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National Water-Quality Assessment Program

Tracking and Forecasting the Nation's Water Quality

Priorities and Strategies for 2013–2023

Twenty-one years ago, Congress established the National Water-Quality Assessment (NAWQA) program of the U.S. Geological Survey (USGS) to answer a fundamental question:

What is the status of the Nation's water quality, and is it getting better or worse?

Since then, NAWQA has been a primary source of nationally consistent data and information on the quality of the Nation's streams and groundwater. Objective and nationally-consistent water-quality data and models provide answers to where, when, and why the Nation's water quality is degraded and what can be done to improve and protect it for human and ecosystem needs. During its first decade (1991–2001), NAWQA focused on establishing a nationally consistent water-quality dataset that could serve as a baseline for trend evaluation, modeling efforts, and research studies. During its second decade (2002–2012), the NAWQA program built upon the baseline investigations by reporting on how water-quality conditions changed over time and by developing regional-scale water-quality models to extrapolate findings to unsampled areas and model-based tools that resource managers can use to evaluate the likely consequences of different management practices or policy scenarios. Water-quality data, models, and scientific knowledge generated by NAWQA are used by national, regional, State, and local agencies to develop more effective, science-based policies and strategies for protecting and managing water quality and aquatic ecosystems. Information produced by NAWQA over the past 21 years also provides the foundation for addressing current and future water-quality issues.

Water Quality Remains a Concern for Human Use and Ecosystem Health

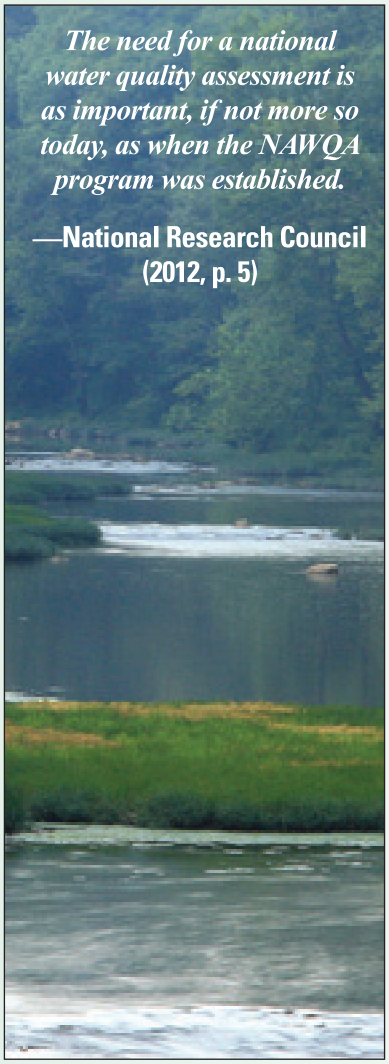
Water-quality issues facing the Nation are growing in number and complexity, and solutions are becoming more challenging and costly. The U.S. Census Bureau projects that our population will increase 25 percent by 2050, to almost 400 million people. Increases in population will be accompanied by development of land for urban and other non-agricultural uses, increased use of fertilizers and pesticides for food production, and greater pressure on existing resources to supply water for energy development, irrigation, drinking water, and ecosystem needs. These factors, alone or in combination, may degrade stream and coastal ecosystems and the quality of drinking water supplies if not effectively managed. Key issues we already know about include:

- ***Contaminants in Streams and Groundwater***—Eighty percent of streams in urban areas were found to have at least one pesticide that exceeded criteria set to protect aquatic life (Gilliom and others, 2006). Of our public and domestic wells—which supply drinking water to over 150 million people—more than 20 percent contain at least one contaminant at levels of potential health concern (DeSimone and others, 2009; Toccalino and Hopple, 2010).

