GEOLOGY FOR PLANNING IN NORTHEASTERN ILLINOIS

VIII. REGIONAL SUMMARY

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OPEN FILE SERIES 1977-2

Illinois State Geological Survey

Urbana, Illinois

May 1, 1977

Prepared for the Northeastern Illinois Planning Commission

This study has been financed in part by a grant from the U.S. Environmental Protection Agency under provisions of PL 92-500. The contents do not necessarily reflect the views and policies of that agency.

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PREFACE

This is the final report in a series of eight reports, prepared during a period of 18 months. The evolution of thought over this period of time has led to certain inconsistancies in the various reports. This report completes the evolution and should provide the "final" general authority for the topics discussed.

INTRODUCTION

Rapid urban expansion in many areas of northeastern Illinois, particularly within the last 30 years, has brought about many attendant problems. As the population has grown and spread out, the construction of homes, new communities and industrial and commercial complexes has taken place at an almost unbelievably rapid pace. Competition between various land-use interests has been intense. Agricultural land throughout the region has diminished rapidly and former farms are now the sites of subdivisions, shopping centers, businesses and industrial developments.

By the late 50s, an awareness of the problems associated with such rapid urban expansion had developed. Such problems as providing adequate water supplies, disposing of waste products, flooding and increasing water and air pollution became apparent. Realizing that the area needed guidance in solving these problems, the Illinois General Assembly created the Northeastern Illinois Planning Commission (NIPC) in 1957. By 1966, the NIPC staff, with significant contribution from technical advisory committees, had produced reports and policy statements covering flood control, drainage improvements, open space, refuse disposal and water resource management.

The landscape of northeastern Illinois has continued to experience the impact of man's competing uses of the land for resource development and commercial, residential, industrial and agricultural purposes. The purpose of this report is to provide a regional interpretation of the physical environment, focusing on the relationship between geologic conditions and the potential for pollution created by intensive land use. Such an understanding provides one of the essential bases for planning decisions affecting the quality of urban, suburban and rural life in the six county region.

Background and Scope of Project

This regional study, Geology for Planning in Northeastern Illinois, was initiated by the Northeastern Illinois Planning Commission (NIPC) under provisions of Section 208 of the Federal Water Pollution Control Act Amendments of 1972 (PL-500). The region includes Kane, McHenry, Lake, Cook, Will and DuPage Counties (fig. 1). Since Section 208 requires that any water quality plan be technically feasible, the Northeastern Illinois Planning Commission requested the Illinois State Geological Survey (ISGS) to provide basic geologic data, natural resource and ground-water information, and interpretive maps on land utilization techniques, waste disposal and land treatment practices.

Project work was supported, in part, by 208 funds and coordinated through the NIPC 208 management staff. Work by the Illinois State Geological Survey was coordinated by John P. Kempton, principal investigator and Geologist in the Hydrogeology and Geophysics Section and administered by Keros Cartwright, Head, Hydrogeology and Geophysics Section.

The major objectives of this study were:

(1) identify and map the distribution of geologic materials in northeastern Illinois,

(2) evaluate the impact of various waste disposal and land treatment practices on the geologic materials,

(3) determine sensitive hydrogeologic environments where there is significant potential for contamination of either ground water or surface water resources.

This final report presents a summary of the principles and methods used and the results obtained during the course of the study. Although it is based in part on the findings of each county study, the broader regional implications are emphasized. Thus, since political or land survey boundaries

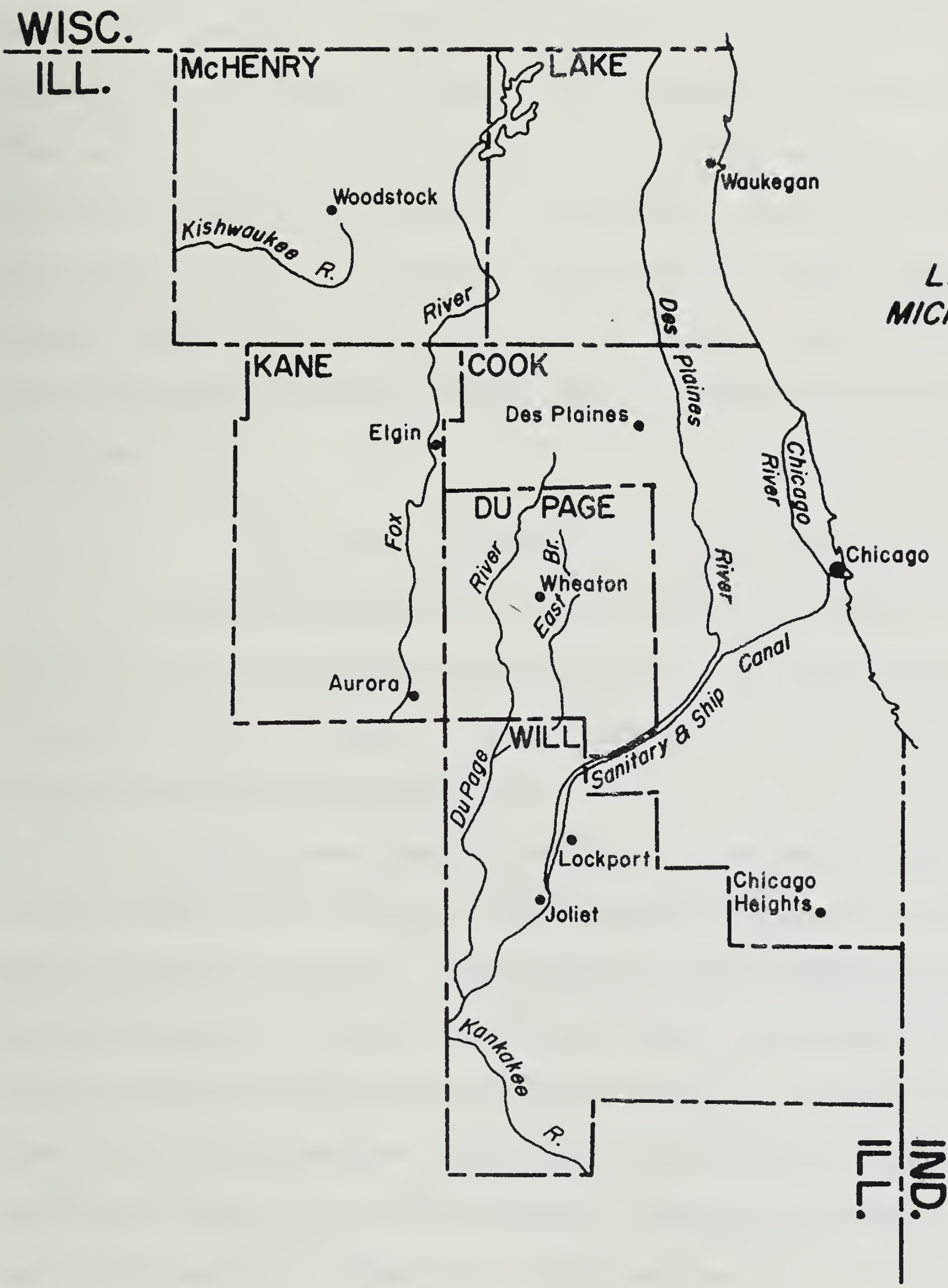


Figure 1. Study area and principal drainageways.

are seldom boundaries of geologic or hydrologic systems, regional mapping is emphasized to provide a basis for regional planning.

Previous work in northeastern Illinois has included a variety of geologic studies, some of which are directly applicable to this project. Alden (1902) and Bretz (1939, 1955) studied the geology of the Chicago metropolitan area; their work has been recently updated by Willman (1971) who provides an extensive list of references. County-wide geology for planning studies have already been published for McHenry (Hackett & McComas, 1969), Lake (Larsen, 1973), and adjacent De Kalb Counties (Gross, 1970); the Lake and McHenry studies have been updated for this current project. Will and Kane County environmental geology studies were in progress when this study was initiated.

General Physiographic and Geologic Setting

Northeastern Illinois is located within the Central Lowland physiographic province of the United States (fig. 2), and lies within two subdivisions of that province, the Great Lakes Section and the Till Plains Section (Leighton, Ekblaw and Horberg, 1948).

The Great Lakes Section consists of a series of north-south trending morainic ridges (fig. 3) which roughly parallel the Lake Michigan shoreline (Wheaton Morainal Country). These ridges are the legacy of continental ice sheets which melted from the area about 13,500 years ago and which mantled the dolomite and shale bedrock with deposits ranging in thickness from locally absent to more than 400 feet (121 meters). Most major drainageways are aligned north-south between the morainic ridges. Immediately adjacent to Lake Michigan, east of the morainic ridges lies a plain that was once the site of a large glacial lake, Lake Chicago. Development of the Chicago metropolitan area has

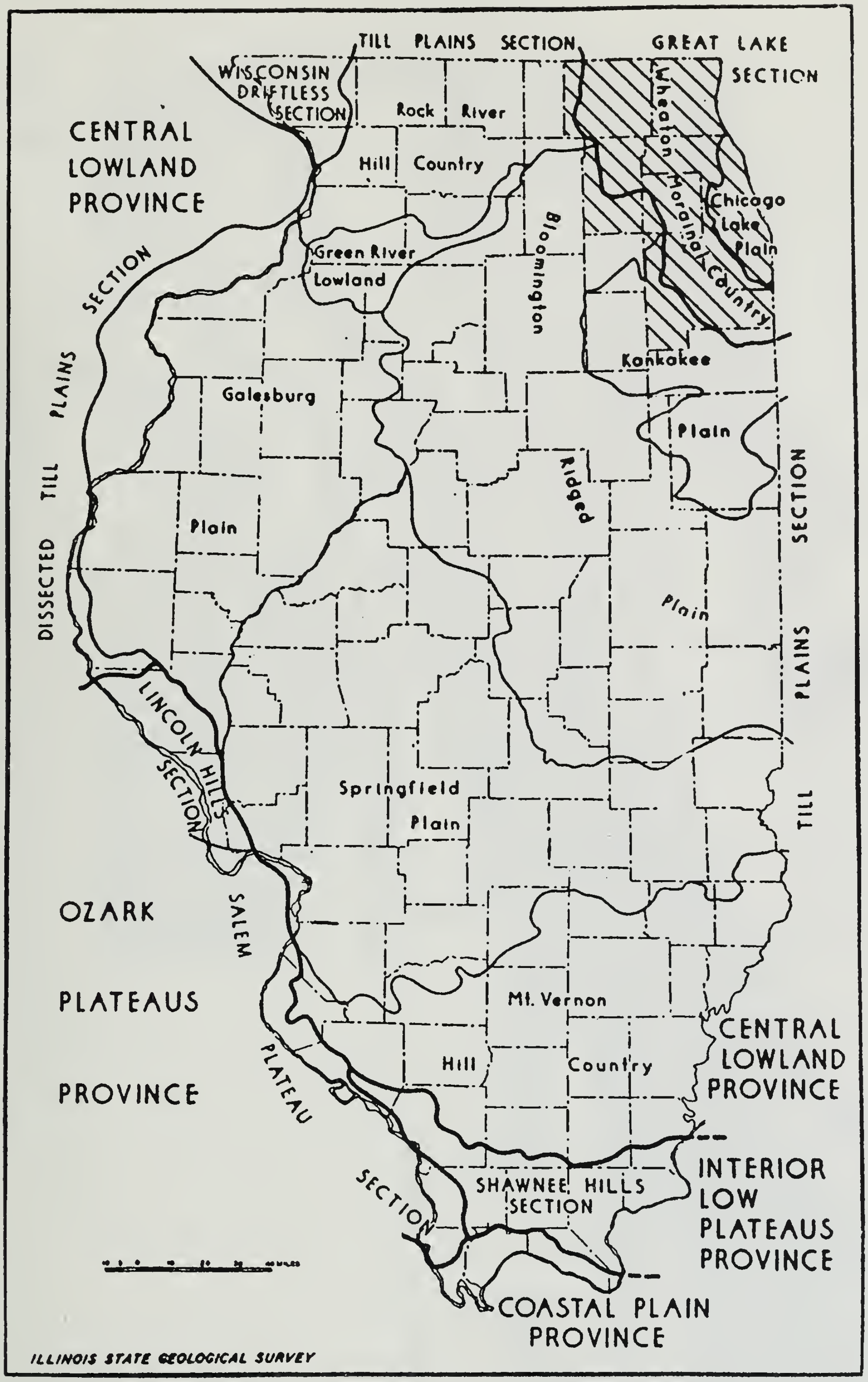


Figure 2. Physiographic divisions of Illinois by Leighton, Ekblaw and Horbert (1948) and location of study area (pattern).

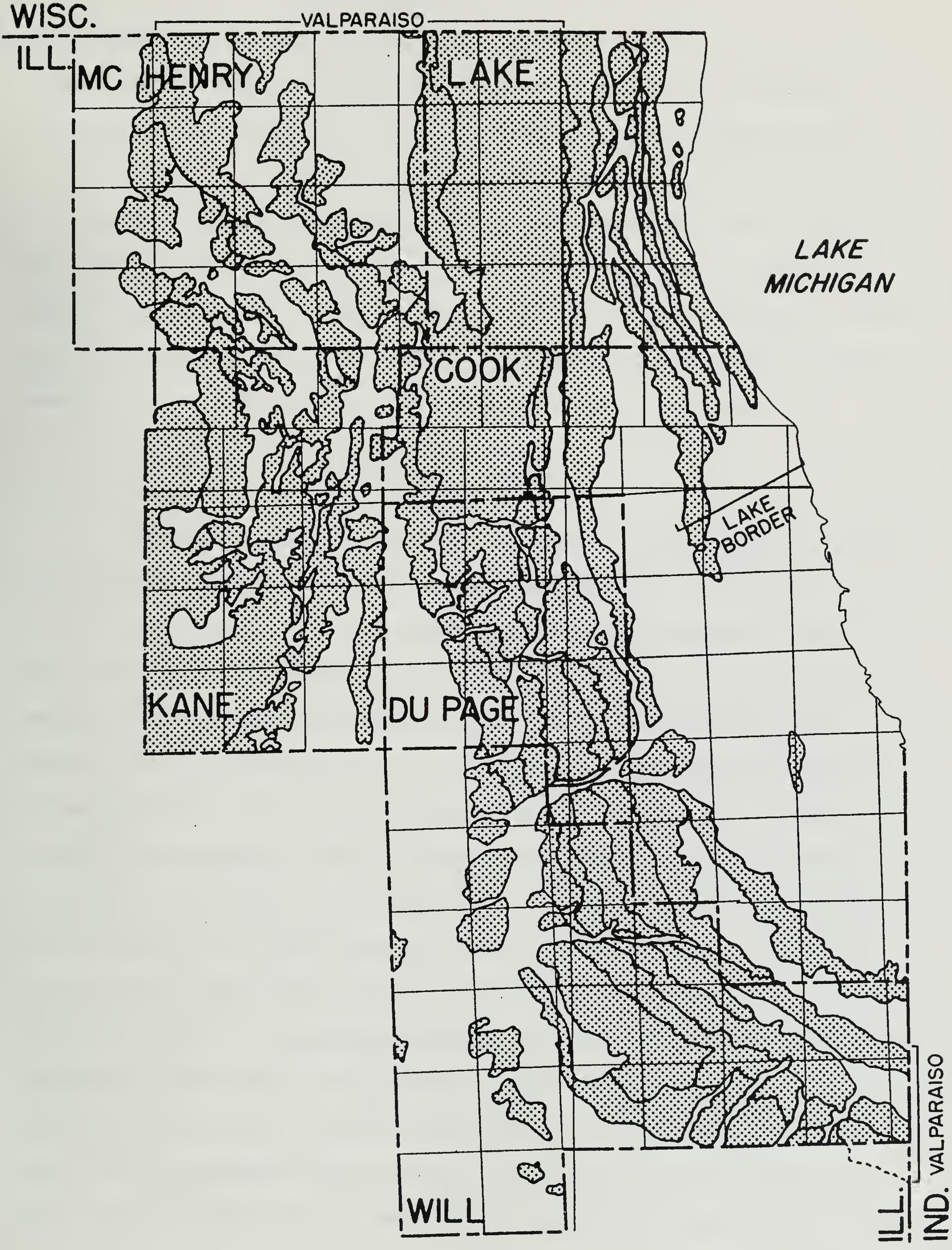


Figure 3. Moraines of northeastern Illinois (from Willman and Frye, 1970).

