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# AN ASSESSMENT OF CLASS V UNDERGROUND INJECTION IN ILLINOIS

*by Stephen L. Burch, Bruce R. Hensel, John S. Nealon, and Edward C. Smith*

**Prepared for the**
**Illinois Environmental Protection Agency**
**Division of Land Pollution Control**
**Permit Section**

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*Illinois Department of Energy and Natural Resources*

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# AN ASSESSMENT OF CLASS V UNDERGROUND INJECTION IN ILLINOIS

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## BACKGROUND

This report examines the potential of Class V injection for contamination of underground sources of drinking water (USDW). In Illinois, Class V wells are commonly used to dispose of stormwater runoff, sewage, and heat pump effluent.

The report first identifies the general construction features of Class V wells and how they are used in Illinois. It then attempts to rank Class V well types in accordance with their potential to contaminate USDW. A methodology is created and applied to general descriptions of typical Class V well types and the fluids they inject. The development of such a method is beneficial to Illinois because it can assist the determination of the appropriateness of various levels of regulation. Additionally, the methodology can be used to identify items pertinent to the development of operating requirements for Class V wells under Title 35 of the Illinois Administrative Code Part 730.

The overall assessment has two goals: (1) to assist the Illinois Environmental Protection Agency (IEPA) in developing proposed operating requirements for Class V wells which can then be submitted to the Illinois Pollution Control Board (IPCB) for inclusion in 35 Ill. Admin. Code 730; and (2) to assist the IEPA in fulfilling the federal requirements promulgated under 40 CFR 146.52. Those requirements call for the following:

(1) information on the construction features of Class V wells in Illinois, and the nature and volume of injected fluids;

(2) an assessment of the contamination potential of these Class V wells on the basis of available hydrogeologic data;

(3) an assessment of the available corrective alternatives where appropriate, and their environmental and economic consequences; and

(4) recommendations for the most appropriate regulatory approaches and for remedial actions where appropriate.

## Legislative Mandates

To facilitate the abatement of health risks, the Safe Drinking Water Act (SDWA) was adopted by Congress in 1974 for the purpose of ensuring that public water supply systems met minimum national water quality standards (DiNovo and Jaffe, 1984). Besides establishing drinking water quality standards, this legislation contains a provision that created the Underground Injection Control (UIC) program. That program provides a framework which is intended to protect underground sources of drinking water from possible contamination by the underground injection of wastes (44 FR 23740).

The State of Illinois has actively operated within this framework and was granted primary responsibility (primacy) for its UIC program. The State UIC program, like the federal program, divides well injection practices into five classes. For all of the classes, the process of underground injection is defined as the "subsurface emplacement of fluids through a bored, drilled, or driven well; or through a dug well where the depth is greater than the largest surface dimension and a principal function of the well is the subsurface emplacement of fluids" (State of Illinois, 1985). These classes can be generally described as follows (also see figure 1):

Class I———Injection of hazardous or nonhazardous industrial and municipal wastes below the lowest USDW.

Class II———Injection associated with oil and gas storage and production.

Class III———Injection involved with solution mining or in-situ gasification of oil shale, coal, etc., and the recovery of geothermal energy.

Class IV———Injection of hazardous wastes into or above USDW. Class IV injection has been banned in the United States.

Class V———All other injection not covered by the first four classes.

Class V injection does not deal with hazardous waste, but does involve injection into, between, or above USDW. Therefore, wells of this type have the potential to emplace fluids containing contaminants into close proximity with ground water that may be used for drinking water.

The operation of Class V wells in Illinois is currently authorized by rule until future regulations become applicable (35 Ill. Admin. Code 704.146). "Authorization by rule" allows injection wells which were already operating at the time Illinois received primacy to continue operating until permit decisions can be formulated. Presently, there are no specific regulations governing the permitting and operation of Class V injection wells although there are general

Injection wells are classified as follows:

a) Class I.

1) Wells used by generators of hazardous wastes or owners or operators of hazardous waste management facilities to inject hazardous waste beneath the lower most formation containing, within 402 meters (1/4 mile) of the well bore, an underground source of drinking water.

2) Other industrial and municipal disposal wells which inject fluids beneath the lowermost formation containing, within 402 meters (1/4 mile) of the well bore, an underground source of drinking water.

b) Class II. Wells which inject fluids:

1) Which are brought to the surface in connection with conventional oil or natural gas production: and may be commingled with waste waters from gas plants which are an integral part of production operations, unless those waters are classified as a hazardous waste at the time of injection;

2) For enhanced recovery of oil or natural gas: and

3) For storage of hydrocarbons which are liquid at standard temperature and pressure.

c) Class III. Wells which inject for extraction of minerals, including:

1) Mining of sulfur by the Frasch process:

2) In situ production of uranium or other metals. This category includes only in-situ production from ore bodies which have not been conventionally mined Solution mining of conventional mines such as stopes leaching is included in Class V

3) Solution mining of salts or potash

d) Class IV.

1) Wells used by generators of hazardous wastes or of radioactive wastes, by owners or operators of hazardous waste management facilities, or by owners or operators of radioactive waste disposal sites to dispose of hazardous wastes or radioactive wastes into or above a formation which within 402 meters (1/4 mile) of the well contains an underground source of drinking water.

2) Wells used by generators of hazardous waste or of radioactive waste, by owners or operators of hazardous waste management facilities, or by owners or operators of radioactive waste disposal sites to dispose of hazardous waste or radioactive waste above a formation which within 402 meters (1/4 mile) of the well contains an underground source of drinking water.

3) Wells used be generators of hazardous waste or owners or operators of hazardous waste management facilities to dispose of hazardous waste, which cannot be classified under 35 Ill. Adm. Code 730.105(a)(1) or 730.105(d)(1) and (d)(2) (e.g., wells used to dispose of hazardous wastes into or above a formation which contains an aquifer which has been exempted pursuant to 35 Ill. Adm. Coda 730.104.

e) Class V. Injection wells not included in Class I, II, III or IV.

Class V wells includes:

1) Air conditioning return flow wells used to return to the supply aquifer the water used for heating or cooling in a heat pump;

2) Cesspools, including multiple dwelling, community or regional cesspools, or other devices that receive wastes, which have an open bottom and sometimes have perforated sides. The UIC requirements do not apply to single family residential cesspools or to non-residential cesspools which receive solely sanitary wastes and have the capacity to serve fewer than 20 persons a day;

3) Cooling water return flow wells used to inject water previously used for cooling;

4) Drainage wells used to drain surface fluid, primarily storm runoff, into a subsurface formation;

5) Dry wells used for the injection of wastes into a subsurface formation;

6) Recharge wells used to replenish the water in an aquifer;

7) Salt water intrusion barrier wells used to inject water into a fresh water aquifer to prevent the intrusion of salt water into the fresh water;

8) Sand backfill and other backfill wells used to inject a mixture of water and sand, mill tailings or other solids into mined out portions of subsurface mines whether what is injected is a radioactive waste or not;

9) Septic system wells used to inject the waste or effluent from a multiple dwelling, business establishment, community or regional business establishment septic tank. The UIC requirements do not apply to single family residential septic system wells, or to non-residential septic system wells which are used solely for the disposal of sanitary waste and have the capacity to serve fewer than 20 persons a day.

10) Subsidence control wells (not used for the purpose of oil or natural gas production) used to inject fluids into a non-oil or gas producing zone to reduce or eliminate subsidence associated with the overdraft of fresh water;

11) Radioactive waste disposal wells other than Class IV;

12) Injection wells associated with the recovery of geothermal energy for heating, aquaculture or production of electric power;

13) Wells used for solution mining of conventional mines such as stopes leaching;

14) Wells used to inject spent brine into the same formation from which it was withdrawn after extraction of halogens or their salts; and

15) Injection wells used in experimental technologies.

Figure 1. Classification of underground injection wells (reprinted from State of Illinois, 1985).

regulations which apply to all injection wells regardless of class. It is expected, however, that such legislation is forthcoming.

Originally, the USEPA separated Class V wells into eleven types. This format was used in the Illinois inventory of Class V injection wells (Davis and Nienkerk, 1984). The State of Illinois, however, subsequently adopted rules and regulations for waste disposal (Title 35: Subtitle G) that separated Class V injection into 15 types. A comparison of the USEPA categorization with that of the state is shown as table 1. It should be noted that some of the state categories fit into two or more of the USEPA categories.

During the course of this study, however, the USEPA's LEC (Lead Effort Contractor) recommended further modifications and refinements of the categorization scheme. The new classification (listed in Appendix A) emphasizes eight major Class V activities. Each of these activities is further subdivided into well types that are more indicative of the type of fluid being injected into the subsurface.

Table 1. Comparison of Class V Injection Well Categories*

| USEPA Classification | Brief Description | State of Illinois Classification (from figure 1) |
|---|---|---|
| 5A | Air conditioning/cooling water return well | (1) or (3) |
| 5B | Salinity barrier well | (7) |
| 5D | Stormwater drainage well | (4) |
| 5F | Agricultural drainage well | (4) |
| 5G | Other drainage well | (4) or (5) |
| 5N | Nuclear waste disposal other than Class IV | (11) |
| 5R | Recharge well | (6) |
| 5S | Subsidence control well | (10) |
| 5T | Geothermal well | (12) |
| 5W | Waste disposal well | (2),(5),or (9) |
| 5X | Other Class V wells | (8),(13),(14) or (15) |

*After Davis and Nienkerk, 1984

## Illinois Responses to the USEPA Guidances

After the authors started this assessment, the USEPA Office of Drinking Water (Washington, D.C.) issued two memorandums. Both were intended to provide guidance in conducting Class V well assessments. The first (Cook, 1986) sought to expedite the various assessments taking place throughout the United States. It emphasized screening Class V inventories and concentrating on well types. The second guidance (Belk, 1986) provided various attachments suggesting ways in which individual states might structure their reports.

While the authors of this report did make attempts to incorporate ideas from these guidances, it was apparent that some differences of opinion were possible. These differences may influence how an assessment is performed. Therefore, for the purpose of clarification, the differences between this report and the guidances are subsequently mentioned.

This report takes exception to the first guidance (Cook, 1986) concerning proximity of injection wells to ground-water-dependent populations. In our opinion, if all of the USDW are protected, then all of the people will be protected. However, the converse is not true --if only the people are protected, then the USDW may or may not be protected.

The Illinois assessment differs from the second guidance (Belk, 1986) in its attitude towards individual wells. The guidance offers model forms for evaluating the contamination potential attributable to an individual well. While this may be worthwhile it seems ill-advised, in our opinion, because the existing level of inventory information does not allow for a well-by-well assessment. Therefore, the detail of questioning proposed in those forms, although useful to some future database, is not yet warranted except on a test basis.

Typically, while conducting this assessment, our knowledge was limited to a facility-level description. That is, we knew that a facility existed within a community and that it had some number of wells, and in some cases we knew the average depth of those wells. This level of knowledge should not have been surprising because the minimum inventory information required (and therefore available to the database) by Illinois law (Ill. Admin. Code 704.148) specifies only the following:

(1) Facility name and location
(2) Name and address of legal contact person
(3) Ownership of facility
(4) Nature and type of injection wells
(5) Operating status of injection wells

Exceptions to the rule, such as in the case of the City of Crystal Lake, did occur, but generally only minimal information was available in the IEPA files. Therefore, it would have been impossible to complete inspection reports similar to those provided by the second guidance (Belk, 1986).

Because of this situation and the previously completed inventory of Class V wells (Davis and Nienkerk, 1984), which identified a large number of injection wells in Illinois, it was decided to focus this study on the most typical situations. Consequently, Class V well locations were plotted on a map and where ten or more wells were found, a cluster was arbitrarily defined (figure 2). This number was determined to be significant on the basis of the frequencies of occurrence of Class V wells within Illinois communities.

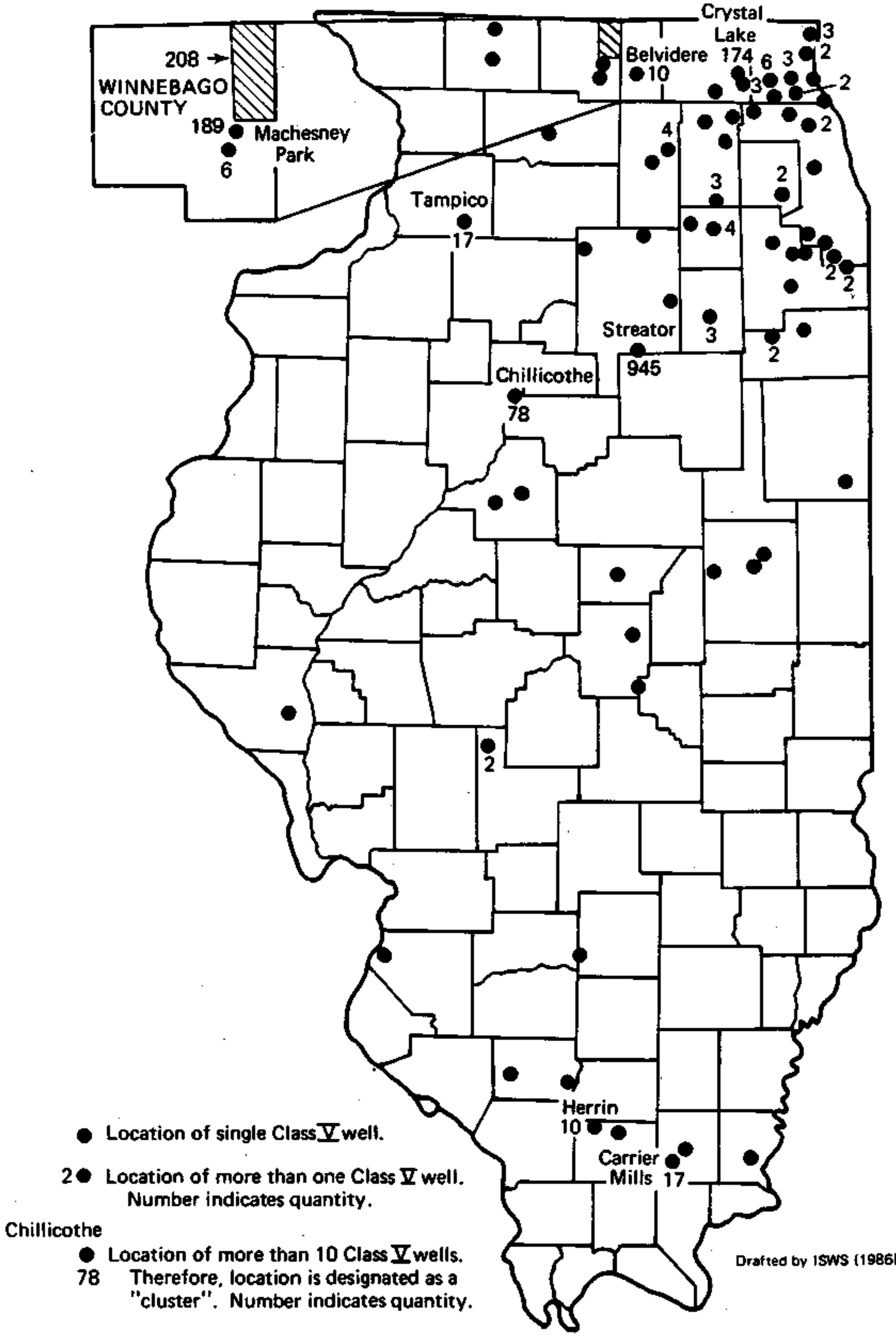



Figure 2. Distribution map of Class V wells in Illinois.

## CLASS V ACTIVITIES IN ILLINOIS

### Overview of the Previous IEPA Inventory

Davis and Nienkerk (1984) fulfilled the first step of the inventory and assessment requirements specified by 40 CFR 146.52: they conducted and published an inventory of Class V wells within the state of Illinois. That inventory, which has since been updated (M. Nienkerk, IEPA, personal communication, 1985), included facility names and locations, names and addresses of legal contacts, ownership information regarding the facilities, information on the nature and type of injection, and the operating status of the injection wells.

The report by Davis and Nienkerk (1984) discusses the scope and methods of the inventory, the data gathered, and certain areas which require further investigation. Some statistics presented in that report have changed as a result of updating. The following changes should be noted:

(1) the number of Class V wells listed on the inventory has increased from 510 to 1,766;

(2) approximately 60 percent of the Class V wells that have been identified are privately owned;

(3) approximately 97 percent of the Class V wells in Illinois are located in the northern third of the state;

(4) the highest concentrations of Class V wells are in the area of Streator (54.0 percent), in northeastern Winnebago County (23.0 percent), and in the city of Crystal Lake (9.9 percent);

(5) the majority of the Class V wells are one of two types: either waste disposal (53.3 percent) or stormwater drainage (41.9 percent) wells; and

(6) Class V wells seem to occur in clusters.

### Types of Class V Wells

On a national scale, there are many types of Class V wells injecting a variety of fluids. In Illinois, however, there are only three common types of Class V wells. The types selected for detailed examination in this study are those that need to be considered either because of their potential to contaminate USDW or because of their potential importance to the state's present and future economic well-being. Because of their relatively large numbers, the primary focus is on stormwater drainage wells and those that drain waste (mostly sewage) into abandoned underground coal mines. Additionally, agricultural drainage wells and ground-water heat pumps (and earth-coupled systems) were selected for further study because of their economic significance. The remaining Class V well types received only a cursory examination.

Because only a few types of wells make up 99 percent of the Class V injection within Illinois, it was concluded that it was not necessary to consider all possible types of Class V wells in detail while assessing the impact of these wells. Recognition of this fact, coupled with the impracticalities of describing activities in which Illinois has no experience, led to the conclusion that some types of Class V injection need not be considered in detail.

To learn more about the general construction features of Class V wells and the fluids being injected, the inventory was used to compile a list of names and addresses of people who control Class V injection wells. Persons (or corporations) who know of or are responsible for the operation of the Class V wells, in communities where clusters occur, were then contacted. Inquiries were made (questionnaire shown as Appendix B) about Class V injection activities pertaining to well construction and operation, and the type of waste being injected. Several common characteristics of each type of injection were discovered during this process. The personal contacts also confirmed the accuracy of the Class V well inventory.

## Waste Disposal Wells

General construction features. The most frequent (53 percent) Class V activity in Illinois involves wastewater and sewage disposal (often mixed with storm runoff). These wells inject nonhazardous waste (including raw sewage) into abandoned, subsurface coal mines. The wells are commonly 75 to 180 feet deep. Most are located in the vicinity of Streator, while the remainder are at Herrin, Carrier Mills, and other places where subsurface coal mining has occurred.

Nature of the fluids injected. Many liquid wastes can be injected by waste disposal wells. The fluids listed on the Class V inventory include coal sludge and slurry, dairy byproducts, nonhazardous industrial wastewater, and untreated sewage. The most common waste is domestic sewage from combined sanitary and storm sewers.

The contaminants in domestic sewage constitute less than 0.1 percent of the total volume by weight (Wenk, 1971). Thus, most domestic sewage is drinking water that was simply used as a transport media. Typical water quality parameters used in describing sewage include dissolved oxygen (DO), five-day biochemical oxygen demand ($BOD_5$), chemical oxygen demand (COD), coliform bacteria, turbidity, and suspended solids (SS).

Nichols (1977) reported that the concentrations of two of those parameters, $BOD_5$ and SS, in the average raw sewage influent at Streator were 83 mg/L and 111 mg/L, respectively. It is probable that these values are typical of the wastes reaching the abandoned coal mine beneath Streator. According to an engineering study at Streator (Warren and Van Praag, Inc., 1975), perhaps 1.34 million gallons per day were being injected into the mine.

A USEPA (1981) Environmental Impact Study (EIS) conducted in the Streator area noted that because the mine outcrops on a valley wall, the injected fluids may have an adverse impact upon the quality of nearby surface waters, i.e., the Vermilion River. Grab samples from the river failed to show that, except for fecal coliforms, the discharges and seepage from the mine had a significant impact on the river. The samples did indicate, however, that high concentrations of fecal coliforms were exiting from slopes along the valley wall where the upper coal seam is exposed.

The EIS surmised that the injected fluids undergo partial biologic degradation before exiting the mine. This is probably a correct conclusion because anaerobic digestion and removal of the settlable solids are possible within the abandoned coal mine. A factor which could possibly reduce the effectiveness of this biodegradation process is the cool temperature within the mine. However, Streator's glass manufacturers inject cooling waters (maximum temperature estimated at 90°F) into the mine and thus moderate the temperature effect.

## Stormwater Drainage Wells

General construction features. Stormwater drainage wells are the second most common type of Class V injection well in Illinois. Stormwater injection is done by what are frequently termed "dry wells" (also known as shallow infiltration wells). More than 700 stormwater drainage wells have been reported to the IEPA. The preferred method is to inject stormwater into shallow deposits of sand and/or gravel. However, in areas underlain by abandoned coal mines, stormwater drainage is through drop shafts to the mines. Fewer than forty of these injection wells are reported to drain to abandoned coal mines.

Dry wells are usually constructed by simply excavating a hole with a backhoe and then stacking concrete culverts (typically 5 feet in diameter and 30 inches high) on top of each other in the hole. The space between the concrete and the edge of the hole is filled with washed gravel (figure 3). Variations on this general design range from placing drainage nets on the bottoms of the holes before installing the culverts to using no casing at all and simply backfilling the hole with gravel or crushed stone.

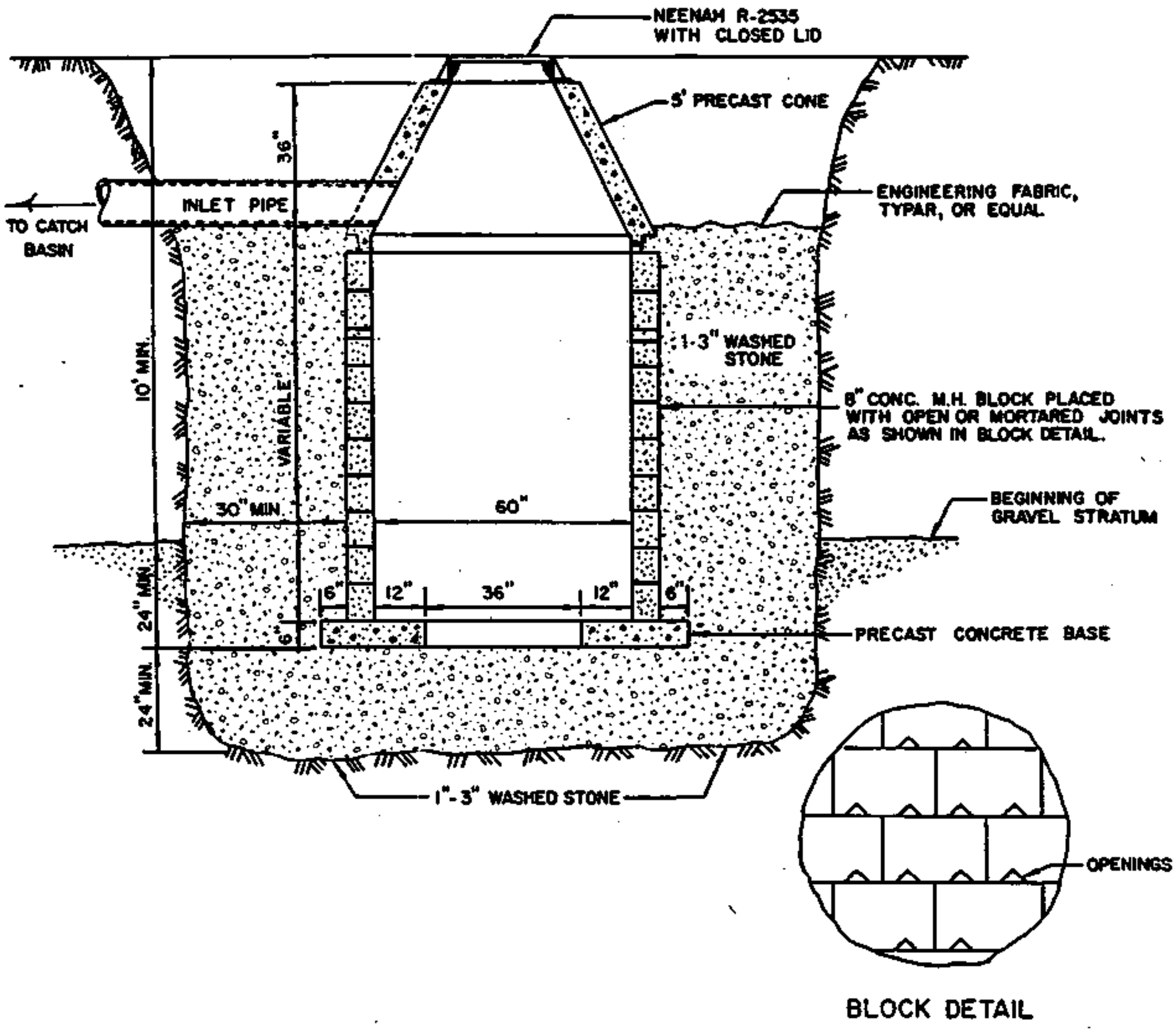



Figure 3. General design of stormwater drainage wells (courtesy of City of Crystal Lake).

Dry wells are typically installed by or for a community's public works department and occasionally without the community's water department even being aware of them. The labor is usually performed by an excavator rather than a well driller, so no records are filed with state agencies responsible for recording well information. Some communities, most notably Crystal Lake, have drawn formal illustrations of how the dry wells are to be constructed and have distributed these drawings to consulting engineers and land developers.

