_year
Phosphorus_Mean_Annual_Load_kg_per_yr
CI_Lower_Bound_Phosphorus_Annual_Load_kg_per_yr
CI_Upper_Bound_Phosphorus_Annual_Load_kg_per_yr

**Overview**

E2RF1 Unique reach identification number for Version 2.0 that reflects revisions in process steps 6, 7, 10, and 11.

StreamName Stream on which reach is located.

Station_ID USGS station identification number where water-quality data were collected, assigned to the split reach.

StationNam Name of USGS station.

Total_Drainage_Area_km2 Total drainage areas upstream summed for a given reach, in square kilometers.

Nitrogen_Mean_Annual_Load_kg_per_yr Mean annual load estimated from Kentucky SPARROW model.

CI_Lower_Bound_Nitrogen_Annual_Load_kg_per_yr Lower bound of 90% confidence interval for loads estimated by Kentucky SPARROW model.

CI_Upper_Bound_Nitrogen_Annual_Load_kg_per_yr Upper bound of 90% confidence interval for loads estimated by Kentucky SPARROW model.

Phosphorus_Mean_Annual_Load_kg_per_yr Mean annual load estimated from Kentucky SPARROW model.

CI_Lower_Bound_Phosphorus_Annual_Load_kg_per_yr Lower bound of 90% confidence interval for loads estimated by Kentucky SPARROW model.

CI_Upper_Bound_Phosphorus_Annual_Load_kg_per_yr Upper bound of 90% confidence interval for loads estimated by Kentucky SPARROW model.

**Overview citation**

National Sparrow Model (https://water.usgs.gov/nawqa/sparrow), STATSGO (http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/description.html), SSURGO (http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/description.html), infiltration-excess overland flow data from Wolock (2003) http://water.usgs.gov/GIS/metadata/usgswrd/XML/ieof48.xml), phosphorus extraction data from Karathanasis (www.ca.uky.edu/agc/pubs/sr/sr100/sr100.pdf) and 1995 wastewater values compiled by Anne Hoos (USGS, written communication July 2007).

# Appendix C. Metadata for estimated streamflow statistics GIS layer as published in the Hydrology of Kentucky KYGEONET tool

**Low-Flow and Mean Annual Flow Data for Kentucky**

# Personal GeoDatabase Feature Dataset

Description | Spatial | Attributes

**Keywords**

**Theme:** InlandWaters

**Description**

**Abstract**

This is a vector data set consisting of lines representing streams in Kentucky. Each line segment is attributed with the 7-day 2-year low-flow frequency values, 7-day 10-year low-flow frequency values, and the mean annual streamflow values for the downstream end of that stream segment. For example, the "7-day 2-year low-flow" is the flow rate, averaged over seven days, that has a 50% chance (i.e. one out of every two years) of being exceeded in any year; the 10-year value has a 10% chance of being exceeded in any year (i.e. one out of every ten years). Low-flow values were calculated using the equations in the USGS Water-Resources Investigations Report 91-4097 "Low-Flow Characteristics of Kentucky Streams". Mean annual streamflow values were calculated using the equation in the USGS Water-Resources Investigations Report 02-4206 "Estimating Mean Annual Streamflow of Rural Streams in Kentucky". Users of the data should be aware of the limitations and accuracy of the equations as explained in those reports and summarized below (see "Constraints on accessing and using the data").

**Purpose**

Provide point and click low-flow and mean annual streamflow values for Kentucky

**Status of the data**

**Time period for which the data is relevant**

**Publication Information**

---

**Data storage and access information**

**Details about this document**

**Low-Flow and Mean Annual Flow Data for Kentucky**

# Personal GeoDatabase Feature Dataset

Description | Spatial | Attributes

**Horizontal coordinate system**

*Projected coordinate system name:* NAD_1983_Lambert_Conformal_Conic

*Geographic coordinate system name:* GCS_North_American_1983

**Details**

**Altitude System Definition**

*Resolution:* 0.000010

*Encoding Method:* Explicit elevation coordinate included with horizontal coordinates

---

**Bounding coordinates**

**Horizontal**

**In decimal degrees**

*West:* -89.674505

*East:* -81.884280

*North:* 39.148144

*South:* 36.457430

**In projected or local coordinates**

*Left:* 3807382.995192
*Right:* 6018412.995192
*Top:* 4305840.751919
*Bottom:* 3348630.751919

---

**Spatial data description**
**Vector data information**
**ESRI description**
**tug**
**upper_levisa**
**lower_levisa**
**big_sandy**
**little_scioto_tygarts**
**little_sandy**
**ohio_brush_whiteoak**
**middle_ohio_laughery**
**licking**
**south_fork_licking**
**north_fork_kentucky**
**middle_fork_kentucky**
**south_fork_kentucky**
**upper_kentucky**
**lower_kentucky**
**upper_green**
**barren**
**middle_green**
**lower_green**
**rough**
**pond**
**upper_cumberland**
**rockcastle**
**lake_cumberland**
**south_fork_cumberland**
**obey**
**lower_cumberland**
**red**
**silver_little_kentucky**
**salt**

**rolling_fork**
**blue_sinking**
**lower_ohio_little_pigeon**
**highland_pigeon**
**lower_ohio_bay**
**tradewater**
**lower_ohio**
**kentucky_lake**
**lower_tennessee**
**lower_mississippi**
**bayou_de_chien_mayfield**
**obion**

**SDTS description**

**Low-Flow and Mean Annual Flow Data for Kentucky**

# Personal GeoDatabase Feature Dataset

Description | Spatial | Attributes

**Details for tug**
*Type of object:* Feature Class
*Number of records:* 8552

---

**Details for upper_levisa**
*Type of object:* Feature Class
*Number of records:* 6153

---

**Details for lower_levisa**
*Type of object:* Feature Class
*Number of records:* 18995

---

**Details for big_sandy**
*Type of object:* Feature Class

*Number of records:* 6003

---

**Details for little_scioto_tygarts**

*Type of object:* Feature Class

*Number of records:* 7427

---

**Details for little_sandy**

*Type of object:* Feature Class

*Number of records:* 12980

---

**Details for ohio_brush_whiteoak**

*Type of object:* Feature Class

*Number of records:* 12595

---

**Details for middle_ohio_laughery**

*Type of object:* Feature Class

*Number of records:* 6046

---

**Details for licking**

*Type of object:* Feature Class

*Number of records:* 48738

---

**Details for south_fork_licking**

*Type of object:* Feature Class

*Number of records:* 16272

---

**Details for north_fork_kentucky**

*Type of object:* Feature Class

*Number of records:* 22892

---

**Details for middle_fork_kentucky**

*Type of object:* Feature Class
*Number of records:* 9389

---

**Details for south_fork_kentucky**
*Type of object:* Feature Class
*Number of records:* 12920

---

**Details for upper_kentucky**
*Type of object:* Feature Class
*Number of records:* 19232

---

**Details for lower_kentucky**
*Type of object:* Feature Class
*Number of records:* 57045

---

**Details for upper_green**
*Type of object:* Feature Class
*Number of records:* 55338

---

**Details for barren**
*Type of object:* Feature Class
*Number of records:* 32458

---

**Details for middle_green**
*Type of object:* Feature Class
*Number of records:* 18098

---

**Details for lower_green**
*Type of object:* Feature Class
*Number of records:* 16244

---

**Details for rough**

*Type of object:* Feature Class

*Number of records:* 18919

---

**Details for pond**

*Type of object:* Feature Class

*Number of records:* 13912

---

**Details for upper_cumberland**

*Type of object:* Feature Class

*Number of records:* 34456

---

**Details for rockcastle**

*Type of object:* Feature Class

*Number of records:* 13557

---

**Details for lake_cumberland**

*Type of object:* Feature Class

*Number of records:* 32224

---

**Details for south_fork_cumberland**

*Type of object:* Feature Class

*Number of records:* 6769

---

**Details for obey**

*Type of object:* Feature Class

*Number of records:* 2899

---

**Details for lower_cumberland**

*Type of object:* Feature Class

*Number of records:* 23319

---

**Details for red**

*Type of object:* Feature Class

*Number of records:* 11963

---

**Details for silver_little_kentucky**

*Type of object:* Feature Class

*Number of records:* 9317

---

**Details for salt**

*Type of object:* Feature Class

*Number of records:* 26040

---

**Details for rolling_fork**

*Type of object:* Feature Class

*Number of records:* 25558

---

**Details for blue_sinking**

*Type of object:* Feature Class

*Number of records:* 10479

---

**Details for lower_ohio_little_pigeon**

*Type of object:* Feature Class

*Number of records:* 6276

---

**Details for highland_pigeon**

*Type of object:* Feature Class

*Number of records:* 7223

---

**Details for lower_ohio_bay**

*Type of object:* Feature Class

*Number of records:* 6951

---

**Details for tradewater**

*Type of object:* Feature Class

*Number of records:* 16718

---

**Details for lower_ohio**

*Type of object:* Feature Class

*Number of records:* 4865

---

**Details for kentucky_lake**

*Type of object:* Feature Class

*Number of records:* 5612

---

**Details for lower_tennessee**

*Type of object:* Feature Class

*Number of records:* 11668

---

**Details for lower_mississippi**

*Type of object:* Feature Class

*Number of records:* 2086

---

**Details for bayou_de_chien_mayfield**

*Type of object:* Feature Class

*Number of records:* 16738

---

**Details for obion**

*Type of object:* Feature Class

*Number of records:* 2513

# Appendix D. Metadata for Kentucky stream-reach drainage polygons GIS layer as published in the Hydrology of Kentucky KYGEONET tool.

## Kentucky Stream Reach Drainage Polygons

## Personal GeoDatabase Feature Dataset

Description | Spatial | Attributes

**Keywords**

**Theme:** drainage basin characteristics
**Place:** Kentucky

**Description**

**Abstract**

Vector data set consisting of polygons representing the drainage areas of stream reaches in Kentucky. Each polygon is attributed with various statistics related to the drainage basin characteristics for that reach and the accumulated statistics for the entire upstream drainage area.

**Purpose**

Provide point and click drainage basin characteristics for the state of Kentucky

_____

**Status of the data**

**Time period for which the data is relevant**

**Publication Information**

_____

**Data storage and access information**

**Details about this document**

# Kentucky Stream Reach Drainage Polygons Personal GeoDatabase Feature Dataset

Description | Spatial | Attributes

**Horizontal coordinate system**

*Projected coordinate system name:* NAD_1983_Lambert_Conformal_Conic

*Geographic coordinate system name:* GCS_North_American_1983

**Details**

**Altitude System Definition**

*Resolution:* 0.000010

*Encoding Method:* Explicit elevation coordinate included with horizontal coordinates

---

**Bounding coordinates**

**Horizontal**

**In decimal degrees**

*West:* -89.679180

*East:* -81.206416

*North:* 39.149668

*South:* 35.640637

**In projected or local coordinates**

*Left:* 3806078.040000

*Right:* 6211058.040000

*Top:* 4306395.750000

*Bottom:* 3058545.750000

---

**Lineage**

**FGDC lineage**

**Process step 1**

---

**Spatial data description**

**Vector data information**

**ESRI description**

**barr**

**bdcm**

**bsan**

**blue**

**high**

**kylk**

**lick**

**lsan**

**lsty**

**locu**

**logr**

**loky**

**llev**

**lomi**

**looh**

**loby**

**lolp**

**lotn**

**mfky**

**mgrn**

**mola**

**nfky**

**obey**

**obio**

**obwo**

**pond**

**red**

**rock**

**roll**

**roug**
**salt**
**slky**
**sfcu**
**sfky**
**sflk**
**trad**
**tug**
**ucum**
**uclc**
**ugrn**
**upky**
**ulev**

**SDTS description**

# Kentucky Stream Reach Drainage Polygons Personal GeoDatabase Feature Dataset

Description | Spatial | Attributes

**Details for barr**
*Type of object:* Feature Class
*Number of records:* 1231

---

**Details for bdcm**
*Type of object:* Feature Class
*Number of records:* 581

---

**Details for bsan**
*Type of object:* Feature Class
*Number of records:* 211

---

**Details for blue**

*Type of object:* Feature Class

*Number of records:* 371

---

**Details for high**

*Type of object:* Feature Class

*Number of records:* 266

---

**Details for kylk**

*Type of object:* Feature Class

*Number of records:* 1240

---

**Details for lick**

*Type of object:* Feature Class

*Number of records:* 1567

---

**Details for lsan**

*Type of object:* Feature Class

*Number of records:* 371

---

**Details for lsty**

*Type of object:* Feature Class

*Number of records:* 246

---

**Details for locu**

*Type of object:* Feature Class

*Number of records:* 1378

---

**Details for logr**

*Type of object:* Feature Class

*Number of records:* 574

---

**Details for loky**

*Type of object:* Feature Class

*Number of records:* 1787

---

**Details for llev**

*Type of object:* Feature Class

*Number of records:* 637

---

**Details for lomi**

*Type of object:* Feature Class

*Number of records:* 84

---

**Details for looh**

*Type of object:* Feature Class

*Number of records:* 185

---

**Details for loby**

*Type of object:* Feature Class

*Number of records:* 236

---

**Details for lolp**

*Type of object:* Feature Class

*Number of records:* 218

---

**Details for lotn**

*Type of object:* Feature Class

*Number of records:* 423

---

**Details for mfky**

*Type of object:* Feature Class
*Number of records:* 301

---

**Details for mgrn**
*Type of object:* Feature Class
*Number of records:* 589

---

**Details for mola**
*Type of object:* Feature Class
*Number of records:* 207

---

**Details for nfky**
*Type of object:* Feature Class
*Number of records:* 732

---

**Details for obey**
*Type of object:* Feature Class
*Number of records:* 547

---

**Details for obio**
*Type of object:* Feature Class
*Number of records:* 369

---

**Details for obwo**
*Type of object:* Feature Class
*Number of records:* 441

---

**Details for pond**
*Type of object:* Feature Class
*Number of records:* 485

---

**Details for red**

*Type of object:* Feature Class

*Number of records:* 795

---

**Details for rock**

*Type of object:* Feature Class

*Number of records:* 435

---

**Details for roll**

*Type of object:* Feature Class

*Number of records:* 815

---

**Details for roug**

*Type of object:* Feature Class

*Number of records:* 603

---

**Details for salt**

*Type of object:* Feature Class

*Number of records:* 795

---

**Details for slky**

*Type of object:* Feature Class

*Number of records:* 292

---

**Details for sfcu**

*Type of object:* Feature Class

*Number of records:* 789

---

**Details for sfky**

*Type of object:* Feature Class

*Number of records:* 443

---

**Details for sflk**

*Type of object:* Feature Class

*Number of records:* 473

---

**Details for trad**

*Type of object:* Feature Class

*Number of records:* 543

---

**Details for tug**

*Type of object:* Feature Class

*Number of records:* 911

---

**Details for ucum**

*Type of object:* Feature Class

*Number of records:* 1239

---

**Details for uclc**

*Type of object:* Feature Class

*Number of records:* 1073

---

**Details for ugrn**

*Type of object:* Feature Class

*Number of records:* 1743

---

**Details for upky**

*Type of object:* Feature Class

*Number of records:* 574

---

**Details for ulev**

*Type of object:* Feature Class

*Number of records:* 711

# Appendix E. Microsoft Power Point ™ training manual used in instruction of “Use of the Kentucky GEONET Hydrology Tool” as presented on February 15, 2008 at Kentucky State University

