USGS MINNESOTA WATER SCIENCE CENTER
SCIENCE PLAN

(Revised April 2007)

INTRODUCTION

This abbreviated version of the science plan describes how the U.S. Geological Survey (USGS), Minnesota Water Science Center (WSC or hereinafter referred as Center), anticipates providing quality services and products to local and State governments of Minnesota, other Federal agencies, and the public in fulfilling the mission of the USGS. The mission of the U.S.Geological Survey (USGS) is to provide geologic, topographic, and hydrologic information that contributes to the wise management of the Nation's natural resources and promotes the health, safety, and well-being of the people. This information consists of maps, data bases, and descriptions and analyses of the water, energy, biological, and mineral resources, land surface, underlying geologic structure, and dynamic processes of the earth. The staff of the Minnesota Water Science Center is charged with focus on water resources in Minnesota, but as part of the a national science organization we have access to entire capabilities of the USGS, such as research, laboratories, and data infrastructure in the fields of geology, biology, and mapping as well as hydrology. The plan is based on priority water resources issues and problems facing the State and the professional judgment of the Center staff on how the Center could best assist with these issues and problems. This science plan was developed by senior technical staff of the Center including project chiefs, the Section Chiefs of Hydrologic Investigations, Environmental Assessments and Data and Networks, NAWQA Study Unit Chief, reports specialist, technical specialists, and WSC Director.

The Minnesota Environmental Quality Board has prepared a document used by State agencies to guide and direct their work. This document, “Minnesota Watermarks – Gauging the Flow of Progress 2000-2010”, has four long-term goals and 9 objectives. The goals are to improve the quality of water resources; to conserve water supplies and maintain the diverse characteristics of water resources to give future generations a healthy environment and a strong economy; to restore and maintain healthy aquatic ecosystems that support diverse plants and wildlife; and, to have reasonable and diverse opportunities to enjoy the State’s water resources. The priority issues developed by the Center complement these Minnesota Watermarks goals.

This plan presents five priority issues consistent with the national and regional roles of the USGS and applied to the hydrologic, environmental and cultural settings of Minnesota and the Upper Midwest. For each issue a variety of more specific goals are presented. We continue to use the Center Science Plan as a guide to direct project and data-networks discussions with cooperators and as a framework for the scientists to use to answer the question: “Where is the Center going in regard to future science?” The management team commonly refers to the general emphasis of the current science plan for decisions about specific opportunities, communications, workforce, training, and customer options for funding.

PHYSICAL AND CULTURAL SETTINGS

Minnesota is a northern headwaters state of relatively low topographic relief and having varied terrestrial and aquatic ecosystems. Rivers and streams in Minnesota flow into the Red River of the North and Hudson Bay drainage, Missouri River, Mississippi River Basin, and into the Rainey

River and Lake Superior Basins (Fig. 1). The relatively flat and hummocky landforms throughout most of the state are the remnants of glaciation. Average precipitation ranges from less than 20 to 32 inches per year from northwestern to southeastern Minnesota. These landforms, geology and associated soils and climate yield diverse land cover and land uses across Minnesota. The southern part of the state is a rich agricultural region. The central and northwestern part of the state has a mix of agriculture, lakes and forests. The eastern part of the state along the St. Croix River is generally forested and has light urban and agricultural development. The northern part of the state is a mix of forests, lakes and wetlands, and open land. The unglaciated southeastern corner of Minnesota is comprised of relatively deeply incised valleys through sedimentary rocks. Agricultural cropland and grazing is distributed mostly along hilltops and narrow valley bottoms with mostly forested hillsides. The Twin Cities Metropolitan Area, consisting of the cities of Minneapolis and St. Paul and their suburbs, is the largest urban area in the state. The Mississippi River, with numerous locks and dams along its course in Minnesota, is navigable via barge and serves as a transportation corridor for commerce to and from the Twin Cities Metropolitan Area. Duluth harbor on Lake Superior is another major freshwater port for Minnesota commerce. Minnesota's economy is based on agriculture, tourism, mining, forestry, manufacturing, commerce, medical and health related businesses, and research and high-technology ventures.

Sand and gravel aquifers in glacial sediments occur throughout most of the state whereas sandstone and dolomite aquifers occur beneath most of southeastern Minnesota. Together they supplied about 65 percent of the drinking water through public and self-supplied domestic systems for Minnesotans in 2000. The Mississippi River is the source of about half of the drinking water used in the Twin Cities Metropolitan Area. Irrigation from ground-water sources has been used to enhance crop production in many of the sand plains. Severe weather and climate patterns are common in the center of the North American continent. In relatively recent hydrologic time in Minnesota, severe flooding occurred in 1993 and 1997, and severe droughts occurred in 1976 and 1988. Regional flooding during the summer of 2002 exceeded several floods of record, particularly in northwestern Minnesota.