The purpose of this type of well is to dispose of stormwater in urban areas. The reason given for constructing dry wells is that urbanization has modified the configuration of the land surface and its natural cover (Becker et al., 1973). The engineering response originally developed at the turn of the century was to intercept the surface runoff and then convey it to the nearest watercourse by storm sewers. This approach relied on the assumption that a stream was nearby and its channel was capable of carrying away large volumes of water. Consequently, where streams were not available stormwater managers turned to dry wells, particularly where flat terrains are underlain by very permeable geologic materials immediately below the land surface. Unfortunately, these shallow water-bearing zones are often used as underground sources of drinking water by the same community disposing of the stormwater.

Nature of the fluids injected. Drainage wells receive stormwater runoff and direct that fluid into the subsurface. Very little is known about the quality of this water. When questioned about the quality of the fluid, most of the people interviewed for this study responded with words to the effect of: "what can it hurt, it's just rainwater." This attitude, coupled with the recognized benefits of artificial recharge and the economics of shorter storm sewer systems, has led to complacency insofar as the possible impacts on ground-water quality are concerned.

However, studies have shown that urbanization greatly increases the quantities of pollutants that reach streams (Randall et al., 1982). Furthermore, these contaminants are carried by suspended solids which have a high affinity for heavy metals and petroleum-based organics. Miller and Esvelt (1979) found, after examining more than 1,400 ground-water samples, that ground-water degradation was possible and was the result of pollutants contained by stormwater runoff to dry wells.

Champaign, Illinois was one of the study areas used by the USEPA for its National Urban Runoff Program (NURP). One of the primary conclusions from that study was that concentrations of lead, copper, and iron in urban runoff at Champaign are well above water quality standards (Bender et al., 1983). Concentrations of lead during the summer of 1982 were observed to range from 0.14 to 0.54 mg/L and showed a positive correlation with the amount of total suspended solids in the sample. These data represent a "first flush." That is, it has been observed (Lager et al., 1977) that the quality of the runoff improves in the later stages of a storm; consequently, water quality data must be normalized before considering the effects of contaminant loading. One must use similar time frames because of differences in travel times between the source of the stormwater contaminants and the sampling point.

Also monitored during the NURP study at Champaign were the variations accompanying snowmelt. In 1982 over 19 inches of snow melted. The community uses anti-skid compounds (road salt) on its streets. Samples were collected as if from a series of storm events because flows increased as the day warmed, peaked, and then decreased to baseflow during the colder nights. The results showed that the predominant pollutant was chloride (Bender et al., 1983). Chloride concentrations ranged from 9 to 245 mg/L with a maximum value of 803 mg/L.

Design variations. Although a general design for construction of dry wells exists, many improvements or adaptations have been attempted to meet particular needs. The most common change involves land sculpturing to enhance the transport of the stormwater to the dry well. Often detention ponds are incorporated into the overall design so that runoff can be stored and injected over a longer period of time. Thus sedimentation becomes a significant factor in evaluating the nature of the fluid that is introduced to the subsurface environment because the suspended solids carry many of the contaminants. Other modifications that influence the nature of the fluid being injected include debris traps beneath inlet grates, lateral pipes to the dry wells, and even grassed filter covers over wells filled with crushed rock.

## Air Conditioning/Cooling Water Return Flow Wells

General construction features. Most wells in this category are associated with ground-water heat pumps. All heat pumps, whether the air-to-air type or the water-to-air type, operate by extracting thermal energy from one medium and transferring it to another. Because ground water occurs at a nearly uniform temperature, it is a desirable fluid to use when designing heating and cooling systems. A ground-water heat pump represents an economically attractive alternative to conventional furnaces and air conditioners.

In Illinois, 68 return flow wells have been reported to the IEPA. Most of these wells are associated with ground-water heat pumps. The remainder are used to dispose of cooling (quenching) water resulting from manufacturing processes. The wells used in these heating and cooling applications are usually less than 200 feet deep, although some may reach depths of 600 feet.

The concern about ground-water heat pumps, in terms of the UIC regulations, stems from the fact that something must be done with the ground water after it circulates through a heat exchanger. The effluent is as clean as when it first entered the apparatus, but it has served its purpose and needs to be disposed of. The question at this point is whether the effluent will be disposed of to a surface stream/lake or to the subsurface. If the choice is to return the fluid to the subsurface through a return well, and that well is finished into or above a USDW, then the heat pump system comes under the jurisdiction of Class V UIC regulations.

The actual design and construction of return flow wells can vary greatly. Some emplace the effluent into the horizon from which it came, while others return the used water to a different horizon. In any case, the physical factors controlling the rate of return include well depth, screen length, screen placement relative to a zone of high hydraulic conductivity, slot size, age of the well, pressure, and static water level.

Type and quantity of fluid. The fluid that is injected into the subsurface is water. After use in a ground-water heat pump system, the fluid differs in only one way: temperature. The effluent will be 5 to 15°F warmer or cooler than the ambient ground-water temperature depending upon whether the system is in a cooling or heating mode.

The quantity of the fluid discharged by a heat pump varies with the size and design of an installation. Generally, for domestic installations, only 4 to 8 gallons per minute (gpm) are needed for about 8 hours per day (Gass, 1980). Doty (1980) points out that the flow rate through a heat pump system is more important than the temperature of the water entering the heat pump. With this in mind and using the estimates of Gass, it is possible to calculate that perhaps 1,920 to 3,840 gallons of water would be used by a typical household each day. This estimate appears valid because a carefully monitored house near Decatur, Illinois used 834,292 gallons in one year (Dexheimer, 1985); this figure amounts to about 2,300 gallons per day.

Because the heat exchanger consists of two coiled copper tubes, one of which is in contact with the water, a potential for contamination exists. One of the tubes carries the ground water to and from the system, while the other contains a refrigerant. The refrigerant is either R-22 (monochlorodifluoromethane) or R-12 (monochloromonofluoromethane). Both refrigerants are stable, non-toxic, non-corrosive fluids that are insoluble in water (Dexheimer, 1985). They are used in capacities of about 4 pounds per system, which is less than that used by a common refrigerator. Most systems are designed such that should a leak develop, they will cease operation (C. Lee, Illinois Geothermal Engineering, Zion, personal communication, 1986). Thus it is unlikely that the system could carry any refrigerant contaminants to the subsurface environment.

Two problems resulting from the injection of return water are possible. The first could be caused by the mixing of two different types of ground water, that is, water from two different aquifers (one of which might not even be a USDW). Because of this interaction, the water quality of one USDW could be slightly degraded. The more likely event, however, is that the changes in temperature could result in blockage of the aquifer as calcium carbonate comes out of solution. Bacon (1981) suggests that because of the generally sparse distribution of heat pump wells, this is not likely to cause a substantial regional problem.

The second possible problem relates to a special situation that exists in parts of Illinois: some ambient ground water exceeds the drinking water standards for radium (Gilkeson et al., 1983). As a consequence, ground-water heat pump systems utilizing this source might pose a problem. For example, several public water supply systems in communities of northeastern Illinois have obtained variances because analyses show that the USDW contain more trace radioactive constituents than the drinking water standards allow. Consequently, if an individual installs a ground-water heat pump in this area and then returns the effluent to the subsurface (especially if to a shallower USDW), this action could contaminate shallow ground water.

Design variations. Thermal systems using the steady temperatures of the subsurface vary greatly in design and construction. One variation is what is known as a "closed-loop, earth-coupled heat exchanger." In a horizontal configuration, a closed loop of piping filled with a solution of calcium chloride or propylene is buried between 6 and 8 feet below the surface depending upon average surface temperatures. As a rule of thumb, about 500 feet of heat exchanger piping is needed for every ton of cooling capacity. Thus most household installations require from 1,000 to 2,000 feet of 2-inch-diameter earth-coupling.

Because of their length-to-depth ratio, it is unlikely that earth-coupled systems fit the concept of injection wells. It is possible, however, that such a system could be installed vertically in a series of holes. If such a system were built, then it would not retain its exemption based on the depth-width criterion. Acceptance of this configuration is unlikely because borehole depth is a function of drilling economy. However, if economics were ignored and a vertical system was installed, the system still should not be considered under the jurisdiction of UIC regulations because the closed-loop system is not intended for injection.

## Agricultural Drainage (Injection) Wells

General construction features. All of the agricultural injection wells listed on the Class V inventory are connected to irridrain systems. An irridrain system irrigates by distributing water through field tiles. The irridrain system has three components: (1) a pump to obtain irrigation water, (2) a water storage and head control basin, and (3) the distribution system. The irridrain systems reviewed in

Illinois use both surface water and ground water for water supplies, and tiles for distribution.

The portion of the system which has been classified as a Class V injection well is the storage and head control basin. This basin is used to regulate flow through the tiles. During wet periods, water is released from the basin to a surface stream or pond, thus draining the field. During dry periods, water is added to the basin and the field is irrigated. Two different types of basins are used with irridrain systems in Illinois. One system uses concrete basins; the other system uses small ponds. Neither of these types is used for or intended for waste injection. Furthermore, the pond does not qualify as an injection well (if it is not deeper than it is wide), and the concrete basin is sealed so as to control leakage. Therefore, irridrain systems are not Class V wells.

Nature and quantity of fluid. The operators of irridrain systems in Illinois have stated that only untreated ground or surface water is used in irrigating fields with these systems. However, the water that drains from the drainage tiles may contain some agricultural chemicals. This water may be released from the drainage tiles to surface water or possibly to a dry well.

Design variations. A type of agricultural system which does not appear on the inventory, but which may exist in parts of Illinois, is the agricultural dry well. One possible situation would exist in an agricultural setting where the surface sediments consist of slow-draining clay. If an aquifer were to exist within 20 to 30 feet of ground surface, a dry well could be bored to this aquifer, which would permit a pathway for fluids to drain. Thus a direct route for migration of insecticides, herbicides, and fertilizers to the aquifer could exist. If this type of injection exists, then it is a Class V injection well and represents a direct potential source of agricultural contaminants to USDW.

## Other Types of Class V Injection

There are other types of Class V injection wells, but they are not common in Illinois. They are summarized below in the interest of thoroughness.

Salinity barrier wells. These wells are used to block the intrusion of salt water into an aquifer which may be hydraulically connected to a body of salt water -- usually an ocean. In such a situation, heavy pumpage of ground water can induce the salt water into the well field. One method used to prevent this intrusion is to pump fresh water into the subsurface between the well field and the saltwater body, thereby creating a salinity barrier. There are no saltwater bodies adjacent to Illinois; however, brine-filled aquifers do exist, and salinity barrier wells may be considered in the future if inter-aquifer flow becomes a serious problem.

Low-level radioactive waste disposal wells. This type of well injects low-level radioactive waste at concentrations low enough to be acceptable in drinking water (SMC MARTIN, INC., 1984). Only one well of this type is listed on the inventory and it should probably not be referred to as an injection well. Rather, it is a tile drainage field used to dispose of very small concentrations of beryllium. Because of the relatively short half-life of beryllium (53 days) and its affinity for clay particles, its disposal (as presently practiced in Illinois) is not expected to present a significant threat to USDW.

Recharge wells. Wells of this type are used to replenish depleted aquifers or those which are being overpumped. The injected fluid is either surface water or heavily treated sewage effluent. Three of these wells were identified in the original inventory; however, two of them proved to be heat pump drainage wells and the third has been abandoned. Recharge wells are not in use in Illinois at this time. However, it is possible to foresee a time when recharge may be desirable in the northeast part of Illinois because heavy pumpage has already greatly lowered the water levels of the deep USDW; concerns about the economics of such a venture and the source and quality of the recharge water limit this option.

Subsidence control wells. This type of injection is similar to that associated with recharge wells except that the purpose is to reduce land subsidence caused by ground-water overdrafts. Injection for subsidence control does not include that associated with the removal of oil and gas from the subsurface. Presently, there are no known Class V injection wells in Illinois which are used for subsidence control. Furthermore, the geology of the state makes it very unlikely that this type of injection will ever be needed.

Geothermal wells. This type of injection is associated with the recovery of geothermal energy for heating, agriculture, and production of electric power. The wells inject water into the subsurface to depths where it can be heated enough to be used as a source of heat energy, and then return it to the surface for utilization (SMC MARTIN, INC., 1984). Geothermal energy is usually produced in places where unusually high geothermal gradients exist, such as volcanic areas. In Illinois there are no known areas of anomalously high temperature gradients. Visocky et al. (1985) noted gradients of 0.7 and 1.7°F per 100 feet of depth in northern Illinois. Gradients in southern Illinois may be as high as 2.5 to 3.0°F per 100 feet (K. Cartwright, Illinois State Geological Survey, personal communication, 1986). Consequently, if this type of injection were to exist, very deep wells would be necessary in order to reach high temperatures (300 degrees Fahrenheit is the minimum temperature considered for geothermal heating). In Illinois such wells would reach below any USDW and therefore would not fit the definition of Class V injection.

Other possibilities. Included in this category are experimental injection wells and those not covered elsewhere. One such well has been used in Illinois. It injected compressed air below the earth's surface as a means of storing energy for later retrieval. This well has reportedly been deactivated.

More exotic uses of injection wells (which might be considered Class V) can be suggested, the most important of which would be the use of injection wells for aquifer restoration or improvement. These wells could be expected to inject a variety of fluids including microbial enhancements, ozone, liquid nitrogen, and/or oxygen-enriched water to enhance cleanup of a contaminated USDW.

# IMPORTANCE OF GROUND WATER TO ILLINOIS

Ground water is important to Illinois because it meets over one-third of the state's demand for water (excluding electrical power generation needs). It has been estimated that approximately 1,100 million gallons (or 3,375 ac-ft) of ground water are withdrawn each day in Illinois (Kirk et al., 1985). The importance of ground water is often understated because Illinois is usually thought of as a state rich in surface water. Figure 4 illustrates the distribution of pumpage from underground sources in Illinois and clearly depicts the impact of the greater Chicago metropolitan area on ground-water withdrawal.

## Availability of Potable Water

The locations of the principal underground sources of drinking water in Illinois are shown in figure 5. These units are designated as principal because they have a potential yield of at least 100,000 gallons per day per square mile and an area of at least 50 square miles (O'Hearn and Schock, 1985). Many of these water-bearing units occur to depths of approximately 2,000 feet below land surface. Others, however, occur at or within about 10 feet of the surface. These shallow water-bearing units (aquifers) are widely dispersed throughout the state and are vulnerable to contamination from many sources, including Class V injection wells (figure 6).

Potable water was first defined in 1914 by the U.S. Public Health Service (Clark et al., 1971). This definition of a drinking water standard was intended to aid engineers in designing water treatment facilities. Thus, potability did not originally refer to the quality of raw water; rather, it described the finished water quality. Therefore, the statement that water is potable is vague, particularly when discussing degrees of ground water contamination. Present drinking water standards contain maximum contaminant levels for many trace and synthetic organic compounds that were not known, were not monitored, or did not exist in earlier years.

## Basic Concepts of Ground Water

In Illinois, ground water is found in all geologic materials below the shallow unsaturated zone. Whether or not it can be used for water supplies depends on two factors: (1) the amount of ground water which can be practically withdrawn from the geologic material, and (2) the quality of the water.

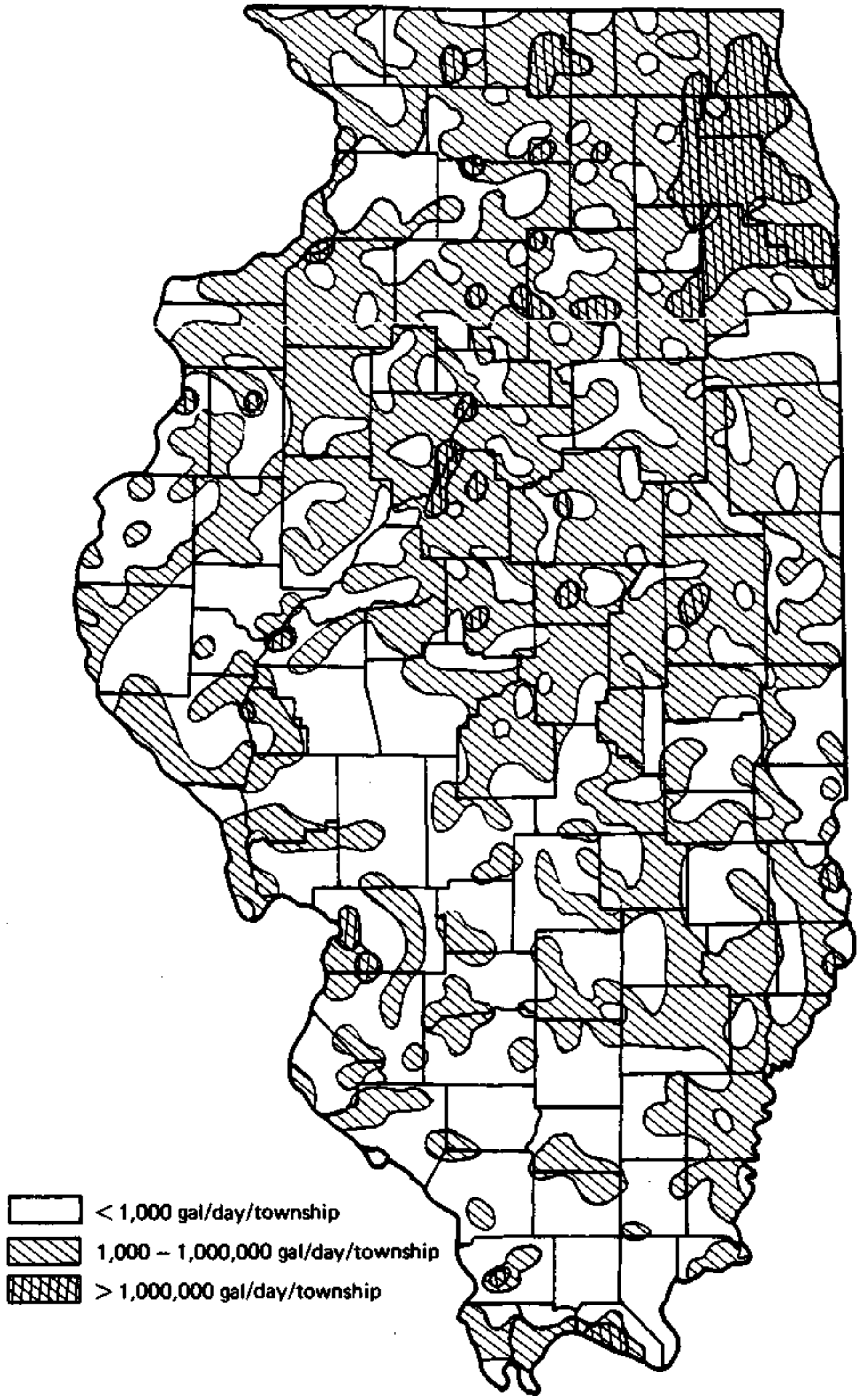



Figure 4. Ground-water pumpage in Illinois (excluding rural domestic and livestock uses).

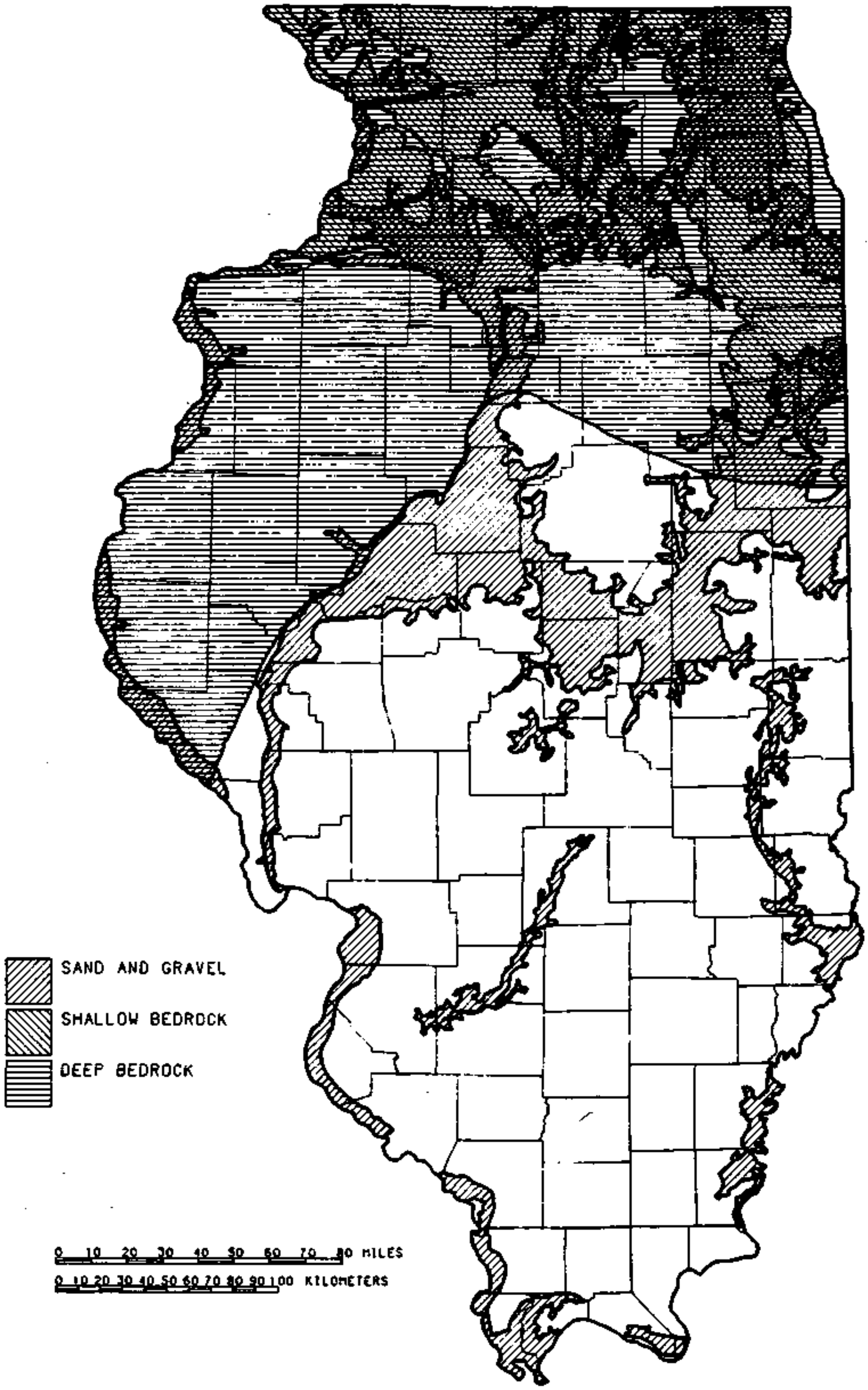



Figure 5. Location map of the principal underground sources of drinking water in Illinois (from O'Hearn and Schock, 1985)

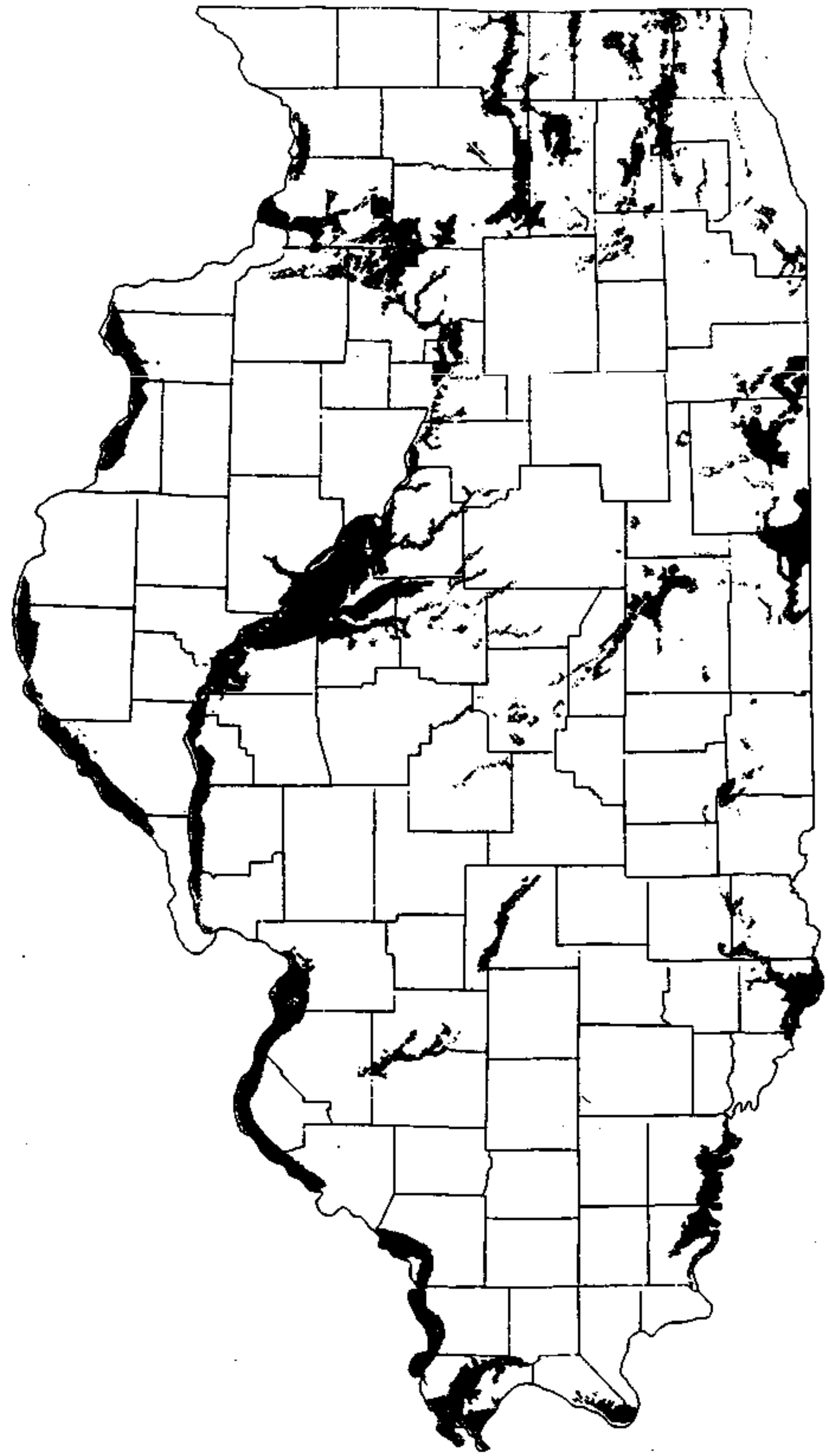


Figure 6. Location map of water-table aquifers in Illinois.