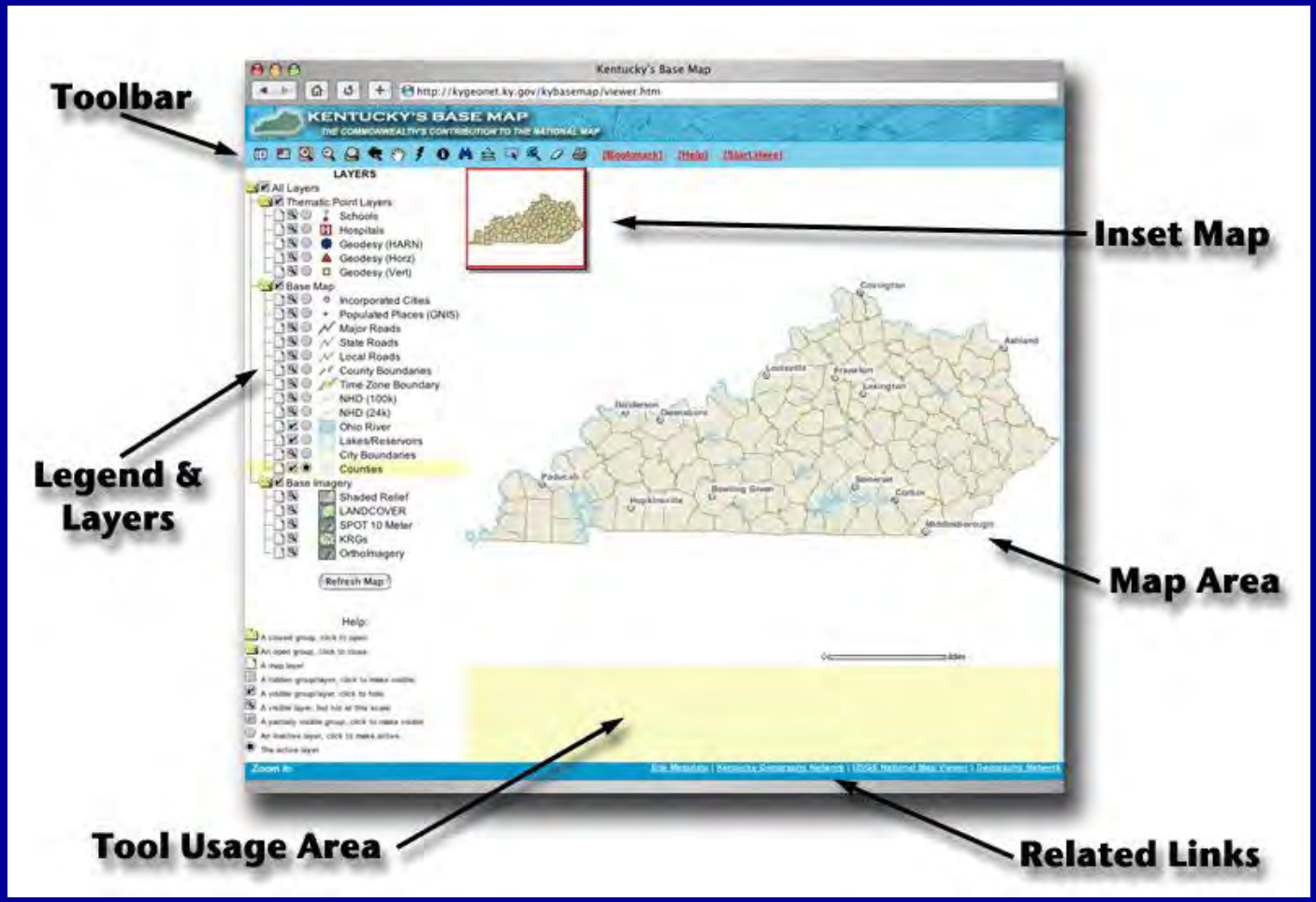
# Use of the Kentucky GEONET Hydrology Tool

Tanja N. Williamson, PhD
Hugh L. Nelson Jr.
Peter J. Cinotto

*USGS Kentucky Water Science Center*

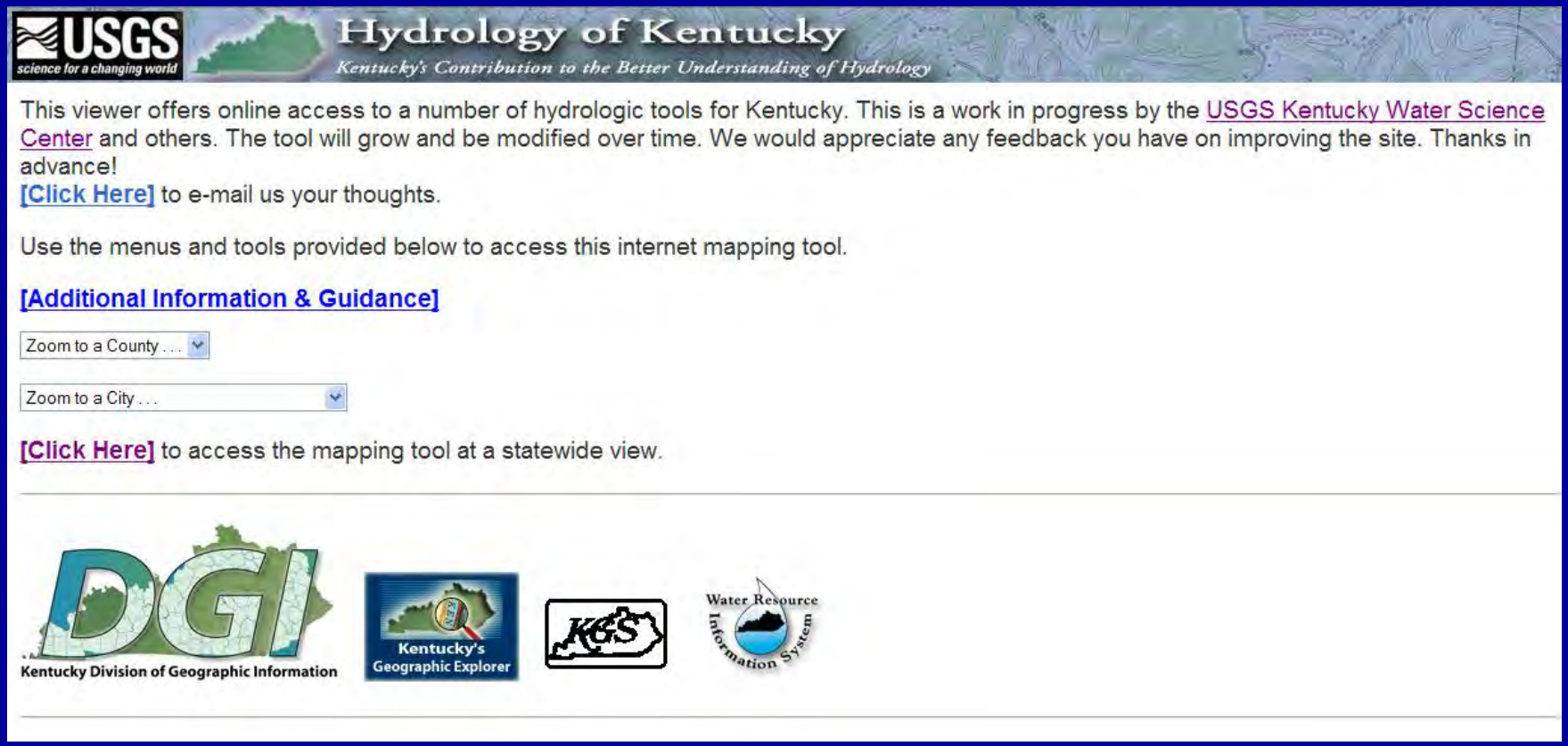

KDOW Training

# What the tool looks like



# Start page

## http://kygeonet.ky.gov/kyhydro/main.htm




# How to use the tool

**How to Use this Tool**

1. **Zoom** into the area of interest (the hydrologic data show up only under a scale of 1:48,000, see scale at bottom of map).

2. **Check** the legend on the left to make sure the data layer that you want is active. Stream Data is the default.

3. **Activate** the layer you desire by clicking on the name of that layer.

4. Left click on the **Identify** button on the toolbar (the one that is an "I" inside the black circle).

5. Left click on a **point of interest**, either within a watershed or at a stream location (you may have to click more than once to land on the stream line). The associated data will be displayed in a small table below the map. If more than one line of values appears, it is likely that you are too close to another stream and you may have to reclick or zoom in farther.

# Start page

- Low flow
- Mean annual flow
- Stream data
- Stream-reach drainage areas
- Water-quality sites
- SPARROW nitrogen and phosphorus
- Karst considerations

# Selecting location

## From the start page


- County
- City
- State

## From the tool bar

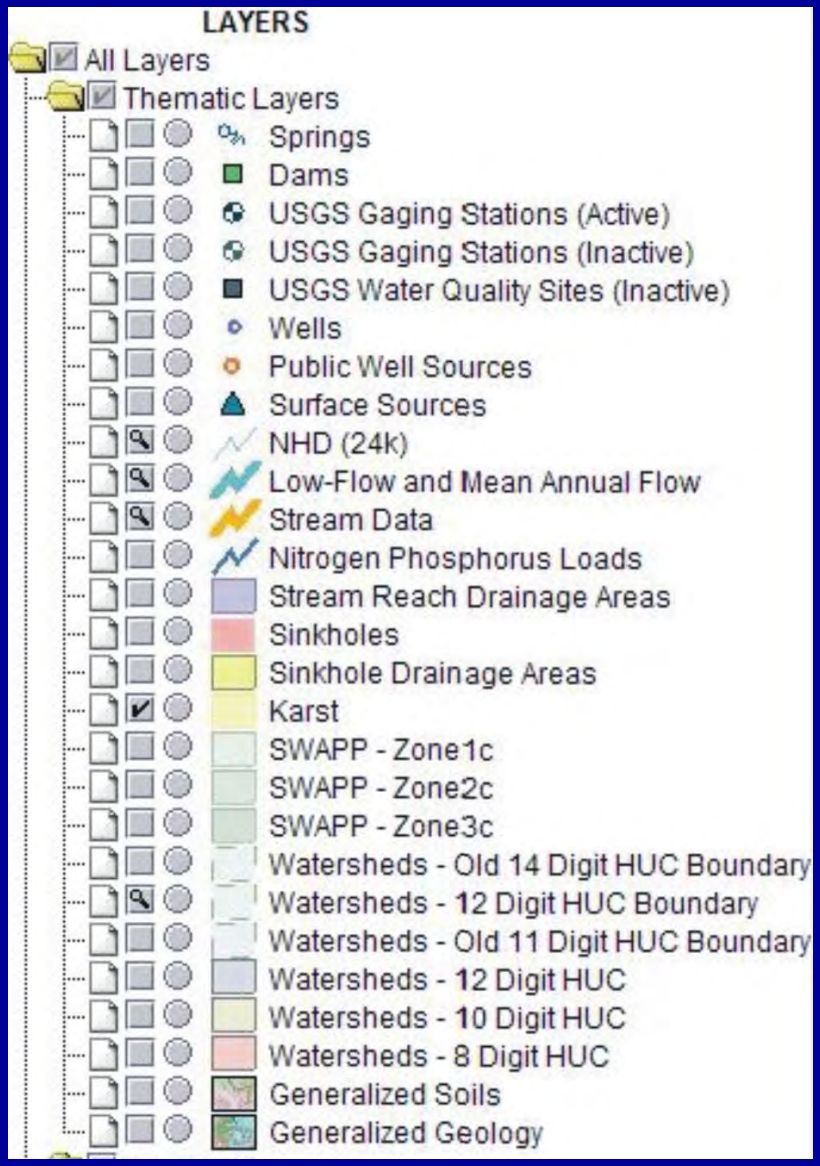
- Zoom in or out
  - Click
  - Draw rectangle
- Zoom to full extent
- Zoom to active layer
- Return to previous extent
- Pan

# Choosing scale

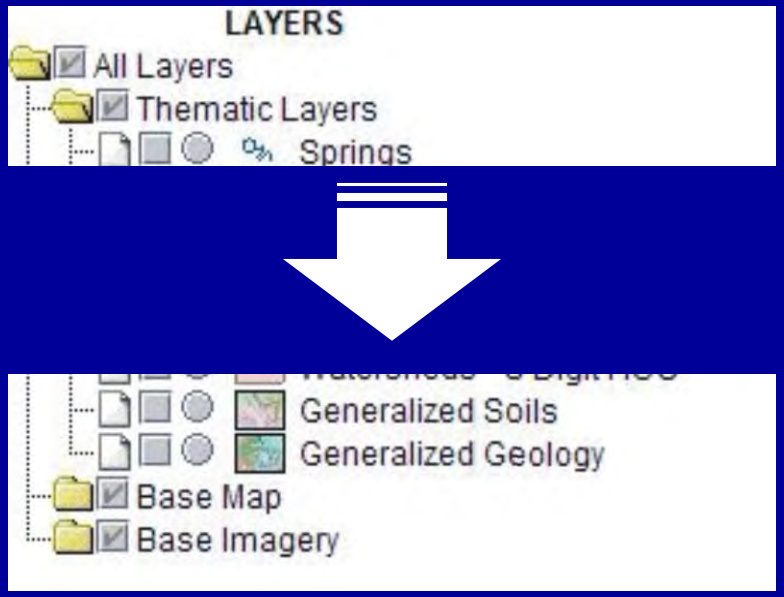

- Must enter value and click **Zoom to Scale**
- Stream layers require a scale of 1:24,000
- SPARROW layer visible at 1:500,000

# Table of Contents

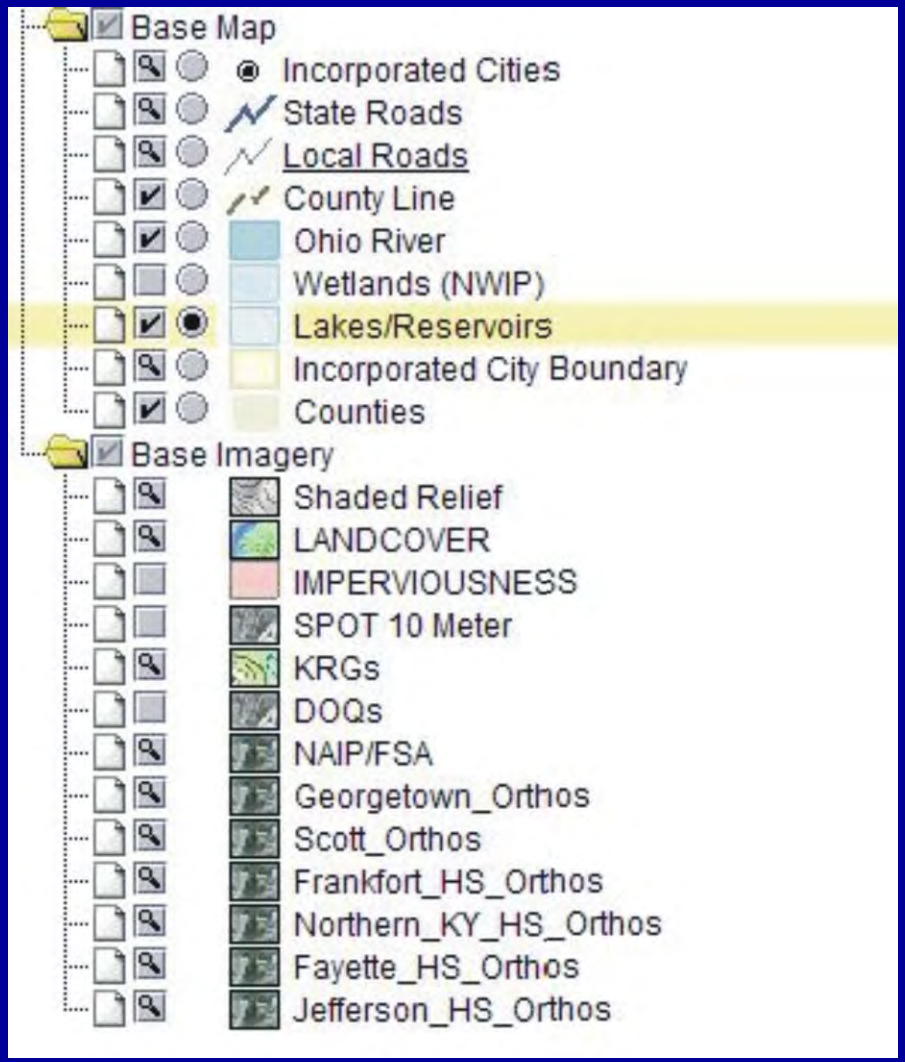
- Springs, dams, wells, public water sources
- SWAPP
- Watersheds
- Soils
- Geology



