A Plan to Improve the Planning and Management of Water Supplies in East-Central Illinois

This report has been a collaborative, joint effort organized by the Mahomet Aquifer Consortium and numerous other individuals including the following stakeholders:

Bradley Uken (Chair): Public **Jeff Smith** (Vice Chair): Agriculture **Shannon Allen**: Soil and water conservation
Morris Bell: Water authorities **Dwain Berggren**: Environment **Robert Betzelberger**: Small business
Frank Dunmire: Rural water districts **Jay Henry**: Electric generating utilities **Evelyn Neavear**: Counties
Mark Sheppard: Industries **William Smith**: Municipalities **Steve Wegman**: Water utilities

Prepared under contract to the Office of Water Resources of the Illinois Department of Natural Resources, Springfield, IL, as authorized by the State Executive Order 2006-01.

June 2009

Champaign, Illinois

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Acknowledgments

The Regional Water Supply Planning Committee (the Committee) for East-Central Illinois wishes to sincerely thank all those who have contributed in various ways to the process of regional water supply planning and contributed to the preparation of a regional plan. In particular, special acknowledgment is extended to the people identified below.

Members of the public and representatives of stakeholder groups have participated in meetings, provided data and information, and reviewed and commented on draft material. Their input has made this a truly grass-roots planning effort and has strengthened the final report.

Paul Berg (municipalities) served as the first Chair of the Committee and helped set the foundations and procedures for the work of the Committee.

Brent O'Neill (water utilities) served as the second Chair of the Committee and capably steered the Committee through many months of fact finding and discussion.

Tom Davis represented the electric generating utilities on the Committee and his careful attention to detail and procedure was greatly appreciated.

Debbie Stone, Deputy Director of the Illinois Department of Natural Resources, has continuously provided support and encouragement for the work of the Committee and briefed the Committee on relevant developments in state government.

Gary Clark, Director of the Office of Water Resources of the Illinois Department of Natural Resources and Technical Advisor to the Mahomet Aquifer Consortium Board of Directors, served as project manager for the grant with the Mahomet Aquifer Consortium, attended many Committee meetings, provided technical input and legal insights to the Committee, and coordinated the work of the Committee with that of the Northeastern Illinois Regional Water Supply Planning Group.

Members of the Board of Directors of the Mahomet Aquifer Consortium have been ever present at Committee meetings and have ably executed the grant with the Office of Water Resources of the Illinois Department of Natural Resources that provided valuable financial support for the Mahomet Aquifer Consortium and the Committee. The pioneering work of the Mahomet Aquifer Consortium over the past 12 years has provided a platform and a stepping stone for water supply planning and management in East-Central Illinois. The Committee acknowledges the dedicated work of Mel Pleines (Mackinaw Valley Water Authority and Chair), Dorland Smith (Illinois Water Authority Association and Secretary-Treasurer), Sharon Martin (Piatt County Board and Assistant Secretary-Treasurer), Craig Cummings (City of Bloomington)), Nancy Erickson (Illinois Farm Bureau), Barry Suits (Illinois American Water) and Tom Berns (Berns, Clancy and Associates).

Technical Advisors to the Mahomet Aquifer Consortium Board of Directors with the Illinois State Water Survey (Allen Wehrmann and George Roadcap), the Illinois State Geological Survey (Edward Mehnert), and the United States Geological Survey, Illinois Water Science Center (George Groschen and Kelly Warner) have provided a sound scientific basis for the work of the Committee and the Mahomet Aquifer Consortium. The Committee expresses its sincere thanks to these Technical Advisors and other scientists and engineers at the Illinois State Water Survey (Vernon Knapp, Kenneth Kunkel, James Angel, Timothy Bryant and Edward Glatfelter) and the Illinois State Geological Survey (Donald Keefer, David Larson and Bill Dey) for providing high-class data and special analyses and for briefing the Committee on climatology, hydrology, groundwater and geology.

Robbie Berg, Coordinator for Earth Partners in Champaign, served as administrator for the Committee, arranged meetings, and kept operations running smoothly.

Melinda Tidrick developed the Committee's website that proved to be so valuable for education and outreach.

Edward Mehnert with the Illinois State Geological Survey and a Technical Advisor to the Mahomet Aquifer Consortium maintained and updated the Committee's web site and briefed the Committee on its use.

Ashley Tittle with Tazewell Department of Public Health kept minutes for the Committee, thus ensuring a true and accurate record of the Committee's business.

William Mullican III, Deputy Executive Administrator, Office of Planning, Texas Water Development Board, briefed the Committee on the work of the Texas Water Development Board and shared his personal thoughts on some of the challenges facing East-Central Illinois.

Ellis Sanderson, Richard Schicht, William Walton (former employees of the Illinois State Water Survey), Bob Duvall and Rick Frendt (Patrick Engineering Inc.) contributed to technical discussions that helped put the Committee's recommendations on a sound footing.

Derek Winstanley, Chief of the Illinois State Water Survey, spearheaded regional water supply planning and management for the Illinois State Water Survey and the Illinois State Geological Survey and briefed the Committee on many aspects of climate, surface water and groundwater. After retiring as Chief, he served as a consultant to the Mahomet Aquifer Consortium and facilitated the Committee's preparation of the report.

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June 2009, Champaign, Illinois

EXECUTIVE SUMMARY

East-Central Illinois is not facing an immediate water crisis, but the East-Central Illinois Water Supply Planning Committee (the Committee) is driven by a desire to avoid crises that sometimes plague other states and countries. A recent headline describes the water problems in the southeastern United States:

"Georgia Water Woes: Drought Leads to Widespread Water Shortages"

The Committee believes strongly that stakeholders in the region can shape the future, rather than allowing runaway events to take control and crises to occur. A regional plan – a framework for action and a series of action items – provides a means to shape the future. It is the Committee's belief that implementation of a regional plan can lead to more desirable headlines, such as:

"Sustainable Water Supplies for East-Central Illinois"

MANDATE

The regional plan has been developed by the Committee in compliance with Executive Order 2006-01 issued by the Governor directing the Illinois Department of Natural Resources, in coordination with the Illinois State Water Survey, to engage in regional water supply planning.

PLANNING PROCESS

To implement the Executive Order, the Office of Water Resources of the Illinois Department of Natural Resources signed a contract with the Mahomet Aquifer Consortium to complete over a three-year period specified tasks in a priority water quantity planning area for 15 counties in East-Central

Illinois: Vermilion, Iroquois, Ford, Champaign, McLean, Macon, DeWitt, Piatt, Woodford, Tazewell, Mason, Logan, Menard, Cass and Sangamon. The regional plan focuses on the Mahomet Aquifer System that underlies a large portion of the planning area together with the surface waters of the major river basins. Funding for the crucial third year was not provided and this caused some important tasks in the work plan to be curtailed.

Wittman Hydro Planning Associates, Inc. of Bloomington, Indiana, developed for the Mahomet Aquifer Consortium and the Committee scenarios of how much water may be needed in the region to 2050.

Using the water demand data provided by Wittman Hydro Planning Associates, Inc. and geological data and information provided by the Illinois State Geological Survey, the Illinois State Water Survey conducted analyses to evaluate how drought, climate change, water withdrawals and discharges affect streamflow, reservoir yield and groundwater availability. Most of this work was conducted under contract with the Office of Water Resources of the Illinois Department of Natural Resources. A final report from the State Surveys was not available for the Committee's use; therefore, the Committee relied upon preliminary results in the form of draft materials and PowerPoint presentations on climate scenarios, groundwater flow modeling results, and surface water yield analyses to form its findings and recommendations.

From March 2007 through June 2009 the Committee held 31 public meetings, received public comments, was briefed on and discussed many aspects of water supply planning and management, and conducted outreach and educational activities.

The regional water supply plan builds on the Committee's findings: key findings are summarized after the recommended regional plan below. Major relevant features of the region, including a summary of the water demand scenarios, are described in Appendix 1 of the report. Appendix 2 provides an overview of water supply planning and management relevant to East-Central Illinois.

RECOMMENDED REGIONAL WATER SUPPLY PLAN

A FRAMEWORK FOR ACTION

The Committee selected a strategic planning framework within which to construct a plan. Within this framework, the Committee considered a multitude of interconnected economic, social and environmental factors. Given the time and resources available, the Committee focused on the impacts of withdrawing water from the Mahomet Aquifer System and the major river basins to meet water demand scenarios to 2050.

The Committee has identified a set of guidelines for regional water supply planning and management based on the following six foundations:

Self governance;	**Adaptive management;**	**Shared responsibilities;**
Sustainable water supplies;	**Sound science;**	**Informed public.**

The sustainability of water supplies is defined as the provision of dependable and adequate supplies of clean water to meet the demands of all users in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social costs.

KEY COMPONENTS

Vision of the future

In the years ahead, others will view East-Central Illinois as a model for regional water supply planning and management. This is because future generations will inherit a legacy of responsible water supply planning and management that will allow them to continue to be good stewards and managers, rather than inheriting diminished resources and chronic problems. The provision of dependable and adequate supplies of clean water for all users at reasonable economic and environmental cost will enhance public health and the quality of life, reduce conflict, and preserve and enhance economic, agricultural and environmental resources and opportunities.

Goal

The goal is to make recommendations that will be adopted and implemented by stakeholders to improve the planning and management of water supplies in East-Central Illinois.

Planning and management standards

In order to protect aquifers, surface waters and ecosystems while allowing for the development of water resources, the Committee recommends a number of voluntary standards for water supply planning and management.

- Water supplies should continue to be planned and managed to meet demand in compliance with existing laws, regulations and property rights, with due determination and consideration of acceptable and/or unacceptable impacts.

- Water supplies should be planned and managed with enhanced regional cooperation and coordination to address shared responsibilities and the interests of future generations. Enhanced regional cooperation and coordination should be achieved through voluntary efforts in the spirit of self-governance.

- Withdrawals from the confined Mahomet Aquifer should be managed so that head in any well (pumping or non-pumping) finished in the confined Mahomet Aquifer does not fall below the top of the aquifer. i.e., there is no loss of saturated thickness. It will be important to monitor heads in pumping and non-pumping wells and provide a water-level watch for all stakeholders.

- The earlier evaluation of the sustainability of pumping to capacity by Illinois American Water (51.1 million gallons per day (mgd)) should be reevaluated to include additional withdrawals from the Mahomet Aquifer by other communities and industries out to 2050, with consideration of drawdown in pumping and non-pumping wells.

- The transition zone between the confined and unconfined parts of the Mahomet Aquifer should be defined and an appropriate standard(s) be developed to protect the aquifer, surface waters and ecosystems, while allowing for groundwater development.

- A standard(s) should be set to protect shallow confined aquifers, surface waters and ecosystems, while allowing for groundwater development.

- In the unconfined parts of the Mahomet Aquifer in the Havana Lowlands, a standard(s) should be developed and implemented to limit the reduction of saturated thickness in the unconfined aquifer and protect surface waters and ecosystems, especially in summer during drought conditions, while allowing for groundwater development.

- The Committee recommends that key aquifer recharge areas, key stream reaches, and ecosystem-sensitive stream flows be identified and preserved and/or restored.

- Water supply facilities should be designed, constructed and operated in a manner that prevents unacceptable impacts to surface waters, including streamflow and water levels in lakes, wetlands and aquatic and riparian ecosystems, while providing sufficient water to meet demand. Unacceptable impacts need to be defined.

- Criteria and standards to protect the aquifers should be reevaluated when criteria and a standard(s) are developed to protect surface waters and aquatic and riparian ecosystems from possible unacceptable impacts of groundwater withdrawals, once unacceptable impacts are defined.

- Public water supplies should be managed to provide dependable and adequate supplies of water during, at a minimum, recurrence of the multi-year droughts-of-record similar to those that occurred in the 1930s and 1950s. A 90 percent confidence level should be used for yields. Bloomington, Decatur and Springfield urgently need additional sources of water and/or need to reduce water demand to be able to provide adequate supplies of water during a drought-of-record, which can recur at any time. Emergency response plans for all water supply facilities should be updated or prepared to provide adequate supplies of water in low-probability situations in which adequate water supplies cannot be provided through normal operations and capacities.

- Efficiencies of water withdrawal, treatment, distribution and use, and use of water from alternative sources (such as reused water, detained stormwater, and conjunctive use of surface water and groundwater) should be increased. This should include obtaining maximum feasible efficiencies in all existing, committed and planned water supply facilities, which should be supplemented with additional facilities only as necessary to serve anticipated water supply needs. Identification and uniform implementation of best management practices for water supply facilities, where feasible, will help minimize the sum of water supply system operating and capital investment costs and increase water use efficiencies and sustainability. Examination of water pricing policies and practices may lead to identification of additional strategies to reduce water demand.

- Water supply facilities should be designed for staged or incremental construction, where feasible, to permit maximum flexibility to accommodate changes in population and economic growth, changes in technology for water supply management, new scientific understanding, and possible new or revised management standards.

- A continuous process for water supply planning should be implemented and regional and local water supply plans should be developed, reviewed and updated at least every five years.

- All water supply managers and other stakeholders in the region should be encouraged to review a regional plan, suggest modifications, and become partners in regional water supply planning and management.

ACTION ITEMS

The main recommendation is to establish a permanent process and structure for regional water supply planning and management involving a diverse set of stakeholders.

The Committee recommends that the Mahomet Aquifer Consortium retool to provide leadership, administrative structure and process to fulfill an expanded role for regional water supply planning and management in East-Central Illinois.

- The mission should be broadened to include leadership and coordination of regional water supply planning and management activities – for surface water as well as groundwater – in the 15-county region.

- Membership of the Board of Directors and its Technical Advisors should be broadened to include the type of stakeholder and geographical diversity represented on the Regional Water Supply Planning Committee.

- The Mahomet Aquifer Consortium should establish a continuous process and structure for regional water supply planning and management to implement a regional plan, including an appropriate committee structure to engage stakeholders.

- Engage in a continuous process of regional water supply planning and management and implement a regional plan.

- Broader participation in Members’ meetings should be encouraged and meetings rotated throughout the region.

- To be effective, the Mahomet Aquifer Consortium will need a permanent staff and appropriate financial and operating resources.

While encouraging the Mahomet Aquifer Consortium to identify its own means to implement a regional plan, the Committee recommends two strategies to the Mahomet Aquifer Consortium, the Illinois Department of Natural Resources, and the University of Illinois at Urbana-Champaign.

- As a critical early step, the Mahomet Aquifer Consortium is encouraged to identify its resource needs and to take action to secure them. Stable and adequate funding from state government and local entities is needed to support efforts to implement the regional plan. Federal funds also should be pursued as a possible source.

- The University of Illinois at Urbana-Champaign is encouraged to consolidate and strengthen its important role as a partner in regional water supply planning and management.

KEY FINDINGS

- Demand for water and water withdrawals will increase. Using different combinations of assumptions, a plausible range of increases in total surface water and groundwater withdrawals in the region by 2050 (excluding electric power generation) is about 220 to 420 mgd more than modeled, normal-weather withdrawals of about 340 mgd in 2005. This range of increase would be about 100 to 300 mgd above 2005 reported and estimated withdrawals of about 460 mgd, which was a drought year in parts of the region. Withdrawals for electric power generation (the large majority of which are from surface waters and are non-consumptive) could decrease by 7 percent to about 1,218 mgd or increase by 2 percent to about 1,342 mgd.

- Under normal weather conditions, groundwater withdrawals from the Mahomet Aquifer are reported to increase from about 220 mgd in 2005 to 260 mgd in the Less Resource Intensive (LRI) scenario in 2050, 280 mgd in the Baseline (BL) scenario, and 300 mgd in the More Resource Intensive (MRI) scenario. Withdrawals would be much higher in a drought year, especially for irrigation, and would increase with some climate change scenarios.

- An extreme climate scenario for water supplies would be a decrease in mean annual precipitation, a recurrence of severe multi-year droughts, and an increase in temperature. The probability of such a scenario occurring is unknown. However, severe multi-year droughts may recur and pose a great threat to water availability and some water supplies in the region, especially those from surface waters and shallow aquifers. Building capacity to be prepared for severe multi-year droughts also would provide protection against the adverse impacts of possible climate change.

- Even during periods of drought and with possible climate change, there is sufficient water in the region to meet the future water demand scenarios considered, provided that adequate infrastructure and drought preparedness plans are developed and implemented and economic and environmental costs can be tolerated.

- Withdrawing water from rivers and aquifers, storing, treating, distributing water, and discharging waste water have social and economic benefits and economic and environmental costs. Determining how much water is to be withdrawn from different sources necessitates balancing and weighing benefits against costs and risks.

- Reservoirs are the prime sources of water supply for Decatur, Danville, Springfield and Bloomington. Bloomington's current use is about 12 mgd and the 90 percent estimate of yield in a drought-of-record is 11.0 mgd. Decatur currently uses about 37 mgd and the 90 percent yield estimate is 34.6 mgd. Springfield uses about 32 mgd and its 90 percent yield estimate is 23.4 mgd. Due to increasing water demand and increasing sedimentation, all three cities will have increasing water supply deficits during droughts of record in the future, unless additional sources of supply are developed and/or demand is reduced. Decatur could face the possibility of water shortages within a single drought season. By 2050, Danville will have a water supply deficit with the Baseline water demand scenario and a greater deficit with the More Resource Intensive water demand scenario.

- Withdrawing sufficient water from aquifers to meet demands to 2050 results in increasing drawdown of heads in wells finished in the aquifers, expanding cones of depression, a reversal of groundwater flow in some areas, and reduced baseflow in many streams. The bull's eye of concern is in Champaign County, where drawdown could lower head in some wells to less than 50 feet above the top of the Mahomet Aquifer in some scenarios. Some shallow aquifers increasingly are dewatered locally, wells finished in these aquifers go dry, and water levels in other wells drop below the pumps and will require pumps to be lowered to sustain yields.

- The possibility of a slight increase in water withdrawals for electric power generation does not appear to create a problem, although projections of future electricity demand and associated water withdrawals are highly uncertain.

- The concept of the sustainability of water supplies is not uniformly or comprehensively integrated in water supply management plans in the region.

- Water supplies in East-Central Illinois are planned and managed largely in piecemeal manner by individual managers and local and sub-regional authorities. There is no planning and management process or structure for comprehensive water supply planning and management across the region.

- The University of Illinois at Urbana-Champaign, through the Illinois State Water Survey, Illinois State Geological Survey and other departments, provides valuable technical assistance for water supply planning and management

- The public and many local decision makers have limited understanding of water supply issues and often are misinformed.

Based on the above findings, the Committee concludes that improvements in regional water supply planning and management are needed to continue to provide benefits and to reduce costs and risks for current and future residents of East-Central Illinois, those outside the region who depend on goods and services produced in the region, and the environment.

CONCLUSIONS

Many of the building blocks of sound water supply planning and management already are in place. We need to strengthen the blocks, add a few new ones, and reinforce the cement between the blocks. Adding planning and management at the regional level is the cement that can improve communication and coordination among stakeholders. The Committee recommends to today's stakeholders a regional water supply plan that will allow them to realize the potentials of the water resources in the region, shape their own future, and provide a worthy inheritance for future generations.

In the absence of improved water supply planning and management, the Committee believes that future generations in the region face increased threats of water conflicts, crisis management, degradation of the environment, and threats to public welfare and economic development. These threats can be avoided or minimized by implementing the recommended regional plan.

The Foreword to the 1967 state water plan began with the assertive statement that "Illinois must plan the long-range development of its water resources, if the state is to meet the needs of the future." Forty two years later, that challenge remains.

A plan with no new laws or regulations and voluntary participation is perhaps more challenging to implement than having to comply with new laws or regulations. Self-governance requires stakeholders' participation and all to maintain open-minded, informed, just views of our personal, community and common welfare.

REFERENCES AND SOURCES OF INFORMATION

References and sources of information are provided in the report. The following key websites can be accessed via the Internet:

Regional Water Supply Planning Committee
http://www.rwspc.org/

Mahomet Aquifer Consortium
http://www.mahometaquiferconsortium.org/

Illinois State Water Survey
http://isws.illinois.edu/

1. INTRODUCTION

Purpose of the report

The purpose of this report is to document the development of a plan for regional water supply planning and management in East-Central Illinois prepared by the Regional Water Supply Planning Committee (the Committee).

Mandate

In January 2006, Executive Order 2006-01 was issued by the Governor directing the Office of Water Resources of the Illinois Department of Natural Resources, in coordination with the Illinois State Water Survey, to define a comprehensive program for state and regional water supply planning and management[1]. Regional water supply plans are to be developed in accordance with existing laws, regulations and property rights. The Illinois Department of Natural Resources, assisted by the Illinois State Water Survey and the Illinois State Geological Survey, selected two priority areas for pilot planning: Northeastern Illinois and East-Central Illinois. A copy of the Executive Order is provided on page 5.

The planning area and process

To implement the Executive Order, the Office of Water Resources of the Illinois Department of Natural Resources signed a three-year contract with the Mahomet Aquifer Consortium[2] to complete specified tasks for 15 counties in East-Central Illinois: Vermilion, Iroquois, Ford, Champaign, McLean, Macon, DeWitt, Piatt, Woodford, Tazewell, Mason, Logan, Menard, Cass and Sangamon. Funding for the crucial third year was not provided and this caused some important tasks in the work plan to be curtailed.

The Committee[3] has twelve members, one each from the following interest areas: Agriculture, Small Business, Public, Water Authorities, Water Utilities, Municipal, Environmental, County, Rural Water Districts, Industry, Electric Generating Utilities, and Soil and Water Conservation Districts. The members also are balanced geographically by region as follows: West region (Cass, Logan, Mason, Menard, Sangamon, and Tazewell Counties); Central region (DeWitt, Macon, McLean, Piatt, and Woodford Counties); and East region (Champaign, Ford, Iroquois, and Vermilion Counties).

The Executive Order states that motivation for developing regional water supply plans is recognition that the citizens of Illinois rely on surface water and groundwater for personal consumption, and industries of the state use a significant amount of water for economic development. It also recognizes that the increasing demands on Illinois' water resources and the impacts of drought may lead to conflicts between users and adversely affect the health of the state's citizens, the environment and the economy. Further, it is stated that the quantity of surface water and groundwater in Illinois must be assessed properly through a sound planning process as an essential part of any responsible, economically viable and secure water supply development.

The Committee interprets the Executive Order to imply that regional water supply plans should identify strategies for the reduction of conflict and adverse impacts on public health, the economy and the environment; that is, water supply plans should be developed to enhance public health, economic development and environmental protection.

The time horizon selected for the study is 2050. The accuracy and usefulness of estimates of conditions decades ahead always are open to question, but 2050 was chosen as it reflects two generations in the future. The study thus requires consideration of the needs of at least two future generations as well as those of the current population. Although some issues may require consideration of a more distant future, uncertainties increase over time and the usefulness of longer-term analysis would be questionable. The Committee is fully cognizant of major uncertainties associated with planning to 2050 and mindful of the future beyond 2050.

In developing a regional water supply plan, the Committee has drawn on the following information: i) relevant laws, regulations and property rights; ii) the history of water supply planning; iii) characteristics of the region; iv) scenarios of how much water may be needed to 2050; v) analyses of the impacts of drought and possible climate change on water demand and water supply; vi) evaluations of the environmental impacts of withdrawing sufficient water to meet demand; vii) challenges and opportunities for providing additional sources of water and decreasing water demand; and viii) water supply planning and management efforts in other states.

The Mahomet Aquifer and the overlying shallow aquifers within the boundary of the buried Mahomet Bedrock Valley are referred to as the Mahomet Aquifer System. All these aquifers are sand or sand and gravel. The regional plan focuses on the Mahomet Aquifer System and the surface waters of the major river basins. A map of the region is shown in Figure 1.

Wittman Hydro Planning Associates, Inc. of Bloomington, Indiana, developed for the Mahomet Aquifer Consortium and the Committee three scenarios of water demands and water withdrawals for the region to 2050[4]. Analyses of the sensitivity of water demands and water withdrawals to climate change and drought also were conducted. The water demand and withdrawal scenarios and sensitivity analyses are summarized in Appendix 1 of this report.

The water demand study used historical data from individual water users as reported to the Illinois State Water Survey and as provided to the consultant by some facility managers, but these data were not confirmed with individual users in all cases. Also, the water demand models used variables and factors not necessarily used by individual water operators in their planning efforts. Therefore, regional, county and sector water demand data in the water demand report and point withdrawal data provided to the Illinois State Water Survey likely differ from individual water users' planning results; they are not intended to provide definitive future water withdrawals for individual operators, or a sufficient basis for site-specific infrastructure planning. More detailed data are needed for site-specific planning and management.

The Committee utilized the best available data and information. Drawing on the water withdrawal scenarios provided by Wittman Hydro Planning Associates, Inc. and geological data and information provided by the Illinois State Geological Survey, the Illinois State Water Survey conducted analyses to evaluate how drought, climate change, water withdrawals and discharges affect streamflow, reservoir yield and groundwater availability. A final report from the State Surveys was not available for the Committee's use; therefore, the Committee relied upon preliminary results in the form of draft materials and PowerPoint presentations on climate records and climate scenarios, groundwater flow modeling results, and surface water yield analyses[5,6] to form its findings and recommendations.

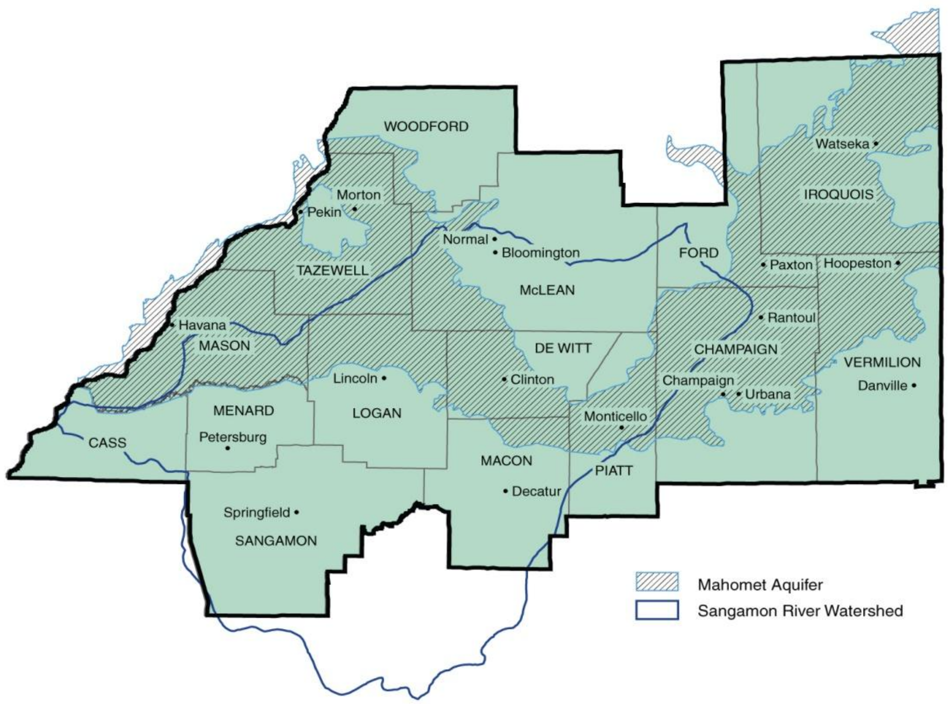

Figure 1. The East-Central Illinois water supply planning region[2].

