Planning the Third Decade (Cycle 3) of the National Water-Quality Assessment (NAWQA) Program: An update presented to the NAWQA National Liaison Committee, March 26, 2010

Cycle 3 Vision

The NAWQA program will be a leading source of scientific information for the development of effective policies and management strategies to protect and improve water quality for human and ecosystem needs. NAWQA data, water-quality models, and scientific studies will characterize where, when, why, and how the Nation's water quality has changed, or is likely to change in the future, in response to human activities and natural factors.

Background

Since October 2008, the NAWQA Cycle 3 Planning Team (hereafter referred to as the planning team) has asked for stakeholder input regarding water-quality issues that should be addressed in the coming decade to support National efforts to improve and protect our freshwater resources for humans and aquatic ecosystems. Conversations with external stakeholders, USGS scientists and managers, and NAWQA's National Research Council (NRC) ad hoc advisory committee yielded a "*national needs*" survey of water-quality issues that the planning team used to prepare a Cycle 3 Science Framework. The Framework document described the top eleven issues identified by the stakeholders, NAWQA's role in addressing each issue, and potential approaches for Cycle 3 (available online at: http://pubs.usgs.gov/of/2009/1296/pdf/OF09-1296.pdf). The Framework document was sent to the groups listed above asking them to prioritize their top 4-5 issues and to provide comments on the proposed approaches and assessment activities.

Stakeholder feedback on the Framework report was received last fall (2009) along with comments from the NRC Ad Hoc Committee (published separately in a NRC Letter report available at: http://www.nap.edu/catalog.php?record_id=12843). The planning team has spent the last few months developing a draft Cycle 3 Science Plan that incorporates this feedback.

Goals of NAWQA Liaison Committee Meeting

The presentation that follows provides an overview of the issues selected for emphasis in the Cycle 3 Science Plan and a description of some of the new design features being contemplated for Cycle 3 to meet the national needs outlined by NAWQA stakeholders. Your role today is to tell the planning team:

- **What excites you**
- **What seems challenging**
- **What seems like a reach, and**
- **How we can work together to address the most important issues and policy questions and leverage our strengths and resources.**

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Critical Issues

The consensus of the stakeholders and planning team was that NAWQA needs to focus the Cycle 3 design on four important issues. These four issues represent the highest priority topics based on the "national needs" assessment conducted over the past 18 months. The issues are among the Nation's leading causes of water-quality impairment and represent a mix of ongoing and new topics for NAWQA. So what are the issues and why are they important?

Excess Nutrients

- Complex issue of long-term concern; has been a focus of NAWQA data collection, modeling, and synthesis activities in Cycles 1 and 2
- Can lead to eutrophication in streams, rivers, lakes and reservoirs, and coastal estuaries,
- Hypoxia, harmful algal blooms, and related problems caused by nutrients affect drinking water supplies, recreational water quality, and the health of aquatic ecosystems

Contaminants

- Another long-term focus of ongoing NAWQA investigations
- Of interest to a wide variety of stakeholders at the local, state, and national levels
- People want to know if their water is safe to drink, are fish safe to eat, and are rivers safe to swim in
- Contaminants are a leading cause of ecosystem impairment
- NAWQA is currently evaluating a broad list of traditional and emerging contaminants for potential inclusion in Cycle 3 assessment activities

Sediment

- This important issue was only minimally addressed by NAWQA in Cycles 1 and 2
- One of the leading causes of water-quality impairment in the country
- Sediment affects aquatic ecosystems
- Billions of dollars are spent each year to mitigate sediment-caused environmental problems

Streamflow Alteration

- Flow exerts a major influence on the physical, chemical, and biological properties of streams and rivers.
- Affects aquatic organism habitat by influencing water temperature, and the physical structure of the stream channel and associated riparian features
- Human activities, and climatic factors, that alter the natural flow regime can directly or indirectly affect aquatic communities
- A new topic for NAWQA, but critical to assess factors affecting aquatic ecosystem health

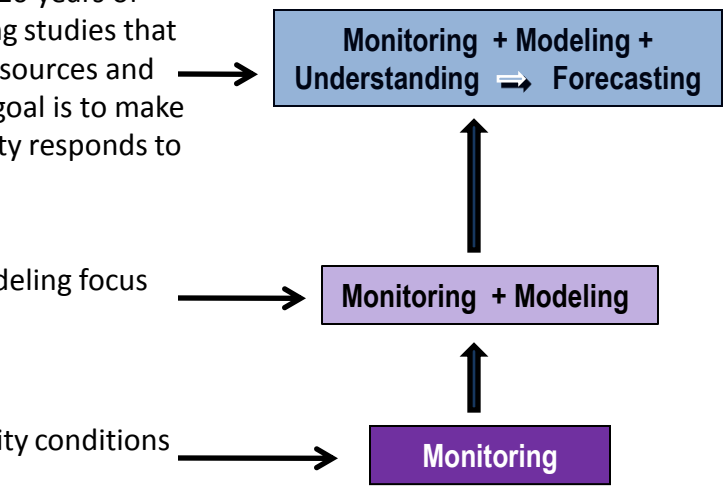
Evaluating Future Changes in Water Quality

