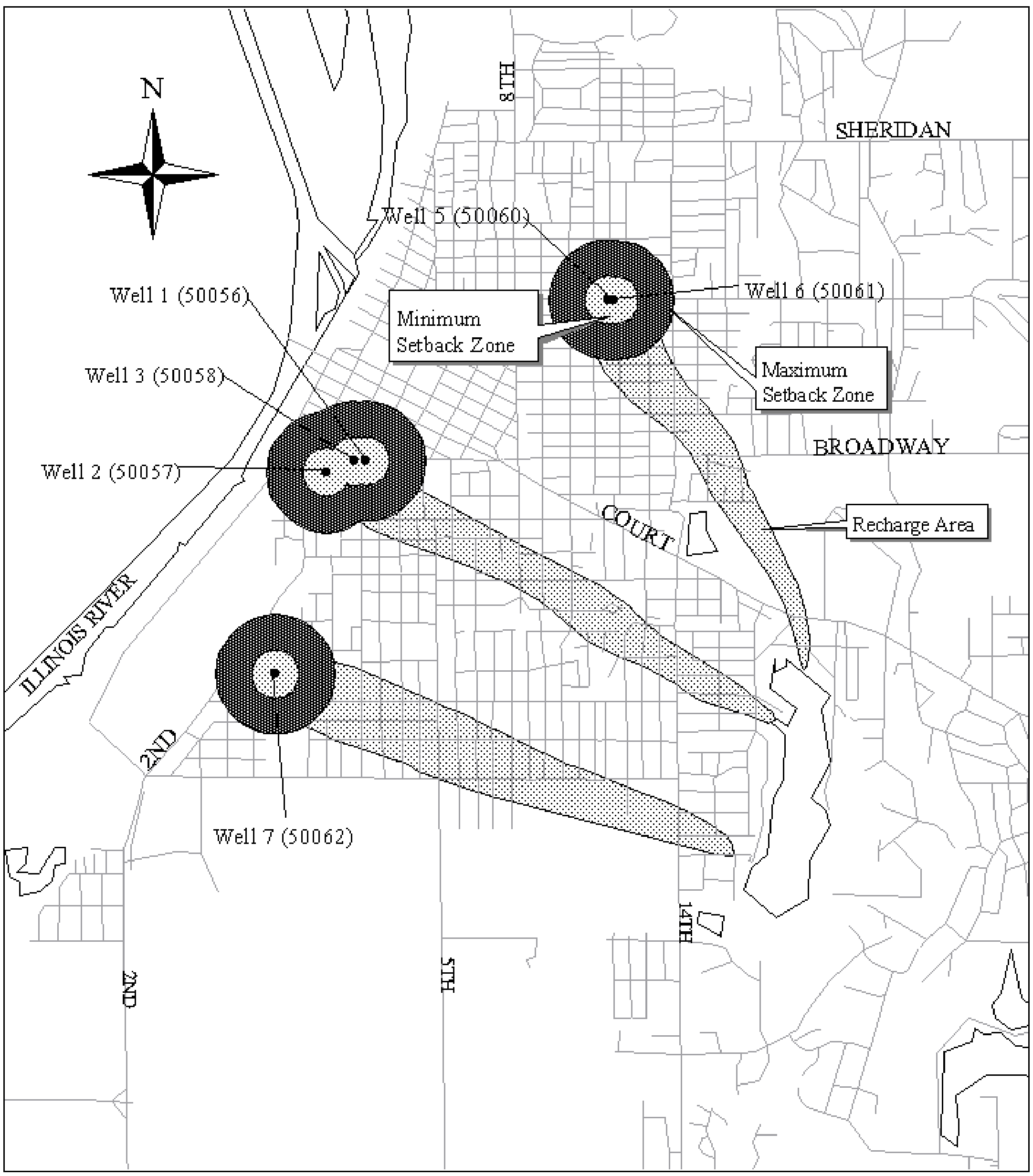
GUIDANCE DOCUMENT FOR GROUNDWATER PROTECTION NEEDS ASSESSMENT



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Prepared by
Illinois Environmental Protection Agency, Illinois State Geological Survey, and the Illinois State Water Survey

January, 1995

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Acknowledgement

This document was prepared with input from the Governor appointed Groundwater Advisory Council (GAC), and Regional Groundwater Protection Planning Committee members. Public input was provided at a Regional Groundwater Protection Policy Forum sponsored by the GAC, and Regional Committees on April 11, 1994. In addition, Rita Bair of USEPA Region V provided input. The Interagency Coordinating Committee on Groundwater reviewed and also provided input to the document. Additionally, editorial support was provided by Roger Selburg (IEPA) and Anthony Dulka (IEPA).

GUIDANCE DOCUMENT
FOR GROUNDWATER PROTECTION
NEEDS ASSESSMENTS *

INTRODUCTION

The purpose of this document is to serve as a guidebook for conducting Groundwater Protection Needs Assessments (GPNA). Counties and municipalities served by a community water supply were authorized to conduct GPNAs under Section 17.1 of the Illinois Groundwater Protection Act adopted in 1987. The intent of a GPNA is to provide a comprehensive evaluation of the groundwater protection measures necessary in order to assure a long-term supply of potable water that is not highly vulnerable to contamination.

Although the Groundwater Protection Act (Act) authorizes counties and municipalities to perform needs assessments and identifies what should be done for such assessments, the Act does not provide a specific methodological approach to be followed. Therefore, the Illinois Environmental Protection Agency (IEPA), the Illinois State Geological Survey (ISGS) and the Illinois State Water Survey (ISWS) have developed the approach discussed herein for undertaking a GPNA. The methodology provides a framework for guiding communities, counties, and private consultants through a process of determining the need for groundwater protection beyond the baseline provided by the statewide application of minimum or maximum wellhead setback zones.

There are broad-based economic implications of groundwater contamination to companies, counties and municipalities. These potential problems could be eliminated or alleviated in the future if more preventive, proactive management strategies are developed and implemented. The Act established initial protection measures by establishing minimum setback zones, that prohibit new potentially threatening sources of contamination from locating within these sensitive areas. Additionally, the Act provided the authority for counties and municipalities to expand setback zones up to 1,000 feet from community water-supply wells. Although these setback zones provide a baseline of protection, without having detailed knowledge of the site-specific, hydrogeologic conditions in a community, it is likely that a significant portion of a groundwater resource utilized by a community water supply would benefit from regional groundwater protection.

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ADVANTAGES OF GROUNDWATER PROTECTION

The pollution of groundwater can have wide-ranging economic implications to local communities and businesses (Bhagwat and Berg, 1992). Groundwater contamination can produce significant economic hardships for local businesses and communities, including the following:

- devalued real estate;
- diminished home sales or commercial real estate sales;
- loss to the tax base;
- consulting and legal fees;
- increased operation and maintenance costs;
- increased water rates for alternative water supplies as well as the cost of new equipment and treatment; and
- remediation costs including site characterization, feasibility studies, and long-term treatment and disposal costs.

All of these costs have a potential to adversely affect local economic development.

The USEPA prepared an assessment of the national water supply replacement cost due to groundwater contamination from nine types of contamination sources. The total national value of resource damage from these sources was estimated to be greater than $28 billion. The USEPA study also provided a summary from a site-specific case involving a leaking underground storage tank that has cost $1.9 million in state funds, and $1 million in cost for direct and borrowed funds to the community for aquifer rehabilitation. Now over 13 years later, groundwater from this site still requires treatment, and daily monitoring will be required for 3 years following the completion of the aquifer rehabilitation program. In addition, for contamination cases where the only feasible alternative is drilling new wells, the cost of installing new transmission and distribution line to connect private well users to existing community water supplies is substantial. In cases where these alternatives were necessary, costs have ranged from $70 thousand to over $2.3 million, depending on the extent of contamination and the population served.

The IEPA has also evaluated some of the costs associated with contaminated community water supplies in Illinois. For example, in December 1981, the Rockford Water Utility could no longer utilize municipal water supply wells 7 and 7A because of contamination by volatile organic compounds (VOCs). These wells, with a capacity of 7.5 million gallons per day, representing one fourth of Rockford's water needs, were permanently lost to the City. In order to supplement this loss, the City had to drill new wells into deeper and less productive aquifers. Over the past five years the City has added five new wells at a cost of approximately $7.5 million. To further compound this situation, several hundred private wells in the southeast Rockford area have been hooked up to the city system, at a cost of approximately $4 million. It is estimated that the approximate combined cost for the entire southeast Rockford contamination site will be approximately $15-20 million.

Another example is the City of Fox River Grove, which spent $500,000 to design and install a VOC stripping tower to treat water from two of their community water supply wells contaminated by VOCs. The cost for designing a similar air stripping tower for the City of Freeport, because of VOC contamination, was $570,000. In yet another example, it cost the State, through a grant to the Village of Chandlerville, $260,000 to find and install an alternate source of drinking water because pesticides exceeding the drinking water standards were present in the community's only water supply well.

These and other examples (Bhagwat and Berg, 1992) document that the cost of groundwater contamination is significant. In contrast, the cost of implementing a local groundwater protection program can reduce costs of contamination. Groundwater protection can be achieved by applying certain design and/or operating practices for new potential sources of contamination. Another approach that can be utilized to protect groundwater in relation to new and existing potential contamination sources is now being implemented by many companies, and is referred to as pollution prevention. Pollution prevention involves reviewing the use of all hazardous and liquid chemicals in plant or company processes. When possible, the process is adjusted to eliminate waste products or replace hazardous with non-hazardous materials. Thus, a pollution prevention program can:

- reduce operating costs;
- reduce risk of criminal and civil liability;
- improve employee morale and participation;
- enhance company's image in the community; and
- protect public health and the environment.

In addition, a local groundwater protection program established in community well recharge area(s), as determined by a GPNA, allows a community to focus its management efforts, avoid excessive management and regulation in areas that do not contribute groundwater to the wells, and avoid spending time and funds on protecting non-critical areas where groundwater contamination potential is low. This type of prevention program could also allow the State to provide a waiver to reduce the community well monitoring required under the Safe Drinking Water Act (SDWA).

In summary, it will cost a community considerably less to conduct a GPNA and to implement a local groundwater protection program than to not consider these as essential elements in a community's continued economic development and run the greater risk of potential contamination. Also, communities that deliver water that exceeds the drinking water standards are placed on restricted status and are not issued permits for water main extensions that would allow the expansion of the distribution system.

PILOT GROUNDWATER PROTECTION NEEDS ASSESSMENTS IN ILLINOIS

Background

Four pilot GPNAs have been conducted in Illinois to date. These pilot assessments were conducted in an effort to determine a technical basis for a GPNA methodology under a range of different settings and conditions. Additionally, these assessments also provided the basis for establishing a comprehensive groundwater protection program for each of these community supplies. Each of the pilot assessments were conducted under a different set of geologic and cultural conditions. The following profiles of the pilot assessments are described to help provide the reader with an idea of how these conditions can vary, which affects the outcome and the approach that can be taken.

Pleasant Valley Public Water District

The Pleasant Valley Public Water District (PWD) was the first community water supply in the state to take advantage of the authority to establish a maximum setback zone in 1988. This was also the first effort of a community water supply interacting with a county board (Peoria County) to adopt a local groundwater protection ordinance. Furthermore, the District was interested in determining their protection needs beyond the setback zones because they were concerned about certain land-uses beyond their 1,000 foot maximum setback zones. Because of this concern they initiated a pilot GPNA which was conducted by Clark Engineers MW, Inc. The Pleasant Valley PWD lies entirely within Peoria County. The District includes one section of Rosefield Township and a 33 acre section of Peoria Township. The District supplies water to 1296 services and sells water to an additional 300 services. The average daily water usage was 513,000 gallons per day (gpd). The only groundwater resource in the area capable of supplying the water necessary for the District is located in a small area east of Kickapoo Creek.

The GPNA conducted for Pleasant Valley PWD determined that the surficial soils in the area were comprised of sands, gravels and clay. The soils are underlain by sand that is the sole source of water for the District. The GPNA also determined the area on the land surface that provided recharge to the community water supply wells for a five-year period as shown in Figure 1. The next step of the assessment conducted by Clark Engineers was to evaluate the existing potential sources of contamination located within this 5 year recharge area. This evaluation determined that there were several industrial and commercial operations located within the District's recharge area beyond the maximum setback zones established for the wells . Therefore any type of release or accidental spill in the recharge area could result in contaminating the District's water supply.

The GPNA for Pleasant Valley recommended that the industrially zoned area of the recharge

areas be re-zoned to provide better harmony between the two types of use in the area. In addition, it recommended that early warning leak detection systems be used in conjunction with other best management practices at existing underground gasoline storage tanks.

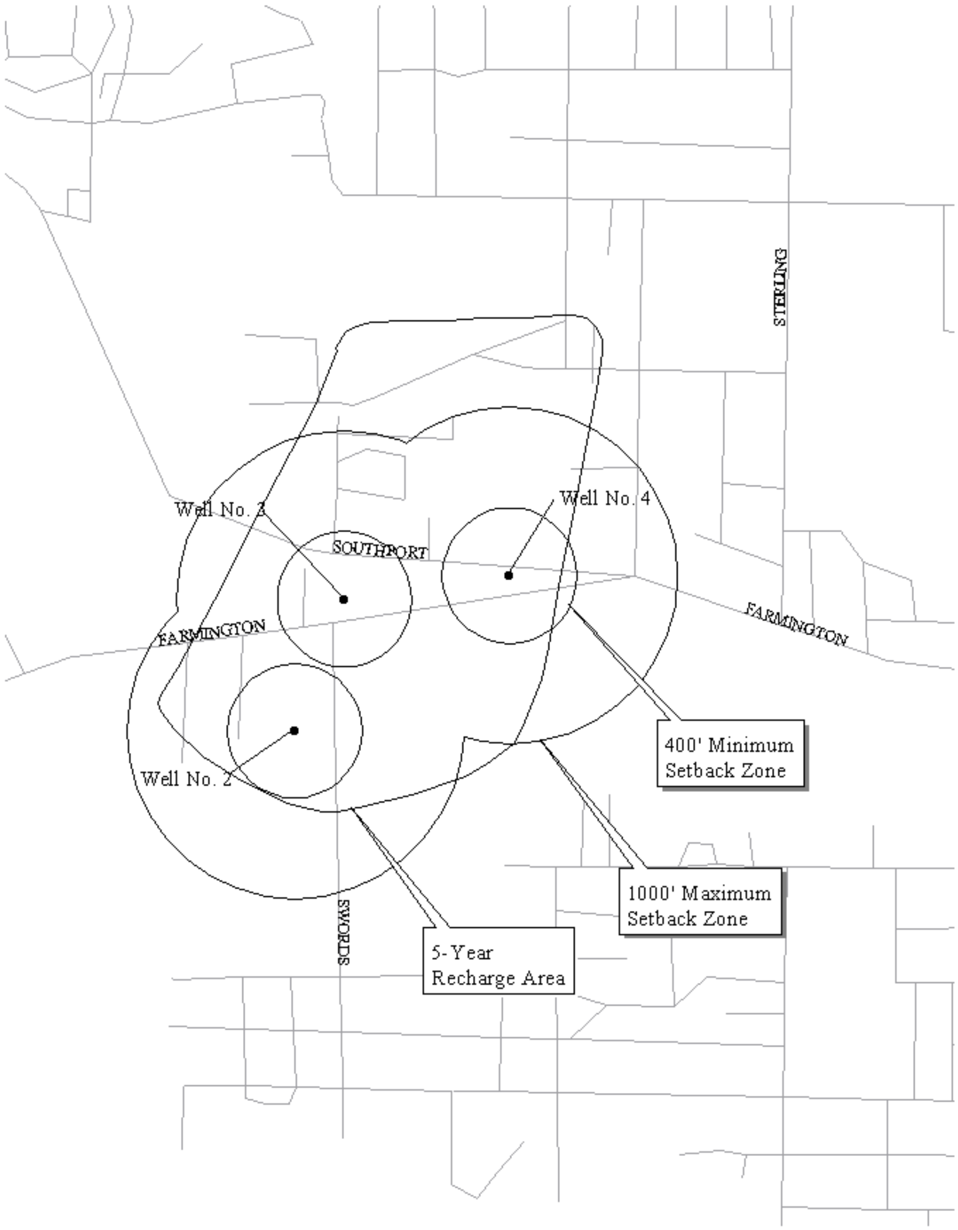

Figure 1.Map of the 5-year recharge area for Pleasant Valley Public Water District (from Clark Engineers, 1992)

Village of Woodstock

The ISGS, ISWS and IEPA are in the process of conducting a pilot groundwater protection needs assessment for the Village of Woodstock in McHenry County. The pilot assessment being conducted in Woodstock is different in many respects from the assessments conducted in other areas, primarily because of the size of the study area (55 square miles), and the complexity of the hydrology and geology. The ISGS has identified four principal shallow sand and gravel aquifers in the study area (Berg, 1994). None of these is present as a continuous sheet across the study area, and thicknesses can vary considerably over a relatively short lateral distance. In addition, hydraulic connections between aquifers are present as "windows" where intervening confining units pinch out. Potentiometric surface maps for the four aquifers have been prepared and will be used for model verification. A three-dimensional model of the flow within these units is being prepared.

Village of Cary

The Village of Cary, also located in McHenry County, hired Baxter & Woodman, Inc. to conduct a GPNA. The Village is located in the southeastern corner of McHenry County, and has a population of approximately 13,000. The rate of development increased significantly when the railroad was extended from Chicago in 1854 (Baxter & Woodman, 1992). The Village currently pumps an average of 1,300,000 gallons of water per day on an annual basis from its wells, and it is projecting that this average consumption may reach as much as 3.35 million gallons of water per day. The current consumption is estimated by Baxter & Woodman to be 66 percent residential, and 34 percent industrial, business and municipal needs.

The community water supply is primarily utilizing groundwater from shallow sand and gravel aquifers at a depth of less than 250 feet. In addition, two of the Village's wells are greater than 1,000 feet deep and are utilizing groundwater from sandstone deposits. Baxter and Woodman choose to determine the 10 year recharge areas for the existing sand and gravel aquifer wells, and for a new well utilizing the same sand and gravel aquifer. The recharge area determinations indicated that the areas extended beyond the minimum and potential maximum setback zones in an area that primarily extends upgradient from the wells. The upgradient zones ranged from 2,500 to 9,000 feet. Because of the regional direction of groundwater flow, activities in other municipal jurisdictions were determined to have potential groundwater contamination impacts on the Cary water supply. The geology and land-uses in the predominant portion of the Cary well recharge areas were determined to be highly susceptible to groundwater contamination.

The GPNA also recommended a plan of action for establishing a local groundwater protection program for the Village. The plan of action contained both regulatory and non-regulatory options. The regulatory recommendations included: establishment of maximum setback zones and regulated recharge areas, updating the Village zoning code to include Groundwater Protection Act references, establish performance criteria in the manufacturing district (within the well recharge areas), and establish a contingency fund for emergency responses and cleanup. The following non-regulatory approaches were also recommended: town meetings to inform the public about the vulnerability of the groundwater resources; cooperative program to coordinate the groundwater protection efforts of state and local governments, business and citizens; and develop a list of contractors with emergency response and groundwater contamination cleanup capabilities.

City of Pekin

The IEPA conducted a GPNA for the City of Pekin which is supplied water by the Illinois American Water Company (IAWC). The City of Pekin is located in Tazewell County east of the Illinois River. The Pekin study area was comprised of approximately 20 square miles. The community water supply supplies approximately 4,420,000 gpd to 13,514 services. The IAWC-Pekin community water supply utilizes a homogeneous unconfined sand and gravel aquifer that is present between a bluff and the Illinois River. The aquifer material pinches out against the bluff, and to the north. The assessment for Pekin also determined the recharge areas for the wells, and determined the characteristics of the soils and the geologic vulnerability. Unlike the other pilot assessments, the aquifer material pinched out before a 5 year time of travel was obtained as illustrated in Figure 2. Like the other assessments the existing potential sources of contamination and land-use zoning was evaluated relative to the recharge areas.

The GPNA determined that there was some indirect protection provided in the recharge areas because the majority of the land-use zoning was residential, and the homes were hooked up to a municipal sewer system. Furthermore, there did not appear to be any business being conducted in the homes that might have an adverse affect on groundwater (e.g., furniture refinishing). However, there were also areas that were zoned industrial and commercial within and proximate to the Pekin well recharge areas. Additionally, a number of existing potential contamination sources were located within the recharge areas.

The GPNA helped establish a focus for developing a local groundwater protection strategy. The Central Regional Groundwater Protection Planning Committee in cooperation with the Mayor and Pekin City Council established a team comprised of representatives from: local business; Pekin Planning and Zoning Department; Pekin Engineering Department; Pekin High School; IAWC staff; the Central Planning Committee; the local Fire Chief; Department of Energy and Natural Resources(DENR) and the IEPA. The primary purpose of this team was to work together to educate local businesses, other community residents about the benefits of groundwater protection, and to concurrently implement the recommendations made in the GPNA.

During this process it was determined that if one of the Pekin well recharge areas was Contaminated it would result in a loss of 5-7 million gallons of production supply. It was also determined that the approximate cost for treating groundwater would be $4,000,000 or $15,000,000 to build a surface water treatment plant. Additionally, it was concluded that contamination of this supply would be detrimental to further economic development because new business coming into the area will place an increased demand on the use of uncontaminated groundwater.

To implement a groundwater protection program the team first organized a pollution prevention, and Class V well injection workshop for the businesses in Pekin. A second pollution prevention workshop was organized specifically to provide technical assistance to automotive repair shops which comprise the majority of the existing businesses located within the recharge areas of the IAWC-Pekin community water supply wells. Secondly, the team developed an amendment to the existing zoning ordinance that required certain best management practices for existing potential sources and created a new overlay zoning ordinance with special/conditional use permits for new uses in the commercial and industrial zoned parcels within the well recharge areas. Appendix I contains a copy of the ordinance for further information.

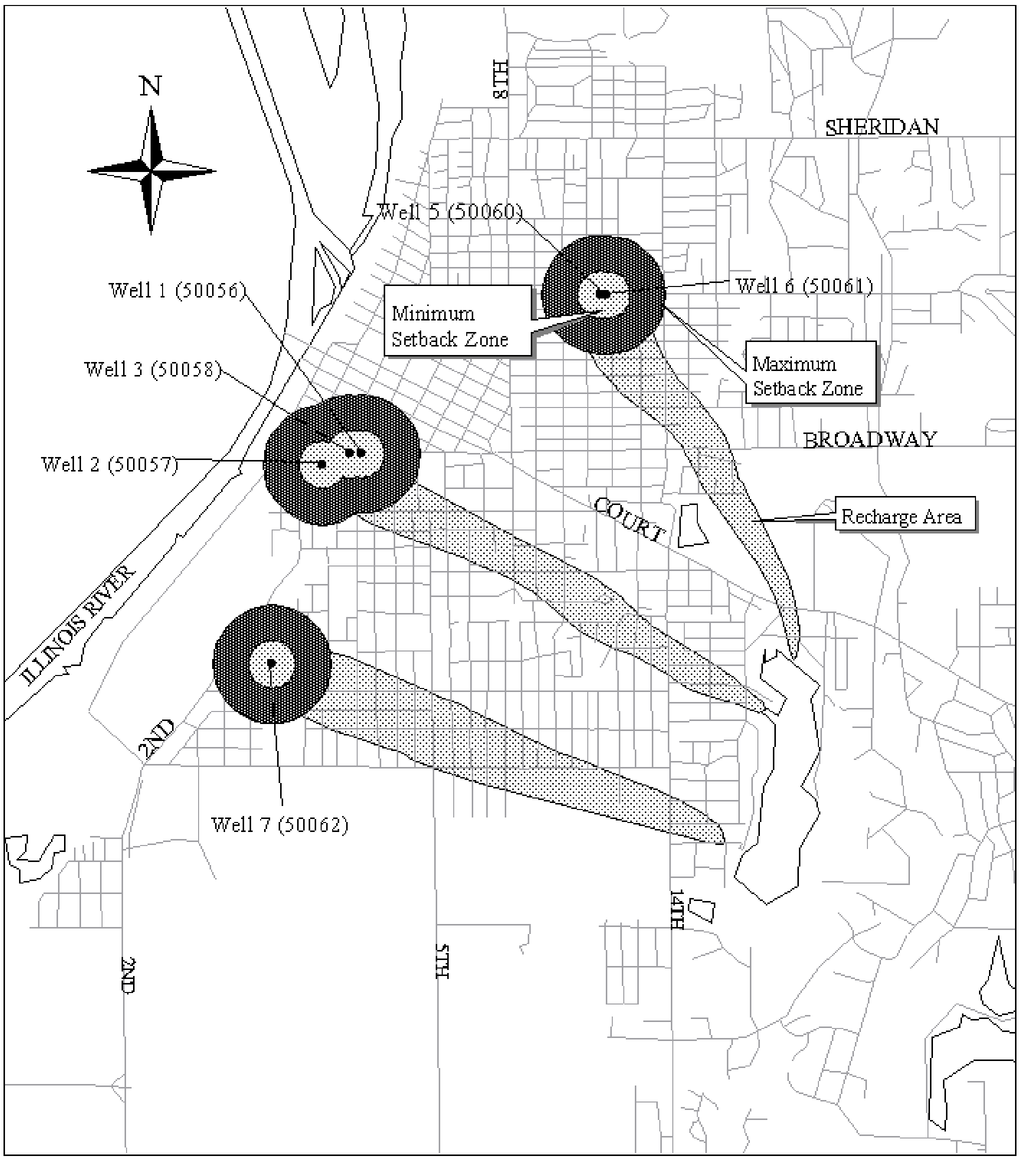

Figure 2. Map of the recharge areas and setback zones for the City of Pekin (from Adams et al., 1992)

GROUNDWATER PROTECTION NEEDS ASSESSMENT DEVELOPMENT PROCESS

Phase I Scoping Process

The term GPNA as used in this document infers a very rigorous procedure. This type of approach may not be appropriate for smaller public water supplies; however, other less rigorous approaches could be applied. Therefore, before a community initiates a full scale GPNA, a phased approach should be utilized to determine if one is necessary or appropriate to the extent described for needs assessments in this document. One of the first steps of this evaluation process should be to determine if the community is withdrawing its groundwater from a confined or unconfined aquifer system. Confined aquifers are generally overlain by clay or shale, and the pumping and static water levels are above the top of the aquifer utilized by a well. To determine the lateral extent of a confining layer the following general procedure should be utilized:

- Published reports and maps at the Illinois State Geological Survey, Illinois State Water Survey, and United States Geological Survey should be consulted for regional geologic/hydrologic information. For some regions of Illinois, detailed county studies and other more site-specific investigations may also be available. Consult lists of publications from the above agencies for availability of information for site-specific studies;

- Local unpublished information should also be obtained prior to and during the GPNA. In addition to water-well log information discussed below, state, county, and municipal agencies often have geologic/hydrologic information from bridge, road, and building construction efforts, landfill siting endeavors, and as part of a septic tank permitting process. Planning and health departments, road commissions, and soil and water conservation districts usually have considerable data of this type in their files;

- Considerable data (including engineering test borings and water-well logs, etc.) are often available at the ISWS, ISGS, and some local health departments to help determine the sequence of geologic deposits for a given area. Of basic importance to a regional groundwater characterization is knowledge of the locations of wells in the area. It is critical that information clearly delineating aquifers be obtained and used. The highest quality data are from deep test-drilling for water resources, engineering borings for bridges and waste-disposal facilities, and exploratory test drilling and/or surface outcrop descriptions;

- Much data can be derived by examining water-well records. However, due to difficulties in accurately locating private water wells from the locations given in the well records (particularly older records), many records can not be used. Locations should be verified by checking the address on the water-well log against county plat books and road maps, or by personally interviewing well owners. In some cases water-well drillers should be contacted to obtain more accurate locations because local drillers maintain records of the wells they have constructed;

- Questionable logs of private water wells should be compared to logs of nearby wells that had been recorded by a geologist or geotechnical engineer. These high-quality logs are referred to as *key stratigraphic control logs*. If the stratigraphic data depicted for the questionable log does not compare well to the stratigraphy of the key stratigraphic control log, the private water-well log should not be used. Where key stratigraphic control logs are not available, comparisons should be made to logs of other wells nearest to the questionable log. A decision whether or not to use the log then should be based on the degree to which the log can be integrated with current knowledge of the regional geology; and

- Of basic importance is determination of well depth and the open or screened interval of the well (i.e., the aquifer developed by each well). This becomes important in selecting wells to use for measurement of groundwater levels. Wells completed in different aquifers or at different depths within the same aquifer will produce water levels that cannot be compared to one another.

If after the above approach is utilized, and a community is still uncertain as to the type of aquifer they are utilizing the IEPA, ISWS and ISGS can all assist with this type of determination. Additionally, Appendix II provides guidance on *Hydrogeology and Groundwater Contamination* fundamentals. Groundwater from confined aquifer systems are not as vulnerable to contamination from activities conducted on the land surface. However, these aquifer systems become vulnerable if improperly abandoned wells or other types of potential routes of contamination breach this confining layer. Therefore, if a community is utilizing a confined aquifer, resources would be better focused on determining if there are any potential routes of contamination that breach the confining layers, and these routes should be properly abandoned. The community well integrity should also be evaluated to determine if there are any flaws in well construction that would allow leakage from the land surface along the well casing into the confined aquifer. If a community is utilizing a unconfined aquifer, additional scoping criteria should be evaluated.

Communities utilizing an unconfined aquifer system need to evaluate existing aquifer property data (e.g., data obtained from a pumping well test). In many instances, this type of data may be available at the ISWS. This data along with a minimum of three water level readings from existing wells utilizing the same aquifer in the area should be used to determine if the well is obtaining recharge beyond a minimum or maximum setback zone. At a minimum the area supplying recharge for a 5 year period should be determined. This simple and quick approximation can be calculated with the equation (Todd Uniform Flow Equation) described on page 34 of the *Maximum Setback Zone Workbook* prepared by the IEPA. In addition, the United States Environmental Protection Agency's (USEPA) public domain wellhead protection area (WHPA) computer code could also be utilized to determine well recharge areas. If aquifer property data is not available, a community could assume that the recharge area exceeds the minimum and maximum setback zone. The ISWS performed a case study analysis on 300 community water supply wells utilizing unconfined aquifers, and determined that the recharge areas exceeded the minimum and maximum setback zones in the upgradient direction for 90 percent of the wells.

The next step of the scoping process should evaluate the existing land-use zoning within a topographic quadrangle area around the community water supply or within an approximated recharge area. If the area within the recharge area is zoned residential, residences are on a municipal sewer system, and there are in home businesses that might have an adverse affect on groundwater a detailed GPNA may not be necessary. In other words, a less rigorous approach could be utilized to determine the protection needs of the local groundwater resources. For example, a local household hazardous waste collection and groundwater protection education program (e.g., the residences located within the recharge areas may have household hazardous wastes) could be conducted within the approximated recharge area as described above. However, if there is industrial, commercial and/or agricultural land-use zoning adjacent to the community water supply wells, there is a potential for groundwater contamination to occur. If there are existing potential sources of contamination or the land-use zoning allows for new industrial, commercial and/or agricultural land-uses to locate adjacent to the wells, the next step before considering to proceed with a GPNA is what potential there is for establishing controls to reduce or lessen the likelihood of contamination. If there is no potential for establishing these controls, the community may not want to invest in a GPNA which primarily provides a sound technical basis for establishing controls or best management practices to reduce the vulnerability of contamination to the community's groundwater supply.

Evaluation of the information described in this section should enable a community to decide if it should proceed with a GPNA. This is not meant to infer that a local groundwater and wellhead protection program should not be implemented. It is only intended to be a decision process for conducting a rigorous GPNA. Other less rigorous approaches should be utilized by smaller public water supplies. The supply could request the IEPA to conduct a hazard review as one alterative. If a decision to proceed is made, a community should undertake phase II of the development process.

Phase II-Detailed Technical Analysis and Options Development

The first part of the assessment will consist of detailed technical analysis and development of options. The technical analysis will determine the character of the geologic materials and soils; the regional groundwater flow system; the size and shape of the community well recharge areas; the existing potential contamination sources within the recharge area; an evaluation of the hazard posed by each potential source; the land-use zoning within the recharge area; county and municipal jurisdiction boundaries relative to the recharge areas; and, the water supply contingency plans in the event of an emergency or groundwater contamination cleanup. The technical analyses provide the basis for developing a set of groundwater protection options. The technical analyses described above are thoroughly discussed in the Methods and Procedures Section of this document.

At the end of this phase, a community should confirm the appropriateness of proceeding with the GPNA.