# Table of Contents

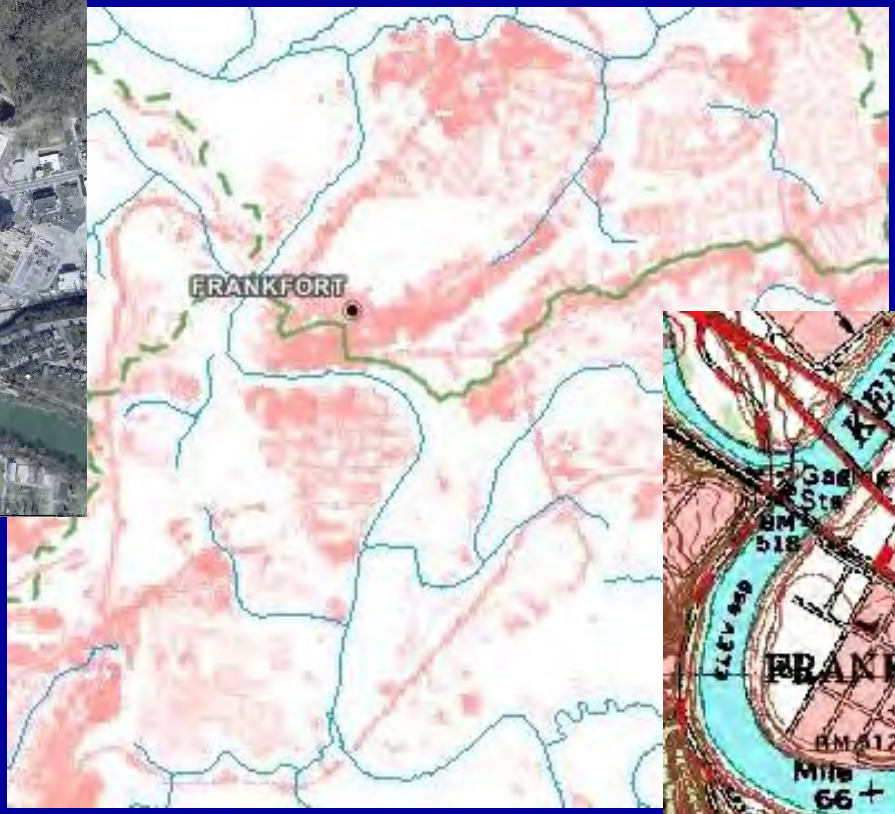



What is available depends on scale



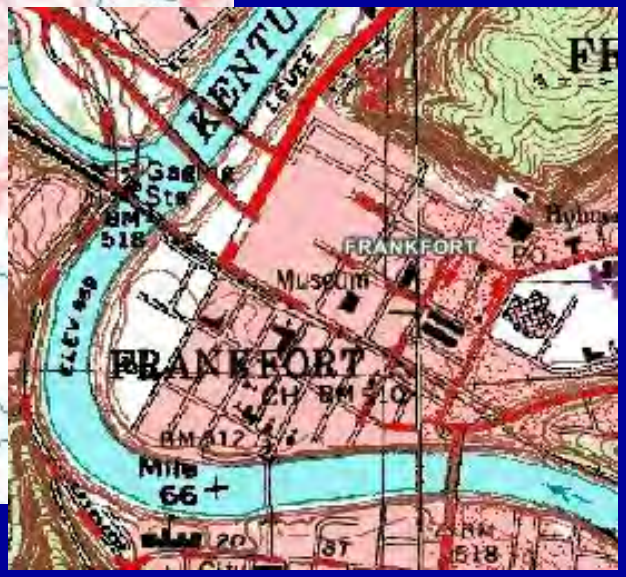
# Base Layers


Orthophoto




Imperviousness – KY 2007

Topographic




USGS science for a changing world

Hydrology of Kentucky

*Kentucky's Contribution to the Better Understanding of Hydrology*

# Base Layers


Shaded Relief

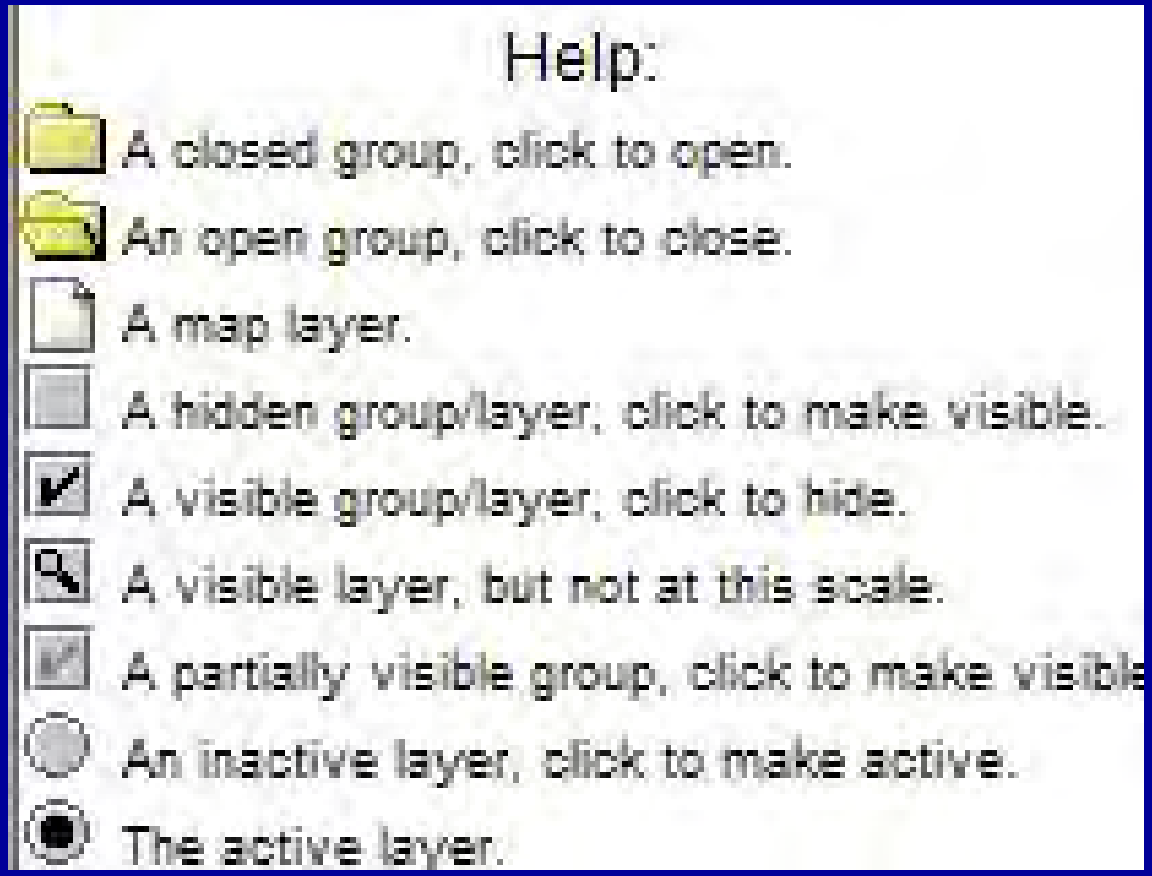

Landcover – NLCD 2001

SPOT – 10m

# Selecting a Layer

- Visible √
- Active ◉
- Identify 
- Hyperlink 

# Help


Help:
A closed group, click to open.
An open group, click to close.
A map layer.
A hidden group/layer, click to make visible.
A visible group/layer, click to hide.
A visible layer, but not at this scale.
A partially visible group, click to make visible
An inactive layer, click to make active.
The active layer.

# Other Toolbar Options


- Kentucky maps page
- Return to start page
- ArcIMS help

# Kentucky Maps Page


# ArcIMS Help

## Using the ArcIMS HTML Viewer

There are many GIS Internet Viewers active within Kentucky. They are available for many separate mapping applications and have been developed to allow the staff and the public to view maps and the associated feature attribute data. This page will assist you in understanding the different functions of the viewers by displaying a short description of each button and how to use them. Keep in mind that although the viewers are very similar, the data presented is different in each instance.

**The basic functions you will be able to perform using the viewer include:**

Zooming in to an area and displaying specific information

Database searches by a category or key word

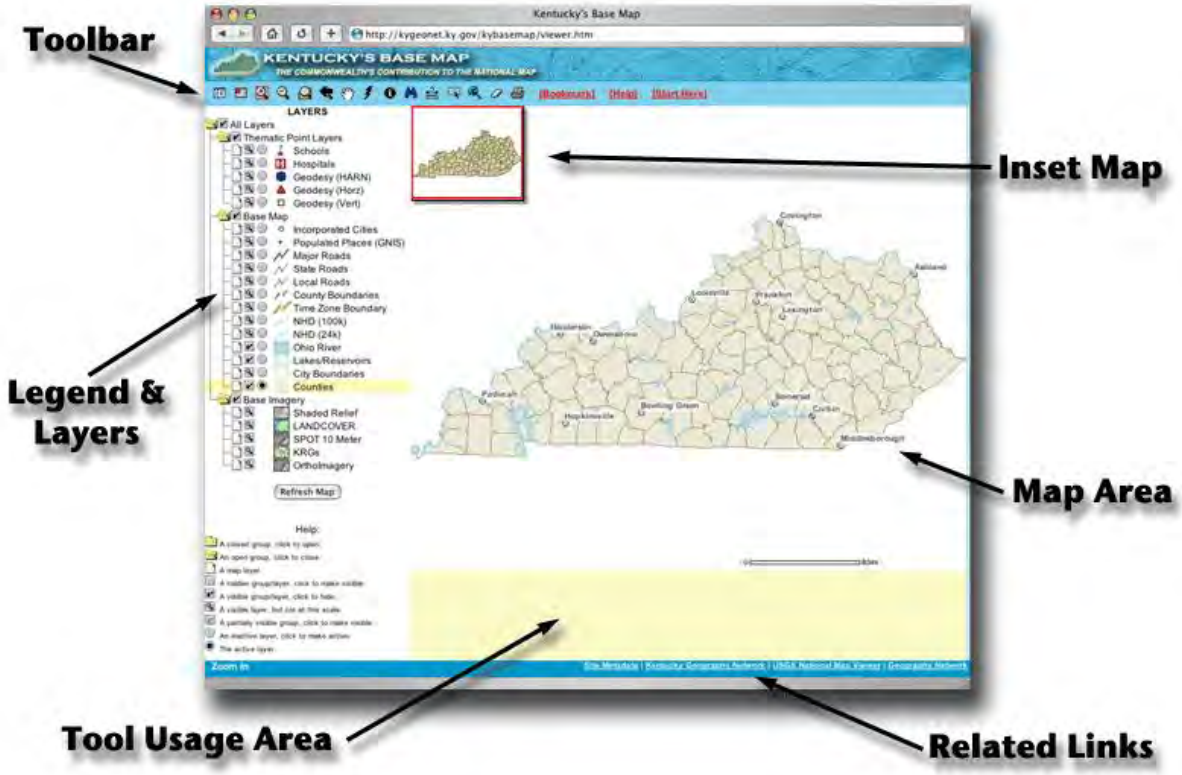
Measuring distances

Creating a buffer zone around a feature

---

To the right is an image showing the basic layout of the viewer and its main components.

Click on an area of the viewer in order to



# ArcIMS Help

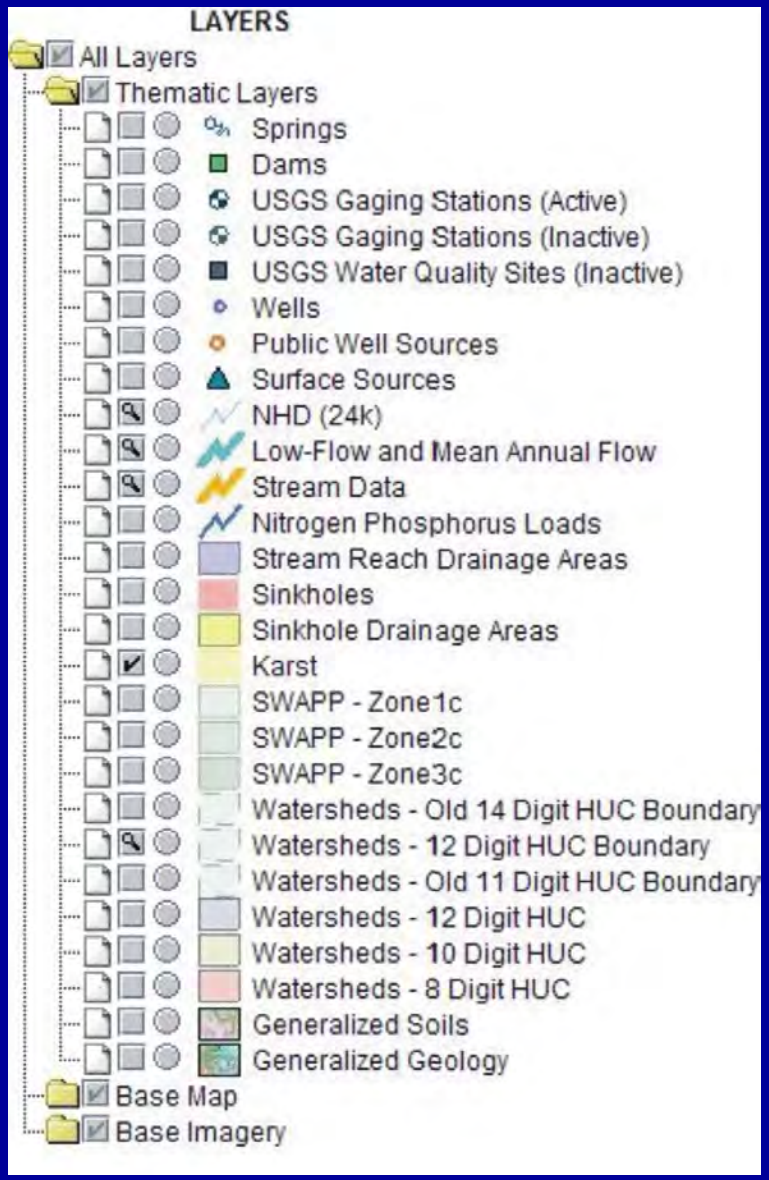

| | Tool | Description |
|---|---|---|
| | **Layer/Legend Toggle** | Allows the user to toggle between displays of the Map Legend and Map Layers in the far right frame within the viewer. The Layer view displays which layers are available at the current scale. There are 2 options you can check for each layer. By checking "Visible", the layer will be displayed inside the view. By selecting "Active", you will be able to select, query, search and identify features of this layer. Only one layer can be active at any one time. The Refresh Map button is used to show changes if you select or unselect the Visible option. The Legend view displays each layer that is visible and the graphic used to symbolize features on that layer. |
| | **Zoom In** | Allows the user to zoom in by either clicking in the view area or dragging the + cursor to create a boxed area that will determine the extent of the new view. |
| | **Zoom to Full Extent** | Allows the user to return to the original view of Kentucky with county boundaries displayed. |
| | **Return to Previous Extent** | This button takes the user back to the scale and position of the last view. |
| | **Pan Up** | This button pans or moves the map display up (north) in order to obtain a new view directly north of the current view at the same scale. |

# General question

- Gathering data for withdrawal permits
  - Drainage characteristics
  - Low flow
  - Peak flow
  - Water quality
- Explore data layers
- Become familiar with caveats