Ground water occupies the void spaces in a geologic material. These void spaces may be between grains of a clay, sand, or sandstone; or the voids may be fractures in a dolomite, limestone, or shale. The percentage of void space in a geologic material is defined as porosity. A geologic material in which all of the void spaces are filled with water is saturated. The ability to withdraw useful amounts of water from this geologic material depends on the ease with which water moves through these void spaces. In general, water will move more readily through large, interconnected voids than through small voids. Thus a coarse-grained sandstone will yield a greater amount of water than a fine-grained sediment, even though the sediment may have a greater porosity, mainly because the void spaces in the sandstone are larger.

The measure of the ability of a geologic unit to transmit water is its hydraulic conductivity. In general terms, a formation with a high hydraulic conductivity will yield more water for a given thickness than a formation with low hydraulic conductivity. Table 2 lists typical values of hydraulic conductivity for common geologic materials in Illinois.

Table 2. Estimated Hydraulic Conductivities for Typical Illinois Geologic Materials*

| Geologic Material | Hydraulic Conductivity (cm/sec) |
|---|---|
| Clean sand and gravel | $1 \times 10^{-3}$ |
| Fine sand and silty sand | $1 \times 10^{-5}$ to $1 \times 10^{-3}$ |
| Silt (including loess) | $1 \times 10^{-6}$ to $1 \times 10^{-4}$ |
| Gravelly till (less than 10% clay) | $1 \times 10^{-7}$ to $1 \times 10^{-5}$ |
| Till (less than 25% clay) | $1 \times 10^{-8}$ to $1 \times 10^{-6}$ |
| Clayey till (greater than 25% clay) | $1 \times 10^{-9}$ to $1 \times 10^{-7}$ |
| Sandstone | $1 \times 10^{-4}$ |
| Cemented fine sandstone | $1 \times 10^{-7}$ to $1 \times 10^{-4}$ |
| Shale | $1 \times 10^{-11}$ to $1 \times 10^{-7}$ |
| Dense limestone/dolomite (unfractured) | $1 \times 10^{-11}$ to $1 \times 10^{-8}$ |
| Dense limestone/dolomite (fractured) | $> 1 \times 10^{-4}$ |

*After Berg et al., 1984

A geologic unit which yields water in sufficient amounts to be economically developed is known as an aquifer. If the unit yields water that is of a high enough quality, then it is referred to as an USDW. Thus not all aquifers are USDW. Most ground water in Illinois is obtained from unconsolidated sand and gravel, sandstone, or fractured limestone and dolomite. However, where these materials are absent, ground water may be obtained in very small quantities as seepage from cracks and small sand lenses within till deposits (predominantly glacial clays and silts), or possibly from fractures in shales.

Geologic materials which do not yield adequate amounts of ground water are known as aquitards. They are also referred to as confining layers because: (1) ground water in an aquifer below these layers is often under artesian pressure, and (2) they restrict the movement of ground water between aquifers. These layers are usually characterized by clay deposits (including till), shales, or massive unfractured limestones and dolomites.

Aquifers (some of which may be USDW) are either confined or unconfined. Unconfined (water table) aquifers in Illinois generally consist of unconsolidated sand and gravel near-surface deposits. The top of the saturated zone in an unconfined aquifer is called the water table. Because unconfined aquifers often are not protected by overlying materials of low hydraulic conductivity (which can retard the movement of contaminants), they are the most susceptible to contamination. If ground water in an aquifer is under pressure such that water in a well will rise above the top of that aquifer, then that aquifer is considered to be confined. The level to which the water will rise in wells in a confined aquifer is known as the potentiometric surface.

The quality of water within an aquifer is vital to whether or not that aquifer may be used as a source of drinking water. The quality may be such that it can be improved, or the water may be undrinkable because of natural and/or manmade causes. Naturally occurring low-quality water is usually the result of high concentrations of dissolved solids. If the water is too salty for most uses, it is referred to as brackish. Waters which are high in dissolved solids are referred to as brines. Most of Illinois is underlain by brine aquifers. Brine and brackish aquifers are found at depths greater than 2,000 feet in the northern part of the state; however, they may be as shallow as 100 feet in southern areas. Another possible form of naturally occurring ground-water contamination is naturally occurring radioactive elements.

Contaminants spread through an aquifer in the form of a plume. The mechanisms that influence plume migration are listed on the next page.

(1) Advection: the process by which the contaminants are carried by the natural movement of ground water. Advection causes a plume to migrate in the direction of ground-water flow.

(2) Dispersion: the process by which the plume mixes with the ambient ground water. Dispersion causes the peak concentration of the plume to decrease, while also causing the size of the plume to increase.

(3) Attenuation: this term applies to all reductions in concentration which can happen to constituents of a plume. The migration of certain components of a plume will be severely retarded by chemical reactions in the ground-water system, such as the adsorption of heavy metals to certain clay particles, while other components, such as chloride, will not be adsorbed.

Contaminant plume development varies, even if given the same amount of time and initial concentration, as illustrated in figure 7. In case A (figure 7a), where contaminants quickly seep into a sand with a high hydraulic conductivity, they are carried in the direction of flow by ground water (advection). As the plume moves in the direction of regional flow, the contaminants mix with ground water and cause the peak concentration of the plume to decrease while the size of the plume enlarges (dispersion). The plume does not readily flow through the lower clay layer because the hydraulic conductivity of that clay is very low. Thus the underlying confined aquifer is not affected by the contamination of the shallower aquifer.

In case B (figure 7b), the spill occurs over a soil/clay layer. The low hydraulic conductivity of the soil and clay retards movement of the fluid, while the concentration of the contaminants is reduced by adsorption of contaminants onto clay particles (attenuation). Thus only very small amounts of contaminants reach the aquifer. In this case, the potential for ground-water contamination is reduced because, unlike in case A, the contaminants are retarded by the clay layer.

## Class V Injection and the Ground-Water Environment

The ability to inject fluid into a geologic material is similar to the ability to withdraw water from that material. Materials with high hydraulic conductivity are more desirable as injection zones than are materials with low hydraulic conductivity. Injection into non-aquifer materials such as shales and clays is not feasible, because these materials have low hydraulic conductivities and will not accept fluids at a rate suitable for injection.

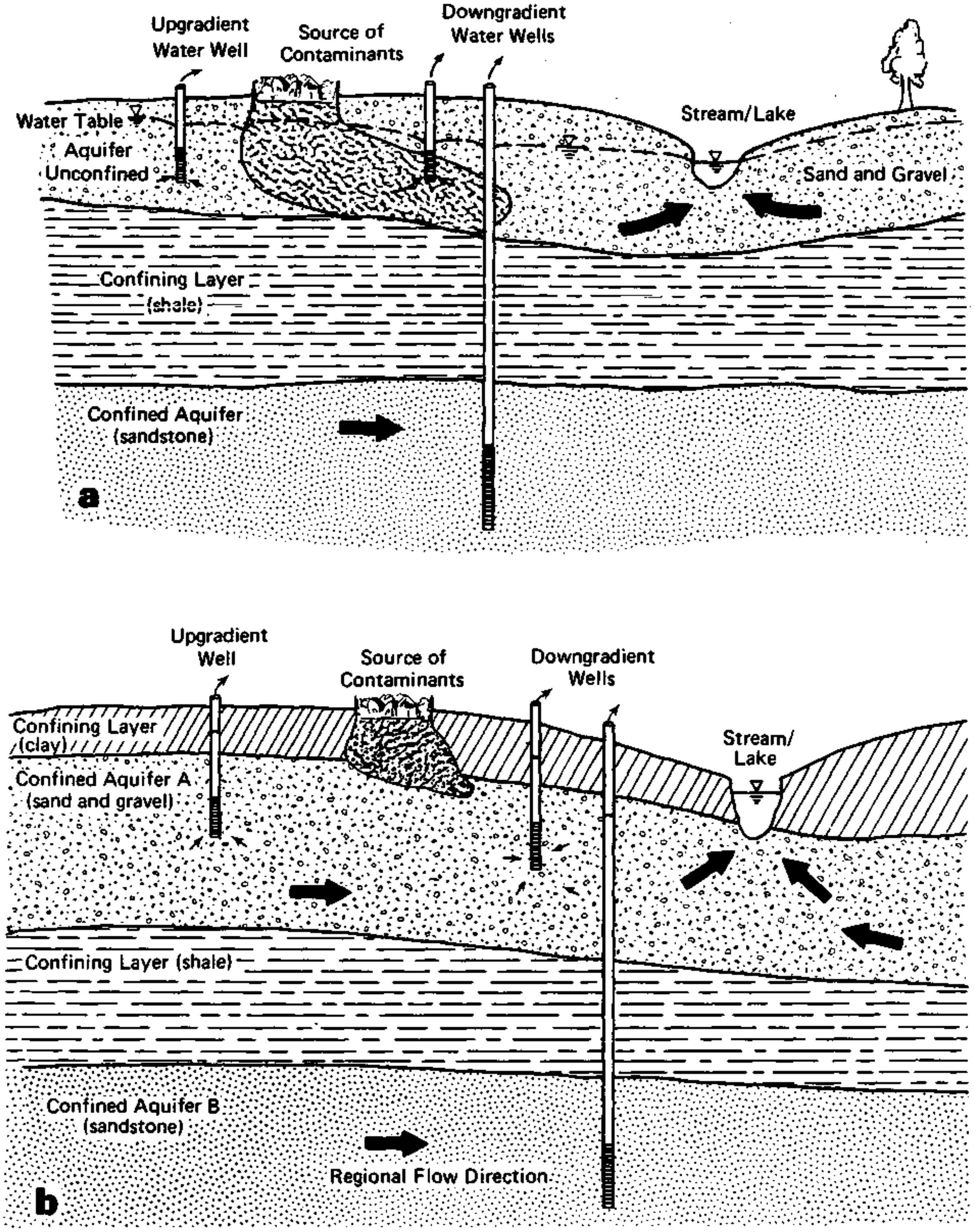



Figure 7. Examples of contaminant plume migration: Case a, plume configuration affected by advection and dispersion only; Case b, plume configuration affected by advection, dispersion, and attenuation in the form of adsorption in the unsaturated clay zone.

Injection of contaminants into the shallow ground-water environment has much the same effect as a surface spill directly on a sand aquifer. The actual effect which shallow injection will have on the aquifer is dependent on the volume and composition of the injected fluids. Figure 8 illustrates some of the potential hazards of dry-well injection into a sand aquifer. Dry-well injection poses a substantial threat to ground water because the fluid is injected directly into the aquifer. Thus, fluids such as stormwater drainage are allowed to flow directly into the aquifer, bypassing many of the biological and chemical reactions which might normally occur in the overlying soil and which would decrease the concentration of any potential contaminants. Furthermore, dry wells used for stormwater drainage concentrate the contaminants at discrete locations within the aquifer, whereas nonpoint sources are more likely to be less concentrated.

Injection into open caverns is done in two geologic environments. Most frequently, it occurs in areas where underground coal mining has been practiced. The second method of underground injection is by disposal of wastes into dolines (sinkholes). This form of injection is limited to the relatively small karst areas but nevertheless presents a potential problem.

Disposal of wastes into an abandoned coal mine is the more common form of disposal into caverns. It is accomplished by dumping wastes down abandoned mine shafts, boreholes, or wells drilled specifically for waste disposal. The wastes are then supposedly contained within the mine(s), which usually have natural shale and clay confining layers above and below the coal seam. Injection into open caverns below the ground surface may present potential threats of ground-water contamination. Figure 9 illustrates some of these hazards. The potential for ground-water contamination depends on the volume and composition of the fluid injected and on the proximity and degree of interconnection between the coal mine and any potable aquifers. Contamination of an aquifer due to this type of injection is dependent on a pathway for contaminants to migrate from the coal mine to the aquifer. This pathway could consist of unsealed boreholes or wells, or seepage through confining beds. Injection into shallow coal mines also presents a possible contamination threat to any surface water bodies, if any mine outlets exist near that surface water body.

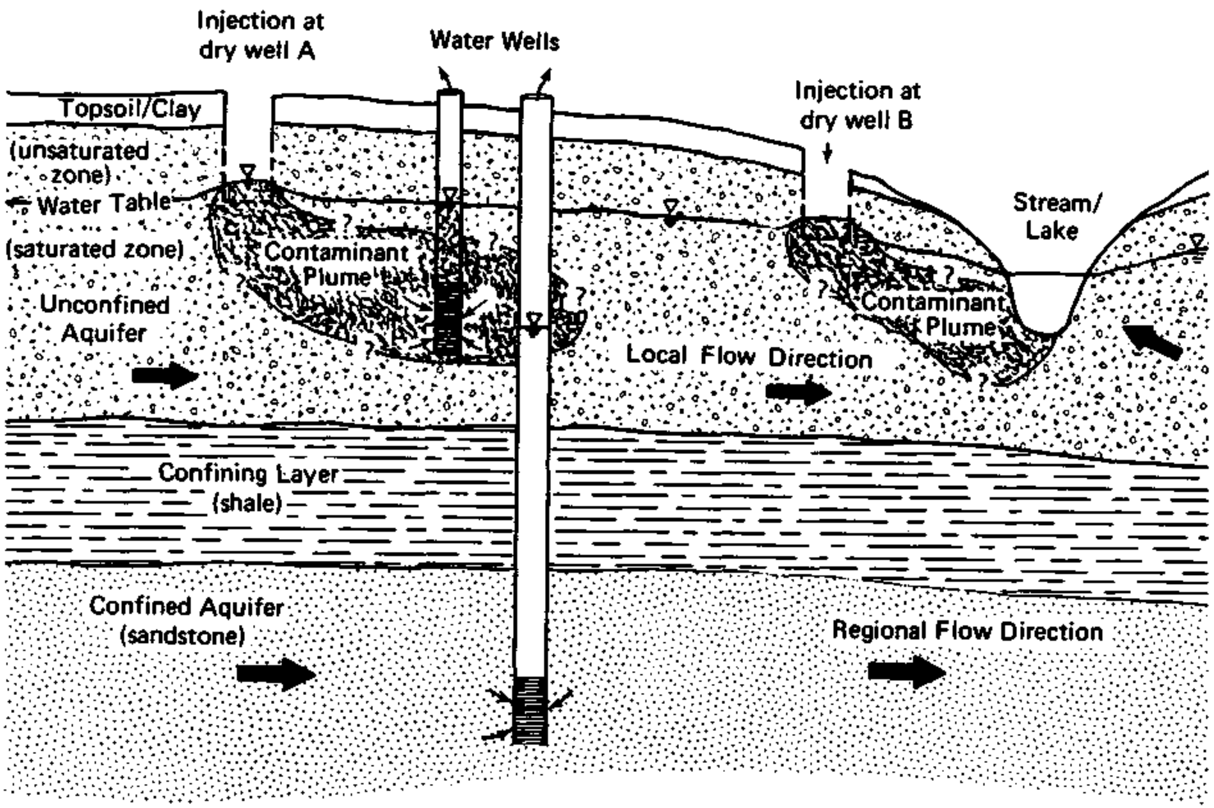



Figure 8. Dry well injection into an unconfined aquifer. Injection at dry well A allows possible contaminants to bypass many of the possible attenuation effects of the surficial topsoil/clay zone. Shallow wells near the injection well are affected by possible contaminants, while deep wells are protected by a confining shale layer. Injection at dry well B does not affect any downgradient wells. In this case, contaminants are discharged to a local surface water body.

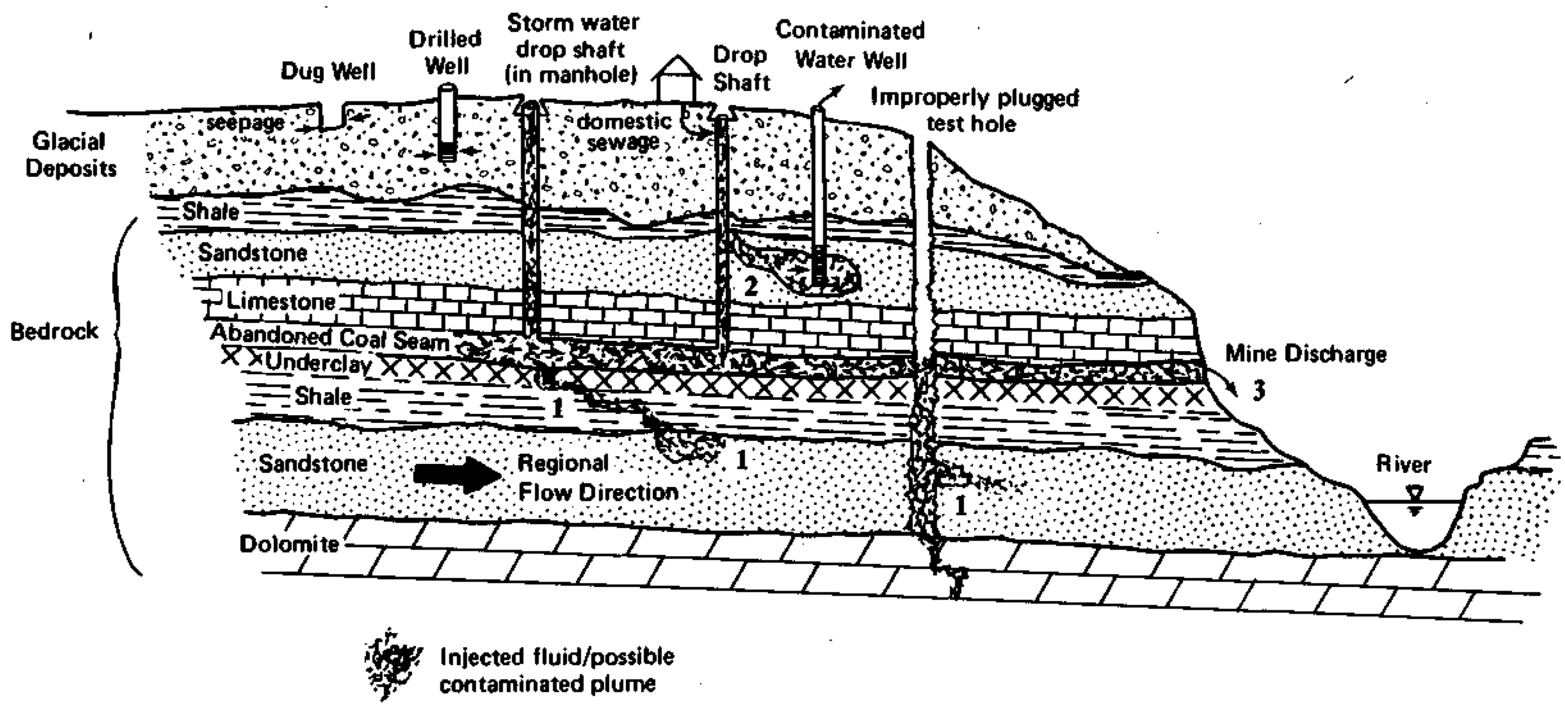



Figure 9. Three possible routes of ground-water contamination after injection of wastes into a coal mine: 1) seepage through cracks or fractures in the underlying shale layer or through an improperly sealed test hole contaminates a deeper aquifer, 2) leakage from an improperly constructed injection/disposal casing allows contaminants to reach an overlying aquifer, or 3) seepage from an exposed face of the coal seam reaches a surface water body.

# EXAMPLES OF CLASS V ACTIVITY IN ILLINOIS

## Introduction

Several areas of Illinois have been reviewed to assess the potential for contamination due to Class V underground injection. Because more than 80 percent of the Class V injection wells in Illinois are located in eight clusters, these activities are described individually. Because of the proximity of the wells to one another, some Eeneralizations about the geology, occurrence of ground water, injection zone, and potential for contamination can be made for each area.

The areas around Class V well clusters were studied. Geologic cross sections were constructed for each of these localities so a determination could be made of where the injection horizon was located relative to the USDW. Such a determination is useful in making inferences about the contamination potential to USDW associated with each well type.

Files for wells around each cluster were reviewed to discover preferred ground-water usage patterns. All wells (both public and private) within about 2 miles were counted and categorized by aquifer. The water-producing formation was noted and compared to the lithology shown on the cross section. The results for all wells in each community were tabulated and the preferred USDW was noted. Several sites were found to be entirely dependent on ground water for drinking water, while other locations relied primarily on surface water supplies. As might be expected, there are some communities that have a cluster of Class V wells and use both surface and ground water for water supply. Consequently, it is important to look for interaction between the injection horizon and surface water bodies.

## Northeast Winnebago County (Rockton, Machesney Park, Roscoe, and Harlem Townships; Population over 25,000)

Many of the Class V wells in this area (figure 10) are reported to be along U.S. Highway 51, which follows the Rock River Valley. The glacial drift in this valley reaches a thickness of over 300 feet. The drift generally consists of interbedded tills, outwash, and lacustrine deposits (figure 11). The thick and extensive outwash deposits of sand and gravel found in the valley are used as a source of ground water. The Ordovician age St. Peter Sandstone of the Ancell group underlies the Rock River Valley. This sandstone yields large quantities of water to many users throughout the region.

An estimated 400 Class V stormwater drainage wells are present in this area. These wells are typically large in diameter (3 to 5 feet) and no more than 10 feet deep. Some wells have been overgrown with grass (about 200 along U.S. Highway 51) and are presumed lost, while others (about 190 in Machesney Park) are vacuumed yearly. In all

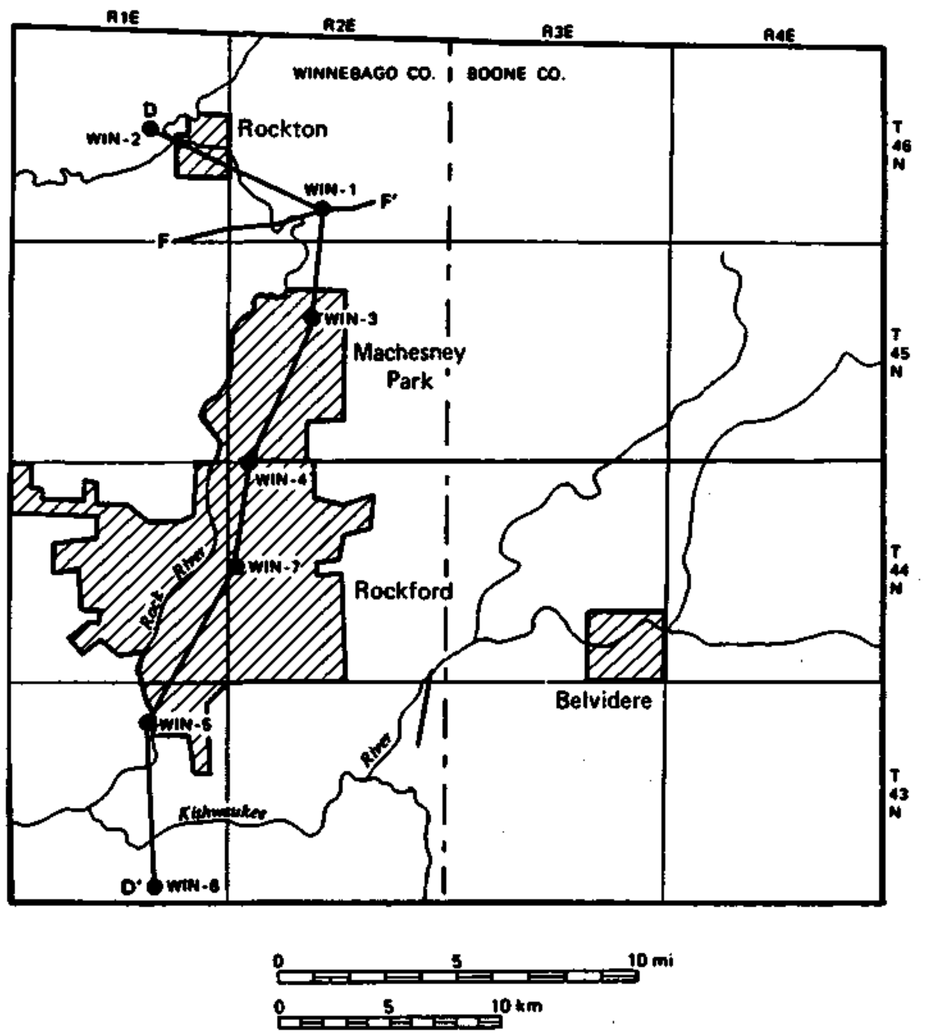



Figure 10. Location map of northeast Winnebago County, illustrating the locations of cross sections and the communities of Rockton, Machesney Park, and Belvidere (after Berg et al., 1984).