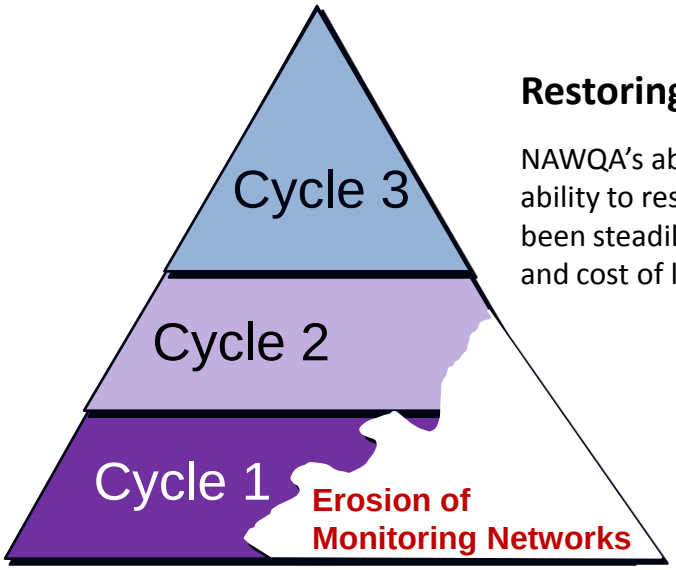
A recurring "*national need*" expressed by the stakeholders for Cycle 3 is to develop a capacity to evaluate and forecast changes in water-quality conditions in response to change caused by large –scale environmental drivers such as climate, or human activities at the land surface. To accomplish this NAWQA will remain true to its long-term objectives of assessing the status of the Nation's water resources, how those resources are changing over time, and, developing a better understanding of the factors that affect water quality and aquatic ecosystems. Although the overall objectives remain the same, the approaches used to achieve these objectives and the needs outlined by our stakeholders have evolved over time as described below:

Cycle 3 is being built on a foundation of 20 years of monitoring, modeling, and understanding studies that describe linkages between contaminant sources and their transport to receiving waters. The goal is to make progress on forecasting how water quality responds to changing environmental conditions

Cycle 2 moved to a monitoring plus modeling focus emphasizing trends and understanding

Cycle 1 established baseline water-quality conditions with a primary emphasis on monitoring





Restoring NAWQA's Monitoring Networks

NAWQA's ability to achieve Cycle 3 goals will depend on our ability to restore a robust monitoring capability, which has been steadily eroded by the combined effect of inflation and cost of living increases.

The decline in monitoring capacity has most affected our surface-water quality and ecologic monitoring components, especially with respect to frequency of sample collection, as illustrated on the next page.

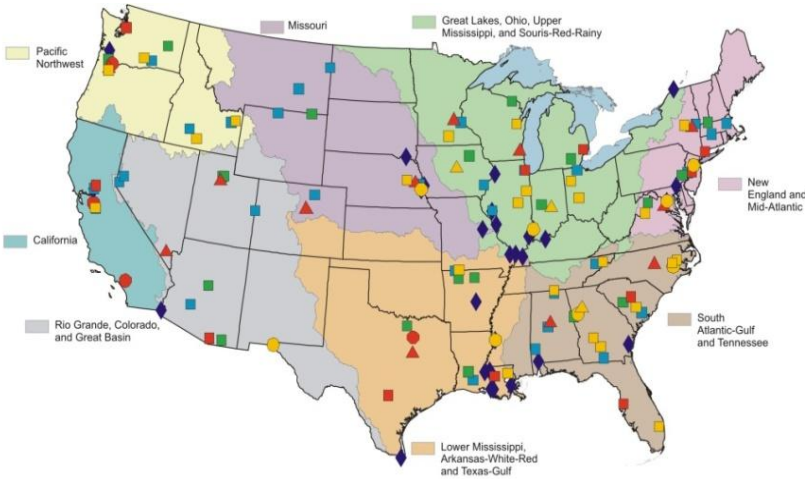
Status +Trends + Understanding

Current Fixed-Site Network

The map below shows the 145 long-term surface-water quality monitoring sites currently operated by the USGS NAWQA and National Stream Quality Accounting (NASQAN) networks. Not shown are five National Monitoring Network (NMN) sites.

Surface Water Sites

- Urban core sites (4)
- Agricultural core sites (8)
- Urban indicator sites sampled every 2 years (12)
- Agricultural indicator sites sampled every 2 years (3)
- Urban indicator sites sampled every 4 years (12)
- Agricultural indicator sites sampled every 4 years (25)
- Integrator sites sampled every 4 years (30)
- Reference indicator sites sampled every 4 years (19)
- National stream quality accounting network (32)



Background Info about Fixed Sites

- **NASQAN**
  - USGS National Stream Quality Accounting Network
  - Consists of 32 non-wadeable large river sites distributed to provide data on loads nutrients, sediment, and other water-quality constituents for large coastal estuaries and key tributaries in the Mississippi River Basin sampled annually.
- **NAWQA**
  - Consists of 113 smaller wadeable streams and rivers sampled on a rotational basis.
- **National Monitoring Network**
  - Consists of a handful of annually sampled river sites operated by USGS that are part of a larger water-quality network designed by the National Water Quality Monitoring Council.

Years of flat funding combined with increased monitoring costs has greatly reduced the amount of data collected in a given year. The National Research Council and others are concerned about whether or not NAWQA monitoring is truly national in scope.