- ***Degraded Stream Health***—Forty-two percent of wadeable stream miles in the United States are in poor or degraded condition (U.S Environmental Protection Agency, 2006). Widespread causes include excess nutrients and sediment, habitat disturbance, and altered streamflow. Minimum and maximum stream flows were found to be altered by human activities at 86 percent of almost 3,000 streams assessed across the Nation, and the likelihood of biological impairment increased with the severity of flow alteration (Carlisle and others, 2010).

- ***Changing Stream and Groundwater Quality***—Despite major efforts to reduce sources of nitrogen and phosphorus contaminating streams and rivers, analysis of trends in concentrations from about 1993 to 2003 show minimal changes at the majority of sites monitored, although most sites with significant change show nutrient concentrations increasing. During the same period, the percentage of wells with nitrate concentrations greater than the drinking water standard increased from 16 to 21 percent (Dubrovsky and others, 2010).

- ***Deteriorating Estuary Conditions***—Almost two-thirds of the Nation's major estuaries are degraded by excess nutrients, which cause "dead zones" (areas of low dissolved oxygen) that threaten economically important fisheries. The spread of dead zones is projected to worsen through 2020 in 48 of these estuaries as population growth, agriculture, and other development increase the amount of nutrients flowing into coastal waters (Diaz and Rosenberg, 2008).



Photograph by Alan Cressler, U.S. Geological Survey

Investments in Monitoring and Modeling Are Needed to Address Current and Future Challenges

For NAWQA's third decade (2013–2023), a new strategic Science Plan has been developed that describes a 10-year strategy for building upon and enhancing assessment of the Nation's freshwater quality and aquatic ecosystems. The plan continues strategies that have been central to NAWQA's long-term success, but it also adjusts the monitoring design, data analysis, and reporting to address monitoring and science information needs identified by NAWQA stakeholders and the National Research Council (2012). Meeting stakeholder needs for more timely reporting of water-quality information and development of decision-support tools are key components of the plan. Example products include (1) annual Web-based reporting of the concentrations, loads, and trends of nutrients, sediment, and other contaminants in rivers flowing into important coastal estuaries; (2) maps showing the distributions of nitrate and arsenic in water-supply aquifers at the depths pumped by domestic or public-supply wells, and (3) model-based decision-support tools that allow managers to evaluate how water-quality or ecosystem condition may change in response to different scenarios of population growth, climate change, or land-use management.

Monitoring and Modeling Activities To Begin in Fiscal Year 2013

Restoring and enhancing monitoring networks, particularly for surface water, and expanding development of NAWQA modeling tools were the highest priorities of stakeholders and the National Research Council (2012). An overview of surface-water and groundwater monitoring and modeling activities that will be started in fiscal year 2013 (FY13) shows how these broad approaches will be used to assess specific water-quality issues with available funding.