From March 2007 through June 2009, the Committee held 31 meetings, received public comments, and was briefed on and discussed many aspects of water supply planning and management. Using this information and data and information provided by Wittman Hydro Planning Associates, Inc. and the Illinois State Geological Survey and the Illinois State Water Survey (the Scientific Surveys), the Committee developed a plan for water supply planning and management in East-Central Illinois. The Committee also drew on earlier efforts at water supply planning and management in Illinois and experiences of other states that have developed, and continue to develop regional water supply plans, especially Texas[7].

The Committee developed its own operating guidelines. Policy recommendations required the votes of two thirds of the members present for approval.

To inform the public about water supply planning and management and the activities of the Committee, members of the Committee, the Mahomet Aquifer Consortium, the Illinois Department of Natural Resources and the Scientific Surveys conducted extensive outreach and educational activities.

Meetings and agendas were announced and were open to the public, brochures and reports were distributed, and copies of presentations, contact information and other materials were made available via the Internet[2,3,5,6]. A draft final copy of the report was made available for public review and comment for four weeks. Comments and suggestions received helped to strengthen the final report.

Report structure

The report presents the major findings of the Committee (Chapter 2), the Committee's recommended regional water supply plan (Chapter 3) and the Committee's conclusions (Chapter 4). References are provided at the end of each chapter and each appendix. A glossary and references for additional background information are provided at the end of the report.

Two appendices are attached to the report: Appendix 1 describes the major relevant features of the region, including a summary of the water demand scenarios; Appendix 2 documents the history of water supply planning and management in Illinois in general and East-Central Illinois in particular. Included in Appendix 2 are summaries of relevant laws, regulations and property rights and relevant functions of water agencies.

References

1. Executive Order 2006-01 (http://www.illinois.gov/Gov/pdfdocs/execorder2006-1.pdf, accessed February 17, 2009).
2. The Mahomet Aquifer Consortium (http://www.mahometaquiferconsortium.org, accessed February 17, 2009).
3. The East-Central Illinois Regional Water Supply Planning Committee (http://www.rwspc.org/, accessed February 18, 2009).
4. Wittman Hydro Planning Associates, Inc., 2008. *Water Demand Scenarios for the East-Central* Illinois *Planning Region: 2005-2050.* Wittman Hydro Planning Associates Inc., Bloomington, IN (http://www.mahometaquiferconsortium.org/, accessed February 19, 2009).
5. Roadcap, G.S. and H.A. Wehrmann, 2009. *Impact of Future Water Demand on the Mahomet Aquifer: Preliminary Summary of Groundwater Flow Modeling Results*, Illinois State Water Survey, Institute of Natural Resource Sustainability, University of Illinois at Urbana-Champaign, Champaign, March 2009.
6. PowerPoint presentations (http://isws.illinois.edu/wsp/meetings/wsdefault.asp, accessed March 28, 2009).
7. Texas Water Development Board (http://www.twdb.state.tx.us/home/index.asp, accessed February 19, 2009).

EXECUTIVE ORDER 2006-01

2006-01

EXECUTIVE ORDER FOR THE DEVELOPMENT OF STATE AND REGIONAL WATER-SUPPLY PLANS

WHEREAS, the citizens of Illinois rely on surface water and groundwater for personal consumption, and industries of the State use a significant amount of that water for economic development; and

WHEREAS, the increasing demands on Illinois' water resources and the impacts of drought may lead to conflicts between the multiple water supply users and may adversely affect the health of the State's citizens as well as adversely impacting the environment and the economy; and

WHEREAS, the quantity of surface water and groundwater in Illinois must be properly assessed through a sound planning process as an essential part of any responsible, economically viable and secure water supply development for the citizens of the State; and

WHEREAS, the Illinois Interagency Coordinating Committee on Groundwater, the Illinois State Water Survey, and the Illinois State Water Plan Task Force have identified the Priority Water Quantity Planning Areas that are most at risk for water shortages and conflicts; and

WHEREAS, the Illinois Integrated Water Quantity Planning and Management Committee recommends the development of regional aquifer and watershed plans for managing water supplies;

THEREFORE, BE IT ORDERED that the following actions shall be executed:

Consistent with the authority granted to the Department of Natural Resources under the Rivers, Lakes, and Streams Act, 615 ILCS 5/5 *et seq*. and the Level of Lake Michigan Act, 615 ILCS 50/1 *et seq.*, the authority of the Department of Natural Resources' Office of Water Resources under 20 ILCS 801/5-5, the Office of Water Resources, in coordination with the State Water Survey, shall:

1. Define a comprehensive program for state and regional water supply planning and management and develop a strategic plan for its implementation consistent with existing laws, regulations and property rights,

2. Provide for public review of the draft strategic plan for a water supply planning and management program;

3. Establish a scientific basis and an administrative framework for implementing state and regional water supply planning and management;

4. Develop a package of financial and technical support for, and encouragement of, locally based regional water supply planning committees. These committees, whether existing or

new entities, shall be organized for participation in the development and approval of regional plans in the Priority Water Quantity Planning areas;

5. By December 31, 2006, ensure that Regional Water Quantity Plans are in process for at least two Priority Water Quantity Planning Areas.

EFFECTIVE DATE

This Executive Order shall be in full force and effect upon its filing with the Secretary of State.

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Rod R. Blagojevich, Governor

Issued by Governor: January 9, 2006
Filed with Secretary of State: January 9, 2006

2. FINDINGS

Findings are important facts, issues and challenges related to water supply planning and management in East-Central Illinois identified by the Committee. Findings subsequently provide a basis for recommending a regional water supply plan (Chapter 3).

This chapter begins with the Committee's findings related to the flow of water through and the storage of water in the environment. This is followed by findings related to climate variability and change, present and future water demands and withdrawals, impacts of groundwater withdrawals, future water availability, the costs and benefits of water withdrawals, and the balance among water availability, demand and supply. Findings related to current laws, regulations and property rights, institutional organization and governance, and technical assistance then are presented. A summary of key findings is provided at the end of the chapter, followed by conclusions.

The water cycle

Nature's plumbing system consists of water storage vessels and conduits – aquifers and river basins. Water moves through the environment continuously at varying rates dependent upon climatic, soil and geological conditions (Figure 2 and Appendix 1). Variations and changes in climate cause the amount of water available in surface waters and shallow aquifers to vary over time. Spatial variations in soil and geology strongly influence the flow of water through the environment – including groundwater recharge, discharge and water storage, and create spatial differences in the impacts of withdrawing water from aquifers and streams. Knowledge of the water [hydrologic] cycle and intertwined water supply issues provides a sound basis for water supply planning and management[1].

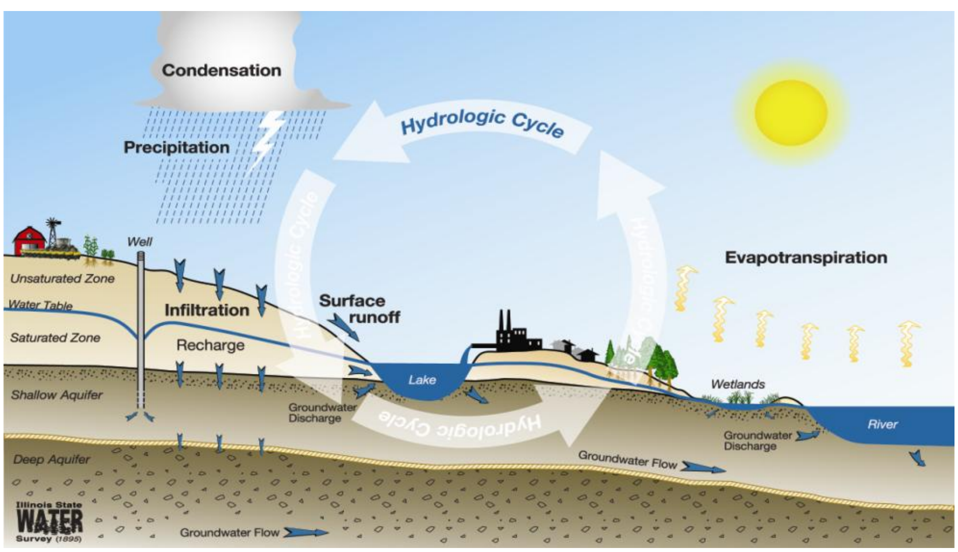

Figure 2. The water [hydrologic] cycle (from the Illinois State Water Survey).

Healthy aquatic and riparian ecosystems are essential components of the natural water infrastructure and it is important to maintain their integrity and diversity. However, knowledge and understanding of the impacts of water withdrawals on aquatic and riparian ecosystems in the region is rudimentary. More is known about the impacts of waste water discharges on streamflow and aquatic and riparian ecosystems. Such discharges are regulated to meet water quality standards.

Climate

Precipitation and temperature are the most important climatic variables affecting water availability and water demand: water demand generally increases with higher temperature and lower precipitation; the availability of surface water and shallow groundwater generally decreases with higher temperature and lower precipitation. In general, prolonged hot and dry weather conditions stress water resources.

Historical climate records indicate a high degree of variability from year-to-year and decade-to-decade in precipitation, streamflow and groundwater elevation in shallow aquifers (Appendix 1). Figure 3 shows the smoothed record over the past century of precipitation in the Illinois River watershed, streamflow in the lower Illinois River, and groundwater elevation in a shallow well at Snicarte in Mason County. Streamflow and groundwater elevation are strongly influenced by precipitation: typically, a 20 percent decrease in precipitation results in more than 50 percent decrease in runoff. Flow in many small streams and recharge to reservoirs and shallow aquifers is reduced during periods of drought[1].

In selecting the magnitude and frequency of droughts to plan for, precipitation return periods often are considered. For example, precipitation with a 1-in-50 year return period (a 50-year drought) has a 2 percent chance of occurring each year; precipitation with a 1-in-100 year return period (a 100-year drought) has a 1 percent chance of occurring each year. In Illinois, summer (May-September) precipitation with a 50-year drought is about 38 percent below normal (1971-2000), and with a 100-year drought it is about 42 percent below normal[1]. Specified precipitation amounts can be transformed into streamflow amounts in each river basin, thus allowing the hydrological impacts of climate variability and change to be evaluated.

The availability of surface water supplies to meet demand typically is limited most during severe droughts. The past 30 years generally have been wet and favorable for water supplies, although periodic droughts and floods have created problems. A two year drought occurred in 1988-1989 and 2005 was a drought year in many parts of the state. State-wide precipitation in 1988 averaged only 29.6 inches – 25 percent below normal (1971-2000) – but 1988 was only the eight driest year on record[1]. More severe 12-month droughts and severe multi-year droughts have occurred in the past, especially in the first 60 years of the 20th Century. Drought conditions persisted from April 1952 through March 1957, the longest recorded drought in Illinois history[1]. In 1953-1954, the worst drought on record for Springfield, runoff into Lake Springfield averaged only 0.1 inches, compared to 9.0 inches in an average year and 1.1 inches in the 1988-1989 drought[2]. For Decatur, the worst drought on record occurred in 1930-1931 and for Bloomington in 1939-1940[2]. Tree-ring analysis indicates a 10-year drought in the region from 1565 through 1574[1]. It is multi-year droughts that have the greatest, long-reaching, persistent impacts on water availability. Generally high precipitation over the past few decades may have led to a false perception and acceptance of low risk in water supply planning and management.

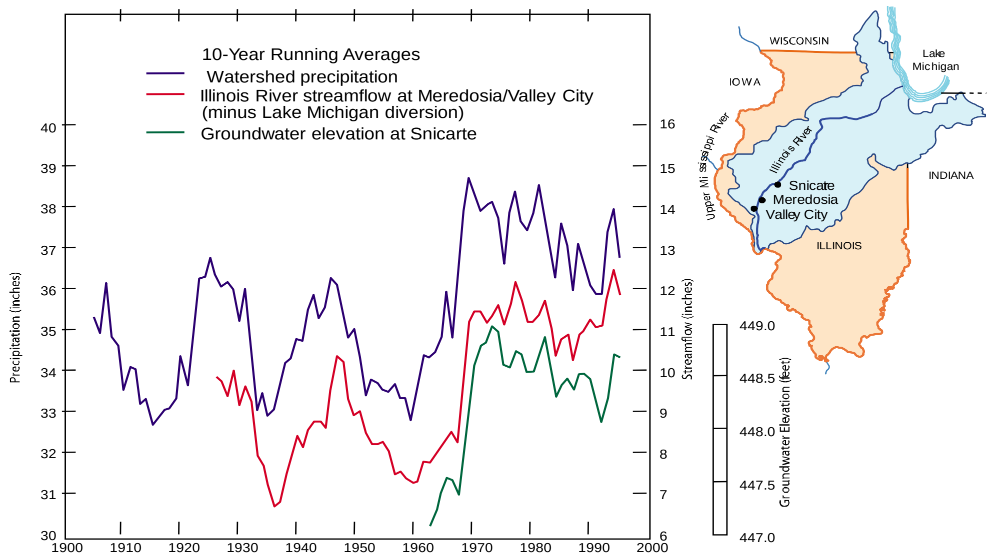

Figure 3. Precipitation in the Illinois River watershed (top), streamflow in the lower Illinois River (middle) and groundwater elevation at Snicarte (bottom) are closely correlated[1]. The Snicarte well is completed in the unconfined Mahomet Aquifer some 4 miles east of the Illinois River.

Although guidelines by the Illinois Environmental Protection Agency are for six months water storage for a 40-year drought, there are no state requirements for water storage or drought preparedness. Since the 1960s, Illinois State Water Survey scientists and engineers have focused on estimating yields associated with specific drought frequencies, such as a 50-year drought. Best estimates of water yields with 50 percent confidence limits traditionally have been considered to be firm numbers. Recognizing that these best estimates may overestimate available water, the Illinois State Water Survey now gives emphasis to estimating yields for specific drought frequencies, analyzing uncertainty in data and methods, and providing confidence limits on yield estimates[2]. Acceptance of a 90 percent confidence limit provides a higher degree of confidence and less risk in water supply planning and management than a 50 percent confidence limit.

High temperature also reduces water availability, but much less than a reduction in precipitation: it has been calculated that an increase in temperature of 7 degrees Fahrenheit (^{o}F) results in only a few percent decrease in runoff[1]. In 1952-56, average annual precipitation across Illinois was 18 percent below normal and temperature was 2.1^{o}F above normal; average annual runoff was 48 percent below normal[1].

Global annual average temperature has increased over the past 150 years such that the current global average temperature is higher than at any time since the mid-19th Century. However, annual average temperature in Illinois in recent decades has increased much less than the global average, and it is no warmer today in Illinois than it was in the 1930s and 1940s. Annual precipitation in Illinois has increased markedly since the early 20th Century, but precipitation also was high in the 19th Century before decreasing near the end of the century. Climate records indicate that the global temperature trend has not been a consistent indicator of regional climate conditions in Illinois[1].

Geology and hydrology

Geologic and hydrologic conditions vary throughout the region and, together with climate variations, have major implications for water supply (Appendix 1).

In the eastern half of the region, surface water supplies are limited by low flow in headwaters and few valleys suitable for reservoirs: east of Decatur, only Danville has a surface water supply; elsewhere, there is great dependence on groundwater. In the western half of the region, streamflow generally is higher and Decatur, Bloomington and Springfield have reservoirs. Reservoirs are designed to yield specified amounts of water during specified drought periods. Reservoir yield can fall short of meeting required water demand, if a drought occurs that is more severe than the drought planned for. In all reservoirs, sedimentation causes loss of storage capacity over time and environmentalists are concerned about the ecological impacts of constructing and operating reservoirs.

Groundwater exists essentially everywhere, but nearly all groundwater withdrawals in the region are from sand and gravel aquifers that have capability to transmit substantial quantities of water. A map of the estimated potential yield of sand and gravel aquifers in Illinois, expressed as recharge rates, is available at http://www.isws.illinois.edu/wsp/figures.asp?id=7&pg=wsground.

Throughout the region, discontinuous shallow aquifers are the source of some community and most self-supplied domestic water supplies. Water levels in these aquifers respond quickly to climate variations: water levels drop during periods of drought and rebound quickly when precipitation increases. Aquifers, streams, lakes, reservoirs and wetlands are like bathtubs – the amount of water in a bathtub decreases as water is withdrawn or lost, unless the faucet (precipitation) is turned on. Across Illinois, some 82 community groundwater supplies are at risk of water shortages under moderate to severe drought conditions, including about a dozen in East-Central Illinois[1].

The withdrawal of groundwater always causes head (water level) in a production well and surrounding wells to decline and a cone of depression to form (Figure 4). The decline in head is called drawdown. Where aquifers are physically connected, pumping water from a deeper confined aquifer can affect an overlying shallow aquifer. For example, a well in Champaign finished in the Glasford Aquifer is reported by the Illinois State Water Survey[3] to no longer yield water, probably due mainly to extensive pumping from nearby wells in the deeper Mahomet Aquifer (Appendix 1).

Well interference occurs when one well competes and interferes with the groundwater available to another well drawing from the same or connected aquifer. A single high capacity well or a group of wells pumping large amounts of water from a limited aquifer may stress the system. The cones of depression associated with individual wells can merge to form a large sub-regional cone of depression: withdrawals in and around Champaign County have formed a large, persistent cone of depression tens of miles across, extending into neighboring counties. It is important to consider the cumulative impacts of pumping groundwater from many wells in multiple jurisdictions.

Groundwater recharge occurs in all parts of the region, but at varying rates. Groundwater recharge to the confined Mahomet Aquifer is impeded more by thick, relatively impermeable layers of silt and clay (till) than by changes in land cover, such as urbanization[3]. In the Illinois State Water Survey groundwater flow model, soils developed on the fine-grained till are assigned a recharge rate of 1.75 inches per year, although much of that water drains off to surface waters and does not recharge the confined Mahomet Aquifer[3]. There is evidence that recharge to the confined Mahomet Aquifer is greatest in areas where relatively impermeable layers of silt and clay are absent and leakage from streams provides a large amount of water to the aquifer system. East of the Havana Lowlands in Mason and Tazewell Counties, the Mahomet Aquifer is almost completely covered by till, except in the narrow alluvial valleys of some major streams. With the exception of four critical stream segments, the alluvial sand deposits do not appear to be connected to the Mahomet Aquifer. The following four key segments appear to provide a large amount of water to the aquifer system by direct leakage from the stream[3]:

- The Middle Fork of the Vermilion River in northeastern Champaign County and eastern Ford County;
- The Sangamon River between Mahomet and Fisher;
- The Sangamon River south of Monticello through Allerton Park; and
- Sugar Creek near McLean.

Statewide maps of aquifer sensitivity to contamination[4,5] and potential for aquifer recharge[6] in Illinois have been published. The map of potential aquifer recharge is based principally on surficial textural classifications, so is qualitative.

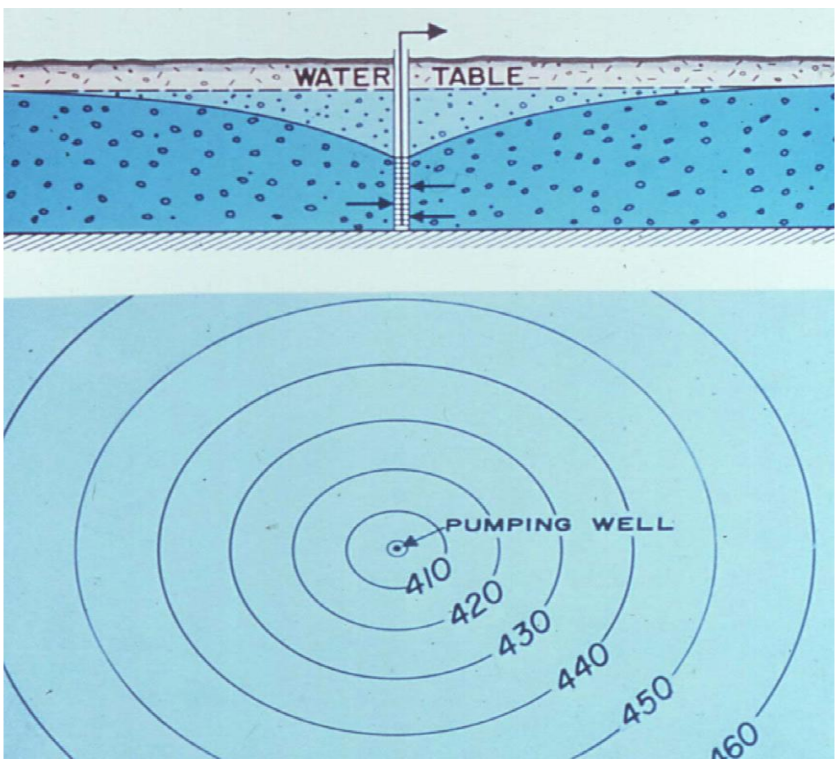

Figure 4. Diagram to illustrate head elevations and creation of a cone of depression when groundwater is pumped from an unconfined aquifer. An unpumped water table elevation of 460 feet is shown (from the Illinois State Water Survey).

In the Havana Lowlands, the geology and hydrology of the Mahomet Aquifer are different than in the central and eastern parts of the aquifer. Overlying relatively impermeable tills are absent in the

Havana Lowlands and the aquifer is unconfined and behaves like a quick-response shallow aquifer: droughts and large groundwater withdrawals for crop irrigation in summer lower groundwater levels and create cones of depression, but water levels typically rebound after the growing season and with a return to higher precipitation (Appendix 1). In the Illinois State Water Survey groundwater flow model, soils in the dunal areas are assigned a recharge rate of 15.0 inches per year, and 8.8 inches per year where there are thin, fine-grained lake-bed deposits covering them[3]. Due to sub-regional variations in geological and hydrological conditions, drawdown (lowering of the water table) in the unconfined aquifer in the Havana Lowlands is much less than, for example, drawdown (lowering of head) in the confined Mahomet Aquifer in Champaign County, even though withdrawals in the Havana Lowlands are much greater[3].

As noted above, surface waters and groundwater are connected through the water cycle. Over time, groundwater withdrawals are balanced by a reduction in groundwater storage, a reduction in natural groundwater discharge to surface waters, and/or an increase in groundwater recharge. In general, an aquifer is more able to support a large amount of water withdrawn from widely distributed wells rather than from wells that are close together, although the economics of withdrawing, treating and distributing water may favor the latter.

Water withdrawal and use

Water withdrawn and used in East-Central Illinois meets domestic, commercial and industrial needs in the region and the needs of people outside the region for some goods and services produced in the region, such as agricultural products and electricity. Past, present and possible future water withdrawals and uses have been described in detail and are summarized in Appendix 1. Key findings from the water demand report[7] are presented here.

The average amount of water withdrawn per person each day in the region in 2005 for residential, commercial, industrial and recreational uses and agriculture and irrigation (adjusted to normal weather and excluding electric power generation) was about 312 gallons. High water withdrawals for irrigation in Mason and Tazewell counties are a main reason why regionally-averaged per capita water withdrawals are so high. Average per capita water withdrawal from public water supplies in 2005 was 147 gallons. Average per capita domestic water withdrawal was estimated to be about 82 gallons per day. The commercial and industrial sector also has its own water supplies, much of which is not for potable water use. Withdrawals in this self-supplied sector averaged 160 gallons per employee per day in 2005.

Once water is withdrawn it is distributed and used. Two types of water use are recognized – consumptive use and non-consumptive use. Water consumption represents that part of water withdrawn that is evaporated, transpired by plants, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment and is not available for immediate or economical reuse. Almost all withdrawals for once-through, electric power generating systems represent non-consumptive use, because nearly all the water withdrawn is returned to the source after passing through the condensers. Furthermore, some of the water withdrawn for commercial, industrial and public uses also is non-consumptive, as treated waste water discharged to surface waters is available for reuse. A large but undetermined portion of the smaller withdrawals for three closed-loop, electric power generating plants and water withdrawn for agricultural irrigation is evaporated (consumed). Groundwater that is withdrawn, used, treated and discharged to surface waters is removed from aquifers, but is available for reuse in receiving surface waters.

In 2005, population in the 15-county region was just over one million. Total surface water and groundwater withdrawals were modeled to be 339 millions of gallons per day (mgd). In fact, 2005 was a drought year, especially in western parts of the region, and water withdrawals were reported and estimated to be about 120 mgd higher than modeled withdrawals adjusted to normal weather.

Adjusted to normal weather, public water supply sector withdrawals in 2005 were modeled to be 127 mgd, self-supplied domestic 9 mgd, self-supplied commerce and industry 64 mgd, agriculture and irrigation 139 mgd, and 1,315 mgd were withdrawn for electric power generation. The electric power generation sector withdrew the most water, but, as noted above, most withdrawals are for non-consumptive use.

For all sectors combined, groundwater withdrawals from the Mahomet Aquifer in 2005 (adjusted to normal weather conditions) are simulated to have been about 220 mgd[9].

The above figures are for average day withdrawals throughout the year, but withdrawals generally are higher in summer than in other seasons. Peak day withdrawals for public water supplies typically are 50 to 100 percent higher than annual average day withdrawals and up to a factor of 7 higher for irrigation. In 2005, a drought summer, peak day water withdrawals for irrigation in the Havana Lowlands in Mason and Tazewell Counties were reported to be almost one billion gallons.

Peak day demand plays a key role in water demand planning and management and most operators have drought response plans. Title IV of the Illinois Environmental Protection Act indicates that there should be continuous operation and maintenance of public water supply installations in order to protect the public from disease and to assure an adequate supply of pure water for all beneficial uses. This concept is carried forward in the Illinois Pollution Control Board Rules, in particular 601.101 (Appendix 2). This could be interpreted as a 100 percent dependability standard for public water supplies. In general, continuous water supplies are planned for by developing capacity to supply water with a high probability of meeting peak day demand; contingency or emergency response plans are implemented to address unusual situations. Perfect water supply dependability, meaning no chance of future shortfall, generally is not optimal where water development costs are high.

The historical record of water conservation in the region is reported to show a slight declining trend in regional per capita water withdrawals in the public supply sector, although per capita water withdrawals in 2005 were slightly higher than in 1990. In the self-supplied commercial and industrial sector, a conservation trend is reported to reflect gains in the efficiency in production processes and technologies.

A comprehensive, consistent, reasonably accurate and regularly updated inventory of water withdrawals is necessary for water supply planning and management. The Illinois State Water Survey operates a voluntary water withdrawal reporting system – the Illinois Water Inventory Program. Much progress has been made and, even though some important data gaps remain and funding for the program is unstable, the Illinois Water Inventory Program remains the best source of Illinois water withdrawal data.

Future water demand and withdrawal scenarios

Many factors interact to determine how much water will be needed and will be withdrawn. A plausible range of water withdrawal scenarios has been produced, including consideration of drought and climate change[7], and are summarized in Appendix 1. Key findings from the water demand report are presented here.