Features of Fixed Sites

- Long-term data collection at fixed sites supports NAWQA's efforts to identify and understand water-quality trends, estimate loads, and develop large-scale transport models
- Although **~150 sites** seems adequate it is important to note that we have greatly reduced the frequency of monitoring at most of these sites to accommodate decreases in real dollars to support monitoring activities over time.
- **Only 49 sites are monitored every year**
  - Of these, **37 sites** are either NASQAN or NMN sites.
  - Of the remaining sites operated by NAWQA, **15 sites** are monitored **every 2 years**
  - **86 sites** are monitored only **every 4 years**
- **Limitations of Current Design**
  - Does not meet public and stakeholder needs for basic water-quality information at national and regional scales
  - Does not adequately support targeted regional and intensive studies needed to develop our understanding of the causes of contamination
  - Does not support development of improved modeling and statistical tools for extrapolation and forecasting

Possible Upgrades for Fixed-Site Network

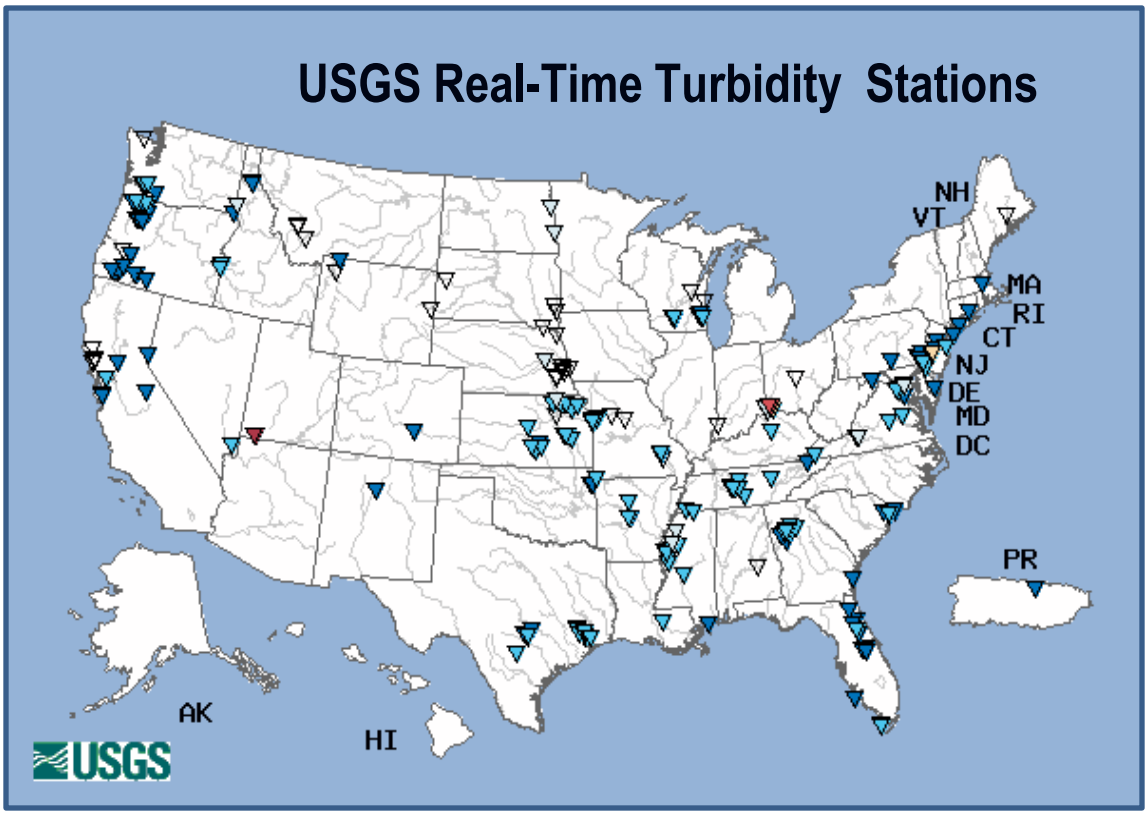
This comparison table gives you a sense of the magnitude of change in the fixed-site network that we think would be necessary to meet stakeholder needs and Cycle 3 objectives. Compared to the current fixed-site design, a straw-man design for the Cycle 3 surface water quality and ecology fixed-site network would do the following:

Current Network		Cycle 3 Network
• **150 sites**	More than double the number of sites	• **~350 sites**
• **Most only sampled every 2 or 4 yrs**	Return to perennial sampling	• **All sites sampled every year**
• **No continuous monitors**	Provide real-time monitoring of basic parameters	• **Most with real-time monitoring**
• **58 ecological sampling sites**	Increase the number of ecological sites	• **225 ecological sampling sites**
• **Single-year drinking-water intake sampling**	Increase number of stream intake sites sampled annually	• **25 stream or river drinking water intake sites**
• **No lake or reservoir sites**	Include lakes and reservoirs	• **50 lake or reservoir drinking intake sites**
• **Existing contaminant analyses**	Expand contaminant analysis	• **Expanded contaminant coverage**
• **Minimal suspended sediment**	Enhance suspended sediment monitoring	• **Expanded suspended sediment with turbidity monitoring**

New Design Features:
Real-Time Water-Quality Monitoring

Sensor and data transmission technology have advanced significantly over the past decade and there are a number of reasons to supplement the traditional NAWQA fixed-interval sampling design with continuous real-time water-quality monitoring. Real-time water-quality monitoring can provide:

- **Continuous monitoring of temperature, specific conductance, dissolved oxygen, and turbidity**
- **Surrogates for hard to measure constituents like sediment and bacteria**
- **Improved temporal resolution for hydrologic events (storms)**
- **Better detection of trends and seasonal patterns**
- **More accurate load estimates**
- **Richer data sets for model calibration**