Phase III-Design of a Groundwater Protection Management Plan Suitable for Local Conditions

A groundwater protection management plan can be developed with one or a combination of approaches. In general, there are three basic types of groundwater protection options that a community water supply could design using the GPNA as a basis. The three options are regulatory (state and/or local); non-regulatory, or legislative. The four pilot assessments described previously provide an idea of what might or might not be a suitable approach. In the Pleasant Valley PWD example, the best option for protecting the delineated recharge areas appears to be the adoption of a state regulation (regulated recharge area). The reason for this approach is two fold: 1) the District has no local zoning authority , and 2) the County Board which has jurisdiction and zoning authority prefers that the state take the lead on protecting the recharge area. Certain non-regulatory (e.g., pollution prevention technical assistance) approaches would also be appropriate for the Pleasant Valley PWD. A local regulatory approach for the Village of Cary is complicated because of multi-jurisdictional issues, but would still benefit from non-regulatory approaches. In the City of Pekin however, the best approach appears to be a local regulatory approach coupled with non-regulatory and state regulatory (maximum setback zone) methods. The groundwater protection management options are also discussed in detail in the Methods and Procedures Section of this document.

The groundwater protection strategy designed under a GPNA should recognize the barriers, flexibility, enforcement capability and resources needed in relation to each specific option chosen. A community may decide to implement options in a phased manner to reflect local conditions and readiness to proceed.

Phase IV-Evaluation and Refinement

The last phase of a GPNA should provide careful assessment of the approach that is taken. A strategy for a local groundwater protection program should also include a system for on-going evaluation and refinement. The initial strategy is developed through negotiations with the various local interest groups. The following section provides a detailed technical discussion of how a GPNA may be conducted.

GROUNDWATER PROTECTION NEEDS ASSESSMENT: METHODS & PROCEDURES

Background

Although the Act authorizes counties and municipalities to perform needs assessments and identifies what should be done for such assessments, the Act does not specify any methodological approach to be followed. Therefore, the IEPA, ISGS and the ISWS, have developed an approach, discussed herein, for undertaking a GPNA. The methodology provides a framework for guiding communities, counties, and private consultants through a process of determining the need for groundwater protection beyond the baseline provided by the statewide application of minimum or maximum wellhead setback zones. The methodology is the result of our knowledge and experience gained through conducting several GNPAs. This methodology will help provide consistency in the results produced by any number of groups or agencies that may undertake a GNPA across the state. Because each study area will possess some unique conditions, the methodology should be thought of as a working model that can be adapted and improved for the individual situation.

GPNAs should consider six general areas that include:

1) a detailed geologic and hydrologic evaluation and determination of recharge area(s);
2) identification of potential contamination sources and potential routes in the recharge areas;
3) identification of the hazard associated with potential contamination sources and potential routes;
4) evaluation of the protection provided either directly or indirectly by existing local zoning controls;
5) identification and evaluation of water supply contingency plans; and
6) recommendations of voluntary local or state regulatory management controls that could be applied to protect well recharge area(s).

The GPNA methods and procedures developed by conducting several GNPAs will provide guidance for use by any number of groups or agencies that may undertake a GNPA throughout the state.

Hydrogeologic Investigations and Recharge Area Determination

Table 1 outlines the major parts of the methodology discussed in this section. Within this section, a phased approach to geologic and hydrologic characterization within an area of investigation is described. The methodology is structured as though an investigator is literally "starting from scratch" with little or no background information. The process emphasizes the compilation and development of existing information into a conceptual framework of the geology and the groundwater system. As new information is collected and assimilated, knowledge should be gained on the effects of geologic and anthropogenic influences on the movement of the groundwater within the region. A more detailed description of each step follows.

Hydrogeologic investigations should be undertaken to establish a stratigraphic and geologic materials framework, within which aquifers can be delineated and the contamination potential for land areas can be assessed by evaluating the degree of protection afforded naturally by near-surface low-permeability materials. It is necessary that a study be sufficiently detailed so that at the very least, the direction of groundwater movement is determined. If recharge areas or capture zones for wells are to be delineated, aquifer properties, such as transmissivity and hydraulic conductivity, must be determined so that groundwater flowpaths and velocities can be calculated. If existing information does not provide sufficient data, a detailed drilling program may be warranted in order to determine the geometry, distribution, and relationships among aquifer units and interfingering confining beds.

Table 1. Summary of Major Aspects of Hydrogeologic Investigations for GNPAs

1. Delineate the study area
2. Compile and assess existing information
    a) Meet with local officials involved in groundwater
3. Develop a hydrogeologic data base
    a) Assess the spatial distribution, types, and numbers of wells
    b) Select representative wells for mapping
4. Describe the geologic framework
    a) Prepare geologic maps and cross sections
5. Describe the groundwater flow system
    a) Select representative wells for collection of groundwater level data
    b) Measure groundwater levels in selected wells & determine groundwater surface elevations
    c) Prepare potentiometric surface maps and determine direction of groundwater movement
6. Delineate groundwater recharge areas or capture zones
    a) Assemble data for flow modeling
    b) Calibrate flow model (compare modeled heads with actual head measurements)
    c) Perform flow path analysis to delineate groundwater capture zones
7. Evaluate and summarize results of all investigations

1. Delineate the Study Area

The selection of the study area for a GPNA must consider the local and regional geologic and hydrologic conditions. Most areas characterized by a thick surficial sand and gravel aquifer, shallow fractured and/or high permeability sandstones, and expansive buried sand and gravel aquifers will require large "assessment areas" in order to account for potential recharge areas a considerable distance from municipal boundaries, and to ensure that well-capture zones extend beyond artificial map boundaries when necessary. For example, the assessment area for the GPNA of Woodstock (Berg, 1994) was the entire 7.5-minute Woodstock topographic quadrangle, encompassing about 55 square miles. This was necessary because of the extensive and thick sand and gravel aquifers underlying the region. More restrictive assessment may be warranted where natural boundaries, such as a major river, confine the GPNA region, or where aquifers are known to be generally low yielding and not aerially extensive. The assessment area for the Pekin GPNA (Adams *et al*., 1992) included only about 20 square miles.
The area is bounded on the west by the Illinois River and on the east by a river bluff.

It is essential to consider the cultural and physical setting of the GNPA region in order to place the area of investigation in its proper context. Trends in population growth over time as well as changing patterns of growth should be evaluated as they relate to potential stresses on groundwater resources and groundwater quality. Information on numbers of private wells and septic systems versus hook-ups to municipal water and sewer lines can be valuable. Changing patterns of industrial growth and commercial development should also be documented for potential impacts on groundwater. An historical assessment of industrial/commercial establishments may reveal long-forgotten waste-disposal sites that potentially pose a threat to groundwater. An understanding of the cultural setting may show an immediate need for the GPNA and suggest specific neighborhoods or industrial/commercial growth corridors where particular concern for groundwater protection is warranted.

For example, two state maps created under the direction of Illinois Public Act 83-1268 (see Shafer, 1985) can be used to help highlight potential areas for investigation. Areas prioritized as "intensive study needed" on those two maps contained all of the following four elements:

1) current groundwater withdrawals of greater than 100,000 gallons per day per township,
2) potential significant groundwater withdrawals, identified as aquifers capable of yielding greater than 100,000 gallons per day per square mile and covering an area greater than 50 square miles,
3) a high degree of potential hazardous substance sources, more than 2.0 hazardous substance-related facilities per square mile, and
4) the presence of aquifers highly susceptible to contamination, where permeable deposits occur within 50 feet of land surface.

If a community has wells which lie within such areas or contains areas highlighted on one or both of those maps, that community should consider undertaking a GNPA. Additionally, the IGPA required DENR to develop an *Appropriate Groundwater Recharge Area Map* to help designate priority groundwater protection planning regions (The IEPA has designated, in cooperation with the ISWS, ISGS and ICCG, three regions to date. GPNAs should also be targeted toward communities located in these regions. The priority planning regions are discussed further under the Groundwater Protection Management Options Section of this document.

Review of the physical setting of the GPNA area is important because the physical setting relates closely with eventual geologic and hydrologic findings. Included in a discussion of the physical setting should be a description of the region's topography (distribution and elevation ranges of major uplands and lowlands), rivers and streams (including their direction of flow), and, where appropriate, local soil conditions.

An understanding of these elements will help in characterizing local recharge/discharge of groundwater and may help define a recharge area within or connecting to a GPNA area.

2. Compile and Assess Existing Information

It is important to utilize existing regional and local studies that have been conducted within and adjacent to a given GPNA area. Regional geologic and hydrologic studies will help place geologic and hydrologic conditions found in a GPNA area within a proper perspective. An understanding of the regional geology/hydrology will improve predictability of finding aquifers and other geologic materials in the GPNA area, improve confidence in eventual findings, and minimize geologic/hydrologic inconsistencies between the GPNA area and its' surroundings. Published reports and maps at the Illinois State Geological Survey, Illinois State Water Survey, and United States Geological Survey should be consulted for regional geologic/hydrologic information. For some regions of Illinois, detailed county studies and other more site-specific investigations may also be available. Consult lists of publications from the above agencies for availability of information for site-specific studies.

Local unpublished information should also be obtained prior to and during the conductance of a GPNA. In addition to water-well log information discussed below, state, county, and municipal agencies often have geologic/hydrologic information from bridge, road, and building construction efforts, landfill siting endeavors, and as part of a septic tank permitting process. Planning and health departments, road commissions, and soil and water conservation districts usually have considerable data of this type in their files. Particularly important is local soils data obtainable from the United States Department of Agriculture, Soil Conservation Service (USDA-SCS) county offices. Surficial geologic maps easily can be derived from soil maps. In addition, land-use capabilities for specific soils are provided. Finally, engineering and geologic consulting firms often will share geologic and hydrologic findings from siting and site-characterization investigations providing that litigations are no longer a possibility and/or their client agrees that release of the information is satisfactory.

Early in the planning process, a meeting could be conducted to coordinate all local and regional officials involved in activities that may assist in the needs assessment. These agencies may include: regional groundwater protection planning committees, state and local health departments, municipal and/or private water and wastewater departments, the IEPA (including the Divisions of Land Pollution Control and Public Water Supplies), the Soil Conservation Service, the Attorney General's Office, the Office of the State Fire Marshal, city or regional planning commissions, local university staff, environmental groups, the ISGS, the ISWS, and the

United States Geological Survey (USGS).

The purpose of the meeting is two-fold: to brief the agencies about the project and to request relevant information they may have pertaining to groundwater. The principal information of interest includes: the location of regulatory monitoring wells, consultant's reports, water-level measurements, pumping records for city wells, actual or potential sources of groundwater contamination, and chemical analyses of groundwater samples.

Local officials are valuable resource people, especially if they have been directly involved in groundwater quality investigations of their own. Their involvement will help to avoid the duplication of previously accomplished tasks and may assist in gaining increased participation from local residents and other agencies not previously identified as possible resources.

3. Develop a Hydrogeologic Data Base

Considerable data (including engineering test borings and water-well logs, etc.) are often available at the ISWS, ISGS, and some local health departments to help determine the sequence of geologic deposits for a given area. Of basic importance to a regional groundwater characterization is knowledge of the locations of wells in the area. It is critical that information clearly delineating aquifers be obtained and used. The highest quality data are from deep test-drilling for water resources, engineering borings for bridges and waste-disposal facilities, and exploratory test drilling and/or surface- outcrop descriptions. These data are regarded as the highest quality because a geologist or geotechnical engineer was responsible for describing the samples and cores and because considerable care had been taken to accurately locate the drilling or outcrop observation sites.

Much data can be derived by examining water-well records. However, due to difficulties in accurately locating private water wells from the locations given in the well records (particularly older records), many records can not be used. Locations should be verified by checking the address on the water-well log against county plat books and road maps, or by personally interviewing well owners. In some cases water-well drillers should be contacted to obtain more accurate locations because local drillers maintain records of the wells they have constructed.

In areas of irregular topography, a precise location of a well is essential. For example, mislocation of a well by as little as 500 feet, could mean that its assumed land-surface elevation could be 30 to 50 feet higher or lower than it actually is. This means that the subsurface stratigraphy (including the position of aquifers) depicted on the well log also could be 30 to 50 feet higher or lower than it actually is, and stratigraphic correlations may be inaccurate.

The quality of the information can be another problem when using driller's logs from private water wells. Questionable logs of private water wells should be compared to logs of nearby wells that had been recorded by a geologist or geotechnical engineer. These high-quality logs are referred to as *key stratigraphic control logs*. If the stratigraphic data depicted for the questionable log does not compare well to the stratigraphy of the key stratigraphic control log, the private water-well log should not be used. Where key stratigraphic control logs are not available, comparisons should be made to logs of other wells nearest to the questionable log. A decision whether or not to use the log then should be based on the degree to which the log can be integrated with current knowledge of the regional geology.

It will be necessary to review well logs to determine the number, spatial distribution, and types of wells in the needs assessment study area. It is desirable that the locations of wells used for the database be evenly distributed in order to achieve maximum coverage of the study area, and to minimize "data gaps". As an example, Figure 3 shows the distribution of well-log information used to assess the geology for the Woodstock GPNA (Berg, 1994). In urban areas, private wells may be clustered in particular areas because either the aquifer is limited in extent or adjacent areas (e.g., streets or blocks) are served by city water. Based on the distribution of the data, representative data points should be selected for use in constructing detailed geologic cross sections and for eventual selection in the measurement of groundwater levels.

Of basic importance is determination of well depth and the open or screened interval of the well (i.e., the aquifer developed by each well). This becomes important in selecting wells to use for measurement of groundwater levels. Wells completed in different aquifers or at different depths within the same aquifer will produce water levels that cannot be compared to one another.

If possible, it is important to establish general trends in groundwater flow direction and to gain a regional perspective on areas of groundwater recharge and discharge. These areas may change with seasonal or temporal events (e.g., floods on major rivers). Historical pumpage information, particularly major groundwater withdrawals by municipal and industrial wells, may be important to the interpretation of the direction of groundwater flow. These trends provide a foundation for determining the general direction of contaminant transport and well recharge areas.

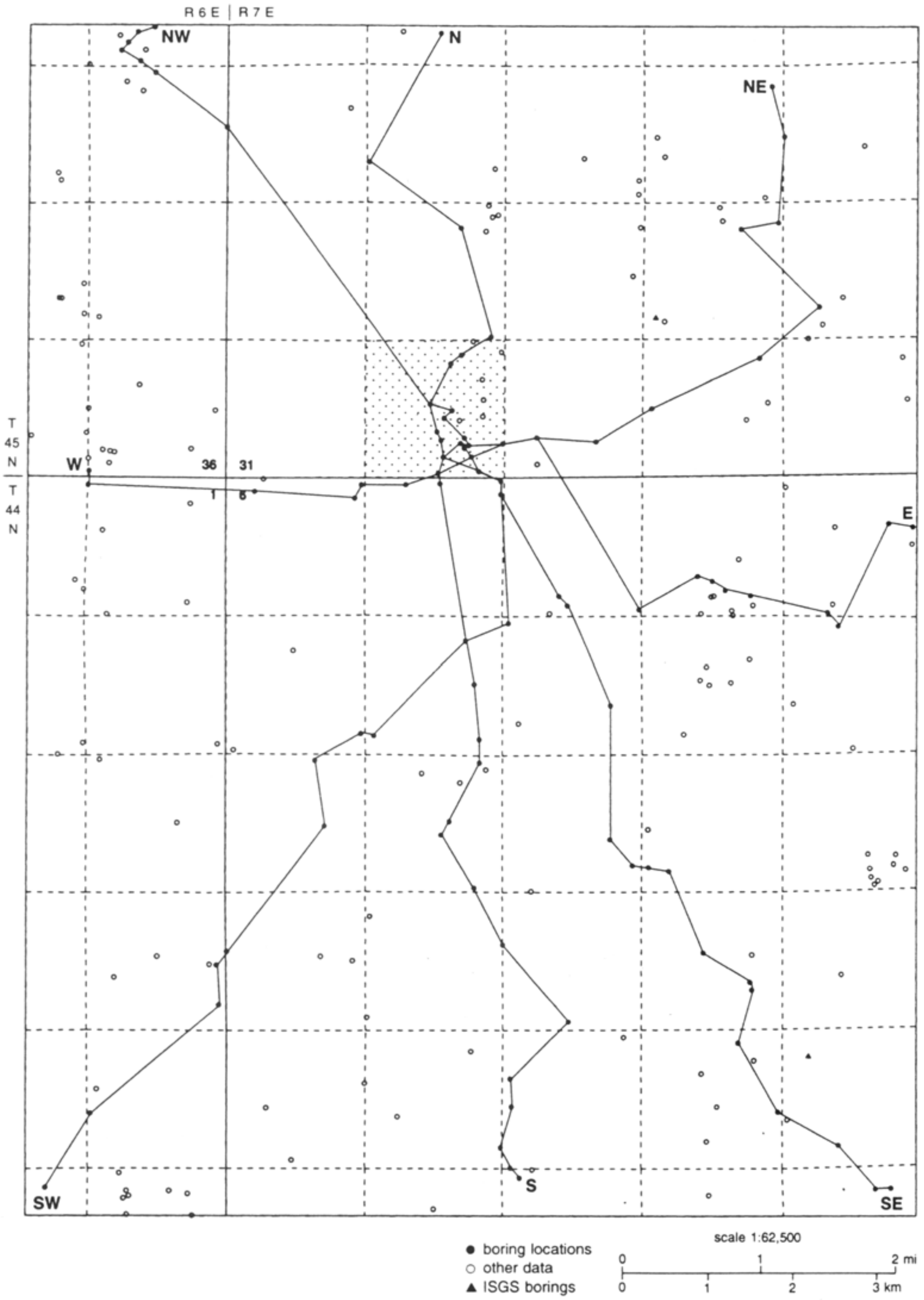

Figure 3 Distribution of well-log data points used to define the geology for the Woodstock GNPA (from Berg, 1994)

4. Describe the Geologic Framework

The materials that comprise the geologic framework of a given GPNA area will consist of bedrock and Quaternary sediments. The latter are commonly referred to as overburden, unconsolidated materials, or drift.

Bedrock materials in Illinois are comprised primarily of limestone, dolomite, shale, and sandstone however coal, fluorspar, and other rocks also may be common in some regions of Illinois (Willman *et al*., 1975). Bedrock is generally mapped in detail where it occurs within 50 feet of the surface. There may be a lack of detailed bedrock maps where the glacial drift is greater than 50 feet. The thick glacial drift makes quarrying of aggregate materials economically unfeasible. Consequently, data from the mineral-resource industries is unavailable. For most of these regions, however there should be sufficient regional information on the geology of the bedrock surface to meet the needs of the GPNA.

These Quaternary deposits, which are predominantly glacial, consist of (1) pebbly, silty clay to sandy loam diamicton (non-to poorly sorted sediment that contains a wide range of particle sizes) deposited directly by glaciers (till) or re-deposited in the ice-marginal zone (debris flow deposits); (2) outwash, which is mostly sand and gravel deposited by meltwater rivers; (3) ice-contact deposits, primarily sand and gravel deposited in contact with glacial ice; and (4) lacustrine deposits, predominantly silt and clay that settled out in quiet-water lakes and ponds. Also common in Illinois are post-glacial river deposits (alluvium) and wind-blown materials (loess).

Quaternary diamicton, outwash, and ice-contact deposits are the most common glacial materials found in Illinois. Diamicton units can be further differentiated according to their stratigraphic position and age, grain-size characteristics, and clay-mineral composition. Publications of the ISGS should be consulted when evaluating and mapping bedrock and unconsolidated deposits. The most recent nomenclature should be used when referring to particular geologic formations and members.

Prepare Geologic Maps and Cross Sections

The methodology to characterize the geology of a GPNA area includes several basic elements. Soils maps, available from county offices of the U.S. Department of Agriculture, Soil Conservation Service (SCS) should be used to determine surficial geologic materials throughout the study area. This information should be combined with deeper subsurface information derived from water-well, engineering, and test-drilling logs. Geologic cross sections then should be constructed to interpret the subsurface geologic materials and display their occurrence and relationships. Finally, stack-unit maps (which show the sequence of geologic materials in their order of occurrence over a specified area and to a specified depth) should be created to provide a three-dimensional relationship between the soils and the underlying geologic formations.

The procedure for determining the nature of the uppermost 5 feet of materials begins by grouping soil series shown on SCS soil-survey maps into soil-parent material groups (Figure 4). These groups should be differentiated according to their parent material composition (i.e. alluvium, outwash, till, etc.) and geomorphic position on the landscape. Parent material groups are then color coded and assigned a preliminary stack-unit symbol. This information is transferred to 1:24,000-scale topographic quadrangles. Outlines of the grouped soils can be highlighted for easy visibility and if desired, a mylar copy can be used to create a digitized computer file of the map. Computer programs are available that can be used to edit and label the soils map. Software can also be used to edit and label the soils map. The complexity of stack-unit maps is in large part a reflection of the original soil-parent material groupings.

Although soils information is vital to help map surficial geologic materials and to determine attenuative properties of materials, soils represent only the upper five feet of the geologic section. Since soils are classified according to their parent materials, without extensive subsurface geologic interpretation, it is difficult to determine if, for instance, the sand that a soil is developed from is modern alluvium, glacial outwash, or eolian deposits. In addition, the SCS has limited access to information on soil properties in urban areas. Therefore, generalizations on soils and geology (or the obtaining of more site-specific information if available) must be used to establish geologic parent materials in urban areas. Soils in urbanized areas also tend to be highly disturbed often making identification of native parent materials very difficult.

Materials below the 5-foot limit of soil surveying can be determined by examining logs of water wells and other borings available for a given area. All of these data should be plotted onto topographic quadrangles. Cross-sections (Figure 5) and isopach maps can be constructed in order to illustrate the thickness and continuity of subsurface geologic units (particularly aquifers) and their stratigraphic relationships.

Geologic mapping for a GPNA should include with the construction of a stack-unit map. The stack-unit mapping methodology is discussed in detail by Kempton (1981), Berg et al. (1984), and Berg and Kempton (1988). It may be desirable for many areas of the State, particularly those with thick glacial deposits, to construct a stack-unit map to a depth of 100 feet (30.5 m). The 100-foot depth limit is selected because many thick glacial-drift areas have thick deposits of sand and gravel at or near land surface. Therefore, potential is high that many land-use activities (e.g., landfilling of wastes in 50-foot buried trenches) could adversely affect these and deeper aquifer systems. It is often not feasible to construct a stack-unit map extending to the bedrock surface because the map would be overly complex and very difficult to interpret. However, it still would be desirable to map the thickness and aerial distribution of any aquifers below the 100-foot depth. An example of a 100-foot stack-unit map, from the Woodstock GPNA (Berg 1994) is shown in Figure 6.

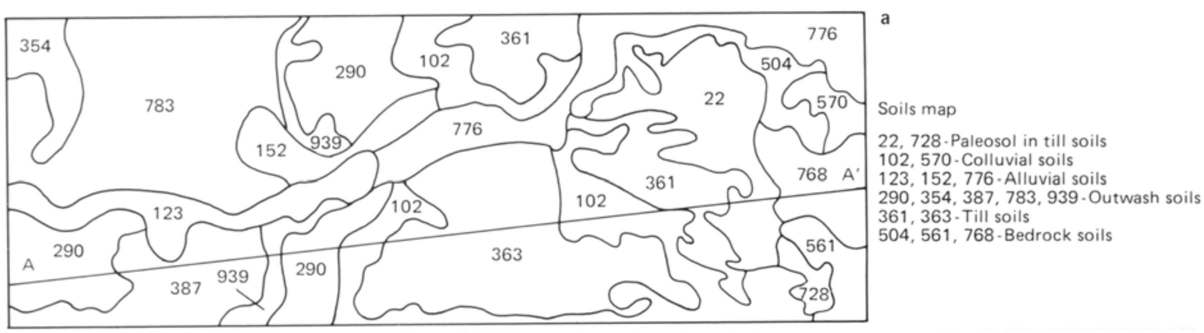

Figure 4. Soils interpreted according to geologic parent materials (from Berg, Kempton, and Cartwright, 1984)

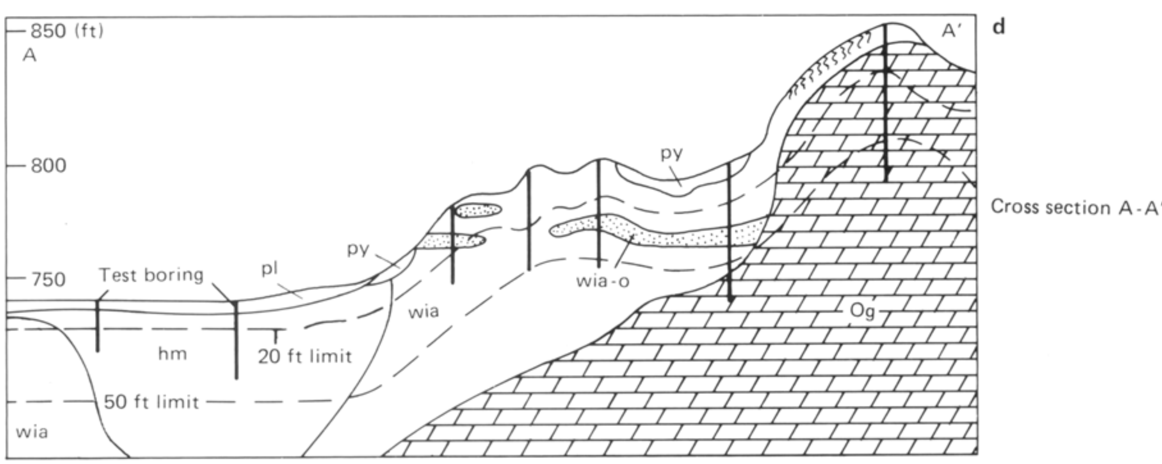

Figure 5. Geologic cross section A-A' using data derived from water well logs (from Kempton and Cartwright, 1984)

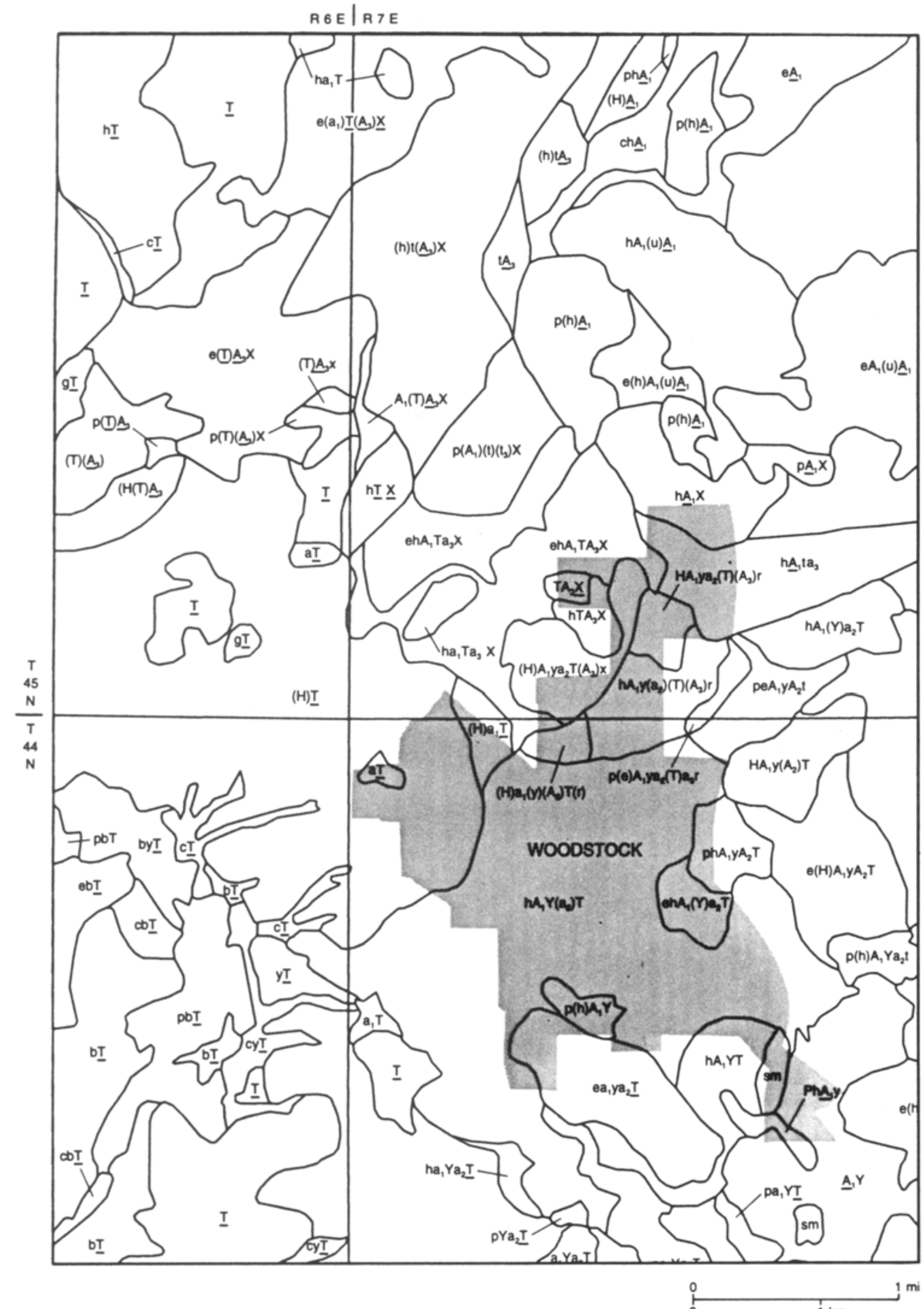

Figure 6. Stack-unit map to a depth of 100 feet for a portion of the Woodstock topographic quadrangle (from Berg, 1994)

Legend for the stack-unit map

Unit thickness (ft) <20	20–50	>50	Material Description
g	G	G	Accretion gley: poorly drained, possibly laminated, fine grained deposits in depressions
c	C	C	Cahokia Alluvium: stream deposits consisting of a mixture of sand, silt, and clay
p	P	P	Grayslake Peat: peat and muck with possible interbedded clay and silt that formed in swampy depressions
e	E	E	Equality Formation, Carmi Member: bedded fine grained lacustrine deposits with some sand
d	D	D	Equality Formation, Dolton Member: mainly sand with beds of silt and gravel
b	B	B	Henry Formation, Batavia Member: sands and gravels occurring as an upland unit deposited mostly along the fronts of moraines
w	W	W	Henry Formation, Wasco Member: ice-contact sand and gravel deposits in kames
h	H	H	Haeger diamicton: sandy loam to loam diamicton that averages 10 to 15 feet thick and is typically yellowish brown, structureless, and friable
u	U	U	Wedron Formation undifferentiated diamicton
a_1	A_1	A_1	Haeger diamicton, sand and gravel facies: surface or near surface proglacial outwash deposits, 20 to 120 feet thick, from ice advances that deposited several diamicton units, but mostly the Haeger
y	Y	Y	Yorkville diamicton: gray silty to silty clay diamicton, which is often texturally variable
a_2	A_2	A_2	Yorkville diamicton, sand and gravel facies: proglacial outwash sands and gravels between 5 and 50 feet thick
t	T	T	Tiskilwa diamicton: pink loamy diamicton, often more than 150 feet thick
a_3	A_3	A_3	Tiskilwa diamicton, sand and gravel facies (Ashmore Member): proglacial sands and gravels 20 to 100 feet thick
r	R	R	Robein Silt: organic-rich, accretionary silt
x	X	X	Glasford Formation undifferentiated diamictons
a_4	A_4	A_4	Glasford Formation undifferentiated sands and gravels: proglacial sands and gravels overlying bedrock
z	Z	Z	Undifferentiated sand and gravel within a member; only occurs within Tiskilwa

m Surface mined land

L Lake

arentheses surrounding lower case letters (e.g., (y)): material is discontinuous within its mapped rea.

arentheses surrounding upper case letters (e.g., (Y)): material is usually between 20 and 50 feet hick; material may be less than 20 feet thick (but never absent) through a part of its mapped area. arentheses surrounding upper case letters that are underlined (e.g., (Y)): material is usually more han 50 feet thick; material may be less than 50 feet thick (but never absent) throughout a part of its apped area.

Legend for the Woodstock stack unit map

Several mapping conventions should be followed in preparing the 100-foot depth stack-unit map:

First, only geologic units two-feet thick or more should be mapped. Second, lower case letters, upper case letters, and underlined upper case letters can be used to indicate the thickness of the geologic materials within the mapped area. The scheme is as follows:

1. Lower case letters indicate that the material is always less than 20 feet thick; e.g., y.
2. Upper case letters indicate that the material is always between 20 and 50 feet thick; e.g., Y.
3. Upper case letters that are underlined indicate that the material is more than 50 feet thick; e.g., <u>Y</u>.

