STRATEGY FOR THE PROTECTION OF UNDERGROUND WATER IN ILLINOIS

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By

The Illinois State Water Plan Task Force

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Statement of the Problem

Concern over the protection of underground water is widespread and growing. The addition of this topic to the State Water Plan's list of issues is the direct result of public input during the 1981 Progress Report hearings. Approximately 40 percent of the State's population is dependent upon underground water. Usage is concentrated in the northern half of Illinois and involves over 1700 community water supplies. The authority to protect underground water resources in Illinois is distributed among eight state agencies. However, in many cases, protection of underground water use is included in the statutes as a secondary objective. As a result, these statutes and regulations are at most only partially effective for the protection of underground water.

Policy

The Water Plan Task Force has adopted a policy statement proposed by its Underground Water Work Group as follows:

"It is the policy of the State Water Plan Task Force to protect, preserve, and manage the underground water resources of the State, as a natural and public resource. The Task Force recognizes the essential and pervasive role of groundwater in the economic and social well-being of the people of Illinois, and its vital importance to the general health, safety and welfare.

It is further recognized as consistent with this policy that the underground water resources of the State be utilized for beneficial and legitimate purposes; that unreasonable waste and degradation of the resource be prevented; and that the underground water resource be managed and developed to allow for maximum sustained utilization."

Issues

A. **ESTABLISHMENT OF LEVELS OF PROTECTION DESIRED:**

It is recommended that underground waters of the State be classified into four sub-classifications which take into account potential as well as current uses.

B. **DETERMINATION OF USERS AND USES OF UNDERGROUND WATERS:**

Those who use underground waters and the uses to which these waters are put are recommended for continued identification and classification.

C. **DEVELOPMENT OF RESOURCE INVENTORY:**

The quality and quantity, location of existing underground waters, recharge areas and regional flow systems will be addressed. Data and information management as well as resource assessment will be included.

D. **TREATMENT AND TREATABILITY OF UNDERGROUND WATER:**

Treatability of water is concerned with the levels of contaminants (naturally occurring or caused by man) and options available to make the water usable for specific purposes. Emphasis is placed on prevention of contamination.

E. **INTERAQUIFER EXCHANGE:**

Interaquifer exchange may be caused by natural or man-made pathways by which the water in one aquifer may travel to others, thus affecting quality in the receiving aquifers. Emphasis is placed on prevention of contamination and adequate siting to minimize existing or future problems. Fissures, for example, may provide a natural pathway. In addition, most industrial and water supply wells draw from multiple aquifers. Damaged casings and abandoned wells

are examples of man-made pathways. Consideration of these aspects in permit issuance and renewal by the State can help minimize problems.

F. **DETERMINATION OF LOCAL, STATE AND FEDERAL RESPONSIBILITIES FOR PROTECTION OF UNDERGROUND WATER:**

The roles and responsibilities of public, private and governmental interests will be evaluated. In addition, the legal water rights and needs at the State level will be defined. While eight State agencies have statutory jurisdiction affecting underground waters, the Illinois Pollution Control Board and the Illinois Environmental Protection Agency have an extremely broad mandate to protect waters of the State.

G. **IDENTIFICATION OF DEGRADATION AND DEPLETION OF UNDERGROUND WATERS:**

Degradation sources, susceptibility, pollution control strategies, adequacy, availability and depletion of underground waters will be evaluated.

H. **DEVELOPMENT AND IMPLEMENTATION OF PROGRAMS:**

The preceding seven issues help define the underground water problems. The next step, if this information is to be effectively used, is to employ the information as a basis to protect, enhance and preserve underground water quantity and quality, and implement the programs which are developed. This may require statutory and regulatory changes and new authorities for underground water management.

A more detailed discussion of each of the above issues follows.

Description of the Issues

A. **ESTABLISHMENT OF LEVELS OF PROTECTION DESIRED**

The purpose of this issue is to define, classify and establish protection criteria according to the highest level of existing or future uses to assure underground water suitable for desired uses. The following is presented in a format compatible with standard administrative procedure. It includes protection levels, classification and management requirements.

1.0 Definitions

1.1 Domestic Use Underground Waters

Underground waters capable of being used directly for domestic use or food processing with no or minimum treatment. Minimum treatment shall include disinfection and fluoridation for public water supply use of underground water.

1.2 General Non-Domestic Use Underground Waters

Underground waters capable of being used for agricultural, industrial, recreational or any other legitimate beneficial non-domestic uses.

1.3 Geomorphic Flood Plain

The land between valley walls and adjacent to and including the bed of any stream, river or lake, consisting of the modern flood plain and terraces of abandoned flood plains.

1.4 Limited Use Underground Waters

Underground waters whose naturally occurring characteristics render them generally unsuitable for withdrawal from the ground for domestic or general non-domestic use.

1.5 Imminent Surface Return Flow Underground Waters

Underground waters which are below the geomorphic flood plain and hydraulically connected to the surface waters within that plain.

1.6 Recharge Areas

Areas of land surface from which underground waters are recharged.

2.0 Classification of Underground Waters

2.1 All underground waters of the State are designated Domestic Use Underground Waters, except for specific underground waters designated below as Limited Use under 2.2 or specific underground waters reclassified as General Non-Domestic Use or Limited Use in response to a petition submitted pursuant to 2.3.

2.2 All underground waters naturally containing more than 10,000 mg/l of total dissolved solids are designated Limited Use Underground Waters.

2.3 Any person or state agency may submit a petition to the Illinois Pollution Control Board (IPCB) to reclassify specific underground waters as General Non-Domestic Use or Limited Use. In making a determination to reclassify underground waters the following factors shall be considered:

a. Whether the petitioner has identified with sufficient specificity the particular underground waters for which reclassification is requested;

b. Whether the petitioner proposed a use of the specific underground waters which is legitimate and beneficial;

c. The existing and forecasted use of the specific underground waters;

d. The existing and forecasted extent of contamination, if any, of the specific underground waters;

e. The existing and forecasted quality of the specific underground waters;

f. The technical feasibility and capital costs of eliminating or reducing any contamination of the specific underground waters or maintaining existing water quality;

g. Whether contaminants will continue to be discharged by petitioner or other persons to the specific underground waters;

h. The existing or forecasted impact on private or public water supplies by either contamination or interruption;

i. The feasibility and cost of alternative water sources for those users adversely affected;

j. The impact on property values;

k. Whether the specific underground waters have been designated an exempt aquifer under 35 Ill. Adm. Code Subtitle G; and

l. For imminent surface return flow underground waters, the impact on the quality of surface waters and aquatic life.

2.4 Specific underground waters may be classified under 2.3 as Limited Use or General Non-Domestic Use underground waters only if such waters will not cause or threaten to cause water pollution of other waters of the State.

2.5 Due to the importance of instituting an underground water classification system, it is recommended that effective and timely classification actions be taken.

3.0 Requirements Applicable for Management of Underground Waters

3.1 Water Quality Standards

a. All underground waters classified under 2.1 as Domestic Use Underground Waters shall meet the water quality standards set forth in 35 Ill. Adm. Code Part 302, Subparts B and C, except for those waters whose naturally occurring characteristics cause them to exceed the applicable standards. For those waters whose naturally occurring characteristics cause them to exceed the applicable standards, only incidental traces of those contaminants exceeding applicable standards may be added.

b. All underground waters classified under 2.3 as General Non-Domestic Use Underground Waters shall meet the water quality standards set forth in 35 Ill. Adm. Code Part 302 Subpart B, except where the petitioner demonstrates by convincing evidence that concentrations above those standards will not threaten public health or welfare, depress property values, offend the senses, adversely affect aquatic life (for imminent surface return flow underground waters) or materially reduce their suitability for legitimate non-domestic beneficial uses.

3.2 Right to Continued Supply of Unpolluted Water

The owner or operator of any facility or activity which adversely affects by pollution the water supply of any person who obtains all or part of a supply of water for domestic, agricultural, industrial or other legitimate beneficial use from an underground water source, shall replace the water supply or provide treatment to applicable standards at the owner or operator's cost unless:

a. the underground water source has been classified for limited use and the level of contamination does not adversely affect an existing beneficial use; or

b. the underground water source has been classified for general non-domestic use, the water supply is being used for domestic use, and the level of contamination does not adversely affect domestic use.

3.3 Use of Limited Use Underground Waters

a. No public water supply may withdraw water from Limited Use Underground Waters for distribution for domestic use, absent specific designation (by the agency with jurisdiction) that such waters are the best source of water available.

b. No person may withdraw water from Limited Use Underground Waters within the influence of any underground waste injection well, absent specific designation (by the agency with jurisdiction).

4.0 Recharge Areas

4.1 Classification of Critical Recharge Areas

Any person or state agency may submit a petition to the IPCB to classify any recharge area, or portion thereof, which recharges Domestic Use Underground Waters as a Critical Recharge Area. The following factors shall be considered in determining whether to classify a recharge area as a Critical Recharge Area:

a. The existing and forecasted susceptibility of the underground water to contamination from existing or proposed facilities and activities within the recharge area;

b. The existing and forecasted number of persons withdrawing water from these underground waters for domestic use;

c. The existing and forecasted quantities of water withdrawn from these underground waters for legitimate and beneficial uses;

d. The existing and forecasted quantities of water available for withdrawal from these underground waters;

e. The existing and forecasted quality of water within these underground waters and availability of alternative sources of water supply; and

f. The existing and forecasted uses of land within the recharge area.

4.2 Siting of Facilities in Critical Recharge Areas

No facility should be constructed or activity undertaken within a critical use recharge area if operation of such facility or activity will cause or have the potential to cause, either alone or in combination with other existing or proposed facilities or activities, levels of contaminants to exceed water quality standards for Domestic Use Underground Waters under 3.1(a).

4.3 Due to the importance of instituting recharge area protection, it is recommended that effective and timely actions be taken to implement and carry out the critical recharge area program.

B. USERS AND USES OF UNDERGROUND WATERS

The successful development of an underground water management plan must consider who is using underground water, how it is used, and in what quantities, and where the withdrawn water is ultimately discharged. The Illinois State Water Survey has collected water use information since 1895. Collection of information originally was limited to the metropolitan Chicago area, Peoria, and the East St. Louis area. In 1978, the Water Survey, in cooperation with the U.S. Geological Survey, initiated the Illinois Water Inventory Program. The program has been documenting current water uses to permit better planning and proper management of Illinois' existing water resources. The Illinois Water Inventory Program is intended not only to show changes in the quantities of water use but also indicate trends in use and provide the basic data required for establishing water budgets, developing water use plans, and evaluating hydrologic unit and aquifer systems.

The Illinois Water Inventory Program currently is collecting withdrawal data in the following categories: public water supply, self-supplied industry (including thermoelectric power generation, manufacturing, mineral extraction, and hydroelectric power generation); rural use (domestic, livestock and irrigation); and fish and wildlife management areas. These data are further categorized by county, districts, hydrologic units of aquifer systems, major aquifer systems, and standard metropolitan statistical areas. The State Water Survey and the Division of Water Resources (IDOT) jointly survey the use of water in the metropolitan Chicago area as part of the Lake Michigan allocation process.

C. DEVELOPMENT OF RESOURCE INVENTORY

1. Quantity

The underground water resources of Illinois historically have been defined by the joint activities of the Illinois State Water and Geological Surveys. Regional and special area studies have, for the most part,

defined the locations and yield potentials of the underground water resources of Illinois.

The underground resources of the State of Illinois have been estimated to be capable of yielding as much as 7 billion gallons per day. However, the increased demands for water, competition for water among various user classification, concentrations of population and water demands, and regionally limited underground resources have created a need for problem-oriented, area-specific studies. There are a few areas in need of detailed, comprehensive studies. Examples are as follows:

Northeastern Illinois
Rockford Area
Rock Island-Moline
Peoria-Pekin
East St. Louis Area
Portions of east central Illinois overlying the buried Mahomet bedrock valley
The surficial deposits associated with the Sangamon River bottomlands

The manpower and financial resources to accomplish these studies in a timely fashion do not presently exist. It is therefore imperative that a plan of resource assessment, with prioritized areas of study, be developed.

The recent passage of the Water Use Act of 1983 (PA 83-700) has established a mechanism for identifying areas of underground water withdrawal conflicts, but has provided no method for resolution of potential problems. Experience in northeastern Illinois has demonstrated that local governments do not have the capability to effectively manage the States' underground water resources due to local political priorities or a lack of detailed knowledge concerning the resources' response to overpumpage. This role must be undertaken by the State of Illinois by formulation of regional water districts among other methods to maximize the use and minimize the abuse of Illinois' underground water resources.