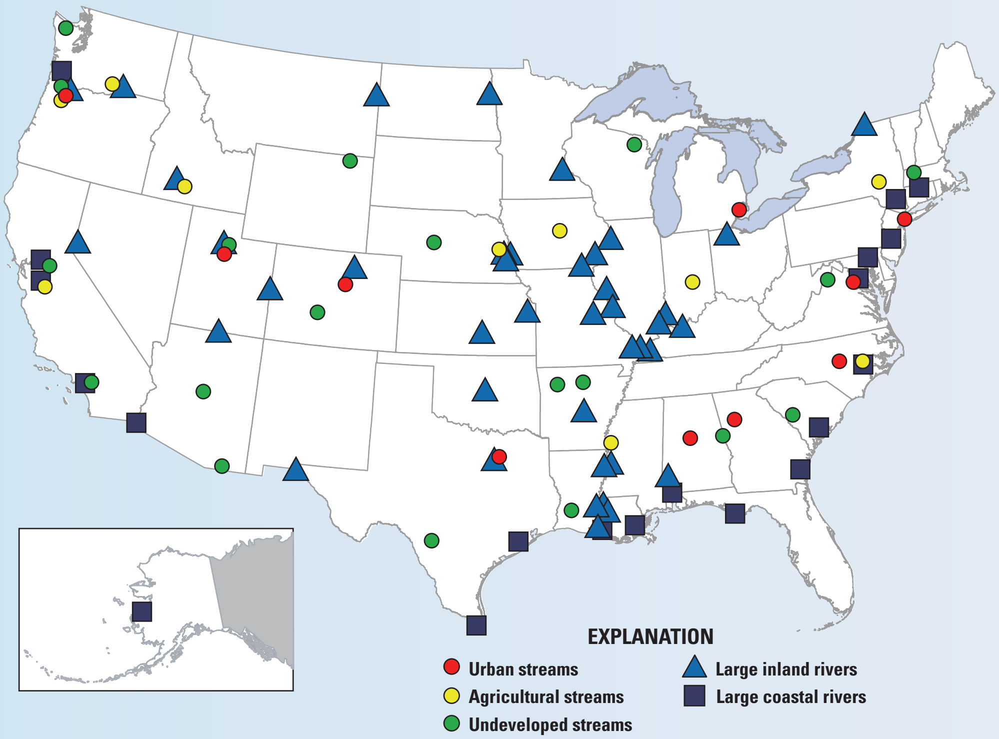


Figure 1. Beginning in fiscal year 2013, NAWQA will monitor 100 stream and river sites every year.

Surface-Water Monitoring and Modeling

The NAWQA strategy will continue to focus on assessing nutrient, sediment, and contaminant concentrations and transport in rivers and streams in major river basins throughout the Nation, particularly the Mississippi River basin, and also watersheds of critical estuaries such as Chesapeake Bay and San Francisco Bay. Water-quality models that estimate nutrient and sediment loads (SPARROW models; Schwarz and others, 2006) and pesticide concentrations in streams (WARP models; Stone and Gilliom, 2009) will be updated and enhanced in four regions of the country—the Mississippi River basin and rivers draining the northeast, southeast, and west—as well as for the national scale. Planned enhancements include increased temporal resolution (shorter time scale), updated contaminant source data, and simulation of seasonal to annual variations in streamflow, contaminant concentrations, and loads. The improved models will be used to develop more effective decision-support tools to forecast how nutrient and sediment loads will change in response to changes in climate, land use, or management practices.

NAWQA has evolved from a water quality program emphasizing data collection and trend assessments to one that has the potential to predict and forecast pollutant occurrence and trends under multiple scenarios at nationally significant scales.

—National Research Council (2012, p. 158)

Water-quality monitoring in FY13 will be done at a network of 100 sites (fig. 1), most of which are long-term USGS monitoring sites that have more than 20 years of data. The national network includes 61 large river sites that will provide basic coverage of large-scale trends in nutrient, sediment, and contaminant loading to inland or coastal receiving waters, and 39 wadeable stream sites that will be used to track trends in water-quality and ecosystem condition at urban, agricultural, and undeveloped watersheds selected to represent the national diversity of environmental settings. Most sites will be sampled 12 to 18 times per year for a wide range of contaminants. Continuous monitoring of key water properties, including salinity, nitrate and turbidity, will start at 5 sites equipped with state-of-the-art water-quality sensors. These data will improve estimates of nutrient and sediment loads, and the continuous water-quality data will be incorporated into water-quality models. At the 39 wadeable stream sites, evaluations of the condition of algal, macroinvertebrate, and fish communities will be conducted annually.

Groundwater Monitoring and Modeling

NAWQA is the only Federal program that assesses the status of the Nation's groundwater quality and reports on how these conditions are changing over time. Groundwater studies are planned in 20 principal aquifers, which collectively account for more than 75 percent of the national groundwater used for drinking water (fig. 2). Statistical models and monitoring data will be combined to generate maps of selected contaminant occurrence at the depth zones used for domestic and public supply. In four principal aquifers—the Central Valley of California, the Coastal Lowlands of the lower Gulf Coast states, the Glacial, and the Northern Atlantic Coastal Plain—groundwater-quality data will be combined with groundwater flow models to provide a three-dimensional estimate of the amount of groundwater available in each aquifer, its vulnerability to contaminants derived from natural and (or) human sources, and an understanding of how groundwater quality may respond to changes in climate, land use, and water use over time.

