Illinois State Water Survey
Annual Report 2002-2003

Reaching Out to Illinois and the World...

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2003

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Front Cover: World satellite color shaded relief image courtesy Environmental Systems Research Institute, Inc.
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Printed by authority of the State of Illinois (10-03—XXXXX—4M)

Illinois State Water Survey
Annual Report
July 1, 2002 – June 30, 2003

From the Chief's Desk

The Illinois State Water Survey (ISWS) was established in the 19th Century to provide high-quality, reliable data to help ensure safe drinking water and water for industry, navigation, and waste management in a young, rapidly developing state. The ISWS provides similar data for a much more mature, still growing Illinois in the 21st Century. Although the ISWS also has grown and diversified, Illinois residents are still the primary clients. Through research, monitoring, service, education, and outreach activities, the ISWS meets data and information needs identified through interactions with government officials (state, county, and local); researchers; teachers and students; representatives of nongovernmental organizations, businesses, and professional organizations; and the public.

The ISWS also has a broad constituency outside Illinois. In fact, about 45 percent of the 17 million "hits" per year on the ISWS' Web site originate outside Illinois, including 10 percent from other countries. The strength and attraction of the ISWS are twofold.

First, it is a repository of unique, high-quality, century-long databases and reports derived from the many projects of its scientists. These databases and reports are in great demand throughout the nation and the world.

Second, the ISWS employs world-class scientists who compete nationally for external grants and contracts to work on problems that often also have great relevance outside of Illinois. Obtaining external funding for projects with such broad applications allows the ISWS to meet the needs of residents of Illinois, other states, and even other countries. These important projects for Illinois generate about $8.3 million of the ISWS' $12.3 million annual budget and support 125 staff members.

Providing new and economical water supplies is a key concern for many small communities. The Midwest Technology Assistance Center (MTAC), funded by the U.S. Environmental Protection Agency (USEPA), coordinates with other agencies and organizations to evaluate problems and recommend solutions to capacity development needs of small public and Native American tribal water systems throughout the Midwest. In addition to serving as MTAC's home, the ISWS is conducting two MTAC projects on arsenic in Illinois groundwater and low-cost treatment options to remove it from drinking water.

Chief Derek Winstanley stands before the photo gallery of ISWS Chiefs.

Many activities and industries in the Midwest are sensitive to weather and climate. The Midwestern Regional Climate Center (MRCC) provides services and research to develop and disseminate climate information throughout this region. The MRCC also is housed at the ISWS and is funded by the National Oceanic and Atmospheric Administration (NOAA).

Natural and synthetic chemicals enter the atmosphere and are transported great distances by winds before their return to the Earth's surface. For 25 years, a host of federal agencies, Native American Tribes, state governments, and others have funded the National Atmospheric Deposition Program (NADP) and its Central Analytical Laboratory at the ISWS to conduct chemical analyses of precipitation samples collected weekly at 250 sites nationwide. This long, unique record provides a basis for quantifying the amount of chemicals deposited from the atmosphere and for establishing trends. Analysts use NADP data to evaluate the effectiveness of existing pollution control programs, such as those for acid rain, and the need for new control programs.

Fine particles are air pollutants that can penetrate deep into the lungs and affect human health. Because little is known about these pollutants, the Lake Michigan Air Directors Consortium, on behalf of the Midwest Ozone Group, is funding ISWS scientists to monitor and determine the chemical composition of these fine particles.

Illinois farmers may have an opportunity to be paid for implementing farming practices that extract carbon dioxide from the atmosphere and store carbon in the soil. Removing carbon dioxide, a greenhouse gas, from the atmosphere reduces the greenhouse effect; storing carbon in the soil improves soil fertility. This significant national project, supported by NOAA, is monitoring transfers of carbon between the atmosphere and corn and soybeans.

Research results from ISWS studies of lake effects are contributing to improved weather forecasts. When air masses cross the Great Lakes, they often absorb heat and moisture, which can result in heavy lake-effect snowfall around the lakes in winter. The projects are funded by the National Science Foundation (NSF) and the U.S. Department of Commerce.

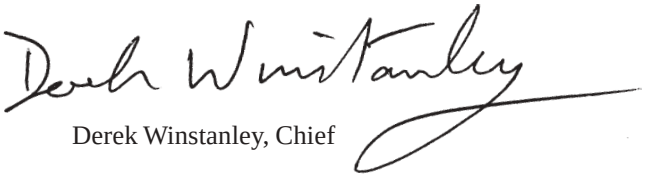
Changes in climate and air quality are two of the most important effects of global warming. With funds from the NSF, NOAA, USEPA, and the U.S. Department of Energy, ISWS scientists are developing improved mathematical models to simulate possible future changes in climate and air quality in Illinois and the rest of the nation. These models run on supercomputers at the University of Illinois and at other major national institutions.

The U.S. Supreme Court allows Illinois to withdraw more than two billion gallons of water per day from Lake Michigan and requires that Illinois monitor not only withdrawals, but also precipitation over northeastern Illinois and water that flows into the lake. To assist with Lake Michigan diversion accounting, the U.S. Department of the Interior funds ISWS operation of the 25-site Cook County Precipitation Network in northeastern Illinois. The Office of Water Resources at the Illinois Department of Natural Resources uses these data in diversion accounting.

Sediment buildup is one of the biggest problems in Illinois' rivers, lakes, and reservoirs. Excess sediment chokes rivers and reduces water storage capacity in lakes and reservoirs. The ISWS is creating sediment budgets and developing mathematical models that simulate construction of islands using dredged sediment for a project funded by the U.S. Army Corps of Engineers. Other NSF-funded studies are examining restoration of the Illinois River floodplain.

There is great demand for ISWS databases on precipitation chemistry, climate, floodplains, air quality, soil moisture, sediment, quality of surface waters and groundwater, water withdrawals and use, and the nitrogen cycle. More than one million users annually access these and other ISWS databases via the Web for research and education; ecosystem restoration and protection; provision of new, safe water supplies; transportation; national and international environmental assessments; urban and regional planning; building design; insurance claims; protection of human health; agriculture; construction of dams, levees, reservoirs, and islands; water and air-quality regulations; and policy-making.

I am pleased to present the *Illinois State Water Survey Annual Report* for 2002–2003, which highlights the importance of the ISWS to millions of clients throughout Illinois, the nation, and the world.



Derek Winstanley, Chief

Achievements

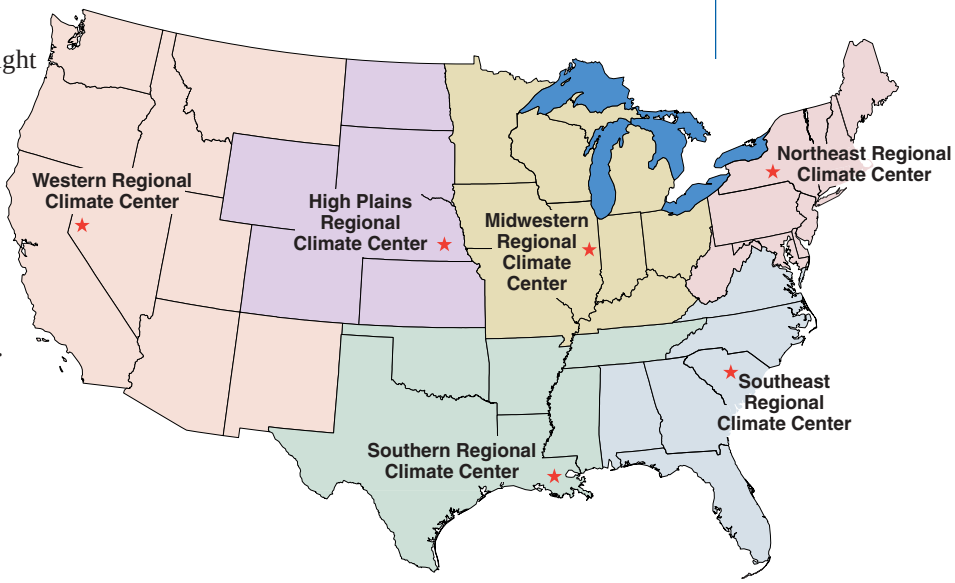
Since the ISWS was founded in 1895, there have been many noteworthy achievements under eight different Chiefs (www.sws.uiuc.edu/chief/pastchiefs.asp). A special Web site (www.sws.uiuc.edu/hilites/achievements.asp) has been created to recognize these achievements. For example,

This radar image shows the hook echo, the unique signature of a tornado discovered by ISWS scientists in 1953.

- Fifty years ago the ISWS played a key role in developing radar technology that today is used routinely worldwide to provide early warnings for tornadoes and storms. The ISWS is proud of its long history of weather radar research.

The 50th anniversary of the hook echo discovery featured a reception with Glenn Stout, Don Staggs, and Stan Changnon, staff members in 1953.

- The current system of regional climate centers in Illinois and eight other states stems from ISWS efforts back in 1981. The ISWS pioneered activities in climate services that significantly altered and improved the nation's delivery of climate data and information, and also greatly enhanced their use and value for Illinois and the nation.



There are six regional centers in the United States.

The ISWS operates the 25-site Cook County Precipitation Network, which includes gage 14 south of downtown Chicago.

- Since the 1950s, ISWS atmospheric scientists have played significant roles in major Illinois policy issues for Illinois, including weather modification and global climate change, acid rain, and diversion of Great Lakes water at Chicago.

There are also links to historical information and a recent video about the ISWS that was shown on the Discovery Channel. Regular updates keep the site current.

Water Survey Staff at Work

George Roadcap discusses restoration activities in the Lake Calumet area with members of the Board of Natural Resources and Conservation.

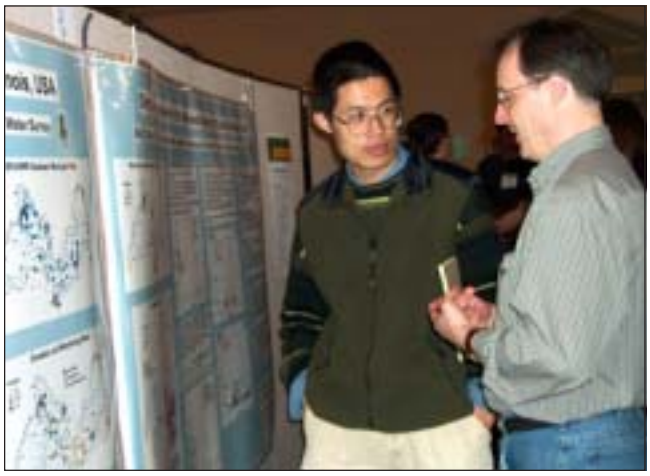
Watershed Science Section head Mike Demissie and Becky Howard go over details for a report on the Illinois River watershed.

Scientists Momcilo Markus and Ed Krug work on a water chemistry model for the Mississippi River basin.

Chemist Loretta Skowron helps a young scientist test water at the State Fair.

Atmospheric Environment Section head Kenneth Kunkel and Dr. Jinhong Zhu focus on results of a study funded by the Illinois Board of Higher Education. The scientists analyzed an extensive dataset of global climate simulations from 20 models to investigate how well the models provide information critical for use in assessing future water supplies in Illinois.

Using weather equipment located outside ISWS headquarters in Champaign, scientist David Kristovich explains methods for measuring atmospheric conditions to Dr. Howard Elementary School students.



A poster on arsenic distribution in the Mahomet Aquifer serves as the starting point for a conversation between groundwater geochemist Walt Kelly (right) and a Ph.D. student in the UIUC Department of Geology at the Environmental Horizons 2003 conference. The aquifer is the main groundwater resource for east-central Illinois.

Maria Peters, MRCC service climatologist, answers climate data and information requests from the general public and other callers.

