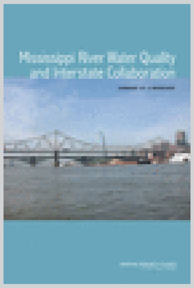

Mississippi River Water Quality and Interstate Collaboration: Summary of a Workshop

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Mississippi River Water Quality and Interstate Collaboration

SUMMARY OF A WORKSHOP

Committee on Mississippi River Water Quality Science
and Interstate Collaboration

Water Science and Technology Board

Division on Earth and Life Studies

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Contents

1

Introduction

This report summarizes presentations and discussions of Mississippi River and basin water quality management, monitoring, and evaluation programs that took place at a workshop that was held in St. Louis on November 18-19, 2013. The workshop was organized and moderated by the National Research Council (NRC) *Committee on Mississippi River Water Quality Science and Interstate Collaboration*. Members of the NRC committee structured the meeting agenda, identified and invited guest speakers (the meeting agenda is listed in this report as Appendix A), and authored the following report.

The November 2013 workshop and this report build upon several years of work by NRC committees on the topics of Mississippi River water quality, the Clean Water Act, and nutrient control actions. Committees of the NRC have issued three reports on these topics (see NRC, 2008, 2009, 2012):

- 2008: *Mississippi River Water Quality and the Clean Water Act: Progress, Challenges, and Opportunities*;
- 2009: *Nutrient Control Actions for Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico*; and
- 2012: *Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico: Strategies and Priorities*.

A consistent theme throughout these three reports is the critical importance of systematic and coordinated water quality evaluation and monitoring as a basis for improved scientific understanding of the links between nutrient loads and water quality, and as an important step for nutrient management efforts that strive to improve water quality. Among their many findings, these reports have noted marked differences among water quality monitoring resources, personnel, the number of monitoring sites, and the setting of water quality standards in the ten states along the Mississippi River corridor. Those reports have encouraged stronger collaboration among these ten river corridor states in water quality monitoring activities, and also noted opportunities for a stronger role for federal agencies with water quality monitoring expertise and responsibilities.

To further complement the work of these previous NRC studies, a two-day workshop was convened to focus on science initiatives and challenges in Mississippi River basin water quality monitoring and evaluation. (Box 1-1 contains the statement of task for this report and that guided the structure of the workshop.) The workshop examined a wide array of challenges and progress in water quality monitoring and evaluation in states along the Mississippi River corridor, and provided a forum for experts from U.S. federal agencies, the Mississippi River states, nongovernmental organizations, and the private sector to share and compare monitoring and evaluation experiences from their respective organizations. The workshop was convened, and this report issued, as "stand-alone" products. At the same time, the National Research Council will continue to seek opportunities to organize studies or other activities to promote the science of water quality evaluation and monitoring across the Mississippi River basin and into the northern Gulf of Mexico, and to encourage the interstate collaboration that will be crucial to more systematic monitoring regimes and approaches for basin-wide monitoring.

There are a great many science and policy issues surrounding nutrient management and water quality issues across the Mississippi River basin and that extend into the northern Gulf of Mexico. These issues include implementation of Total Maximum Daily Load (TMDL) plans, risk management associated with management of reactive nitrogen, costs of nutrient management, the intersection of nutrient management and food production and security, nutrient management impacts on greenhouse gas emissions, and water quality trading. Any or all of these issues conceivably could be discussed in the context of Mississippi River water quality, and they all will need to be considered at some level for better management of nutrients and reducing effects on water quality across the Mississippi River basin. To provide a focused workshop and report, this project adhered closely to the scientific, monitoring, and evaluation issues described in its statement of task (Box 1-1), and did ". . . not make recommendations regarding budgets, resource management practices, or economic policies."

BOX 1-1
Report Statement of Task

An ad hoc committee will issue a consensus report summarizing scientific challenges and priorities regarding Mississippi River water quality monitoring and evaluation.

The report will be based in large part on presentations and information gathered during a two-day public workshop. This event will include presentations that focus on the science behind understanding Mississippi River basin water quality conditions. The emphasis will be on the science and evaluation of water quality conditions, along with discussion and dialogue about these and other related issues. The geographical focus will be on the 10-state Mississippi River corridor and the northern Gulf of Mexico. The committee will develop the agenda, select and invite speakers and discussants, and moderate the discussions.

Goals of the two-day workshop include the following:

- promote basin-wide dialogue of current scientific understanding of water quality conditions,
- discuss scientific uncertainties, relevant issues of time and scale, and priority areas for future water quality monitoring and evaluation,
- discuss ongoing programs for nutrient management and downstream water quality implications,
- discuss institutional frameworks for future water quality evaluation and administration, and
- provide a platform for future discussion, collaboration, and learning of water quality conditions and changes along the Mississippi River and across the river basin.

Following the workshop, the committee will convene an additional meeting at which it will prepare a brief consensus report that provides the committee's conclusions regarding scientific challenges and priorities for Mississippi River water quality monitoring and evaluation. The report will not make recommendations regarding budgets, resource management practices, or economic policies.

Financial support for the workshop and report was provided by The McKnight Foundation, the U.S. Department of Agriculture's Natural Resources Conservation Service, the Walton Family Foundation, and the National Academies' Presidents Fund.

MISSISSIPPI RIVER BASIN WATER QUALITY AND THE EFFECTS OF NUTRIENTS

Across the Mississippi River basin and into the northern Gulf of Mexico, issues associated with excessive loads of the primary nutrients nitrogen (N) and phosphorus (P)—and resultant water quality effects—

are of great interest and importance at local, regional, and national scales (Figure 1-1). Although necessary to support aquatic habitats and species, these nutrients often exist in excess concentrations as a result of high loadings from a variety of pathways and sources, including erosion, run-off and tile drainage of nutrient-rich soils, applications of fertilizer and animal manure, discharges of municipal and industrial water treatment plants, urban runoff, and atmospheric deposition. Excess nutrient concentrations have a variety of effects across a range of scales and include local water quality impairments, such as freshwater algal blooms in lakes and rivers, contamination of groundwater, and areas of hypoxic waters in marine coastal waters and estuaries, including the northern Gulf of Mexico. Understanding the sources and amounts of nutrient loading within the basin is a necessary predecessor for mitigation efforts that produce measurable improvements in water quality.

Agricultural producers, university scientists and extension experts, state and federal agencies, nongovernmental organizations, and the pri-

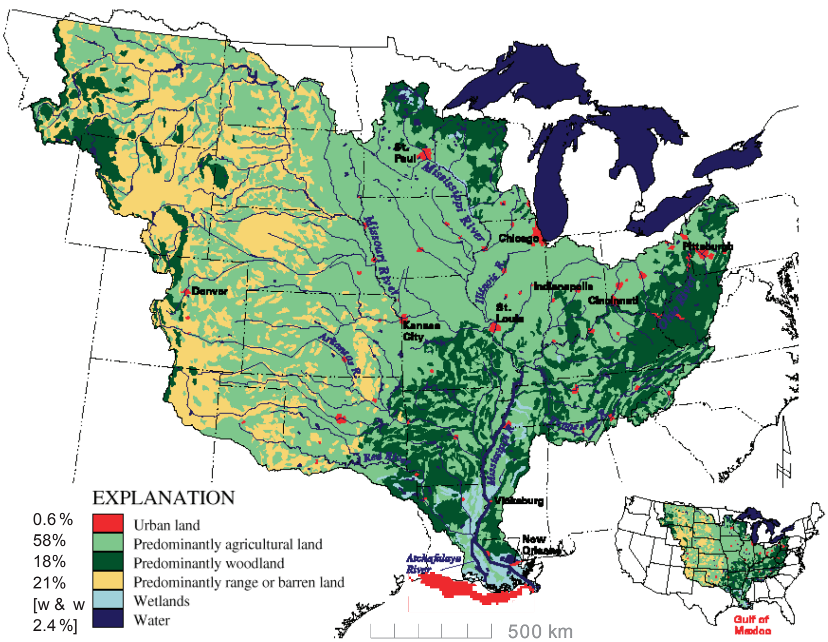

FIGURE 1-1 Mississippi River basin, major tributaries, land uses, and typical summertime extent of Northern Gulf of Mexico hypoxia (in red). The Mississippi River basin extends over 31 states and covers 41 percent of the conterminous United States.
SOURCE: NRC, 2009.

vate sector are engaged in an impressive array of nutrient management and water quality monitoring activities. States along the Mississippi River corridor, and across the basin, conduct TMDL assessments as required under the Clean Water Act. Prominent interstate bodies, such as the Ohio River Valley Water Sanitation Commission (ORSANCO) and the Upper Mississippi River Basin Association (UMRBA), support many initiatives designed to promote interstate collaboration on nutrients issues. Water quality concerns across the basin and into the northern Gulf of Mexico led to the establishment of the Mississippi River/Gulf of Mexico Watershed Nutrient Task Force in 1997 with the participation of five federal agencies and 12 states in the basin. Several other federally sponsored activities have been implemented in the basin, including the U.S. Department of Agriculture's Mississippi River Basin Healthy Watersheds Initiative (MRBI), and basin-wide water quality modeling by the U.S. Geological Survey in the agency's "SPARROW" (Spatially Reference Regression on Watershed Attributes) studies (see Alexander et al., 2008).

THE SCIENCE OF NUTRIENTS AND WATER QUALITY

The science of nutrients and water quality is concerned in large part with determining the levels of nutrient concentrations and loads that will impair water quality in fresh or marine waters, as well as helping define goals and management strategies that are appropriate for reducing nutrient levels and restoring ecological values and their associated uses. Assessment of water quality conditions typically is based upon a combination of water quality monitoring data, and evaluation of those data using watershed or field-scale modeling.

Nutrients are essential for aquatic life; however, it often is difficult to determine levels of "excessive" nutrient concentrations with precision. The difficulties of measuring effects of nutrients on ecosystems and species are complicated by the many variables that affect these relationships, which include factors such as water temperature, dissolved oxygen levels, turbidity, water velocity, light levels, sediment quality, presence of wetlands, and other characteristics and features. Further, the definition of an impaired water body is site specific, and depends in part on the desired condition or use of the water body (e.g., drinking water source, aquaculture, etc.) established by the relevant State/Commonwealth of jurisdiction, or tribe, under the Clean Water Act.