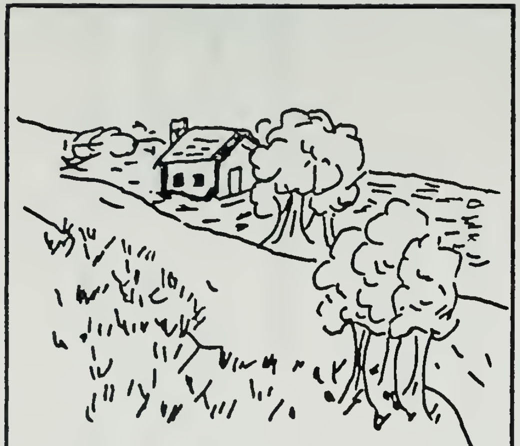
been centered on the Lake Michigan Plain (fig. 2). The Till Plains Section in northeastern Illinois is generally composed of more subdued topography with the morainic ridges often not as well defined in northeastern Illinois.

Both the morainic uplands and intermorainic areas are characterized by local drainageways which may be irregular and poorly developed. Glacial till, deposited directly by the melting glaciers, is the most ubiquitous surface and near-surface deposit. Water-laid, coarse-textured glacial outwash and fine-textured glacial lake deposits may overlie, underlie, and be interbedded with the various glacial tills that are mapped in the area.

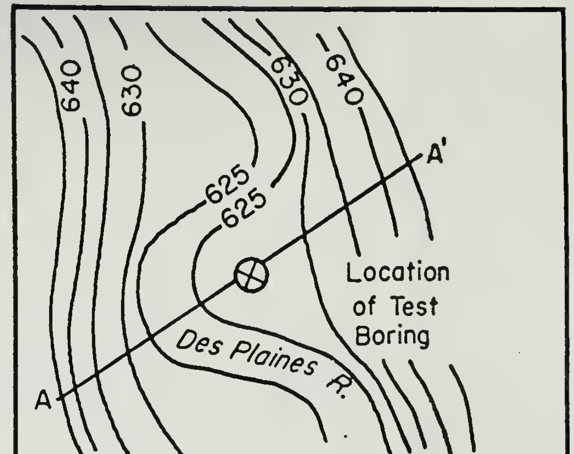
Methods and Procedures

Initial phases of this project included the preparation of a set of maps detailing geologic materials to a depth of 20 feet (6.1 meters) for each of the six counties (fig. 4). In addition, a series of interpretive maps for each county was prepared by applying certain criteria to the basic geologic materials map and selected additional maps. The geologic materials were mapped at the 1:24,000 scale on U. S. Geological Survey topographic maps (7½ minute quadrangle) which were then photographically reduced to the scale of 1:62,500 (approximately 1 inch = 1 mile) and traced onto county base maps generated by the ILLIMAP system (Swann et al., 1970). Various types of data were utilized for the basic mapping of geologic materials, including field and laboratory studies, logs and sample descriptions of water wells and engineering borings, test data from engineering borings, previously published and unpublished ISGS reports, interpretations from aerial photographs, USDA Soil Conservation Service soil survey investigations, and University of Illinois Agricultural Experiment Station reports. The general reference used for the soils-geology relationships in northeastern Illinois was Wascher et al., (1960).

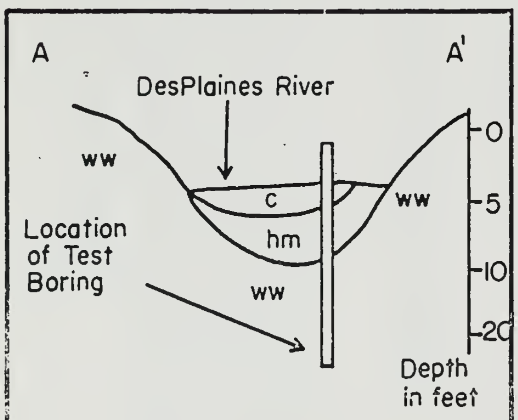
Figure 4. Illustration of how surficial map shows sequence of formations with depth.



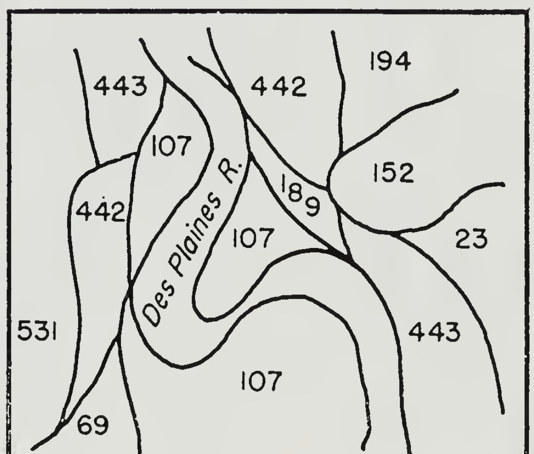
A. Area of Interest: Example - The DesPlaines River Valley



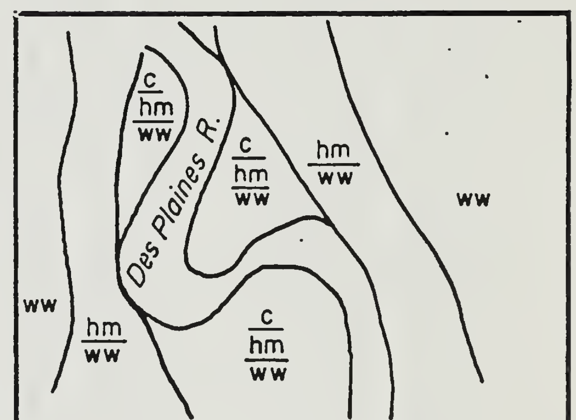
B. Topographic Map showing location of cross-section (A-A')



C. Cross-Section A-A'



D. Soils Map



E. Completed Surficial Map to a depth of 20'

The series of interpretive maps for each county generally included five maps detailing conditions for various waste disposal and land treatment practices; a map showing generalized terrains; maps indicating ground water, sand and gravel, rock, clay, and peat resources; and maps indicating limitations for various land uses.

Specifically, this report summarizes, for the region, the work done for selected phases of the project. Previous reports in this series gave detailed background information on hydrogeology and mapping criteria (Volume I) and discussed the detailed work done for each of the six counties (Volumes II-VII). This volume focuses upon the region as a whole and includes a regional map detailing geologic materials to a depth of 20 feet (plate 1), a generalized terrain map (plate 2) and six interpretive maps (plates 3 through 8). The interpretive maps (plates 3 through 8) include:

1. Hydrogeologic rating of northeastern Illinois as to relative significance for natural recharge (plate 3)
2. Conditions for land burial of waste (plate 4)
3. Conditions for surface spreading of wastes (plate 5)
4. Conditions for waste disposal by septic systems (plate 6)
5. Conditions for application of fertilizers and soil additives (plate 7)
6. Conditions for application of herbicides and insecticides (plate 8)

The maps are presented at a scale of 1:126,720 and were prepared from photoreductions of the county maps. By necessity, some of the detail included in the individual county maps has been eliminated; Volumes II-VII should be consulted for more specific information on each of the six counties.

Personnel

Many present and former members of the staff of the Illinois State Geological Survey have made significant contributions to this study. Principal contributors to the mapping and reports for the individual counties were: Kane County, R. H. Gilkeson and A. A. Westerman; McHenry County, S. A. Specht and A. A. Westerman; Lake County, K. L. Stoffel and J. I. Larsen; Cook County, J. E. Bogner; Will County, J. I. Larsen; and DuPage County, S. M. Taylor and R. H. Gilkeson. In addition, Keros Cartwright provided hydrogeologic background and aided in the preparation of the recharge, discharge and artificial recharge map; L. R. Follmer provided interpretations of USDA Soil Conservation Service and University of Illinois Agricultural Experiment Station soils maps as an aid in mapping the geologic materials and poorly drained soils; and H. D. Glass provided interpretations and data on clay minerals. In addition, P. B. DuMontelle, W. G. Dixon, and J. L. Phelps prepared information for land utilization and J. M. Masters, J. C. Bradbury and W. A. White prepared information for mineral resources. S. A. Specht provided general assistance in the preparation of all maps.

GEOLOGIC MATERIALS AND PRINCIPAL TERRAINS

Geologic materials to a depth of 20 feet (6.1 meters) are shown in plate 1. Descriptions of the geologic materials mapped in northeastern Illinois are given in the legend for plate 1 and in table 1, which gives the stratigraphic nomenclature and relative stratigraphic position for the various mapping units. Table 2 is a summary of the physical and mineralogical properties of the units. Figure 4 illustrates how the surficial map shows the sequence of formations with depth. Figure 5 shows examples of some generali-

zations that were employed to make the regional map (1:126,720 scale) from the 1:62,500 county maps.

Properties and Distribution of Materials

Glacial Tills

Plate 1 shows a variety of glacial and glacial-related deposits The most ubiquitous geologic materials in the six county region are the various glacial tills of the Wedron and Winnebago Formations. In general, from east to west across the region, progressively older tills of these formations are exposed at the land surface. Texturally, the tills range from extremely fine-grained silty clays (table 2) such as the Wadsworth and Yorkville Tills (ww and wy) to extremely coarse-textured gravelly sandy silts such as the Haeger Till (wh). Because each individual till unit is relatively consistent in physical properties and is encountered over large areas in northeastern Illinois, the tills form the major mapping units for near-surface geologic deposits in northeastern Illinois. The distinct physical and mineralogical characteristics of the various tills (table 2) result from the types of materials incorporated into the moving ice that deposited the till, the distance these materials have been transported, and the sub-ice topography.

It is significant to note that silty and clayey tills (wy, ww) are the principal surface materials of the eastern four counties of the region (Lake, Cook, DuPage and Will), as well as of small portions of the eastern side of Kane County and south-central McHenry County. In this area, they directly underlie approximately 60 percent of the area. With the exception of a limited area of occurrence west of the Fox River in Kan and McHenry Counties, the Fox River can be considered the western boundary of the silty and clayey tills.

Table 1

Detailed Description of
Geologic Units which are Mapped in
Cook, Du Page, Kane, Lake, Mc Henry and
Will Counties within 20 Feet of Land Surface
(in approximate order of deposition)

m	Made-land areas; includes major fills, filled channels, ponds, and reclaimed land areas along the Lake Michigan shoreline; also includes land reclaimed from past extractive operations where fill consists mainly of transported material.
sm	Land disturbed by extractive operations; includes coal strip mines, quarries, gravel pits, clay pits and spoil piles; depth of excavation and thickness and composition of spoil and fill variable but frequently similar to material removed for extractive operation.
lmr	Lake Michigan Formation, Ravinia Sand Member; well sorted, largely medium-grained beach sand containing lenses of gravel, principally occurs as modern beaches along Lake Michigan.
pl	Parkland Sand; wind-blown dune deposits; mainly fine-grained sand, may overlie or grade into similar materials (e.g., Equality, Dolton Member).
gl	Grayslake Peat; peat, muck and locally marl, dominantly sandy silty or clayey organic-rich material, frequently includes high percentage of recognizable plant remains.
py	Peyton Colluvium; mainly fine-grained slopewash along valley sides; consists of material derived from adjacent uplands by downslope gravity movement; original structure destroyed; gradational to Cahokia (valley alluvium).
ag	Accretion-gley; local wash in poorly drained upland depressions of present surface; may include some loess and organic matter.
c	Cahokia Alluvium; flood-plain and channel deposits of present rivers and streams; consists mainly of poorly sorted silty clay and silty sand, locally contains lenses of sand and gravel, may include small areas of organic material.
ri	Richland Loess; yellow brown wind-blown silt; thin discontinuous on Wedron Formation and Henry Formation, frequently too thin to map.
e	Equality Formation (undifferentiated); medium to fine-textured water-laid silt, sand and clay, deposited in glacial lakes.

ec Equality Formation, Carmi Member; largely underwater deposits in glacial lakes, mainly bedded silt with some fine sand, frequently laminated and containing beds of clay or silty clay, some massive.

ed Equality Formation, Dolton Member; largely shoreline deposits of glacial lakes, can include deltaic, near-shore-type deposits; mostly medium-grained sand with local lenses of sandy gravel along beaches and bars, some silt and clay where gradational to Carmi Member.

h Henry Formation (undifferentiated); sand and gravel deposited as outwash plains or valley trains, ranges from coarse gravel to fine silty sand; locally containing silt and clay, till inclusions and boulders; locally equivalent to interbedded sand and gravel within Wedron Formation (-o).

hw Henry Formation, Wasco Member; sand and gravel deposited as ice contact hills and ridges (kames, eskers and kame terraces), poorly sorted, irregularly bedded with variable grain-size; commonly contains lenses and masses of silt, clay and till.

ww Wedron Formation, Wadsworth Till Member; mostly gray clayey and silty clay till, calcareous, relatively low in pebbles, cobbles and boulders, low sand content in matrix, may contain local thin lenses of silt.

wh Wedron Formation, Haeger Till Member; mostly yellowish brown to gray brown gravelly, silty sand till, calcareous, frequently thin and patchy over sand and gravel (wh-o). Marginal areas (Mc Henry, Kane) may include some stagnant ice features - thin tills with hills and ridges of sand and gravel and small poorly drained low-lying areas of equality, accretion gley and occasionally Grayslake Peat.

wy Wedron Formation, Yorkville Till Member; mostly dark gray to brownish gray clayey and silty clay till, calcareous, sparcely pebbly, generally uniform.

wm Wedron Formation, Malden Till Member; mostly yellowish brown to gray sandy silt till, calcareous, pebbly, locally contains incorporated pinkish gray sandy silt till (Tiskilwa) along northern margin; occasionally overlies sand and gravel (wm-o) within 20 feet of land surface.

wt Wedron Formation, Tiskilwa Till Member; mostly reddish brown to reddish gray sandy silt till, generally uniform, occasional lenses of silt.

wic Winnebago Formation, Capron Till Member; brown to pinkish gray sandy loam till, calcareous, generally uniform texture contains light brown silty phase below sandy plane in subsurface.

wia Winnebago Formation, Argyle Till Member; pinkish tan or salmon, sandy loam till, calcareous, can include lenses of sand and gravel and silt, found within 20 feet of the surface only in northwestern Mc Henry County.