About 2,500 wells, distributed among 79 existing networks, will be resampled over the next decade for key water properties, nitrate, and trace elements (fig. 2) to assess how shallow groundwater quality is changing beneath urban and agricultural lands and in deeper domestic wells. Subsets of wells in selected networks will also be sampled for pesticides, contaminants of emerging concern (pharmaceuticals, hormones, and high production volume chemicals), radiochemicals, microbial contaminants, and tracers that indicate the approximate age of the groundwater. About 1,500 deep public supply wells will be sampled in the next decade to help characterize water-quality conditions in parts of the aquifers that were not examined in previous decades; remaining samples will be collected from domestic wells and shallow monitoring wells underlying urban and agricultural areas.

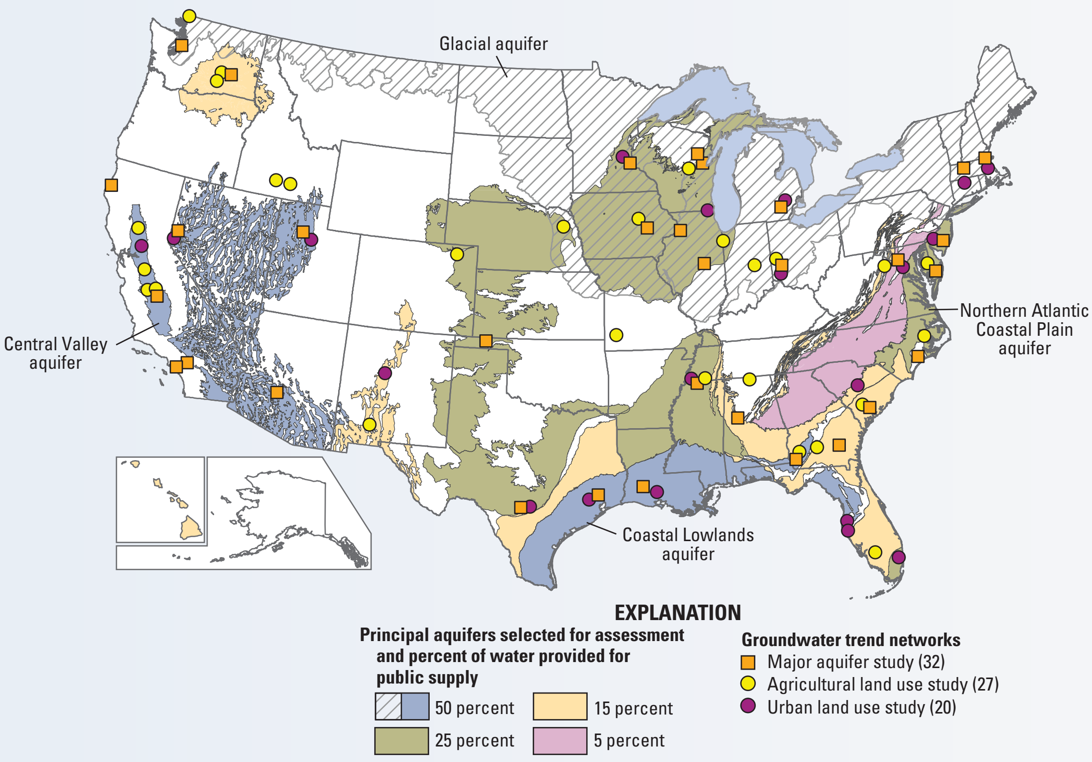


Figure 2. Seventy-nine NAWQA well networks in 20 principal aquifers will be resampled to assess decadal-scale trends in groundwater quality. Each groundwater trend network consists of 25 to 30 wells in a principal aquifer, distributed randomly across areas ranging from several hundred to several thousand square miles. Seven or eight trend networks will be resampled in fiscal year 2013; a similar number of networks will be resampled in each subsequent year of the decade.