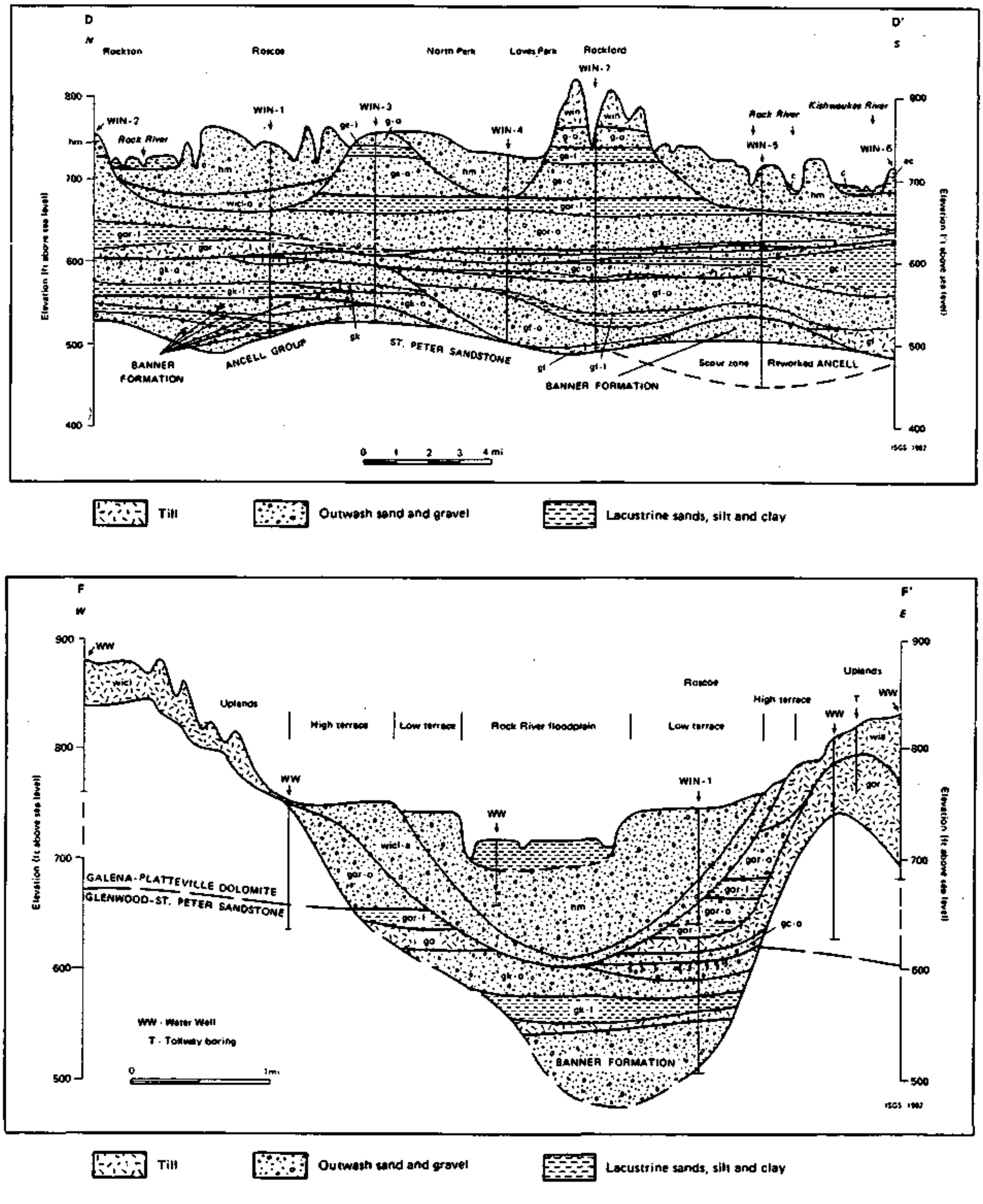



Figure 11. Cross sections along and across the Rock River Valley in northeast Winnebago County (after Berg et al., 1984)

cases, these dry wells use the shallow sand and gravel as an injection zone.

Ground-water usage patterns within the area vary from one locality to the next. For instance, Rockton (population about 2,300) has 596 water well records on file with the ISWS. Of these 596 wells, 93 percent are domestic wells finished in the shallow sand and gravel aquifer. Machesney Park (population about 20,000), on the other hand, has about 175 water wells, of which only 30 percent are finished in the drift. Clearly, no particular USDW is the most preferred.

The potential for contamination of the shallow drift aquifers due to Class V stormwater injection is high. The primary potential contaminant is probably road salt (CaCl and/or NaCl). The stormwater drainage wells present a direct pathway for road salt contamination of the shallow aquifer. Other potential contaminants are oil, gasoline, and antifreeze, all of which are commonly found on road pavements and which could be flushed by rains into stormwater drainage wells. The potential effects of these possible contaminants can not be estimated with the available data.

### Belvidere (South-Central Boone County; Population 15,000)

The city of Belvidere is situated in and along the Kishwaukee River Valley. The surficial deposits consist of loess, which has a high vertical hydraulic conductivity, and overlie the Argyle Till Member of the Winnebago Formation. Sand and gravel deposits are generally present in the Kishwaukee River Valley at various depths in the drift; however, these deposits are utilized by few water wells. The drift at the Belvidere area is generally less than 50 feet thick and in some places less than 10 feet thick. The area of thickest drift is towards the Kishwaukee Valley, where the drift may be as much as 150 feet thick. As a result, the uppermost bedrock unit (the Galena-Platteville Dolomite) is the underground source of drinking water preferred by most domestic users. Larger quantities and yields are available from the deeper St. Peter, Ironton-Galesville, and Mt. Simon sandstones.

There are 10 stormwater drainage wells located in Belvidere. These dry wells are large-diameter wells less than 10 feet deep. The injection zone is the upper sand and gravel deposits in the till. Deep bedrock wells provide the public water supply at Belvidere. No wells finished in the shallow sand and gravel are recorded at the State Water Survey, although shallow sand point wells may exist and be pumped by domestic users. The potential for contamination of drinking water supplies at Belvidere appears to be low. The general absence of water wells and the relatively low number of injection wells make contamination of a well unlikely.

## Crystal Lake (Southeast McHenry County; Population 18,000)

The city of Crystal Lake (figure 12) is situated over unconsolidated glacial deposits as much as 300 feet thick. These deposits can be separated into three groups (figure 13). The uppermost group consists of sand and gravel deposits of the Batavia Member of the Henry Formation and may reach thicknesses of 60 or more feet. Tills composed mostly of clay with some limited sand and gravel lenses underlie the sands and gravels. The till ranges in thickness from 100 to more than 200 feet and provides an effective barrier between the upper aquifer and a lower basal deposit. The basal glacial deposits, where present, consist of sand and gravel up to 20 feet thick. This basal unit is capable of yielding usable quantities of ground water and may be in hydraulic connection with the underlying bedrock (a fractured Silurian age dolomite).

The city has 174 stormwater drainage wells. The wells are constructed of 5-foot-diameter perforated concrete blocks and are 10 to 12 feet deep (figure 3). The injection zone is the upper sand and gravel. Public water supplies at Crystal Lake are obtained from the deeper bedrock although some private use is made of the shallow sand and gravel. The injection of stormwater, which may contain road salt and other contaminants, may affect the water quality of private wells finished in the upper sand and gravel and/or the lake around which the community is situated. There is little threat of contamination to the bedrock aquifer.

## Tampico (Southeast Whiteside County; Population 950)

The village of Tampico (figure 14) is situated over thick glacial drift which fills the ancestral Mississippi River Valley. Surface deposits consist of 0 to 5 feet of loess (figure 15). Beneath the loess are 50 to 90 feet of sand and gravel. These deposits are Holocene age Parkland Sand and Pleistocene age outwash deposits from the Batavia Member of the Henry Formation. Underlying the sand and gravel is a till layer 30 to 50 feet thick. The basal unit consists of extensive sand and gravel deposits associated with the buried ancestral Mississippi River Valley. These deposits, which are locally 90 to 110 feet thick, may contain fine-grained silt and clay deposits of limited areal extent. Bedrock is Silurian age fractured dolomite.

Tampico has 17 stormwater drainage wells. The typical well is 5 to 6 feet in diameter and 7 feet deep. The injection zone is the upper sand and gravel unit. Records on file at the State Water Survey show only two wells, both used for public water supply, located within city limits. One well is finished in the upper sand and gravel unit and the other is finished in the lower unit. Area wells are known to utilize both sand and gravel units, as well as the fractured dolomite.

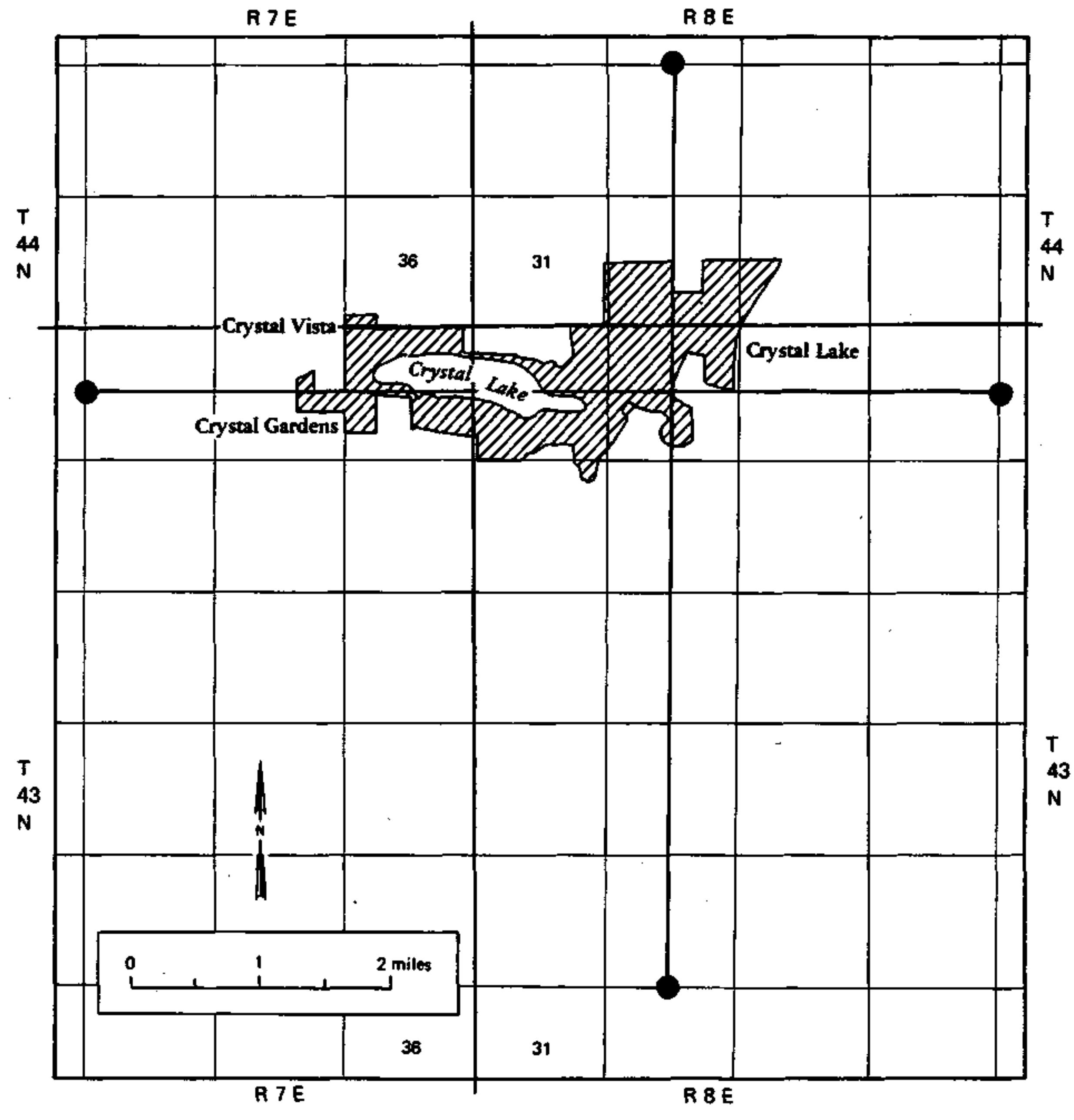



Figure 12. Locations of cross sections through the Crystal Lake area, McHenry County.

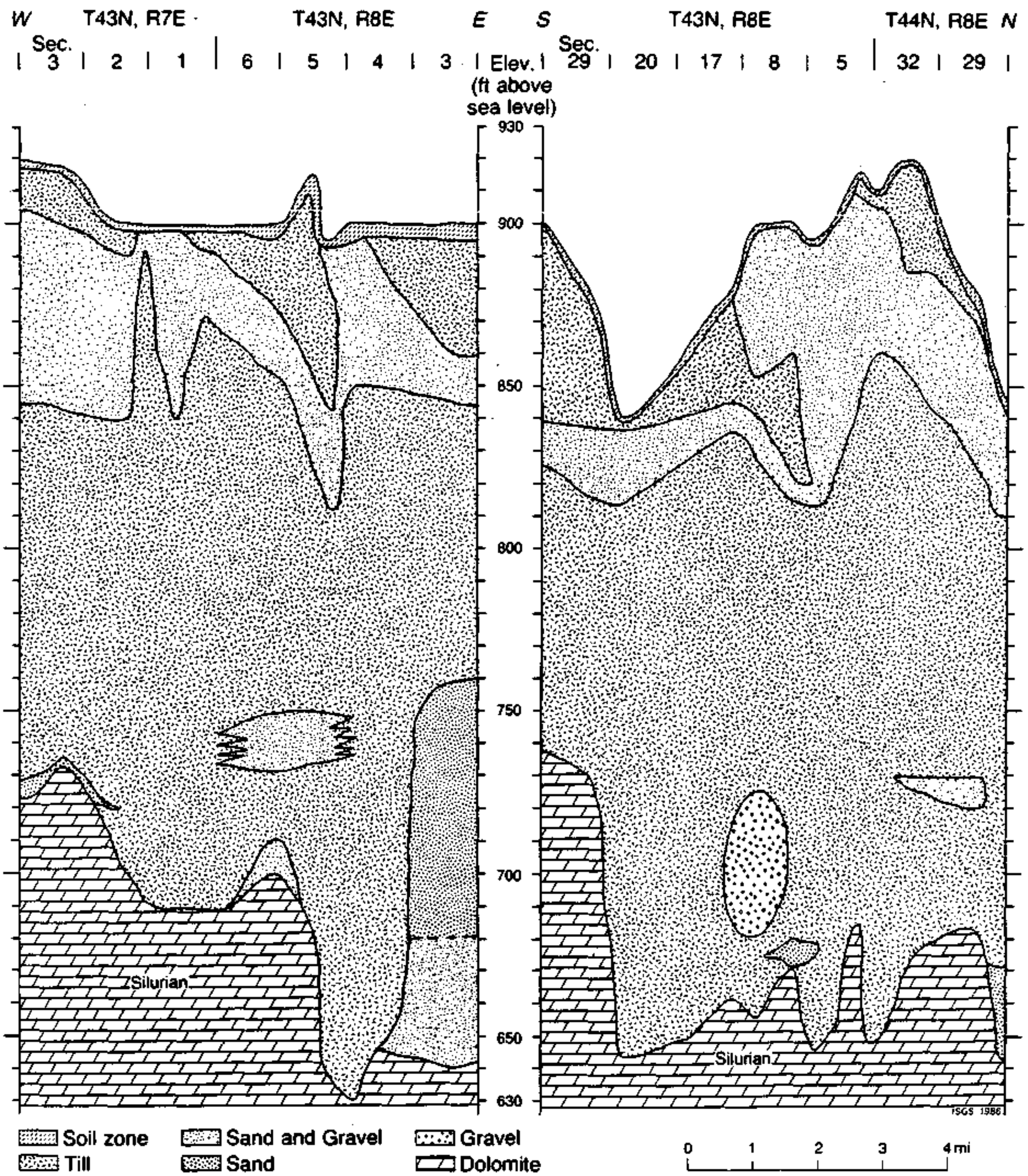



Figure 13. Cross sections through Crystal Lake area. Approximate orientations of cross sections are indicated.

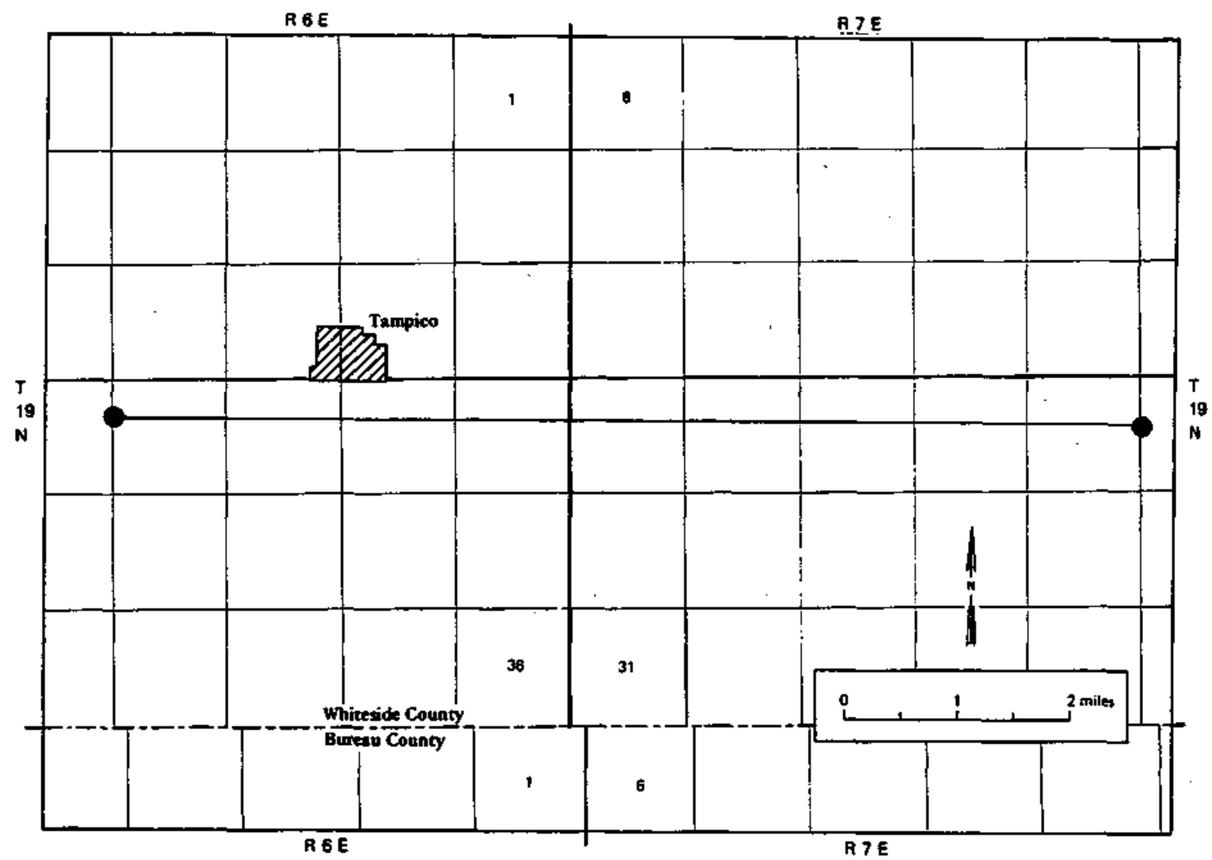



Figure 14. Location of cross section through the Tampico area, Whiteside County.

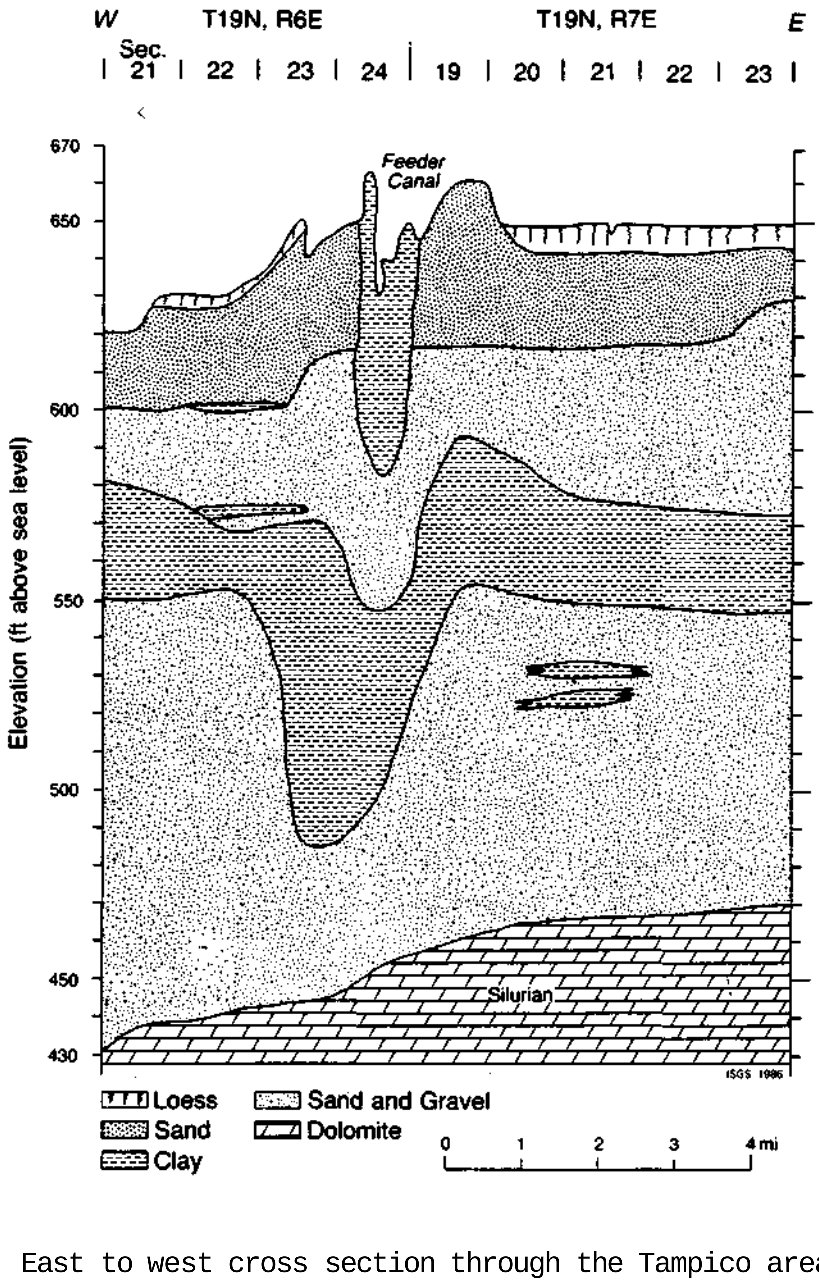



Figure 15. East to west cross section through the Tampico area. Note that only sections 22 and 23, T.19N., R.6E. are near Tampico.

The potential for contamination at this location is similar to that at Crystal Lake. The upper sand and gravel is subject to possible degradation from road salt and other urban runoff entering the USDW through the stormwater drainage wells.

### Chillicothe (Northeast Peoria County; Population 6,000)

The city of Chillicothe is situated on the western bank of the Illinois River (figure 16). Underlying 5 to 10 feet of loess is a thick and extensive deposit of coarse-grained sand and gravel (figure 17). The upper part of this water-bearing unit is a terrace deposit of the Mackinaw Member of the Henry Formation. Below it is an older sand and gravel, possibly the Sankoty Sand Member of the Banner Formation. Combined, these units are 60 to 120 feet thick and average about 90 feet. These deposits are cut by the Illinois River to the east and terminate against bedrock uplands about 0.5 mile north, 3.5 miles west, and 6 miles south of the city. The bedrock is composed of shale and sandstone (Pennsylvanian age Carbondale Formation).

The city of Chillicothe utilizes 78 stormwater drainage wells. These Class V wells are typically large-diameter wells 10 to 14 feet deep that inject directly into shallow sand and gravel. The public water supply is derived from several wells which are finished into the same zone but are 100 to 125 feet deep. All wells in this area are potentially affected by compounds which may be injected into the aquifer through these drainage wells.

### Streator ({Southern LaSalle County; Population 15,000)

The city of Streator is located north and east of the Vermilion River (figure 18) on upland deposits of the Yorkville Till Member of the Wedron Formation. The till may be overlain by 5 to 10 feet of loess. Some sand and gravel deposits are present in the till; however, they are not extensive. The uppermost bedrock is shale, sandstone, and several coals of the Pennsylvanian age Carbondale Formation (figure 19). The Herrin No. 6 Coal has been mined out beneath much of the city. A second, deeper coal, the Rock Island No. 2 Coal, was also mined in the Streator vicinity. Portions of the bedrock, including the Herrin Coal, are exposed along the valley wall of the Vermilion River. The coal seams are bounded above and below by geologic materials which have a very low hydraulic conductivity. They may, however, be interconnected at random by test holes. Consequently, contamination of a locally important Pennsylvanian sandstone is possible. Together, the Pennsylvanian units are approximately 200 feet thick. They overlie other water-bearing formations of Ordovician age limestone and sandstone (St. Peter) which are of regional importance (figure 20). Ground water from these units is utilized by local industries.