Other complications in establishing water quality monitoring regimes and protocols relate to design of the monitoring program and intended uses of data. It is not feasible to monitor and sample water quality at all points across or within a given water body or stream network. Thus, decisions have to be made about water quality monitoring strategies regarding frequency of monitoring (daily, monthly, continuous, etc.); time of day; monitoring during, or after, storms; appropriate locations and depths to be monitored; and appropriate balance of samples from, for example, a river's main channel and slower-velocity backwater areas. Moreover, and with regard to nutrient effects on downstream waters, statistically significant effects may not be measured for years or even decades. In addition, data needs for regulatory activities, such as TMDL assessments, and other uses such as contaminant fate and transport modeling, often need to be considered in designing monitoring programs.

Numerous federal, state, local, and private sector programs and activities have been established and are devoted to monitoring, evaluating, and modeling of water quality, and the effects of nutrients across the Mississippi River basin. All these activities of course have varying mandates, missions, and activities but portions of these programs are devoted to managing water quality and the implications of nutrient loads.

The following chapter includes summaries of presentations and discussions at the workshop, and text boxes that summarize two luncheon presentations. The report's final chapter summarizes priorities and future opportunities in water quality monitoring, modeling, and evaluation as identified by workshop participants.

2

Workshop Topics and Presentations

USDA HEALTHY WATERSHEDS INITIATIVE

This session focused on the U.S. Department of Agriculture (USDA) Healthy Watersheds Initiative, including its conservation goals and related monitoring activities. Participants were Thomas Christensen and Wayne Honeycutt of the USDA Natural Resources Conservation Service (NRCS) in Washington; Michele Reba of the USDA Agricultural Research Service (ARS) in Jonesboro, Arkansas; and Ranjith Udawatta of the University of Missouri, Columbia.

Thomas Christensen provided an overview of NRCS soil and water conservation programs relating to nutrient management and involving various kinds of monitoring in the Mississippi River basin. He noted that USDA is not a monitoring agency but needs monitoring systems and data to properly manage and support its various NRCS programs. The NRCS works with many partners in meeting its monitoring needs. He pointed out that erosion control programs on farm lands date from the Dust Bowl era of the 1930s, whereas the first programs focused on water quality began in the 1980s. His points were (1) that the water quality programs are less mature than the programs that were designed to maintain soil productivity; and (2) programs that maintain soil productivity on fields do not necessarily improve water quality in adjacent water bodies.

In 2009 the NRCS established the Mississippi River Basin Healthy Watersheds Initiative (MRBI) to provide incentives for implementation of agricultural management practices that could improve water quality in vulnerable watersheds (USDA, 2014a). He emphasized that identifying vulnerable land is a key scientific challenge. The NRCS adopted three approaches to assess the effectiveness of management practices financed and installed under the MRBI. The first is "edge-of-field" (EOF) monitoring by farmers, the second is intensive monitoring of selected watersheds under USDA's Conservation Effectiveness Assessment Project (CEAP), and the third is a network of "paired watershed" studies (for more information on the CEAP, see USDA, 2014b). These paired watershed studies entail investigation of conservation practice effectiveness in a study watershed, and comparing results with observations from a nearby "control" watershed.

"Edge-of-field" monitoring may be defined as monitoring conducted at the field level to determine directly whether nutrient management practices are helping remove nutrient export from the field. Priority small watersheds within the Mississippi River Basin Healthy Watersheds Initiative were the first locations where NRCS offered voluntary cost-sharing assistance for the implementation of edge-of-field water quality monitoring to help assess the efficacy of conservation systems (Figures 2-1 and 2-2). NRCS can cost-share with producers on edge-of-field monitoring activities, but it needs partners to assist producers with managing monitoring stations and covering the producers' share of the cost (for more background on edge-of-field monitoring within the MRBI, see Mills and Christensen, 2012, and Christensen and Honeycutt, 2013).

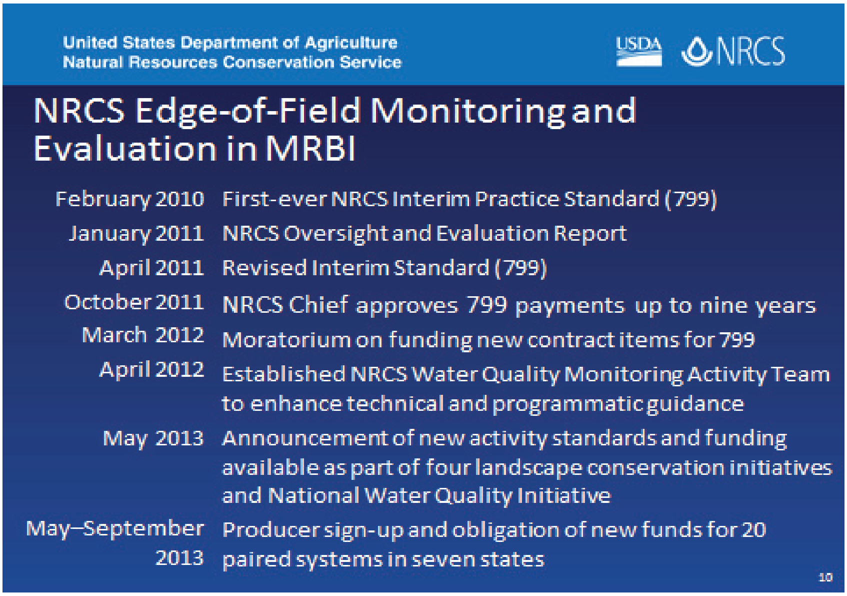

FIGURE 2-1 NRCS edge-of-field monitoring protocol and history.
SOURCE: Christensen and Honeycutt, 2013.

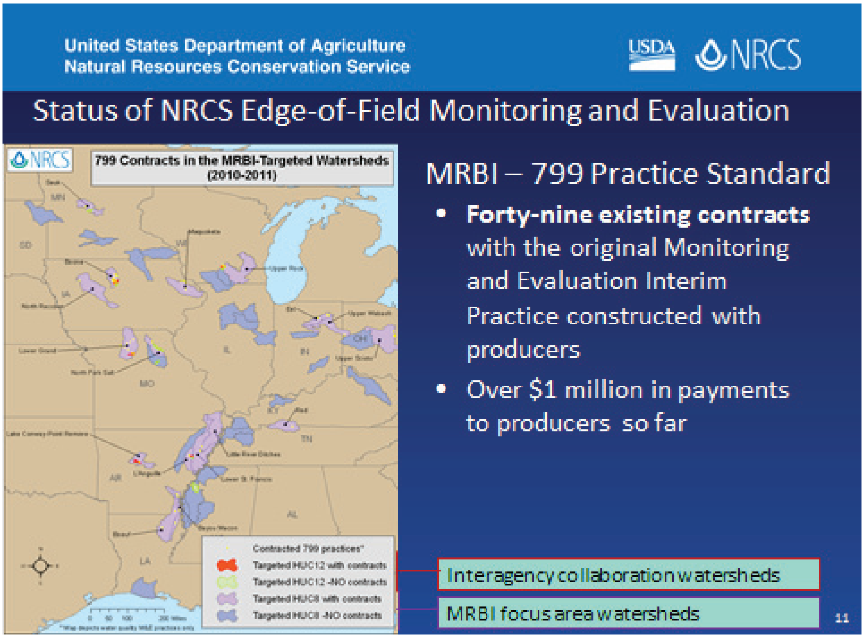

FIGURE 2-2 Edge-of-field monitoring and evaluation within the Mississippi River Basin Healthy Watersheds Initiative.
SOURCE: Christensen and Honeycutt, 2013.

One definition of the "paired watershed" approach is as follows:

> Paired watershed field studies are used to evaluate watershed scale impacts of conservation practices. These are field studies designed to enable comparison of before-and-after monitoring data collected for similar watersheds in which a particular conservation practice is tested with one but not the other. Paired watershed studies involve assessment of the response of both a control watershed and an impact watershed before and after implementation of a conservation practice of interest. (King et al., 2008)

Several invited speakers through the course of the two-day workshop mentioned this paired watershed approach, and its value in helping understand and validate results from nutrient management activities (for more on the paired watershed concept, see also Clausen et al., 1996).

Thomas Christensen further explained that the watersheds selected for financing in the MRBI program are targeted for a variety of reasons. These include maximizing the benefits of conservation funding, producing significant environmental benefits in a short time period, avoiding inefficiencies of random conservation practice implementation, and learning lessons about using conservation practices to more efficiently improve water quality. At the scale of individual farms, targeting conservation practices implies using the right practice, at the right landscape position, in the right amount, and at the right time. This type of targeting is known popularly as "precision conservation." He noted that from 2010-2013, USDA Environmental Quality Incentives Program (EQIP) funding was used to install conservation practices in the MRBI watersheds. He further explained that the CEAP, which is focused on evaluating conservation benefits, involves extensive water quality monitoring and modeling in five select MRBI watersheds. Results of the CEAP assessments indicated that targeted implementation of management practices enhanced conservation effectiveness by from 1.3 to 1.7 times for nitrogen, phosphorus and sediment losses relative to previous untargeted implementations of the same practices. A broad lesson from the NRCS monitoring experience is that longer monitoring periods are needed, and clear, comprehensive guidance about monitoring protocols are important to obtain useful data about conservation practice performance.

Wayne Honeycutt of the NRCS focused a portion of his remarks on his agency's work in edge-of-field (EOF) water quality monitoring. NRCS has established protocols for evaluating conservation effectiveness through EOF water quality monitoring and in paired watershed studies. Protocols for EOF monitoring include system installation protocols and data collection and evaluation protocols. He emphasized the importance of calibration and quantification in evaluating water quality models. NRCS experience with EOF monitoring has shown that it requires a long time period (e.g., minimum of three years) to show results, requires consistent application and protocols, and requires clear guidance for farmers.

He stated that paired watershed studies and edge-of-field monitoring provide useful data for models to evaluate the impacts and effectiveness of conservation practices on water quality at various scales. Scientists from USDA's ARS (often working in collaboration with partners) have developed an impressive array of agricultural system and water quality models, including

- EPIC (Environmental Policy Integrated Climate);
- RZWQM (Root Zone Water Quality Model);
- APEX (Agricultural Policy and Environmental Extender); and
- SWAT (Soil and Water Assessment Tool).

These models operate across a variety of scales and, when calibrated properly using edge-of-field or paired watershed scale monitoring data, are able to evaluate a wide range of agricultural conservation practices under dry, average, or wet climatic conditions. He stated that these models have not been calibrated for new agricultural technologies and require further refinements for greater accuracy, including better accounting of fertilizer and manure management effects on surface runoff water quality, tillage and fertilizer management impacts on drainage water quality, and impact of alternative drainage water management practices on water quality. He also discussed the importance of data quality assurance and reporting requirements.