Major drivers determining water withdrawals are the number of people living and working in the region, the demand for products produced in the region, and the average amount of water withdrawn per person.

Population in the 15-county region of East-Central Illinois is expected to increase from 1.03 million in 2000 to 1.34 million in 2050 – a 30 percent increase.

If the average amount of water withdrawn per person remains constant and population increases by 30 percent, total water withdrawals also will increase by 30 percent.

If population increases or decreases by more or less than the official 30 percent and the average amount of water withdrawn per person remains constant, water withdrawals will change by the percentage change in population.

If population increases by 30 percent and the average amount of water withdrawn per person increases or decreases, total water withdrawals will increase by 30 percent plus or minus the percentage change in the average amount of water withdrawn per person.

The major variables that could result in a change in the average amount of water withdrawn per person and, hence, total water withdrawals are reported to be household income, the price of water, drought, an increase in temperature, employment and productivity, new industrial facilities, the number of irrigated acres, and water conservation. Water conservation and water prices probably are more amenable to control than the other factors influencing water demand.

Demand for water and water withdrawals will increase. Using different combinations of assumptions, a plausible range of increases in total surface water and groundwater withdrawals in the region by 2050 (excluding electric power generation) is about 220 to 420 mgd more than 2005 modeled normal-weather withdrawals of about 340 mgd. This range of increase would be about 100 to 300 mgd above 2005 reported and estimated withdrawals of about 460 mgd, which was a drought year in parts of the region. Withdrawals for electric power generation (the large majority of which are from surface waters and are non-consumptive) could decrease by 7 percent to about 1,218 mgd, or increase by 2 percent to about 1,342 mgd.

Under normal weather conditions, groundwater withdrawals from the Mahomet Aquifer are reported to increase from about 220 mgd in 2005 to 260 mgd in the Less Resource Intensive (LRI) scenario in 2050, 280 mgd in the Baseline (BL) scenario, and 300 mgd in the More Resource Intensive (MRI) scenario[8]. Withdrawals would be much higher in a drought year, especially for irrigation, and would increase with some climate change scenarios.

Impacts of groundwater withdrawal

The Illinois State Water Survey, using data and a geological model provided by the Illinois State Geological Survey, created a groundwater flow model to simulate the impacts of withdrawing water to meet the three water demand scenarios[9]. All increases in pumpage were assigned to existing high capacity wells. A 95 percent confidence level for simulating heads is reported to be about +/- 5 feet. Simulations have not been conducted for domestic self-supplied withdrawals or pumping from possible new wellfields in the Mahomet Aquifer to serve Bloomington, Springfield, and/or other communities[9]. Recharge rates were adjusted up and down by 2 percent per decade to simulate the impacts of potential future climate changes[9]. The modeling results are preliminary.

Pumping from the confined Mahomet Aquifer is greatest in Champaign County and drawdown (decline in head) is and will continue to be greatest in and around Illinois American Water's production wells (Figures 5 and 6). The bull's eye of concern is in Champaign County, but in all cases head in the Petro North observation (non-pumping) well on Rising Road west of Champaign remains above the top of the Mahomet Aquifer, i.e., the aquifer is not dewatered locally (Figure 7). However, in a model cell in northern Champaign, near the boundary of the aquifer, head in the MRI scenario is modeled to drop to less than 25 feet above the top of the aquifer. Available head above the top of the aquifer is greatest in the LRI scenario and least in the MRI scenario.

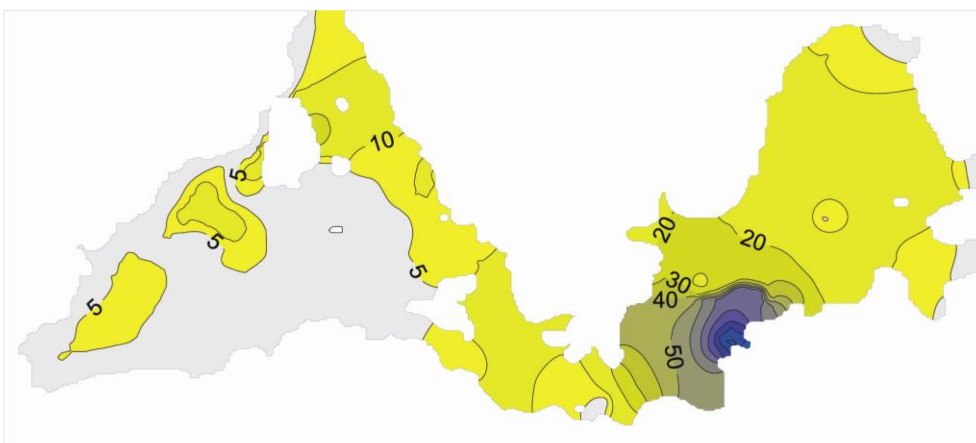

Figure 5. Simulated drawdown (feet) from 1930 to 2005 based on estimated historical withdrawals that increased over time[9].

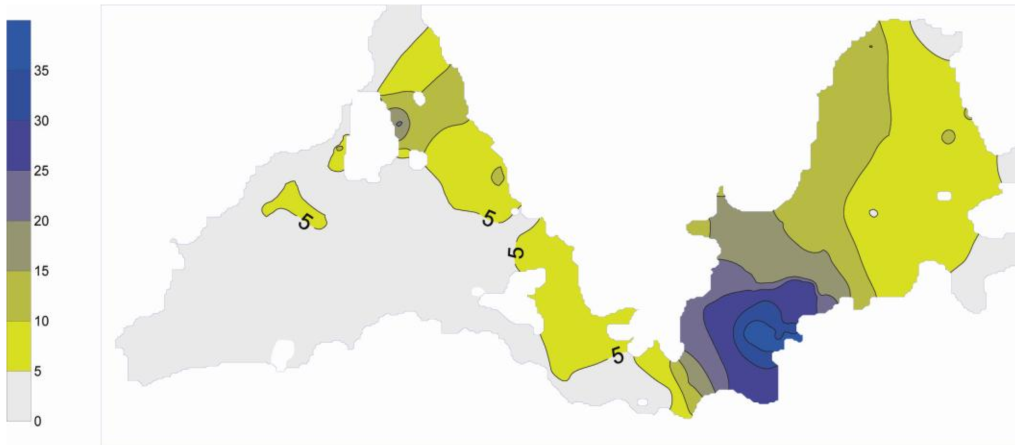

Figure 6. Simulated drawdown (feet) from 2005 to 2050 for the MRI demand scenario[9].

When simulating a 2040 pumping scenario of 51.1 mgd by Illinois American Water, Wittman Hydro Planning Associates, Inc. concluded that such pumping would be sustainable west of Champaign[10]. Conditions were considered to be sustainable as long as water levels were predicted to remain above the top of the Mahomet Aquifer, i.e., the Mahomet Aquifer remains saturated. However, in this simulation, heads about three miles to the east of the Petro North well drop to the top of the aquifer and drop below the top of the aquifer in a worst-case scenario, i.e., the aquifer starts to become unsaturated, or partially dewatered. This analysis did not include additional withdrawals from the Mahomet Aquifer by other communities or industries out to 2040, or withdrawals from the Glasford Aquifer. It was recognized that increased pumping by other users would add to the drawdown caused by increased pumping of 16 mgd by Illinois American Water and "reduce the capacity of the aquifer system to yield water in the Champaign area and will exacerbate the effects of expansion of the ILAW source of supply". Also, it was concluded that "dewatering of shallow water-bearing zones will affect some local wells and will ultimately reduce the capacity of the Mahomet Aquifer due to decreased vertical leakage"[10]. Illinois American Water concluded that this level of pumping by Illinois American Water and the resulting impacts would be sustainable in Champaign County[11] [see also Appendix 1].

Figure 7 shows past, present and possible future head above the top of the Mahomet Aquifer (elevation 515 feet) in the Petro North well. Head has declined about 83 feet since predevelopment (1930) and is projected to continue to decline under all scenarios considered: the LRI, BL and MRI scenarios to 2050, linear extrapolation of the 1935-2007 trend in head to 2050, and a scenario of Illinois American Water pumping 51.1 mgd in 2040. Head in this observation well some distance away from the main production wells is expected to remain above the top of the aquifer. Also, heads in Illinois American Water's production wells typically drop an additional 20-30 feet during pumping[3]. A further consideration is that data from the Illinois State Water Survey groundwater flow model are for transient simulations of average day withdrawals. Heads are expected to be somewhat lower under equilibrium conditions and in summer, especially during drought periods when water demand is higher. In some wells, head at some locations could drop close to or below the top of the aquifer in some pumping scenarios.

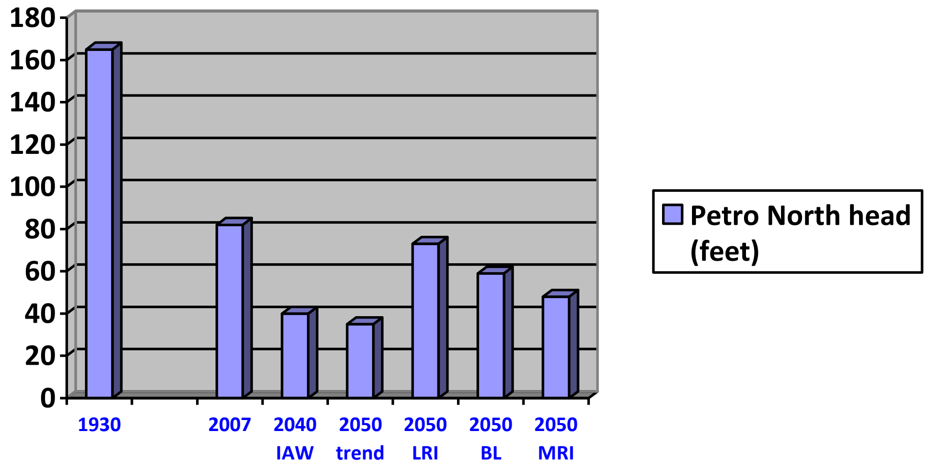

Figure 7. Head (feet) above the top of the Mahomet Aquifer in the Petro North observation well on Rising Road, west of Champaign. The 1930 head is a best estimate[3,8]. The 2007 head is from observations[3,8]. The 2040 IAW head (Illinois American Water pumping 51.1 mgd) is from visual interpretation of Figure 34 in reference[10]. The 2050 trend head is a linear extrapolation of 1930-2007 head data[3,8]. The 2050 LRI, BL and MRI heads are from groundwater flow model simulations of the three water demand scenarios[9].

Withdrawing water from the aquifers also has other hydrologic and groundwater flow impacts: in the confined aquifer, recharge is increased by increasing infiltration from the shallow aquifers. Water levels in the shallow unconfined aquifers also are lowered and parts of the shallow aquifers in Champaign County are dewatered locally[10].

Furthermore, Mahomet Aquifer groundwater flow from Champaign County to Piatt County, estimated to have been 10 mgd in predevelopment times, already has been reversed and Champaign County now "imports" an estimated 3 mgd from Piatt County[3]. By 2050, water from even further west will be pulled into the expanding cone of depression centered in Champaign County[9]. Possible implications of this groundwater flow reversal for water availability in Piatt County have not been evaluated.

The above simulations are for average day demand, but withdrawals for irrigation occur only in summer. When withdrawals for the summer season are simulated, and periodic withdrawals for the large industrial wellfield in Champaign County are included, the greatest impacts still are in the confined part of the aquifer east of the Havana Lowlands, even though hundreds of millions of gallons of water per day are pumped for irrigation in the Havana Lowlands[9].

In the Havana Lowlands, groundwater elevation in the vicinity of pumping wells varies by up to 15 feet or more between wet and dry years, and in dry years some small streams may go dry (Appendix 1). Both drought and irrigation pumping reduce groundwater elevation and saturated thickness in the unconfined aquifer (Figure 8). However, there are huge amounts of water in storage in the unconfined aquifer and saturated thickness was reduced by only about seven percent in the drought year of 2005, and has since recovered[3]. This is due to the fact that the unconfined aquifer in the Havana Lowlands is able to release about 1,000 times more water out of storage per foot of drawdown than in the confined aquifer[9]. Withdrawals in the Havana Lowlands are projected to continue to increase and groundwater elevation and saturated thickness to decrease in the growing season in all three water demand scenarios[9]. There is a limit to the increase, however, as a point is reached where all irrigable farmland acreage is assumed to be irrigated. However, even with higher withdrawals, groundwater elevation and saturated thickness can recover quickly after the growing season and/or drought.

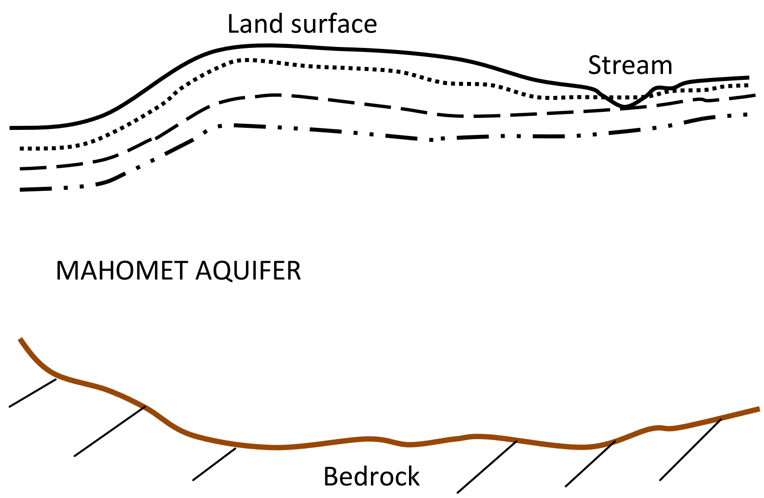

Figure 8. Simplified diagram of groundwater elevations in the unconfined Mahomet Aquifer in the Havana Lowlands. The zone between the land surface and the water table is unsaturated. The top dashed line (······) represents the water table – the highest groundwater elevation and the top of the saturated zone. All the material between the water table and bedrock is saturated. In a drought period, groundwater elevation drops (▬▬ ▬▬). Large groundwater withdrawals for irrigation cause groundwater elevation to decline further (▬▬ · · ·). Lowering of groundwater elevation caused by drought and pumping can cause some headwater streams to go dry and reduce flow in larger streams.

It was concluded from simulations of the Illinois State Water Survey groundwater flow model that groundwater development has caused a significant decrease in the amount of baseflow discharge to streams in the region, although a confidence level for calculated changes in streamflow is not presented[9]. Baseflow discharge to the Upper Sangamon River and Quiver Creek watersheds is modeled to have decreased by about 35-40 percent since 1930, due to reduced groundwater discharge, increased leakage out of the rivers, and increased capture of recharge at the surface. Future reductions in groundwater discharge to streams are greatest in the MRI scenario and with an assumed decrease in recharge due to climate change. Groundwater discharge to streams increases in the LRI scenario and in a climate change scenario in which recharge is assumed to increase. Under normal weather conditions in all the demand scenario, streams do not dry out; but streams do go dry during drought periods[9]. Analyses have not been completed that describe changes in the frequency with which streams go dry, or remain dry, in groundwater development scenarios.

It has been calculated that in the BL scenario a reduction of 8 inches (40 percent) from normal (1971-2000) summer precipitation of about 20 inches would result in an increase in total regional water demand (excluding electric power plants) of 106 mgd above 2005 normal weather withdrawals[7].

Again in the BL scenario, an increase in temperature of 3 ^{o}F – the mid-point in the temperature scenarios – would result in an increase in total regional water demand (excluding electric power plants) of about 39 mgd. An increase in temperature of 6 ^{o}F – top of the range of temperature scenarios – would result in an increase in total regional water demand (excluding electric power plants) of about 78 mgd[7].

An extreme climate scenario for water supplies would be a decrease in mean annual precipitation, a recurrence of severe multi-year droughts, and an increase in temperature. All these factors would combine to increase water demand and decrease water availability. However, the probability of occurrence of various climate scenarios is unknown, and changes in drawdown due to changes in water demand under conditions of potential climate change have not been simulated.

All the above simulations are for transient runs, i.e., they simulate drawdown in 2050 associated with pumping in 2050. However, a further factor to consider is the response time for the aquifer system to adjust to specified pumping levels. Even if pumping is held constant at 2050 pumping rates, there can be a delayed response as the aquifer system adjusts to a new equilibrium, or steady state, among discharge, recharge and water storage. The Illinois State Water Survey has not reported on steady-state drawdowns[9], but they could be an additional few feet[8]. And, of course, if pumping continues to increase beyond 2050, the transient and steady-state impacts will continue to increase.

The Committee finds that allowing water levels in wells to drop below the top of the confined Mahomet Aquifer and for the aquifer to become partially dewatered (dry), even locally, would represent a stressed situation. Similarly, the Committee finds that loss of too much saturated thickness in unconfined aquifers would represent a stressed situation, especially if streams go dry, or remain dry for a longer period as a result of groundwater development.

The main reason to use a range of scenarios is to demonstrate that determining future water demands depends on the choice of assumptions about uncertain future conditions. Different assumptions can lead to the identification of different futures and different management strategies. A regional water supply plan, therefore, can be developed only in the context of considerable uncertainty about future conditions – uncertainty that poses challenges, risks and opportunities.

Future water availability

The amount of surface water and groundwater available in the future will depend on climate conditions, groundwater recharge and discharge rates, streamflow, reservoir capacities, and the amount of water that is withdrawn from storage.

Precipitation and water availability will continue to vary from year-to-year and decade-to-decade (Appendix 1). Even without considering human-induced climate change or using climate models, it is reasonable to assume that severe multi-year droughts may recur in the future. With recurrence of droughts that occurred in the 1930s and 1950s, water levels in many streams, lakes, reservoirs, wetlands and shallow aquifers will drop to low levels and stress many water supplies and aquatic ecosystems.

Global climate models indicate that annual average temperature in Illinois could increase between 0 ^{o}F and 6 ^{o}F by the year 2050 and continue to increase beyond that date (Appendix 1). However, there is considerable range in climate model projections and it is not possible to attach a probability to future temperature changes in the state. If temperature does increase, evapotranspiration will increase and diminish water levels in streams, lakes, reservoirs, wetlands and shallow aquifers, but much less than during a severe drought.

Scenarios of future precipitation amounts in Illinois produced from global climate model simulations range from a substantial increase in precipitation to a substantial decrease (Appendix 1). As with temperature, it is not possible to attach a probability to future precipitation changes in Illinois. If average annual precipitation decreases by several inches, water levels in streams, lakes, reservoirs, wetlands and shallow aquifers will decrease, but not as much as during a severe drought. Conversely, if mean annual precipitation increases, water levels in streams, lakes, reservoirs, wetlands and shallow aquifers will increase.

The susceptibility of the confined Mahomet Aquifer to long-term changes in temperature and precipitation is unknown, but it is expected to be much more protected from the potential impacts of climate change than shallow aquifers and surface waters. Groundwater flow model simulations indicate that water levels in the unconfined Mahomet Aquifer in the Havana Lowlands could go up or down by several feet with possible climate change, but head in the confined aquifer is modeled to be little impacted by climate change[9].

Trying to determine how many gallons of water are available, or will be available in the region is subject to many assumptions and is unlikely to produce meaningful management information. The approach that many scientists and engineers have adopted is to evaluate the benefits and costs of storing and withdrawing water to meet demand, rather than focusing on how many gallons of water will be available.

Benefits and costs of water withdrawals

Providing water to meet demand involves considerations of benefits and costs. Many benefits arise from using water. However, withdrawing water from an aquifer, stream, lake, reservoir or wetland, or building a reservoir also has financial and environmental costs: storing or withdrawing a small amount of water has small costs; storing or withdrawing a large amount of water can have large costs. Perhaps the largest social and economic costs occur when insufficient water is supplied to meet demand and water shortages occur.

A key challenge is to determine the economic and environmental costs of water supply management that are socially acceptable. A more comprehensive analysis requires balancing the social and economic benefits of providing water to meet demand against the economic, social and environmental costs of providing, or failing to provide water to meet demand. It also requires comparing the costs and benefits of providing water to meet demand against the costs and benefits of reducing water demand. Such comprehensive cost-benefit analyses have not been conducted for East-Central Illinois; hence, the

Committee is not in a position to evaluate alternatives or recommend water supply plans based on full cost-benefit analysis.

Balancing water availability, demand and supply

Water demand scenarios combined with data and information on water availability lead the Committee to conclude that there is sufficient water available in East-Central Illinois to meet water demands to 2050, provided that i) economic and environmental costs can be tolerated, and ii) drought preparedness plans are developed and implemented.

The Committee does not have data on the capacity of all existing water supply facilities to meet existing and future water demands; the capacity of supply facilities was beyond the scope of this planning effort. However, providing dependable and adequate supplies of clean water to meet increased demand undoubtedly will require costly expansion of many water facilities, construction of new facilities, and/or reduction in demand. Funding for new infrastructure and operations may raise problems, but facility managers have authority and responsibility to resolve these problems. The Committee will not make recommendations in support of or in opposition to specific water supply development or conservation projects.

The Committee does view one of its roles to be the gathering and posting of data and information on water supply issues for deliberation by the public and diverse interest groups. The water demand scenarios and climate change sensitivity studies for the region are two examples; revealing what the Committee views as a possible early indication of an emerging issue – dewatering at least one well finished in the Glasford Aquifer in Champaign – is another.

Reservoirs are the prime sources of water supply for Decatur, Danville, Springfield and Bloomington. Bloomington's current use is about 12 mgd and the 90 percent estimate of yield in a drought of record is 11.0 mgd. Decatur currently uses about 37 mgd and the 90 percent yield estimate is 34.6 mgd. Springfield uses about 32 mgd and its 90 percent yield estimate is 23.4 mgd[2]. All three cities will have increasing water supply deficits in the future during droughts of record, unless additional sources of supply are developed[2]. Decatur could face the possibility of water shortages within a single drought season. Increasing deficits are due to increasing demand, and for Bloomington and Springfield to declining yields due to sedimentation. Droughts of record – or worse – could occur at any time. The 90 percent yield estimate for Bloomington in 2050 decreases to 10.1 mgd and for Springfield to 21.8 mgd. Decatur has a dredging program that removes sediment from their lake at about the same rate as sediment is being deposited from the Sangamon River. It is assumed that they will maintain this program, and thus the capacity of the reservoir will not change substantially over time[2]. Water demand in 2050 in the BL scenario increases to 16 mgd for Bloomington, 56 mgd for Decatur and 37 mgd for Springfield[2]. Water demands increase in the MRI scenario[7]. Danville will have a water supply deficit with the BL scenario by 2050[2], and a greater deficit with the MRI scenario[7]. In the absence of measures to augment water supply or reduce water use, it is expected that the Springfield power plant will need to shut down, should a 40- to 50-year drought occur in the next decade, although sufficient water would still be available for potable water use[1]. Ashland is expected to become part of Cass County Rural Water District, thus receiving a more dependable supply of water.

If limits on water storage and withdrawals are identified to protect the environment and ensure sustainable water supplies, these could pose additional challenges to balancing water withdrawals and water demand in some parts of the region, and result in higher water prices.

A regional perspective can bring to water supply planning greater unity in identifying future water demands and risks of drought and climate change, an analytical framework for evaluating the long-term, area-wide impacts of water withdrawals, and guidance on the sustainability of water supplies. In short, regional planning focuses on shared responsibilities and opportunities. The Committee believes that meaningful participation by all water facility managers in a regional planning process with their review, acceptance and implementation of regional guidance can lead to sustainable water supply management throughout the region, without diminishing the authorities and responsibilities of local water supply managers.

Water prices are reported to significantly influence water demand in the region[7] – the higher the price the lower the demand. Water rate structures and water prices vary across the region due to the number of local historical and current management strategies and policies. In this pilot study, the Committee has not discussed water rates in detail.

Current laws, regulations and property rights

Appendix 2 provides a summary of relevant water laws, regulations, and property rights. Key findings are presented here.

Water currently is stored, withdrawn, treated and distributed and waste water is discharged by public and private water system operators for beneficial use in accordance with existing laws, regulations and property rights. Complaints can be addressed through the courts.

Water withdrawals in the state are subject to the riparian doctrine of reasonable use. In the case of a complaint, the legal system allows for adjudication by the courts of the relative needs of landowners. The lowering of the water table or reduction in water pressure by a groundwater user that reduces or eliminates the use of a neighbor's well is not necessarily unreasonable. Also, the law does not specify that it is unreasonable *per se* to dewater an aquifer, does not treat groundwater and surface water as a linked resource, and does not define the sustainability of water supplies.

Permits to withdraw water are required only for the public navigable waters of the Illinois River, the lower Sangamon River and lower Sangamon River South Fork, where maintenance of minimum instream flows is regarded as a benefit to the public. The construction of all water withdrawal and storage facilities is regulated, as are discharges of waste water.

An important component of the Water Use Act relating to groundwater is to establish a means of reviewing potential water conflicts before damage to any person is incurred and to establish a rule for mitigating water shortage conflicts (Appendix 2). Some counties are exempt. In the event that a land occupier or person proposes to develop a new point of withdrawal, and withdrawals from the new point can reasonably be expected to occur in excess of 100,000 gallons on any day, the land occupier or person is required to notify the Soil and Water Conservation District before construction of the well begins. The District in turn is required to notify other local units of government that have water systems that may be impacted by the proposed withdrawal. The District then is required to review, with assistance of the Illinois State Water Survey and the Illinois State Geological Survey the proposed point of withdrawal's effect upon other users of the water. The findings of such reviews are to be made public. However, this is an unfunded mandate for the Soil and Water Conservation Districts and the Scientific Surveys and the reviews are not conducted. Individual utilities and water authorities develop and implement their own plans with varying degrees of public participation and review.

The riparian doctrine of reasonable use states that wasteful and malicious use of water is unreasonable. The Committee is unaware of malicious uses of water in the region, but there is no doubt that some uses are inefficient and wasteful. There are varying degrees of leakage and unaccounted for flow in water treatment and distribution systems, perhaps up to 15 percent or more. The efficiency of water used for all purposes could be improved.

Institutional organization and governance

Appendix 2 provides information on institutional organization and governance relevant to water supply planning and management. Key findings are presented here.

Individual local, county, state and federal governments, non-governmental organizations, rural water districts, and private entities have individual roles, authorities and responsibilities to plan and manage water supplies. State-level activities for water supply planning and management in Illinois are conducted by various agencies, consistent with a variety of statutory authorities and responsibilities. However, there is no general statute in Illinois that allows comprehensive water resources management at the state level.

Thirteen Water Authorities in the region have roles in the planning and management of water supplies in the region, mainly to protect local interests. Their current authorities, geographical coverage and management strategies are insufficient to provide a framework for comprehensive management of water supplies across the region.

The Illinois Department of Natural Resources and the Illinois Environmental Protection Agency co-chair the Governor’s Drought Response Task Force. The Task Force meets to coordinate state response to drought situations. The Committee is pleased that the co-chairs are revising the state’s drought response plan to include drought preparedness. Being prepared for drought is an important component of providing dependable and sustainable water supplies.