Third, parentheses added to the stack-unit symbol indicate either that the material is discontinuous or that it is not uniformly of a particular thickness. The following conventions can be used:

1. Parentheses surrounding lower case letters indicate that the material is discontinuous within its mapped area; e.g., (y).
2. Parentheses surrounding upper case letters indicate that the material is generally between 20 and 50 feet thick, but may be less than 20 feet thick (but never absent) over a portion of its mapped area; e.g., (Y).
3. Parentheses surrounding underlined upper case letters indicate that the material is generally more than 50 feet thick, but may be less than 50 feet thick (but never absent) over a portion of its mapped area. e.g.,<u>(Y)</u>.

The ability of a stack-unit map to predict (with a "reasonable" degree of confidence) the occurrence of any given map unit depends on the scale of the map. Based upon informal comparisons between geologic information portrayed at a scale of 1:24,000 to 1:62,500 with known occurrences of materials from borehole data, there is about a 75 percent probability that geologic units that are mapped within any stack-unit succession <u>are</u> present. For map units representing thicknesses of more than 20 feet and 50 feet and marked by parentheses, it is assumed that there is a 75 percent probability that the material <u>is</u> more than 20 feet thick and 50 feet thick, respectively.

The fewer the number of materials in a stack unit, the greater is the probability that the units depicted actually will be present. (e.g., where thick deposits of sand and gravel occur). The stack symbol is less representative of the geology in places where materials vary in thickness due to erosion, or where multiple units are mapped in succession. Finally, the materials depicted within the boundaries of any stack-unit polygon are most likely to occur in the central portion of the mapped area. Near the boundaries of stack-unit map areas, materials are more likely to pinch out or to undergo a facies change from one material to another. Boundaries between map areas containing different stacked sequences of materials should be interpretively drawn from existing data points. Unless better information is available, boundaries should be drawn midway between two data points.

5. Describe the Groundwater Flow System

Once the geologic framework has been established, and aquifers and their confining beds have been delineated, specific hydrologic aspects of the GPNA can be conducted.

Select Representative Wells for Collection of Groundwater Level Data

A first step is the selection of representative wells within the study area for eventual collection of groundwater level data. Much of the work in this step should have already been accomplished during the geologic investigative phase. A preliminary list will likely include all private, industrial, and municipal wells of all depths, aquifers, and well capacities. This list must be pared down to include only those wells which, at a minimum, have a geological log and well construction details (i.e., depth, screened interval), and correct address of the well owner. To save time during the actual water-level measurement process and to ensure that a sufficient number of wells are available for use, it is strongly advised that well locations be verified prior to inclusion on a list of wells for the mass measurement. Verification usually includes opening the well cap and taking a water-level measurement. This procedure ensures the ability to take a water-level measurement (i.e., no obstacles in the well) from each well included in a future mass measurement. The final list of wells to verify should probably contain enough sites to compensate for at least 50% negative or non-response from well owners.

Mass Measurement of Groundwater Levels in Selected Wells and Determination of Groundwater Surface Elevations

A number of methods are used for measuring depth-to-water including chalked steel tape, electric drop line, air line, pressure transducer, and float apparatus (Garber and Koopman, 1968). The chalked steel tape method involves the use of a weighted surveyor's graduated steel tape and carpenter's chalk. Typically, the bottom 5 feet of the tape is chalked and the tape is lowered into the well until a portion of the chalked end of the tape is in the water. The upper end of the tape is held against the measuring point (e.g., the edge of the well casing) and a note is made of the foot reading at the measuring point. Next, the tape is withdrawn from the well and note is made of the foot reading where the wetted chalk line appears. Subtraction of the wetted chalk length from the held tape length provides the depth-to-water measurement. The electric dropline method works in a similar fashion only with this method, an electrode at the bottom of the tape provides a signal at the surface when the bottom hits water; by carefully raising and lowering the dropline and noting exactly when the signal is activated, an accurate depth-to-water reading can be made. Air lines and pressure transducers provide information on depth-of-water above a submerged point, and obviously, the depth to that submerged measuring point must be known. Both methods basically provide pressure data (air or water pressure) that can be converted to height of water which can be translated to depth-to-water or elevation data. Floats are typically used in conjunction with a chalked tape or dropline technique to initially provide depth-to-water information after which the float mechanism with a clock drive provides depth-to-water changes over time.

A *mass measurement* of water levels in wells involves taking depth-to-water measurements in selected wells over a relatively short period of time (i.e., days to weeks depending on the size of the study area and the rapidity of water-level responses to meteorological conditions) to produce an instantaneous view of water levels in an aquifer or aquifers, free of any temporal variation. A depth-to-water measurement is taken while the well is not pumping and is generally repeated several times to ensure that water levels are not changing rapidly (as might happen if the well or other nearby wells were going on or off).

Prepare Potentiometric Surface Maps and Determine Direction of Groundwater Movement

Depth-to-water measurements are converted to elevations by subtracting the depth measurement from the elevation of the point from which the measurement is taken (e.g., the top of the well casing, often called the *measuring point*). The resulting water-level elevation represents what is called the aquifer's *potentiometric* or *hydraulic head*. The head value is usually presented in feet or meters above mean sea level similar to surface features on a topographic map. For studies covering large areas (tens of square miles), measuring point elevations can be estimated from USGS topographic maps. However, for smaller study areas or where multiple aquifers exist such that the difference in hydraulic heads in each aquifer is small, the accuracy of estimated measuring point elevations from topographic maps may be poor. In such cases, the measuring point of each well must be accurately surveyed, generally by differential leveling from known bench marks. High-end global positioning systems also have the ability to determine elevations accurately.

After calculating the hydraulic head at each well, the water level elevations are plotted on a map. Each measured point represents a point on the *potentiometric surface* of the aquifer in which the wells are completed. The potentiometric surface is an imaginary surface which describes the level to which water will rise in tightly cased wells (which do not allow vertical communication between overlying or underlying aquifers). This surface can be contoured just as the land surface is contoured on a topographic map. A contour of the mapped surface represents a line of equal head or equal potential. Generally, the potentiometric surface of an aquifer is much smoother than the overlying land surface. Quite often, particularly for shallow, unconfined aquifers, the potentiometric surface will often conform to the overlying land surface. That is, the potentiometric surface will be higher in topographically high regions and lower in topographically low regions. A number of software packages can contour a set of randomly located data such as groundwater elevations but one should not rely on such tools without manually preparing a contour map as a check.
Generally, groundwater moves in a direction perpendicular to the potentiometric surface contours from higher elevation (potential) to lower elevation (potential). Areas or locations where the groundwater elevations are lowest are often referred to as *sinks*. Sinks are locations of groundwater discharge such as lakes, streams, rivers, and wells.
Examples of two groundwater contour maps are shown in Figures 7 and 8. The first map shows the groundwater contours in a shallow sand and gravel aquifer along the Rock River in northern Illinois (Wehrmann, 1983). Notice how the contours generally parallel the river. Flow direction, perpendicular to the contours and from higher elevation to lower, is directed toward the river. The second map shows groundwater contours for a much larger area along the east bank of the

Mississippi River near East St. Louis (Kohlhase, 1987). Here again, one can see a general trend of groundwater flow from higher groundwater elevation along the river bluff to lower elevation near the river. Notice also, however, the several markedly lower regions which appear as bullseyes on the contour map. These lower areas are caused by groundwater withdrawals by municipal and industrial pumpage. Flow lines drawn perpendicular to the contours in these areas indicate radial flow toward the pumping centers and particularly in the NW¼ of T2N, R9W we see indications of groundwater movement from the river toward the pumping center.

As will be discussed in following sections, getting a sense of where groundwater is moving from and where it is moving to is probably one of the most important concepts to understand and determine as part of any GPNA. It is with this information that proper plans can be made to address groundwater protection schemes.

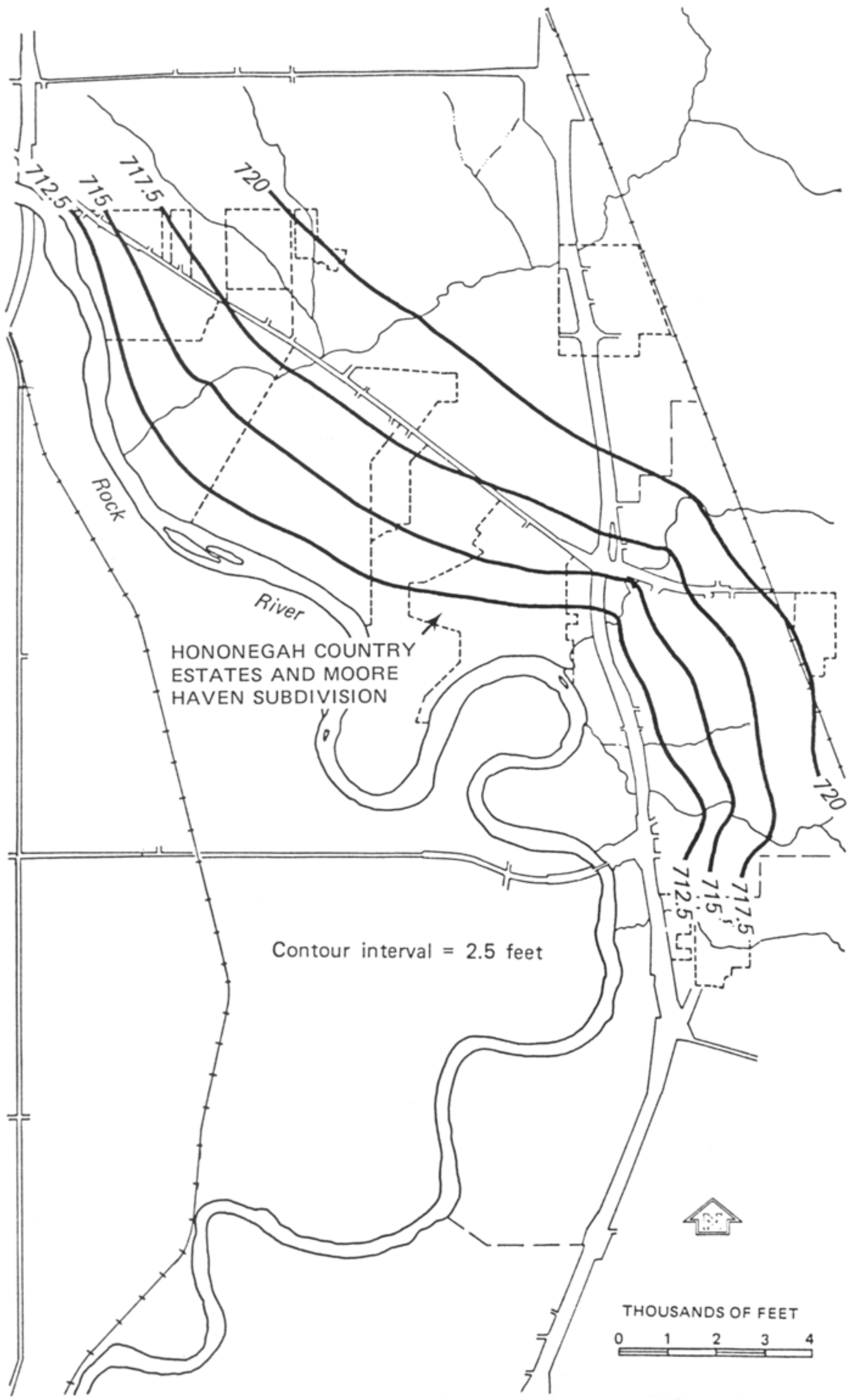

Figure 7. Shallow groundwater elevations near Roscoe, Illinois (from Wehrmann, 1983)

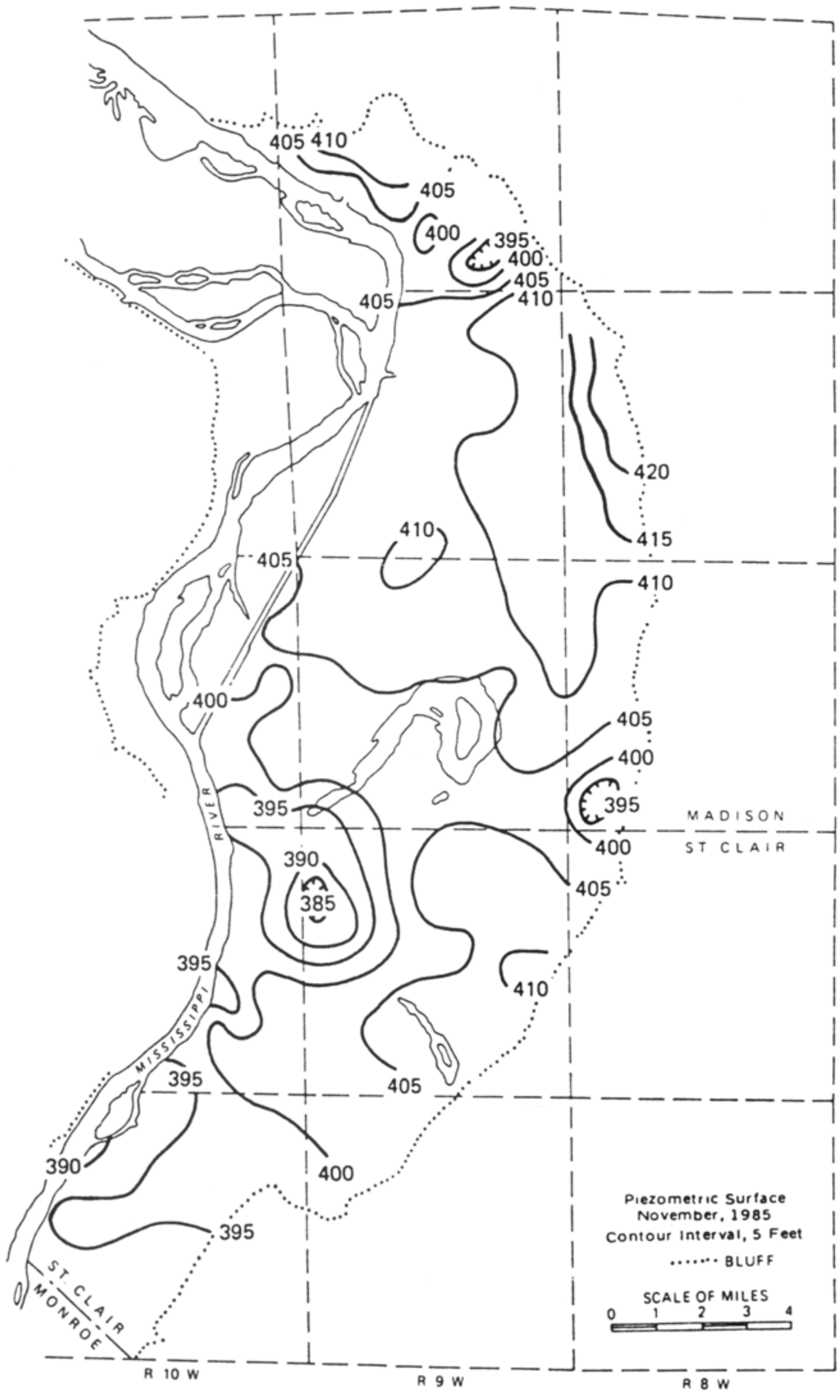

Figure 8. Approximate elevation of the Potentiometric surface in the American Bottoms, Illinois in November 1985 (from Kohlhase, 1987)

6. Delineate Groundwater Recharge Areas or Capture Zones

The withdrawal of ground water by a well causes a lowering of water levels in the area around the well. The difference between water levels during nonpumping and pumping conditions is called *drawdown* (figure 9). From a three-dimensional perspective, the pattern of drawdown around a single pumping well resembles a cone with the greatest drawdown adjacent to the pumping well. The area affected by the pumping well, therefore, is called the *cone of depression* and is also referred to as the *radius of influence* or *lateral area of influence* (LAI). Within the LAI, the velocity of the groundwater continuously increases as it flows toward the well due to the gradually increasing slope in the cone of depression (according to Darcy's Law, Appendix II). The slope of the water surface is called the *hydraulic gradient* (_h/_l in Darcy's Law).

If a computed drawdown cone is overlain on the nonpumping potentiometric surface, an area can be defined such that all water within that area will eventually be pulled into the well creating the cone of depression. The area of the water entering the LAI of the well is referred to as the *zone of capture* (ZOC). A diagram depicting the ZOC for a well within a regional flow field is shown in Figure 10. Generally, the ZOC extends upgradient from the pumping well to the edge of the aquifer or to a groundwater divide (a line beyond which groundwater is flowing in a different direction). The ZOC may receive recharge directly from the overlying land surface in the case of a water table (unconfined) aquifer or may receive recharge from some distance away as is the case with some confined aquifers. Often, the boundaries of a ZOC are calculated on the basis of time; that is, the boundary within which water will reach the well in a certain period of time. Such a ZOC is referred to as a *time-related capture zone*. A 5-year time-related capture zone, for example, outlines the area within which the water at the edge of the zone will reach the well within 5 years.

The estimation of recharge areas beyond applicable setback zones should follow a logical progression from field investigation through groundwater flow modeling to the calculation of time-related capture zones. A generic plan containing the progressive steps used in collecting the field data, estimating aquifer parameters where field data are unavailable, and incorporating these data into a mathematical model is summarized in Table 4. Geostatistical techniques may be useful for characterizing spatially variable aquifer conditions and to make optimal use of limited available data by providing the best possible estimate of aquifer conditions at locations where field data are not available (Wehrmann and Varljen, 1990).

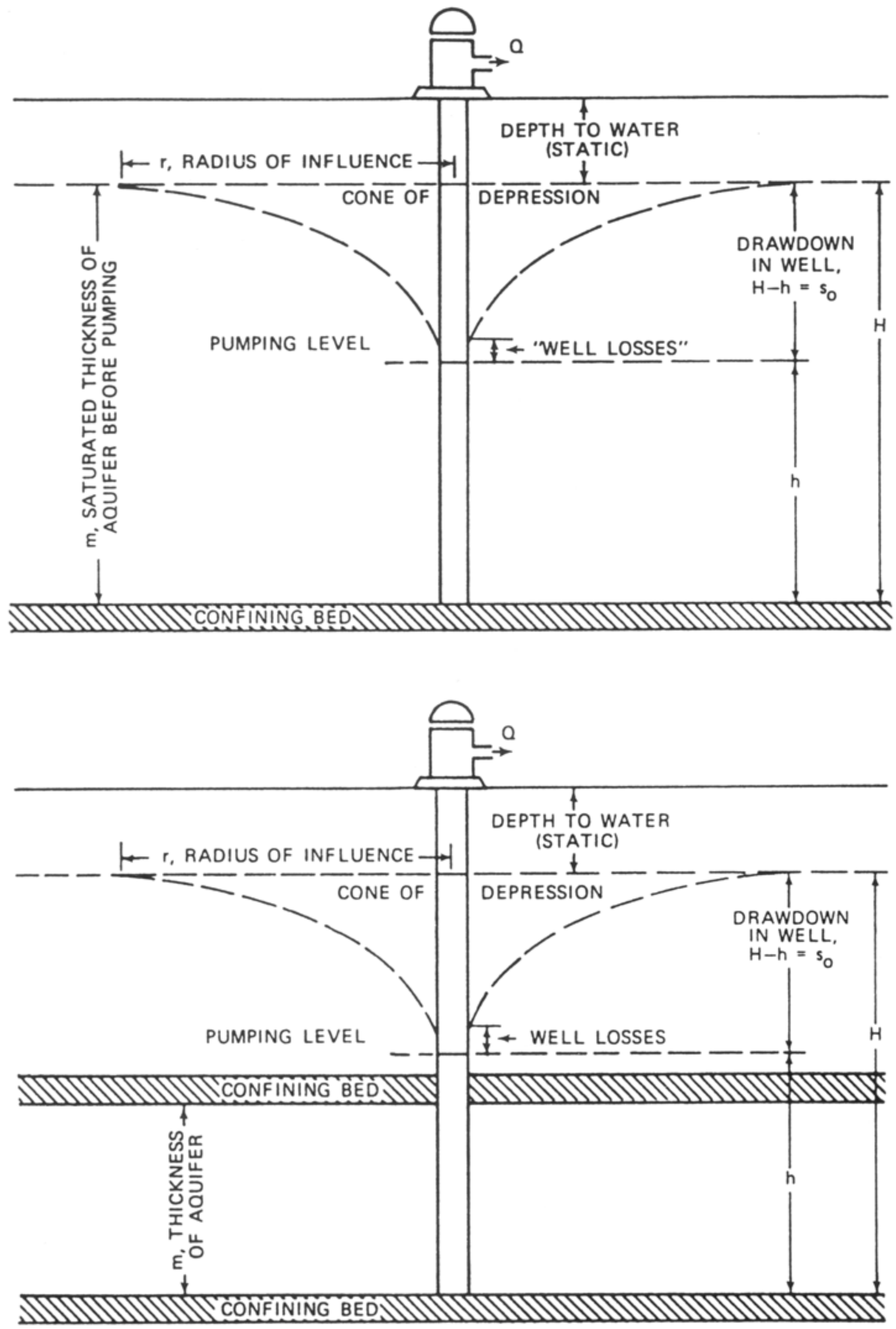

Figure 9. Drawdown, cone of depression, and radius of influence under a) unconfined conditions, and b) confined conditions

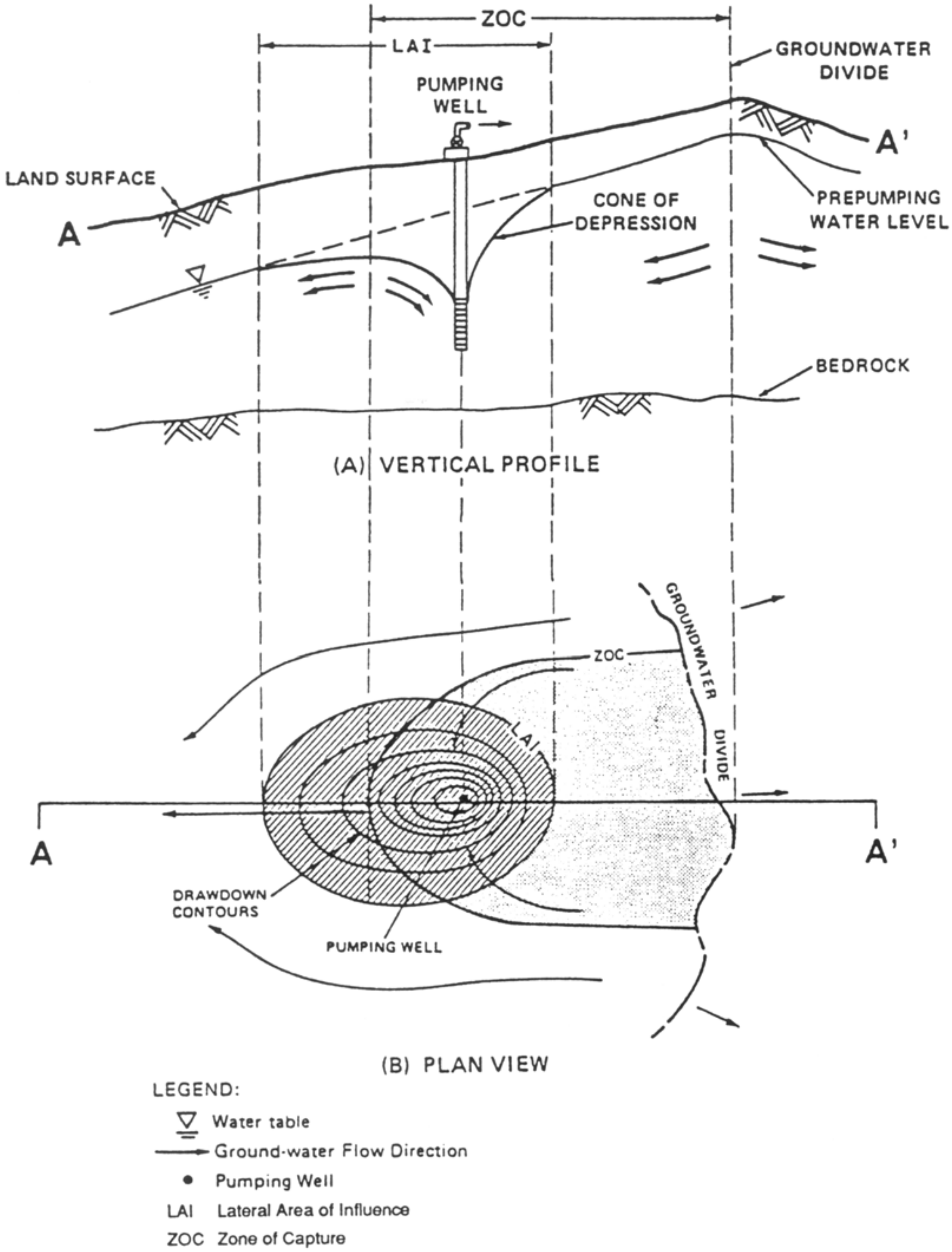

Figure 10. Relationship between the cone of depression, and the zone of capture (ZOC) within a regional flow field (from IEPA, 1992)

Table 2. Methodology used to define time-related capture zones

I. Determine physical and hydraulic conditions of the aquifer
   a. Establish natural groundwater flow direction and gradient
   b. Determine spatial distribution of aquifer conditions (thickness, etc.)
   c Determine aquifer hydraulic properties through production or slug test analyses

II. Create discrete head distribution over domain of interest
   a. Choose appropriate flow model based on amount & quality of hydrogeologic data
   b. Use assembled data to estimate boundary and initial conditions,etc.
   c. Model groundwater flow under nonpumping and pumping conditions using a ground-water flow model [e.g., MODFLOW[a], PLASM[b], QUICKFLOW[c]]

III. Create time-related capture zones for different pumping conditions
   a. Select time period for reverse pathline calculations (e.g., 5 years) and estimate effective porosity of aquifer materials
   b. Use 2-D flow model output (the head distribution) as input for reverse pathline analysis [e.g., GWPATH[d], MODPATH[e]]

[a]MODFLOW: Modular Three-Dimensional Finite-Difference Ground-Water Flow Model,
[b]PLASM: Prickett-Lonnquist Aquifer Simulation Model, Prickett and Lonnquist, 1971
[c]QUICKFLOW: Analytical 2D Ground-Water Flow Model, Geraghty & Miller, 1991
[d]GWPATH: Interactive Ground-Water Flow Path Analysis, Shafer, 1987
[e]MODPATH: MODFLOW Pathline Analysis,Pollock, 1989

Groundwater flow modeling is undertaken for three reasons. First, modeling can improve conceptualization of the groundwater flow system. In this capacity, modeling helps to evaluate where future data collection efforts should be focused. Second, and most importantly for capture zone delineation, modeling is used to provide an estimate of the head distribution across the area of investigation. The head distribution is necessary for flow path and travel-time analyses which are used as the basis for estimating capture zones. Finally, groundwater flow modeling can be used to determine the effect of changing withdrawal patterns (for example, by the addition of a new well) on the groundwater flow field and, hence, the spatial pattern of a well's capture zone.

Groundwater modeling generally follows a three-step process: 1) conceptual modeling, 2) mathematical modeling, and 3) sensitivity studies. A conceptual model is a qualitative description (e.g., pictorial and/or narrative) that represents relevant components and structures (i.e., physical boundaries to flow such as lakes, streams, bedrock walls, and wells) occurring within the groundwater system, the interaction between components and structures, and all internal and/or external processes (e.g., recharge, pumpage) that affect system performance (Harrison, et al., 1985). Once the conceptual model of site-specific groundwater flow is completed, mathematical models can be selected. Mathematical models are simply a set of equations which describe the physical processes of flow within the aquifer(s) and other geologic units (Mercer and Faust, 1981). These models should be consistent with the complexity of the conceptual model, the objectives of the modeling effort, and the amount and detail of available data. Sensitivity studies are often conducted as part of modeling efforts to examine the effects of changes in certain model input parameters on model output (i.e., hydraulic heads). For example, a sensitivity analysis of groundwater travel times should focus on the sensitivity of groundwater velocity along the expected flow path to the distribution of hydraulic conductivity values over the area being modeled.

Mercer and Faust (1981) categorized the data requirements for a predictive groundwater model. They separate data requirements into three groups: (1) data describing the physical framework, (2) data describing the stresses on the system, and (3) data pertaining to other factors. Table 3 summarizes the data needs for groundwater flow modeling.

Table 3. Data requirements for a predictive groundwater flow model

Physical framework

- Hydrogeologic map showing aerial extent, boundaries, and boundary conditions of all aquifers under investigation
- Topographic map showing surface water bodies
- Water table, bedrock configuration, and saturated thickness maps
- Hydraulic conductivity map showing aquifer and boundaries
- Hydraulic conductivity and specific storage maps of any confining beds
- Map showing variation in storage coefficient of aquifer
- Relationship of saturated thickness to hydraulic conductivity
- Relationship(s) of any stream(s) and aquifer (hydraulic connection)

Stresses on groundwater system

- Type and extent of recharge areas (irrigated areas, recharge basins, recharge wells, etc.)
- Surface water diversions
- Time-varying groundwater pumpage
- Streamflow (if applicable)
- Precipitation
- Evapotranspiration

Other factors

- Information on the local water supply

- Legal and administrative rules

- Planned changes in regional water and/or land use (Mercer and Faust, 1981)

Errors in model use are usually due to inadequate data supporting the attempted level of modeling sophistication. Occasionally, errors occur as the result of the misapplication of models (Wood et al., 1984).

Where available data are extremely limited or for municipalities without the financial resources to spend on detailed hydrogeologic studies, less sophisticated modeling techniques are more appropriate. Under such circumstances, aquifer hydraulic conditions are idealized, or simplified, and calculations can be completed with the use of a calculator or a simple analytic or semi-analytical computer model (e.g., WHPA Code). The simplest, least complex condition is where the aquifer is assumed to be infinite in aerial extent (i.e., no boundaries) and the aquifer hydraulic properties are homogeneous and isotropic (i.e., constant in all directions), and the slope of the potentiometric surface is assumed to be zero (flat). Analytic computer models can quickly compute head values within an aquifer under such idealized conditions. Additional simple complexities can also be handled analytically. This includes simple boundary conditions and regional hydraulic gradients (i.e., the slope of the potentiometric surface is not flat).

Where aquifer conditions are more complex and cannot be satisfactorily idealized to simulate real conditions, then more sophisticated mathematical models may be necessary. This generally involves numerical, as opposed to analytical, models. Numerical models discretize or slice the aquifer in discrete sections or intervals. In this way, rather than assigning one value to represent a property (e.g., hydraulic conductivity) for the whole aquifer, multiple values of that property can be assigned to represent particular areas within the aquifer. This allows representation of spatially variable properties and should provide a more accurate solution for the hydraulic head at specific points within the aquifer.

Once the head conditions within the aquifer system are determined, then capture zones are delineated. A generic capture zone may be determined using the equations presented by Todd (1980) or using some simplifying assumptions to broadly bound a time-related capture zone as done by Gibb and others (1984). However, the most common technique for delineating time-related capture zones is to use the hydraulic head field (the flow model output) as input to programs that calculate groundwater flow paths and velocities (e.g., GWPATH, MODPATH). With the flow paths and velocities determined, these computer "tools" then also portray the capture zone for the selected travel time. Such techniques were used in the delineation of capture zones for the cities of Rockford (Wehrmann and Varljen, 1990), Pekin (Adams et al., 1992), and Cary (Baxter & Woodman, 1993). Examples of time-related capture zones calculated from flow model output are shown in Figures 11 and 12 for the cities of Pekin and Rockford. Similar modeling efforts were used in Cary and Figure 13 shows not only the potentiometric surface and the 5- and 10-year capture zones but selected flow paths within the capture zone.