Among Gloria Marsh's many shipping/receiving duties is receipt of daily UPS deliveries.

Engineers Alena Bartosova and Sally McConkey examine water quality data for the Fox River Watershed Investigation project.

Scientist Yu-Feng Lin and Becky Bennett discuss his proposal before she submits it to the UIUC Grants & Contracts Office.

Phyllis Ballard starts the tracking process for precipitation samples from more than 250 U.S. sites. Daily and weekly samples are processed and analyzed at the NADP's Central Analytical Laboratory. This is the 25th year of operation for this precipitation chemistry research program at the ISWS.

OFFICE OF THE CHIEF

Extension and Education Activities

Kwabena Adu-Sarkodie (second from left), 2003 W.C. Ackermann scholarship recipient, is shown with Chief Winstanley, Bill Ackermann, and Nicholas Schneider.

William C. Ackermann Scholarship Recipient

Kwabena Adu-Sarkodie was the 2003 recipient of the $1,000 W.C. Ackermann scholarship. Adu-Sarkodie plans to complete his M.S. degree in environmental engineering during summer 2003 at the University of Illinois at Urbana-Champaign (UIUC). His thesis examines optimal chemical treatment of water with ozone. His long-term goal is to solve real-life problems as an environmental engineering consultant.

Chief Derek Winstanley, Illinois State Water Survey (ISWS), and Executive Director Nicholas Schneider, Nature of Illinois Foundation, presented Adu-Sarkodie with the scholarship on April 16, 2003. Also in attendance was Bill Ackermann, son of former ISWS Chief William C. Ackermann. The scholarship was established in memory of Dr. William Ackermann, ISWS Chief Emeritus and UIUC professor of engineering from 1956–1979. Adu-Sarkodie is the tenth scholarship recipient.

ISWS Hosts UIUC Undergrads

During National Chemistry Week last October, the ISWS hosted 18 chemistry undergraduates, their graduate assistant, and professor John Shapley from the Discovery Program at the UIUC. “Water, the Elixir of Life,” an introductory class, covers such topics as the hydrologic cycle, water availability, water purification, and the physical properties of water. Three ISWS scientists described their research and environmental monitoring projects. Visitors also toured ISWS laboratories.

Peoria Clean Water Celebration

More than 3,000 students from 54 middle schools and 8 high schools, their teachers, and representatives from the ISWS and other agencies attended the 10th annual Clean Water

Kingsley Allan talks with a group of students at the Clean Water Celebration.

Celebration in Peoria on March 24, 2003. Getting students to think globally and act locally about water is the goal of this event highlighting rivers in Illinois using a combination of biology, botany, ecology, and environmental resource management. Participants from Illinois and neighboring states attended workshops, made presentations about local rivers and water projects, networked with other river stewards, and learned about current water issues. Group environmental projects researched and designed by high-school students were featured.

Visitors to the ISWS booth learned about watersheds in Illinois and saw a computer animation documenting changes in the Illinois River at Peoria over time. Giveaways included ISWS maps, raingages supplied in conjunction with the local section of the American Chemical Society, bookmarks, and publications about the ISWS and water supplies in Illinois.

Young Scientists Conduct Water Tests at State Fair

Children had the chance to play scientist at the Illinois State Fair in Springfield on August 9–18, 2002. "Test the Water" staffed by ISWS volunteers gave youngsters the opportunity to test four different waters with colored test strips that depicted chlorine, pH, hardness, and alkalinity levels of samples. As children conducted tests, ISWS staffers discussed water testing, purification, and naturally occurring metals found in water.

Misters at Hydro-House once again provided visitors with a respite from the heat as they entered the Discovery Park tent. Hydro-House highlights the hydrologic cycle and features children's artwork on water themes. One lucky visitor won a Super-Soaker water gun, awarded on the last day of the fair.

Most children and adults who took the "H_2O Challenge" could detect a difference between the taste of Springfield water and distilled water. They also learned about water purification and resource management issues from ISWS volunteers.

The ISWS, Midwestern Regional Climate Center, and the East Central Illinois Section of

Mark Peden (right) presents the Super-Soaker to the winner, Winella Wise.

A young scientist tests water (left), and other State Fair visitors examine ISWS displays.

the American Chemical Society co-sponsored distribution of hundreds of "Rain Check Network" raingages. The network was developed to allow children or their classes to submit daily rainfall totals to a Web site (www.sws.uiuc.edu/hilites/stfair/raingage/) maintained by the ISWS. Not only does the site contain information about rainfall events and a direct link to on-line weather and climate resources, but it also allows retrieval of specific data by date, city, zip code, or reporter's initials.

Teams of students compete for prizes and trophies at the Illinois Science Olympiad.

Networking with Illinois Science Teachers

The Illinois Science Teachers Association met in St. Charles in November 2002 for a two-day annual conference that offered more than 90 workshops, demonstrations, and 18 interactive sessions to earn continuing education credits. Staff from the ISWS networked with 1,500 science teachers, student teachers, and teacher trainers; distributed hundreds of raingages and demonstrated on-line resources available in the "Rain Check Network"; and gave away maps of Illinois' watersheds.

Geographic Information Systems

Geographic Information Systems (GIS) at the ISWS turned 20 in 2003. Just as in other high-technology fields, hardware and software have improved dramatically over this period. More than one million users worldwide use Environmental Systems Research Institute GIS software. The ISWS was among the first to use early versions.

Based on existing GIS data/models by past scientists and GIS technicians, and three-dimensional animation software, the ISWS is moving into computer animation. For example, an animation about the Illinois River watershed was included in a recent Discovery Channel segment about the ISWS. Another animation on impacts of the Ice Age in Illinois (http://www.sws.uiuc.edu/chief/gis/gallery.htm) is being used as an educational tool for non-scientific audiences to explain groundwater availability and rich soils in Illinois as a result of prehistoric events.

The glacier retreats from Illinois, leaving smoothed topography and glacial moraines (top). Shallow aquifers (bottom) were a result of glaciation.

Over millions of years, glacial ice repeatedly covered the Northern Hemisphere. These glaciers and meltwater deposits filled low bedrock and helped create Illinois' prairie. Much of the water used in Illinois today comes from aquifers formed as buried sands and gravels filled ancient river valleys. Fertile soils that produce some of the world's best crop yields resulted from fine-grained loess spread by winds over nearly all of Illinois and portions of the Midwest.

The federally funded Lands Unsuitable for Mining Program, a joint project with the other Scientific Surveys, initially provided the incentive to build many of the core statewide GIS databases of Illinois' roads, towns, rivers, and streams. Ensuing projects have used these databases and created others that are available from the GIS Web page (www.sws.uiuc.edu/chief/gis/).

Quality Management

Several components form the basis for collecting and reporting environmental data as part of the quality management system at the ISWS. The ISWS Quality Management Plan (QMP), the umbrella document, describes processes and procedures for data collection and reporting.

This plan is patterned after a national consensus standard, ANSI/ASQC E4-1994, and a U.S. Environmental Protection Agency (USEPA) guidance document designed to help agency contractors develop agency-specific plans. The ISWS QMP meets requirements of that agency, USEPA, and other funding agencies that support environmental data collection and reporting activities at the ISWS.

The Quality Assurance/Quality Control (QA/QC) Committee at the ISWS promotes development and implementation of the ISWS quality system for data collection, research, and public service. The Committee assists with annual review and revision of the ISWS QMP and helps staff develop project-specific QA plans and Standard Operating Procedures (SOPs). The Committee also serves as a staff resource on approved QA/QC practices.

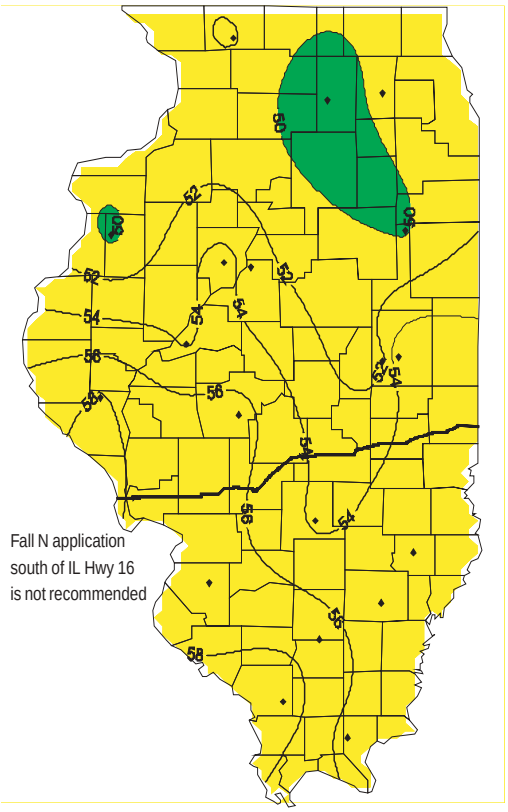
The Web is the distribution mechanism for information and guidance on developing quality systems. The ISWS Web site (Staff Only section) provides links to guidance documents from the USEPA, the U.S. Geological Survey, the National Environmental Laboratory Accreditation Conference, and a list of current ISWS QA plans and SOPs.

Enhancing Availability of Monitoring Data on Water and Atmospheric Resources in Illinois

The Water and Atmospheric Resources Monitoring (WARM) Program (www.sws.uiuc.edu/warm) serves the interests of Illinois citizens by operating, maintaining, and disseminating data from several long-term observation networks across Illinois. Program staff have constructed a growing database to increase understanding about water and atmospheric resources of Illinois and interactions of related variables. More importantly, these data provide essential information for local, regional, and statewide decisions on weather and water extremes from droughts to floods.

Expansion of WARM's Web-based data dissemination system is increasing the amount of current and historical information available. Observations include streamflows, reservoir levels, and in-stream sediment concentrations from selected Illinois waterways, as well as soil moisture, soil temperature, and meteorological information from an array of automated data collection sites around Illinois. The Web site displays daily maps of several variables in addition to monthly and historic summaries of tabular information.

Data are being provided for Illinois' agricultural community in cooperation with the University of Illinois' Extension and Information Technology and Communication Services. New WARM Web pages allow farmers to track the growth and development of agricultural pests. Pest development during the growing season correlates well highly with daily air and/or soil temperatures. Different growth stages of pests present varying crop concerns. For example, this information helps farmers identify when field scouting is advised



Daily 10 a.m. soil temperatures at a 4-inch depth are used to determine when to apply nitrogen fertilizer to Illinois fields in fall.

and project when specific pests may be reaching critical stages for particular crops. Tracking heat unit accumulations applied to growth development potential for crops also is included.

Plans are underway to increase data available for northwestern Illinois where there is a gap in information coverage. A new Illinois Climate Network weather station will provide better representative data for this region.

What's New on the Web

Many additions, updates, and extensive downloadable data have attracted record numbers of users to the ISWS Web site (www.sws.uiuc.edu/docs/wsfaq/). Usage has risen since last year to 17 million hits, a new high for the ISWS. New users have discovered the ISWS Web site because of diligent efforts to increase its visibility in more than 1,000 search engines such as Google, AltaVista, Yahoo!, and many others. Searches in most popular search engines usually rank the ISWS Web site in the top 10 results.

The Illinois Water Supply Web site addresses many water issues in a question and answer format enhanced by numerous photos, graphs, other illustrations, and a glossary. Among the topics covered are water use in Illinois, effects of water quality on supplies for drinking water, legal issues, and challenges encountered in fair allocation of this precious resource. The new site contains many statistics about the sources of water supplies in Illinois, and how precipitation, surface water, and groundwater together meet water needs for Illinois. Monthly expansion and updating keep information current.

Users find information quickly because the search engine that powers the ISWS Web site was completely redesigned to include boolean, wildcard, and weighted searches. The publications search engine was improved to accommodate searches for all publications within particular spans of years.