2. **Quality**

Data on the quality of Illinois underground water resources are collected by the Illinois EPA, the Illinois Department of Public Health, the U.S. Geological Survey, and the State Geological and Water Surveys. The State Water Survey is the official repository for this water quality data. A data base of approximately 30,000 analyses of public water supply, industrial, irrigation and private wells is maintained in paper form and in a computerized data storage system.

In 1979 a summary of Illinois underground water quality conditions was accomplished by the Water Survey and the Illinois EPA. This study delineated areas of data deficiencies and the general limitations of the data base. In addition, the potential use of the data base for developing an economical and rational underground water quality monitoring program was presented.

To most effectively address the issue of monitoring and managing Illinois underground resources, it is recommended that an expanded "real time" computer based analyses of already routinely collected underground water quality data, with adequate quality control be developed. Results from that effort would form the basis for interagency decisions in establishing additional data collection priorities. To address the multiple underground water quality data needs of state and local planning agencies, a technical advisory committee representing interested State and Federal agencies should be established to periodically review the results of continuing data interpretations and modify monitoring recommendations to meet emerging needs and priorities.

D. TREATMENT AND TREATABILITY OF UNDERGROUND WATER

Although modern technology can obtain safe drinking water from any water solution, the controlling factor is economic. A

water supply which historically has pumped water from an underground source with minimal and inexpensive treatment cannot be expected to accept passively the introduction of contaminants which require extensive additional treatment equipment and greatly increased cost of treatment.

Drinking water treatment involves physical and chemical processes which are designed to handle large quantities of water with high efficiency. Although each plant is designed specifically for the water it is to treat, the design is based on the selection of specific processes to be employed, their order of application, and the quantity of water to be delivered. The aim is not to provide absolutely pure H_2O, but to provide a water which is clean (no particulate matter, objectionable color, odor or taste) and which does not contain any substance which is unsafe to drink *in the quantities present in the water.*

The treatment processes themselves are generally aimed at removing solids by sedimentation and filtration, gases by aeration, and dissolved substances by ion exchange or by conversion to solids or gases which can be removed as stated above. Some substances can be removed by adsorption, either as gases or liquids. For high dissolved solids, reverse osmosis or distillation are also available.

With this array of options, the cost of treatment varies with the quantity of a contaminant, the nature of the contaminants, and the diversity of contaminants present in the water to be treated.

If disinfection to prevent microbiological disease is the only treatment, the presence of contaminants such as man-made synthetic chemicals may be undetected for a long period of time. Since these chemicals will not be affected by disinfection, once they are detected the installation of additional treatment will be necessary to remove them. This can be quite expensive. The smaller the system the higher the per capita cost. Water rates may increase by more than 500%. It may be cheaper to cap and abandon the affected wells and look for other water sources which will not require as much treatment.

There are other options which may be used. Those available for a water supply after contamination of its underground raw water source (not in priority order) are:

1. Seek new source or blend with other sources.
   (new well, surface source, draw from neighboring supply)

2. Seal off contaminated aquifer.
   (draw from other aquifers above and/or below contamination)

3. Install treatment.
   (activated carbon, aerator, coagulation and filtration, ion exchange, reverse osmosis, distillation, etc.)

4. Combinations of the above options.

The ultimate cost of obtaining safe drinking water after unexpected contamination of a source is usually appreciably higher than the cost of prevention or contingency planning. For management of water resources the use of resource inventories, aquifer contamination susceptibility maps, landfill siting maps, and other appropriate information will be of inestimable value in preventing aquifer contamination and minimizing any resultant damage. All of this information will also indicate the areas less likely to become contaminated and aid in proper well site selection. Whenever possible, prevention of contamination is by far the best choice of options available.

E. INTERAQUIFER EXCHANGE

Each aquifer contains underground water with distinct chemical characteristics, which when mixed may degrade the quality of the underground waters. The exchange may be caused by natural geologic discontinuities (e.g., fissures or stratigraphic changes) or be man-made (e.g., multiple aquifer completions, damaged casings, improper plugging of abandon wells).

Examples of interaquifer exchange of underground water are numerous in Illinois. The whole northern part of Illinois has deep wells with multiple

aquifer completions; this has resulted in occasional problems with increased chloride contents of pumped waters and well breakdowns resulting from precipitation of insoluble salts on the well screens and pumps. Increased use and competing demands for underground water will aggravate this problem in the future. Western Illinois is another area where multiple aquifer completion has allowed sulfate water to enter the St. Peter Sandstone; since poor quality water exists above the main aquifer, this region is especially sensitive to this problem. An area of natural mixing occurs along the south side of the Illinois River between Marseilles and La Salle where deep saline waters are mixing with shallow potable waters. Other areas of natural brine discharges occur in widespread areas of southern Illinois.

Regions of multiple aquifer well completions need to be catalogued, and well construction guidelines developed for multiple aquifer completions. Areas of natural interaquifer exchange also need to be catalogued. Impacts of underground water developments should be assessed and considered in permit issuance and/or renewals by the State.

F. DETERMINATION OF LOCAL, STATE AND FEDERAL RESPONSIBILITIES FOR PROTECTION OF UNDERGROUND WATERS

Local units of government can affect underground water quality and quantity to some extent by use of their powers to pass ordinances and by land use management through zoning. In addition, they have certain other powers under various state statutes wherein they will join with state agencies in reaching siting decisions, notably in the case of landfills, where local hearings are held to supplement the Illinois Environmental Protection Agency's technical examination of the proposed site qualifications.

Illinois statutes assign at least some responsibility for protection of underground water to six state agencies: Illinois Pollution Control Board; Illinois Environmental Protection Agency; Illinois Department of Public Health; Illinois Department of Transportation; Illinois Department of Mines and Minerals; Illinois Department of Agriculture. In addition, the Illinois Emergency Services and Disaster Agency and the Illinois Commerce Commission have some responsibilities.

A report prepared for the Illinois Environmental Protection Agency by the College of Law of the University of Illinois at Urbana-Champaign, published June 1979, makes the following statement:

"Illinois agencies currently regulate nearly all of the activities listed in Table 1[1]. The regulations, however, have been adopted for a variety of different purposes and at different times by at least nine different agencies. Consequently, Illinois lacks the comprehensive approach to the protection of ground water quality needed for adequate control of all sources of ground water pollution. The present patchwork of miscellaneous statutes and regulations provides too many opportunities for gaps and overlaps in regulatory control. Furthermore, the majority of the controls which have been adopted reflect a lack of awareness of the existence and importance of ground water resources, or a lack of understanding of the problems peculiar to ground water pollution.

1. Lack of awareness of ground water resources

The lack of awareness of underground water resources produces two categories of problems. First, some activities with the potential to pollute underground water are not subject to regulation. Second, other activities have been regulated, but the protection of ground water is either a secondary goal of the regulatory controls, or only an incidental benefit produced by regulations intended to achieve quite different goals.

[1] *The Table 1 which is referred to lists the classification of sources and causes of ground water pollution used in determining level and kind of regulatory control.*

Fortunately, in Illinois the first category is small. The most serious omission at present is probably the failure to regulate the disposal of wastes in shallow wells[2]. Occasional lapses also occur within the context of established regulatory schemes. For example, the Illinois Environmental Protection Agency's (IEPA) Technical Policy Statement on public water supplies appears to apply to water supplies drawn from both surface and underground waters. Yet the specific criterion requiring public systems to eliminate the pollution of water applies only to surface waters. (IEPA, Technical Policy Statement, Part 307C) The statement emphasizes that "surface waters are by their nature continually subject to both natural and man-made pollution", but fails to acknowledge that underground waters are not only subject to similar threats of pollution, but also are more difficult to clean once polluted. All such omissions should be corrected.[3]

The second category is somewhat larger. A number of control measures include the regulation of underground water only as a secondary purpose. The Conservation of Oil and Gas Act (96 1/2 5401-54541), for example, mentions the need to protect freshwater bearing strata. Protection of underground water, however, is only one of fifteen goals stated in the Act. (96 1/2 5409) In addition, the structure and language of the Act strongly indicate that the economic production of oil and gas would outweigh the need to protect underground water resources. The Water Well Construction Code (111 1/2 116.111-116.118) also is an example of legislation under which protection of underground water is only incidental to pursuit of other goals. The Code charges the Department of Public Health (IDPH) with the regulation of well construction to "protect the public health". (111 1/2 116.112) Strict standards for the location and construction of water wells, as mandated by the Code and implemented by the IDPH regulations, can certainly help prevent pollutants from entering underground water supplies through wells. The nature of the regulations, however, indicates that the IDPH was principally concerned with the spread of disease. The regulations include, for example, minimum distances between wells and privies. (IDPH Water Well Construction Code Rules and Regulations, Rule 5.2) Regulations intended to reduce the spread of disease may not be adequate to prevent pollution from all types of sources. All regulations only incidentally benefiting underground water should be reviewed to insure that underground water is, in fact, receiving adequate protection.

2. **Lack of understanding of the problems of ground water pollution**

Prevention rather than clean-up is the key to the maintenance of good underground water quality. A general prohibition against water pollution such as the language contained in the Illinois Environmental Protection Act's (IEPAct) 1012 is often not adequate to prevent the pollution of underground water. Such regulations are typically not enforced until someone detects the pollution and initiates enforcement proceedings. By the time pollution is noticeable, large portions of an aquifer may already be contaminated with little possibility for a rapid restoration of water quality. Underground water quality protection requires more specific measures based on permit processes, construction standards, and/or monitoring in order to prevent the entry of the contaminants into the aquifer in the first place. In Illinois the general water pollution prohibition of the Illinois Environmental Protection Act or the state-administered federal NPDES permit system is occasional-

2 *This has been addressed by the Underground Injection Control Program now administered by IEPA.*

3 *This will be corrected in the reissue and codification of the Technical Policy Statements now in progress.*

ly the only control applying to a particular activity with the potentional to cause underground water pollution."

The federal government, also, has statutory authority in this area. This control essentially is within the regulatory powers of the USEPA.

Summarized, these authorities are as follows:

RCRA (Resource Conservation and Recovery Act) (USEPA) -

The hazardous waste program establishes standards for treatment, storage and disposal of hazardous waste; it seeks to protect underground water as a principal point of vulnerability.

Under Subtitle C. Section 3004, USEPA must promulgate regulations establishing standards applicable to owners or operators of hazardous waste treatment, storage and disposal facilities. A "hazardous waste" under Section 1004(5), because of its quantity, concentration or physical, chemical, or infectious characteristics, may either (a) lead to illness or mortality or (b) "pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported or disposed of, or otherwise managed." This section, by referring to protection of "human health or the environment", covers all environmental media, including underground water.

The Subtitle D Solid Waste regulations contain provisions ensuring that land disposal facilities present "no reasonable probability of adverse effects on health or the environment from disposal of solid waste at such facility." These standards address underground water.

The Act also authorizes enforcement actions to abate imminent hazards caused by solid waste or hazardous waste.

(The State of Illinois EPA has interim authority to administer this program.)

CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act) (Superfund) (USEPA) -

This statute authorizes USEPA to respond to releases or substantial threats of releases into the environment, including underground water, of any hazardous substance, pollutant or contaminant which may present an imminent and substantial danger to the public health and welfare.

Section 101(3) defines environment as including "navigable waters, the waters of the contiguous zone, and the ocean water to which the natural resources are under the exclusive management authority of the United States under the Fishery Conservation and Management Act of 1976" and any other surface water, underground water, drinking water, water supply, land surface or subsurface strata, or ambient air within the United States...."

(Activities of this program can be administered by either the Illinois EPA or United States EPA.)

Safe Drinking Water Act (USEPA) -

This statute authorizes USEPA to set maximum contaminant levels and monitoring requirements for public water systems.

The Underground Injection Control program regulates the uses of underground injection wells to protect drinking water aquifers. The Act states that the program regulations must contain "minimum requirements for effective programs to prevent underground injection which endangers drinking water sources." Section 1421(d)(2) specifies that the source of concern is "underground water which supplies or can reasonably be expected to supply any public water system". This is further defined as a system providing piped water for human consumption, if at least 15 connections or 25 individuals depend upon it.

(The State of Illinois has authority to administer this program which is split between Illinois EPA and Illinois Department of Mines and Minerals.)

The Sole Source Aquifer provisions allow USEPA to designate an aquifer as the sole source of drinking water for an area,

guaranteeing protection from contamination by projects receiving Federal financial assistance. Section 1424(e) of the Act provides local, regional or state agencies a legal mechanism (petition the USEPA Administrator) to protect the recharge zones of special aquifers. The USEPA Administrator may designate an aquifer which is a sole or principal drinking water source if contamination "would create a significant hazard to public health." If the designation is made, no federal financial commitment may be made for any project which the Administrator determines may contaminate such an aquifer through a recharge zone so as to create a significant hazard to public health.