The California State Water Resources Control Board has worked closely with the U.S. Geological Survey to develop a comprehensive monitoring and assessment program for California's groundwater basins. The approach, methods, and results from NAWQA studies have been fully integrated into California's plans to evaluate groundwater quality on a statewide basis.

—Arthur G. Baggett, Jr., State Water Resources Control Board

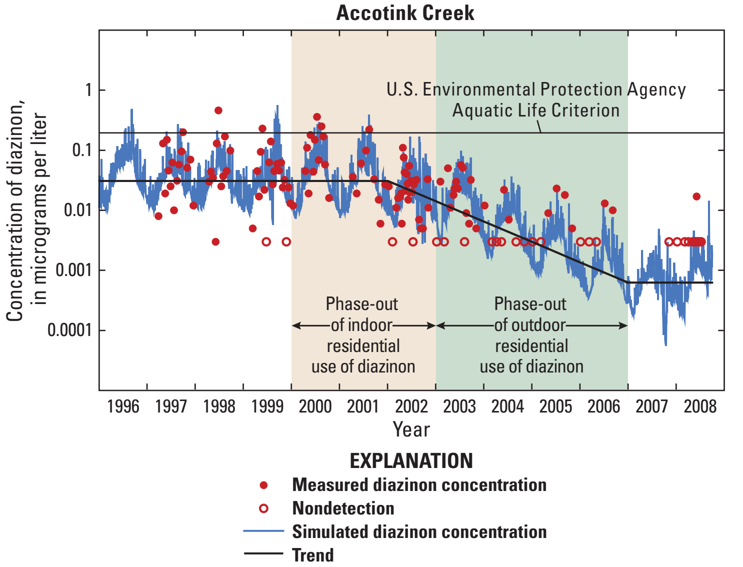
Products Designed to Meet the Nation's Water-Quality Information Needs

The NAWQA program's third decade will yield advances in water-quality information and science that can markedly improve the effectiveness of water-quality policies and management decisions. Examples of the types of data and information products planned for the next decade are described below.

Restoring Monitoring for Reliable and Timely Status and Trend Assessments

The NAWQA program will work with State and Federal partners to fill monitoring gaps in critical watersheds and aquifers by leveraging available resources and collaborating with other programs to build an expanded and sustainable national network. Monitoring approaches will emphasize rapid feedback on changing water-quality conditions so that managers can identify emerging problems, develop effective responses, and evaluate the performance of management strategies. Recent analyses of water-quality trends have shown that monitoring must be frequent and sustained every year to reliably detect trends at the time scales at which important changes in contaminant sources and management strategies occur. Therefore, the Science Plan emphasizes returning to yearly intensive monitoring of sites that are part of NAWQA's surface-water-quality network, rather than a rotational approach with many sites only periodically monitored.

For example, monitoring data for Accotink Creek, a small urban stream near Washington, D.C., shows the importance of frequent sampling to detect and quantify the decline in stream concentrations of diazinon that occurred following the phase-out of the residential use of this insecticide that began in 2000. Being able to document the effectiveness of water-quality improvement strategies in a timely manner, as demonstrated by the every-year monitoring approach used in this example, is vital to regulatory agencies and other stakeholders in order to track the performance of management practices and determine implications for future strategies.