PRIORITY WATER RESOURCES ISSUES IN MINNESOTA

Based on the physical and cultural settings summarized above, the following priority water resources issues have been identified:

- **Effects of land use on water quality and quantity**
- **Water availability**
- **Long-term trends in water quantity and quality**
- **Effects of physical and chemical factors on aquatic ecosystems**
- **Fate and transport of anthropogenic compounds through hydrologic systems**

I. EFFECTS OF LAND USE ON WATER QUALITY AND QUANTITY

Background

Federal and State environmental agencies recognize the need to better understand agricultural and urban land-use effects on ground- and surface-water quality, and to gain understanding of the efficacy of restoration programs to improve water quality. Land-use practices have affected ground-water and surface-water quality in both urban and agricultural areas. Row crop production, logging, mining, and animal feeding operations are important factors in the State's economy, but have resulted in negative effects to the quality of ground and surface waters. Agriculture has been associated with elevated levels of some nutrients and pesticides in ground and surface waters. Soil erosion from agriculture, logging and mining contributes sediment loads to surface waters. Drainage from impervious surfaces and disturbed soils from urban and suburban areas result in greater storm-water runoff. Elimination of riparian buffers has allowed excess runoff and contaminants to enter surface waters. The conversion of farmland to urban and residential land use and development of lakeshores is an ongoing process. These changes have introduced new contaminants to streams, wetlands, lakes and ground water, altered aquatic and terrestrial habitat, and changes ecosystem processes. Federal and State programs, such as CRP, CREP, and Rim also are changing land use as more acreage is returned to more natural conditions. Amelioration of negative effects and methods for remediation and restoration have not been rigorously or completely evaluated in terms of surface- and ground-water quantity and quality or such ecological aspects as biodiversity.

Specific goals

A. Describe effects of land use and changing land use on the quality of water and associated aquatic resources. (Agricultural and urban effects, road de-icing effects, road construction effects)

B. Describe effects of various storm-water management practices on the quality and ecological integrity of small streams, which may include water quantity

C. Estimate effects of major land-use conversion, such as predominantly agricultural to suburban, on stream and ground water quality

D. Assess performance and water-quality effects of restoration of physical, chemical and biological components of aquatic resources through use of management practices of land and water use

II. WATER AVAILABILITY

Background

Increasing population and development in the Twin Cities Metropolitan area have resulted in increased water demand and an increased contamination potential to ground and surface water supplies. There is concern that nutrients, pesticides, microorganisms, and various chemicals (including emerging contaminants, such as pharmaceuticals) may limit the availability of water supplies. Growth of southwestern Minnesota communities has been restricted because of the lack of available water supplies. The areal extent of aquifers in southwestern Minnesota is unknown because of limited hydrologic information. Water from these aquifers generally contains high concentrations of dissolved solids. Mine pit lakes in northern Minnesota are the source of water for many Iron Range communities. Recharge areas for these lakes are unknown and are difficult to delineate because of the complex hydrogeology and the disturbance of natural materials caused by mining. Knowledge of the recharge areas and ground-water/surface-water interaction is necessary for the wise management of land and water resources.

Specific goals

A. Maintain and make readily available basic data about streamflow, water stage, and water quality to assess water availability for growth regions

B. Identify emerging contaminants in source waters for drinking water

C. Document trends in water use, water supplies and water availability

D. Quantify recharge to surficial and confined aquifer systems

E. Assess water availability from fractured crystalline and well-indurated sedimentary rocks and susceptibility to surface contamination

F. Assess availability in alluvial aquifer systems of southwestern Minnesota

G. Assess water-resources sustainability through better understanding of quantity of, flow through, and quality of surface waters, ground waters, and interactions between these systems.

III. LONG-TERM TRENDS IN WATER QUANTITY AND QUALITY

Background

State and Federal agencies that manage water resources rely on the USGS to provide streamflow, stage, and water-quality data. Historical streamflow data are used for planning transportation projects, waste-load allocation, flood and drought predictions, and water-supply projections. Long-term records are used to better understand the effects of climate change on hydrology. Water quality data are used to understand loadings and concentrations of chemicals and sediment in rivers. Several State agencies are developing similar capabilities; their QA/QC, however, may not match ours, making data compatibility an issue.