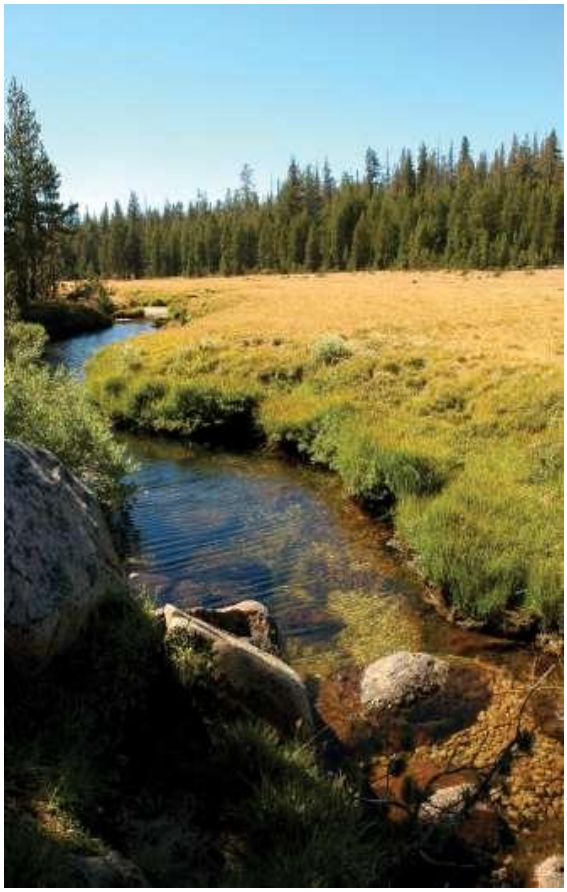
Map showing location of real-time turbidity monitors installed at existing USGS stream gages. Only a few of these sites are co-located with existing NAWQA or NASQAN sites. Most of these monitors have less then 5 years of record and prospects for long-term funding are uncertain. Different colored symbols represent different recorded turbidity ranges (see URL: http://waterwatch.usgs.gov/wqwatch/).

New Design Features:
More Reference Sites

There is a significant need for increased monitoring and study of relatively undisturbed reference sites to evaluate the effects of large-scale environmental factors such as climate change or land use on water resources and the importance of key stressors like excess nutrients, contaminants, sediment, and streamflow alteration on aquatic ecosystems. The current NAWQA monitoring network has only 19 reference sites that are sampled once every four years which is inadequate to evaluate cause and effect relationships and develop predictive models for ecological condition.

By increasing the number of reference sites we will be able to:

- **Provide benchmarks for evaluating:**
  - **— reference biological condition**
  - **— background concentrations**
  - **— effects of changing climate**
- **Sample sites on an annual basis**
- **Build and maintain a National Reference Site monitoring network**



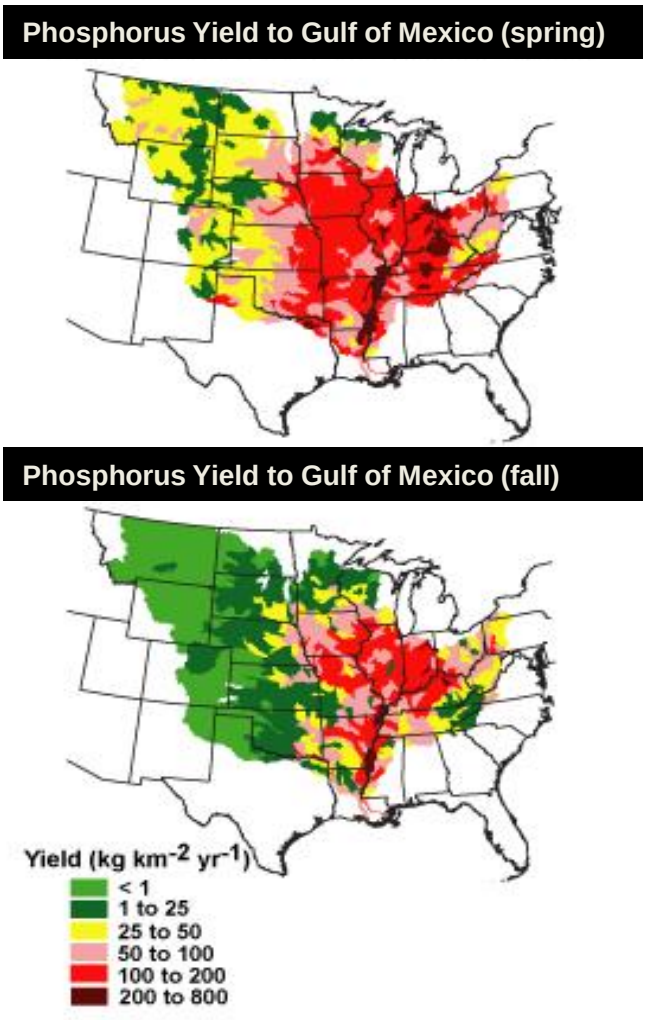
This need presents a significant opportunity to coordinate with other USGS Programs such as the Global Change and Hydrologic Benchmarks Programs as well as with EPA's National Aquatic Resource Assessment Program. The anticipated outcome would be a long-term National Reference Site monitoring network that would be supported by multiple USGS Programs and external partners.

