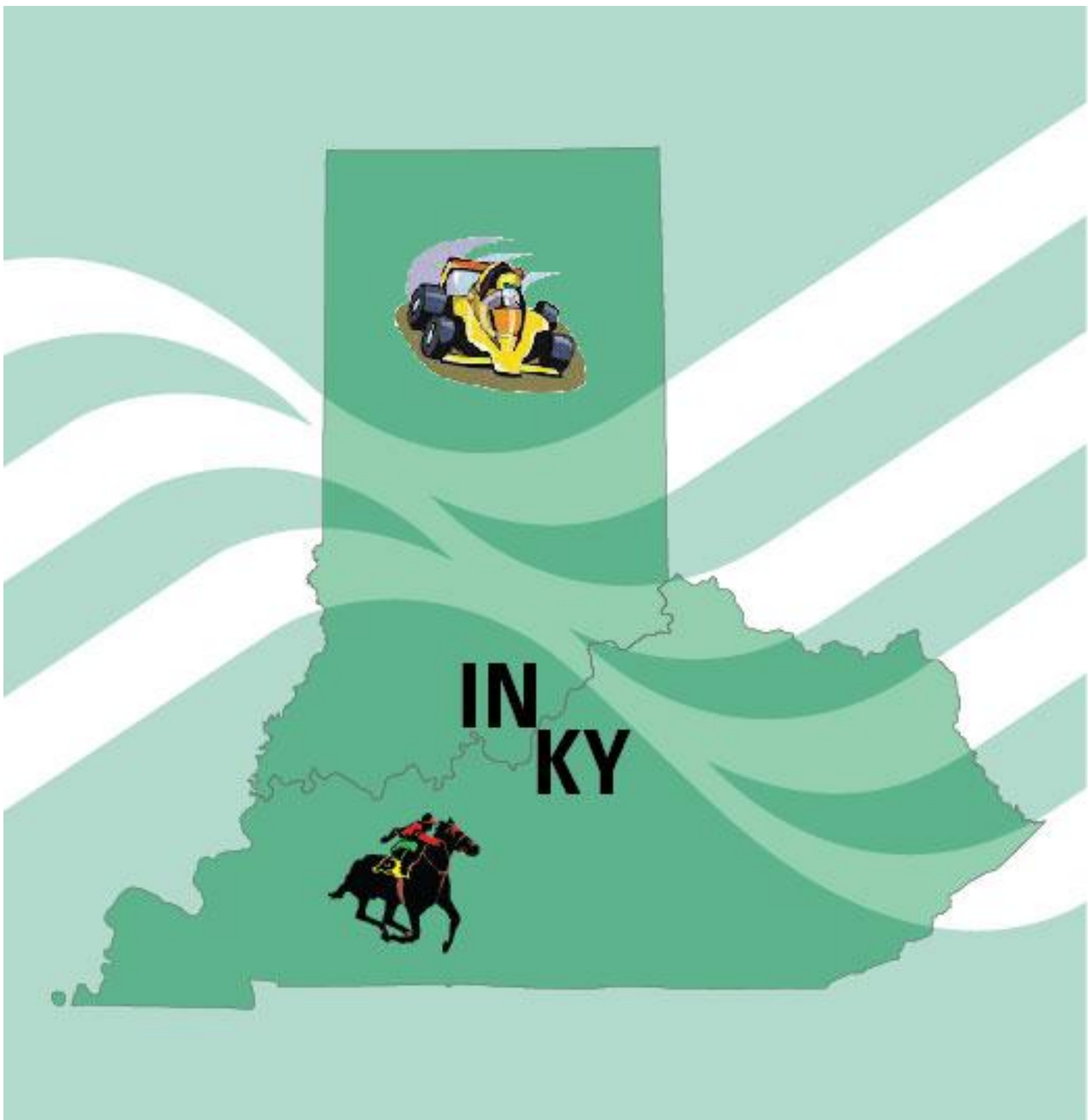
U.S. Geological Survey Indiana–Kentucky Water Science Center Commonwealth Strategic Science Plan, 2012–17



U.S. Department of the Interior
U.S. Geological Survey

Acknowledgments

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Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Area	
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m^3/s)

Abbreviations used in this report

BMPs - best-management practices
CAFOs - concentrated animal feeding operations
CSG – crest stage gage
CSOs - combined sewer overflows
DSS – decision support system
FY – fiscal year
GIS – geographic information system
IDEM – Indiana Department of Environmental Management
IDNR – Indiana Department of Natural Resources
IWRSS - Integrated Water Resources Science and Services
KDOW – Kentucky Division of Water
NADP – National Atmospheric Deposition Program
NAWQA - National Water-Quality Assessment
NHD - National Hydrographic Dataset
NWS – National Weather Service
USGS – U.S. Geological Survey
WATER - Water Availability Tool for Environmental Resources
WIM - Wisconsin Internet Mapping
WSC – Water Science Center

Executive Summary

The USGS Indiana–Kentucky Water Science Center Commonwealth provides reliable hydrologic and water-related ecological information to aid in the understanding of the use and management of water resources in Indiana, Kentucky, and the Nation. Input for the new 3–5 year Commonwealth strategic science plan was received from cooperators, stakeholders, and staff and was considered in the development of the objectives and strategic actions for each of six science-focus areas:

1. **Hydrologic Monitoring Networks:** Strategic actions for the next 3–5 years include optimizing and expanding Indiana and Kentucky surface-water, groundwater, water-quality, and precipitation networks in order to provide a foundation for activities within the other five science-focus areas.
2. **Hazards:** Strategic actions for the next 3–5 years include building geospatial tools for hazards monitoring, investigating stream dynamics and erosion hazards, studying karst hazards, investigating transport and fate of contaminants, and investigating dam and levee stability.
3. **Ecosystems Science:** Strategic actions for the next 3–5 years include the establishment of "supergage" monitoring stations, investigating drivers of ecosystem health, studying broad regional issues such as Gulf of Mexico hypoxia, and studying emerging issues that affect ecosystem health.
4. **Water Availability and Demand:** Strategic actions for the next 3–5 years include developing data and interpretive products for water management; addressing groundwater-data needs; determining impacts of climate change; and evaluating relations between landscapes, water withdrawal and returns, streamflow, and ecological functions.
5. **Energy Production and Impacts:** Strategic actions for the next 3–5 years include convening professional meetings dedicated to understanding the impact of energy production on water resources, developing techniques of ecological assessment for sites impacted by energy production, strengthening geophysical capabilities for studies of energy production and refuse storage, developing an understanding of soil-gas intrusion, and assessing the impact of biofuel crops on water quality and quantity.
6. **Public Health:** Strategic actions for the next 3–5 years include increasing the understanding of public health related to water resources, applying technologies for identifying and measuring pathogens at beaches and within watersheds, and using fate and transport models to enhance methods of assessing environmental impacts of influences on public health.

Introduction

The mission of the U.S. Geological Survey (USGS) is to serve the Nation by providing reliable scientific information to describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect our quality of life. As the Nation's largest water, earth, and biological science and civilian mapping agency, the USGS collects, monitors, analyzes, and provides scientific understanding about natural resource conditions, issues, and problems. The diversity of our scientific expertise enables us to carry out large-scale, multi-disciplinary investigations and provide impartial scientific information to resource managers, planners, and other stakeholders (U.S. Geological Survey, 2011). Having a workforce of about 9,000 employees with diverse backgrounds, education, and experience, the USGS can bring a unique integrated approach to the Nation’s water-resource issues. The USGS is an interdisciplinary scientific agency, and the interdisciplinary nature of the workforce and organizational structure brings strength to its capability.

USGS water science starts within Water Science Centers (WSCs), located in every State in the Nation. These WSCs build important relationships with State and local agencies that are vital to the management of water resources in the United States. These WSCs are supported by a regional and national structure, which includes offices dedicated to providing development of models, methods, tools, databases, and quality-assurance measures to support the WSCs and maintain consistency in USGS programs and products.

The USGS Indiana and Kentucky WSCs work together closely, under one Director, within a “Commonwealth” model. The Indiana-Kentucky WSC Commonwealth is organized with a Deputy Director in each State office who reports to the Director. Technical and support staff in each State report to the Deputy Director. The combined staff of the Commonwealth is approximately 100 employees, which is composed of hydrologists, research hydrologists, hydrologic technicians, biologists, geospatial specialists, management, administration, and information technology support personnel. The USGS Indiana WSC office is located in Indianapolis, Indiana. The USGS Kentucky WSC consists of three offices: Louisville, Kentucky (main office), Murray, Kentucky (field office), and Williamsburg, Kentucky (field office) (fig. 1).

Figure 1. U.S. Geological Survey Water Science Center offices in Indianapolis, Indiana (top left), and Louisville, Kentucky (bottom left), and field offices in Murray, Kentucky (top right), and Williamsburg, Kentucky (bottom right).

The USGS Indiana-Kentucky WSC Commonwealth model allows the two WSCs to more effectively share resources and staffing to address problems common to both States, while still maintaining a strong focus on issues specific to each State individually. The Commonwealth concept will improve the level of service the USGS provides to Indiana and Kentucky and at the same time will increase efficiencies by having a Director and other support staff shared by both WSCs.