Redesign of Web site sub-pages for compatibility with more browsers also has increased the ease of site navigation. Links to major ISWS Web site areas now appear on each page. This redesign is being phased in along with content updates sitewide. Administrative pages have been revised. Projects within all scientific areas are being updated for the next phase of redesign.

Weather information available from the ISWS homepage was expanded. This new information is meant as a guide, not official quality-controlled data. It helps inform the public about current weather conditions, including wind direction, wind gusts, relative humidity, dewpoint, barometric pressure, and other variables.

The ISWS Library site (www.sws.uiuc.edu/chief/library/) has added a bibliography of new journal articles and other external publications by ISWS staff. This information and the database of ISWS publications (www.sws.uiuc.edu/pubs/isearch.asp) are updated regularly, and all these publications are available from Publications Distribution (www.sws.uiuc.edu/chief/shipping.asp) or the ISWS Library.

The ISWS has made significant contributions to science over the years, and a new section (www.sws.uiuc.edu/hilites/achievements.asp) highlights achievements such as first use of a hook echo to track tornados by radar, establishment of Regional Climate Centers in the United States, and involvement of ISWS scientists in Illinois policy issues. Additional topics are being added.

Program Planning and Management

Planning and management of programs, facilities, equipment, budgets, and staff are accomplished through the Water Survey's Strategic Plan. An annual update of the plan, including current year action items, has been completed. This plan will be coordinated with the Department of Natural Resource's Strategic Plan as it is developed under Governor Blagojevich's administration.

The University of Illinois' five-year initiative for an integrated business and student services system on all three campuses calls for activation of the finance segment on July 1, 2003. The human resource module will be activated on January 1, 2004. This suite of integrated products operates from a common database and will provide real-time access to vital information for University departments. The new system has made it necessary to implement comprehensive changes for the management of University of Illinois funding and also has required various degrees of training for all staff members at the Water Survey.

Planning and Management of Water Supplies

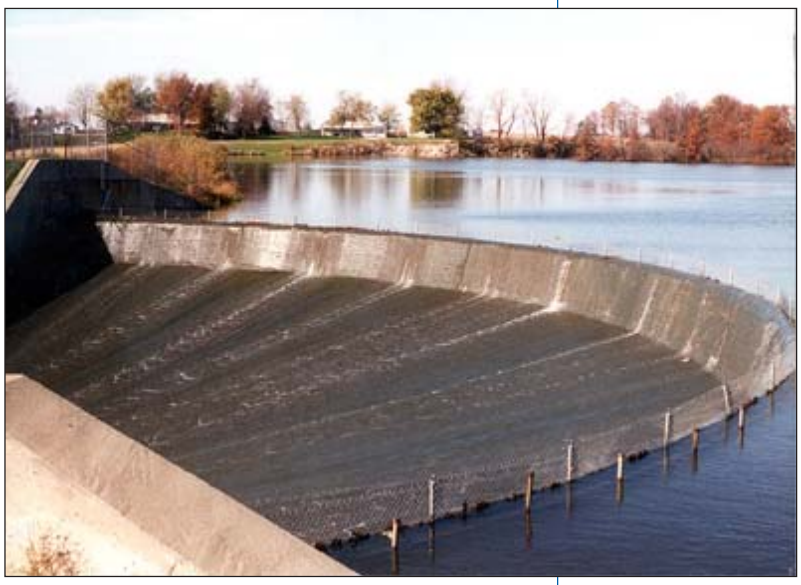
There have been many activities and much media coverage about water-supply issues over the past 12 months. The outcome has been increased public awareness and concern about water-supply challenges facing Illinois. The main message from the ISWS has been that there is no reason why anybody in Illinois should ever experience water shortages. Although water is an abundant and renewable natural resource, ensuring the provision of reliable supplies of clean water to meet increasing demands necessitates improved water-supply planning and management.

Constituents have diverse opinions about an appropriate institutional framework and process for improved water-supply planning and management. However, in December 2002, in response to an Executive Order issued by Governor Ryan in April 2002, a subcommittee of the Interagency Coordinating Committee on Groundwater (ICCG) delivered a report on integrated planning and management to the ICCG outlining such a framework and process (www.sws.uiuc.edu/docs/wsfaq/docs/ICCGSubcommitteeReport.pdf).

The ICCG and its Groundwater Advisory Council considered the report and concurred with most of the goals (www.sws.uiuc.edu/docs/wsfaq/docs/ICCGExecOrderNo5.pdf). In its January 2003 report to the Governor, the ICCG concluded that "[c]ommunities need to know not only if their water supply can support their growth plans but also how to grow in a way that minimizes the impact of urbanization and other uses on the resource. The future of Illinois communities rests on our success."

Everyone seems to agree that water-supply planning must be based on the best scientific information available. The ISWS asserts that such a mandate requires comprehensive studies of groundwater, surface waters, climate variability and change, economics, supply-and-demand projections, system capacities, and water conservation and reuse.

In May 2003, the Illinois House of Representatives and the Illinois Senate passed bills requiring the Illinois Department of Natural Resources to conduct scientific studies of groundwater in all major aquifers in Illinois as a basis for improving water-supply planning and management. After careful consideration of the bills, Governor Blagojevich felt that resources necessary to implement the studies could not be provided at a time of financial restraint and vetoed the bills, even though he recognizes the importance of the studies.



Lake Paradise is a public water-supply reservoir.

Also in 2003, the Steering Committee on Water Supply in the Southern Lake Michigan Basin was established under the leadership of the Northeastern Illinois Planning Commission. Several meetings held in Chicago were attended by 30 water planners and managers from Illinois, Wisconsin, and Indiana. Chief Winstanley represented the ISWS. The Steering Committee established as its goal the creation of a regional consortium, operating under the *Wingspread Tri-State Regional Accord* signed in 2002, to plan and manage the water supply in the region. There also was widespread recognition of the need to improve the scientific basis for water-supply planning and management.

The ISWS will continue to participate in followup meetings of these groups and stands ready to conduct the scientific studies proposed. Many ISWS projects already are providing relevant data and information, but the ISWS also recognizes that only with the injection of substantial financial resources can the comprehensive studies be completed in a timely manner.

Carbon Sequestration

Soil organic carbon (SOC) sequestration is an important factor for mitigating climate change and improving cropland agriculture. Crops naturally use the greenhouse gas, carbon dioxide (CO_2), from the atmosphere; the greater the crop productivity, the greater the amount of CO_2 used. Agronomic practices that enhance sequestration of crop biomass in soil as SOC also enhance removal of CO_2 from the atmosphere, and improve and sustain soil fertility.

Effectively reducing the concentration of CO_2 in the atmosphere and mitigating climate change requires long-term sequestration of SOC for decades or even longer. This can be accomplished by sequestering SOC in deeper soil layers, where it is more permanent, than near the soil surface.

Changing from conventional to conservation tillage practices is reported to increase SOC. This SOC is surficial, and most of the carbon is sequestered in the top 15 centimeters (cm). More than 80 percent of Corn Belt SOC lies between 15 and 150 cm deep, and growing crops access and deplete this fertile subsoil. Agronomic practices place such heavy demands on subsoil SOC that losses in deeper soil layers may exceed surficial SOC increases.

Thus, the whole soil profile must be considered in order to assert that carbon is being sequestered permanently in the soil. Future research is recommended on methods that result in SOC sequestration in deep soils and nutrient buildup using conservation tillage practices.

ANALYTICAL CHEMISTRY & TECHNOLOGY UNIT

Serving the Interests of Illinois through Chemistry and Technology

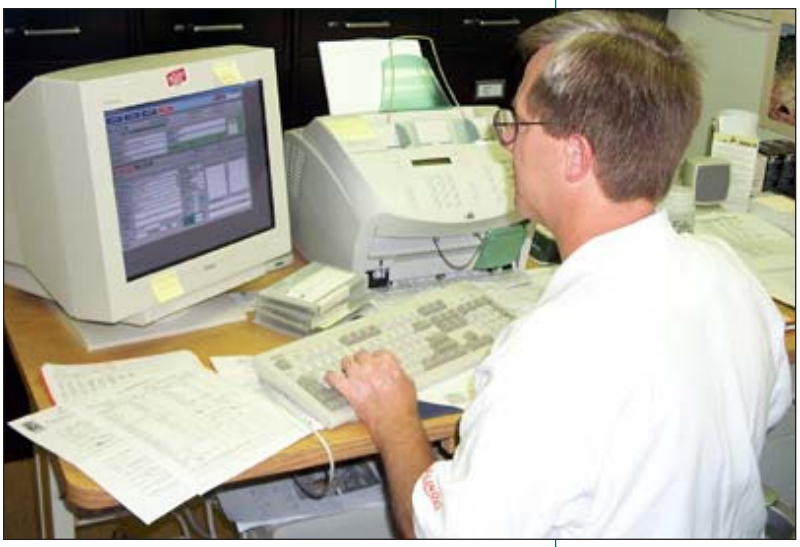
All Analytical Chemistry and Technology Unit programs are service oriented. Although services and programs offered have changed over the years, they continue to meet needs at local, state, regional, and national levels.

Public Service Laboratory

Since 1897, the Public Service Laboratory (PSL) at the ISWS has provided analytical services, advice, and referrals concerning the quality of water resources in Illinois. These requests are from citizens with private wells, municipalities, well drillers and engineers, health care providers, and state agencies throughout Illinois.

As the needs and concerns of the State have changed, so too have PSL services. A hundred years ago the main tests conducted were measurements of nitrate and bacteria from a public health standpoint due to concern about the spread of waterborne diseases. Since then, public health departments have been established and are responsible for microbial analyses, while the ISWS has expanded its capabilities for measuring the mineral content of Illinois waters. The impetus for this direction largely was due to the recognition of economic benefits gained from water-quality data. For example, water quality affects corrosion and scaling in water distribution and plumbing systems, and millions of dollars are spent annually for water treatment. Mineral analyses conducted at the PSL use USEPA-approved methods and quality control protocols.

Analytical services at the PSL routinely include measurements of metals, anions, pH, alkalinity, and dissolved solids. Because arsenic concentrations continue to be of concern, all samples are analyzed to detect micrograms per liter. Last year PSL chemists analyzed inorganic parameters of about 500 samples and responded to nearly 500 phone and e-mail requests for information and referrals. More than 233,700 samples have been analyzed since the ISWS first was established.



Brian Kaiser provides private citizens who submit samples with a written report explaining what the analysis means, and highlighting any findings that are a cause for concern.

Internal analytical services also are provided in support of research at the ISWS, other IDNR agencies, and the UIUC. Analytical services available include both inorganic and organic parameters using standard methods. Experienced PSL staff provide accurate data by following rigorous quality control practices. The PSL also participates in biannual performance evaluation tests provided by National Institute of Standards and Technology-certified vendors.

A vital service component includes consultations with principal investigators about sample collection and preservation, holding times, analytical methods, sampling containers, sample volumes, and acceptable laboratory practices. Considerable effort is made to accommodate scheduling needs of field projects. Methods development also is available for nonroutine sample matrices or limited sample volumes.