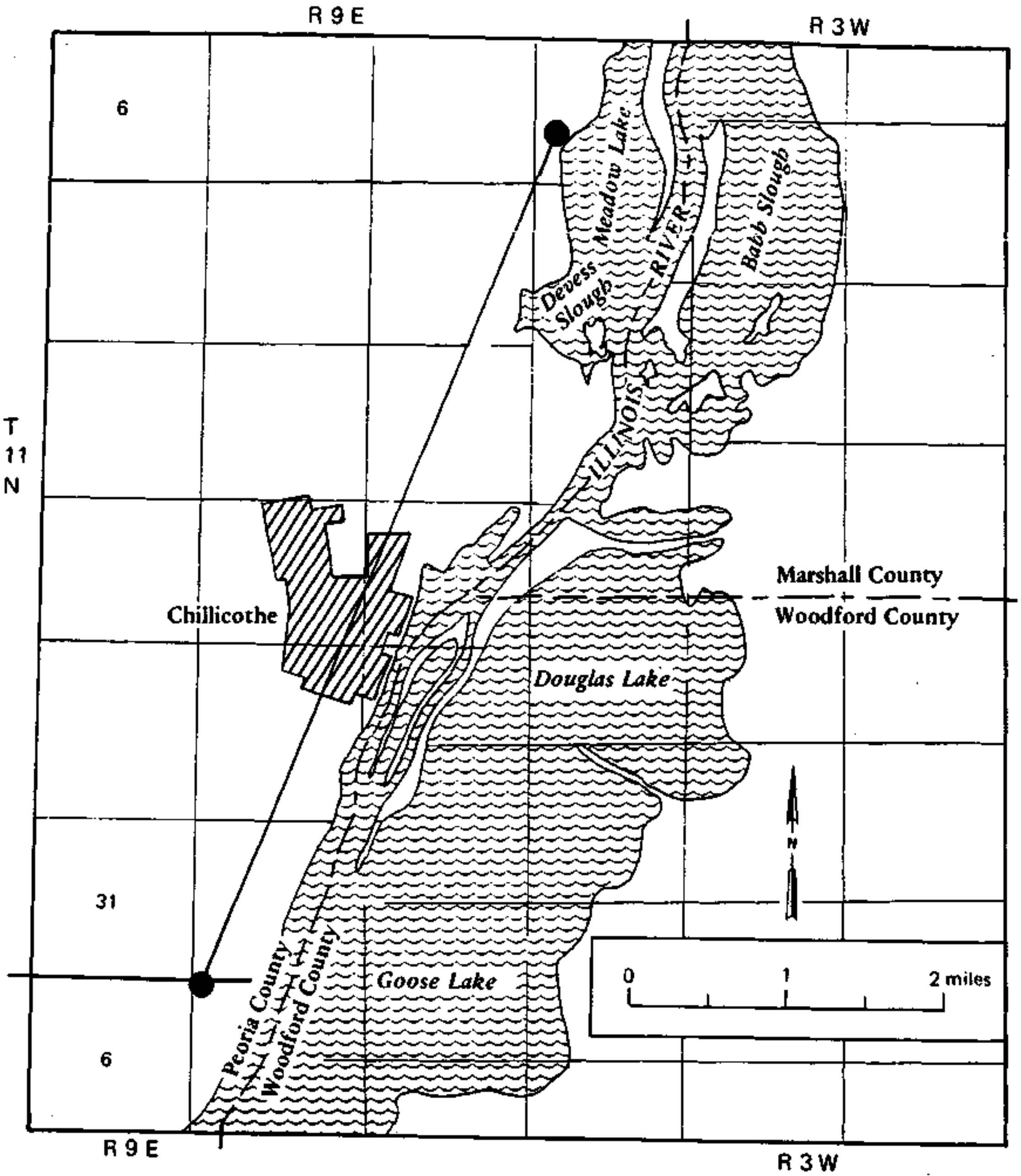



Figure 16. Location of cross section through the Chillicothe area, Peoria County.

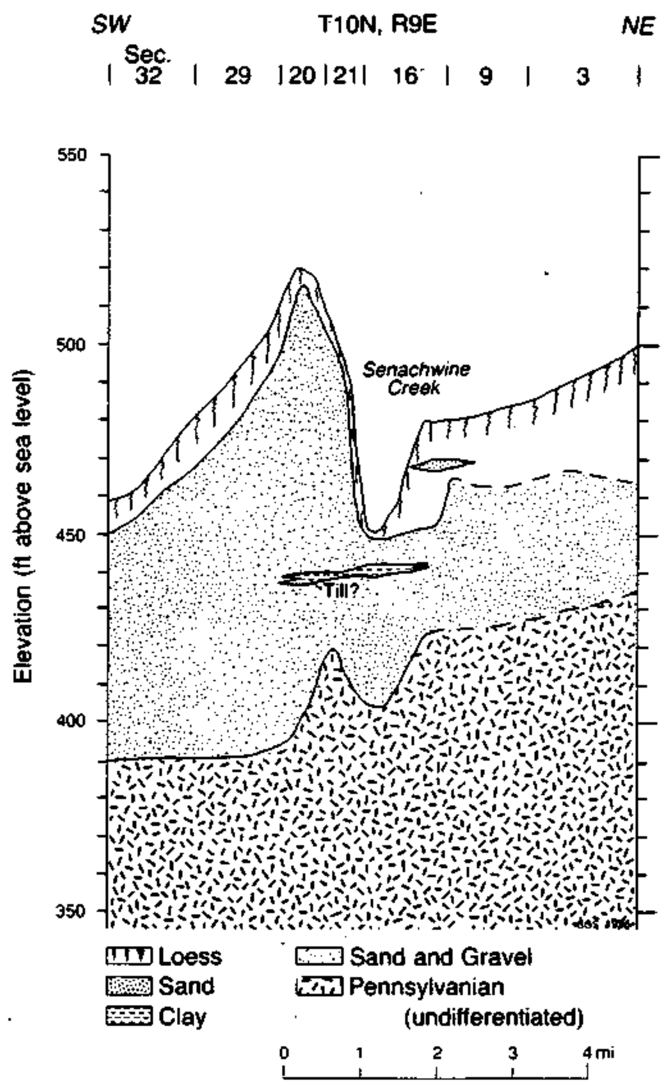



Figure 17. Northeast to southwest cross section through the Chillicothe area. Line of section is approximately parallel to Illinois River.

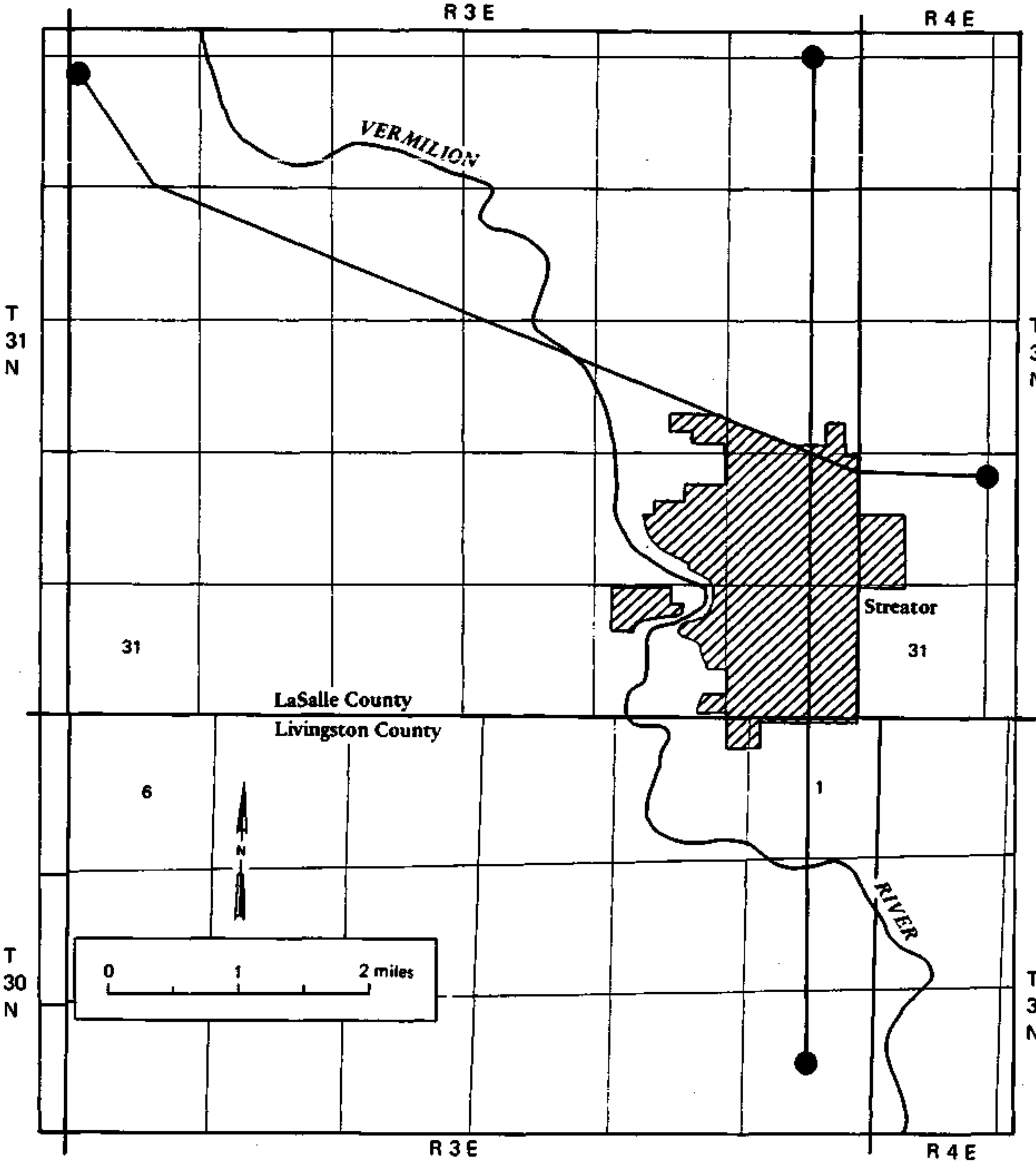



Figure 18. Locations of cross sections through the Streator area, LaSalle County.

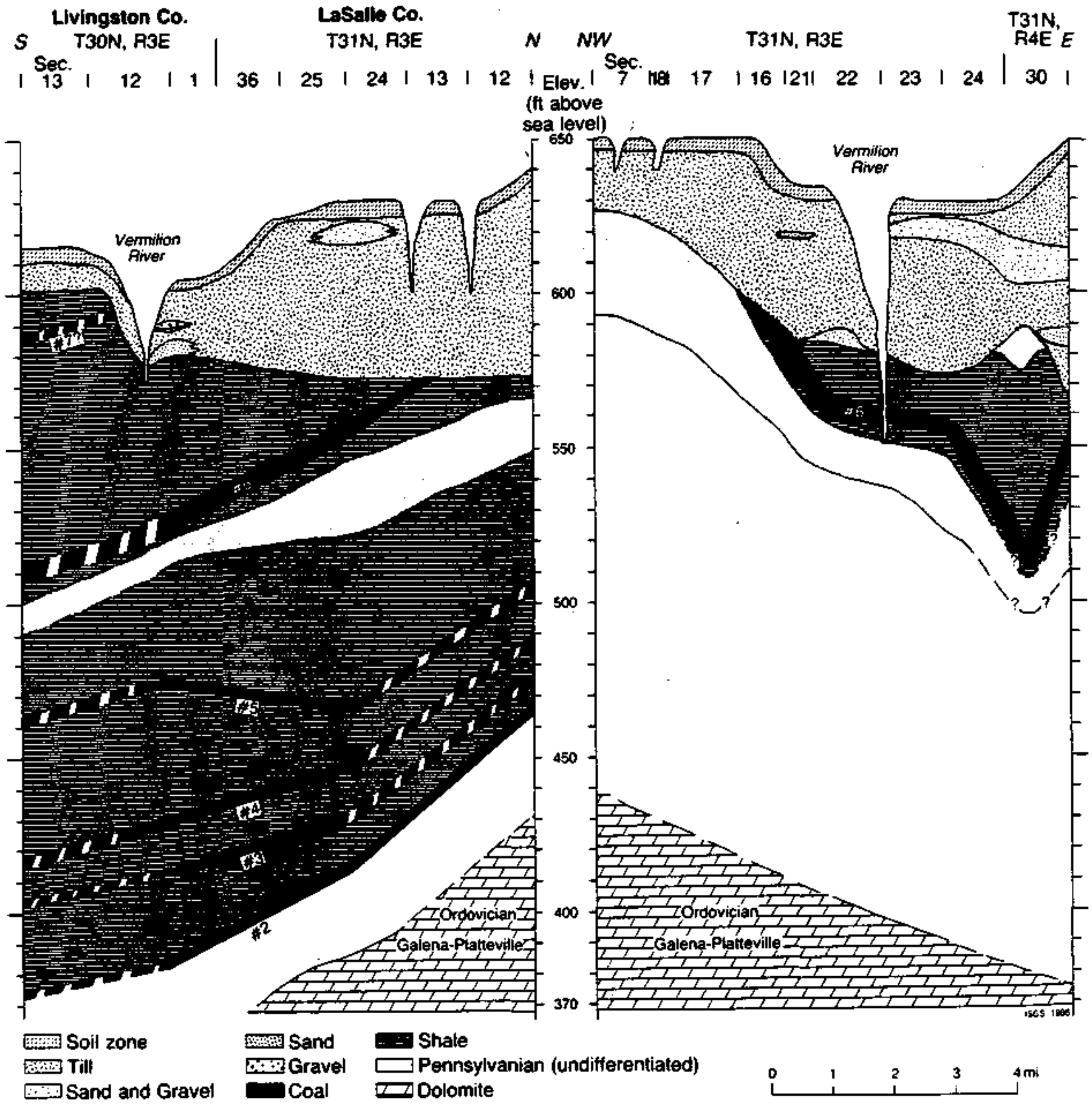



Figure 19. Cross sections through Streator area, illustrating coal seams. Approximate orientations of cross sections are indicated.

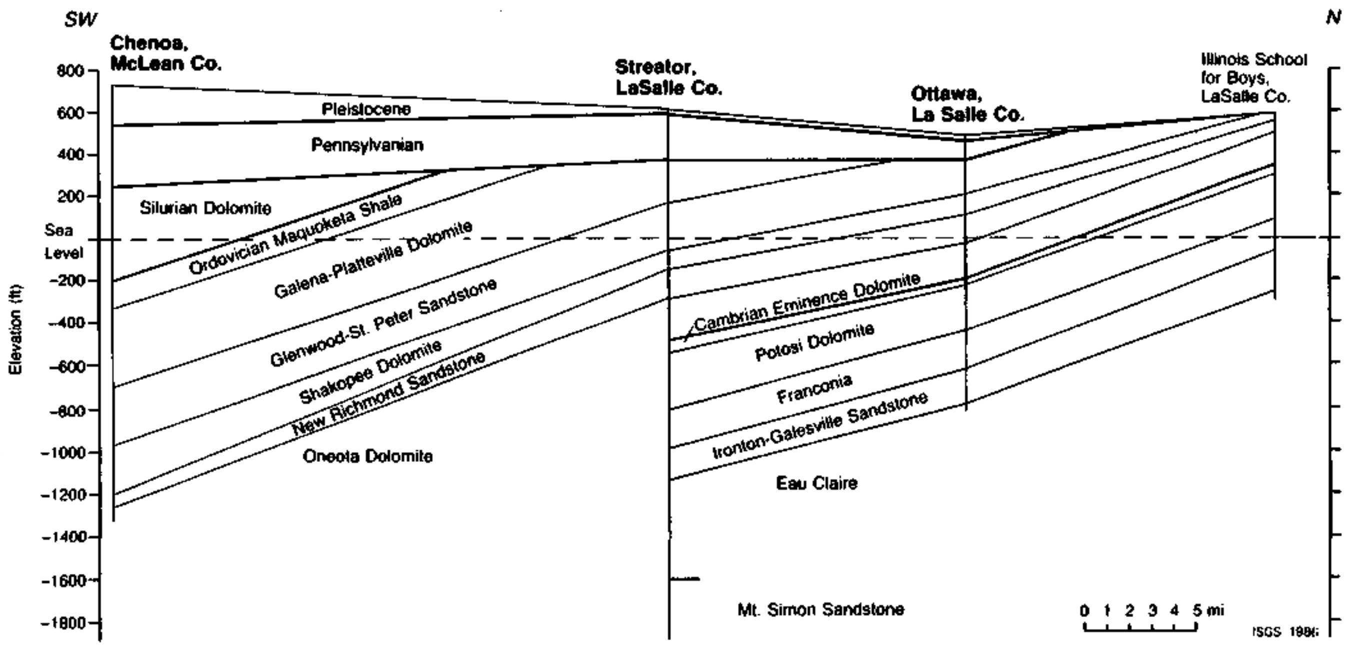



Figure 20. Regional cross section through LaSalle County based on deep drilling logs. Illustrates stratigraphic relationships of deeper sandstones to the Pennsylvanian age strata (from Willman and Payne, 1942).

Hundreds of Class V injection wells, or perhaps even more than a thousand such wells, are located in the Streator area. Drop shafts to the roof rock of the abandoned Herrin No. 6 coal mine are commonplace. No pressure is used when injecting: the fluids simply fall to the mine (the injection zone) under the influence of gravity. Because the city draws its public water supplies from the Vermilion River upstream of where the mine opening discharge occurs, there is no immediate threat to the residents using this public water supply. However, there are water wells finished in the drift, in the sandstone just below the Herrin No. 6 Coal, or in the deeper Ordovician and Cambrian aquifers. Although there is no pressure buildup, there is still some potential for leakage from the coal mine, which may adversely affect some of these water wells.

### Carrier Mills (Southwest Saline County; Population 2,200)

The town of Carrier Mills is located in the unglaciated portion of southern Illinois. The unconsolidated surficial deposits consist of up to 15 feet of, loess over a thin layer of lacustrine silt and clay of the Carmi Member of the Equality Formation.. The bedrock (Pennsylvanian age Carbondale Formation) consists of heavily faulted beds of shale with lesser amounts of sandstone, limestone, siltstone, coal, and clay. The Springfield No. 5 Coal has been extensively mined out beneath the city. Surface mining has also been practiced in some local areas.

There are 17 known Class V injection wells in Carrier Mills. All of these wells, according to the Class V inventory, are believed to be disposing of domestic sewage into abandoned coal mine seams approximately 75 to 100 feet deep. No records of active water wells are on file with the Illinois State Water Survey; however, some dug wells are likely to exist in the rural areas. If any drilled wells are finished in sandstone or fractured shales (50 to 130 feet below ground surface), they may be susceptible to potential leakage from the coal mine. Leakage may occur through or along poorly sealed borings, fractures, and fault zones. Because the community relies on surface water supplies some distance away, it is unlikely that public drinking water supplies will be contaminated.

### Herrin (Northwest Williamson County; Population 11,000)

The city of Herrin overlies glacial deposits of the Vandalia Till Member of the Glasford Formation. This clay-rich till is 20 to 75 feet thick. Underlying the till is Pennsylvanian age bedrock of the Modesto and Carbondale Formations. The bedrock consists primarily of shale, with lesser amounts of sandstone, limestone, coal, and clay. The area is heavily faulted. Much of the city has been undermined, especially to the north and west.

There are 10 Class V injection wells at Herrin, according to the inventory, which inject domestic sewage into the abandoned Herrin No. 6 coal mine. All of these wells are approximately 90 feet deep. No water wells are known to operate within the city, which utilizes surface water supplies. The absence of any significant ground-water resource near the abandoned mine makes contamination due to Class V injection at Herrin unlikely.

### Hartford Farms (North of Mazon, Central Grundy County)

Although not the site of a cluster, this location was selected for study because it typifies an activity of concern with regard to Class V underground injection. Hartford Farms owns and operates three irridrain systems. These systems were identified by Davis and Nienkerk (1984) as needing further study and evaluation. This particular operation is listed on the Class V injection well inventory.

The unconsolidated deposits at Hartford Farms are approximately 50 feet thick. A surficial layer of loess, about 5 feet thick, overlies glacial deposits of the Carmi Member of the Equality Formation. These materials are 10 to 15 feet thick and consist of fine-grained silt and clay. Underlying the Carmi Member is a sand layer which may be 5 to 20 feet thick, and in some places there is another thin clay layer, all of which lies directly on the Pennsylvanian age bedrock. The Pennsylvanian bedrock is about 250 feet thick and does not yield significant quantities of ground water. It does, however, overlie a fractured dolomite (the Ordovician age Galena-Platteville Formation), which is a regionally important USDW.

The only portion of any irridrain system that approximates a Class V well is the water storage and head control standpipe. The standpipes are constructed of concrete or steel, 3 feet in diameter and about 6 feet deep. They are sealed at the sides and bottoms, with portholes for the drainage tiles on one side of the standpipe and one porthole on the other side for use as an overflow outlet. The standpipes can be and are used to regulate the flow rate within the field tiles. This single component of the irridrain system fits the deeper-than-wide Class V criterion, although the standpipe is not intended as an injection device and does not carry wastewater.

Because the irridrain system, operating in its irrigation (injection) mode, emplaces water into the surficial loess which is underlain by materials of low hydraulic conductivity, it poses little potential for ground-water contamination. Likewise, the rate of injection is low because the hydraulic conductivity of the receiving geologic material is probably less than what would be considered acceptable for other forms of underground injection. On the basis of these observations, it is not appropriate to consider these systems as Class V injection wells.

## ASSESSING THE CONTAMINATION POTENTIAL OF CLASS V HELLS

Because the goal of this assessment is to rank Class V well types in accordance with their potential to contaminate USDW, the focus of this report now shifts to finding a mechanism upon which to base conclusions.

### Assessment Methodologies

The current emphasis in environmental assessments seems to be a return to the original reason for conducting the studies: to organize large amounts of complicated information and to weigh different factors according to their relative impact upon the environment. This has not always been the case. Often it appeared that the purpose for conducting the studies was to collect voluminous inventories of biological data (Heer and Hagerty, 1977). Now the importance has shifted back to decision-making. Because the options surrounding these decisions are not always clear, compromises are made. The term frequently employed in the 1980's to describe this process is "risk assessment" (Canter and Knox, 1985).

The concept of risk is a complex notion. One way to consider it is from the perspective of consent (MacLean, 1986) or, in other words, what is acceptable or (more specifically) what is acceptable to the public? The concept of public risk involves centralized decisions about future policy, and these decisions therefore have the potential to affect large numbers of people. The primary practical concern of these decisions is how to determine how safe is safe enough. Decisions can not be based on market or quasi-market solutions because they involve more than project activities and associated costs. The old methodologies, which were often based on cost-benefit analysis, are being replaced by other methods based on acceptable risk.

It has long been recognized by environmental impact assessors that some means of quantitative evaluation is needed. As a result, a number of schemes have been developed over the years. During this experience it has been learned that selection of the best methodology depends on the specific needs of the user and the type of project being undertaken (Jain et al., 1977). It seems appropriate, therefore, to examine some of the methodologies previously used to determine if they can be adapted to fit the needs of this project. A brief review of other significant assessment methodologies is presented.

## LeGrand Method

LeGrand (1964) described a relatively simple system for evaluating contamination potential associated with landfills on the basis of characterization of a site, particularly where little geologic or hydrologic data are available. The method is based on the summation of five factors: depth to water, distance to point of water use, sorptive capacity of earth materials, relative permeabilities of earth materials, and hydraulic gradient. The LeGrand system was designed for rapid comparison of one site with another and is largely limited to sites underlain by unconsolidated sediments.

## USGS Method

Leopold et al. (1971) developed a matrix to assess possible actions on the basis of environmental characteristics and conditions. The environmental characteristics were subdivided into categories (table 3) that also included societal and cultural criteria.

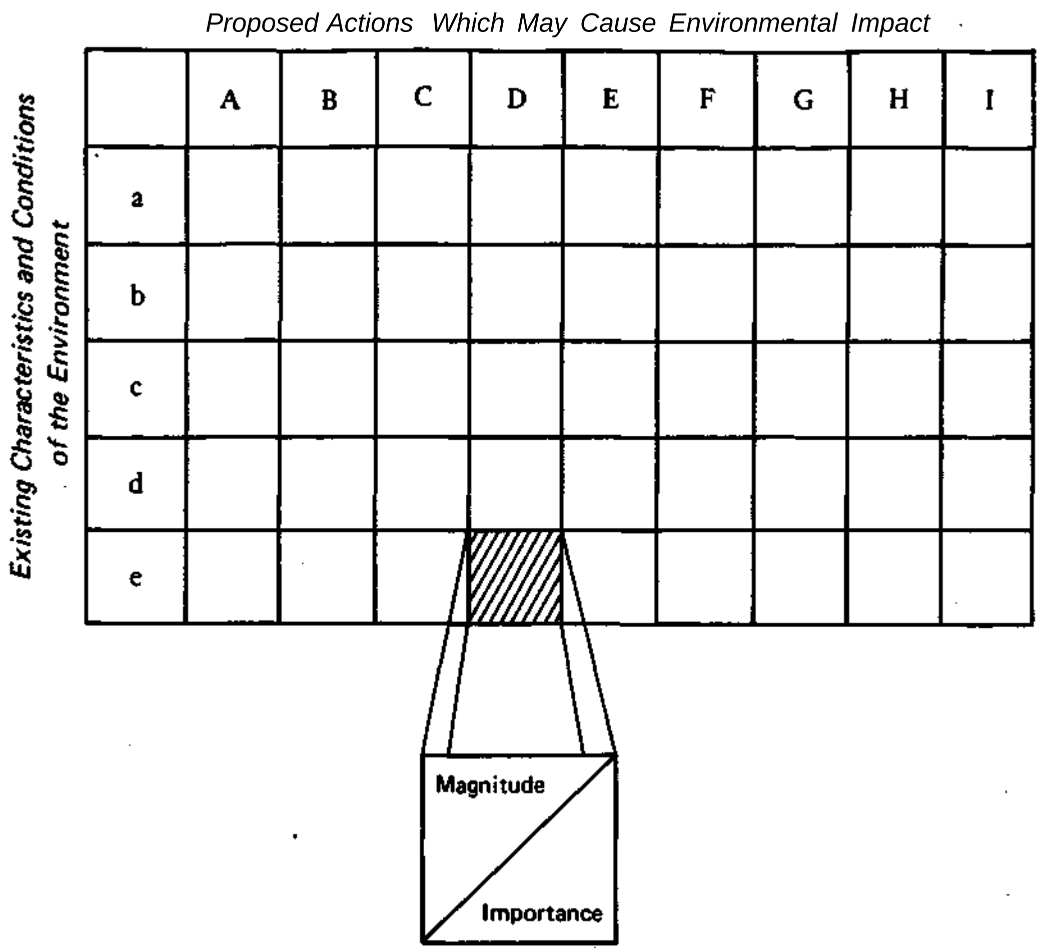
Table 3. Assessment Categories Used by the USGS Model*

a. Physical and chemical characteristics
b. Biologic conditions
c. Cultural factors
d. Ecological relationships
e. Other characteristics

*After Leopold et al., 1971

This USGS model is a serious attempt at quantifying an environmental assessment. In a matrix format, it uses numeric values to show the magnitude and importance of an impact on an environmental characteristic (figure 21). This scheme might, for example, identify that a particular action might have a dramatic impact on some aspect of the environment, even if that aspect was of little importance. Like the LeGrand model, it continues the concept of weighting the significance of a particular variable.