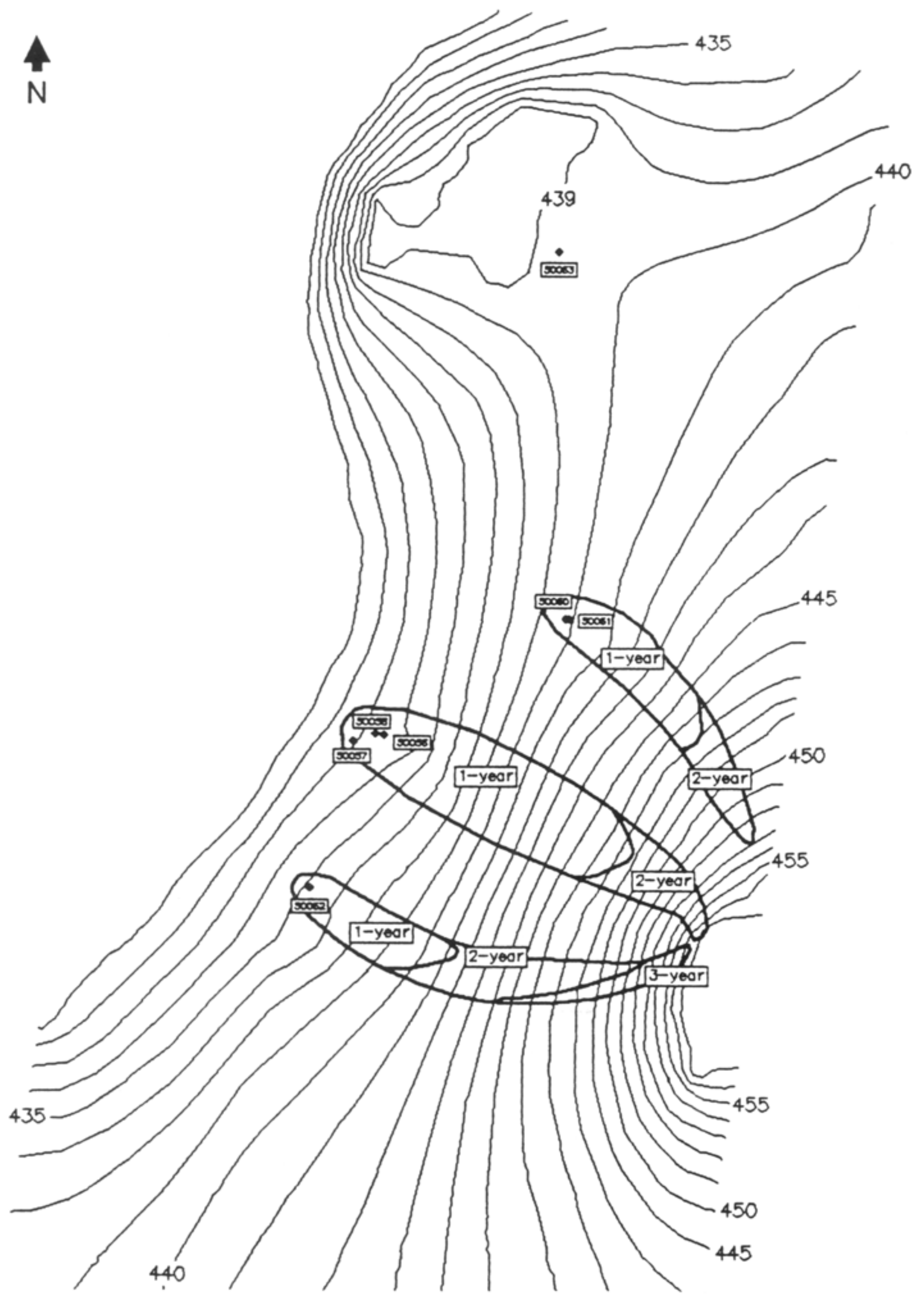

Figure 11. MODFLOW groundwater head contours and 1-and 2-year time-related capture zones for Pekin (Adams et al., 1992)

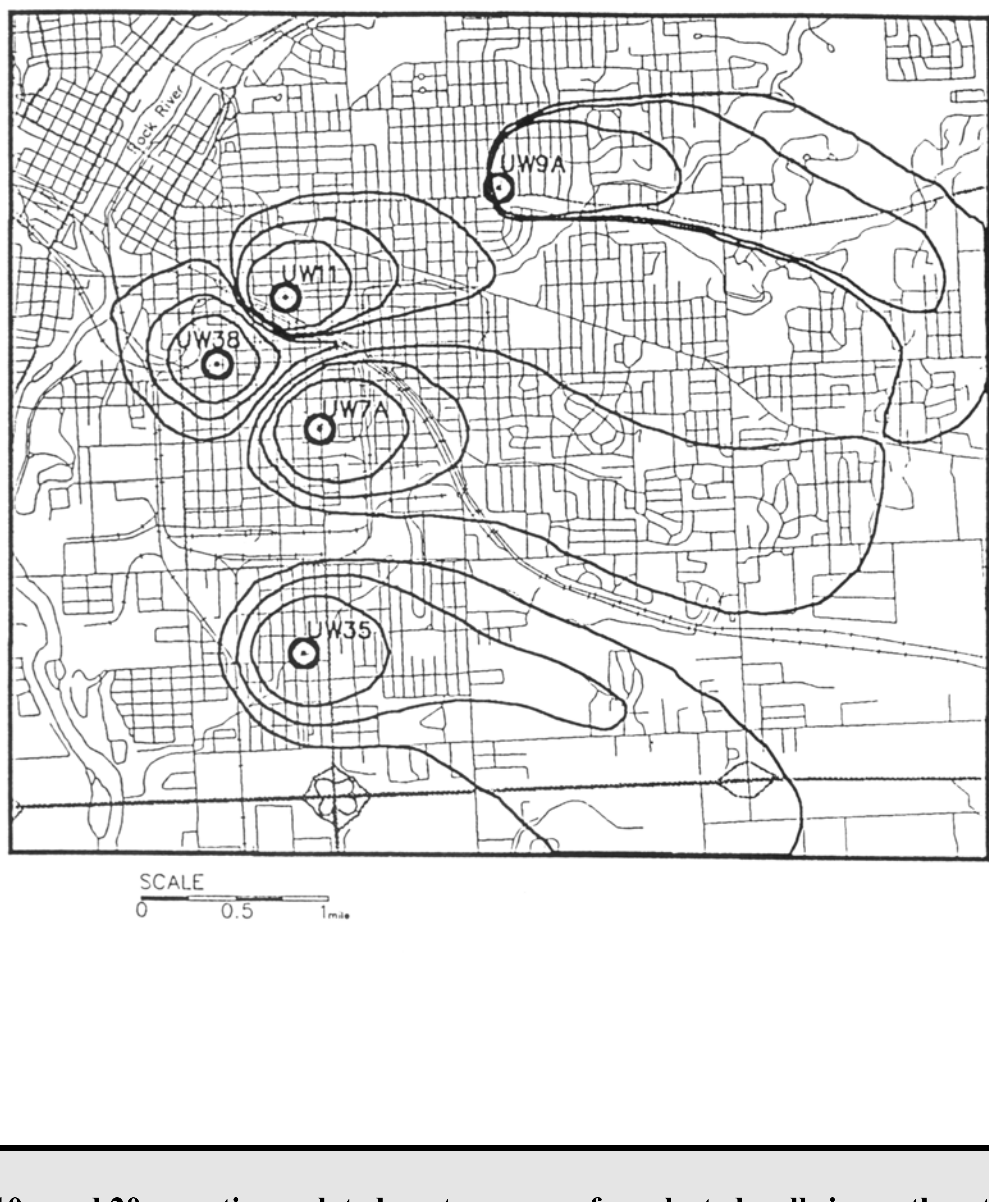

Figure 12. 5-, 10-, and 20-year time related capture zones for selected wells in southeast Rockford (Wehrmann and Varljean, 1990)

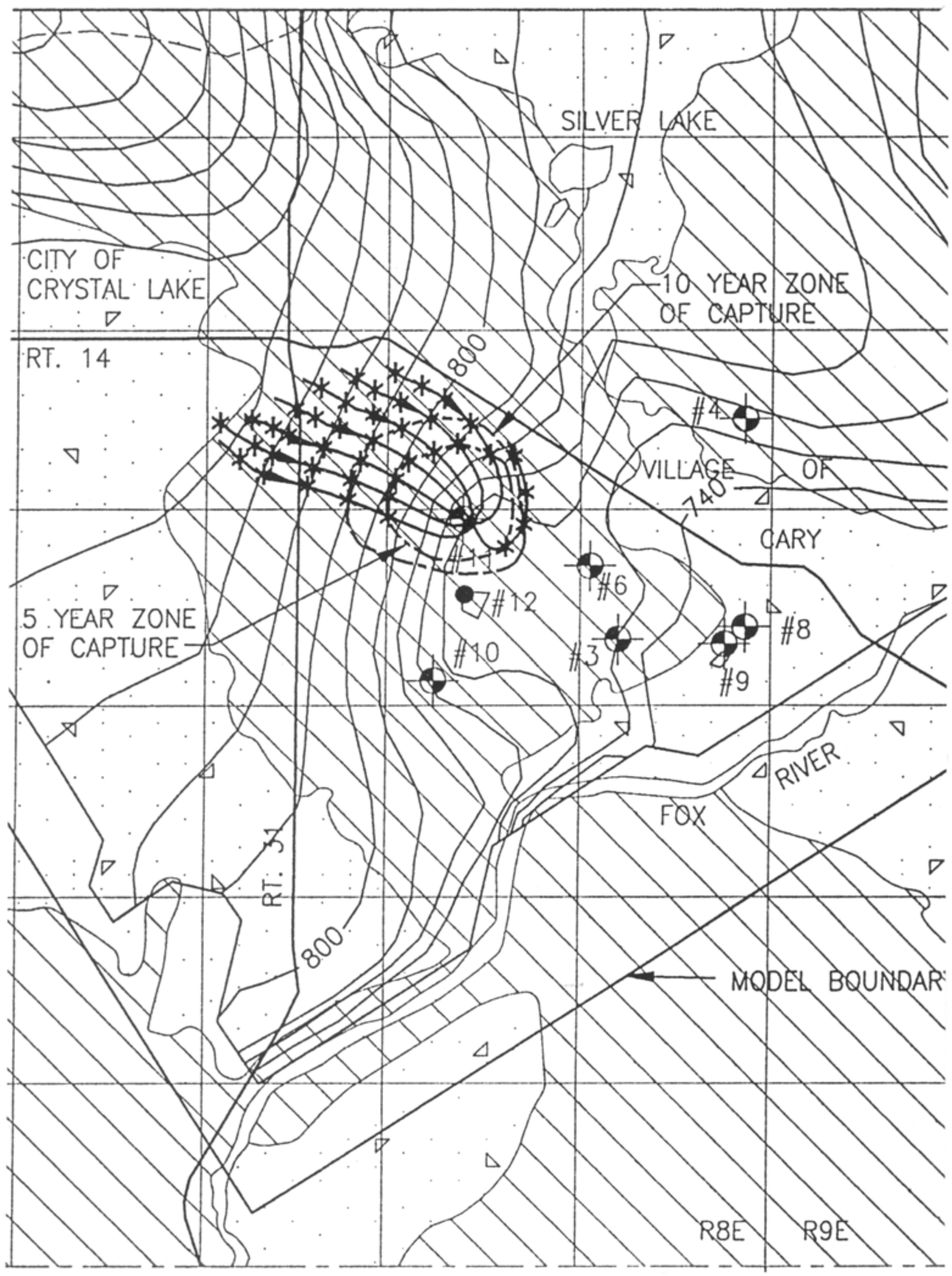

Figure 13. Pathlines and 5- and 10-year capture zones for well No. 11, Cary, Illinois (from Baxter and Woodman, 1992)

7. Evaluate and Summarize Results of All Investigations

The final step of the geologic/hydrologic characterization of a GPNA is to evaluate all data and summarize findings on the occurrence of existing and potential future areas of groundwater contamination. The data should be sufficient to determine the direction of groundwater movement within the study area and to support the development of time-related capture zones for the wells of interest. A final report may include several of the following items:

a. detailed description of the study area,
b. description of the geology of the study area including geologic cross sections constructed from monitoring well logs and geologic samples supplemented with nearby well data and regional information,
c. summary of groundwater levels measured in wells (well hydrographs),
d. groundwater contour maps describing the direction of groundwater movement within the study area,
e. results of hydrologic tests, such as well production tests performed on water supply wells and slug tests performed on monitoring wells,
f. results of modeling including a discussion of how the model was set up (e.g., boundary conditions, aquifer hydraulic properties, etc.), discussion of differences between modeled and actual heads, and flow path analyses, and
g. description and map of the modeled capture zones.

Identification of Potential Sources and Routes of Groundwater Contamination

The methodology of characterizing potential sources and routes of groundwater contamination, similar to mapping procedures, consists of several basic elements. The first step in this process is to assimilate all existing information. This effort should include information from the: well site survey report (prepared by IEPA); state and local health departments; local fire department (e.g.,underground storage tank status, and community right-to-know); zoning department; or other points of contact which might identify areas of concern within the delineated recharge area. This existing information should be transposed onto a large-scale base map displaying the recharge area. Figure 14 illustrates the location of potential contamination sources located with a global positioning system and overlain onto an electronic base map for the City of Pekin. This base map will be a necessary element in all additional aspects of the potential source/route identification and assessment process. Therefore, it must be consistent with other maps used for the GPNA, allowing the locational information to be linked to any other maps necessary for the assessment process. For example, Figure 15 shows an overlay of the existing potential contamination sources relative to the recharge areas and the geologic vulnerability.

Next, a preliminary field visit should be conducted. This visit should consist of a drive by or windshield survey to verify the preliminary information and identify additional areas of concern. The following basic information should be collected during this phase of the potential source and potential route identification process:

- community well number and name;
- description of the potential source or route;
- address of potential source or route; and
- distance and direction of potential source or potential route relative to the community water supply well location.

This information should be correlated with a map of the wells, as illustrated in Figure 14.

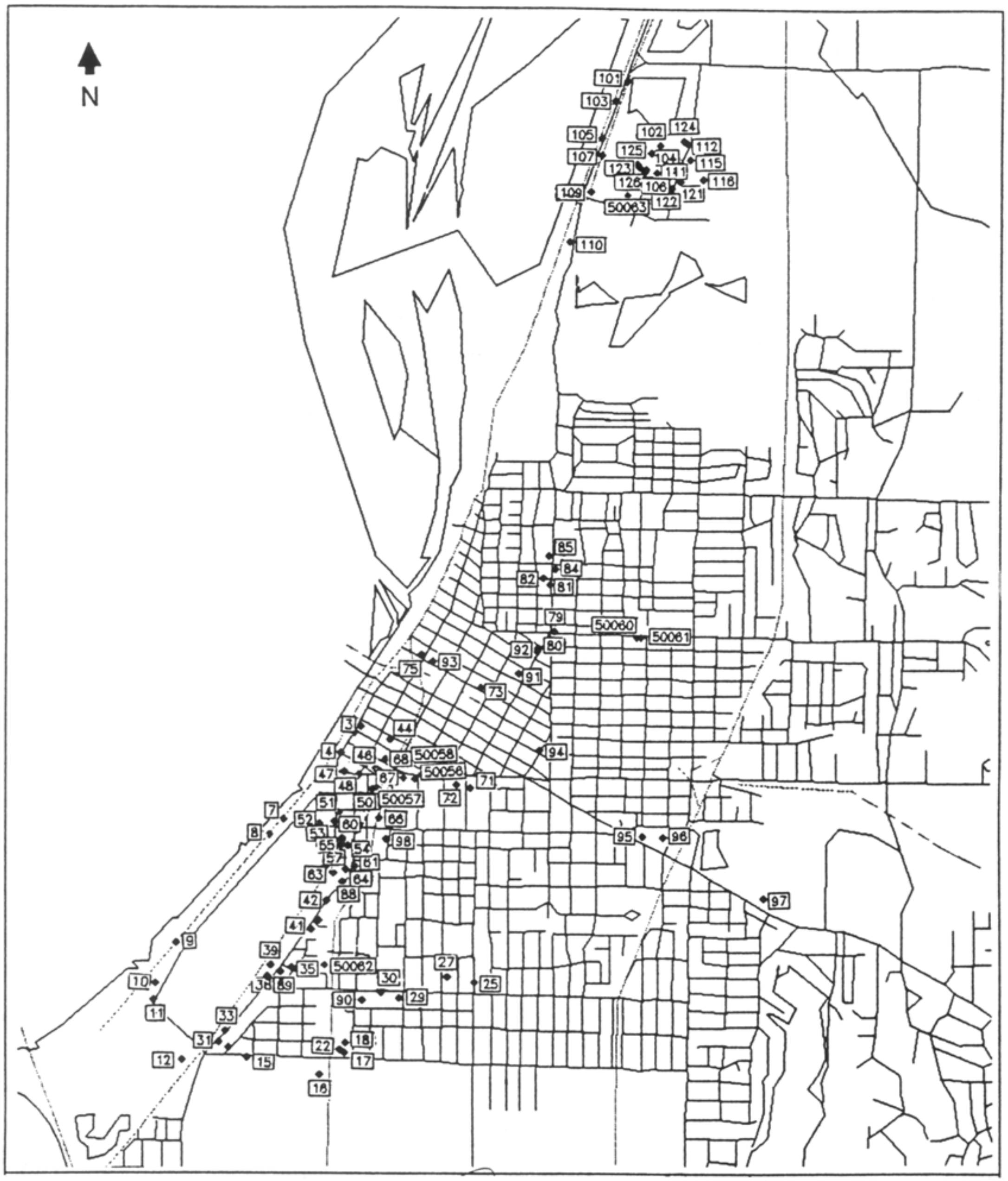

Figure 14.Location of potential contamination sources in Pekin (Adams et al., 1992)

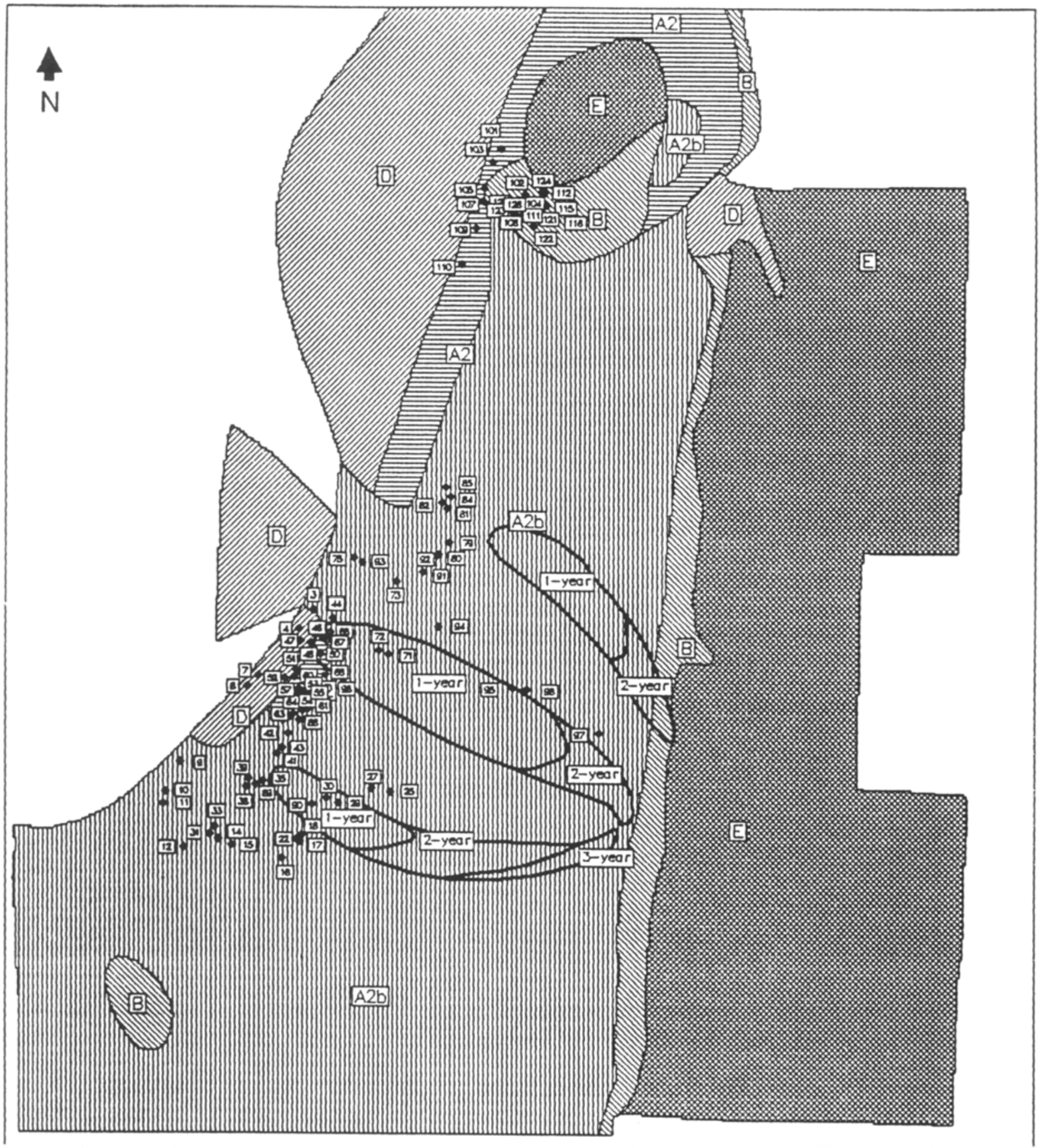

Figure 15.Location of potential contamination sources of contamination relative to recharge areas and geologic vulnerability in Pekin (Adams *et al.*, 1992)

On-site Inspection of Potential Groundwater Contamination Sources

After the initial survey a follow-up evaluation must be conducted. This evaluation will be much more comprehensive than the initial survey and may require a number of days to complete. The comprehensive evaluation must include on-site inspections of all potential sources/routes and an inventory of all non-point sources of contamination. The inspections should include identification of any possible threats to the groundwater and exact geographical locations. Site-specific inspection forms should be completed to facilitate the completeness and consistency of the information obtained from these inspections. Appendix III contains an example on-site inspection form.

Non-point sources (e.g., cropland, golf courses, etc.) should also be adequately inventoried and mapped. Appendix IV illustrates the interview and inventory form utilized for agricultural non-point sources in Pekin. This form was based, in part, on the interview form utilized by USEPA during the National Pesticide Survey. Additionally, while conducting an inventory of existing potential sources, historical land-uses should be inventoried.

Evaluation of Potential Sources and Routes of Contamination

Upon completion of the field identification process (the windshield survey and comprehensive on-site inspection), the assessment of the degree of hazard posed to the groundwater supply by each potential source and route must be determined. In order to determine a degree of hazard posed by each potential source or route identified, a detailed evaluation process is necessary. This evaluation should involve the access of all IEPA regulatory or multi-media reports (i.e., Bureaus of Air, Land, Water, and Office of Chemical Safety), Illinois Emergency Management Agency (formerly Emergency Service and Disaster Agency), Illinois State Fire Marshal, and local information (i.e., sewer maps, etc.). As illustrated in Appendix V, a hazard review work sheet may be completed to document the information obtained and evaluated during the review process. This review process should involve performing a search of permit information, cleanup site information, registered underground storage tanks, toxic chemical release reports, and groundwater monitoring data within the delineated recharge area(s). Table 3 illustrates the sources of information that should be utilized.

Table 4. Summary of regulatory information useful in GPNA source assessments

Illinois Environmental Protection Agency Division of Land Pollution Control	Compliance monitoring permits and (RCRA, UIC, & Solid Waste, Generic),
Division of Air Pollution Control	Air pollution permits
Division of Water Pollution Control	Permits (Industrial, Municipal, Facility/ Process
Division of Public Water Supplies	Compliance monitoring
Office of Chemical Safety	Emergency response incidents and spills. Toxic
Illinois State Fire Marshal	Registered underground storage tanks.
Illinois Emergency Management	Emergency plans submitted by facilities Agency

The next phase of the assessment is to determine if potential primary sources, potential secondary sources, potential routes or other possible sources meet certain minimal hazard and Illinois Responsible Property Transfer Act (RPTA) criteria. Minimal hazard criteria are defined in Section 14.5 of the IGPA, and in the minimal hazard certification rules (35 Ill. Adm. Code 670). If a site does not meet minimal hazard or RPTA requirements, then it may be considered a potential hazard. The following illustrate examples of minimal hazard criteria and RPTA:

- Has any on-site landfilling, land treating, or surface impounding of waste, other than landscape waste or construction and demolition debris taken place, and will such circumstances continue?;

- Are there any on-site piles of special or hazardous waste present, will such circumstances continue, and is piling of other wastes which could cause contamination of groundwater consistent with Agency 35 Ill. Adm. Code 670 ?;

- Are there any underground storage tanks present at the site, and will such circumstances continue?;

- Is the use and management of containers and above ground tanks consistent with Agency 35 Ill. Adm. Code 670 ?;

- Has any on-site release** of any hazardous substance or petroleum taken place which was of sufficient magnitude to contaminate groundwaters?;

- Has any situation(s) occurred at this site which resulted in a "release" of any hazardous substances or petroleum?;

- Have any hazardous substances or petroleum, which were released, come into direct contact with the ground surface at this site? (Note -- do not automatically exclude paved or otherwise covered areas that may still have allowed chemical substances to penetrate into the ground.);

- Have any of the following actions/events been associated with the release(s) referred to above?;

    Hiring of a cleanup contractor to remove obviously contaminated materials including subsoils;

    Replacement or major repair of damaged facilities;

    Assignment of in-house maintenance staff to remove obviously contaminated

---

** ***"Release" means any sudden spilling, leaking, pumping, pouring, emitting, escaping, emptying, discharging, injecting, leaching, dumping or disposing into the environment beyond the boundaries of a facility, but excludes (a) any release which results in exposure to persons solely within the workplace, with respect to a claim which such persons may assert against their employer; (b) emissions from the engine exhaust of a motor vehicle, rolling stock, aircraft vessel, or pipeline pumping station; (c) release of source, byproduct, or special nuclear material from a nuclear incident, as those terms are defined in the Atomic Energy Act of 1954, if such release is subject to requirements with respect to financial protection established by the Nuclear Regulatory Commission under Section 170 of such Act, and (d) the normal application of fertilizer.***

materials including subsoils;

Designation, by the IEPA or the IEMA, of the release as "significant" under the Illinois Chemical Safety Act;
Reordering or other replenishment of inventory due to the amount of substance lost;

Temporary or more long-term monitoring of groundwater at or near the site;

Stopped the use of an on-site or nearby water well because of offensive characteristics of the water;

Coping with fumes from subsurface storm drains or inside basements, etc.;

Signs of substances leaching out of the ground along the base of slopes or at other low points on or adjacent to the site;

On-site release(s) that may have been of sufficient magnitude to contaminate groundwaters; and

More than 100 gallons of either pesticides or organic solvents, or 10,000 gallons of any hazardous substance, or 30,000 gallons of petroleum present at any time.

A hazard review work sheet can be used to evaluate these considerations for each potential or other possible source in the study area. Once all the hydrogeologic, locational data, and detailed discovery information (from the hazard review work sheets) is integrated together, a picture will emerge that should summarize the degree of threat posed by each potential source/route.

This initial picture should allow for prioritization of the threat posed by each potential source within the delineated recharge area(s). This phase of the assessment should incorporate the potential source characteristic results, and should also take into consideration the geologic sensitivity, attenuative soil properties, and depth to the water table. Computerized mapping software (Geographic Information System) can be used to relate all of the variables described above, and to evaluate the potential hazards to the groundwater in the study area. This evaluation should result in a final hazard determination.

Evaluation of the Land-Use Zoning

In addition to the evaluation of existing potential sources/potential routes of groundwater contamination, a GPNA should also evaluate the land-use zoning within the recharge area(s) of the community water supply wells. The zoning throughout the county or municipal jurisdiction(s) should also be considered in relation to the development of new water supply wells. Evaluation of the zoning within well recharge areas is important because these zoning maps are the blue print for community growth and development. The determination of the protection needs within a community well recharge area(s) will depend on the types of land-uses allowed to locate and operate in these sensitive areas. A computerized mapping program can be used to relate land-use and property boundaries to the boundary of a recharge area as illustrated in Figure 16.

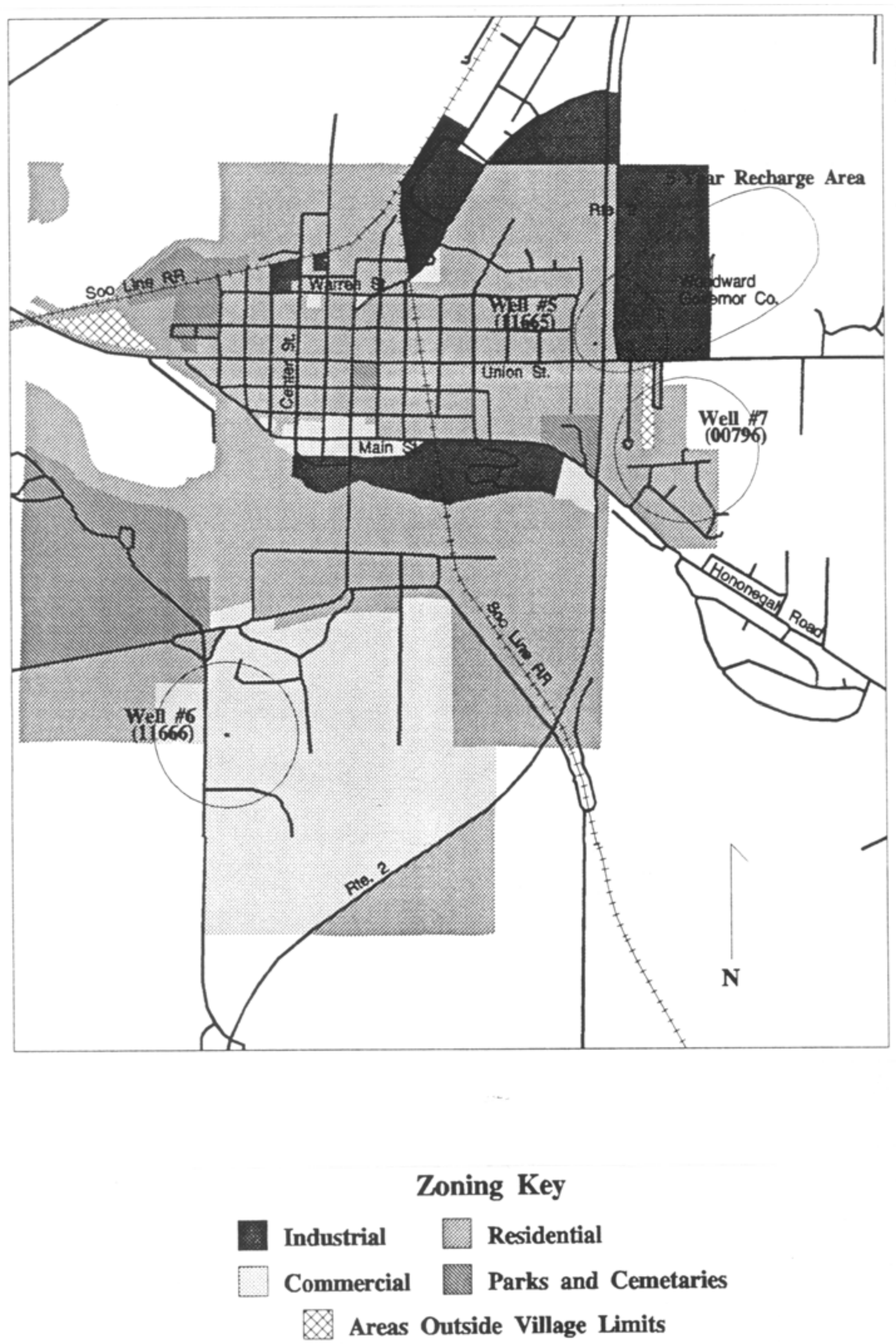

Figure 16. Land-use zoning relative to the recharge areas of the City of Rockton community water supply wells (from Cobb, 1994)

Community Water Supply Contingency Plan Evaluation

When an emergency occurs, it is too late to start planning for it. Therefore, a comprehensive and flexible emergency plan must already be in place. A contingency plan should outline response procedures in the event of water supply disruption due to contamination or any other reason. State drinking water officials can assist in identifying both the individuals and organizations to notify immediately after an accidental release, as well as the types of equipment likely to be needed in the event of a contamination incident.

The goals of a contingency plan include: prevention of further damages; control over the damage that has occurred; and prompt restoration of water services on at least a temporary or preferably a permanent basis.

A plan of action needs to accomplish the following:

- allow for the fastest possible emergency response time;
- minimize the amount of contaminant released;
- assure that other officials or emergency response personnel know who to contact; and
- provide for alternative water supply sources.

The periodic occurrence of natural disasters, chemical contamination, physical disruptions, and civil disorders can all threaten the supply and distribution network of public drinking water supplies to some degree. The minimization of impact on the public and the timely restoration of water supply service to an affected area depends on an updated, efficient, and effective water supply contingency plan.

According to the "Emergency Planning for Drinking Water Systems-Illinois", 1983, contingency plans should include procedures for public notification, inventory information, water source contamination, power and mechanical failures, distribution system problems, and staffing. Up-to-date inventories will help in determining the type of repair possible and whether permanent or temporary correction can be obtained.

Up-to-date Inventories should include item specifications (e.g., pumps, skid mounted treatment devices, etc.,) and availabilities, replacement components, relevant drawings and descriptions, contractor and vendor directories, nearby water utility directories, contracts with alternate potable water supplies, and alternate sources of transportation.