(Illinois EPA has authority to administer this program.)

Clean Water Act (USEPA) -

This statute makes general reference to underground water protection in municipal wastewater treatment, planning, and research programs. Its principal regulatory programs, however, focus on surface water.

The first part of the Act that mentions ground water is Section 102, Comprehensive Programs for Water Pollution Control, which states that "the Administrator shall, after careful investigation and in cooperation with other federal agencies, state water pollution control agencies, interstate agencies and municipalities and industries involved, prepare or develop comprehensive programs for preventing, reducing or eliminating the pollution of the navigable waters and ground waters and improving the sanitary condition of surface and underground water...."

In addition, Section 208(b)(2), Subsection (G)(I) and (K) are requirements for the Water Quality Management Plans. The Plan must, according to (G) identify mine-related runoff, both surface and subsurface and methods to control the runoff....; (I) salt water intrusion from the reduction of fresh water flow, including, "irrigation, obstruction, groundwater extraction .... and set forth procedures and methods to control such intrusion;" (K) "propose a process to control the disposal of pollutants on land, or in subsurface excavation within such as area, to protect ground and surface water quality."

(Illinois EPA has authority to administer this program.)

TSCA (Toxic Substances Control Act) (USEPA) -

This statute authorizes USEPA to restrict or prohibit the manufacture, distribution, and use of products presenting an unreasonable risk of injury to health or the environment. Section 3(5) defines "environment" to include "water, air and land and the interrelationship which exists among and between water, air and land and all living things". This covers underground water.

(Illinois EPA is formulating a Toxics Strategy to interface with this program.)

Uranium Mill Tailings Radiation Control Act (USEPA) -

This statute establishes health and environmental standards applicable to management of uranium mill tailings. Under Section 275(a), USEPA must establish standards covering certain cleanup and disposal activities that the Department of Energy will undertake at inactive uranium mill tailings and depository sites. Under Section 275(b) USEPA must regulate the transfer and disposal of uranium mill tailing active sites. This statute allows protection for all media above and below ground and provides that standards be designed to protect "public health, safety and the environment."

Atomic Energy Act (USEPA) -

This act gives USEPA the authority to establish standards applicable to materials governed by the Act. These standards are implemented by the Nuclear Regulatory Commission.

(Illinois Dept. of Nuclear Safety has authority to administer this program.)

FIFRA (Federal Insecticide, Fungicide, and Rodenticide Act) (USEPA) -

This statute gives USEPA the responsiblity to control the use of pesticides, taking environmental impacts into consideration, including those affecting underground water.

In Section 3 of the Act, USEPA is made responsible for registering, cancelling, suspending or changing the classification of individual pesticides. In making this decision, USEPA considers a broad range of environmental impacts from pesticides, including those affecting underground water. In deciding whether to register, cancel, suspend or change the classification of a pesticide, USEPA considers whether uses of the pesticide will cause "unreasonable adverse effects on the environment". Section 2(j) defines environment as "water, air, land and all plants and man and other animals living therein, and the interrelationships which exist among these". This broad definition covers underground water.

(Illinois Dept. of Agriculture has authority to administer this program.)

SCMLCRA (Surface Coal Mining Land Conservation and Reclamation Act (IDMM) -

This statute provides extensive powers which are specifically aimed at protecting both surface and underground waters. Under this Act IDMM must find that mining operations are designed to prevent material damage to the hydrologic balance.

(Illinois Department of Mines and Minerals have authority to administer this program.)

With all of the overlapping authorities, it will be difficult to formulate and carry out a unified underground water control program in which requirements and regulations of the various levels of government are involved.

G. IDENTIFICATION OF DEGRADATION AND DEPLETION OF UNDERGROUND WATERS

Protection of the underground water resources of Illinois has long been a concern of water-related agencies, whether their primary interests are supply, water quality, or research. Protection of underground waters continues to be of concern to many agencies.

The soils and geology of Illinois generally afford limited natural protection of underground waters. A recent study by the Illinois State Geological Survey and the Illinois Environmental Protection Agency, outlined areas of the State which may be susceptible to degradation.

Overall the quality of underground water in Illinois remains good, despite the contamination potential of industries, urban areas, and modern agriculture. Incidences of serious degradation are few in number and of only local impact. However, regional changes have occurred in population centers, such as the Metropolitan Chicago and East St. Louis areas. Examples of the many possible sources of underground water contamination are listed in Table I.

TABLE 1

Some Potential Sources of Contamination

- Surface water pollution
- Solid waste disposal
- Individual sewage systems (septic tanks, etc.)
- Hazardous waste disposal
- Liquid waste and sludge disposal
- Animal feed lots
- Well disposal of wastes
- Water wells
- Oil and gas wells
- Waste water irrigation
- Fertilizer application
- Pesticide applicaton
- Salt application
- Waste storage
- Oil storage
- Gas stations
- Salt storage
- Natural gas storage
- Coal storage
- Industrial materials storage
- Mining
- Pipelines
- Sewers
- Spills
- Surface impoundments
- Underground storage tanks

The underground water resources of Illinois are abundant, though not evenly distributed throughout the state. In some areas, withdrawal of underground water exceeds the rate of recharge, resulting in declining water levels, increasing mineralization, and source depletion. Excessive withdrawal leads to higher pumping costs, the need to drill deeper wells, and the need to locate new sources. Northeast Illinois is an example of an area where high levels of withdrawal have drastically reduced water levels.

Under this issue, information (including data discussed in the issues on Users and Uses of Underground Water and Resource Inventory) will be reviewed and analyzed on a statewide basis. Also, it should help answer several questions, including:

- what is the health risk associated with the problem?
- what is the magnitude of the problem?
- what is the location and extent of the problem?
- what is the future of the problem?
- what can be done to resolve the problem?

The information generated as a result of this analysis will also assist in strategy development. As a part of this, maps will be used to delineate specific management zones. Strategies could include selection of priority areas, programs to protect susceptible areas or important aquifers, curtailing use, etc. Strategy development can closely inter- face with Issue H: ***Development and Implementation of Programs*** and can lead to their institutionalization.

H. DEVELOPMENT AND IMPLEMENTATION OF PROGRAMS

The objectives of the Illinois Underground Water Protection Program are:

1. Promote efficient development of underground water supplies;
2. Prevent deterioration of underground water; and
3. Prevent overdevelopment of underground water resources.

It is important that the public understand and support the objectives of this program. In order to gain this support, the State will actively promote public participation in program development. Public participation will:

1. Foster intergovernmental cooperation;
2. Disseminate underground water information; and
3. Seek public input into strategy development and decision making.

The Illinois Underground Water Protection program includes a resource protection strategy and a resource management strategy. The aim of the protection strategy is to prevent deterioration of underground water quality. The aim of the management strategy is to promote efficient development without interfering with the users of underground water any more than necessary.

Where underground water is in an aquifer which covers a very limited area, control should be delegated to local management authority with state supervision as appropriate. Where the aquifer covers a larger area, management control must be with the state. For those aquifers which cross state boundaries management control should be by interstate agreements.

The protection strategy assures long term suitability while the management strategy maximizes availability.

Program Strategy - Recommendations by Issue

The recommendations given below are listed by issue and further categorized into short-term and long-term events. Short-term is within the next two years while long-term is within a five-year time frame.

Many recommendations cover program elements and authorities of more than one state agency and therefore the agencies will be expected to work together as necessary and also to request appropriate funding to implement those recommendations. Furthermore many of the issues are inter-related. These inter-relationships must be considered, even if not specifically mentioned, as part of the relevant issues.

A. ESTABLISHMENT OF LEVELS OF PROTECTION DESIRED

The Illinois Environmental Protection Agency is currently preparing a proposed regulation for presentation to the Pollution Control Board. This will be part of the water pollution control regulations, and will include the material listed under this same title in the description of the issues.

SHORT-TERM RECOMMENDATIONS:

1. Regulations for classification of aquifers should be in effect within the next two years.

LONG-TERM RECOMMENDATIONS

1. The regulations shall be evaluated five years after implementation to determine what changes, if any, must be made. Consideration shall also be given to legislation which can make underground water protection more effective.

B. DETERMINATION OF USERS AND USES OF UNDERGROUND WATERS

Work is underway to consolidate water use information collected by various state and federal agencies. While the data available is not all inclusive for the State, it is of value, and will become more valuable as time goes on and additional information is entered.

SHORT-TERM RECOMMENDATIONS:

1. Illinois Department of Mines and Minerals shall immediately initiate a notice procedure to all other concerned State agencies which details the location of all new public, commercial, industrial and private water wells and Class* IV and V wells permitted.

2. A well location confirmation program and well numbering system created and maintained by Illinois State Geologic Survey for both existing and future wells shall be used by all state agencies.

3. Illinois State Water Survey shall establish a process to add pertinent data for all public and other significant water supply wells into the Illinois Water Inventory System as they are permitted.

* United States Environmental Protection Agency and Illinois Environmental Protection Agency have adopted injection well classifications as follows:

- *Class I includes industrial and municipal disposal wells that inject below all underground sources of drinking water in the area.*
- *Class II includes all injection wells associated with oil and gas storage and production.*
- *Class III includes special process injection wells, for example, those involved in the solution mining of minerals.*
- *Class IV includes wells used by generators of hazardous wastes or hazardous waste management facilities that inject into or above underground sources of drinking water.*
- *Class V includes all other injection wells which inject non-hazardous fluids into or above underground sources of drinking water.*

LONG-TERM RECOMMENDATIONS:

1. Illinois State Water Survey shall maintain the Illinois Water Inventory Program and publish an updated underground water usage report at least every five years.

2. Illinois State Water Survey and Division of Water Resources shall continue to monitor the water quantities used in the metropolitan Chicago area as part of the Lake Michigan allocation process and publish a report at least every five years.

C. DEVELOPMENT OF RESOURCE INVENTORY

1. Quantity

While general information on this issue has been collected in the past, there is not a compilation of specific or timely quantity data. Some work is being done to identify the areas of the State where quantity problems may occur, but the bulk of this effort has been postponed until additional resources become available.

The Water Use Act of 1983 (PA 83-700) is a recent effort to address the issue of quantity conflicts or competition for water. However, no particular method for resolving conflicts was prescribed in the Act. No funds have been appropriated to state agencies to perform the work outlined in the Act.

SHORT-TERM RECOMMENDATIONS:

a. Illinois State Water Survey shall continue its water level monitoring efforts.

b. Illinois Department of Agriculture, Department of Energy and Natural Resources and Illinois Department of Mines and Minerals shall develop and institute procedures to implement the Water Use Act of 1983 (PA 83-700).

c. Illinois State Water Survey shall establish a process to add pertinent data for all new wells into the Illinois Water Inventory System as they are permitted.

d. Department of Energy and Natural Resources shall develop and maintain the resource data needed for an underground water management program.

LONG-TERM RECOMMENDATIONS:

a. Where currently recorded groundwater pumpage in any given aquifer is determined to exceed 75% of the estimated long term safe yield, Department of Energy and Natural Resources shall report the determination to Division of Water Resources. The Division of Water Resources shall designate these ares as "Potential Groundwater Management Areas," or areas in need of more detailed resource evaluation.

b. Results of the Water Use Act of 1983 (PA 83-700) shall also be used to delineate additional areas of potential groundwater withdrawal conflict requiring more detailed evaluation.

c. Department of Energy and Natural Resources shall conduct detailed studies of these designated areas for more accurate definition of resource-yield potential and current usage. Department of Energy and Natural Resources shall also conduct comprehensive water resource evaluation (quantity/quality) studies in known problem areas of the state such as Northeastern Illinois, East St. Louis, etc.

d. Based on the results of these detailed studies, Division of Water Resources shall designate the area as a "Groundwater Management Area" if the updated groundwater pumpage is greater than 75% of the detailed yield estimates.

e. The Division of Water Resources or local underground water management authority shall use the information provided by Department of Energy and Natural Resources to manage the resource as provided under new law.

2. Quality

Quality and quantity investigations frequently cannot be separated. This must be borne in mind when implementing the recommendations below.

Work is now under way to establish protocols for an eventual underground water monitoring network for the state. The pilot program began in April of 1984. The results from the pilot operation will be studied and necessary changes to sampling methods and procedures implemented. A monitoring network will then be established to cover the whole state.