-o Generalized units associated with glacial tills (w, ww, wh, wy, wm, wt, wi, wic or wia): outwash, any subsurface sand gravel deposit; usually well-sorted, continuous, but may be locally poorly sorted with lenses of silt, clay and till. Ranges from coarse gravel to fine silty sand. Includes some surface outwash where continuity into subsurface can be demonstrated.

-a Ablation drift; discontinuous deposits of till and waterlaid materials which were deposited on top of associated till during deglaciation. Ablation till is generally coarser textured than associated till and frequently is underlain, overlain, or interbedded with discontinuous outwash sand and gravel or lacustrine silt and clay.

-l Subsurface lacustrine deposit; generally fine-textured, frequently laminated deposits of glacial lakes. Some deposits may be laterally continuous.

Pk Kewanee Group (Pennsylvanian)-Carbondale (top) and Spoon Formation; largely shale and sandstone with thin beds of coal, clay and limestone.

S Silurian dolomite - Racine (top), Sugar Run, Joliet, Kankakee, Elwood and Wilhelmi Formations; largely dolomite, slightly to moderately argillaceous with scattered chert nodules; Racine Formation contains large reefs of massive to well bedded pure dolomite, minor beds of shale and shaley dolomite in lower part and locally bordering reefs in upper part; partly limestone in places near Kankakee Valley; fills pre-Silurian valleys as much as 100 feet deep in Maquoketa Shale in some areas.

Om Maquoketa Group (Ordovician), Neda Formation (top), Brainard Shale, Fort Atkinson Limestone, and Scales Shale; red shale and oolite in local areas at the top; upper part largely greenish gray shale that in places grades laterally to silty argillaceous dolomite and dolomitic siltstone; limestone and dolomite with interbedded shale in middle part; largely gray to brownish gray shale in lower part.

Og Galena Group (Ordovician), Wise Lake (top) and Dunleith Formations; mostly pure, medium- to thick-bedded, yellow-gray to tan dolomite above; thinner bedded, slightly less pure, and locally cherty dolomite below; limestone mottled with dolomite locally.

TABLE 2

Physical and Mineralogical Properties of Geologic Units
Mapped in Northeastern Illinois

Units		Data N	qu	w	γd	Gvl	Sd	St	Cl	M	I	C-K
Peyton Colluvium (p)	$\bar{X}$	13.5	2.04	23.1	98.7	1.4	10.1	50.6	39.3	70.8	19.9	9.3
(K, W)*	n	23	37	41	28	44	52	52	52	12	12	12
	R	6-23	0.4-8.9	12-34	85-118	0-14	0-65	10-70	21-69	40-87	7-42	4-18
Peyton Colluvium (py)	$\bar{X}$	-	0.26	24.3	101.6	-	11	54	35		no data	
+ Accretion-gley (ag)	n	-	5	5	5	-	3	3	3		probably similar	
(D)*	R	-	0.1-0.4	21.8-25.2	101-115	-	5-16	43-66	23-42		to py	
Parkland Sand (pl)						no data						
Lake Michigan Formation (lm)						no data						
Grayslake Peat (gl)	$\bar{X}$	1.9	0.28	111.8	52	2	8	52.4	39.6			
(K, M, L, D)*	n	20	10	20	5	6	10	10	10		no data	
	R	0-5	0.1-0.5	34-265	30-74	0-3	0-23	26-72	22-61			
Cahokia Alluvium (c)	$\bar{X}$	8.2	1.2	26.1	107	3.8	28.7	44.7	26.6	64	23	11
(K, M, L, W)*	n	25	15	23	7	44	48	48	48	8	8	8
	R	2-25	0-2.9	11-51	100-117	0-51	0-59	16-73	6-49	6-93	4-66	2-28
Richland Loess (ri)	$\bar{X}$	12	2.1	24	101	1	7	50	43	72	19	9
(K)*	n	6	10	10	5	8	8	8	8	7	7	7
	R	9-19	0.4-3.9	20-31	94-104	0-3	0-13	40-61	35-53	55-85	12-28	3-18
Equality Formation	$\bar{X}$	20.1	1.2	27.9	95.8	0.8	8.5	60	31.3	27.4	56.7	15.9
Carmi Member (ec)	n	154	126	191	65	172	198	198	198	50	30	50
(K, M, C, D)*	R	1-75	0.1-6.6	8-100	43-131	0-26	0-82	9-94	2-84	2-95	36-86	4-28
Dolton Member (ed)	$\bar{X}$	20	-	-	-	6.3	38.8	46	15.2	-	-	-
(K, M, L)*	n	19	-	-	-	13	13	13	13	-	-	-
	R	7-39	-	-	-	0-30	12-91	7-81	2-63	-	-	-
Henry Formation	$\bar{X}$	22	(1.3)	(17)	-	28.5	52.7	32.5	14.8	9	73	18
Mackinaw	n	251	(4)	(19)	-	112	113	113	113	20	20	20
and Batavia	R	3-119	(0.7-2.3)	(11-23)	-	0-76	5-91	2-92	0-53	-	35-84	12-28
Members (h)												
(K, C, W)*												
Wasco Member (hw)	$\bar{X}$	36	(2.3)	(10)	-	25	41	43	16	10	69	21
(K)*	n	56	(3)	(9)	-	21	21	21	21	14	14	14
	R	-	(2-3.5)	(8-13)	-	4-55	1-80	19-85	1-39	2-28	51-78	11-27
Wedron Formation	$\bar{X}$	27.3	4.87	17.5	114.9	3.9	12.5	42.7	44.8	7.5	74.5	18
Wadsworth Till	n	370	474	481	48	470	626	626	626	178	178	178
Member (ww)	R	5-78	0.5-13	7.2-30	105-125	0-29	0-29	0-69	4-90	9-81	3-15	9-23
(L, C, W, D)*												
Haeger Till Member	$\bar{X}$	56	0.6	9.3	151	21	55	35.5	9.5	17.5	70	12.5
(wh) (M)*	n	18	3	10	3	17	17	17	17	7	7	7
	R	16-92	0.5-0.7	5.6-12	148.5-156.6	2-26	41-64	29-41	2-20	12-25	56-76	9-18
Yorkville	$\bar{X}$	20	2.9	13	126	12	26	42	32	5	75	20
ablation (wy-a)	n	29	48	55	25	80	80	80	80	28	28	28
(K)*	R	11-26	0.6-8.3	10-24	114-136	2-40	7-53	17-66	15-90	-	-	-
Yorkville Till	$\bar{X}$	24.4	3.62	17.0	117	3.4	10.2	46.5	43.3	3.2	78.2	18.6
Member (wy)	n	98	582	992	608	379	987	987	987	130	130	130
(K, W, D)*	R	3-106	0.6-10	9.2-35	91-138	0-29	0-54	18-83	13-68	2-3	72-81	16-25
Composite	$\bar{X}$	21.3	3.3	14.9	120	6.9	16.7	43.3	40	6.2	76.2	15.6
wy & wy-a	n	134	139	192	77	204	206	206	206	84	84	84
(K, M)*	R	3-106	0.6-9.7	10-31	94-136	1-40	2-53	17-75	13-90	1-33	30-87	8-23
Malden Till	$\bar{X}$	17	2.1	13	128	13	36	43	21	9	73	18
Member (wm)	n	33	37	44	13	54	54	54	54	27	27	27
(K)*	R	5-100	0.5-4.5	9-25	119-135	0-32	4-57	23-63	6-38	1-22	64-82	12-23
Malden	$\bar{X}$	32	-	11	104	5	55	34	11	22	61	16
Outwash (wm-o)	n	44	-	3	1	13	13	13	13	3	3	3
(K)*	R	6-100	-	8-13	-	0-23	3-83	4-80	0-29	19-26	60-62	14-19
Tiskilwa	$\bar{X}$	28	2.3	10.6	-	16.9	42.8	39.4	17.8	16.8	62.1	21.1
ablation (wt-a)	n	132	12	105	-	41	43	43	43	48	48	48
(K, M)*	R	6-77	1.4-6.2	6-30	-	5-70	16-62	18-54	8-37	4-23	54-73	13-28
Tiskilwa Till	$\bar{X}$	36	2.8	12	124.3	6.7	35.1	38.3	26.6	12.8	64.2	23
Member (wt)	n	166	182	334	84	315	315	315	315	164	164	164
(K, M)*	R	7-90	0.5-9.7	8-18.3	82.9-156	0-25	4-52	28-71	6-45	5-27	37-71	9-35
Winnebago Formation	$\bar{X}$	28	2.2	9.2	146	6	48	34	18	16	62	22
Capron Till	n	23	9	8	4	21	21	21	21	12	12	12
Member (wic) (M)*	R	7-66	1.1-5.0	7-11	145.4-147.3	5-10	31-61	27-45	12-25	7-23	57-69	12-33
Argyle Till	$\bar{X}$	32	2.0	10	149.8	18	43	33	24	19.5	57.5	23
Member (wia) (M)*	n	17	3	2	2	18	18	18	18	13	13	13
	R	15-44	-	-	-	1-19	31-61	28-37	10-32	2.7-30.5	50-64	18-33

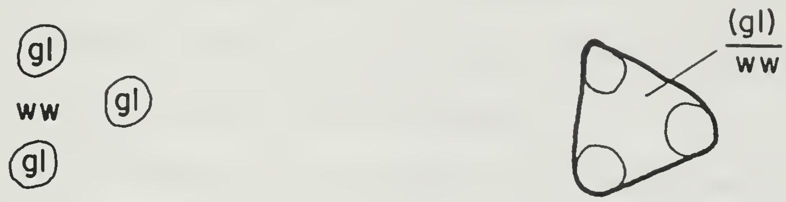
Explanation of Symbols:

$\bar{X}$ = mean
n = number of tests
R = range of data: low value - high value
N = number of blows per foot (Standard Penetration Test)
qu = unconfined compressive strength in tons per square foot
w = natural moisture content in percent
γd = dry density in pounds per cubic foot
Gvl = percent of gravel in total sample
Sd, St, Cl } = percent of sand, silt and clay, respectively, in ≤ 2mm fraction of sample
M = percent montmorillonite and expandables in clay fraction
I = percent illite in clay fraction
C-K = percent chlorite plus kaolinite in clay fraction

* Counties (K - Kane, M - McHenry, L - Lake, C - Cook, W - Will, D - DuPage) from which data was available.

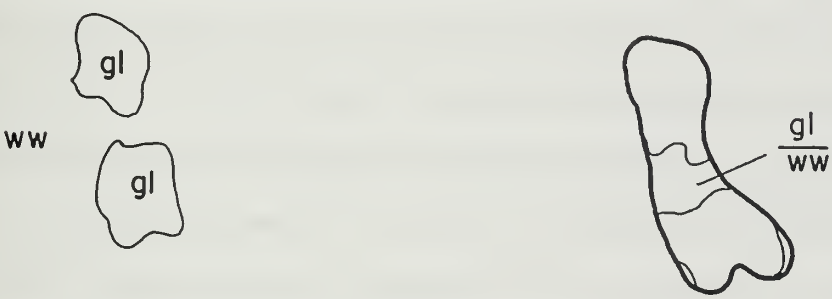
Figure 5. Some mapping generalizations used for reduction of county maps (1:62,500) to regional scale (1:126,720).

Example a:



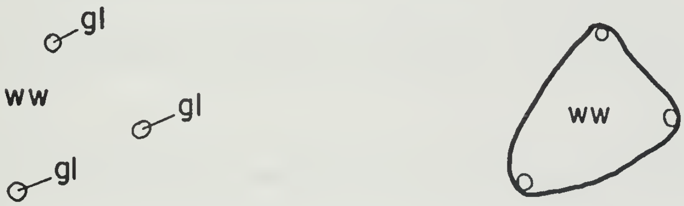
Individual mapped areas 25-75% of larger area

Example b:



Individual mapped areas ≥ 75% of larger area

Example c:



Individual mapped areas ≤ 25% of larger area

Tills of intermediate texture (wm, wt, wic, wia) cover much of central and western Kane County and portions of western McHenry County. A sandy, gravelly till (wh) is locally present in the central and eastern McHenry County and very small areas of western Lake and northwestern Cook Counties, but often is thin and discontinuous. This till is extensively underlain by relatively thick sand and gravel.

All tills mapped in northeastern Illinois may contain discontinuous lenses of associated water-laid materials. Although each till unit has a characteristic range of physical and mineralogical properties, the amount of associated water-laid deposits may locally cause some textural and mineralogical variations. The associated water-laid deposits may consist of coarse-grained outwash sand and gravel or fine-grained lacustrine (lake-deposited) silts and clays. In some cases, the water-laid materials have sufficient regional continuity to be mapped separately as major outwashes, such as wh-o in Lake and McHenry Counties. A lacustrine unit mapped in Cook County, w-l, may be quite widespread and continuous in the subsurface. Ablation tills such as wt-a, wic-a, and wy-a are rather specialized deposits that have some of the characteristics of their related tills, but are generally more coarse-grained and variable in texture than their related tills. This may be a consequence of reworking by glacial meltwater on the surface of the melting glacier.

For interpretive mapping and ultimately for planning purposes, the tills are the most predictable and uniform geologic materials mapped in the region. With the possible exception of the Haeger (wh), they are also relatively impermeable units which do not readily transmit fluids. In addition, most of the tills mapped in northeastern Illinois also contain 20 to 50 percent clay (table 2), which gives them appreciable potential for cation exchange.

Lake Deposits

Another type of relatively fine-grained deposit mapped in northeastern Illinois is lacustrine sediment. This type of deposit generally has less predictable physical properties and is more discontinuous and localized than the tills. Surficial lacustrine sediments that were deposited in glacial and early post-glacial lakes (ec) are found in upland depressions in morainal areas, on parts of the Lake Chicago Plain, and in intermorainal areas or stream valleys where drainage was ponded. Lacustrine deposits are often characterized by their lack of topographic relief and finely laminated beds of silt and/or clay. Their potential for cation exchange depends on the relative percentage of clay at a particular locality. In northeastern Illinois, surficial lacustrine deposits are most common in eastern Lake County, northeastern, central and southern Cook County, in northern and central Will County, and in north-central Kane County, and south-central McHenry County.

Coarser-textured deposits associated with shoreline features of large glacial lakes (ed) are mapped only in Cook and eastern Lake Counties where they indicate former high water levels of glacial Lake Chicago. The shoreline features included beaches, bars, spits, and deltas that consist predominantly of sand and some gravel which has a relatively high permeability and low capacity for cation exchange.