New Design Features:
Development of Dynamic Models for Scenario Testing and Forecasting

Assessing and forecasting the effects of changing environmental conditions on water quality and aquatic ecosystems will require that NAWQA move from "average condition" models to "dynamic" or "time-varying" models. These models need to be developed at a variety of time scales ranging from monthly to seasonal to annual models. We recognize that key ancillary data sets, such as chemical inputs and best management practices, may not be available for some time scales.

To do this we'll need to develop:

- **Time-series of key data: contaminant concentrations and loads**
- **Time-series of ancillary data over time (changes in chemical inputs, land-use changes, management practices, etc.)**
- **Use real-time water-quality monitoring and satellite real-time data to support development of key data sets at different times scales (daily, monthly, seasonal, etc.)**
- **Partnerships with other agencies (EPA, USDA, and state offices)**

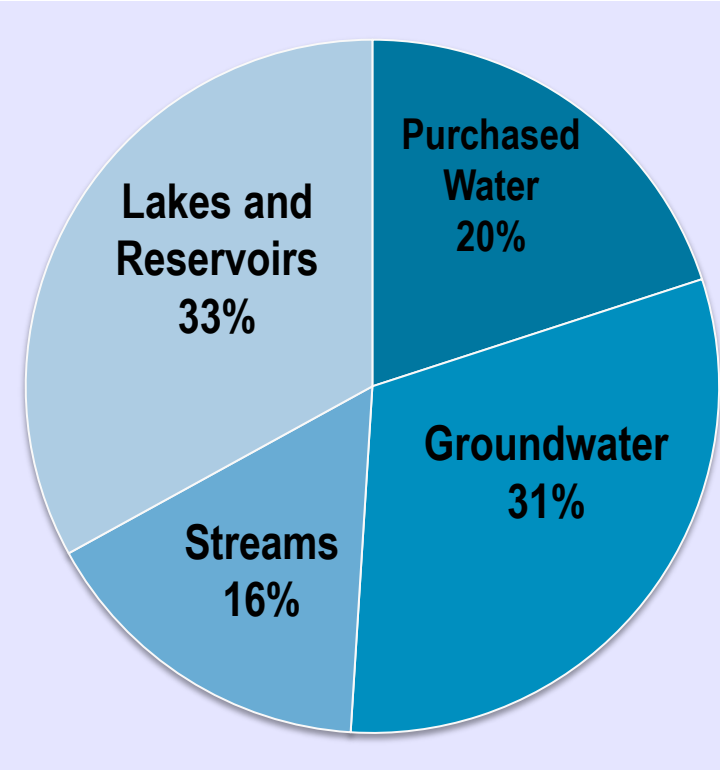


Maps illustrating hypothetical results of a seasonal SPARROW model of phosphorus yields in the Mississippi River Basin.

New Design Features:
Monitoring Drinking-Water Intakes in Lakes and Reservoirs

With respect to the national need to characterize sources of water for human use, we are proposing to add monitoring of a major source of public supply: lakes and reservoirs. In order to recognize the complex processes that control water-quality over time and space in lakes and reservoirs, NAWQA will focus the initial assessment on source-water quality including:

- **Characterizing water quality at drinking-water intakes of representative lake and reservoir supplies**
- **Monitoring contaminants with human health implications:**
  - **Pesticides**
  - **Algal toxins**
  - **Pathogens**
- **Potentially developing a pilot study designed to develop an understanding of the processes that govern source-water quality in lakes and reservoirs**

