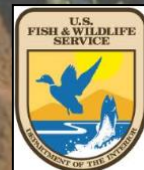


Kentucky Agriculture Science and Monitoring Committee (KASMC) – 3-year cooperative scope of work and work plan (2015-2017)



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“Dedicated to coordinating agricultural science and monitoring efforts in Kentucky in order to promote sustainable agriculture and a healthy environment”

Contents

Introduction	7
Table 1. KASMC Members and primary-contact information	9
Objectives and Approach	11
Current and on-going KASMC focal points	12
Task 1 – Science and Research	12
Task 2 – Monitoring surface water and groundwater availability and quality	15
Surface water and water quality	16
Groundwater availability and quality	20
Task 3 – Stabilize funding for existing networks and obtain funding for future monitoring needs	26
Surface water and water quality	26
Table 2. Funding needs for ORSANCO monitoring stations:	27
Table 3. Ohio River at Cannelton, IN; Funding needs:	28
Table 4. Wabash River at New Harmony, IN; Funding needs:	29
Table 5. Cumberland River at Pinkneyville, KY; Funding needs:	29
Table 6. Tennessee River near Paducah, KY; Funding needs:	30
Table 7. Ohio River at Olmsted Lock and Dam / L&D 52, KY; Funding needs:	31
Table 8. Ohio River near Greenup, KY; Funding needs to continue work at present scope:	32
Table 9. Ohio River near Greenup, KY; Funding needs to upgrade site to match data collected at other USGS “sentry gages” as noted herein:	33
Table 10. Green River at Spottsville / Sebree, KY; Funding needs:	35
Table 11. Licking River at Hwy 536 near Alexandria, KY; Funding needs:	37
Table 12. Funding needs for miscellaneous new monitoring stations:	38
Table 13. TOTAL funding needs for the 3 critical monitoring sites with known funding deficits (Ohio River @ Greenup, KY; Licking River near Alexandria, KY; and Green River @ Spottsville, KY):	39

Groundwater Monitoring Needs: Recommendations 40

Task 4 - Continued outreach and education..... 42

Task 5 - Continued collaboration and sharing of resources..... 44

Recommended KASMC focus areas 46

References 46

Figures

Figure 1. Screen capture of KASMC web page show current funding opportunities for collaborative research as of December, 2013 (http://go.usa.gov/W7VP).	12
Figure 2. Illustration showing the South Fork Little River Basin, Kentucky.	13
Figure 3. Map showing locations of the NRCS Mississippi River basin Initiative Focus Areas in Kentucky.	17
Figure 4. Map showing Recovery Potential Screening Tool agriculture-based rankings by watershed (HUC12 scale) in Kentucky with major river basins shown as red outlined areas.....	18
Figure 5. Flow chart showing watersheds and their relative positions within the Ohio River Basin that were ranked as priorities for monitoring by KASMC members. Shaded cells (tan) indicate that current monitoring, in some form, is being conducted at that point.....	19
Figure 6. Map showing distribution of aquifer types in Kentucky (courtesy, Rob Blair, Kentucky Division of Water, 2013).	20
Figure 7. Distribution of high-yield irrigation wells in Jackson Purchase area in 2012 and 2013 (Source: KGS and KDOW).	21
Figure 8. Groundwater levels in the USGS Viola Well from 1950 to the present; these data show a rise in groundwater levels at this location (Graves County) of almost 10 feet over the period of record.	22
Figure 9. Groundwater observation wells and springs proposed for the Kentucky Groundwater Observation Network (KGON), maintained by the Kentucky Geological Survey. Additional target areas are indicated where future monitoring sites are anticipated to be established.....	23
Figure 10. Map showing all groundwater sites sampled as part of the KDOW and ITAC groundwater observation network through 2013 (courtesy, Rob Blair, Kentucky Division of Water, 2013).	25
Figure 11. Map showing presently active groundwater sites sampled as part of the KDOW and ITAC groundwater observation network (courtesy, Rob Blair, Kentucky Division of Water, 2013).	25
Figure 12. Nutrient movement in the hydrologic cycle (Belval and Sprague, 1999). Figure 10.	41
Figure 13. KASMC members from the US Geological Survey (Howard Reeves - left) and the Kentucky Geological Survey (Charles Taylor - right) discuss irrigation at the 2013 AgriBusiness Association of Kentucky's annual meeting. These talks were given at the request of fellow KASMC member Jay McCants.	42

Figure 14. KASMC members touring the research facilities at Murray State University during the 2nd annual KASMC executive meeting in Murray, Kentucky.....	43
Figure 15. KASMC members from Kentucky State University (Farm Manager Eddie Reed) and USGS (Hydrologic Technician Ryan Thompson) at a new streamgage built on the Kentucky State University (KSU) research farm in Frankfort, Kentucky. The gage was constructed with surplus USGS equipment and donated labor from KSU and USGS staff. This gage will benefit students and researchers at KSU and was the result of KASMC-lead collaboration.	44
Figure 16. Monitoring station located at the mouth of the Green River at Spottsville, KY and example real-time nitrate data. This monitoring station was constructed and will be operated through 2015 under a KASMC-based partnership between the Kentucky Governor’s Office of Agricultural Policy (GOAP), Kentucky Corn Growers Association (KyCGA), and US Geological Survey (USGS).....	45

Introduction

The Kentucky Agriculture Science and Monitoring Committee (KASMC) was created in 2009 and now includes over 25 members who represent a wide range of state, federal, and local agencies, academic institutions, and the agricultural industry (Table 1). KASMC membership continually increases due to the positive results of on-going KASMC activities and increased awareness resulting from active participation by the many KASMC members. KASMC members work collectively to coordinate resources and expertise in order to address the agricultural science and monitoring needs of Kentucky. Committee members have collaborated on numerous proposals, projects, and outreach efforts. KASMC meetings are generally held quarterly and include both presentations and site visits. Meetings are hosted at locations around Kentucky to allow members to become familiar with agricultural facilities and institutions that contribute to the KASMC mission. Subsequent to its formation, KASMC was integrated as a subcommittee under Kentucky's Agriculture Water Quality Authority (AWQA) and now provides information to help resource managers steer Kentucky's agricultural policies. Primary operational functions within KASMC (such as hosting the KASMC web page, organizing meetings and events, and so forth) fall to the committee chairs and the resources of their respective organization; currently, the co-chairs of KASMC are Pete Cinotto from the U.S. Geological Survey (USGS) and Kimberly Richardson from the Kentucky Division of Conservation (KDOC).

KASMC is committed to providing sound, unbiased scientific data that effectively balance both socio-economic and environmental issues in order to promote sustainable agriculture and a healthy environment. With this goal in mind, KASMC will identify focal points for agricultural science and monitoring activities that effectively target and address the most critical issues. KASMC enables cooperative science and efficient collaboration among researchers from all applicable entities within Kentucky and the region.

This 3-year cooperative scope of work and provisional work plan will describe the on-going activities and priorities of KASMC. In addition, we identify research and monitoring focal points where additional work is required to better meet KASMC's mission of coordinating agricultural science and monitoring efforts in Kentucky in order to promote sustainable agriculture and a healthy environment.

Currently, KASMC is focused on the promotion of agricultural research, the collection of defensible surface-water and groundwater-quality and -quantity data for monitoring purposes, the continuation of outreach activities, and the fostering of collaboration. Agricultural research is a KASMC priority and KASMC actively works to communicate research needs and funding opportunities to all KASMC members. Data required for specific research (short-term) and long-term monitoring are differentiated herein. Short-term focused data are beneficial to reach specific conclusions while monitoring requires a longer period of record to reach statistically-

significant conclusions regarding long-term trends, loads, and other statistics. In addition, an effective long-term monitoring network is critical to taking relatively short-term (2-5 year duration) research projects and viewing them in a broader, regional context.

While research-based data needs (short-term projects) will vary from project to project and may, or may not, benefit from the vast amount of data currently available in Kentucky, improvements in long-term monitoring of surface water and groundwater are needed. There are presently 14 long-term surface-water monitoring stations identified herein as key locations for effective monitoring of nutrient, microbial, and sediment loads to the state's major streams and to the Mississippi River. Many of these surface-water stations have some combination of adequate data for tracking and quantifying other important water-quality parameters and (or) are funded through multiple agencies and KASMC partners while others are in need of additional funding or upgraded instrumentation to effectively provide defensible data.

Groundwater monitoring needs are presently less well defined than those for surface water. Systematic long-term collection of water level measurements, karst spring discharges, and groundwater quality data, are needed for better characterization of productive aquifers and to improve assessments of groundwater availability. While efforts have been made to improve the accessibility of groundwater quality data in recent decades, long-term records (>5 years) of water-level measurements are not available for most parts of the state and (or) are decades out-of-date. To make statistically significant and defensible decisions regarding groundwater availability and groundwater quality, the network of long-term groundwater-observation wells needs to be expanded to include all agricultural areas within Kentucky.

Outreach activities and collaboration are on-going and KASMC members have had great success in collectively promoting our mission and working together. KASMC members routinely speak at public events, serve as technical resources, and publish defensible science.

Table 1. KASMC Members and primary-contact information

Organization	Primary contacts	Email	Phone	Location
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Objectives and Approach

The objective of the Kentucky Agriculture Science and Monitoring Committee (KASMC) is to coordinate agricultural science and monitoring efforts in Kentucky in order to promote sustainable agriculture and a healthy environment.

This objective will be addressed through active communication and interaction with KASMC members from across Kentucky. KASMC members include, but are not limited to, academia; federal, state, and local governments; utilities; and producers (Table 1). Scientific expertise from all established resources in Kentucky will be utilized to address complex agricultural issues as identified in cooperation with legislative bodies, regulatory agencies, producers, and the citizens of Kentucky.

Specifically, KASMC will:

- 1) Develop an interdisciplinary approach that integrates, as practical, all established scientific resources and expertise within Kentucky to address agricultural issues.
- 2) Establish collaborative relationships among all KASMC members.
- 3) Provide coordinated, unbiased scientific data and interpretations needed to make decisions related to agricultural issues to producers, managers, and the public.
- 4) Openly facilitate the transfer of technologies to applicable parties and agencies.

This report provides a detailed plan for the promotion of science and research activities, monitoring activities, funding needs, outreach and education, and collaboration. Measures of success are noted where applicable.

Current and on-going KASMC focal points

Task 1 – Science and Research

Continue to develop and fund agricultural research

Identify focused science and research needs that are quantifiable and relatively short-term in nature (1-5 year project duration). Identify funding mechanisms for these research projects and make information and application requirements available to KASMC membership in a convenient manner.

Measures of Success

Maintain effective communication within KASMC membership and within the agricultural community and set, as an action item, the development of relevant proposals with a goal of developing at least 3 per year. New targeted research projects have been currently identified (2013) and initiated among KASMC members. KASMC will also establish a clearing-house on the KASMC web page with simple access to all funding possibilities and relevant requests for proposals (RFPs). Note that this process has already started (as of 2013) and funding opportunities are being supplied by KASMC members to the KASMC committee chair persons for inclusion on the KASMC web page (<http://go.usa.gov/W7VP>) (fig. 1).



Figure 1. Screen capture of KASMC web page show current funding opportunities for collaborative research as of December, 2013 (<http://go.usa.gov/W7VP>).