Lake deposits composed principally of sand also occur in southwestern Will County. These deposits are more widespread than beach deposits and are thought to be deltaic sediments deposited in a rather extensive glacial lake which covered southwestern Will County and much of adjacent Grundy and Kankakee Counties.

Outwash Sand and Gravel

The principal coarse-textured deposits in northeastern Illinois

include 1) outwash sands and gravels interbedded with the tills, some of which may be present at the surface as well as in the subsurface (e.g., wh-o) and 2) surficial outwash deposits (h), which are widespread in McHenry and eastern and southwestern Kane Counties. Localized surficial outwash deposits are mapped in many upland areas. Linear deposits of valley train outwash mark the position of glacial drainageways which carried large volumes of water discharging from the melting ice. Valley train deposits are found in most of the major river valleys in northeastern Illinois, including those of the Kishwaukee, the Fox, the DuPage and the Des Plaines Rivers.

Outwash sands and gravels may be utilized as shallow sources of ground water where they are thick and extensive. Often, a buried outwash deposit (-o) directly overlies creviced dolomite bedrock (S) and they form a single hydrologic unit. Sands and gravels may readily transmit contaminants due to their moderate to high permeability and low cation exchange capacity. Where sand and gravel deposits are sufficiently thick and found at shallow depths, they may also be utilized as a mineral resource.

Other Materials

The tills, lacustrine sediments, and outwash deposits are the most widespread units mapped in northeastern Illinois. Other geologic materials include: accretion gley (ag), colluvium (py), peat (gl), and modern stream alluvium (c). Except for the alluvium, these deposits are much more localized and occur mainly in isolated, poorly drained depressions on the surface of moraines and till plains or in valleys where drainage is not well integrated. These generally fine-grained deposits are important, however, because they are often poorly drained and frequently flood, have a high probability of containing a significant percentage of organic material and are often unstable.

Where peat (gl) is mapped, mainly in western Lake County, it indicates a deposit that may consist predominantly of decayed organic matter. The localized depressional deposits (gl, py, ag) may grade into lacustrine sediments (ec) which are also fine-grained and frequently poorly drained.

Bedrock (Pk, S, Om, Og) underlies the entire sequence of glacial and postglacial material. Locally, along major river valleys such as the Des Plaines and the Fox, bedrock is exposed where the drift cover has been eroded away. The Silurian dolomite (S) is the principal bedrock unit directly below the glacial materials along and east of the Fox River where it forms the lower part of the shallow aquifer system. It is or has been quarried for a variety of purposes in Cook, Will, DuPage and Kane Counties. The Pennsylvanian rocks (Pk) which occur only in the southwestern corner of Will County have been mined for coal.

Man has also contributed to or modified the materials mapped in northeastern Illinois. The highly urbanized portions of the six county region are characterized by significant amounts of surficial fill (m), made land areas (m), filled channels (m) and land disturbed by extractive operations (sm). Because of scale limitation, only major fills and extensive extractive operations are indicated on plate 1. The variety of natural and non-earth materials utilized as fill precludes a detailed description of this group of materials; they must be individually investigated. In areas disturbed by extractive operations (sm), there is a high probability that much of the disturbed land consists of locally derived natural materials.

Principal Terrains

In order to summarize the elements of the landscape, considering both the geologic materials and the topography as they relate to resources

and land-use characteristics, terrain analysis similar to that used by Hackett and McComas (1969) was applied to the region. As a consequence of glacial deposition, each of the major physiographic features in the region is underlain by a predictable sequence of subsurface materials. Identification of the principal terrain elements provides the basis for differentiating those areas in which the conditions for a variety of interpretations relating to land-use and resources are likely to be similar.

Definition

For simplicity, a twofold categorization of the terrains of the region was established. For the purposes of this study, therefore, terrain analysis consists of: 1) outlining major uplands, intermediate areas, and lowlands; 2) integrating the main characteristics, including the relative hydraulic conductivities (permeabilities) of geologic materials with their terrain position. Uplands are generally characterized by high, rolling topography with slopes often greater than 4 percent and underlain mainly by glacial till or occasionally sand and gravel; intermediate areas are generally flat to rolling plains underlain by a wide range of materials; and lowlands generally include valleys often underlain by medium to coarse-textured materials (table 3). Plate 2 shows the basic outline of the principal terrains while plate 3 shows principal materials distinctions related to general hydraulic conductivities (i.e., till and other fine-textured materials vs. outwash sand and gravel), combined with principal terrain features.

Generalized slope characteristics were derived from topographic maps and compared with slopes shown for soils on Soil Conservation Service (USDA) Soils Maps. Definition of terrains was somewhat subjective and some of the boundaries are rather arbitrary. The boundaries between Uplands and

Plains were based in part on the relative elevation between areas as well as slope characteristics. Upland areas, therefore, have been mapped where slopes of 4 to 7 percent or greater tend to occur frequently within a given area and on the highest position on the landscape. However, in some cases, areas were mapped as uplands because they were significantly higher than surrounding terrains, even if these areas did not meet slope criteria.

Although the identification of most lowland areas was normally rather obvious, some areas did pose problems. The western margin of the Lake Chicago lowland in portions of west-central Cook County, just east of the DuPage County line is characterized by a generally rolling, gently sloping surface, which ranges from slightly above 660 feet (200 meters) above sea level along the county line to 610 feet (185 meters) about 8 miles to the east. Since a principal materials boundary was mapped along the west side of the Des Plaines River Valley, this was the terrain boundary chosen. Other somewhat arbitrary decisions were those related to extending lowland terrains up-valley to the head-waters of major streams and into minor tributary valleys. In general, where valleys are less pronounced topographically and narrow to less than one-half mile in width, they have been included within the intermediate (plain) terrain.

In a broad sense, the distribution of terrains and the characteristics of the materials which compose each terrain dictate the rate and direction of both surface and ground-water movement by being the determining factors for both the gradient and hydraulic conductivity. Therefore, this combination of characteristics suggests the relative significance of a given area for natural recharge to shallow aquifers, areas suitable for certain types of artificial recharge, and the potential for pollution in a given area.

TABLE 3

Legend for Plate 2, Principal Terrains

UNIT SYMBOL	DESCRIPTION
A	Uplands - generally high, frequently > 4% slopes some > 7% slopes; composed principally of till, some sand and gravel.
B	Plains - flat to rolling, some slopes > 4%; distribution of materials highly variable.
C	Lowlands - mainly larger valleys, locally steep side-slopes > 4%; mostly medium to coarse textured materials.

Distribution of Terrains

Plate 2 shows the distribution of the principal terrains in northeastern Illinois. The greatest concentration of upland terrains as identified for this study lies mainly in the northwestern portion of the region. They are most extensive in McHenry, Kane, southwestern Lake and northwestern Cook Counties. The only other extensive upland areas are mapped in central and southeastern Will County. For the most part, the geologic materials which compose the upland terrains in McHenry and northwestern and south-central Kane Counties are either coarse- or medium-textured tills often underlain by sand and gravel within 20 feet of land surface (plate 3). The remaining uplands in Kane, Lake, Cook and Will Counties are underlain mostly by fine-textured tills.

The lowland terrains are generally adjacent to the principal rivers of the region and their tributaries: the Des Plaines, the DuPage, and the Kankakee. Since all of the rivers and streams of the area have transported and deposited sediments, alluvial deposits make up most of the materials directly under and adjacent to the stream valleys. These sediments range from very fine-textured materials including organic-rich sediments to relatively coarse-textured materials derived from sand and gravel outwash deposits or sorted from the till over which the stream flows. In some areas, however, streams may have cut through the alluvium and flow directly on till, sand and gravel or bedrock. In addition, the shoreline of Lake Michigan in northeastern Lake County and the Lake Chicago Plain in eastern Cook County are also mapped as lowlands. The Lake Chicago Plain contains the Calumet and Chicago Rivers as well as portions of the Des Plaines River and Salt Creek.

Although a significant proportion of the area mapped as lowlands is directly underlain by sand and gravel, there are notable exceptions. For example, the lower portions of the Fox Valley in Kane County and the DuPage,

Des Plaines and Kankakee Valleys in Will County are floored by bedrock, principally Silurian dolomite. In northeastern McHenry and northwestern Lake Counties the lowlands adjacent to the Fox River and the Chain-O-Lakes contain considerable areas underlain by peat or other organic-rich sediments. Much of the Lake Chicago lowlands of eastern Cook County is directly underlain by till or thin, fine-textured lake sediments.

Between the areas mapped as uplands and lowlands are the intermediate areas mapped as plains. These relatively flat areas, with slopes generally no more than 4 percent, are underlain by various tills. However, locally they may be directly underlain by areas of sand and gravel or finer textured, water-laid sediments. Numerous small, poorly drained shallow depressions dot the landscape in these intermediate areas, particularly in Lake County. As is the case with upland terrains, the glacial till which underlies the plains is predominantly coarse- to medium-textured west of the Fox River Valley and fine-textured to the east. The most extensive areas of fine- to medium-textured lake deposits are concentrated particularly in the north-central part of Kane County and southeastern Cook County. Fairly extensive areas of sand and gravel directly underlie this terrain, particularly in the eastern portion of McHenry County and just east of the Fox River in portions of western Lake, Cook and DuPage Counties.

On a regional basis, land surface elevations in northeastern Illinois range from 1189 feet (360 meters) about 4½ miles (2.8 kilomenters) northeast of Harvard in McHenry County to just below 520 feet (158 meters) along the Kankakee and Des Plaines Rivers at the western border of Will County. Some of the lowland areas of McHenry County are higher (above 925 feet or 280 meters) than the upland areas mapped in Will County at 830 feet (252 meters). Therefore, it should be emphasized that the topographic aspects of terrains is mainly the relationship of local landscape characteristics.

HYDROGEOLOGIC PROPERTIES RELATED TO GROUND-WATER RECHARGE

In order to fully understand the maps pertaining to natural and artificial recharge characteristics, waste disposal and land treatment practices, it is necessary to have a working knowledge of some basic hydrogeologic principles and their application in northeastern Illinois. General references on the hydrogeology of northeastern Illinois include Suter, et al. (1959), Walton (1965), Sheafer and Zeizel (1966) and Hughes, Landon and Farvolden (1971) and the Northeastern Illinois Planning Commission (1974).

Hydrogeologic Principles

In the humid climate of northeastern Illinois, ground water is derived from precipitation that falls mainly as rainfall and seeps into the ground. The water infiltrates through loose particles of the soil and percolates downward through the soil. This process is illustrated in figure 6a. Below a certain depth, which is called the "top of the zone of saturation" or "water table," almost all openings (pores) in the earth materials are filled with water. Above the "water table" the pore spaces are filled with both water and air. This definition of water table is independent of the earth materials, and therefore is not related to the availability of ground water to wells (see "aquifer" below).

Openings in which ground water is stored in the zone of saturation range in size from tiny pores between particles of clay and silt, to larger pores in sand and gravel, to large crevices in dolomite and limestone. The porosity of an earth material refers to its pore space and is expressed quantitatively as the percentage of total volume. The size and interconnection of the openings determine the relative ease with which an earth material transmits water under a pressure gradient; this is referred to as the hydraulic conduc-

tivity or permeability of the earth materials. Permeability refers to the ability of an earth material to transmit any fluid, while hydraulic conductivity refers to a property of both the material and water (Domenico, 1972).

Earth materials which have interconnected openings large enough to transmit water readily to a well or spring are called aquifers. An aquifer (an imprecisely defined term) is a natural earth material which yields water to a well in sufficient quantity to satisfy the need for which the well was drilled. Thus, an aquifer which will produce sufficient water to a well to supply a single residence might not necessarily be an aquifer for a municipal well. Our use of the term aquifer refers to earth material capable of supplying at least several residences, but not necessarily supplying large quantities of water.

Under natural conditions in northeastern Illinois, the water table roughly parallels the surface topography, rising under the uplands and intersecting the ground surface along perennial streams, lakes, swamps, and springs. At these points of intersection, ground water is discharged to surface water bodies by gravity flow from adjacent areas where the water table is higher. This is illustrated in figure 6b. The position of the water table and the discharge of ground water to streams fluctuate from season to season and from year to year. We wish to emphasize that the water table can be located in any of the surficial materials found in northeastern Illinois. Even after the water table is encountered, ground water is not necessarily available to a well. Water will be available only after encountering material with sufficient hydraulic conductivity to transmit water to a well. The presence of water does not necessarily mean the presence of an aquifer. A large excavation below the water table will fill with water, though slowly, even in materials of very low hydraulic conductivity.

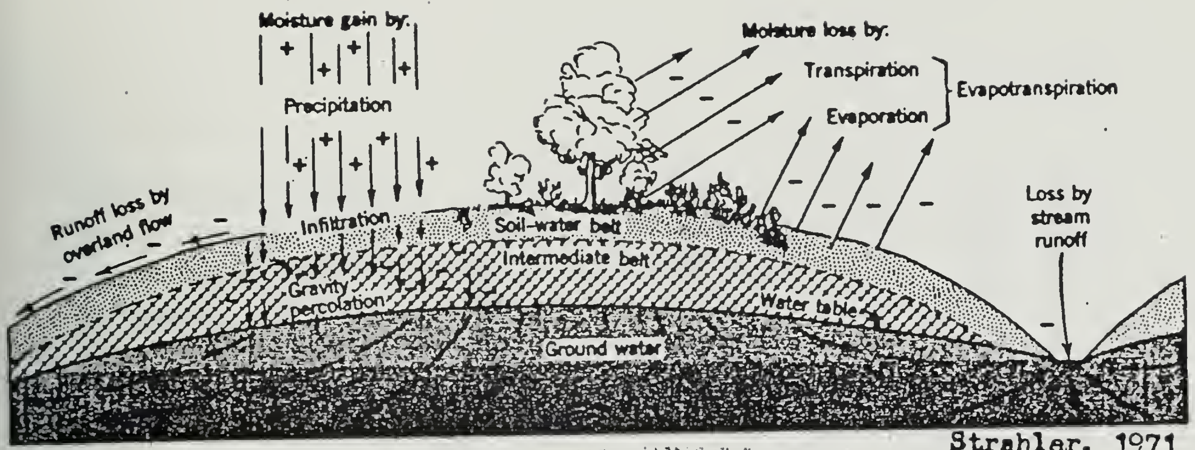
The addition or replenishment of water to the ground-water reservoir is called recharge. A ground-water "flow system" describes the progressive movement of water through the earth from recharge areas to discharge areas. While the driving force for ground-water movement is gravity, the direction of ground-water movement is a function of potential (or energy). The path that ground water follows through the earth from the recharge to the discharge area may be thought of as imaginary lines of flow (fig. 6a). This path may have both vertical and horizontal components at any given point in the system.

Any complete regional flow system is composed of small, local systems superimposed on larger systems. A small, local flow system might include only a small pond acting as a discharge area for the uplands immediately adjacent to it, which would be the local recharge area. This small system could, in turn, be superimposed on a secondary system that finally discharges into a major stream such as the Des Plaines River or the Fox River. Figure 6b illustrates the concept of local and regional flow systems. Figure 7 gives an example of a hypothetical flow system in northeastern Illinois.