Michele Reba of the USDA ARS office in Jonesboro, Arkansas, provided a state perspective on USDA conservation and water quality monitoring programs in Arkansas. Agriculture is important to the Arkansas economy, with rice, cotton, and soybeans as leading products. The state is the largest producer of rice in the United States, and ranks fourth among states in terms of irrigated agricultural acres. Arkansas has a statewide network for monitoring water quality and quantity, which assists the ARS in its studies of conservation practices. The ARS collaborates with various partners in these studies, especially Arkansas State University and the University of Arkansas.

Arkansas has been a center of MRBI project activity. Michele Reba described seven ongoing monitoring areas. Sites have been established in these areas with plans to monitor them each for 5 to 6 years. In partnership with Arkansas State University, there are 10 fields with edge-of-field monitoring, five of which have paired control fields. Edge-of-field monitoring at these sites includes water flow velocity and depth, and for water quality, turbidity, suspended sediment, and nutrient concentrations. She emphasized the challenges that weather variability poses for interpreting results of data collection. Results have provided insight into the effectiveness of cover crops and various field-scale water management approaches. In addition, the data obtained have been used for model calibration.

Ranjith Udawatta of the University of Missouri-Columbia described MRBI and other conservation activities in Missouri, which are focused on erosion control, a particular challenge for the state. Missouri has approximately 105,000 farms, more than any of the nearby major agricultural states of the Midwest. The large amount of agricultural activity, combined with erosive soil types and relatively high precipitation rates, leads to excessive soil erosion and associated sediment and nutrient loadings to water bodies. He described field-scale conservation practice monitoring and assessment activities under way in Missouri. He discussed the challenges involved in collaborating with landowners, and providing appropriate and effective incentives to support their participation in edge-of-field monitoring activities.

MISSISSIPPI RIVER WATER QUALITY MONITORING AND SCIENCE: FEDERAL AND STATE PERSPECTIVES

This session examined federal and state agency monitoring of Mississippi River water quality. Due to the large amount of water flow and quality monitoring activity of the U.S. Geological Survey (USGS) in the Mississippi River and the basin, the session focused on USGS activities and partnerships. Participants in this session were Michael Woodside, Lori Sprague, and Dale Robertson of the USGS; Greg Jackson of the Mississippi Department of Environmental Quality (MDEQ); and Glenn Skuta of the Minnesota Pollution Control Agency (MPCA).

There is a long history of monitoring nutrient loadings and trends for the Mississippi River basin. A portion of this work has been conducted by scientists from the U.S. Geological Survey (for example, see Goolsby, 2000, which documents annual flux of nitrates from the Mississippi River basin to the Gulf of Mexico, 1950-1999). Much of this work also has been accomplished by scientists across the river basin and in the Mississippi River states, much of which are described in NRC (2008).

Michael Woodside of the USGS provided an overview of USGS monitoring activities in the Mississippi River basin. The USGS conducts long-term monitoring at 40 sites within the Mississippi River watershed. There are many additional monitoring sites which the USGS operates jointly with states. Water quality monitoring at this collection of sites includes real-time monitoring of nitrate at 40 locations. The USGS aggregates and interprets water quality data, and publishes annual National Water Quality Assessment (NAWQA)[1] and National Stream Quality Network (NASQAN)[2] reports with water quality data and assessment summaries. He emphasized the importance of having information about site conditions (e.g., flow, ambient temperature, precipitation) corresponding to a particular water quality measurement. He discussed USGS efforts in real-time nitrate monitoring, and USGS collaborative efforts with USDA on water quality modeling.

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[1] The USGS NAWQA provides an understanding of water quality conditions; whether conditions are getting better or worse over time; and how natural features and human activities affect those conditions. For more information, see: https://water.usgs.gov/nawqa/.

[2] The objectives and scope of the USGS NASQAN program have changed several times since its beginnings in 1973 to reflect changes in funding, technology, and societal priorities and needs. The latest design for NASQAN was implemented in October 2007. Under this design, the major objective of the NASQAN program is to report on concentrations and loads of selected constituents delivered by major rivers to the coastal waters of the United States, and select inland subbasins in priority river basins, to determine sources and relative yields of constituents within these basins. For more information, see: https://water.usgs.gov/nasqan/.

Lori Sprague of USGS presented a summary of USGS nitrate monitoring data in the Mississippi River for 1980-2010. She emphasized the importance of flow normalization, to account for inter-annual variability and remove the effects of streamflow on nitrate flux. The flow-normalized data reveal that there has been a 14 percent increase in nitrate flux to the Gulf of Mexico from the Mississippi River over the 30-year period, with greater increases in nitrate flux in the last decade of the period (Figure 2-3; see also USGS, 2014a). The Iowa River and the Illinois River provide the largest flow-normalized fluxes of nitrate to the Mississippi River. She noted that the number of NAWQA monitoring sites nationally has been reduced from 496 sites in Cycle 1 (1991-2001) to 100 sites in Cycle 3 (2013-present) due to budget reductions. This has resulted in reduced spatial coverage within the Mississippi River basin monitoring network. The USGS is working to obtain additional data via partnerships with states and other organizations. She noted further that future research efforts would include trend studies within the NAWQA program.

Dale Robertson of USGS provided an update on SPARROW (SPAtially Referenced Regression on Watershed Attributes) model and its application to the Mississippi River basin (see also USGS, 2014b). In the context of assessment and management of nutrients in runoff, typical goals of SPARROW modeling are: (1) determine P and N loading to various receiving

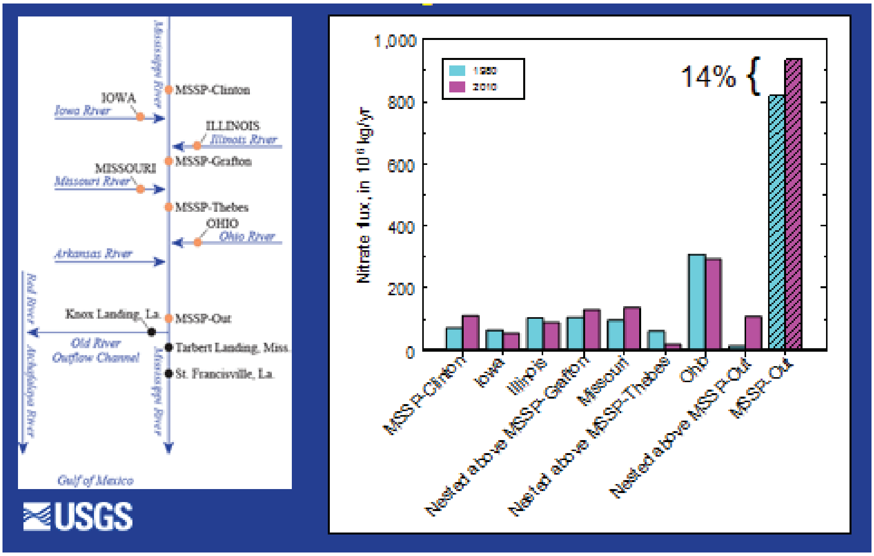

FIGURE 2-3 Flow-normalized nitrate flux changes of the Mississippi River and tributaries, 1980-2010.
SOURCE: Sprague et al., 2013 (based on data from Murphy et al., 2013).

waters over large spatial scales using monitoring data and landscape and land use; (2) determine the main contributing basins and subbasins; (3) determine main causes of high loads; and (4) provide information to states and regional organizations to support regional interpretation and guide local, more in-depth studies. SPARROW employs mass balance modeling and regression techniques to determine the relative influence of various sources. Various analyses have been performed with SPARROW for the Mississippi River basin, providing indications of the significant nutrient mass loading source areas within the basin. The database providing the foundation for these analyses was developed with 2002 data and encompasses numerous water quality station identification numbers, different agency codes, and nutrient source loading sites. He reported that the analyses of nutrient inputs to the Mississippi River with SPARROW have been refined, with improved data for model calibration (e.g., actual data rather than estimates for nitrogen and phosphorus inputs from municipal wastewater treatment plants). SPARROW results also present relative rankings of Mississippi River basin states of nutrient loads that ultimately are delivered to the northern Gulf of Mexico. He reported that SPARROW is being modified to make it easier to use for decision support analyses. SPARROW Mapper is being developed and will allow the user to select the area of interest for analysis via a map-based user interface. Further, new auxiliary decision support tools will enable users to select data for particular regions, examine scenarios, and illustrate results graphically. He also noted that current scientific understanding indicates that Gulf hypoxia results from both nitrogen and phosphorus. This represents a shift in thinking about these issues, as there was a longstanding view that phosphorus was the main cause of eutrophication in freshwater ecosystems, while nitrogen was the main problem downstream in saltwater ecosystems.[3]

Greg Jackson of the Mississippi Department of Environmental Quality presented a state perspective on monitoring for management of nutrient inputs to the Mississippi River. He described the state's nutrient reduction strategies, which include development of numeric nutrient criteria, engaging partners and stakeholders, and implementing and monitoring nutrient reduction methods. He noted that the state is striving to be more proactive in its activities related to nutrient yields and monitoring. A particular focus of effort is the Delta Reduction Project, which involves a collaboration of MDEQ, USGS, and Mississippi State University. This project involves a treatment watershed with testing of various nutrient control methods, and

[3] For a thorough discussion of the changing fluxes of nitrogen and phosphorus into the northern Gulf of Mexico, changes in N:P ratios, and changes in their respective effects on northern Gulf ecosystems, see US EPA, 2007.

a related control area. Reduction of phosphorus loadings is being achieved. He noted that an important, but perhaps little-known, challenge for the Delta region is depletion of available groundwater. Recovery and reuse of runoff is important for preservation of groundwater resources.

Glenn Skuta of the Minnesota Pollution Control Agency described the wide range of partnership activities that MPCA has with USGS in regard to monitoring. The cooperative stream gaging network is valuable to the state in monitoring pollutants, especially nutrient discharges. Minnesota has established a Watershed Pollutant Load Monitoring Network. USGS monitoring resources are critical to this network. Minnesota has stepped in to support some USGS monitoring sites in danger of being abandoned due to federal budget cuts.

Following this session, the workshop hosted a luncheon talk by Elizabeth Hubertz from Washington University in St. Louis (summarized in Box 2-1).