Core Strengths

USGS strengths include national quality-assurance standards and policies; the long-term archiving of hydrologic data, reports, and other products; and the unbiased science that underlies every mission activity of the agency. Two other major strengths of the USGS are a business model that supports a high level of partnering with other agencies, academia, and the private sector; and a diverse workforce of scientists and physical-science technicians from multiple disciplines, which allows the agency to apply an integrated scientific approach to water-resource problems.

Core scientific strengths of the USGS Indiana-Kentucky WSC Commonwealth include

- Real-time hydrologic monitoring of streamflow at 413 surface-water gaging stations and real-time water-quality data available online at 66 of these locations

- Collection of long-term water-level data from a statewide network of groundwater wells and real-time monitoring at 111 wells
- Database of hydrologic and water-quality information with Internet-based and mapping interfaces
- A National Water-Quality Assessment (NAWQA) study unit for the White River and Miami River Basins in Indiana and Ohio
- Two statewide-monitoring networks for the presence of mercury in streams and precipitation
- Investigations into the effects of nutrients on algal biomass and biological communities
- Biological monitoring of aquatic communities
- Active development of models to predict water-quality constituents, such as suspended sediment and phosphorous, using surrogate measurements
- Flood-inundation maps tied to USGS streamgages and National Weather Service (NWS) flood-forecast points
- Fluvial erosion hazard program and geomorphic analysis of fluvial systems
- Streamflow estimation for ungaged basins and delineation of small, upland streams
- Low-flow studies and drought-monitoring program
- Borehole and surface geophysics tools and studies
- Automated sampling for stream water and precipitation quality
- Bathymetric mapping tools and studies
- Karst hydrology and water-tracer tests
- Groundwater monitoring and modeling of the Ohio River alluvial aquifer and the effects of riverbank filtration
- Development of a "center of excellence" in watershed-modeling techniques and programming

Vision for USGS Science in Indiana and Kentucky

The USGS Indiana-Kentucky WSC Commonwealth provides reliable hydrologic and water-related ecological information to aid in the understanding of the use and management of water resources in Indiana, Kentucky, and the Nation.

The USGS Indiana-Kentucky WSC Commonwealth, through strong partnerships with our cooperators and stakeholders, strives to be a national leader in the water-resources community by consistently delivering high-quality hydrologic data in a timely and efficient manner.

Input for Strategic Science Directions

Input was collected from USGS cooperators, stakeholders, and staff to help determine strategic science directions for the USGS Indiana-Kentucky WSC Commonwealth for the next 5 years. The strategic science directions discussed in this report are focused on Indiana and Kentucky; at the same time, they align with national and regional USGS mission areas and programs. A number of listening sessions were held at multiple locations with USGS cooperators and stakeholders from Indiana and Kentucky to collect input for this plan. The listening sessions were framed with five key questions for participants:

1. What programmatic changes within your agency's priorities, if any, will change the direction of your water-resource programs?
2. What are the major water-resource issues facing Indiana/Kentucky, and what type of information/data will you need to better address these issues?
3. What do you think is the appropriate role of the USGS in Indiana/Kentucky water-resource programs?
4. What USGS information do you currently use, and how quickly do you consider USGS when water-resource issues arise?
5. When looking at the big water-resource issues in Indiana/Kentucky, what are some ways that Federal/State/local agencies can work together on a holistic approach to those bigger issues?

Science Objectives and Strategic Actions

The science objectives and strategic actions within this plan are organized into six major science-focus areas:

1. Hydrologic Monitoring Networks
2. Hazards
3. Ecosystems Science
4. Water Availability and Demand
5. Energy Production and Impacts
6. Public Health

The input received from Commonwealth cooperators, stakeholders, and staff was considered in the development of the objectives and strategic actions for each of the six science-focus areas.

Hydrologic Monitoring Networks

The USGS has the principal responsibility within the Federal Government to provide the hydrologic information and understanding needed by others to achieve the best use and management of the Nation's water resources. Basic data are the key to solving many water-quantity or -quality problems. The foundation of all USGS water-resource information is the long-term hydrologic monitoring networks. All of the programs, scientific analyses, and conclusions done by the USGS are based on data collection. For this reason, the Hydrologic Monitoring Networks focus area intersects with the other five focus areas presented in this plan (fig. 2); it is the backbone of our organization. There is a strong and continuing need for reliable and continuous measurements of water levels and streamflow for both operational and scientific purposes.

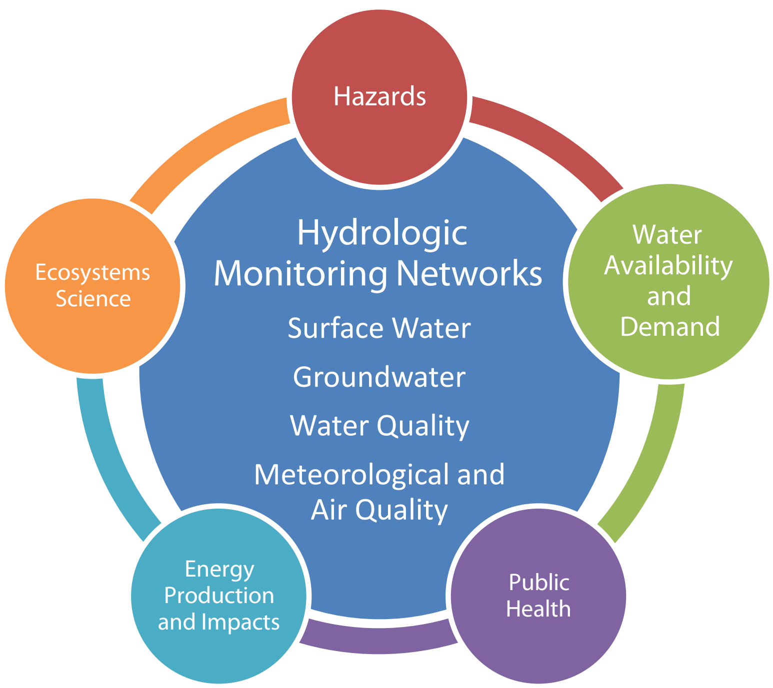

Figure 2. The foundation of all U.S. Geological Survey (USGS) water-resource information data from long-term hydrologic monitoring networks; all USGS science-focus areas depend on a monitoring component, and thus, intersect with the Hydrologic Monitoring Networks focus area.

The USGS operates (in 2012) a network of 202 surface-water-monitoring sites in Kentucky, all of which have their data transmitted in near real time to be available on the Internet. At 48 of the 202 sites, as many as 5 water-quality characteristics are routinely monitored (water temperature, specific conductance, dissolved oxygen, turbidity, and pH). The USGS also operates 1 real-time, groundwater-monitoring well and 95 real-time precipitation sites in Kentucky. Figure 3 provides locations of USGS fixed monitoring stations in Kentucky.

The USGS operates (in 2012) a network of 211 surface-water-monitoring sites in Indiana, all of which have their data transmitted in near real time to be available on the Internet. At 18 of the 211 sites, as many as 5 water-quality characteristics are routinely monitored (water temperature, specific conductance, dissolved oxygen, turbidity, and pH). The USGS also operates 16 real-time, groundwater-monitoring wells and 50 real-time precipitation sites in Indiana. Figure 4 provides locations of USGS fixed monitoring stations in Indiana.

Operation and maintenance of the surface-water-monitoring networks includes measuring streamflow during flood and drought conditions. Flooding is the single most costly and life threatening natural disaster in Indiana, Kentucky, and the Nation. Data from these networks are used to monitor streamflow and stream stage during flood conditions. The NWS uses streamflow data from the networks in their forecast models to provide flood warnings and alerts. Additionally, data from these networks are used to monitor streamflow during drought conditions, and the data are critical to State, local, and Federal officials who manage water availability and water use. Other users of these data have responsibility for power generation, habitat and wildlife protection, navigation, recreation, and flood control.

The results of the strategic-listening sessions were clear: continuing data collection and making it readily accessible on the Internet were of principle importance. To continue these efforts, there has to be sufficient funds to support the operations. Both Federal and State funds are expected to decline or at best remain flat over the next several years. Some of the listening-session responses pointed to the high cost of network operations and the cooperator's inability to continue to cover annual increases in these costs.

The addition of more real-time water-quality monitoring at existing surface-water-monitoring sites was a recurring theme in many of the listening sessions. In particular, there was interest in identifying less expensive surrogate measurements that could be an indicator of other water-quality constituents but could be continuously monitored.

These are primary goals to improve the availability of hydrologic information to address resource-management needs while helping to reduce the economic and human cost of natural disasters.