Recharge is diffuse over large areas and does not come from a point source or even from small local areas. In relatively humid areas such as northeastern Illinois, streams which flow perennially or for most of the year serve as ground-water discharge areas. The entire interstream area, therefore, forms the recharge area.

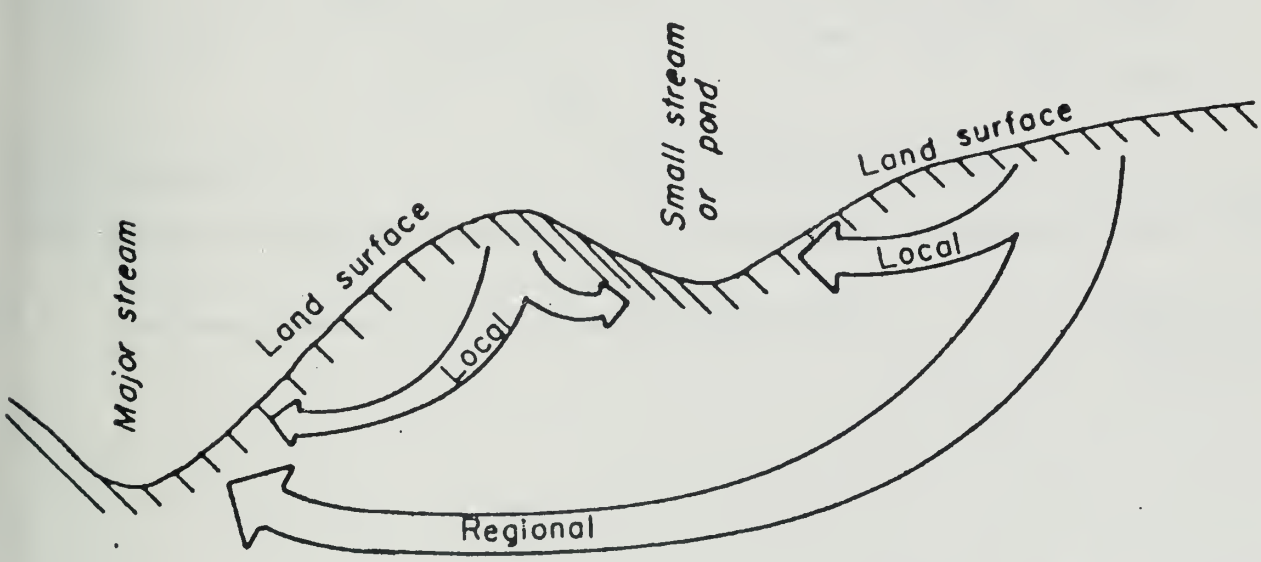
Aquifers of Northeastern Illinois

In northeastern Illinois, ground water is obtained from four major aquifers: 1) sand and gravel aquifers in the glacial drift; 2) the shallow dolomite aquifer, including the Silurian dolomite and the Galena-Platteville Dolomite; 3) the Cambrian-Ordovician Aquifer, in which the Ironton-Galesville



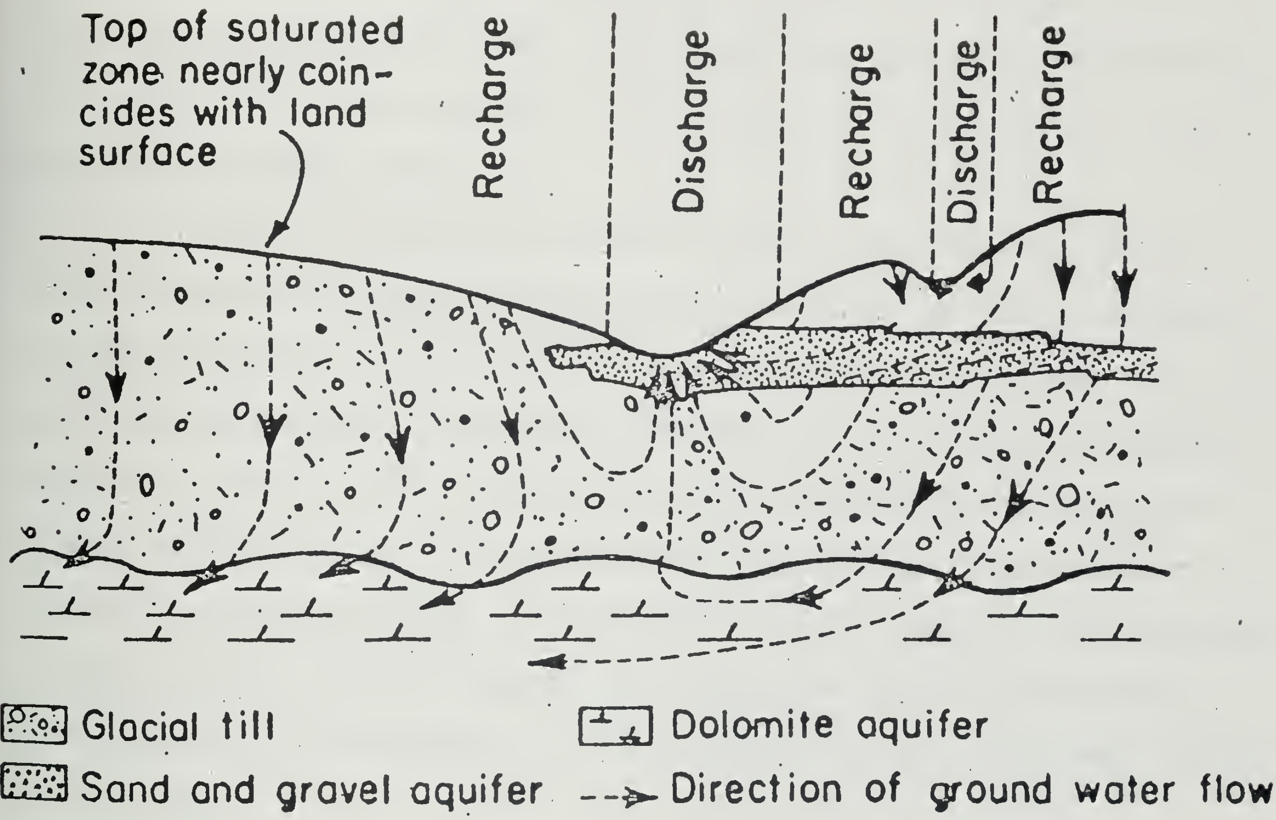
Strahler, 1971

Figure 6a. Hydrologic cycle in Northeastern Illinois



Cartwright & Sherman, 1969

Figure 6b. Concept of superimposed local and regional flow systems in Northeastern Illinois



igure 7. A hypothetical flow system that could exist in northeastern Illinois.

Hughes, Landon, Farvolden, 1971

and Glenwood-St. Peter Sandstones are the most productive units; and 4) the Mt. Simon Aquifer, which consists of the Mt. Simon Sandstone and the basal sandstone of the Eau Clair Formation (Suter et al., 1959).

For this report, only the sand and gravel aquifers in the glacial drift and the shallow bedrock aquifers were considered, especially where they lie at or near the land surface or where they form a continuous hydrogeologic unit with basal sands and gravels in the glacial drift. Together they form the shallow aquifer system.

Detailed information on bedrock aquifers in northeastern Illinois can be obtained from Hughes, Kraatz, and Landon, 1966. Information regarding current water levels in municipal wells penetrating bedrock aquifers and projections of future water levels can be obtained from the Illinois State Water Survey. It should be noted that there are both widespread declines in the piezometric surfaces of the deep sandstone aquifers, which are most severe around major pumping centers, and localized cones of depression in the shallow dolomite aquifer. Specific details can be obtained in Csallany and Walton, 1963; Sasman, 1965; Sasman et al., 1973; and other Illinois State Water Survey publications.

Relationship of Ground-Water Movement to Terrains

The eventual destination of all precipitation which falls on northeastern Illinois, other than that which evaporates or is transpired by vegetation, is the Mississippi River (mostly via the Kishwaukee, Fox, and Des Plaines Rivers) or Lake Michigan. Of that water that enters these streams or the lake, most will be as direct surface runoff. Only a small portion of the precipitation will enter the ground-water system. Of that portion which enters the ground, some will be held as soil moisture, and when that is satisfied, the remainder moves into the ground-water reservoir.

To a rather significant extent, the nature of the topography, surface soils and underlying geologic materials determine how much water will enter the ground-water reservoir. Climatic factors (including temperature and rainfall frequency and intensity) and type and distribution of vegetation are also important. In addition, storm sewers in urban areas and field tile in agricultural areas may considerably alter natural drainage and recharge characteristics. However, regionally, the inter-relationship of surface soils, geologic materials and the terrain configuration determines the rate of recharge and the direction of ground-water movement.

Since the rate of ground-water movement is directly related to both hydraulic conductivity and hydraulic gradient, uplands directly underlain by sand and gravel will allow for relatively rapid infiltration and ground-water movement. On the other hand, where the uplands are directly underlain by silty, clayey till, which has considerably lower hydraulic conductivities, surface runoff may be greater and infiltration rates and ground-water movement generally will be slower. Thus the total amount of recharge to a given area over a given period of time tends to be considerably less for till terrains than for terrains composed of sand and gravel.

The distribution pattern of terrains also affects the direction of ground-water movement. Since ground water moves under the influence of gravity from the place of intake to a lower place of discharge, movement of ground water is from the uplands or plains toward the lowlands. For the most part, it is likely that more water will enter the deeper portions of the shallow aquifer system (sand and gravel within the drift and underlying Silurian dolomite) from upland and plain terrains. This is because the distance to regional zones of discharge is greater, thus providing the opportunity for some ground water to move downward to deeper portions of the shallow aquifer system (see

figs. 6b and 7). A very small portion of this water may actually move downward through the Maquoketa Shale and into the Cambrian-Ordovician Aquifer (Walton 1965, p. 3-6). Water which infiltrates to the ground-water reservoir in the lowland terrains adjacent to the principal zones of discharge will move directly toward these zones and become surface water. This water will not add significantly to the ground-water resources of the area unless intercepted by nearby wells.

Natural Recharge

Natural recharge to the ground-water system occurs in a very diffuse pattern over the landscape, not at specific definable locations. The rates and occurrences of recharge events are dependent upon many factors, the most important of which are soil moisture condition, permeability of soil, precipitation intensity, and location within the ground-water flow system. Some recharge will occur in almost all areas, except in the discharge zones themselves. In the past, designation of prime natural recharge areas has often concentrated only on the nature of the surficial materials, without taking into consideration their relative hydrogeologic position. The terrain map (plate 2) of the region was considered as an intermediate step in producing a regional hydrogeologic map that would provide the basis for evaluating the regional shallow groundwater system. Plate 3 evaluates both the surficial materials and regional terrain characteristics to establish the relative natural recharge potential of various parts of the landscape. There were basically two reasons for this approach: 1) suitably distributed, long-term water level records for wells penetrating the glacial drift and shallow bedrock aquifers were generally not available; and 2) even when well records were available, the complexities of local and regional flow systems in the shallow aquifers did not lend themselves

to attempts at three dimensional mapping. Therefore, the map implies the relative rates and highly generalized directions of ground-water movement to indirectly yield the relative amounts of recharge over a given area and period of time.

The map (plate 3) shows the distribution in northeastern Illinois of nine categories of natural recharge potential in order of decreasing significance. It should be noted that: 1) upland and plain areas in categories 1 through 6 may all contribute significant recharge to the shallow aquifers, and 2) areas in categories 7 through 9 may contribute principally local recharge. However, the proximity of areas mapped in categories 7 through 9 to major areas of ground-water discharge may limit significantly their overall contribution to the shallow aquifer system. Since less than 25 percent of the region is included in categories 7 through 9, a large portion of the remaining area contributes some recharge to the shallow aquifer system. Therefore, from the viewpoint of ground-water resources, it is likely that west of the Fox River, most of this recharge supplies sand and gravel aquifers within the glacial drift. East of the Fox, the recharge supplies both sand and gravel aquifers and the Silurian dolomite aquifer. The Silurian is generally less than 50 feet thick or absent west of the Fox River, except for relatively small areas in central and western McHenry County.

Probably the largest percentage of recharge enters the shallow ground-water system throughout much of the upland and plain terrains of McHenry County. Although there is likely to be considerable local discharge into the tributaries of the Fox and Kishwaukee Rivers, much of the recharge infiltrates through the relatively sandy surface deposits (categories, 1-3, plate 3) and into the deeper portions of the shallow ground-water system. Since the glacial deposits average at least 200 feet (60 meters) in thickness in McHenry, Lake,

Table 4

Legend for Plate 3

Hydrogeologic Rating of Northeastern Illinois as to Relative Significance for Natural Recharge to Shallow Aquifers

Areas rated in descending order of significance as natural recharge areas with respect to hydraulic conductivity (permeability) and position in the landscape (terrain characteristics).

1. Upland or plain underlain by thick, extensive sand and gravel.

2. Upland or plain underlain by relatively thin or patchy sand and gravel underlain within 20 feet by till (or other fine-textured material).

3. Upland or plain underlain by thin till or other fine-textured sediments over relatively thick extensive sand and gravel or dolomite within 20 feet of surface.

4. Upland or plain underlain by relatively thin coarse-textured materials and/or sandy tills.

5. Upland or plain underlain by thick loam (intermediate textured) till.

6. Upland or plain underlain by thick silty clay till, fine-textured, water-laid sediments or shale.

6a. Lowland lake plain underlain by thick silty clay till and/or fine to medium-textured water-laid sediments.

7. Upland or plain, directly adjacent to lowland, with any combination of sand and gravel, thin till over sand and gravel and/or dolomite or sand and gravel over dolomite, with relatively high, steep slopes (valley sides) separating lowland from adjacent terrain.

8. Lowland terrain underlain principally by sand and gravel and/or Silurian dolomite.

9. Lowland terrain underlain principally by silty, clayey materials, some organic-rich and/or shale bedrock.

northern Kane and northwesternmost Cook Counties, it is possible that some of this ground water also moves farther eastward than the Fox River and discharges into Lake Michigan.

Surface elevations of the principal recharge areas mapped in McHenry County range from about 900 feet (273 meters) to more than 1100 feet (333 meters) locally. Surface elevations of the adjacent Kishwaukee River lowlands range from 800 feet (242 meters) to 900 feet (273 meters) while those of the Fox River lowland range from about 740 feet (224 meters) on the north to about 730 feet (221 meters) at the south boundary of the county. Since much of the area of McHenry County is characterized by thick surficial sand and gravel which is underlain by medium-textured till, water will move through the gravel above the till toward the numerous lowlands, particularly the Fox River lowlands, and will be discharged. Although not all of the water will reach the deeper system, the relative average elevation of the upland and plain terrains of this area with respect to the lowlands and to other areas of northeastern Illinois suggest that recharge to the shallow ground-water system is still significant.

