Circular 182

Water-Level Trends and Pumpage in the Deep Bedrock Aquifers in the Chicago Region, 1991-1995

by Adrian P. Visocky
Office of Ground Water Resources Evaluation & Management

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STATE OF ILLINOIS
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DEPARTMENT OF NATURAL RESOURCES
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STATE WATER SURVEY DIVISION

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WATER-LEVEL TRENDS AND PUMPAGE IN THE DEEP BEDROCK AQUIFERS IN THE CHICAGO REGION, 1991-1995

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SUMMARY

This report considers pumpage and water-level changes from 1991-1995 in deep bedrock wells penetrating the Cambrian and Ordovician aquifers in northeastern Illinois. These aquifers are the most highly developed system for large ground-water supplies in Illinois. Collectively, this system has been described as the "Cambrian-Ordovician aquifer" in earlier reports, but formal hydrostratigraphic unit names, reported by Visocky et al. (1985), have designated this system as the "Midwest Bedrock Aquigroup." An informal term, "deep bedrock aquifers," is used in this report for convenience.

The deep bedrock aquifer system is encountered at depths ranging from about 200 feet below the land surface in areas of north-central Illinois to an average of about 1,000 feet at Chicago. The aquifers have a collective thickness of 300 to 1,300 feet in the Chicago region, averaging 700 feet, and are composed chiefly of sandstones and dolomites. Most of the water is derived from the sandstone units. This report emphasizes the eight counties of the Chicago metropolitan area: Cook, DuPage, Grundy, Kane, Kendall, Lake, McHenry, and Will.

As a result of the shift to other sources of water, levels in deep wells in most areas of the Chicago region rose sharply between 1991 and 1995, particularly in the western Cook-eastern DuPage County and northern Cook-southern Lake County areas. Elsewhere, significant declines occurred in parts of the Fox Valley in Kane County, in an industrial well in McHenry County, and in some wells at Joliet in Will County. On average, however, water levels rose in all eight counties in the Chicago region. Average annual water-level rises during the four-year period varied from one foot in Kane and Kendall Counties to 45 feet in DuPage County, with an average overall rise of about 15 feet. This overall rise in water levels continued the positive trend begun in the 1985-1991 period, following a continued record of declines since detailed record-keeping began in the 1950s.

With the shift of water supplies from deep wells to surface water or shallower aquifer sources, total deep pumpage in the Chicago region in 1994 was within three percent of the practical sustained yield.

INTRODUCTION

In May 1959, the Illinois State Water Survey and the Illinois State Geological Survey published Cooperative Ground-Water Report 1 (Suter et al., 1959), which discussed the geology and ages depending on various water-use schemes, and offered alternatives for meeting projected water-supply needs to the year 2010. Contract Report 292 (Visocky, 1982) and Research Report 119 (Burch, 1991) described the impact of additional Lake Michigan withdrawals on deep-well pumpage and water-level trends. Cooperative Ground-Water Report 10 (Visocky et al., 1985) provided an updated hydrogeologic evaluation of the water resources of the deep bedrock aquifers.

In response to expanding urban development, the increasing use of lake water and other sources for public supplies, and growing interest in regional water resources development, this report provides a detailed discussion of ground-water withdrawals and water-level trends in northeastern Illinois. The report covers a 15-county area from Lake Michigan to north-central Illinois and from the Wisconsin border south to Kankakee County. Particular emphasis, however, has been given to the eight counties of the Chicago region because of the significant shift in pumpage from the deep bedrock aquifers to Lake Michigan and other sources in this region and water-level changes due to increasing ground-water withdrawals in some areas and decreasing withdrawals in others.

During spring 1992, major new Lake Michigan allocations were implemented in DuPage County, and many deep well pumps were turned off. Significant switches to lake water and other shallow sources also occurred in Cook, Kane, and Lake Counties since the last water-level measurement in fall 1991. This report describes the detailed water-level measurement made in the fall of 1995 and documents the response of the deep bedrock aquifers to major reductions of pumpage resulting from the switch to other water sources in those four counties.

Pumpage figures for the period, 199l-1994 (1995 figures were incomplete), used in this report, were taken from the Illinois Water Inventory Program, which gathers water-use information from questionnaires filled out by public water-supply operators and self-supplied industries. Since these data have not yet been published formally and are subject to final revisions, they must be considered preliminary.

In this report, pumpage for public use includes use by municipalities, subdivisions, mobile home parks, and institutions. No attempt has been made to determine the final use of water within these categories. Available records indicate that 111 public water supplies obtained water from deep wells in 1994, compared to 105 in 1991.

Pumpage for self-supplied industries includes only pumpage from wells owned and operated by the industries. (For convenience, country clubs are included in this category in this report.) Records indicate that at least 107 self-supplied industries in the Chicago region used deep wells in 1994, compared to 85 in 1991.

This report does not include pumpage from deep wells for individual domestic and rural residences or for farm supplies. Few wells serve these uses in the Chicago region, and total estimated pumpage for these uses in northeastern Illinois is extremely limited.

Water levels in deep wells were measured by a variety of methods and under a wide range of operating conditions and reliability. Most measurements were taken with altitude gages attached to air lines permanently suspended in the wells. Other measurements were obtained with graduated steel tapes or electric droplines that set off either light or sound signals when the probe touches water. A few wells are open holes and can be measured very accurately. Most wells, however, are equipped with pumps that limit or prevent access for measurement. Water levels are affected by recent pumpage of the well itself or by pumpage at adjacent wells. The reliability of the water-levelmeasuring equipment and the experience of the person taking the measurement are also important considerations. Altitude gages, for example, are generally limited to a precision of about a foot, while steel tapes and electric droplines can be read with a precision of as much as 0.01 foot and 0.02 foot, respectively.

The eight counties of the Chicago region, with abbreviations used in this report, are:

Cook	COK	Kendall	KEN
DuPage	DUP	Lake	LKE
Grundy	GRY	McHenry	MCH
Kane	KNE	Will	WIL

The seven northern counties outside of the Chicago region included in this report are:

Boone	BNE	Lee	LEE
DeKalb	DEK	Ogle	OGL
Kankakee	KNK	Winnebago	WIN
LaSalle	LAS		

Acknowledgments

Partial support for the fall 1995 field data collection described in this report was provided by the Illinois Department of Natural Resources, Office of Water Resources. The author wishes to acknowledge the numerous individuals and organizations who generously contributed information incorporated in this report. Operators of more than 85 percent of the public and self-supplied industrial water-supply systems reported their annual pumpage in response to mailed questionnaires.

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SYSTEM		SERIES AND MEGAGROUP	GROUP AND FORMATION	HYDROSTRATIGRAPHIC UNITS		LOG	THICKNESS (ft)	DESCRIPTION
								Unconsolidated glacial deposits – pebbly clay (till), silt, and gravel
[redacted]								
				Prairie				vial silts, sands and gravels.
Tertiary & Cretaceous			Undifferentiated				0 –100	Sand and silt.
Carboniferous	Pennsylvanian		Undifferentiated		Pennsylvanian		0 – 500	Mainly shale with thin sandstone, limestone, and coal beds.
	Mississippian	Valmeyeran	St. Louis Ls Salem Ls Warsaw Ls Keokuk Ls Burlington Ls	pi Valley	St. Louis - Salem aquifer Keokuk – Burlington aquifer		0 – 600	Limestone; cherty limestone; green, brown, and black shale; silty dolomite.
		Kinderhookian	Undifferentiated					
[redacted]								
			Port Byron Fm	per Bed				
[redacted]								
Silurian			Waukesha Ls Joliet Ls		Silurian dolomite aquifer		0 – 465	Dolomite, silty at base, locally cherty.
		Alexandrian	Kankakee Ls Edgewood Ls					
		Cincinnatian	Maquoketa Shale Group		Maquoketa confining unit		0 – 250	Shale, gray or brown; locally dolomite and/or limestone, argillaceous.
[redacted]								
			Galena Group				0 – 450	Dolomite and/or limestone, cherty. Dolomite, shale partings, speckled.
			Gr | Glenwood Fm					Sandstone, fine- and coarse-grained; little dolomite; shale at top.
[redacted]								
		Canadian	Prairie du Chien Group: Shakopee Dol, New Richmond Ss	drock	unit | Prairie du Chien			Dolomite, sandy, cherty (oolitic), sandstone. Sandstone, interbedded with dolomite. Dolomite, white to pink, coarse-grained,

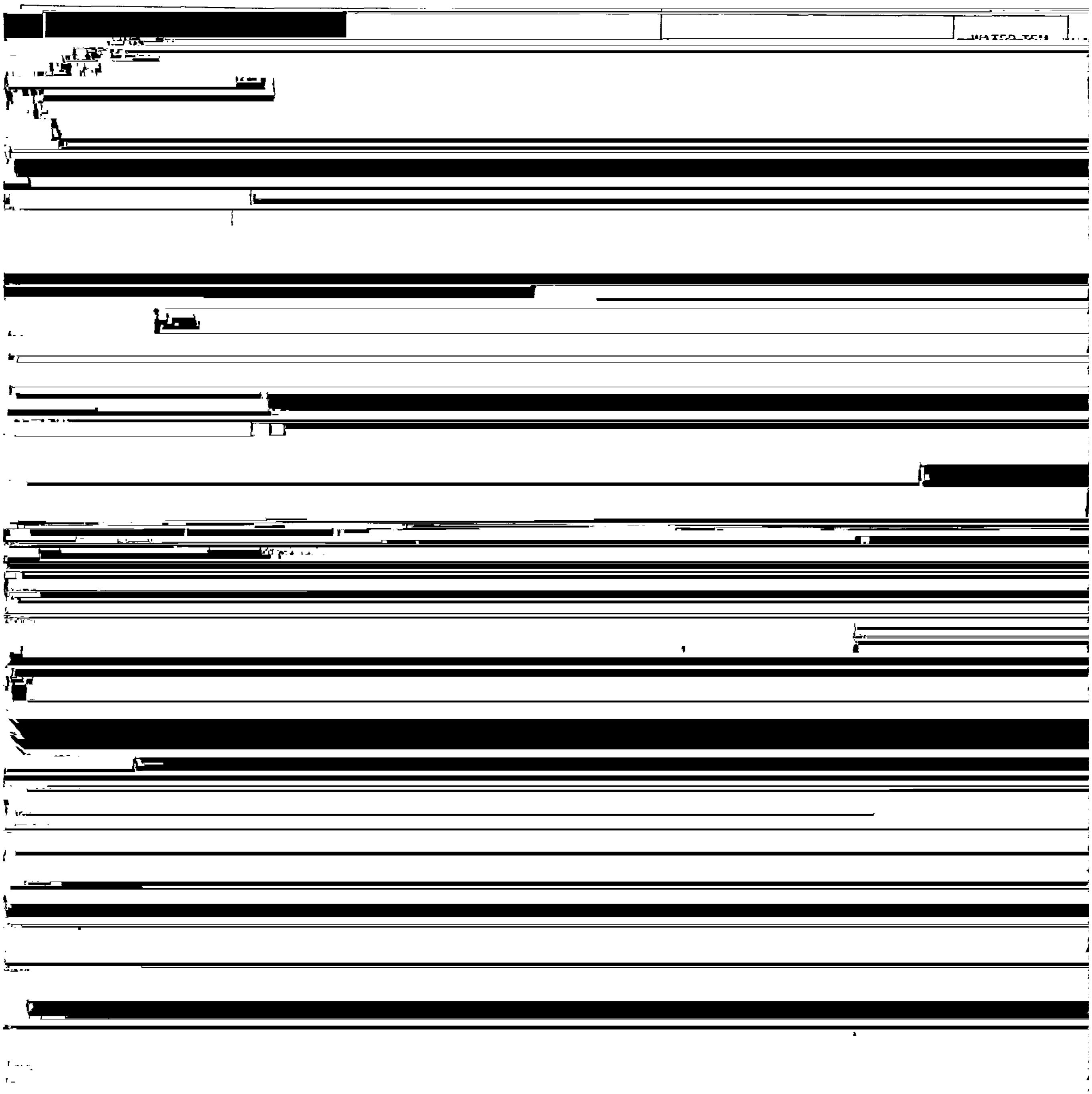


Figure 2. Concluded

The sequence of rocks that make up the Cambrian and Ordovician units described in this report were first defined by Suter et al. (1959) as the “Cambrian-Ordovician Aquifer” and have been referred to by this name in most subsequent reports. A local term, “deep sandstone aquifer,” is often used informally in northeastern Illinois in reference to the two major sandstone aquifers within the deep bedrock system. Visocky et al. (1985) introduced formal hydrostratigraphic names first proposed by Cartwright (1983) in describing major aquifers, in order to reduce confusion with rock stratigraphic terminology. The name “Midwest Bedrock Aquigroup” was suggested for the sequence of rocks from the Maquoketa Shale Group (the top of the overlying confining layer) to the top of the Eau Claire Formation (the underlying confining layer). Since this formal terminology is not familiar to most readers and has not as yet been formally adopted by the scientific community, an informal description, “deep bedrock aquifers,” will be used in this report.