The Illinois State Water Survey is conducting a Department of Energy and Natural Resources funded study to assess available underground water quality data and make recommendations for a statewide underground water monitoring program. The results of this study should prove invaluable in future planning and monitoring efforts.

SHORT-TERM RECOMMENDATIONS:

a. Illinois Environmental Protection Agency shall continue to develop the quality component of the underground water monitoring prototype and a statewide monitoring strategy.

b. Illinois Environmental Protection Agency shall establish a compliance monitoring system which integrates facility-related monitoring into the base monitoring strategy.

c. The Work Group on Underground Water shall continue as an Interagency Underground Water Technical Advisory Committee to oversee both short-term and long-term program efforts and review, appraise and update the long-term strategies as required. Illinois Environmental Protection Agency shall chair this committee.

LONG-TERM RECOMMENDATIONS:

a. Illinois Environmental Protection Agency shall implement monitoring strategy and data system for all aquifers, public water supply wells and facility compliance monitoring.

b. The Interagency Underground Water Technical Advisory Committee shall review every three years and revise as necessary the 35 Ill. Adm. Code: Subtitle C water quality standards applicable to underground water.

c. Whenever Department of Energy and Natural Resources conducts comprehensive water quantity studies, quality shall also be considered where appropriate.

D. TREATMENT AND TREATABILITY OF UNDERGROUND WATER

The primary responses to poor underground water quality are installation of adequate treatment or use of an alternate suitable source. Work done under the other issues, such as inventories and maps is important to addressing the issue of treatment. It will be necessary to use newly emerging technologies for the removal of contaminants from water either by treatment in the aquifer or after withdrawal, as well as for preventing contamination from entering the aquifers.

SHORT-TERM RECOMMENDATIONS:

a. Illinois Environmental Protection Agency shall utilize permit authorities to avoid potential future contamination.

b. Use treatment of underground water or alternate sources where contamination has occured.

LONG-TERM RECOMMENDATIONS:

1. Efforts of Short-Term Recommendations shall be continued and augmented as further information and new technologies become available.

E. INTERAQUIFER EXCHANGE

Additional resources and program responses are needed to search for abandoned wells and see that they are closed properly, to enforce the regulations on abandonment of wells as the occasion arises, and to examine the existing wells to make sure that they are properly constructed to minimize interaquifer exchange where it is undesirable. This will require a major effort until the bulk of the deficiencies are corrected.

SHORT-TERM RECOMMENDATIONS:

1. Illinois Department of Public Health shall modify construction guidelines for multi-aquifer well completions to prevent undesirable interaquifer exchange.

2. Illinois Environmental Protection Agency and Illinois Department of Mines and Minerals shall continue to implement the injection control program for all classes of injection wells.

3. The Illinois Abandoned Mine Lands Reclamation Council shall consider the potential problems of interaquifer exchange in its reclamation efforts.

LONG-TERM RECOMMENDATIONS:

1. All agencies shall implement guidelines to improve the exchange of permit information.

2. Department of Energy and Natural Resources shall catalogue multiple aquifer completions in Illinois.

3. Department of Energy and Natural Resources shall locate and map areas of natural interaquifer exchange.

4. Illinois Environmental Protection Agency and Illinois Department of Mines and Minerals shall continue to implement the Mine Permitting Programs.

5. The Illinois Abandoned Mine Lands Reclamation Council shall develop a mitigation program covering, among other things, mine shaft pollution of multi-aquifers.

F. COORDINATION OF LOCAL, STATE AND FEDERAL RESPONSIBILITIES FOR PROTECTION OF UNDERGROUND WATER.

Regulatory authorities will be further identified to unify underground water regulations, criteria and standards. The state will coordinate state and local programs. Federal oversight is provided through the interface of programs such as SDWA, UIC, RCRA, CERCLA, SMRCA and CWA. Coordination of state agency authorities will be accomplished through adminstrative mandates, interagency coordination and cooperative agreements.

SHORT-TERM RECOMMENDATIONS:

1. Illinois Department of Public Health shall evaluate implementation of the Well Construction Code to determine if it is effective in preventing chemical, radiological and biological pollutants from entering water supplies through wells.

2. Evaluate existing State and local authorities to clarify underground water regulations, criteria and standards.

3. Continue to promote an active public participation program by:

a. Fostering local, county and State intergovernmental cooperation.

b. Disseminating public information.

c. Seeking public input into strategy development and the decision making process.

4. Units of local government shall be encouraged to consider underground water protection and management under their existing land use and planning powers.

LONG-TERM RECOMMENDATIONS:

1. Illinois Environmental Protection Agency shall be the lead agency to coordinate local, State and Federal activities relating to underground water protection as applicable.

2. The Underground Water Work Group shall recommend legislation enabling local groundwater management authorities with state supervision as appropriate.

G. MITIGATION OF DEGRADATION AND DEPLETION OF UNDERGROUND WATER

Maps have been prepared which help define those areas of the State which need the most immediate attention. Strategies for mitigation will be developed. Action will be taken as strategies are developed to correct the degradation and depletion situations identified. Special efforts will augment the routine underground water quality and compliance programs and will be directed at specific problems which are identified. Underground water availability will be assessed. These efforts will be supplemented by implementation of the Water Use Act of 1983 (PA 83-700).

Cooperating agencies shall prioritize management areas of the state using quality/quantity maps, facility compliance monitoring data and land base activities as applicable.

SHORT-TERM RECOMMENDATIONS:

1. Illinois Department of Mines and Minerals shall revise the well drilling permit application form in cooperation with Illinois Environmental Protection Agency to require the applicant to identify and locate proximate wells and pollution sources. Illinois Department of Mines and Minerals will be responsible for review of the applications to assure that well interference or aquifer contamination will not result. Illinois Environmental Protection Agency will provide locations of known waste sources to assist Illinois Department of Mines and Minerals in its screening procedures.

2. Programs should distinguish between facility related contamination and aerial or non-point source contamination (i.e., salt application, mining, etc.).

3. Illinois Environmental Protection Agency and Emergency Services and Disaster Agency will evaluate the state's spill response procedure methodology to deal with underground water contamination.

4. Illinois Environmental Protection Agency will identify areas where contamination has occurred. Evaluate clean-up response and potential for future contamination as a result of the clean-up action taken pursuant to Section 22 of the Illinois Environmental Protection Act, as revised.

5. Illinois Environmental Protection Agency will incorporate the Toxics Strategy program elements into the underground water protection strategy.

6. Illinois Department of Mines and Minerals shall continue to implement the brine pit waste control program pursuant to the Water Quality Management Plan.

7. Illinois Environmental Protection Agency will define the state's role and responsibility in the federal Leaking Underground Storage Tank program.

8. Illinois Environmental Protection Agency will continue to implement Water Quality Management Plan recommendations regarding agricultural chemicals and their application, feedlots, salt storage, and septic tank operations.

9. Illinois Environmental Protection Agency will update and maintain the inventory and contamination assessment of pits, ponds and lagoons.

LONG-TERM RECOMMENDATIONS:

1. Utilize all available information and authorities to resolve underground water withdrawal conflicts and avoid long-term depletions.

2. Develop procedures to mitigate known contamination and/or depletion problems.

3. Determine sources of possible underground water contamination not otherwise identified and take steps to mitigate contamination effects.

4. Cooperate with the federal administration of the Leaking Underground Storage Tank program.

5. Continue to refine and develop procedures for contamination clean-up response.

6. Develop programs for control of pits, ponds and lagoons to minimize contamination of underground water with priority attention given to significant sites identified in state inventories.

Appendix A - Maps

A. Introduction

The following maps are township 'worst case' maps. That is, for each township the worst case was taken as the situation for that township. While this method may indicate a worse condition overall than actually exists, it does point out those areas which, if not already having a problem, are liable to experience one in the near future. These maps are intended to display regional information that is applicable for state-wide planning purposes and not for site specific information. This must be borne in mind when examining the maps. These maps were developed by the Illinois State Water Survey. (Refer to Appendix B for more detailed discussion on map development modeling.)

B. Use to Yield Analysis

1. Sand and Gravel Aquifers
2. Shallow Bedrock Aquifers
3. Deep Sandstone Aquifers
4. Worst Case Analysis — All Aquifers Combined - Maximum Use Yield Ratio
5. Recallocation Analysis — All Aquifers Combined - Total Use vs. Total Yield
6. Discussion

The first three maps (sand and gravel aquifers, shallow bedrock aquifers, and deep sandstone aquifers) show the conditions for supplies now drawing from each aquifer. The fourth map combines the other three to show the overall present condition. The last map shows what the situation would be if, in each township, all aquifers would be used.

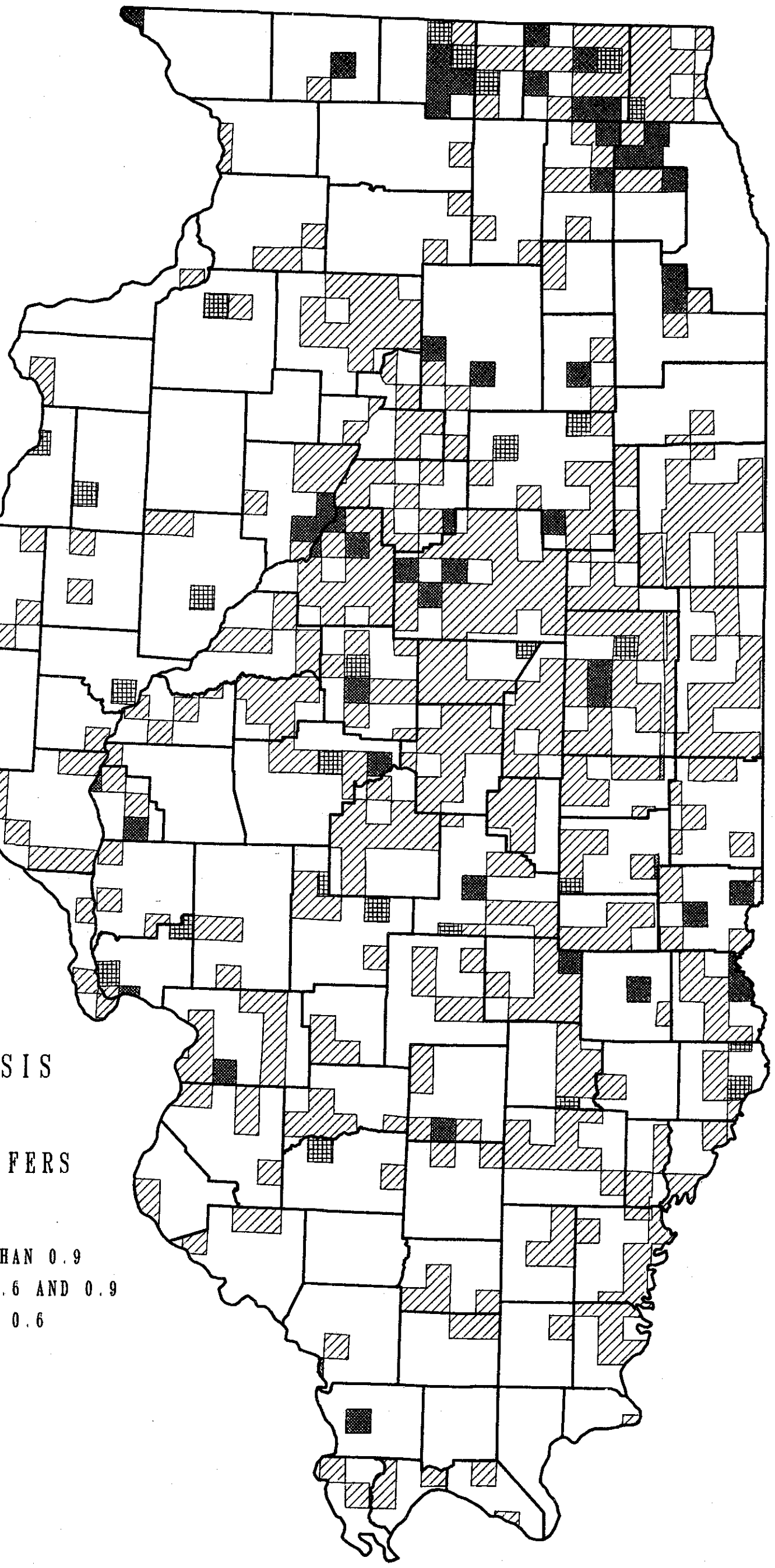
C. Groundwater Quality Model

1. Sand and Gravel Aquifers
2. Shallow Bedrock Aquifers
3. Deep Sandstone Aquifers
4. All Aquifers Combined - Maximum Priority Shown
5. Groundwater Quality Trends - Sand and Gravel Aquifers
6. Groundwater Quality Trends - Shallow Bedrock Aquifers
7. Groundwater Quality Trends - Deep Sandstone Aquifers
8. Discussion