Much of the uplands and plains in Kane County is also underlain by intermediate-textured tills and some coarse-textured materials throughout the large areas of upland and plain present in the county. Therefore, recharge to the shallow ground-water system in Kane County may be substantial, but its effects may be of less regional significance. Although some ground-water discharges into the Kishwaukee River, much of it may discharge into the Fox River drainage system.

Throughout much of the rest of the region, in large portions of Cook, Lake, DuPage and Will Counties, the upland and plain terrains are composed predominantly of silty, clayey till (category 6) which have somewhat lower hydraulic conductivities and lower hydraulic gradients and, therefore,

recharge more slowly. However, since nearly the entire area is underlain by the Silurian dolomite aquifer, and there are relatively extensive areas of upland and plain terrains between the lowlands and valley discharge areas, the total recharge to the shallow aquifer system east of the Fox River is also significant.

Piskin (1971) has suggested, on the basis of the relationship of thickness and textural data from glacial deposits to data available from the principal pumping centers, that vertical permeabilities of the glacial deposits west of the Fox River are higher than those to the east, and should therefore affect recharge rates.

Walton (1965), in summarizing the recharge available to the shallow dolomite aquifers in selected areas of northeastern Illinois east of the Fox River, gives rates ranging from 52,000 to 225,000 gallons per day per square mile, averaging roughly 132,500 gpd/sq.mi. Although the recharge rates at one or two of the localities described by Walton also included recharge induced from streams flowing across small areas of exposed Silurian dolomite, the figures are probably in the proper order of magnitude for recharge available to the shallow aquifer system in the area east of the Fox River and underlying the relatively thick silty, clayey till. However, only one locality was listed west of the Fox River (Woodstock area); the recharge rate to the deepest sand and gravel aquifer there was reported as 127,000 gpd/sq.mi.

There are, therefore, many factors which must be taken into account when considering the almost infinitely complex subject of ground-water recharge. However, from the above discussion, the concept that significant recharge to the shallow aquifer system occurs throughout much of northeastern Illinois is probably of paramount importance. Even though rates may be slow throughout large portions of the region underlain by thick silty, clay tills, very substantial amounts of water move into the shallow aquifers through these materials.

Finally, one factor discussed only briefly in a previous section needs special mention. Natural recharge of precipitation to the shallow aquifer system has probably been altered significantly over extensive portions of northeastern Illinois. There is some indication, both on a theoretical basis and documented by field studies (Savini and Kammerer, 1961, p. A 18- A 21) that limited urbanization (e.g., subdividing) may tend to enhance recharge locally. This is due partly to the addition of water to lawns from rainfall drainage from roofs, by heavy watering of lawns, and occasionally by outflow from septic systems. Thus the addition of water, often imported, to these areas, in excess of normal rainfall evenly distributed, provides greater opportunity for soil moisture conditions to be satisfied and the hydraulic pressure to drive water downward into the ground-water system. Obviously, in areas of intensive urbanization, where essentially all land is either paved or covered with buildings and where storm sewer systems are well developed, recharge is absent.

However, it should also be emphasized that agricultural practices may also reduce natural recharge, by use of field tile for drainage of an extensive field of row crops and by removing the natural vegetation which allowed for better infiltration of precipitation. Some agricultural practices actually promote surface runoff, thereby lessening the available water for infiltration. Therefore any maps which show "natural" recharge conditions (e.g., plate 3) must be used with these conditions in mind.

Artificial Recharge

As an adjunct to defining and characterizing the areas of natural recharge, some of the same approaches and information can aid in establishing, from a hydrogeologic prespective, areas which may be suitable for artificial recharge of the shallow aquifers. This kind of information is useful to water

resources planning. However, delineating areas for artificial recharge of shallow aquifers implies additional considerations beyond those necessary for determining regional recharge areas. These include: 1) a potential source of water for recharge, 2) reservoir and aquifer storage capacity data, and 3) the need to concentrate artificial recharge operations in areas where water levels have been lowered by heavy pumpage. In addition, consideration must be given to the quality of the water which can be recharged, problems of clogging in recharge systems, poor quality of ground water in some surficial aquifers, particularly along major drainageways. The economics of developing artificial recharge capability must also be weighed against the direct reuse of waste water, since some treatment is usually necessary before artificial recharge can be initiated.

Artificial recharge by use of the standard pit or well techniques can be accomplished only if there is an aquifer available which can accept and transmit water. Therefore, the maps of surficial deposits (plate 1), terrains (plate 2) and natural recharge characteristics (plate 3) all have a bearing on outlining the occurrence of such aquifers. Surface spreading of water is another method of artificially recharging shallow aquifers, but such methods require more land, would be limited to rural areas and would probably be used in conjunction with surface spreading of waste water. Induced infiltration occurs when pumpage from nearby wells lowers water levels under streams or lakes and therefore induces recharge from the surface water body into the aquifer.

For the most part, surficial sand and gravel aquifers close to a source of surface water have been considered as the most feasible for artificial recharge either by pit or well. In northeastern Illinois, most of the significant surficial sand and gravel aquifers are located along the principal drainageways in areas mapped as lowland terrains. Some also are present below up-

land areas of McHenry, Kane and the westernmost portions of Lake, Cook and DuPage Counties. Many of these deposits are adjacent to the principal streams of the region, providing a source of water.

In serveral areas, heavy pumpage of ground water from the shallow aquifers has lowered water levels significantly (Prickett et al., 1964). In these areas, which include some upland areas, artificial recharge may be practical locally by pit or well (Scheaffer and Zeizel, 1966, p. 106-109).

It should be apparent from the preceeding discussion that only limited areas in northeastern Illinois have potential for significant artificial recharge to the shallow aquifers in any significant amounts. They are situated mainly along the principal rivers, the Fox, DuPage and Des Plaines, where relatively thick, extensive sand and gravel deposits are present (plate 1) and where pumpage has lowered water levels (Prickett, et al., 1964; Sheaffer and Zeizel, 1966). However, as additional shallow aquifers are developed along the major drainageways, artificial recharge may be more common. Also it may become economical or necessary to develop artificial recharge facilities in upland areas by either transporting surface water or using water from treatment plants. In such cases, upland sand and gravel deposits could be utilized as areas for artificial recharge, provided they are confined and not subject to rapid drainage to local discharge zones.

WASTE DISPOSAL AND LAND TREATMENT PRACTICES

A major objective of this project has been to indicate geologic conditions where waste products and land treatment practices may pollute water resources. To accomplish this goal, a series of five waste disposal maps were prepared for each individual county and then incorporated into five regional maps (plates 4-8). Intended to be used as a guide for regional planning, the

maps designate areas in northeastern Illinois where particular combinations of earth materials, topography, and ground-water flow systems indicate conditions most sensitive to various waste disposal and land treatment practices. Previous reports (Northeastern Illinois Planning Commission, 1973; Sheaffer, von Boehm and Hackett, 1963) have focused on solid waste.

By necessity, the boundaries of the areas designating particular conditions are somewhat generalized. These maps indicate the probability of finding suitable or unsuitable sites within a given area, but they cannot be considered a replacement for individual site evaluations. Investigation of any proposed waste disposal site is necessary because of the local range in composition of natural earth materials, limitations of mapping scale, and the random distribution of available data. In addition, certain considerations (such as distance to and number of nearby wells, frost depth, depth to seasonal water table, minor slope variations, position of the site with respect to ground-water flow system, areas near or at mapped materials boundaries and the density of disposal sites in a given area) cannot be evaluated regionally but should always be included as part of individual site evaluations.

The criteria on which these waste disposal and land treatment maps were based were reviewed by the state office of the USDA Soil Conservation Service, staff members of the University of Illinois Department of Agronomy, the Divisions of Water Pollution Control and Land/Noise Pollution Control of the Illinois State Environmental Protection Agency, planning commissions and health departments of the six counties, and the technical staff of the Northeastern Illinois Planning Commission. The cooperation of all is gratefully acknowledged.

General Criteria for Mapping

Character of Material

Cation exchange capacity - hydraulic conductivity: A prime consideration in regard to waste disposal in geologic materials is their cation exchange capacity (CEC). Naturally-occurring clays (particle sizes < .002 or < .004 mm) are composed mainly of clay minerals such as illite, chlorite, vermiculite, or montmorillonite with small amounts of associated non-clay minerals such as quartz, dolomite, and calcite. Clay minerals have a distinctive layered structure, in which the number and type of layers are generally fixed, but the number and type of accessory ions which satisfy requirements of space and charge within, between, and around layers are variable. Places where accessory ions (most often cations) may fit into the clay mineral structure are called exchange sites; the number of available cation exchange sites in a sample of a particular type of clay mineral determines its cation exchange capacity (CEC). Some clay minerals hold their accessory ions more loosely than others and have a "high cation exchange capacity." Some stable clay minerals are characterized by an increasing CEC as they weather to less stable forms. Organic materials also have a high cation exchange capacity and will cause deposits which contain a significant percentage of organic matter to have a relatively high CEC. The cation exchange capacity of a specific geologic material is a measure of its potential to release cations to and to adsorb cations from the ground water moving through it. If the ground water contains objectionable cations derived from industrial, domestic, or agricultural waste products, the CEC has a direct bearing on problems of waste disposal. In such instances, the CEC is a reasonably direct measure of the attenuation capacity of the geologic materials.

As suggested above, the range in CEC values is generally related to both the clay and organic content of the earth materials; as a rule, materials having a higher percentage of clay and organic matter have higher CEC values. Clays are prominent in bedrock shale deposits, in many fine-grained lacustrine (lake) deposits, and in many glacial tills; organic material is common in peat bogs, in certain other lowland depressions, and in the active soil zone (solum). The upper part of the solum (A horizon) generally exhibits the highest CEC values. Coarse-grained materials (sands and gravels) have a very low cation exchange capacity. It should be noted that most geologic materials in northeastern Illinois have a relatively low exchange capacity.

The porosity and hydraulic conductivity (permeability) are related to the grain size, mineralogy, and sedimentation history of the earth materials (Todd, 1959). The latter two factors exhibit moderate uniformity for the region and therefore, have relatively small influence on porosity and hydraulic conductivity as compared to grain size. In general, the finer the grain size, the greater the porosity (void volume); however, the larger the grain size, the larger the hydraulic conductivity.

In the following discussion and individual map legends, reference is made to geologic materials having low to high hydraulic conductivities and cation exchange capacities. In general, materials having low hydraulic conductivities have values of about 10^{-5} cm/sec or less while materials having high hydraulic conductivities have values about 10^{-2} cm/sec or greater. Low values for cation exchange capacity in northeastern Illinois are generally less than about 5 milliequivalents (meq)/100g while high values generally exceed 15 meg/100g ranging up to 35 meq/100g. Recent research has shown that a material with a CEC of 10 meq/100g is generally sufficient, given a reasonable thickness, to attenuate all but the most highly mobile ions.

Attenuation capacity: The attenuation capacity of an earth material is defined as the ability of that material to remove pollutants from the water as it passes through the material. This is a complex physical-chemical relationship, but the two major factors involved are the cation exchange capacity (CEC) and precipitation of insoluble compounds resulting from pH changes and chemical reactions. The CEC is the larger factor, and as the name implies is an exchange phenomenon which results in the capture of a pollutant and release of the natural ion present in the exchange position of the clay. In northeastern Illinois, the ion released is generally calcium (resulting in increased hardness of the surrounding ground water) and occasionally sodium.

The attenuation capacity of geologic materials is different for each specific compound and complex and gives a relative mobility index of the individual ions, compounds, and complexes. Recent research has shown that most toxic metals such as lead, mercury, and chromium, are relatively immobile, even when in competition for cation exchange sites with organic-rich garbage leachate. However, some toxic substances, such as arsenic and chromite (Cr^{6+} ion) are mobile under some conditions. Ammonia, iron and sodium ions, found in most common wastes, are relatively mobile. Chloride ions, also found in most wastes, move almost without any attenuation by earth materials.

Slope and Terrain Factors

Slope is also an important mapping consideration for waste disposal and land treatment practices. In general, steeply sloping land is undesirable for most wastes disposal methods. Slope was not directly considered in maps indicating conditions for land burial of wastes because slope would have to be taken into account in site selection and trench design. In general, references to steep slopes in the following sections refers to slopes greater than four percent and in particular, slopes greater than seven percent. The terrain

map should be consulted as to where these slope conditions are most likely to occur, while the detailed USDA Soil Conservation Service county soil maps and reports give more precise information on slopes, surface drainage and erodability.

Summary of Regional Interpretations

The maps presented in this report (plates 4-8) evaluate conditions relative to:

(1) land burial of wastes (including sanitary landfills), plate 4

(2) surface spreading of wastes, plate 5

(3) waste disposal by septic systems, plate 6

(4) application of fertilizers and soil additives, plate 7

(5) application of herbicides and insecticides, plate 8.

Designated areas in the five map series are presented generally in order of decreasing restraints. In general, where more than one statement applies for a given area on each map, the category judged to be the most severe limitation is the one applied to the area.

At some locations, where materials are generally considered unsuitable, the hydrogeologic system may be a mitigating factor in regard to selection of waste disposal sites. For example, sites along major rivers would normally be considered unsuitable where the underlying materials are coarse-grained and have moderately high hydraulic conductivities and low CEC's. However, flow paths in such areas are predictable and a leachate-producing waste disposal operation would result in a limited zone of pollution between the waste disposal site and the major river, a regional discharge area. Important considerations with regard to such sites are: 1) if this zone of pollution, which will exist in a finite space for a finite time is acceptable (under

present Illinois Pollution Control Board Standards, it is not); and 2) if there are, or may be in the future, pumping wells in the area which may cause leachate to migrate outside of the predictable "zone." Research (Hughes, Landon, Farvolden, 1971) has suggested that, when properly located, spaced, constructed, and monitored, such sites may not degrade the quality of the surface water body. Because such sites must be evaluated individually and carefully monitored during and after waste disposal operations, regional mapping of such areas was purposely excluded from this study.

Land Burial of Wastes (including sanitary landfills)

Plate 4 differentiates areas for the burial of all types of waste products in the ground. We have not distinguished the state of the waste product, that is, whether it is solid, semi-solid, or liquid. The state of the material governs only the time it may take to mobilize a pollutant in the trench and the initial rates of loading. The attenuation capacity of the earth materials for individual ions, compounds, and complexes, and the release rate of non-attenuated ions, compounds, and complexes determine the pollution potential of buried wastes.

The specific criteria for land burial of wastes include considerations of the burial of both domestic refuse and industrial chemical waste, some of which may be toxic. Land areas are differentiated according to their capacity for long retention time, attenuation characteristics (mainly cation exchange capacity), and release rates to the environment. Mapped areas are generally listed in ascending order of their capacity to provide protection from pollution of both ground water and surface waters. For most land burial situations, the basic assumptions are: 1) burial in a trench 20 feet (6.1 meters) deep, and 2) burial below the water table, therefore, contact with ground water.

The latter assumption recognizes the fact that in northeastern Illinois, the top of the zone of saturation is usually much less than 20 feet (6.1 meters) below the land surface. In addition, it has been shown that, in the low permeability materials preferred for disposal sites, the water table will rise into the refuse, creating a ground-water mound. Thus, even though disposal may have been above the water table, the refuse will come in contact with the ground water.