The deep bedrock aquifers consist of two major sandstone aquifers, the Ancell aquifer (composed of the Glenwood Formation and St. Peter Sandstone) and the Ironton-Galesville aquifer (composed of the Ironton and Galesville Sandstones). Separating these two aquifers is a confining unit made up mainly of dolomite and shale with some sandstone.

The Ancell aquifer is present throughout northeastern Illinois and frequently exceeds 200 feet in thickness. In some sections of north-central Illinois, faulting and erosion have placed this aquifer immediately below the glacial drift. The majority of public and industrial wells finished in the Ancell aquifer in the Chicago region produce less than about 200 gallons per minute (gpm). In north-central Illinois, however, the Ancell aquifer yields several hundred gpm to wells and is the primary source of ground water for some municipal and industrial supplies.

The Prairie du Chien, Eminence-Potosi, and Franconia Formations underlie the Ancell aquifer and constitute the “middle confining unit” above the Ironton-Galesville aquifer. The formations of the confining unit are present throughout much of northern Illinois, although the upper units have been eroded extensively in the north. In some areas, these formations provide moderate amounts of water to wells tapping the deep bedrock aquifers.

The Ironton-Galesville aquifer underlies the Franconia Formation and overlies the Eau Claire Formation, another confining unit. It occurs throughout northeastern Illinois, and on a regional basis it is the most consistently permeable and productive unit of the deep bedrock aquifers. Most of the high-capacity deep municipal and industrial wells in the Chicago region obtain a major part of their yields from this aquifer.

Prior to the switch to Lake Michigan water, supplemental yields were obtained from wells penetrating the Elmhurst-Mt. Simon aquifer, particularly in parts of western and northwestern Cook County, eastern Kane County, parts of DuPage and Lake Counties, the Joliet area of Will County, and farther west in Ogle and Winnebago Counties. A major problem with the Elmhurst-Mt. Simon aquifer is the possibility of obtaining water high in chloride concentrations. In the Chicago region, water below an elevation of about 1,300 feet below sea level (msl) is commonly too salty for municipal or industrial use. Over the years, heavy pumping of the deep bedrock aquifers has gradually degraded the water quality in some areas by inducing upward migration of highly mineralized water from the deeper sections of the Elmhurst-Mt. Simon aquifer. The potentiometric surface of the Ironton-Galesville aquifer is lower than that of the Elmhurst-Mt. Simon aquifer, causing the upward movement of the poorer quality water. Numerous wells in Cook, DuPage, and Kane Counties, originally drilled into the Elmhurst-Mt. Simon aquifer, have since been plugged above these formations to exclude this poor-quality water.

The primary source of recharge to the deep bedrock aquifers is precipitation, which percolates through the glacial deposits where the Galena-Platteville dolomite or older rocks are the uppermost bedrock formation. This area is defined essentially by the western limits of the Maquoketa Shale Group and, to a small extent, by the northern limits of the Pennsylvanian-age shales. It encompasses major portions of north-central and northwestern Illinois. The Maquoketa shales are the primary overlying confining material in the Chicago region, along with the underlying Galena-Platteville unit, which locally yields small quantities of water.

Until recently, heavy ground-water withdrawals over the years had lowered water levels at the major pumping centers and established steep hydraulic gradients north, west, and southwest of Chicago and Joliet. As a result, large quantities of water from recharge areas in northern Illinois and relatively minor quantities from southeastern Wisconsin were transmitted toward pumping centers, along with small amounts derived from vertical leakage downward through the Maquoketa and Galena-Platteville units (Walton, 1960). Because of the overpumpage, water derived from storage within the deep bedrock aquifers supplemented the water moving horizontally or vertically, and it, too, moved toward the cones of depression in the potentiometric surface. In recent years, as pumpage from deep bedrock wells has lessened in favor of shallower sources, water levels have undergone a redistribution in which former cones of depression have disappeared and new, smaller cones have begun to develop and grow in outlying areas. However, because water levels in the former cones ofdepression are still recovering, established patterns of ground-water flow from recharge areas inward toward the Chicago area continue. In addition, lesser amounts of water are derived from the south in Illinois, from the southeast in Indiana, and from the northeast beneath Lake Michigan.

PRODUCTION FROM DEEP BEDROCK WELLS

The first deep well in northern Illinois was drilled in Chicago in 1864. It had an artesian flow at ground surface estimated at 150 gpm, or about 200,000 gpd. A considerable number of deep wells were in operation in the Chicago region by 1900, and pumpage was estimated at 23 mgd. Pumpage increased at a rather irregular rate during the first half of the twentieth century and reached 75.6 mgd in 1955, as shown in figure 3. During the succeeding 24 years, pumpage for public and industrial uses increased dramatically by 142 percent at an average rate of 4.5 mgd per year. It reached an all-time high of 182.9 mgd in 1979. Public and industrial pumpage dropped to 175.9 mgd in 1980, 157.7 in 1985, 112.7 mgd in 1991, and 67.1 mgd in 1994 (as this report went to press, complete pumpage figures for 1995 were not yet available).

Pumpage, 1991-1994

The period from 1980 to 1985 saw the first overall decline in pumpage, at a rate of 3.6 mgd per year since the peak pumpages of the late 1970s. This decline continued during the period from 1985 to 1991, but at a steeper rate—7.5 mgd per year—double the rate of decline of the previous five years. The previous rate of decline doubled again during the 1991-1994 period—15.2 mgd per

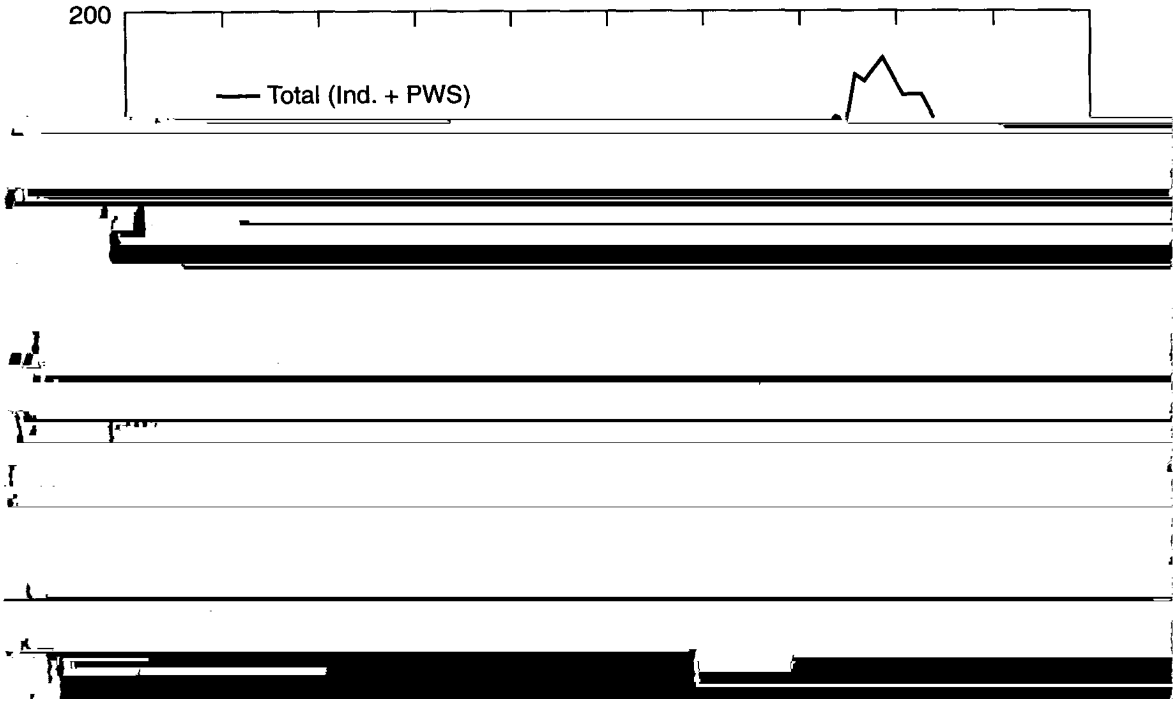


Figure 3. 1900-1994 production from the deep bedrock aquifers in the eight-county Chicago region, subdivided by use

year. The largest part of the decline—27.5 mgd—occurred between 1991 and 1992 and was attributable to a shift of public water supplies in DuPage and Lake Counties to Lake Michigan water and a partial shift in Kane County to the Fox River. Between 1992 and 1993 another large decline occurred—22.8 mgd—attributable to shifts in public water-supply sources in DuPage and Lake Counties, but also in Cook County. Total pumpage then rose slightly in 1994 to 67.1 mgd.

Other reasons for the pumpage fluctuations between 1985 and 1991 were a combination of several factors. They include climate (water use rises during warm, dry periods), shifts in population, and the replacement of deep bedrock wells with shallower wells in order to meet the Safe Drinking Water Standards for radium and barium (USEPA, 1976, 1991).

During the period 1991-1994, pumpage for public and industrial supplies from deep bedrock wells declined from 112.7 to 67.1 mgd. Total pumpage in 1993 was 63.3 mgd, the smallest deep bedrock well pumpage since sometime in the 1945-1950 period. Table 1 shows the distribution of pumpage in the eight-county Chicago region between 1991 and 1994, subdivided by public and industrial use categories and by counties.

Ground-water production from the deep bedrock aquifers decreased in all counties but McHenry and Will in amounts ranging from 30.3 mgd in DuPage County to 0.4 mgd in Kendall County. Production in McHenry and Will Counties increased by 3.1 mgd and 0.3 mgd, respectively.