The USGS model is not without its problems. Most importantly, it fails to consider the secondary impacts of an action. The model is also limited in its applicability to assessing underground injection because it is oriented toward accounting for surface water and biological impacts.




General Procedure:

Where an interaction occurs within the matrix, indicate two scores for that element. The first (on a scale of 1 to 10) indicates the **magnitude** of the impact and is represented in the upper left corner. The second score (also on a scale of 1 to 10) indicates the **importance** of the possible impact. It is represented in the lower right corner of the element.

SAMPLE MATRIX

| | A | B | C | D | E |
|---|---|---|---|---|---|
| a | | 2/1 | | | 8/5 |
| b | | 7/2 | 8/8 | 3/1 | 9/7 |

Figure 21. Schematic diagram and essential procedures of the USGS system for evaluating environmental impacts (after Leopold et al., 1971).

## Jain Method

To assess the impacts of Corps of Engineers projects upon water resources, Jain (1975) and Jain et al. (1977) identified a checklist of impacts that might result from activities the Army might undertake. Most significant was that Jain recognized that some of these activities might have positive as well as negative impacts and that secondary impacts ought to be considered. As a result he developed a methodology for describing and measuring the overall impact of a project. He too developed a series of categories describing the environmental aspects of air, water, land, ecology, sound, and socio-economic factors and evaluated the impacts that a multitude of Army activities might have on these factors.

Jain disagreed with the LeGrand method on the grounds that summing a numeric score for each environmental impact has the drawback of masking the distribution of impacts. His approach was more closely aligned with the approach presented by the USGS, but differed in that equal weight was assigned to each environmental attribute. Then it becomes the responsibility of the individual reviewing the assessment to implicitly decide which attribute is more important than another. Jain reasoned that this approach was best because it allowed the ranking of importance to vary with the group considering the assessment, with geographic regions, and with time. Therefore Jain (1975) recommended that a bar chart, similar to the one shown as figure 22, be used to summarize an assessment.

Jain stressed that the methodology should be based on a checklist rather than on a matrix. A checklist approach lists specific environmental parameters to be investigated, but does not require establishing direct cause-effect links for project activities. The most significant advantage of this approach is the insight it gives the investigator in uncovering almost all possible areas of project impact. Consequently this method is useful primarily as a memory aid and not as a quantitative evaluation tool (Heer and Hagerty, 1977). The disadvantage is that many such checklists produce ungainly tabulations of baseline data.

## The Canadian Approach

Phillips (1976), while consulting for the Environmental Protection Service of Canada, developed a scheme that ranked both wastes and sites, and then combined those data in a quantitative way to arrive at a waste-site score. This score is then scaled to one of ten possible scales of acceptability.

The Canadian approach relied heavily on the previously described LeGrand (1964) method for site evaluation and the waste rating system developed by Pavpni et al. (1972). The Canadian method adopts Pavoni's scheme because it is "effects-oriented." That is, it

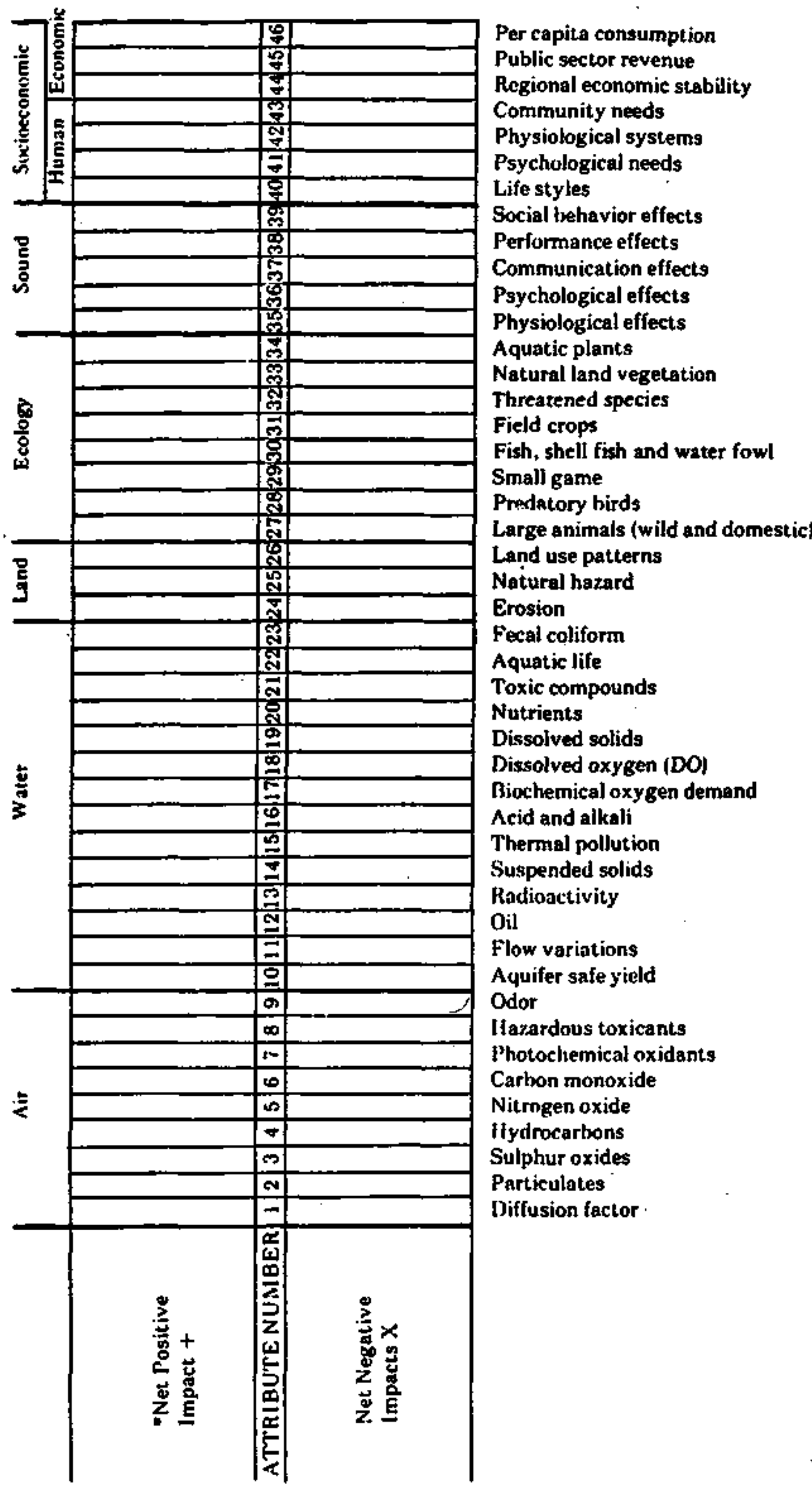



Figure 22. Example of the bar-chart approach to evaluating environmental impacts (from Jain, 1975).

Table 4. Variables Used in the Canadian Approach*

| Waste Considerations | Site Considerations |
|---|---|
| Human toxicity | Soil permeability |
| Ground water toxicity | Soil sorption |
| Disease transmission potential | Water table depth |
| Chemical persistence | Hydraulic gradient |
| Biological persistence | Infiltration rate |
| Sorptive properties | Proximity of water users |
| Viscosity of waste | Thickness of unconsolidated sediments |
| Solubility | |
| pH | |
| Application rate (Volumetric) | |

*After Phillips (1976)

considers human toxicity, ground-water toxicity, disease transmission potential, biodegradability, and mobility. Phillips modified Pavoni's parameters slightly and combined them with LeGrand's model. The result is summarized in table 4.

## The DRASTIC Model

The DRASTIC model (Aller et al., 1985) was developed for the United States Environmental Protection Agency (USEPA). It was designed to permit the evaluation of the pollution potential of any hydrogeologic setting in the United States. Fourteen "ground-water regions" are identified and each of these is subdivided into smaller hydrogeologic settings. Inherent to these settings are the physical characteristics that affect the pollution potential of ground water contained within them. Seven factors are considered significant and hence are used to name the model. They are: (D)epth to water table, net (R)echarge, (A)quifer media, (S)oil media, (T)opography, (I)mpact of the vadose zone, and hydraulic (C)onductivity of the aquifer.

The DRASTIC model is very similar to the LeGrand system because each factor is evaluated and weighted in terms of importance, relative to the others. An index is computed by summing the values assigned to each of the factors. The higher the index, the greater the potential for ground-water contamination.

The disadvantages of the DRASTIC model are that it does not account for the significance of cultural influences, modifications of the land, proximity of populations, toxicity of the contaminants, or fate of the contaminants.

## Hazard Ranking System (HRS)

The Hazard Ranking System model was developed by the MITRE Corporation (USEPA, 1982) for ranking the relative potential of uncontrolled hazardous substance facilities to cause human health or safety problems, or ecological or environmental damage. It is a means for applying uniform technical judgement to the potential hazards presented by a facility relative to other facilities.

The HRS model is applicable to an assessment of Class V injection wells because it considers:

- Migration routes and their characteristics
- Containment features
- Waste characteristics such as toxicity and persistence, and quantity of waste
- Targets likely to be impacted (population served by ground water) and the proximity of that target to the potential hazard

The HRS model bears a striking resemblance to the waste stream portion of the Canadian model. It has the advantage of considering ground and surface water, as well as some of the site considerations used by the Canadian model. It also makes provisions for accessibility by humans and animals to contaminants. This feature could be modified to incorporate the Class V need to factor in susceptibility to abuse of an injection well.

## DEVELOPMENT OF A CLASS V WELL RANKING SYSTEM

The focus of the assessment problem, the authors determined, should be the development of a scientifically defensible ranking system that would allow one well type to be evaluated against another. The validity of the system depends on which factors are deemed important and which are not. Moreover, it was critical to determine if those factors are common to all or just some well types.

Recall that an examination of the inventory indicated that Illinois has only a few types of Class V wells and that these wells tend to be clustered (figure 2). That is, more than 80 percent of the 1,766 Class V wells are located in eight communities. Further study of the inventory revealed that the predominant function of these wells is to dispose of (1) untreated sewage, and (2) stormwater runoff.

With this background in mind, consider how the cluster concept could be applied to a ranking system in Illinois. Because only one Class V well type usually exists in each cluster, it is generally possible to describe the features of a generic well type at each cluster. Therefore, after the person listed on the inventory was contacted, some general conclusions could be made about the well depth, diameter, and well operation at each facility.

### Factors Selected for Inclusion in the Ranking System

Four major categories were evaluated by the ranking system: (1) the nature of the injected fluid; (2) the quantity of fluid injected; (3) the construction and design features of the well; and (4) the cultural practices that have an influence on the well. No reliability testing for the exclusion or inclusion of these factors was performed. Their relevance is based strictly on the authors' experience, the USEPA guidelines, experience of others as evidenced in the literature, and the telephone questionnaires. Within each of the major categories, there are many subtopics as presented in table 5. Description of geologic controls was not emphasized because unlike the other classes of underground injection, Class V does not overly concern itself with isolating the injected fluid. Instead, it knowingly emplaces the fluid directly into or in close proximity to USDW.

### Numeric Ranking System

Critics of analytical methodologies argue that numeric ranking lends a false air of scientific legitimacy to the results (Congressional Research Service, 1983), but this is not the purpose of our effort. Rather, our purpose is to draw attention to the uncertainties inherent in any assessment. By understanding the capabilities and limitations of a system, it may be possible to incorporate appropriate adjustments into a future management scheme.

Table 5. Factors Used in the Ranking System, by Major Category

Characteristics Describing the Nature of the Injected Fluid

- $BOD_5$
- TDS (Total dissolved solids)
- Heavy metals likely to be present in injected fluid
- Average pH (daily)
- Mean annual temperature of injected fluid (degrees Fahrenheit)
- Persistence (biodegradability)
- Human toxicity
- Contaminant mobility
- Homogeneity of injected fluid

Characteristics Describing the Quantity of Injected Fluid

- Rate of injection (gallons per minute)
- Frequency of injection (continuously, a few times daily, random)

Construction and Design Features of the Injection Well

- Injection horizon relative to USDW
  - Into
  - Above
  - Between
- Well materials
  - Casing type
  - Annulus material
- Abandonment of well possible?

Cultural Practices and Their Potential Influences

- Land use pattern (zoning)
- Source of public water supplies (surface or ground)
  - Distance
- Private domestic water wells
  - Distance
- Relationship of injection horizon and withdrawal horizon
- Community need of injection wells
- Existence of secondary benefit of injection
- Accessibility of injection well (potential for abuse)

The numeric ranking system developed for this study relies on the assignment of importance to a variety of decision factors. This approach differs from that of Jain (1975), who believed that it is better to provide equal weight to all environmental attributes. His reasoning was based upon the conviction that it is the responsibility of the individual reviewing alternatives to implicitly decide which attribute is more important.

Like the DRASTIC method (Aller et al., 1985), the ranking system developed for assessing Class V wells has three major parts: weights, ranges, and scores. The first part (weights) refers to the importance of one factor relative to another. Values of importance are scaled from 1 (the least important) to 10. Table 6 is based on work by Linstone and Turoff (1975) and provides some guidance in determining importance. For example, whether or not the injection horizon is a USDW might be "Very important" and receive 10 points while another factor, such as well diameter, would be "Most unimportant" and would be weighted at only 2 points.

The second part of the ranking system recognizes that a factor in the natural world may occur at several values. It considers that this factor fluctuates between some minimum and maximum value. This variability is described as the factor's "range." A subjective rating score is associated with values possible within that range. By considering range as part of the evaluation system, we are able to introduce sensitivity into the assessment process.

The third part of the ranking system is the calculation of a score based on the product of the weight times the rating for that factor. The scores are summed and yield an index for a particular generic description. Indices can be compared to determine which Class V well type presents the greatest contamination potential to USDW in Illinois.

Any ranking system is only as good as the information upon which it is based. Furthermore, it can be misused if its developers' intent is not adhered to. The system described has practical limits of technical accuracy and comprehensiveness. No attempt to solicit outside opinion was made as to how much weight to attach to each factor. Therefore, the system represents only one opinion. Furthermore, the ranking system is a simplification of the real world and is intended for use as a "measuring stick" of well types. It is <u>not intended</u> for ranking individual Class V wells.

Table 7 is presented to list the weights and rating used in this report.

Table 6. Predefined Importance Scale*

| Points | Scale | Definition |
|---|---|---|
| 10 | Very important | A most relevant point that must be resolved, dealt with, or treated. A first-order priority that has direct bearing on major issues. |
| 8 | Important | Relevant to the issue, but does not have to be fully resolved. A second-order priority that has significant impact. |
| 6 | Moderately important | May be relevant to the issue and may be a determining factor to a major issue. A third-order priority that may have impact. |
| 4 | Unimportant | Insignificantly relevant point. Not a determining factor to any major issue. Of low priority and with little impact. |
| 2 | Most unimportant | Point with no relevance nor any priority. It has no measurable effect and should be dropped as an item to consider. |

*After Linstone and Turoff, 1975

## Table 7. Weights and Ratings Used in the Ranking System

### Characteristics Describing the Nature of the Injected Fluid

| | Weight | Rating |
|---|---|---|
| $BOD_5$ | | |
| > 150 mg/l | 3 | 4 |
| 100 - 150 mg/l | 3 | 3 |
| 50 - 100 mg/l | 3 | 2 |
| 25 - 50 mg/l | 3 | 1 |
| < 25 mg/l | 3 | 0 |
| TDS | | |
| > 2,500 mg/l | 5 | 5 |
| 1,000 - 2,500 mg/l | 5 | 4 |
| 500 - 1,000 mg/l | 5 | 3 |
| 250 - 500 mg/l | 5 | 2 |
| 100 - 250 mg/l | 5 | 1 |
| < 100 mg/l | 5 | 0 |
| Heavy metals likely to be present in injected fluid | | |
| Yes | 6 | 5 |
| Maybe | 6 | 3 |
| No | 6 | 0 |
| Temperature of injected fluid (degrees Fahrenheit) | | |
| < 40 | 3 | 2 |
| 40-50 | 3 | 1 |
| 50-60 | 3 | 0 |
| 60-70 | 3 | 1 |
| > 70 | 3 | 2 |
| Average pH (daily) | | |
| 2 - 4 | 4 | 4 |
| 4 - 6 | 4 | 2 |
| 6 - 7 | 4 | 1 |
| 7 - 9 | 4 | 0 |
| 9 - 10 | 4 | 1 |
| 10 - 12 | 4 | 2 |
| > 12 | 4 | 4 |

Table 7 (Continued)

| | Weight | Rating |
|---|---|---|
| Persistence (biodegradability) | | |
| Degrades very slowly | 10 | 4 |
| Degrades slowly | 10 | 3 |
| Degrades moderately | 10 | 2 |
| Degrades quickly | 10 | 1 |
| Degrades very quickly | 10 | 0 |
| Human toxicity | | |
| Severe toxicity | 10 | 5 |
| Moderate toxicity | 10 | 3 |
| Slight toxicity | 10 | 1 |
| No toxicity | 10 | 0 |
| Contaminant mobility | | |
| Very mobile in subsurface | 6 | 5 |
| Moderately mobile | 6 | 3 |
| Relatively immobile | 6 | 1 |
| Homogeneity of influent | | |
| Very little (diversity) | 4 | 3 |
| Somewhat (only 2 or 3 constituents) | 4 | 2 |
| Very uniform in quality | 4 | 1 |

## Characteristics Describing the Quantity of Injected Fluid

| | Weight | Rating |
|---|---|---|
| Rate of injection | | |
| > 50 gpm | 6 | 4 |
| 10 - 50 gpm | 6 | 2 |
| < 10 gpm | 6 | 1 |
| Frequency of injection | | |
| Continuously | 6 | 3 |
| Daily (predominantly) | 6 | 2 |
| Random | 6 | 1 |

## Construction and Design Features of the Injection Well

| | Weight | Rating |
|---|---|---|
| Injection horizon relative to USDW | | |
| Into | 10 | 5 |
| Above | 10 | 3 |
| Between | 10 | 1 |

Table 7 (Continued)

| | Weight | Rating |
|---|---|---|
| **Well materials** | | |
| Casing type | | |
| No casing in hole | 4 | 3 |
| Loosely jointed (bricks, etc) | 4 | 2 |
| Impervious (PVC, steel, etc.) | 4 | 1 |
| Annulus material | | |
| No materials used | 4 | 4 |
| Backfilled w/earthen material | 4 | 3 |
| Earthen material w/bentonite | 4 | 2 |
| Cement above injection horizon | 4 | 0 |
| **Abandonment of well possible?** | | |
| No | 4 | 2 |
| Maybe | 4 | 1 |
| Yes | 4 | 0 |

## Cultural Practices and Their Potential Influences

| | Weight | Rating |
|---|---|---|
| **Land use pattern** | | |
| Zoned industrial | 5 | 4 |
| Zoned commercial | 5 | 3 |
| Zoned agricultural | 5 | 2 |
| Zoned residential | 5 | 1 |
| Zoned public/quasi-public | 5 | 1 |
| **Source of public water supplies** | | |
| Ground-water daily pumpage within 3 miles (in same hydrogeologic unit) | | |
| > 1 MGD | 6 | 6 |
| 300,000 - 1 MGD | 6 | 5 |
| 100,000 - 300,000 | 6 | 4 |
| 25,000 - 100,000 | 6 | 3 |
| 8,000 - 25,000 gal | 6 | 2 |
| < 8,000 gal | 6 | 1 |

NOTE: IT SHOULD NOT BE CONSTRUED THAT SMALL USERS ARE UNIMPORTANT. RATHER, THIS FACTOR IS INCLUDED SO THE INFLUENCE OF PUMPING CAN BE INCLUDED IN THE ASSESSMENT.

| | Weight | Rating |
|---|---|---|
| Surface water withdrawals within 1 mile (where wells are hydraulically connected with surface water) | | |
| > 1 MGD | 5 | 3 |
| 100,000 - 1,000,000 gal/day | 5 | 2 |
| < 100,000 gal/day | 5 | 1 |

Table 7 (Concluded)

| | Weight | Rating |
|---|---|---|
| Private domestic water wells | | |
| Distance to wells in same hydrogeologic unit | | |
| < 1/2 mile | 6 | 5 |
| 1/2 to 1 mile | 6 | 4 |
| 1 to 3 miles | 6 | 3 |
| > 3 miles | 6 | 1 |
| Distance to wells NOT in same hydrogeologic unit | | |
| < 1/2 mile | 4 | 3 |
| 1/2 to 1 mile | 4 | 1 |
| > 1 mile | 4 | 0 |
| Community need of injection wells | | |
| Wells already in use | 3 | 2 |
| Actual or perceived need | 3 | 1 |
| No need for wells | 3 | 0 |
| Existence of secondary benefit of injection possible | | |
| No secondary use/benefit | 3 | 2 |
| May be benefit (recharge/subsidence) | 3 | 1 |
| Demonstrable benefit | 3 | 0 |
| Accessibility of injection well (potential for abuse) | | |
| Abuse likely (no barriers) | 4 | 5 |
| Barrier, but no control entry | 4 | 3 |
| Security/control personnel | 4 | 1 |
| 24-hour surveillance w/barriers | 4 | 0 |

# APPLYING THE RANKING SYSTEM TO ILLINOIS CLASS V WELLS

## Assumptions Used in Ranking Well Types

The principal assumption made is that general descriptions of well types can be made. Because Class V wells tend to be located in clusters, they are assumed to have similar hydrogeologic properties within each cluster. Furthermore, it is presumed that most of the wells disposing of untreated raw sewage (Appendix A, well type 5W9) are located in the Streator cluster. Similarly, stormwater drainage wells (Appendix A, well type 5D2) at Machesney Park, Crystal Lake, and Chillicothe can be collectively described and rated by the numeric ranking system.

## Rating of Well Types Common to Illinois

### Assumptions Used in Rating the Streator Cluster

Class V wells at Streator are typically 70 to 90 feet deep and inject untreated fluids from the combined sewer system into an abandoned coal mine. The term "combined" is used to mean that sewage, industrial wastewater, and stormwater are transported by the same conveyance system. Although this mixture is directed toward the city's wastewater treatment plant, much of it is diverted via drop shafts to the abandoned coal mine. The index of contamination potential is calculated to be 217 (table 8).

Assessing the situation at Streator is difficult. In fact, the activities seem to be bent upon defying the Class V approach of considering well types. This is because the injected fluids mix freely once delivered to the mine. As a result, evaluation of well type (i.e., means of conveyance) is unimportant. Instead the focus is on the collective impact of the Streator cluster. Because the approach taken in this report is not based on a strict concern with well type, it is possible to assess how the practice at Streator may impact USDW. Data from the USEPA (1981) report have been used to prepare the following description and are subsequently used in ranking the contamination potential of the Streator situation.

<u>The industrial contribution.</u> The glass industries in Streator are major water consumers in that community. In their industrial processes, water is used to cool and wash glass molds. When its utility is gone, the water is often discharged to the sewers as industrial wastewater (USEPA, 1981). The quantity used daily by industries amounts to about 1.38 million gallons (USEPA, 1981, sec. 4.3.1) according to a USEPA industrial waste inventory made during 1976. Of this consumption, approximately 82 percent becomes industrial wastewater and subsequently 74.5 percent of that wastewater (or 0.84 MGD) is discharged to the mines. The decline in the number of industries at Streator has lowered industrial water consumption.