On the maps which show conditions for land burial of wastes, gravel pit areas are mapped as if original materials are present. Each pit (shown on geologic materials maps) should be treated as a special case to determine suitability for land burial of wastes. In most areas, only household refuse should be considered as fill and then only if the site can be engineered to assure protection of ground water.

The land burial map (plate 4) differs somewhat from the other maps of waste disposal and land treatment practices in that the nature of materials deeper than 20 feet were considered. Since burial to a depth of 20 feet (6 meters) was assumed, the presence or absence of aquifers or potential aquifers within 50 feet of the base of the trench were considered in preparing the map.

For the most part, the distribution of areas with the most severe limitations for land burial of waste (map unit A, plate 4) is in the southern portions of Kane, DuPage and Cook Counties and in western and southern Will County, mainly in the Fox, DuPage, Des Plaines and Kankakee River Valleys where the Silurian dolomite is at or within 25 feet (7.5 meters) of land surface. There is significant potential for developing ground-water supplies from the dolomite in most of these areas. If there is heavy pumpage in the future, the fracture and joint systems in the dolomite will allow rather rapid, nearly unimpeded movement of water and contained contaminants to nearby shallow wells

Table 5

Legend for Plate 4, Land Burial of Wastes

UNIT SYMBOL	DESCRIPTION
A	Area where creviced bedrock aquifer is within 25 feet of land surface. Area should be limited to disposal of nonpolluting wastes
B	Area where sand and gravel aquifers are present at or within 20 feet of land surface. Area generally should be limited to nonpolluting wastes. In a few places where area mapped is in close proximity to large ground- or surface-water bodies and/or where flow paths are predictable, dilution rates will normally result in undetectable change in water quality from leachates of normal household refuse.
C	Area where bedrock aquifer is within 25 to 50 feet of land surface (within 20 feet of refuse). Area should be limited to nonpolluting wastes or disposal under controlled conditions (i.e., engineered sites where leachate is collected and treated).
D	Area where sand and gravel aquifers may be present within 25 to 50 feet of land surface (within 20 feet of refuse). The area may be suitable for normal household refuse under controlled conditions.
E	Area with over 50 feet of fine-grained material (mainly glacial till) with low hydraulic conductivity, moderate cation exchange and fair to good surface drainage. This area affords good attenuation of contaminants and is suitable for all wastes except mobile, nonattenuated, hazardous substances. In a small portion of this area (shown as E^+ inside a dashed boundary), 300 feet or more of continuous fine-grained glacial till may be present with very low hydraulic conductivity, moderate to high exchange capacity, and fair to good drainage. These conditions, if proven to exist, could afford good attenuation and long-term containment time for nonattenuated wastes and be suitable for almost any waste product.

for the region, since the interpretive maps are in most cases wholly derived from it. Although the criteria for the various interpretations may change, the occurrence, distribution and character of the geologic materials obviously remain the same except where locally modified by man's activities. The degree to which the geologic materials can be accurately and clearly mapped is therefore basic to the usefulness and reliability of that map and all derivative maps. Thus an understanding of the limitations as well as the usefulness of the mapping will be a guide as to how the maps can best be used to gain the maximum benefits from them.

Map of Geologic Materials

The main elements to be considered in evaluating the accuracy of the geologic materials maps are: scale; the type, amount and distribution of basic data; geologic complexity of the area; and depth to which data are needed. In northeastern Illinois, all of the above factors are interrelated.

The basic mapping, initially compiled on U. S. Geological Survey 7½-minute topographic quadrangle maps at a scale of 1:24,000, incorporated all geologic data available, including well and engineering boring logs, descriptions of well and boring samples and field observations. These data were supplemented with information obtained from soil survey maps which together provided the maximum possible accuracy for selecting the boundaries between surficial geologic materials and determining the distribution of deposits to a depth of 20 feet (6 meters).

As a general rule, the availability of data on geologic materials decreases with depth; therefore, so does the accuracy. For the most part, the overall distribution of subsurface data and the continuity or uniformity of the occurrence of most geologic units within the upper 20 feet (6 meters)

have been considered 75 to 95 percent accurate, with respect to both material and boundaries of map units shown. While subsurface boundaries are probably least accurate, the boundaries of mapped surface units are tied closely to the accuracy of the boundaries of soil parent materials as determined from the soil survey maps (McComas, Hinkley and Kempton, 1969). Since geologic deposits are frequently wedge-shaped with gradational margins, the mapped position of the boundary between otherwise well defined units of geologic materials may therefore be the least accurate aspect of the map and therefore the most subject to change as more detailed field data become available. On the other hand, large areas mapped as one geologic material more than 20 feet (6 meters) thick are probably the most accurate parts of the map. In the final analysis, the uniformity of composition of each of the various glacial tills has provided the most reliable means for establishing the sequence and distribution of all of the glacial deposits.

Interpretive Maps of Pollution Potential

The delineation of deposits shown on the geologic materials map was the principal basis for the interpretations made in preparing the various pollution potential maps. However, other factors such as general slope characteristics, depth to an aquifer, surface drainage and the nature of the general shallow ground-water flow system were also evaluated. Of these, only the ground-water flow system is not well defined.

It should be emphasized that certain elements were not considered. Among these were: 1) state of waste materials (only mobilization time was considered), 2) burial of low-level radioactive waste which requires some 500 years containment, and 3) site specific or seasonal factors (e.g., distance to

nearest water well, frost depth, seasonal water table, local slope variations, local variations in geologic materials and density of disposal sites in a given area).

In certain instances, some interpretations have been based on a personal judgement of the behavior of a given material with respect to the movement of potential pollutants through that material. Certain generalizations have also been made, particularly at the 1:126,720 scale, such as the elimination or combining of small units. In several instances, specific details of surface drainage were not mapped where the potential for ground-water pollution was considered the main limitation (e.g., along most valleys).

One of the more significant aspects of the use of the maps is their relationship to interpretations made directly from soil survey maps. It should be emphasized that interpretations made from soil survey maps are based on detailed knowledge of the material to a maximum depth of at most 5 feet (1.5 meters). Such information, which includes cation exchange capacities, hydraulic conductivity, and character of surficial geologic materials, is extremely useful and necessary for determining application rates in treatment of fields. However, conclusions derived from soil survey maps must be reconciled with the interpretive maps based on geologic data which provide the depth consideration necessary to support both acceptance characteristics and ground-water pollution potential. This is particularly important for land burial of wastes where burial is in trenches as deep as 20 feet (6 meters) below land surface. Septic systems utilize filter fields which commonly are developed in the lowermost part of the solum (lower B horizon) in northeastern Illinois and therefore also are more greatly affected by the hydraulic conductivity of the parent geologic materials. Septic systems may also directly transmit pollutants to shallow aquifers without the benefit of the higher cation exchange capacity of the upper solum.

These interpretive maps are intended to be practical regional guides for determining the possibility of polluting the shallow ground water system by different waste disposal methods and land treatment practices. They also indicate the limitations imposed by the acceptance rates of the various geologic materials, thereby indicating areas where high density use could cause surface water pollution. When used in conjunction with the soil interpretations they should provide a sound basis for local and county planning and for regional plans for reducing water pollution.

PRINCIPAL FINDINGS AND RECOMMENDATIONS

This project has yielded new information, resulted in the updating and detailing of existing maps, and provided impetus to some studies which were in progress. Although this regional summary report has emphasized information related to water quality planning, other interpretations providing the remaining elements necessary for comprehensive resource-based land-use planning have been produced (see previous volumes), or are in preparation. Much of the regional physical data and mapping necessary for such resource-based planning is presented in this report, particularly the basic mapping and characterization of the geologic materials. Additional interpretive maps for land utilization and the development of mineral resources have been prepared and included with the county reports. Many of these maps, when completed at the regional scale, will provide additional information and, in combination with the maps prepared for this report, will present a comprehensive overview for regional planning.

It is hoped that one of the more significant contributions of this study has been to emphasize the importance of the geologic framework to the understanding of both surface and ground-water resources and water quality problems. Without a detailed knowledge of both the distribution and character of geologic materials over or through which water moves, an overall understanding

of the effects of man's activities on water availability, quantity and quality cannot be adequately determined. This series of reports is intended to present information on the physical conditions which will provide the framework for water quality management.

Principal Findings

The following is a list of the most important conclusions concerning the hydrogeologic system in northeastern Illinois. These conclusions were drawn on the basis of regional evaluation and they are not necessarily listed in order of importance.

1. Generally, over much of the area east of the Fox River, the potential for pollution of the shallow aquifer system (sand and gravel and Silurian dolomite) is slight because of the thick cover of fine-textured materials. The main exceptions are: portions of the Des Plaines River Valley, mainly in southwestern Cook County, southeastern DuPage County and western Will County; and also along the Kankakee River, portions of the DuPage River System and immediately adjacent areas. However, large areas west of the Fox River including much of McHenry County and portions of Kane County, contain by far the largest surficial or near surface sand and gravel aquifers. Therefore, along with the DuPage and southern Des Plaines Valleys these areas have the greatest potential for ground-water pollution from both surface and land-burial practices.

2. Conversely, the area east of the Fox River Valley has greater potential for pollution of surface water, due to a combination of the occurrence of fine-grained surficial materials and widespread urbanization and local industrial development. West of the Fox River Valley, generally higher infiltration rates probably reduce the overall percentage of surface runoff, although in some of the rolling upland areas underlain by finer textured materials,

the pollution potential to local streams could periodically be significant from agricultural or scattered, small urban developments, including commercial complexes. In the major valleys local surface-water runoff or ground-water discharge may carry pollutants from adjacent urban, industrial or agricultural sources directly into the rivers and streams.

3. Natural recharge to the shallow aquifer system is diffuse and occurs throughout the region. The differences are mainly due to varying rates of infiltration and migration and the distance from major discharge zones, i.e., the principal rivers, streams and lakes. There are few if any areas of northeastern Illinois that are critical for preservation as "prime" areas of natural recharge to the shallow aquifer system in their present state. There is evidence that some agriculture practices such as row cropping tend to restrict natural recharge while some types of development (low density suburban with large lawns) may actually increase natural recharge.

4. Regionally, artificial recharge would appear to have only a small potential for supplying the ground-water needs of the region and may be of only local significance, even after the entire shallow aquifer system has been fully developed.

Areas that are directly underlain by permeable surficial sand and gravel or dolomite aquifers that are locally recharged, while at the same time adjacent to regional discharge zones, are potentially significant as areas for artificial recharge, once development has or is about to exceed total natural recharge. Such areas are concentrated along portions of the Fox, Des Plaines, DuPage and Kankakee River Valleys as well as extensive areas of the Kishwaukee River Valley and some of its tributary valleys. Elsewhere, potential sources of recharge water are extremely scarce and may be limited to waste water.

5. Throughout sizeable portions of northeastern Illinois, poor surface drainage is a significant local constraint to waste disposal and land treatment practices. Areas of poor surface drainage are delineated in detail in the county reports and are shown in a more general way on the various regional interpretive maps.

Recommendations

In the past, many water-management and planning goals and policies for northeastern Illinois have been proposed, based on the available technical data and on both standard techniques and innovative approaches (Sheaffer and Zeizel, 1966; Northeastern Illinois Planning Commission, 1974). This summary report, and the previous reports in this series, present some new concepts developed from the growing body of technical information. This work also suggests the need for some additional investigations and data needs.

The following recommendations are offered:

1. Planning and zoning should be directed at encouraging the location of future waste-disposal sites in the least sensitive geologic environments. These are upland areas underlain by relatively thick, fine-grained deposits. Since earth materials have a finite capacity for attenuation of pollutants, large landfills may pose more of a threat to the ground-water reservoir than a number of dispersed small landfills.

2. From data currently being collected on the quality of surface water, studies should be made of the relationship of both type and concentration of pollutants to the geologic characteristics of each terrain and to urban-industrial-agricultural sources and practices.

3. Areas considered to have a high potential for ground-water pollution should be monitored to determine ground-water quality. Conversely,

areas of known ground-water pollution should be studied to verify the relationships between the geologic conditions, the ground water and the pollutants.

4. Ground-water recharge in low-density suburban areas should be enhanced by storm-water detention basins and surface spreading of storm water. Such practices could be particularly significant in areas of relatively rapid infiltration. The potential for ground-water pollution must be considered in this practice.

5. Inasmuch as new data on geology, mineral resources, water resources and environmental problems are continually being obtained from the intense human activity in northeastern Illinois, programs should be established for collecting and managing the data and updating the basic and interpretive maps.

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Table 5

Legend for Plate 4, Land Burial of Wastes, continued:

UNIT SYMBOL	DESCRIPTION
E, continued -	
	Areas labeled B', C', D', E' same as areas B, C, D, or E except that drainage is poor to very poor and/or in a local discharge area. These factors may cause pollutants to return to surface causing surface water pollution problems where insufficient dilution, but decreases potential for pollution of the ground water.

finished in the dolomite. Therefore, landfills developed in quarries in the dolomite or in sand and gravel or even till directly above or on the dolomite have a high potential for yielding contaminants which are likely to migrate toward or into pumping wells and/or the adjacent river.

In a similar manner, where sand and gravel deposits are at or within 25 feet (7.5 meters) of land surface (map unit B, plate 4) there is a high potential for contaminants to be transmitted to nearby wells finished in the sand and gravel or discharging directly into nearby streams. Such areas are concentrated principally in McHenry and Kane Counties and adjacent portions of Lake, northern Cook and DuPage Counties. Other areas occur in eastern and central Lake County and north-central Cook County, the latter two areas are principally the sand and gravel in the Des Plaines River Valley.

Map units C and D are areas where dolomite (C) or sand and gravel (D) are likely to occur within 25 to 50 feet (7.5 to 15 meters) of land surface. The former is mapped most extensively in western and southern Will County and throughout portions of the southern half of Cook County. Other C areas are present in DuPage and southern Kane Counties. In most of these areas, the dolomite is overlain by glacial till in areas adjacent to the larger lowland drainageways, mainly the Fox, DuPage, Des Plaines, and Kankakee Rivers and Salt Creek. Most of map area D is located in western and south-central McHenry County and central and southern Kane County.

Map area E (more than 50 feet, 15 meters, of fine-grained material) is distributed widely through Lake, Cook and Will Counties, in scattered areas of DuPage County, in generally elongated strips in western McHenry and Kane Counties, and in portions of eastern Kane County. In general, these areas are principally composed of till greater than 50 feet (15 meters) thick. In some areas of western Kane and McHenry Counties, central Lake County, northern

Cook County and central and southeastern Will County, the sequence of till may be as much as 200 feet (61 meters) or more thick.

Areas where surface drainage is poor due to ground-water discharge or in frequently flooded areas are indicated with an apostrophe on plate 4 (B', C', D', E'). In many of these areas, the subsurface conditions may be fair to good for developing a landfill, but the surface conditions could pose serious engineering problems for development. Such areas would also include the larger depressions containing significant thickness of organic material. Therefore, any area indicated as either having surface drainage problems or directly adjacent to a discharge area (areas B', C', D', E') should probably be treated as an area having potentially significant limitations, due to surface water pollution, and be troublesome to design, engineer and operate.