All projects are coordinated to maximize efficiency and minimize analytical costs. The PSL's workload reflects issues of concern to the State of Illinois and the nation. In addition to

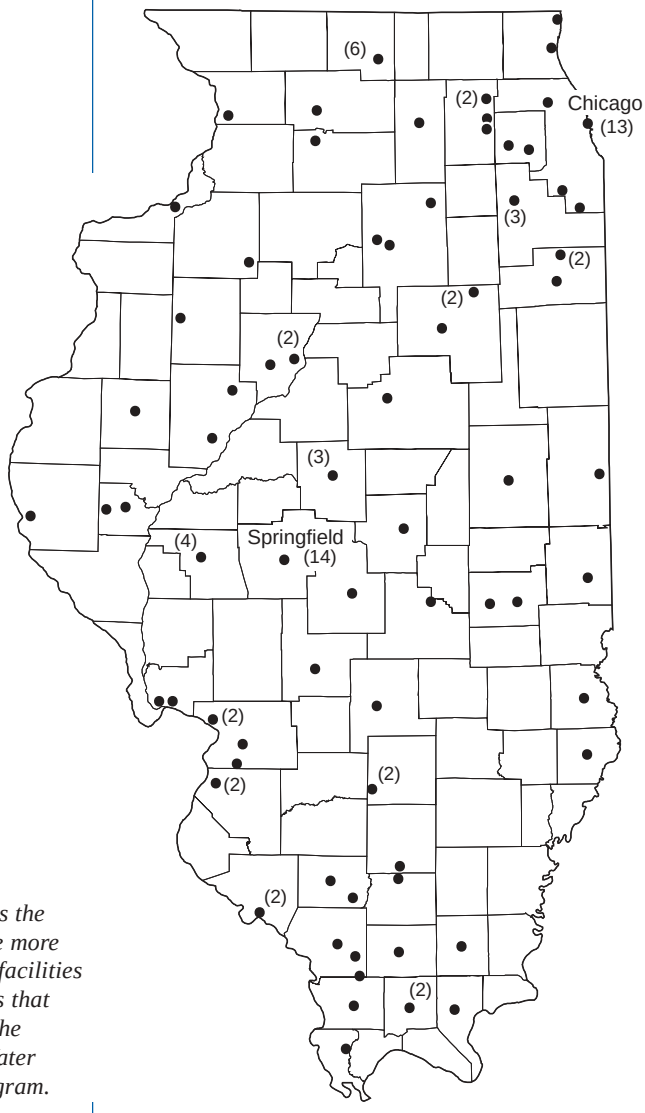
complete mineral analyses, there is a continued focus on nitrogen and phosphorous compounds, arsenic, and nonvolatile organic carbon.

Institutional Water Treatment Program

Institutional Water Treatment Program (IWTP) staff have worked with state facilities since 1949, when the Department of Mental Health and the Department of Corrections asked the ISWS to provide water treatment expertise related to drinking water and industrial water systems. The IWTP has grown and now provides these services to more than 100 departments, agencies, and many state universities. This program serves the interests of the citizens of Illinois by protecting the environment, prolonging equipment life, minimizing fuel usage, and saving money.

Staff visit participating institutions and tailor chemical treatment programs for individual system design, usage, and water quality. The IWTP works with the Department of Central Management Services to coordinate a statewide chemical bid annually so small and large facilities receive the best possible prices.

Effective chemical treatment of potable water systems is critical to protect the public's health. With effective chemical treatment, heating and cooling systems also function at peak operating efficiency, thereby reducing fuel and water expenses. The IWTP provides on-site training about water treatment and how to perform necessary tests, with an emphasis on the importance of maintaining systems to reduce operating and maintenance costs. Staff also conduct site visits to monitor treatment effectiveness, confirm accuracy of operator tests, and collect samples for complete laboratory analyses because field tests may not always detect developing problems. Participating facilities pay a portion of program costs.



This map shows the locations of the more than 100 state facilities and institutions that participate in the Institutional Water Treatment Program.

Midwest Technology Assistance Center

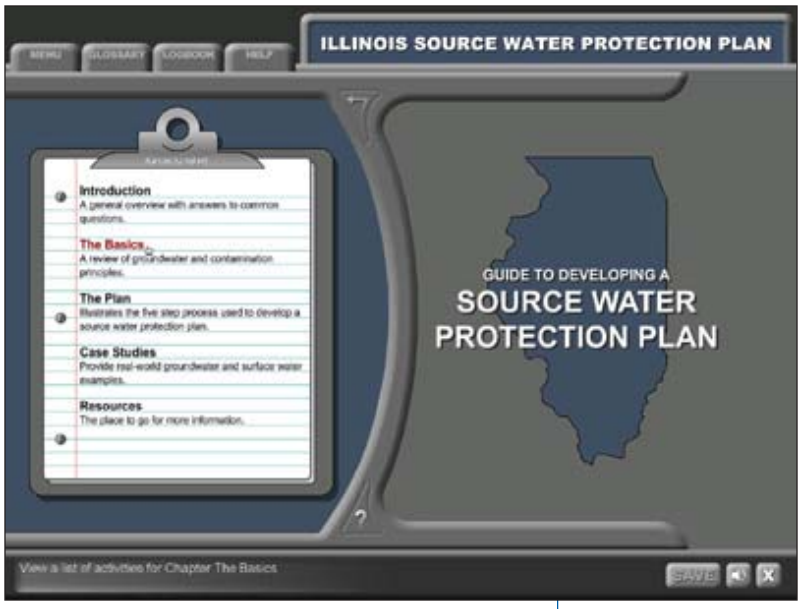
The Midwest Technology Assistance Center (MTAC) for Small Public Water Systems, founded in 1998, enhances the technical, managerial, and financial capacity of small public water systems (see sidebar). The Center's competitive grants, technical and training projects, and information dissemination address topics that extend beyond the boundaries of Illinois and the Midwest. Close cooperation with other regional technology assistance centers established by the USEPA, and with other partner agencies and organizations, ensures efficient response to the highest priority needs of small public water systems and Indian tribal systems in the Midwest and around the nation.

A variety of MTAC-funded training and educational workshops around the state help operators and managers of small systems further develop their skills related to source water protection, treatment for arsenic, disinfection, financial benchmarking and rate setting, and security issues. Areas emphasized over the next two years are vulnerability assessments, information technology security, and emergency planning.

The MTAC Competitive Grants Program annually solicits research proposals to address issues critical to small systems in the Midwest. Current projects include studies dealing with arsenic in Illinois' groundwater, source water protection, denitrification of nitrate-contami-

nated groundwater, and developing supply and demand projections for water usage over the next 20 years. Many of these issues are national in scope and address needs identified by the USEPA for small systems.

The Web site (http://mtac.sws.uiuc.edu/) is linked to the seven other Technology Assistance Centers around the country. Sharing information and products through this network in cooperation with the National Drinking Water Clearinghouse, USEPA Headquarters and Regional Offices, and local technical assistance provider organizations, such as the Illinois Rural Water Association, Illinois Section of the American Water Works Association, and the Environmental Training Center at Southern Illinois University, makes the work of MTAC have a truly national impact.



The Illinois Source Water Protection CD, an interactive training tool, was created to simplify the process of developing a source water protection plan for small public drinking water systems in Illinois.

Help in Preparing Emergency Response Plans Available for Small Public Water Systems

In cooperation with the Illinois Section of the American Water Works Association (ISAWWA), the MTAC has developed a tool that guides operators and administrators of small water systems through preparation of an emergency response plan.

Small water systems, those serving less than 3,300 people, may obtain a CD-ROM of the *Public Water System Emergency Planning Interactive Guide for Small Public Water Systems* and accompanying workbook at no charge from the ISAWWA while supplies last.

The guide contains a detailed description of different types of emergencies encountered in four categories: Loss of Pressure–Contamination, Natural Disasters, Technological Disasters, and Sabotage or Terrorism. A discussion of each emergency includes the potential for occurrence, warning signs, and mitigation information. There is also an interactive quiz to test operator or administrator knowledge of emergency situations.

Operators or administrators of individual systems can modify the guide's sample forms and lists for their own emergency contacts, media contacts, log forms, damage reports, and mutual aid agreements. The CD also contains full-text PDF versions of the U.S. Department of Transportation's 2000 *Emergency Response Guidebook* and the U.S. Environmental Protection Agency's June 2000 *Public Notification Handbook*.

Later this year, MTAC and ISAWWA will produce a new version in compliance with vulnerability assessment requirements for larger systems, those serving populations of less than 10,000 people. National distribution of that version will be through the Association of Safe Drinking Water Administrators.

Floods like the one depicted in this picture are one of the potential problems addressed by the emergency response planning CD.

ATMOSPHERIC ENVIRONMENT SECTION

Atmospheric Data Collection and Research: Serving the Interests of Illinois

The atmosphere provides Illinois with water resources and a suitable environment for economic and recreational activities; thus, hazardous atmospheric events and conditions can have adverse impacts on the state's economy, environment, and residents. Short-term occurrences include damaging thunderstorms, tornadoes, hail, freezing rain, heavy rains, floods, snowstorms, heat waves, cold waves, droughts, and air pollution. Over longer time scales, climate variations and change have affected Illinois and are expected to occur in the future, but impacts are uncertain (see sidebar).

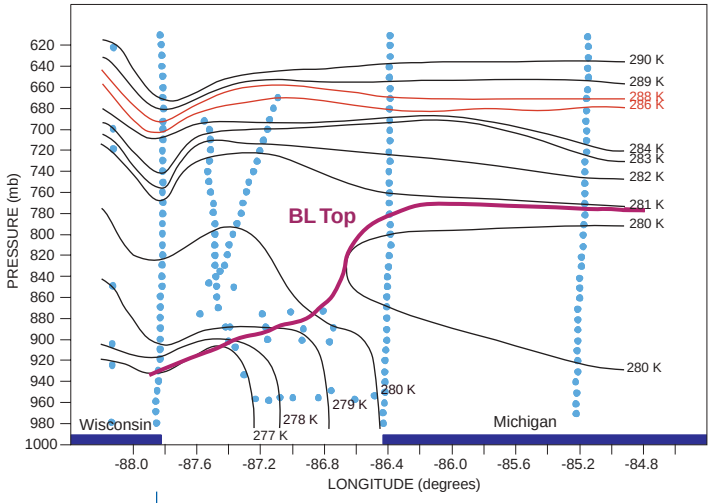
Illinois Studies and Education

Unusual conditions were associated with two major rainstorms that dropped more than 10 inches of rain over east-central Illinois and more than 12 inches across northern Illinois in August 2002. The storms were close in time and space at the end of a very dry summer, unlike past heavy rainstorms that occurred when soil moisture levels were near to above average. Consequently, dry soils absorbed much of the rainfall, and only minor flash-flooding occurred.

It is well known that Lake Michigan tends to increase snowfall in northeastern Illinois so better prediction of lake-effect snowstorms could be of great benefit for the Chicago area. In order to better predict these storms, it is first necessary to understand them. Recently, observations taken in December 1997 for a long-term National Science Foundation-funded field project provided the first detailed information about how Lake Michigan enhances large-scale snowstorms. Analysis of data collected by project aircraft, radars, and balloons revealed that low clouds over the lake provided regions of rapid snowfall growth. Heat and moisture from the lake also strengthened upward air motions, further enhancing snowfall.

Federal ambient air-quality standards for aerosol particles less than 2.5 micrometers in diameter ($PM_{2.5}$) specify an annual average concentration no higher than 15 micrograms per cubic meter. Information is needed on the magnitude and composition of these particles in rural areas in Illinois because air flows from these areas into urban areas and provides the background concentration of $PM_{2.5}$ that is then increased by local sources in urban areas. Field sampling for a Lake Michigan Air Directors Consortium-funded project to monitor $PM_{2.5}$ and its gaseous precursors at the Water Survey's Bondville site began in May 2003. The project includes semi-continuous monitoring of $PM_{2.5}$ mass, elemental and organic carbon, particulate sulfate, nitrate, ammonium and other major ions, gas-phase ammonia, sulfur dioxide, nitric acid, and nitrogen oxides.