While there are many agricultural-research actives currently underway in Kentucky, an example of on-going agricultural research conducted by KASMC members is the Little River Water-Quality Consortium's and U.S. Geological Survey's effort to develop and apply a multiple-source tracking approach. Previous water-quality monitoring efforts in the basin applied standard methods to measure fecal-indicator bacteria, nutrients, and sediment, but did not identify the potential sources of contamination. In this

current study, a multiple-source tracking approach is being used to identify potential sources of fecal, nitrogen, and sediment contamination in streams across various land uses and variable hydrologic conditions, and (2) provide insight into pathways to improve water quality for various constituents in the South Fork Little River basin (fig.2). Detailed objectives for this current as of 2014) project are the following:

- 1) Identify potential source(s) of bacterial contamination using a microbial-source tracking approach (host-associated genetic markers);
- 2) Evaluate the utility of stable isotopes in nitrate for characterizing potential sources and transport pathways of nitrate;
- 3) Identify or “fingerprint” potential sources of fine-grained suspended sediment.

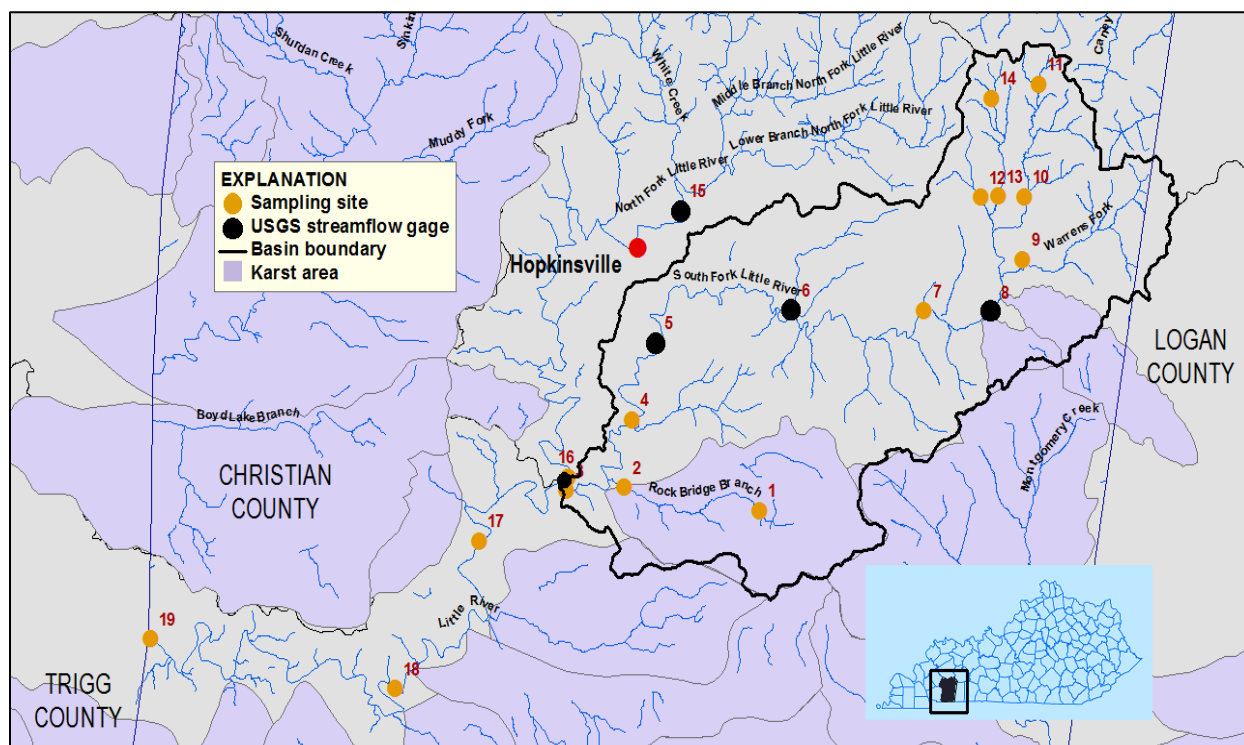


Figure 2. Illustration showing the South Fork Little River Basin, Kentucky.

Considerable scientific information on contributing source(s) in the South Fork Little River needs to be identified and quantified for resource managers to explore the full range of restoration options. This study will provide a picture of the potential sources of *E.coli*, nitrate, and fine-grained suspended sediment in the basin that has not been captured through more traditional measurements of solute concentration and flux. It also will provide a scientific basis to explore and evaluate potential, future water-quality improvements resulting from changes in the management of nonpoint source pollution.

The Little River project highlights the ability of KASMC partners to pool resources and conduct high-quality, transparent, defensible science. Project partners in this effort include a wide range

of state, local and federal government agencies; industry and producers; and academic institutions. Among the project partners are:

- U.S. Geological Survey
- Hopkinsville Surface and Stormwater Utility
- Governor's Office of Agricultural Policy-Kentucky Agricultural Development Board
- Christian County Agriculture Development Board
- Trigg County Agriculture Development Board
- Todd County Agriculture Development Board
- Hopkinsville Water Environment Authority
- Kentucky Corn Growers' Association
- Christian County Health Department
- Christian County Fiscal Court
- Kentucky Small Grain Growers' Association
- Kentucky Farm Bureau
- Kentucky Cattlemen's Association
- Kentucky Poultry Federation
- Kentucky Division of Conservation, Environmental & Public Protection Cabinet
- Kentucky Division of Water, Environmental & Public Protection Cabinet
- Kentucky Department of Agriculture
- UK College of Agriculture, Cooperative Extension
- Kentucky State University, Cooperative Extension
- Kentucky Proud
- Agri-Chem, LLC
- H&R Agri-Power
- AgriBusiness Association of Kentucky
- USDA-Agricultural Research Service
- Natural Resources Conservation Service
- Many local producers

Task 2 – Monitoring surface water and groundwater availability and quality.

In many cases, 10 years of monitoring data are the minimum required to make significant statements regarding critical determinations such as flow conditions, trends, and constituent loading (Searcy, 1959; specific requirements are described at length in Helsel and Hirsch, 2002); this period of record is a longer duration than many targeted research projects as noted above in task 1. Placement of these monitoring stations is therefore critical and must be optimized to minimize waste of both time and resources. Once these stations are established, it is expected that they operate in place for years if not decades. These long-term monitoring records are critical to determining BMP effectiveness, developing and supporting nutrient management strategies, evaluating drought planning and mitigation, and identifying other issues that relate to Kentucky agriculture. Long-term monitoring sites are, generally, more difficult to maintain as long-term funding for a stable network is not as common as short-term grants for targeted research.

Monitoring points are typically “integration points” and quantify contributions from all upstream contributing areas. Given this, monitoring must be coordinated at multiple points along the stream system and the type of monitoring required at each point will vary according to significance. For example, some stations on the main-stem of the Ohio River do not have, and likely do not require, real-time data collection as the upstream contributing area is vast and, statistically, there is little to be gained from this increased resolution at many stations. For this reason, the USGS established a real-time monitoring station on the Ohio River near the confluence with the Mississippi River (Olmsted Lock and Dam) and samples on a scheduled basis at other, upstream locations such as the Ohio River at Cannelton, Indiana (located between major tributaries). However, real-time or higher resolution data can more-readily identify fate and transport mechanisms at smaller scales such as the confluence of the Green River and the Ohio River. This increase in temporal and spatial resolution extends all the way to field-scale studies where very detailed research-level data is appropriate and required in most cases. In fact, it is the availability of these data that enables an understanding of how field management and regional conservation approaches ultimately impact water-quality of larger streams like the Ohio and Mississippi rivers. **In ALL cases, methods and sampling protocols must be documented and adhered to in order to maintain a defensible dataset. Methods used in the monitoring stations described herein are published and available on the KASMC web page (<http://go.usa.gov/W7VP>) or available directly from the respective KASMC partners listed.**

Note that many other sites are monitored, to some degree, in Kentucky and the surrounding states and a wide range of data are routinely collected using a wide range of protocols; data from these sites provide much useful information, but may not be currently identified as relevant for agricultural science and monitoring. Given this, it is expected that additional monitoring stations and/or data sources (KASMC partners) may be added at a later date if identified or designated as a requirement by KASMC. The USGS, for example has over 9000 streamflow-gaging stations around the Nation and over 1.5 million data-collection sites currently stored in the USGS National Water Information System (NWIS) database; some of these USGS sites are situated for specific purposes such as monitoring the supply of water for a critical generating station and, therefore, may not be directly useful for KASMC purposes. Other data from specific sources, such as some volunteer networks, may be very useful for screening (finding problems) and initial assessments, but could lack the defensibility required by KASMC for long-term

monitoring data (monitoring data are expected to stand up to scientific scrutiny and colleague review). Given this, the KASMC 3-year cooperative scope of work and work plan (2015-2017) presented herein will be updated as a “living document” to include all data as possible to defensibly monitor and assess Kentucky’s agricultural contributions to water quality with quality-assured / quality-controlled protocols and data. Note that data not collected or archived with established methods or protocols, or in a manner that will provide adequate, defensible, statistical strength, may be noted herein as applicable for specific research, screening, qualitative assessments, and(or) other beneficial agricultural-based science and applications, but will not be noted as applicable for long-term monitoring – monitoring bears its own distinction in this role.

Surface water and water quality

Optimization of the long-term surface-water and water-quality monitoring network began under the previous, informal, KASMC cooperative scope of work and work plan. Preliminary network optimization was successfully accomplished through development of the NRCS Mississippi River Basin Initiative (MRBI) targeted basins in Kentucky (<http://www.nrcs.usda.gov/>) (fig. 3) and further refined through use of the EPA / Kentucky Division of Water (KDOW) “Recovery Potential Screening Tool” or RPST. The RPST ranked individual watersheds by agricultural metrics (fig. 4) and created a map of priority areas for targeted monitoring. Based on these results, the flow chart in figure 5 was developed and work began to monitor water quality at priority locations in Kentucky and quantify major contributions from adjacent states as possible. Note that applicable water-quality data are currently being collected at the locations shown in figure 5 through several monitoring programs and organizations; however, long-term sustainable funding has not been secured for all currently active sites and some are slated to go off-line in June of 2015 (this is described in greater detail in task 3 below).