USE:YIELD ANALYSIS

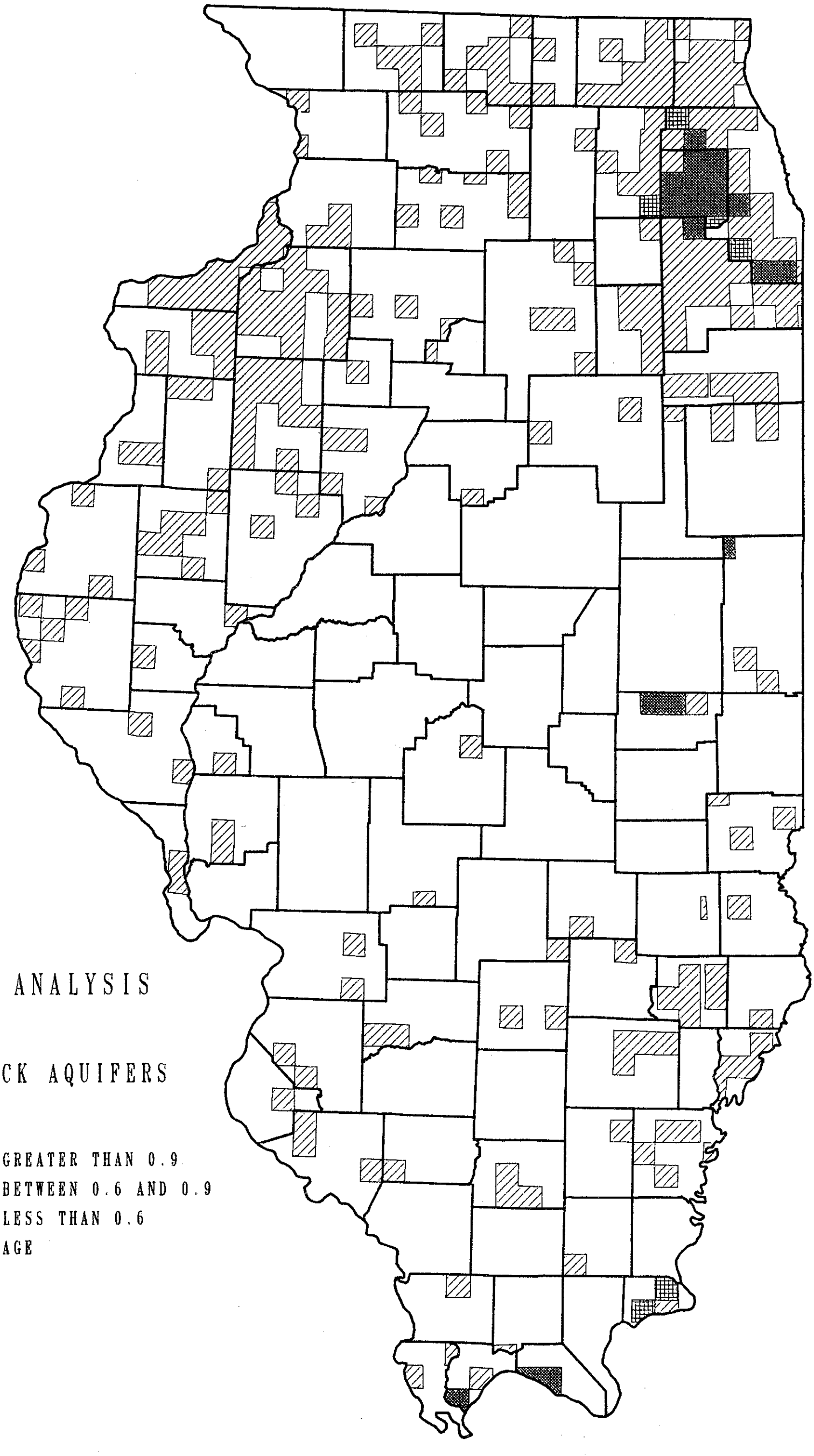
SAND AND GRAVEL AQUIFERS

- USE:YIELD RATIO GREATER THAN 0.9
- USE:YIELD RATIO BETWEEN 0.6 AND 0.9
- USE:YIELD RATIO LESS THAN 0.6
- NO REPORTED PUMPAGE



USE:YIELD ANALYSIS

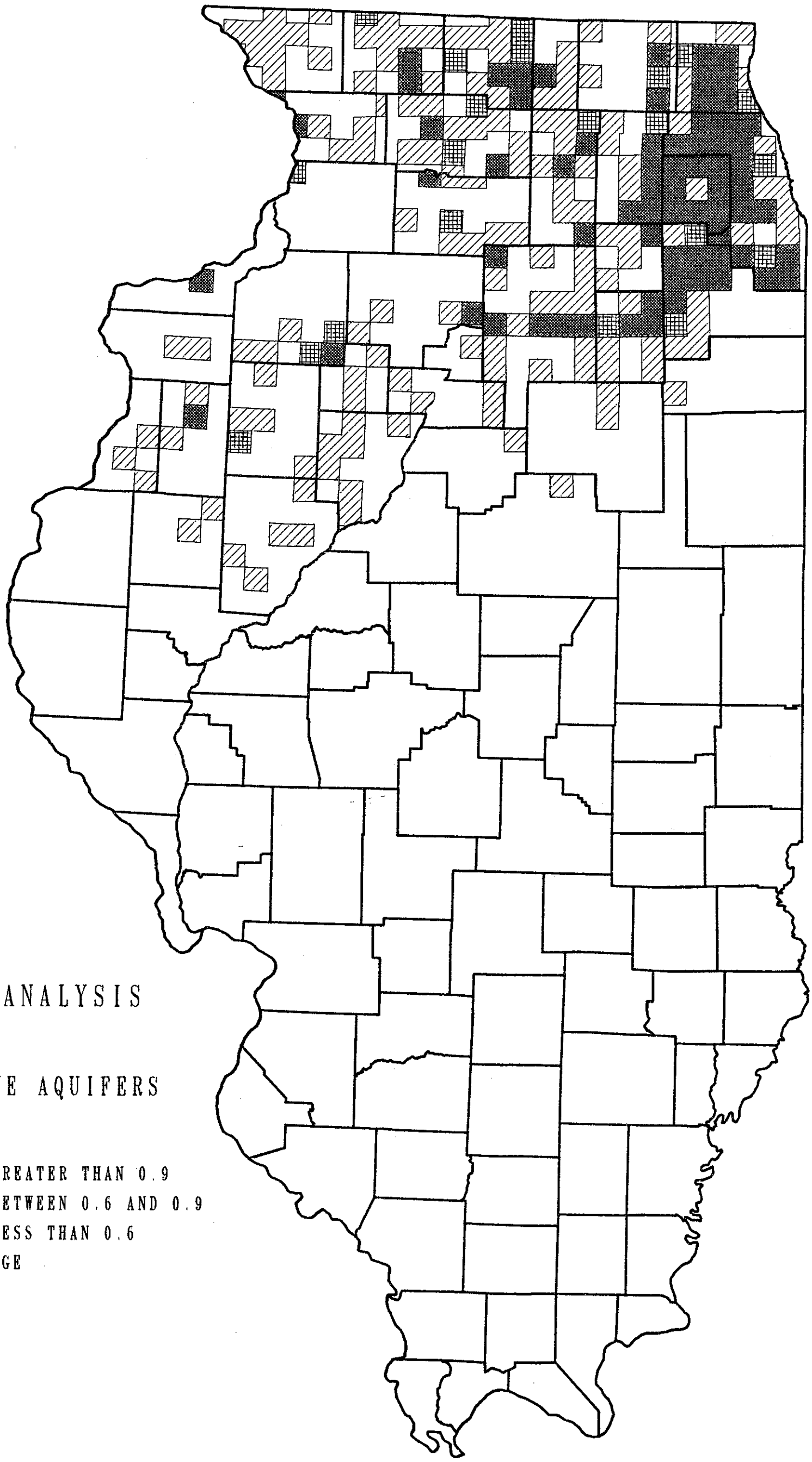
SHALLOW BEDROCK AQUIFERS



- USE:YIELD RATIO GREATER THAN 0.9
- USE:YIELD RATIO BETWEEN 0.6 AND 0.9
- USE:YIELD RATIO LESS THAN 0.6
- NO REPORTED PUMPAGE

USE:YIELD ANALYSIS

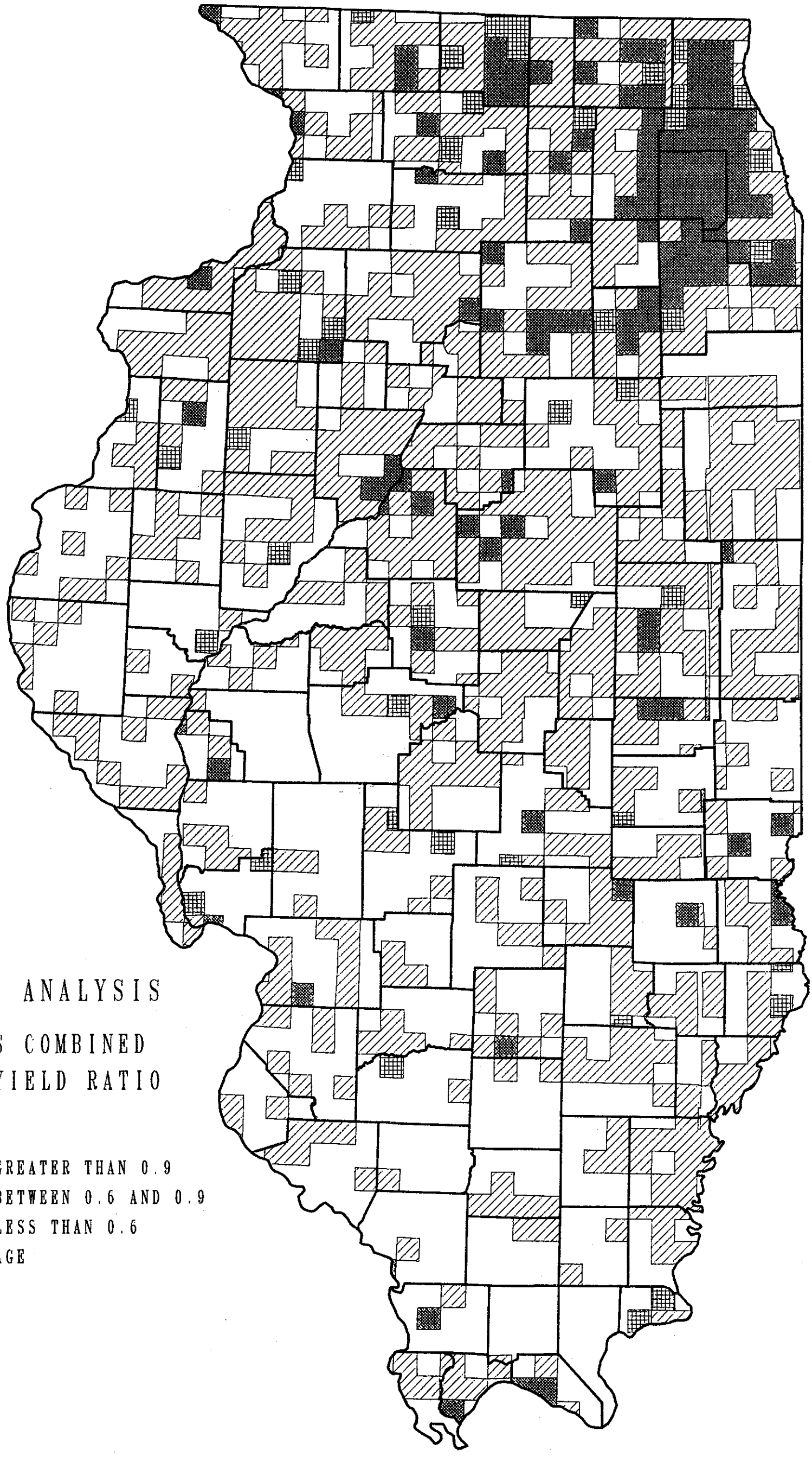
DEEP SANDSTONE AQUIFERS



- USE:YIELD RATIO GREATER THAN 0.9
- USE:YIELD RATIO BETWEEN 0.6 AND 0.9
- USE:YIELD RATIO LESS THAN 0.6
- NO REPORTED PUMPAGE