The State Climatologist informs Illinois citizens about weather and climate. In addition to providing information about Illinois, activities range from conducting group tours of outdoor weather instruments, providing information to elementary and secondary students for science reports, providing data and technical guidance to assist graduate students with their thesis work, maintaining a Web site (http://www.sws.uiuc.edu/atmos/



Convective cloud layer growth was analyzed as cold air crossed Lake Michigan on December 5, 1997. Winds were from Wisconsin to Michigan, and heavy bars (along bottom axis) indicate shorelines of both states. Circles denote locations where balloons and aircraft collected data for the Lake-Induced Convection Experiment.

statecli/index.htm) that provides historical data and information on various climate topics, to working closely with the local National Weather Service on all aspects of the climatology exam given to 34 middle-school teams for the Illinois Science Olympiad.

Regional Studies

Atmospheric processes occurring in neighboring states also affect Illinois. Three multi-year investigations of the impacts of the Midwest's variable climate during the past 100+ years were completed in 2003.

Use of Lake Michigan water is of critical importance to Illinois as a major source of drinking water in the Chicago metropolitan area and as a recreational resource, and past fluctuations in lake levels have brought major economic impacts and legal problems. Examination of fluctuations on Lakes Michigan–Huron, Superior, and Erie over a 141-year period indicated that both Lakes Michigan and Erie have **U**-shaped distributions: high levels early in the 19th Century, lowest levels in the 1930s, and high levels late in the 20th Century. Lake Superior exhibited a gradual increase from 1861 until about 1950, but a flat trend thereafter. Two distinct periods of great fluctuations and change occurred on all four lakes: 1923–1938 and 1973–2001. There also was clear evidence of major spatial differences in basin climates of individual lakes.

Planning for future variations in precipitation has been a key factor in design of hydrologic and agricultural activities and human-made structures that must handle runoff. Potential climate change makes understanding past variations even more critical. Thus, 1898–2002 data were analyzed to determine past regional and temporal fluctuations across the Midwest. The records revealed more frequent dry conditions in southern sections (Kentucky, southern Illinois, and Missouri) than in the north (Minnesota, Upper Michigan, and Wisconsin). The temporal distribution showed four distinctly different periods: near average (1898–late 1920s), dry (1930s–1950s), near average (1958–1972), and wet (1973–2002).

Prior to settlement in the 19th Century, tall grass prairie covered Illinois and most of the Midwest for more than 10,000 years, helping to develop uniquely rich soils. Twentieth Century scientists struggled to explain why there was prairie in an area where the climate suggested forests. Using long climate records, three climate factors were detected to explain the prairie: (1) more frequent, quite severe droughts limited tree growth; (2) frequent prairie fires due to Native Americans and lightning from abnormally large numbers of thunderstorms during the fire season (winter) enhanced growth of grasses while killing most trees; and (3) dry cold seasons inhibited growth of oak–hickory forests located south of the prairie.

Native prairie flowers and grasses cover Goose Lake Prairie near Morris, Illinois, where the original tall grass prairie has been restored over several miles.

National Issues

National issues are also important for Illinois. For example, the atmospheric sciences literature is devoid of information on the national impacts of weather and climate conditions. Such measures are needed to understand the importance of weather and climate, and as a basis for projecting effects of future climate change at a national level that, in turn, will affect Illinois.

Estimated annual economic impacts of weather and climate on weather-sensitive sectors (energy, agriculture, insurance, transportation, and retail business) have been

Scientist Allen Williams monitors instruments for analysis of ambient nitrous oxides (NOx).

Scientist David Gay adjusts controls for the field chromatographic system.

derived from data for the past 50 years. Average annual direct losses were $17.5 billion (1997 dollars), only one percent of the total federal expenditures in 1997 ($1.601 trillion), and 0.2 percent of the nation's 1997 Gross Domestic Product ($8.111 trillion). The highest one-year loss, $54.4 billion in 1972, was 3.3 percent of the 1997 federal expenditures. Average annual gains due to weather and climate were $10.9 billion. Study results showed minor direct economic impacts at the national level.

Odors in livestock facilities are an issue in Illinois and other regions of the country. Although humans can sense animal odors at very low concentration levels, research is hampered by the expense and difficulty of objective measurements of odor levels. A technique has been developed to measure organic acids—a major component of the complex mixture composing hog odor—in hog odor at levels comparable to the threshold of human sensory detection, however. The technique relies on generating nanometer-sized alkaline particles that chemically react with acids in an odor sample and perceptibly change the particle size. It also can be applied to other classes of compounds besides organic acids to provide a basis for distinguishing between different components of hog odor.

Modeling Illinois' Future Climate and Air Quality

Sophisticated models being developed and used by the ISWS hold promise for making major strides in understanding future climate and air-quality conditions in Illinois and across the nation. The expanded ISWS modeling program is helping explain complex interactions among physical processes (e.g., climate change, atmospheric chemistry, atmospheric circulation changes, and Illinois' hydrologic cycle) that occur in the atmosphere and adding these to analyses, monitoring, and experiments.

Regional climate models (RCMs) can provide more specific and accurate information about the climate of Illinois than current global climate models (GCMs). The ISWS is using these RCMs for studies and taking a leadership role in developing the next generation RCM, the Climate–Weather Research and Forecasting model. Scientists from federal government and university research groups also are contributing to development of this "community" model, which promises greater accuracy, computational efficiency, and ease of use than GCMs.

The objective of a collaborative three-year study with the UIUC's Department of Atmospheric Sciences is to quantify and understand uncertainties associated with impacts of global climate and emission changes on U.S. air quality between now and 2020, 2050, and 2100.

Scientists will couple two high-resolution models (one for air quality and the ISWS' RCM), and also use a global chemistry–climate model and a detailed regional emissions model. Together these models and access to recent GCM simulations will provide a complete system for simulating and analyzing global, regional, and local interactions that determine air quality in Illinois. The USEPA is funding the study, which will focus on ozone and airborne fine particulate matter, both of which have adverse effects on human health.

Groundwater Data Collection and Research: Serving the Interest of Illinois

Public Service and Information

The ISWS has been collecting and evaluating data on groundwater resources for more than a century. This tremendous archive includes data and information on well locations, depths, and yields; groundwater levels; water withdrawals; aquifer hydraulic properties; and groundwater quality. Such a long-term program is essential for accurate and updated evaluation of groundwater resources in developing areas.

In addition to data collection and management, Groundwater Section (GWS) staff provide information services for the general public, industry, and government agencies. Approximately 1,200 annual requests cover topics ranging from development of a small domestic supply well to potential effects of new land development on existing groundwater resources. These data can be used to make decisions about management and protection of groundwater resources and also serve as the basis for GWS research programs.

Increasing accessibility to these valuable databases requires continual evaluation of innovative methods for obtaining and storing groundwater data. Automated data processing, storage, and retrieval greatly enhance data usability (see sidebar). Availability of large datasets and staff expertise are unique services for the people of Illinois.

Water Resources for Kane County

A five-year project being funded by Kane County demonstrates the expertise and capabilities that Illinois communities can expect from the GWS. Water resources pose quite a challenge for Kane County officials and the GWS. In addition to natural constraints on water availability, several other factors warrant consideration: future population growth and increased industrial/commercial demands, impaired water quality, and legal issues. The ISWS and Illinois State Geological Survey jointly proposed a series of hydrologic and geologic studies to provide technical support for management and protection of water resources listed in the *Kane County 2020 Land Resource Management Plan*. Specific objectives of the research are to help preserve groundwater availability, protect groundwater quality, provide a basis for formulating policy and management strategies for Kane County's water resources, and also provide baseline data and a framework for future studies in Kane County.

The Surveys plan to accomplish these objectives through fieldwork, records searches, development and analysis of existing databases, and mapping and modeling of area geology and of groundwater and surface water systems. Significant strides were made during the first year in several areas: geologic mapping, groundwater mapping, and numerical model development. The GWS mapping efforts have focused on developing a network of public and private wells finished in shallow aquifers for mass measurement of groundwater levels this fall. More than 900 candidate

Bob Olson, left, talks with driller Don "Butch" Baker during a 200 gallon per minute, 24-hour test in the Big Creek bottoms as part of a search for a supplemental water supply for the City of Paris, Edgar County.

Scott Meyer (right) measures the water level in Barrington Well No. 2 while David Schmidt, Superintendent of Utility Operations, looks on.

wells already have been inventoried and surveyed using a hand-held global positioning system. The goal is to have 1,000 wells in the network by fall.

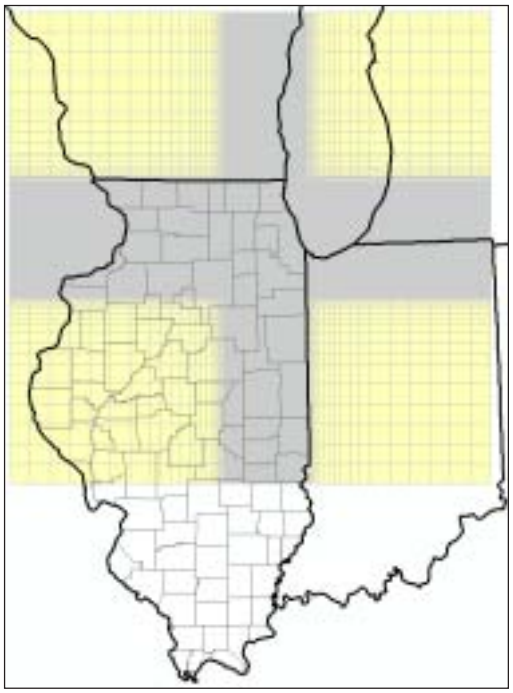
Water-level data will be used to create potentiometric surface maps depicting groundwater elevations in sand-and-gravel and shallow bedrock aquifers. These maps will provide irreplaceable baseline data for identification of changes in groundwater levels from increased withdrawals, land-use changes, or climate change. They also will be used to model groundwater flow in the shallow aquifers.

Groundwater modeling activities have included assembling an interstate geological framework, building a database of historical water withdrawals by aquifer, and assembling data for a regional three-dimensional computer model from the aquifers' deepest layers of pre-Cambrian bedrock to the land surface.

Modeling will help scientists interpret hydrologic and geologic data, and also provide analytical tools to quantify groundwater resources in the shallow and deep aquifer systems. It will be used to estimate recharge rates, leakage between aquifers, aquifer responses to increased aquifer development, and aquifer yields; assess surface water/groundwater interactions; evaluate alternative management scenarios; and establish a framework for future modeling studies. The proposed modeling consists of two high-resolution groundwater flow models at a local scale nested within a lower resolution regional model of northeastern Illinois (see figure).

Each nested model has a specific purpose. The regional model will be used to evaluate regional flow patterns, provide boundary conditions for local models, and estimate yields from the deep bedrock aquifer system. Embedding a local model of the deep aquifer system in the regional model will allow evaluation of well interference impacts between individual high-capacity public supply wells finished in the deep bedrock aquifer system. The nested model also will provide a framework for future models of the deep aquifer system.

A second local model embedded in the regional model will provide a high-resolution representation of the shallow aquifer system underlying Kane County. This local model actually may consist of several separate models, depending on local shallow geologic complexity and interactions of the shallow aquifer system. This model or set of models will be used to estimate and map shallow aquifer groundwater availability, recharge, and discharge rates; delineate capture zones surrounding high-capacity public water-supply wells; and assess groundwater/surface water interactions. It also will provide a tool for analyzing shallow aquifer responses to various management strategies and a framework for



A plan view of the regional 3-D groundwater flow model being developed in support of water resources investigations for Kane County. The model covering parts of Wisconsin, Michigan, Indiana, and Illinois will provide the framework for detailed analyses using local-scale models.

future models of water management and contaminant transport.