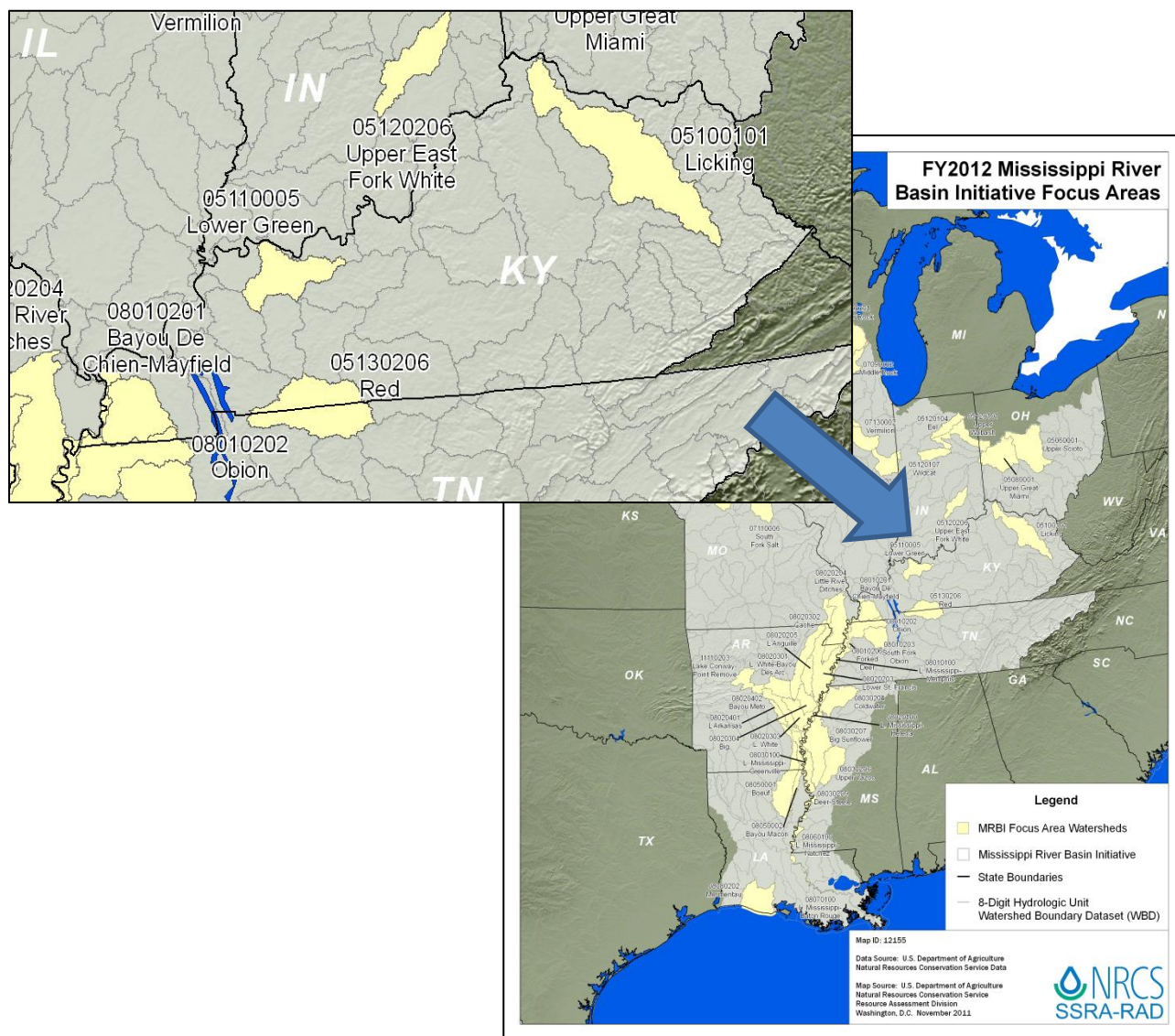


Figure 3. Map showing locations of the NRCS Mississippi River basin Initiative Focus Areas in Kentucky.

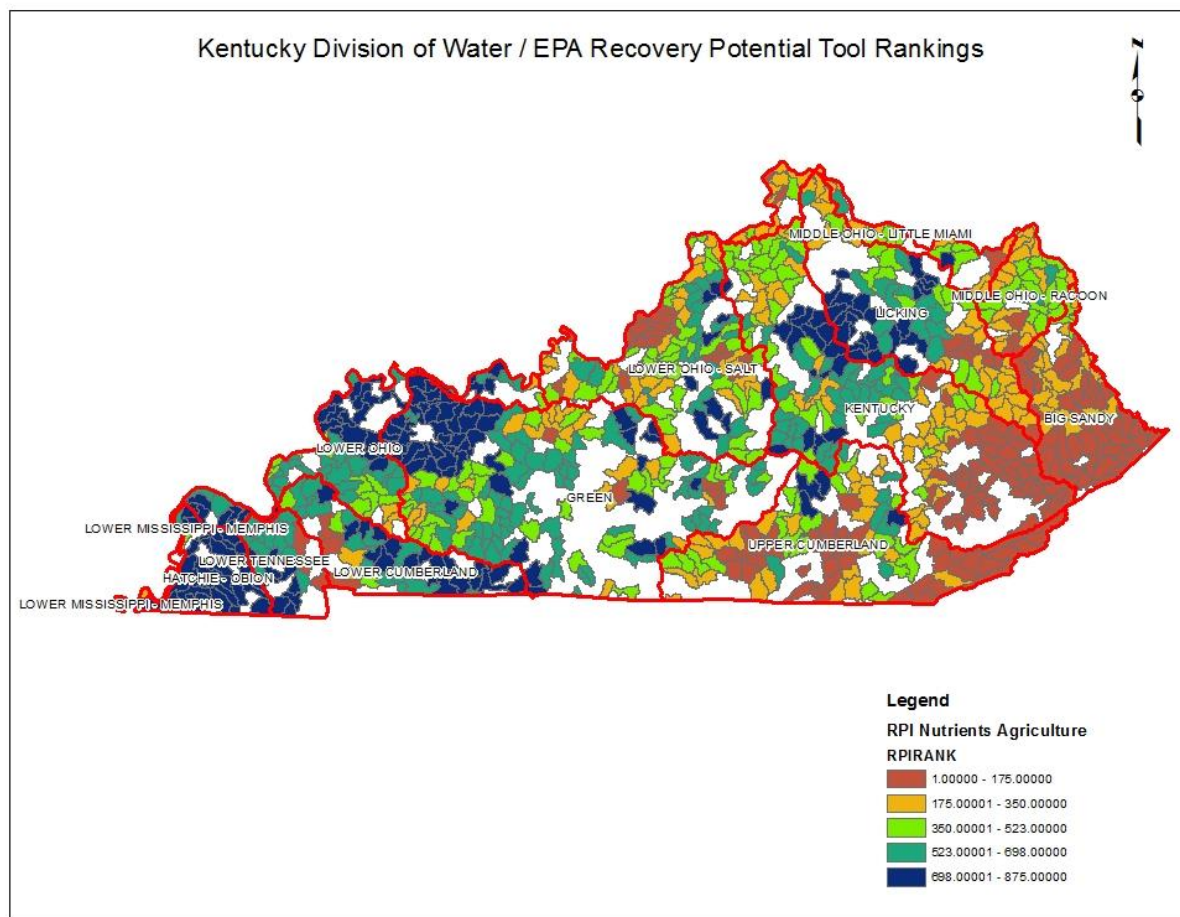


Figure 4. Map showing Recovery Potential Screening Tool agriculture-based rankings by watershed (HUC12 scale) in Kentucky with major river basins shown as red outlined areas.

Optimized sampling stations to quantify nutrient contributions to the Ohio / Mississippi Rivers from Kentucky.

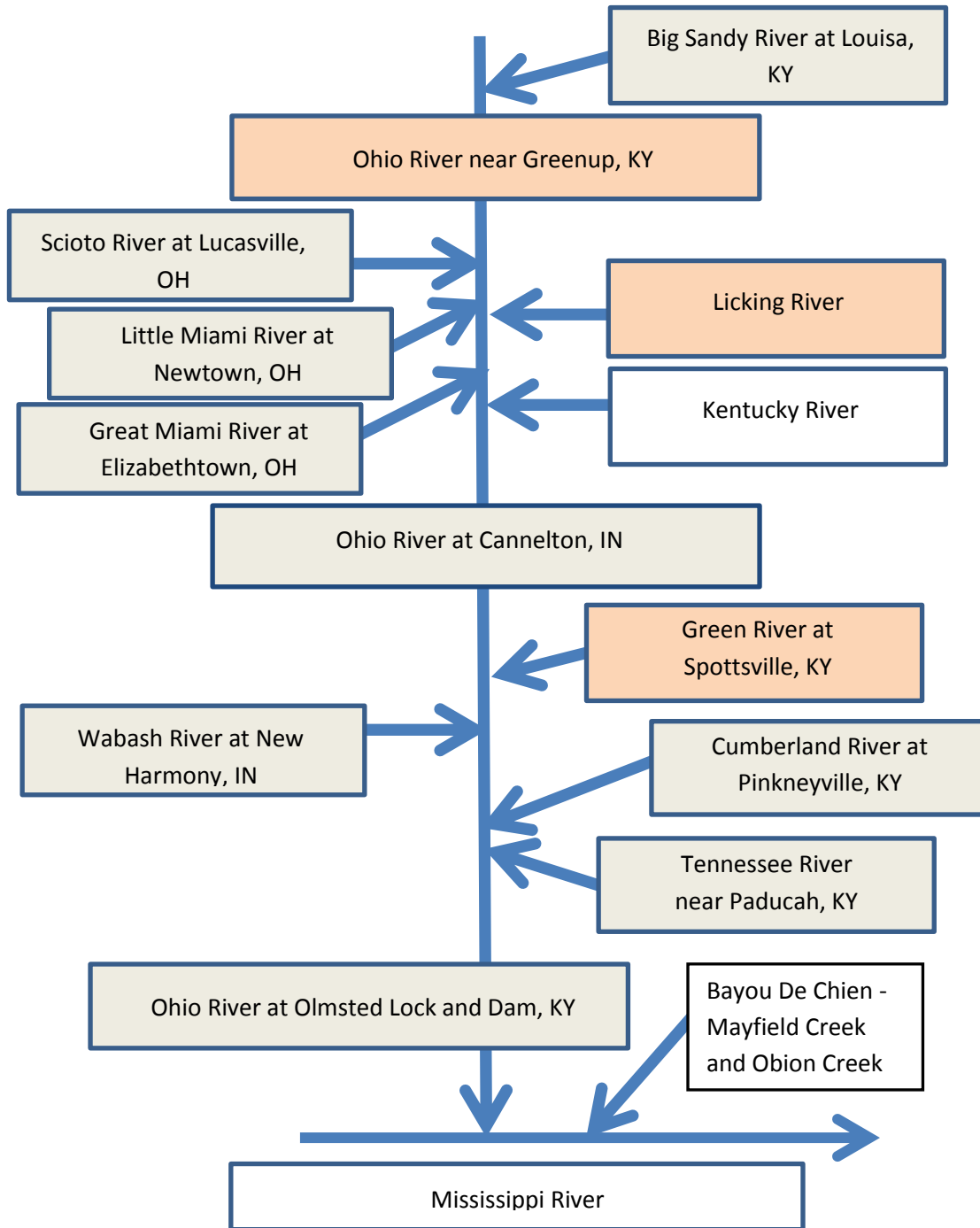


Figure 5. Flow chart showing watersheds and their relative positions within the Ohio River Basin that were ranked as priorities for monitoring by KASMC members. Shaded cells (tan) indicate that current monitoring, in some form, is being conducted at that point.

Groundwater availability and quality

Unlike states such as Kansas and Nebraska that are heavily dependent on groundwater for irrigation, Kentucky's annual precipitation and the state's relative abundance of surface streams is generally sufficient for most agricultural production needs. And because of geological and topographical variability, aquifer characteristics that control groundwater availability and quality also varies considerably across the state (fig. 6). Many parts of the Commonwealth do not possess aquifers capable of yielding large quantities of groundwater to wells, and in many locations groundwater quality also limits its use. Yet highly-productive aquifers are present, and extensively utilized, in the Jackson Purchase area, in alluvial sediments along the Ohio and lower Green river valleys, and in many parts of the state underlain by karstic limestone or other fractured sedimentary rocks. The sensitivity of groundwater to contamination or degradation by human activities likewise varies greatly from place to place, depending on topographic and geological factors that affect groundwater recharge, flow, and storage. In most parts of Kentucky, fresh groundwater suitable for agricultural needs and other uses is available to wells completed at depths of 100-300 ft. below land surface. At greater depths, groundwater is often highly mineralized (high in total dissolved solids) and may possess objectionably high concentrations of chlorides, sulfides, or other chemical constituents that may further limit its use.