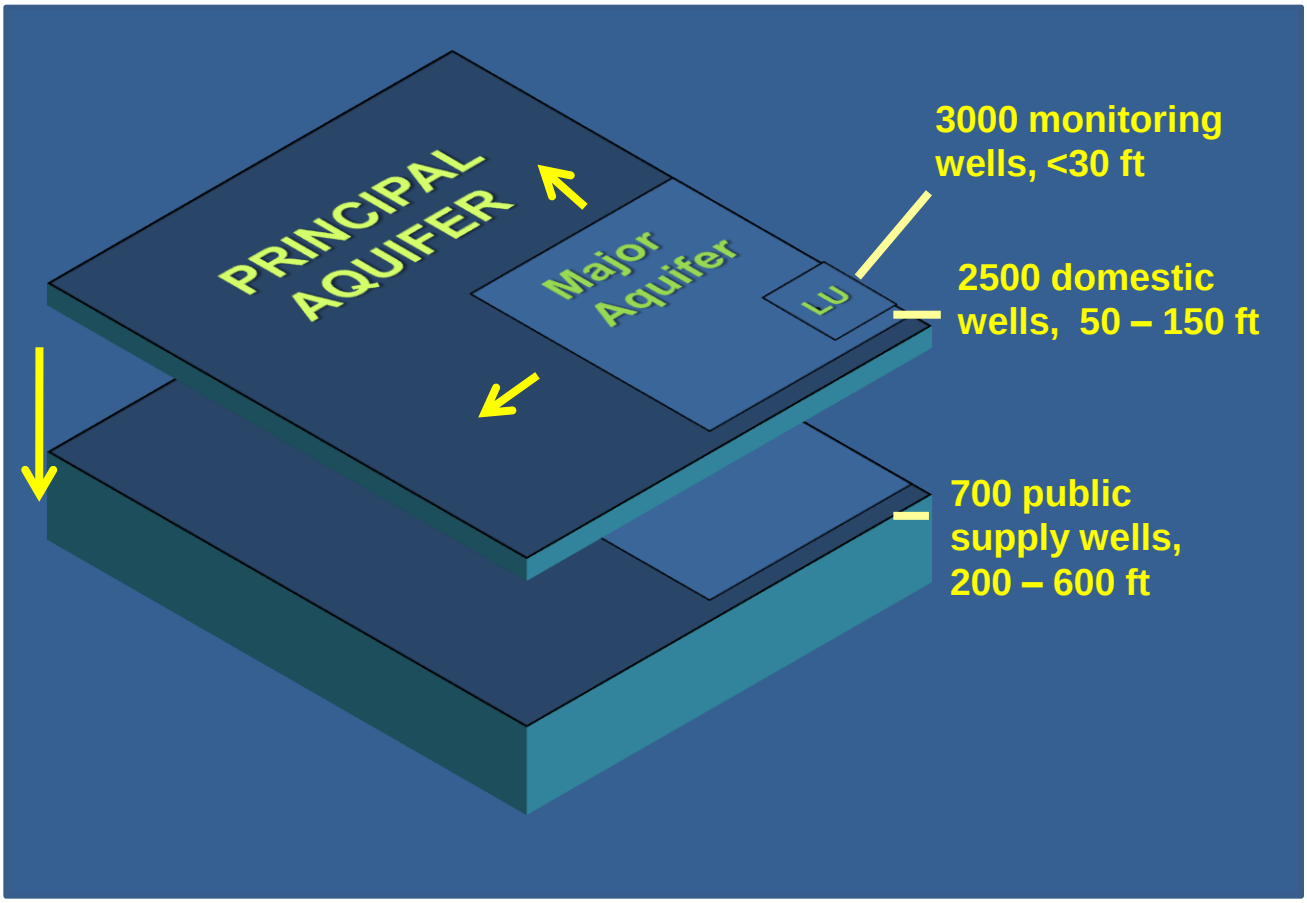


Percent source water by type used for public supply by community water systems in the United States. Previous NAWQA sampling has focused on stream and groundwater sources with minimal sampling of lakes and reservoirs.

New Design Features:
Characterizing Deep Groundwater Used for Public Water Supply

In past Cycles NAWQA put most of its resources into characterizing the shallow parts of aquifer systems, installing monitoring networks to characterize recently recharged groundwater beneath specific land use (LU) settings (urban, agricultural) and for regional surveys. These major aquifer surveys primarily sampled domestic wells, a resource not regulated by the Safe Drinking Water Act. A key gap in this design is insufficient monitoring of deeper parts of aquifers that are tapped mostly by public supply wells and supply over 80% of the population dependent on groundwater for drinking water.

This does not mean we will abandon monitoring in shallower parts of these aquifers (indeed we will retain selected shallow land-use and domestic well networks for long-term trends monitoring). However, expansion to public supply depths will eventually enable us, using NAWQA and other data, to develop a three-dimensional (3-D) picture of groundwater quality in selected aquifer systems.