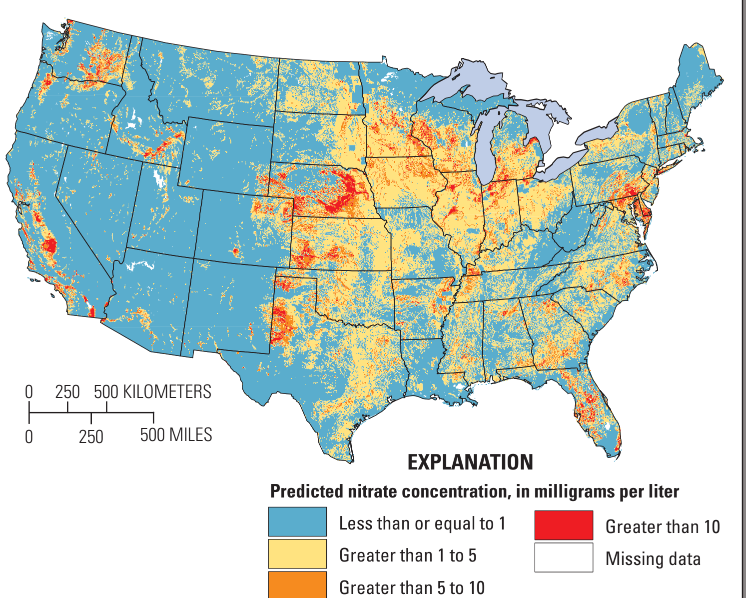
The products and studies produced by the USGS are beyond reproach and represent an independent scientific voice that water planners look to for guidance.

—Dave Kanzer, Senior Water Resources Engineer, Colorado River Water Conservation District

Transforming Data and Models into Tools for Decisionmakers

The NAWQA program's water-quality models quantitatively link sources and management practices to water-quality benefits and effects and can do so at multiple hydrologic scales—from headwater streams to rivers flowing into estuaries, and from shallow groundwater to deep regional aquifers. In the first two decades of NAWQA, progress was made on the application of models to evaluate the vulnerability of streams and groundwater to selected contaminants, such as nitrate. Progress was also made on the application of models that link causal factors and individual contaminants at regional and national scales.

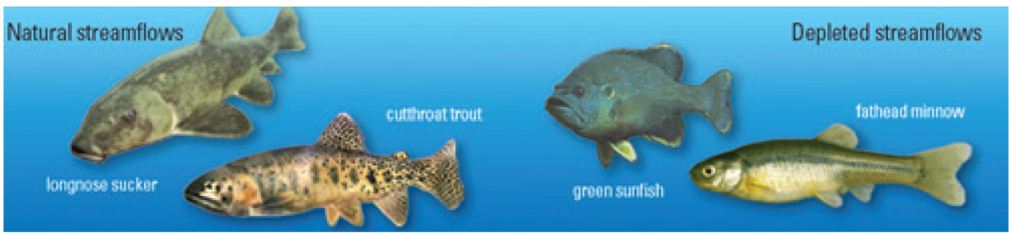
Findings from a national nitrate model for shallow groundwater (Nolan and Hitt, 2006) illustrate the type of information that will be further refined as data and information on sources of contaminants, management practices, and other important factors improve. Such models can be developed for other contaminants—dissolved solids, arsenic, and pesticides—and for specific regions of the country. They provide resource managers with an important starting point for evaluating which aquifers or streams are likely to have contaminant concentrations high enough to impair drinking water supplies or threaten the health of aquatic organisms. Other models examine how groundwater interacts with surface water to affect contaminant transport and the amount of time it takes water and contaminants to move from the land surface, through aquifers, and then to streams. The resulting modeling tools can be used by resource managers to evaluate changes in water quality caused by different management practices or regulatory policies and how long it will take for the effects of those changes to be observed in their watershed or aquifer.



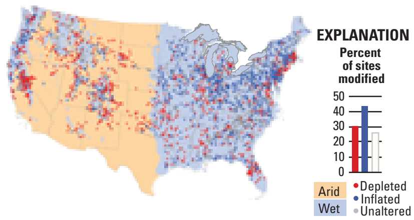
Providing Data and Tools to Predict Ecological Condition in Streams

Targeted regional studies will provide resource managers with data and tools to understand and predict ecological conditions in relation to streamflow alteration and concentrations of contaminants, nutrients, and sediment. New national and regional models of potential stressors, such as altered streamflow, nutrient delivery, and contaminant toxicity, will provide managers with critical information on stressors that affect ecological health. For example, Carlisle and others (2010) showed that streams that had altered streamflows had fewer sensitive fish species than streams characterized by more natural flow regimes.