WORST CASE ANALYSIS

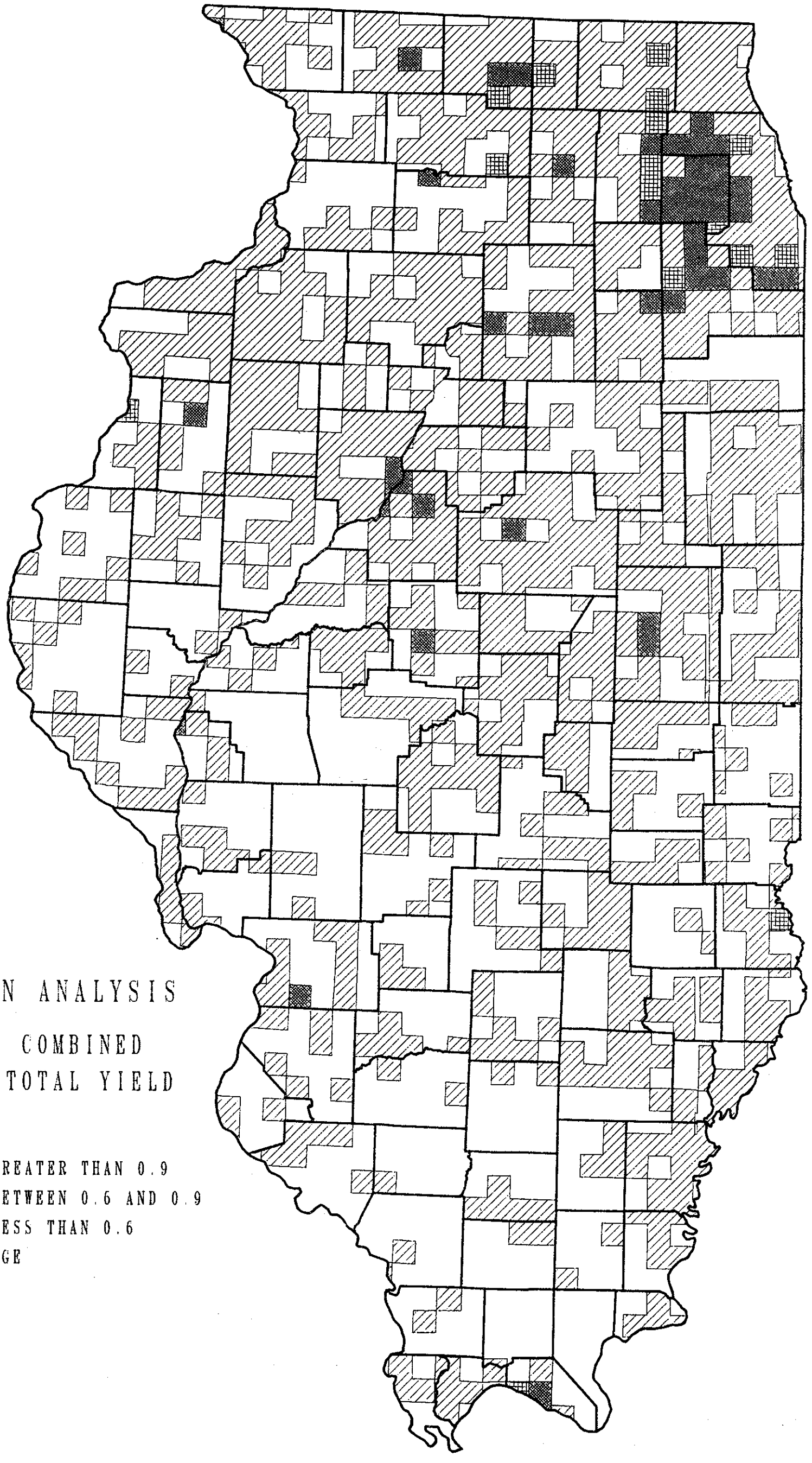
ALL AQUIFERS COMBINED
MAXIMUM USE:YIELD RATIO



- USE:YIELD RATIO GREATER THAN 0.9
- USE:YIELD RATIO BETWEEN 0.6 AND 0.9
- USE:YIELD RATIO LESS THAN 0.6
- NO REPORTED PUMPAGE

REALLOCATION ANALYSIS

ALL AQUIFERS COMBINED
TOTAL USE VS TOTAL YIELD



- USE:YIELD RATIO GREATER THAN 0.9
- USE:YIELD RATIO BETWEEN 0.6 AND 0.9
- USE:YIELD RATIO LESS THAN 0.6
- NO REPORTED PUMPAGE

8. Discussion

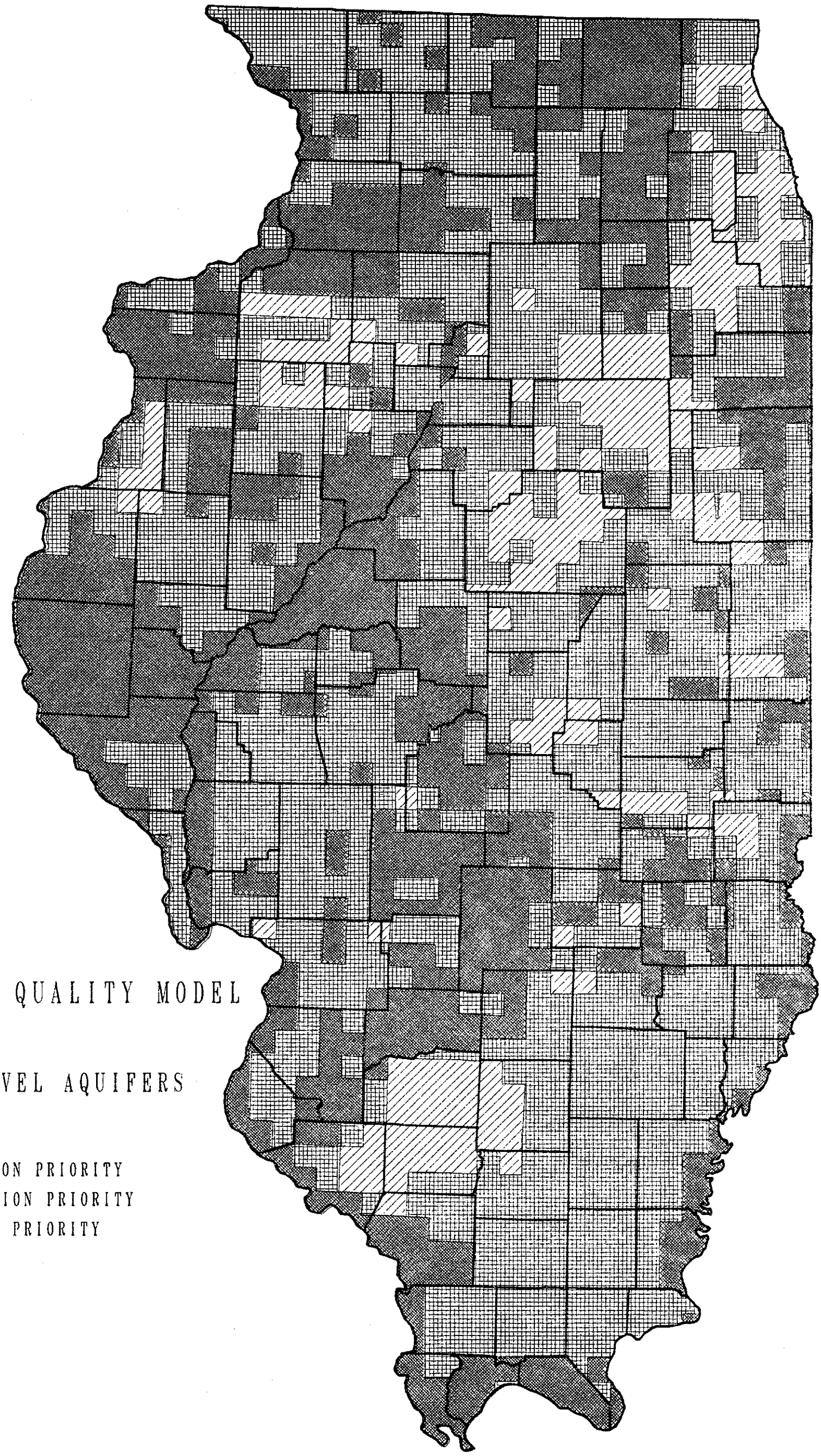
These maps indicate the susceptibility to contamination from the surface for the various aquifers. The fourth map is a worst case analysis, combining the preceding three.

The last three superimpose on the respective susceptibility maps those areas where adequate information is available to determine trends.