ASSESSING WATER QUALITY CONDITIONS WITHIN THE GULF OF MEXICO HYPOXIA TASK FORCE: FEDERAL AND STATE PERSPECTIVES

Participants in this session were Joseph Pietrowski of the U.S. Environmental Protection Agency; Michael Woodside of the U.S. Geological Survey; William Northey of the Iowa Department of Agriculture; Ken Brazil of the Arkansas Natural Resources Commission; and Warren Goetsch of the Illinois Department of Agriculture.

Joseph Pietrowski of the U.S. Environmental Protection Agency provided an overview of the activities of the Mississippi River Gulf of Mexico Watershed Nutrient Task Force (Task Force). The Task Force was established in 1997 and is composed of representatives from several federal agencies, and from all states along the Mississippi River corridor and Indiana and Ohio. The Task Force has issued two Action Plans, one in 2001 and a second in 2008 (see US EPA, 2001, 2008). He noted that the 2008 Action Plan reiterated goals from the 2001 document, and identified 11 specific action items. The action items included state-level nutrient reduction strategies, and complementary federal strategies aimed at supporting the state efforts. An assessment of progress on the Action Plan was conducted in 2013 (US EPA, 2013). One finding was that all participating states are on track to have nutrient management strategies by 2014. He also discussed the roles and importance of states in helping achieve nutrient reduction goals, and he noted that the states were being guided in large part by a memorandum issued in 2011 from then-acting EPA Assistant Administrator Nancy Stoner that identified guiding principles for nutrient reduction ("the Stoner memo"; see US EPA, 2011). He discussed

BOX 2-1
Lunch Speaker
Elizabeth Hubertz, Environmental Law Clinic
Washington University in St. Louis

At lunch on Day 1, Elizabeth Hubertz provided her perspective on the current state of legal control of nutrient discharges to water bodies in the United States. She began by reminding the audience that the Clean Water Act is the basis for any legal action to control nutrient discharges, but noted that the CWA "doesn't have much to say about nonpoint source pollution." There is pressure being applied for action through the CWA via the citizen suit provisions of the law. She described the October 2013 decision in the case of Gulf Restoration Network vs. Lisa Jackson (former EPA Administrator). The suit was filed after the EPA denied a petition in 2011 from a coalition of Mississippi River environmental groups requesting the EPA to determine under the CWA that numeric nutrient criteria (NNC) are necessary to maintain quality in the waters of the states in the Mississippi River basin. In the October 2013 decision, the court concluded that the CWA requires the EPA to make a determination within six months as to whether NNC are necessary, and that the EPA has broad discretion to consider nonscientific factors in making that necessity finding. She also described a related case in Florida, which resulted in a court decision requiring EPA to develop NNC for the waters of Florida. The EPA developed draft NNC, in 2010, but then the State of Florida developed their own and EPA subsequently relented, and will allow the Florida NNC to have primacy. She discussed the status of the Total Maximum Daily Load nutrient allocations developed in 2010 for the Chesapeake Bay watershed by the seven states in the basin and the EPA. The TMDL was challenged by a coalition of interested parties, but the TMDL was upheld by the court in December 2012. Also in December 2012, EPA denied a petition filed by the Natural Resources Defense Council to request that nutrient removal be added to the secondary treatment requirements under the CWA. She concluded by describing a July 2013 decision in a lawsuit brought by the Iowa League of Cities against EPA, regarding guidance issued by the EPA to encourage nutrient removal in municipal wastewater treatment. The court sided with the Iowa League of Cities, concluding that EPA cannot issue guidance and treat such as de facto rulemaking.

many of the challenges associated with measuring progress toward nutrient reduction goals, and affirmed that achievement of these goals for the basin would require partners beyond federal and state agencies.

Michael Woodside of the U.S. Geological Survey described two important initiatives for water quality monitoring in the Mississippi River Basin: development of the Water Quality Portal by USGS and EPA, and the Task Force Monitoring Collaborative (for more information, see National Water Quality Monitoring Council, 2014[4]). The Water Quality Portal will

[4] Available online at http://www.acwi.gov/monitoring.

provide a web-based tool that combines USGS and EPA monitoring data, and efforts are under way to include USDA water quality data, as well. The site will allow users to extract specific types of data via specification of up to seven identifiers. The Task Force Monitoring Collaborative has retrieved over 670,000 nutrient monitoring records collected by 48 agencies in the Mississippi River basin since 2000. Data from the EPA STORET and the USGS National Water information System databases are included.

William Northey of the Iowa Department of Agriculture explained that in the past three years the Task Force has seen a greater level of engagement among the Mississippi River basin states in a variety of nutrient reduction and monitoring activities. He noted that a common framework is needed to help guide state-level water quality monitoring activities. He discussed challenges involved in better nutrient management and reductions, and accurate monitoring and evaluation, and noted the long-term nature of addressing these issues. He described some studies that had been conducted by agronomic experts and other scientists at Iowa State University in developing the state's nutrient strategy. He noted the need for an action-oriented approach to nutrient management and related monitoring activities. He emphasized the need for development of new tools (e.g., for determining and controlling optimal levels and timing of fertilizer applications). He noted that there is likely to be intense interest in monitoring in small watersheds, and he stressed the importance of recognizing differences across watersheds and how those differences affect outcomes. He also noted that there had been a 30 percent reduction in nitrogen flux reported from farm land by use of a cover crop.

Ken Brazil of the Arkansas Natural Resources Commission described the collaborations now taking place among the Task Force members, and the action-oriented initiatives in the participating states. He emphasized the importance of using adaptive management to make use of what is being learned on a continuous basis. He also emphasized that different states and different regions within states have unique challenges with respect to nutrient management and monitoring. These include technical as well as cultural challenges. As he noted, different regions will engage with conservation programs in different ways, and he stressed the importance of flexibility in implementing conservation programs.

Warren Goetsch of the Illinois Department of Agriculture observed that more producers are becoming interested and engaged in nutrient management, but progress is slow as this represents a cultural change in agricultural practices. He expressed the view that as awareness of the impacts of nutrients becomes more widespread in the agricultural community, there will steadily be more producers engaged in better nutrient management practices. He also mentioned a program in the State of Illinois, "Keep it for the Crops (KIC)," which seeks to reduce nutrient yields through adoption of "the 4 Rs of nutrient use: right sources, right rate, right time, and right place.[5]

STATE-LEVEL SCIENCE AND MONITORING OF NUTRIENTS AND WATER QUALITY

Participants in this session were Timothy Hall of the Iowa Department of Natural Resources, David Duhl of the Tennessee Department of Environment and Conservation, Richard Raynie of the Louisiana Coastal Protection and Restoration Authority, and Glenn Skuta of the Minnesota Pollution Control Agency.

Timothy Hall of the Iowa Department of Natural Resources directed many of his comments to the background work and strategies within the Iowa nutrient reduction strategy. He noted that agriculture is the predominant land use in the state, comprising 92 percent of all land in Iowa. He reported that the Iowa nutrient reduction strategy was completed in May 2013. From the analyses that were conducted in preparation of the strategy, it became clear that inter-annual variations in precipitation are very important in governing nutrient mobilization and export.

David Duhl of the Tennessee Department of Environmental Conservation discussed monitoring of nutrients in the watersheds of the state. The statewide monitoring program has enabled identification of nutrient-impaired streams. He emphasized the importance of stakeholder engagement in the design of monitoring programs.

Richard Raynie of the Louisiana Coastal Protection and Restoration Authority (CPRA) discussed the coordination among Louisiana state agencies on nutrient monitoring and management. CPRA interest in nutrients is in the context of ecosystem restoration, while the Louisiana Department of Environmental Quality is focused on and conducts the state water quality monitoring program. The state has developed watershed implementation plans for 50 watersheds, and these are monitored at relatively fine scale. The state also has developed a System Wide Assessment and Monitoring Program (SWAMP), which includes data sharing among various state agencies. He noted the challenge of scale—both spatial and temporal—in the monitoring programs of the state. He emphasized the importance of coordination of state and federal agency monitoring programs to leverage existing long-term monitoring networks and for consistency of measurements and data reporting. He also described Louisiana's 2012 Coastal Master Plan, which has a strong focus on sediment management and its implications for wetlands construction. With regard to nutrients, he noted that the planned

[5] For more information on the KIC program, including some of its monitoring goals, please visit its website at http://www.kic2025.org.

water diversions from the Mississippi River (intended for restoration purposes) had implications for nutrient levels and water quality.

Glenn Skuta of the Minnesota Pollution Control Agency discussed some of the initiatives within the Minnesota state government aimed at improving water quality and monitoring, notably $12 million/year from a state sales tax (approved by state-wide referendum) that is intended to be devoted to water resource protection initiatives. The Minnesota surface water monitoring program includes a watershed pollutant load monitoring network, and monitoring of rivers, streams, lakes, and wetlands. Much of the monitoring is conducted by local groups that follow MPCA protocols. The watershed monitoring program involves comprehensive monitoring of selected watersheds on a 10-year cycle. The first 10-year cycle will be completed in 2018.

MISSISSIPPI RIVER INTERSTATE COLLABORATION AND STATE-LEVEL MONITORING AND ASSESSMENT

Participants in this session were Jim Baumann (retired) of the Wisconsin Department of Natural Resources, Paul Davis (retired) of the Tennessee Department of Environment and Conservation, Gregg Good of the Illinois Environmental Protection Agency, Larry Taylor of the Kentucky Department for Environmental Protection, and Peter Tennant of the Ohio River Valley Water Sanitation Commission.

The Mississippi River and many of its tributaries flow along the boundaries between states. Some degree of interstate collaboration among these states is needed to ensure consistency in implementation of numerous programs under the federal Clean Water Act. Jim Baumann (retired) from the State of Wisconsin Department of Natural Resources described, for example, collaborative efforts of Wisconsin and Minnesota to develop consistent TMDLs for Lake Pepin. Consistent methods for water quality monitoring are especially important for waters shared by two or more states. Water quality standards used to evaluate water quality monitoring data require consistency across states in order to arrive at consistent assessments of impaired boundary waters.

There are several examples of interstate collaboration in monitoring and assessment in the Mississippi River basin. These include the Upper Mississippi River Basin Association (UMRBA), the Ohio River Valley Sanitation Commission (ORSANCO), the Lower Mississippi River Conservation Committee (LMRCC), and more informal partnerships between states such as Wisconsin and Minnesota, and Kentucky and Ohio.

Gregg Good from the State of Illinois Environmental Protection Agency, and past state designee and participant in Upper Mississippi River Basin Association activities, provided an overview of the UMRBA.