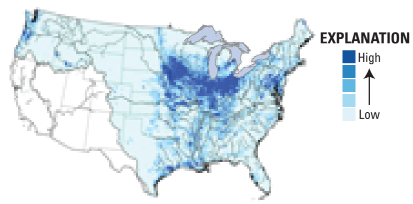
The regional studies will provide detailed understanding of how natural and human factors affect water quality and ecological conditions in major regions of the Nation, improve understanding of how stream quality will respond to management scenarios, and provide information that facilitates investment in the most effective restoration strategies. The first of these regional assessments is being developed in collaboration with the States and the U.S. Environmental Protection Agency's National Rivers and Streams Assessment program and will focus on stream quality in the agricultural Midwest, a region encompassing parts of 12 states (U.S. Geological Survey, 2012). Other regional studies may be done in the humid southeast, arid southwest, the Atlantic Highlands, and the Rocky Mountains.



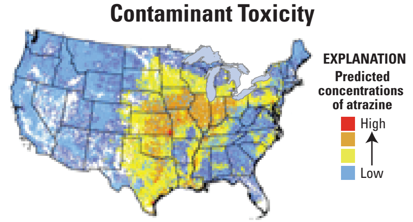
Altered Streamflow



Nutrient Delivery



Contaminant Toxicity



The [NAWQA] program has translated and interpreted its high-quality, nationally consistent data with sophisticated tools so that policy and decision makers can use the program's science to inform efficient decision-making.

—National Research Council (2012, p. 7)

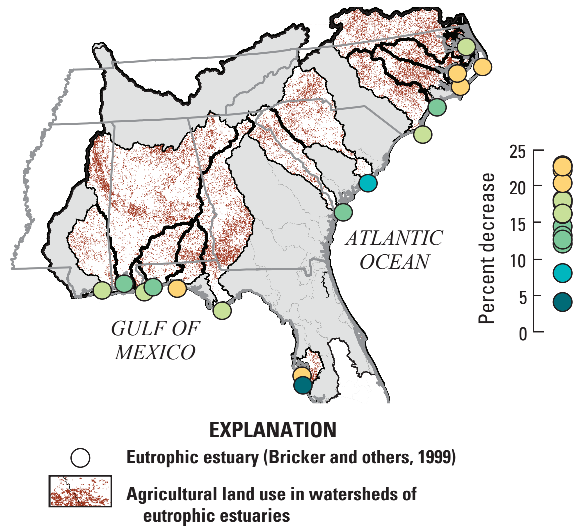
Forecasting Future Conditions and Testing Policy Scenarios

Forecasting and scenario-testing tools—an array of statistical and simulation models—developed by NAWQA will enable timely evaluation of current water-quality issues as well as the possible effects of future scenarios of changing climate, land use, and management practices. Enhanced versions of the SPARROW model, as well as other water-quality models, will be converted into Web-accessible tools that managers can use to evaluate how water quality and aquatic ecosystems may change in response to different scenarios.

For example, SPARROW was used to predict how a 50-percent reduction in agricultural nitrogen inputs would decrease loadings to eutrophic estuaries in the eastern Gulf of Mexico and the South Atlantic Coastal Plain (Hoos and McMahon, 2009). The model showed that resulting nitrogen loads to estuaries would decrease from as little as 5 percent to a maximum of 24 percent, indicating that—in terms of total annual nitrogen load—reduction of agricultural sources alone may not markedly improve eutrophication in some of these estuaries.

Similarly, coupled groundwater quality and flow models will enable water managers to evaluate the amount of time it may take for contaminated shallow groundwater to reach production zones used as drinking water supplies.