Finally, aside from the depth distinction, plate 4 also differs from the remaining maps, developed to indicate pollution potential from other waste disposal and land treatment practices, by eliminating consideration of the surface soil profile. Disposal in a trench or pit more than 5 feet (1.5 meters) in depth is obviously below the soil profile.

Surface Spreading of Wastes

Plate 5 differentiates areas where there may be pollution problems resulting from the spreading of wastes on the land surface or in the active soil zone (solum). The primary concern of this mapping is with the placement of industrial and sewage wastes, by any method, on the land surface. The solum generally develops sufficient hydraulic conductivity to allow certain amounts of water to pass. In placing wastes on the land surface, the application rates must be adjusted to prevent overloading of the soil. Proper application rates are dependent on the slope, soil types, and soil characteristics as well as

precipitation. (See Graffis et al., 1976, for discussion of application rates.) It is assumed that the proper application rate (loading) will be determined. The map therefore differentiates areas that are environmentally sensitive, areas where extra precautions should be taken, and areas where spreading should be discouraged (table 6). Certain types of potentially hazardous wastes must be evaluated separately.

A large area of east-central Cook County was not interpreted for surface spreading of wastes (plate 5). This area is not covered by USDA Soil Conservation Service detailed soil maps as it composes the major portion of the intensively urbanized area of Cook County including the city of Chicago. Such development precludes the use of surface spreading techniques for waste disposal.

The geologic conditions which are the limiting factors for the surface spreading of wastes are those which 1) permit rapid downward movement of contaminants into the shallow aquifers, or 2) promote runoff of contaminants into surface water bodies. They are shown on plate 5 (also see table 6). The first includes areas where extensive areas of dolomite (A) or sand and gravel (B) lie directly below land surface; the second, areas of clayey till, poor surface drainage and/or steep slopes (C).

The most extensive area where dolomite is at or generally within 5 feet (1.5 meters) of land surface is along the lower portions of the Des Plaines and Kankakee Rivers in Will County. Much of this area may also be subject to flooding. Areas directly underlain by sand and gravel (map unit B) occur in much of McHenry County, significant areas in Lake County and portions of eastern and southern Kane County, northwestern Cook and western Will Counties and in other scattered areas. Although a large proportion of these areas are in lowland terrains adjacent to the principal rivers, locally sizeable areas

Table 6

Legend for Plate 5, Surface Spreading of Wastes

T OL	DESCRIPTION
	Area where a shallow creviced bedrock aquifer is within 5 feet of the surface. This area is the most environmentally sensitive. Waste spreading should be avoided.
	Area where high infiltration rates may cause ground water pollution of surface sand and gravel aquifer.
C	Area where there may be acceptance problems due to very poor internal soil drainage, ground-water discharge, steep slopes or materials of low hydraulic conductivity. Included in this category are areas where slopes greater than 7% are likely to occur and where slopes greater than 4% may be common. (Consult detailed county soil maps and general terrain map - Plate 2.)
D	Area where shallow sand and gravel or creviced bedrock aquifers lie within 20 feet of land surface below variable thicknesses of materials of moderate hydraulic conductivity. Overapplication may cause local ground-water pollution.
E	Area with no known limitations, where spreading of wastes on land surface should not cause local ground-water pollution.

lie in the upland and plain terrains, particularly in eastern McHenry County and adjacent areas of northeastern Kane, western Lake and northwestern Cook Counties.

Regionally, acceptance problems (Map area C) due to relatively impermeable materials or poor drainage are by far the most likely condition to be encountered in northeastern Illinois. Since there are a variety of geologic conditions included under the general heading of acceptance problems, additional detail must be developed for specific local areas or sites. As a general rule, areas underlain by silty, clay till allow only slow, limited infiltration. Therefore, over-application of wastes by spreading may result in water-logging of the surface materials, standing water in flat areas, or excessive runoff from slopes. Therefore, the specific conditions at any site, as represented by the geologic materials map (plate 1), flood hazard maps, and Soil Conservation Service detailed soil maps and interpretations, should be consulted, particularly within map area C for specific projects.

Waste Disposal by Septic Systems

The criteria used for this map (plate 6, table 7) are based on the Illinois Department of Public Health's definition of a public system - one serving 11 or more residences. We have considered that the pollution potential is the same for one septic system serving 11 residences as for 11 systems serving 11 residences. Criteria have been established by the U. S. Department of Agriculture relating soil characteristics to operation of septic systems. There criteria should be consulted along with the regulations (based in part on the USDA criteria) of the Illinois Department of Health.

There are two factors to consider regarding septic system operation: 1) are the soils sufficiently permeable to accept the waste; and 2) will the

Table 7

Legend for Plate 6, Waste Disposal by Septic System

UNIT SYMBOL	DESCRIPTION
A	Areas where very high infiltration rates may cause ground-water pollution of surface sand and gravel aquifers.
B	Areas where a bedrock or sand and gravel aquifers is within 20 feet of surface and where severe pollution problems could arise.
C	Area where there may be acceptance problems due to steep slopes, very poor soil drainage or ground-water discharge. Wastes may come to land surface. Included in this category are areas where slopes greater than 7% are likely to occur and where slopes greater than 4% may be common (consult detailed county soil maps and general terrain map - Plate 2).
D	Area where there may be acceptance problems due to the very low hydraulic conductivity of the surface materals. Wastes may stay on the surface. May also include some characteristics of Area C.
E	Area with no known limitation, where septic systems should not cause pollution problems provided they are constructed and operated properly, based on sound, standard soil testing procedures

septic system pollute the ground or surface waters. Soils with high hydraulic conductivities will readily accept septic waste, but may produce a pollution hazard; conversely soil with very low hydraulic conductivities does not present a pollution hazard (unless septic effluent is forced to the surface), but septic systems will not operate properly. The septic system map (plate 6) is not applicable, from a pollution standpoint, to evaluating the very minimal impact of widely scattered individual systems.

The geologic conditions which are the most sensitive for potential pollution of ground water from the intense use of septic systems are those where extensive sand and gravel aquifers occur directly below land surface (map unit A, plate 6) or sand and gravel or dolomite aquifers occur within 20 feet of the land surface. Construction of septic systems could also be a problem where dolomite is at or very near land surface. The distribution of these areas is essentially the same as the most sensitive areas for the development of sites for land burial of wastes (plate 4); these are mainly present over large areas of McHenry County and along the principal lowland terrains associated with the main river valleys.

The principal type of septic system used is still the buried tank with a shallow overflow seepage (filter) field, buried generally at depths between 3 and 6 feet (1 to 2 meters). Therefore, the attenuation of the contaminants by the entire surface soil profile is not effective, particularly if the underlying material has a relatively high hydraulic conductivity. The close spacing of many septic systems in small areas within areas mapped as A or B is therefore likely to produce a severe pollution problem by effectively promoting recharge of the septic effluent to the shallow aquifers.

Map units C and D are areas where the principal limitations are acceptance problems. Area C includes areas where steep slopes may locally

allow septic effluent to move rapidly to the land surface and into drainageways without receiving adequate filtering and attenuation. Elsewhere within area C, high water table conditions may not allow the septic effluent to enter the ground and the septic systems will not work properly, or will cause the effluent to move upward to land surface. These conditions may also locally occur in areas mapped as A and B.

In areas mapped as D, the principal acceptance problem is the low hydraulic conductivity of the materials. Through these areas, the probability that septic effluent may remain at or near the surface for long periods of time is rather high. As a result, septic systems within large concentrations of systems may operate poorly during periods of heavy rainfall, such as in the spring.

When planning for development using individual septic systems, careful attention should be given to the many local variations in near-surface geologic conditions and soil characteristics. Particular attention should be paid to local soil drainage conditions shown on the SCS detailed soils maps and near-surface materials shown on plate 1. As in the case of plate 5, the area of east-central Cook County is not shown on plate 6. This is the area not covered by detailed soil survey maps and lies within the Metropolitan Sanitary District of Greater Chicago.

Application of Fertilizer and Soil Additives

The proper application rates of fertilizer and soil additives should result in their being held in the soil for plant needs. Application rates should be adequate to supply seasonal plant needs; this depends upon the character and fertility of the solum. See Graffis et al., 1976, for discussion of application rates.

Plate 7 differentiates areas where special care must be taken to avoid excessive application of fertilizers and soil additives: This map, which indicates the distribution of areas where geologic conditions relate to the application of fertilizers and soil additives, is very similar to plate 5 (Surface Spreading of Wastes). The nature of the local surface soil is, of course, the prime consideration for determining proper application rates, but the character and distribution of the near surface geologic materials also influence the regional potential for ground-water or surface-water contamination (table 8).

The most geologically sensitive areas for pollution of shallow aquifers by overapplication of fertilizers and soil additives are generally in areas west of the Fox River which are still principally agricultural. These sensitive areas (map units A and B) are concentrated in McHenry County, northeastern Kane County, northwestern Cook County and western Will County. Scattered areas also occur in Lake, DuPage and the remainder of Cook Counties. A buildup of trace elements used as plant food in additives could cause local problems. Nitrogen, one of the most mobile of elements, is frequently a significant pollutant when applied in excess, particularly as liquid ammonia. Local buildup of nitrates is common around feedlots. Map area D could be susceptable locally to pollution problems caused by these situations. Map unit C includes areas which may have acceptance problems due to high water tables, poorly drained soils, flood prone areas, steep slopes and low hydraulic conductivity of geologic materials.

At should also be noted, however, that the only areas that appear to have no serious limitations are also found mainly in the central and western portions of McHenry County and in portions of northeastern and southwestern

Table 8

Legend for Plate 7, Application of Fertilizers and Soil Additives

UNIT SYMBOL	
A	Area where high infiltration rates and low cation exchange capacity may allow excess fertilizer and soil additives to enter shallow ground-water system.
B	Area where shallow creviced bedrock aquifer is within 5 feet of surface.
C	Area where there may be surface runoff problems because of poorly drained soils, ground-water discharge, steep slopes, or materials of low hydraulic conductivity included in this category are areas where slopes greater than 4% may be common (consult detailed county soil maps and general terrain map, plate 2).
D	Area where shallow sand and gravel aquifers may be present within 20 feet or less of land surface.
E	Area with no known limitations in which the use of fertilizers and soil additives will probably not cause ground-water or surface-water pollution problems, provided application rates are not excessive.

Kane County. Specific local soil types are the principal controlling factors for determining application rates, and may vary depending on a variety of factors. This information should be obtained from local extension or USDA field offices, and soil reports.

Application of Herbicides and Insecticides

The proper use of herbicides and insecticides should result in their being retained in the active soil zone (solum). There are few reported instances of ground-water pollution by herbicides and insecticides; there are some reports of surface-water pollution. The glacial till materials generally contain sufficient clay to have a strong attenuating capacity for organic compounds; thus, herbicides and insecticides are generally immobile, except in soils with very low clay contents. Plate 8 differentiates areas where special care must be used in application. See Graffis et al., 1976, for discussion of application rates.

As for the preceeding waste disposal and land treatment practices discussed, the areas which are directly underlain by sand and gravel and/or dolomite aquifers have the greatest potential for ground-water pollution (Map unit A, plate 8). These areas are concentrated mainly along the major drainageways and in upland and plain terrains of McHenry County, adjacent portions of Kane, Cook and DuPage Counties, and areas adjacent to the Des Plaines Valley in eastern Will County.

It is important to note that in over half of northeastern Illinois, particularly east of the Fox River, conditions are conducive to surface runoff problems (area B, plate 8 and table 9). Even portions of the areas shown as map unit A may be subject to periodic flooding or high water table which may retard retention of the chemicals in the solum and tend to promote runoff to

Table 9

Legend for Plate 8, Application of Herbicides and Insecticides

UNIT SYMBOL	DESCRIPTION
A	Area of surface sand and gravel and near-surface bedrock aquifers with high infiltration rates, where herbicides and insecticides may readily enter the ground-water system.
B	Area where there may be surface runoff problems because of poorly drained soils, ground-water discharge, steep slopes, or materials of low hydraulic conductivity. Included in this category are areas where slopes greater than 7% are likely to occur and where slopes greater than 4% may be common (consult detailed county soil maps and general terrain map).
C	Area with no known limitations where the application of herbicides and insecticides are not likely to cause ground-water or surface-water pollution, provided prudent practice is used.

surface water. Since a large portion of the area east of the Fox River is now highly urbanized, the problem of pollution by herbicides and insecticides is obviously less significant. In the remainder of the region (area C), no significant limitations are known to exist. The intensely urbanized area not covered by detailed soil survey maps including Chicago and adjacent areas was also left uninterpreted on plate 8.

General Discussion

The similarities of the five maps, interpreting the pollution potential of geologic materials relative to various waste disposal and land treatment practices, should now be quite apparent. In essence, the major map elements are controlled by the character and distribution of the near-surface deposits. The significance of these materials is further modified by their position in the landscape (terrain position) and the toxicity and mobility of the potential contaminants. For example, in interpretations for land burial of wastes it is necessary to evaluate the pollution potential to depths of at least 30 feet (9 meters) below the base of the waste materials. This will identify areas where sand and gravel or dolomite aquifers occur at the depths below 20 feet (6 meters) which may be reached by pollutants from land burial sites. The recognition of areas of poor surface drainage or other conditons where leachate from buried wastes may return to the surface imposes another set of constraints.

The map for land burial of wastes (plate 4) along with that interpreting the geologic conditions relative to pollution potential from septic systems (plate 6) can be considered as interpretations reflecting point sources of pollution, providing one septic system is utilized for treatment of numerous units. The distinction as a point source of pollution, however, becomes vague

when large numbers of units or clusters of units have individual systems or sites scattered over wide areas.

The maps for surface spreading of wastes (plate 5) and the application of fertilizers and soil additives (plate 7) or herbicides and insecticides (plate 8) consider non-point sources of pollution, although surface spreading of wastes currently is a relatively local and restricted practice. For these practices, overapplication is probably the principal cause of water pollution or surface water contamination. Therefore, plates 5, 7 and 8 are quite similar; the differences are mainly in detail due to the degree of pollution potential from over application and to some extent to the toxicity of the pollutant and the soil retention capacity of the soil for the substance applied.

Finally, plates 4 through 8 are, in some respect, maps which may collectively supply insight into the potential for pollution of both surface and ground water from a variety of common sources such as the widespread use of salt on highways, accidental spills, and certain commercial or industrial practices such as "temporary storage" of waste products and discarded equipment on the land surface. Such sources of potential pollution are very common in highly urbanized and industrialized areas such as northeastern Illinois.

LIMITATIONS OF MAPPING - CORRECT USE OF MAPS

The maps prepared to show the geologic conditions relative to waste disposal and land treatment practices were the principal products of this study and are basic for 208 planning. Therefore, the adequacy of the criteria established to make such interpretations are important to the overall value of these maps. However, the accuracy of the map of the geologic materials (plate 1) is the principal limiting factor in the preparation of any interpretive maps