GROUNDWATER QUALITY MODEL

SAND AND GRAVEL AQUIFERS

HIGHEST PROTECTION PRIORITY
MODERATE PROTECTION PRIORITY
LOWER PROTECTION PRIORITY



GROUNDWATER QUALITY MODEL

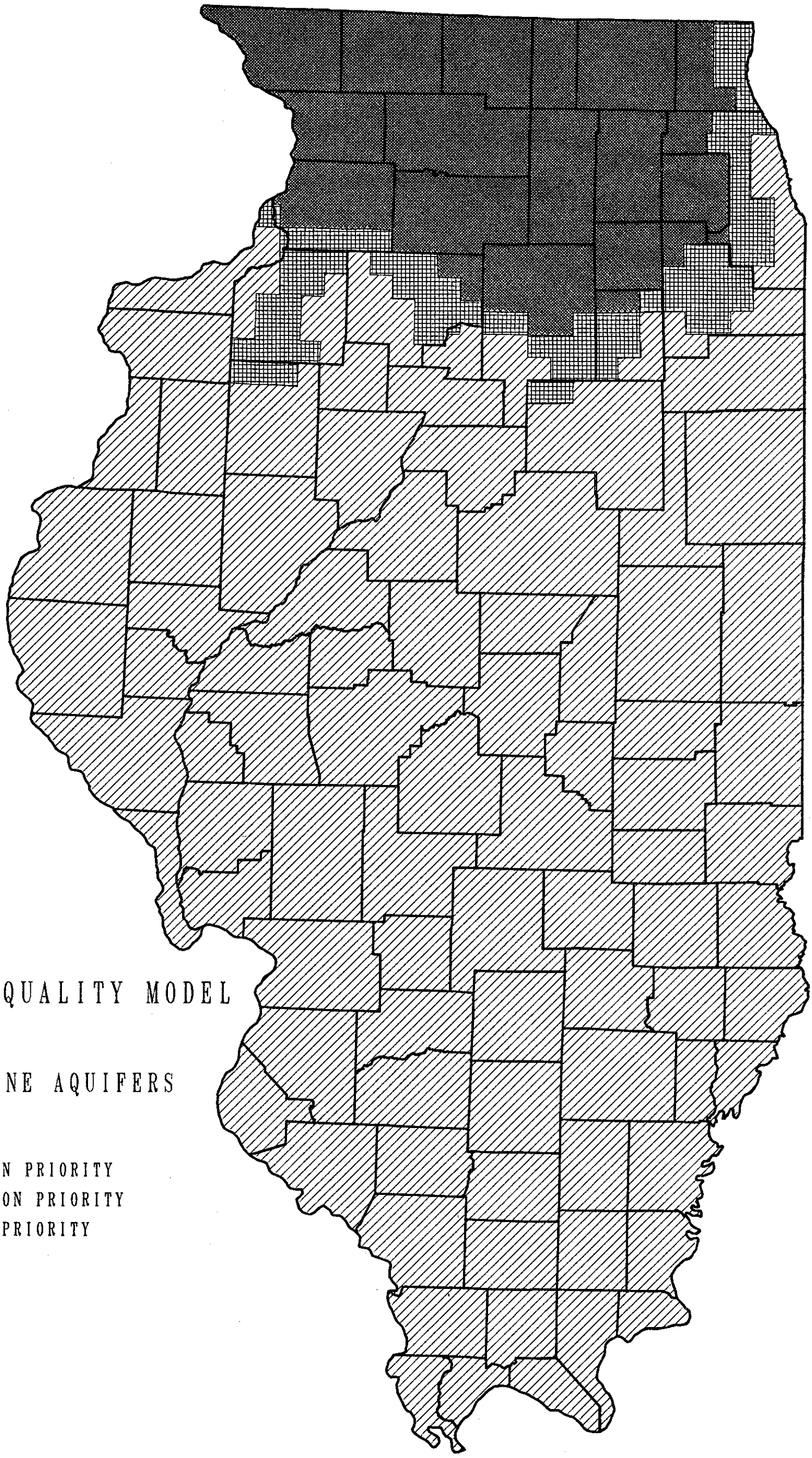
SHALLOW BEDROCK AQUIFERS

- HIGHEST PROTECTION PRIORITY
- MODERATE PROTECTION PRIORITY
- LOWER PROTECTION PRIORITY

GROUNDWATER QUALITY MODEL

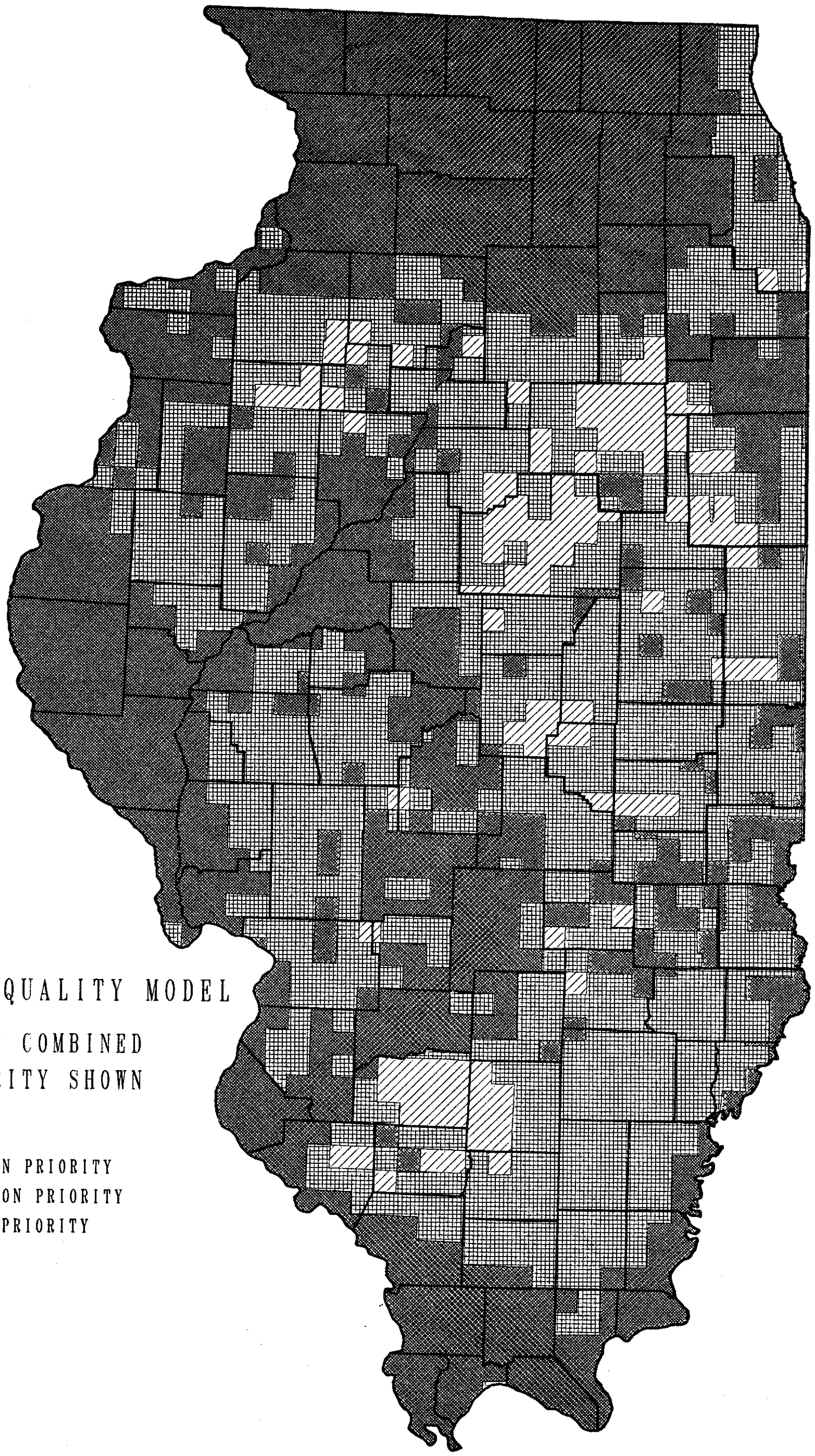
DEEP SANDSTONE AQUIFERS

- HIGHEST PROTECTION PRIORITY
- MODERATE PROTECTION PRIORITY
- LOWER PROTECTION PRIORITY



GROUNDWATER QUALITY MODEL

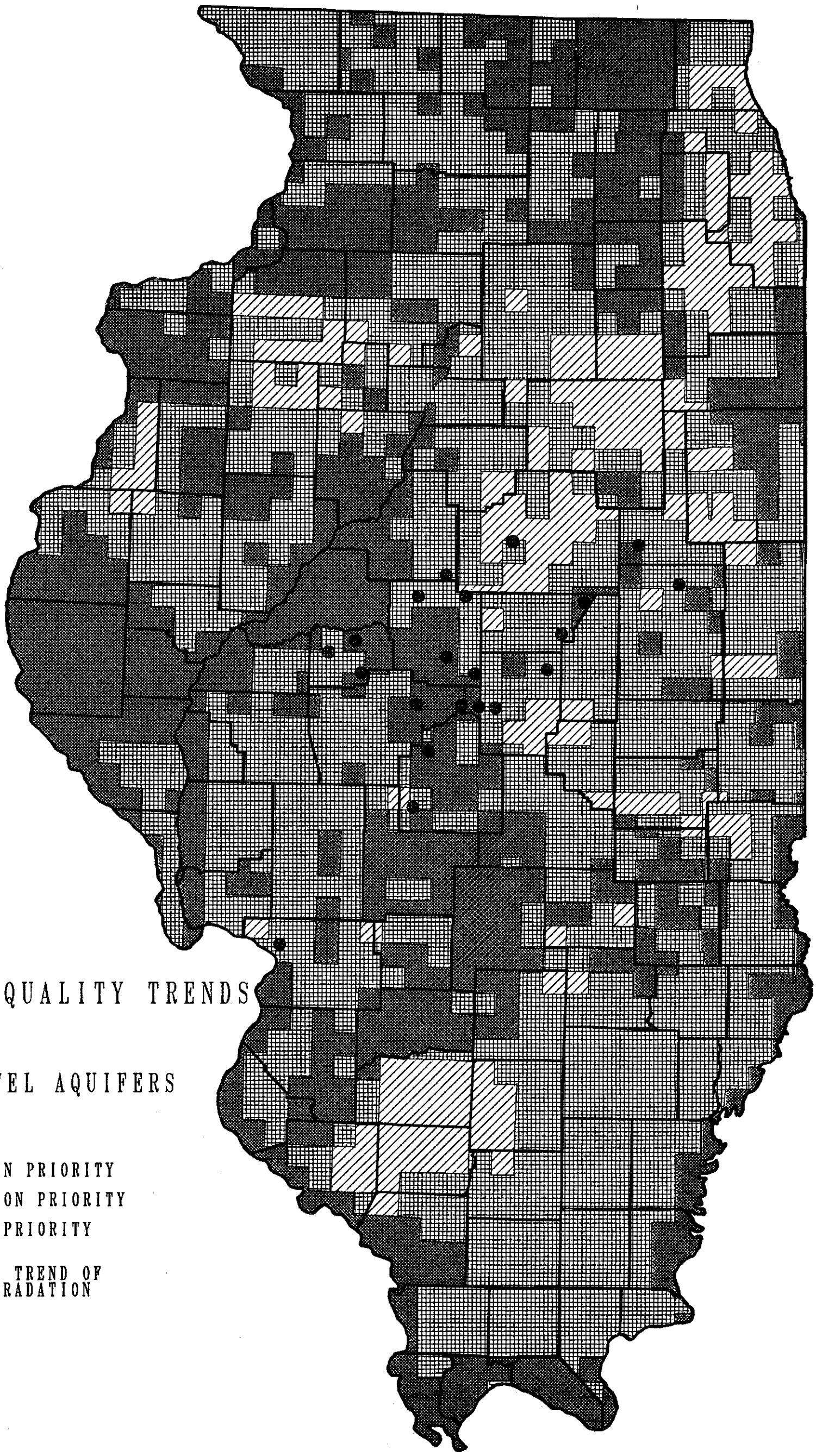
ALL AQUIFERS COMBINED
MAXIMUM PRIORITY SHOWN