Table 8. Possible Contamination Index for the Streator Cluster

| | Weight x | Rating = | Score |
|---|---|---|---|
| BO0$_5$ | | | |
| 50 - 100 mg/l | 3 | 2 | 6 |
| TDS | | | |
| 500 - 1,000 mg/l | 5 | 3 | 15 |
| Heavy metals likely to be present in injected fluid | | | |
| Maybe | 6 | 3 | 18 |
| Temperature of injected fluid (degrees Fahrenheit) | | | |
| 60-70 | 3 | | 1 3 |
| Average pH (daily) | | | |
| 7-9 | 4 | 0 | 0 |
| Persistence (biodegradability) | | | |
| Degrades moderately | 10 | 2 | 20 |
| Human toxicity | | | |
| Slight toxicity | 10 | 1 | 10 |
| Contaminant mobility within injection zone | | | |
| Very mobile in subsurface | 6 | 5 | 30 |
| Homogeneity of influent | | | |
| Very little (diversity) | 4 | 3 | 12 |
| Rate of injection | | | |
| < 10 gpm | 6 | 1 | 6 |
| Frequency of injection | | | |
| Continuously | 6 | 3 | 18 |
| Injection horizon relative to USDW | | | |
| Between | 10 | 1 | 10 |
| Well materials | | | |
| Casing type | | | |
| Impervious (PVC, steel, etc.) | 4 | 1 | 4 |
| Annulus material | | | |
| No materials used | 4 | 4 | 16 |
| Abandonment of well possible? | | | |
| Maybe | 4 | 1 | 4 |

Table 8 (Concluded)

| | Weight | x | Rating | = | Score |
|---|---|---|---|---|---|
| Land use pattern | | | | | |
| Zoned residential | 5 | | 1 | | 5 |
| Source of public water supplies | | | | | |
| Surface water withdrawals within 1 mile (wells hydraulically connected) | | | | | |
| > 1 MGD | 5 | | 3 | | 15 |
| Private domestic water wells | | | | | |
| Distance to wells NOT in same hydrogeologic unit | | | | | |
| 1/2 to 1 mile | 4 | | 1 | | 4 |
| Community need of injection wells | | | | | |
| Wells already in use | 3 | | 2 | | 6 |
| Existence of secondary benefit of injection possible | | | | | |
| May be benefit (recharge/subsidence) | 3 | | 1 | | 3 |
| Accessibility of injection well (potential for abuse) | | | | | |
| Barrier, but no control entry | 4 | | 3 | | 12 |

INDEX = 217

Consequently, in 1985, the industries consumed only about 0.77 MGD and the amount reaching the mines has been estimated at about 0.47 MGD. If it is assumed that the industrial wastewater flows continuously within the sewer system and that it enters the mine through 600 drop shafts (Class V wells), then the calculated injection rate is about 0.5 gallons per minute (gpm) per shaft.

The Streator Final Environmental Impact Statement (USEPA, 1981) indicates that three types of industrial wastewater reach the abandoned mine (i.e., the injection horizon). They are contaminated process waters (71.9 percent), clean cooling waters (25.3 percent), and sanitary wastes (2.8 percent). Most of the industries are unable to supply specific information on the chemical characteristics of their wastewaters (USEPA, 1981). One firm did indicate, during a telephone interview with the senior author, that oil-skimmings were discharged to the mine(s?) because these contaminants could introduce impurities into the glass being manufactured. These undesirable oil-skimmings are the result of lubricants coming in contact with cooling waters which are flushed over hot molds.

The domestic contribution. The sewer service area at Streator is not as large as the water service area. As a result, many of those households outside the sewer service area discharge much of their domestic wastewater to drop shafts finished in the abandoned coal mines. Those households in the service area direct their domestic sewage to the wastewater treatment plant; however, not all of it reaches the plant. This is because an unknown amount is diverted by drop shafts to the mine and some is diverted to surface waters before reaching the plant.

One approach to estimating the size of the domestic wastewater flow at Streator (USEPA, 1981) has been to use population data. If the population outside the sewage service area is considered by itself, then it is estimated that approximately 0.53 MGD of domestic wastewater is contributed to the mines. If 74.5 percent (the figure used in the industrial calculations) of the 0.96 MGD used by those residing within the service area reaches the sewage plant, then another 0.19 MGD (0.96 - 0.72 = 0.24) is injected into the mines. Consequently, the total amount of domestic wastewater being injected is approximately 0.77 MGD (0.53 + 0.19).

## Assumptions Used in Rating Stormwater Drainage Wells

Stormwater drainage wells receive runoff from parking lots, streets, building roofs, and highways. Although construction detail varies among the clusters, there are some common characteristics. The most obvious is that these wells are typically about 15 feet deep and 5 feet in diameter. They are likely to have been constructed by an excavator, rather than by a water well driller. As a result, few records are ever kept. The index of contamination potential for this type of injection is calculated to be 311 (table 9).

Table 9. Possible Contamination Index for Stormwater Drainage Wells

| | Weight | x | Rating | = | Score |
|---|---|---|---|---|---|
| BOD5 | | | | | |
| 50 - 100 mg/l | 3 | | 2 | | 6 |
| TOC | | | | | |
| 250 - 500 mg/l | 5 | | 2 | | 10 |
| Heavy metals likely to be present in injected fluid | | | | | |
| Yes | 6 | | 5 | | 30 |
| Temperature of injected fluid (degrees Fahrenheit) | | | | | |
| 50-60 | 3 | | 0 | | 0 |
| Average pH (daily) | | | | | |
| 6 - 7 | 4 | | 1 | | 4 |
| Persistence (bipdegradability) | | | | | |
| Degrades moderately | 10 | | 2 | | 20 |
| Human toxicity | | | | | |
| 51ight toxicity | 10 | | 1 | | 10 |
| Contaminant mobility | | | | | |
| Very mobile in subsurface | 6 | | 5 | | 30 |
| Homogeneity of influent | | | | | |
| Somewhat (only 2 or 3 constituents) | 4 | | 2 | | 8 |
| Rate of injection | | | | | |
| < 10 gpm | 6 | | 1 | | 6 |
| Frequency of injection | | | | | |
| Random | 6 | | 1 | | 6 |
| Injection horizon relative to USDU | | | | | |
| Into | 10 | | 5 | | 50 |
| Well materials | | | | | |
| Casing type | | | | | |
| Loosely jointed (bricks, etc) | 4 | | 2 | | 8 |
| Annulus material | | | | | |
| Backfilled w/earthen material | 4 | | 3 | | 12 |
| Abandonment of well possible? | | | | | |
| Maybe | 4 | | 1 | | 4 |

Table 9 (Concluded)

| | Weight | x | Rating | = | Score |
|---|---|---|---|---|---|
| Land use pattern | | | | | |
| Zoned residential | 5 | | 1 | | 5 |
| Source of public water supplies | | | | | |
| Ground-water daily pumpage within 3 miles (in same hydrogeol. unit) | | | | | |
| > 1 MGD | 6 | | 6 | | 36 |
| Private domestic water wells | | | | | |
| Distance to welts in same hydrogeoIogic unit | | | | | |
| < 1/2 mile | 6 | | 5 | | 30 |
| Distance to wells NOT in same hydrogeologic unit | | | | | |
| 1/2 to 1 mile | 4 | | 1 | | 4 |
| Community need of injection wells | | | | | |
| Wells already in use | 3 | | 2 | | 6 |
| Existence of secondary benefit of injection possible | | | | | |
| No secondary use/benefit | 3 | | 2 | | 6 |
| Accessibility of injection well (potential for abuse) | | | | | |
| Abuse likely (no barriers) | 4 | | 5 | | 20 |

INDEX =311

The fluid injected into these wells is likely to be low in TDS, but is quite likely to carry or have dissolved within it heavy metals such as lead, chromium, cadmium, and copper (Bender et al., 1983). Lager et al. (1977) have determined the concentration of BOD5 in stormwater runoff to be between 50 and 100 mg/l. The pH of the fluid being injected is likely to be at or near neutrality while its average annual temperature is likely to measure from 50 to 60 degrees Fahrenheit. The contaminants entering the well are not likely to be toxic to humans in nominal concentrations, but they may bioaccumulate and become so at a later time. The contaminants probably will vary in degradability but, on the whole, are likely to be persistent in the subsurface environment. The occurrence of contaminants may vary seasonally as in the case of road salt.

This type of Class V well is frequently located in areas underlain by permeable layers of sand and gravel. These water-table deposits often represent locally important USDW. Although these injection wells need not have a casing (e.g., as in Tampico, where an excavation is simply backfilled with crushed rock and allowed to grass over), they usually do. The casing is usually constructed by loosely stacking one concrete culvert on top of another. The injected fluid exits the well through the opening at the bottom of the stack and/or through the loose joints between the culverts. The annulus of the well is commonly filled with washed gravel (or some other aggregate).

Stormwater drainage wells are prevalent in urban areas. At some locations, such as at the city of Crystal Lake, the fluid is injected into one USDW, while much of the public water supply is drawn from another (deep bedrock). The situation is different in communities (for example, Chillicothe) which inject into the same USDW they rely on for public water supply. Frequently these injection well clusters are surrounded by private domestic well owners who also withdraw water from the injection horizon.

Little or no benefit to the ground-water regime has been demonstrated by the practice of stormwater injection. These wells do, on the other hand, have the potential to be abused by either deliberate dumping or accidental spills.

## Assumptions Used in Rating Heat Pump/Air Conditioning Return Flow Wells

Most of the Class V wells in this category are associated with ground-water heat pumps. These systems are used to heat or cool a space depending upon the season. The technology employed in this effort either extracts or adds thermal energy to ground water which circulates through a heat exchanger. The contaminant then, in the loosest sense of the word, is heat. An exception would be when water is returned to an aquifer other than its source. In this case, the contaminant might be more than just heat. The index of contamination potential for wells returning water to its source is calculated to be 210 (table 10).

Table 10. Possible Contamination Index for Heat Pump/Air Conditioning Return Flow Wells

| | Weight | x | Rating | = | Score |
|---|---|---|---|---|---|
| $BOD_5$ | | | | | |
| < 25 mg/l | 3 | | 0 | | 0 |
| TDS | | | | | |
| 250 - 500 mg/l | 5 | | 2 | | 10 |
| Heavy metals likely to be present in injected fluid | | | | | |
| No | 6 | | 0 | | 6 |
| Temperature of injected fluid (degrees Fahrenheit) | | | | | |
| 40-50 | 3 | | | | 1 3 |
| Average pH (daily) | | | | | |
| 7 - 9 | 4 | | 0 | | 0 |
| Persistence (biodegradability) | | | | | |
| Degrades very quickly | 10 | | 0 | | 0 |
| Human toxicity | | | | | |
| No toxicity | 10 | | 0 | | 0 |
| Contaminant mobility | | | | | |
| Relatively immobile | 6 | | | | 1 6 |
| Homogeneity of influent | | | | | |
| Very uniform in quality | 4 | | 1 | | 4 |
| Rate of injection | | | | | |
| 10 • 50 gpm | 6 | | 2 | | 12 |
| Frequency of injection | | | | | |
| Daily (predominantly) | 6 | | 2 | | 12 |
| Injection horizon relative to USDU | | | | | |
| Into | 10 | | 5 | | 50 |
| Well materials | | | | | |
| Casing type | | | | | |
| Impervious (PVC, steel, etc.) | 4 | | 1 | | 4 |
| Annulus material | | | | | |
| Backfilled w/earthen material | 4 | | 3 | | 12 |
| Abandonment of well possible? | | | | | |
| Yes | 4 | | 0 | | 0 |

Table 10 (Concluded)

| | Weight | x | Rating | = | Score |
|---|---|---|---|---|---|
| Land use pattern | | | | | |
| Zoned residential | 5 | | 1 | | 5 |
| Source of public water supplies | | | | | |
| Ground-water daily pumpage within 3 miles (in same hydrogeol. unit) | | | | | |
| > 1 MGD | 6 | | 6 | | 36 |
| Surface water withdrawals within 1 mile (wells hydraulically connected) | | | | | |
| < 100,000 gal/day | 5 | | 1 | | 5 |
| Private domestic water wells | | | | | |
| Distance to wells in same hydrogeologic unit | | | | | |
| < 1/2 mile | 6 | | 5 | | 30 |
| Distance to wells NOT in same hydrogeologic unit | | | | | |
| > 1 mile | 4 | | 0 | | 0 |
| Community need of injection wells | | | | | |
| Actual or perceived need | 3 | | 1 | | 3 |
| Existence of secondary benefit of injection possible | | | | | |
| Demonstrable benefit | 3 | | 0 | | 0 |
| Accessibility of injection well (potential for abuse) | | | | | |
| Barrier, but no control entry | 4 | | 3 | | 12 |

INDEX = 210

The chemical nature of the fluid being withdrawn from USDW, circulated, and subsequently injected in the subsurface is not likely to be altered. Because the majority of ground-water quality analyses in Illinois indicate that the concentration of TDS is between 250 and 500 mg/l for public water supplies (Broten and Johnson, 1985), it is assumed that the TDS concentration of the fluid being injected will be about the same. Little other information on the chemical nature of the fluid exists, but it is assumed that BOD5 levels will be very low, pH might be slightly basic, and heavy metals are likely to be undetectable in the injected fluid.

The temperature of the injected fluid will vary seasonally. Because heating requirements in Illinois exceed cooling demands, it is assumed that the overall effect of the heat pump system will be to cool the USDW. Consequently, an average annual temperature ranging from 40 to 50°F will most likely characterize the injected fluid. The fluid is not likely to be toxic to humans, and the temperature problem should not persist in the subsurface due to its large buffering capacity. Compared to other Class V fluids, this type is probably the most homogeneous.

Wells injecting heat pump effluent will be receiving fluid at about 10 gpm for about 8 hours each day. The injection horizon will almost assuredly be a USDW although not necessarily the same one from which the water was withdrawn. The casing used with this type of well is likely to be PVC since this is a fairly new practice. Ordinarily little attention is paid to grouting the annulus.

Another difference between injection wells of this type and others concerns abandonment practices. The return flow well associated with heat pumps is not likely to be plugged; instead it will simply be disconnected from the heat exchanger and the water will be rerouted to the plumbing system. As a result, this type of injection well has the potential to be converted into an ordinary domestic water supply well. Therefore, it is more correct to think of this practice as a decommissioning of a Class V well, rather than an abandonment effort.

In Illinois, fewer than 70 ground-water heat pump return flow wells are known to exist. They are scattered widely and tend to be located in suburban areas. If enough ground water is available for heat pump operation, then it is probable that the public water supply also uses that same aquifer. Hence, it is assumed that public water supply pumpage exceeds 1.0 MGD (10,000 people @ 110 gpd per capita) in the area near the heat pump return flow wells. This assumption is based on the observation that families who can afford these wells live in more urban areas (Davis and Nienkerk, 1984).

The abatement of the energy crisis of the early 1980's has contributed to a decrease in interest about this form of heating and cooling. Nevertheless, there probably still remains a need for this technology and it is likely to expand sometime in the future. Therefore, because of its potential to conserve energy, it is assumed that a secondary benefit is associated with this type of underground injection.

## Results of the Ranking System

The application of the ranking system to the generic well types indicated the following. First, the greatest contamination potential seems to be associated with stormwater drainage wells. Second, the impact of fluids injected into abandoned coal mines, relative to the other types of Class V wells, is disguised. Third, the contamination potential associated with ground-water heat pumps is minimal.

Scores developed during the ranking are summarized for three types of Class V injection. Each summation serves as an index and these can be compared. Table 11 is useful as a reference because it is a thumbnail comparison of the indices for the major well types in Illinois.

Table 11. Summary of Numeric Ratings of Class V Well Types

| Description | Well Type | Index |
|---|---|---|
| Stormwater drainage | 5D2 | 311 |
| Streator sewer disposal | 5W9, 5D4, & 5D2 | 217 |
| Heat pump/air cond. returns | 5A7 | 210 |

### Discussion

In assessing the results of the ranking system, it is critical to look beyond the overall index computed for each well scenario. Each aspect (i.e., each major category described in table 5) of the ranking system should be examined separately, and then they should all be examined together. This is because the scores are not distributed equally throughout the ranking system as Jain (1975) suggested they might be. Instead, the category describing the chemical characteristics of the injected fluid is given the greatest weight: 221 possible points. By contrast, the other categories describing quantity, construction/design details, and cultural influences have maximum scores of only 42, 86, and 130, respectively.

Clearly the ranking system devotes more attention to evaluating chemical characteristics and cultural influences than it does to the other two categories. Some might argue that too many factors are evaluated within each of these categories. Nevertheless, this approach is followed throughout the ranking system because as Jain (1975) points out, a checklist approach provides (or at least has the potential to provide) the reviewer additional insight. As a consequence, however, a bias is built into the system.

The bias in favor of the categories describing chemistry and "people" (cultural influences) is justifiable because the overall goal of Class V UIC is to prevent possible violation of drinking water standards. If the goal had been to isolate the injected fluid, then hydrogeologic factors would have been more fully considered. But it is assumed that the goal of prohibiting the movement of contaminants into USDW has already been circumvented. That is to say, the assessment recognizes that the injection of fluids into USDW already occurs. Because the objective of the ranking system is to evaluate the impact of Class V wells on USDW, it therefore seems appropriate to emphasize the categories that describe the chemistry which has the potential to impact the water that people drink.

When examining the results of the ranking system, the reviewer should be aware of the distribution of the scores among categories. Table 12 lists the scores for each category. A graphic representation of the scores (figure 23) also illustrates how the distribution varies among well types. Finally, it is important to remember that the rating system is merely an organized method of correlating views and information. By exercising the method, one can better appreciate how the variables interplay even if one does not agree with the weighting or the score determined for that variable.

Stormwater drainage wells. The most significant observation to be made from the ranking (table 11) is that the index for stormwater drainage wells clearly exceeds the other indices. This is particularly noteworthy in light of the public perception that "it is just rain water."

The primary reason stormwater drainage wells scored high is that they inject directly into USDW. The second major reason for a high stormwater drainage well index is the probability that the injection horizon is actively being pumped. Therefore, a strong likelihood exists that the natural hydraulic gradient will be modified by the pumping wells. Because quite frequently the Class V injection wells are in urban areas, contaminants may be induced into a public drinking water supply well. This situation is likely to be occurring at Chillicothe and Machesney Park. Private wells at Crystal Lake may also be threatened. Consequently, a greater weight and corresponding score is attributed to this factor.

Other factors that increase the level of concern about stormwater drainage wells include:

- the likelihood that heavy metals may occur within the injected fluid;

Table 12. Results of Ranking System by Major Category

CLASS V WELL TYPES

| MAJOR CATEGORIES OF CLASS V RANKING SYSTEM | Stormwater Drainage | Streator Scenario | Heat Pump Return Flow | Maximum Points Possible |
|---|---|---|---|---|
| Chemical Characteristics | 118 | 114 | 29 | 221 |
| Quantity/ Rate | 12 | 24 | 24 | 42 |
| Construction/ Design Details | 74 | 34 | 66 | 86 |
| Cultural Influences | 107 | 45 | 91 | 130 (109)* |
| Overall Index | 311 | 217 | 210 | |

*For ground-water-based public water supply, the possible score for this category is 130. The maximum for a surface-water system, however, is 109 points.

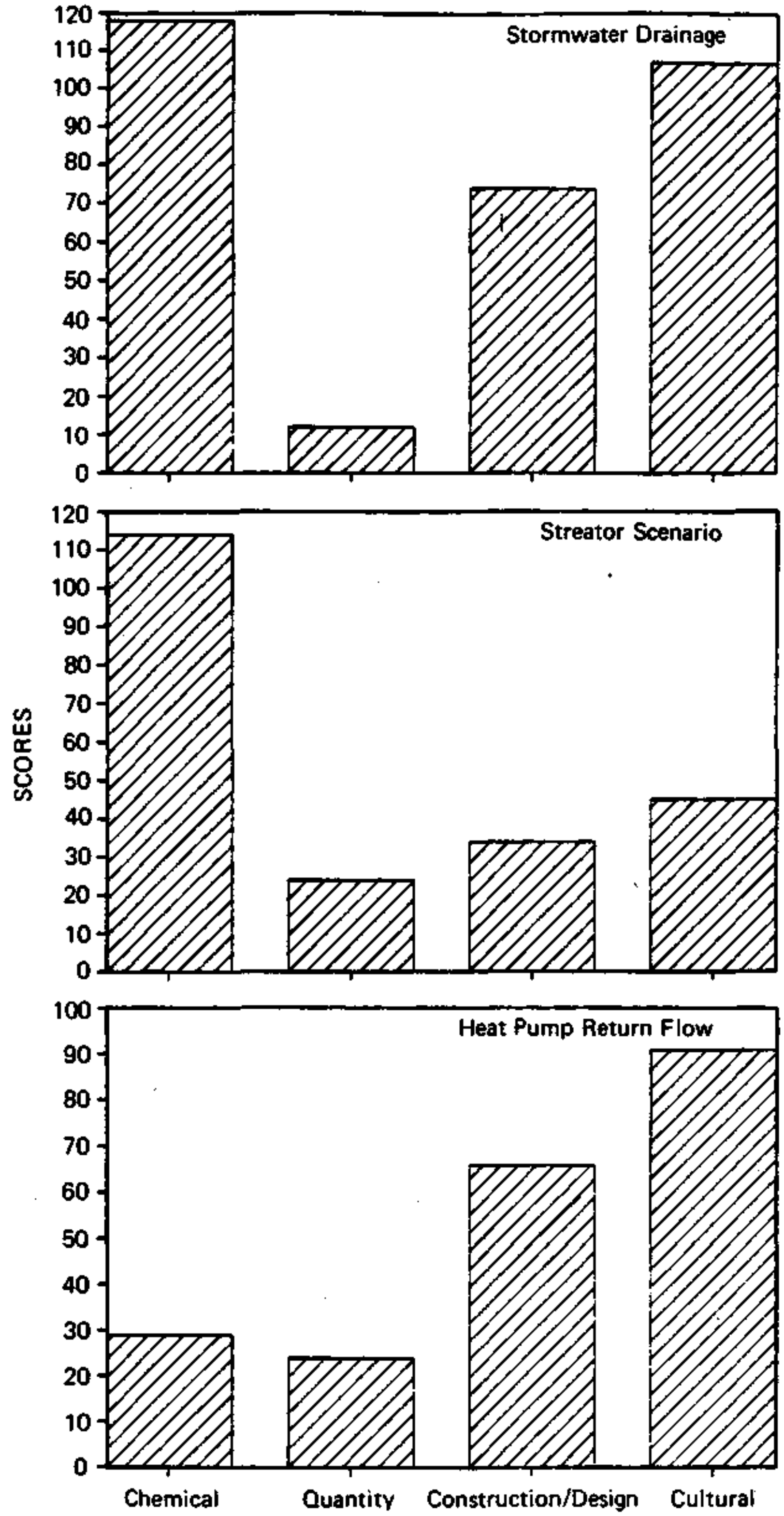



Figure 23. Histograms of points scored by each category of the Class V well ranking system.

- the likelihood that these wells will inject very mobile contaminants, such as chlorides resulting from the use of road salt, into the ground-water system;

- the high probability that private domestic wells are withdrawing water from the injection horizon and that these wells are rarely checked for trace contaminants; and

- the susceptibility of this type of well (and therefore the USDW) to spills and/or deliberate acts of disposal involving far more toxic compounds than those typically occurring in stormwater.

<u>The Streator cluster</u>. A high level of concern about the injection of combined sewer effluent at Streator is not warranted. This is because the fluid is not injected into a USDW. A closer examination reveals that the impact resulting from the practice of injection into abandoned coal mines is muted because the fluid is: (1) placed between USDW; and (2) isolated from them by confining beds of low permeability (hydraulic conductivity). Consequently, a lower overall contamination index results.

The distribution of scores (figure 23) for the Streator scenario is similar to that for stormwater drainage wells. In fact, the chemical characteristics category score (114) is almost the same as that for stormwater drainage wells. If not for the construction category, the overall indices for these two well types would be nearly equal.

<u>Heat pump return flow wells</u>. Although the index for heat pump return flow wells was almost as high as that for the wells at Streator, they very definitely should not be considered to have the same potential for ground-water contamination. The heat pump wells received a large number of points (50) because they inject effluent into aquifers (commonly USDW). These wells also scored additional points because of their likelihood to be near public (+36 points) and private (+30 points) water supplies.

If the distribution of scores among the major categories is compared to those for stormwater drainage wells and for the Streator scenario, then a difference in pattern is obvious. The histogram illustrating the scores by category (figure 23) clearly indicates that the difference is due to the chemical characteristics of the injected fluid. Heat pumps scored only 29 points in this category. Because of this low score, ground-water heat pumps are not considered to have much potential for ground-water contamination.

## Accuracy and Relevance of the Estimates

Obviously with our present incomplete knowledge, we cannot expect to provide an exact assessment of the contamination potential of the practice of Class V underground injection. Yet we can design a decision model that gives some sense of the process needed in formulating a policy dealing with these wells. Whatever this policy, it will involve the concept of public risk and therefore needs to be founded on an accurate ranking system. Consequently, it is relevant to question whether a broad enough perspective has been taken to the basic problem of underground injection and whether the ranking system focuses on the right variables.

A re-examination of the ranking system highlights the impact of assigning weights to certain factors. In most cases, the scores determined for each factor would not change significantly if the rating were changed. But if more or less weight were given to a factor, that is, if its degree of importance was increased or decreased, then the score for that factor could change radically. In this study, the location of the injection horizon relative to the USDW, along with the distance to a public water supply in the same hydrogeologic unit where the injection is occurring, were chosen as the most important factors.

The simplest method of validating this conclusion is by providing replication. Perhaps the best way to verify or refute the weighting used in this study would be by conducting a Delphi exercise. Briefly described, this exercise works by asking several respondents (unknown to each other and in different locations) to complete an importance questionnaire. The participants would evaluate the importance of the factors used in the ranking system (table 5) and would return their response to a central person serving as a moderator. The moderator would then summarize the first round and mail out the results with the same questionnaire again so that each respondent had a chance to rethink his or her previous position. Experience has shown (Linstone and Turoff, 1975) that three rounds of the exercise will lead to stability in defining areas of agreement, as well as areas of disagreement.