The UMRBA represents the five states--Iowa, Illinois, Minnesota, Missouri, and Wisconsin—in the upper Mississippi River basin. The UMRBA consists of gubernatorial representatives from the five states and, in the realm of water quality, seeks improved implementation and consistency of the Clean Water Act and better interstate coordination and collaboration in water quality and water quality monitoring. Mr. Good noted that UMRBA is staffed by five people in St. Paul, Minnesota. The UMRBA has a Water Quality Task Force and an Executive Committee. These groups meet four times each year and work to promote interstate collaboration and consistency of water quality assessments along the river. They collaboratively assess interstate watersheds (e.g., eight such watersheds in Illinois). They have issued reports on fish consumption advisories, biological indicators, nutrients, monitoring strategies, and assessment methods. In 2013 UMRBA developed a basin-wide monitoring strategy. A consistent water quality assessment methodology is in development. He also explained that the UMRBA uses monitoring procedures developed by the EPA Environmental Monitoring and Assessment Program (EMAP), plus assessment of submersed aquatic vegetation and some other protocols from the U.S. Army Corps of Engineers/USGS Long Term Resource Monitoring Program (LTRMP), headquartered in LaCrosse, Wisconsin.[6]

Peter Tennant of the Ohio River Sanitation Commission (ORSANCO) provided an overview of his organization, which is managed by commissioners representing eight states in the Ohio River Basin. ORSANCO is staffed by 22 people in Cincinnati, Ohio. The mission and authorities of ORSANCO are focused on water quality. ORSANCO monitors pollutants that degrade water quality, and works collaboratively with basin states in this effort. Examples of chemical monitoring activities include metals, organic compounds, bacteria, algae, nutrients, and dissolved oxygen. Nutrient and algae monitoring was begun in 1999. ORSANCO also monitors biological indicators, including fish populations and tissue and macroinvertebrates. Funding to support ORSANCO comes from a mixture of federal and state sources, including U.S. EPA funding under section 106 of the Clean Water Act. ORSANCO provides recommendations for states' (Clean Water Act section) 303d lists for water bodies requiring TMDL assessments. He described ORSANCO's efforts toward these recommendations as "95 percent there."

Paul Davis (retired) of the Tennessee Department of Environment

[6] LTRMP is a cooperative federal-state program (five states in the Upper Mississippi River Basin) that has been collecting physical, chemical, and biological data on the Upper Mississippi River using standardized protocols since the mid-1990s. For more information, see http://www.umesc.usgs.gov/ltrmp.html.

and Conservation described the activities of the Lower Mississippi River Conservation Commission, which represents six states in the Lower Mississippi River Basin and in which Mr. Davis has participated. Their primary mission is the restoration of natural resources in the Mississippi River floodplain, including habitat for fish and wildlife. The LMRCC Executive Committee is drawn from 12 natural resource conservation and environmental quality agencies in the six member states. LMRCC has no paid staff. Louisiana is the only member of LMRCC that has continuous water quality monitoring stations along the Mississippi River. In general, LMRCC does not have the funding or authority to address nutrient reductions in the Gulf of Mexico. The LMRCC has no water quality monitoring responsibilities or programs, nor does it have any such plans.

Larry Taylor of the Kentucky Department for Environmental Protection described water quality monitoring activities in Kentucky, and interstate collaboration efforts of Kentucky, especially with Tennessee. Kentucky has a watershed monitoring and management program that includes a 5-year rotation for focused monitoring. He emphasized that managing shared resources is needed along rivers for cross-border consistency. He described the collaborative engagement of Kentucky with LMRCC, ORSANCO, and USGS to monitor and evaluate major tributaries to the Ohio River.

MONITORING AND EVALUATING WATER QUALITY: METHODS AND UNCERTAINTIES IN MOVING FROM FIELD TO WATERSHED SCALES

Participants in this session were Craig Cox of the Environmental Working Group in Ames, Iowa; Mark David of the University of Illinois; Matthew Helmers of Iowa State University; Douglas Schnoebelen of the University of Iowa; and Lori Sprague of the U.S. Geological Survey in Boise, Idaho.

Craig Cox of the Environmental Working Group noted two important issues regarding scale and monitoring: scales at which harm is evident, and relevant management units. He stressed the importance of meaningful, science-based interpretation of monitoring data. He also expressed the view that land use management was the biggest missing piece in trying to attain sustained nutrient loading reductions and improved water quality. With regard to land management and nutrient control activities, he stated that "The nation does not deal with multiple pollutants in a strategic way." He suggested focusing not on watersheds where challenges are the greatest (e.g., low landowner participation rates, or steep and isolated terrain), but rather on productive agricultural land that has the highest nitrogen loads.

Mark David of the University of Illinois noted that there was good understanding of nutrient and water quality trends "directionally," but that better scientific information was required at the watershed scale. He noted that a key limitation in conducting studies at watershed scale is access to private land and participation by landowners. He further noted that even when studies can be conducted at the watershed scale, there is a challenge of obtaining a pre-development or pre-activity baseline record. He also discussed the importance of individual landowners' perceptions of nutrients and water quality, wondering how to better engage those parties who may not perceive any issues or problems regarding water quality. He noted a major issue is how to help pay, and/or regulate, private landowners in order to achieve watershed-scale response. He noted that landowners have installed more tile drainage and put more land into production in the last few years (presumably because of expiration of conservation easements and rising prices for commodity crops, such as corn).

Matthew Helmers of Iowa State University discussed the importance of tracking practices on the land. He noted that there has been useful work done in this regard with remote sensing, but emphasized that detailed data about agricultural practices are needed (e.g., data on rate, locations, and timing of nutrient application).

Douglas Schnoebelen of the University of Iowa discussed the importance of using numerical modeling to help understand riverine processes at different scales. He emphasized the importance of integration of models designed for different scales in order to understand watershed scale processes and effects.

Lori Sprague of the U.S. Geological Survey expressed the view that there are good examples for monitoring at different scales and across state boundaries. She cited the monitoring of the Susquehanna River as part of the Chesapeake Bay Project as a notable example. This monitoring effort involves multiple states and multiple government agencies, but is conducted in a coordinated manner and with consistent methods. She discussed ongoing challenges associated with interpreting the causes of trends in water quality data for nutrients and other contaminants, and that more ancillary data on environmental conditions and flows are needed to interpret trends in water quality data. She also noted the complications involved in determining sources and relative values of nutrient inputs, explaining that this is not simply a matter of subtracting municipal and industrial loads (point sources, with relatively accurate and reliable data) from total loads in rivers, then attributing the rest to agriculture.

CASE STUDIES OF AGRICULTURE AND WATER QUALITY ACROSS THE MISSISSIPPI RIVER BASIN

Participants in this session were Dennis Busch of the University of Wisconsin (UW)-Platteville, David Gustafson of Monsanto, Maria Lemke of The Nature Conservancy, Jerry Hatfield of the USDA-ARS National Laboratory for Agriculture and the Environment (Ames, Iowa), Richard Warner of the National Great Rivers Research and Education Center (Alton, Illinois) and the University of Illinois, and Roger Wolf of the Iowa Soybean Association.

Dennis Busch of the University of Wisconsin-Platteville discussed his work in paired-watershed research. He discussed the importance of cost factors in edge-of-field monitoring, as well as the need to identify and minimize barriers to water quality monitoring. He discussed the USDA Natural Resources Conservation Service Conservation Innovation Grants (CIG) program. The CIG program is voluntary and intended to stimulate development and adoption of innovative conservation approaches and technologies, while leveraging federal investment in environmental enhancement and protection, and in conjunction with agricultural production (USDA, 2014c). He also mentioned that he had been conducting some of his work at UW-Platteville in collaboration with the Great Lakes Regional Water Program (GLRWP, 2014).

David Gustafson (Monsanto) and Maria Lemke (The Nature Conservancy) jointly discussed some of their work in the Mississippi River basin. They discussed the role of cover crops as transformative practices. They, too, discussed paired-watershed projects. They also described the concept of using wetlands to help reduce nutrients in runoff in areas of tiled drainage. David Gustafson mentioned the availability of innovation grants through the Conservation Technology Information Center of West Lafayette, Indiana (CTIC, 2014). Maria Lemke mentioned "bundling" of conservation and nutrient reduction practices to increase incentives to landowners. She described studies and steps toward a water fund to pay for reducing nitrogen loading from a watershed that is 90 percent agricultural and is a source of drinking water for the city of Bloomington, Illinois. Since the watershed is largely tiled, results could be transferred to other tiled watersheds.

Jerry Hatfield of the USDA-ARS Laboratory for Agriculture and the Environment discussed some of his work on farming practices and water quality monitoring in Walnut Creek and the South Fork of the Iowa River. He discussed some of the implications for water balance of changes in crop types. He also talked about the prospects of precision cropping practices, and the implications for production and water quality of different soil types. He said that he used county-level fertilizer sales to identify a "tipping point" for nitrogen loading of streams. The tipping point occurs when land use shifts from predominantly small grains and hay to row crops (corn and soybeans). Nitrogen fertilizer use tracks the shift. He also reported success in reducing nitrate from tile-drained watershed (1,200-acre subbasin of N Walnut Creek, Iowa River drainage) that resulted from "precision conservation"—wet filter strips and other practices targeted to 10 percent of the watershed.

Richard Warner of the National Great Rivers Research and Education Center discussed land grant colleges along the river and in the basin, and the prospects for them to help connect community colleges and support environmental education. He mentioned two new efforts in which his organization is involved: Great Lakes-Gulf virtual observatory (which includes mayors and others looking for practical information about water quality), and the Great Rivers Ecological Observatory Network (which is focusing on real-time water and environmental monitoring).[7] He also noted exciting prospects for employing sensors to improve monitoring networks and data collection.

Roger Wolf of the Iowa Soybean Association discussed nutrient management and water quality issues in Iowa's Raccoon and Des Moines Rivers, both of which drain into and through the city of Des Moines. He discussed activities of Agriculture's Clean Water Alliance in Iowa, and the Iowa Soybean Association. In his comments regarding water quality monitoring, Roger described the importance of engaging the watershed community in monitoring, and noted that farmers want good information about water quality conditions. He noted the value of edge-of-field monitoring and its empowering effect on landowners, but he also noted that this practice illustrates the challenges on detecting clear water quality responses to changes in land use practices or cropping types. He emphasized the importance and prospects of giving farmers a scientifically credible voice in playing leadership roles in water quality management. He noted that Iowa soybean growers value their association because it has its own water analysis lab and works with environmental partners. This is an important point because it reiterates points other speakers made that growers want access to data and value cooperation over confrontation.