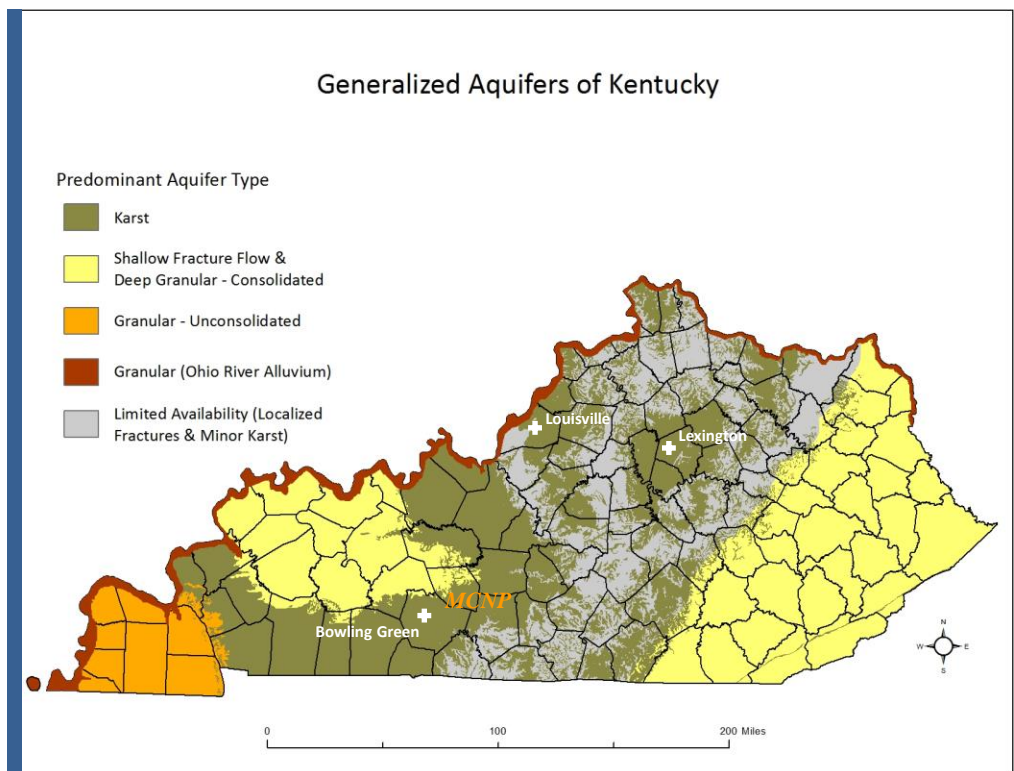


Figure 6. Map showing distribution of aquifer types in Kentucky (courtesy, Rob Blair, Kentucky Division of Water, 2013).

At present, specific needs for groundwater monitoring for agricultural interests in Kentucky are not well defined, and are the subject of ongoing evaluation by KASMC partners such as the KGS, KDOW, USGS, and others. One exception is the need for improved monitoring of groundwater conditions in major aquifers in the Jackson Purchase area and other parts of western Kentucky where construction of high-yield irrigation and public water-supply wells is increasing (fig. 7). Current monitoring efforts there, and in other parts of the state, are largely focused on collecting representative groundwater samples to

track annual and (or) multi-annual changes in basic water-quality indicators and reconnaissance sampling for selected potential groundwater contaminants, including nitrates, bacteria, and pesticides. These, and other active or planned groundwater monitoring activities relative to agricultural interests are described briefly below.

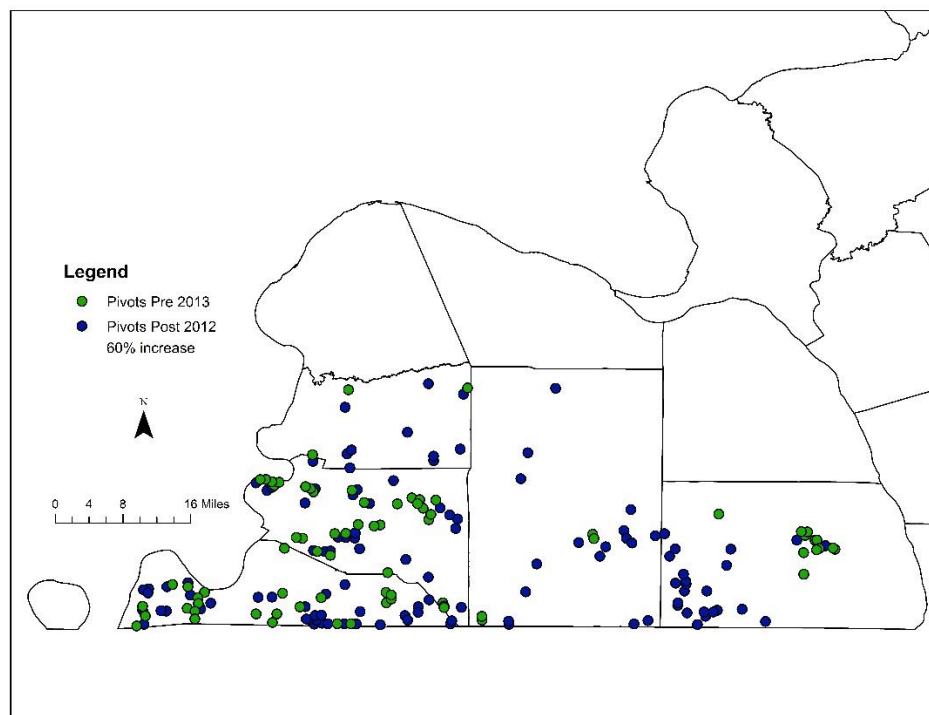


Figure 7. Distribution of high-yield irrigation wells in Jackson Purchase area in 2012 and 2013 (Source: KGS and KDOW).

Long-Term Water-Level Measurements

Although one-time or multiple intermittent water-level measurements provide useful information about aquifers and groundwater conditions, long-term continuous records of water levels (3-5 years minimum) are needed to track changes in groundwater recharge and storage due to seasonal variability in precipitation and to make statistically defensible resource management decisions. Unfortunately, since the mid-1990s there has been no statewide observation well network or systematic effort to collect water-level data apart from occasional short-term, site-specific studies. As a consequence, long-term groundwater-level data records are critically lacking in most parts of the state. Presently, only one water-level observation well—located in Graves County, KY, and maintained by the USGS with federal funding (fig. 8)—is being actively monitored and has a record of water-level measurements of longer than 25 years. Data from the Graves County (Viola) well (accessible at <http://waterdata.usgs.gov/ky/nwis/gw>) indicates that groundwater levels have risen at that monitoring location since the 1950's when the well was first measured. While this is obviously only representative of that one specific location, these groundwater data are in stark contrast to many other wells in the Nation where groundwater resources are significantly taxed by effects of drought and agricultural withdrawals (most notably in the western United States). Because similar well data are

lacking for other locations and counties in the Purchase area, the larger regional significance of the trend exhibited by the Viola well cannot be confirmed or evaluated.

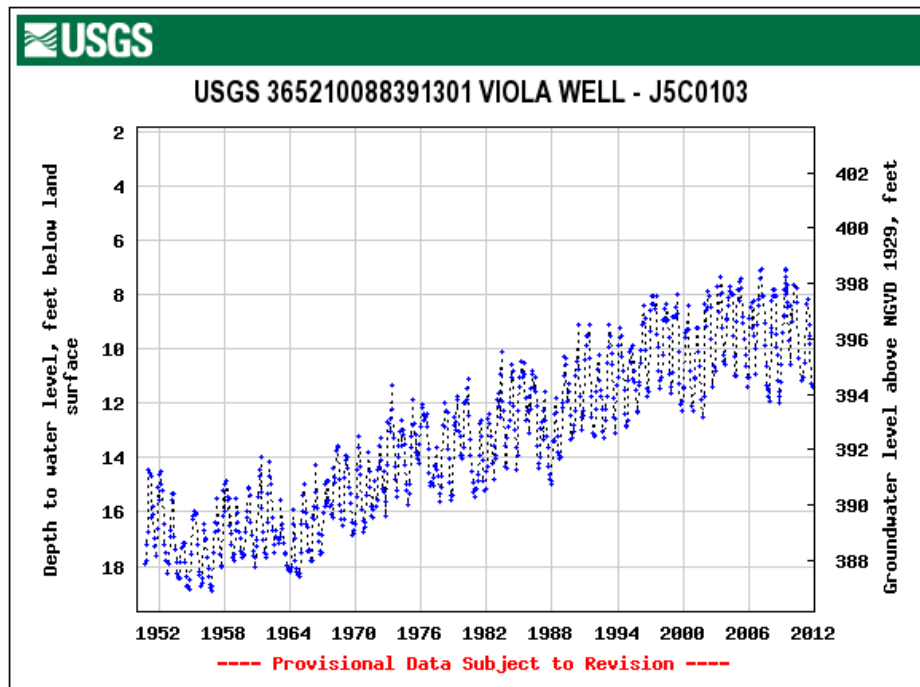


Figure 8. Groundwater levels in the USGS Viola Well from 1950 to the present; these data show a rise in groundwater levels at this location (Graves County) of almost 10 feet over the period of record.

In 2013, in accordance with a state legislative mandate (KRS 151.625), the Kentucky Geological Survey began planning to partly redress the lack of long-term water-level data. A new statewide groundwater observation network (the Kentucky Groundwater Observation Network, or “KGON”) is being created which will be primarily used for the collection of continuous long-term groundwater-level (GWL) data (fig 9). Existing water wells in selected locations (and aquifers) are being inspected and, if determined suitable and accessible for monitoring, repurposed as network observation wells. It is anticipated that some newly drilled wells will be required in some locations where suitable wells are not available. Well clusters—a grouping of one or more wells completed at different depths—will also be incorporated in the network at some locations to more effectively monitor multiple aquifer zones in complex geological settings. KGS will initiate KGON in 2014-2015 with approximately 12-15 observation wells instrumented with pressure transducers and automatic data loggers, using approximately \$55,000 in internal funds. An additional 12-15 observation well locations are expected to be added to the network by the KGS in 2015-16. KGS is committed to the operation and maintenance of the KGON for a minimum of 5 years, however, any additional expansion of the network and longer-term operation or network equipment upgrades will likely depend on securing additional outside funding. The KGS anticipates being assisted in these efforts by collaboration with other KASMC members including the USGS and the Kentucky Division of Water (KDOW).

Livestream Karst Spring and Well Monitoring

In the karst areas of the state, large perennial springs fed by underground cave streams may serve as the best overall monitoring points for groundwater discharged from limestone aquifers. Three karst spring observation stations (fig. 9) are expected to be included in the KGON in 2014-15, and monitored using instrumentation provided by a one-time \$72,000 grant contributed by “Livestream”—an innovative EcoArts project focused on raising public awareness about groundwater and the environment (<http://www.livestreamky.com/>). Continuous measurements of stage (water depth), specific conductivity, pH, temperature, and turbidity will be collected using integrated multi-parameter probes and automatic data-logger equipment. The three karst spring sites are purposefully located in different major karst terrains across the state: (1) Western Pennyroyal, (2) Inner Bluegrass, and (3) Eastern Pennyroyal. Discharge measurements will be collected from the springs so that rating curves can be constructed for each spring, enabling translation of the stage data to equivalent discharge (springflow) measurements. Plans developed by KGS call for pairing of the springs with one or more water-level observation wells located in each spring’s basin (as delineated by previous water-tracer tests) in order to establish a monitoring cluster. Such clusters will enable simultaneous monitoring of both the slower-flow bedrock-matrix and quick-flow conduit components of the local karst aquifers. In addition to the springs, one observation well to be added to the KGON is also funded by the Livestream project—it is intended to monitor water levels, specific conductivity, pH, and temperature, in the recharge area for the Upper Claiborne-McNairy Formation—a major aquifer zone used for agricultural irrigation and public water supply in the Jackson Purchase area.