Production for public supplies decreased 46.1 mgd during the period 1991-1994 and was 46.6 mgd in 1994, which represents 69 percent of the total deep bedrock production in the Chicago region. Self-supplied industrial water use increased 0.6 mgd or 3 percent during this period to 20.5

Table 1. 1985-1994 Distribution of Pumpage from Deep Bedrock Wells in Northeastern Illinois, Subdivided by Use and County (millions of gallons per day)

Year	*County*	*Public*	*Industrial*	*Total*
1985	COK	48.67	8.72	57.39
	DUP	31.60	0.29	31.89
	GRY	2.11	7.26	9.37
	KNE	22.01	0.39	22.40
	KEN	0.92	0.32	1.74
	LKE	7.54	1.16	8.70
	MCH	3.26	1.28	4.54
	WIL	14.81	6.88	21.69
	Total	**130.92**	**26.80**	**157.72**
1986	COK	27.08	6.44	33.52
	DUP	29.01	0.06	29.06
	GRY	2.13	8.63	10.76
	KNE	21.58	0.43	22.01
	KEN	0.91	0.68	1.59
	LKE	6.89	1.30	8.19
	MCH	3.05	1.27	4.32
	WIL	14.50	6.95	21.45
	Total	**105.15**	**25.76**	**130.91**
1987	COK	12.40	4.51	16.91
	DUP	31.17	0.04	31.21
	GRY	2.23	8.09	10.32
	KNE	21.08	0.34	21.42
	KEN	0.94	0.51	1.45
	LKE	6.64	1.29	7.93
	MCH	2.98	1.16	4.14
	WIL	14.53	6.18	20.71
	Total	**91.97**	**22.12**	**114.09**
1988	COK	11.70	5.83	17.53
	DUP	32.37	0.06	32.43
	GRY	2.59	5.71	8.30
	KNE	22.89	0.37	23.26
	KEN	1.24	0.33	1.57
	LKE	7.89	0.33	8.22
	MCH	3.25	1.58	4.83
	WIL	15.41	5.57	20.98
	Total	**97.34**	**19.78**	**117.12**

Table 1. Continued

Year	*County*	*Public*	*Industrial*	*Total*
1989	COK	11.06	4.56	15.62
	DUP	30.74	0.07	30.81
	GRY	0.99	6.47	7.46
	KNE	18.99	0.23	19.22
	KEN	0.66	0.01	0.67
	LKE	7.45	0.99	8.44
	MCH	3.68	0.96	4.64
	WIL	14.00	4.12	18.12
	Total	**87.57**	**17.41**	**104.98**
1990	COK	10.27	4.04	14.31
	DUP	31.42	0.07	31.49
	GRY	2.61	7.75	10.36
	KNE	20.68	0.19	20.87
	KEN	0.90	0.31	1.21
	LKE	7.10	0.31	7.41
	MCH	3.16	1.26	4.42
	WIL	14.06	6.87	20.93
	Total	**90.20**	**20.80**	**111.00**
1991	COK	10.19	4.58	14.77
	DUP	33.80	0.08	33.88
	GRY	2.03	7.83	9.86
	KNE	20.92	0.20	21.12
	KEN	1.21	0.30	1.51
	LKE	7.90	0.32	8.22
	MCH	2.70	0.42	3.12
	WIL	13.98	6.22	20.20
	Total	**92.73**	**19.95**	**112.68**
1992	COK	11.00	2.55	13.55
	DUP	13.72	0.03	13.75
	GRY	2.26	7.95	10.21
	KNE	13.54	0.55	14.09
	KEN	1.08	0.30	1.38
	LKE	4.53	0.80	5.33
	MCH	2.64	1.99	4.63
	WIL	16.23	7.00	23.23
	Total	**65.00**	**21.17**	**86.17**

Table 1. Concluded

Year	*County*	*Public*	*Industrial*	*Total*
1993	COK	5.43	3.35	8.78
	DUP	2.80	0.02	2.82
	GRY	2.18	7.25	9.43
	KNE	11.60	0.44	12.04
	KEN	0.57	0.30	0.87
	LKE	2.10	0.48	2.58
	MCH	3.03	1.95	4.98
	WIL	15.14	6.69	21.83
	Total	**42.85**	**20.48**	**63.33**
1994	COK	6.81	3.38	10.19
	DUP	3.51	0.05	3.56
	GRY	2.14	6.82	8.96
	KNE	12.16	0.46	12.62
	KEN	0.80	0.33	1.13
	LKE	2.30	1.65	3.95
	MCH	4.24	2.01	6.25
	WIL	14.62	5.84	20.46
	Total	**46.58**	**20.54**	**67.12**

Note:
County names were abbreviated as follows: COK (Cook), DUP (DuPage), GRY (Grundy), KNE (Kane), KEN (Kendall), LKE (Lake), MCH (McHenry), and WIL (Will).

mgd in 1994. This represents approximately 31 percent of the deep well production, compared to 18 percent in 1991, i.e., with the shift of public water supplies to other sources, industrial pumpage represents a larger portion of the total deep bedrock water withdrawals.

Another interesting part of the deep bedrock water-use statistics is the number of new deep wells constructed and the number taken out of service and sealed. For examples, during the years 1991-1995, 43 new wells were drilled: 30 by public water systems and 13 by industries. By contrast, 49 deep wells were sealed: 41 by public water facilities and 2 by industries. Of the 41 public water wells abandoned, 32 were from Cook and DuPage Counties alone, reflecting the switch to Lake Michigan water.

Public Pumpage

Public pumpage declined by 50 percent between 1991 and 1994, from 92.7 mgd to 46.6 mgd. In 1993, public pumpage was even lower: at 42.8 mgd. The biggest part of the decline occurred in 1992, when pumpage fell to 65.0 mgd, a decline of 27.7 mgd or 60 percent of the total decline in the 1991-1994 period. The greatest decreases in public pumpage occurred in DuPage, Kane, Lake, and Cook Counties, which dropped 30.3, 8.8, 5.6, and 3.4 mgd, respectively. The only significant increase, 1.5 mgd, occurred in McHenry County. Public pumpage in Grundy, Kendall, and Will Counties changed little from 1991 to 1994.

The number of major pumping centers (those in which facilities withdrew 1.0 mgd or more) decreased between 1991 and 1994. Records identify 26 major public water supply facilities in 1991. By 1994, this number had dropped to 16, of which the largest number (7) were in the Fox River valley of Kane County. Other major centers were two each in western Cook, western DuPage, and western Will Counties, and one each in northern Grundy, southern Lake, and eastern McHenry Counties. Pumpage at these major centers ranged from 1.0 to 10.8 mgd, as shown in table 2.

Ironically, records also indicate that the number of facilities using deep wells during this period actually increased overall: 111 public water facilities relied on deep wells in 1994, compared to 105 facilities in 1991. Since the number of major pumping centers declined over this period, the increase no doubt reflects an increase in smaller facilities, such as in subdivisions.

Table 2. Major Public Water-Supply Pumping Centers from Deep Bedrock Wells in the Chicago Region, 1994

Pumping Center	*Pumpage (mgd)*	*Pumping Center*	*Pumpage (mgd)*
Joliet	10.8	Batavia	1.4
Aurora	3.6	Bellwood	1.2
Crystal Lake	3.4	Elgin	1.2
West Chicago	1.9	Western Springs	1.2
Morris	1.9	St. Charles	1.2
Lake Zurich	1.8	Lockport	1.2
Montgomery	1.8	North Aurora	1.1
Bartlett	1.4	Geneva	1.0

Self-Supplied Industrial Pumpage

Self-supplied industries in the Chicago region withdrew 20.5 mgd of ground water from the deep bedrock in 1994, a slight increase from the 20.0 mgd withdrawn in 1991. Since 1991, pumpage ranged between 20.0 mgd and 21.2 mgd, and averaged 20.5 mgd. Actually, industrial withdrawals have been fairly consistent since about 1987, ranging between 17.4 mgd and 22.1 mgd, and averaging 20.3 mgd. The all-time highs for industrial pumpage from deep wells for the region were 48.1 mgd in 1966 and 48.2 mgd in 1973. Historically, comparably low industrial pumpage occurred in 1915, when withdrawals amounted to about 18.8 mgd. The only significant decreases in pumpage between 1991 and 1994 were in Cook County (1.2 mgd) and in Grundy County (1.0 mgd). Pumpage increased in Lake and McHenry Counties by 1.3 mgd and 1.6 mgd, respectively. Pumpage remained virtually the same in DuPage, Kane, Kendall, and Will Counties.

The major self-supplied industries in the Chicago region in 1994 were those producing organic chemicals, electric power, and food products. These industries accounted for 15 mgd or 73 percent of industrial pumpage. Other industries included irrigation systems; manufacturers of metals, construction machinery, telephone equipment, and boilers; and textile mills.

The number of industrial facilities using deep wells increased from 85 to 107 between 1991 and 1994. Six self-supplied industries pumped more than 1.0 mgd from deep wells in 1994, compared to three in 1991. Production from these six industries ranged from 1.1 to 5.0 mgd and totaled 13.6 mgd, accounting for 66 percent of the industrial deep well pumpage.

Pumpage Related to the Practical Sustained Yield

Schicht et al. (1976) estimated that the practical sustained yield of the deep bedrock aquifers, regardless of the scheme of well development, cannot exceed about 65 mgd. The practical sustained yield of the deep aquifers is defined as the maximum amount of water that can be withdrawn withouteventually dewatering the most productive water-yielding formation, the Ironton-Galesville Sandstone. The yield is largely limited by the rate at which water can move from recharge areas eastward through the aquifers to pumping centers. This movement, in turn, is dependent on the gradient of the potentiometric surface in the direction of flow. Schicht et al. (1976) suggested that the 65 mgd could be obtained by increasing the number of pumping centers, shifting some centers of pumping to the west, and spacing wells at greater distances *[in fact, with the abandonment of wells by facilities switching to Lake Michigan for water, the major pumping centers have, by default, shifted westward from the immediate Chicago area]*. Burch (1991) concluded from his digital computer model study of the aquifer system that the location of the pumping centers is less important than the *number* of centers, however.

Based on records of deep well production, the estimated practical sustained yield of the aquifer system was exceeded from sometime in the late 1940s through 1992. Burch (1991) had predicted that the switch to lake water in DuPage and Lake Counties in 1992 would reduce total withdrawals from deep wells to amounts at or below the practical sustained yield. Water-use information indicates that the total withdrawals for 1993 and 1994 were within three percent of the 65 mgd estimated by Schicht et al (1976). If pumpage remains close to this amount over the next five-year inventory period (1995-2000), water levels should gradually stabilize over most of the study area. The measurement of water levels in fall 2000, thus, would provide an opportunity to test the validity of the current practical sustained yield and to make ground-water resource management decisions as appropriate.

WATER LEVELS IN DEEP BEDROCK WELLS

The first deep bedrock well in Chicago was drilled in 1864 at 950 West Chicago Avenue, the corner of Chicago and Western Avenues (Leverett, 1899). The well was finished in dolomites of the lower part of the Galena and Platteville Groups. According to Leverett, *"This well was sunk by a band of Spiritualists with a view to prospecting for petroleum, and it is reported that the site of the well was determined by Mr. James, a so-called medium, while entranced. Only a small amount of oil was found, but at a depth of 711 feet a strong flow of water was struck, which rose to a height of 80 feet above the surface, or 111 feet above Lake Michigan."* Because it had such a high artesian pressure, the well flowed freely, as did many of the early wells in the region.