A final set of comments was provided by David DeGues of The Nature Conservancy (TNC), who provided an overview of a range of soil and water conservation projects in which TNC has engaged agricultural producers and other partners. He reported that TNC is in the early stages of watershed-scale projects, including paired watershed projects, and always is looking for partners. He noted that a continuing challenge is how to get enough landowners involved in order to conduct watershed-

[7] For more information on this network, see http://www.ngrrec.org/News-Stories/WaltonGrant3_14/.

scale projects. An important element is "selling" projects to landowners; in some respects, "sales training" is needed for conservation officers. In discussing potential involvement with landowners, it is important to look at the obstacles from the perspective of the producer. He cited the REACH (Research and Education to Advance Conservation and Habitat) project in Mississippi as a good example of how to engage producers. REACH involves a network of cooperative farms in Mississippi; the program provides coordination and support to document the benefits of conservation efforts. In regard to nutrient control, he expressed the view that it is important to focus on water management. He stated that improved water management in agricultural production will "pull the nutrients along."

This second day of the workshop also featured a luncheon talk delivered by Tony Thompson of Willow Lake Farm in Windom, Minnesota, summarized in Box 2-2.

The workshop concluded with an open forum involving all participants at the workshop, with the discussion led by a panel comprised of the NRC committee members. The discussion opened with a review by the committee chairman David Dzombak of key messages from presentations at the workshop, including important needs in monitoring,

BOX 2-2
Lunch Speaker
Tony Thompson, Willow Lake Farm
Windom, Minnesota

The lunch speaker on Day 2 was Tony Thompson, a Minnesota farmer with a strong interest in soil and water conservation who has participated in a number of conservation projects with the University of Minnesota. His farm encompasses 3,000 acres and 15 separate fields in which he grows corn, soybeans, and alfalfa. He also operates 13 wood-chip bioreactors for production of biofuels. Tony described farming in southern Minnesota as limited by water and temperature. He has particular concern about tillage and drainage practices. He described himself as a ridge till farmer who is very careful with fertilizer application. He participated in a controlled drainage pilot project that changed his drainage practices. He expressed his strong belief in careful use of tillage and drainage to "soften the touch of agriculture." He has a keen interest in the early history of farming and the presettlement landscape of Windom, Minnesota, is a proponent of agro-ecology, and works with and mentors young farmers and others who are considering careers in agriculture. He sees in these young people a strong interest in advancing the evolving culture of agriculture, which gives him optimism about the future of conservation in agriculture.

modeling, coordination, and public engagement for improved understanding of water quality conditions in the Mississippi River basin. Discussion ensued on these topics, resulting in expansion and refinement of the committee's list of key messages and priorities, which are outlined in the following section.

3

Challenges and Opportunities for Improving Water Quality Monitoring

Workshop participants engaged in wide-ranging discussion about water quality monitoring and evaluation along the Mississippi River and across the basin over the two days of the program. Some of those themes were discussed repeatedly and were of high future priority to workshop participants. The themes summarized in this section, in the committee's view, stood out as future water quality monitoring and evaluation priorities identified by the participants. These themes are not ranked.

IMPORTANCE OF ACTION-ORIENTED MONITORING AND EVALUATION

Managing nutrients across the Mississippi River basin and achieving related water quality goals is a tremendous challenge on several scales of both space and time. There is much to be learned about the overall system in order to determine the most effective actions to implement. Monitoring of land, water, and human activities on the land and water is critical to developing this knowledge.

The USDA/NRCS Mississippi River Basin Healthy Watersheds Initiative (MRBI) is built upon action-oriented monitoring and evaluation. Along with its achievements and values (including project implementation and a commitment to promoting more active water quality monitoring to assess project outcomes), the MRBI experience has highlighted challenges associated with realizing short-term water quality changes and improvements with discrete management projects. The 2009 NRC report noted that it often takes many years—often at least ten years—to realize statistically significant water quality results from a given land or nutrient management project or action (NRC, 2009). Identifying nutrient and land management practices that support improvements in water quality is a long-term endeavor that will entail sustained monitoring initiatives in tandem with nutrient management actions. This dual "action-learning" strategy was recommended in the 2009 NRC report and via its recommendation for the Nutrient Control Implementation Initiative (NCII). This spirit of action-oriented learning also is reflected in the USDA NRCS Mississippi River Basin Healthy Watersheds Initiative. The MRBI is a prominent example of pairing nutrient management actions with monitoring activities to improve understanding of system responses.

IMPORTANCE OF LONG-TERM MONITORING, CONSISTENT METHODS, AND COMPLEMENTARY DATA

Much has been learned from long-term monitoring in the Mississippi River basin, primarily at U.S. Geological Survey monitoring sites. The USGS has partnered effectively with states for operation and maintenance of many water quality monitoring stations. As the number of USGS monitoring sites has declined due to budget reductions, in some instances states have been able to step in to keep some sites operating. More long-term monitoring sites will help improve understanding of nutrient sources and nutrient fate and transport across the basin.

Long-term monitoring also is important for field evaluation of conservation practices. Plans for edge-of-field or watershed-scale monitoring will be more effective to the extent they can be conducted for several years in order to evaluate performance of conservation practices under a sufficiently broad range of inter-annual variability.

Interpretation and modeling of water quality data are greatly aided by complementary data on environmental conditions at the time of sampling (e.g., temperature, flow, and precipitation). As was pointed out by many workshop participants, more routine collection of such data in water quality monitoring plans would strengthen the overall water quality database for the basin.

Development and implementation of consistent methods and protocols for evaluation of water quality and conservation practices has enabled significant advances in basin-level analysis and modeling. Continued effort for standardization of methods is challenging but will be critical to the value of these studies.

Several workshop participants noted the value of "paired watershed" studies, which have documented benefits of improved nitrogen fertilizer management practices and wetland restoration on water quality (e.g., in Iowa and Illinois). Conducting watershed-scale studies with adequate controls for comparison is challenging, but an important part of study design and in reliability and validity of results. Paired watershed studies were mentioned by many workshop participants as effective for accelerating the adoption of conservation practices that improve water quality. They also provide useful data for evaluation and improvement of watershed scale agricultural water quality models. Workshop participants generally supported expansion of the number of paired watershed studies in the Mississippi River basin.

Several workshop participants noted the importance of monitoring system design, and in this context it is useful to distinguish management-level monitoring and research-grade monitoring. Although research monitoring establishes methods and protocols, the level of detail is often not feasible or useful for larger-scale, management-level needs.

Results of on-farm demonstrations, pilot projects and paired watershed studies are documented using a variety of water quality monitoring techniques. Sophisticated techniques include continuous storm-based monitoring of discharge and pollutant concentration data with H-flumes and ISCO samplers. It is challenging to monitor pollutant losses during winter months because of ice and snow, yet losses can be important during these periods. Less sophisticated water quality monitoring often is conducted using grab samples, for example, which may provide inaccurate estimates of pollutant loadings during storm events. Sensor technology is evolving and improving rapidly.

Workshop participants noted the great potential regarding development and deployment of simple, reliable, and inexpensive water quality monitoring equipment for use by farmers. Simple monitoring equipment could provide more localized feedback to farmers about the water quality impacts of their farming practices on specific fields. If such simple approaches were available, farmers would better understand how much sediment, phosphorus, or nitrate they are losing from their fields and could better target and evaluate alternative practices.

TRACKING CHANGES IN LAND MANAGEMENT

Many workshop participants noted that a longstanding challenge to advancing understanding of the effectiveness of soil and water quality conservation practices in agriculture is acquisition of detailed knowledge about what landowners actually are doing on their property. There have been relatively few research studies in which land management practices have been intensely monitored and documented. Information about timing and rate of fertilizer application, for example, is critical for understanding performance of measures aimed at limiting nutrient inputs to or retaining nutrients within watersheds. Innovative approaches are needed to enable more accurate and extensive monitoring of land management practices in relation to soil and water conservation efforts. There are successful examples upon which to build. Jerry Hatfield of the USDA-ARS cited several examples, including studies in the Raccoon River Watershed for which detailed data on land practices have been collected. The study design included farmer production buyouts for two years for monitoring of tile drainage systems.

Advances in satellite remote sensing have facilitated better assessment of changes in land management. Whereas older technology (e.g., Landsat) has a spatial resolution of 30 meters and a return frequency of 15 days, newer satellite technology (e.g., Worldview) has a spatial resolution of 1.1 meters and a return frequency of 1.1 days (Mulla, 2013). The National Agricultural Statistics Service (NASS) has taken advantage of newer satellite technology to issue high resolution Cropland Data Layer (CDL) information that can be used to make accurate assessments of change in land management over time (Wright and Wimberly, 2013).

LANDOWNER PERCEPTIONS AND CONSERVATION PRACTICES

In the current regulatory structure, the study and implementation of conservation practices requires the voluntary cooperation of owners of private land. Conservation agencies have worked in this context for many years. Implementation and assessment of conservation practices has often been impeded by inadequate knowledge of activities on private property, due to limited or no access and/or variable levels of landowner cooperation. Workshop discussants noted that, at the same time, there remains inadequate understanding of what motivates landowners to cooperate, how levels of cooperation vary with socio-economic status, size of operations, and other factors. To the extent that implementation and effectiveness of conservation practices will continue to be dependent on voluntary cooperation, it is important that behavioral factors governing voluntary cooperation be better understood. There are great opportunities for additional studies and research and that can take the form of polls of farmer attitudes, perceptions, and priorities regarding nutrient reduction practices (see Arbuckle, 2013), models of economic choice and preference, and how rates of adoption vary across among various agricultural and conservation practices.

The need and desire of agricultural producers for better information about water quality conditions, and practices that may support improved water quality conditions, was described by some workshop speakers. This articulates the value in further exploring public communication strategies and messages to better understand how to encourage stronger engagement on water quality issues. It also would be useful to better understand how to apply and learn from results from effective land use and nutrient management actions.

IMPORTANCE OF MODELING IN MONITORING PROGRAMS, AND DEVELOPMENT NEEDS

Models are used to interpret water quality monitoring data and are thus critical for any monitoring program. Modeling exercises and results also are a useful complement to data collection. For example, areas that are remote or otherwise difficult to access (e.g., hilly terrain) present challenges for implementing data collection stations or collecting samples, and data collection always will have some limits.