Certainly one difficulty in designing a Class V ranking system is to avoid biasing the factors toward one well type while brushing lightly over those attributes that more precisely describe another. The objective of describing factors that are common to all types is often reached at the expense of more precisely defining the nature of any one type. As a result, early versions of the ranking system included factors which were excluded in the version presented here. For example, variables relating to settleable solids, precipitation, pan evaporation, and confining bed thickness were excluded, while BOD5 and average daily temperature of the injected fluid were kept.

The point is: have we asked the right questions and do we have some basis upon which to rank Class V well types? The question of whether the practice of Class V underground injection is conscionable has not been considered. Rather, to paraphrase the National Academy of Sciences (1975), we have focused on providing information which is believed to be useful to the regulators in considering the practice of Class V injection by well types, so that separate evaluations of risk and benefit for each major category of use can be made.

# APPROPRIATE CLASS V REGULATORY MECHANISMS

## Toward Developing a Regulatory Mechanism

The initial premise of this study is that underground injection of wastes will continue, and that the major task at hand is to somehow link an appropriate level of control with this activity. To better understand this task we should start by considering the definition of control and how that relates to our opening premise. One may find, in a dictionary, that "control" refers to: (1) the authority to direct or regulate; and (2) a holding back; restraint; or means of curbing.

The manager of the UIC program has the advantage of the experience stemming from the regulation of other classes of underground injection. If the regulatory mechanism selected for Class V is consistent with those of other classes, then the development of criteria and standards for the entire class of injection is likely. Selection of this approach is improbable due to the variable nature of Class V wells and their possible benefits to society. Thus, this study concludes that in complying with the mandate (40 CFR 146.52(4)) to determine the "appropriateness of applying a regulatory mechanism," the choice will be to establish a specific regulatory mechanism for each type of Class V well.

The regulatory mechanisms available to the UIC manager include, but are not limited to, the following. A permit system may be used, whereby each well is considered after an application is made to the IEPA. This action results in a written warranty to the receiver to engage in a specific activity. Permit by rule is a second mechanism available to the UIC manager. It functions by establishing a "blanket-like rule" under which all wells under consideration are permitted without need for the review process. Under a self-monitoring system, the permittee submits water samples periodically to the IEPA. Should the primary drinking water regulations be violated, then more stringent review and permitting could be invoked as provided by the general UIC application (40 CFR 144.12(c)). The agency could establish a surveillance system where on-site inspections of Class V well constructions are conducted. Another mechanism would involve establishment of a monitoring well system. Although there are at least four types of monitoring (reconnaissance, surveillance, subjective, and objective), the value of any of this information is in making comparisons over time. Finally, the UIC manager can, at a minimum, continue the present reporting system, whereby Class V wells are reported and inventoried.

## Stormwater Drainage Wells

Although the manager of the UIC program in Illinois has several options available, the choice of the most appropriate involves consideration of other issues. Most obvious is the current lack of any statewide program for dealing with stormwater runoff. It is currently unclear which government agency would be best suited to administer the effort. As a result, the UIC program manager must act without the benefit of knowing precisely what the stormwater management goals are or should be. A second concern to the UIC program is the recognition that some regulatory efforts at controlling stormwater drainage have already been attempted in Illinois (Lager et al., 1977; Bender et al., 1985). Therefore any new regulations may come into conflict with existing ordinances and be slowed in implementation because of the legal process. A third concern involves coordination within the IEPA because the UIC manager surely knows that a permit to introduce contaminants into USDW is likely to one day impact the Division of Public Water Supplies at the IEPA. The final concern is the same that faces all regulatory schemes: whatever the plan, it will be only as effective as the regulatory agency's ability to establish the means to implement a workable system.

It is useful to first reflect on the entire perspective of stormwater management. Traditionally, the approach has been to drain away excess water as quickly as possible with little or no regard for its quality or final destination. In so doing, the designers of stormwater systems focused on collection and conveyance systems and ensured that they were large enough to move large quantities of water (Bender et al., 1985). Generally this irresponsible approach impacted streamflows, erosion, and in some cases flooding. However, one of the tools in the designers' arsenal impacted and still continues to impact ground water: the so called "dry wells." These wells, whose name is a misnomer because they are not usually dry, come under the regulatory authority of the UIC program.

In Illinois more than 700 stormwater drainage wells have been reported to the IEPA. More are suspected to exist, particularly in populated areas underlain by shallow deposits of sand and gravel. A relationship appears to exist between populations overlying this type of deposit and the number of stormwater drainage wells in a community (figure 24). The sand and gravel deposits receiving this stormwater are frequently used as a source of drinking water. Therefore, a conflict of interests occurs because the goal of the UIC program is to prohibit (40 CFR 144.12(a)) the movement of contaminants into USDW "if it [the injection] may cause a violation" of any drinking water regulation.

The existence of contaminants in stormwater is undeniable. Evidence illustrating the level of contamination (table 13) has been documented by Lager et al. (1977) and Bender et al. (1983). Additional information concerning stormwater quality is available from the Ontario Ministry of the Environment (1980) and was determined for Section 208 of the Federal Water Pollution Control Act (United States).

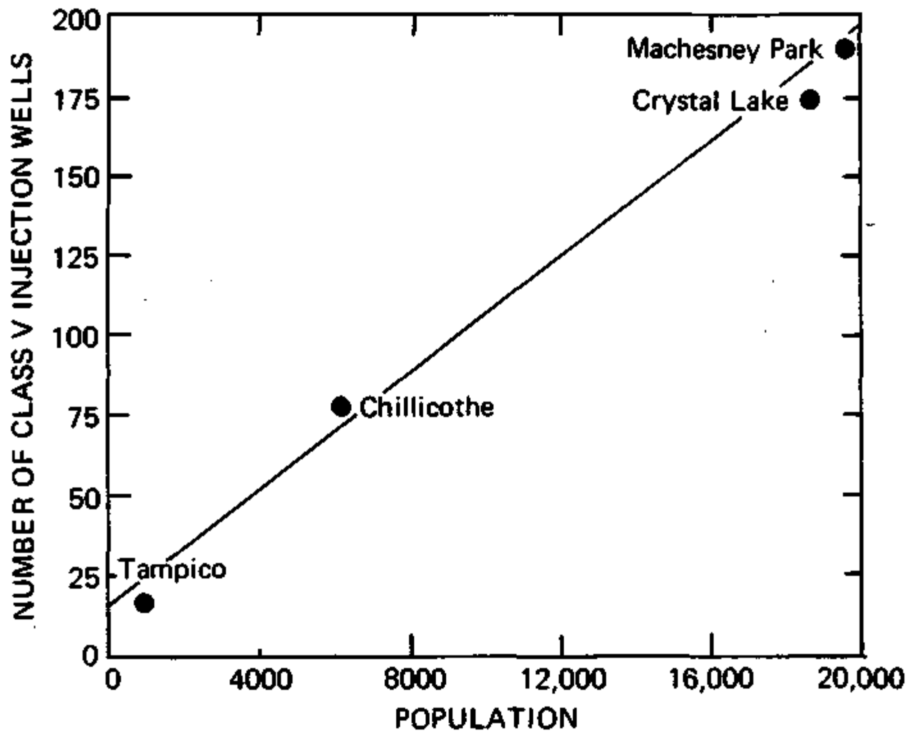



Figure 24. Graph of urban populations versus the number of stormwater drainage wells in those urban areas.

Table 13. Selected Drinking Water Standards and Contaminants Commonly Found in Stormwater Runoff

| Constituent | Max. Concentration Allowed | Observed Levels Mean | No. of Samples |
|---|---|---|---|
| $BOD_5$ (mg/l) | | 56 | 84* |
| Chromium (mg/l) | 0.05 | 0.23 | 232* |
| Fecal coiiforms (#/ml) | | 230 | 327* |
| Total diss. solids (mg/l) | 500 | 195-362** | |
| Lead (mg/l) | 0.05 | 0.071-0.377** | |

* Source: Lager et al. (1977) for Durham, NC
** Source: Bender et al. (1983) for Champaign, IL

## Considerations on Regulating Stormwater Drainage Wells

The authors of this report are inclined to conclude, on the basis of the results of the ranking system, that the highest level of regulation, a permit system, is warranted for stormwater drainage wells. One benefit of a permit system might be an increased consistency in the construction of this well type. As it currently stands, it is possible that the Illinois UIC program might be faced with a veritable hodgepodge of stormwater drainage well designs. For example, Naperville, Joliet, and the Metropolitan Sanitary District of Greater Chicago have already drafted regulations regarding stormwater management (Lager et al., 1977; Bender et al., 1985) and these regulations have the potential to influence design.

However, the idea of permitting an activity that knowingly contaminates USDW seems absurd. It is counter to the very idea of protecting the quality of drinking water. The concept of regulation is or should be, by definition, aimed at restraining or holding back a particular activity. Because permitting seems to sanctify the practice of injecting contaminants, it is contradictory to the goals of SDWA. Therefore, instead of allowing the practice of stormwater drainage to continue, the strategy should be to discourage this practice.

If stormwater drainage wells are to be tolerated, then the regulatory mechanism that is finally adopted should emphasize location, particularly when dealing with publicly owned facilities. It is important to deal with each injection well individually. When laterals bring fluids to the well, it is important to know precisely where the inlet catchbasin is located so that the source area can be determined. Because detention ponds have been shown to be useful in improving the quality of the stormwater runoff (Randall, 1982) perhaps allowances should be made for incorporating them into any final permitting process.

Some stormwater drainage wells may be more desirable than others because their location (i.e., cultural influences) affects the contamination potential. Consequently, the UIC manager should attempt to utilize zoning ordinances to limit future construction to residential areas. Furthermore, policies should prohibit injection wells from being near and/or in the flow path toward public water supply wells. It is obvious that the critical factor involved with this sort of waste disposal is the quality of the fluid being injected. Therefore the regulatory mechanism should not be overly concerned with well construction and the fact that these wells are not constructed by licensed well drillers. Rather, the emphasis should be placed on isolating the fluids which are injected, and positioning the Class V wells away from water supply wells and recharge areas to those supply wells. Disadvantages of depending on siting would be: (1) the need for constant review of city zoning ordinances to ensure that the situation had not changed; and (2) the fact that new water supply wells could not be added to existing systems if the area had previously been permitted for injection.

## Domestic Wastewater Disposal Wells

The inventory of Class V wells indicates that about half of the Class V wells in Illinois inject fluids into abandoned coal mines. The size and therefore the potential impact of this problem are misleading because most of this activity occurs in one locale: the Streator area. While the idea of disposing of raw sewage in abandoned coal mines is not pleasing, there are worse Class V practices. This is because the mined-out coal seams are usually bounded above by shale and below by an underclay, both of which are geologic materials of low hydraulic conductivity (permeability). Consequently, the injected waste is reasonably well isolated from USDW; correspondingly, the contamination potential index is lower.

Although it is doubtful that the UIC program would ever encourage injection into abandoned coal mines, it seems likely that in certain situations this practice might be endured. If this were done in Illinois, it seems likely that specific construction, operating, monitoring, and reporting requirements for injection wells would be appropriately specified by a permit system.

Current regulations (Title 77, Ch. 1, Sec. 905.20(h)) of the Illinois Department of Public Health specifically prohibit the discharge of domestic sewage or effluent from any private sewage disposal system into any well or into any underground mine. Therefore it is uncertain whether the UIC program has jurisdictional authority concerning this practice.

Some have intimated that drainage fields and related disposal practices ought to come under Class V regulation. Often discussion centers on whether a design fits the deeper-than-wide criterion and, ultimately, on what constitutes a well. According to Title 35, Subtitle G, Sec. 730.130, a well refers to the dimensions of a hole, whether drilled or dug. Consequently the point of contention should not involve pipe, casing, and/or tile diameters. For example, it has been suggested by some that a drain field should be considered under the UIC program because a 12-inch-drameter vertical pipe might lead to 6-inch laterals. Therefore because the vertical diameter is larger than that of the horizontal diameter the facility should be construed as an injection well. This is incorrect because the entire system configuration should be kept in mind rather than the diameters of the plumbing.

In our opinion, septic systems and leach (seepage) fields should not be classified as Class V injection wells, because they do not meet the deeper-than-wide criterion. Furthermore responsibility in Illinois for disposal of sewage from these facilities rests with the Department of Public Health.

## Heat Pump/Air Conditioning Return Flow Wells

A small number of Class V wells in Illinois are used in conjunction with heat pumps. Fewer than 70 have been reported to the IEPA, although it is generally acknowledged that more exist. Because the use of ground-water heat pumps for single family residences seems of no harm to USDW, it is appropriate that they should be permitted by rule. However, it should be stated that new wells drilled for this purpose should be constructed by licensed well drillers and in accordance with the Illinois Water Well Construction Code (Ill. Rev. Stat., 1981; Ch. 96 1/2 and 111 1/2). The permits for these injection wells should be linked to the property rather than to the landowner so that in the event of property transfer the well's authorization is maintained.

On a related note, it should be recalled from a previous discussion that earth-coupled heat pump systems were not considered to fall under the jurisdiction of the UIC program. Two reasons are cited: (1) in horizontal systems, the largest surface dimension exceeds that of the depth, and (2) even if the system is deeper that it is wide, the principal function is not the emplacement of fluids.

## Other Types of Class V Wells

The remainder of Class V well types should be handled on a case-by-case basis.

# CONCLUSIONS

The approach used throughout this assessment has focused on well types. It was determined at the beginning of the effort that consideration of individual wells was inappropriate unless an individual well warranted remedial action as mandated by the general provisions of the UIC permit program (Ill. Admin. Code 704.102 and 704.122(d)). The more prudent method of assessing Class V wells was to determine their number and understand their function within the state of Illinois.

There are 1,766 reported Class V injection wells in Illinois. The majority of these wells are used for waste disposal (53.3 percent) and stormwater drainage (41.9 percent). Class V wells tend to be clustered and located in small communities and/or urban areas. Eight of these clusters account for more than 80 percent of the total known number of Class V wells.

Most of the stormwater drainage wells are in small communities which overlie shallow sand and gravel aquifers. Waste disposal wells, by contrast, tend to be located in communities which overlie abandoned coal mines. Other types of Class V wells exist in Illinois; however, they are widely scattered.

Several quantitative methodologies for assessing environmental impacts exist. Perhaps those most applicable to the Class V UIC program are the Canadian model (Phillips, 1976) and the Hazardous Ranking System (USEPA, 1982).

For this study, a numeric rating system was developed. It evaluates four major categories: (1) the nature of the injected fluid; (2) the quantity of fluid injected; (3) the construction and design features of the well; and (4) the cultural practices that have an influence on the well. This system does not weight the categories equally because the goal of prohibiting the movement of contaminants into USDW has already been circumvented by the very act of injection. Thus hydrogeologic factors are not weighted as heavily as they might be if isolation of the contaminants was more important. Instead the emphasis is shifted to describing the chemical aspects of Class V injection and the cultural factors that influence the impact of the injection. Consequently, a reviewer of the rating system should be aware of the category scores as well as the total score for a well type.

Stormwater drainage wells ranked highest in the rating of the contamination potential of Illinois Class V well types. They clearly exceeded the scores of wells disposing wastes into abandoned subsurface coal mines and wells returning ground-water heat pump effluent to USDW. Although not evaluated by the rating system because of their infrequent occurrence in Illinois, it is probable that industrial drainage wells may pose an even greater contamination potential to surficial aquifers.

Because drainage wells tend to overlie surficial deposits of sand and gravel, it is these aquifers that are the most vulnerable to contamination by Class V wells. It would be prudent to further identify these aquifers and check for the existence of unreported Class V wells. To neglect these deposits is to write off the value of these formations as a drinking water resource.

A policy of "differential protection" has been adopted by the USEPA. Since 1984, the USEPA under its Ground-Water Protection Strategy has recognized the need for resource management (budgetary and ground water) and the vulnerability of some ground waters to contamination. As a result, it has been suggested that some aquifer units may need to be protected more than others. Stated differently, it may be that a process of "controlled degradation" is acceptable. In the case of Class V, that might be construed to mean that the risk of drinking water contamination posed by stormwater drainage wells is acceptable.

Whatever the choice, Illinois must choose what is best for Illinois. It is obvious from the Safe Drinking Water Act amendments of 1986 that the goal at the federal level is to enhance state groundwater protection efforts. Therefore, it is incumbent upon the IEPA UIC regulators to propose workable solutions that are compatible with the overall goals of environmental protection.

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# APPENDIX A
## Descriptions of Class V Well Types

(Reprinted from USEPA Contractor's Draft Report on Class V Wells, March 1987)

TABLE 1-1

CLASS V INJECTION WELL TYPES

| WELL CODE | NAME OF WELL TYPE AND DESCRIPTION |
|---|---|
| | DRAINAGE WELLS (a.k.a. DRY WELLS) |
| 5F1 | Agricultural Drainage Wells - receive irrigation taiiwaters, other field drainage, animal yard, feedlot, or dairy runoff, etc. |
| 5D2 | Storm Water Drainage Wells - receive storm water runoff from paved areas, including parking lots, streets, residential subdivisions, building roofs, highways, etc. |
| 5D3 | Improved Sinkholes - receive storm water runoff from developments located in karst topographic areas. |
| 5D4 | Industrial Drainage Wells - wells located in industrial areas which primarily receive storm water runoff but are susceptible to spills, leaks, or other chemical discharges. |
| 5G30 | Special Drainage Wells - used for disposing water from sources other than direct precipitation. Four types were reported: landslide control drainage wells (Montana), potable water tank overflow drainage wells (Idaho), swimming pool drainage wells (Florida), and lake level control drainage wells (Florida). |
| | GEOTHERMAL REINJECTION WELLS |
| 5A5 | Electric Power Reinjection Wells - reinject geothermal fluids used to generate electric power - deep wells. |
| 5A6 | Direct Heat Reinjection Wells - reinject geothermal fluids used to provide heat for large buildings or developments - deep wells. |
| 5A7 | Heat Pump/Air Conditioning Return Flow Wells - reinject groundwater used to heat or cool a building in a heat pump system - shallow wells. |
| 5A8 | Groundwater Aquaculture Return Flow Wells - reinject groundwater or geothermal fluids used to support aquaculture. Non-geothermal aquaculture disposal wells are also included in this category (e.g. Marine aquariums in Hawaii use relatively cool sea water). |

TABLE 1-1

CLASS V INJECTION WELL TYPES

| WELL CODE | NAME OF WELL TYPE AND DESCRIPTION |
|---|---|
| | DOMESTIC WASTEWATER DISPOSAL WELLS |
| 5W9 | Untreated Sewage Waste Disposal Wells - receive raw sewage wastes from pumping trucks or other vehicles which collect such wastes from single or multiple sources. (No treatment) |
| 5W10 | Cesspools - including multiple dwelling, community, or regional cesspools, or other devices that receive wastes and which must have an open bottom and sometimes have perforated sides. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Settling of solids) |
| 5W11 | Septic Systems (Undifferentiated disposal method) - used to inject the waste or effluent from a multiple dwelling, business establishment, community, or regional business establishment septic tank. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Primary Treatment) |
| 5W31 | Septic Systems (Well Disposal Method) - examples of wells include actual wells, seepage pits, cavitettes, etc. The largest surface dimension is less than or equal to the depth dimension. Must serve greater than 20 persons per day if receiving solely sanitary wastes. (Less treatment per square area than 5W32) |
| 5W32 | Septic Systems (Drainfield Disposal Method) - examples of drainfields include drain or tile lines, and trenches. Must serve more than 20 persons per day if receiving solely sanitary wastes. (More treatment per square area than 5W31) |
| 5W12 | Domestic Wastewater Treatment Plant Effluent Disposal Wells - dispose of treated sewage or domestic effluent from small package plants up to large municipal treatment plants. (Secondary or further treatment) |
| | MINERAL AND FOSSIL FUEL RECOVERY RELATED WELLS |
| 5X13 | Mining, Sand, or Other Backfill Wells - used to inject a mixture of water and sand, mill tailings, and other solids into mined out portions of subsurface mines whether what is injected is a radioactive waste or not. Also includes special wells used to control mine fires and acid mine drainage wells. |

TABLE 1-1

CLASS V INJECTION WELL TYPES

| WELL CODE | NAME OF WELL TYPE AND DESCRIPTION |
|---|---|
| 5X14 | Solution Mining Wells - used for in-situ solution mining in conventional mines, such as stopes leaching. |
| 5X15 | In-situ Fossil Fuel Recovery Wells - used for in-situ recovery of coal, lignite, oil shale, and tar sands. |
| 5X16 | Spent-Brine Return Flow Wells - used to reinject spent brine into the same formation from which it was withdrawn after extraction of halogens or their salts. |
| | OIL FIELD PRODUCTION WASTE DISPOSAL WELLS |
| 5X17 | Air Scrubber Waste Disposal Wells - inject wastes from air scrubbers used to remove sulfur from crude oil which is burned in steam generation for thermal oil recovery projects. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.) |
| 5X18 | Water Softener Regeneration Brine Disposal Wells - inject regeneration wastes from water softeners which are used to improve the quality of brines used for enhanced recovery. (If injection is used directly for enhanced recovery and not just disposal it is a Class II well.) |
| | INDUSTRIAL/COMMERCIAL/UTILITY DISPOSAL WELLS |
| 5A19 | Cooling Water Return Flow Wells - used to inject water which was used in a cooling process, both open and closed loop processes. |
| 5W20 | Industrial Process Water and Waste Disposal Wells - used to dispose of a wide variety of wastes and wastewaters from industrial, commercial, or utility processes. Industries include refineries, chemical plants, smelters, pharmaceutical plants, laundromats and dry cleaners, tanneries, carwashes, laboratories, etc. Industry and waste stream must be specified (e.g. Petroleum Storage Facility - storage tank condensation water; Electric Power Generation Plant - mixed waste stream of laboratory drainage, fireside water, and boiler blowdown; Car Wash - Mixed waste stream of detergent, oil and grease, and paved area washdown; Electroplating Industry - spent solvent wastes; etc.). |

TABLE 1-1

CLASS V INJECTION WELL TYPES

| WELL CODE | NAME OF WELL TYPE AND DESCRIPTION |
|---|---|
| 5X28 | Automobile Service Station Disposal Wells - repair bay drains connected to a disposal well. Suspected of disposal of dangerous or toxic wastes. |
| | RECHARGE WELLS |
| 5R21 | Aquifer Recharge Wells - used to recharge depleted aquifers and may inject fluids from a variety of sources such as lakes, streams, domestic wastewater treatment plants, other aquifers, etc. |
| 5B22 | Saline Water Intrusion Barrier Wells - used to inject water into fresh water aquifers to prevent intrusion of salt water into fresh water aquifers. |
| 5S23 | Subsidence Control Wells - used to inject fluids into a non-oil or gas producing zone to reduce or eliminate subsidence associated with overdraft of fresh water and not used for the purpose of oil or natural gas production. |
| | MISCELLANEOUS WELLS |
| 5N24 | Radioactive Waste Disposal Wells - all radioactive waste disposal wells other than Class IV wells. |
| 5X25 | Experimental Technology Wells - wells used in experimental or unproven technologies such as pilot scale in-situ solution mining wells in previously unmined areas. |
| 5X26 | Aquifer Remediation Related Wells - wells used to prevent, control, or remediate aquifer pollution, including but not limited to Superfund sites. |
| 5X29 | Abandoned Drinking Water Wells - used for disposal of waste. |
| 5X27 | Other Wells - any other unspecified Class V wells. Well type/purpose and injected fluids must be specified. |

# APPENDIX B
Class V Contact Person Questionnaire

NAME
PHONE NO.

# CLASS V CONTACT PERSON QUESTIONNAIRE

Statement of Objective/Purpose

My name is________________and I am with the Illinois State ________Survey in Champaign. We are working on a project for the Illinois EPA to assess underground injection of non-hazardous wastes. One of the things we are doing is contacting people who have knowledge or experience with disposal wells. Your name, as our letter stated, was selected from an IEPA list of well owners or controllers.

In Illinois there are about 1,700 wells that dispose of sewage, storm runoff, and heat pump effluent. Other types of injection wells exist, but generally they are not found in Illinois. whether by design or not these wells inject non-hazardous material into or above underground sources of drinking water. The Safe Drinking Water Act (Federal) prohibits any activity that allows the movement of fluid containing contaminants that violate any of the primary drinking water standards or that may otherwise adversely affect the health of persons.

Because the EPA has no information on the operation or impact of these wells we want to assess the environmental risk associated with each type of underground injection. So do you have a few minutes now that I could ask you a few questions?

Yes_______________No_______(call back when?)

Did you receive our recent letter?

Yes_______________No _____

Do you have any particular questions?

1. What is the legal location of your well(s)?
T.________R.________Sec.__________1/4 1/4

2. What do you inject or dispose of underground? __
(a). Sewage
How many people use the facility?
(b). Stormwater
(c). Heat pump effluent
(d). Other (please explain?)

3. Are any chemical analyses available that might describe the fluid you are injecting?

4. How much and how often do you use your injection well?
(a). Daily
(b). Monthly
(c). Infrequently
(d). Other (please describe)

5. What diameter and type of casing does your well(s) have?

6. How deep is your well(s)?
Length of casing (Enter zero if no casing) __________

Total depth of borehole (in feet) _______

Intercepted old mine shaft? (Yes, No, Don't Know) ____

7. Do you know if the annulus between the well casing and borehole is filled? If so, with what?

Yes, it is filled _______

No, it is not filled _____

Contact person doesn't know _________

8. Do you know who drilled the well and when? It would be helpful so we might check with them. Please enter response below.