Water supplies in East-Central Illinois, however, are planned and managed largely in piecemeal manner by individual managers and local and sub-regional authorities. Time horizons for planning vary from years to decades. Assumptions about future conditions that affect water demand and methods of water availability and impact analysis vary. No uniform dependability standard is implemented, resulting in varying risks of water shortages. The concept of the sustainability of water supplies is not uniformly or comprehensively defined or integrated in water supply management plans. Communication and cooperation among stakeholders are limited. Technical expertise at the local level often is limited. The public and many local officials have limited understanding of water supply issues and often are misinformed. Although there is an increasing tendency for managers to be aware of and take into consideration conservation and area-wide impacts of withdrawals, there is no planning and management process or structure for comprehensive water supply planning and management across the region. Existing laws and regulations do not provide explicit authorities and responsibilities for providing dependable supplies of water for future generations in a sustainable manner. Yet, despite all this, there have been relatively few conflicts or water shortages.

Regional, or area-wide, planning has become increasingly accepted in many states and other countries. This acceptance is based, in part, on awareness that issues of physical and economic development and of environmental deterioration transcend the geographic limits of local units of government. It has also been recognized that sound resolution of area-wide problems requires cooperation and coordination among all units and agencies of government concerned and private interests.

In Texas, for example, the Texas Water Development Board (the Board) has under Texas Water Code authority and responsibility for conservation and development of water across all 16 regions of the state[12]. The Board's main responsibilities are threefold: collecting and disseminating water-related data; assisting with regional water planning and preparing the state water plan for the development of the state's water resources; and administering cost-effective financial programs for the construction of water supply, wastewater treatment, flood control and agricultural water conservation projects. The Board has a strategic plan, rules for regional and state water planning, and has produced a State Water Plan.

The way that Texas engages all water supply managers in each water supply planning region is for the Board to provide an opportunity for them to evaluate the Board's water demand projections and suggested management strategies and to submit to the Board for approval a portfolio of water management strategies tailored to meet each region's water supply needs. The Board's suggested management strategies include conservation, reuse of waste water, and new supply development to meet water demands under worst-case drought conditions. The regions' plans can include modifications to the Board's projections and suggested management strategies, but environmental and economic impacts must be assessed and guidelines established by the Board must be adhered to. However, it is the stakeholders in each region who decide how water supplies and demands are balanced. The Board provides technical assistance to the regions to enable county-by-county review of the Board's projections and the counties engage municipalities, utilities and other entities.

Membership in the Texas planning process is voluntary, but state support for financing water supply and treatment projects is tied to participation in the State Water Plan. The Texas loan program is similar to the existing Water Pollution Control Loan Program and the Public Water Supply Loan Program administered by the Illinois Environmental Protection Agency[13].

The Board[12] identifies the following five benefits of its model that has well established authorities, responsibilities, incentives and oversight:

- Broad-based growth of public knowledge of water resource issues;
- Fostering a direct link between water planning and implementation;
- Enhanced cooperation among different interest groups;
- Improved relationships between environmental and development interests; and
- Implementation of water management strategies.

To the list of benefits could be added regional self-sufficiency.

The sustainability of water resources is addressed in different ways in different states. In Texas, for example, the sustainable development of surface waters is based on safe yield during a drought of record, which already is well regulated and considered in reservoir management. Sustainability of groundwater resources is not required by state law, but most planning groups have adopted a policy of sustainability for their aquifers. In most cases, sustainability is intended to maintain groundwater availability at current levels through perpetuity. All but five of the state's aquifers have what are described as sustainable values of water availability, and three of these will meet sustainable values in 2060. Several planning groups recommended temporarily overdrawing from their aquifers. In Texas and other states, it is recognized that some environmental costs of providing adequate supplies of water to meet demand must be acknowledged; but the balance between environmental and economic values is variable.

In a regional water supply plan for Southeastern Wisconsin[14], the sustained ability of supplies to meet probable future needs is addressed by establishing objectives, principles and standards. Some examples of the standards are provided below.

- The use of the deep sandstone aquifer should be managed so that the potentiometric surface in that aquifer is sustained or raised under use and recharge conditions within the Southeastern Wisconsin Region.
- The use of groundwater and surface water for water supply purposes should be carried out in a manner which minimizes adverse impacts to the water resources system, including lakes, streams, springs, wetlands and aquatic ecosystems.
- Important groundwater recharge and discharge areas should be identified for preservation or application of land development plans and practices which maintain the natural surface and groundwater hydrology, while protecting the groundwater quality. The use of groundwater and surface water for water supply purposes should be carried out in a manner which minimizes adverse impacts to the water resources system, including lakes, streams, springs, and wetlands.
- Residential per capita water usages should be reduced to the extent practicable.
- Both indoor and outdoor water uses should be optimized through conservation practices that do not adversely affect public health.
- Water uses for commercial, industrial, and institutional land uses should be reduced to the extent practicable.
- Unaccounted-for water in utility systems should be minimized.
- The regional water supply plan should consider the possibility of long-term climate cycles that can affect recharge rates and water demand.
- The recommended regional water supply plan components should be adaptable to change in scope, capacity, and effectiveness to the extent practicable.

The Southeastern Wisconsin Regional Planning Commission (the Commission) defines unacceptable damage as "a change in an important physical property of the ground or surface water system – such as water level, water quality, water temperature, recharge rate, or discharge rate – that approaches a significant percentage of the normal range of variability in that property. Impacts that are 10 percent or less of the range in annual or other historic period of record for any property are considered acceptable, unless it can be shown that the cumulative effect of the change may cause a permanent change in an aquatic system by virtue of increasing the extremes of that property to levels known to be harmful. In the specific case of the deep sandstone aquifer, the term sustainability is interpreted to mean that the potentiometric surface in that aquifer is maintained at current levels or raised based upon use and recharge conditions within Southeastern Wisconsin”[15].

Technical information for developing alternative and recommended water supply plans is provided in a comprehensive report on state of the art of water supply practices (best management practices) prepared by Ruekert and Mielke, Inc. [16].

The Commission is the official area wide planning agency for the seven-county Southeastern Wisconsin Region. The permissible scope and content of that plan, as outlined in the enabling legislation, extends to all phases of regional development, implicitly emphasizing the preparation of plans for the use of land and for supporting transportation, utility, and other public infrastructure facilities. The work of the Commission emphasizes close cooperation among various levels, units, and agencies of government, with oversight. Water supply system planning recommendations initially are advanced at the regional systems level of planning and are followed by implementation actions in the form of local project planning.

The Southeastern Wisconsin regional water supply plan includes the following major components:

- Development of water supply service areas and water demand forecasts;
- Documentation of existing and potential water supply problems and issues as revealed by inventories, analyses, and forecasts to be prepared under the planning program;
- Development of recommendations for water conservation efforts to reduce water demand;
- Development and evaluation of alternative means of addressing the identified water supply problems and issues, culminating in the identification of recommended sources of supply and in recommendations for development of the basic infrastructure required to deliver that supply;
- Identification of groundwater recharge areas to be considered for protection from incompatible development;
- Specification of any new institutional structures found necessary to carry out the plan recommendations; and
- Identification of any constraints to development levels in subareas of the region that may emanate from water supply sustainability concerns.

Unlike many states, Illinois does not have statutory mandates for developing and implementing regional water supply plans, permitting of water withdrawals and allocations, or mandatory water withdrawal reporting.

Technical assistance

The University of Illinois at Urbana-Champaign, through the Illinois State Water Survey, Illinois State Geological Survey and other departments, provides valuable technical assistance for water supply planning and management utilizing resources made available through the state budget and fees-for-service. The water supply planning process in East-Central Illinois is dependent upon the technical support of the Scientific Surveys and the Committee wishes to maintain and strengthen this relationship.

Summary of key findings

- A fundamental fact remains valid: withdrawing and using water is necessary for sustaining life and for domestic, commercial, industrial, agricultural and recreational uses.

- Water is stored, withdrawn, treated and distributed and waste water is discharged by public and private water supply operators for beneficial use in accordance with existing laws, regulations and property rights.

- Climate, surface waters, groundwater and aquatic and riparian ecosystems are physically interconnected and associated resource management issues are intertwined.

- Demand for water and water withdrawals will increase. Using different combinations of assumptions, a plausible range of increases in total surface water and groundwater withdrawals in the region by 2050 (excluding electric power generation) is about 220 to 420 mgd more than 2005 (normal weather) modeled withdrawals of about 340 mgd. This range of increase would be about 100 to 300 mgd above 2005 reported and estimated withdrawals of about 460 mgd, which was a drought year in parts of the region. Withdrawals for electric power generation (the large majority of which are from surface waters and are non-consumptive) could decrease by 7 percent to about 1,218 mgd or increase by 2 percent to about 1,342 mgd.

- Under normal weather conditions, groundwater withdrawals from the Mahomet Aquifer are reported to increase from about 220 mgd in 2005 to 260 mgd in the Less Resource Intensive (LRI) scenario in 2050, 280 mgd in the Baseline (BL) scenario, and 300 mgd in the More Resource Intensive (MRI) scenario[8]. Withdrawals would be much higher in a drought year, especially for irrigation, and would increase with some climate change scenarios.

- An extreme climate scenario for water supplies would be a decrease in mean annual precipitation, a recurrence of severe multi-year droughts, and an increase in temperature. All these factors would combine to increase water demand and decrease water availability, especially in surface waters and shallow aquifers. The probability of such a scenario occurring is unknown. However, severe multi-year droughts may recur in the future and pose a great threat to water availability and some water supplies in the region, especially those from surface waters and shallow aquifers. This is a bigger threat than a possible decrease in precipitation and increase in temperature with climate change. Some water supply facilities are not adequately prepared for severe multi-year droughts. Building capacity to be prepared for severe multi-year droughts also would provide protection against the adverse impacts of possible climate change.

- Surface water and shallow groundwater supplies typically are and will continue to be limited during periods of drought. Even during periods of drought and with possible climate change, there is sufficient water in the region to meet the future water demand scenarios considered, <u>provided that adequate infrastructure and drought preparedness plans are developed and implemented and economic and environmental costs can be tolerated.</u>

- Withdrawing water from rivers and aquifers, storing, treating, distributing water, and discharging waste water have social and economic benefits and economic and environmental costs. Determining how much water is to be withdrawn from different sources necessitates balancing and weighing benefits against costs and risks.

- Reservoirs are the prime sources of water supply for Decatur, Danville, Springfield and Bloomington. Bloomington's current use is about 12 mgd and the 90 percent estimate of yield in a drought-of-record is 11.0 mgd. Decatur currently uses about 37 mgd and the 90 percent yield estimate is 34.6 mgd. Springfield uses about 32 mgd and its 90 percent yield estimate is 23.4 mgd. Due to increasing water demand and increasing sedimentation, all three cities will have increasing water supply deficits in the future during droughts of record, unless additional sources of supply are developed and/or demand is reduced. In a drought-of-record, Danville will have a water supply deficit with the BL scenario by 2050 and a greater deficit with the MRI scenario.

- Withdrawing sufficient water from aquifers to meet demands to 2050 results in increasing drawdown in wells finished in the aquifers, expanding cones of depression, a reversal of groundwater flow in some areas, and reduced baseflow in streams. The impacts increase in proportion to the amount of water withdrawn: they are greatest with the MRI scenario and in summer when demand is highest, especially in periods of drought and with an assumed increase in temperature. The bull's eye of concern is in Champaign County, where drawdown could lower head in some wells to less than 50 feet above the top of the Mahomet Aquifer in some scenarios. Some shallow aquifers increasingly are dewatered locally, some wells finished in these aquifers go dry, and water levels in other wells drop below the pumps and will require pumps to be lowered to sustain yields.

- The Committee finds that allowing water levels (heads) in wells finished in the Mahomet Aquifer to drop below the top of the confined aquifer and for the aquifer to become partially dewatered (dry), even locally, would represent a stressed situation. Similarly, the Committee finds that loss of too much saturated thickness in unconfined aquifers would represent a stressed situation, especially if streams go dry, or remain dry for a longer period as a result of groundwater development.

- Groundwater flow model simulations indicate that groundwater development and the creation of a large cone of depression have reversed groundwater flow from Champaign County to Piatt County and caused a significant decrease in the amount of baseflow discharged to streams. Groundwater withdrawals in other parts of the region also have reduced groundwater discharge to streams.

- The possibility of a slight increase in surface water withdrawals for electric power generation does not appear to create a problem, although projections of future electricity demand and associated water withdrawals are highly uncertain.

- The efficiency of water use can be improved and water demand reduced. Many factors influencing water demand, e.g., population, income and drought, are impossible or difficult to control. The price of water and water conservation are two factors influencing water demand that perhaps are most amenable to control.

- The varied physical, demographic and economic characteristics of the region result in distinct sub-regional variations in water availability, water storage ability and water demand that need to be factored into the development of a regional plan.

- There are uncertainties, errors and data gaps in all aspects of water supply planning and management, especially climate, water availability, water withdrawals, uses and losses, and estimates of the impacts of water withdrawals. Research and monitoring can reduce the uncertainties and errors and fill some of the data gaps, but available data and a range of plausible scenarios provide a solid basis for assessing and managing risks and identifying regional guidelines.

- Activities for water supply planning and management in Illinois are conducted by various agencies, consistent with a variety of statutory authorities and responsibilities.

- Common law provides users of water with only limited guidance to answering many issues that will likely arise in the future: for example, common law does not define the sustainability of water supplies. The planning concept of the sustainability of water supplies, which does not have a uniform, agreed upon definition, is not uniformly or comprehensively integrated in water supply management plans in the region.

- Water supplies in East-Central Illinois are planned and managed largely in piecemeal manner by individual managers and local and sub-regional authorities. There is no planning and management process or structure for comprehensive water supply planning and management across the region.

- Lack of funding prevents the mandatory review of the potential impacts of new high capacity groundwater withdrawals and realization of the full potential of the voluntary Illinois Water Inventory Program to provide a comprehensive and consistent data base of water withdrawals .

- There is no central authority for collecting, analyzing, archiving and disseminating water-related data for the region and insufficient input by stakeholders in setting priorities.

- The public and many local decision makers have limited understanding of water supply issues and often are misinformed.

- Regional water supply planning increasingly has become accepted in many states and other countries. This acceptance is based, in part, on awareness that problems of physical and economic development and of environmental deterioration transcend the geographic limits of local units of government. It also has been recognized that resolution of regional problems requires enhanced cooperation and coordination among all stakeholders.

Conclusions

In examining the issues and challenges of water supply planning and management in East-Central Illinois and recognizing the efforts of other states, the Committee was faced with three key issues: (i) identifying whether changes to water supply planning and management need to be made in the region; (ii) if so, identifying the changes that need to be made, and (iii) determining whether such changes can be achieved within existing laws, regulations and property rights.

Based on the above findings, the Committee concludes that improvements in regional water supply planning and management are needed to continue to provide benefits and to reduce costs and risks for current and future residents of East-Central Illinois, those outside the region who depend on goods and services produced in the region, and the environment. The above findings facilitate identification of improvements that need to be made. A recommended regional water supply plan is presented in Chapter 3.

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3. RECOMMENDED REGIONAL WATER SUPPLY PLAN

East-Central Illinois is not facing an immediate water crisis, but the Committee is driven by a desire to avoid crises that sometimes plague other states and countries, as illustrated in recent headlines:

"Georgia Water Woes: Drought Leads to Widespread Water Shortages"[1]

"Water shortage threatens a million in Australia"[2]

"Israel Faces Acute Water Shortage"[3]

The Committee believes strongly that stakeholders in the region can shape the future, rather than allowing runaway events to take control and crises to occur. A regional plan – a framework for action and a series of action items – provides a means to shape the future. It is the Committee's intention that implementation of the regional plan can lead to more desirable headlines such as:

"Voluntary standards set to protect the Mahomet Aquifer"

"Sustainable water supplies for East-Central Illinois"

"No drinking water shortages in East-Central Illinois"

The regional plan builds on the Committees findings (Chapter 2) and information in Appendices 1 and 2. In the framework for action, elements of strategic planning are first described, followed by identification of major factors considered by the Committee in focusing its recommendations. A set of recommended guidelines, a vision of the future, a goal, and a set of standards for regional water supply planning and management then are presented. The recommended action items are strategies to implement the plan.

FRAMEWORK FOR ACTION

Strategic planning

The framework selected by the Committee is a strategic planning framework. Strategic planning is a systematic process to determine through strategic thinking and analysis where an entity or effort is going and how it's going to get there. Strategic planning is responsive and adaptive to a dynamic, changing environment and keeps efforts focused and relevant. Participation in a consensus-building process provides stakeholders with shared ownership of and responsibility for shaping the future and can lead to the creation of a regional organizational structure to effectively deploy resources to achieve a desired future.

Strategic planning is a well-established and structured process requiring the development of the following key components:

Vision: A short, succinct, and inspiring statement of what the Committee intends to achieve for regional water supply planning and management in East-Central Illinois. It describes aspirations for the future, without specifying the means that will be used to achieve the desired ends.

Goal: The state of affairs that a plan is intended to achieve in alignment with the vision.

Standard: A norm, consistent with identified principles, used to establish uniform criteria, methods, processes and practices. Standards also can serve as a basis of comparison to determine the adequacy of plan proposals to attain goals.

Plan: A design which seeks to achieve agreed-upon goals. The process of planning and the production and implementation of a plan are necessary for the wise management of resources.

Action items: A combination of strategies, institutional arrangements, funding requirements and other measures to implement a plan.

Factors considered

To this point, the Committee has identified the need to meet the requirements of Executive Order 2006-01 and has documented key findings. As a prelude to developing a specific framework for action, the Committee identifies and comments on a complex multitude of interrelated environmental, societal and economic factors relevant to water supply planning and management. Figure 9 illustrates diagrammatically major interrelated factors relevant to providing dependable and adequate supplies of clean water for all users at reasonable cost.

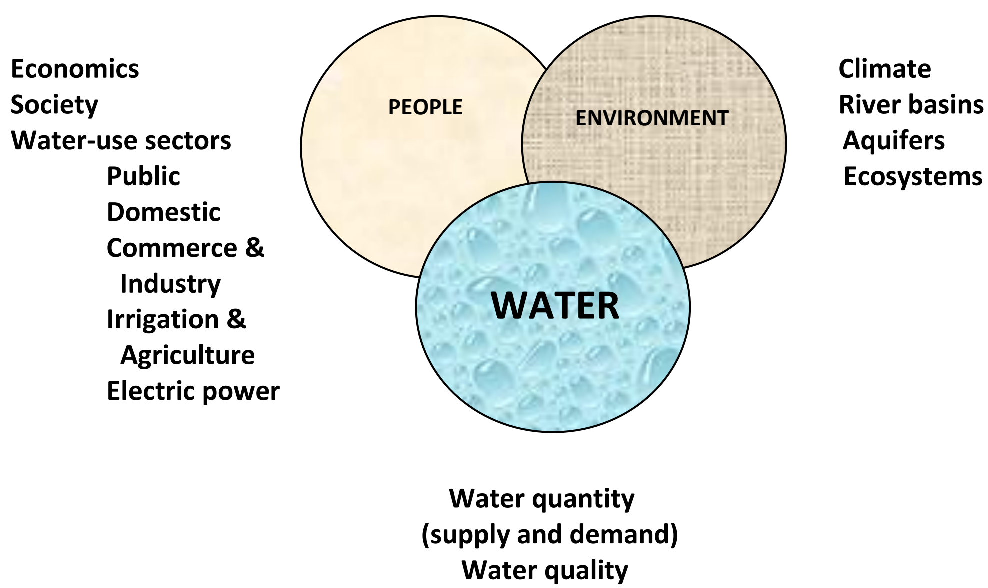

Figure 9. Major environmental, societal and economic factors that need to be considered in regional water supply planning and management.

There is probably little debate that all users should be provided with dependable and adequate supplies of clean water to meet their needs at reasonable cost, but there can be much debate on the meaning of the terms “adequate”, “dependable”, “all users”, and “reasonable cost”. There follows a brief discussion of these key terms.

The provision of adequate supplies of water generally means that water supply should satisfy user needs, as expressed in water demands. But this raises questions as to how user needs or water demands are specified. In economics, water – like other resources – is regarded as a scarce resource and the balance between supply and demand is governed largely by price and the ability and willingness to pay. This is why the price of water and family income are reported to be key factors in explaining historical trends in water withdrawals and in constructing scenarios of future withdrawals in East-Central Illinois[4]. The average family is likely to resist paying a high price for water unless income also increases.

Different values and priorities also can be assigned to water use. Some uses of water – drinking water, for example – are essential for life. Other uses of water – washing cars and watering lawns – may be regarded as less essential. During periods of water shortage, priorities often are set within the water-use sectors and restrictions implemented.

Another example of the complexities of water demand is that many water demands can be reduced by implementing, for example, conservation measures and more efficient technologies. An increase in the price of water is reported to reduce demand[4], but the price of water charged by utilities varies greatly and price is not the only factor influencing water demand. Some utilities charge customers a flat rate for unlimited water use, some increase their rates as more water is used, and others reduce their rates as more water is used. Other municipal water systems utilize costs subsidies and do not reflect the full cost of providing water in their water rates. It is evident, therefore, that economic principles do not uniformly explain water prices or water demand. And in addition to residential, commercial, agricultural and industrial uses, water is needed for recreation and navigation. Aquatic and riparian ecosystems also need large amounts of water, which at present are not accounted for. Fundamental issues in water supply planning and management, therefore, are whether all water demands should be treated equally and what role pricing should play in shaping demand.

While users generally prefer to pay as little as possible for services, when properly educated they also understand that providing quality and dependable service often necessitates higher cost. Providing dependable service requires, for example, consideration of the safety, security and continuity of water supplies. An issue is the level of uninsured or unprotected risk that should be planned for. Put another way, should utilities plan to provide a continuous and uninterrupted supply of water for all contingencies, regardless of the low probability of occurrence and high cost of dealing with extreme events?

In water supply planning and management, a key issue is the willingness to pay the cost of constructing and operating facilities to meet water demand during drought, when water availability generally decreases and water demand increases. Planning only for a moderate drought leaves open an uninsured or unprotected risk of water shortages during a severe drought.

Similarly, economics and the willingness to pay are key determinants in the use of what traditionally have been regarded as exotic sources of water. Examples of possible exotic water supplies for East-Central Illinois are desalinating water pumped from the deep St. Peter or Elmhurst-Mt. Simon Aquifers, transporting and treating water from the Mississippi or Illinois Rivers, and treating and transporting used water and stormwater runoff for reuse. Clearly, economics and value judgments play key roles in strategies to provide dependable and adequate supplies of clean water at reasonable cost.

And cost is not restricted to monetary cost. When water is withdrawn from aquifers and streams, or reservoirs are constructed, there can be non-monetary environmental costs, or impacts. As with monetary costs, a key issue is to determine the environmental costs that are acceptable or tolerable. This issue is closely related to an often-stated desire to minimize or reduce the environmental impacts of withdrawals and protect the environment and long-term productive yields.

Drinking water quality and the protection of water quality in the environment also are important considerations in water supply planning. All public water supplies are treated to meet drinking water standards, but there are no requirements for treating water withdrawn from private domestic wells. Treating water to reduce the concentration of naturally occurring chemicals, such as iron and arsenic, and man-made pollutants involves costs that are borne by the consumer. Natural and man-made pollutants also can cause adverse non-monetary impacts to the environment. In turn, preventing adverse environmental impacts can necessitate additional monetary costs to the consumer.

Determining monetary and non-monetary costs that users are willing and able to accept in the provision of dependable and adequate supplies of clean water and protection of the environment is a key management consideration.

Other factors also must be considered in water supply planning. These include equity and a desire for future generations as well as all current residents to have access to dependable and adequate supplies of clean water at reasonable cost. As climate variability and the possibility of climate change can affect water availability, water quality and water demand, the risks and opportunities associated with climate variability and change also must be identified and considered.

It is clear that many complex factors need to be considered and weighed in developing a water supply plan. Acknowledging that everything is related to everything else is perhaps a truism, but provides too large, complex and unwieldy a framework for this pilot study. Given the time and resources available, the Committee focused on the impacts of withdrawing water from the Mahomet Aquifer System and the major river basins to meet water demand scenarios to 2050. The Committee has not addressed the following important topics in any substantial manner:

- Economics;
- Social and cultural factors;
- Law and regulation;
- Water infrastructure;
- Water treatment;
- Water losses;
- Water efficiencies and conservation;
- Water rates and prices;
- Consumptive water use;
- Storm water and floods;
- Effluent water and water reuse;
- Water utility operations;
- In-stream and riparian water uses (ecosystems, recreation, navigation etc);

- Status of ecosystems and cause of change;
- Ecosystem management;
- Water quality;
- Land-cover changes; and
- Land-use, transportation, and development planning.

Future water supply planning and management efforts require detailed consideration of these important factors.

Guidelines

The Committee recommends a set of guidelines for regional water supply planning and management. Guidelines are a combination of laws, rules, concepts, principles and standards that reflect legal, moral and operational values and perspectives. A list of primary and secondary guidelines, a vision statement and a goal are provided, followed by a set of planning and management standards. Together with the above findings, these guidelines are used to shape the identification of recommended action items.

Primary guidelines

- The concept of the sustainability of water supplies is adopted as a foundation for regional water supply planning and management. The sustainability of water supplies is defined as the provision of dependable and adequate supplies of clean water to meet the demands of all users "in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social costs"[5].

- The concepts of shared responsibilities, self-governance, adaptive management by stakeholders, and an informed public also are adopted as foundations for planning and managing regional water supplies.

- Regional water supply planning and management should be based on sound science.

Consistent with Executive Order 2006-01, recommendations for regional water supply management are made within existing laws, regulations and property rights.

Secondary guidelines

- Adequate supplies of water to meet demand means the use of water to meet the natural wants of people (i.e., domestic uses) and a fair share for artificial wants, without using water in a wasteful or malicious manner. Adequate supplies of water also are required to meet the needs of riparian and aquatic ecosystems. Inherent in the word "adequate" is an assumption of dependability, security and low risk such that sufficient water to meet reasonable demand also will be made available during periods of drought (when water availability is reduced and demand is higher) and other contingency situations.

- An indefinite time means for all future generations. The time horizon adopted for the study – 2050 – allows consideration of present generations and two future generations. The future beyond 2050 is much more uncertain, but is considered.

- The water cycle and water budgets provide appropriate frameworks for planning and managing regional water supplies.

  - Water is a precious renewable natural resource with limits and vulnerabilities that needs to be managed wisely.

  - At specific locations, the natural dynamics of the water cycle, ecological dependencies on the natural water cycle, and human-induced changes to the water cycle need to be well documented, recognized as an integrated system, and considered as a balanced water economy.

  - Variations and changes in climate, especially precipitation and temperature, affect the demand for and availability of surface water and groundwater and need to be considered. It is important to use long-term climate records and consider natural and human-induced changes in climate.

  - Surface water and groundwater are linked physically and should be managed as a common resource.

  - The rate at which water is replenished after it is withdrawn varies from seconds in a high-flow stream of free water to decades to centuries between packed sand grains in deep aquifers. Temporal and spatial variations in groundwater recharge rates and the replenishment of surface waters need to be considered.