There are many different kinds of water quality models, from simple conceptual models to quantitative, process-based models that can consider loads and concentrations in domains of different scales. Process-based land-water interaction models in common use, such as the SWAT, APEX, and EPIC models (referenced earlier), are useful for identifying sources of pollutants, evaluating the effectiveness of conservation practices, identifying optimal locations to target for conservation practices, and identifying factors responsible for temporal changes in water quality. The statistical land-water interaction model SPARROW from the USGS (Alexander et al., 2008) has been used for identifying watersheds that contribute the largest pollutant loads and for assessing the causal factors for these loadings. Models focused on in-stream water quality, such as HSPF (Singh et al., 2005), are useful for establishing load allocations to point and nonpoint sources, but are less useful in evaluating the effectiveness of agricultural practices, or factors responsible for trends.

There was some discussion among workshop participants about building models that can help bridge from small scale to large watershed scale. Currently, "mechanistic" models are limited to small scale, and several participants mentioned the need to build mechanistic models that can "scale up" to the larger, watershed scale.

To assist design and implementation of monitoring programs at the watershed and basin scales, additional process models that can be advantageous at larger scales would be helpful. To date process-based models for land-water interactions largely have been focused at the field and small-watershed scale; additional attention on process-based models at the large-watershed and basin scale would complement the field and watershed-scale efforts. To represent the diverse processes and pathways for pollutant transport that operate across scales and to account for the changing importance of differing drivers across scales, routine model refinement, as new production approaches and land management practices are developed, would be useful.

A range of water quality models has been developed for different scales and purposes in the Mississippi River states. There often are inconsistencies in these models across states and agencies that use them for evaluations of nutrient management and water quality. Stronger collaboration among federal agencies, states, and university scientists in determining models appropriate for certain kinds of common applications, could bring more consistency to monitoring data evaluation efforts and support a more systematic approach to water quality assessments for the basin. Some workshop participants suggested the value of a "modeling collaborative" for the Mississippi River basin that could discuss these inconsistencies, the need to better link smaller- with larger-scale spatial models, and other applications issues and challenges. Further, there may be opportunities for this collaborative group to broaden its scope, and to include models of economics and social behavior and (for example) how they might interface productively with models of physical systems.

INTERSTATE AND INTERAGENCY COLLABORATION ON MONITORING

The Mississippi River Basin Task Force Monitoring Collaborative is an initiative that includes compilation of nutrient monitoring data from federal and state agencies. Criteria have been established for data screening, and data are categorized in various ways. This effort provides a foundation of available data. Many workshop participants noted that the Water Quality Data Portal, an initiative of the USGS and the EPA, is providing a useful vehicle for data sharing. The USGS and EPA team is working with the USDA to include their water quality data.

More and better coordinated interstate and interagency collaboration in monitoring is fundamental to consistent and efficient monitoring programs, particularly for large rivers that form boundaries between states.

Workshop participants noted the limited interstate coordination in the Mississippi River basin on issues relating to hypoxia in the Gulf of Mexico. The Upper Mississippi River Basin Association (UMRBA), the Ohio River Valley Water Sanitation Commission (ORSANCO), and the Lower Mississippi River Conservation Committee (LMCRCC) are coordinating organizations, but their missions, authorities, geographic extent, and levels of resources all differ from one another. The result is no real interstate, basin-wide organization on water quality monitoring and evaluation. These circumstances were described in the 2009 NRC report, which presented a recommendation to create an interagency, interstate Mississippi River Water Quality Center (NRC, 2009).

The 2008 NRC report also offered several recommendations regarding interstate collaboration as it relates to water quality monitoring and evaluation. Given the prominence of this theme at the November 2013 workshop, some of those recommendations merit repeating here:

- The lower Mississippi River states should strive to create a cooperative mechanism, similar in organization to the UMRBA, in order to promote better interstate collaboration on lower Mississippi River water quality issues.
- There is a clear need for federal leadership in system-wide monitoring of the Mississippi River. The EPA should take the lead in establishing a water quality data sharing system for the length of the Mississippi River.
- The EPA Administrator should ensure coordination among the four EPA regions along the Mississippi River corridor so that the regional offices act consistently with regard to water quality issues along the Mississippi River and in the northern Gulf of Mexico.
- The EPA should encourage and support the efforts of all 10 Mississippi River states to effect regional coordination on water quality monitoring and planning and should facilitate stronger integration of state-level programs. (NRC, 2008, pp. 11-12)

The Gulf of Mexico Hypoxia Task Force 2008 Action Plan identified a number of specific actions to be taken. Participating states have presented various plans to help extend nutrient monitoring efforts. During the workshop it was noted that several states are in the process of developing nutrient reduction strategies, and some participants wondered at what point states will be prepared to observe and evaluate possible changes in water quality.

Workshop participants also noted the growing interest in nutrient trading, and the exploration of nutrient trading along the Ohio River by ORSANCO in partnership with the Electric Power Research Institute. Participants felt that nutrient trading schemes offer promise for nutrient management, but will require reliable, targeted monitoring for implementation. Nutrient trading activities would provide further impetus for coordination and a systems view for design of monitoring systems for the Mississippi River basin.

References

Alexander, R. B., R. Smith, G. Schwarz, E. Boyer, J. Nolan, and J. Brakebill. 2008. Differences in phosphorus and nitrogen delivery to the Gulf of Mexico from the Mississippi River Basin. Environmental Science & Technology 42 (3): 822–830.

Arbuckle, J. G., Jr. 2013. Farmers' Nutrient Management Strategies: Results from the Iowa Farm and Rural Life Poll. Iowa Water Resources Coordinating Council Meeting, November 20, 2013. Available online at: http://www.soc.iastate.edu/staff/arbuckle/ArbuckleWRCC20Nov13.pdf. Accessed May 1, 2014.

Christensen, T., and W. Honeycutt. 2013. USDA Healthy Watersheds Initiatives: Progress, Lessons, Future Steps in Monitoring and Assessment. Presentation to NRC Committee on Mississippi River Water Quality Science and Interstate Collaboration. November 18, 2013. St. Louis, Missouri.

Clausen, J. C., W. E. Jokela, F. I. Potter, and J. W. Williams. 1996. Paired watershed comparison of tillage effects on runoff, sediment, and pesticide losses. Journal of Environmental Quality 25: 1000-1007.

CTIC (Conservation Technology Information Center). 2014. Conservation Technology Information Center. Available online at: http://www.ctic.purdue.edu/. Accessed May 1, 2014.

Goolsby, D. A. 2000. Mississippi Basin nitrogen flux believed to cause Gulf hypoxia. Eos, Transactions of the American Geophysical Union 81: 325-327.

GLRWP (Great Lakes Regional Water Program). 2014. Great Lakes Regional Water Program: Applying Knowledge to Improve Water Quality. Available online at: http://greatlakeswater.uwex.edu/. Accessed May 1, 2014.

King, K. W., P. C. Smiley, Jr., B. J. Baker, and N. R. Fausey. 2008. Validation of paired watershed practices for assessing conservation practices in the Upper Big Walnut Creek watershed, Ohio. Journal of Soil and Water Conservation 63 (6): 380-395.

Mills, A., and T. Christensen. 2012. Progress Through MRBI and Water Quality Monitoring in MRBI's Small Watersheds. Mississippi River/Gulf of Mexico Watershed Nutrient Task Force Meeting, Tuesday, September 11, Des Moines, Iowa. Available online at: http://water.epa.gov/type/watersheds/named/msbasin/upload/AnnMills-TomChristensenMRBIUpdate.pdf. Accessed May 1, 2014.

Mulla, D. J. 2013. Twenty-five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. Biosystems Engineering 114: 358-371.

Murphy, J. C., R. M. Hirsch, and L. A. Sprague. 2013. Nitrate in the Mississippi River and its tributaries, 1980–2010—An update. U.S. Geological Survey Scientific Investigations Report 2013–5169, 31 pp.

NRC (National Research Council). 2008. Mississippi River Water Quality and the Clean Water Act: Progress, Challenges, and Opportunities. Washington, DC: The National Academies Press.

NRC. 2009. Nutrient Control Actions for Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico. Washington, DC: The National Academies Press.

NRC. 2012. Improving Water Quality in the Mississippi River Basin and the Northern Gulf of Mexico: Strategies and Priorities. Washington, DC: The National Academies Press. National Water Quality Monitoring Council. 2014. Water Quality Portal. Available online at: http://www.waterqualitydata.us/. Accessed May 1, 2014.

Singh, J., H. V. Knapp, J. G. Arnold, and M. Demissie. 2005. Hydrologic modeling of the Iroquois River watershed using HSPF and SWAT1. Journal of the American Water Resources Association 41(2): 343-360.

Sprague, L. A, J. C. Murphy, and R. A. Hirsch. 2013. Nitrate in the Mississippi River and its Tributaries, 1980 to 2010. Presentation to NRC Committee on Mississippi River Water Quality Science and Interstate Collaboration. November 18, 2013. St. Louis, Missouri.

USDA (U.S. Department of Agriculture) A Natural Resources Conservation Service. 2014a. Mississippi River Basin Healthy Watersheds Initiative. Available online at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/wi/programs/?cid=nrcs142p2_020764. Accessed May 1, 2014.

USDA Natural Resources Conservation Service. 2014b. Conservation Effects Assessment Project. Available online at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/ceap/. Accessed May 1, 2014.

USDA Natural Resources Conservation Service. 2014c. Conservation Innovation Grants. Available online at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/. Accessed May 1, 2014.

US EPA (U.S. Environmental Protection Agency). 2001. Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico. Mississippi River-Gulf of Mexico Watershed Nutrient Task Force, U.S. Environmental Protection Agency. Available online at: http://water.epa.gov/type/watersheds/named/msbasin/upload/2001_04_04_msbasin_actionplan2001.pdf. Accessed May 1, 2014.

US EPA. 2007. Hypoxia in the Northern Gulf of Mexico: An Update by the EPA Science Advisory Board. Available online at: http://water.epa.gov/type/watersheds/named/msbasin/upload/2008_1_31_msbasin_sab_report_2007.pdf. Accessed May 1, 2014.

US EPA. 2008. Gulf Hypoxia Action Plan 2008 for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico and Improving Water Quality in the Mississippi River Basin. Available online at: http://water.epa.gov/type/watersheds/named/msbasin/upload/2008_8_28_msbasin_ghap2008_update082608.pdf. Accessed May 1, 2014.

US EPA. 2011. March 16, 2011, Memorandum from EPA Acting Administrator Nancy Stoner to EPA Regional Administrators, Regions 1-10. Available online at: http://water.epa.gov/scitech/swguidance/standards/criteria/nutrients/upload/memo_nitrogen_framework.pdf. Accessed May 1, 2014.