Suter et al. (1959) inferred that the potentiometric head of the water in the sandstone aqui-

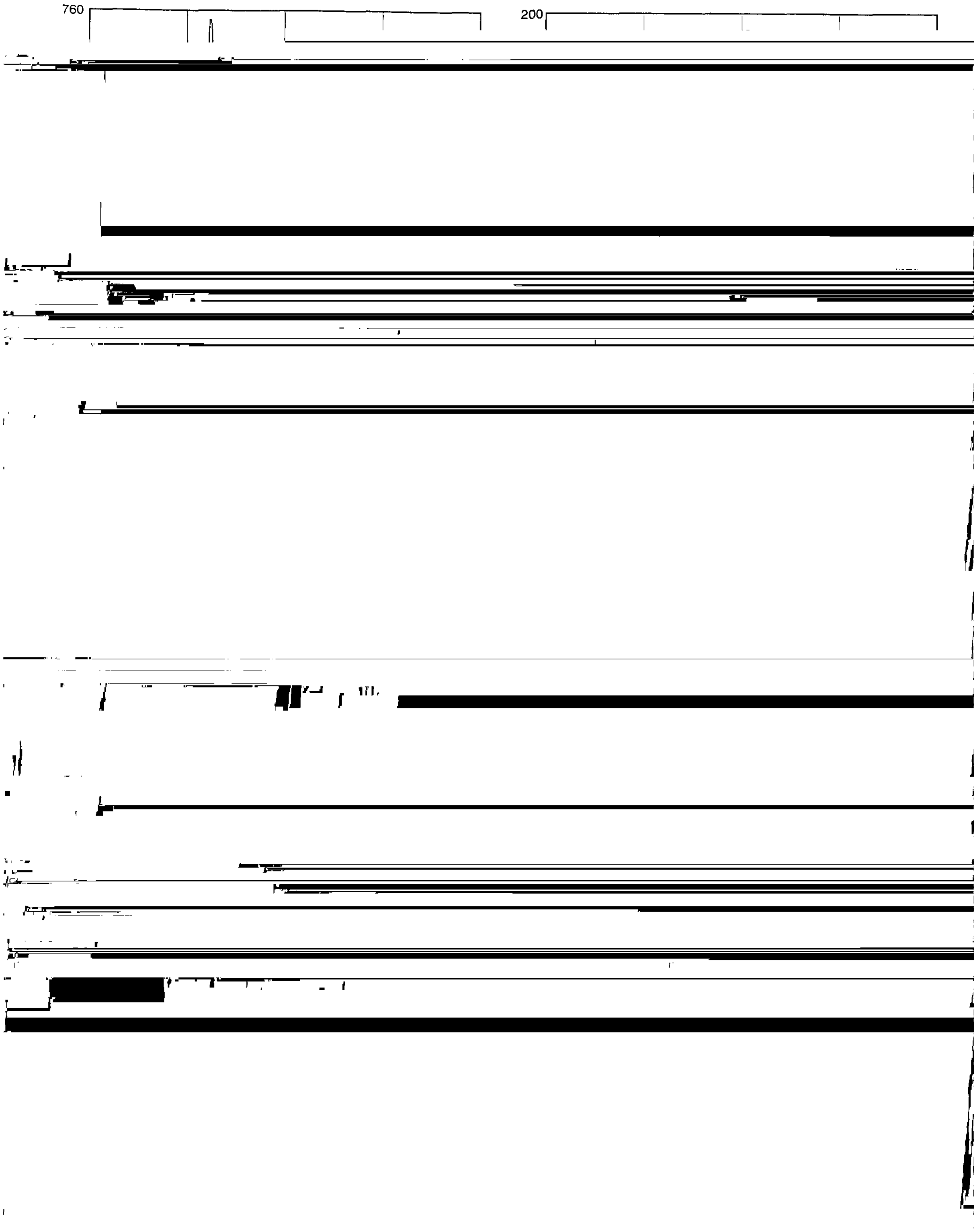


Figure 4. Water levels in selected observation wells in northern Illinois, 1975-1985

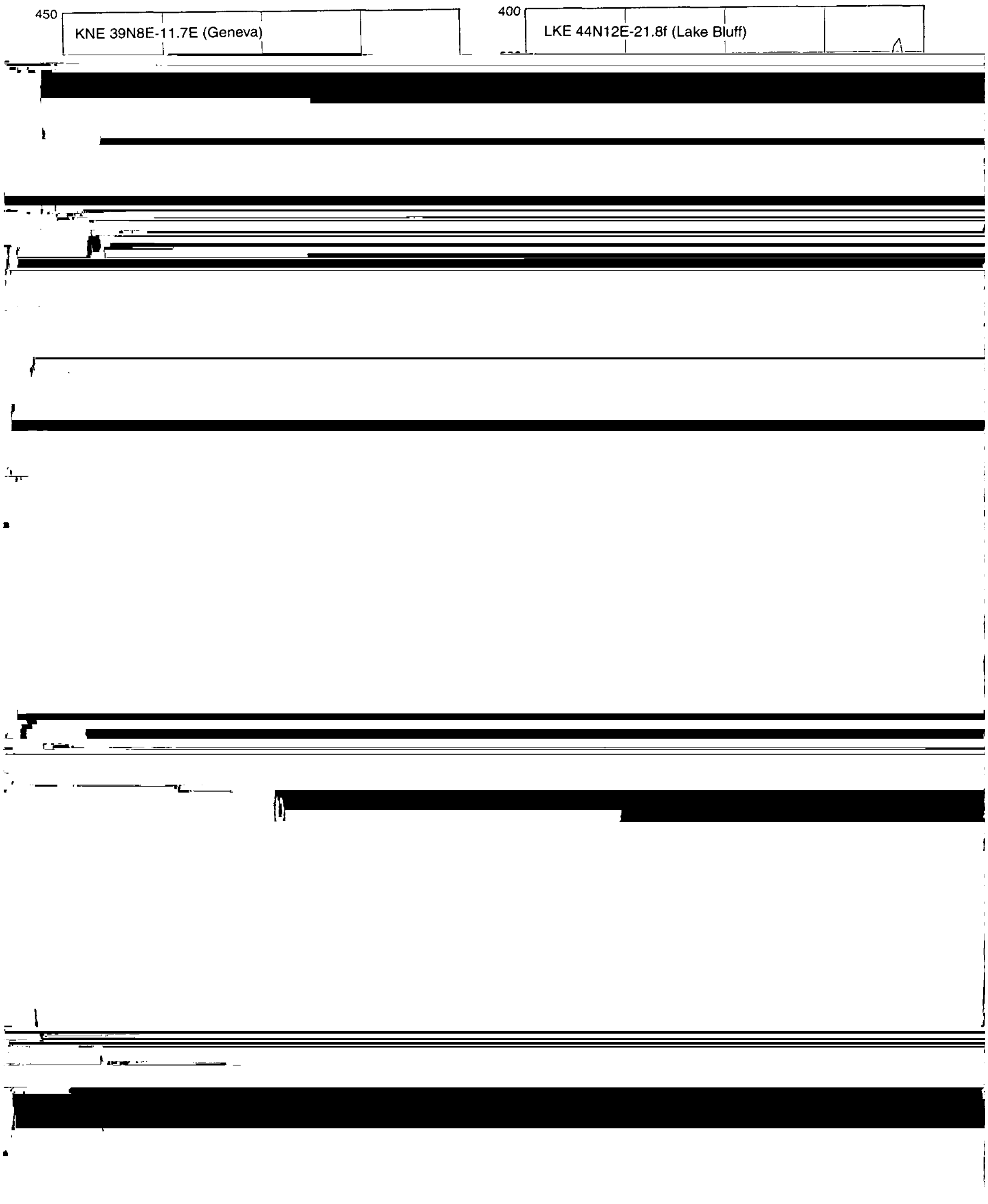
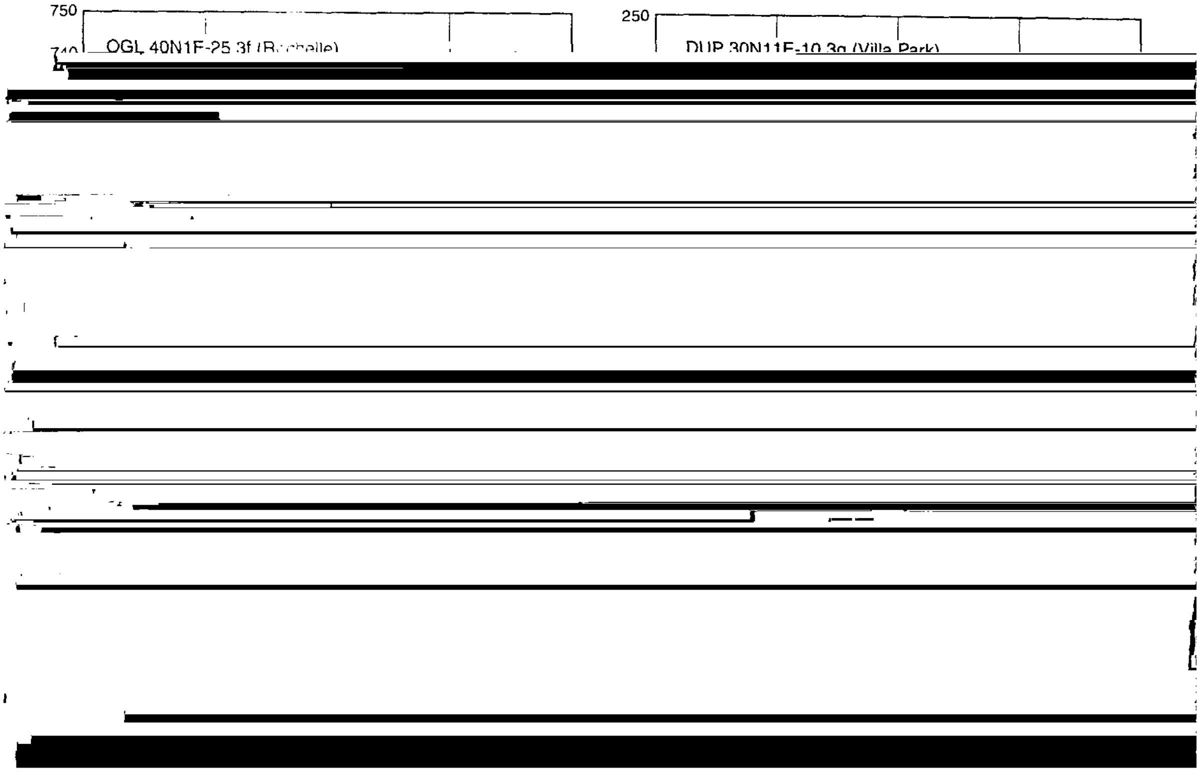