  - Local water availability and withdrawals are strongly influenced by local climatic, geographic, geologic, economic and social factors and by regional, national and global climatic, economic and social factors. Examples of regional, national and global factors are climate change and economic conditions that influence the demand for Illinois products. Interrelationships between local, regional, national and global conditions need to be considered.

  - There are marked local and sub-regional differences in the availability and use of water and water demand that need to be recognized.

  - Withdrawals of water at individual points can have local impacts on surface waters and groundwater. The impacts of multiple withdrawals at many points can accumulate over larger regions, such as in the large cone of depression centered in Champaign County. Both local and cumulative regional impacts need to be considered.

  - Water withdrawals usually are reported as the average amount of water withdrawn each day throughout the year. The impacts of water withdrawals usually are calculated using average day withdrawals. However, more water generally is withdrawn in summer and during periods of drought. The largest amount of water withdrawn on any specific day exceeds average day and peak season withdrawals. When calculating water demand

and the impacts of withdrawals, peak-season and peak-day withdrawals should be considered along with average day withdrawals.

- The amount of water that can be withdrawn in a sustainable manner is not a fixed amount; it is a function of local conditions and the value judgments of stakeholders. Withdrawing water from streams and aquifers produces benefits (social and economic) and costs (economic and environmental), and competition among users can produce conflicts. Benefits, costs and competition among users need to be considered in determining sustainable (or unsustainable) water supplies.

- Withdrawing any amount of water from streams and aquifers has environmental impacts. Impacts can be small, hardly measurable and inconsequential for small withdrawals, such as from a domestic well. Impacts increase as larger amounts of water are withdrawn. Ultimately, large withdrawals can cause streams and some shallow aquifers to go dry locally. Whereas stakeholders may find it easy to determine that extreme and dramatic impacts are unacceptable, a more difficult challenge is to agree upon what may constitute possible thresholds for subtle unacceptable impacts. Stakeholders with different values may have differing views on acceptable and unacceptable impacts and a range of stakeholder values need to be considered.

- As dependable and adequate supplies of clean water are necessary for all people and ecosystems, fair treatment of these diverse stakeholders and future generations needs to be considered and calculated in balance sheets when managing water supply. Water is required to meet human needs and wants, and water withdrawals are viewed as benefits to a society that are chargeable as immediate costs to consumers in its economy. Water prices include the measurable costs of withdrawing, treating and distributing water and providing the dependable, secure supplies of the quality that consumers demand. Water prices also are influenced by consumer resistance to paying prices they see as unreasonable. However, there can also be less tangible, indirect, and deferred costs – real costs – usually unaccounted in water prices and consumer concerns. These are the costs water withdrawals impose on a society's supporting ecosystems and its future generations. Aquatic and riparian ecosystems can be affected by water supply withdrawals and discharges. Unsustainable water use would place future generations and their environment in jeopardy, leaving them an inheritance of loss and high cost.

- Below is a generic list of possible indicators of unsustainable water supplies that the Committee has considered.

  - Drawdown in aquifers resulting in:
    - ✓ Long-term reduction in storage;
    - ✓ Wells going dry or water levels falling below the pumps;
    - ✓ Partial or complete dewatering in portions of aquifers;
    - ✓ Changes in regional groundwater flow;
    - ✓ Surface subsidence; and
    - ✓ Reduction in surface water caused by groundwater withdrawals.
  - Changes in stream geomorphology caused by changes in streamflow.
  - Sedimentation in lakes and reservoirs.

  - Water quality degradation.
  - Loss of aquatic and riparian ecosystem integrity and diversity.
  - Population changes due to water availability, or lack thereof.
  - Inadequate infrastructure capacity to meet increasing water demands, and to be prepared for drought and possible climate change.
  - Economic, social and demographic stresses due to the above changes.

- The Committee has insufficient measures to document the current status of all these indicators. Indeed, some indicators are not expected to be significant in the region. Other potential impacts, such as water level in a well falling below the pump, can be mitigated – at cost. Some data and information relevant to understanding the impacts of withdrawals can be found in Chapter 2 and Appendix 1.

- There are many sources of uncertainty in water supply planning and management and uncertainty can be a major source of risk to managers and the entities and communities they serve. Sources of uncertainty include incomplete scientific understanding, inadequate methods of data analysis, and a lack of ability to predict with confidence the values of future demographic, economic and social factors that influence water demand and climate change. Uncertainty is not a reason not to plan ahead. Water supply planning and management need to embrace the best scientific data available and reasonable assumptions about future demographic, economic, social and climatic factors, while maintaining an ability to deal with change, new information, and complexity.

- A lesson learned from earlier efforts to strengthen water supply planning and management in Illinois is that attempts to add new laws and regulations as a means to improve the management of water supplies have met with strong resistance. Stakeholders should be given the opportunity and incentives to participate in regional planning and management and solve their own problems through individual and collective actions, with some level of accountability and oversight.

- The following principles provide a sound basis for the conduct and reporting of science for water supply planning and management:

  - Data, models and reports should be in the public domain;
  - The strengths and limitations of data, analyses and assessments should be documented;
  - Data, analyses, assessments and documents should be peer reviewed thoroughly; and
  - Uncertainty should be specified.

KEY COMPONENTS

Vision of the future

In the years ahead, others will view East-Central Illinois as a model for regional water supply planning and management. This is because future generations will inherit a legacy of responsible water supply planning and management that will allow them to continue to be good stewards and managers, rather than inheriting diminished resources and chronic problems. The provision of dependable and adequate supplies of clean water for all users at reasonable economic and environmental cost will enhance public health and the quality of life, reduce conflict, and preserve and enhance economic, agricultural and environmental resources and opportunities.

Goal

The goal is to make recommendations that will be adopted and implemented by stakeholders to improve the planning and management of water supplies in East-Central Illinois.

Planning and management standards

Ensuring the sustainability of water supplies requires consideration of spatial variations in hydrogeology and climate, temporal variations in climate, environmental, economic and social factors, future generations, and management authorities and responsibilities. Drawing on sustainable indicators and, where possible, identifying thresholds and criteria of acceptable and unacceptable impacts, the Committee recommends the standards below for planning and managing water supplies in East-Central Illinois. The standards should be implemented voluntarily. Because of close linkages among surface water and groundwater resources and current data limitations and uncertainties, certain standards will require resolution through balance, compromise and further study, and possible revision.

Compliance with existing laws, regulations and property rights

- The Committee recommends that water supplies continue to be planned and managed to meet demand in compliance with existing laws, regulations and property rights, and with due consideration of acceptable and/or unacceptable impacts. Planning and managing water supplies to meet demand can ensure that water shortages do not occur.

- The Committee recommends that water supplies be planned and managed with enhanced regional cooperation and coordination to address shared responsibilities and the interests of future generations. Enhanced regional cooperation and coordination should be achieved through voluntary efforts in the spirit of self-governance.

Sustainable water supplies

- There is no consistent agreement on definitive, objective criteria to define the sustainability of water supplies. In states that have attempted to incorporate sustainability in water supply planning and management, indicators and criteria for sustainable water supplies vary widely. Determining acceptable or unacceptable impacts of withdrawals requires consideration of a balance between benefits and costs and the exercise of subjective judgment. In the absence of full benefit and cost analyses, the Committee has drawn on scientific and engineering data and information, and members of the Committee have exercised personal and collective judgments in making recommendations about the sustainability of water supplies.

- The Committee finds that partial dewatering of a confined aquifer, even locally, is a sign of stress that should be avoided. The Committee recommends that withdrawals from the confined Mahomet Aquifer be managed so that head in any well (pumping or non-pumping) finished in the confined Mahomet Aquifer does not fall below the top of the aquifer, i.e., there is no loss of saturated thickness. This will ensure that the entire confined aquifer is protected from becoming dewatered, even locally. The Committee recommends that pumps in new and refurbished wells be placed at the top of the aquifer, or higher, although wells could penetrate the full depth of the aquifer. In some existing wells, pumps are placed below the top of the aquifer. The Committee recommends that when head in any well (pumping or non-pumping) drops to 30 feet above the top of the aquifer, a review be undertaken and management strategies implemented to ensure that head does not drop below the top of the aquifer. It will be important to monitor heads in pumping and non-pumping wells and provide a water-level watch for all stakeholders.

- Available head between the current head and the top of the aquifer can be consumed by public and/or private withdrawals. Drawdown can be reduced and withdrawals increased by, for example, increasing the distance between production wells. Drawdown also can be reduced by demand-side management. Current engineering practices in confined aquifers often try to avoid dewatering an aquifer, although there is evidence that parts of the deep bedrock aquifers in northeastern Illinois have been partially dewatered.

- The Committee recommends that implementation of the recommended standard to protect the confined Mahomet Aquifer not be delayed until other standards (below) are developed.

- The Committee recommends that the earlier evaluation of the sustainability of pumping to capacity by Illinois American Water (51.1 mgd) be reevaluated to include additional withdrawals from the Mahomet Aquifer by other communities and industries out to 2050, with consideration of drawdown in pumping and non-pumping wells. The 2006 study by Wittman Hydro Planning Associates, Inc. did not include additional withdrawals by other communities and industries beyond 2004 (see Chapter 2 and Appendix 1) in concluding that water levels were predicted to remain above the top of the Mahomet Aquifer.

- Between the central and western parts of the region, there is a transition zone between the confined and unconfined parts of the Mahomet Aquifer. The Committee recommends that the transition zone be defined and an appropriate standard(s) be developed to protect the aquifer, surface waters and ecosystems, while allowing for groundwater development.

- The Committee recommends further study to develop a standard(s) to protect shallow confined aquifers and related surface waters and ecosystems, while allowing for groundwater development. Geological and hydrological characteristics of shallow confined and unconfined aquifers vary over small spatial scales and a standard(s) for acceptable or unacceptable impacts of withdrawing water from these aquifers cannot be set at this time due to the highly variable conditions and paucity of data. Heads in some wells finished in shallow confined aquifers – the Glasford Aquifer in and around Champaign-Urbana, for example – are likely to continue to decline and more wells finished in the Glasford Aquifer are likely to go dry with increased withdrawals from the Mahomet Aquifer. Implementing a standard to prevent dewatering of the upper portions of the confined Mahomet Aquifer is expected to reduce further adverse impacts in the Glasford Aquifer.

- Hydrogeology in the unconfined Mahomet Aquifer in the Havana Lowlands is different than in the confined Mahomet Aquifer to the east of the Havana Lowlands. Current engineering practices typically allow for loss of about one half of saturated thickness in high-capacity production wells in unconfined aquifers. The Committee recommends a standard(s) be developed and implemented to limit the reduction of saturated thickness in the unconfined aquifer and protect surface waters and ecosystems, especially in summer under drought conditions, while allowing for groundwater development. Such a standard(s) cannot be developed at this time due to lack of data and information. A method needs to be developed to separate out the influences of low precipitation and heavy pumping on drawdown and reduced streamflow. More data and analyses are needed to better understand the influence of variations of flow in the Illinois River on groundwater elevation. Acceptable instream and riparian impacts of reduced streamflow due mainly to irrigation pumping also need to be determined.

- The Committee recommends that key aquifer recharge areas, key stream reaches, and ecosystem-sensitive stream flows be identified and preserved and/or restored. Water supply planners also must understand the nature, extent, cause and trend of impacts (such as water withdrawals) on ecosystems.

- The Committee recommends that water supply facilities be designed, constructed and operated in a manner that prevents unacceptable impacts to surface waters, including streamflow and water levels in lakes, wetlands and aquatic and riparian ecosystems, while providing sufficient water to meet demand. Little is known in the region of possible adverse impacts on surface waters and aquatic and riparian ecosystems of surface water capture resulting from groundwater withdrawals. Meaningful criteria and a standard(s) to protect surface waters and aquatic and riparian ecosystems from possible unacceptable impacts of groundwater withdrawals cannot be set at this time, but need to be developed. Indicators of instream biological diversity and integrity should include biological sensitive stream data gathered by the Illinois Department of Natural Resources[6].

- The magnitude of droughts and their impacts on water availability and water demand vary across the region. The Committee recommends that public water supplies be managed to provide dependable and adequate supplies of water during, at a minimum, recurrence of the multi-year droughts-of-record, similar to those that occurred in the 1930s and 1950s. A 90 percent confidence level should be used for yields. Bloomington, Decatur and Springfield urgently need additional sources of water and/or need to reduce water demand to be able to provide adequate supplies of water during severe droughts, which can recur at any time. The Committee also recommends that emergency response plans be updated or prepared to provide adequate supplies of water in low-probability situations in which adequate water supplies cannot be provided by normal operations and capacities. The objectives are to minimize the risk of water shortages and adapt to the possibility of climate change.

- The Committee recommends that efficiencies of water withdrawal, treatment, distribution and use, and use of water from alternative sources (such as reused water, detained stormwater, and conjunctive use of surface water and groundwater) be increased. This should include obtaining maximum feasible efficiencies in all existing, committed and planned water supply facilities, which should be supplemented with additional facilities only as necessary to serve anticipated water supply needs. Identification and uniform implementation of best management practices for water supply facilities, where feasible, will help minimize the sum of water supply system operating and capital investment costs and increase water use efficiencies and sustainability. Examination of water pricing policies and practices may lead to identification of additional strategies to reduce water demand.

Adaptive management

- The Committee recommends that water supply facilities be designed for staged or incremental construction, where feasible, to permit maximum flexibility to accommodate changes in population and economic growth, changes in technology for water supply management, new scientific understanding, and possible new or revised management standards.

- Surface water and groundwater resources are linked through the water cycle. Even though the confined aquifer can be protected from dewatering, surface waters will continue to be captured by groundwater withdrawals. It has not been determined in any locality whether a reduction in streamflow due to groundwater pumping will result in unacceptable impacts to surface waters and aquatic and riparian ecosystems. The Committee recommends that criteria and standards to protect the aquifers be reevaluated when criteria and a standard(s) are developed to protect surface waters and aquatic and riparian ecosystems from possible unacceptable impacts of groundwater withdrawals.

- The Committee recommends a continuous process for water supply planning and that regional and local water supply plans be reviewed and updated by stakeholders at least every five years.

Shared responsibilities

- The Committee recommends that all water supply managers and other stakeholders in the region be encouraged to review a regional plan, suggest modifications, and become partners in regional water supply planning and management.

- The Committee recommends that local water supply management plans be developed to be in compliance with guidelines contained in a regional plan, and that the local plans be reviewed independently.

Sound science

- The Committee recommends that research and data collection, analysis, management and exchange be planned cooperatively by academic institutions, appropriate units of government, the private sector, and other stakeholders.

Informed public

- The Committee recommends that public knowledge of water resources, water demand, and water supply planning and management be increased, particularly when plans are made, reviewed, and updated.

Action items

The Committee's recommended action items are a set of strategies to implement the guidelines contained in the framework for action.

The main recommendation is to establish a permanent process and structure for regional water supply planning and management involving a diverse set of stakeholders.

The foundations for the recommendation are sustainable water supplies, self-governance, shared responsibilities, adaptive management, sound science and an informed public. The focus is on leadership and coordination. Key recommended strategies are identified below.

- Articulate the need for and benefits of regional water supply planning and management.
- Improve education and outreach so that local decision makers and the public are better informed about regional water supply issues.
- Coordinate voluntary participation in regional water supply planning and management and integrate diverse opinions.
- Encourage and facilitate all water supply operators to participate in a review of the plan and, with guidance, have an opportunity to modify the plan, including the water demand scenarios. As the regional plan addresses both groundwater and surface water supplies, major communities such as Bloomington, Decatur, Springfield, Danville and Champaign-Urbana should be encouraged to participate in regional planning.
- Encourage, facilitate and provide technical assistance to water supply operators in the preparation of local water supply and management plans that are consistent with the guidelines in a regional plan. Review of the local plans will result in a collective regional plan.

- Recommend best management practices for water supply management.

- Coordinate implementation of a regional plan - with monitoring and reporting of progress to establish accountability.

- Identify key indicators relevant to water supply planning and management (e.g., population, the economy, the environment, water withdrawals and uses, streamflow, groundwater levels, climate and land-use changes, regulations etc.), monitor and report changes, and assess their implications for sustainable water supplies.

- Continuously engage in regional water supply planning and update the regional plan on a periodic basis, at least every five years.

- Consider incorporating in future plans subjects not addressed in the current plan, e.g., water quality, instream and riparian water needs, ecosystems, infrastructure, land-use, water pricing etc.

- Coordinate the identification of technical objectives and requirements for major data collection, analysis and distribution efforts and continue to receive technical assistance in water supply planning and management.

The Committee recommends that the Mahomet Aquifer Consortium retool to provide leadership, administrative structure and process to fulfill an expanded role for regional water supply planning and management in East-Central Illinois.

The Committee is impressed with the foresight and dedication of the Mahomet Aquifer Consortium for over a decade in providing leadership to support sound science and the identification of options for managing groundwater resources in the region. No other group has a similar credential in the region. The Committee recommends a number of changes to the Mahomet Aquifer Consortium.

- Broaden the mission to include leadership and coordination of regional water supply planning and management activities – for surface water as well as groundwater – in the 15-county region.

- Broaden membership of the Board of Directors and its Technical Advisors to include the type of stakeholder and geographical diversity represented on the Regional Water Supply Planning Committee.

- Establish an appropriate committee structure to implement the regional plan.

- Engage in a continuous process of regional water supply planning and management and facilitate implementation a regional plan.

- Encourage broader participation in Members’ meetings and rotate the meetings throughout the region.

- Continue and improve a website to provide information to the public.

The Committee believes that the Mahomet Aquifer Consortium does not need authority to fulfill this new role and recommends that the Mahomet Aquifer Consortium simply assume this expanded role.

- To be effective, the Mahomet Aquifer Consortium will need a permanent staff and appropriate financial and operating resources.

While encouraging the Mahomet Aquifer Consortium to identify its own means to implement the regional plan, the Committee recommends to the Mahomet Aquifer Consortium, the Illinois Department of Natural Resources, and the University of Illinois at Urbana-Champaign the following three strategies:

- A critical early step is for the Mahomet Aquifer Consortium to identify its resource needs and to take action to secure them. Stable and adequate funding from state government through the Illinois Department of Natural Resources and local entities is essential to support efforts to implement a regional plan. Federal funds also should be pursued as a possible source.

- Funding is needed for the operation of the Mahomet Aquifer Consortium, continuance of the Illinois Water Inventory Program, providing technical assistance to water supply operators, and data collection, analysis, management and distribution. The Committee recommends establishing an *ad hoc* group to investigate opportunities for creating incentives to water supply operators to participate in implementing the regional plan and in funding some of the needed activities.

- The University of Illinois at Urbana-Champaign is encouraged to consolidate and strengthen its important role as a partner with local entities and state agencies, especially the Department of Natural Resources, in regional water supply planning and management.

  The Committee recommends that the four divisions of the newly created Institute of Natural Resource Sustainability and other departments, in coordination with the Mahomet Aquifer Consortium, develop a plan to assist the Mahomet Aquifer Consortium; the four divisions are the Illinois State Water Survey, the Illinois Geological Survey, the Illinois Natural History Survey and the Illinois Sustainable Technology Center. Recognizing that there can be no higher priority for Illinois than providing sustainable supplies of clean water, the Committee recommends that the University give appropriate high priority to assisting the Mahomet Aquifer Consortium. One manifestation of its commitment could be the use of a small amount of core state resources to keep the groundwater flow model operational and to conduct and report on assessments of the impacts of new high capacity wells, in coordination with Soil and Water Conservation Districts, if additional state funds are not available. Such assessments (an average of about 16 per year since 1992, mainly in Tazewell, Mason and Cass Counties[7]) should include evaluations of proposed compliance with the guidelines established in a regional plan. This would implement for the region the increasingly important, but unfunded 1983 Water Use Act mandate to conduct and report on impact assessments for new high capacity wells.

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4. CONCLUSIONS

Water is the lifeblood of Illinois: it nourishes and sustains life and economic development. Aquifers and river basins – the vessels that contain water – and aquatic and riparian ecosystems are integral and precious parts of our environment.

The history of water supply planning and management in Illinois demonstrates a hesitant and tortuous path towards the type of regional water supply planning and management discussed in this report – a path that many other states already embrace.

To protect public health, safety and welfare and stimulate economic development, it is essential to provide dependable and adequate supplies of clean water to meet demand at reasonable cost. In so doing, we must also protect the environment and our natural resources. These objectives can be achieved through improvements in water supply planning and management consistent with existing laws, regulations and property rights.

The regional water supply plan recommended by the Committee – a framework for action and action items – is based on a wealth of scientific and engineering data and information. That is not to say that there are no data gaps, that our understanding of water resources in the region is perfect, or to deny major uncertainties in future climate conditions and water demand. Combined, these limitations pose uncertainties and risks for water supply planning and management. The Committee has considered uncertainty and risk and has grappled with diverse social values.

The Committee has identified six foundations for improving water supply planning and management in East-Central Illinois – sustainable water supplies, adaptive management, sound science, self-governance, shared responsibilities, and an informed public.

Implementing planning and management standards will ensure sustainable water supplies, protect the environment, and minimize the risks of water shortages and conflict. Establishing a regional framework and process for water supply planning and management also will enhance the level of confidence for existing businesses to stay and new businesses to locate in East-Central Illinois. However, it must be recognized and accepted that complying with these standards may in some cases increase costs and lead to higher water prices for consumers; for example, increasing the distance between production wells to ensure that heads stay above the top of a confined aquifer, or locating regional well fields away from streams to minimize reductions in streamflow may increase infrastructure and operating costs.

Many of the building blocks of sound water supply planning and management already are in place. We don't need to demolish the existing structure; we need to strengthen the blocks, add a few new ones, and reinforce the cement between the blocks. Adding planning and management at the regional level is the cement that can improve communication and coordination among operators, stakeholders, scientists, the public and local and state agencies. The Committee recommends to today's stakeholders a regional water supply plan that will allow them to realize the potentials of the water resources in the region, shape their own future, and provide a worthy inheritance for future generations.

The Committee considers the alternatives to improving water supply planning and management to be undesirable. Such alternatives include the possibility of failing resources, threats of water shortages, crisis management, unscientific and wasteful approaches, stakeholder rivalries, degradation of the environment, threats to public welfare and economic development, and non-collaborative government control. An alternative to an informed public is a fearful, poorly informed public and conflicted stakeholders who will see many reasons to blame water planners and providers for their problems. The Committee believes that these undesirable alternatives can be avoided or minimized by implementing the regional plan to maintain and increase the flow of the life blood of Illinois.

In a letter transmitting the 1967 state water plan to the people of Illinois[1], Governor Otto Kerner wrote, "… but the recommendations are of little value unless the words are translated into the reality of clean streams, water and open space for recreation, safe water supplies, and freedom from destructive floods. ….. For too long we have relied on piecemeal measures to solve our water problems."

The Foreword began with the assertive statement that "Illinois must plan the long-range development of its water resources, if the state is to meet the needs of the future." Forty two years later, that challenge remains.

A plan with no new laws or regulations and voluntary participation is perhaps more challenging to implement than having to comply with new laws or regulations. Self-governance requires stakeholders' participation and all to maintain open-minded, informed, just views of our personal, community and common welfare.

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GLOSSARY

Adaptive Management: A management approach where decisions made sequentially over time allow adjustments to be made as more information becomes available.

Aquifer: A saturated geologic formation that can yield economically useful amounts of groundwater to wells, springs, wetlands, or streams.

Aquifer (confined): soil or rock below the land surface that is saturated with water and can yield economically useful amounts of groundwater . There is a layer(s) of relatively impermeable material both above and below it and it is under pressure so that when the aquifer is penetrated by a well, the water will rise above the top of the aquifer.

Aquifer (unconfined): An aquifer whose upper water surface (water table) is at atmospheric pressure, and thus is able to rise and fall.

Artificial Wants: Use of water for other than natural wants. This includes water for irrigation and propelling machinery.

Average Day Demand: The average quantity of water used each day over a one year period.

Base Flow: The sustained flow of a stream in the absence of direct runoff. It includes natural and human-induced streamflows. Natural base flow in a perennial stream is sustained largely by groundwater discharges.

Bedrock: The solid rock beneath the soil and surficial rock. A general term for solid rock that lies beneath soil, loose sediments, or other unconsolidated material.

Benefit: Something that has a good effect and promotes well being.

Climate: The statistical characterization of weather conditions in a region over a period of years.

Climate Variability: Variations in the statistical characterization of climate in a region over time.

Climate Change: A statistically significant change in climate over periods at least 30 years.

Commercial Water Use: Water used for motels, hotels, restaurants, office buildings, other commercial facilities, and institutions. Water for commercial uses comes both from public-supplied sources, such as a county water department, and self-supplied sources, such as local wells.

Community Water System: A public water system which serves at least 15 service connections used by year-round residents, or regularly serves at least 25 year-round residents. Any public water system serving seven or more homes, 10 or more mobile homes, 10 or more apartment units, or 10 or more condominium units is considered a community water system, unless information is available to indicate that 25 year-round residents will not be served.

Cone of Depression: A three-dimensional representation of the drawdown created around a pumping well. Taking the shape of an inverted cone, the drawdown is greatest at the pumping well and decreases logarithmically with distance from the pumping well to zero at the radius of influence.

Confining Unit: A layer of relatively impermeable geologic material which hampers the movement of water into and out of an aquifer. When an aquifer underlying a confining unit is penetrated by a well, the water level in the well will rise above the elevation of the top of the aquifer.

Confined Aquifer: An aquifer that has a potentiometric surface not exposed to the atmosphere.

Conjunctive Use: Application of surface water and groundwater to meet the demand for a beneficial use.

Conservation: The preservation, care and management of natural and cultural resources.

Consumptive Water Use: That part of water withdrawn that is evaporated, transpired by plants, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment and is not available for immediate or economical reuse. It is also referred to as water consumed.

Contaminant: A substance in water that adversely affects beneficial use.

Cost: The monetary or non-monetary expense or loss paid for providing something.

Desalination: The removal of salts from saline water to provide freshwater.

Dewatering an Aquifer: Removal of water from the upper portion of a confined aquifer. In most cases complete dewatering of an aquifer does not occur. However, complete dewatering can occur when a deeper, hydraulically connected aquifer is pumped to an extent that the upper aquifer is drained.

Discharge: The volume of water that passes a given location within a given period of time.

Domestic Water Use: Water used for household purposes, such as drinking, food preparation, bathing, washing clothes, dishes, vehicles, and dogs, flushing toilets, and watering lawns and gardens.

Drawdown: The difference between the pumping water level and non-pumping water level in a well. For an aquifer system, the difference between the natural condition water level and the water level as influenced by withdrawal of groundwater.

Drought: A long period of extremely dry weather. Drought is an example of climate variability.

Ecosystem: A group of interdependent organisms together with the environment they inhabit and depend on.

Efficiency: The degree to which something is done well without waste.

Evaporation: The process of liquid water becoming water vapor, including vaporization from water surfaces, land surfaces, and snow fields, but not from leaf surfaces.

Evapotranspiration: The sum of evaporation and transpiration.