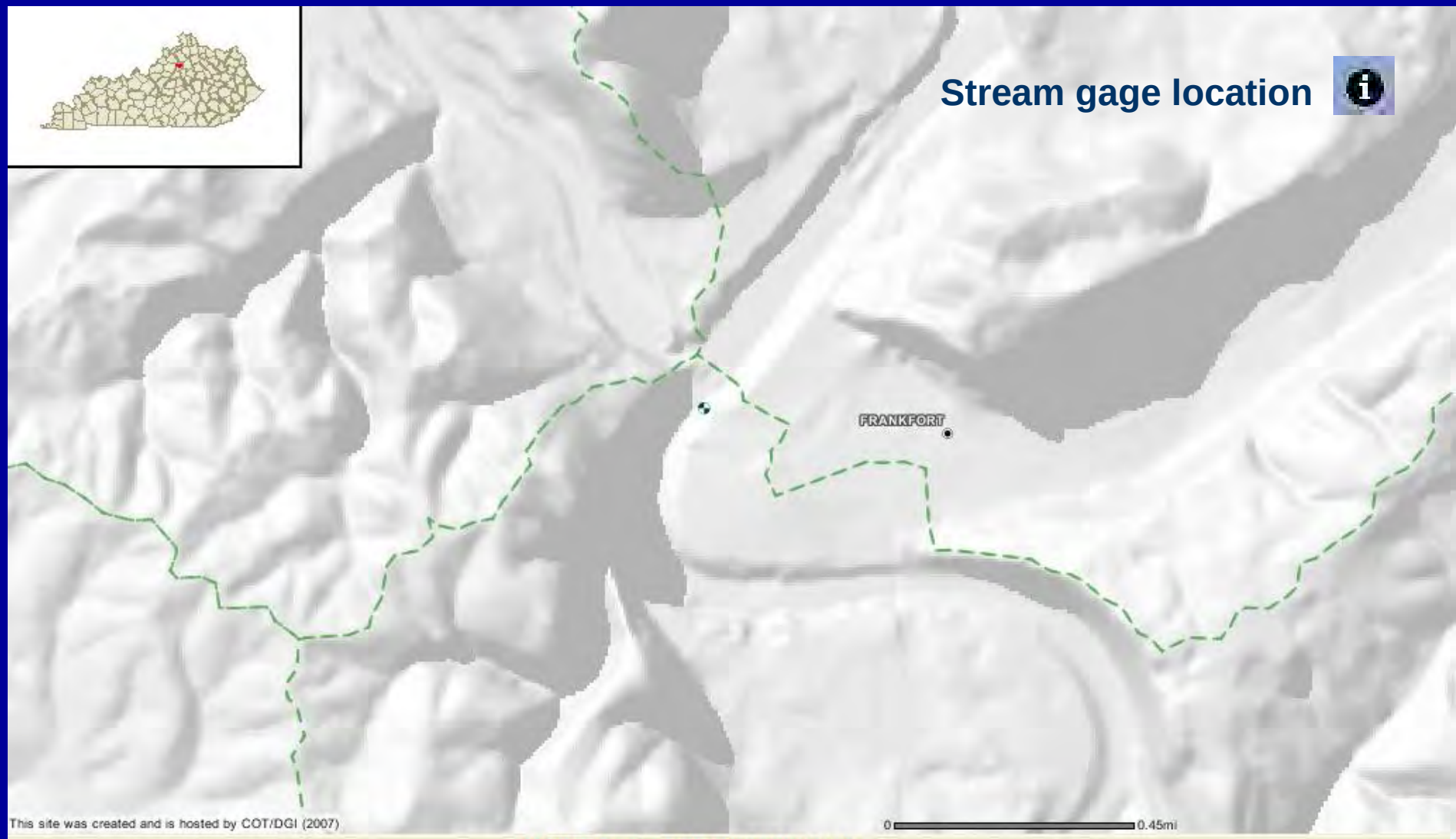
# Drainage characteristics

- Gages
- Stream data
- Drainage areas
- Mean annual flow



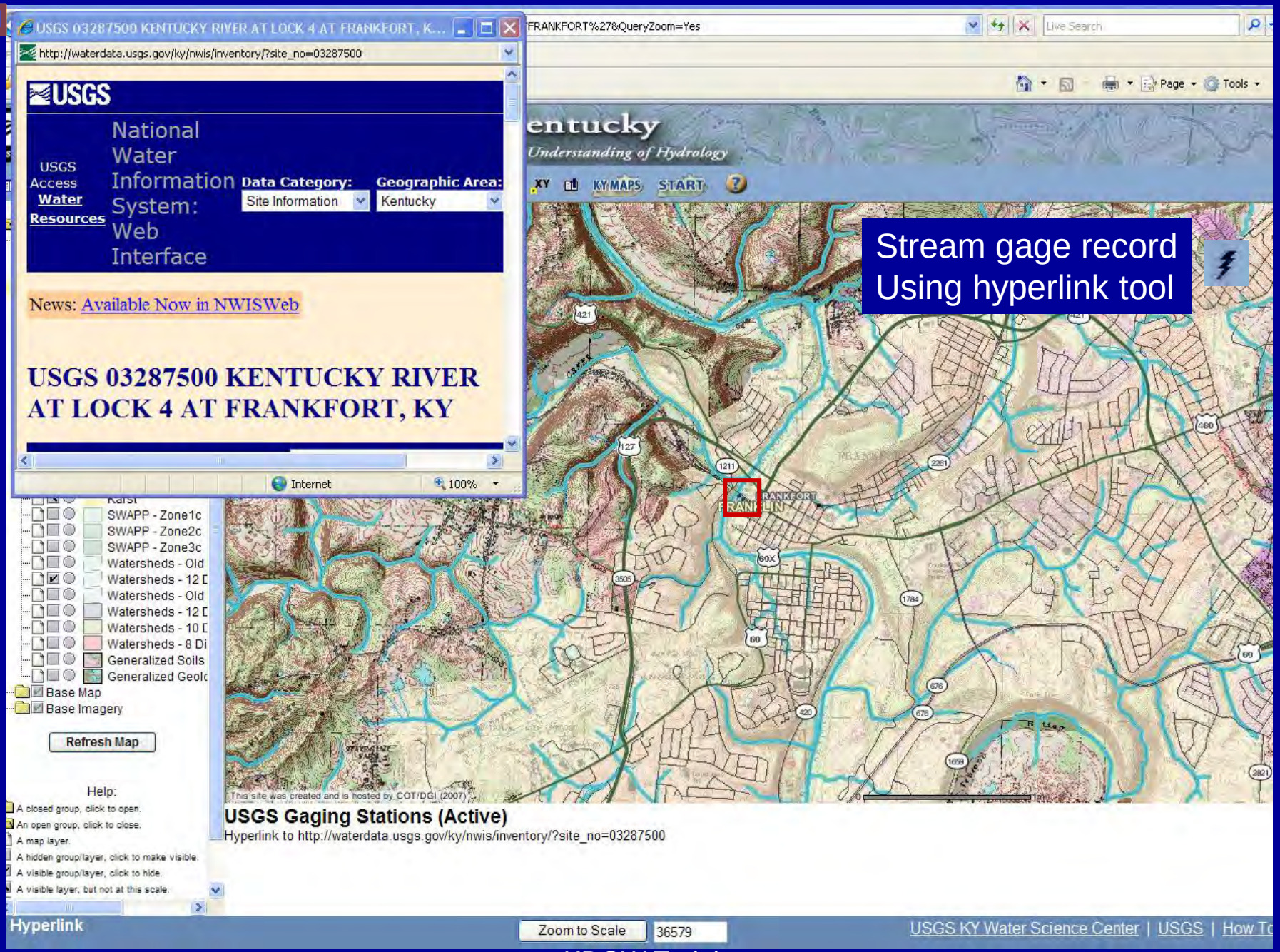
## Stream gage location






**USGS Gaging Stations (Active)**

| SITEID | NAME | DATA | TYPE | COOPERATOR | LATDD | LONGDD | LATITUDE | LONGITUDE | STATUS | LINK | SHAPE.area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 03287500 | KY R at Frankfort Lock 4 | Q/QW/P | RT | COOP/OFA | 38.20166667 | -84.88166667 | 381206 | 845254 | Active | http://waterdata.usgs.gov/ky/nwis/inventory/?site_no=03287500 | 0 |




KDOW Training

USGS

USGS Access
**Water Resources**

National Water Information System: Web Interface

Data Category: Site Information | Geographic Area: Kentucky | GO

News: Available Now in NWISWeb

# USGS 03287500 KENTUCKY RIVER AT LOCK 4 AT FRANKFORT, KY

Available data for this site | Site home page | GO

## Stream/River Site

### LOCATION

Latitude 38°12'06", Longitude 84°52'54" NAD27
Franklin County, Kentucky , Hydrologic Unit 05100205

### DESCRIPTION

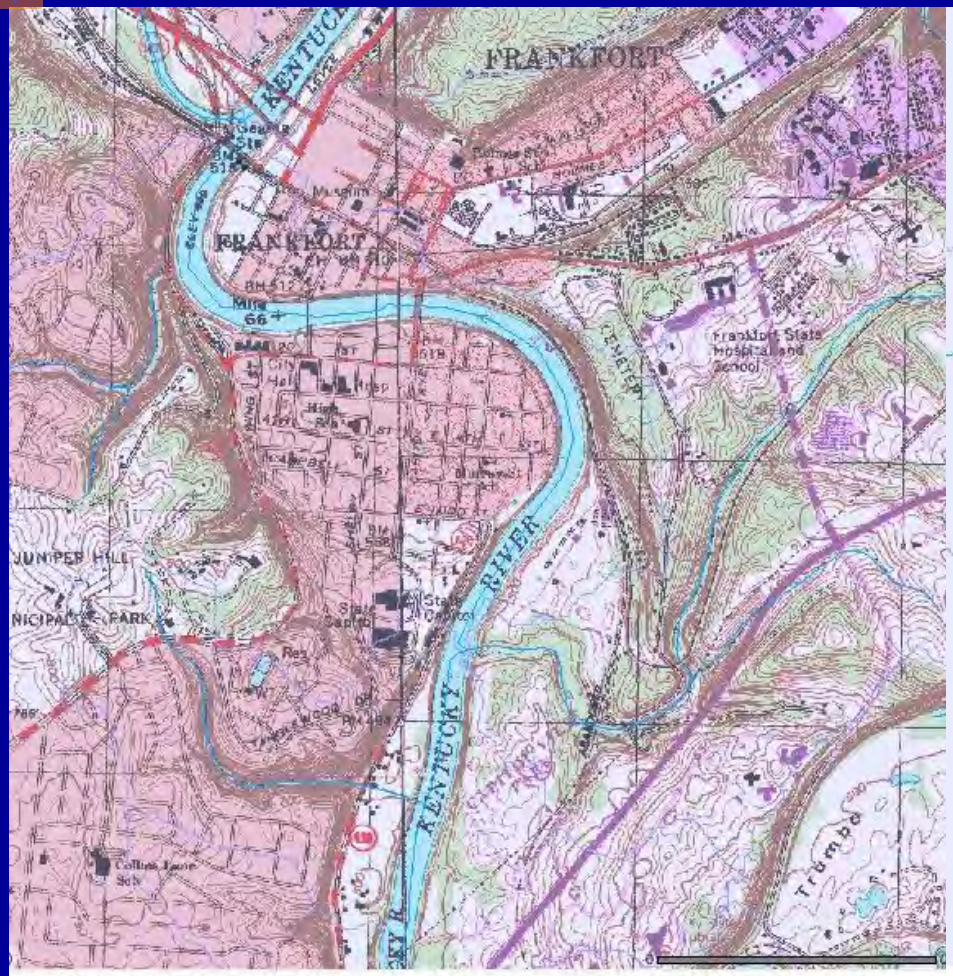
Drainage area: 5,411.0 square miles
Contributing drainage area: 5,292.00 square miles,
Datum of gage: 462.1 feet above sea level NGVD29.

### AVAILABLE DATA:

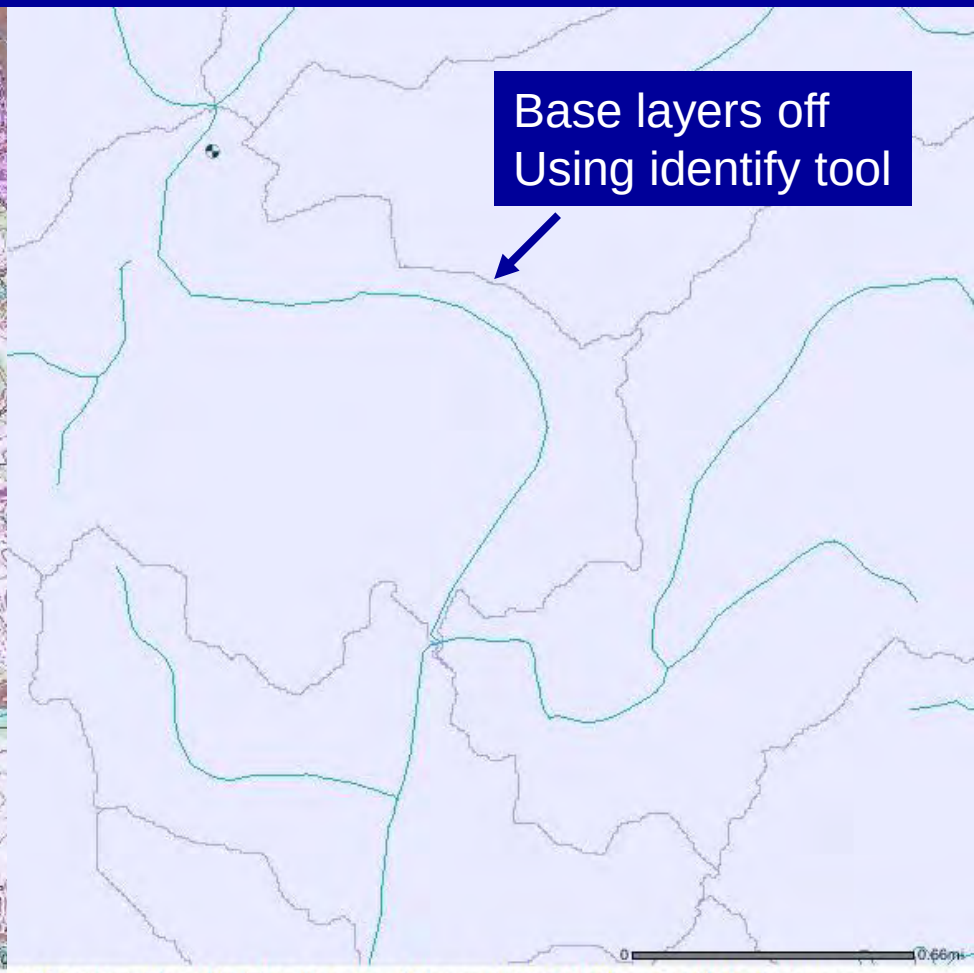
| Data Type | Begin Date | End Date | Count |
|---|---|---|---|
| Real-time | This is a real-time site | | |
| Daily Data | | | |
| Temperature, water, degrees Celsius | 2001-06-23 | 2007-10-11 | 6711 |
| Precipitation, total, inches | 2001-06-23 | 2007-10-11 | 6588 |
| Discharge, cubic feet per second | 1925-10-01 | 2007-10-11 | 29411 |
| Gage height, feet | 1989-08-04 | 2007-10-11 | 5977 |
| Specific conductance, water, unfiltered, microsiemens per centimeter at 25 degrees Celsius | 2001-06-23 | 2006-10-11 | 5535 |
| Dissolved oxygen, water, unfiltered, milligrams per liter | 2001-06-23 | 2006-10-11 | 4860 |
| pH, water, unfiltered, field, standard units | 2001-06-23 | 2006-10-11 | 5625 |
| Daily Statistics | | | |
| Temperature, water, degrees Celsius | 2001-06-23 | 2006-09-30 | 1499 |

# Drainage Area Polygons


**'Stream Reach Drainage Areas'** contains selected data for larger stream reaches (between tributaries). The data reflect two levels, (1) the mean of the local reach watershed and (2) the mean including all upstream or accumulated reaches to that point for the following watershed characteristics: watershed elevation in feet (MEANELEV & ACCMEANELEV), watershed slope in percent (MEANSLOPE & ACCMEANSLOPE), watershed slope in degrees (MEANSLOPEDEG & ACCMEANSLOPEDEG), watershed area in square feet (ACCAREA), watershed area in square miles (SQMI & ACCSQMI), impervious area in percent (PCTIMPERVIOUS & ACCPCTIMPERVIOUS), and the wetness index ( MEANWETNESSINDEX & ACCMEANWETNESSINDEX). After selecting the Identify tool, click on an stream line to get data for the drainage area at a location of interest.This tool works best at a scale between 1:40,000 and 1:100,000. Also, to see the watershed boundaries better, click off the Base Map, Base Imagery, and all Watershed buttons on the legend. Make sure that the check mark is on for this layer in the legend.




Stream Reach Drainage Areas is now the Active Layer

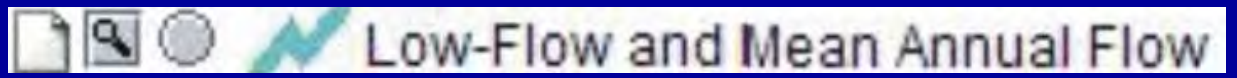



Stream Reach Drainage Areas is now the Active Layer

| Rec | MEANELEV | ACCMEANELEV | MEANSLOPE | ACCMEANSLOPE | MEANSLOPEDEG | ACCMEANSLOPEDEG | ACCAREA |
|---|---|---|---|---|---|---|---|
| 1 | 619.79699707 | 1112.4366455 | 15.33170032 | 24.09809875 | 8.71654319 | 13.54886627 | 147839564748.566 |

| PCTIMPERVIOUS | ACCPCTIMPERVIOUS | ACCMEANWETNESSINDEX | SQMI | ACCSQMI |
|---|---|---|---|---|
| 21.73550033 | 1.43491303 | 5.66584791 | 1.43236699 | 5303.01469053 |

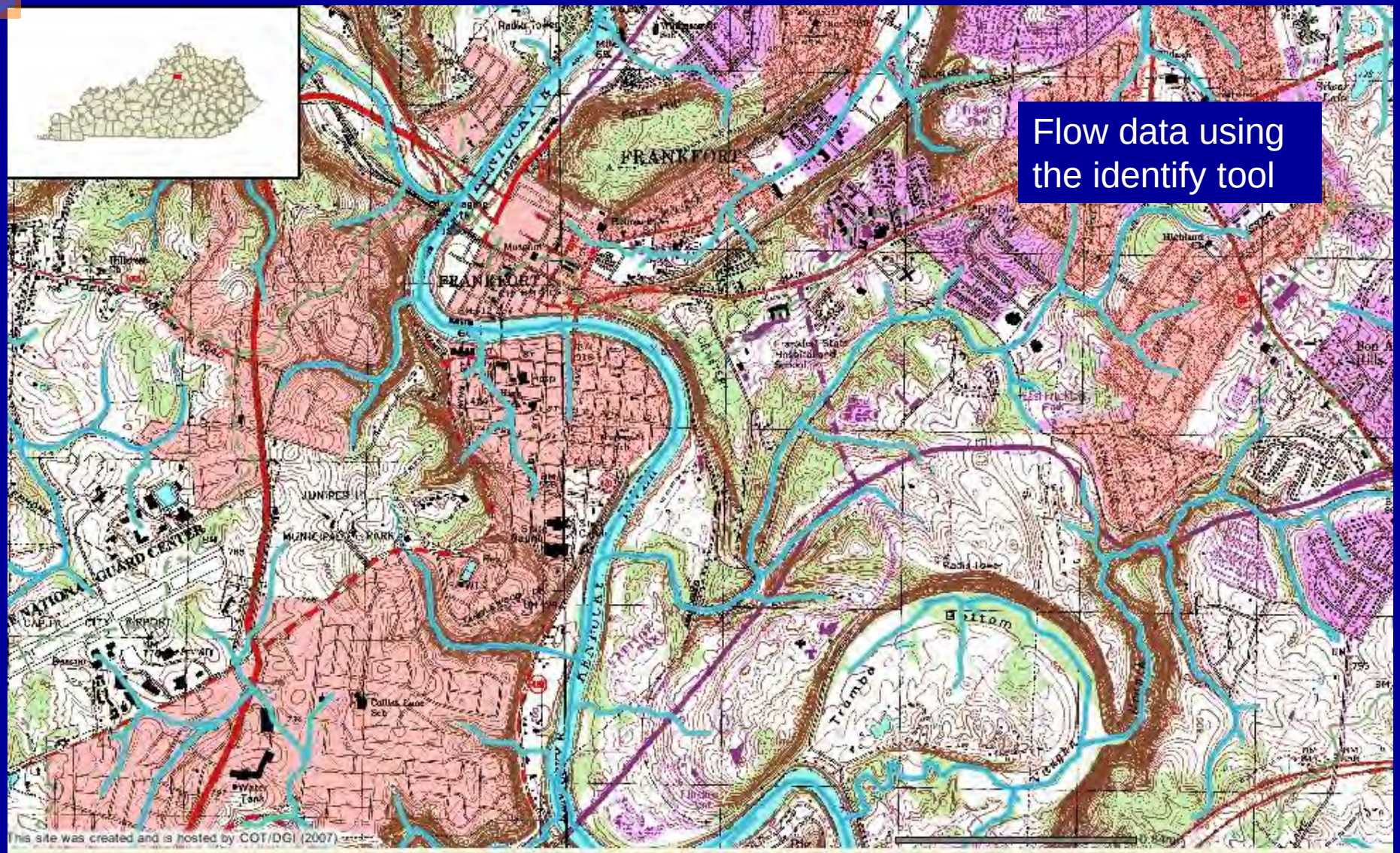
# Low and Mean Annual Flow




- Must be zoomed in at 1:24,000
- Units are cubic feet per second
- lf7Q - low flow discharge averaged over 7 days
- lf7Q2 – low flow with 50% chance of occurring in any given year
- lf7Q10 – low flow with 10% chance of occurring in any given year
- Restrictions for karst areas and drainage basin size.