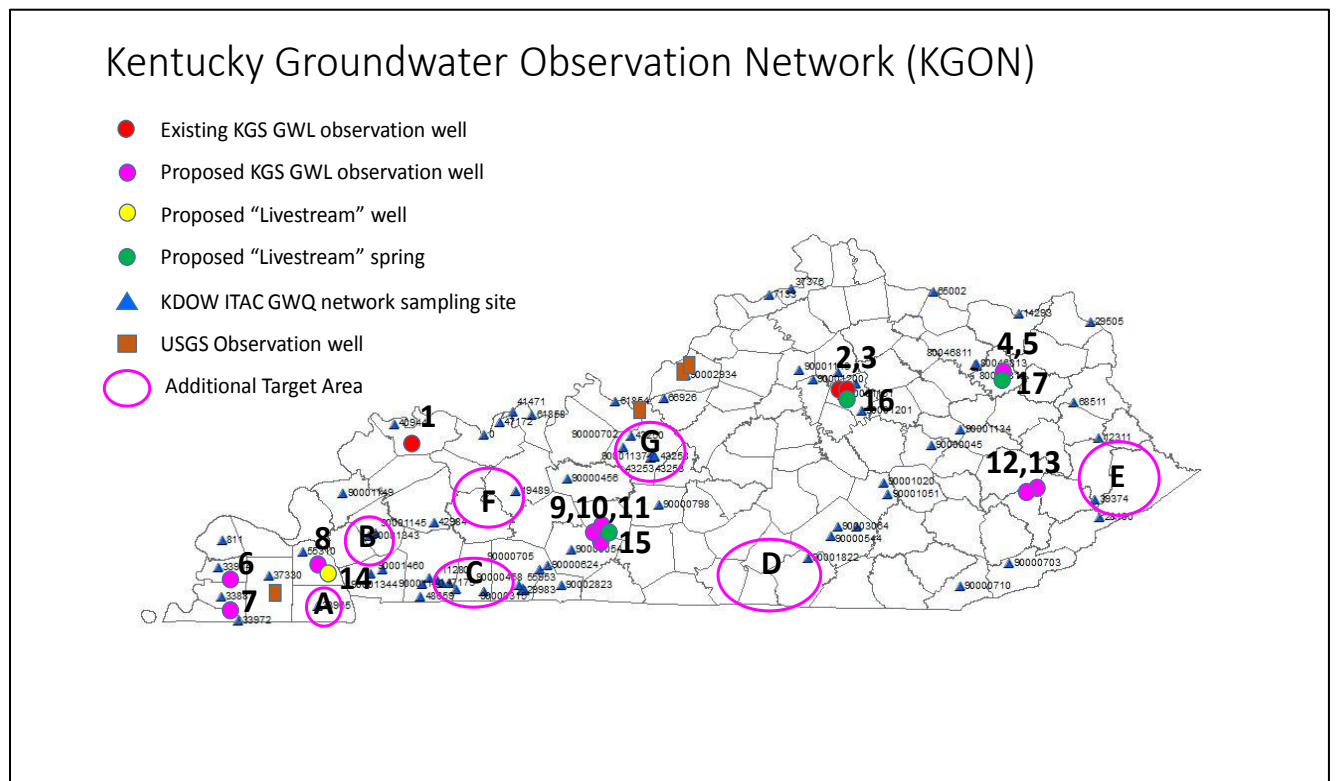


Figure 9. Groundwater observation wells and springs proposed for the Kentucky Groundwater Observation Network (KGON), maintained by the Kentucky Geological Survey. Additional target areas are indicated where future monitoring sites are anticipated to be established.

Aquifer (Water-Table or Potentiometric Surface) Mapping

In addition to collecting continuous long-term water-level data by way of the KGON, KGS is making plans to conduct a series of synoptic water-level measurements of aquifers in certain locations of the Jackson Purchase area where high-yield irrigation wells are being installed. A proposal for a pilot project to map groundwater levels in the upper Claiborne aquifer in Hickman and Fulton Counties was submitted to the Kentucky Small Grain Growers Association in 2014 seeking to obtain funds to help support this project. The water-level measurements, and other hydrogeologic data being collected are intended to provide an up-to-date “snapshot in time” of aquifer conditions that will enable KGS to better assess groundwater storage and availability. It is intended that this pilot study be utilized as a model for future efforts and that additional aquifer mapping projects will be successively conducted throughout the other Jackson Purchase counties until the entire area has been covered. The data being collected by this pilot project will benefit agricultural irrigation interests, as well as other groundwater users in the Purchase area. Approximately 68 percent of the 196,400 residents (U.S. Census, 2010) in the Purchase utilize groundwater as their primary drinking-water source. The majority of these residents obtain drinking water from 30 municipal wells. Private domestic wells are used by 22 percent of residents. Industrial manufacturers are also major users of groundwater in the Jackson Purchase.

Groundwater-Quality Data Collection

KDOW has led the legislatively mandated (KRS 151.629) Interagency Technical Advisory Committee (ITAC) on Groundwater in compiling and assessing groundwater-quality data for Kentucky. KDOW selected public and private water-supply wells and springs to serve as a sampling network (ITAC Groundwater Monitoring Network, accessed at <http://www.uky.edu/KGS/water/gnet/> Initial studies). Initial groundwater-quality sampling activities started in the late 1990s using general operating funds and monies from the Water Well Drillers Certification Fees (agency receipts), funding from the Federal Insecticide Fungicide, and Rodenticide Act (FIFRA, KY Dept. of Agriculture), and through individually funded Clean Water Act 319(h) assessment projects. Since that time, wells and springs in the network have been sampled using a rotating cycle and generally following the Kentucky Basin Management Unit Framework (<http://water.ky.gov/watershed/Pages/Basins.aspx>) developed for 303d surface water quality assessments. Roughly 19,000 sample results from approximately 6300 groundwater sources have been obtained statewide (fig. 10). Sampling locations selected for the 2014 cycle are shown in figure 11. Through the KDOW/ITAC network, data have been collected on a broad range of parameters, including most of the Primary and Secondary Drinking Water Standards from US EPA for treated, public drinking water. All data collected from the network are stored and accessed through the webpage maintained by the KGS Groundwater Data Repository (<http://www.uky.edu/KGS/water/research/gwreposit.htm>).

Measures of Success

Define and begin to develop defensible, available, and statistically-significant monitoring networks in Kentucky for surface-water and groundwater availability and quality. These networks will eliminate, or greatly reduce, redundancy and serve to better leverage limited resources available for this critical task.

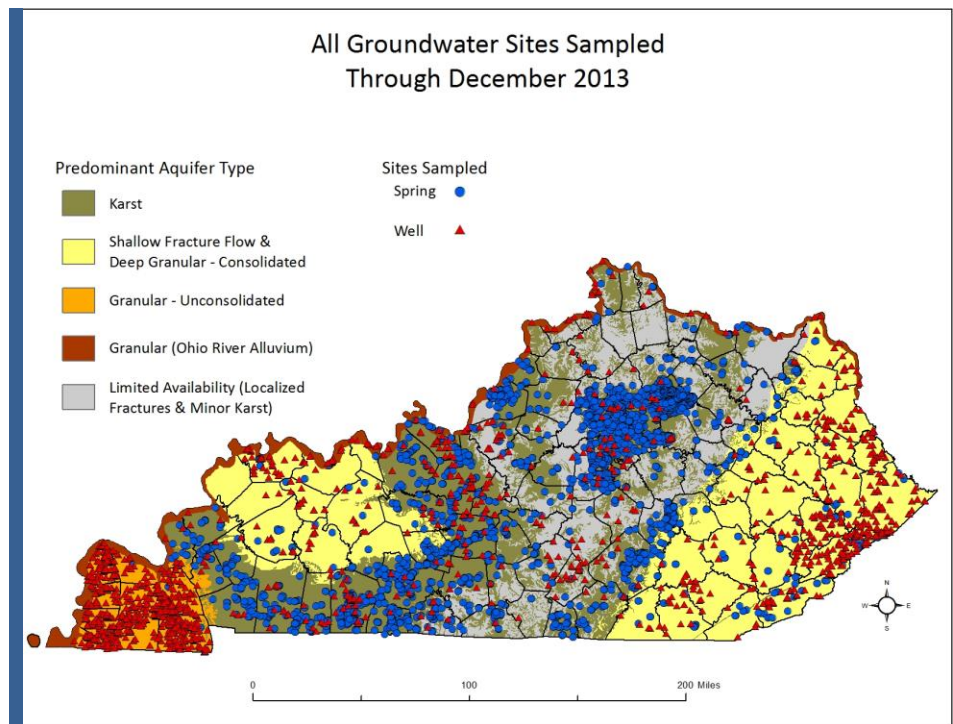


Figure 10. Map showing all groundwater sites sampled as part of the KDOW and ITAC groundwater observation network through 2013 (courtesy, Rob Blair, Kentucky Division of Water, 2013).

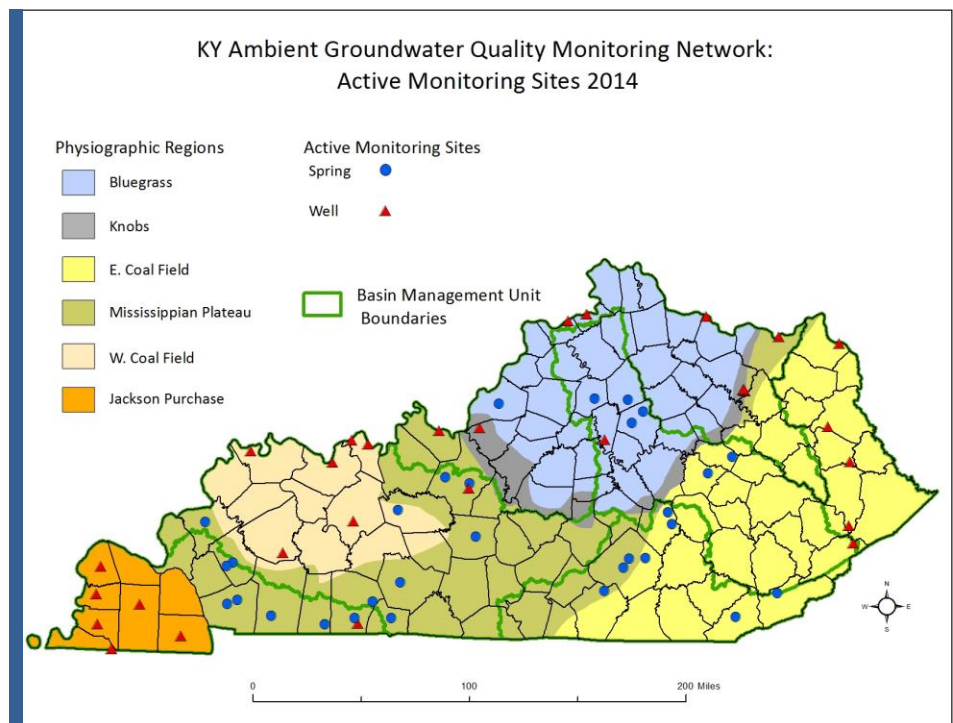


Figure 11. Map showing presently active groundwater sites sampled as part of the KDOW and ITAC groundwater observation network (courtesy, Rob Blair, Kentucky Division of Water, 2013).

Task 3 – Stabilize funding for existing networks and obtain funding for future monitoring needs

Long-term monitoring stations are critical to assess the performance of water- and land-use management actions and to determine key statistics such as trends and loads with respect to variations in climate, land-use / land-cover, and(or) other commonly occurring changes. For example, climate can vary widely by decade and precipitation in wet years or dry years can cause large changes in how constituents move to and within a stream. Samples only collected during wet years may give the erroneous impression that certain loads are higher than they would be if more representative, long-term data were used. Given this, it is critical to develop a plan to secure long-term funding for key monitoring points; this monitoring-based funding is quite different in nature than typical research grants that are focused on specific issues and generally only fund a project for 1-5 years.