Figure 4. Continued


750
OGL 40N1E-25.3f
250
DUP 30N11E-10.3g (Villa Park)

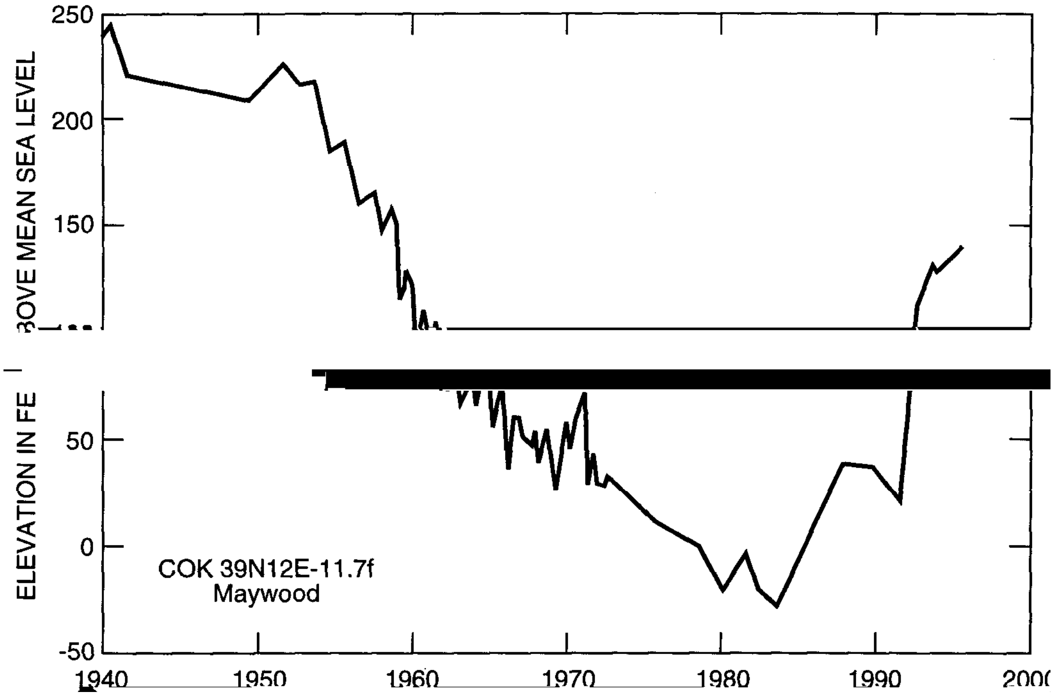


Figure 6. Representative trend of deep well water levels in Cook County since 1940

1991-1995

Between 1991 and 1995, average water-level changes in the 11 observation wells were all upward, with the exception of the well at Geneva. Water levels rose in these wells from 0.5 ft/yr south of Joliet to 30 ft/yr at Maywood, while water levels declined 16.5 ft/yr at Geneva.

Of the 364 wells that were measured in the eight-county Chicago region in fall 1995, 279 wells had also been measured in 1991. Water levels between 1991 and 1995 rose in 231 of these wells (83 percent), declined in 42 wells (15 percent), and showed no change in 6 wells (2 percent). This represents a considerable growth of the trend noted in the 1985-1991 period in which rises

Table 3. Average Changes in Nonpumping Water Levels in Selected Deep Bedrock Observation Wells in the Chicago Region (ft/yr)

Well & Location	1975-1980	1980-1985	1985-1991	1991-1995
COK 37N14E-27.5e (Chicago)	-4.4	+8.0	+5.5	+4.8
COK 38N13E-11.lh (Chicago)	-2.8	+3.2	+5.2	+9.5
COK 39N12E-11.7f (Maywood)	-6.2	+4.6	+2.8	+30.0
COK 41N11E-25.2h (Des Plaines)	-4.4	+0.2	+11.5	+13.2
KNE 39N8E-11.7e (Geneva)				

Table 4. Average Water-Level Changes in Nonpumping Deep Bedrock Wells in the Eight-County Chicago Region (ft/yr)

County	*1975-1980*	*1980-1985*	*1985-1991*	*1991-1995*
Cook	-10	-4	+12	+15
DuPage	-12	-9	+2	+38
Grundy	-5	-5	-2	
Kane	-7	-2	+l	
Kendall	-1	-3	-3	
Lake	-14	-1	+l	
McHenry	-8	-7	+l	
Will	-6	+2	-8	
Weighted average				
Number of observations				

Table 5. Average Water-Level Changes in Selected Nonpumping Deep Bedrock Wells in the Extended Chicago Region (ft/yr)

Well & Locution	*1975 1980*	*1980-1985*	*1985-1991*	*1991-1995*
BNE 44N3E-25.8b (Belvidere)	+2.8	-2.0	+0.7	+1.5
LAS 33N1E-16.8a (Peru)	-0.6	+0.2	+0.2	-0.2
LAS 33N3E- 1.6b (Ottawa)	-2.4 est-	2.4 est	+2.8	-1.0
OGL 40N1E-25.3f (Rochelle)	+2.6	+2.6	+1.5	+0.8
WIN 44N1E-23.6d (Rockford)	+0.8	+0.4	-1.2	+1.8

Also, the proximity to the primary recharge area in north-central Illinois lessens the effect of pumpage on water levels.

During the periods 1975-1980, 1980-1985, and 1985-1991, average water-level changes in five selected observation wells in the extended area ranged from rises of 2.8 ft/yr (in the early period at Belvidere in Boone County and in the late period at Ottawa in LaSalle County) to an estimated decline of 2.4 ft/yr (in the early and middle periods at Ottawa). The well at Rochelle in Ogle County exhibited modest, continuous rises during all three periods.

During the period 1991-1995, average water-level changes were small and mixed, rising between 0.8 ft/yr at Rochelle (Ogle County) and 1.8 ft/yr at Rockford (Winnebago County) and declining in LaSalle County between 0.2 ft/yr at Peru and 1.0 ft/yr at Ottawa.

Water levels in 143 wells in seven northeastern Illinois counties in the extended area were measured in both 1991 and 1995. Seventy-one wells in all seven counties indicated water-level rises. They ranged from one foot in DeKalb, Lee, Ogle, and Winnebago Counties to 156 feet in Ogle County. The large rise in Ogle County occurred at an industrial well. Rises of 50 feet or more were observed in three wells each in DeKalb and Ogle Counties. Declines were noted in 63 wells in all seven counties, ranging from one foot in DeKalb, LaSalle, and Winnebago Counties to 76 feet in LaSalle County. The large decline in LaSalle County occurred at a well in Marseilles. Declines of 50 feet or more were observed at two wells in LaSalle County and at one well in Winnebago County. Overall, the weighted average water-level change was +0.5 ft/yr and ranged from +7.5 ft/yr in Ogle County to -1.9 ft/yr in LaSalle County.

reports of this series. "Piezometric surface" was originally used to imply an artesian head at some level above the top of the aquifer. "Potentiometric surface" more appropriately refers to the water-level surface, whether or not it is above the top of the aquifer.

Previous reports have included several potentiometric surface maps of areas of the deep bedrock aquifers in northern Illinois. Maps for 1950 (Foley and Smith, 1954), 1971 (Sasman et al., 1973), and 1980 (Sasman et al., 1982) cover all of the northern part of the state. Maps for 1958 (Suter et al., 1959), 1959 (Walton et al., 1960), 1960 (Sasman et al., 1961), 1961 (Sasman et al., 1962), 1966 (Sasman et al., 1967), 1975 (Sasman et al., 1977), 1980 (Sasman et al., 1982), 1985 (Sasman et al., 1986), and 1991 (Visocky, 1993) have been limited to northeastern Illinois. The 1980 map included coverages of both the northern and northeastern portions of the state. The 1991 map is included in this report for comparison with the 1995 map.

Potentiometric Surface, 1991

Figure 7 shows the potentiometric surface of the deep bedrock aquifers in fall 1991. Water-level data used to prepare the map are included in the appendix. The general features of the 1991 potentiometric surface map differ very little from those of the potentiometric maps for 1980 and 1985.

The deepest cones of depression in the Chicago region in 1991 were in the Joliet and Elmhurst areas, where some levels were as much as 300 feet and 180 feet below msl, respectively. Significant cones of depression were present in northern Cook County (Morton Grove-Niles and Prospect Heights), Kane County (Aurora), southern Lake County (Mundelein-Vernon Hills and Lincolnshire), and McHenry County (Crystal Lake and Ringwood areas).

The zero-foot msl contour line encompassed eastern and southern DuPage County, much of western and southwestern Cook County, a portion of southern Lake County, and most of the northern half of Will County. The areal extent of this contour had diminished since 1985 to about 647 square miles. The negative 100-foot contour extended for about 151 square miles around the Ehmhurst and Joliet areas.

Other notable depressions in the potentiometric surface were identified in southwestern Will County and northeastern and southeastern Grundy County. The potentiometric surface was below the top of the Ancell aquifer in large portions of central and eastern DuPage County; in northern Will County; and in small portions of Kane, Kendall, and Grundy Counties. Together, these depressions amounted to approximately 366 square miles. An area of similar size was dewatered along the Illinois River valley in LaSalle County.

For the entire study area, the 1991 potentiometric surface map showed the areas of highest elevation in Boone/Winnebago and DeKalb/Lee/Ogle Counties. A major depression in the potentiometric surface was apparent in Winnebago County (at Rockford), and smaller depressions were seen in Boone County (Belvidere), DeKalb County (DeKalb), and LaSalle County (Ottawa and LaSalle-Peru).

The general pattern of ground-water flow in the deep bedrock aquifers was primarily from high elevations in north-central Illinois toward the east and southeast. Locally, flow traveled toward the deep cones of depression in southern Lake and northern Cook Counties, in eastern DuPage County (Elmhurst), and in Will County at Joliet. Some of the water moving toward these cones of

Figure 7. Potentiometric surface of the deep bedrock aquifers in northeastern Illinois, fall 1991

depression was intercepted by pumping centers at Aurora, Bloomingdale-Carol Stream, Geneva-St. Charles, Morris, Naperville, and industrial pumping centers in Grundy, southern Cook, and southern Will Counties. In addition, water from the recharge area west of the Chicago region was diverted into cones of depression at Rockford, Belvidere, DeKalb, and the Illinois River valley in LaSalle County.

Potentiometric Surface, 1995

Figure 8 shows the potentiometric surface of the deep bedrock aquifers in Fall 1995. Water-level data used to prepare the map appear in the appendix. The general features of the 1995 potentiometric surface map continue to resemble those of the maps for 1985 and 1991, despite differences in details around former pumping centers.

The deepest cones of depression in the Chicago region in 1995 were in the Joliet and Western Springs areas, where levels were as much as 246 feet and 78 feet below msl, respectively. The major cone of depression observed at Elmhurst in 1991 shrank in size and depth, but significant cones of depression were present in the Western Springs, Elk Grove, Rolling Meadows, Wheeling-Mt. Prospect, and Northbrook-Glenview areas (western and northern Cook County); Geneva-St. Charles (Kane County); Lake Zurich (southern Lake County); and Crystal Lake and Ringwood (McHenry County).

The zero-foot-msl contour line was centered around the Joliet area of northwestern Will County and southern Cook County and was present in small areas of western, central, and northern Cook County. The areal extent of this contour has diminished since 1991 to about 243 square miles. The negative 100-foot contour extended for about 77 square miles around the Joliet area, about half of its size in 1991.

Other notable depressions in the potentiometric surface were identified in northeastern and southeastern Grundy County and in southwestern Will County. The potentiometric surface appeared to remain below the top of the Ancell aquifer in the Joliet area (northern Will County) and small areas along the Illinois River (LaSalle County).

For the entire study area, the 1995 potentiometric surface map showed the areas of highest elevation once more in Boone/Winnebago and DeKalb/Lee/Ogle Counties. A major depression in the potentiometric surface remained at Rockford, and smaller or shallower depressions were again seen at Belvidere, LaSalle-Peru, and Ottawa.

The general pattern of ground-water flow in the deep bedrock aquifers continued to originate from high elevations in north-central Illinois toward the east and southeast. Locally, flow traveled toward the deep cones of depression in northern and western Cook County and Joliet. Some of the water moving toward these cones of depression was intercepted by pumping centers along the Fox River valley in Kane County, Morris, and Crystal Lake, and by industrial pumping centers in Grundy, eastern McHenry, southern Cook, and southern Will Counties. In addition, water from the recharge areas west of the Chicago region was diverted into cones of depression at Rockford, Belvidere, DeKalb, and the Illinois River valley in LaSalle County. Ground-water divides in figures 7 and 8 indicate the approximate limit of diversion for the deep bedrock aquifers west of the Chicago region.