# Low and Mean Annual Flow

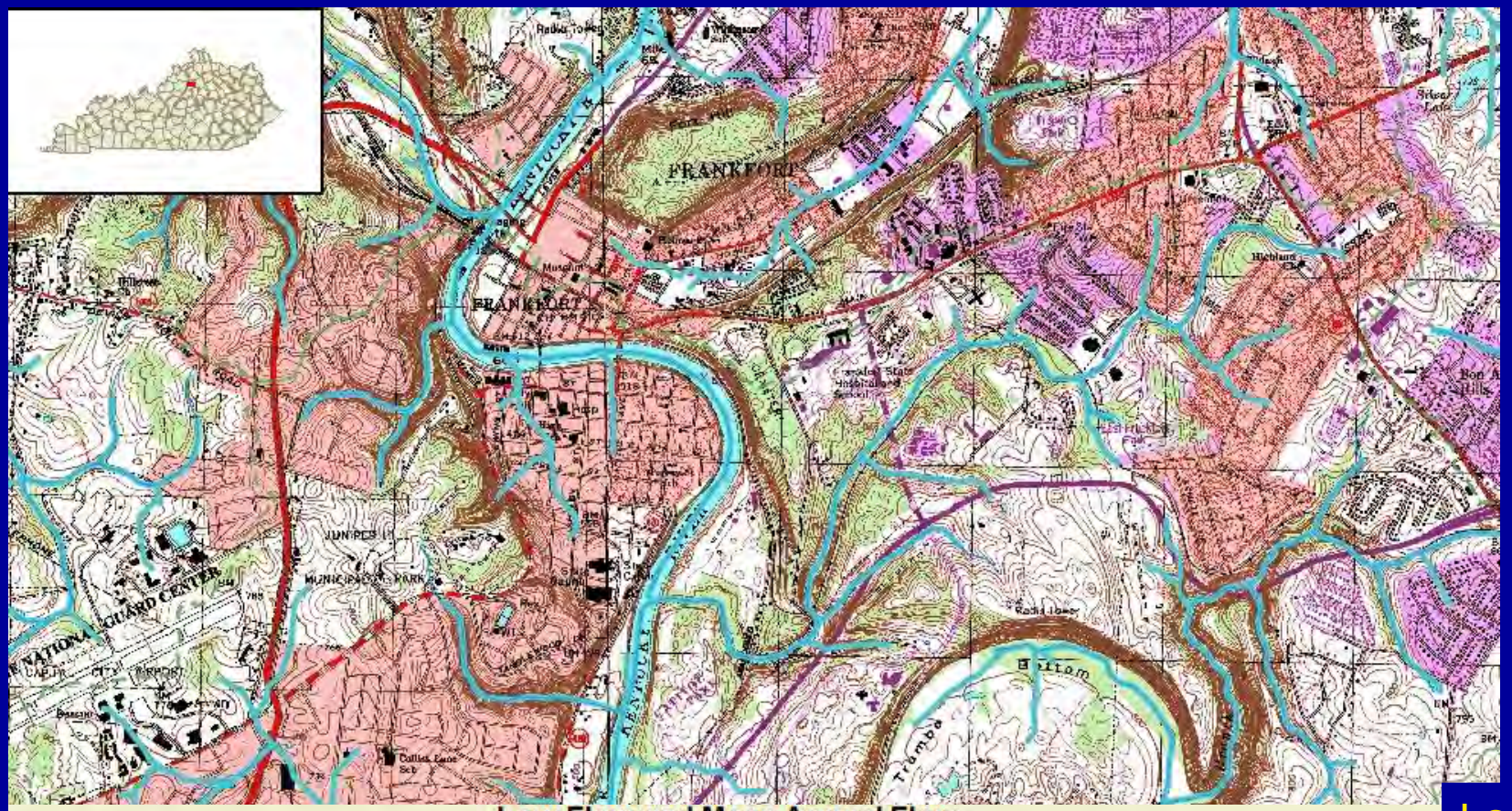
**'Low-flow and mean annual flow'** is a vector data set consisting of COLOR lines representing streams in Kentucky. We recommend viewing this layer with the 'Stream Data' layer turned off. Each line segment is attributed with the 7-day 2-year low-flow frequency values (lf7Q2), 7-day 10-year low-flow frequency values (lf7Q10), and the mean annual streamflow values (MEAN_ANNUAL_FLOW) for the downstream end of that stream segment (all in CFS). For example, the "7-day 2-year low-flow" is the flow rate, averaged over seven days, that has a 50% chance (i.e. one out of every two years) of being exceeded in any year; the 10-year value has a 10% chance of being exceeded in any year (i.e. one out of every ten years). Low-flow values were calculated using the equations in the USGS Water-Resources Investigations Report 91-4097 "Low-Flow Characteristics of Kentucky Streams" (http://pubs.usgs.gov/wri/wrir_91-4097/). Mean annual streamflow values were calculated using the equation in the USGS Water-Resources Investigations Report 02-4206 "Estimating Mean Annual Streamflow of Rural Streams in Kentucky" (http://ky.water.usgs.gov/pubs/wrir_2002_4206.pdf). Users of the data should be aware of the limitations and accuracy of the equations as explained in those reports and summarized in the metadata for the layer. Drainage area and other streamflow characteristics are available in the 'Stream Data' layer below. This tool works best at a scale less than 1:24,000. After selecting the Identify tool, click on an COLOR stream line to get data for a location of interest.




## Low-Flow and Mean Annual Flow

| Rec | ARCID | GRID_CODE | FROM_NODE | TO_NODE | Enabled | lf7Q2 | lf7Q10 | mean_annual_flow | Shape.area | Shape.len |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22511 | 59002 | 22552 | 22454 | 1 | 66.5 | 13 | 6624 | 0 | 714.85256368375 |

# Exporting Data to Excel




**Low-Flow and Mean Annual Flow**

| Rec | ARCID | GRID_CODE | FROM_NODE | TO_NODE | Enabled | lf7Q2 | lf7Q10 | mean_annual_flow | Shape.area | Shape.len |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 22804 | 41768 | 22723 | 22835 | 1 | 0 | 0 | 1.8 | 0 | 1253.0866756275 |

Save to Excel

Look for scroll bar

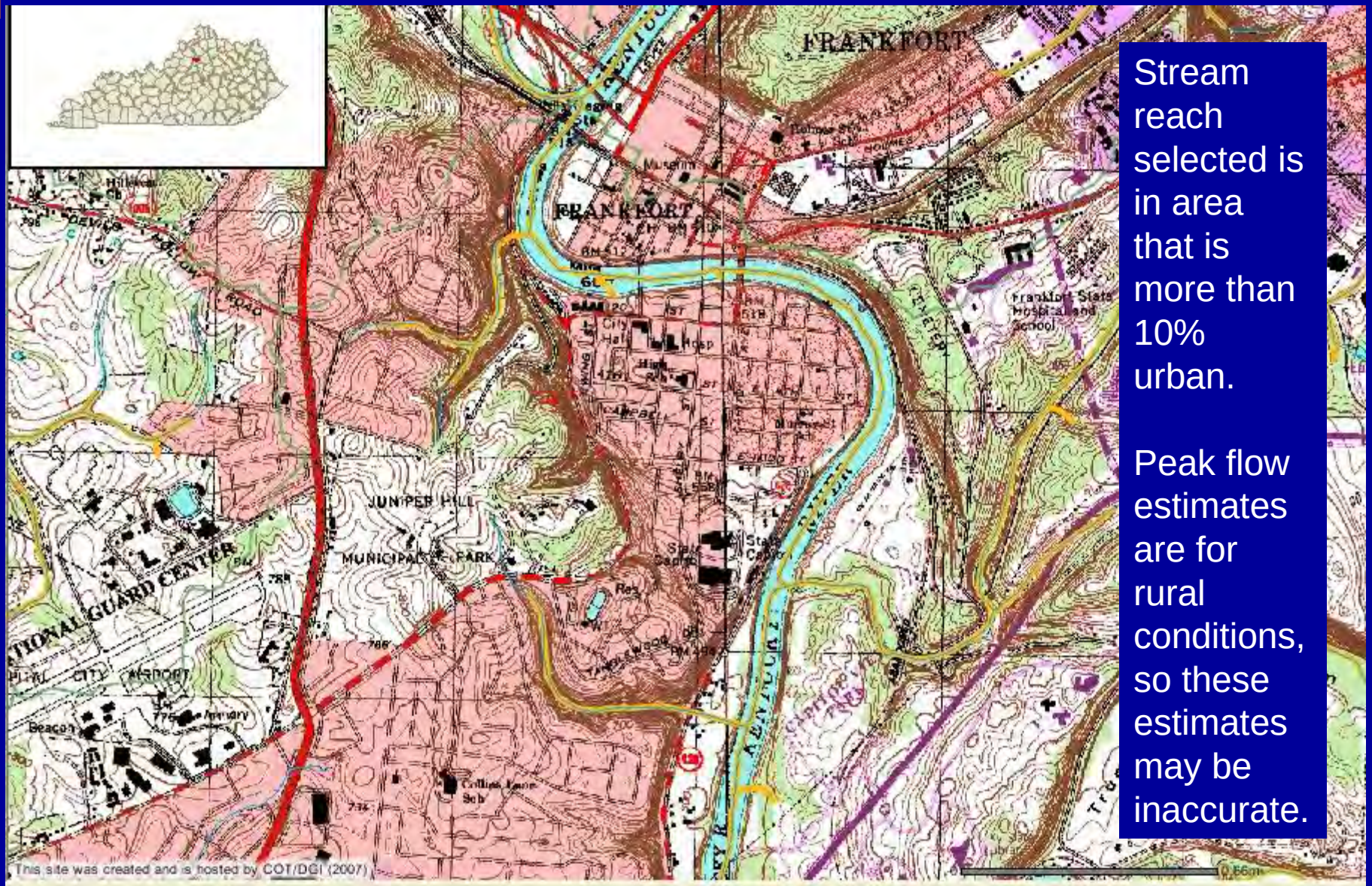
# Peak Flow


- Must be zoomed in at 1:24,000
- Drainage areas ($mi^2$)
- Peak flows (cfs)
- Approximate recurrence intervals (yr)
  - Q2 = 50%
  - Q5 = 20%
  - Q10 = 10%
  - Q25 = 4%
  - Q100 = 1%
  - Q200 = 0.5%
  - Q500 = 0.2%

# Peak Flow


**'Stream Data'** contains the following data for streams with orange lines: drainage area (in SQMI), the peak flows Q2 to Q500 (in CFS), and 3 qualifier boxes. An 'X' in the SIZERANGE box means the site is outside the drainage area range of the KY peak flow equations, an 'X' in the URBANAREA box means the site has an upstream impervious area percentage greater than 10 percent and the values given are for rural conditions, and an 'X' in the LAKES box means the site is located in a lake. This tool works best at a scale less than 1:24,000. After selecting the Identify tool, click on an orange stream line to get data for a location of interest.

- Must check restrictions
- Unregulated stream reaches
- Rural drainage basins

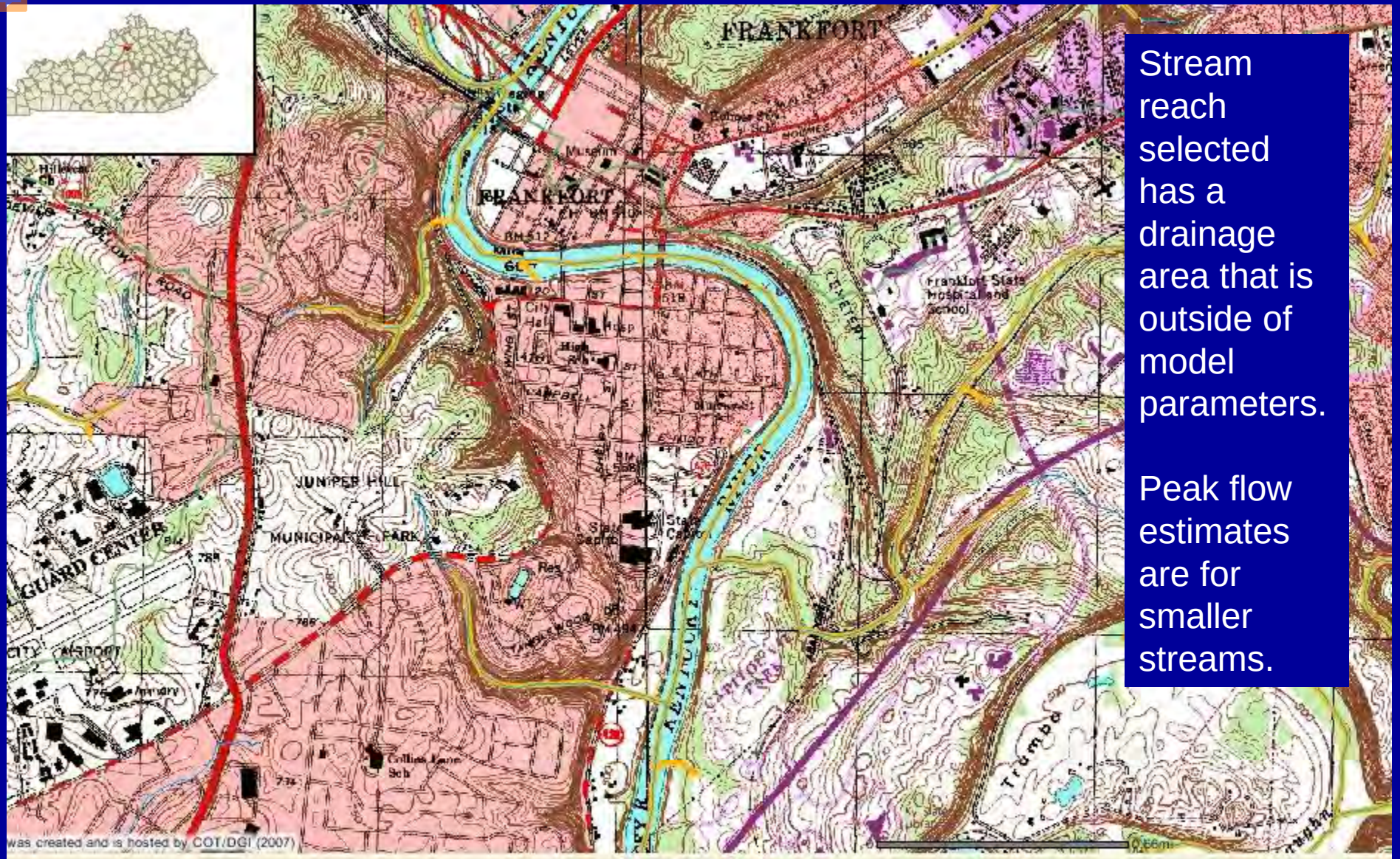



Stream reach selected is in area that is more than 10% urban.

Peak flow estimates are for rural conditions, so these estimates may be inaccurate.

**Stream Data**

| Rec | SQMI | Q2 | Q5 | Q10 | Q25 | Q50 | Q100 | Q200 | Q500 | SIZERANGE | URBANAREA | LAKES | SHAPE.area |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.32 | 280.49 | 438.44 | 554.88 | 713.71 | 839.12 | 968.85 | 1103.8 | 1288.61 | | Greater than 10 percent | | 0 |




Stream reach selected has a drainage area that is outside of model parameters.

Peak flow estimates are for smaller streams.