Surface water and water quality

The flow chart shown in figure 5 shows the key monitoring locations for regionally determining “what comes into Kentucky and what comes out of Kentucky” in terms of nutrients and other constituents as well as stations that quantify fate and transport of key water-quality parameters. This monitoring network also establishes a consistent and defensible base for the determination of surrogates that will ultimately cut long-term cost. For example, turbidity (how cloudy the water is) is a less-expensive surrogate for suspended-sediment concentration that is a key to understanding how phosphorus moves through the watershed. Note that costs will vary by site based upon specific equipment installed, site conditions, and(or) in-kind contributions from various KASMC partners; some sites, for example, have higher, or lower, initial construction costs due to the type of equipment required (such as higher-cost acoustic sensors). **All costs herein should be considered APPROXIMATE values for reference only; note that prices will likely increase over time due to rising costs and inflation.**

Data-collection and analysis methods typically follow those set forth by the Ohio River Valley Water Sanitation Commission (ORSANCO) or USGS. ORSANCO river-water samples are collected as near to the centerline of the river as possible from lock chamber guidewalls, bridges, and in some cases from raw water intake lines. To sample from outside structures, an acid, distilled water, and native water-rinsed bailer, stainless steel bucket, or Kemmerer sampler is used with sufficient nylon rope attached to reach the river surface. Samples are transferred from the collection device to a likewise triple-rinsed ten-liter plastic carboy. The sample water is distributed from the carboy to sample bottles, each containing preservative if required by the analytical methods to be employed. Samples at ORSANCO sites are collected every second month, in January, March, May, July, September, and November. Constituents sampled for by ORSANCO include: ammonia, hardness, sulfate, total organic carbon, nitrate / nitrite, total kjeldahl nitrogen, chloride, phenolics, total suspended solids, cyanide, and total phosphorus (ORSANCO, 2014). USGS samples are collected as width- and depth-integrated samples (to account for differences in water quality across the river as the Ohio River is not always well mixed). Set USGS protocols for sample collection, handling, and analysis are followed based on published standards (USGS, 2014). Samples are collected at USGS sites a total of 15 times annually, of which 12 are scheduled in advance, and 3 are reserved for high-discharge conditions. Streamflow is measured at the time of sampling enabling estimation of chemical loads. Constituents sampled for by USGS include: 253

different pesticides; inorganic and organic carbon (total and dissolved forms); nutrients (total and dissolved forms); 12 metals (dissolved form); chloride, fluoride, and sulfate (dissolved form); turbidity (laboratory); total dissolved solids; alkalinity (laboratory and field); suspended sediment (sand/fine break and concentration); and field parameters (pH, dissolved oxygen, temperature, specific conductance, and turbidity).

Of the 14 key monitoring stations shown in figure 5, only 9 are funded for the long-term through a stable funding source (typically the USGS National Stream Quality Accounting Network (NASQAN) program or ORSANCO); these are (from upstream):

ORSANCO monitoring stations indicate the concentrations of constituents (converted to loads when streamflow is known) coming from the respective river basins and are important factors in determining the relative contributions from Kentucky basins. Note that several of these monitoring stations are located in adjacent states and, thus, do not rank high in the Kentucky Division of Water / EPA Recovery Potential Screening Tool (RPST) or in other Kentucky-based priority-basin rankings; however, they are critical, none the less, in determining Kentucky-based nutrient loads.

1. Big Sandy River at Louisa, KY (ORSANCO)

Data collected from approximately 1975 to the present day.

2. Scioto River at Lucasville, OH (ORSANCO)

Data collected from approximately 1975 to the present day.

3. Little Miami River at Newtown, OH (ORSANCO)

Data collected from approximately 1976 to the present day..

4. Great Miami River at Elizabethtown, OH (ORSANCO)

Data collected from approximately 1975 to the present day.

Table 2. Funding needs for ORSANCO monitoring stations:

Component	Required			ORSANCO	Needed
ANNUAL Collection of other water-quality samples	Cost not available			Cost not available	\$0
ANNUAL Laboratory fees for water-quality analyses	Cost not available			Cost not available	\$0

Coupled USGS / ORSANCO monitoring stations, as with other monitoring stations, indicate the concentrations and, when streamflow is known, loads coming from the respective river basins and are important factors in determining the relative contributions from Kentucky basins. As noted above, USGS and ORSANCO typically have different sampling protocols and some variation in the constituents sampled; however, the overlap provides for an additional level of quality assurance and quality control. All quality assurance / quality control and protocols must be published, repeatable, and defensible.

Operational cost varies at these monitoring stations based upon the constituents measured, the equipment installed, and the site-specific sampling requirements (travel, boats, etc.) at each site.

5. Ohio River at Cannelton, IN (USGS and ORSANCO)

USGS data collected from 1974 to the present day, ORSANCO data collected from approximately 1975 to the present day.

Table 3. Ohio River at Cannelton, IN; Funding needs:

Component	Required		ORSANCO	USGS	Needed
ANNUAL Collection of other water-quality samples	\$57,000		Cost not available	\$57,000	\$0
ANNUAL Laboratory fees for water-quality analyses	\$22,577		Cost not available	\$22,577	\$0

6. Wabash River at New Harmony, IN (USGS and ORSANCO)

USGS data collected from 1996 to the present day, ORSANCO Data collected from approximately 1999 to the present day.

Table 4. Wabash River at New Harmony, IN; Funding needs:

Component	Required		ORSANCO	USGS	Needed
ANNUAL Collection of other water-quality samples	\$57,000		Cost not available	\$57,000	\$0
ANNUAL Laboratory fees for water-quality analyses	\$22,577		Cost not available	\$22,577	\$0

7. Cumberland River at Pinkneyville, KY (ORSANCO)

Data collected from approximately 1989 to the present day. Station provides concentrations and, when streamflow is known, loads from both the Cumberland and Tennessee Rivers at this point as the rivers are mixed at / below the lakes. This site pairs with the joint monitoring station “Tennessee River near Paducah, KY” noted below.

Table 5. Cumberland River at Pinkneyville, KY; Funding needs:

Component	Required			ORSANCO	Needed
ANNUAL Collection of other water-quality samples	Cost not available			Cost not available	\$0
ANNUAL Laboratory fees for water-quality analyses	Cost not available			Cost not available	\$0

8. Tennessee River near Paducah, KY (USGS and ORSANCO)

USGS data collected from 1973 to the present day, ORSANCO data collected from approximately 1975 to the present day. This station provides concentrations and, when streamflow is known, loads from both the Tennessee and Cumberland River as they are mixed at / below the lakes. This site pairs with the joint monitoring station “Cumberland River at Pinkneyville, KY” as noted above.

Table 6. Tennessee River near Paducah, KY; Funding needs:

Component	Required		ORSANCO	USGS	Needed
ANNUAL Collection of other water-quality samples	\$47,000		Cost not available	\$47,000	\$0
ANNUAL Laboratory fees for water-quality analyses	\$22,577		Cost not available	\$22,577	\$0

9. Ohio River at Olmsted lock and dam, KY (USGS) and Ohio River at lock and dam 52 (ORSANCO);

While the USGS and ORSANCO monitoring sites are positioned at slightly different locations on the Ohio River, they effectively function as a single site. USGS data near Olmsted Lock and dam has been collected from 1954 to the present day. This site is equipped as a USGS “sentry gage” with real-time water-quality and streamflow instrumentation; real-time data (available at <http://waterdata.usgs.gov/ky/nwis/>) include stream velocity and discharge (to determine loads), pH, dissolved oxygen, temperature, specific conductance, nitrate, and turbidity. This station shows what is entering the Mississippi River at the bottom of Kentucky. Note that this is a very large site with complexities related to the lock and dam; therefore, this site has a slightly higher annual operation and maintenance cost related to streamflow. ORSANCO data at Lock and Dam 52 has been collected from approximately 1993 to the present day. This station also provides concentrations and loads entering the Mississippi River from the Ohio River basin.

Table 7. Ohio River at Olmsted Lock and Dam / L&D 52, KY; Funding needs:

Component	Required	ORSANCO	U.S. Army Corps of Engineers (USACE); funding partner at Olmsted only	USGS	Needed
ONE-TIME Construction of gage and first year operation for streamflow	\$26,000		\$26,000		\$0
ONE-TIME Cost of 5-parameter water-quality sonde	\$9,000			\$9,000	\$0
ONE-TIME Cost of Nitrate sonde	\$24,000			\$24,000	\$0
ANNUAL Operation and Maintenance of surface-water gage (after first year)	\$21,200		\$21,200	\$0	\$0
ANNUAL Operation and Maintenance of 5-parameter water-quality sonde	\$27,000			\$27,000	\$0
ANNUAL Operation and Maintenance of nitrate sonde	\$12,000			\$12,000	\$0
ANNUAL Collection of other water-quality samples	\$48,000	Cost not available		\$48,000	\$0
ANNUAL Laboratory fees for water-quality analyses	\$22,577	Cost not available		\$22,577	\$0

Two stations have short-term funding through a partnership between the Kentucky Governor’s Office of Agricultural Policy (GOAP), USGS, the Kentucky Corn Growers Association (KYCGA), and ORSANCO. Note that the GOAP / USGS / KYCGA agreement is multi-year and was broken into annual costs for this summary; given that, funding percentages per partner are APPROXIMATE and for reference only. These short-term stations collect data on specific constituents that are described by site below; these sites are (from upstream):

10. Ohio River near Greenup, KY (GOAP, USGS, KYCGA, ORSANCO)

USGS data has been collected from 1970 until discontinued in 2007 due to funding cuts; station was re-established in 2013 as part of new short-term agreement between USGS, GOAP, and KYCGA (funding expires for this station at the end of 2015). Constituents sampled for at Greenup by USGS differ from other sites as described above; here USGS also samples for: silica, nutrients (total and dissolved forms), suspended sediment (sand/fine break and concentration), field parameters (pH, dissolved oxygen, temperature, specific conductance, and turbidity), and streamflow at the time of sampling. ORSANCO data and methods are consistent with other ORSANCO stations noted above and have been collected from approximately 1992 to the present day. This station is critical in that it provides concentrations and, when streamflow is known, loads coming into Kentucky from upstream in the Ohio River basin. Note that two options for this site are presented below; first is a continuation of the work presently begin performed in order to establish statistically-significant data for trends and loads of the constituents described, second is an option to significantly upgrade the site to become a USGS “sentry gage” with much greater real-time capability.