In minimizing contamination, the success of any emergency action may depend largely on the local water utility pre-emergency planning, especially if the water requires extensive additional treatment. Water source contamination could lead to an extended shutdown of a water utility causing water treatment procedures to be initiated immediately. The restoration of a contaminated area should include the examination of the chemical and biological nature of the contaminant with regard to human and ecological effects.

Emergency information must be available and readily accessible thorough a chain of notification with alternate individuals for each person with a primary responsibility. The Emergency Planning Check List in "Emergency Planning for Drinking Water Systems-Illinois", 1983, includes a prioritized directory listing. This checklist should include telephone numbers for the Illinois Emergency Management Agency and the appropriate local county office. In addition, the water supply should maintain an updated IEPA organizational chart which includes contacts with emergency response, water supply and cleanup program staff.

The degree of water service interruption to consumers during emergency conditions can be, in part, measured by local utility companies in terms of their procedures for both electrical and mechanical failures. Such planning calls for easily accessible alternate electrical and mechanical components for the water system. Up-to-date diagrams and drawings are essential in minimizing the response time.

Another key element in a contingency plan is related to distribution system problems. In the event of an emergency, work and repairs must be prioritized. The procedure for maintaining pressure in a system may include the following list: location of failure, determination of damage extent, boil orders issued, problem isolation, and repair procedures.

A well-trained staff is essential in order for a contingency plan to run efficiently. In addition, these persons should be adequately trained. A Plan should include procedures addressing natural disasters and man-made events. Furthermore, the contingency plan information should be indexed and paginated for prompt retrieval. In addition, the evaluation of the most feasible economic alternatives may be beneficial. The addition of these factors will produce a comprehensive and easily accessible plan to act quickly and efficiently in the event of an emergency.

IEPA's "Emergency Planning for Drinking Water Systems" and USEPA's technical assistance document entitled "Guide to Groundwater Supply Contingency Planning for Local and State Governments" both recommend including a listing of the accessibility of financial resources and the existence of agreements with nearby water supplies and alternate sources to provide potable water should an emergency occur.

A contingency plan is an important preventive aspect of a needs assessment. The contingency planning process is also an integral part of USEPA's Wellhead Protection Program (WHPP), established under the 1986 Amendments to the Safe Drinking Water Act. The WHPP was developed primarily to protect the groundwater that supply wells and well fields that contribute drinking water to public water supplies systems.

Groundwater Protection Management Options

A GPNA should also contain and recommend groundwater protection management options and recommendations. Management strategies should be used to minimize threat (potential sources) of contamination, and protect public water supplies for continued use. The first step in evaluating the groundwater protection management options, should consider the extent to which existing local controls provide, either directly or indirectly, some measure of groundwater protection within the recharge areas of community water supply wells. A review should be conducted to determine if any county or municipal ordinances or planning documents related specifically to groundwater protection exist.

If there are no existing groundwater protection ordinances or documents, a number of options exist for protecting the well recharge area(s). There are four major types of management strategies that could be applied. In general these options include: state regulatory, local regulatory, non-regulatory and legislative approaches. State regulatory options include minimum setback zones, maximum setback zones and/or regulated recharge areas. Local options include zoning, subdivision control and health regulations. Non-regulatory options include actions which a community or local citizens may undertake to protect groundwater, typically not involving regulation of private property, such as water quality monitoring, land acquisition, and collection of household hazardous waste. Legislative options are used by communities in cases where local authority is not available for a particular action. The following description of local management options was based, in part, on a document entitled "Wellhead Protection Programs: Tools for Local Government, 1993" prepared for the United States Environmental Protection Agency by Horsley and Whitten, Inc.

1. Local Groundwater Protection Management Options

Zoning is one of the oldest land use controls used by local governments since the early 1900's. Historically, local governments adopted zoning regulations to minimize conflicts between varying land uses. Zoning is used to divide a political jurisdiction into zones or districts, with each district being assigned for particular land uses and having different development restrictions.

A zoning ordinance accompanies a zoning map. In the zoning ordinance, the local government indicates what development restrictions apply in each district. Development restrictions typically include: 1) type of land use allowed, 2) density of development, 3) placement of structures on lots (setbacks), 4) street frontage, 5) parking, and 6) signage. Procedures for approval of uses and structures are also explained in ordinances. Zoning is most useful in directing future development. In some cases, local governments may be restricted from adopting zoning regulations applying to existing uses.

One form of zoning that could be applied to protect recharge areas is referred to as an overlay zoning district. *Overlay districts* are adopted by communities to protect a range of resources including recharge areas, surface watersheds, and wetlands or to protect from threats such as floods. To establish an overlay district, the community must have a map of the recharge area necessary for protection of a resource (i.e. recharge area). Once a community knows which areas impact its public groundwater supplies, an overlay district is adopted within which additional land use controls apply. Examples of controls applied in overlay districts include prohibiting or restricting certain uses, or imposing performance standards and site design requirements. Overlay zoning invokes taking an already zoned area and overlying an additional zoning district and regulations on that land area. An advantage of an overlay district is that regulatory changes only apply to areas affecting a particular resource. Uses located outside the zone may continue without additional restriction.

Prohibition of various uses maybe be appropriate within the overlay district dependent upon the characteristics of the aquifer, and the types of development being proposed. *Special / conditional use permits* may be applied in an overlay zone. A local government may identify uses which are only allowed in a recharge area if they meet certain conditions; for example, if they do not threaten the public well's water quality. The special/conditional use permit process provides an added opportunity for evaluation of a project's potential impacts before approval. A special /conditional use may be required to meet specific performance standards (for example, no handling of toxic or hazardous materials) before a permit is issued. The special/conditional use permit process is useful when a particular use may not pose a major threat to a water supply provided that certain precautions are taken.

Health regulations are another form of local groundwater protection management. Health regulations are usually contaminant specific (e.g. for septic systems, underground storage tanks, toxic and hazardous materials, abandoned wells). Examples of typical health regulations include the following:

- nitrogen loading standards ;
- groundwater monitoring for business or industrial uses that handle toxic or hazardous materials;
- groundwater monitoring for businesses or industrial uses that handle toxic or hazardous materials;
- on-site inspection programs to ensure proper design, construction, and operation; and
- well closure requirements.

Subdivision controls and drainage standards have also been utilized by local governments as a part of groundwater protection strategies. Street drainage requirements may be included in subdivision control regulations to require pre-treatment of road runoff to reduce contaminant levels before it is discharged to groundwater or surface water. Street drainage requirements may also be included in subdivision control regulations to require pre-treatment of road runoff to reduce contaminant levels before it is discharged to groundwater or surface water. Subdivision regulations are useful for controlling impacts of future, versus existing, development.

Non-regulatory approaches for protecting recharge areas are those not involving land regulation, and include voluntary pollution prevention, negotiations for land acquisition and public education. *Pollution prevention techniques* include the following:

Source Reduction
Ways to reduce the amount of waste generated
- Maintain better inventory and control of raw materials
- Use of detergents in place of solvents where possible
- Segregate wastes into recyclable and non-recyclable portions
- Substitute water-based paints for solvent based paints
- Use solvent sinks, hot tanks, and jet sprayers
- Improve general housekeeping:
    - Operate equipment properly
    - Avoid and limit leaks and spills
    - Improve product transfer and leak collection procedures

Recycling and Resource Recovery
Ways to recycle waste fluids or recover usable resources
- Contact local recyclers for reclamation of waste oil, anti-freeze, transmission fluid, solvent and lead acid batteries
- Use low cost gravity separation to reclaim solvents
- Re-use waste materials (solvents, automotive fluids) when possible

Land acquisition is also an effective means of protecting a well recharge area. While regulations often work to protect groundwater, complete control via ownership is far more effective. However, the primary draw back to land acquisition is the cost. Local governments may seek land donations, may pursue purchases of land, or may obtain conservation easements including restricting use of the land. Incentives for land donation include a variety of tax savings, including elimination of estate or capital gains taxes, real estate taxes, and loss of insurance and maintenance costs. A portion of the value of the donation may be deducted from federal and state income taxes. Bargain sales of property sold at less than the fair market value may qualify as a charitable contribution and frequently qualifies for a deduction from federal and state income taxes.

A *conservation easement* is an approach used by many local governments or land trusts to protect sensitive environmental resources at relatively little cost. An easement is a limited right to use or restrict land owned by someone else.
Hazardous waste collection days and public education programs are other examples of non-regulatory local groundwater protection efforts. Hazardous waste collection days and public education programs are aimed at getting citizens involved with groundwater protection efforts. Household hazardous wastes are potential sources of contamination. Common household wastes include pesticides; herbicides; solvents; septic system cleaners; metal cleaners; pool chemicals; paints and paint thinner. Hazardous waste collection days remove small quantities of waste from home owners , avoiding the possibility that these sources of contamination would be placed on the land surface or in septic systems.

Public education programs include sponsoring and holding informational meetings, creating advertisements and flyers, questionnaires, posters and artwork, demonstration projects and community events. Public education is a key aspect of any effort to create a local groundwater protection program. Public education efforts are important in building public support for regulatory changes and local funding. Public education efforts are also necessary to teach the public about proper disposal (such as returning used motor oil to service stations) and safe alternatives for household hazardous wastes (such as baking soda and vinegar instead of toxic chemicals).

Signage is an approach that has been used by local governments and European countries as a form of education. Use of signs along roadways or at public facilities may be used to increase awareness of where recharge protection areas are located. Signs serve to educate individuals, and also provides a mechanism for notification in cases of an accidental contaminant release. Therefore, signage may be used to lessen impacts associated with contaminant spills.

Coordination with special regional groundwater protection planning committees is also a key approach to public education, and establishing local groundwater protection programs. Public education programs are conducted state wide, but are emphasized in *Priority Groundwater Protection Planning Regions*. Section 17.2(a) of the IGPA requires the Agency, in cooperation with DENR, to establish a regional groundwater protection planning program. The IGPA also requires the Agency to establish a regional planning committee for each priority groundwater protection planning region. Each committee is to be appointed by the Director of the Agency and include representatives from among the following:

- counties and municipalities in the region;
- owners or operators of public water supplies which use groundwater in the region;
- at least three members of the general public which have an interest in groundwater protection; and
- the Agency and other State agencies as appropriate.

From among the non-state agency members, a chairperson is selected by a majority vote. Members of a regional planning committee serve for a term of two years.

The Agency utilized the priority recharge area map, groundwater pumpage data, population affected, water supply characteristics, solid waste planning efforts, and other factors to select three priority groundwater protection planning regions. The IGPA, specifies that each regional planning committee shall be responsible for the following:

1. identification of and advocacy for region-specific groundwater protection matters;
2. monitoring and reporting the progress made within the region regarding implementation of protection for groundwater;

3. maintaining a registry of instances where the Agency has issued an advisory of groundwater contamination hazard within the region;

4. facilitating informational and educational activities relating to groundwater protection within the region; and

5. recommending to the Agency whether there is a need for regional protection pursuant to rulemaking before the Board. Prior to making any such recommendation, the regional planning committee must hold at least one public meeting at a location within the region. This meeting may be held after not less than 30 days notice is provided, and must provide an opportunity for public comment."

The Northern and Central Groundwater Protection Planning Committees were established in April of 1991, and the Southern committee was established in late 1992. The Northern Planning Committee has established four subcommittees: an education subcommittee; a public relations subcommittee; a technical subcommittee; and a planning and zoning subcommittee. The Central Planning Committee has established an education subcommittee and the Pekin Groundwater Protection Education Committee. The Southern Planning Committee has established an education subcommittee and a public relation subcommittee. The Southern Planning Committee has established an education subcommittee and a public relation subcommittee.

The Agency is working with the regional planning committees to establish local groundwater protection programs by determining county and municipal target audience contacts within their respective regions. The Agency and committee members follow-up with one-on-one meetings/workshops with target audiences after initial contacts are made to encourage the development and implementation of local groundwater protection programs. Local groundwater protection programs that have been encouraged include: voluntary pollution prevention; enhanced performance/operation standards; local zoning options; and IGPA regulatory actions.

2. State Regulatory Groundwater Protection Management Options

The IGPA automatically established some groundwater protection for community water supply wells. Minimum setback zones of 200 or 400 radial feet around each community water supply well in the State were established by the legislature. *Minimum setbacks* prohibit the location of new potential primary sources, new potential secondary sources of contamination, and new potential routes of contamination within these radial areas. The use of these definitions is described in a technical assistance document prepared in 1988 by the IEPA entitled "*A Primer Regarding Certain Provisions of the Illinois Groundwater Protection Act*". The IGPA also establishes the authority for any county or municipality supplying groundwater to a community water supply well to establish a maximum setback zone. *Maximum setback zones* expand the prohibition for new potential primary sources of contamination up to 1,000 feet from the wellhead. Maximum setback zones can be based on the lateral area of influence and/or the regional gradient. If the latter is taken into account, an irregularly shaped maximum setback zone based on the regional gradient can be established. If the later is taken into account an irregularly shaped maximum setback zone based on the regional gradient can be established. The procedure required for establishing a maximum setback zone is discussed in a second technical assistance publication prepared by the IEPA in 1990 entitled a "*Maximum Setback Zone Workbook*".

The Illinois Pollution Control Board ("Board") rulemaking R89-5 "*Groundwater Protection: Regulations for Existing and New Activities within Setback Zones and Regulated Recharge Areas (35 Ill. Adm. Code 601, 615, 616 and 617) ("Technical Standards")*"were established pursuant to Section 14.4 of the Act. These regulations are gap filling regulations that apply to certain activities that are potential primary or potential secondary sources of contamination that were not previously regulated. Existing activities are regulated within setback zones and within a 2,500 foot distance from the wellhead within a regulated recharge area. Certain new activities are prohibited if located within this 2,500 foot distance, but others are subject to design, operating and/or monitoring requirements if located anywhere within the boundary of a regulated recharge area. Appendix VI provides a summary of the types of activities, and associated areas regulated.

Additionally, the Illinois Department of Agriculture ("IDOA") has developed "*Containment Rules for Agrichemical Facilities (8 Ill. Adm. Code 255)*", the "*Illinois Lawn Care Products Application and Notice Act (8 Ill. Adm. Code 256)*", and the "*Cooperative Groundwater Protection Rules (8 Ill. Adm. Code 257)*". All of these regulations manage certain existing and new potential groundwater contamination sources located within the setback zones or regulated recharge areas of potable water supply wells. All of these regulations and rules manage certain existing and new potential groundwater contamination sources located within the setback zones or regulated recharge areas of community water supply wells.

The IGPA also establishes the authority to establish a *regulated recharge area*. A regulated recharge area is defined under Section 3 of the Act, as follows:

> "Regulated recharge area" means a compact geographic area, as determined by the Board, the geology of which renders a potable resource groundwater particularly susceptible to contamination.

Therefore, regulated recharge areas are established on a site-by-site basis through a Board rulemaking procedure.

The pilot GPNAs have developed the technical hydrogeologic basis for determining a recharge area for a community water supply well. There are various conditions under which the Agency may pursue a regulated recharge area under Section 17.3 of the Act. The Agency may propose to the Board a regulation establishing the boundary for a regulated recharge area if any of the following conditions exist:

- the Agency has previously issued one or more advisories within the area;
- the Agency determines that a completed GPNA demonstrates the need for regional protection; or
- mapping completed by the Department identifies a recharge area for which protection is warranted.

The Agency shall propose a recharge area regulation if a regional planning committee, as described above, files a petition requesting and justifying such an action unless such action is determined to be unwarranted. In promulgating a regulation to establish a boundary for regulated recharge area the Board is required under Section 17.4 of the Act to consider: the adequacy of protection for potable resource groundwater by any applicable setback zones; applicability of the Technical Standards adopted under Section 14.4; refinements in the groundwater quality standards which may be appropriate for the delineated area; and the extent to which the delineated area may serve as a sole source for public water supply. The Board is also required to consider the factors under Title VII of the Act.

In developing the regulation for the boundary of the regulated recharge area, the Agency would also evaluate the criteria the Board is required to consider. In other words, consideration could be given, on a site- by-site basis, to: prohibitions for certain types of new potential contamination sources; application of technology controls and best management requirements for existing and new potential contamination sources; and enhancements of the groundwater quality standards within the boundary of a delineated recharge area. For example, additional constituents could be covered or more rigorous nondegradation or preventive measures could be specified.

The range of groundwater protection options discussed above are thoroughly discussed in a document prepared by the Department of Urban and Regional Planning of the University of Illinois at Champaign-Urbana in cooperation with the Illinois Chapter-American Planning Association, and is entitled "*Groundwater Protection by Local Government*".

In summary, the IGPA contains a number of provisions designed to protect community water supply wells, as discussed in the introduction to this document. After evaluating land-use zoning, further analysis should involve determining the degree of protection provided to the recharge area(s) by the existing minimum setback zones. After this evaluation is conducted, the following options and questions should be considered:

- Protection awareness techniques (e.g., identification of the recharge areas);

- Pollution prevention techniques may be established if the industrial, commercial, agricultural and/or residential make up of the recharge area lends itself to such techniques. In other words, pollution prevention techniques can be applied to existing potential sources of contamination located within the recharge area. Pollution prevention projects can provide successful long-term groundwater protection that usually save companies money, decrease liability and increase worker/community safety, all while protecting the environment more effectively than most add-on controls. Information regarding generic and specific (e.g., solvent use) methodologies are readily available from the Agency and the Hazardous Waste Research and Information Center;

- Establishment of maximum setback zone(s) is the first step towards increasing groundwater protection beyond wellhead setback zones. The region of protection can be expanded further by the establishment of a regulated recharge area under an Illinois Pollution Control Board regulation pursuant to Section 17.4 of the Illinois Environmental Protection Act;

- Recharge area specific groundwater standards;

- Siting prohibitions for certain potential sources such as landfills;

- Non-regulatory options for re-zoning areas could be considered in areas where there is a threat to groundwater. Options include applying certain best management practices to existing potential contamination sources within zoned residential, commercial, industrial and/or agricultural district(s) located within the recharge area(s). Such standards might limit on-site storage amounts or regulate the storage methods related to hazardous material in an overlay zone within the recharge area;

- Incentive and educational programs could be established in cooperation with Regional Groundwater Protection Planning committees and/or a local team or work group to educate the public and businesses in the area about groundwater protection;

- Materials available through the Department of Energy and Natural Resources Groundwater Protection Education Program should be obtained. These materials should be used in conjunction with several community education programs to introduce the public and businesses to the requirements of the IGPA and the need for contingency planning;

- A current list of contractors, which have the ability to provide the following, should be maintained: soil boring equipment with vertical groundwater sampling capabilities, materials for monitoring well installations, groundwater extraction and treatment systems, and volatile organic chemical analysis. The list should include estimated response times, current contacts, and telephone numbers for each contractor;

- Addressing procedures for public notification, inventory information, water source contamination, power and mechanical failures, distribution system problems, and staffing;; and

Prevention of groundwater contamination is a reordering of a philosophy of operations and maintenance. It must not be assumed that contamination occurs solely as a result of catastrophic leaks or spills. Certainly events of this nature can result in groundwater contamination problems. However, at least as many problems may occur as a result of poor housekeeping, equipment attrition and poor maintenance, improper or uncontrolled product transfers, erosion or corrosion of tanks and piping, and minor common daily operations. These activities, which may appear benign, may in fact cause an accumulation of contaminants or problems, and unanticipated costs.

CONCLUSION

This document is intended for use by county officials, municipal officials and consultants. In addition to this guidance document four pilot GPNAs have been conducted. In summary, several regions in Illinois have been targeted for groundwater investigations (Shafer, 1985 and Keefer and Berg, 1990), and a methodology has been developed as a guide for the planning and execution of future GPNAs and regional groundwater quality characterization studies within Illinois. This methodology will help provide consistency in the design of such efforts that may be undertaken by any number of different groups or agencies across the state. The methodology is the result of our knowledge and the experience gained through conducting pilot GPNAs as well as other geologic mapping and groundwater assessment studies. Because each study area will possess some unique conditions, the methodology should be thought of as a working model that can be adapted and improved for the individual situation.

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APPENDIX I
PEKIN GROUNDWATER
PROTECTION ORDINANCE

CITY OF PEKIN GROUNDWATER PROTECTION AREA ORDINANCE

CONTENTS

Exhibits

SECTION 1: TITLE

This Ordinance shall be hereinafter known as the "Groundwater Protection Ordinance", may be cited as such, will be hereinafter referred to as "this Ordinance.

SECTION 2: FINDINGS

The City of Pekin finds that:

WHEREAS, the continued availability of a natural, uncontaminated supply of water is an important and vital resource benefiting the residents of the City of Pekin; and

WHEREAS, it is in the best interest of the present and future residents of the City of Pekin both economically and in regard to health, that steps be taken to reduce the risk of contamination to the water supply; and

WHEREAS, restricting the number of future potential sources of contamination to the water supply of the City of Pekin pursuant to the guidelines established by this Ordinance and the Illinois Groundwater Protection Act is a reasonable means by which to attempt to provide for a continued unpolluted source of water for the residents of the City of Pekin and surrounding areas; and

NOW, THEREFORE, BE IT ORDAINED by the City Council of the City of Pekin, Counties of Tazewell and Peoria, State of Illinois:

SECTION 3: PURPOSE AND INTENT

A. PURPOSE

In the interest of securing and promoting the public health, safety, and welfare, to preserve the quality and quantity of groundwater resources in order to assure a safe and adequate water supply for the present and future generations, and to protect and preserve groundwater resources currently in use and those aquifers having a potential for future use as a public water supply, the provisions of this Ordinance shall apply to all properties located within the City of Pekin. This Ordinance establishes regulations for land uses within the Groundwater Protection Areas for: inspection and monitoring standards for new regulated substance facilities; uniform standards for release reporting; emergency response; substance management planning; permit procedures; and enforcement.

B. INTENT

It is the intent of this Ordinance to provide a method:

1. To protect the groundwater resources of the City of Pekin and the surrounding area.

2. To provide a means of regulating land uses within the Groundwater Protection Areas.

3. To protect the City of Pekin's drinking water supply and that of the surrounding area from potential impacts by facilities that store, handle, treat, use, or produce substances that pose a hazard to groundwater quality.

SECTION 4: DEFINITIONS

Except as stated in this Ordinance, and unless a different meaning of a word or term is clear from the context, the definition of words or terms in this Ordinance shall be the same as those used in the Illinois Environmental Protection Act and the Illinois Groundwater Protection Act (415 ILCS 5/14 et seq.), as amended from time to time.

A. "Act" means the Illinois Environmental Protection Act (415 ILCS 5/1 et seq.)

B. "Agency" means the Illinois Environmental Protection Agency.

C. "Aquifer" means saturated (with groundwater) soils and geologic materials which are sufficiently permeable to readily yield economically useful quantities of water to wells, springs, or streams under ordinary hydraulic gradients.

D. "Board" means the Illinois Pollution Control Board.

E. "City" means the City of Pekin, Tazewell and Peoria Counties, Illinois.

F. "Containment Device" means a device that is designed to contain an unauthorized release, retain it for cleanup, and prevent released materials from penetrating into the ground.

G. "Facility" means:

(i) any building, structure, installation, equipment, pipe or pipeline including but not limited to any pipe into a sewer or publicly owned treatment works, well, pit, pond, lagoon, impoundment, ditch, landfill, storage container, motor vehicle, rolling stock, or aircraft; or

(ii) any site or area where a hazardous substance has been deposited, stored, disposed of, or placed, or otherwise come to be located.

H. "Groundwater" means underground water which occurs within the saturated zone and geologic materials where the fluid pressure in the pore space is equal to or greater than atmospheric pressure.

I. "Groundwater Protection Area" ("GWPA") means the portion of an aquifer within the minimum setback zone, maximum setback zone, or 5-year capture zone of a well or wellfield, as delineated in Exhibit 2 of this Ordinance.

J. "Groundwater Protection Area Permit" means an authorization by the City for a person to store, handle, use or produce a regulated substance within a GWPA.

K. "Groundwater Protection Overlay Zones" are zones of the GWPA designated to provide differential levels of protection. Each GWPA is subdivided into three Groundwater Protection Overlay Zones as described below and as illustrated in Exhibit 2.

1. Zone 1: Minimum Setback Zone - The geographic area located between a well or wellfield providing potable water to a community water supply and a radial area of 400 feet (122 meters).

2. Zone 2: Maximum Setback Zone - The geographic area located between a well or wellfield providing potable water to a community water supply and a regular or irregularly shaped area not to exceed 1,000 feet (305 meters) from the wellhead, but excluding the minimum setback zone .

3. Zone 3: 5-Year Capture Zone - The geographic area located between a well or wellfield providing potable water to a community water supply and the delineated 5-year zone of capture but excluding zones 1 and 2.

L. "New Potential Primary Source" means:

(i) a Potential Primary Source which is not in existence or for which construction has not commenced at its location as of February 1, 1995; or

(ii) a Potential Primary Source which expands laterally beyond the currently permitted boundary, or if the primary source is not permitted, the boundary in existence as of February 1, 1995; or

(iii) a Potential Primary Source which is part of a Facility that undergoes major reconstruction. Such reconstruction shall be deemed to have taken place where the fixed capital cost of the new components constructed within a 2-year period exceed 50% of the fixed capital cost of a comparable entirely new Facility.

Construction shall be deemed commenced when all necessary federal, state and local approvals have been obtained, and work at the site has been initiated and proceeds in a reasonably continuous manner to completion.

M. "New Potential Route" means:

(i) a Potential Route which is not in existence or for which construction has not commenced at its location as of February 1, 1995, or

(ii) a Potential Route which expands laterally beyond the currently permitted boundary or, if the Potential Route is not permitted, the boundary in existence as of February 1, 1995.

Construction shall be deemed commenced when all necessary federal, state and local approvals have been obtained, and work at the site has been initiated and proceeds in a reasonably continuous manner to completion.

N. "New Potential Secondary Source" means:

(i) a Potential Secondary Source which is not in existence or for which construction has not commenced at its location as of February 1, 1995; or

(ii) a Potential Secondary Source which expands, laterally beyond the currently permitted boundary or, if the Secondary Source is not permitted, the boundary in existence as of February 1, 1995, other than an expansion for handling of livestock waste or for treating domestic wastewaters; or

(iii) a Potential Secondary Source which is a part of a Facility that undergoes major reconstruction. Such reconstruction shall be deemed to have taken place where the fixed capital cost of the new components constructed within a 2-year period exceed 50% of the fixed capital cost of a comparable entirely new facility.

Construction shall be deemed commenced when all necessary federal, state and local approvals have been obtained, and work at the site has been initiated and proceeds in a reasonably continuous manner to completion.

O. "Operator" means any person in control of, or having responsibility for daily operation of a facility.

P. "Owner" means any person who owns a site, facility or unit or part of a site, facility or unit, or who owns the land on which the site, facility or unit is located.

Q. "Person" means any person, individual, public or private corporation, firm, association, joint venture, trust, partnership, municipality, governmental agency, political subdivision, public officer, owner, lessee, tenant, or any other entity whatsoever or any combination of such, jointly or severally.

R. "Potable Water" means water that is satisfactory for drinking, culinary, and domestic purposes meeting currently accepted water supply practices and principals.

S. "Potential Primary Source" means any Unit at a Facility or Site not currently subject to a removal or remedial action which:

(i) is utilized for the treatment, storage, or disposal of any hazardous or special waste not generated at the site: or

(ii) is utilized for the disposal of municipal waste not generated at the Site, other than landscape waste and construction and demolition debris; or

(iii) is utilized for the landfilling, land treating, surface impounding or piling of any hazardous or special waste that is generated on the Site or at other sites owned, controlled or operated by the same person; or
(iv) stores or accumulates at any time more than 75,000 pounds (34,020 kilograms) above ground, or more than 7,500 pounds (3,402 kilograms) below ground, of any hazardous substances.

T. "Potential Route" means abandoned and improperly plugged wells of all kinds, drainage wells, all injection wells, including closed loop heat pump wells, and any excavation for the discovery, development or production of stone, sand or gravel.

U. "Potential Secondary Source" means any Unit at a Facility or a Site not currently subject to a removal or remedial action, other than a Potential Primary Source which:

(i) is utilized for the landfilling, land treating, or surface impounding of waste that is generated on the Site or at other sites owned, controlled or operated by the same person, other than livestock and landscape waste, and construction and demolition debris; or

(ii) stores or accumulates at any time more than 25,000 pounds (11,340 kilograms) but not more than 75,000 pounds 34,020 kilograms) above ground, or more than 2,500 pounds (1,134 kilograms) but not more than 7,500 pounds (3,402 kilograms) below ground, of any hazardous substances; or

(iii) stores or accumulates at any time more than 25,000 gallons (94,633 liters) above ground, or more than 500 gallons (1,893) liters) below ground, of petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance; or

(iv) stores or accumulates pesticides, fertilizers, or road oils for purposes of commercial application or for distribution to retail sales outlets; or

(v) stores or accumulates at any one time more than 50,000 pounds (22,680 kilograms) of any de-icing agent; or

(vi) is utilized for handling livestock waste or for treating domestic wastewaters other than private sewage disposal systems as defined in the "Private Sewage Disposal Licensing Act.". (225 ILCS 225/1 et seq.)

V. "Recharge Area" means the area through which precipitation and surface water can enter an aquifer.

W. "Regulated Substances" means those substances found in Exhibit 1, attached hereto and incorporated herein.

X. "Saturated Zone" means the zone in which the voids in the rock or soil are filled with water at a pressure greater than atmospheric pressure.

Y. "Setback Zone" means a geographic area designated pursuant to the Act and this Ordinance, containing a potable water supply well or a potential source or potential route, having a continuous boundary, and within which certain prohibitions or regulations are applicable in order to protect groundwaters.

Z. "Site" means any location, place, tract of land, or facilities, including but not limited to buildings, and improvements used for purposes subject to regulations or control by the Act or regulations thereunder.

AA. "Unauthorized Release" means any spilling, leaking, emitting, discharging, escaping, leaching, or disposing of a regulated substance in a quantity greater than 1 gallon (8 pounds) from a facility into a containment system, into the air, into groundwater, surface water, surface soils or subsurface soils. Unauthorized release does not include: intentional withdrawals of regulated substances for the purpose of legitimate sale, use, or disposal; and discharges permitted under federal, state, or local law.

BB. "Underlying Permit" includes the Building Permits, Sewer Tap Agreements, Stormwater Retention Permits, Occupancy Permits, Preliminary Plat and Final Plat (required by the Pekin Subdivision Ordinance) and any other applicable approval or permit required by the City in relation to the facility

CC. "Unit" means any device, mechanism, equipment, or area (exclusive of land utilized only for agricultural production).

DD. "Well" means any excavation that is drilled, cored, bored, driven, dug, fitted or otherwise constructed when the intended use of such excavation is for the location, diversion, artificial recharge, or acquisition of groundwater.

EE "Well Field" means an area which contains one or more wells for obtaining a potable water supply.

FF. "Well Number" means a well number owned and operated by Illinois American Water Company or Groveland Township Water District, as depicted on Exhibit 2.

SECTION 5: ESTABLISHMENT OF SETBACK ZONES

A. Minimum Setback Zones are hereby established as set forth in Exhibit 2, as that area within a 400 feet (122 meters) radius of each existing or permitted community water supply well within the City or within 400 feet (122 meters) of the city limits of the City.

B. Maximum Setback Zones are hereby established as set forth in Exhibit 2, as that area within a regular or irregularly shaped 1,000 feet (305 meters) radius of each existing or permitted community water supply well within the City, or within 1,000 feet (305 meters) of the city limits of the City.

C. 5-Year Capture Zones are hereby established as set forth in Exhibit 2, which incorporates and adopts the recharge areas identified by the Groundwater Protection Needs Assessment dated November, 1992, performed for the City pursuant to Section 17.1 of the Act.

SECTION 6: APPLICABILITY

A. Persons who own and/or operate one or more facilities in a Groundwater Protection Area (GWPA) shall comply with this Ordinance. This obligation shall be joint and several.

B. All facilities within a Groundwater Protection Area must comply with this Ordinance prior to issuance of any underlying permits. Existing facilities which are not applying for an underlying permit shall have one year from the effective date of this Ordinance to come into compliance.

C. If the City Code Enforcement Officer determines that a facility, otherwise exempt from the permit requirements of this Ordinance, has a potential to degrade groundwater quality, then the City Code Enforcement Officer may classify that facility as a new potential primary source, a potential route, or potential secondary source, and require that facility to comply with this Ordinance accordingly. Such determination shall be based upon site-specific data and shall be eligible for appeal pursuant to Section 17 of this Ordinance.

D. The following are exempt from the permit requirements of this Ordinance:

1. The storage and handling of regulated substances for resale in their original unopened containers of five (5) gallons (19 liters) or forty (40) pounds (18 kilograms) or less shall be exempt from the permit requirements of this Ordinance.