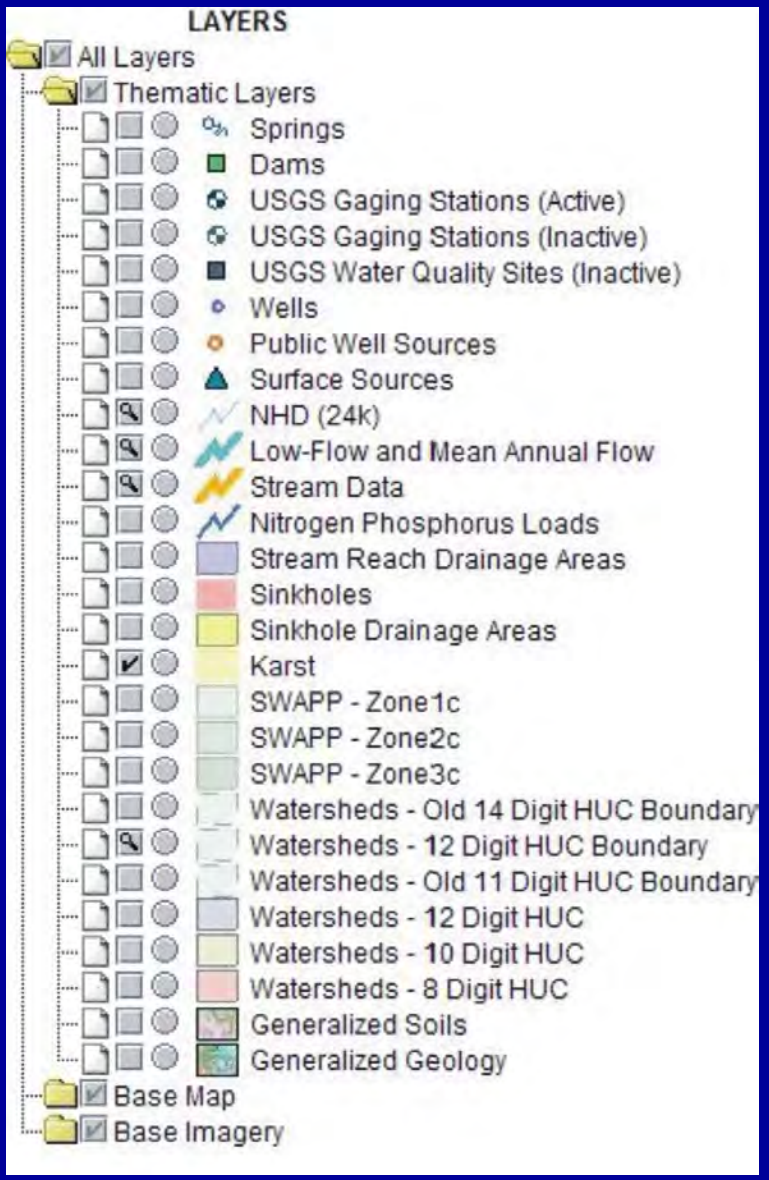
## Stream Data

| Rec | SQMI | Q2 | Q5 | Q10 | Q25 | Q50 | Q100 | Q200 | Q500 | SIZERANGE | URBANAREA | LAKES | SHAPE.area | SHAPE.len |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 5302.2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | Out of range | | | 0 | 366.195840563153 |

# Water Quality

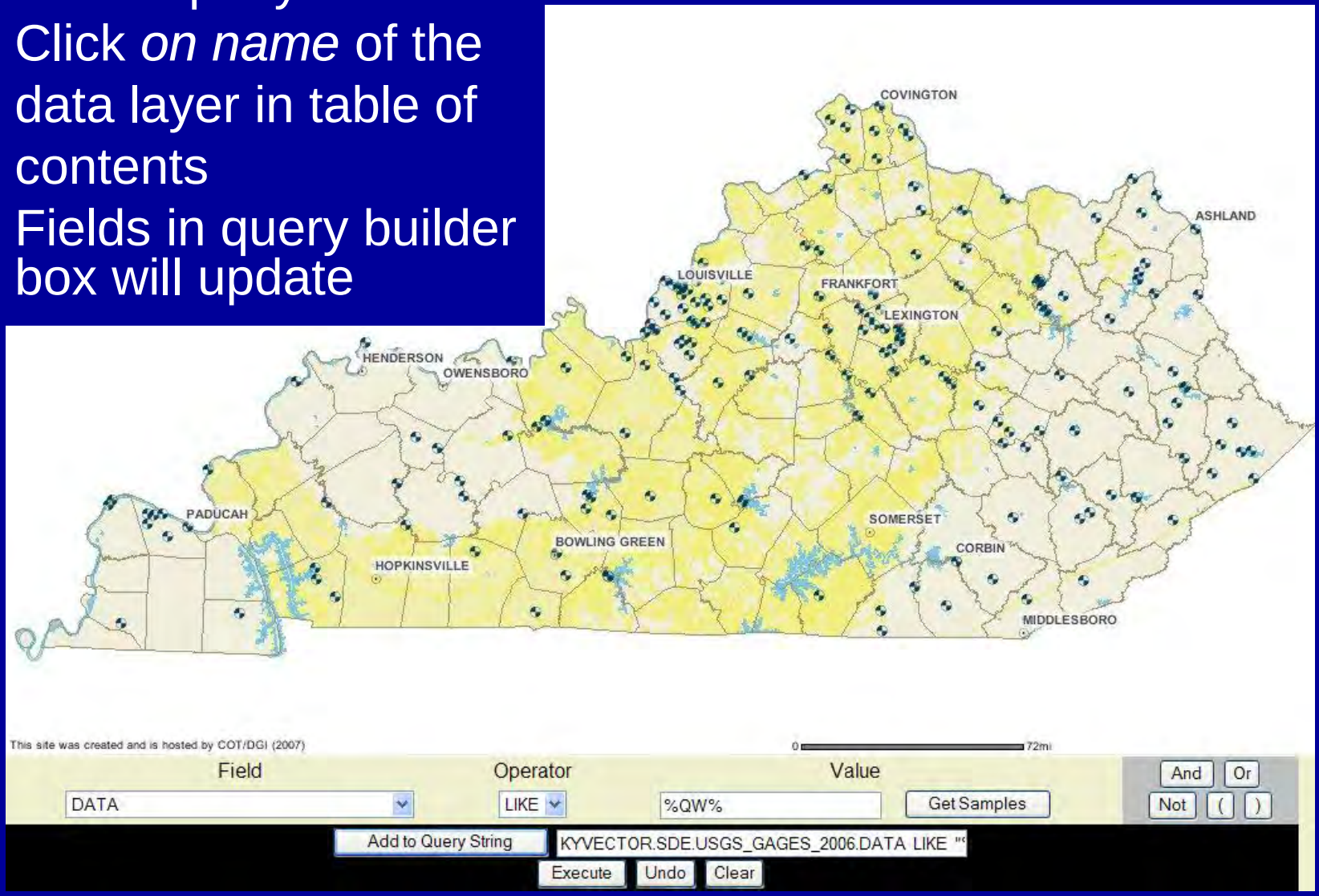
- USGS sites
  - Active
  - Inactive

- SPARROW
  Spatially Referenced
  Regression On
  Watershed attributes
  - Nitrogen
  - Phosphorus

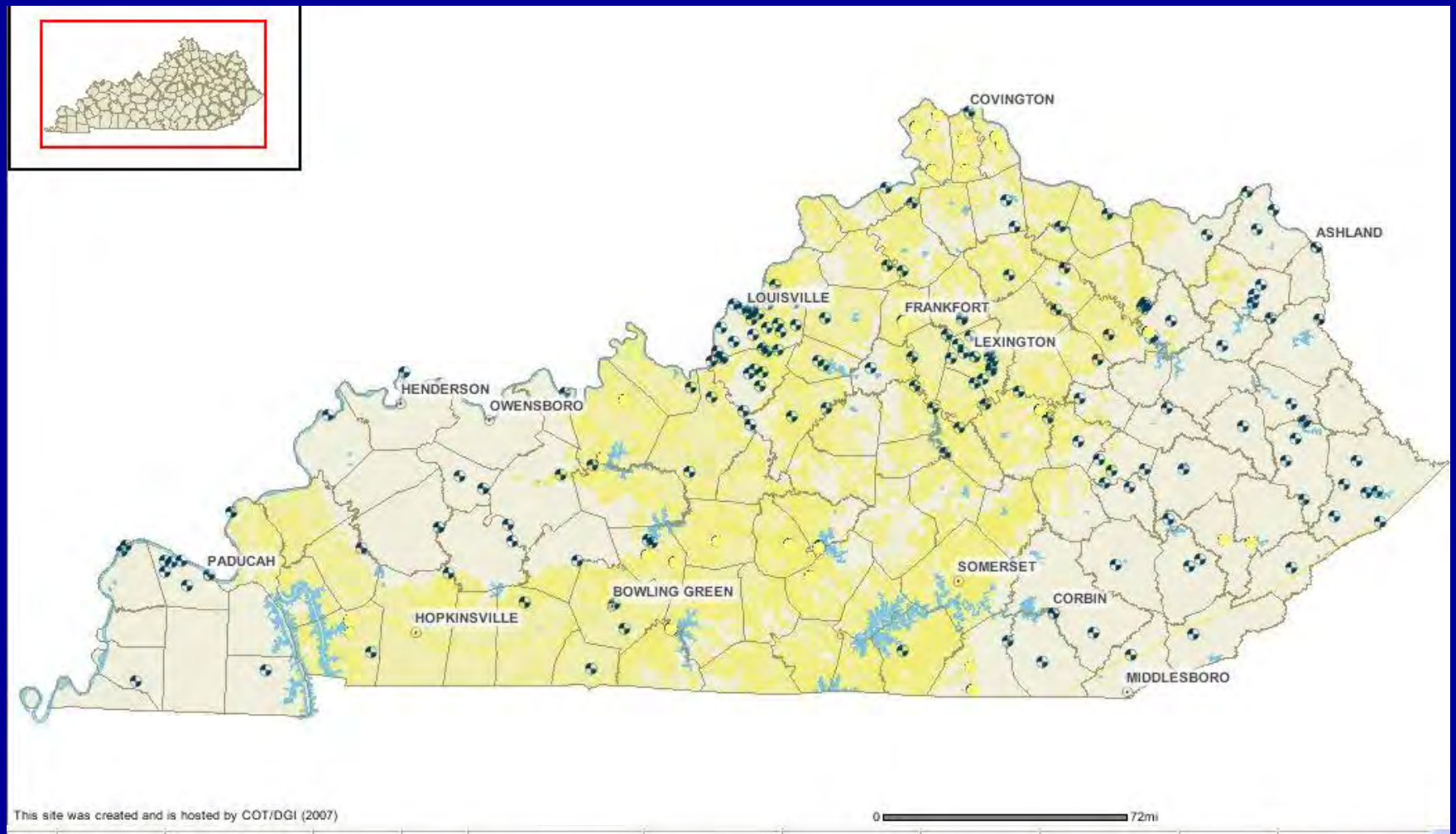


# Query for Water Quality Sites

- Select query button
- Click *on name* of the data layer in table of contents
- Fields in query builder box will update



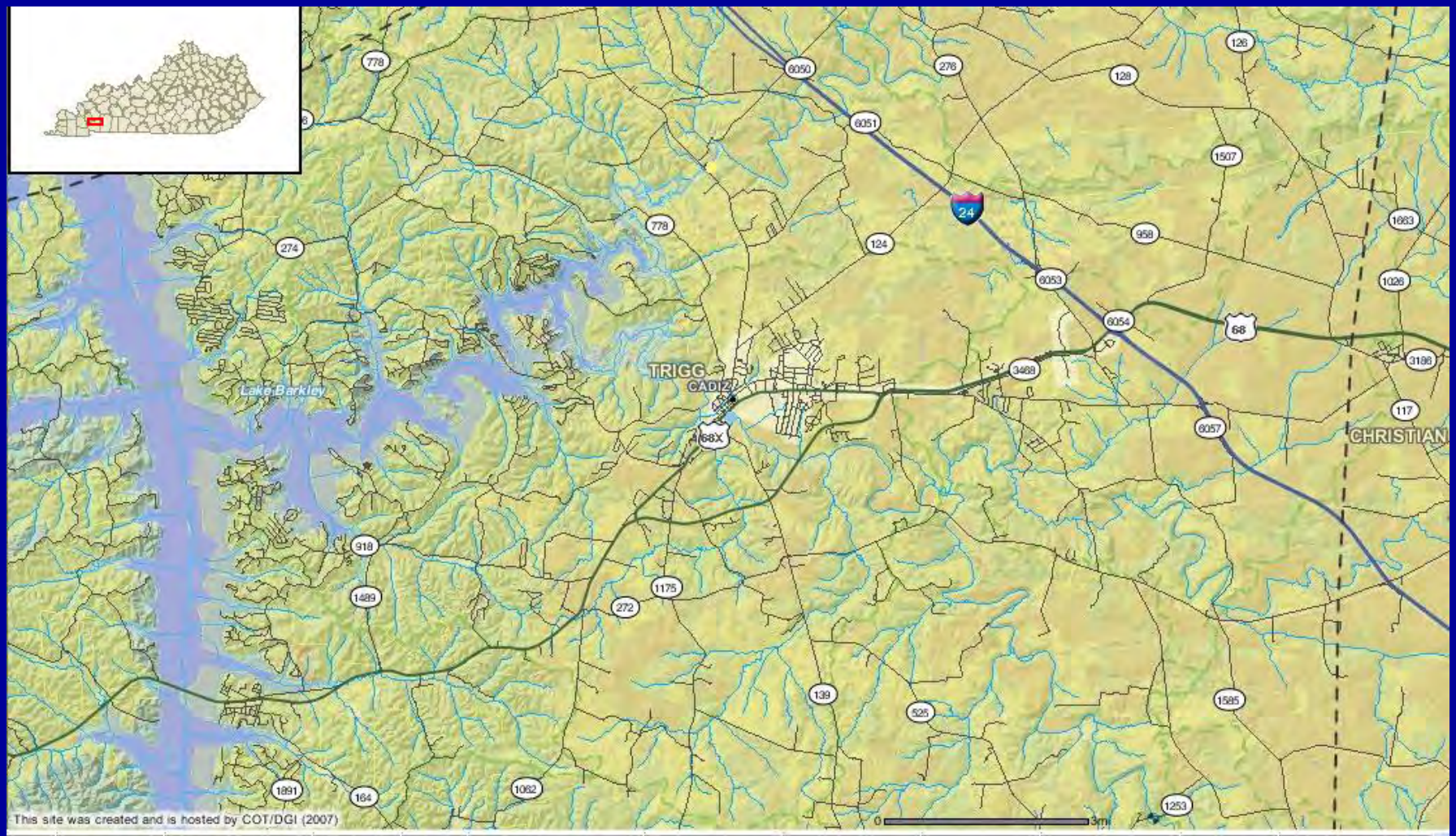
# Query Results




| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 03438090 | Cadiz Town Spring at Cadiz | Q/QW | RT | COOP | 36.86138889 | -87.83611111 | 365141 | 875010 | Active | http://waterdata site_no=03438 |

More Records **Zoom to these records**

# Zooming to Record of Interest




| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 03438090 | Cadiz Town Spring at Cadiz | Q/QW | RT | COOP | 36.86138889 | -87.83611111 | 365141 | 875010 | Active | http://waterdata site_no=03438 |

# Water Quality


## Nitrogen

Source variables
- Wastewater
- Agricultural land
- Atmospheric deposition

- Delivery variable
  - Soil permeability

## Phosphorus

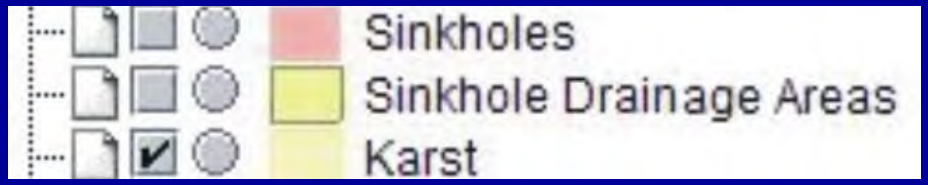
Source variables
- Wastewater
- Pasture land
- Soil phosphorus

- Delivery variable
  - Infiltration exceedence overland flow


| Rec | E2RF1 | StreamName | Station_ID | Station_Name | Drainage_Area_km2 | Avg_TN_Load_kg_per_yr | Lower_Bound_TN_kg_per_yr |
|---|---|---|---|---|---|---|---|
| 1 | 15169 | KENTUCKY R | | | 14284 | 10378259.33 | 7068350.35 |
| 2 | 15170 | BENSON CR | | | 252 | 208794.75 | 157001.29 |

| Upper_Bound_TN_kg_per_yr | Avg_TP_Load_kg_per_yr | Lower_Bound_TP_kg_per_yr | Upper_Bound_TP_kg_per_yr |
|---|---|---|---|
| 17859694.04 | 1662805.41 | 632897.13 | 8468502.19 |
| 329563 | 40079.91 | 15252.5 | 226300.82 |

# Karst




- Karst
- Sinkholes
- Sinkhole drainage areas

**Cautionary Notes**

Note that the state map on the browser shows the **areas of karst** in yellow. At this point in time, this current drainage area tool is based on surface topographic features only and is a very "approximate" estimator of drainage area in karst terrain. **Use with caution in karst areas** as there are large uncertainties in the underground basin contributions and linkage to work of KGS, KDOW, and USGS related to karst basin delineations needs to be incorporated.