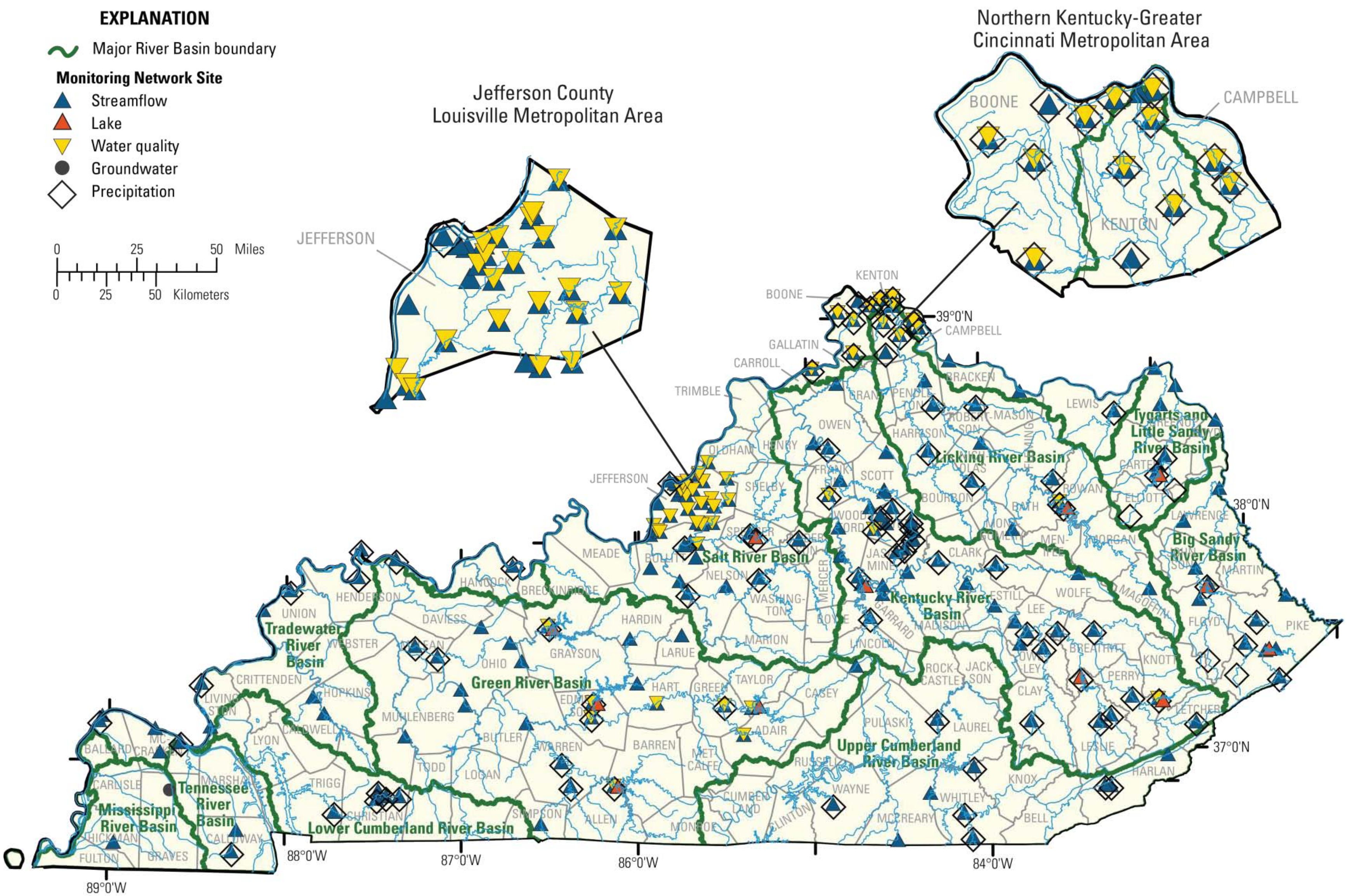

Figure 3. Active monitoring-network sites in Kentucky, 2012.

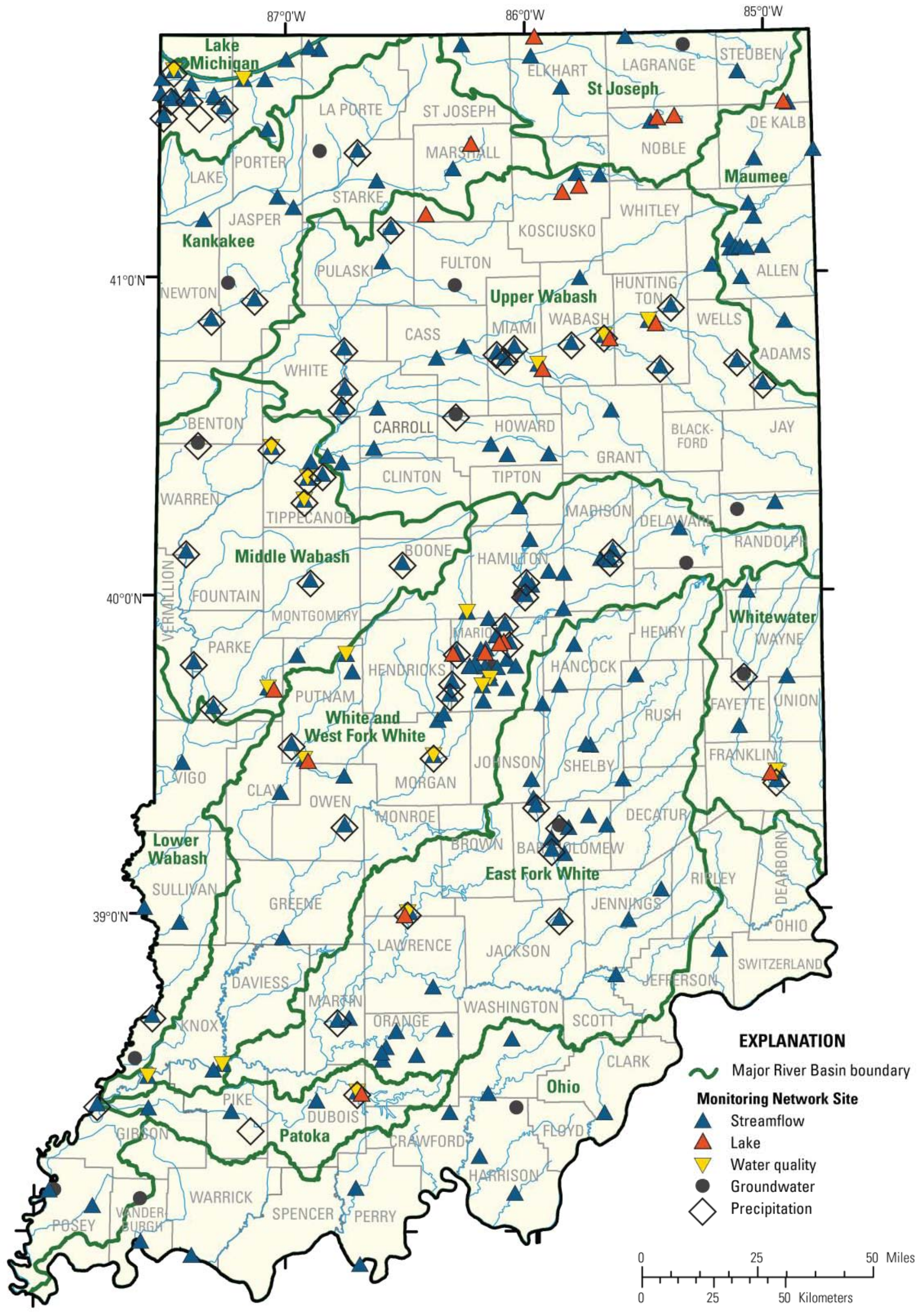

Figure 4. Active monitoring-network sites in Indiana, 2012.

Major questions for the Hydrologic Monitoring Network focus area include

1. How can the Indiana and Kentucky hydrologic monitoring networks be optimized to meet the objectives of the following five science-focus areas?
2. What gaps in network functions and coverage need to be filled to help water managers and policy makers make informed decisions for routine management, hazard mitigation, and enhanced resource planning in Indiana and Kentucky?

Objectives

The USGS Indiana-Kentucky WSC Commonwealth will work cooperatively to build and maintain observation networks and research programs that meet the following objectives:

1. Work to maintain its leadership in providing water-resources information for their States and the Nation. The quality of the hydrologic information provided by the Commonwealth will be the standard to which others are compared. The Commonwealth will strive to be on the forefront of hydrologic research and related technical capabilities.
2. Look for opportunities to reduce the hazards associated with data-collection activities. Advancements in acoustic technologies and other opportunities to use measurement methods that keep our personnel out of the water, off the ice, and out of roadways will be adopted where feasible and appropriate.
3. Use the tools available to monitor real-time data on the Internet and ensure it is accessible and accurate.
4. Maintain contingency operations at other offices in the event Indiana and Kentucky servers fail for an extended period of time. Explore new ways to enhance the accessibility and presentation of data on the Internet.

Strategic Actions and Products (next 3–5 years)

1. **Network Analysis**
   a. *Coverage*: Verify the geographical coverage of the network and identify any gaps.
   b. *Technology*: New techniques or equipment to improve data accuracy or efficiency in data collection.
   c. *Instrumentation*: Replace old and obsolete instrumentation.
   d. *Funding*: Maintain working relations with current cooperators and expand the cooperator base through networking.
   e. *Safety*: Address hazards that pose a danger to staff or environment on a short- or long-term basis.