Geomorphology: The study of the characteristics, origin, and development of landforms.

Goal: The state of affairs that a plan is intended to achieve in alignment with the vision.

Groundwater: Water in the saturated zone occupying saturated pore spaces and fissures. The upper surface of the saturated zone is called the water table.

Groundwater Mining: A process whereby groundwater is removed from an aquifer at a rate greater than it can be recharged, resulting in ever-lowering groundwater levels. Groundwater mining is synonymous with groundwater depletion.

Groundwater Recharge: The entry of water into the saturated zone of an aquifer. Infiltration of precipitation and its movement to the water table is one form of natural recharge. Also, the volume of water added by this process.

Groundwater Storage: The quantity of water in the zone of saturation.

Guidelines: A combination of laws, rules, concepts, principles and standards that reflect legal, moral and operational values and perspectives. Guidelines can include a vision of the future and goals.

Head; Hydraulic Head: The height above a standard datum of the surface of a column of water that can be supported by the static pressure at a given point. The level to which water will rise in a tightly encased well finished in a hydrogeologic unit. Groundwater flows from high head to low head.

Headwater: (1) the source and upper reaches of a stream; also the upper reaches of a reservoir. (2) the water upstream from a structure or point on a stream. (3) the small streams that come together to form a river. Also may be thought of as any and all parts of a river basin except the mainstream river and main tributaries.

Hydraulic Gradient: Difference in hydraulic head between two measuring points within a water system. In an aquifer, the rate of change of hydraulic head per unit of distance of flow at a given point and in a given direction.

Hydrologic cycle: see Water Cycle.

Hydrology: Study of the physical behavior of water from its occurrence as precipitation to its entry into streams, lakes, reservoirs, and aquifers and its return to the ocean or atmosphere.

Impact: An effect requiring the specification of underlying conditions and assumptions. For example, the operation of a well for the purpose of withdrawing groundwater, by the laws of physics, must affect water pressure in the aquifer and water levels in wells finished in that aquifer; it can also affect water pressure and water levels in connected aquifers and surface waters. The degree of impact is dependent upon a number of physical and hydraulic factors.

Impermeable: A layer of solid material, such as rock or clay, which does not allow water to pass through.

Induced Recharge: The process by which water enters the ground from a surface water source as a result of withdrawal of groundwater adjacent to the source. Wells, infiltration galleries, and collector wells located directly adjacent to and fed largely by surface water cause surface water to move into the groundwater system.

Industrial Water Use: Water used for industrial purposes in such industries as steel, chemical, paper, food processing, and petroleum refining.

Infiltration: The flow of water from the land surface into the subsurface.
Infrastructure: The underlying foundation or basic framework of a system.

Instream Water Use: Water that is used in, but not withdrawn from, surface waters for such purposes as hydroelectric-power generation, navigation, water-quality improvement, fish propagation, wildlife, habitat, and recreation. Sometimes called non-withdrawal use or in-channel use.

Interference: Drawdown caused by a nearby pumping well. Interference between pumping wells can affect well yield and is a factor in well spacing for well field design.

Irrigation: The controlled application of water for agricultural and other purposes through manmade systems to supply water requirements not satisfied by rainfall.

Municipal Water System: A community water system.

Leakage: Movement of water through a porous medium, often used in the context of water movement from a groundwater system to surface water, or vice versa. Leakage of water from a stream through an underlying porous medium, such as sand, can result in a loss of water from the stream and a gain in water in the groundwater system.

Minimum Instream Flow: The minimum flow a stream should contain for instream uses such as for critical ecological habitats and recreation. May refer either to specific instream water needs as determined by scientific studies or a protected flow level set by regulation.

Natural Wants: Quenching thirst, for household purposes, and for cattle and other domestic purposes.

Non-consumptive Water Use: Water use that incurs no consumptive loss.

Normal value: A climate value using 1971-2000 climate data.

Objective: A goal or end toward the attainment of which plans and policies are directed.

Peak Day Demand: The highest quantity of daily water usage in a municipal water system in a given year.

Per Capita Water Use: The average amount of water used per person during a standard time period, generally per day.

Percolation: 1) The movement of water through the openings in rock or soil. (2) The entrance of a portion of the streamflow into the channel materials to contribute to ground water replenishment.

Periglacial: Occurring or operating adjacent to the margin of a glacier.

Permeability: The ability of a material to allow the passage of a fluid, such as water through rocks. Permeable materials, such as gravel and sand, allow water to move quickly through them, whereas impermeable material, such as clay, does not allow water to flow freely.

Plan: A design which seeks to achieve agreed-upon objectives.

Program: A coordinated series of policies and actions to carry out a plan.

Potable Water: Water of a quality suitable for drinking.

Potentiometric Surface: A surface representing the total head of groundwater in a hydrogeologic unit defined by levels to which water will rise in tightly cased wells. A potentiometric surface can be defined for both confined and unconfined aquifers and sometimes is referred to as a water-level. A potentiometric surface or head map can be used to determine groundwater flow directions.

Precipitation: Rain, snow, hail, sleet, dew, and frost.

Principle: A fundamental opinion, understanding, or generally accepted tenet used to support objectives and prepare standards, plans and strategies.

Proglacial: Immediately in front of or just beyond the outer limits of a glacier or ice sheet.

Public Water System: A system providing piped water to the public for human consumption, if the system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least 60 days out of the year. A public water system is either a "community water system" or a "noncommunity water system." A public water system includes: (a) Any collection, treatment, storage, and distribution facilities under control of the operator of the public water system and used primarily in connection with the public water system, and (b) Any collection or pretreatment storage facilities not under control of the operator of the public water system which are used primarily in connection with the public water system.

Public Water Supply: Water withdrawn by public governments and agencies, such as a county water department, and by private companies that is then delivered to users. Most people's household water is delivered by a public water supplier.

Pumpage: The total volume of water pumped from a source or sources during a unit of time.

Recharge: Water added to the saturated zone, or the process of adding water to the recharge zone. Factors such as precipitation, temperature, land forms, land cover, soil moisture content and depth to water table influence the rate of groundwater recharge.

Recycled Water: Water that is used or can be used more than one time before it passes back into the natural hydrologic system.

Reservoir: A pond, lake, or basin, either natural or artificial, for the storage, regulation, and control of water.

Return Flow: (1) That part of a diverted flow that is not consumptively used and returned to its original source or another body of water. (2) (Irrigation) Drainage water from irrigated farmlands that re-enters the water system to be used further downstream.

Return Period: The time period with a specified percent chance of an event being equaled or exceeded in any given year.

Riparian: Along or near the bank of a river.

Risk: The danger that injury, loss or damage will occur.

River Basin: An area of land drained by a river and its tributaries.

Rule of Reasonable Use: Use of water to meet natural wants and a fair share for artificial wants.

Runoff: That part of the precipitation, snow melt, or irrigation water that appears in uncontrolled surface streams, rivers, drains or sewers. Runoff may be classified according to speed of appearance after rainfall or melting snow as direct runoff or base runoff, and according to source as surface runoff, storm interflow, or ground-water runoff. (2) The total discharge described in (1), above, during a specified period of time. (3) Also defined as the depth to which a drainage area would be covered if all of the runoff for a given period of time were uniformly distributed over it.

Saturated Zone: The zone in which all interconnected pore spaces are filled with water, usually underlying the unsaturated zone.

Scenario: A plausible specific set of assumptions used to estimate future water withdrawals or future climate change.

Seepage: Movement of water through a porous medium, often used in the context of water movement from a groundwater system to surface water, or vice versa.

Self-supplied Water: Water withdrawn from a surface or groundwater source by a user rather than being obtained from a public supply. An example would be home-owners obtaining water from their own well.

Soil Moisture: Water content in a soil, usually expressed as a percent (by weight or volume.

Standard: A norm, consistent with identified principles, used to establish uniform criteria, methods, processes and practices. Standards also can serve as a basis of comparison to determine the adequacy of plan proposals to attain goals.

Strategic Plan: The long-term vision and goals of an organization or program and an outline of how they will be achieved.

Strategy: An action to implement a plan.

Stream: A general term for a body of flowing water; natural water course containing water at least part of the year.

Streamflow: The water discharge that occurs in a natural channel. A more general term than runoff, streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Subsidence: A dropping of the land surface as a result of groundwater being pumped. Cracks and fissures can appear in the land. Subsidence is virtually an irreversible process.

Surface Water: Water that is on the Earth's surface, such as in a stream, river, lake, reservoir or wetland. Surface water is naturally replenished by precipitation and naturally lost through evaporation to the atmosphere, discharge to the oceans, and sub-surface seepage.

Sustainability: Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs.

Sustainability of Water Supplies: The provision of dependable and adequate supplies of clean water to meet the demands of all users "in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social costs".

Sustainable Water Supply System: An example of a definition of a sustainable water supply system is one that functions in perpetuity; maintains the natural integrity of its waters and protects them from irreparable harm; distributes water equitably to sustain the good health and vitality of the living communities in its surrounding ecosystem; and continually monitors the natural resources it affects. All definitions of sustainability require explicit definition of key terms.

Thermoelectric Power Plant Water Use: Water used in the process of the generation of thermoelectric power. Nuclear power plants and plants that burn coal and oil are examples of thermoelectric-power facilities.

Transpiration: The process by which water that is absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface, such as leaf pores.

Unaccounted-for Water: The difference between the volume of water pumped into the distribution system and the volume of water sold or otherwise accounted-for (generally expressed as a percentage of total pumpage).

Unconfined Aquifer: An aquifer that has a potentiometric surface exposed to the atmosphere.

Wastewater: Water that has been used in homes, industries, and businesses that is not for reuse unless it is treated.

Water Availability: The amount of water in rivers, streams, lakes, reservoirs, and aquifers at a given time that is available to be withdrawn.

Water Conservation: Practices that promote the efficient use of water, such as minimizing losses, reducing wasteful use, and protecting availability for future use.

Water Cycle: The circuit of water movement from the oceans to the atmosphere and to the Earth and return to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transportation.

Water Demand: (1) The amount of water required by a water user or users at a specific point or area within a water supply system. (2) The amount of water required at a specific point or area within a water supply system to meet the requirements of a water user or users and allow for leakages and unaccounted-for water.

Water Distribution System: A group of water mains usually consisting of a network of piping, including transmission and distribution main which is designed to deliver water from water supplies to water users.

Water Resources: Sources of water that are useful, or potentially useful, to humans.

Water Storage: The amount of water in a reservoir, river, stream, lake, pond, aquifer or tank at a specified time.

Water Supply: The amount of water provided to meet water demand.

Water Supply Management: Actions, laws, regulations, strategies, policies etc. to develop the use of water and protect water resources.

Water Supply Planning: The process by which data are collected and processed to assess water demand and water-supply development alternatives.

Water Supply System: Facilities designed to collect, pump, and furnish a supply of water for meeting water demands.

Water Table: The elevation of fully saturated sediment or rock in a geological profile. The water table is the surface on which the fluid pressure in the pores of an aquifer is equal to atmospheric pressure.

Water Use: Water that is used for a specific purpose, such as for domestic use, irrigation, or industrial processing. Water use pertains to human's interaction with and influence on the hydrologic cycle, and includes elements, such as water withdrawal from surface and groundwater sources, water delivery to homes and businesses, consumptive use of water, water released from wastewater-treatment plants, water returned to the environment, and instream uses, such as using water to produce hydroelectric power.

Watershed: The land area that drains water to a particular stream, river, or lake. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge.

Well: An artificial excavation put down by any method for the purposes of withdrawing water from aquifers. A bored, drilled, or driven shaft, or a dug hole whose depth is greater than the largest surface dimension and whose purpose is to reach underground water supplies or oil, or to store or bury fluids below ground.

Wetland: An ecosystem whose soil is saturated for long periods seasonally or continuously, including marshes, swamps, and ephemeral ponds.

Withdrawal: Water removed from a ground- or surface-water source for use.

Yield: The amount of water that can be supplied from a reservoir, lake, stream, spring, or aquifer under explicitly stated conditions and assumptions.

Zone of Saturation: In a porous or fractured matrix, the interval where all interstices are filled with water. The surface of this zone is called the water table.

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REFERENCES FOR ADDITIONAL BACKGROUND INFORMATION

This report discusses findings involving several scientific fields. Because it is necessarily short and concise, useful background information about many subjects of potential interest to readers have been omitted or only briefly considered. This is particularly true of geological and environmental information because the report purposefully concentrates on the hydrological aspects of water resources. Hopefully, such shortcomings as the reader may find will be addressed by the more self-explanatory and comprehensive regional studies recommended here and in the Appendices and their references.

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APPENDIX 1

East-Central Illinois in Perspective

Contents

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Introduction

One reason for developing regional water supply plans is recognition of the diversity of environmental, social and economic conditions across Illinois. Agricultural East-Central Illinois, for example, is very different from the Chicago Metropolitan Area. Therefore, an underlying philosophy of this planning project involves making water supply plans for distinct geographic and hydrographic regions rather than applying a single statewide, "one-solution-fits-all" approach.

Water supplies are drawn from aquifers and from streams, reservoirs and lakes that occur within watersheds or river basins. In all regions, aquifers do not coincide with river basins, and neither aquifers nor river basins coincide with county boundaries. In the 15-county region of East-Central Illinois focus is on the Mahomet Aquifer System and the major river basins; the Mahomet Aquifer System includes the Mahomet Aquifer and the overlying shallow aquifers within the boundary of the Mahomet Bedrock Valley. There is considerable internal homogeneity within the region, but also considerable sub-regional diversity that needs to be considered in developing a regional water supply management plan.

This appendix describes geographical characteristics of East-Central Illinois that are relevant to water supply planning, focusing on groundwater resources. It also includes a summary of regional water use and water supply developments and issues in Champaign, McLean, Mason and Tazewell Counties to illustrate some important reasons for selecting East-Central Illinois as a priority water quantity planning area for the present study and necessary future investigations.

Geography of East-Central Illinois

The total area of the 15-county region is 6,394,936 acres (9,992 square miles) with a population of 1,033,772 in 2000. Average population density was 103.4 persons per square mile. Population ranged from 188,951 in Sangamon County to only 12,486 in Menard County. There were 8 communities with population greater than 30,000: Springfield, Champaign, Urbana, Decatur, Pekin, Bloomington, Normal and Danville [1]. The population of 1,033,772 in 2000 and the projected population of 1,221,729 in 2030[1] are far short of the population of 1,605,000 projected for the 15-county region in 2020 in the 1967 state water plan[2]. This illustrates the difficulties in accurately projecting future population and water demand.

The region is a glaciated plain formed by the last two continental ice sheets to enter the state. It is a terrain of near-level and slightly undulating surfaces rippled at intervals by nearly concentric curving lines of low hills – the glacial moraines that characterize the landscape of northeastern Illinois. Its western edge – the sandy dune lands of the Havana Lowlands in Mason and southern Tazewell Counties – is a wide, long floodplain scoured flat during the last glacial episode by a torrent of glacial meltwater descending the Illinois Valley. Elevations range from over 900 feet in southeast McLean County to less than 500 feet along the lower Sangamon River.

Present day surface drainage follows the south and westward courses cut by the meltwater streams draining off the ice fields into the tributaries and main valleys of the Illinois and Wabash Rivers. For the most part, the better drained lands are found in the older, more eroded glacial plain south and west of the Shelbyville Moraine. Behind (east of) the Shelbyville Moraine on the younger glacial plain, drainage was ponded in many local sags, depressions and glacial-like basins until the state's drainage laws were enacted in 1879. In the ensuing 30 years, most agricultural lands were tiled and ditched. Minor natural streams involved in these systems were straightened and deepened. The total effect has been to lower the water table generally and to hasten runoff, greatly affecting the recharge of shallow aquifers and stream regimens.

Land use in the 15-county region of East-Central Illinois is predominantly agricultural with corn and soybeans the main crops. Total harvested cropland in 2002 was 5,249,516 acres – 82.1 percent of the region – of which 150,880 acres, or 2.4 percent, were irrigated, mainly in Mason and Tazewell Counties[1].

The water resources, economy and society of the region are strongly influenced by climate and geology.

Underlying the region are layers of ancient bedrock millions of years old. In a few parts of the region, dolomite and sandstone yield potable water to wells. The bedrock is largely covered by many layers of mud, sand and gravel as much as 400 feet thick. These beds were laid down by glaciers, streams and wind, largely during and after the advances and retreats of three continental ice sheets. Gaining an understanding of the distribution and nature of glacial, proglacial and wind-borne materials provides the basis for understanding the major aquifers, streams, landscapes, and soils of the region[3,4]. The soils are some of the richest agricultural soils in the world and support high yields.

The Mahomet Aquifer extends across the region from the Indiana border to the Illinois River, ranges from 8 to more than 14 miles wide, and is complex in nature[4] (Figure 1 (page 3)and Figure 1.1). A simplified conceptual model shown in Figure 1.1. is the basis for the groundwater flow model of the Mahomet Aquifer System. This conceptual model is in turn a simplification of the hydrogeologic conceptual model of the region that is, in turn, a simplification of the geologic conceptual model of the region. This series of models represents the process of simplifying the complexities of the deposits in order to make the groundwater flow model more manageable.

The average thickness of the coarse-grained sand-and-gravel deposit that constitutes the Mahomet Aquifer is about 100 feet. It is buried about 100-200 feet below the surface in the eastern and central parts of the region, where smaller sand and gravel bodies – minor aquifers, younger in age – lie above it and occasionally intersect it. More often, several layers of fine-grained glacial till – gravelly, silt and clay muds – separate the Mahomet Aquifer from those above it[4]. Water moves/seeps very slowly through these fine-grained, compacted layers, and so they act as confining layers, slowing recharge to the Mahomet Aquifer and protecting it from surface pollution and the effects of climate variability.

The Mahomet Aquifer rests upon the surface and sides/walls of the underlying bedrock valley system.

Especially in the eastern and central parts of the Mahomet Aquifer, the groundwater it contains generally is 3,000 to 10,000 years. Scientists who determined the water ages reported that "Rain and snow that falls on the surface in Champaign County begins a roughly 3,000-year journey downwards to the Mahomet Aquifer, traveling at an average rate of less than an inch a year. Once it reaches the aquifer, it travels laterally in every compass direction but south. After about 7,000 years, water that journeyed westward seeps into the Illinois River along the river bottom near Havana, Illinois"[4]. Such were the natural predevelopment conditions, but these have been modified by groundwater development. It takes much longer to replace water taken out of storage from the more deeply buried, till-confined parts of the Mahomet Aquifer than it does to replace water withdrawn from surface waters and shallow unconfined aquifers.

In the Havana Lowlands in Mason and Tazewell counties, there are no confining layers of silt and clay covering the aquifer to impede the infiltration of precipitation. The aquifer's sands and gravels outcrop at the surface and this part of the Mahomet Aquifer system is an unconfined aquifer where recharge is direct and fast. These characteristics are the reasons why there is much crop irrigation in Mason and Tazewell Counties: the low water-holding capacity of the sandy soils makes irrigation beneficial and facilitates faster groundwater recharge.

Recharge to the Mahomet Aquifer in the eastern and central parts of the planning region generally is limited by the low permeabilities of overlying clay and silt beds – the confining layer(s). Where there are direct connections – overlapping contacts – between the Mahomet Aquifer and overlying shallow aquifers, recharge can be greater. Not all aquifer interconnections have been found, but they have been discovered to occur in several areas, such as is southwestern McLean County and along the Sangamon River in Piatt County. These interconnections have large effects on the flow patterns in the Mahomet Aquifer[5,6].

The second major source of potential recharge to the Mahomet Aquifer is leakage from streams that cut down into the Mahomet sands or into shallow sand bodies at or near their connections to the underlying Mahomet Sand. However, the reaches of streams and rivers where water can be induced into the groundwater system by pumping wells are generally limited. Stretches of three streams – Sugar Creek near McLean, the Sangamon River at Allerton Park, and the Middle Fork of the Vermilion River southeast of Paxton – have potential to leak large amounts of water into the aquifer. Other large streams such as the Illinois River, the Mackinaw River, and the lower Sangamon River flow in channels cut into the aquifer and serve primarily as groundwater discharge points.

The impacts of groundwater withdrawals and waste-water discharges on streamflow must be taken into consideration[5,6]. Groundwater discharges can help maintain low flows in receiving streams: Champaign-Urbana, for example, discharges treated waste water to the Salt Fork and the Kaskaskia River.

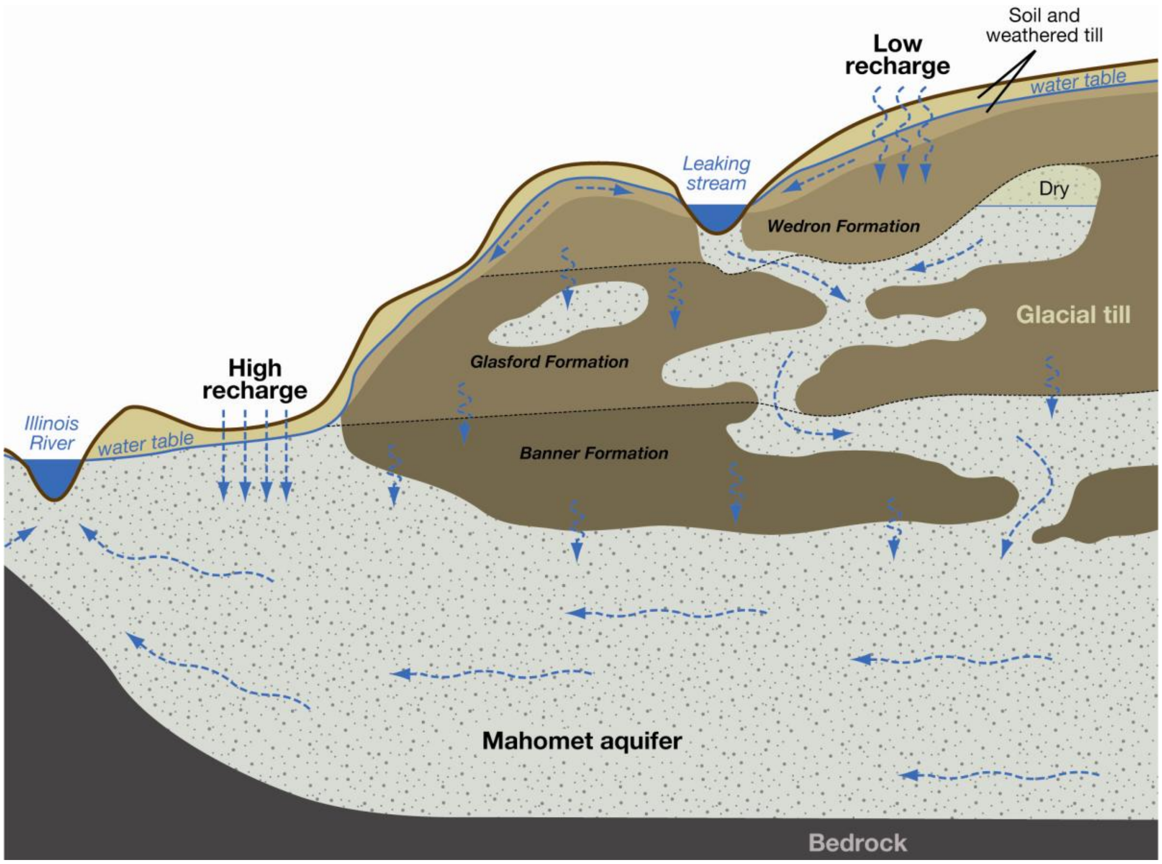

Figure 1.1. Schematic diagram of the Mahomet Aquifer System
(from the Illinois State Water Survey).

The water tables in shallow unconfined aquifers typically are highest in March and typically fall about 3.5 feet through autumn due to increased evapotranspiration and reduced recharge[7]. Similarly, streamflow in late summer typically is about 60 percent lower than in spring[7]. Changes in water levels caused by pumping water from aquifers and surface waters, discharging water to surface waters, and year-to-year climate variations are superimposed on this natural seasonal variability. In shallow, unconfined aquifers water levels typically have a range of about 5 feet or more from wet years to dry years (e.g., Snicarte in Figure 3 (page 9)).

The Mahomet Aquifer is one of the largest groundwater resources of the state.

Streams, reservoirs and lakes are other major source of water supply, especially for Springfield, Decatur, Bloomington, Danville and the nuclear power plant at Clinton. The region includes the Sangamon River Basin and parts of the Kaskaskia, Mackinaw, Vermilion (Wabash Basin), Vermilion (Illinois Basin), Embarras, Wabash and Iroquois River Basins. Because the land is quite flat and there are no deep river valleys, suitable sites for large reservoirs are limited, especially in headwater areas in the eastern half of the region.

The Sangamon River basin drains about 5,448 square miles in central Illinois (see Figure 1). The river is about 250 miles long and its watershed represents about 10 percent of the land area of the state. The basin is triangular in shape with a major east-west axis of about 120 miles and a minor north-south axis of about 90 miles. Drainage is generally from east to west. Land-surface elevation in the basin ranges from about 430 feet above mean sea level at the confluence of the Sangamon and Illinois Rivers at Browning to almost 930 feet at the crest of the Bloomington Moraine in McLean County. Major tributaries to the Sangamon River are Salt Creek (1,803 square miles) and the South Fork (1,180 square miles)[8].

Major parts of the Sangamon River Basin overlie the Mahomet Aquifer and there are important natural hydraulic connections between surface waters and groundwater. These connections are important from both a water quantity and water quality standpoint and are important considerations for water supply planning and management.. Also, there are important man-made connections between surface water and groundwater withdrawals: for example, the well field in DeWitt County operated by Decatur is used sporadically to supplement the water supply from Lake Decatur; LyondellBasell occasionally pumps groundwater from the Mahomet Aquifer near Bondville to supplement the surface water flow in the Kaskaskia River. Because of these hydraulic connections, groundwater withdrawn from the aquifers and discharges of treated and untreated groundwater can result in changes in streamflow.

Climate in the region typically is continental with cold winters, warm summers, and frequent fluctuations in temperature, precipitation, humidity, cloudiness, and wind. Average climatic conditions conceal large monthly, annual and decadal variations to which major businesses are highly sensitive[9,10,11].

Average annual temperature is about 51^{o}F in the north and 53^{o}F in the south. Average winter highs are in the 30s and average summer highs in the 80s. Days with sub-zero temperature occur occasionally in winter and days above 100^{o}F occur occasionally in summer. The average length of the growing season ranges from about 175 days in the north to 185 days in the south[9].

Average annual precipitation is about 40 inches per year in the east and south and 36 inches in the west. The highest annual precipitation recorded is over 50 inches, but it falls to less than 25 inches in a drought year. Multiple-year droughts have occurred, especially in the first 60 years of the 20th Century, and have had major effects on water availability and water demand[10,11]. High temperature and low precipitation typically diminish streamflow and the amount of water in lakes, reservoirs and shallow aquifers. Water availability in the deeper confined portions of the Mahomet Aquifer is thought to be much more resistant to climatic variations[5,6]. During hot and dry periods the demand for water from all sources increases.