Stream and drainage basin data are not valid for these areas

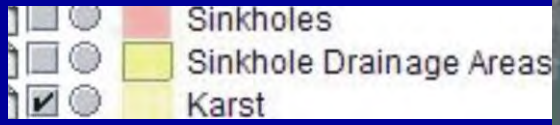
# Karst Areas of Kentucky


USGS science for a changing world

Hydrology of Kentucky

*Kentucky's Contribution to the Better Understanding of Hydrology*

# Karst Areas - Sinkholes




A GIS Sinkhole Coverage for the Karst Areas of Kentucky

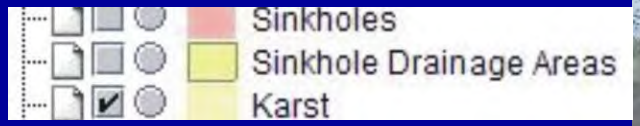
http://www.uky.edu/KGS/gis/sinkpick.htm KGS with Kentucky Speleological Society

USGS science for a changing world

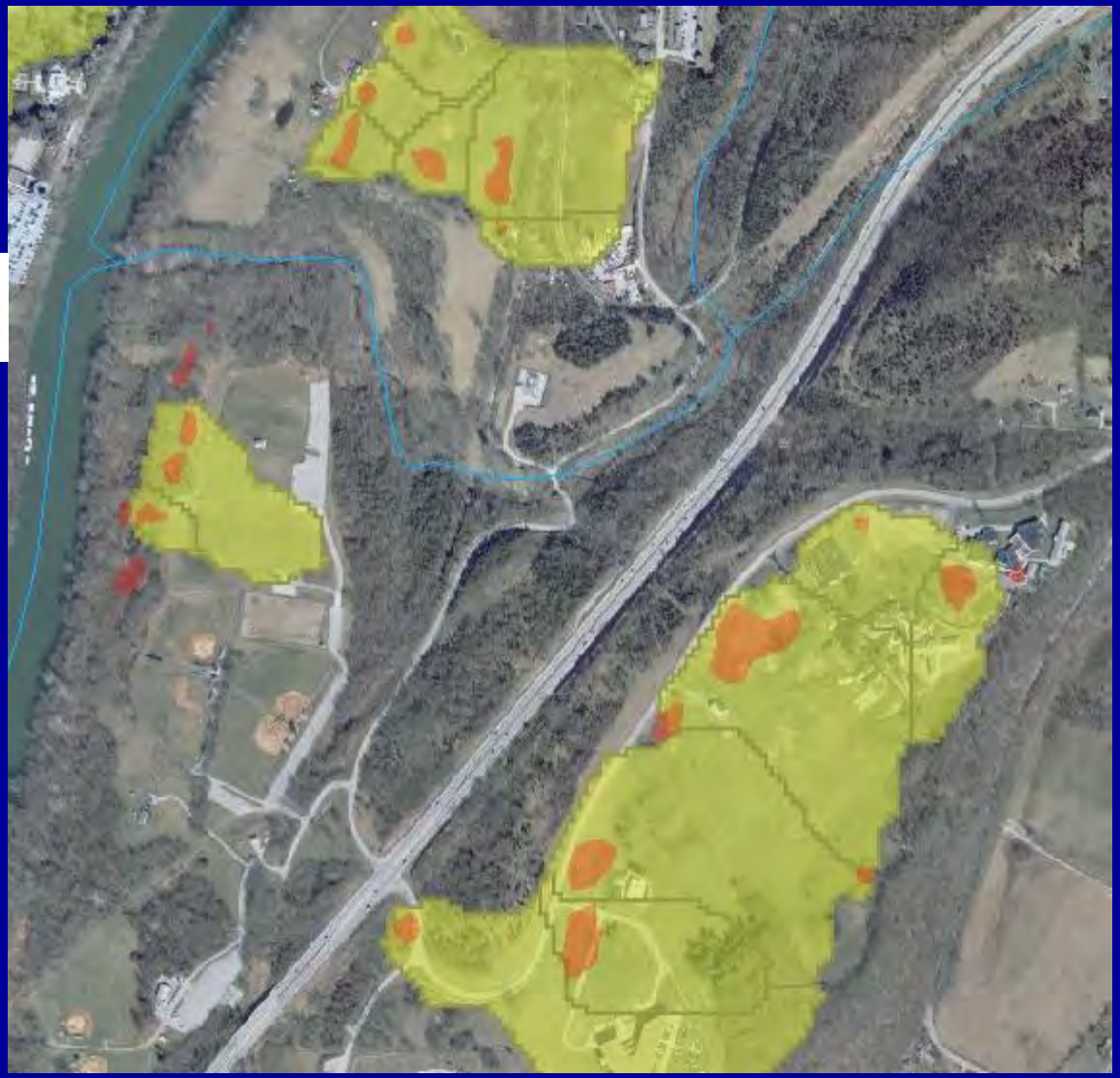
Hydrology of Kentucky

*Kentucky's Contribution to the Better Understanding of Hydrology*

# Sinkhole Drainages




Yellow areas are drained to subsurface via depressions shown in red



# Karst Areas

Non-existent stream

- Mapped based on surface topography
- DEM

No water channel on the surface

# Other Ways to Access Data Layers

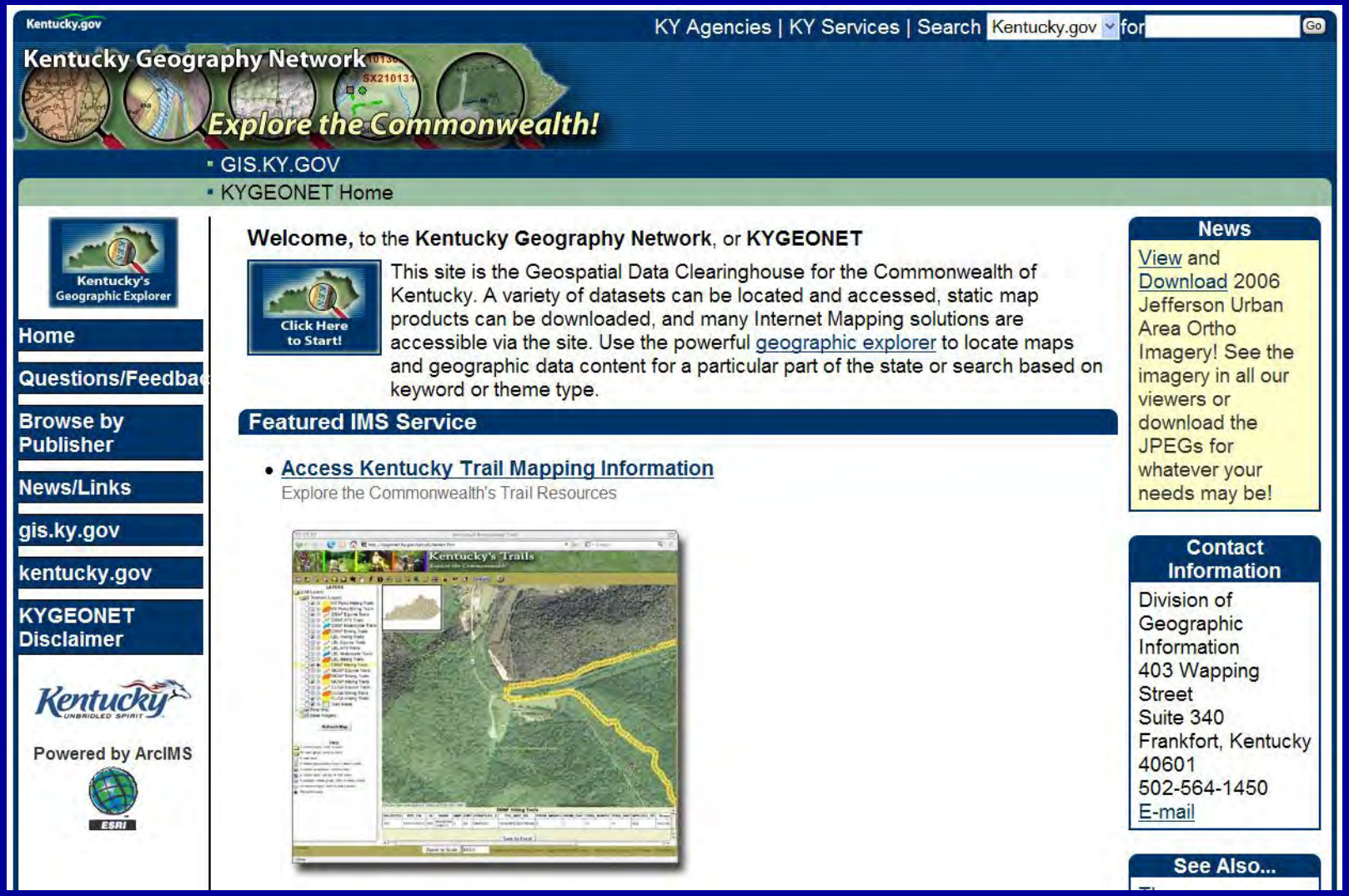
- Downloadable Data

  Kentucky Geographic Explorer

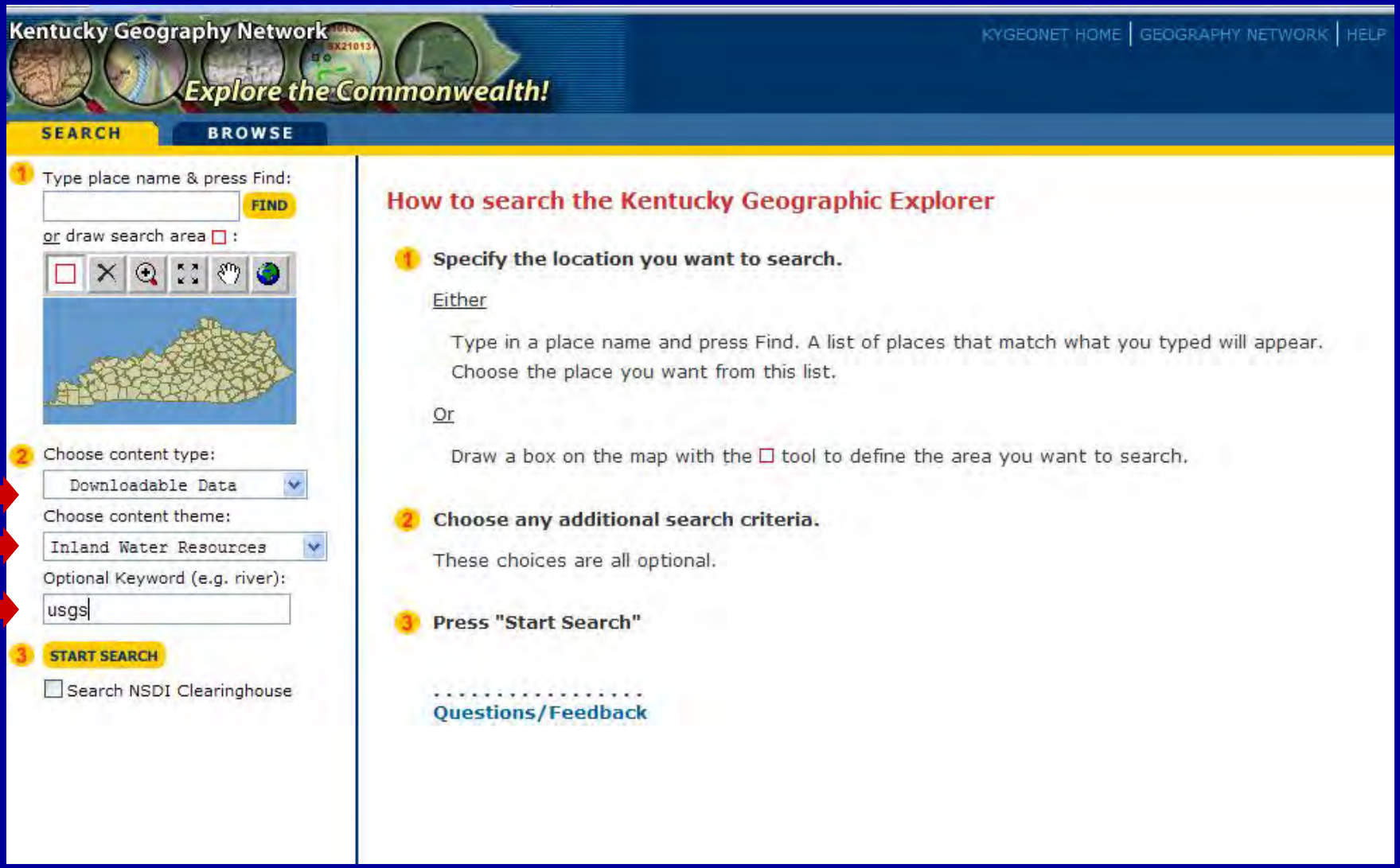
- Connecting through ArcMap

# Kentucky Geonet Home Page

## kygeonet.ky.gov



# Kentucky Geographic Explorer



# Search Results from Geographic Explorer

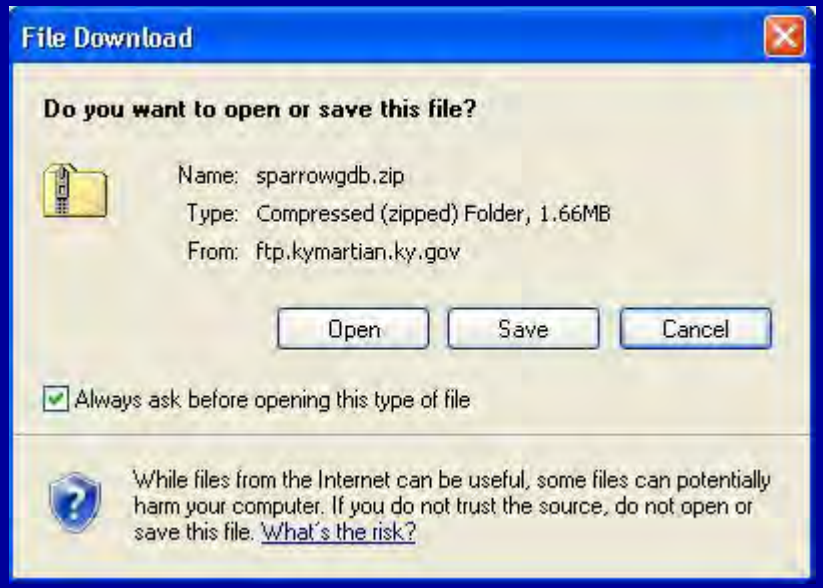
# Metadata

- Summary
- Links to
  - details
  - coverage area
  - contact
  - data

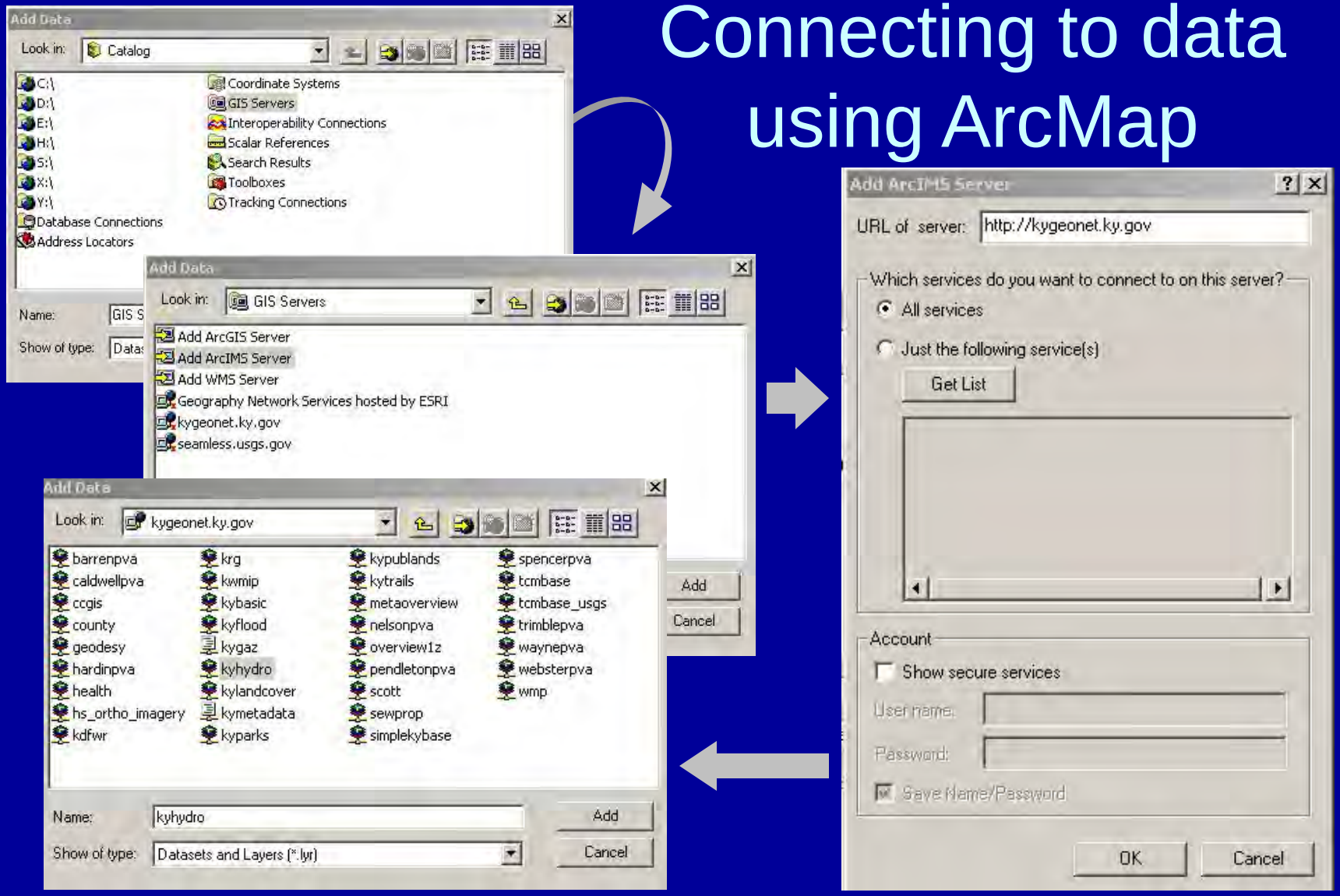
# Downloading Data

**Content Citation:**

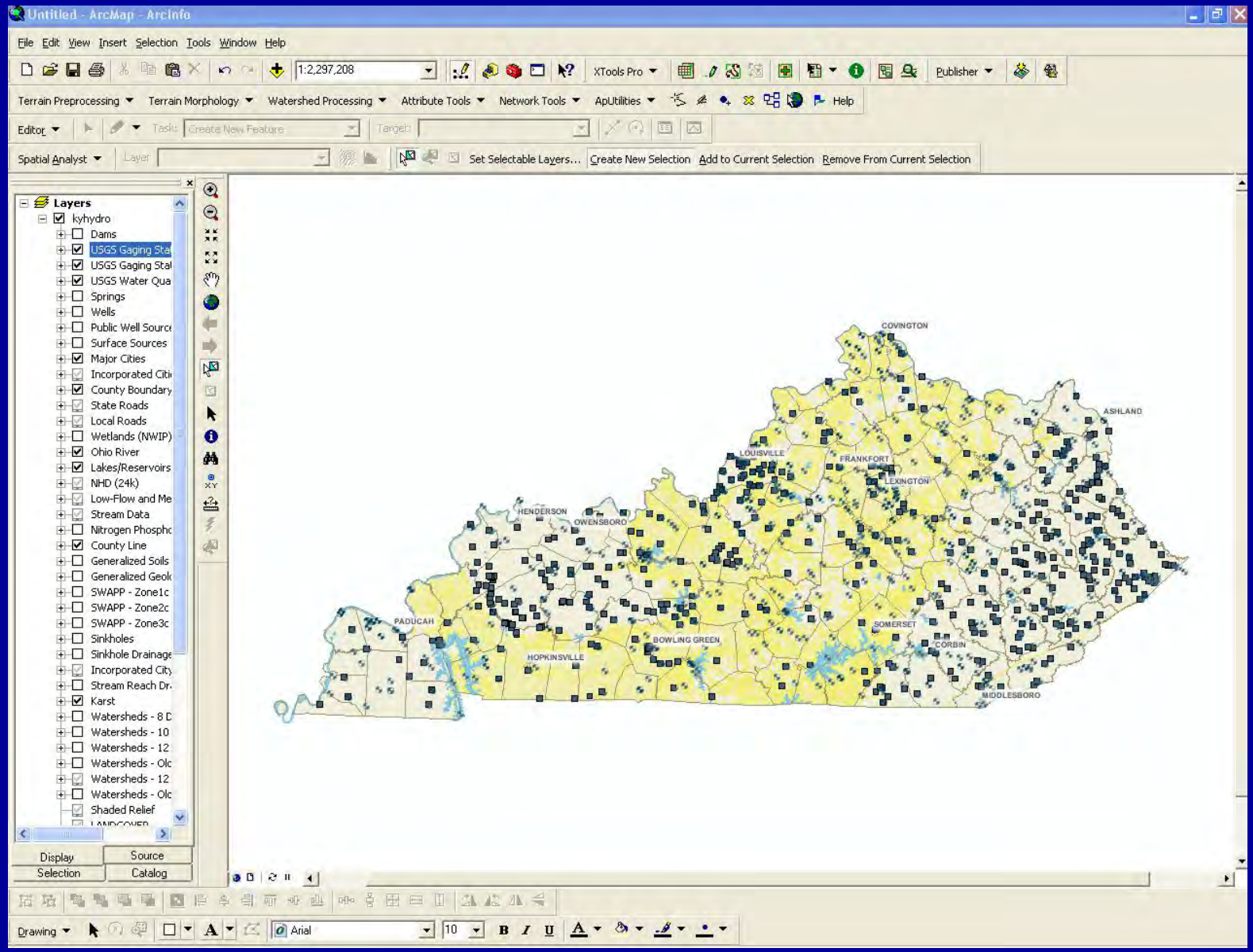
| | |
|---|---|
| **Title of Content:** | **Nitrogen and Phosphorus Loads in Kentucky Streams at 1:500,000 Scale** |
| **Type of Content:** | Downloadable Data |
| **Content Publisher:** | U. S. Geological Survey |