2. **Surface-Water Networks**
    a. *Real-Time Streamgaging Network*: The goal over the next 5 years is to expand the network 1–5 percent while attempting to minimize cost increases. Another goal is the addition of more gages on small basins (less than 10 square miles).
    b. *Crest-Stage Gage Network*: The goals are to instrument, with simple pressure sensors, all Kentucky crest-stage gage sites, which will allow for quick capture of high-water events electronically, and to establish a crest-stage gage network for Indiana.
    c. *Rain-Gage Network*: The first goal for the rain-gage network is to create basin coverage by installing gages within the headwaters of the larger basins, which would be beneficial to flood forecasters. Another goal is to identify and reposition any rain gages that are not located in ideal locations.
    d. Develop a "Streamgaging 101" seminar and (or) presentations for cooperators and partners.
3. **Groundwater Networks**
    a. Indiana's network should be evaluated to identify data gaps and determine an optimal number of stations and the locations of those stations. For Kentucky, the lack of groundwater-observation wells necessitates the reestablishment of a statewide or "representative-aquifer" network. All of the wells should be equipped with continuous recorders and real-time telemeters.
4. **Water-Quality Networks**
    a. *Surface-Water Quality Network*: The goal is to increase the network 5–10 percent through new stations and installation at established surface-water sites.
    b. Add temperature probes to real-time gaging stations.
    c. Include the collection of a suspended-sediment sample with every streamflow measurement.
5. **Groundwater-Quality Network**
    a. The goal is to create statewide, real-time networks for selected sites across Indiana and Kentucky.

Milestones and (Timelines)

1. **Network Analysis**
    a. Produce a geographic information system (GIS) map product that will show all current networks and areas that need more attention in expanding (April 2012).
    b. Provide new technology training to personnel in both WSCs in order to build a workforce with both expertise and flexibility (continuous effort throughout both WSCs starting in 2012).
    c. Upgrade the Local Readout Ground Station (LRGS) at the Kentucky WSC and keep both centers up-to-date with the latest data-management software as it is released within the USGS.
    d. Increase the amount of face and phone time with cooperators to show them we have the same goals (starting in 2012).

e. Maintain the network including routine troubleshooting (strive to perform all the safety needs by 2015).

2. Surface-Water Networks

a. Determine where growth is needed from the GIS map product and make contacts in those areas. Have at least three meetings to attract potential cooperators, with each meeting including one current cooperator and several potential cooperators (annually, starting in 2012).
b. Add level sensors to one-half of the crest stage gage (CSG) network each year, starting with the sites that have long or multiple CSG staffs (annually).
c. Determine which existing rain gages need to be moved to collect accurate rainfall data, and relocate the affected rain rages (by the end of 2013). Meet with NWS personnel to get their input as to where new rain gages should be located (by the end of 2013). Meet with NWS personnel and potential, new, and existing cooperators to complete the network coverage (starting in 2012).
d. Develop a "Streamgaging 101" information module for presentations at cooperator and partnering meetings by 2013

3. Groundwater Networks

a. Meet with cooperators and stakeholders to begin a networks optimization and analysis program for the existing Indiana network and a new Kentucky network (first meeting by the end of FY 2012, then ongoing).

4. Water-Quality Networks

a. Meet with Lexington-Fayette Urban County Government personnel to continue talks about adding a water-quality network to the existing surface-water gages (early 2012).
b. Determine where growth is needed from the GIS map product and determine where overlap(s) may exist from the surface-water network. Begin talks with potential cooperators starting in spring 2012 with the intention of having a 0.5 percent growth each year.
c. Add temperature probes to existing sites at a rate of 1-3 per year starting in October 2012.
d. Start collecting a suspended sediment sample as streamflow measurements are collected and have the Kentucky Sediment Lab perform the analysis starting in October 2012.

5. Groundwater-Quality Network

a. Meet with cooperators and stakeholders in an attempt to build a program in Indiana and Kentucky with a groundwater-quality component (first meetings in FY 2012, then ongoing).

Hazards

USGS Hazards science encompasses both water- and geology-related extreme events, which often are sudden in occurrence and catastrophic in their effect on the Nation's people,

commerce, and infrastructure. Though many of these events may seem random and unpredictable, usually in hindsight it is realized that with proper planning, monitoring, and assessment, the hazards could have been anticipated and their adverse impacts mitigated or minimized. Therefore, perhaps more than any other mission area in the USGS, identification and evaluation of hazards requires anticipation of monitoring needs, real-time and long-term data collection, evaluation of past records of extreme hydrologic or geologic events, and development of improved numerical modeling tools that are capable of accurately forecasting and simulating the effects of naturally occurring or human-induced hazardous events.

Flooding is the one hazard that causes more deaths and damage than any other naturally occurring phenomena in Indiana and Kentucky. Nationally, three-quarters of all Federal-disaster declarations are owing, at least in part, to flooding; in terms of total flood damages assessed during 1955–63 and 1963–99, Indiana ranks 26th and Kentucky ranks 17th among all States (National Weather Service data *http://www.flooddamagedata.org*). Resource managers, policymakers, emergency responders, and the general public have long depended upon USGS networks, data, analysis, and modeling to help forecast or assess the occurrence and severity of flooding and flood impacts. Given the likelihood that extreme storm events become more intense and prevalent as a consequence of climate change, it is likely that future USGS program-development efforts will continue to be geared largely toward monitoring stream discharge, rainfall-runoff modeling, flood forecasting and flood-inundation mapping, and assessment of fluvial-erosion hazards.

A principal goal of the USGS is to lead the Nation in state-of-the-science hazards-monitoring and to maintain a hazards identification and research program built on a robust underpinning of hazards-data collection, analysis, assessment, and modeling. The USGS collects accurate and timely non-biased information from modern earth observation networks, assesses areas at risk from natural hazards, and conducts focused research to improve hazard predictions. In addition, the USGS works actively with the Nation's communities to assess the vulnerability of cities and ecosystems and to ensure that science is effectively applied to reduce losses.

The USGS Indiana-Kentucky WSC Commonwealth is well-positioned to serve these needs by providing critical hydrologic observations, geological-framework data, analytical methods and hydrologic/geologic modeling tools, and the scientific expertise needed to address hazards.

Major questions for the Hazards focus area include

1. What are the potential hazards that Indiana and Kentucky communities may face in the next 5 years?
2. What scientific information and data are needed to improve understanding and response to the risk that Indiana and Kentucky communities and ecosystems face from these hazards?
3. What gaps in scientific understanding and data need to be filled, or what improved data-analysis/modeling tools need to be developed, to help water managers and policymakers reduce the vulnerability of Indiana and Kentucky communities and ecosystems to hydrologic and geologic hazards?

Objectives

The USGS Indiana-Kentucky WSC Commonwealth will work cooperatively to build and maintain monitoring networks and research programs that meet the following objectives:

1. Identify, anticipate, and evaluate impacts of hydrologic and geologic hazards and extreme events, with focus in the five previously identified topical areas.
2. Apply USGS observational data and scientific resources to help communities identify their current and future exposure to water- and geology-related hazards that could lead to emergencies and conflicts. Elements necessary to identify such exposure include
    a. Assessments of current community exposure to hydrologic or geologic hazards
    b. Providing access to new and (or) improved science tools, such as Internet-based flood-inundation mapping tied to streamgages (fig. 5) to help water managers, policymakers, and the public understand the risks imposed by natural and human-induced water-related hazards.

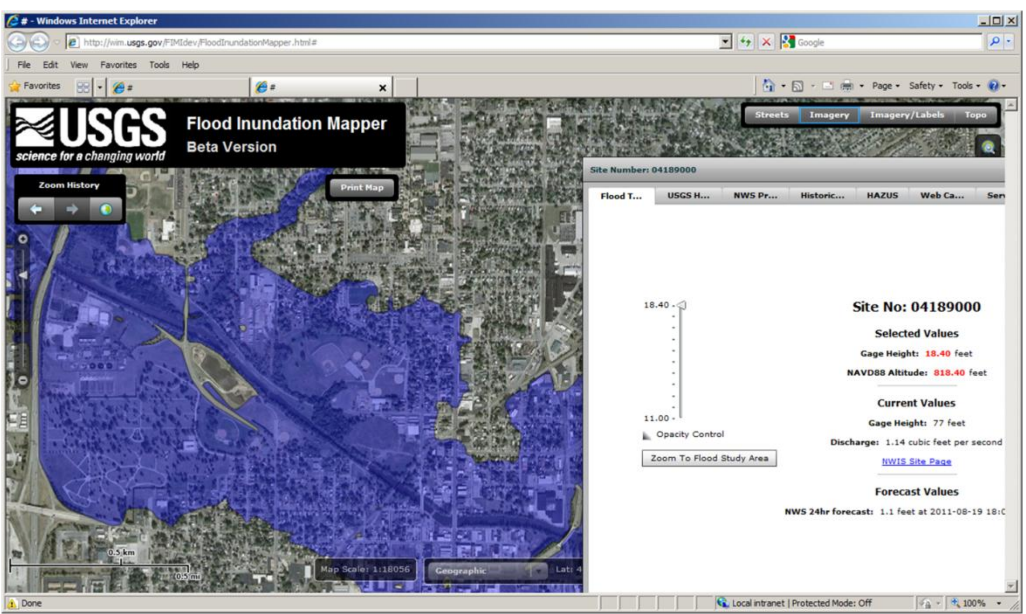

Figure 5. Example of flood-inundation mapping data available on the Internet.

c. Improved communication of USGS data and findings, regarding potential or actual hazards, to government agencies, watershed groups, and the general public through timely publications, oral presentations, the Internet, and as appropriate, through traditional news and modern social-media outlets.