Climate in Illinois has changed in the past due to natural factors and no doubt will do so again in the future. Future climatic conditions are highly uncertain due to natural variability and the possibility of human-induced climate change. Most global climate models suggest that average annual temperature in Illinois could increase by 0 ^{o}F to 6 ^{o}F by 2050. However, climate models are quite inconsistent in their projections of future precipitation in Illinois: some models show higher precipitation, and some show lower precipitation. Even in the absence of human-induced climate change, severe droughts may recur from time-to-time[10,11].

There are high concentrations of naturally occurring arsenic in some parts of the Mahomet Aquifer and the water tends to be “hard” (i.e., high concentrations of minerals)[4] . Water in streams, reservoirs and shallow aquifers is more susceptible to pollution and high concentrations of nitrate exceeding the drinking water standard occur occasionally in untreated water. All public water supplies must meet federal and state water quality standards, but private domestic supplies are unregulated.

Regional water withdrawals and use

The Illinois Water Inventory Program at the Illinois State Water Survey is a voluntary program to inventory water withdrawals throughout the state and was begun in 1978. For each water-using facility inventoried, the database includes locations and amounts of water withdrawn from surface water and groundwater sources, as well as significant amounts of water purchased from other facilities. Return flows are not subtracted from the withdrawal to determine water use; however, facilities with significant return flow are flagged for data retrieval to determine consumption. Agricultural uses of water for row-crop irrigation are not significantly tracked for a number of reasons, one being the lack of meters on irrigation wells. Livestock water use is similarly limited, while rural domestic uses are not inventoried. Water withdrawn for row-crop irrigation can be estimated from county-irrigated acreages and precipitation deficits. For the 2005 inventory, 89 percent of the questionnaires were returned and estimates were made to fill data gaps; the percentage of questionnaires returned for the 2008 inventory could be as high, but ultimately depends on the number of staff available to follow up on non-reporters. Data can be summarized geographically by county, township, and drainage basin, as well as by various water use and water source categories for inclusion in the National Water Information System[12]. Funding for the Illinois Water Inventory Program is unstable and its future in question.

An accurate and complete inventory of water withdrawals would provide a solid foundation for many applications, but an inventory of current withdrawals is only one factor in determining future water withdrawals. The inherent inability to predict future withdrawals accurately is due mainly to the large uncertainties and assumptions that have to be made about economic, demographic, social and climatic factors that drive water demand.

In total, about 1,783 mgd were withdrawn from groundwater and surface water in the region in 2005 and used for domestic, commercial, agricultural, industrial and recreational purposes. About 80 percent (1,315 mgd) was used for thermoelectric power generation and 20 percent (468 mgd) for public and domestic supplies, irrigation, agriculture, commerce and industry. The irrigation and agriculture figure included 226.5 mgd of water for crop irrigation, 2.4 mgd for irrigating 72 golf courses, and 4.2 mgd for watering a total of 785,410 dairy cows, beef cattle, hogs, horses, sheep and chickens[1].

The reported and estimated 468 mgd withdrawn for public and domestic supplies, commerce and industry, and irrigation and agriculture in 2005, a drought year, slightly exceeded the 1967 state water plan's projection of 453 mgd water demand for the 15 counties in 2020[2].

In 2005, some 947,000 people were served by public water supplies in the region and public water supply withdrawals were about 140 mgd. The Bloomington, Decatur, Springfield, Ashland and Danville service areas rely on surface waters and the remaining communities rely on groundwater. On average, each person served by public water supplies used 145 gallons of water per day, ranging from a high of 288 gallons in Decatur and 220 gallons in Beardstown to as little as 50 gallons per day in residual Menard County and 58 gallons per day in residual Vermilion County[1]. This range reflects variations in personal water use and the amount of water used for commercial and industrial purposes in each community [note: Decatur and Beardstown have large industrial facilities].

Many larger utilities supply water to communities within a service area. Some communities outside the Mahomet Aquifer are served by water pumped from the Mahomet Aquifer. Arcola, Tuscola and other communities to the east and south of Champaign, for example, are served with water pumped from Illinois American Water's wells near Champaign. LyondellBassell and Cabot Corporation in Tuscola occasionally use water pumped from the Mahomet Aquifer near Bondville that is transported south via the Kaskaskia River. The new ethanol plant at Gibson City will receive water pumped from the Mahomet aquifer near Paxton. Decatur has emergency wells in the Mahomet Aquifer in DeWitt County.

Within the region, an estimated 108,076 people obtained water from self-supplied domestic sources, mainly shallow wells, and used an estimated average of about 82 gallons per person per day for a total of 8.9 mgd[1].

Wittman Hydro Planning Associates, Inc. identified a number of factors to account for the historical changes in water withdrawals in the region[1]. The most important factor was population: more people use more water. But, as has been shown, the amount of water used per person varies considerably when commercial and industrial uses are included. Weather and climatic conditions, especially air temperature and precipitation, also have strong influences on overall per capita water use. Other major factors influencing water use are employment, income, the price of water, industrial processes, and conservation. Wittman Hydro Planning Associates, Inc. uses all these factors to construct scenarios of future water demand.

From 1985 to 2005 the population served by public water supplies in the region increased by about 106,000, or about 13 percent, and the amount of water used by the average person increased by about 11 percent[1]. Thus, the 25 percent increase in public water supplies of about 27 mgd could be accounted for by an increase in the number of people and an increase in the amount of water used by the average person.

The price of water is reported[1] to influence how much water is used in the region: the average person tends to use more water if it costs less, and *vice versa*. In 2005, the marginal price of water [defined as the difference in the total water bill between 5,000 and 6,000 gallons of monthly usage] ranged from a low as $0.85 in Watseka in Iroquois County to a high of $6.40 in Hudson in McLean County. The average marginal price across the region was $2.81, which declined slightly from $3.02 in 1985[1]. Thus, the slight decline in the price of water probably was one of the factors accounting for an increase in the amount of water used per person.

Family income also is reported to influence water demand[1]. Generally, the demand for water increases as income increases, and *vice versa*. In 2005, median family income in the region was $44,578, which in real dollars had increased from $42,781 in 1985[1]. Therefore, another factor accounting for the increase in the amount of water used by the average person since 1985 probably was an increase in family income.

Climatic conditions also have influenced water demand historically[1]. Especially in 2005, hot conditions throughout the region and drought, especially in the western counties, resulted in increased water withdrawals. Regional water withdrawals in 2005 (excluding water for electric power production) were about 130 mgd greater than they would have been in a non-drought year, and most of the increase was for irrigation. Peak day withdrawals for public water supplies typically are 50-100 percent greater than annual average day withdrawals. For irrigation, peak day withdrawals can be 700 percent greater than annual average day withdrawals.

The demand for water for residential, commercial and industrial purposes continues to increase. Some of the increasing water demand is to meet the needs of an increasing number of residents in the 15-county region and some is to meet the needs of people in other parts of the state, nation and world for water-consuming goods produced in East-Central Illinois; for example, large quantities of electricity, agricultural goods, processed food, and ethanol produced in the region are “exported”. Assuming that these exports will continue, this means that the future demand for water in the region must take into account East-Central Illinois’ role in meeting external demands for the region’s products, as well as the needs of the residents of the region.

Some water supply operators already have recognized the need to expand capacities for various reasons that include increasing water storage to be prepared for future droughts, increasing pumping capacity to meet growing peak day demands, and expanding water treatment facilities. Illinois American Water recently developed a new regional well field and expanded its water treatment capacity. Springfield and Decatur are seeking to expand their public water supplies and options include expanding reservoir capacities and withdrawing water from the Mahomet Aquifer, shallow aquifers and gravel pits. Bloomington also is evaluating a possible new regional well field in the Mahomet Aquifer. In the past few years, water withdrawals for irrigation have increased dramatically, in part due to the drought of 2005. New industrial plants, if built, would use additional amounts of water.

Population in the 15-county region of East-Central Illinois is expected to increase from 1.03 million in 2000 to 1.34 million in 2050 – a 30 percent increase[1]. By varying the values of some factors that change the average amount of water withdrawn by each person and including the impacts of drought and possible climate change, it is calculated, using data in the Wittman Hydro Planning Associates, Inc. report[1], that water withdrawals in the region (excluding electric power generation) could increase by 220 to 420 million gallons per day more than 2005 withdrawals of about 340 million gallons per day (adjusted to normal weather). This range of increase would be about 100 to 300 mgd above 2005 reported withdrawals of about 460 mgd, which was a drought year in parts of the region. Additional large withdrawals will be needed to meet peak season and peak day demands.

Using data in the Wittman Hydro Planning Associates, Inc. report[1], total water withdrawals for the 15-county region in 2005 and for three scenarios to 2050 are shown in Figure 1.2. – under normal (1971-2000) weather conditions and excluding water withdrawals for the electric power generation sector. Increased water withdrawals with drought conditions in 2050 for the Baseline (BL) scenario also are shown.

The BL scenario is a business-as-usual scenario. The Less Resource Intensive (LRI) scenario assumes less water demand and the More Resource Intensive (MRI) scenario assumes an increase in water demand. Population growth and the percentage of population employed are the same in all three scenarios.

The three public water supply factors whose values are varied in the scenarios are family income, water price and conservation. Family income is assumed to grow at 0.5 percent per year (in real dollars) in the LRI scenario and 1.0 percent per year in the MRI scenario. The price of water is assumed to increase at 1.5 percent per year (in real dollars) in the LRI scenario and is assumed to be constant in the MRI scenario. A combination of lower family income, higher water price, and more conservation in the LRI scenario lead to lower water demand. In the MR scenario, a combination of higher family income, constant water price, and less conservation lead to higher water demand.

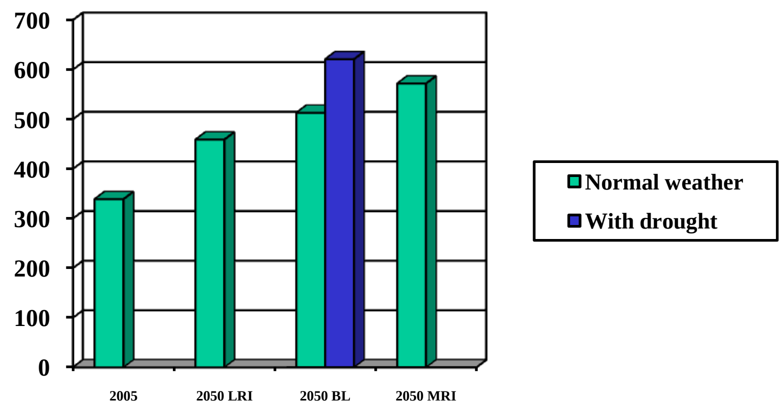

Figure 1.2. Water withdrawals (mgd) in East-Central Illinois in 2005, in 2050 for three scenarios (under normal weather conditions), and with drought conditions for the BL scenario.

In the self-supplied industrial and commercial sector, increasing water demand from the LRI to the MRI scenario is driven primarily by assumptions that the number of new water-intensive industries will increase, water use will be less efficient, and there will be less conservation. In all three scenarios, it is assumed that growth in health services will outpace retail trade growth and manufacturing will decline.

The major assumption accounting for increasing water demand from the LRI to the MRI scenario in the self-supplied irrigation and agriculture sector is a faster growth in irrigated cropland and golf course acres.

Total water withdrawals for each of the 15 counties in East-Central Illinois in 2005 (adjusted to normal weather conditions) and in 2050 are shown in Table 1 (excluding electric power generation). In 2005, 84 percent of total withdrawals occurred in Champaign, Macon, Mason, McLean, Sangamon and Tazewell counties. This percentage remains virtually unchanged in the three scenarios to 2050.

Using data in the Wittman Hydro Planning Associates Inc. report[1], total water withdrawals by water use sector are shown in Figure 1.3. for 2005 and for three scenarios to 2050 with normal weather conditions.

For electric power generation, it is assumed that future water withdrawals will continue to be from surface waters that serve six major thermoelectric power plants in DeWitt, Mason, Sangamon, Tazewell, and Vermilion Counties and a new clean-coal power plant with a closed-loop cooling system will be added in Woodford County[1]. These plants withdraw about 80 percent of all water in the region, but almost all withdrawals for once-through, electric power generating systems represent non-consumptive use, because nearly all the water withdrawn is returned to the source after passing through the condensers. A large but undetermined portion of the smaller withdrawals for three closed-loop, electric power generating plants is evaporated (consumed).

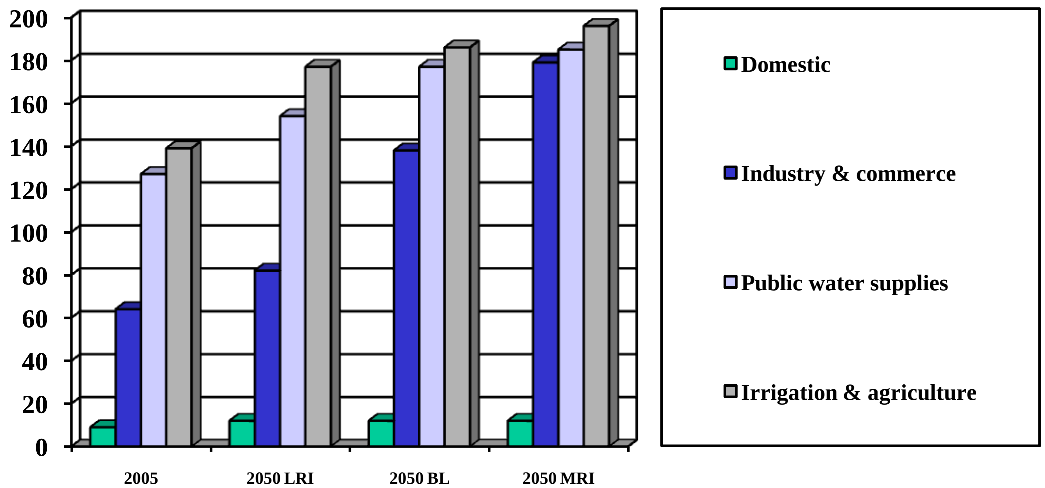

Figure 1.3. Water withdrawals (mgd) in East-Central Illinois by water use sector in 2005 and for three scenarios in 2050 (under normal weather conditions).

It is evident that many geographical, economic and social factors influence the demand for water in the region. The major variables identified that could result in a change in the average amount of water withdrawn per person each day and, hence, total water withdrawals are household income, the price of water, drought, an increase in temperature, employment and productivity, new industrial facilities, the number of irrigated acres, and water conservation. In the historical records and the scenarios water conservation is a relatively minor factor. Some of the factors – population, household income, climate, employment and productivity – are difficult to control. Water conservation and water prices are more amenable to control.

Growing water demand in Champaign and Mason and Tazewell Counties was one of the major reasons for selecting East-Central Illinois as a priority water quantity planning area. The following sections document the growing demand for water in these counties and exemplify the need for regional water supply planning.

County	2005 normal withdrawals	LRI 2050 withdrawals	BL 2050 withdrawals	MRI 2050 withdrawals
Cass	13	20	22	24
Champaign	35	46	52	57
DeWitt	2	3	3	3
Ford	5	9	10	12
Iroquois	6	8	9	10
Logan	6	8	10	10
Macon	38	51	59	68
Mason	94	111	117	125
McLean	18	26	30	32
Menard	3	4	4	4
Piatt	3	4	4	5
Sangamon	30	38	43	47
Tazewell	71	112	127	149
Vermilion	13	18	18	20
Woodford	4	6	6	6
TOTAL	**341**	**464**	**514**	**572**

Table 1.1. Total water withdrawals in millions of gallons per day (excluding electric power generation) for counties in East-Central Illinois in 2005 (adjusted to normal weather conditions) and three scenarios to 2050[1].

Water withdrawals in Champaign County

Large groundwater withdrawals at Champaign-Urbana began in 1885 when wells for a municipal supply were constructed in the shallow Glasford Aquifer. By the 1940s, water-levels in wells finished in the shallow aquifer near Champaign-Urbana had declined by 100 feet and were about 40 feet below the top of the aquifer (i.e., the aquifer was partially dewatered). Twelve municipal wells were drilled in the deeper Mahomet Aquifer between 1947 and 1964. Withdrawals from the shallow aquifer decreased and water levels in wells finished in that aquifer had increased by 55 feet in 1952, still some 45 feet below the pre-development level. In 1963 withdrawals from the Mahomet Aquifer in the Champaign-Urbana area were 17.83 mgd (9.29 mgd municipal and 8.54 mgd industrial) and water levels in wells finished in the Mahomet Aquifer had declined by 35 feet at Champaign-Urbana. Water levels in wells finished in the shallow aquifer declined by about 10 feet from 1954 to 1963. These data suggested to Visocky and Schicht that the Glasford and Mahomet Aquifers act as a single hydraulic unit under steady state conditions during periods of large groundwater withdrawals: pumping from the Mahomet Aquifer lowered water levels in both aquifers in the vicinity of the pumping[13].

In the 1960s, engineers and scientists at the Illinois State Water Survey developed an analog computer model to simulate groundwater flow in the Mahomet Aquifer System[13,14]. Withdrawals from the Mahomet Aquifer System in a 1,300 square mile area near Champaign-Urbana were stated to be 30.3 mgd (18.6 mgd municipal and 11.7 industrial). It was estimated that an additional 15.0 mgd would be needed by the year 2000, bringing total withdrawals to about 45 mgd. Predicted long-term pumping levels were calculated to further reduce water levels in the Mahomet Aquifer to the northwest of Champaign by about 30 feet and in the overlying shallower aquifer by up to 25 feet. Pumping levels for the additional wells would still be above the top of the Mahomet Aquifer.

Today, on an average day, Illinois American Water pumps some 23 mgd from the Mahomet Aquifer near Champaign to serve communities and commerce and industry in its service area, and some additional 16 mgd are withdrawn in Champaign County[1]. In 2007, water-level elevation (head) in the Petro North observation well on Rising Road, a few miles west of Champaign, was about 83 feet lower than the predevelopment (1930) water level (Figure 7 (page 17)). The current water level is about 80 feet above the top of the aquifer at that location. The historical records indicate an average drop in water level of 1.08 feet per year since 1930.

Illinois American Water has reported that it expects the average day pumping rate will increase to 26.8 mgd in 2016, with a peak day pumping rate of 44.6 mgd[15]. The capacity of Illinois American's 21 wells in 2006 nominally was about 45 mgd[16], although operational capacity was less, perhaps around 38 mgd. Accordingly, it can be estimated that Illinois American Water needs additional average day pumping capacity of about 7 mgd by 2016.

In forward simulations, Wittman Hydro Planning Associates, Inc.[16] used an average day pumping rate for Illinois American Water of about 35 mgd in 2004, 38 mgd in 2016 and 51 mgd in 2040. Analysis was conducted on the effects of Illinois American Water pumping an additional 16 mgd by 2040 (20 mgd from a new well field near Bondville and 4 mgd reduced pumping from existing wells).

It was concluded that pumping an additional 16 mgd would lower water levels in this part of the Mahomet Aquifer an additional 40-50 feet. Conditions were considered to be sustainable as long as water levels were predicted to remain above the top of the Mahomet Aquifer, i.e., the Mahomet Aquifer remains saturated. However, in this simulation, heads about three miles to the east of Petro North drop to the top of the aquifer and drop below the top of the aquifer in a worst-case scenario, i.e., the aquifer starts to become unsaturated, or partially dewatered. The analysis did not include additional withdrawals from the Mahomet Aquifer by other communities or industries out to 2040, or withdrawals from the Glasford Aquifer. It was recognized that increased pumping by other users would add to the drawdown caused by increased pumping of 16 mgd by Illinois American Water and "reduce the capacity of the aquifer system to yield water in the Champaign area and will exacerbate the effects of expansion of the ILAW source of supply". Also, it was concluded that "dewatering of shallow water-bearing zones will affect some local wells and will ultimately reduce the capacity of the Mahomet Aquifer due to decreased vertical leakage"[16].

Illinois American Water concluded that this level of pumping will be sustainable in Champaign County[15]. Wittman Hydro Planning Associates, Inc.[16] concluded that "the sustainability of Champaign-Urbana public water supply will likely be determined by what other people do". It should be noted that the Glasford Aquifer already is reported to be dewatered in at least one well in Champaign[17].

This brief overview illustrates evolving scientific understanding of groundwater resources and their development in Champaign County. Similar syntheses of the scientific understanding of surface water and other groundwater resources in the region would no doubt also reveal that management decisions are made utilizing the best available data at the time. The fact that data availability and analytical methods and tools change over time provides sound justification for supporting adaptive management.

The possibility of a new regional wellfield in McLean and Tazewell Counties

In 1993, with funding from the Long Range Water Plan Steering Committee, the Illinois State Water Survey and the Illinois State Geological Survey began a study of the aquifers in southwest McLean and southeast Tazewell Counties to estimate the availability of groundwater and determine the hydrogeologic feasibility of developing a regional water supply[18]. The study had two goals: (1) to determine the quantity of water a well field in the Sankoty-Mahomet Sand aquifer could yield; and (2) to determine the possible impacts to groundwater levels and existing wells that might occur in the Sankoty-Mahomet Sand aquifer and overlying aquifers from the development of a well field pumping 10-15 mgd. Hypothetical well field pumping of 15 mgd was simulated at four locations. The results varied from a maximum drawdown of 8 feet in the Hopedale scenario to 55 feet of drawdown in the Armington scenario. If a well field similar to the well fields modeled was installed in the study area, as many as 400 private wells may be impacted. In certain areas near the Mackinaw River, a well field would greatly reduce the groundwater portion of baseflow entering the Mackinaw River. Pumping three of the well fields together, at a total rate of 37.5 mgd, indicated that the aquifer should be able to sustain withdrawals in excess of 37.5 mgd, if the pumpage is distributed in the study area.

Irrigation in Mason and Tazewell Counties

In the Havana Lowlands – the sand plain underlain immediately by the unconfined aquifer in Mason and Tazewell Counties – a number of studies have been conducted to try to understand water budgets, yields and the impacts of increasing groundwater withdrawals.

Walker *et al*.[19] estimated that irrigation withdrawals for 1959 and 1960 in Mason and Tazewell Counties averaged about 0.25 mgd per year. The report indicated that long-term yield of the system was limited to recharge from precipitation. Recharge was estimated to be 10.3 inches per year for sandy soils and 2.6 to 5.7 inches per year where till overlies the aquifer. Regional recharge was estimated to be about 300 mgd on an annual average basis.

Bowman and Kimpel[20] estimated that groundwater withdrawals increased to about 106 mgd in 1989, a drought year.

The Imperial Valley Water Authority was established in 1989 to manage water in Mason County and four townships in Tazewell County. Since that time, irrigated cropland and the amount of water withdrawn for irrigation have increased greatly. In 1997, withdrawals were about 37 billion gallons during the June through September growing season (i.e., an average of 311 mgd through the growing season, or 104 mgd through the year). In 2005, a drought year, withdrawals were about 72 billion gallons (i.e., an average of 586 mgd through the growing season, or 196 mgd through the year, i.e., 65 percent of Walker *et al*.'s 300 mgd recharge estimate[19]). By 2007, withdrawals in a non-drought year had decreased to about 57 billion gallons (i.e., an average of 468 mgd through the growing season, or 156 mgd through the year). The highest monthly withdrawals of 942 mgd were in July 2005[20]. Irrigated cropland in Mason and Tazewell counties more than doubled from 76,352 acres in 1985 to 166,168 acres in 2007[1].

Historical records demonstrate declines in water levels in drought years. For the two-year period September 1995-August 1997, a total of only 53.01 inches of precipitation was recorded in the Imperial Valley area, which was less than the 55.08 inches recorded in 2004-2006, another drought period. Water level in the 42-feet deep Snicarte well did not drop below 40 feet in 1997, but the well dried out in 2006[22] and water level has since recovered[23]. The difference in water levels is perhaps due to a combination of heavier precipitation in 1992-1995 than in 2001-2004 and to 52 billion gallons of irrigation withdrawals in 1996 compared to 72 billion gallons in 2005[22].

A number of studies illustrate the complexity of understanding water budgets and the impacts of withdrawals for crop irrigation in the Havana Lowlands. Based on the development and application of a detailed numerical groundwater flow model for the sand-and-gravel aquifer, Clark [24] concluded that the Mahomet Aquifer contributed less than one percent of the total inflow to the larger aquifer system in the Havana Lowlands. Crane and Quiver Creeks and the Mackinaw River act as primary internal drainage streams, conveying more than 37 percent of the modeled outflow rising from the aquifer system. Total groundwater outflow from the aquifer system to the Illinois River was calculated to be 398 mgd: this is 33 percent greater than Walker *et al.'s*[19] calculated average annual recharge of 300 mgd and 6 percent greater than Clark's calculated recharge rate of 377 mgd. Clark estimated groundwater outflow to the Illinois River to be 20 percent of the 7-day, 10-year low flow of 1,971 mgd in the Illinois River at Beardstown. Maximum regional drawdown for the drought years of 1988 and 1989 was 8 feet and maximum regional drawdown for the simulation of two consecutive 1988 drought years (worst case simulation) was 15 feet; 14 interior half-mile stream reaches went dry. Drawdown was due to a combination of low precipitation and groundwater pumping. No data have been presented on streams going dry in drought years in the absence of irrigation pumping, or on the potential impacts on aquatic and riparian ecosystems of streams going dry.

Clark[24] also reported on earlier analysis by the Illinois State Water Survey using the Precipitation Augmentation for Crops Experiment (PACE) watershed model. For the 44 years of simulation (1950-1993), the calculated mean annual recharge rate was 9.4 to 12.6 inches for cropland in the Havana Lowlands. In 1956, a drought year, recharge was calculated to be only 1.6 inches, compared to 3.7 inches in 1988, another drought year. This demonstrates the sensitivity of recharge in the unconfined aquifer to variations in precipitation from year-to-year.

A study conducted by Sanderson and Buck in 1995[25] showed recharge rates in the range of 1.3 to 32.0 inches per year. The study concluded with the suggestion that extensive development of the groundwater resource for agricultural irrigation during the past three decades has not diminished the resource. The early 1990s was a time of high precipitation and withdrawals were much less than in recent years. The authors recommended that groundwater levels be considered during or following a significant drought period to monitor and document effects of the drought and the above average withdrawals for irrigation.

Wilson et al. recently reported on data collected from the Imperial Valley rain gauge network and groundwater observation well network for September 2005 through August 2006[22]. A purpose of the networks is to collect long-term data to determine the impacts of groundwater withdrawals in dry periods and during the growing season, and the rate at which the aquifer recharges. It was concluded that 2005-2006 groundwater levels continued to decline because of below-average precipitation. However, no methodology was presented to separate out the influences on water levels of below-average precipitation and water withdrawals.

A thorough understanding of relationships among precipitation, evapotranspiration, groundwater levels, stream flows and water withdrawals remains to be developed. Such an understanding is necessary to be able to understand the natural variability of the system and the impacts of groundwater withdrawals on streamflow and aquatic and riparian ecosystems.