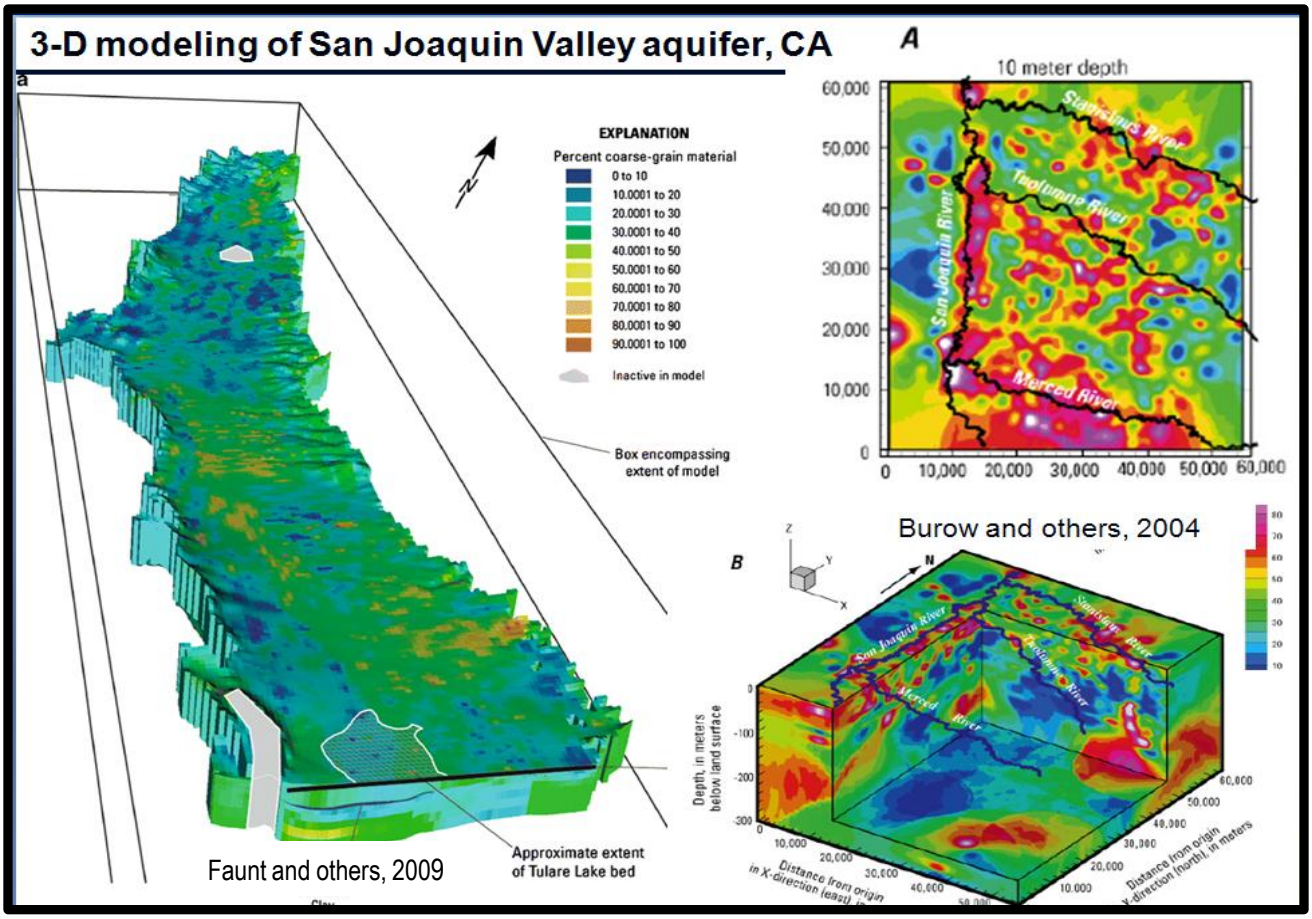


Conceptual diagram drawn to vertical scale illustrating distribution of wells sampled by various NAWQA groundwater status and trends networks in Cycles 1 and 2.

New Design Features:
Three-Dimensional Groundwater Flow and Transport Models

What would 3-D groundwater monitoring and modeling look like and how would it help us manage groundwater supplies? Water-quality and hydrogeologic information about a particular aquifer would be used to develop a three-dimensional picture of concentrations of a key water-quality constituent, and modeling would be used to explore the past, present, and future factors controlling the distribution. For example, we are already working on a model of nitrate distribution in the San Joaquin Valley of California.

The diagram below shows the distribution of different types of sedimentary layers, including coarse-grained sediment units that tend to correspond with old river beds, which in turn have been correlated with elevated nitrate concentrations spatially and with depth. This information provides a general picture of the current status of nitrate in the aquifer. Expanding this approach, by combining the geochemical information with flow models developed by the USGS Groundwater Resources Program, one could evaluate how nitrate concentrations might change in response to changing pumping patterns, land-use or water-use patterns, or the effects of climate change.