- HIGHEST PROTECTION PRIORITY
- MODERATE PROTECTION PRIORITY
- LOWER PROTECTION PRIORITY

GROUNDWATER QUALITY TRENDS

SAND AND GRAVEL AQUIFERS

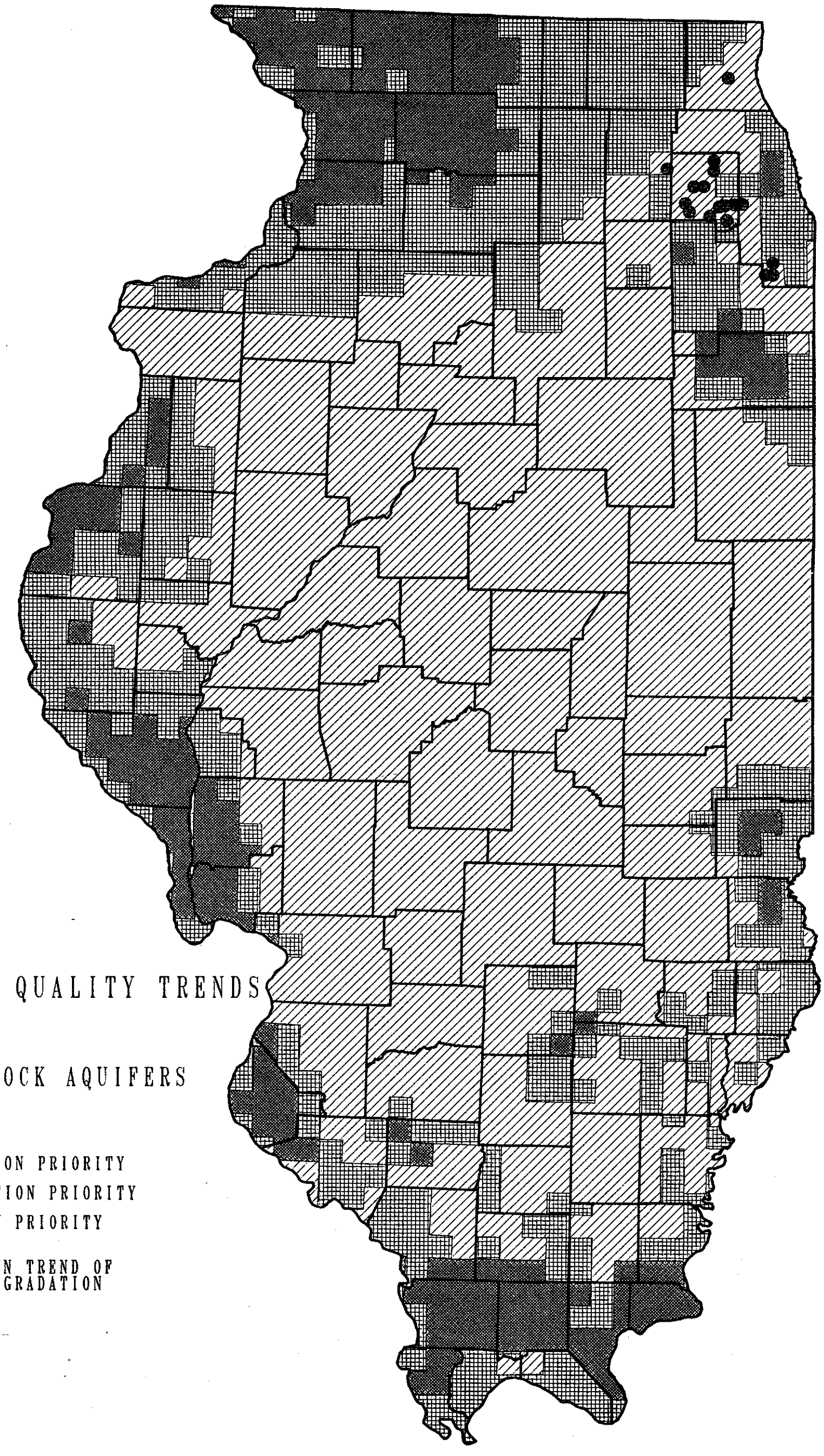


- HIGHEST PROTECTION PRIORITY
- MODERATE PROTECTION PRIORITY
- LOWER PROTECTION PRIORITY

- LOCATION OF KNOWN TREND OF WATER QUALITY DEGRADATION

GROUNDWATER QUALITY TRENDS

SHALLOW BEDROCK AQUIFERS



- HIGHEST PROTECTION PRIORITY
- MODERATE PROTECTION PRIORITY
- LOWER PROTECTION PRIORITY

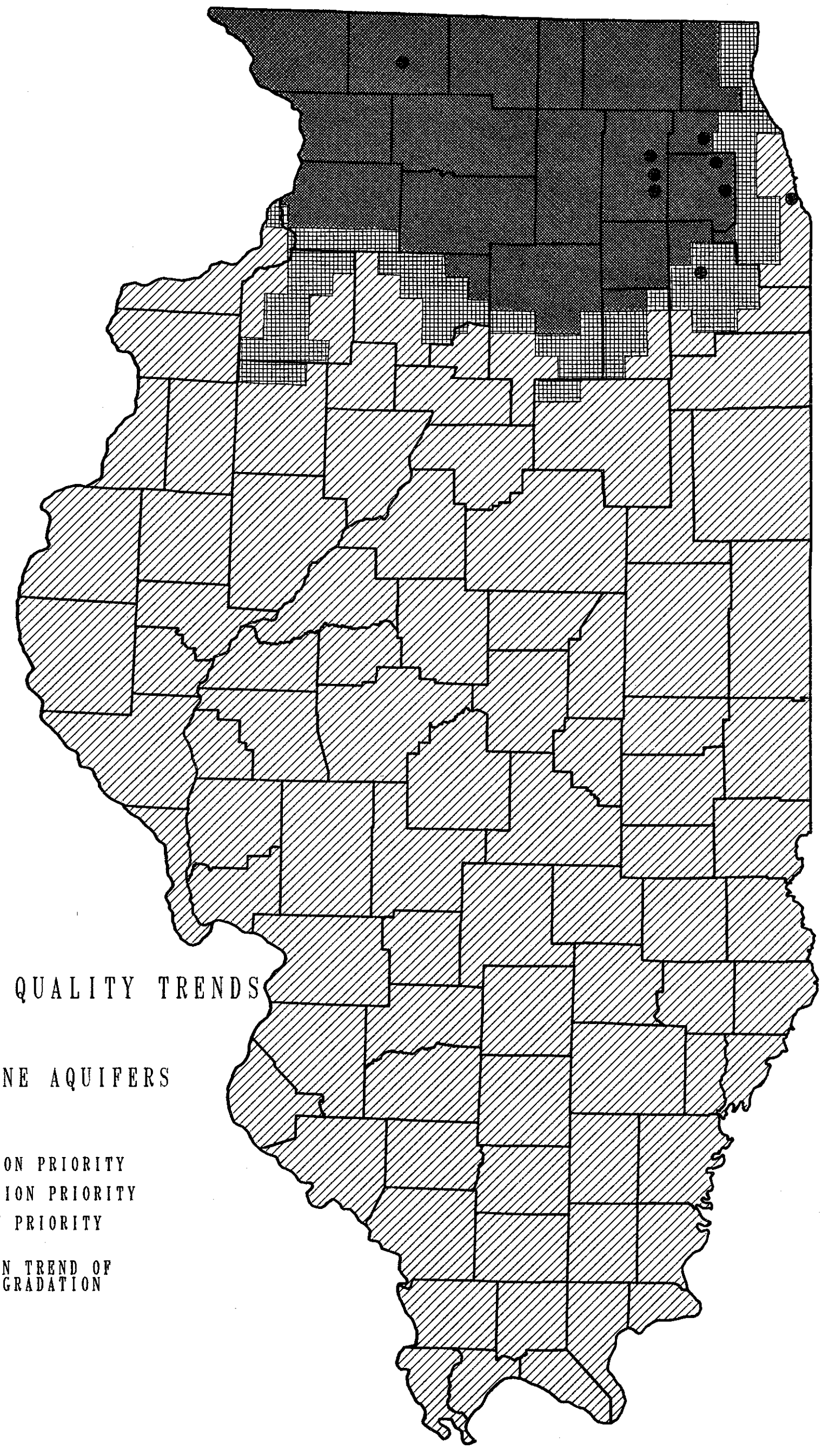
- LOCATION OF KNOWN TREND OF WATER QUALITY DEGRADATION

GROUNDWATER QUALITY TRENDS

DEEP SANDSTONE AQUIFERS

- HIGHEST PROTECTION PRIORITY
- MODERATE PROTECTION PRIORITY
- LOWER PROTECTION PRIORITY

- LOCATION OF KNOWN TREND OF WATER QUALITY DEGRADATION



Appendix B - Map Modeling

A. USE TO YIELD COMPARISON MAPS

Maps showing ranges of potential yield for shallow bedrock and sand and gravel aquifer systems were digitized and intersected with the township base map. An areally weighted mean potential yield was computed for each township. A constant potential yield was estimated for the deep sandstone aquifer system. Table B1 lists the ranges of potential yield and the values used for each range. These choices were made to obtain a conservative estimate of yield.

After the mean potential yields for each aquifer system in each township were computed, they were compared to the groundwater withdrawals in that township from each respective aquifer system. This was accomplished by calculating the use to yield ratio, which represents the fraction of the total resource being utilized. The results were categorized and plotted for each aquifer system.

The categorization procedures were developed to identify areas where problems may exist. It was assumed that if the use to yield ratio was greater than 0.9 (90% utilization), a probable problem area was identified. If the use to yield ratio was between 0.6 and 0.9 (60-90% utilization), the problem of overpumpage could exist. A use to yield ratio less than 0.6 represents an area where overpumpage does not probably occur.

Further spatial analysis was performed to identify all locations with a problem in any aquifer system. This analysis consisted of identifying the maximum use to yield ratio in each township. The results of this comparison represent a worst case analysis.

The final water use analysis consisted of summing the yield and pumpages from all aquifer systems, and computing a total use to total yield ratio. The purpose of this exercise is to illustrate areas where overpumpage in one aquifer system might be alleviated by shifting the distribution of pumpage between that aquifer system and another. The categorization system used in previous analyses was also applied in this case.

B. GROUNDWATER QUALITY MODEL MAPS

The identification of areas of concern for groundwater quality utilized three sets of data: an aquifer susceptibility map, maps showing mean concentrations of total dissolved solids and locations of known

TABLE B-1

Ranges of Potential Yield and Model Yield

Aquifer System	Range of Potential Yield	Model Value
Sand and Gravel	Other sources preferred	4,000 gpd/mi^2
	Less than 50,000 gpd/mi^2	20,000 gpd/mi^2
	100,000 - 150,000	100,000
	150,000 - 200,000	150,000
	200,000 - 300,000	200,000
	300,000 - 400,000	300,000
	1,000,000 - 3,000,000	1,000,000
	3,000,000 - 5,000,000	3,000,000
Shallow Bedrock	Other sources preferred	4,000
	Less than 50,000	20,000
	50,000 - 100,000	50,000
	100,000 - 200,000	100,000
Deep Sandstone	—	20,000

trends of water quality degradation. The thrust of the modeling effort was to identify areas with a high susceptibility to contamination, good ambient water quality, and without any trends toward a decrease in that quality.

The map depicting aquifer susceptibility to contamination used in this study is "Potential for Contamination of Shallow Aquifers from Land Burial of Municipal Wastes" (Berg et al., 1983). This map is divided into coded polygons which, for the purposes of digitization were divided into 3 groups. Table B-2 lists the classification of codes used by this model. The susceptibility criteria was not applied to the deep sandstone aquifer systems, which were assumed not susceptible to contamination from the surface.

TABLE B-2

Classification of Map Codes

Classification	Codes
1.	A2, AX, B1, B2, C2
2.	A1, A4, A5, BX, C1, C3
3.	C4, C5, D, E, F, G
4.	A3*

* No A3 polygons were found at map scale

The maps depicting ambient water quality consisted of contours of mean total dissolved solids (TDS) concentration, with a 500 mg/l contour interval. Closed polygons were formed by contours and, where appropriate, the state boundary. The deep sandstone aquifer system TDS map depicted an area where TDS concentrations exceed 10,000 mg/l. Thus, between all the maps four possible codes could be assigned; these represent areas with mean TDS concentration less than 500 mg/l, between 500 and 1000 mg/l, between 1000 and 10,000 mg/l and greater than 10,000 mg/l. These categories were assigned ratings of 1, 2, 3 and 9, respectively.

The aquifer susceptibility and ambient water quality maps were digitized and intersected with the township base map to enable the computation of an areally weighted mean rating of susceptibility and quality for each township. The locations of known trends were also digitized and intersected with the base map to permit automated adjustment for this factor.

The computations performed by the model consisted of determining the mean ratings for susceptibility and ambient quality, determining the number of known trends in that township, summing all three factors, dividing by a normalizing factor, and categorizing the results. Two model runs were performed using this methodology. They differed in the treatment of aquifer susceptibility and by the normalizing factor.

The first model run treated the three susceptibility codes as if they represented high, moderate and low susceptibilities. These qualitative categories were applied to classifications 1, 2 and 3, respectively, in Table B-2. As a result, the mean susceptibility would range between 1.0 and 3.0. The mean ambient water quality rating would range between 1.0 and 3.0 for sand and gravel and shallow bedrock aquifer systems. The mean water quality would range between 1.0 and 9.0, but would be limited to less than or equal to 3.0 in areas of potable water. A value of 1.0 was added for each occurence of a known trend. The composite rating was normalized by 7.0 for sand and gravel and shallow bedrock models and by 4.0 for the deep sandstone model, based on "reasonable" maximums for each set of results. Examination of the normalized results for all three models revealed that categorization by setting divide points at 0.5 and 0.75 would provide fairly even distribution for all models.

The second models run treated the susceptibility map classifications as system-specific. For the sand and gravel aquifer system, areas defined by classification 1 were susceptible to contamination; all others were not. Similarly for the shallow bedrock model, areas defined by classification were susceptible. Since this rating system was binary (susceptible or not), the susceptibility rating was given by the percentage of non-susceptible area within the township, in keeping with the theme that a low rating reflected a higher priority. Since the mean rating varied from 0.0 to 1.0, it was multiplied by 3.0 to give it

equivalent weight when compared to the water quality rating. The three criteria were summed, as in the first model run, but a normalizing factor of 6.0 was applied. This change was made because this figure better represents the maximum for the vast majority of townships.

As in the water use analysis, a combination plot was made. In this case, the plot depicts the maximum priority determined from the results of all three models. A summary of model parameters for both runs is included in Tables B-3a and B-3b.

TABLE B-3a.

Water Quality Model Parameters
First Model Run

$$P_R = (S + Q + \quad T)/N$$

P_R = Priority Rating
S = Mean Susceptibility Rating
Q = Mean TDS Rating
pT = Number of Trend Occurences
N = Normalization

Aquifer System	Susceptibility Map Classification	S	TDS Concentration	Q	T	N
Sand & Gravel	A2, AX, B1, B2, C2	1	<500	1.0	1.0	7.0
	A1, A4, A5, BX, C1, C3	2	500-1000	2.0		
	C4, C5, D, E, F, G	3	>1000	3.0		
Shallow Bedrock	A2, AX, B1, B2, C2	1	E500	1.0	1.0	7.0
	A1, A4, A5, BX, C1, C3	2	500-1000	2.0		
	C4, C5, D, E, F, G	3	>1000	3.0		
Deep Sandstone	N/A	-	<500	1.0	1.0	4.0
			500-1000	2.0		
			>1000	3.0		
			>10,000	9.0		

Categories Plotted: High Priority <0.5
Moderate Priority 0.5-.75
Low Priority >0.75

TABLE B-3b.

Water Quality Model Parameters
Second Model Run

$$P_R = (3S + Q + T)/N$$

Aquifer System	Susceptibility Map Classification	S	TDS Concentration	Q	T	N
Sand & Gravel	A2, AX, B1, B2, C2	0	<500 mg/l	1.0	1.0	6.0
	A1, A4, A5, BX, C1, C3	1	500-1000	2.0		
	C4, C5, D, E, F, G	1	>1000	3.0		
Shallow Bedrock	A2, AX, B1, B2, C2	1	<500 mg/l	1.0	1.0	6.0
	A1, A4, A5, BX, C1, C3	2	500-1000	2.0		
	C4, C5, D, E, F, G	3	>1000	3.0		
Deep Sandstone	N/A	-	<500 mg/l	1.0	1.0	3.0
			500-1000	2.0		
			>1000	3.0		
			>10,000	9.0		

Categories Plotted: High Priority <0.5
Moderate Priority 0.5-.75
Low Priority >0.75