Figure 6. Examples of impacts of fluvial-erosion hazards in Indiana include the threat of loss or major damage to a residence (left) and damage to a heavily travelled urban bridge in Indianapolis (right).

d. Increased staff involvement and exposure to scientific meetings and literature with the intention of building knowledge of important or critical hazard issues and increasing program-development opportunities.
e. Pursuing multidisciplinary and (or) multi-agency collaborative investigative studies of hazards issues.

3. Expand USGS monitoring networks (streamgaging, reservoir monitoring, and groundwater-monitoring sites), as needed, for assessing flooding and other hydrological emergencies (including drought), making operational decisions during extreme hydrologic events, and providing information needed to help with emergency response and longer-term recovery and hazard mitigation. There may be a need to
   a. Evaluate the distribution of streamgaging stations with regard to closing the gaps in basin or stream-reach coverage, or to expand the networks to include gages on presently unmonitored streams in high-risk areas upstream of urban populations and critical infrastructure where flooding may contribute to other hazards (such as tank farms, gas-transmission pipelines, and wastewater-treatment/disposal facilities).
   b. Pursue or develop new methods or technologies for improved early warning or for advanced monitoring, investigation, and assessment of the effects of potential hazards.
4. Develop new process-based hydrological modeling tools that fully utilize data collected from USGS and other observation networks and can be applied to forecast the occurrence and severity of hazardous conditions or extreme events, identify and evaluate contributing natural or human-induced factors, and aid in the planning or implementation of emergency response or hazard-mitigation efforts.

Strategic Actions and Products (next 3–5 years)

1. **Strategy - Networks**
    a. Coordinate data surveillance and investigative-project efforts with needs of partners.
    b. Work toward the development of a network optimized for flood-forecast monitoring and low-flow trend analysis to provide data needed for flooding and water-supply issues.
    c. Promote hydrologic-alert tools linked to the streamgaging network, such as the USGS WaterAlert program.
    d. Develop real-time and planning geospatial tools for hazards monitoring that are linked to USGS hydrologic monitoring networks and NWS hydrologic forecasting systems, including flood-inundation mapping linked to streamgages and flood-forecast points.
2. **Strategy – Flood-Inundation Mapping, Fluvial-Erosion Hazards, and Landslides**
    a. Program-development efforts should utilize the natural synergy between flooding and streamflow by building-in a geomorphic and streamflow-dynamics analysis as part of flood-monitoring and flood-inundation projects.
    b. Utilize geomorphologic expertise to help develop/address program needs related to assessment and mapping of potential landslide hazards, particularly within large river basins in Indiana and Kentucky.
    c. Continue to develop program in bridge scour and its countermeasures, stream restoration, sediment transport, debris transport and accumulation, fluvial geomorphology, stream ecology, and aquatic and riparian habitat.
3. **Strategy - Karst:** Attempt to develop projects by focusing more on the role of karst in flooding and in groundwater/surface-water interaction by conducting necessary field studies, including use of water-tracing tests, to investigate and characterize subsurface-flow routes and potential contaminant-transport characteristics in karst. Mapping the geographic distribution and density of karst features such as sinkholes and sinking streams is one of the more useful indicators of karst hazards potential and potential karst aquifer vulnerability. Recent pilot projects were conducted in Kentucky among the USGS, the Kentucky Division of Water (KDOW), and the USGS National Hydrographic Dataset (NHD) program to develop methods and protocols for adding karst drainage data to the NHD. Efforts should be made to expand upon this preliminary work and lead regional and (r) national collaborative efforts to incorporate local karst data into the NHD. A similar opportunity may exist to explore collaboration between the Commonwealth and the National Karst Map project coordinated by the USGS Geologic Division, Eastern Regional Mapping Program. Good potential exists for additional collaboration with flood-monitoring and flood-inundation focus areas, and with transport and fate of contaminant spills or releases.

4. **Strategy - Transport and Fate of Contaminant Spills or Releases:** Focus potential program-development efforts on needs for an Internet-based time-of-travel assessment tool and on the collection of field data needed to calibrate and verify reactive and non-reactive potential contaminants. There is potential for collaboration in the karst-hydrogeology focus area, particularly with regard to the utilization of water-tracer test methods and assessments of locations (watersheds) dominated by internal (sinkhole) drainage. Also focus on design and testing of new integrated real-time sensor technologies to serve as early warning "sentry" tools for protecting water supplies by detecting harmful substances introduced into surface water or groundwater, or to monitor for growth of toxic algae in surface-water supplies.
5. **Strategy - Dam, Pond, and Levee Stability:** Develop pilot projects where high-hazard dams and levees are monitored using geotechnical and embankment water sensors for assessing structural integrity combined with streamgages to monitor inflows and outflows. Maintain close communication and collaboration with USGS Office of Groundwater Branch of Geophysics as a potential way to expand project-development opportunities at the State, regional, and national levels. Develop pilot projects that simulate failure of dam and levee structures or systems and subsequent inundation.

Milestones and (Timelines)

1. **Strategy - Networks:**
    a. Develop project proposals (FY 2012–17) to create and apply a suite of hydrologic/geospatial modeling tools by leveraging existing resources such as the Federal Emergency Management Agency's RiskMAP program, the USGS Hazards Gateway, the Water Availability Tool for Environmental Resources (WATER) (*http://ky.water.usgs.gov/projects/waterbudget/index.html*), and StreamStats (*http://water.usgs.gov/osw/streamstats/*) (early 2012, and ongoing). The Integrated Water Resources Science and Services (IWRSS) (*http://www.nws.noaa.gov/oh/docs/IWRSS_1p_summary.pdf*) initiative may provide an ideal framework for this effort.
    b. Meet with State and Federal transportation departments, and possibly develop project proposals, to review and assess adequacy of existing State and Federal highway hydrologic-design data and procedures (early 2012, and ongoing). Key assumptions used for hydrologic design often include stationary, unchanging rainfall frequency established from the historical record, and the equivalence of the rainfall and runoff frequencies. Both of these assumptions may be questionable and could lead to less-than-optimal designs of hydraulic infrastructure and affect frequency and intensity of urban floods.
    c. Development of new procedures is warranted to estimate urban peak flows, runoff volumes, and hydrographs. Identify potential partner and develop project proposal to address this issue by early 2012. Calibration of traditional unit-hydrograph and hypothetical-design-storm methods of hydrologic design also can be done (Melching and Marquardt, 1997). More recent approaches for estimating peak-flow frequencies in urban basins that check for trends and adjust for basin land-

use changes over time (non-stationarity of the annual peak-flow record) may be appropriate as well (Moglen and Shivers, 2006).

2. **Strategy – Flood-Inundation Mapping, Fluvial-Erosion Hazards, and Landslides:**
    a. Develop new flood-inundation mapping products tied to USGS streamgages and NWS flood-forecast points (FY 2012–17).
    b. Pursue project to develop State fluvial-erosion hazards assessment programs in Indiana and Kentucky. Elements of these programs would include stream-erosion mapping, tools for assessing streams, and tools for assessing existing- and design-infrastructure resilience to erosion (FY 2012–17)
    c. Explore need for project to improve or refine regional stream variability indexes (FY 2012–17)
    d. Investigate and recommend to management potential approaches to developing projects to assess bank erosion and landslide potential in susceptible areas of Indiana and Kentucky, perhaps using a Hydrologic Unit Code-mapping approach. (FY 2012–17)
3. **Strategy - Karst:**
    a. Complete Lost River/Orange County investigation in FY 2013 and evaluate potential for follow-up work or technology transfer to other localities.
    b. Complete FY 2012 collaborative karst-mapping project with NHD and the KDOW, present outcome as paper-presentation submitted to appropriate national conference, and develop follow-up proposal.
    c. Contact appropriate USGS Geological Division staff and discuss potential for collaborative work on National Karst Map project or similar inter-disciplinary karst-mapping project (mid/late FY 2012).
4. **Strategy - Transport and Fate of Contaminant Spills or Releases:**
    a. Develop/implement pilot for Wildcat Creek near Kokomo with the USGS Wisconsin Internet Mapping (WIM) group (FY 2012–13).
    b. Pursue project to develop a national Internet-based riverine time-of-travel application linked to streamgages to track hazardous substances introduced accidentally or purposefully into streams (FY 2012, and ongoing). This could be integrated with StreamStats. This tool would enable officials to monitor and "forecast" the transport of a contaminant, its expected maximum concentration, and perhaps its duration, in the event of an emergency. This tool would be based in GIS and tied into streamflow data managed by the USGS. Also, consider the potential for adopting RiverSpill, a GUI-based tool developed for the EPA currently being tested in Ohio and Utah.
    c. Compile a database of fluorescent dye time-of-travel studies performed on area streams, and results of other previously conducted stream reaeration studies to identify data gaps and assess the adequacy of existing contaminant-transport data for use in Internet-based assessment-tool development (FY 2012, and ongoing).

5. **Strategy - Dam, Pond, and Levee Stability:**
    a. Contact stakeholders to assess ash ponds (early FY 2012).
    b. Continue work in FY 2012 and beyond on existing projects to develop an assessment protocol of impoundment areas based upon site characteristics using non-intrusive geophysical methods. Quantify physical properties of impoundments such as sediment deposits through displacement and bathymetry surveys, and provide assistance data for qualifying stability of potential changes within the impoundment walls via resistance and seismic characteristics of the structure and its holdings.
    c. Set up meeting or conference call with USGS Office of Groundwater, Branch of Geophysics to explore potential collaboration on methods development and publication of a protocol for geophysical assessments—perhaps through publication of a USGS Techniques and Methods report.