2. De Minimus Usage of Regulated Substances: Facilities that use, store, or handle regulated substances in quantities of five (5) gallons (19 liters) or forty (40) pounds (18 kilograms) or less of any one regulated substance, and in aggregate quantities of twenty (20) gallons (76 liters) or one-hundred (100) pounds (45 kilograms) or less of all regulated substances, shall be exempt from the permit requirement of this Ordinance.

3. Single family residences provided that no home business is operated on the premises.
4. Public interest emergency use and storage of regulated substances.

5. Regulated substances used by or for the City in wastewater treatment processes.

6. Fueling of equipment not licensed for street use, provided that such fueling activities are conducted in a containment area that is designed and maintained to prevent leakage or other violations of this Ordinance.

E. The following are exempt from this Ordinance:

1. Fuel tanks and fluid reservoirs attached to a private or commercial motor vehicle and used directly in the operation of that vehicle.

2. Existing heating systems using fuel oil.

3. The activities of construction, repairing or maintaining any facility or improvement on lands within Zones 1, 2, or 3 provided that all contractors, subcontractors, laborers, material men and their employees when using, handling, storing or producing Regulated Substances in Zones 1, 2, or 3 use those applicable "Best Management Practices" set forth in Exhibit 3, attached hereto and incorporated herein.

4. Cleanups, monitoring and/or studies undertaken under supervision of the Illinois Environmental Protection Agency or other state regulatory Agency or the United States Environmental Protection Agency.

5. Activities specifically regulated under 35 Ill. Adm. Code 601.615, 616, and 617 (Regulations for existing and new activities within setback zones and regulated recharge areas); 8 Ill. Adm. Code 255 and 256 (Regulations for secondary containment for agricultural pesticide and fertilizer facilities); and 8 Ill. Adm. code 257 (cooperative groundwater protection program for agricultural chemical facilities within appropriate setback zones).

6. If the owner of a new potential primary source, new potential secondary source, or new potential route is granted an Exception by the Board (other than land filling or land treating) pursuant to the Act, such owner shall not be subject to this Ordinance to the same extent that such owner is not subject to the Act.

7. If the owner of a new potential primary source, new potential secondary source, or new potential route is issued a Certificate of Minimal Hazard by the Agency pursuant to the Act, such owner shall not be subject to this Ordinance to the same extent that such owner is not subject to the Act.

F. Any action by the Agency or Board referred to this section shall not be final and binding on the City under this Ordinance until the City has received notice of such proposed action and has had reasonable opportunity to present evidence concerning its interest.

SECTION 7: OPERATING PERMITS AND PERMIT CONDITIONS

A. GENERAL CONDITIONS

1. No person, persons, corporation, or other legal entities shall install or operate a facility in a GWPA without first obtaining a Groundwater Protection Operating Permit from the Code Enforcement Officer.

2. The focus of review for all permits shall be on the substances that will be stored, handled, treated, used or produced and the potential for these substances to degrade groundwater quality.

3. All permits required pursuant to this Ordinance must be issued prior to or concurrent with the issuance of permits for construction activities or underlying permits.

4. The Code Enforcement Officer shall not issue an Operating Permit for a facility unless adequate plans, specifications, test data, and/or other appropriate information has been submitted by the owner and/or operator showing that the proposed design and construction of the facility meets the intent and provisions of this Ordinance and will not impact the short term, long term on cumulative quantity or quality of groundwater.

5. The application for Operating Permits pursuant to this Ordinance shall be made on a form provided by the City of Pekin and shall be accompanied by a fee of two hundred dollars ($200). The annual renewal fee shall be twenty-five dollars ($25) and shall accompany the annual certification statement.

6. Any person who owns or operates more than one facility in a single zone of the (GWPA) shall have the option of obtaining one permit for all operations if the operations at each facility are similar and the permit requirements under this Ordinance are applicable to each facility individually.

7. An Operating Permit, issued by the Code Enforcement Officer shall be effective for 1 year. The Code Enforcement Officer shall not issue a permit to operate a facility until the Code Enforcement Officer determined that the facility complies with the provisions of these regulations.

8. The facility owner shall apply to the City of Pekin for permit renewal at least 60 days prior to the expiration of the permit. If an inspection of the facility reveals noncompliance, then the Code Enforcement Officer must verify by a follow-up inspection that all required corrections have been implemented before renewing the permit.

9. Operating Permits may be transferred to a new facility owner/operator if the new facility owner/operator does not change any conditions of the permit, the transfer is registered with the City of Pekin within 30 days of the change in ownership, and any necessary modifications are made to the information in the initial permit application due to the change in ownership.

10. Within 30 days of receiving an inspection report from the City of Pekin, the Operating

Permit holder shall file with the City of Pekin a plan and time schedule to implement any required modifications to the facility or to the monitoring plan needed to achieve compliance with the intent of this Ordinance or the permit conditions. This plan and time schedule shall also implement all of the recommendations of the Code Enforcement Officer.

B. PERMIT APPLICATIONS

1. The Operating Permit application shall include at a minimum:

a. Name, address, and phone number of owner/operator.

b. Property address, legal description and tax identification number of the facility.

c. The names and volumes of all regulated substances which are stored, handled, treated, used, or produced at the facility being permitted in quantities greater than the de minimis amounts specified in Section 6 of this Ordinance. Copies of all leases pertaining to the facility.

d. A detailed description of the activities conducted at the facility that involve the storage, handling, treatment, use or production of regulated substances in quantities greater than the de minimis amounts specified in Section 6 of this Ordinance.

e. A description of the containment devices used to comply with the requirements of this Ordinance.

f. A Regulated Substances Management Plan for the facility.

g. A description of the procedures for inspection and maintenance of containment devices.

h A description of the method for disposal of regulated substances.

i. 10 copies of a site plan showing the location of the facility and its property boundaries and the locations where regulated substances in containers larger than five (5) gallons (19 liters) or forty (40) pounds (18 kilograms) in size are stored, handled, treated, used, produced, the location of each containment device.

2. CONDITIONS FOR GWPA PERMITS ISSUED TO NEW FACILITIES

a) Containment Devices

1) The owner/operator of a facility must provide containment devices adequate in size to contain on-site any unauthorized release of regulated substances from any area where these substances are either stored, handled, treated, used, or produced. Containment devices shall prevent such substances from penetrating into the ground. Design requirements for containment devices include:

i. The containment device shall be large enough to contain 110 (one hundred ten) percent of the volume of the container in cases where a single container is used to store, handle, treat, use, or produce a regulated substance. In cases where multiple containers are used, the containment device shall be large enough to contain 150 percent of the volume of the largest container or 10 percent of the aggregate volume of all containers, whichever is greater.

ii. All containment devices shall be constructed of materials of sufficient thickness, density, and composition to prevent structural weakening of the containment device as a result of contact with any regulated substance. If coatings are used to provide chemical resistance for containment devices, they shall also be resistant to the expected abrasion and impact conditions. Containment devices shall be capable of containing any unauthorized release for at least the maximum anticipated period sufficient to allow detection and removal of the release.

iii. If the containment device is open to rainfall, then it shall be able to accommodate the volume of precipitation that could enter the containment device during a 24-hour, 100-year storm, in addition to the volume of the regulated substance storage required in Subsection 1(a) above.

iv. Containment devices shall be constructed so that a collection system can be installed to accumulate, temporarily store, permit detection of the presence of, and permit removal of any storm runoff or regulated substance.

v. Containment devices shall include monitoring procedures or technology capable of detecting the presence of a regulated substance within 24 hours following a release.

b. Regulated Substances Management Plan

1.) REGULATED SUBSTANCES MANAGEMENT PLAN

a. A Regulated Substances Management Plan indicating procedures to be followed to prevent, control, collect, and dispose of any unauthorized release of a regulated substance shall be required as a condition of each Operating Permit. If a spill prevention control plan or similar contingency plan has been prepared in accordance with Illinois or United States Environmental Protection Agency requirements, a Regulated Substance Management Plan is not required as long as all of the regulated substances are included in the spill prevention control plan.

b. The Regulated Substances Management Plan shall include:

1.) Provisions to address the regulated substances monitoring requirements.

2.) Provisions to train employees in the prevention, identification, reporting, control, disposal, and documentation of any unauthorized release of a regulated substance.

2.) The owners or operators of all new facilities shall implement regulated substances monitoring as part of the Regulated Substances Management Plan required by Section 15 of this Ordinance. Visual monitoring must be implemented unless it is determined by the City of Pekin Fire Department to be infeasible.

3.) All regulated substance monitoring activities shall include the following:

a). A written routine monitoring procedure which includes, when applicable: the frequency of performing the monitoring method, the methods and equipment to be used for performing the monitoring, the location(s) from which the monitoring will be performed, the name(s) or title(s) of the person(s) responsible for performing the monitoring and/or maintaining the equipment, and the reporting format.

b). Written records of all monitoring performed shall be maintained on-site by the operator for a period of 3 years from the date the monitoring was performed. The City of Pekin may require the submittal of the monitoring records or a summary at a frequency that the City may establish. The written records of all monitoring performed in the past 3 years shall be shown to the City upon demand during any site inspection. Monitoring records shall include but not be limited to:

i). The date and time of all monitoring or sampling;

ii). Monitoring equipment calibration and maintenance records;

iii). The results of any visual observations;

iv). The logs of all readings of gauges or other monitoring equipment, or other test results; and

v). The results of inventory readings and reconciliations.

4) Procedures for the in-house inspection and maintenance of containment devices and areas where regulated substances are stored, handled, treated, used, and produced shall be identified in the Operating permit for each facility. Such procedures shall be in writing, and a log shall be kept of all inspection and maintenance activities. Such logs shall be submitted to the Code Enforcement Officer with the renewal applications available for inspection at other times upon 48 hours notice. Inspection and maintenance logs shall be maintained on-site by the owner or operator for a period of at least 3 years from the date the monitoring was performed.

C. REPORTING

The permittee shall report to the Code Enforcement Officer 15 days after any changes in a facility including:

1. The storage, handling, treatment, use, or processing of new regulated substances;

2. Changes in monitoring procedures; or

3. The replacement or repair of any part of a facility that is related to the regulated substance(s).

SECTION 8: GROUNDWATER PROTECTION OVERLAY ZONES

A. The location of Groundwater Protection Areas in the City are defined in Exhibit 2 to this Ordinance. Groundwater Protection Area maps shall be placed on file with the Department of Planning/Zoning/Building/Public Works, and the Pekin Fire Department.

B. In determining the location of facilities within the zones defined by Exhibit 2, the following rule shall apply.

1. Facilities located wholly within a GWPA zone shall be governed by the restriction applicable to that zone.

2. Facilities having parts lying within more than one zone of a GWPA shall be governed by the restrictions applicable to the more restrictive zone.

3. Facilities having parts lying both in and out of a GWPA shall be governed by the

restrictions applicable to the more restrictive zone.

SECTION 9: REGULATIONS WHICH APPLY WITHIN THE MINIMUM SETBACK ZONE (ZONE 1) OF THE GWPA

A. PROHIBITED USES AND ACTIVITIES

1. Except as provided in Sections 6, no person shall place a new potential primary source, new potential secondary source, or new potential route within the minimum setback zone(s) of any existing or permitted community water supply well in the City or within 400 feet (122 meters) of the City limits of the City.

2. Except as provided in Section 6, no person shall alter or change an existing potential primary source, potential secondary source, or potential route where the alteration or change would result in a potential source or route that would be prohibited under this Ordinance if it were a new potential source or route.

3. No person shall conduct any activity or engage in a use of property which shall constitute an interference with the health and safety or welfare of a community water supply well. Such activities are declared to be a public nuisance and are prohibited by this Ordinance.

B. REVIEW AND APPROVAL OF PROPOSED ACTIVITIES

1. All proposals for new facilities which use, store, handle, treat or produce a regulated substance within the minimum setback zone (Zone 1) must be reviewed by the Code Enforcement Officer for compliance with this Ordinance including obtaining a Groundwater Protection Permit pursuant to this Ordinance, prior to issuance of any underlying permit.

2. No groundwater operating permit shall be issued unless a finding is made by the Code Enforcement Officer that the proposal will not impact the long term, short term or cumulative quality of the aquifer. The finding shall be based on the present or past land use activities conducted at the facility; regulated substances stored, handled, treated, used or produced; and the potential for the activities or regulated substances to degrade groundwater quality.

3. New sources of sanitary sewerage (residential and non-residential) shall, as a condition of the building permit, be required to connect to an IEPA permitted central sanitary sewer system prior to occupancy.

SECTION 10: REGULATIONS WHICH APPLY WITHIN THE MAXIMUM SETBACK ZONE (ZONE 2) OF THE GWPA

A. PROHIBITED USES AND ACTIVITIES

1. Except as provided in Section 6, no person shall place a new potential primary source within the maximum setback zone(s) of any existing or permitted community water supply well in the City or within 1000 feet (305 meters) of the City limits of the City.
2. Except as provided in Section 6, no person shall alter or change an existing potential primary source where the alteration or change would result in a potential source or route that would be prohibited under this Ordinance if it were a new potential source or route.

3. No person shall conduct any activity or engage in a use of property which shall

constitute an interference with the health and safety or welfare of a community water supply well or other water well by the accidental, negligent, or intentional introduction of contaminants. Such activities are declared to be a public nuisance and are prohibited by this Ordinance.

B. REVIEW AND APPROVAL OF PROPOSED ACTIVITIES

1. All proposals for new facilities which use, store, handle, treat or produce a regulated substance within the maximum setback zone (Zone 2) must be reviewed by the Code Enforcement Officer for compliance with this Ordinance including obtaining a Groundwater Protection Permit pursuant to this Ordinance, prior to issuance of any underlying permit.

2. No groundwater operating permit shall be issued unless a finding is made by the Code Enforcement Officer that the proposal will not impact the long term, short term or cumulative quality of the aquifer. The finding shall be based on the present or past land use activities conducted at the facility; regulated substances stored, handled, treated, used or produced; and the potential for the activities or regulated substances to degrade groundwater quality.

3. New sources of sanitary sewerage (residential and non-residential) shall, as a condition of the building permit, be required to connect to an IEPA permitted central sanitary sewer system prior to occupancy.

SECTION 11: REGULATIONS WHICH APPLY WITHIN THE 5-YEAR CAPTURE ZONE (ZONE 3) OF THE GWPA

A. REVIEW AND APPROVAL OF PROPOSED ACTIVITIES

1. All proposals for new facilities which use, store, handle, treat or produce a regulated substance within the 5-year Capture zone (Zone 3) must be reviewed by the Code Enforcement Officer for compliance with this Ordinance including obtaining a Groundwater Protection Permit pursuant to this Ordinance, prior to issuance of any underlying permit.

2. No groundwater operating permit shall be issued unless a finding is made by the Code Enforcement Officer that the proposal will not impact the long term, short term or cumulative quality of the aquifer. The finding shall be based on the present or past land use activities conducted at the facility; regulated substances stored, handled, treated, used or produced; and the potential for the activities or regulated substances to degrade groundwater quality.

3. New sources of sanitary sewerage (residential and non-residential) shall, as a condition of the building permit, be required to connect to an IEPA permitted central sanitary sewer system prior to occupancy.

SECTION 12: UNAUTHORIZED RELEASES

A. General Provisions

All unauthorized releases shall be reported to the Pekin Fire Department according to the provisions of this section. All unauthorized releases shall be recorded in the owner's inspection and maintenance log. An unauthorized release is an "unauthorized release requiring recording" if the release is completely captured by the containment device. If the containment device fails to contain the entire release, the release is an "unauthorized release requiring reporting."

B. Unauthorized Releases Requiring Recording

1. Unauthorized releases requiring recording shall be reported to the Pekin Fire Department within 24 hours after the release has been, or should have been detected.

2. The incident report shall be accompanied by a written record including the following information:

a. The type, quantities, and concentration of regulated substances released.

b. Method of cleanup.

c. Method and location of disposal of the released regulated substances including whether a hazardous waste manifest(s) is used.

d. Method of future release prevention or repair. If this involves a change in operation, monitoring, or management, the owner must apply for a new Operating Permit.

e. Facility operator's name and telephone number.

3. The Pekin Fire Department shall review the information submitted pursuant to the report of an unauthorized release requiring recording, shall review the Operating Permit, and may inspect the facility. The Pekin Fire Department shall either find that the containment standards of this Ordinance can continue to be achieved or shall recommend the revocation of the permit until appropriate modifications are made to allow compliance with the standards.

C. Unauthorized releases Requiring Reporting

1. Unauthorized releases requiring reporting shall be verbally reported to the Pekin Fire Department immediately.

2. A written report shall be submitted promptly thereafter containing the following information that is known at the time of filing the report:

a. List of type, quantity, and concentration of regulated substances released.

b. The results of all investigations completed at that time to determine the extent of soil or groundwater or surface water contamination because of the release.

c. Method of cleanup implemented to date, proposed cleanup actions and approximate cost of actions taken to date.

d. Method and location of disposal of the released regulated substance and any contaminated soils, groundwater, or surface water.

e. Proposed method of repair or replacement of the containment device.

f. Facility owner's name and telephone number.

3. Until cleanup is complete, the owner shall submit reports containing the reporting

required by Section 7C. to the Code Enforcement Officer and the Pekin Fire Department every month or at a more frequent interval specified by the Fire Department.

4. The Pekin Fire Department shall either find that the containment standards of this Ordinance can continue to be achieved or shall recommend the revocation of the permit until appropriate modifications are made to allow compliance with the standards.

D. Upon confirmation of an unauthorized release to groundwater, the owner shall be responsible for immediately accomplishing the following:

1. Locate and determine the source of the unauthorized release of the regulated substance(s).

2. Stop and prevent any further unauthorized release(s).

3. Comply with the requirements for an unauthorized release(s) requiring reporting.

E. No new regulated substance(s) may be introduced at the site of the regulated substance(s) that caused the violation.

F. If an unauthorized release creates or is expected to create an emergency situation with respect to the drinking water supply of the City or a public water supply well within 1000 feet (305 meters) of the City, and if the facility owner fails to address the unauthorized release within 12 hours, the City or its authorized agents shall have the authority to implement removal or remedial actions. Such actions may include, but not be limited to, the prevention of further groundwater contamination; installation of groundwater monitoring wells; collection and laboratory testing of water, soil, and waste samples; and cleanup and disposal of regulated substances. The facility owner and operator jointly and severally shall be responsible for any costs incurred by the City of Pekin or its authorized agents in the conduct of such remedial actions, including but not limited to all consultant, engineering and attorney fees.

G. Reporting a release to the Pekin Fire Department does not exempt or preempt any other reporting requirements under federal, state, or local laws.

SECTION 13: CLOSURE PERMITS AND PERMIT CONDITIONS

A. No person shall close or cause to be closed a facility regulated pursuant to this Ordinance without first obtaining a Closure Permit from the Code Enforcement Officer. The Code Enforcement Officer shall not issue a permit to temporarily or permanently close a facility unless adequate plans and specifications and other appropriate information have been submitted by the applicant showing that the proposed closure meets the intent and provisions of this Ordinance.

B. Closure Permits shall be required for all facilities that cease to store, handle, treat, use, or produce regulated substances for a period of more than 365 days or when the owner has no intent within the next year to store, handle, treat, use, or produce regulated substances. During the period of time between cessation of regulated substance storage, handling, treatment, use, or production, and actual completion of facility closure, the applicable containment and monitoring requirements of this Ordinance shall continue to apply.

C. Prior to closure, the facility owner shall submit to the Code Enforcement Officer a proposal describing how the owner intends to comply with closure requirements. Owners proposing to close a facility shall comply with the following requirements:

1. Regulated substances shall be removed from the facility, including residual liquids, solids, or sludges to levels specified by the Illinois Environmental Protection Agency.

2. When a containment device is to be disposed of, the owner must document to the Code Enforcement Officer that disposal has been completed in compliance with the Act.

3. An owner of a containment device or any part of a containment device that is destined for reuse as scrap material shall identify this reuse to the City.

D. The owner of a facility being closed shall demonstrate to the satisfaction of the Code Enforcement Officer that no detectable unauthorized release has occurred or that all unauthorized releases have been cleaned up. This demonstration can be based on the ongoing leak detection monitoring or soils sampling performed during or immediately after closure activities.

E. If an unauthorized release is determined to have occurred, the facility owner shall comply with Section 12 of this Ordinance.

F. Facility closure will be accepted as complete by the Code Enforcement Officer upon implementation of the Closure Permit conditions and compliance with all other provisions of this Ordinance.

G. No person shall temporarily or permanently abandon a facility in an GWPA without complying with the requirements of this Ordinance.

H. The application for a Closure Permit pursuant to this Ordinance shall be made on a form provided by the City of Pekin and shall be accompanied by a fee of two hundred dollars ($200).

I. Any person who owns or operates more than one facility in a single zone of the (GWPA) shall have the option of obtaining one permit for all simultaneous closures if the operations at each facility are similar and the permit requirements under this Ordinance are applicable to each facility individually.

SECTION 14: PENALTIES

A. A violation of any of the provisions of this Ordinance shall constitute a misdemeanor and a nuisance. It shall be a separate offense for each and every day or portion thereof during which any violation of any of the provisions of this Ordinance is committed, continued, or permitted.

B. Any owner or operator who violates any provisions of this Ordinance shall be subject, upon conviction in court, to a fine not to exceed $500 per day per facility.

C. In addition to any fines and penalties set forth above, the owner or operator shall reimburse the City of Pekin, for all reasonable costs incurred as a result of responding to, containing, cleaning up, or monitoring the cleaning up and disposal of any spilled or leaked regulated substance including but not limited to consultant , engineering and legal fees.

SECTION 15: ENFORCEMENT

A. The City shall be the administering agency and shall have the power and authority to administer and enforce the provisions of this Ordinance. The City shall have the right to conduct inspections of facilities at reasonable times to determine compliance with this Ordinance.

B. The Code Enforcement Officer may revoke any permit issued pursuant to this Ordinance after notice to the permittee and after affording the permittee an opportunity to meet either in person or by telephone if it finds that the permit holder:

1. Has failed or refused to comply with any provision of this Ordinance;

2. Has submitted false or inaccurate information in a permit application;

3. Has refused lawful inspection;

4. Has an unauthorized release and the Code Enforcement officer finds that the containment standards of this Ordinance cannot continue to be achieved.

SECTION 16: NOTICE OF VIOLATION

Whenever it is determined that there is a violation of this Ordinance, the notice of violation issued shall:

A. Be in writing and delivered to the owner or operator by regular mail; and

B. Be dated and signed by the authorized City agent making the inspection; and

C. Specify the violation or violations; and

D. Specify the length of time (not less than 72 hours) to correct the violation after receiving the notice of violation.

SECTION 17: APPEALS

The Mayor shall appoint, subject to the City Council's approval, the Groundwater Appeals Committee. Said committee shall consist of the Fire Chief, Public Works Director, and Code Enforcement Officer.

A. Any decision by the Code Enforcement Office or Fire Department under this Ordinance may be appealed to the Groundwater Appeals Committee.

B. The Groundwater Appeals Committee shall also hear petitions to exempt a facility from the requirements of Section 7 of this Ordinance as follows:

1. The applicant may demonstrate that the 5-year capture zone area(s) map incorrectly identify the facility as being within the Groundwater Protection Overlay Zone(s). The burden of proof shall rest upon the applicant to demonstrate that the facility location is not within a delineated 5-year capture zone area. The applicant shall be required to present detailed hydrogeologic and hydrologic information to the Groundwater Appeals Committee that the facility location is, in fact, not within a 5-year capture zone area.

2. The applicant may be required to present detailed technical information that a material(s) on the Regulated Substances List does not endanger the GWPA in the event

of an unauthorized release. To continue the permit appeal process, the applicant shall provide funds to the Groundwater Appeals Committee to pay for the technical review by the Groundwater Appeals Committee's choice of consultant(s) of said hydrogeologic and hydrologic information and/or regulated substance information and shall base its recommendation, in part, on the report by said consultant(s).

C. Procedures

1. Appeals to the Groundwater Appeals Committee take place by filing an appeal in writing with the City Clerk of the City within 14 days after receipt of a decision in writing from the Code Enforcement Officer or the Fire Department. Petitions to the Groundwater Appeals Committee to exempt a facility should also be filed with the City Clerk of the City. A hearing with the Groundwater Appeals Committee will be held within 30 days of submission of the appeal or petition. A decision by the Groundwater Appeals Committee will be made in writing within 30 days of the hearing.

SECTION 18: SEVERABILITY

If any section, subsection, subdivision, paragraph, sentence, clause or phrase in this Ordinance, or any part thereof, or application thereof to any person, firm, corporation, public agency or circumstance, is for any reason held to be unconstitutional or invalid or ineffective by any court of competent jurisdiction, such decision shall not affect the validity of effectiveness of the remaining portions of this Ordinance or any part thereof. It is hereby declared to be the legislative intent of the City Council that this Ordinance would have been adopted had such unconstitutional or invalid provision, clause, sentence, paragraph, section or part thereof not then been included.

SECTION 19: INCONSISTENT ORDINANCES REPEALED

All other Ordinances or parts of Ordinances in conflict herewith are hereby repealed.

SECTION 20: SAVING CLAUSE

Nothing in this Ordinance hereby adopted shall be construed to affect any suit or proceeding pending in any Court, or any rights acquired, or liability incurred, or any cause or causes of action acquired or existing, under any act or Ordinance hereby repealed as cited in Section 19 of this Ordinance.

SECTION 21: ENACTMENT

(a) This Ordinance is deemed necessary for the general health, safety and welfare of the City of Pekin.

(b) Each section of this Ordinance and every part of each section of this Ordinance is hereby declared to be an independent section and part of section and the holding of any section or part thereof to be void and ineffective for any cause, shall not be deemed to affect any other section or part thereof.

(c) This Ordinance is adopted in accordance with the powers granted to the City of Pekin pursuant to its home rule powers under Article 7 of the Constitution of the State of Illinois.

(d) This Ordinance shall be in full force and effect from and after its passage and publication in pamphlet form according to law.

PASSED by the City Council of the City of Pekin, Illinois, at its meeting held on the day of , 1995.

MAYOR

APPROVED this , day of , 1995

MAYOR

ATTEST:

CITY CLERK

EXHIBIT 1
REGULATED SUBSTANCES LIST

Acid and basic cleaning solutions
Antifreeze and Coolants
Arsenic and arsenic compounds
Bleaches, Peroxides
Brake and transmission fluids
Brine solution
Casting & Foundry chemicals
Caulking agents and sealants
Cleaning solvents
Corrosion and rust prevention solutions
Cutting fluids
Degreasing solvents
Disinfectants
Electroplating solutions
Explosives
Fire extinguishing chemicals
Food processing wastes
Formaldehyde
Fuels and additives
Gasolines
Glues, adhesives and resins
Greases
Hydraulic fluid
Indicators
Industrial and commercial janitorial supplies
Industrial sludges and stillbottoms
Inks, printing and photocopying chemicals
Laboratory chemicals
Liquid storage batteries
Medical, pharmaceutical, dental, veterinary and hospital solutions
Mercury and mercury compounds

Metals finishing solutions
Oils
Paints, primers, thinners, dyes, stains, wood preservatives, varnishing and cleaning compounds
Painting solvents
PCB's
Plastic resins, plasticizers and catalysts
Photo development chemicals
Poisons
Polishes
Pool chemicals in concentrated form
Processed dust and particulates
Radioactive sources
Reagents and standards
Refrigerants
Roofing chemicals and sealers
Sanitizers, disinfectants, bactericides and algaecides
Soaps, detergents and surfactants
Solders and fluxes
Stripping compounds
Tanning industry chemicals
Transformer and capacitor oils/fluids
Water and wastewater treatment chemicals

EXHIBIT 3

"BEST MANAGEMENT PRACTICES" FOR THE CONSTRUCTION INDUSTRY

A) The general contractor, or if none, the property owner, shall be responsible for assuring that each contractor or subcontractor evaluates each site before construction is initiated to determine if any site conditions may pose particular problems for the handling of any Regulated Substances. For instance, handling Regulated Substances in the proximity of a Groundwater Protection Overlay Zone or water bodies may be improper.

B) If any Regulated Substances are stored on the construction site during the construction process, they shall be stored in a location and manner which will minimize any possible risk of release to the environment. Any storage container of 55 gallons, (208 liters) or 440 pounds (200 kilograms), or more, containing Regulated Substances shall have constructed below it an impervious containment system constructed of materials of sufficient thickness, density and composition that will prevent the discharge to the land, ground waters, or surface water, of any pollutant which may emanate from said storage container or containers. Each containment system shall be able to contain 150% of the contents of all storage containers above the containment system.

C) Each contractor shall familiarize him/herself with the manufacturer's safety data sheet supplied with each material containing a Regulated Substance and shall be familiar with procedures required to contain and clean up any releases of the Regulated Substance. Any tools or equipment necessary to accomplish same shall be available in case of a release.

D) Upon completion of construction, all unused and waste Regulated Substances and containment systems shall be removed from the construction site by the responsible contractor, and shall be disposed of in a proper manner as prescribed by law.

APPENDIX II
HYDROGEOLOGY AND GROUNDWATER CONTAMINATION FUNDAMENTALS

HYDROGEOLOGY AND GROUNDWATER CONTAMINATION

Introduction

An understanding of the mechanisms leading to groundwater contamination is necessary for the development of an effective and efficient statewide groundwater quality protection program. Evaluating the potential hazards that result in groundwater contamination involves consideration of the hydrogeologic factors which make some aquifers more susceptible to contamination than others.

Knowledge of basic groundwater flow and contaminant transport is essential to understanding the mechanisms leading to groundwater contamination. Therefore, this document provides background information related to groundwater occurrence and movement and a description of principal aquifers in Illinois. A summary of the mechanisms involved in groundwater contamination is presented, including descriptions of contaminant sources, how aquifers become contaminated, and how contaminants migrate within aquifers.

The Hydrologic Cycle

Groundwater is an integral part of the hydrologic cycle (Figure 17). Most precipitation reaching the surface of the earth evaporates or runs overland into lakes and streams, while a smaller portion infiltrates the soil. The amount of water that infiltrates is dependent upon the amount and intensity of precipitation, the permeability of the soil, the type and density of plant growth on the soil, and antecedent soil moisture conditions.

Water infiltrating the soil may evaporate, or be used by plants and transpired. The remainder migrates downward through pore spaces in soil or rock, eventually reaching a zone where all pore spaces are saturated. The surface of this zone of saturation is called the "water table". All water below the water table is considered groundwater. The water table can be determined by measuring the elevation of water surfaces in wells which penetrate the saturated zone.

Under natural conditions, the water table forms a surface which resembles the overlying land surface topography, only in a more subdued and smoother configuration. The water table generally will be at higher elevations beneath upland areas and at lower elevations in valley bottoms. The water table may intersect the ground surface along perennial streams, springs, and lakes which are natural areas of groundwater discharge.

Groundwater moves in a fashion somewhat analogous to surface water, only at much slower rates. While surface water moves downhill in response to gravity, groundwater moves downgradient from areas of higher potential energy to areas of lower potential energy. Groundwater flows from recharge zones, where infiltration occurs, to discharge zones, where groundwater discharges into streams and lakes (Figure 18).