A key component of the proposed modeling study is review of hydrologic and aquifer property data, and its storage, retrieval, analysis, and documentation via modern database and geographic information system technologies. The ISWS will compile several types of hydrologic data from its archives and from published literature: pumping histories for high-capacity water-supply wells, aquifer hydraulic properties, water-quality data, surface water elevations and flows, and climate data. There also will be a review and reanalysis of aquifer tests within the GWS aquifer properties database, where appropriate. All data will be included in a database developed specifically for the project.

Techniques and tools used and lessons learned during this groundwater availability project likely will provide benefits that extend beyond Kane County's borders to all of northeastern Illinois and will serve as a prototype for similar investigations across the United States.

Arsenic Removal from Groundwater

In 2001, the USEPA lowered the arsenic maximum contaminant level (MCL) for arsenic from 50 micrograms per liter (mg/L) to 10 mg/L to be effective by 2006. The IEPA estimates that approximately 50 Illinois utilities that use groundwater as their water source may be out of compliance.

Steve Burch saves the contents of a split-spoon sampler collected during construction of an observation well for Illinois River restoration investigations at the Emiquon Natural Area west of Havana.

Most groundwaters in Illinois with arsenic concentrations above the new MCL also have iron concentrations of at least 0.5 milligrams per liter. Almost all water treatment plants that use such groundwater also use some form of iron removal. Some common iron removal processes remove arsenic, but removal effectiveness varies.

Recent research is characterizing chemical reactions that affect concurrent iron and arsenic removal. One phase involved collecting samples of raw and finished water from 10 water treatment plants using Mahomet aquifer water containing at least 10 mg/L of arsenic. Samples were analyzed for different physical and chemical forms of arsenic. Some treatment plants satisfied the new MCL. Others barely exceeded the MCL,

Tom Holm collects a groundwater sample to assess nutrient contributions to the Big Ditch in northern Champaign County.

and process modifications, such as improved filtration, may bring these plants into compliance. Samples were subjected to comprehensive water-quality analyses. Arsenic removal was depicted accurately by a linear model that used iron, alkalinity, silica, phosphate, and organic carbon. Staff also collected raw and treated water samples from approximately 30 other water treatment plants statewide for another phase of the research.

Combined data from this sampling and from Mahomet aquifer treatment plants will be used to describe arsenic removal in water treatment plants in Illinois and geochemical factors (such as pH, dissolved oxygen, and oxidation/reduction potential) that affect arsenic removal. Research results will prove useful for communities in Illinois and across the Midwest that must reduce arsenic concentrations in their raw water before distribution as finished waters to the public.

Using Digital Databases to Visualize Groundwater Data

A cooperative effort between the ISWS and the IEPA is enhancing access to three important statewide databases maintained by the ISWS on groundwater quality, aquifer hydraulic properties, and water use in Illinois. Very few such statewide databases on groundwater even exist in other states.

The databases contain critical information for applied and theoretical groundwater research, as well as basic groundwater information for the general public, water resources managers, and public agencies. Improved data access, especially for other agencies that routinely require such information, is in the best interests of Illinois.

The Source Water Assessment and Protection (SWAP) Program, developed by the IEPA, provides information to the public about the protection of Illinois' drinking water sources. Using a point-and-click environment, users access this information on the Web via an IEPA-developed Internet mapping server (IMS) interface.

Both agencies recognized the value of the databases for the SWAP Program and that they would need to work together to develop the data into a format compatible with the IEPA system. The goal is to enhance data quality, provide data access for other agencies, and also foster a cooperative relationship between the ISWS and the IEPA. An ISWS IMS site has been developed to improve internal accessibility to the ISWS databases in a manner similar to the IEPA's SWAP site. The Illinois Water Inventory Program database is already on the ISWS IMS site, and the Groundwater Quality database will be soon. The Aquifer Hydraulic Properties database will be on the site by early 2004.

The ISWS and IEPA sites are not accessible to the general public because the databases contain public well locations and other sensitive data that raise homeland security issues. The sites are, however, accessible to scientists at the ISWS and other State agencies, which has improved response to public needs. Improved data access will also greatly enhance scientific analysis of the data by allowing users to map specified data, view the map on screen, print the information, and download the specified raw data for further analysis.

A Resource Not Just for Scientists, Resource Managers, and Policy-Makers

An explicit goal of the National Atmospheric Deposition Program (NADP), a national research support project, is to "provide scientists, resource managers, and policy-makers with high-quality information on the exposure of managed and natural ecosystems to biologically important chemical deposition and other stressors from changes in the nation's chemical climate." However, there is also a commitment to public education/outreach through development of informational brochures and the support of educational activities which are used by people of all ages. Educators and students comprise about 40 percent of the data requests from the NADP Web site (nadp.sws.uiuc.edu/).

Elementary and Secondary Schools

Seventy-five fourth-grade students and teachers from Champaign's Dr. Howard school made a special field trip to the NADP's Central Analytical Laboratory or CAL (nadp.sws.uiuc.edu/cal/) for their "Chemistry, Light, and Photography" unit last November. They learned about weather monitoring and about collection and chemical analysis of rain samples. They tested the pH of different solutions and learned about the pH of rain from different parts of the country.

Visits to the analytical laboratory, a precipitation collection site, and a weather station taught them the importance of scrupulous laboratory practices to avoid skewing sample results and gave them an opportunity to see and learn about scientific instruments used to collect rain samples and to monitor weather conditions.

Each student received a raingage and instructions to enter data into a special ISWS Web site designed just for that purpose. A followup classroom activity let students select an NADP site, determine its average sulfate concentration using Web site data, and compare their results to annual NADP sulfate results for the same site.

As part of Urbana Middle School's School-to-Work program, NADP scientists have talked with students about their research, their educational backgrounds, and what the network measures by tracking a sample's journey from start to finish. Students were shown how to access data from the NADP's Web site and also worked in small groups to measure the pH of common household chemicals.

High school students from across the country continue to access the NADP's Web site to complete exercises for *Inside Rain, Working with Precipitation Chemistry Data*. The National Science Teachers Association developed this hands-on, high-tech curriculum for grades 9–12 with financial support from the U.S. Geological Survey and the expertise of NADP scientists to help science teachers use the wealth of data and information on the NADP site. Students retrieve tabular data, maps, and other information during on-line

Chemist Brigita Demir (far right) shows fourth-graders how to measure the pH of rain and other solutions.

classroom sessions. These activities and laboratory exercises teach them about precipitation chemistry, atmospheric deposition processes, and the effects of the changing content of precipitation on the environment.

Colleges

Data, maps, and other information from the NADP increasingly are being used at the college level in undergraduate textbooks, as the basis for a science curriculum, and for classroom instruction. In an effort to introduce contemporary issues into the university classroom, textbook publishers have added sections and chapters on topics such as acidic deposition and precipitation chemistry. Among the several fields using NADP maps and data in textbooks are chemistry (*Chemistry in Context*, American Chemical Society), environmental science (*Ecosystem Change and Public Health*, The Johns Hopkins University Press), and landscape architecture (*Northeastern Landscaping Book*, Sunset Books, Inc.).

The NADP's annual map summaries also have been used in classrooms at the UIUC for studies of the atmospheric transport of pollutants. As part of the curriculum for a UIUC chemistry class last November, students toured the CAL and talked with the analysts about the types of measurements they perform on precipitation samples.

Illinois and the Nation

The NADP Program Office participates in the UIUC's Extension Service Environmental Stewardship Week, which teaches elementary students about environmental science through hands-on learning centers. A program by NADP scientists focused on pH and water quality and helped students compare the pH of household chemicals, water from Lake Jacksonville, and rain samples from the NADP network. Approximately 1,200 children and their parents participated in this annual event at the Western Illinois Youth Camp in Jacksonville.

Training has proven to be an invaluable part of the NADP design to collect long-term, high-quality precipitation data. It is a key to the success of this program, which produces "data...considered authoritative by the environmental sciences community." Since 1980, the CAL has conducted annual training courses that teach operators of NADP field sites how to collect high-quality research samples. The course attracts people from more than 300 sites in 49 states, Puerto Rico, and the Virgin Islands. The mix of new site operators and a few seasoned operators makes peer interactions especially effective. Differing geography and climate at NADP sites also enrich discussions about problems operators encounter during weekly sample collection.

The course places special emphasis on ensuring equipment in good working condition and strict adherence to standard operating procedures (see sidebar) in a format that mixes lecture, hands-on instruction, discussions, and a tour of the CAL's analytical facilities. Sessions on data reporting, quality assurance, and researchers' use of data round out the course. Participants leave with a renewed sense of their value to the network and the skills they need to collect research samples.

The 2003 course provided hands-on instruction in field operations for the National Trends Network (NTN), the Mercury Deposition Network (MDN), and the Atmospheric Integrated Research Monitoring Network (AIRMoN). Organizations represented included the National Park Service, the U.S. Forest Service, U.S. Fish and Wildlife Service, U.S. Geological Survey, U.S. Environmental Protection Agency, Native American tribal groups, several universities, local government agencies, and private volunteers.

In November 2002, NADP staff prepared a slide show for the 20th anniversary of continuous precipitation chemistry monitoring at the NADP Konza Prairie site in Kansas. The presentation included general program goals; quality assurance, data uses, and significant national trends for the various networks and at the Konza site; and ideas for future research (ammonia trends and

Scott Dossett (far right) shows field operators some troubleshooting techniques for raingages.

monitoring inputs of total nitrogen and metals such as mercury).

The World

The NADP Web site receives more than one million hits annually, links the world to quality-assured data and information about chemicals in precipitation, and offers a new resource for educating tomorrow's scientists—one that NADP founders never even dreamed of 24 years ago. All NADP and CAL publications, reports, and quality assurance documents are available on the Web site. Scientists also retrieve the most up-to-date NADP pH maps for the United States and tailor them for their own use or as a starting point to discuss acids and bases in nature, precipitation chemistry, causes and effects of "acid rain," and even "the politics of acid rain."

The site also provides several educational publications for researchers, educators, and the public in PDF format (*Inside Rain: A Look at the National Atmospheric Deposition Program*, *Monitoring Mercury in North American Precipitation*, *Nitrogen in the Nation's Rain*, and *National Atmospheric Deposition Program 2001 Annual Summary*), and a high-school science curriculum developed by the National Science Teachers Association with support from the U.S. Geological Survey (*Inside Rain: Working with Precipitation Chemistry Data*).

ISWS Scientists Set the Standards

For more than a century, the American Society for Testing and Materials, now ASTM International, has set laboratory standards for materials, products, and measurement methods. Scientists, engineers, and technicians rely on these rigorous, proven standards, recognized worldwide, to ensure that they are following proper laboratory procedures. Early in the 1980s, NADP scientists at the ISWS initiated an effort to establish ASTM standards for acid rain measurements.

Scientists at ISWS first began measuring rainfall chemistry in the early 1970s. By the late 1970s, acid rain was attracting national and international attention, and an expert panel of the National Academy of Sciences recommended a nationwide network to measure acid rain. Early experience with rainfall chemistry measurements led to selection of the ISWS as the CAL for the NADP, which began operations in 1978. Because CAL measurements often were found to be the most accurate when compared with measurements from other U.S. and Canadian laboratories, CAL methods came to be recognized as the "standard" for acid rain measurements. All that remained was their acceptance as official ASTM methods.

The ASTM had not considered standard test methods for acid rain measurements until CAL scientists joined its committee on sampling and analysis of atmospheres. These scientists were instrumental in forming an atmospheric deposition subcommittee that focused on terminology, practices, guides, and test methods for acid rain. Subsequent task groups drafted methods that could withstand the rigorous ASTM process to disseminate consensus standards, which led to ASTM guides for siting network stations, collecting and preserving samples, quality control/assurance practices, and standard methods for measuring precipitation pH and major acidic and alkaline species found in precipitation.