Figure 7. Karst-related hazards often take the form of collapse sinkholes, such as this example from a residential area in Jessamine County, Kentucky.

Ecosystem Science

"Ecology" or "ecosystem science" is the study of the interaction between organisms and their environment and the consequences of natural or human-induced change on the ecosystem.

It encompasses the disciplines of biology, botany, microbiology, habitat, climate, water quality, and other fields to achieve a comprehensive view of ecosystems and their health. Ecology is the science and "ecosystem health" is the mission area of the USGS.

Categories of human activities generally are drivers of change in ecosystems through unintended consequences of these human activities or stressors. The effects of drivers and stressors on ecosystems health can be detected, quantified, and scientifically interpreted by measurement of indicators.

The ecosystems-health mission is a counterpart to the USGS public-health mission. Some of the same drivers, stressors, and indicators of impacts on public health also apply to aquatic ecosystems and their connected terrestrial components. Issues of ecosystems health affect a broader and more complex mix of habitats and species than public health. While public-health impacts can be managed by physical and behavioral changes, natural communities mostly receive and react to stressors.

Important drivers of changes to ecosystems health in Indiana and Kentucky are row crop and animal agriculture, urban areas, energy production, and climate/land-use change. Stressors include sediment, nutrients, chemical contaminants, pathogens, and altered streamflow and water temperature. These stressors affect streams, lakes, groundwater, wetlands, forests, and riparian corridors that comprise aquatic and terrestrial ecosystems found in agricultural, rural, suburban, and urban landscapes.

Society values ecosystems for the practical services they provide and because of our inherent connection to the natural world. Consequently, substantial human effort and public/private resources have been dedicated to protect and restore the health of ecosystems. As a Federal earth science agency, the USGS has a special role in helping society evaluate the effectiveness of the State, regional, and national public/private resources directed toward ecosystems health in Indiana and Kentucky. Therefore, the ecosystems-health mission area of this USGS strategic science plan focuses on the drivers, stressors, and indicators of change to ecosystems health and the benefits from past and future investments toward protection and restoration. In addition, this science plan anticipates global processes that may have State and regional implications for Indiana and Kentucky in the years ahead.

Major questions for the Ecosystem Science focus area include

1. **Agriculture:** To what extent are agricultural Best-Management Practices (BMPs), requirements for Concentrated Animal Feeding Operations (CAFOs), and regulation of agricultural pesticides having a beneficial effect on ecosystems health?
2. **Urban areas:** To what extent are improvements to municipal wastewater-treatment plants and the reduction in combined sewer overflows (CSOs) having a beneficial effect on ecosystems health?
3. **Energy production**: To what extent are regulations to reduce the emissions of mercury from power plants, cement plants, and utility boilers having a beneficial effect on ecosystems health? What are the impacts of low-head dam removal on riverine ecosystems?
4. **Resource extraction**: To what extent are coal mining, coal-mine reclamation, and oil and gas drilling affecting ecosystems health?
5. **Climate and land-use change**: To what extent are the patterns and extremes in streamflow and water temperature having an effect on ecosystems health?

Figure 8. Runoff from urban and agricultural lands can lead to the nutrient enrichment of streams.

Objectives

The USGS Indiana–Kentucky WSC Commonwealth will measure and interpret indicators of ecosystems health and will document and communicate the relations of these indicators to drivers and stressors of ecosystem health in Indiana and Kentucky. The objectives of the Commonwealth ecosystems-health mission are

- **Establish a reference for evaluating changes in ecosystems health.** Establish an integrated hydrologic, chemical, and biologic knowledge base to serve as the reference for assessing natural and human-induced beneficial or adverse changes to ecosystems health.
- **Monitor and interpret the status of ecosystems health.** Continue to be the source of reliable, quality-assured, and openly available data and peer-reviewed scientific interpretations about indicators of ecosystems health and the related drivers and stressors.
- **Provide technical support for decisions affecting ecosystems health**. Assist agencies and groups to identify and evaluate solutions for maintaining or restoring ecosystems health and to support water-quality standards, criteria, and designated uses for streams and lakes.
- **Communicate information about the status of ecosystems health.** Actively engage government agencies, watershed groups, and interested citizens through publications, oral presentations, websites, and social media.

Strategic Actions and Products (next 3–5 years)

1. **Supergages**: The USGS will lead the development and operation of a small number of comprehensive monitoring stations in Indiana and Kentucky, generically termed "supergages." These supergages will be located at two kinds of sites in selected large watersheds within or downstream from major physiographic regions. (1) *Integrator* sites have the largest upstream drainage areas, incorporate multiple drivers and stressors, and have implications for interstate transport downstream. (2) *Indicator* sites are nested upstream from the integrator sites to focus on specific drivers, stressors, or physiographic regions.
   Priority will be given to long-term, real-time streamflow-gaging stations for adding monitoring components to develop a supergage. Stations will be selected to provide a gradient of increasing watershed scale. USGS will work with its partners to identify supergage locations in Indiana and Kentucky that best satisfy their collective regulatory and science objectives.

   Monitoring components include *physical/chemical* and *biological* measures of ecosystems health. Physical/chemical measures are monitored with (a) continuous-recording sensors for water-quality characteristics and constituents, (b) automated water samplers, (c) groundwater-level-recording wells, (d) weather stations, and (e) automated precipitation samplers. Biological measures are monitored 1–3 times per year and include populations and taxa from biological communities (algae, aquatic invertebrate, and fish) and in-stream habitat conditions. Monitoring data collection and management will be based on standard operating procedures.

Important capabilities of a supergage are (a) long-term records that can be used to determine temporal trends including seasonality and annual increases/decreases; (b) streamflow discharge data that can be used to estimate constituent loads; (c) capacity for low-cost predictions of constituent concentrations with parameters or surrogates measured by sensors; (d) continuous or sequential constituent concentrations or loads for models instead of estimates from a few discrete samples; (e) hydrologic integration of stream, groundwater, and precipitation data; (f) capacity to automatically collect water samples at stage or time intervals during a streamflow event or during an emergency; (g) real-time and quality-assured historic data freely accessible through the Internet from the USGS database; and (h) capacity to integrate data into national and international monitoring networks.

2. **Technical support**: The USGS will work with its Federal, State, local, academic, and private partners to develop and implement interpretive studies related to drivers of ecosystems health in Indiana and Kentucky. These studies can be based on data mined from historic records and new data collection at supergages and other sites, along with related ancillary data. Emphasis will be on documenting effects on ecosystems health from public/private investments addressing the major questions about agriculture, urban areas, energy production, and resource extraction listed earlier in this plan. In addition, USGS will participate with its partners on monitoring councils, committees, and work groups to communicate USGS technical-support activities.
3. **Communications**: USGS will coordinate with its partners regarding access to the data from the network of supergages, along with the interpretive studies related to ecosystems health. USGS will document the standard operating procedures and quality assurance used at the supergages. USGS will disseminate results from the supergages and interpretive studies through print, radio-television, Internet, social media, and technical meetings. USGS will work with its partners to develop Internet-based decision tools for managers and policymakers that provide geographically organized access to interpretive predictions and classifications from USGS studies, along with the supporting data.
4. **Integration and coordination**: The supergages in Indiana and Kentucky can include monitoring components that qualify the sites to be included in proposed and national networks related to ecosystems health. Examples include MercNet for mercury, the National Atmospheric Deposition Program networks, and others. USGS will seek out opportunities to integrate data from the supergages into the national networks. The technical-support studies may be relevant to broader regional or national issues such as nutrient and sediment transport and the zone of hypoxia in the Gulf of Mexico. USGS will coordinate with its partners on these large-scale issues.

5. **Emerging issues**: Three emerging issues could affect ecosystems health: global climate and land-use change, natural and human-induced disasters, and chemicals and pathogens known as emerging contaminants. USGS will look for opportunities to outfit supergages and other monitoring studies to evaluate signals and effects of these emerging issues. Most threats will involve multiple ecosystems because the boundary between ecosystems is gradual and some species exist at these boundaries. (a) Global climate and land-use change can affect weather, such as air temperature, and precipitation frequency, intensity, and depth that would result in altered patterns and extremes of streamflow and water temperature. The patterns, frequency, and extremes of droughts, floods, and water temperatures could affect ecosystems health by making conditions unfavorable for native species and favorable for invasive species. (b) Natural disasters such as hurricanes, blizzards, earthquakes, and forest fires tend to affect large areas that can include ecosystems in Indiana and Kentucky. Human-induced disasters such as chemical spills and fires, releases from nuclear-power plants, and acts of terrorism tend to be more localized but can affect ecosystems in these two States. (c) Emerging contaminants are chemicals and pathogens without monitoring requirements and sometimes without standards, criteria, or analytical techniques.