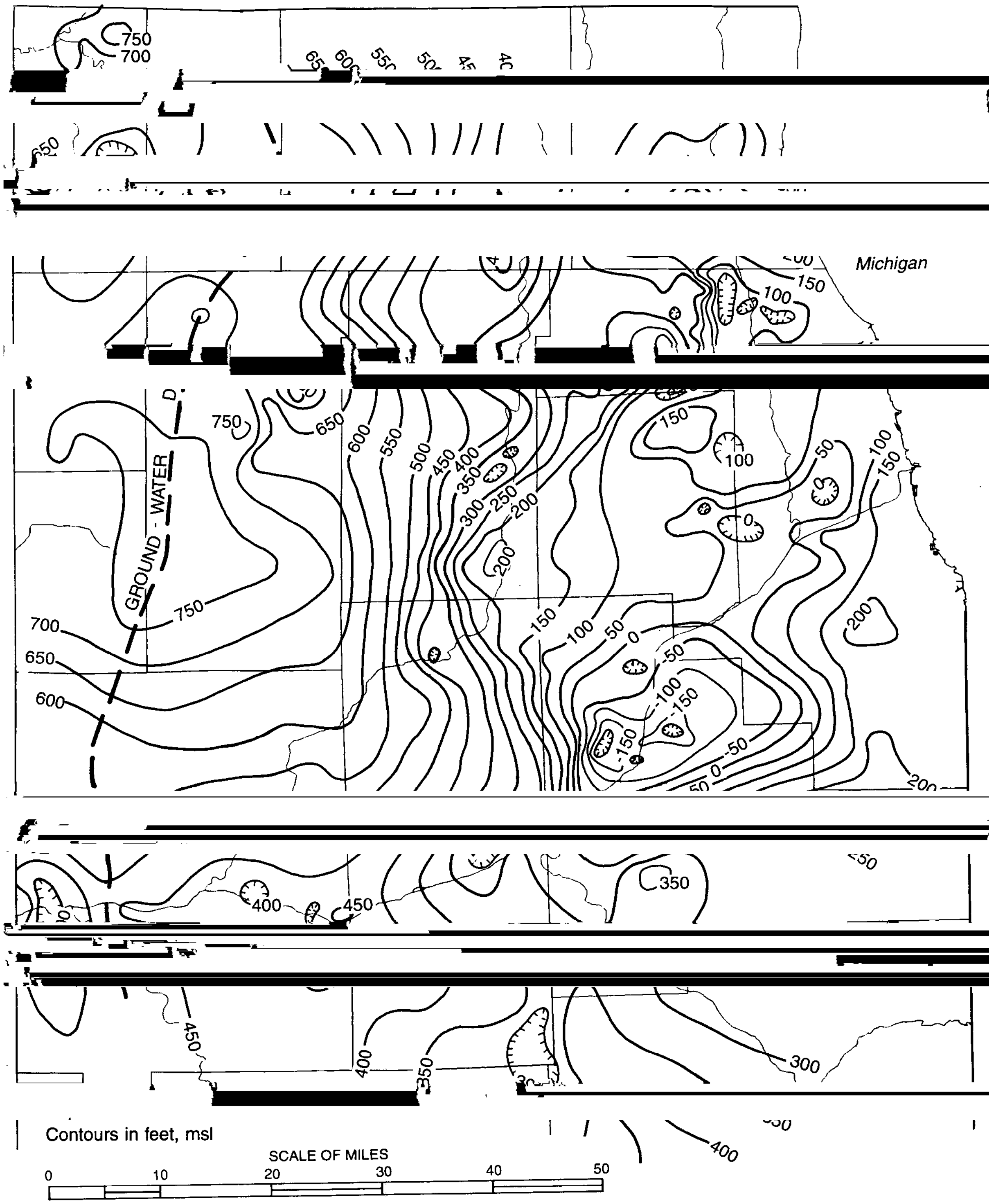


Figure 8. Potentiometric surface of the deep bedrock aquifers in northeastern Illinois, fall 1995

Changes in Potentiometric Surface, 1991-1995

Using potentiometric surface maps and the observed water-level changes in deep wells for 1991 and 1995, a map of water-level changes (figure 9) was prepared. Potentiometric surface maps were overlaid on one another, and the 1995 contours were subtracted from those on the 1991 map. Resulting data points, along with observed changes in deep wells, were used in constructing the map of water-level changes. Those changes observed in wells between 1991 and 1995 are listed in the appendix.

As was noted earlier, water-level changes in individual wells do not always correspond to or agree with regional trends observed in the majority of wells in a given region. These individual anomalies are usually not readily apparent at the time of measurement and most often are the result of effects of recent pumpage in the well or in nearby wells. In preparing a difference map, therefore, anomalous data points must be reconciled with the surrounding data, so that a set of difference contours is generated that is both consistent and reasonable.

In addition to anomalies among the *measured* data, it must be acknowledged that the precision and accuracy with which *difference* data points are generated (by subtracting one potentiometric surface map from another) are artifacts of the precision and accuracy of the potentiometric surface maps themselves. For example, slight shifts in the plotting of water-level contours on either or both maps can potentially alter the locations and values of their differences. In the same manner that anomalous measured data must be reconciled with nearby points, difference data points must also be reconciled with measured data points at nearby wells. The degree of difficulty with which this reconcilement is accomplished is a measure of the uncertainty in the resulting water-level change map.

The most obvious recovery of deep water levels occurred in southern Lake, eastern DuPage, and western Cook Counties, where water levels rose more than 200 feet. Water-level rises were widespread over an area extending from central Lake County to extreme northwestern Will County and westward to the southeastern tip of Kane County. This recovery was primarily due to the transition from the use of deep well water to the use of lake water for public supplies. The most notable switchover of such water sources occurred in spring 1992 in DuPage County shortly after the 1991 water-level measurements were concluded. Water-level rises were also found in small areas scattered over portions of western Will County and Grundy County. In the eight-county Chicago region, water-level rises of 50 feet or more occurred over an area of about 1,340 square miles or 29.9 percent of the region. Rises of 100 feet or more occurred over an area of about 610 square miles or 13.6 percent of the region.

Declines in the potentiometric surface were mostly centered on an area in southern McHenry County and northern Kane County. Additionally, scattered small areas of water-level declines were noted in portions of Will and eastern Kane Counties. In the eight-county region, declines of 50 feet or more extended over a total area of about 238 square miles or 5.3 percent of the area. Declines of 100 feet or more occurred over an area of about 114 square miles or less than 3 percent of the area.

Outside of the eight-county Chicago region, rises and declines of 50 feet or more were insignificant in occurrence, and most water-level changes were less than 50 feet,

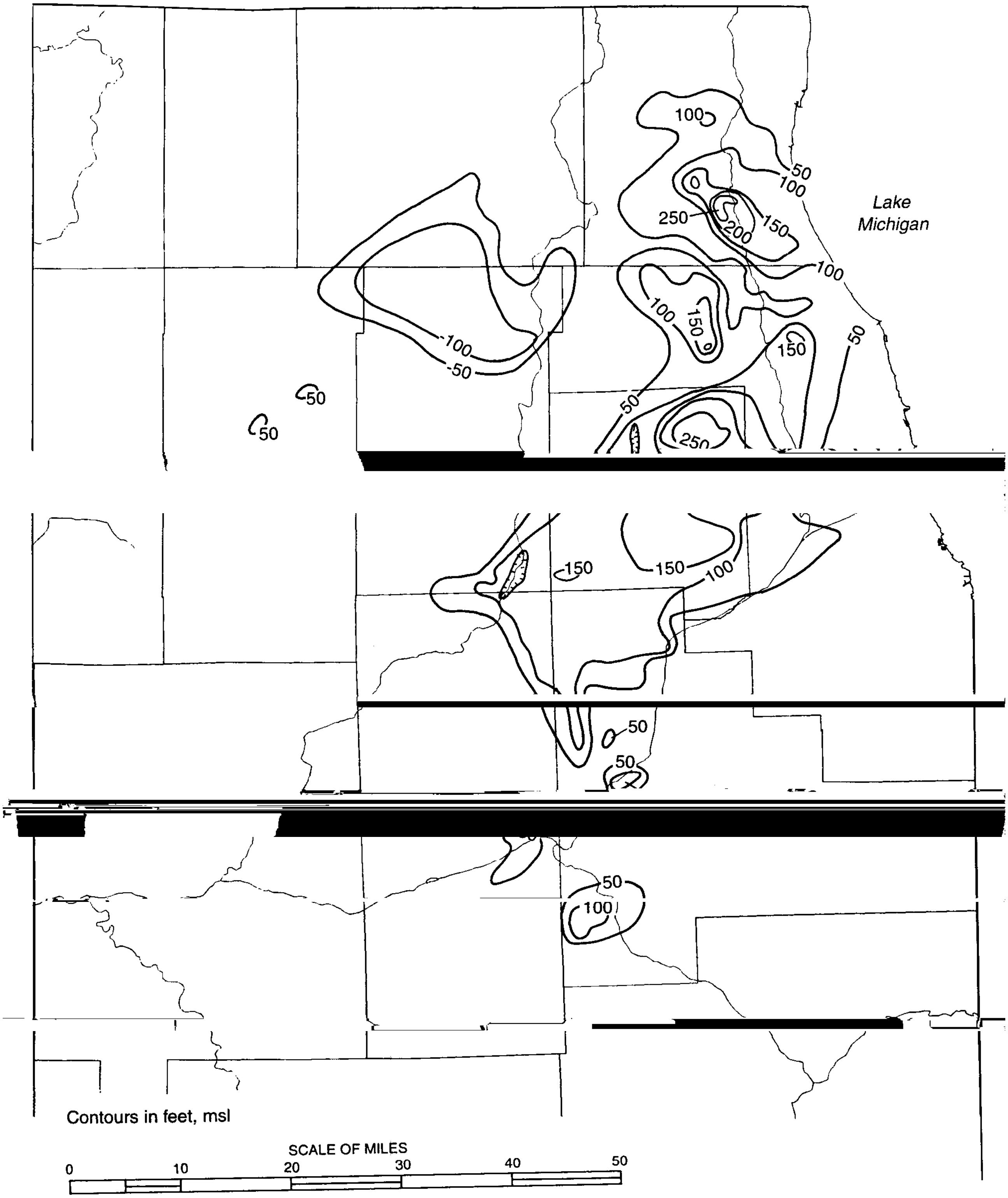


Figure 9. Changes in the potentiometric surface of the deep bedrock aquifers in northeastern Illinois, 1991-1995

REFERENCES

Burch, S.L. 1991. *The New Chicago Model: A Reassessment of the Impacts of Lake Michigan Allocations on the Deep Bedrock Aquifers in Northeastern Illinois.* Illinois State Water Survey Research Report 119,52p.

Cartwright, K. 1983. Classification of Hydrostratigraphic Units in Illinois. Illinois State Geological

Sasman, R.T., T.A. Prickett, and R.R. Russell. 1961. *Water-Level Decline and Pumpage during 1960 in Deep Wells in the Chicago Region, Illinois.* Illinois State Water Survey Circular 83,43p.

Schicht, R.J., J.R. Adams, and J.B. Stall. 1976. *Water Resources Availability, Quality, and Cost in Northeastern Illinois.* Illinois State Water Survey Report of Investigation 83,90p.