In addition to receiving awards of appreciation for their contributions, ISWS scientists have served in leadership positions in ASTM's acid deposition subcommittee for more than a decade. As ASTM International continues to develop standard test methods for precipitation chemistry measurements, ISWS scientists continue to lead the way.

WATERSHED SCIENCE SECTION

Science in Support of Watershed Management and Restoration: Surface Water Availability and Variability

The Watershed Science Section (WSS) is committed to providing the best scientific information and knowledge in support of watershed management and restoration in Illinois and, by example, influencing those practices in the United States and other nations. The ISWS has a long history of cutting edge research that guides water resource practices.

Watershed management and restoration (see sidebar) is one of the most important resource management issues that has emerged in recent years. Resource managers at all levels, including grassroots citizen groups, county and regional agencies, and state and federal agencies, all recognize that water-quantity and quality issues must be managed on a watershed basis.

Watershed management in Illinois is not only a local issue, but also of regional, national, and international importance. Illinois is in the center of the Mississippi River basin, which occupies 40 percent of the conterminous United States. Almost all runoff from Illinois enters the Mississippi River and its major tributary, the Ohio River. A small portion of Illinois also falls within the Great Lakes basin, which—along with the diversion of Lake Michigan water—has a very important role in national and international water issues. What happens in Illinois influences water quantity and quality in the State and beyond its borders, navigation and commerce along national and international waterways, international treaties on water use, and many other issues.

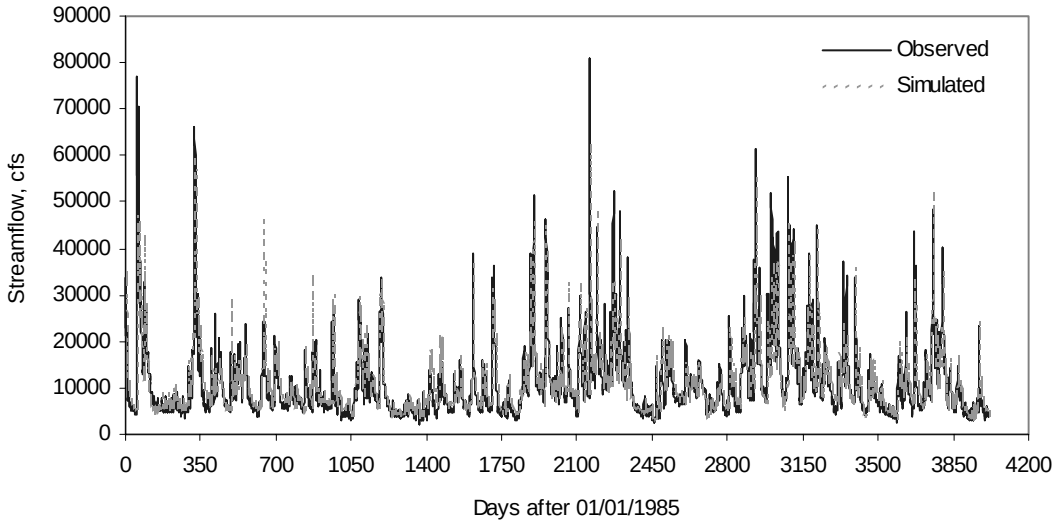
Most WSS research addresses issues related to quantity and quality of surface water at local, state, and national levels. Basic information for watershed management requires understanding water-quantity and flow characteristics of Illinois' rivers and streams. Because they can affect quantity, quality, and distribution (both spatial and temporal) of surface waters in a watershed, impacts of natural and human factors on streamflows also must be analyzed. These factors include climate variability, land-use changes, and hydrologic modifications, such as reservoirs, water-use withdrawals, and effluent discharges.

Two methods can be used to study flow quantity and quality of Illinois' streams: statistical analysis of available monitoring records or watershed modeling, which provides a mathematical representation of physical processes that influence runoff, streamflow, and water-quality characteristics. No model can simulate watershed processes without sufficient data for both model calibration and input, so effective modeling also requires extensive monitoring.

Modeling Watershed and River Processes

A major initiative undertaken by the ISWS is to develop a watershed model for the entire Illinois River basin using the BASINS modeling system developed by the USEPA. This multipurpose system facilitates examination of environmental information, supports analysis of environmental systems, and provides an integrated watershed and modeling framework for management alternatives. The system combines a geographic information system, national watershed databases, and utilities to build projects and organize and evaluate data, including watershed delineation and land-use and soils classifications.

System interfaces are watershed models for sediment transport and water-quality processes, and an in-stream water-quality model. With these tools, scientists can use the BASINS system to explore conditions under various management alternatives for watersheds and simulate changes in floodplains, watersheds, channels, land uses, and hydrology. As part of the initial phase of model development for the entire Illinois River basin, the model was calibrated with four major sub-



Observed and simulated streamflows are compared at the USGS gaging station near Marseilles, Illinois, 1985-1995.

watersheds of the Illinois River basin: the Spoon, Vermilion, Iroquois, and Kankakee River watersheds.

Model performance is shown in the figure, which compares model output and observed streamflows for a 10-year period (1985–1995). Simulating watershed hydrology and river dynamics is an important first step in analyzing various watershed processes, not only river water quality and sediment transport, but also multidisciplinary watershed issues that integrate hydrology with ecological and socioeconomic concerns.

Development of the BASINS model for the entire Illinois River basin opens the door for a wide range of applications of relevance for large-scale watershed and water resource issues. For example, the WSS plans to develop a consistent set of hydrologic models for all major watersheds in Illinois. A separate model is being developed for the Embarras River watershed.

Evaluating Streamflow Quantity

Statistical and regional methods are particularly useful for analyzing streamflow quantity and frequency and the effects of climate and human impacts on these flows. Such methods provide baseflow conditions for water-quality analyses and regulations, classify the hydrologic character of Illinois streams for use in watershed management, analyze frequency and impacts of droughts and floods in Illinois, assess water availability and public water-supply system yields, and evaluate in-stream flow uses and protected flow levels.

Thus, the Illinois Streamflow Assessment Model (ILSAM) was developed to describe long-term streamflow characteristics of large and small streams throughout Illinois. The model uses a database of processed streamflow and water-use information, and applies hydrologic principles and regional equations to estimate streamflow frequencies at gaged and ungaged sites. With recent completion of analyses for the Mackinaw and Vermilion–Illinois River watersheds, ILSAM analyses have been developed for more than half of Illinois' streams. A new on-line version of ILSAM is being developed to provide easy access to streamflow estimates.

Regional analysis also has been used to establish base flow limits in streams, such as the 7-day, 10-year low flow ($Q_{7,10}$) used to define permit limits for effluent standards and mixing zones according to Illinois Pollution Control Board regulations. The $Q_{7,10}$ value also is used as the base flow for defining minimum flow levels for in-stream uses.

Ted Snider filters a sample from the Sangamon River at Mahomet for nutrient analysis.

Updated $Q_{7,10}$ values reflect current flow conditions for half of Illinois' streams.

Evaluating Water Supply

Many large water supplies have been proposed in Illinois, primarily to meet cooling water needs for new coal- and gas-burning power plants, but also for several new regional public water-supply systems. Most of these proposed withdrawals are from large rivers, such as the Kaskaskia, DesPlaines, and Illinois Rivers, or from large federal reservoirs.

The ISWS has helped regulatory branches of government analyze available water resources, including streamflow and reservoir characteristics, not only to assess whether water resources are sufficient to provide reliable water during periods of severe drought, but also to ensure that these rivers have sufficient water for critical in-stream uses, such as sustaining aquatic habitat and assimilating wastewaters. Consequently, the Kaskaskia River system, once a resource of limited use for water supply, has issued permits that fully use the river's available flow above that reserved for in-stream uses. The ISWS also continues to assess drought impacts on existing public water supplies and their ability to provide an adequate water supply.

Effects of Climate Variability on Water Resources

Water availability in Illinois will depend, in part, on future climate conditions. Hydrologic records collected over the last century indicate that streamflow characteristics can change noticeably as a result of inter-decadal climate variability. Wet and dry extremes experienced in the past not only are likely to recur, they may be surpassed in the future. Most global climatic models (GCMs) predict that the 21st Century generally will be warmer than the previous century, but there is considerable uncertainty whether future conditions will be drier or wetter. Watershed models provide a tool to investigate potential consequences of future climate scenarios.

The WSS is evaluating the potential effects of climate change on Illinois' water resources using selected GCM scenarios as model input. Not surprisingly, modeling results are as varied as the differences in GCM predictions, with potentially large effects on water resources. Other climate change scenarios project moderate increases in precipitation and temperatures, with relatively little overall change in streamflow characteristics, however.

Monitoring Streamflow

The lack of streamflow data for small watersheds in Illinois affects watershed planning and restoration efforts. As part of ongoing research, the WSS operates 19 streamgaging stations for small watersheds of less than 100 square miles in area throughout Illinois, and computes discharge records for 12 of these gages. Streamflow data are needed to analyze stream-channel dynamics, calculate sediment and nutrient loads, and calibrate and validate watershed models. By establishing and maintaining streamgaging stations for small watersheds in Illinois, the WSS is attempting to meet this data need.

Josh Stevens measures water levels at Long Creek for the Lake Decatur watershed project.

Watershed Restoration

The ISWS is known as a leader in stream restoration efforts. Long-lasting, sustainable solutions necessitate addressing water resources and environmental issues on a watershed level. In light of this trend and to meet Illinois' need for scientific information and analysis, the WSS has been engaged in all facets of stream and watershed assessment, restoration, and monitoring.

Growing changes in attitudes toward land stewardship and implementation of restoration activities on the ground are strong evidence that research and outreach efforts are having substantial positive impacts in Illinois. Never has there been a greater need to define watershed problems and critical target areas, test restoration designs, and demonstrate the value of restoration techniques and monitoring.

Much basic research has yet to be done. There needs to be rapid, pragmatic watershed assessment and planning for larger areas in Illinois and economically feasible restoration design applications to "target" critical problem areas. Demonstrating stream, watershed, and landscape restoration techniques and public involvement are important, as are monitoring project effectiveness and determining real costs.

The WSS continues to develop, test, monitor, and adapt stream and watershed restoration techniques to address local, state, regional, and national stream and watershed resource needs. Collectively, techniques developed by the ISWS are being considered for further use statewide, nationwide, and internationally.

Staff also research and demonstrate rapid watershed assessment techniques, including geomorphologic and hydrologic conditions, in conjunction with biological sampling and assessment protocols. Research and monitoring includes project restoration designs with multiple objectives and benefits. For example, creation of riffle and pool structures is being refined. This effective restoration and naturalization technique controls stream-channel incision (grade control) and stabilizes streambanks; provides flow diversity and habitat for fish, macroinvertebrates, and other aquatic species, including plants; oxygenates water; and enhances natural scenery and sounds.

Impacts of habitat restoration on water quality are being assessed in both rural (Lake Pittsfield area) and urban (Waukegan River) environments of Illinois as part of the National Monitoring Program funded by the USEPA and the IEPA. Staff also are cooperating with the IDNR Office of Realty & Environmental Planning to design, install, evaluate, and monitor in-stream restoration techniques for ecosystem partnerships and pilot watersheds throughout the state.

Rapid watershed assessments will be conducted using aerial reconnaissance and physical, water quality, and biological indicators in the Illinois River basin. Assessment protocols will be used to identify critical target areas, as well as needs for background monitoring, data, and resource protection design. Monitoring data will be used for future studies and subsequent restoration projects. Establishing and working with local partnerships and local, state, and federal natural resource and land management agencies are also a high priority.