Milestones and (Timelines)

1. **Supergages:**
    a. Continue the supergage demonstration project at Hazleton, Indiana (fig. 9), to optimize methods for operation and maintenance of the water-quality sensors and instruments. (12/2012)
    b. Identify a supergage demonstration site in Kentucky that can be used for local cooperators and agencies. (12/2012)
    c. Document standard operating procedures and quality-assurance protocols for supergage sensors and instrumentation. (12/2012)
    d. Contact USGS colleagues testing continuous-recording water-quality sensors and identify equipment requirements for integration into supergages. (6/2012)
    e. Research literature and contact USGS colleagues to standardize large river methods for biological surveys of algae, invertebrates, and fish. (6/2012)
    f. Research literature and contact USGS colleagues to identify parameters measureable with water-quality sensors that can proxy for laboratory analyses of water-quality constituents and develop calibration techniques. (6/2012)

Figure 9. Supergage on the White River at Hazleton, Indiana.

2. **Technical support (ongoing timeline)**

   Identify funding opportunities and potential partners for interpretive studies focused on

   a. Agricultural BMPs, CAFOs, or pesticides.
   b. Wastewater-treatment improvements and reductions in CSOs.
   c. Mercury deposition, transport, methylation, watershed loads, and watershed yields.

3. **Communication**

   a. Document standard operating procedures and quality-assurance protocols for supergages. (12/2012)
   b. Present the findings from supergage demonstration projects to State water-monitoring councils. (12/2012)
   c. Work with partners to identify Internet-based decision tools to improve the efficiency of managers and policymakers dealing with ecosystems health issues. (12/2012)

4. **Integration and coordination (ongoing timeline)**

   Identify funding opportunities and potential partners to add

   a. MercNet and National Atmospheric Deposition Program (NADP) network monitoring to a supergage.
   b. Groundwater-level recording wells to a supergage.

5. **Emerging issues (ongoing timeline)**
    a. Identify funding opportunities and potential partners to investigate water temperature and streamflow trends at USGS sites.
    b. Develop procedures and capabilities to respond to disasters with monitoring capabilities at supergages and other selected gages.

Water Availability and Demand

Indiana and Kentucky are water-rich states. Historically, their water resources have been considered adequate to meet needs. Locally, however, increasing water use may lead to demand exceeding the sustainable yield of supplies. Drought also can lead to short-term water shortages. As the populations of Indiana and Kentucky increase and economic activities evolve, water managers at the State and local levels will need information based on sound science in order to achieve the goal of balancing competing water needs while considering environmental, societal, and economic priorities.

The sustainability of Indiana and Kentucky's water supplies will depend upon the ability of each State to protect its water resources from contamination. In many urban areas, surface water and shallow groundwater already have been contaminated. Protection of groundwater resources is of particular concern in shallow glacial and alluvial deposits.

Assessment of the occurrence of chemicals that can harm water quality, such as nutrients and pesticides in water resources, requires recognition of complicated interconnections among surface water and groundwater, atmospheric contributions, natural landscape features, human activities, and aquatic health.

The current state of scientific research indicates that climate change will affect the seasonality, frequency, and intensity of storms and the potential for droughts in the Midwest. Climate change may lead to significant impacts on regional-scale hydrologic processes such as streamflow, storm-water runoff, evapotranspiration, and groundwater recharge, and snowmelt. Reliable data will be needed to institute and evaluate adaptive strategies for managing water supplies during droughts or in locations with limited supply for increasing demands.

Major questions for the Water Availability and Demand focus area include

1. **Monitoring:** Are immediate and long-term water monitoring needs being met?
2. **Water needs:** Are competing water needs well defined and quantified?
3. **Water quality:** Are current and potential impacts on the quality of our water supplies understood and well monitored?
4. **Climate:** To what extent are water availability and demand affected by seasonal variation and (or) potential climate change?
5. **Tools:** Are the needed informational-delivery systems and on-line tools being developed and made available to water managers and resource decision makers?

Objectives

- Determine and deliver the hydrologic data and interpretive products that most effectively assist the water planners and water managers.
- Recognize the increased reliance on groundwater use and expand the available knowledge on groundwater resources in Indiana.
- Quantify the impacts of groundwater use in Kentucky on the availability of the primary surface-water supply.
- Better understand current water use and determine trends in availability and demand.

Figure 10. Water is needed for uses such as drinking, agriculture, and industry.

Strategic Actions and Products (next 3–5 years)

1. Cooperate with State and local government, focusing on selected watersheds or aquifer systems, to provide wide distribution of the data and interpretive products that are needed for water planning and water management.
    a. Determine if current monitoring efforts provide sufficient information at locations of large water demand.
    b. Evaluate the completeness of historic water-use withdrawal records, and attempt to quantify (estimate) historic water use.
    c. Determine if near real-time streamflow estimates can be provided at ungaged locations.
    d. Enhance efficiency of data-collection and data-delivery systems through the use of new technologies.
    e. Develop low-flow statistics for inclusion in StreamStats hydrologic analysis software.
2. Address groundwater-data needs.
    a. Determine data gaps for water-availability studies. These data needs are pronounced in several areas where there is increasing water demand, such as the greater Indianapolis area, parts of northern Indiana, parts of southeastern Indiana, and elsewhere.
    b. Determine aquifer recharge and variability.

3. Determine impacts on water availability and demand by changes that have occurred and may occur over time, including potential climate change.
    a. Document and assess water-use trends.
    b. Determine sedimentation rates in reservoirs.
    c. Document and assess the quality of long-term climatic and hydrologic data records.
4. Evaluate relations between landscape characteristics, water withdrawals and returns, streamflow, and ecological function.
    a. Work with biologists to estimate necessary base flow for ecological systems near surface-water supply withdrawals.
5. Participate in workshop/conferences related to water availability and demand; establish memberships on water availability and demand committees/councils.

Milestones and (Timelines)

1. Cooperate with State and local government, focusing on selected watersheds or aquifer systems, to provide wide distribution of the data and interpretive products that are needed for water planning and water management (ongoing).
    a. Hold discussions with State agencies and local water-utility cooperators to determine geographic areas they are aware of that have experienced water shortages and (or) water conflicts. Determine if monitoring efforts at those locations meet data needs. If more monitoring is needed, determine potential cooperators for selected geographic areas. (FY 2012).
    b. Determine by way of conversations with other groups in the water community if there is indeed a need for estimated streamflows at ungaged locations. (by FY 2013). Determining the target audience and intended use for those estimates would help define the potential range of accuracy needed and thereby provide direction on potential techniques that might be developed (such as developing a model using weather data and nearby surrogate streamgage, or other method).
    c. (Indiana) Develop low-flow statistics for inclusion in StreamStats hydrologic analysis software. The project proposal for this work is under consideration of the Indiana Department of Environmental Management (IDEM) (try to initiate project by the end of FY 2013).
    d. (Kentucky) Establish connections within the KDOW Watershed Management and Assessment group (FY 2012)
    e. (Kentucky) Investigate different opportunities for other agencies' use of the WATER application (by FY 2013).
2. Determine impacts on water availability and demand by changes that have occurred and may occur over time, including potential climate change (ongoing).
    a. Document and assess water-use trends (in Indiana) by updating with data through 2010 the graphical report now being served on the Indiana Department of Natural Resources (IDNR) website. (FY 2013).
    b. Discuss potential bathymetric studies with the U.S. Army Corps of Engineers regarding the determination of sedimentation rates in reservoirs. (FY 2012).
    c. Research literature and contact USGS colleagues regarding additional approaches to address Water Availability and Demand issues (FY 2013).

Energy Production and Impacts

Energy production can require large quantities of water and often can alter the distribution and quality of water that is returned to the environment. The storage, deposition, and secondary utilization of by-products related to energy production also can affect water resources and modify the landscape. Energy-production industries in Indiana and Kentucky include coal, petroleum, natural gas, biofuels, wind, geothermal, and hydroelectric. Each of these energy industries places a unique footprint on water quantity and quality. During 2005, for example, the Indiana and Kentucky thermoelectric-power industries required approximately 9,460 million gallons per day of surface water and 17.7 million gallons per day of groundwater.

Major questions for the Energy Production and Impacts focus area include

1. What are the ecological effects of acidic-mine drainage and mining-related sedimentation on surface water; what information is needed on the hydrology of reclaimed-mine sites for use in additional remedial actions; and how could residential construction be affected by toxic gases related to mine spoils?
2. How is atmospheric deposition of harmful trace metals related to energy combustion?
3. What are the impacts of hydraulic-fracturing methods for energy recovery, brine pits, petroleum-storage tanks, and active and abandoned production wells on adjacent water-supply aquifers?
4. What is the effect of wind farms on weather and climate?
5. What is the impact of biofuel industries in areas such as impacts of water re-use, the effects of biomass production on pesticide and nutrient enrichment, and changes in nutrient and pesticide concentrations in groundwater and surface water as water-quality changes related to increased production of crops used for biofuel production?
6. What are the impacts of traditional and in-stream hydroelectric plants?
7. What are the impacts of carbon sequestration and natural-gas storage on the environment?

Objectives

The USGS Indiana–Kentucky WSC Commonwealth is recognized and utilized by State and other Federal agencies involved with the development and regulation of energy resources for the quality and timeliness of their data and interpretive programs. These programs include optimized monitoring networks, improved quantification of water use and availability, characterizations of waste-disposal techniques and by-product impacts, and developing new techniques and methods of assessment. Mission area objectives include

- Determine the impacts of hydraulic fracturing on the adjacent environment.
- Identify and apply new geophysical methods to hydrologic issues created by oil-and-gas brine pits, storage tanks, and resource development.
- Describe ecosystem modification and recovery related to coal mining and reclamation.
- Assess the integrity of facilities storing coal-combustion wastes.