Singh, K.P., and J.R. Adams. 1980. *Adequacy and Economics of Water Supply in Northeastern Illinois: Proposed Ground-Water and Regional Surface Water Systems, 1985-2010.* Illinois State Water Survey Report of Investigation 97,205p.

Suter, M., R.E. Bergstrom, H.F. Smith, G.H. Emrich, W.C. Walton, and T.E. Larson. 1959. *Preliminary Report on Ground Water Resources of the Chicago Region, Illinois.* Illinois State Water Survey and Geological Survey Cooperative Ground-Water Report 1,89p.

U.S. Environmental Protection Agency. 1976. "National Primary Drinking Water Regulations." *Federal Register,* July 9, 1976:28403.

U.S. Environmental Protection Agency. 1991. "National Primary Drinking Water Regulations." *Federal Register,* July 1, 1991:30274.

Visocky, A.P. 1982. *Impact of Lake Michigan Allocations on the Cambrian-Ordovician Aquifer System.* Illinois State Water Survey Contract Report 292,36p.

Visocky, A.P. 1993. *Water-Level Trends and Pumpage in the Deep Bedrock Aquifers in the Chicago Region, 1985-1991.* Illinois State Water Survey Circular 177,44p.

Visocky, A.P., M.G. Sherrill, and K. Cartwright. 1985. *Geology, Hydrology, and Water Quality of the Cambrian and Ordovician Systems in Northern Illinois.* Illinois State Geological Survey and Illinois State Water Survey Cooperative Ground-Water Report 10, 136p.

Walton, W.C. 1960. *Leaky Artesian Aquifer Conditions in Illinois.* Illinois State Water Survey Report of Investigation 39,27p.

Walton, W.C., R.T. Sasman, and R.R. Russell. 1960. *Water-Level Decline and Pumpage during 1959 in Deep Wells in the Chicago Region, Illinois.* Illinois State Water Survey Circular 79,39p.

Appendix. Water-Level Elevations of the Deep Bedrock Aquifers in Northern Illinois, 1991-1995

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Boone							
00744N03E24.8a	6	Belvidere	868	784	717	712	-5
00744N03E25.3d	1	Pillsbury-Green Giant Pckg Co.	627	770	698	716	18
00744N03E25.4d	2	Pillsbury-Green Giant Pckg Co.	550	770	704	717	13
00744N03E25.6d	2	Dean Foods Co.	868	770	680	670	-10
00744N03E25.8b	3	Belvidere	1803	765	747	753	6
00744N03E26.1e	4	Belvidere	1801	778	711	710	-1
00744N03E34.2a	8	Belvidere	1393	780	610	599	-11
00744N03E35.1f	5	Belvidere	610	800	745	736	-9
00744N03E36.2g	7	Belvidere	969	840	610	625	15
00745N03E27.4c	3	Consumers III. Wtr. Co. -Candlewick Lk.	917	885		675	
00745N04E11.7h	1	Capron	880	912	860		
00745N04E19.8f	1	McLay Grain co.	570	892	834		
Cook							
03135N14E19.4c	22	Chicago Heights	1800	677	222	239	17
03135N14E21.2h	2	Rhone Poulenc Co.	1979	640	156	168	12
03136N12E02.5h	11	Orland Park	1683	712	54	84	30
03136N12E22.6b	3	Citizens Fernway Utility (Westhaven)	1712	720	-65	-54	11
03136N13E01.2g	1	NBI Industrial Terminal	1618	597	139		
03136N13E09.8b	1	Oak Forest	1701	672	104	116	12
03137N11E14.7c	1	Powell Duffryn Terminal	1501	585	-25	20	45
03137N11E28.3b	I	DeAndreis Seminary	1690	740	-40		
03137N11E29.1g	4	Lemont	1685	737	-51	51	102
03137N11E29.4a	3	Lemont	1723	743	-69	-84	-15
03137N12E02.8h	2	Hickory Hills	1608	685	43	66	23
03137N13E26.1g	3	Oak Hill Cemetery	1637	617	235	235	0
03137N14E27.5e	1118	Met. Wtr. Recl. Dist.	1683	590	164	183	19
03137N15E08.1c	2	Falstaff Brewing Co. (2B)	1715	592	-20		
03138N12E05.8d	3	Western Springs	1600	673	-96	-19	77
03138N12E06.6b	4	Western Springs	1913	642	-66	-78	-12
03138N 12E 18.8g	3	Suburban Hospital	1540	685	6	25	19
03138N12E23.2g	13	CPC International, Inc.	1525	600	-35		
03138N12E24.7h	14	CPC International, Inc.	1481	597	-88		
03138NI2E24.8g	12	CPC International, Inc.	1507	597		31	
03138N13E08.1f	4	Rose Packing Co.	1590	594	72	108	36
03138N13E11.lb	1	Bradshaw-Praeger & Co.	1224	597	85	123	38
03138N13E19.4f	3	Viskase Corporation	1665	621	-36		
03138N13E19.6f	2	Viskase Corporation	1590	619	-41	14	55
03138N13E27.5g	1	Tootsie Roll Industries	1565	617	62	97	35
03138N14E07.6c	1	Fleischmann-Kurth Malting Co.	1583	594	102	139	37
03138N14E07.6d	2	Fleischmann-Kurth Malting Co.	1523	594	94	115	21
03139NI2E08.5g	4	Bellwood	1965	645	-110	152	262
03139N12E09.5a	3	Bellwood	1480	624	-96		
03139N12E11.7f	3	Maywood	1640	630	21	141	120
03139N12EI6.2f	5	Bellwood	1845	627	-167	101	268
03139N13E21.6g	1	Kropp Forge Co.	1636	608	-102	-45	57
03139N14E21.7b	1	Industrial Coatings Group, Inc.	1610	593	98	129	31
03139N14E21.7b	2	Industrial Coatings Group, Inc.	1603	593	197	267	70
03140N12E18.6c	1	Nelson Wire Co.	1457	663	-81		
03140N12E31.4c	2	AG Communications System 5 Inc	1468	655	-105		
03140N12E31.4d	1	AG Communications System 5 Inc	1470	655	-85	75	160

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Cook (cont'd)							
03141N09E36.6b	4	Hanover Park	1434	820		291	
03141N10E06.5b	10	Hoffman Estates	1357	810	228	250	22
03141N10EI2.3g	21	Schaumburg	1355	735	60	130	70
03141N10E21.1f	20	Schaumburg	1440	800		190	
03141N10E31.3e	3	Hanover Park	1952	798	201	263	62
03141N10E34.8h	15	Schaumburg	1350	810	165	190	25
03141N10E36.8b	11	Elk Grove Village	1367	725	34	48	14
03141N11E08.3a	6	Rolling Meadows	1602	694	82	245	163
03141N11E09.7g	1	U.S. Army	1812	713	115		
03141N11E14.5b	3	Citizens Waycinden Division	1382	672	32	32	0
03141N11E16.2h	12	Arlington Heights	1780	714		304	
03141N11E23.7f	16	Mt. Prospect	1961	675	37	85	48
03141N11E24.1f	2	Citizens Waycinden Division	1652	660	10	74	64
03141N11E25.2h	7	Des Plaines	1815	655	186	239	53
03141N11E25.6b	4	Touhy Mobile Homes	1515	657	-118	7	125
03141N11E25.6b	5	Touhy Mobile Homes	940	657	65		
03141N11E27.3f	9	Elk Grove Village	1403	681	-34	26	60
03141N11E31.3a	14	Elk Grove Village	1390	702	-16	-108	-92
03141N12E12.8b	1	North Suburban Public Util.	1414	662	-66	99	165
03141N12E26.6e	1	Park Ridge Country Club	1355	643	10		
03141N13E20.7e	1	The Heam Co.	1414	627	27		
03141N13E22.4g	2	Evanston Country Club	1465	608	34	76	42
03141N13E29.8d	1	Howard Commons	1465	624	34		
03142N09E25.5g	4	Willow Creek Church	947	840		251	
03142N09E32.6e	1	Sears Roebuck & Co.	1380	845		225	
03142N09E34.7a	1	Allstate Insurance Co.	1250	850	255	264	9
03142N09E34.8a	3	Allstate Insurance Co.	1370	850	310	298	-12
03142N10E01.8f	15	Palatine					

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Cook (cont'd)							
03142N12E18.4a	1	Donlen Corp.	1330	660	56		
03142N12E19.1b	3	Allstate Insurance Co.	1401	662	-6	67	73
03142N12EI9.1c	1	Allstate Insurance Co.	1400	663	-3	32	35
03142N12E19.1d	2	Allstate Insurance Co.	1404	663	25	43	18
03142N12E19.2a	4	Allstate Insurance Co. (G)	1400	655	6	63	57
03142N12EI9.2e	2	Andersen Consultants	1400	657	23	130	107
03142N12E19.2h	2	Culligan U.S.A.	1380	655	-100	84	184
03142N12E19.3a	1	Allstate Ins. Co. - West Plaza	1352	640	-1	94	95
03142N12E19.3f	1	Andersen Consultants	1400	655	-10	75	85
03142N12E19.4b	2	Allstate Ins. Co. - West Plaza	1328	650	30	78	48
03142N12E19.4e	1	Household Finance Corp.	1308	648	83		
03142N12E23.6b	1	Sunset Mobil Home Park	1415	626	39	54	15
03142N12E28.7e	1	Signode Steel Strapping Co.	1452	670	-35	22	57
03142N12E29.1h	1	Glenbrook Hospital	1406	677	22		
03142N12E32.4f	1	Life Source	1465	670	15		
03142N12E32.6f	2	Zenith Radio Corp.	1400	662	127	108	-19
03142N12E36.7e	2	North Shore Country Club	2017	645	48		
03142N12E36.8f	3	North Shore Country Club	1444	640		106	
03142N13E32.1a	2	Westmoreland Country Club	1477	630		125	
DeKalb							
03737N05E32.1c	1	Somonauk	190	685	656	657	1
03737N05E32.1c	2	Somonauk	502	685	656	648	-8
03737N05E36.7g	3	Sandwich	610	655	639	633	-6
03737N05E36.7h	1	Sandwich	600	667	647	649	2
03737N05E36.7h	2	Sandwich	600	667	635		
03738N04E15.8d	3	Waterman	400	813	771	771	0
03738N04E16.2d	2	Waterman	400	825	770	789	19
03738N05E14.4d	3	Hinckley	605	740	708	719	11
03738N05E15.2d	2	Hinckley	708	740	718	723	5
03740N03E15.7c	2	Kishwaukee College	920	910	705	716	11
03740N03E23.6e	2	Malta	1254	915	735	739	4
03740N03E23.7e	1	Malta	853	915	770	769	-1
03740N04E01.4e	7	Sycamore	1233	835	525	559	34
03740N04E10.7b	14	DeKalb	1313	890	604		
03740N04E15.7a	6	DeKalb	1291	855	594		
03740N04E16.1g	1	DeKalb Univ. Development Corp.	805	880	730	791	61
03740N04E16.2g	2	DeKalb Univ. Development Corp.	970	883	720		
03740N04E21.4f	10	DeKalb	1310	880	623		
03740N04E23.5d	4	DeKalb	1325	885	592		
03740N04E26.3g	1	Del Monte Corp.	1324	890	600	622	22
03740N04E26.3g	2	Del Monte Corp.	1345	890	635		
03740N04E26.6e	7	DeKalb	1328	885	561		
03740N04E33.1h	12	DeKalb	1200	862	584		
03740N04E34.5c	13	DeKalb	1222	865	641		
03740N05E05.5e	5	Sycamore	1270	872		683	
03740N05E06.7a	8	Sycamore	1300	880	641	657	164854.1(641)]Te3e-2271.2(7
03717N05E327gd			67	Sycamore		1143	435
03720N03E26.7h	0			KirkS40617.4(7)-843(3)-8.4(7)-294824(7)-843637			
03720N03E26.7h				KirkS40617.467	3		
03720N04E26.7a	2	75	30	70	67		