How will a 50 percent decrease in agricultural nitrogen inputs change nutrient loads to eutrophic estuaries in the Southeast?



This USGS SPARROW Model decision support system represents a major advance in the availability of sound scientific information to enable the effective management of this growing threat to our valued coastal resources and economies.

—Dr. Robert Magnien, Director of the Center for Sponsored Coastal Ocean Research, National Oceanic and Atmospheric Administration

Start-up Phase of the Science Plan

Anticipated funding for fiscal year 2013—approximately 25 percent of that needed to fully implement the recommended Science Plan—will support a scaled-back start-up phase of the science strategy endorsed by stakeholders and the National Research Council (fig. 3). A combination of funding growth and extensive collaboration with Federal, State, and local agencies, public interest groups, professional and trade associations, academia, and private industry will be needed to fully realize the monitoring and modeling goals laid out in the Science Plan. Partnering with other USGS programs is also important to the success of NAWQA in the coming decade. Collaborative efforts are being planned with the Water Census Program, Groundwater Resources Program, and the Cooperative Water Program on various data collection and modeling activities. These external and internal partnerships will increase geographic and temporal coverage through integration of multiple data sources and improve our ability to assess the Nation's water quality.

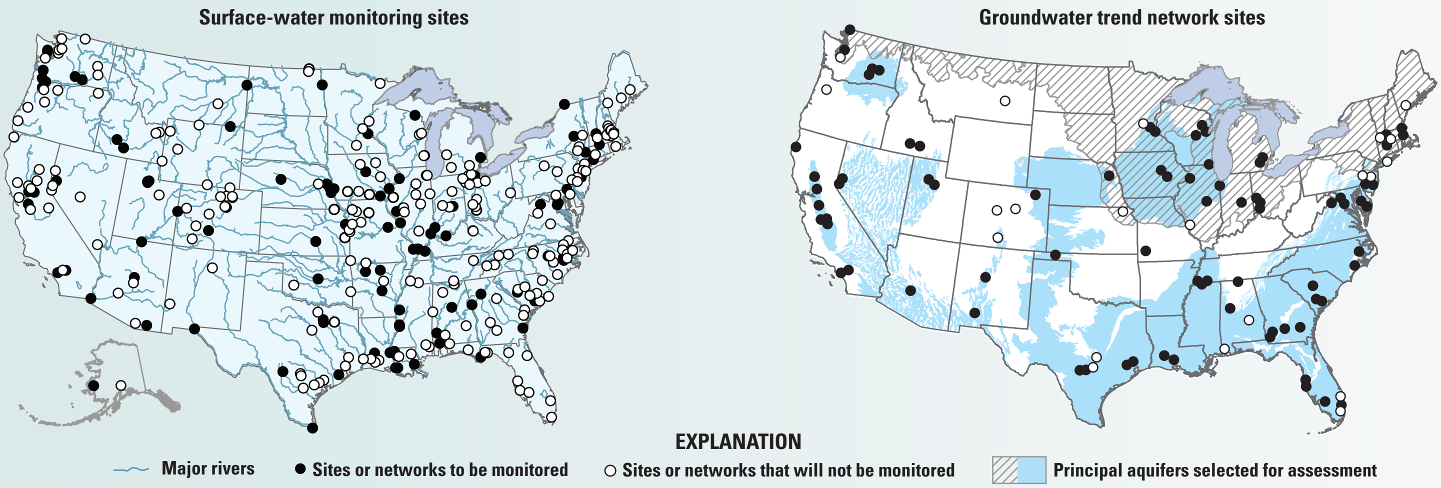


Figure 3. In fiscal year 2013, NAWQA will be able to start every-year monitoring at only 100 of 313 surface-water sites recommended in the Science Plan. The program will also be able to sample only 79 of the 100 groundwater networks recommended for trends monitoring over the next decade.

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