The calculated recharge rates by Walker *et al.*[19] of 300 mgd and Clark[24] of 377 mgd are annual averages. However, there are strong seasonal influences upon recharge, withdrawals and lowering of water levels that available annualized averaged withdrawals do not describe. Water levels are naturally lowest in summer, when evapotranspiration is highest and recharge lowest. Water for irrigation is withdrawn only during summer. What is needed to evaluate the impacts of withdrawals and sustainable yields is for a groundwater flow model to simulate reasonably accurately the natural seasonal hydrological cycle and inter-annual drawdown of groundwater levels and streamflow due to severe drought. This will provide a control run. Seasonal irrigation withdrawals then can be added in a second model run to simulate combined drawdown due to climate variations and water withdrawals. The difference between the two model runs will allow determination of drawdown due to water withdrawals. It is likely that the greatest drawdown will be associated with peak day withdrawals in summer.

In 2005, withdrawals averaged 196 mgd – considerably less than the estimated annual average recharge rate of between 300 and 377 mgd. It is reasonable to conclude from this that such withdrawals do not exceed the annual average recharge rate and are sustainable. However, during the 2005 summer growing season withdrawals averaged 586 mgd – well above the calculated annual recharge rates – and peak day withdrawals were almost one billion gallons. So it must be asked, what is the summer recharge rate and drawdown in a more severe drought year such as 1956, and how much additional drawdown can be tolerated with heavy pumping, given the fact that the aquifer is likely to replenish itself with a return to normal precipitation?

Conclusions

The geographical information and the groundwater case studies, one in the eastern part of the region and two in the west, illustrate a diverse set of water resource conditions across a region with similar climate conditions. They also demonstrate why it is important to consider interactions between climate, surface water, groundwater and social, economic and environmental factors in the development of water supply management plans. Although fresh, potable water is ordinarily a renewable resource in our region, thought always must be given to the potential impacts of withdrawals and determination of sustainable yields.

Some 40 years ago, Illinois State Water Survey engineers reported that the potential yield that could be developed from the confined portion of the Mahomet Aquifer was about 445 mgd[13]. They noted that an estimated 40.2 mgd – a mere 9 percent of the potential yield – were withdrawn in 1965[13]. If Walker *et al.'s* annual average recharge estimate of about 300 mgd for the unconfined portion of the Mahomet Aquifer[19] is added to the potential yield from the confined portion of the Mahomet Aquifer, this raises the potential yield for the whole aquifer to about 745 mgd.

In 2005, a drought year in parts of the region, some 350 mgd were withdrawn from aquifers in the 15-county region[26]. The MRI scenario of water demand in 2050 under drought conditions and with an increase in temperature of 3°F suggests that groundwater withdrawals in the 15-county region could increase to more than 400 mgd.

Although the potential yield of the Mahomet Aquifer is large, withdrawals and the impacts of withdrawals are not distributed uniformly across the region or throughout the year. The largest withdrawals are in the unconfined portion of the Mahomet Aquifer in the Havana Lowlands, but drawdown currently is greatest in the confined aquifer in Champaign County. It is timely, therefore, to continue to evaluate the challenges and opportunities for water resources development and protection in the region.

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26. Surface water withdrawals were subtracted from total non-power plant withdrawal data[1] to obtain an estimate of groundwater withdrawals.

Appendix 2

An Overview of Water Supply Planning and Management Relevant to East-Central Illinois

Contents

Page

Introduction

Water supply planning is not new in Illinois. Although a constituent-based, regional water supply planning approach is new to most of Illinois, other states already have adopted this approach. This chapter provides, in chronological order, historical information on water supply planning and management in Illinois relevant to East-Central Illinois.

Early planning efforts

Water supply planning has long been characterized by a complex interplay among federal, state and local interests and authorities supported by scientific and engineering studies.

In Illinois, most water supply planning and management has been conducted in piecemeal manner at the local level. There are a few exceptions. Upon completion of the Chicago Sanitary and Ship Canal in 1900 the Chicago River was reversed, thus enabling the diversion of water from Lake Michigan. The water permitted to be diverted from Lake Michigan and its watershed is apportioned by the State of Illinois among municipalities, political subdivisions and agencies in the region for domestic use or for direct diversion into the Sanitary and Ship Canal to maintain it in a reasonably satisfactory sanitary condition, in such manner and amounts and by and through such instrumentalities as the state may deem proper, subject to any regulations imposed by Congress, in the interests of navigation or pollution control[1].

Historically, groundwater and surface water have to a large extent been managed separately, despite being interconnected.

As long ago as 1920, Illinois State Water Survey Chief Arthur M. Buswell proposed a comprehensive survey of the volume of groundwater available in Illinois. Twelve years later, Buswell broadened his proposal to include all the state's water resources and to estimate future demand. Although this project was included in the budget requests for several years, it was not funded[2].

Studies by Illinois State Geological Survey scientists and engineers, such as the work of Horberg in the 1940s and 1950s[3,4], provide a foundation for our current understanding of the glacial geology of the Mahomet Aquifer system in East-Central Illinois [i.e., the Mahomet Aquifer and overlying shallow aquifers within the boundary of the Mahomet Bedrock Valley]. In recent years, the Illinois State Water Survey has integrated geology, hydrology and climatology to provide a comprehensive framework for regional water supply planning. At both the Illinois State Water Survey and Illinois State Geological Survey the development and application of mathematical computer models has enabled the integration of the knowledge base in these disciplines and the simulation of possible future environmental conditions.

Institutional and legal changes to manage water supplies also have occurred. In 1948 The Association of Illinois Soil and Water Conservation Districts was formed. It is made up and serves Illinois' 98 Soil and Water Conservation Districts (SWCDs). Each SWCD is a unique local governmental entity mandated by state statute to protect the land, water and related resources located within its borders. Emphasis is on local control and local solutions[5].

The Water Authorities Act of 1951 allowed the establishment of water authorities with broad powers of control over local water supplies, excluding water used for agricultural and most domestic purposes[6]. The powers include the following requirements: the provision by well owners of data and information on water supply, withdrawals and use; the registration of withdrawal facilities; the permitting of withdrawals; the reasonable regulation of water use; the levy and collection of a general property tax; and approval of water facility plans by the Environmental Protection Agency. Today, there are 17 Water Authorities in Illinois, including 13 in East-Central Illinois.

Late 19th century legislation created extensive changes in local landscapes and initiated the organization of many local governmental units managing surface water drainage improvements.

> "These units have their beginnings in the Levee Act and the Farm Drainage Act which became law in 1879 and provided for the construction, reparation and protection of drains, ditches and levees, across the lands of others, for agriculture, sanitary and mining purposes, and to provide for the organization of drainage districts. As the need became more evident, more Acts providing for Sanitary Districts, Surface Water Protection Districts, River Conservancy Districts, Soil Conservation Districts and Public Water Districts were passed by the Illinois legislature. The Act closest in area of jurisdiction to the Water Authorities Act is the Public Water Districts Act of July 25, 1945 which provides areas having a population of not more than 500,000 inhabitants with powers to construct or acquire "Water works properties," and by amendment of July 16, 1951, "sewerage properties" "[7].

The establishment of water authorities and communities taking their own actions to control development near their water supply facilities are reflections of local efforts to protect local interests. A goal of regional water supply planning is to facilitate communication and cooperative management among all local interests for a common good, not to usurp local powers and authorities.

The 1967 state water plan

Recognizing a need for a state water plan, Governor Otto Kerner in 1965 designated Water Survey Chief William C. Ackermann as director of a task force to formulate a comprehensive state plan for water resources[2]. A state water plan was released in 1967[8] and included a recommendation for the state to initiate an integrated and intergovernmental approach to the management of water resources of each region, including the establishment and support of regional water resources commissions. This ambitious and costly state water plan was largely a top-down approach driven by state officials.

In the state water plan, 1965 population of the 15-county region of East-Central Illinois population was given as 745,200 with municipal, industrial and rural water withdrawals of 183 mgd. Population in 2020 was projected to be 1,605,000 with a water demand of 453 mgd. The plan identified many potential reservoir sites of 40 acres or more with a total yield of about 212 mgd in a 1 in 40 year drought. Potential water supplies from major streams (with 95 percent availability) were given as 13,640 mgd and potential practical sustained yields of groundwater supplies as 1,135 mgd. About 98 percent of the streamflow sources were in Cass, Mason, Tazewell and Woodford Counties, which also contained 43 percent of the groundwater potential yields. It was concluded that the increased demands to 2020 were generally within the capability of the resource[8].

The 1967 plan provided policy and program guidance in water resources management through state agencies for such matters as groundwater protection, competition for water, erosion and sediment control, flood damage mitigation, water conservation, aquatic and riparian habitat, recreation, climate change, drought and emergency interruption of supplies and water use law. It recommended that the legal framework governing water be designed so as to create a legal environment which would promote, not restrain, optimum water management; otherwise, it apprehended that the legal framework would be the result of discontinuous, piecemeal development based on short-range considerations and crisis planning. A better state water resources planning program also was recommended.

The 1980 state water plan

Recognizing that the 1967 plan had become increasingly obsolete and observing a trend to shift water resources planning from the federal to state level, Governor James R. Thompson appointed a Task Force in 1980 to produce a new state water plan, primarily to develop an improved water management system[9]. The Task Force consisted of policy-level individuals from state water agencies who sought outside advice, conducted public hearings, and organized 5 regional advisory committees. The problems addressed were of statewide importance, but a detailed inventory of water resources was not required.

Since 1980, the Illinois State Water Plan Task Force has coordinated the activities of state agencies and served as a valuable forum for discussion. The Governor's Drought Response Task Force meets as needed to monitor the conditions of the state's water resources and systems and coordinate the state's response to drought situations. Beck *et al.*[10] reported that the State Water Plan Task Force has identified the lack of statutory authority to take more action to alleviate water shortage problems as the most important weakness of the Drought Response Task Force.

The 1983 Water Use Act

The Water Use Act of 1983[11] brought Illinois under a unified doctrine of common law which covers the development and use of both surface water and groundwater resources. This doctrine is based on the riparian doctrine of reasonable use. Some important aspects of the Water Use Act of 1983 are listed below[10,12].

- Water is a common resource to be shared by all for beneficial use; individuals do not own water rights as they do in some other states.

- The terms "riparian landowner" and "overlying landowner" are considered interchangeable in Illinois water law doctrine.

- All riparian landowners and overlying land owners are entitled to a reasonable use of water in streams and aquifers respectively.

- Reasonable use means the use of water to meet natural wants and a fair share for artificial wants. The key words of this definition are "natural wants" and "artificial wants", which are not defined further in the Act. These terms or words also are not defined or used in any of the leading common law groundwater cases in Illinois. However, it has been reported[13] that these terms were clearly defined in Illinois common law in the 1842 Illinois Supreme Court case of *Evans v. Merriweather.* In a discussion of various common law rules of groundwater rights[10], reference is made to a discussion by Mann *et al*. [13]. In this discussion, the authors summarized the court's definition of natural uses as quenching thirst, for household purposes, and for cattle and other domestic purposes. It specifically excluded water for irrigation and water used for propelling machinery. The authors felt that domestic use was limited to uses of persons living on proprietors land and questioned whether the court meant to include large commercial herds of cattle.

- Wasteful or malicious uses of water are unreasonable.

- The priority uses in times of shortage are natural wants (i.e., domestic uses).

- In the case of a complaint, courts are allowed to consider the relative needs of landowners in order to determine the reasonable artificial uses of water.

- The state does not require registration or permits for allocation of surface water or groundwater withdrawals.

- The lowering of the water table or reduction in water pressure by a groundwater user that reduces or eliminates the use of a neighbor's well is not necessarily unreasonable.

- Seniority in length of use does not increase the right of use.

- The right to transport water for use or sale away from overlying land does not exist without statutory authority.

- The state can encourage but not require effective planning by water supply planners and users.

- There is no general statute in Illinois allowing comprehensive water resource management at the state level.

- Drainage law usually is not included with water quantity law.

- The state does not have statutory authority to intervene in water conflicts between water development entities.

- The General Assembly has authority to modify Illinois water law, but vested interests must be protected. Even under present law, courts in other jurisdictions have determined that the right of the riparian owner is not absolute; it is conditioned on the equal right of every other riparian owner to the use of water[10]. "Thus, if the modifications simply further define and clarify what is considered "reasonable" – an arguably nebulous and uncertain area under present law – persuasive argument can be made that no valid constitutional problems should arise" to the modification of riparian rights[10].

An important component of the Water Use Act is to establish a means of reviewing potential groundwater conflicts before damage to any person is incurred and to establish a rule for mitigating groundwater shortage conflicts. In the event that a land occupier or person proposes to develop a new point of groundwater withdrawal, and withdrawals from the new point can reasonably be expected to occur in excess of 100,000 gallons on any day, the land occupier or person is required to notify the Soil and Water Conservation District before construction of the well begins. The District in turn is required to notify other local units of government with water systems which may be impacted by the proposed withdrawal. The District then is required to review with the assistance of the Illinois State Water Survey and the Illinois State Geological Survey the proposed point of withdrawal's effect upon other users of the water. The findings of such reviews are to be made public. However, this is an unfunded mandate for the Soil and Water Conservation Districts and the Scientific Surveys and reviews are not conducted.

Statutory law and case law, policies, legal opinions, and court decisions guide water management in the state. Management practices are implemented through the state's water management institutions that include public and private entities operating at state, regional and local levels. The policies, regulations, and actions of the management institutions directly and indirectly influence the interface of the demands of water users and the supply of the state's groundwater and surface water resources[10].

Stress on water resources, highlighted by the 1988 drought, led to Governor Jim Edgar's 1992 appointment of a Water Resources and Land Use Priorities Task Force. The Task Force concluded[14] that competition for available water supplies will generate increasing levels of conflict in the context of existing law, especially during droughts. The first recommendation of the Task Force was adoption of a consolidated water resources act, but there was agreement among legislators that sound scientific information on the state's water resources was needed before a comprehensive act could move forward.

A 1996 report on water quantity law[10] – the result of a Task Force recommendation – identified the fractured nature of water use law in Illinois and noted that water quantity law was not comprehensive, was located in numerous areas of the law that divided responsibilities among many state agencies, and was governed to a significant degree by common law and court precedent. It was concluded that elements of the law are outdated, confusing, misinterpreted, or not aligned technically with contemporary water management. The law is fraught with uncertainty and provides users of water with only limited guidance to answering many issues that will likely arise in the future. The authors expressed the opinion that, as demand for water escalates, water users will increasingly look to the courts to resolve disputes.

Entering the 21st century

The Mahomet Aquifer Consortium was formed in November 1998 to further study the Mahomet Aquifer on a regional basis and to develop options for the management of this valuable resource[15]. The Consortium facilitates communication and cooperative management among local interests for a common good, has more than 70 members and the members meet quarterly. Activities to date have focused on further studying the Mahomet Aquifer, but the Mahomet Aquifer Consortium's current role in supporting and facilitating the establishment and work of the Regional Water Supply Planning Committee moves it a step forward in its mission to develop options for the management of the Mahomet Aquifer.

On 6 June 2000, Governor George H. Ryan established a Governor's Water Resources Advisory Committee to focus on water resources and their usage, including water usage by peaker power plants. The Committee met several times, did not produce a report, but identified 12 consensus principles for water supply planning and management.

On 22 April 2002, Governor George H. Ryan signed Executive Order 2002-5 requiring the Interagency Coordinating Committee on Groundwater, chaired by the Illinois Environmental Protection Agency, to report each January on progress in establishing a water quantity planning procedure[16]. Initially, an Interagency Coordinating Committee on Groundwater sub-committee chaired by the Illinois Department of Natural Resources was charged to produce an integrated water resources agenda (groundwater and surface water) and a report assessing the state of water supplies in the state. Building on the consensus principles identified by the Water Resources Advisory Committee, the report of the subcommittee argued that expanded, regional water quantity planning and management is needed to address some of the critical water conflicts emerging in Illinois and recommended an interim framework for establishing regional water management consortia to begin planning[17]. The consensus principles of the Water Resources Advisory Committee can be found on page 10 of the subcommittee's report.

The Interagency Coordinating Committee on Groundwater accepted most of the recommendations of the Subcommittee on Integrated Water Planning and Management and found that the operating principle for water supply planning is simple: the necessary groundwork – including extensive stakeholder involvement – must be developed first, before moving into legislative and regulatory solutions. The Interagency Coordinating Committee on Groundwater and its Groundwater Advisory Committee stated that a new paradigm is essential to get concurrence from constituent groups, including both private and governmental special interest groups and the public, by creating consensus on a planning procedure. Initiating discussion of proposed solutions driven by legislative and regulatory proposals to identify program parameters, without having a defined planning procedure, has proven, historically, to be an arduous task with unpredictable outcomes. As priority water quantity planning areas are identified, the Interagency Coordinating Committee on Groundwater recommended that the state should nurture the development of voluntary, cooperative regional water management consortia in those areas by providing technical and financial assistance for planning and management efforts[18].

In November 2001, the Illinois State Water Survey and Illinois State Geological Survey produced reports on the scientific needs for improving water supply planning and management[19,20] in response to May 2001 resolutions passed by the General Assembly: Senate Resolution 0137 and House Resolution 0365. In 2006, the Illinois State Water Survey published a framework for drought and water supply planning[21]. In response to the recommendations of the Interagency Coordinating Committee on Groundwater[18] and the Subcommittee on Integrated Water Planning and Management[17], the Illinois State Water Survey identified priority aquifers and watersheds for water supply planning[22]. Two priority areas were Northeastern Illinois and East-Central Illinois. East-Central Illinois was identified as a priority water quantity planning area because of expanding use of the Mahomet Aquifer, the aquifer's connections to shallower aquifers and surface streams, especially the Sangamon River, and proposals to develop new groundwater and surface water supplies.

Functions of water agencies

Today, numerous institutions are involved in some facet of water supply planning and management[23]. Most are government entities, but some are private corporations with which municipalities contract. It is handy to think of them on geographical scales: municipal, regional, state, interstate, and federal.

Municipalities, the smallest entities, have control over local water supplies and waterworks. These either operate as local public agencies or as corporations with which the municipality contracts for water. There are more than 1,800 virtually autonomous community water systems in Illinois, each created under separate statutes that provide them with different and sometimes overlapping and conflicting powers[10].

The Illinois Municipal Code (65 ICLS 5)[24] allows corporate authorities to (1) provide for a supply of water by the boring of artesian wells, or by the digging, construction, or regulation of wells, pumps, cisterns, reservoirs, or waterworks, (2) borrow money for these purposes, (3) authorize any person to bore, dig, construct, and maintain the same for a period not exceeding 30 years, (4) prevent the unnecessary waste of water, (5) prevent the pollution of water, and (6) prevent injuries to the wells, pumps, cisterns, reservoirs, or waterworks. The jurisdiction of the city or village to prevent or punish any pollution or injury to the stream or source of water, or to waterworks, extends as far as the waterworks may extend. Each city or village may go beyond its corporate limits to acquire and hold property for the purpose of establishing and operating water works. In the past, concerns about development of groundwater supplies have caused more than 15 communities in East-Central Illinois to invoke the Illinois Municipal Code to try to control groundwater resources development near their wells and well fields[25].

Regional water entities comprise the next spatial group. Illinois has five types: 1) regional water commissions that serve two or more municipalities, 2) water service districts for unincorporated areas, 3) public water districts, 4) water authorities that mix municipalities and rural areas, and 5) river conservancy districts. The Rend Lake Conservancy District, formed in 1960 and is an example of the latter type. It led to the construction of Rend Lake in the 1960s and subsequent development of an intercity water system that supplies water to six southern Illinois counties.

The state of Illinois has several agencies that deal with water supplies. The Illinois Department of Natural Resources is the primary water quantity management agency[26]. First formed in 1823, the Office of Water Resources has a long history beginning with flood control and navigation issues that later grew to include regulation of streams and rivers, locks and dams, construction issues, water conservation, the National Flood Insurance Program and more. There are certain public rights in public waters that are reserved for the citizens of the state and the Office of Water Resources issues permits for activities in and adjacent to the public waters of the state – 8 percent of the total stream miles in the state. Public waters generally may be described as the commercially navigable lakes and streams and the backwater areas of those streams. A list of the public waters of the state is provided[27]. Pursuant to the 1911 Rivers, Lakes and Streams Act [615 ILCS 5], proposed activities in and adjacent to public waters are reviewed to ensure that the public's rights are not diminished by the activities. The maintenance of minimum instream flows in public waters is regarded as a benefit to the public and low flows are protected. Permits are issued to demonstrate that proposed activities do not diminish the public's rights; they are not issued to allocate water use. However, this regulation can pose limitations for obtaining water supply from major public rivers, especially during periods of drought. In East-Central Illinois, the Illinois River, the Lower Sangamon River to approximately one mile south of Mechanicsburg Road bridge, and the Sangamon River South Fork to approximately two miles upstream from the mouth are classified as public waters of the state.

Minimum instream flow in public waters generally is defined as the average flow measured during the 7 consecutive days of lowest flow during any given year. The 7-day 10-year low flow (Q7,10) is a statistical estimate of the lowest average flow that would be experienced during a consecutive 7-day period with an average recurrence interval of ten years. Low flow maps for streams in East-Central Illinois have been published by the Illinois State Water Survey[28]. The Q7,10 protected flow is considered an interim surrogate value where there is insufficient information to define instream flow needs.

The Q7,10 values are affected by natural climate variability, withdrawals, return flows, and streamflow regulation. Because the Q7,10 values can change over time, they are updated approximately every 15 years to account for changes in low flow conditions. Over the past several decades, average streamflow amounts and low flows have increased due to an increase in precipitation; but the first half of the 19th Century was much drier and streamflows were lower (Appendix 1). If such historical dry conditions recur in the future, it could be questioned whether low flows established for a recent 10-year wet period would continue to be appropriate for water resources management. Low flows are expected to increase in streams that receive substantial increases in wastewater discharges.

The Illinois Environmental Protection Agency ensures that (1) Illinois' rivers, streams and lakes will support all uses for which they are designated, including protection of aquatic life, recreation and drinking water supplies, (2) every Illinois Public Water system will provide water that is consistently safe to drink, and (3) Illinois' groundwater resource is protected for designated drinking water and other beneficial uses[29].

The Agency conducts a groundwater protection program with a mission of restoring, protecting and enhancing the state's groundwater as a natural and public resource[30]. The program derives much of its program authority from the Illinois Groundwater Protection Act that emphasizes a prevention-oriented process and relies on a state and local partnerships. The program focuses upon uses of the resource and establishes statewide protection measures directed toward potable water wells[31].

Integration of wellhead protection programs are implemented for community water supply wells in priority groundwater protection planning regions. In general, the first step of developing a groundwater protection program involves determining the recharge area for the wells in unconfined aquifers utilizing existing aquifer property data. The recharge area is based on a five-year time of travel delineation. The second step involves determining the potential sources, potential routes, and the land use zoning within these recharge areas. The Central Groundwater Protection Planning Region includes Peoria, Tazewell, Woodford and Mason Counties[32].

The Illinois Environmental Protection Agency implements permit programs to regulate wastewater discharges and stormwater runoff to Illinois streams and lakes, including storm water runoff. Permits can also provide the facility owner with an approval of the treatment systems about to be built[33]. The Agency also is responsible for monitoring the quality of Illinois' surface water resources[34] and implements watershed management programs[35]. A list of impaired waters has been produced[36] and reports on total maximum daily loads of specified pollutants have been prepared for lakes, streams and watersheds in East-Central Illinois[37]. A total maximum daily load evaluation determines the greatest amount of a given pollutant that a water body can receive without violating water quality standards and designated uses. Pollution reduction goals then are set to improve the quality of impaired waters. Low flows are used in the application of water quality standards.

The Illinois State Water Survey[38] and the Illinois State Geological Survey[39], divisions within the University of Illinois at Urbana-Champaign, collect data and conduct research, as do several other academic institutions.

Under the 1970 Environmental Protection Act, the Illinois Pollution Control Board is responsible for adopting Illinois' environmental regulations and deciding contested environmental cases[40]. The Illinois Environmental Protection Act, under Title IV, indicates that there should be continuous operation and maintenance of public water supply installations in order to protect the public from disease and to assure an adequate supply of pure water for all beneficial uses. This concept is carried forward in the Pollution Control Board Rules, in particular 601.101. This could be interpreted as a 100 percent dependability standard.

The Illinois Department of Agriculture[41] implements the Cooperative Groundwater Protection Program (8 Illinois Administrative Code 257) that establishes a potable water supply well setback zone for a community water supply well. The Department also distributes funds to Illinois' 98 Soil and Water Conservation Districts for programs aimed at reducing soil loss and protecting water quality. It also helps to organize the state's annual soil survey to track progress toward the goal of reducing soil loss on Illinois cropland to tolerable levels.

A major consideration in constructing new wells is to prevent contamination from entering the well. To ensure the safety of these water supplies, the Illinois Department of Public Health[42] and local health departments review water well installation plans, issue permits for new well construction and inspect wells, and deal with the sealing of abandoned wells. The Department also oversees construction and operation of non-community public water systems to make sure water is safe to drink and use.

The Illinois Commerce Commission[43] regulates 33 water, 5 sewer, and 14 investor-owned, combination water and sewer utilities that provide water service to almost 1.15 million people. The Commission also provides comparisons of water and sewer rates.

Interstate compacts comprise the next spatial level of institutions. Illinois is a member of compacts with Missouri, Indiana, the Great Lakes states, and Ohio River states, and these groups deal with regional water issues.

Beck *et al.*[10] discuss federal control of water in Illinois. At least six federal agencies have powers and activities affecting the water supply of Illinois. These include the U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, and the Departments of the Interior, Agriculture, Commerce, and Housing and Urban Development. Many of these institutions interact directly with Illinois state agencies. The U.S. Supreme Court also makes decisions relating to the use and allocation of water supplies. In 1992, the Federal Energy Policy Act[44] established national water efficiency requirements on new and renovated residential and non-residential facilities.

Conclusions

The all-embracing nature of the water cycle and the wide-ranging characteristics of aquifers and watersheds necessitate consideration of time and space scales that are long and broad. Regional water supply planning and management provides an opportunity for all constituents in East-Central Illinois to improve communication and coordination in identifying and addressing issues that transcend local, short-term interests and authorities, but does not detract from these authorities.

Executive Order 2006-01[45] embodies many lessons learned from earlier initiatives in Illinois. In implementing the Executive Order, the Illinois Department of Natural Resources, Illinois State Water Survey, Illinois State Geological Survey and the Regional Water Supply Planning Committee are drawing on lessons learned from other states that have well-established regional water quantity planning procedures, especially from Texas. Texas has a comprehensive, regionalized, stakeholder-to-state-bureau management system coordinating the planning of its many different and variously stressed regions.

Executive Order 2006-01 can be viewed as a continuation of a 50-year trend towards improved water supply planning and management in Illinois. The Foreword to the 1967 State Water Plan[9] began with the assertive statement that “Illinois must plan the long-range development of its water resources, if the state is to meet the needs of the future.” Forty years later this challenge remains.

It is clear from the long history of local action and management in Illinois that the success of any future effort to organize the management of water resources must include the provision of responsible roles for all stakeholders.

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