State and Federal agencies that manage water resources need to know the effects of variability of that resource. The issues of flood control, water availability for drinking and irrigation, wetland management, transportation, hazards, and others, need to use hydrologic data that allows planning for extreme events. For example, flood control structures being built in the Red River of the North Basin are being designed using USGS streamflow data. Water use permits are often evaluated using USGS assessments of aquifer characteristics and long term streamflow data. TMDL evaluations will use USGS data to define the extent of hydrologic variability.

Specific goals

A. Provide leadership for long-term collection, maintenance and management of hydrologic data

B. Evaluate climatic variations and resultant effects on hydrology, such as the effects of significant land-use conversion

C. Expand statewide hydrologic networks to address needs for analysis of change caused by natural and anthropogenic factors

D. Demonstrate significance of differences between suspended sediment and total-suspended solids in streams for regions across Minnesota

E. Develop methods for estimating streamflow and low-flow indices for ungaged streams sufficient for TMDL programs

F. Provide guidance on protocols and quality assurance to groups leading volunteer monitoring of State water resources

G. Develop a center of excellence for hydrologic-data bases in terms of storage, retrieval, and accessibility to users

H. Provide and improve access to USGS data through printed products, computer readable media, and the Internet

IV. EFFECTS OF PHYSICAL AND CHEMICAL FACTORS ON HEALTH OF AQUATIC ECOSYSTEMS AND HUMANS

Background

There is an increased need to understand water resource issues from a multidisciplinary viewpoint. An ecosystems approach encompasses the chemical, physical, and biological interactions that occur in concert through time. For example, in agricultural basins, there is a need to understand the effect of various agricultural practices on hydrology, biology, biogeochemistry, and economy. Resource managers seek to minimize adverse effects on ecosystems, and examine management strategies that will achieve multiple benefits. Chemical data commonly lack a physical or biological ecosystems perspective and so are insufficient to make sound and comprehensive decisions on ecosystem management. The Center seeks to expand understanding of the interrelationships between hydrology, geology, chemistry, biology, and human alterations to the environment, so that resource managers will be able to base decisions on sound, multidisciplinary science.

Specific goals

A. Develop advanced understanding of cause and effect processes based on findings of prior assessments of water resources, such as from the NAWQA Program and hydrologic investigations in Minnesota

B. Advance research in environmental factors affecting amphibians

C. Incorporate knowledge and studies of stream-aquifer relations into research about ecosystem health

D. Collaborate with other researchers and incorporate other information to better understand the ecological effects of emerging contaminants and suspected endocrine-disrupting compounds on aquatic organisms

V. FATE AND TRANSPORT OF ANTHROPOGENIC COMPOUNDS THROUGH HYDROLOGIC SYSTEMS

Background

Sound scientific understanding about how anthropogenic compounds move, store, and (or) degrade in various hydrologic systems can play a significant role in targeting limited resources at mitigating or preventing contamination of waters. Long-term health of ecosystems requires knowledge of water quality and biology coupled with hydrology. Best management practices for protecting water quality can be overlooked without proper information about how certain contaminants can move from sources to water bodies of specific designated use. Planning for emergency responses requires the knowledge of the transport and fate of various contaminants. The work done by USGS researchers and Center staff at the Bemidji oil spill site has been nationally acclaimed as fundamental research on in situ bioremediation. NAWQA studies and hydrologic investigations of agricultural chemicals in surface and ground water have led to better definition of the areal extent of nutrient and pesticide contamination, but more research is necessary to understand the fate and transport of specific chemicals for specific hydrologic environments. This process understanding can be useful for targeting limited resources at mitigating or preventing contamination of waters at local, regional, and national scales, such as examining the causes of hypoxia in the Gulf of Mexico.

Specific goals

A. Develop a better understanding of the biogeochemical processes in hydrologic systems where surface and ground waters interact

B. Develop background water-quality conditions and related factors critically needed to technically support the implementation of water-quality programs, such as impaired waters and TMDL process

C. Develop sufficient understanding of physical, chemical and biological processes controlling the effectiveness of agricultural and (or) urban land and water management practices

D. Apply numerical models (or other comprehensive analytical tools) to test concepts of flow in rivers, watersheds and aquifer systems sufficient to understand the transport of contaminants

E. Understand uptake and movement of contaminants through aquatic biota, mostly in rivers and streams, as a function of downstream effects of selected contaminants

F. Develop improved methods and analytical techniques to conduct any of the above goals