US EPA. 2013. Reassessment 2013: Assessing Progress made since 2008. Available online at: http://water.epa.gov/type/watersheds/named/msbasin/upload/hypoxia_reassessment_508.pdf. Accessed May 1, 2014.

USGS (U.S. Geological Survey). 2014a. Nitrate in the Mississippi River and its tributaries, 1980 to 2010: Are we making progress? Available online at: https://water.usgs.gov/nawqa/pubs/nitrate_trends/. Accessed May 1, 2014.

USGS. 2014b. SPARROW Surface Water-Quality Modeling. Available online at: https://water.usgs.gov/nawqa/sparrow/. Accessed May 1, 2014.

Wright, C. K., and M. C. Wimberly. 2013. Recent land use change in the Western Corn Belt threatens grasslands and wetlands. Proceedings of the National Academy of Sciences 110(10): 4134-4139.

Appendix A

St. Louis Meeting Agenda

National Research Council
Committee on Mississippi River Water Quality
Science and Interstate Collaboration

Chase Park Plaza Hotel
Lindell Ballroom
212-232 N. Kingshighway Boulevard
St. Louis, Missouri 63108

November 18-19, 2013

MONDAY NOV 18

8:30-8:45 ***Opening, introductions, overview of agenda***
David Dzombak, Carnegie Mellon University and NRC committee chair

8:45-9:15 ***National Research Council Studies of Mississippi River Water Quality***
Jeffrey Jacobs, National Research Council, Washington, DC

9:15-10:30 ***USDA Healthy Watersheds Initiatives: Progress, Lessons, Future Steps in Monitoring and Assessment***
Moderator: David Dzombak, Carnegie Mellon University and NRC committee chair

Panel discussants:
Thomas Christensen, USDA NRCS, Washington DC
Wayne Honeycutt, USDA NRCS, Washington DC
Michele Reba, USDA ARS, Jonesboro, AR
Ranjith Udawatta, University of Missouri, Columbia

10:30-10:50 **BREAK**

10:50-12:00 ***Mississippi River Water Quality Monitoring and Science: Federal and State Perspectives***
Moderator: David Dzombak, Carnegie Mellon University and NRC committee chair

Michael Woodside, U.S. Geological Survey, Nashville, TN
Lori Sprague, U.S. Geological Survey, Boise, ID
Dale Robertson, U.S. Geological Survey, Middleton, WI

Panel discussants:
Missouri Department of Natural Resources (invited)
Greg Jackson, Mississippi Department of Environmental Quality, Jackson
Glenn Skuta, Minnesota Pollution Control Agency, St. Paul

12:15-1:15 **LUNCH AND SPEAKER**
An Update of Key Legal Issues and Cases Regarding Mississippi River Water Quality
Elizabeth Hubertz, Washington University Law School, St. Louis

1:30-2:40 ***Assessing Water Quality Conditions within the Gulf of Mexico Hypoxia Task Force: Federal and State Perspectives***
Moderator: David Soballe, U.S. Army Corps of Engineers and NRC committee member

Joseph Piotrowski, U.S. Environmental Protection Agency, Philadelphia, PA

Michael Woodside, U.S. Geological Survey, Nashville, TN
William Northey, Iowa Secretary of Agriculture, Des Moines

Panel discussants:
Ken Brazil, Arkansas Natural Resources Commission, Little Rock
Warren Goetsch, Illinois Department of Agriculture, Springfield

2:40-3:50 ***State-Level Science and Monitoring of Nutrients and Water Quality***
Moderator: Jim Gulliford, Soil and Water Conservation Society and NRC committee member

Panel discussants:
Timothy Hall, Iowa Department of Natural Resources, Des Moines
David Duhl, Tennessee Department of Environment and Conservation, Nashville
Richard Raynie, Louisiana Coastal Protection & Restoration Authority, Baton Rouge
Glenn Skuta, Minnesota Pollution Control Agency, St. Paul

3:50-4:10 **BREAK**

4:10-5:15 ***Mississippi River Interstate Collaboration and State-Level Monitoring and Assessment Activities***
Moderator: David Mulla, University of Minnesota and NRC committee member

Panel discussants:
Jim Baumann, Wisconsin Department of Natural Resources, Madison
Paul Davis, retired, Tennessee Department of Environment and Conservation
Gregg Good, Illinois Environmental Protection Agency, Springfield
Larry Taylor, Kentucky Department for Environmental Protection, Frankfort
Peter Tennant, Ohio River Valley Water Sanitation Commission, Cincinnati

5:30-7:00 **RECEPTION**

TUESDAY NOV 19

9:00-9:15 ***Welcome, recap of Day 1, plans for Day 2***
David Dzombak, Carnegie Mellon University and NRC committee chair

9:15-10:20 ***Monitoring and Evaluating Water Quality: Methods and Uncertainties in Moving from Field to Watershed Scales***
Moderator: David Soballe, U.S. Army Corps of Engineers and NRC committee member

Panel discussants:
Craig Cox, Environmental Working Group, Ames, IA
Mark David, University of Illinois, Urbana-Champaign
Matthew Helmers, Iowa State University, Ames
Douglas Schnoebelen, University of Iowa, Iowa City
Lori Sprague, U.S. Geological Survey, Boise, ID

10:20-10:40 **BREAK**

10:40-12:00 ***Case Studies of Agriculture and Water Quality Monitoring across the Mississippi River Basin***
Moderator: David Mulla, University of Minnesota and NRC committee member

Panel discussants:
Dennis Busch, University of Wisconsin-Platteville
David Gustafson, Monsanto, St. Louis, and Maria Lemke, The Nature Conservancy, Lewiston, IL
Jerry Hatfield, USDA-ARS National Laboratory for Agriculture and the Environment, Ames, IA
Richard Warner, National Great Rivers Research and Education Center, Alton, IL, and University of Illinois, Urbana-Champaign
Roger Wolf, Iowa Soybean Association, Ankeny, IA

12:15-1:15 **LUNCH AND SPEAKER**
Movement of Water and Nutrients through the Farm: A Farmer's Perspective on Agricultural History, Biodiversity, and Technology
Tony Thompson, Willow Lake Farm, Windom, MN

1:30-2:10	***Public comments*** 4 minutes/speaker. First 10 guests to sign up before 12 noon.
2:10-2:50	***Open forum Q/A and discussion***
2:50-3:00	***Final remarks*** *David Dzombak, Carnegie Mellon University and NRC committee chair*
3:00	**ADJOURN**

Appendix B

Acknowledgement of Reviewers

This report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with the procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the NRC in making its published report as sound as possible, and to ensure that the report meets NRC institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

We thank the following for their review of this report: Catherine L. Kling, Iowa State University; Dennis P. Lettenmaier, University of Washington; Nancy N. Rabalais, Louisiana Universities Marine Consortium; Richard E. Sparks, University of Illinois; Thomas Theis, University of Illinois at Chicago; and Alan Vicory, Stantec Consulting, Inc.

Although these reviewers provided constructive comments and suggestions, they were not asked to endorse the report, nor did they see the final draft of the report before its release. The review of this report was overseen by Patrick L. Brezonik, University of Minnesota, who was appointed by the NRC's Report Review Committee. Dr. Brezonik was responsible for ensuring that an independent examination of this report was conducted in accordance with NRC institutional procedures and that all review comments received full consideration. Responsibility for this report's final contents rests entirely with the authoring committee and the NRC.

Appendix C

Committee Member Biographical Information

David A. Dzombak (NAE), *Chair*, is the Walter J. Blenko, Sr. University Professor and Head of Civil and Environmental Engineering at Carnegie Mellon University. He conducts research in water quality engineering and science, on topics pertaining to environmental restoration and the water-energy nexus. Dr. Dzombak is a member of the National Academy of Engineering, a registered professional engineer in Pennsylvania, a Board Certified Environmental Engineer of the American Academy of Environmental Engineers, and a fellow of the American Society of Civil Engineers and Water Environment Federation. He served as the chairman of the NRC Committee on the Mississippi River and the Clean Water Act. Dr. Dzombak holds a BA degree in mathematics from Saint Vincent College, BS and MS degrees in civil engineering from Carnegie Mellon University, and a PhD degree in civil engineering from the Massachusetts Institute of Technology.

James B. Gulliford is the Executive Director of the Soil and Water Conservation Society. The Society is committed to research and the application of soil and water conservation practices on agricultural landscapes to improve agricultural productivity and environmental quality. Mr. Gulliford is a member of the Board of Directors of the Charles Valentine Riley Memorial Foundation, whose purpose is to promote a broader understanding of agriculture as the most basic human endeavor and to enhance agriculture through increased scientific knowledge. He holds a BS degree in forestry management and an MS degree in forestry economics and marketing from Iowa State University.

David J. Mulla is a professor and Larson Chair for Soil & Water Resources in the Department of Soil, Water, and Climate at the University of Minnesota, where he is also the Director for the Precision Agriculture Center. Dr. Mulla studies nonpoint source pollution of surface and groundwater; precision farming and precision conservation; and alternative farm management practices for improved soil conservation and water quality. He has experience in modeling erosion, and losses of phosphorus, nitrogen, and pesticides to surface and ground waters. In 1998, he was appointed to the White House Task Force on Hypoxia in the Gulf of Mexico. In 2011, he was appointed to a National Research Council committee on numerical nutrient criteria (water quality standards) for Florida. His peers elected him as a Fellow in the Soil Science Society of America (SSSA), and as a Fellow in the Agronomy Society of America. In 2012, he received the Pierre C. Robert Precision Agriculture Research Award from the International Society for Precision Agriculture. In 2013, he received the Soil Science Applied Research Award from the SSSA. Dr. Mulla received his BS degree in earth sciences (with emphasis in geophysics) from the University of California at Riverside, and his MS and PhD degrees in agronomy (emphasis in soil chemistry and physics) from Purdue University.

David M. Soballe is a research biologist with the U.S. Army Corps of Engineers. He has over 30 years of research experience in limnology, water quality, and river and reservoir ecology and has held research positions with state, federal, and academic institutions. Dr. Soballe has extensive experience working in interagency groups on water quality monitoring, data acquisition and environmental management and restoration. He has expertise in the requirements and difficulties of monitoring a large floodplain river and in using monitoring data to guide management decisions on restoration. Dr. Soballe played a major role in redesigning and implementing the Long Term Resource Monitoring Program on the Upper Mississippi River. He received his BS degree in biology in 1972 from University of Notre Dame, his MS degree in biological sciences in 1978 from Michigan Technological University, and his PhD degree in animal ecology (limnology) in 1981 from Iowa State University.