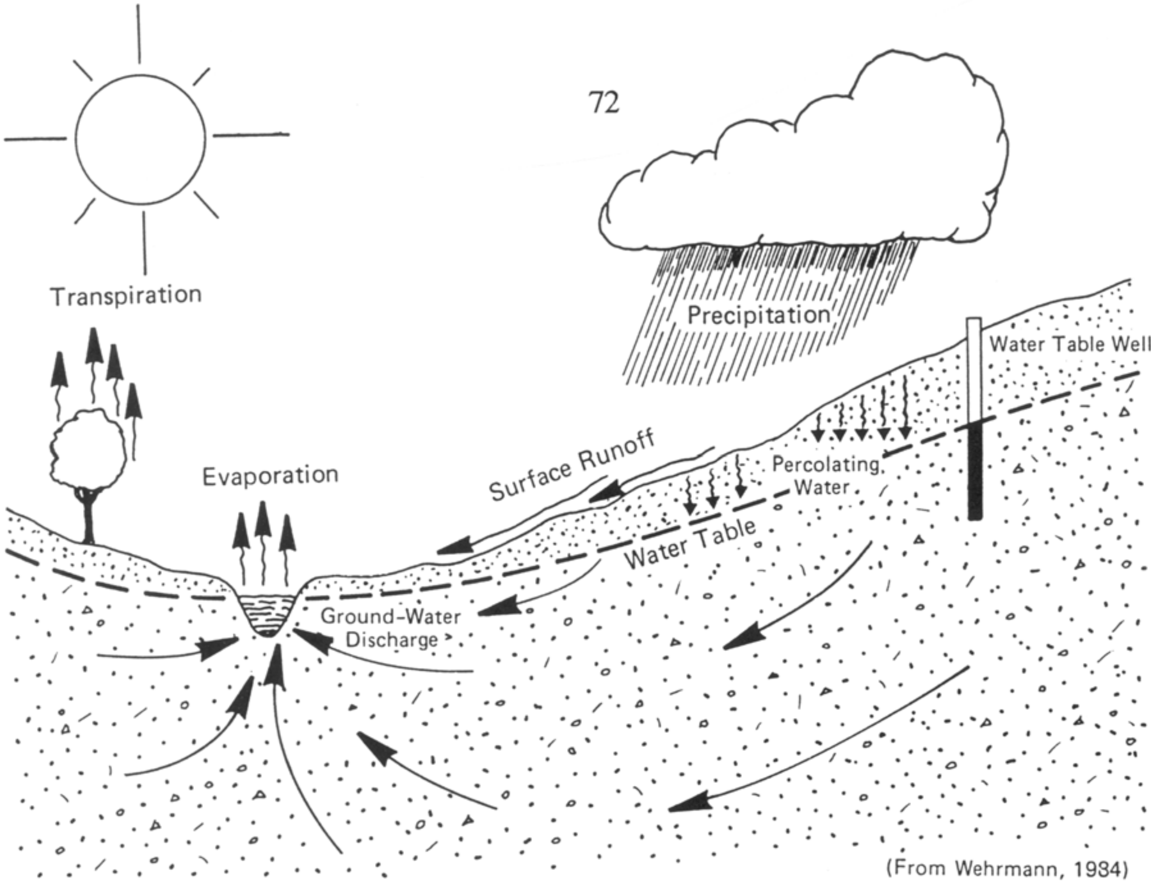


Figure 17.Generalized hydrologic cycle (from Shafer, 1985)

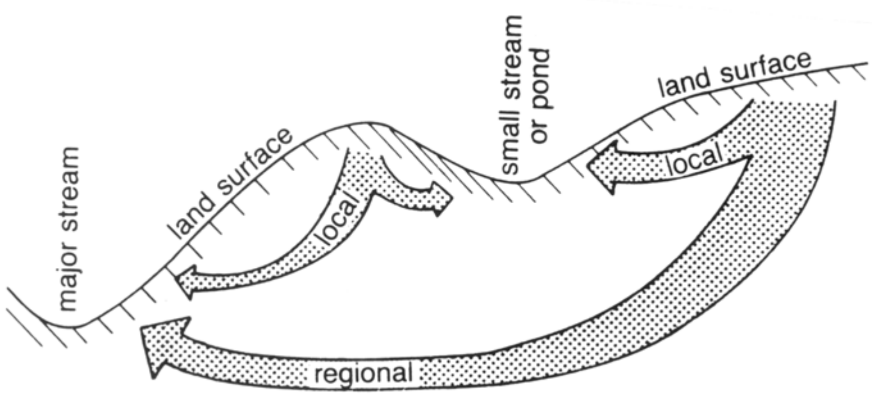


Figure 18. Local and regional groundwater flow systems (from Cartwright and Sherman, 1969)

The direction of groundwater movement can be estimated from a map of the potentiometric surface, i.e., a contour map of the elevations of water levels in observation wells. Generally, groundwater flow will be perpendicular to the contours of the potentiometric surface.

The rate of groundwater movement is related to the permeability of the aquifer and the magnitude of the slope of the potentiometric surface. In quantitative terms, "hydraulic conductivity" is used in place of permeability and is a function of the size and shape of pore spaces, the degree of interconnection of these spaces, and the type of fluid (e.g., water, oil, or brines) passing through the medium.

Figure 19 illustrates different pore configurations. The geologic environment in which the water bearing unit was created (e.g., glacial, wind, water) and the processes that subsequently modified it (e.g., weathering, compaction, or seismic action) will determine the character of pore spaces. Table 4 shows the broad range of hydraulic conductivities for geologic materials found in Illinois.

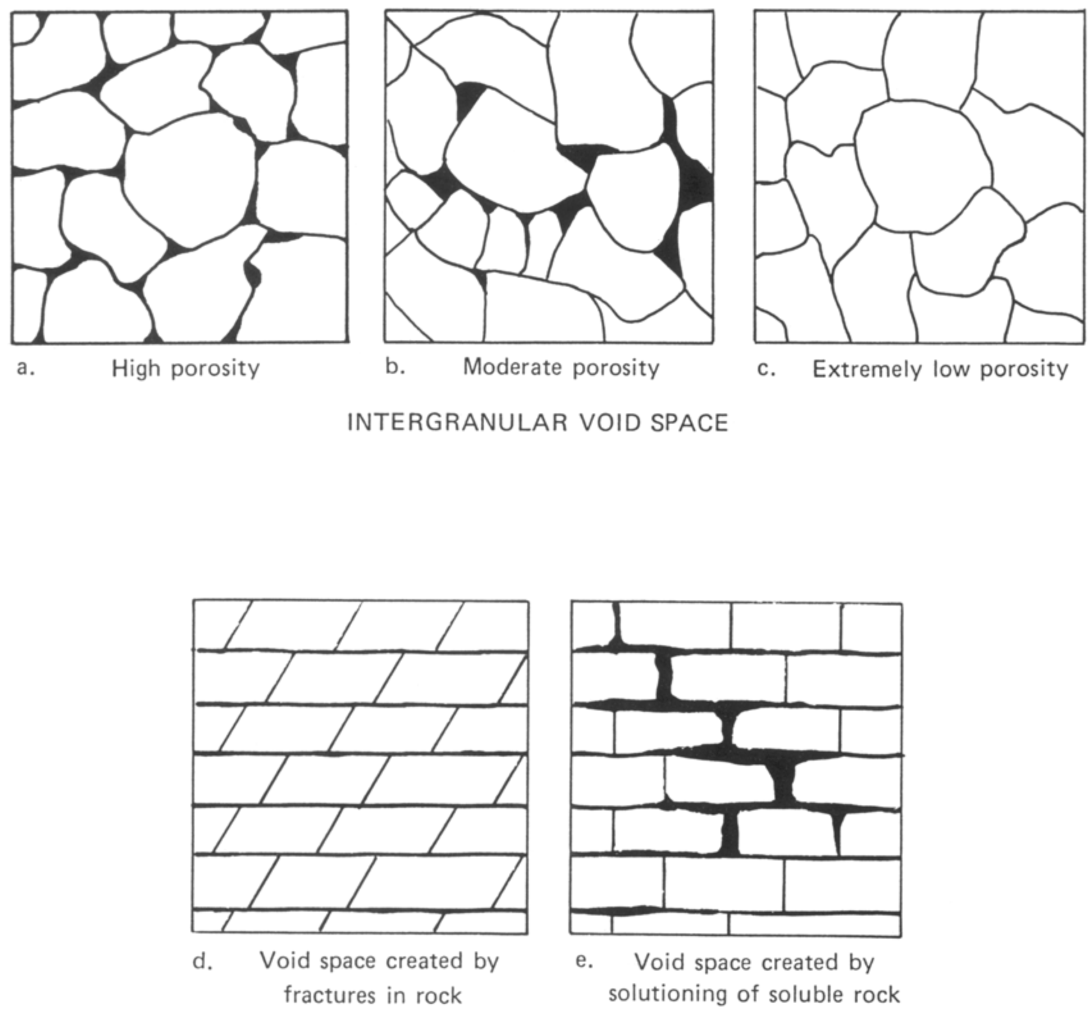


Figure 19. Void space configurations of geologic materials (from Schafer, 1985)

Table 5. Estimated Hydraulic Conductivity of Typical Geologic Materials, in ft/year (Source: Berg et al., 1984)

Dense limestone/dolomite	10^{-5} to 10^{-8}
Till (>25% clay)	10^{-3} to 10^{-5}
Till (<25% clay)	10^{-2} to 10^{-4}
Loess	10^{-3} to 10^{-1}
Sandstone	$>10^{-1}$
Limestone	$>10^{-1}$
Silty sand	10^{-2} to 10
Clean sand and gravel	10

Principal Aquifers in Illinois

An aquifer is a geologic stratum or body capable of yielding water in sufficient quantities to be economically recoverable. Whether or not the water yield is considered economical depends on the amount required by the users. For example, an aquifer supplying domestic wells may not yield an adequate supply for municipal or industrial wells.

In Illinois, high-yield aquifers are those that yield over 100,000 gallons per day per square mile of aquifer area (gpd/mi^2) or 146,000 liters/square kilometers (Lpd/km^2), moderate-yield aquifers can provide between 50,000 and 100,000 gpd/mi^2 (73,000 and 146,000 Lpd/km^2), while low-yield aquifers provide below 50,000 gpd/mi^2 (73,000 Lpd/km^2) (Illinois Department of Energy and Natural Resources, 1984). "Major" or "principal" aquifers in Illinois are high-yield aquifers comprised of geologic units capable of yielding at least 70 gallons (300 liters) of water per minute (100,000 gpd or 432,000 Lpd) to wells completed in them (a designation consistent with the Illinois Water Use Act of 1983). "Minor" aquifers yield between 6 and 70 gpm (6,700 to 100,000 gpd) or 20 to 300 liters per minute (28,800 to 432,000 Lpd). Maps showing major sand and gravel aquifers at any depth and major bedrock aquifers within 90 meters of the surface are shown as Figures 20 and 21.

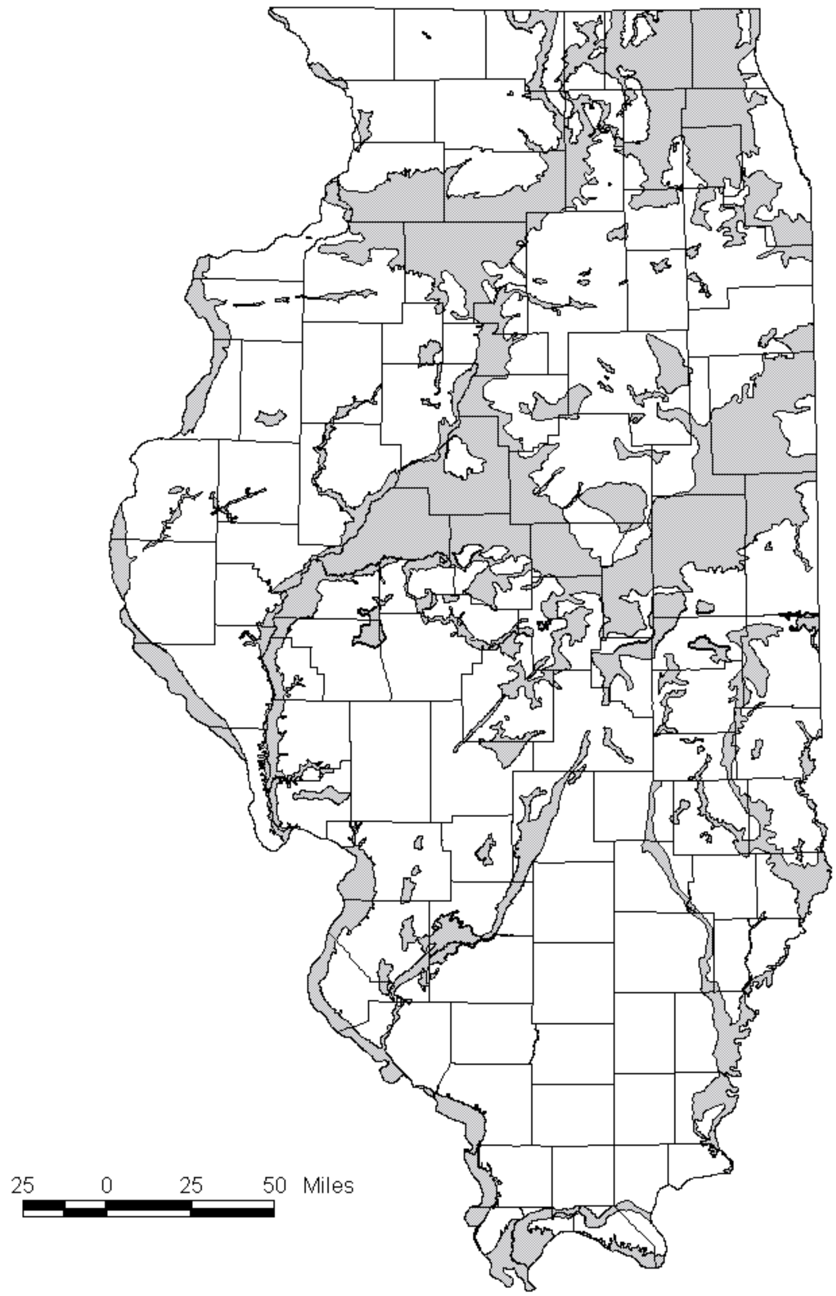


Figure 20. Major sand and gravel aquifers (from Berg, Wehrmann, and Shafer, 1989)

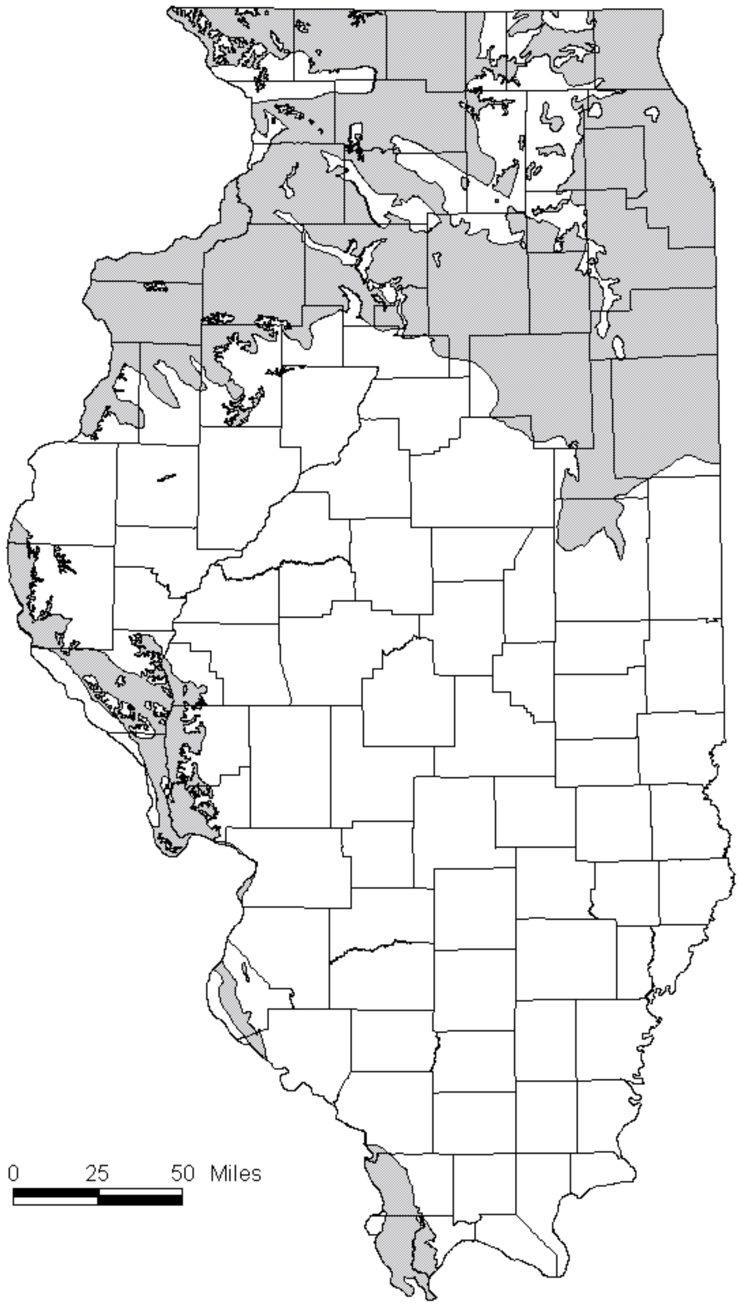


Figure 21. Major bedrock aquifers within 300 feet of ground surface (from Berg, Wehrmann, and Shafer,1989)

Sources of Contamination

All groundwater contains a variety of naturally occurring dissolved minerals. Groundwater may also contain man-made materials that have become dissolved in the water. Recent advances in analytical technology have allowed the detection of very small quantities of dissolved chemical constituents, many of them man-made and many of which may be potentially harmful to human health. A chemical constituent found in water may or may not be considered a contaminant depending on the intended use of the water.

Table 6. Potential sources of groundwater contamination (Wehrmann, 1984)

<u>Waste-Related Activities</u>
Individual sewage systems (septic tank-leach field, cesspools, etc.)
Municipal landfills
Hazardous waste landfills
Liquid waste and sludge disposal (rapid infiltration treatment, etc.)
Treatment lagoons and ponds
Tailings ponds and other mine-related activities
Animal feedlots
Deep well injection

<u>Chemical Application</u>
Fertilizers
Pesticides
Highway de-icing
Waste water irrigation

<u>Chemical Storage</u>
Gas stations
Salt piles
Natural gas storage
Coal piles
Industrial materials storage

<u>Transmission</u>
Pipelines
Sewers
Transportation accidents (train, truck, airplane, ship)
Chemical loading and unloading areas

<u>Aquifer Cross-Connections</u>
Poorly abandoned wells
Multi-aquifer development
Intra-aquifer gradient changes (i.e., from well development)

A wide variety of human activities can lead to groundwater contamination. Table 5 lists a number of potential groundwater contamination sources.

Entry of Contaminants into Aquifers

Contaminant releases are often referred to as originating from point or non-point sources. Point sources are those which may release contaminants from a limited geographic location. Examples include leaking underground storage tanks, septic systems, and injection wells. Non-point contamination situations are more aerially extensive and diffuse in nature. Correspondingly, it is difficult to trace them back to their origin. Agricultural activities (i.e., application of pesticides and fertilizers) and urban runoff are potential non-point contaminant sources.

Hazardous substance releases can occur by design, by accident, or by neglect. Most contamination incidents involve substances released at or only slightly below the land surface. Consequently, it is shallow groundwater which is affected first by contaminant releases. Therefore, shallow groundwater resources are generally considered more susceptible to contamination than deeper groundwater resources.

The mechanism by which groundwater becomes contaminated is similar in many cases. Material that has leaked, spilled, or been disposed may be carried downward through the unsaturated zone to the water table by precipitation and recharge (Figure 22). Specifically, there are at least four ways by which chemicals can contaminate aquifers: infiltration, direct migration, interaquifer exchange, and recharge from surface water.

Infiltration

Contaminants can infiltrate the soil and migrate through pore spaces of surficial material into shallow aquifers. These processes can take place where hazardous substances are spilled, leaked, or improperly stored as well as where agricultural chemicals are applied to soil. In Illinois, the regions where aquifers can be affected most rapidly from infiltration are those with highly permeable bedrock or sand and gravel within 50 feet of the surface. Portions of north--central, northwest, and extreme southern Illinois fall into this category (Berg et al., 1984).

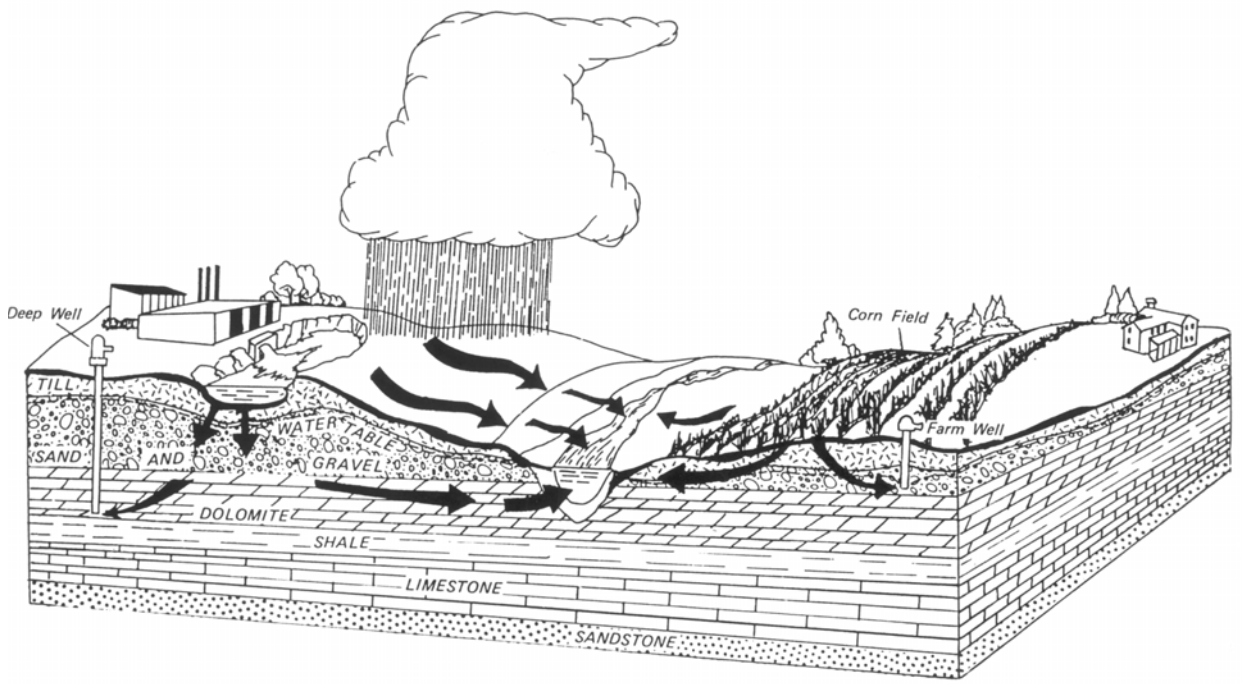


Figure 22. Schematic examples of groundwater contamination (from Shafer, 1985)

Direct Migration

Contaminants can migrate directly into groundwater from below-ground sources (i.e., storage tanks, pipelines) or surface impoundments. Storage or disposal site landfills excavated near the water table also may permit direct contact of contaminants with groundwater. Harris et al. (1982) investigated an industrial waste disposal site where an unlined disposal pit was constructed below the water table. Groundwater hydraulically downgradient from the pit was contaminated as indicated by an increase of over 500% in total organic carbon (TOC) in comparison with upgradient wells. Direct entry to the groundwater system may also occur through old, improperly constructed, or abandoned wells as depicted in Figure 23.

Interaquifer Exchange

Contaminated groundwater can mix with uncontaminated groundwater through a process called interaquifer exchange. This may be induced by natural gradients or by pumping. For example, hundreds of wells in northern and western Illinois are open to many water-bearing units, creating the potential for this mixing process to occur.

A case illustrating the mechanism of interaquifer exchange occurred in Mount Prospect (Cook County), Illinois, where the Mount Simon Aquifer underlies the Galesville sandstone of the Cambrian Ordovician Aquifer. The Mount Simon is known to contain water with higher chloride concentrations and a greater hydrostatic pressure than the water in the Galesville aquifer. In an open bore hole, the Mount Simon aquifer has been known to recharge the Galesville sandstone with water of high chloride content. Consequently, a well in Mount Prospect that was open to both formations and was dormant for three years showed a drastic increase in chloride content as the more highly mineralized water discharged into the Galesville aquifer (Fabbri, 1981). In this case, the source of contamination was natural. However, the same mechanism has the potential to mix high-quality water with groundwater contaminated by man-made hazardous substances.

Recharge from Surface Water

While streams and rivers are usually discharge areas, if the hydraulic gradient of a surface water body has a higher potential than groundwater, contaminants in surface water can flow into the groundwater system. This gradient can exist naturally or be induced by pumping (Figure 24). Schwarzenbach et al. (1983) reported contamination of a glacial sand and gravel aquifer by organic compounds present in an adjacent river. The natural gradient was such that groundwater flow was from the river towards the aquifer. Their investigation determined that volatile organic compounds can be transported from rivers to groundwater.

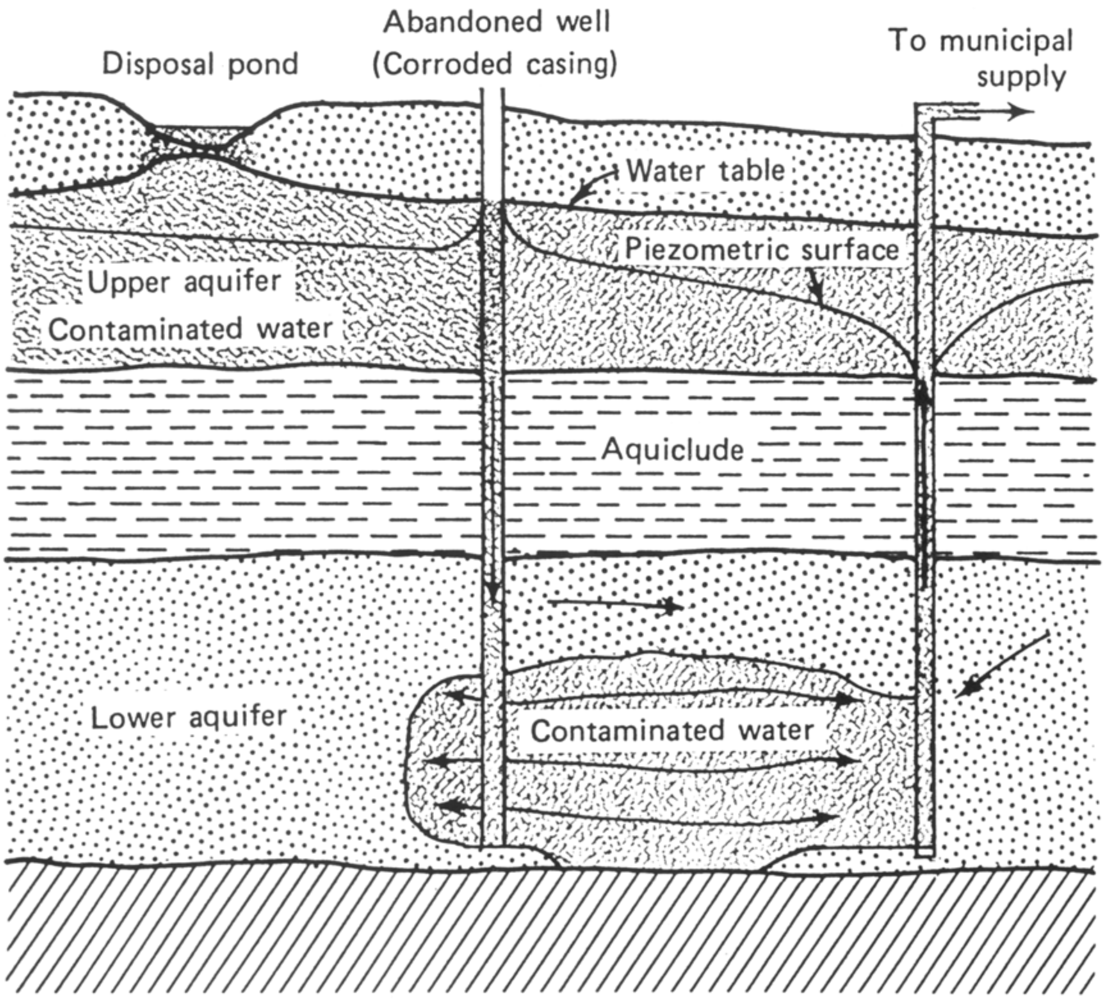


Figure 23. Vertical movement of contaminants along an old, abandoned or improperly abandoned well (from Shafer, 1985)

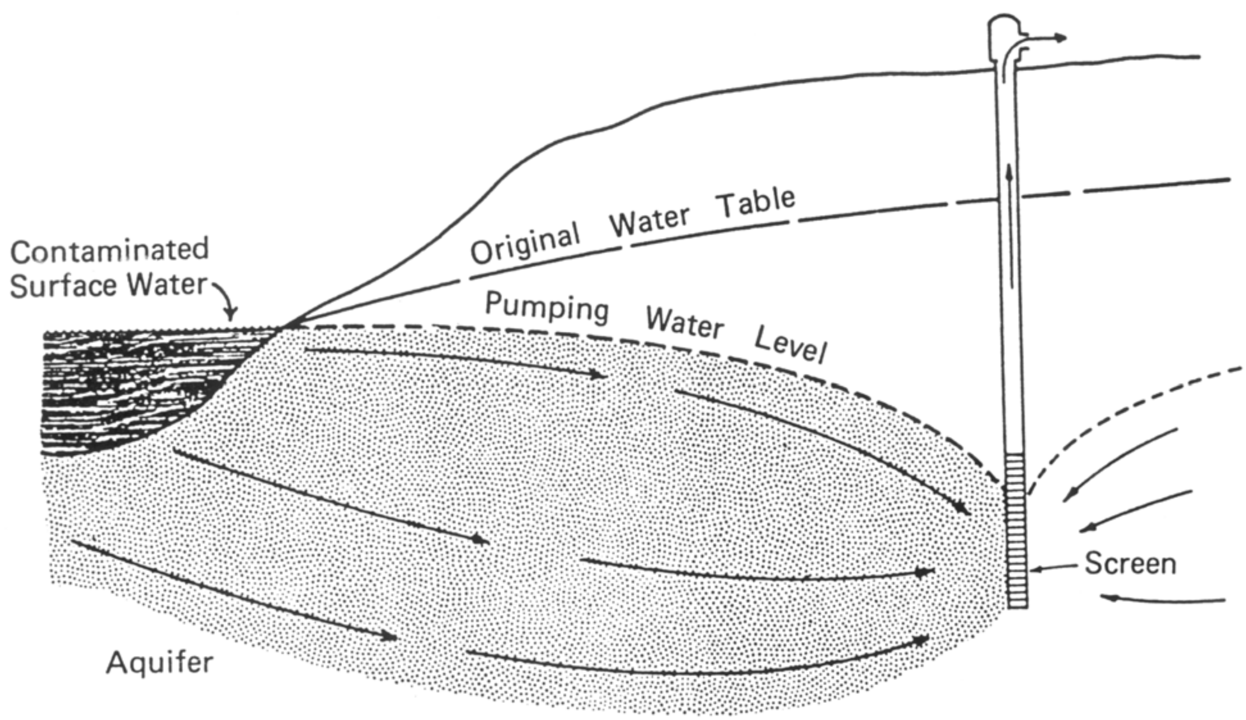


Figure 24. Contaminated water induced to flow from surface water to groundwater (from Shafer, 1985)

Contaminant Migration

Advection

In general, contaminants are transported in the direction of groundwater flow. Transport in this manner, that is, transport of dissolved constituents (solutes) at the same speed as the average groundwater pore velocity is called *advection*. Groundwater movement is governed by the hydraulic principles described by Darcy's Law. This equation states that the flow rate of a liquid through a porous medium is proportional to the head loss and inversely proportional to the length of the flow path:

$$Q = K \cdot A \cdot \_h/L$$

where,

- Q = groundwater flow rate, L^3/T
- A = cross-sectional area of flow, L^2
- $\_h$ = head loss measured between two points a distance L apart, L/L (unitless)
- K = hydraulic conductivity, a measure of the ability of the porous medium to transmit water, L/T

This equation can be rearranged in the following manner to produce the bulk or "Darcian" flow velocity:

$$v = Q/A = K \cdot \_h/L = K \cdot \_h/\_l$$

where,

- v = Darcian velocity of groundwater flow, L/T
- $\_h$ = the change in hydraulic head (head loss), L
- $\_l$ = the distance over which the head loss is measured, L

The Darcian velocity assumes that flow occurs across the entire cross section of the porous material without regard to solid or pore spaces. Actually, flow is limited to the pore space only, so the actual "interstitial" flow velocity is:

$$v_a = v/n = K/n \cdot \_h/\_l$$

where,

- v_a = the actual groundwater flow velocity, L/T
- n = the effective porosity, or the percent of the porous media which consists of interconnected pore spaces, the spaces which contribute to groundwater flow, unitless.

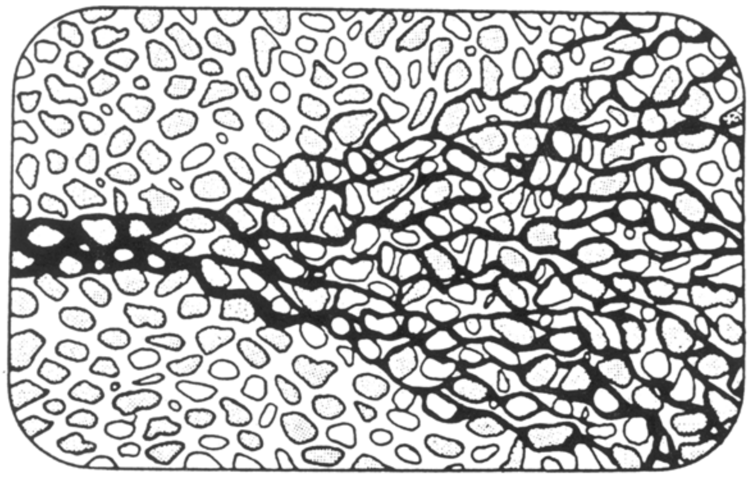
As mentioned earlier, the hydraulic conductivity of a geologic formation depends on a variety of physical factors, including porosity, particle size and distribution, the shape of the particles, particle arrangement (packing), and secondary features such as fracturing and dissolution. In general, for unconsolidated porous materials, hydraulic conductivity values vary with particle size. Fine-grained, clayey materials exhibit lower values of hydraulic conductivity while coarse-grained sandy materials exhibit greater conductivities. Table 4 shows the range of values commonly exhibited by geologic materials.