Table 8. Ohio River near Greenup, KY; Funding needs to continue work at present scope:

Component	Required	ORSANCO	KY Corn Growers (Approximate)	GOAP (Approximate)	USGS (Approximate)	Needed after 2015
ANNUAL Collection of other water-quality samples	\$51,780	Cost not available	\$500	\$30,568	\$20,712	\$51,780
ANNUAL Laboratory fees for water-quality analyses	\$4,575	Cost not available		\$2,745	\$1,830	\$4,575

Table 9. Ohio River near Greenup, KY; Funding needs to upgrade site to match data collected at other USGS “sentry gages” as noted herein:

Component	Required	Needed
ONE-TIME Construction of gage and first year operation for streamflow (acoustic sensor required)	\$40,000	\$40,000
ONE-TIME Cost of 5-parameter water-quality sonde	\$9,000	\$9,000
ONE-TIME Cost of Nitrate sonde	\$24,000	\$24,000
ANNUAL Operation and Maintenance of surface-water gage (after first year)	\$19,500 reduced to \$14,000 after rating developed	\$19,500
ANNUAL Operation and Maintenance of 5-parameter water-quality sonde	\$27,000	\$27,000
ANNUAL Operation and Maintenance of nitrate sonde	\$12,000	\$12,000
ANNUAL Collection of other water-quality samples (if desired to continue)	\$51,780	\$51,780
ANNUAL Laboratory fees for water-quality analyses (if desired to continue)	\$4,575	\$4,575

11. Green River at Spottsville, KY (GOAP, USGS, KYCGA) and Green River at Sebree, KY (ORSANCO)

The USGS station was established in 2013 as part of a new short-term agreement between USGS, GOAP, and KYCGA (funding expires at the end of 2015 for this station). This site is equipped as a USGS “sentry gage” with real-time water-quality and streamflow instrumentation; real-time data (available at <http://waterdata.usgs.gov/ky/nwis/>) include stream velocity and discharge (to determine loads), pH, dissolved oxygen, temperature, specific conductance, nitrate, and turbidity. Currently, USGS is operating the real-time water-quality equipment with short-term federal funding; however, long-term funding needs to be arranged to continue this data collection beyond 2015. Manual water-quality parameters collected at the site are similar to the Ohio River at Greenup station noted above. ORSANCO data and methods are consistent with other ORSANCO stations noted above and have been collected from approximately 1975 to the present day. The ORSANCO Green River at Sebree, KY station correlates with the USGS Spottsville, KY station; these stations provide concentrations and loads and assist in identifying fate and transport mechanisms for nutrients and other constituents from within the Green River basin.

Table 10. Green River at Spottsville / Sebree, KY; Funding needs:

Component	Required	ORSANCO	KY Corn Growers (Approx.)	GOAP (Approx.)	KDOW (Approx.)	USGS (Approx.)	Needed after 2015
ONE-TIME Construction of gage with acoustic technology and first year operation for streamflow	\$40,200		\$500	\$23,620		\$16,080	\$0
ONE-TIME Cost of 5-parameter water-quality sonde	\$9,000					\$9,000	\$0
ONE-TIME Cost of Nitrate sonde	\$24,000					\$24,000	\$0
ANNUAL Operation and Maintenance of surface-water gage (after first year)	\$19,500 reduced to \$14,000 after rating developed			\$11,700		\$7,800	\$14,000
ANNUAL Operation and Maintenance of 5-parameter water-quality sonde	\$27,000					\$27,000	\$27,000
ANNUAL Operation and Maintenance of nitrate sonde	\$12,000				\$2,000	\$12,000	\$10,000
ANNUAL Collection of other water-quality samples	\$54,552	Cost not available		\$32,732		\$21,820	\$54,552
ANNUAL Laboratory fees for water-quality analyses	\$7,350	Cost not available		\$4,410		\$2,940	\$7,350

One station has all equipment and is, operationally, complete, however, the station is lacking funding for operation and maintenance. Current funding partners are Sanitation District No. 1 of Northern Kentucky (SD1), USGS, and KDOW.

12. Licking River at Hwy 536 near Alexandria, KY (USGS, SD1, KDOW) and Licking River at Covington, KY (ORSANCO)

USGS Site was established in 2007 as part of a monitoring program with SD1. Data collected at this site included basic water-quality data (pH, specific conductance, dissolved oxygen, temperature, and turbidity) from 2007 until 2013 when the water-quality data was no longer needed by SD1 and only streamflow data was required. Once this station begins to collect agricultural-based water-quality data as noted below, it will provide concentrations and loads from the Licking River basin and will assist in identifying fate and transport mechanisms for nutrients and other constituents. Currently, SD1 and USGS fund the full operation of the streamflow portion of the gage (operation and maintenance for streamflow are covered). SD1 has also purchased the 5-parameter water-quality sonde for the station (temperature, dissolved oxygen, specific conductance, pH, and turbidity) and USGS has purchased a nitrate sonde. KDOW has supplied funding for construction of the site and operation and maintenance for the nitrate sonde. Given that, there is presently no funding for operation and maintenance of basic 5-parameter water-quality sonde at the site and those parameters are needed to provide complete information at the site. ORSANCO data has been collected from approximately 1975 to the present day following procedures as noted above; as with other paired sites, the USGS and ORSANCO site correlate and provide concentrations and loads originating from the Licking River basin.

Table 11. Licking River at Hwy 536 near Alexandria, KY; Funding needs:

Component	Required	ORSANCO	SD1	KDOW	USGS	Needed
ONE-TIME Construction of standard gage and first year operation for streamflow	\$26,000		\$15,600		\$10,400	\$0
ONE-TIME Construction to upgrade existing older station for water quality	\$6,000			\$6,000		\$0
ONE-TIME Cost of 5-parameter water- quality sonde	\$9,000					\$9,000
ONE-TIME Cost of Nitrate sonde	\$24,000				\$24,000	\$0
ANNUAL Operation and Maintenance of surface-water gage (after first year)	\$14,000		\$8,400		\$5,600	\$0
ANNUAL Operation and Maintenance of 5-parameter water-quality sonde	\$27,000					\$27,000
ANNUAL Operation and Maintenance of nitrate sonde	\$12,000			\$12,000		\$0
ANNUAL Collection of other water- quality samples (if desired – see above for examples)	TBD					TBD – site specific
ANNUAL Laboratory fees for water- quality analyses (if desired – see above for examples)	TBD					TBD – site specific

The final two stations currently have no equipment on site and are not funded; therefore, these monitoring stations would be new construction projects. Historical streamflow and water-quality data have been collected in the areas; however, only very limited data have been collected at the mouths of these basins (no long-term data that are critical to quantifying trends and loads). No funding partners have been identified for these sites.

13. Kentucky River (site to be determined).

When established, data from this station will provide a means to calculate concentrations and loads originating from the Kentucky River basin and will assist in identifying fate and transport mechanisms for nutrients and other constituents.

14. Obion Creek OR Bayou De Chien / Mayfield Creek (site to be determined).

When established, data from this station will provides a means to calculate concentrations and loads originating from the Obion Creek OR Bayou De Chien / Mayfield Creek watersheds and will assist in identifying fate and transport mechanisms for nutrients and other constituents.

Table 12. Funding needs for miscellaneous new monitoring stations:

Component	Required	Needed
ONE-TIME Construction of <u>new station</u> and first year operation for streamflow	\$26,000	\$26,000
ONE-TIME Cost of 5-parameter water-quality sonde	\$9,000	\$9,000
ONE-TIME Cost of Nitrate sonde	\$24,000	\$24,000
ANNUAL Operation and Maintenance of surface-water gage (after first year)	\$14,000	\$14,000
ANNUAL Operation and Maintenance of 5-parameter water-quality sonde	\$27,000	\$27,000
ANNUAL Operation and Maintenance of nitrate sonde	\$12,000	\$12,000
ANNUAL Collection of other water-quality samples (if desired – see above for examples)	TBD – site specific	TBD – site specific
ANNUAL Laboratory fees for water-quality analyses (if desired – see above for examples)	TBD – site specific	TBD – site specific

While each site shown in figure 5 is described in detail above, the TOTAL cost required to build, operate, and maintain **the 3 critical monitoring sites with known funding deficits** is noted below in table 13. These monitoring sites are critical to document loads entering and leaving Kentucky's segment of the Ohio and Mississippi Rivers. Note that the funding needs, shown in the table below, provide, as an option, manually sampled constituents such as phosphate, silica, and so forth (again, these are noted in detail above). The funding needs noted as "w/o extra water-quality samples" only cover near real-time data for streamflow, nitrate, pH, turbidity, specific conductance, temperature, and dissolved oxygen.

Table 13. TOTAL funding needs for the 3 critical monitoring sites with known funding deficits (Ohio River @ Greenup, KY; Licking River near Alexandria, KY; and Green River @ Spottsville, KY):

Site with funding deficit after 2015	Needed – one-time capital costs	Needed – annually after 2015
Ohio River near Greenup, KY (cost includes upgrade of site to USGS sentry gage). Note: This station, and the overall monitoring program, falls within the federal mission and, therefore, USGS may, depending on the availability of funds, provide federal matching dollars to offset the costs shown.	\$59,000	\$53,000 (w/o extra water-quality samples); \$110,000 (with extra water-quality samples)
Licking River at Hwy 536 near Alexandria, KY Note: USGS, Sanitation District of N. Kentucky, and KDOW have already committed some percentage of the annual funding required. This site has not been assessed to provide an accurate estimate for the collection and processing of manual water-quality samples; however, these costs are assumed to be comparable to other sites as shown in this table.	\$9,000	\$27,000 (w/o extra water-quality samples) APPROXIMATELY \$110,000 (with extra water-quality samples)
Green River at Spottsville / Sebree, KY Note: KDOW has already committed some percentage of the annual funding required. This station, and the overall monitoring program, falls within the federal mission and, therefore, USGS may, depending on the availability of funds, provide federal matching dollars to offset the costs shown.	\$0	\$51,000 (w/o extra water-quality samples); \$113,000 (with extra water-quality samples)
TOTAL	\$68,000	\$131,000 (w/o extra water-quality samples) \$333,000 (with extra water-quality samples)

Groundwater Monitoring Needs: Recommendations

Specific comments and recommendations offered by KASMC regarding Kentucky's groundwater monitoring needs are provided below:

- Groundwater-quality monitoring is generally logistically and technically more complicated than surface- water monitoring. Unlike surface streams, which may often be accessed at multiple locations according to convenience, groundwater is accessible only through suitably located and constructed wells. In addition, unlike surface streams, conditions that may affect the quality of groundwater sampled at a well are not directly observable. Factors such as the contributing area, and groundwater flow paths, velocity and residence time in the part of the aquifer sampled by a well are indeterminable unless appropriate methods of aquifer testing and hydrogeologic mapping are first employed. KASMC supports research studies aimed at improving knowledge of the hydrogeology of the state's more productive and heavy-utilized aquifers.
- Real-time *in situ* monitoring of water-quality parameters (pH, conductivity, turbidity, nitrate, etc.) proposed elsewhere in this document for Kentucky's streams is not practical or advisable for water wells because the natural flow rates and exchange of water in-and-out of a well are typically slow and may result in a large volume of relatively stagnant water stored in the wellbore. Conventional groundwater sampling procedures typically require that 3-5 borehole volumes be purged from a well prior to collection of samples, and measurements of changes in water-quality parameters such as pH and conductivity are often monitored during the purging procedure to determine the time at which fresh groundwater is being withdrawn.
- Contrary to the previous paragraph, *in situ* monitoring of water-quality parameters can be successfully accomplished at karst springs in the same manner as surface streams. A basic 4-parameter water-quality instrument (pH, specific conductance, temperature, and dissolved oxygen) typically costs approximately \$8,000, excluding installation, routine maintenance, and data processing/quality assurance costs. KASMC supports the establishment of new groundwater monitoring stations at selected karst springs, particularly where such sites may be used as supplemental monitoring locations for stream monitoring sites discussed elsewhere in this document. Estimated costs are anticipated to be in line with stream monitoring sites, depending on the size (discharge) and physical topographic setting. Prior to the establishment of a spring monitoring station, tracer test data should be consulted to determine the geographic extent of the catchment area of the spring, and to enable land uses that may affect groundwater quality to be identified. For this reason, KASMC advocates funding support for KDOW and KGS to continue conducting water-tracer tests in karst areas needed to complete the state's Karst Groundwater Basin Series maps (<http://www.uky.edu/KGS/water/general/karst/karstgis.htm>).
- Groundwater quality regarding nutrients is especially relevant as elevated concentrations of nutrients in groundwater, if detected, could potentially discharge to streams for many years (fig. 12). In these instances, typical edge-of-field BMPs may not directly address the issue and nutrients could potentially persist for years in adjacent surface waters regardless of BMPs. KASMC advocates the initiation of additional research and monitoring studies such as the present USGS Little River Basin project which utilizes advanced isotope and microbial

fingerprinting techniques to help identify the sources of nutrient and microbial contaminants and track their movements.