- Determine the factors that create stray-gas issues and map potentially afflicted areas.
- Examine the processes affecting the lifespan of bioreactors and model-failure rates based on this knowledge.
- Identify areas where water availability may limit location of biofuel manufacturing.
- Assess the impact of biofuel-biomass production on pesticide and nutrient concentrations.

Figure 11. U.S. Geological Survey (USGS) hydrologists discuss logistics of monitoring at a site impacted by coal mining with State of Indiana officials (left) and a USGS scientist collects a sample of wet deposition containing mercury produced by coal combustion (right).

Strategic Actions and Products (next 3–5 years)

1. Participate in interagency workgroups that regulate aspects of impaired water use and ecosystems affected by energy production.
2. Participate in USGS workgroups researching environmental impacts of energy production.
3. Convene professional meetings dedicated to an improved scientific understanding of the impacts of energy production on water resources.
4. Circulate current and historic publications by USGS to remind cooperators of the hydrologic excellence and experience held in USGS WSCs and provide information about new approaches, methods, and techniques that may be applicable to their issues of concern.
5. Develop, apply, and document techniques of ecological assessment that are unique to sites impacted by energy production and by-product disposal.
6. Strengthen geophysical capabilities by acquiring skills and technologies that are well suited to studies of energy production and refuse-storage issues.
7. Develop soil-gas and other skills that could be used to improve understanding of the processes responsible for stray-gas intrusion.
8. Continue field testing and development of software used by decision-making resource managers before and after coal mining.

9. Use computer simulations to explore the impacts of biofuel-related crops on water quality and availability and GIS analyses to assess the availability of water for biofuel production.
10. Develop understanding and skills required for assessments of hydraulic fracturing on the environment.

Milestones and (Timelines)

Program growth: This measure should be evaluated in terms of the number of projects and data-collection efforts related to this mission area, as well as the overall level of funding (FY 2012).

1. *Professional growth:* This measure should be evaluated in terms of the number and prestige of professional meetings being attended (or led/convened) and publications produced related to this mission area. Increased skills and abilities acquired to complete projects related to energy and water is another valuable indicator (FY 2012).
2. *Staff growth:* This measure will be evaluated by assessing the number of staff and (or) manpower hours required to complete tasks associated with this mission area; the latter would reflect contributions from staff outside of the Commonwealth that are used to complete the work (FY 2012).
3. *Involvement in meetings:* An accounting of the number of meetings with potential cooperators should be used as an indicator for assessing success of these criteria (FY 2012).
4. *Publications on energy-related topics:* The number and quality of publications related to energy and water should be used to evaluate the achieved level of success (FY 2012).
5. *Satisfaction of cooperators:* Re-listening to cooperators at the conclusion of the evaluation period will provide an indication of their level of satisfaction and the Commonwealth's progress in this mission area (FY 2012).

Public Health

Human activities over the past century have dramatically increased the amount of chemical and pathogenic contaminants that are introduced to our Nation's rivers and lakes and affect our drinking and recreational waters. These public-health threats are affected by the inherent relations between people and the physical, chemical, and biological nature of their natural environment. Increasingly, connections between environmental, animal, and human health are being recognized.

The health risks to the public will likely increase with population growth and the associated pressures of development and habitat modification. We can expect environmentally related diseases to increase as chemical and pathogenic contaminants affect the quality of our water. This factor is one of a few that make understanding environmental and ecological health a prerequisite to protecting public health.

The USGS Indiana-Kentucky WSC Commonwealth can play a significant role in providing scientific knowledge and information that will improve our understanding of the relations of environment to public health. The USGS Indiana-Kentucky WSC Commonwealth brings together a broad spectrum of natural-science expertise and information, including extensive data collection and monitoring on varied landscapes and ecosystems across both States.

The USGS Indiana-Kentucky WSC Commonwealth can provide a great service to the public-health community by synthesizing the scientific information and knowledge on our natural and living resources that influence public health, and by bringing this science to the public-health community in a manner that is most useful. Partnerships with public-health scientists and managers are essential to the success of these efforts (Aulenbach and others, 2007).

Figure 12. Cyanobacteria blooms can cause allergic and/or respiratory issues, attack the liver and kidneys, or affect the nervous system in mammals, including humans (U.S. Geological Survey, 2011).

Major questions for the Public Health focus area include

1. What are the potential public-health issues related to water consumption, fish consumption, and recreational use in Indiana and Kentucky in the next 5 years?
2. What information is needed to help water utilities, water managers, and policy makers monitor and assess contaminants relevant to public health in the water resources of Indiana and Kentucky?
3. What gaps in scientific understanding and data need to be filled to help water managers, public-health officials, and policy makers reduce water-related public-health problems in communities of Indiana and Kentucky?

Objectives

1. Assess Pathogenic Microbes and Chemical Contaminants in Water Resources through Monitoring and Data Mining
    a. Establish baselines in natural and urbanized systems, including surface water and groundwater: Baselines capture a snapshot that serves as an assessment of present conditions and a starting point for monitoring future changes.
    b. Monitor surface-water and groundwater quality for public use (drinking water and recreation): Fundamental characterization of hydrologic systems, from the interaction of surface water and groundwater in karst areas to the transport of nutrients and pathogens throughout a watershed, provides an important knowledge base.
    c. Perform data mining on existing datasets to provide short- and long-term context of pathogens and water-quality responses to both natural and anthropogenic forces: These data could provide a rich and important summary of both natural and anthropogenic effects of changes across the Indiana and Kentucky environment, and the causes and effects of those changes on public health.
2. Enhance methods to anticipate and rapidly assess the environmental impacts of natural and anthropogenic influences on public health
    a. Develop fate and transport models of pathogenic microbes and chemical contaminants in water: A comprehensive and quantitative understanding of the processes controlling the fate and transport of surface- and subsurface-chemical contaminants and pathogenic microbes is necessary to develop policies and strategies as they relate to drinking supplies of surface water and groundwater.
    b. Determine components necessary for creating a Decision Support System (DSS) that will allow creative, adaptive-management solutions to rapidly changing environments: Under an increasingly complex world that tries to balance ecological services with anthropogenic needs (food, fuel, energy), a number of alternative scenarios will need to be associated with cost/benefit assessments of what is the best current action to take to minimize losses for either result, while also maximizing societal benefits.

 

Figure 13. Safe drinking water needs to be free of disease-causing pathogens (left); bacterial DNA extraction is one method of testing for harmful microbes (right).

3. Partner and Collaborate with Public-Health Entities: The full benefit the USGS Indiana–Kentucky WSC Commonwealth can provide to our individual States on public-health issues requires creating and enhancing partnerships and collaborations with public-health professionals.
4. Communicate Integrated Public and Environmental Health Science Information: Regular communications to set priorities; plan and conduct joint studies; and disseminate scientific information, data, and reports are required for collaborating with public-health entities.

Strategic Actions and Products (next 3–5 years)

1. Increase understanding of public health in water resources by enhancing technical associations and collaborations with USGS researchers and WSCs, and public-health entities. Also, increase staff exposure to scientific literature and news reports with the idea of remaining current on issues related to water quality and public health.
2. Create new partnerships, strengthen existing partnerships, and enhance collaboration with other entities charged with responsibility for public health.
3. Pursue studies on pathogens and water-quality contaminants with municipalities, water suppliers, and (or) State health agencies so that more can be learned about the types, amounts, pathways, fate, transport, and distribution of pathogens and water-quality contaminants in the waters of Indiana and Kentucky.
4. Pursue and apply technologies (i.e., microbial source tracking) for measuring and identifying pathogens at beaches and within watersheds for protection of public health.
5. Develop, evaluate, and refine predictive models for estimating pathogen concentrations in rivers and at beaches, and develop predictive models of bio-accumulative contaminants in water.
6. Enhance methods to anticipate and rapidly assess the environmental impacts of natural and anthropogenic influences on public health using fate and transport models and decision-support tools. Also, pursue new and better ways to disseminate model results (i.e., the Internet, social networks, text messaging, etc.).

Milestones and (Timelines)

1. Identify and select a lead scientist in both the Indiana and Kentucky WSCs (FY 2012).
2. Establish communication with USGS researchers (i.e., Herb Buxton) on public-health-related issues (end of first quarter of FY 2012).
3. Organize listening sessions with identified public-health partners (2nd quarter of FY 2012); then plan sessions yearly.
4. Establish and maintain a USGS Indiana-Kentucky WSC Public-Health webpage (end of FY 2012).
5. Create partnerships and collaborations with recognized public-health scientists and with established environmental-health organizations on public-health-related problems and develop interdisciplinary collaborations among USGS scientists (end of FY 2012).
6. Identify opportunities to support specific public-health-related activities (throughout FY 2012).
7. Participate in the public-health community, including participation in conferences, technical meetings, and possibly planning activities.
    a. National Conference on USGS Health-Related Research (date unknown at this time).
    b. Other national and local public-health-related conferences (as necessary throughout FY 2012).

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