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
DeKalb(cont'd)							
03742N05E19.4b	3	Genoa	732	830	710	699	-11
03742N05E20.7a	4	Genoa	770	847	642	645	3
DuPage							
04337N11E02.7d	4	Southeast Region Water Facilty	1610	710	-10		
04338N09E01.5a	28	Naperville	1490	730	-40	105	145

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth*

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth Ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Kendall (cont'd)							
09337N06E22.7b	1	Sparkling Spring Water Co.	550	650		581	
09337N07E27.2b	1	Hide-A-Way Lakes Inc.	550	590	386	396	10
09337N07E28.8b	4	Yorkville	1393	628	313	338	25
09337N07E31.5b	1	Hoover Outdoor Ed. Center	850	640		465	
09337N07E32.1e	3	Yorkville	1335	584	330	334	4
09337N08E05.5i	1	AT&T	1332	640		252	
09337N08E05.6e	2	Aurora Sanitary District	1325	628	104	184	80
09337N08E05.9f	1	Caterpillar Tractor Co.	1384	661	97		
09337N08E06.2d	3	Caterpillar Tractor Co.	1352	662	123		
09337N08E06.2f	2	Caterpillar Tractor Co.	1346	660	110		
09337N08E07.2b	6	Oswego	1392	652		202	
09337N08E27.2e	4	Oswego	1396	658		210	
09337N08E20.8h	3	Oswego	1378	640	185	219	34
Lake							
09743N09E11.2a	2	Lake Barrington Shores	1305	815	200	210	10
09743N10E06.5b	1	Wynstone Water Co.	1001	850		244	
09743N20E06.5b	3	Wynstone Water Co.	1000	850		341	
09743N20E06.5c	2	Wynstone Water Co.	1000	860		317	
097043N10E06.7b	4	Wynstone Water Co.	1321	830		235	
09743N10E07.1a	11	Lake Zurich	1358	838		235	
09743N10E13.2g	3	Fields of Long Grove	980	741		183	
09743N10E24.7d	1	Kemper Insurance	1400	796	147	293	146
09743N10E15.2d	2	Kemper Insurance	1402	796	125	160	35
09743N10E16.4d	8	Lake Zurich	1373	868	159	216	57
09743N10E19.4h	10	Lake Zurich	1340	850	170	212	42
09743N10E21.5e	7	Lake Zurich	1333	846		201	
09743N20E23.2b	2	Glenstone Subdivision	980	750		188	
09743N20E29.2h	9	Lake Zurich	1365	875	146	183	37
09743N11E09.4a	8	Vernon Hills (Well 3)	1265	700	-81	220	301
09743N11E28.4d	1	Kemper Sports Management	982	740		169	
09743N11El8.5a	3	Royal Melbourne Homeowner Assn.	925	725		165	
09743N11E18.6a	2	Royal Melbourne Homeowner Assn.	958	725		172	
09743N11El8.7a	1	Royal Melbourne Homeowner Assn.	945	725		181	
09743N11E19.1d	1	Briarcrest Subd. Homeowners Assn.	960	690		196	
09743N11E19.1d	3	Briarcrest Subd. Homeowners Assn.	940	695		190	
09743N11E21.3g	1	Powernail Co.	1258	685	220		
09743N11E22.6d	3	Lincolnshire	1300	667	-3	196	199
09743N11E32.8f	2	Buffalo Grove	1355	703	118	173	55
09743N11E34.2g	6	Pekara Subdivision	980	642		107	
09743N12E30.4f	1	Deerfield Park District	1375	660		157	
09743N12E31.6e	1	Baxter Healthcare Corp.	1456	685	-56	153	209
09743N22E33.6f	1	Kitchens of Sara Lee, Inc.	1350	690	2		
09744N09E24.5d	4	Wauconda	1264	792	303	348	45
09744N10E12.8a	9	Mundelein	1380	830	260	265	5
09744N10E25.1c	10	Mundelein	1421	760	-75	245	320
09744N11E10.3b	3	Countryside Manor	1040	672	167	262	95
09744N11E21.7f	11	Libertyville	1490	703	218	278	160
09744N11E28.4e	12	Libertyville	1926	700	175	275	200
09744N11E31.4h	8	Mundelein	1383	730	65		
09744N11E32.6a	6	Vernon Hills	1912	725	120	425	305
09744N11E33.3g	1	Cuneo Museum Gardens	1290	690	134	262	128
09744N11E33.5a	7	Vernon Hills	1870	685	-25	220	245
09744N12E21.8f	4	Lake Bluff#2	1804	680	346	377	31
09745N10E15.7e	6	Round Lake Beach	1287	790	350	405	55
09745N10E20.4h	7	Round Lake Beach	1250	760	264	380	126

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
LaSalle (cont'd)							
09934N03E35.4a	2	Oak Lane Subdivision	504	610		450	

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Ogle							
14124N10E24.2h	2	Comm. Ed. - Byron Station (Owner #1)	1500	875	627	627	0
14124N10E24.4h	1	Comm. Ed. - Byron Station (Owner #2)	1500	860			
14124N11E01.2b	1	Stillman Valley	300	733	696	697	1
14124N11E01.3a	2	Stillman Valley	460	747	693	693	0
14125N11E31.4e	2	Byron School District #226	250	718		668	
14125N11E31.5h	3	Byron School District #226	418	728		682	

Appendix (continued)

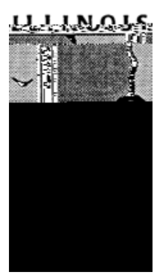
County location	*Well No.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Will (cont'd)							
19734N09E36.5e	7	Joliet Army Ammunition Plant	1649	601	246		
19734N10E07.1a	1	Liquid Carbonic Corp.	1630	620	45		
19734N10E07.5a	1	Peoples Gas SNG Plant	1581	609	49	52	3
19734N10E07.6b	2	Peoples Gas SNG Plant	1597	609	40	29	-11
19734N10E31.7a	12	Joliet Army Ammunition Plant	1709	625		244	
19734N11E17.5d	6	Manhattan	1703	685		164	
19735N09E01.3e	11	Joliet (11D, Gael Drive)	1623	619	-216	-246	-30
19735N09E09.3c	2	Shorewood	1499	605	-5	100	105
19735N09E10.3a	2	Days Inn	1556	570	-30		
19735N09E11.1b	10	Joliet (10D)	1572	610	-139	-235	-96
19735N09E25.1e	3	Caterpillar Tractor Co.	1556	547		-71	
19735N10E02.8b	4	Joliet (4D)	1608	558	-277	-162	115
19735N10E03.4e	3	Joliet Correctional Center	1600	560	-148	-150	-2
19735N10E03.5e	2	Joliet Correctional Center	1550	549	-140		
19735N10E04.2h	1	Sheffield Steel	1595	553	-42		
19735N10E07.4b	9	Joliet (9D, Campbell St)	1671	647	-206		
19735N10E09.1d	1						
19735N10E02.8b2		6h.3( )515.1(Joliet	)2727.5((4D)		)]TJ 25.7891 0	TD 0.0152	Tc 2.3107 Tw [(1608

Appendix (continued)

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Will (cont'd)							
19737N10E25.7c	4	Unocal Corp. Chicago Refinery	1480	590	-46		
19737N10E29.7h	10	Romeoville	1505	640		8	
19737N10E33.1h	2	Romeoville	1520	640	-152	-29	123
19737N10E35.3c	1	Unocal Corp. Chicago Refinery	1460	585	-168		
19737N10E35.3c	2	Unocal Corp. Chicago Refinery	1460	585	-183		
Winnebago							
20143N01E03.7a	34	Rockford	1485	740		661	
20143N02E04.3a	43	Rockford	1500	812		597	
20143N02E17.7h	36	Rockford (Unit Well 36)	1505	864	558	585	27
20144N01E02.3b	3	Rockford (Unit Well 3)	1127	760	635	661	26
20144N01E09.1c	20	Rockford (Unit Well 20)	1200	735	615		
20144N01E11.1d	1	Essex International Inc.	1150	740	685		
20144N01E12.6b	1	Ingersoll Milling Machine Co.	729	746	663	662	-1
20144N01E14.5h	37	Rockford	1434	740		657	
20144N01E15.3c	1	Dean Foods Co.	1125	725	643	688	45
20144N01E17.2d	22	Rockford (Unit Well 22)	1381	760	633	625	-8
20144N01E20.7f	21	Rockford (Unit Well 21)	1205	820	648	650	2
20144N01E21.1e	15	Rockford (Unit Well 15)	1355	810	594	623	29
20144N01E23.6d	801	Rockford (Beattie Pk/Obs Well)	1300	708	686	693	7
20144N01E27.1e	2	Reed Chatwood, Inc.	450	705	665	690	25
20144N01E28.5c	18	Rockford (Unit Well 18)	1380	820	634	649	15
20144N01E33.8f	1	Muller Pinehurst Dairy	482	760	726	727	1
20144N01E33.8f	2	Muller Pinehurst Dairy	465	759	720		
20144N01E34.6h	4	Rockford (Unit Well 4)	1219	730	647	665	18
20144N02E03.4c	30	Rockford (Unit Well 30)	1325	905	578	568	-10
20144N02E07.7e	1	Woodward Governor Co.	1227	725	700	659	-41
20144N02E07.7e	2	Woodward Governor Co.	732	725		637	
20144N02E08.2g	29	Rockford (Unit Well 29)	1357	845	597	576	-21
20144N02E09.3a	25	Rockford (Unit Well 25)	1290	878	610	583	-27
20144N02E11.5g	39	Rockford (Unit Well 39)	1500	890		593	
20144N02E14.5d	31	Rockford (Unit Well 31)	1505	880		579	
20144N02E16.2a	27	Rockford (Unit Well 27)	1280	840	569	554	-15
20144N02E17.6g	17	Rockford (Edgebrook #3)	1195	785		628	
20144N02E18.7a	5	Rockford (Unit Well 5)	1312	792	600	565	-35
20144N02E20.4h	13	Rockford (Unit Well 13)	1457	835	593	557	-36
20144N02E23.1a	3	Best Western Clock Tower Inn	860	818	612	591	-21
20144N02E23.1d	40	Rockford	1466	855		603	
20144N02E25.7g	1	Rockford Park District	1185	793	598	613	15
20144N02E28.5h	26	Rockford (Unit Well 26)	1326	835	632	620	-12
20144N02E29.3a	10	Rockford (Unit Well 10)	1426	865	588	576	-12

Appendix (concluded)

County location	*Well no.*	*Owner*	*Depth ft.*	*Surface elev.*	*Water-level Elevation 1991*	*Water-level elevation 1995*	*Water-level changes, ft. 1991-1995*
Winnebago (cont'd)							
20146N02E18.8a	2	Woodward Governor C. - Air	600	765		703	
20146N02E19.7g	7	Rockton	594	753		628	
20146N02E28.1b	6	North Park Public Water Dist.	780	750	686	686	0
20146N02E29.1b	7	North Park Public Water Dist.	780	750	638	681	43


ILLINOIS