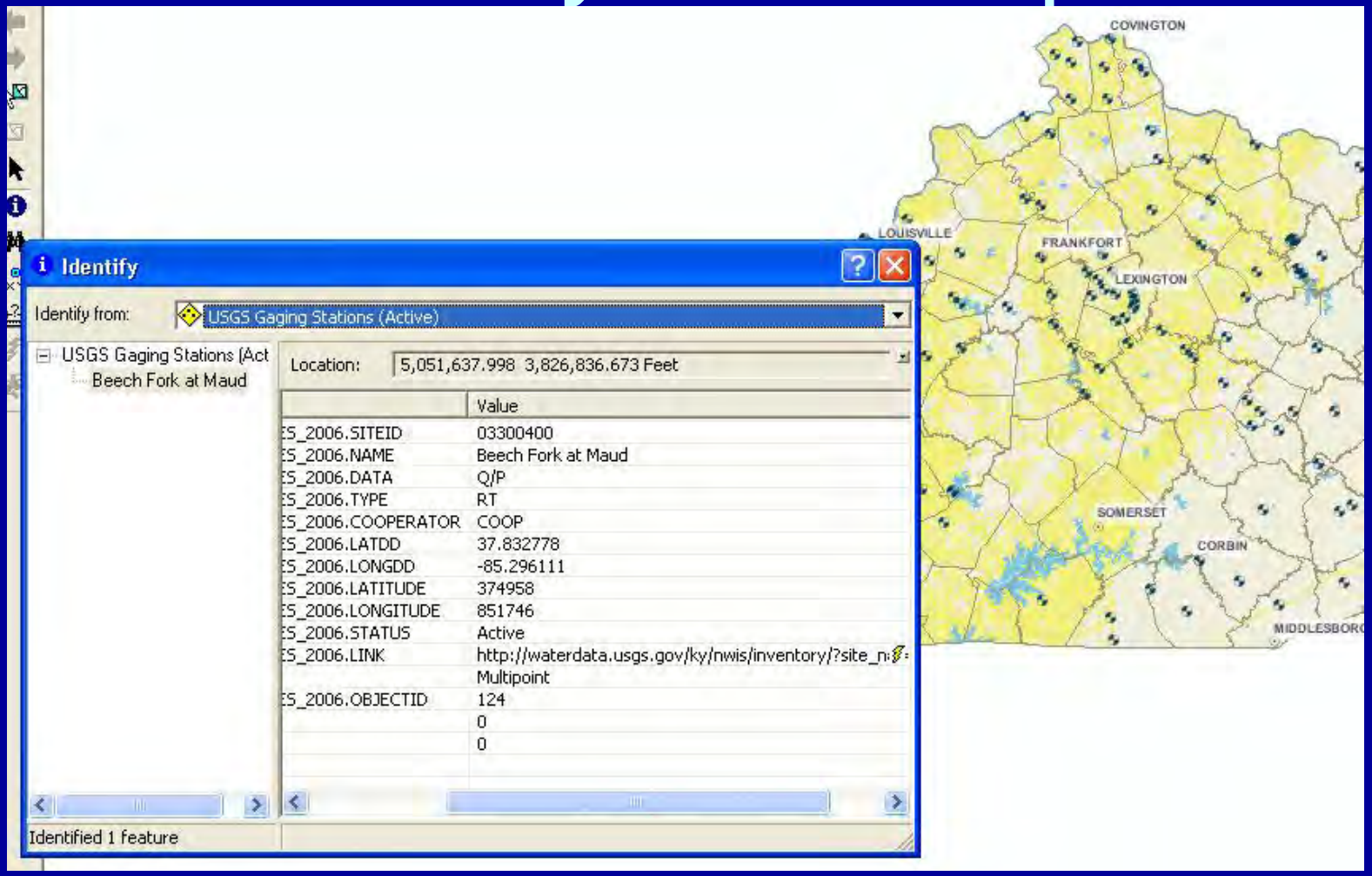
# Connecting to data using ArcMap



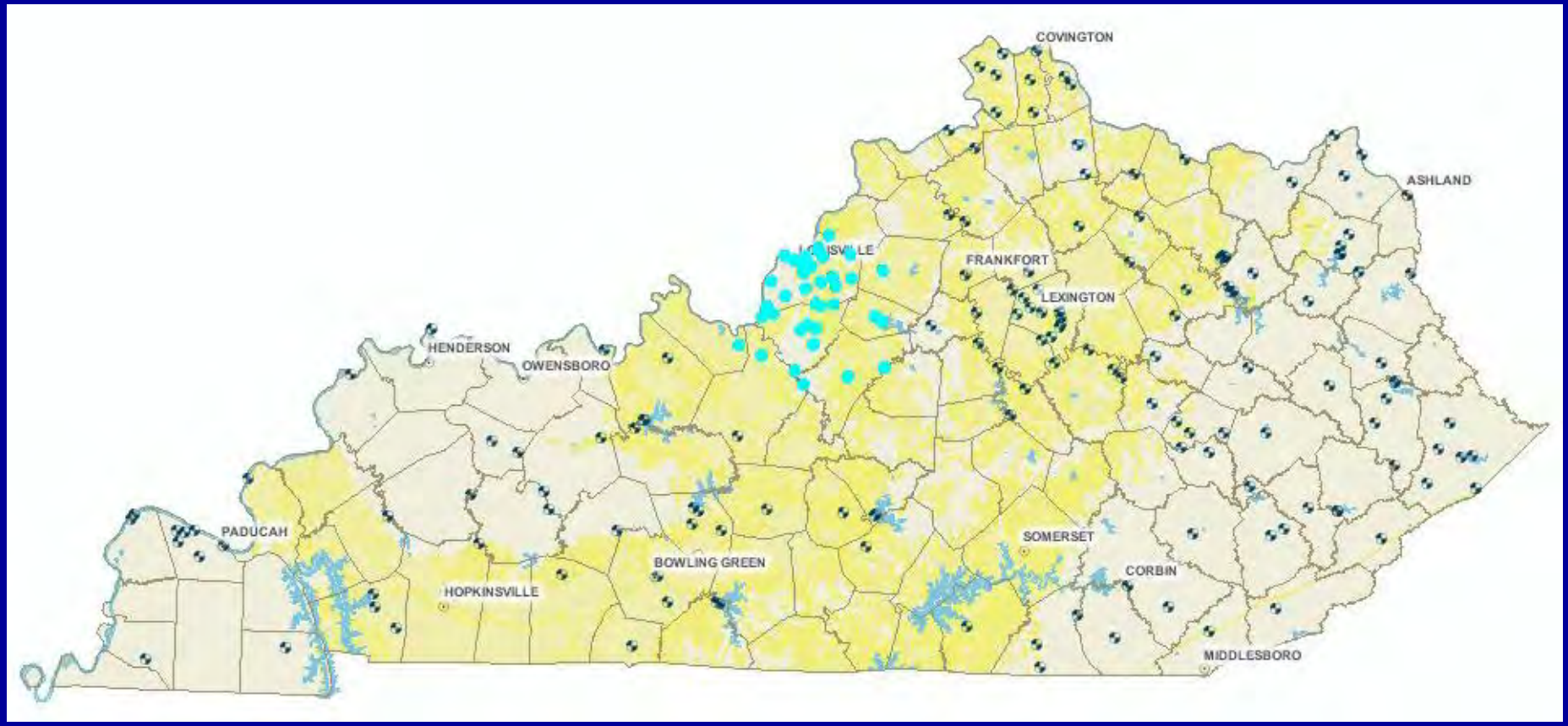
# Using the Tool in ArcMap



# Identify in ArcMap



# Selecting Multiple Sites in ArcMap

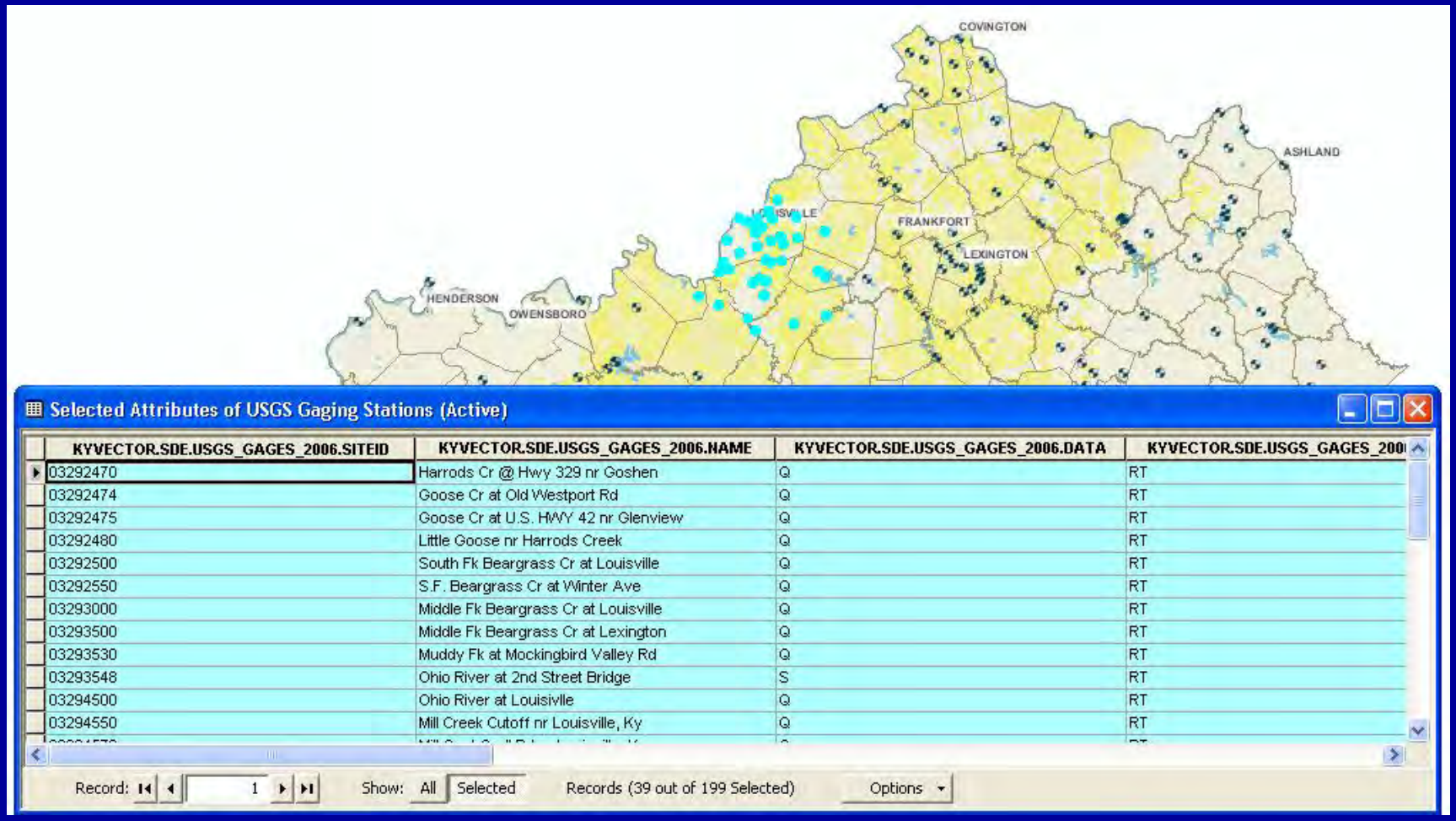



USGS science for a changing world

Hydrology of Kentucky

*Kentucky's Contribution to the Better Understanding of Hydrology*

# Attribute Table in ArcMap




Selected Attributes of USGS Gaging Stations (Active)

| KYVECTOR.SDE.USGS_GAGES_2006.SITEID | KYVECTOR.SDE.USGS_GAGES_2006.NAME | KYVECTOR.SDE.USGS_GAGES_2006.DATA | KYVECTOR.SDE.USGS_GAGES_200 |
|---|---|---|---|
| 03292470 | Harrods Cr @ Hwy 329 nr Goshen | Q | RT |
| 03292474 | Goose Cr at Old Westport Rd | Q | RT |
| 03292475 | Goose Cr at U.S. HWY 42 nr Glenview | Q | RT |
| 03292480 | Little Goose nr Harrods Creek | Q | RT |
| 03292500 | South Fk Beargrass Cr at Louisville | Q | RT |
| 03292550 | S.F. Beargrass Cr at Winter Ave | Q | RT |
| 03293000 | Middle Fk Beargrass Cr at Louisville | Q | RT |
| 03293500 | Middle Fk Beargrass Cr at Lexington | Q | RT |
| 03293530 | Muddy Fk at Mockingbird Valley Rd | Q | RT |
| 03293548 | Ohio River at 2nd Street Bridge | S | RT |
| 03294500 | Ohio River at Louisivlle | Q | RT |
| 03294550 | Mill Creek Cutoff nr Louisville, Ky | Q | RT |

Record: 1 Show: All Selected Records (39 out of 199 Selected) Options

USGS science for a changing world

Hydrology of Kentucky

*Kentucky's Contribution to the Better Understanding of Hydrology*

# Summary

- KY Hydro Tool provides hydrologic data for the State for both online and offline use.
- This is an ongoing effort with future updates and additions expected.