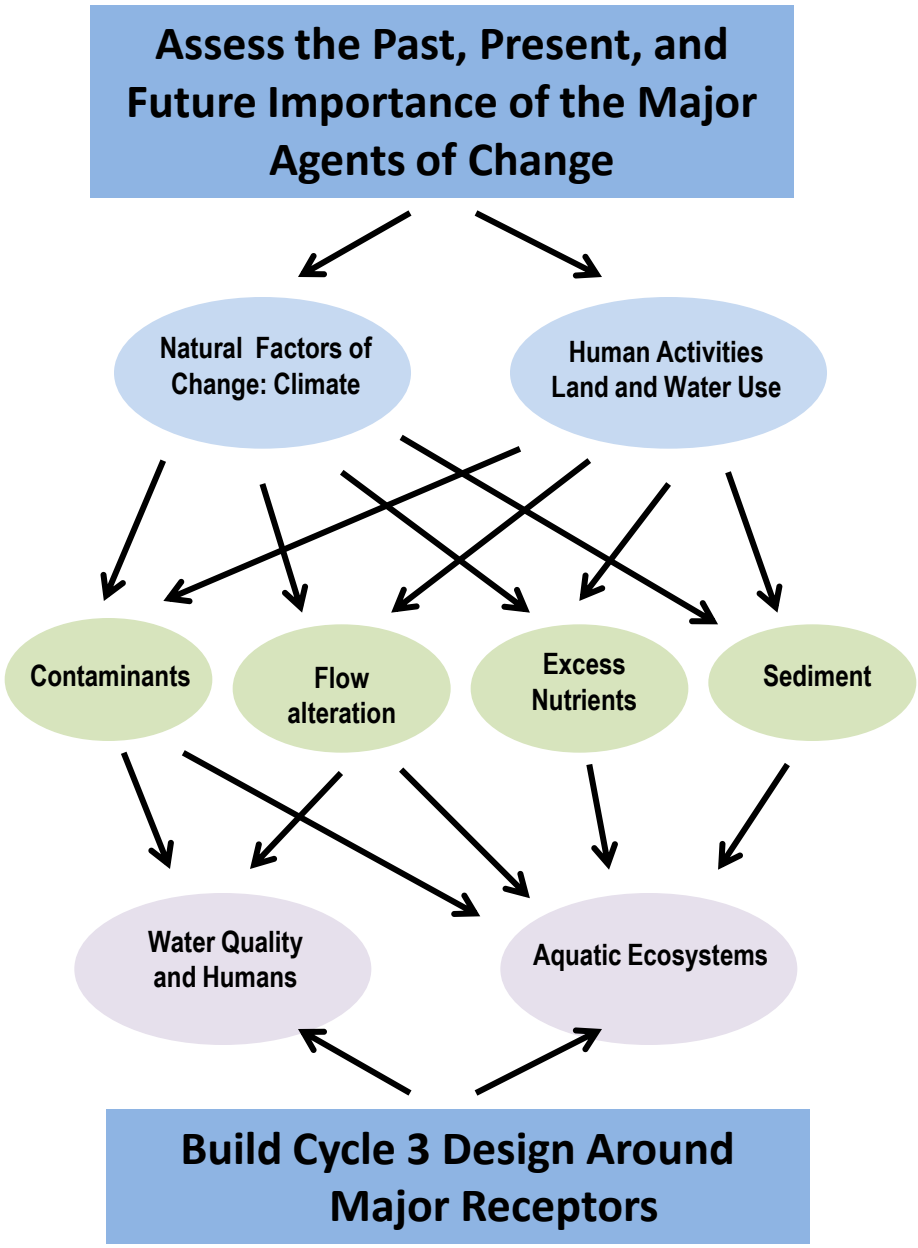


Burow, K.R., Shelton, J.L., Hevesi, J.A., and Weissmann, G.S., **2004**, Hydrogeologic characterization of the Modesto Area, San Joaquin Valley, California: U.S. Geological Survey Scientific Investigations Report 2004-5232, 54 p.

Faunt, C.C., Belitz, K., and Hanson, T. Randall, **2009**, Development of a three-dimensional model of sedimentary texture in valley-fill deposits of Central Valley, California, USA: Hydrogeology Journal: v.18. no. 3., p. 625-649.

Cycle 3 Design Framework

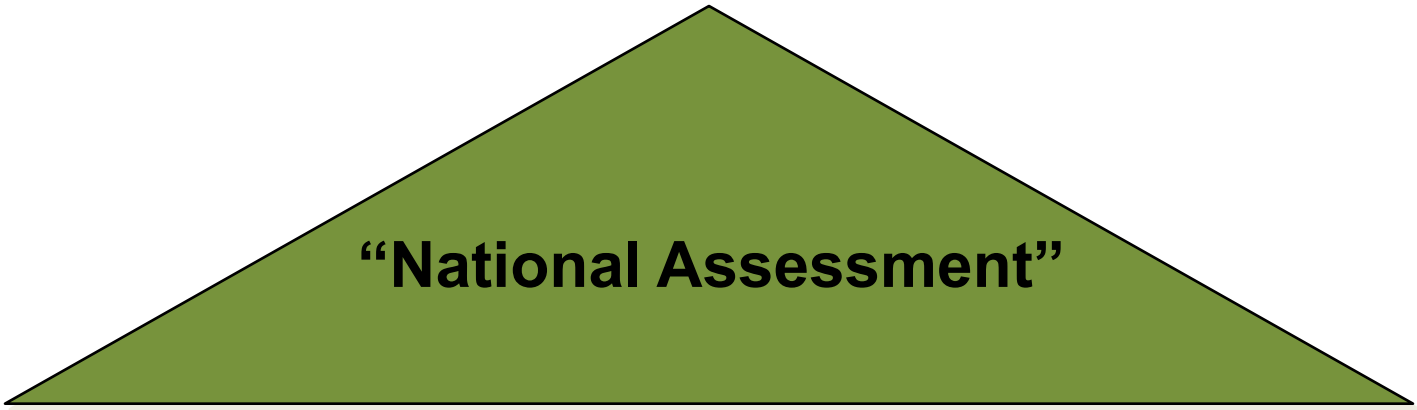
The major agents of change we are using to drive the Cycle 3 design are natural factors, such as climate change and human activities. If we were to summarize this conceptual framework into a simple diagram this is how the various pieces would fit together.



Assess key factors affected by large-scale driving forces that in turn, directly impact water quality and the condition of aquatic ecosystems

We Can't Do This Alone!

To truly assess the Nation's water-quality in a manner that meets the needs the stakeholders have outlined, NAWQA will have to rely on and partner with a number of other agencies in the following way.



EPA

To produce an integrated assessment of the Nation's water quality we need to take advantage of the different approaches used by NAWQA and EPA to assess water quality.

NAWQA

Make collaboration and integration of NAWQA activities with other agencies an explicit goal of Cycle 3 design.

WaterSMART

Partner with USGS WaterSMART Program to obtain water budgets, and a better understanding of how flow alteration is affecting aquatic ecosystems

NOAA

Understanding the effects of excess nutrients on our coastal estuaries requires integrating NAWQA findings on contaminant concentrations and loads with NOAA models of coastal estuaries

USDA

Partner with USDA to improve our knowledge of how nutrients are delivered to coastal waters; develop better ancillary data sets on sources of nutrients and nutrient management practices

Groundwater Resource Program

Couple regional groundwater-flow models with NAWQA data to evaluate how groundwater quality might respond to changing environmental conditions

National Streamflow Information Program

Streamflow data provided by NSIP is foundation for NAWQA design

State and Local Agencies

To develop a 3-D understanding of water quality with depth and improve our water-quality models we need to add state and local data to NAWQA assessments

Next Steps

The next steps the Cycle 3 Planning Team will undertake over the next several months are:

- **Work to finalize the details of the draft Cycle 3 design so we can produce a cost estimate for the "*national needs*" design.**
- **Evaluate options under different budget scenarios**
- **Develop a full draft of the Cycle 3 Science Plan with potential options under different budget scenarios by the end of July**
- **Send draft by July to NAWQA Liaison Committee and others for review and comment**
- **Meet with NAWQA Liaison Committee for input on what the priorities should be under different budget scenarios in late summer**
- **The Cycle 3 Planning Team will take the feedback and begin work on a final draft of the science plan and begin work on a Cycle 3 implementation plan this fall**
- **For additional information contact:**

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