The effective porosity is essentially an estimated parameter because the actual measurement of the volume of interconnected pore spaces in most porous media has not been conducted. Effective porosity is usually estimated as being somewhat less than the total porosity. Total porosity is calculated from ratios of the volumes of saturated and dry porous material. In coarse-grained materials which drain freely, the effective porosity is essentially equal to total porosity and is generally defined as the ratio of the volume of water which drains by gravity to the total volume of saturated porous material.

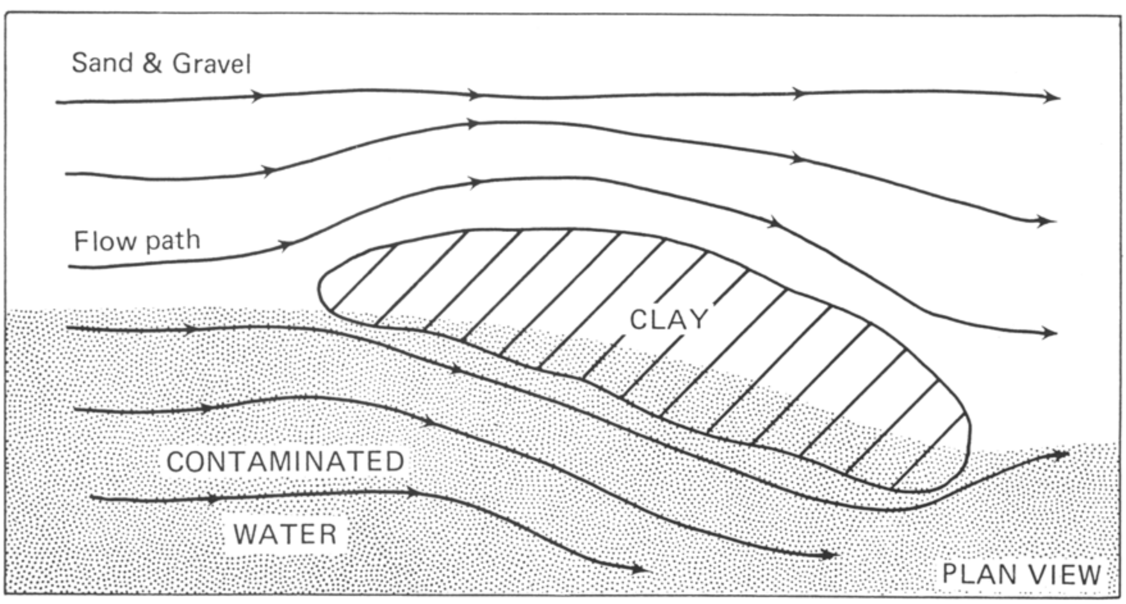
Dispersion

In natural porous materials, the pores possess different sizes, shapes, and orientations. Similar to stream flow, a velocity distribution exists within the pore spaces such that the rate of movement is greater in the center of the pore than at the edges. Thus, in saturated flow through these materials, velocities vary widely across any single pore and between pores. As a result, a miscible fluid will spread gradually to occupy an ever increasing portion of the flow field when it is introduced into a flow system (Figure 25a). This mixing phenomenon is known as *dispersion*. In this sense, dispersion is a mechanism of dilution. Dispersion acts to reduce the peak concentration of a "slug" of material introduced into a flow field. However, dispersion also acts to reduce the travel time of migration because some dissolved material will move ahead of what would actually have been predicted by advective movement only.

Large-scale heterogeneities can also cause dispersion within an aquifer (Miller, 1980). For example, a clay lens within a sand and gravel aquifer will inhibit groundwater flow and distort movement around it (Figure 25b).Groundwater flow will occur within the clay, but at a greatly reduced rate.



a. Flow distortion on a microscopic scale



b. Flow distortion on a macroscopic scale

Figures 25(a) & (b). Dispersion mechanisms (from Shafer, 1985)

Retardation

As water soluble contaminants migrate hydraulically downgradient from their source and are acted on by advection and dispersion, their peak concentrations tend to decline progressively. This is due to dilution,, retardation, and transformation processes. Dilution occurs because dispersive and molecular diffusion processes cause the contaminant to spread out and mix with uncontaminated groundwater. Retardation may occur through a variety of mechanisms including sorption and ion exchange. Transformation processes include phenomena such as biodegradation, volatilization, and radioactive decay.

When contaminants come in contact with surfaces of solids, they may be adsorbed on the surface or absorbed into the solid matrix. Sorptive phenomena serve as limited controls on the migration of organic compounds (Pettyjohn and Hounslow, 1983). Eventually, all potential adsorption surfaces may be occupied, but retardation of ionic (i.e., electrically charged) contaminants may still take place through a process called ion exchange (Miller, 1980). Ion exchange occurs when ions in groundwater displace ions associated with geologic materials. Because finer textured materials (clay in particular) have more surface area per unit volume, they are generally able to more effectively retard chemical constituents than coarser textured materials such as relatively clean sand and gravel. Deposits with high oxide coatings or organic content also often have high sorptive and ion exchange potential.

Some wastes may be degraded by bacteria under the proper conditions. The most degradable substances include those biologically produced, while synthetic organics are generally not as easily degradable (Pettyjohn and Hounslow, 1983). Radionuclides undergo a natural decay process whereby concentrations may be reduced.

Another process that may reduce the concentration of organic contaminants is *volatilization*. Volatilization is the process which occurs when a substance changes from the liquid phase to the gaseous phase. A number of organic compounds (benzene, trichloroethene, and many other low molecular weight compounds) partition into and diffuse through soil gas as a result of their low aqueous solubility and high vapor pressure (low boiling point). Volatilization is enhanced by low soil moisture and high air porosity such as is present in coarse-textured materials like sand and gravel. Remote detection techniques capable of locating subsurface volatile organic chemical plumes by analyzing the overlying soil gases have been devised to take advantage of the result of volatilization (Marrin, 1985).

Potential for Aquifer Contamination in Illinois

Nearly half of Illinois' public water supplies withdraw water from sand and gravel aquifers (Kirk et al., 1984). These aquifers are highly susceptible to contamination (i.e., more rapidly affected by it) because of their relatively high hydraulic conductivity, generally shallow occurrence, and low retardation ability. Fractured rock aquifers, such as limestones and dolomites, contain even less surface area for ion exchange/sorption processes; therefore, very little retardation is possible depending on the size of their fractures.

Figures 26 and 27 illustrate the aquifers in Illinois that are highly susceptible to or can be rapidly impacted by contamination from disposal of municipal wastes. The thickness, permeability, and retardation ability of geologic units within 50 feet of the surface were the criteria used in this groundwater sensitivity rating scheme.

Groundwater contaminant movement is relatively slow and allows time for some response depending on the individual situation and if contamination is discovered early. Contaminant migration can be managed through control of groundwater movement via combinations of hydraulic gradient manipulation and physical barriers. If contamination is not discovered early, contaminant migration can continue over large areas. Two known contaminant plumes in the Rockford area extend over 1 to 2 miles in length. Many tens of years may be required before natural processes can dilute, transform, or flush contaminants from the groundwater system.

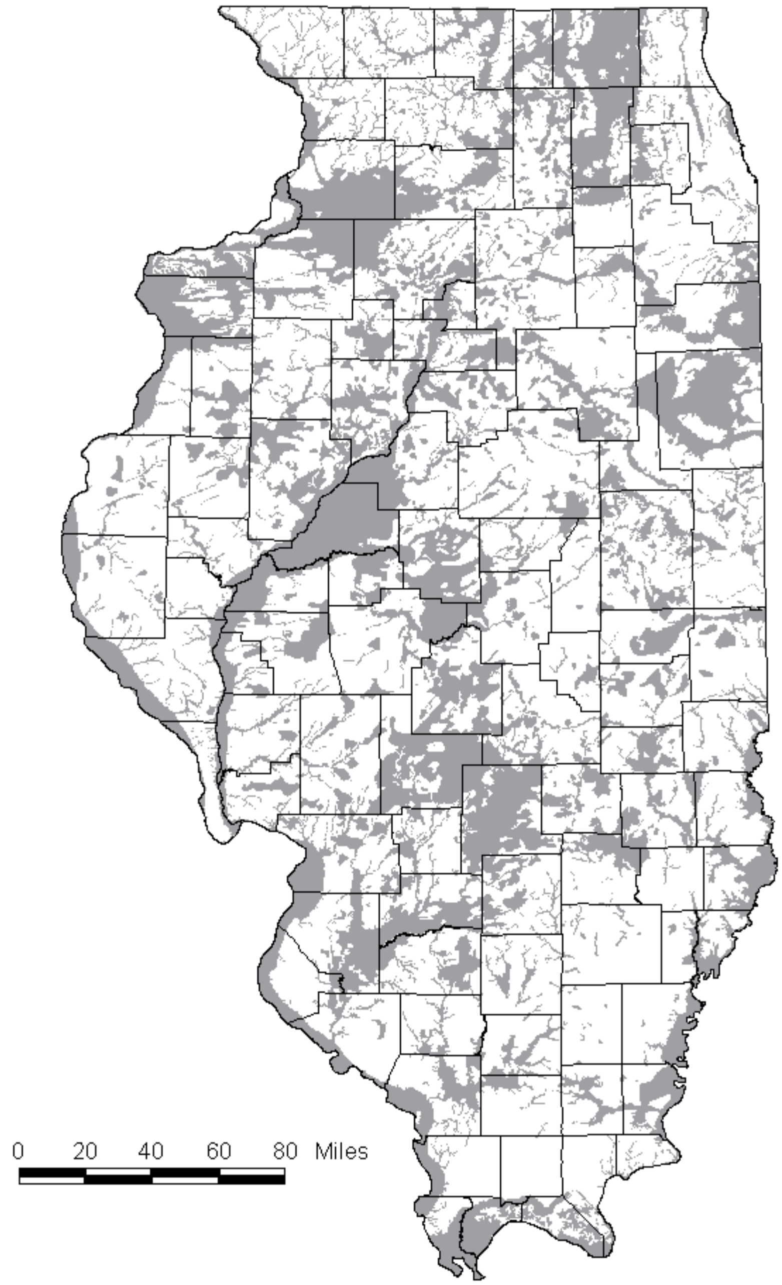


Figure 26. Sand and gravel aquifers susceptible to contamination (from Shafer, 1985)

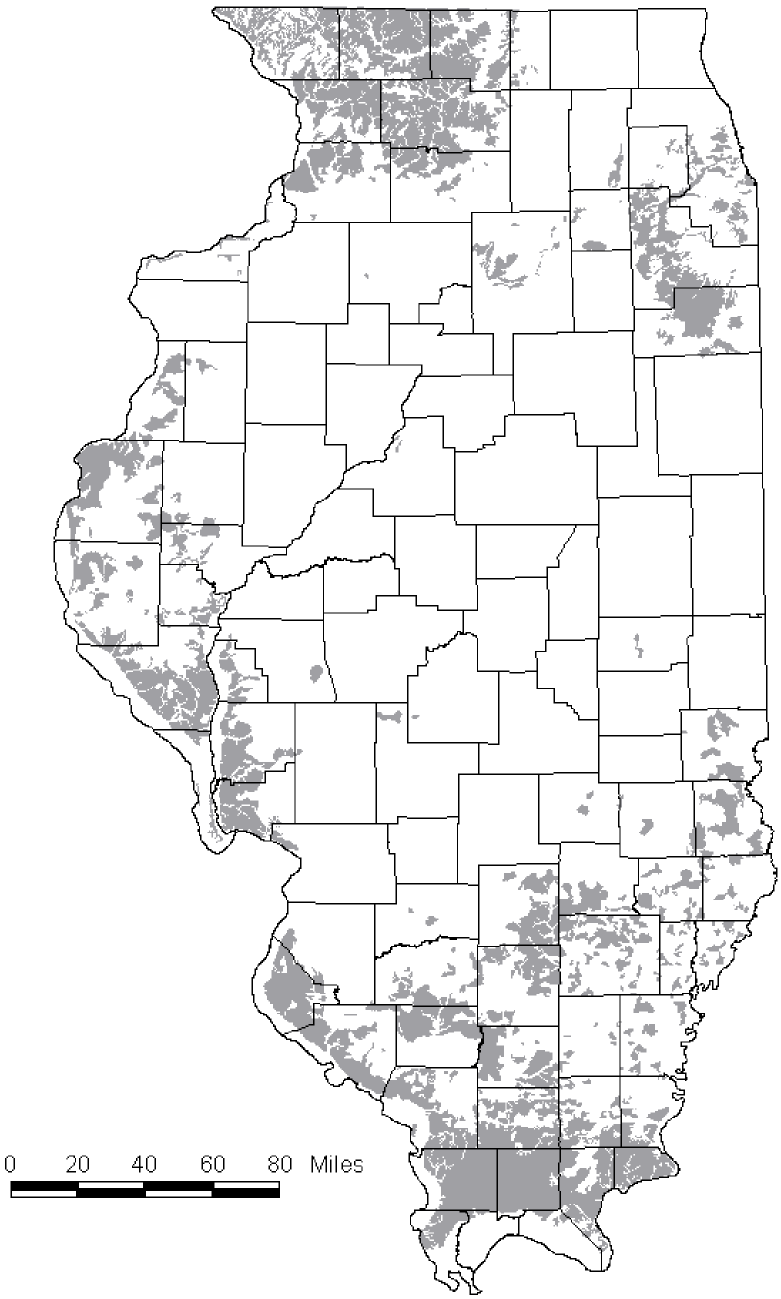


Figure 27. Shallow bedrock aquifers susceptible to contamination (from Shafer, 1985)

APPENDIX III
ON-SITE INSPECTION
EVALUATION FORM

SITE SPECIFIC EVALUATION FORM

1. FACILITY NAME:
2. FACILITY ADDRESS:

3. OWNER/OPERATOR/OTHER:
4. TYPE OF BUSINESS:
5. TYPE OF HAZARD OBSERVED:
6. ARE STORAGE TANKS PRESENT? Yes ______ No ______
   (If no, skip to question 7)

   A. IF YES, ARE THE TANKS ABOVE GROUND (AG) ______
      BELOW GROUND (BG) ______

   B. IS SECONDARY CONTAINMENT PRESENT YES ______
      NO ______

      1. INTEGRITY?
      2.

	TANK AGE	SIZE (GAL)	TANK CONSTRUCTION	TANK CONTENTS	AG/BG
TANK 1					
TANK 2					
TANK 3					
TANK 4					
TANK 5					
TANK 6					
TANK 7					
TANK 8					
TANK 9					
TANK 10					

      2. COMMENTS:

7. ARE SOLVENTS PRESENT? Yes ______ No ______
   (If no, skip to question 8)

	TYPE	STORAGE METHOD	QUANTITY	DISPOSAL METHOD	USE
SOLV 1					
SOLV 2					
SOLV 3					
SOLV 4					
SOLV 5					

A. COMMENTS:

8. IS THE FACILITY SEWERED? Yes ______ No ______

   A. ARE THE FLOOR DRAINS CONNECTED TO THE SEWER? YES ______ NO ______

   B. COMMENTS:

9. IS THE FACILITY SUBJECT TO AN ENVIRONMENTAL REMEDIATION?
   Yes ______ No ______ if no, skip to question 10)

   A. IF YES, WHAT TYPE OF REMEDIATION?

   B. IS THIS REMEDIATION CURRENTLY UNDER AGENCY LITIGATION, VOLUNTARY CLEAN UP, OTHER?

   C. COMMENTS:

10. ARE THERE ANY PHYSICAL OBSERVATIONS WHICH MAY INDICATE A POTENTIAL HAZARD TO GROUNDWATER?
    Yes ______ No ______ if no, skip to question 11)

    A. IF YES, DESCRIBE:

    B. COMMENTS:

11. SUMMARIZE THE RESULTS OF THE FINDING ENUMERATED ABOVE, AND INDICATE THE DEGREE OF POTENTIAL HAZARD THIS FACILITY MAY POSE TO GROUNDWATER:

INSPECTOR: ____

APPENDIX IV
NON-POINT SOURCE
INSPECTION

INTERVIEW WITH:

RESPONDENT NAME: Treva Walker
University of Illinois
Agriculture Extension Office
Peking, IL – ph. 309-347-6614

Q. 1. Between January 1, 1988 and the present, have any crops been farmed within ½ mile of the well?

YES

Q. 2. In 1991, were crops farmed within ½ mile of the well?

YES

In 1991, what crops were farmed within ½ mile of the well? In 1991, what pesticides were used on each crop?

1991				
CROP	PESTICIDE			
1. SOYBEANS	A.	Dual	E.	Dursban
	B.	Treflan	F.	Poast
	C.	Basagran	G.	Pursuit
	D.	Blazer	H.	Galaxy
1. CORN	A.	Lasso	F.	Dual
	B.	Atrazine	G.	Dursban
	C.	Pursuit	H.	Furadan
	D.	Banvel	I.	Counter
	E.	Dyfonate	J.	Thimet
			K.	

Q. 3. Between January 1, 1988 and the present, has any land been used for pasture within ½ mile of the well?

NO (Skip to Q. 5.)

Q. 4. Between January 1, 1998 and the present, what pesticides were used on the pasture?

Q. 5. Between January 1, 1998 and the present, has there been any major non-agricultural pesticide application, such as spraying for gypsy moths or mosquitoes, within ½ mile of the well?

YES

Q. 6. Starting with 1991 and thinking back to 1998, what pesticides have been applied?

Malathion, Pyrethrin, Resmethrin, Dursban

Q. 7. Between January 1, 1998 and the present, has there been an accidental spill of any pesticide, within ½ mile of the well?

YES

Q. 8. Starting with 1988 and thinking back to 1986, what pesticides have been spilled? For each pesticide that was spilled, provide the distance between the well and the closest part of the spill.

	YEAR	PESTICIDE	DISTANCE FROM THE WELL
A.	1988	CAPTAIN	500 feet
B.			

Q. 9. Between January 1, 1998 and the present, has there been an accidental spill of any hazardous chemical, within ½ mile of the well?

DON'T KNOW (Skip to Q. 11.)

Q. 10. Starting with 1991 and thinking back to 1988, what hazardous chemicals have been spilled? For each chemical that was spilled, provide the distance between the well and the closest part of the spill.

	YEAR	HAZ. CHEMICAL	DISTANCE FROM THE WELL
A.	1988		
B.			

Q. 11. Within ½ mile of the well is there a…

A.	Chemical plant or storage facility?	YES
B.	Airport?	NO
C.	Military base?	NO
D.	Septic field?	DON'T KNOW
E.	Water disposal pond?	NO
F.	Landfills, including any that are closed?	NO
G.	Municipal or industrial waste treatment facility?	NO
H.	Municipal or public dump, including any that are closed?	NO
I.	Hazardous waste site, including any that are closed?	NO
J.	Golf course?	NO
K.	Mine, quarry, or gravel pit?	NO
L.	Oil well?	NO
M.	Irrigation or large capacity municipal well?	NO
N.	Pesticide retail outlet?	NO
O.	Grain elevator?	NO

Q. 12. Within ½ mile of the well is there a…

A.	Steam, river, creek, or drainage channel?	YES
B.	Unlined irrigation canal?	NO
C.	Lined irrigation canal?	NO
D.	Unlined drainage ditch?	NO
E.	Lined drainage ditch?	NO
F.	Lined reservoir?	NO
G.	Unlined reservoir?	NO
H.	Natural lake?	YES
I.	Man-made lake?	YES
J.	Bay or estuary?	NO
K.	Spring?	NO
L.	Pond?	YES

Q. 13. Is irrigation used within ½ mile of the well?

NO (Skip to end.)

Q. 14. What irrigation methods are used?

A. Spray (center pivot, handline, traveling gun, other)
B. Flood (furrow, ditch, trickle)
C. Drip
D. Subsurface
E. What other

END

APPENDIX V
HAZARD REVIEW
WORKSHEET

HAZARD REVIEW WORKSHEET

1. Unique I.D. Number 4~, Distance and Direction from the Wellhead:

2. Nature of Business:

3. DLPC Permit Number(s) and Description (e.g., RCRA, Generic, Solid Waste, UIC, etc.):

4. DAPC Permit Number(s) and Description:

5. DWPC Permit Number(s) and Description (e.g., NPDES, Industrial Pre-Treatment, Sewer Plans, etc.):

6. ERU Incidents and Description:

7. ERU 313 Reports and Description:

8. ESDA 302/303 Reports and Description:

9. ESDA 311/312 Reports and Description:

10. PWS compliance monitoring conducted and describe the results (e.g., VOC/VOA sample detects, etc.):

11. ISFM list the underground storage tanks registered, provide the owner name and address:

    OWNER NAME ADDRESS

12. Is the site sewered or non-sewered?

    If the sited is not sewered, describe:

13. Has on-site past or present landfilling, land treating, or surface impoundment of waste, other than landscape waste or construction and demolition debris occurred?

    [ ] Yes. If yes, describe:

    [ ] No.

14. Are there currently any on-site piles of special or hazardous waste?

    [ ] Yes. If yes, describe:

    [ ] No.

15. Are on-site piles of waste (other than special or hazardous wastes) managed according to Agency guidelines?

    [ ] Yes.

    [ ] No. If no, describe:

16. Are there currently any on-site piles of special or hazardous waste?

[ ] Yes. If yes, describe:

[ ] No.

17. (a) Has any situation(s) occurred at this site, which resulted in a “release” of any hazardous substance or petroleum?

[ ] Yes. (Continue to next question.)

[ ] No. (Stop here.)

(b) Have any hazardous substances or petroleum, which were released, come into contact with ground surface at this site? (Note: Don not automatically exclude paved or otherwise covered areas that may still have allowed chemical substances to penetrate into the ground.)

(c) Have any of the following actions/events been associated with the release(s) referred to in question 17 (b)?

[ ] hiring of a cleanup contractor to remove obviously contaminated materials including subsoil’s;

[ ] replacement or major repair of damaged facilities;

[ ] assignment of in-house maintenance staff to remove obviously contaminated materials including subsoil’s;

[ ] designation, by IEPA or ESDA, of a release as “significant” under the Illinois Chemical Safety Act;

[ ] reordering or other replenishment of inventory due to the amount of substance lost;

[ ] temporary or more long-term monitoring of groundwater at or near the site;

[ ] stop usage of an on-site or nearby water well because of offensive characteristics of the water;

[ ] coping with fumes from subsurface storm drains or inside basements;

[ ] signs of substances leaching out of the ground along the base of slopes or at other low points on or adjacent to the site;

(d) The on-site release(s) <u>may</u> have been of sufficient magnitude to contaminate groundwater. Summarize the problem.

18. Are there more than 100 gallons of either pesticides or organic solvents, or 10,000 gallons of any hazardous substance, or 30,000 gallons of petroleum present at any time?

[ ] Yes. If yes, describe:

[ ] No.

19. Do any of the regulated entities have groundwater monitoring systems, and have any exceeded compliance requirements?

[ ] Yes. If yes, describe:

[ ] No.

20. After considering all of the above criteria, does this site potentially pose a hazard to groundwater?

[ ] Yes. If yes, describe:

[ ] No.

APPENDIX VI
SUMMARY OF THE
TECHNOLOGY CONTROL REGULATIONS

Regulations for Existing Land Uses

Illinois Groundwater Protection Act

Special Waste (exclusive of Hazardous Waste needs to be clarified) per Sections 615.401, 615.421, 615.441, 615.461, etc. . . .

LAND USE	REGULATIONS WITHIN MINIMUM SETBACK ZONES	REGULATIONS WITHIN MAXIMUM SETBACK ZONES	REGULATIONS WITHIN REGULATED RECHARGE AREAS
ON-SITE LANDFILLS	Must be closed. Begin by 1994. Finish by 1995.	Must be closed 2 years after the effective date of the ordinance (if after 1992) for new maximum setback zones. Within existing maximum setback zones, must be closed beginning by 1994 and finishing by 1995 per effective date of regulations.	Must be closed if located within 2,500 feet of a well, Begin four years after the Board establishes a RRA. Finish five years after Board establishes RRA.
ON-SITE LAND TREATMENT OF WASTES (except water or waste-water treatment)	Must be closed. Begin by 1994. Finish by 1995. The owner or operator shall comply with the requirements of Sections 615.302 (Closure Performance Standard) and 615.303 (Certification of Closure).	Must be closed 2 years after the effective date of the ordinance (if after 1992) for new maximum setback zones. Within existing maximum setback zones must be closed beginning by 1994 and finishing by 1995 per effective date of regulations. The owner or operator shall comply with the requirements of Sections 615.302 (Closure Performance Standard) and 615.303 (Certification of Closure).	

LAND USE	REGULATIONS WITHIN MINIMUM SETBACK ZONES	REGULATIONS WITHIN MAXIMUM SETBACK ZONES	REGULATIONS WITHIN REGULATED RECHARGE AREAS
ON-SITE SURFACE IMPOUNDMENTS THAT CONTAIN CONTAMINANTS	Must be closed Begin by 1994. Finish by 1995.	Must be closed 2 years after the effective date of the ordinance (if after 1992) for new maximum setback zones. Within existing maximum setback zones, must be closed beginning by 1994 and finish-ing by 1995 per effective date of regulations.	Must meet requirements for groundwater monitoring, inspection, operation, and closure post-closure care.
ON-SITE WASTE PILES (except sludge from water or waste-water treatment)	Must be closed. Begin by 1994. Finish by 1995. If deemed to be a landfill, groundwater monitoring is required pursuant to 35 Ill. Adm. Code 814. If not a landfill, must meet require-ments for design and operation, and closure, six months after the date of first applicability (January 1, 1992). In addition, the owner or operator shall comply with the requirements of Sections 615.302 (Closure Performance Standard) and 615.303 (Certification of Closure).	Must be closed 2 years after the effective date of the ordinance (if after 1992) for new maximum setback zones. Within existing maximum setback zones, must be closed beginning by 1994 and finishing by 1995 per effective date of regulations. If deemed to be a landfill, groundwater monitoring is required pursuant to 35 ill. Adm. Code 814. If not a landfill, must meet requirements for design and operation, and closure, 6 months after the date of first applicability (January 1, 1992). In addition, the owner or operator shall comply with the require ments of Sections 615.302 (Closure Performance Standard) and 615.303 (Certification of Closure).	If not a landfill, must meet requirements for design and operation, and closure, six months after the date of first applicability (January 1, 1992). In addition, the owner or operator must comply with the requirements of Sections 615.302 (Closure Performance Standard) and 615.303 (Certification of Closure), .
UNDERGROUND STORAGE TANKS (does not include tanks regulated by other legisla tion)	Must meet design and operation requirements pursuant to 35 III. Adm. Code 731.	Must meet design and operation requirements pursuant to 35 111. Adm. Code 731.	Must meet design and operation requirements pursuant to 35 III. Adm. Code 731.

LAND USE	REGULATIONS WITHIN MINIMUM SETBACK ZONES	REGULATIONS WITHIN MAXIMUM SETBACK ZONES	REGULATIONS WITHIN REGULATED RECHARGE AREAS
PESTICIDE STORAGE AND HANDLING UNITS	Must meet requirements for groundwater monitor-ing, design and operation, closure and post-closure care. Or can opt into the Part 257 Rule require-ments (Alternative Groundwater Protection Program) currently being developed.	Must meet requirements for groundwater monitor-ing, design and operation, closure and post-closure care. Or can opt into the Part 257 Rule require-menu-(Alternative Groundwater Protection Program) currently being developed.	Must meet requirements for groundwater monitor ing, design and operation, closure and post-closure care. Or can opt into the Part 257 Rule require ments (Alternative Groundwater Protection Program) currently being developed.
FERTILIZER STORAGE AND HANDLING UNITS	Must meet requirements for groundwater monitor-ing, design and operation, closure and post-closure care. Or can opt into the Part 257 Rule require-ments (Alternative Groundwater Protection Program) currently being developed.	Must meet requirements for groundwater monitor-ing, design and operation, closure and post-closure care. Or can opt into the Part 257 Rule require-ments (Alternative Groundwater Protection Program) currently being developed.	Must meet requirements for groundwater monitor ing, design and operation, closure and post-closure care. Or can opt into the Part 257 Rule require ments (Alternative Groundwater Protection Program) currently being developed.
ROAD OIL STORAGE AND HANDLING UNITS (greater than 25,000 gallons stored or accumulated)	Must be closed. Begin by 1994. Finish by 1995.	Must meet requirements for groundwater monitor-ing design and operation for above-ground storage tanks, and closure post-closure care.	Must meet requirements for groundwater monitor ing design and operation for above-ground storage tanks, and closure post closure care.
DE-ICING AGENT STORAGE AND HANDLING UNITS (greater than 50,000 pounds stored or accumulated)	Must meet requirements for groundwater monitor-ing, design and operation, and closure post-closure care.	Must meet requirements for groundwater monitor ing, design and operation, and closure post-closure care.	

Regulations for New Land Uses

Illinois Groundwater Protection Act

Special Waste (exclusive of Hazardous Waste needs to be clarified) per Sections 616.401, 616.421, 616.441, 616.461, etc. . . .

LAND USE	REGULATIONS WITHIN MINIMUM SETBACK ZONES	REGULATIONS WITHIN MAXIMUM SETBACK ZONES	REGULATIONS WITHIN REGULATED RECHARGE AREAS
ON-SITE LANDFILLS	Prohibited if considered a primary or secondary source of contamination.	Prohibited if considered a primary source of contamination.	Prohibited if within 2,500 feet of a well and considered a primary source of contamination.
ON-SITE LAND TREATMENT UNITS (except water or wastewater treatment)	Prohibited if considered a primary or secondary source of contamination.	Prohibited if considered a primary source of contamination.	Allowed
ON-SITE SURFACE IMPOUNDMENTS THAT CONTAIN CONTAMINANTS	Prohibited if considered a primary or secondary source of contamination.	Prohibited if considered a primary source of contamination.	Allowed' In addition, must meet Inspection requirements.
ON-SITE WASTE PILES (except sludges from water or wastewater treatment)	Prohibited if considered a primary or secondary source of contamination.	Prohibited if considered a primary source of contamination.	Prohibited if within 2,500 feet of a well and considered a primary source of contamination.
UNDERGROUND STORAGE TANKS (does not include tanks regulated by other legislation)	Must meet design and operation requirements pursuant to 35 III. Adm. Code 731.	Must meet design and operation requirements pursuant to 35 III. Adm. Code 731.	Must meet design and operation requirements pursuant to 35 III. Adm. Code 731.
PESTICIDE STORAGE AND HANDLING UNITS	Prohibited if considered a primary or secondary source of contamination. Or can opt into the Part 257 Rule requirements (Alternative Groundwater Protection Program) currently being developed.	Prohibited if considered a primary source of contamination. Or can opt into the Part 257 Rule requirements (Alternative Groundwater Protection Program) currently being developed.	Allowed' Or can opt into Part 257 Rule requirements (Alternative Groundwater Protection Program) currently being developed.

LAND USE	REGULATIONS WITHIN MINIMUM SETBACK ZONES	REGULATIONS WITHIN MAXIMUM SETBACK ZONES	REGULATIONS WITHIN REGULATED RECHARGE AREAS
FERTILIZER STORAGE AND HANDLING UNITS	Prohibited if considered a primary or secondary source of contamination. Or can opt into the Part 257 Rule requirements (Alternative Groundwater Protection Program) currently being developed.	Prohibited if considered a primary source of contamination. Or can opt into the Part 257 Rule requirements (Alternative Groundwater Protection Program) currently being developed.	Allowed Or can opt into the Part 257 Rule requirements (Alternative Groundwater Protection Program) currently being developed.
ROAD OIL STORAGE AND HANDLING UNITS (greater than 25,000 gallons stored or accumulated)	Prohibited if considered a primary or secondary source of contamination.	Prohibited if considered a primary source of contamination. In addition, must meet design and operation requirements for above ground storage tanks.	Allowed" In addition, must meet design and operation requirements for above-ground storage tanks.
DE-ICING AGENT STORAGE AND HANDLING UNITS:			
Indoor	Prohibited if considered a primary or secondary source of contamination.	Prohibited if considered a primary source of contamination. In addition, must meet design and operation requirements for Indoor Storage Facilities.	
Outdoor	All prohibited.	All prohibited.	

* Allowed if requirements are met for groundwater monitoring, design and operation, and closure post-closure care.