Many landowners accept riffle and pool structures, such as this one monitored and designed by ISWS staff for streambank/ streambed stabilization. This useful technique improves water quality as streamside vegetation filters chemical pollutants. It also prevents nonpoint source erosion and provides flow diversity and habitat for aquatic plants and animals.

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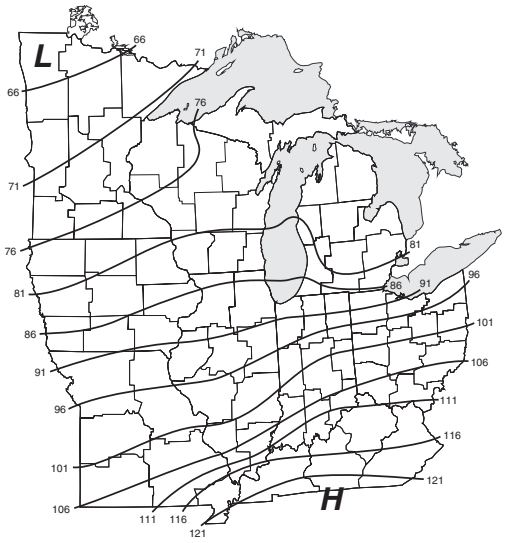

This pattern depicts average annual precipitation (cm) based on 1898-2002 data for the Midwest.

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Using a vibrocore, Kip Stevenson and Jim Slowikowski collect sediment samples up to 3 meters long from Peoria Lake.

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Markus, M., C.W.-S. Tsai, and M. Demissie. 2003. Uncertainty of Weekly Nitrate-N Forecasts Using Artificial Neural Networks. *ASCE Journal of Environmental Engineering* **129**(3):267–274.

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Wesolowski, D.J., M.L. Machesky, D.A. Palmer, M.K. Ridley, P. Bénézeth, L.M. Anovitz, Z. Zhang, and P. Fenter. 2002. Ion Adsorption on Metal Oxide Surfaces in Aqueous Solutions to 300°C. *Proceedings, Fifth International Conference on Solvothermal Reactions*, (R.E. Riman, ed.), East Brunswick, NJ, pp. 49–54.

Stratton Dam is on the Fox River.

HONORS

Nani Bhowmik
Member, National Science Foundation Site Visit Team, National Center for Earth-Surface Dynamics, University of Minnesota, Minneapolis

Van Bowersox
Reviewer, National Academy of Sciences, National Research Council report, *Air Emissions from Animal Feeding Operations*

Mark Brooks
Chair, National Association of Corrosion Engineers Technical Committee TEG 156X, (Corrosion and Corrosion Control in Potable Water Systems Used in Buildings)

Joyce Changnon
Vice Chair, State Universities Retirement System Members Advisory Committee

Stanley Changnon
Member, Climate Research Committee, National Academy of Sciences; and Member, Publication Board, *Meteorological and Geoastrophysical Abstracts*, Committee on Transportation, and Committee on Societal Impacts, American Meteorological Society

Mike Demissie
Member, Research Proposal Review Panel, U.S. Environmental Protection Agency, Washington, DC

Karen Harlin
Secretary, East Central Illinois Local Section, American Chemical Society, and Chair, National Chemistry Week Activities; and Secretary, National Atmospheric Deposition Program Network Operations Subcommittee

Laura Keefer
Secretary/Treasurer, American Water Resources Association, Illinois Section

Walton Kelly
Co-recipient, Donald A. Holt Award, Illinois Council on Food and Agricultural Research, 2003

Edward Krug
Member, Regional Technical Advisory Group, U.S. Environmental Protection Agency, Region 5; and Member, Nutrient Standards Science Committee, Illinois Environmental Protection Agency

Kenneth Kunkel
Chair, U.S. Climate Reference Network Science Panel, 2003

Randall Locke
Vice Chair, Illinois Groundwater Association

Sally McConkey
Vice Chair, Illinois Association for Floodplain and Stormwater Management

George Roadcap
Chair, Data and Scientific Assessment Committee, Mahomet Aquifer Consortium

Jas Singh
Recipient (with R.J. Hudson), Second Place, Poster Presentation Award, 25th Midwest Environmental Chemistry Workshop, Chicago, IL, October 6, 2002: *Inverse Modeling of the Nitrogen Fluxes in Tile Drained Agricultural Fields: Application of Shuffled Complex Evolution Method to the DRAINMOD Model*

Loretta Skowron
Recipient, Award of Appreciation, American Society for Testing and Materials International, Committee D22 on Sampling and Analysis of Atmospheres

Kent W. Smothers
Symposium Chair, *Total Building System Protection*, National Association of Corrosion Engineers Annual Meeting, March 2003

Gary Stensland
Chair, National Atmospheric Deposition Program Ad Hoc Committee, Scientific Underpinning for NADP Siting Criteria, 2001–2003

Douglas Walker
Scientific Committee and Session Chair, Probabilistic Approaches and Groundwater Modeling, American Society of Civil Engineers, Environmental and Water Resources Institute Symposium, 2003; and National Center for Supercomputing Applications/University of Illinois at Urbana-Champaign Faculty Fellow (FY2004)

Daniel Webb, Brian Kaiser, and RuthAnn Nichols
Recipients, Certificate of Appreciation for conducting Water-Quality section, Illinois Science Olympiad, April 5, 2003

Steven Wilson
Science Advisor, Imperial Valley Water Authority; and Member, Geomorphology Technical Advisory Committee, Watershed Planning for Peoria Lake Tributaries, Tri-County Regional Planning Commission

Derek Winstanley
Appointed Chair, Illinois Interagency Workgroup on Climate Change, September 2002; Appointed Member, Regional Water Supply Steering Committee for NE Illinois, SE Wisconsin and NW Indiana, February 2003; and Member, Subcommittee on Integrated Water Planning and Management of the Interagency Coordinating Committee on Groundwater

Members of the Board of Natural Resources and Conservation and the Scientific Surveys visit a landfill site near Lake Calumet where sediment dredged from the Illinois River will become productive soil.

ADJUNCT & EMERITUS APPOINTMENTS

Adjuncts to University of Illinois at Urbana-Champaign

Office of the Chief
Derek Winstanley, Department of Geography

Atmospheric Environment Section
James Angel, Department of Geography
Kenneth Beard, faculty, Department of Atmospheric Sciences
Stanley Changnon, Department of Geography and Department of Atmospheric Sciences
Steven Hollinger, Department of Natural Resources and Environmental Sciences
David Kristovich, Department of Atmospheric Sciences and Department of Geography
Kenneth Kunkel, Department of Atmospheric Sciences

Adjuncts to Illinois State Water Survey

Dr. Geoffrey Hewings
Regional Economics Applications Lab
Department of Geography
University of Illinois at Urbana-Champaign
Urbana, IL

Dr. Scott Isard
Department of Geography
University of Illinois at Urbana-Champaign
Urbana, IL

Dr. Roger Pielke, Jr.
University of Colorado
Boulder, CO

Thomas Prickett
Thomas A. Prickett & Associates
Urbana, IL

Russell Lane, Principal Scientist Emeritus, 1981
Ralph Evans, Principal Scientist Emeritus, 1984
Stanley Changnon, Chief Emeritus, 1985
Robert Sasman, Professional Scientist Emeritus, 1987
Richard Schicht, Principal Scientist Emeritus, 1989
Eugene Mueller, Principal Scientist Emeritus, 1990
Donald Staggs, Professional Scientist Emeritus, 1990
Richard Semonin, Chief Emeritus, 1991
Chester Neff, Principal Scientist Emeritus, 1992
Michael Terstriep, Principal Scientist Emeritus, 1993
Krishan Singh, Principal Scientist Emeritus, 1996
Wayne Wendland, Principal Scientist Emeritus, 1996
Thomas Butts, Senior Professional Scientist Emeritus, 1998
Raman Raman, Principal Scientist Emeritus, 1998
Donald Gatz, Principal Scientist Emeritus, 1999
Nani Bhowmik, Principal Scientist Emeritus, 2001
Shundar Lin, Senior Professional Scientist Emeritus, 2001
Harry Ochs, Principal Scientist Emeritus, 2002
Mark Peden, Senior Professional Scientist Emeritus, 2002

CONTACTS

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Associate Coordinator for Toxics and Mercury Deposition Network: Clyde Sweet, (217) 333-7191
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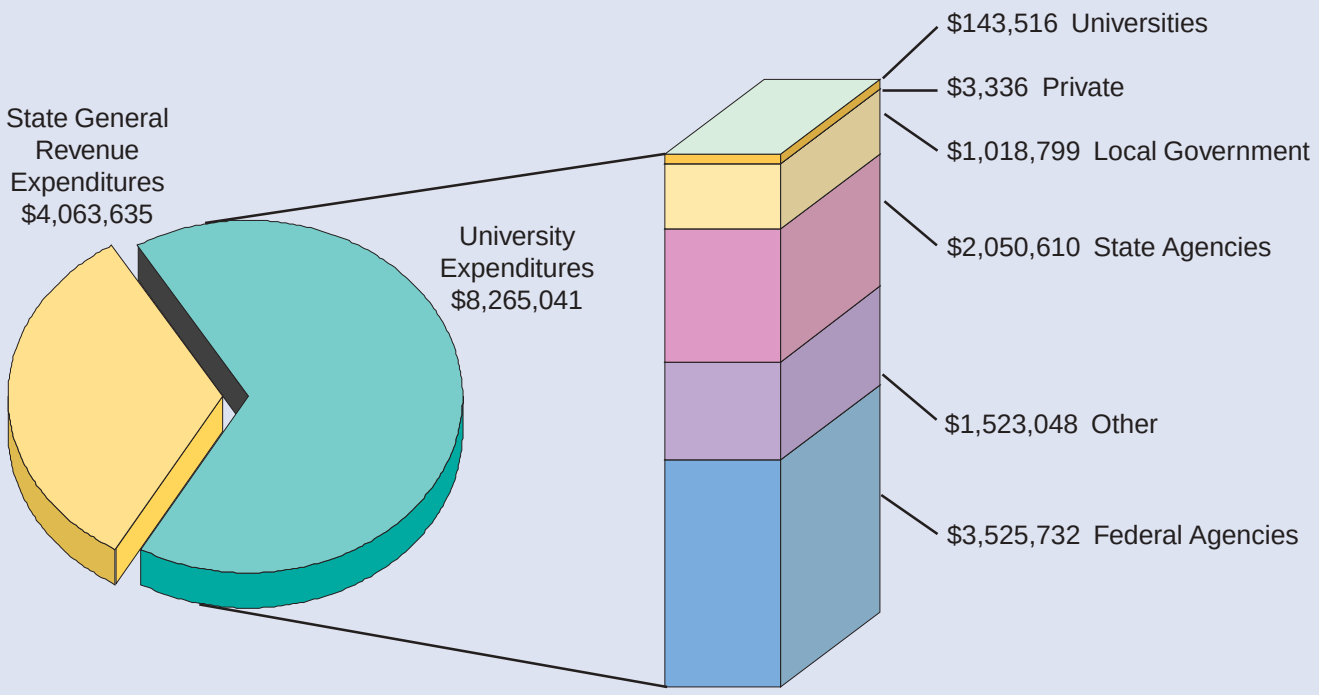
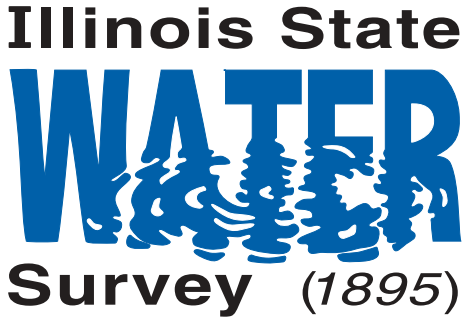
FINANCIAL STATEMENT, FY 03



Total Expenditures $12,328,676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