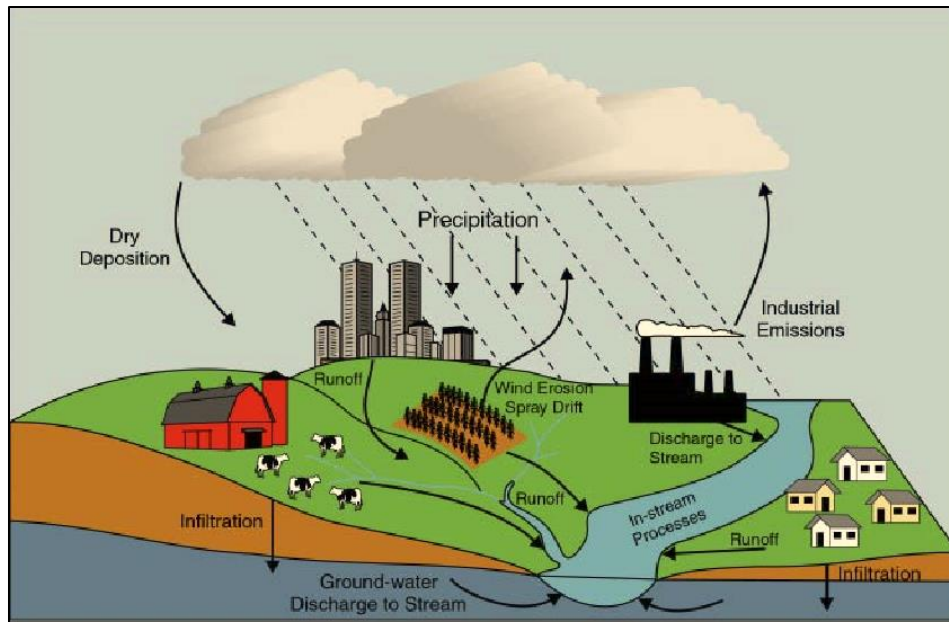


Figure 12. Nutrient movement in the hydrologic cycle (Belval and Sprague, 1999). Figure 10.

- The new long-term groundwater-level observation network (KGON) and pilot aquifer mapping study currently being planned and implemented by KGS are anticipated to provide up-to-date information about groundwater availability crucially needed to support agricultural irrigation. These data are also crucial to the needs of other groundwater users, including those reliant on public and private water wells as sources of potable water. Therefore, KASMC fully supports these efforts and will cooperate to help KGS and its partners (KDOW, USGS, ITAC) successfully implement these projects.
- As a final recommendation, it is suggested that the status of groundwater data and monitoring in Kentucky relative to agricultural concerns be reviewed by the KASMC during the first quarter of 2015 and every year thereafter. Data availability, interpretations, needed funding support, and other pertinent issues relative to ensuring proper use and management of the state's groundwater resources, and their long-term viability, will be discussed at these annual reviews and additional KASMC recommendations can be put forward to the appropriate partners.

Measures of Success

Measures of success will be determined by the ability to establish, and maintain, long-term surface-water monitoring stations and groundwater wells that defensibly and accurately quantify and qualify relevant water-quantity and water-quality constituents that relate both directly and indirectly, to agriculture

Task 4 - Continued outreach and education

KASMC will maintain a public presence and actively engage all agricultural entities within the Commonwealth of Kentucky and, as applicable, the surrounding region. These outreach and education activities will serve to gain public awareness of KASMC's mission and agricultural science and monitoring issues within Kentucky.

Measures of Success

Staffing KASMC displays and actively participating in community activities such as the meetings / conventions of the Kentucky Association of Conservation Districts, school events, and other agricultural-based forums. To date, KASMC members have actively reached out to the community on many occasions. For example, KASMC members have given numerous talks and have organized events to assist our partners and the agricultural community as a whole (figs. 13 and 14).



Figure 13. KASMC members from the US Geological Survey (Howard Reeves - left) and the Kentucky Geological Survey (Charles Taylor - right) discuss irrigation at the 2013 AgriBusiness Association of Kentucky's annual meeting. These talks were given at the request of fellow KASMC member Jay McCants.



Figure 14. KASMC members touring the research facilities at Murray State University during the 2nd annual KASMC executive meeting in Murray, Kentucky.

Task 5 - Continued collaboration and sharing of resources

KASMC will actively seek to collaborate and share resources to increase the effectiveness of limited resources and to better address agricultural science and monitoring needs in Kentucky. Calls for proposals, request for assistance, and(or) other opportunities to apply, or improve, agricultural science and monitoring in Kentucky will, as applicable and possible, be coordinated within the KASMC community to leverage available skill sets, areas of expertise, and financial resources.

Measures of Success:

Development of collaborative studies incorporating personnel, equipment, and(or) funding from multiple KASMC partners is ongoing. To date KASMC members have actively collaborated on numerous smaller projects (fig. 15) and have partnered to fund several critical monitoring locations identified in Task 2 above. KASMC members from the Kentucky Governor's Office of Agricultural Policy and USGS partnered to construct and operate a critical monitoring station at the mouth of the Green River in western Kentucky to monitor nutrients from this basin where land use is predominately agricultural (fig. 16).



Figure 15. KASMC members from Kentucky State University (Farm Manager Eddie Reed) and USGS (Hydrologic Technician Ryan Thompson) at a new streamgage built on the Kentucky State University (KSU) research farm in Frankfort, Kentucky. The gage was constructed with surplus USGS equipment and donated labor from KSU and USGS staff. This gage will benefit students and researchers at KSU and was the result of KASMC-lead collaboration.

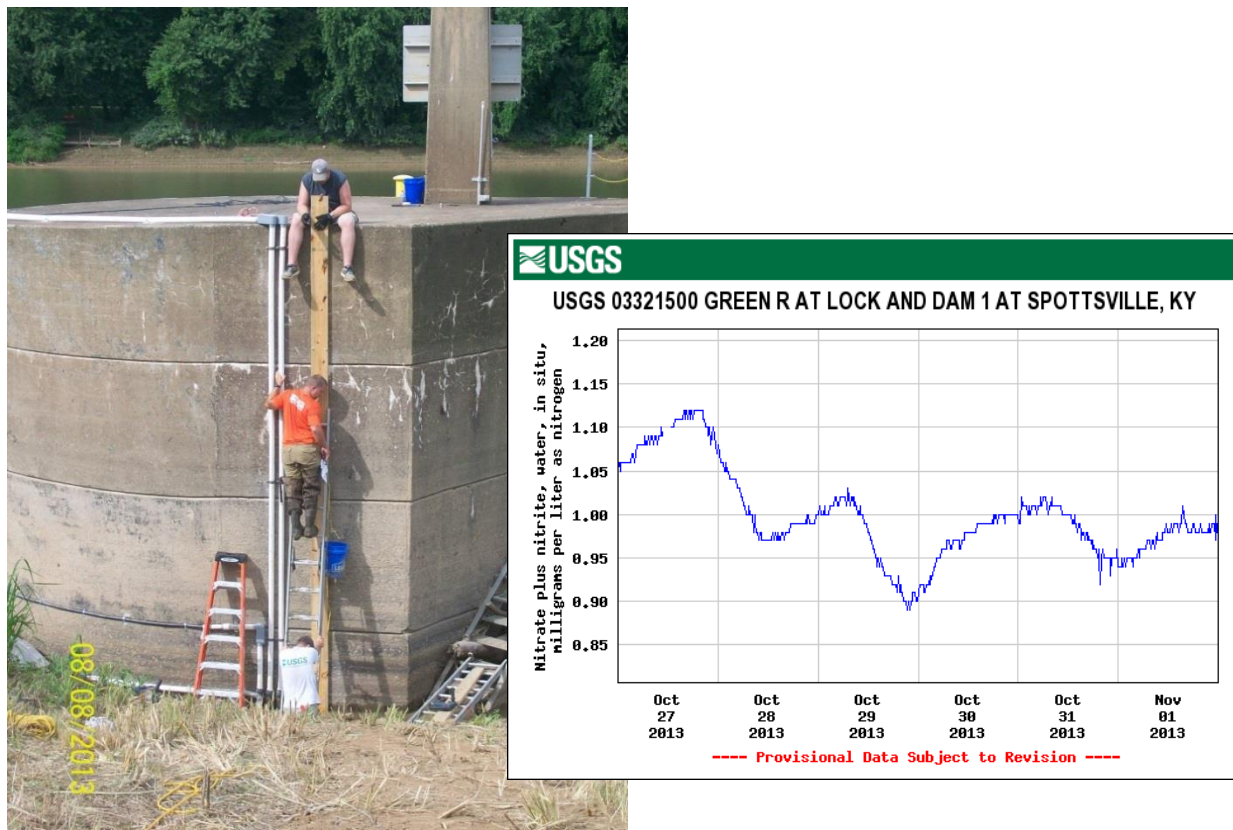


Figure 16. Monitoring station located at the mouth of the Green River at Spottsville, KY and example real-time nitrate data. This monitoring station was constructed and will be operated through 2015 under a KASMC-based partnership between the Kentucky Governor's Office of Agricultural Policy (GOAP), Kentucky Corn Growers Association (KyCGA), and US Geological Survey (USGS).

Recommended KASMC focus areas:

A long-term goal of KASMC is to develop studies to better quantify agriculture-related processes such as storm-water runoff; fate and transport of nutrients, pesticides, and pathogens; and BMP effectiveness. Ideally these studies would occur at, or near, production-agriculture facilities to enable “real-world” applications, data sharing, and cost effectiveness. The model for this task is based, in part, upon “Discovery Farms” programs located in Wisconsin and North Dakota (links provided below) that KASMC would like to emulate in Kentucky.

<http://www.uwdiscoveryfarms.org/>

http://nd.water.usgs.gov/discoveryfarms/nd_farms/index.html

Anticipated Products:

Publications that quantify the effects of various agricultural practices and processes will be produced; these publications will be intended to assist in the development of sustainable, productive agriculture while helping to protect the environment and human health. Studies and publications will generally have a direct connection to the mission of the Kentucky Agriculture Water Quality Authority (AWQA).

Measures of Success:

Creation of a coordinated study site on, or near, a representative Kentucky production-agriculture facility.

References

Belval, D.L., and Sprague, L.A., 1999, Monitoring Nutrients in the Major Rivers Draining to Chesapeake Bay, U.S. Geological Survey Water-Resources Investigations Report 99-4238, 8 p.

Helsel, D.R., and Hirsch, R.M., 2002, Statistical methods in water resources: U.S. Geological Survey Techniques of Water-Resources Investigations, book 4, chap. A3, 510 p.

Ohio River Valley Sanitation Commission (ORSANCO), 2014, Bimonthly Water Quality Sampling, accessed on-line at <http://www.orsanco.org/bimonthly-water-quality-sampling> on 1/27/2014.

Searcy, J.K., 1959, Flow-duration curves, Manual of hydrology—Part 2. Low-flow techniques: U.S. Geological Survey Water-Supply Paper 1542-A, 33 p.

US Geological Survey (USGS), 2014, Water-Quality Methods & Techniques, accessed on-line at <http://water.usgs.gov/owq/methods.html> on 1/27/2014.