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REDUCTION OF 1987 WATER YEAR PRECIPITATION DATA FOR LAKE MICHIGAN DIVERSION ACCOUNTING

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Prepared for the
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FINAL REPORT

to

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INTRODUCTION

The volume of water diverted from Lake Michigan into the State of Illinois is monitored to ensure that the diversion does not exceed a limit of 3,200 cfs as imposed by the U.S. Supreme Court Order of 1967 (Pavia, 1979). An important component of the monitoring procedure is the accurate representation of the precipitation which falls over Chicago/Cook County and parts of northeastern Illinois. The precipitation patterns over the Chicago area during the 1983-1986 Water Years (1 October through 30 September) were unusual compared to previous climatic studies of Chicago-area precipitation (Changnon, 1961; Changnon, 1968; Huff and Changnon, 1973; Vogel, 1988, 1989, 1990). This was due to Water Year totals at a number of the stations being unusually low as compared to others in the Chicago area and northeastern Illinois. Inspection of these sites (Vogel, 1988) revealed that the unusual patterns were caused by 1) inadequate raingage exposure and 2) differing observing, data reduction, and quality control practices utilized by the groups responsible for gathering the data. Vogel (1988) had established that unusual distributions of precipitation began to occur in 1967, with precipitation amounts decreasing markedly at some of the sites in the area, corresponding

with the aforementioned problems noted in the data collection networks. The 1987 Water Year (1 October 1986 through 30 September 1987) again exhibited an unusual precipitation pattern. Figure 1 shows the raw, uncorrected pattern for this Water Year. It indicates very low precipitation amounts in portions of the northern and southern Cook County region, with general maxima in the north central and extreme southern sections of the area.

High-quality precipitation amounts, on an hourly basis, are vital for the accounting procedure used by the Northeastern Illinois Planning Commission (NIPC) and the Chicago District of the U.S. Army Corps of Engineers (COE) for monitoring Lake Michigan water diversion. Thus, a procedure was devised (Vogel, 1988) to correct the questionable precipitation data and make it suitable for use in the accounting procedure. This procedure, described later, was used here to correct data collected during the 1987 Water Year. Cumulative corrections at each station and a modified spatial precipitation pattern for the Water Year are presented.

RAINGAGES AND DATA

Thirteen raingages (Table 1) are used to evaluate precipitation in the Lake Michigan diversion accounting procedure. All except for Park Forest are recording devices which provide hourly amounts. These particular raingages are managed by three different organizations; 1) the National Weather Service (NWS); 2) the City of Chicago (CC); and 3) the Metropolitan Water Reclamation

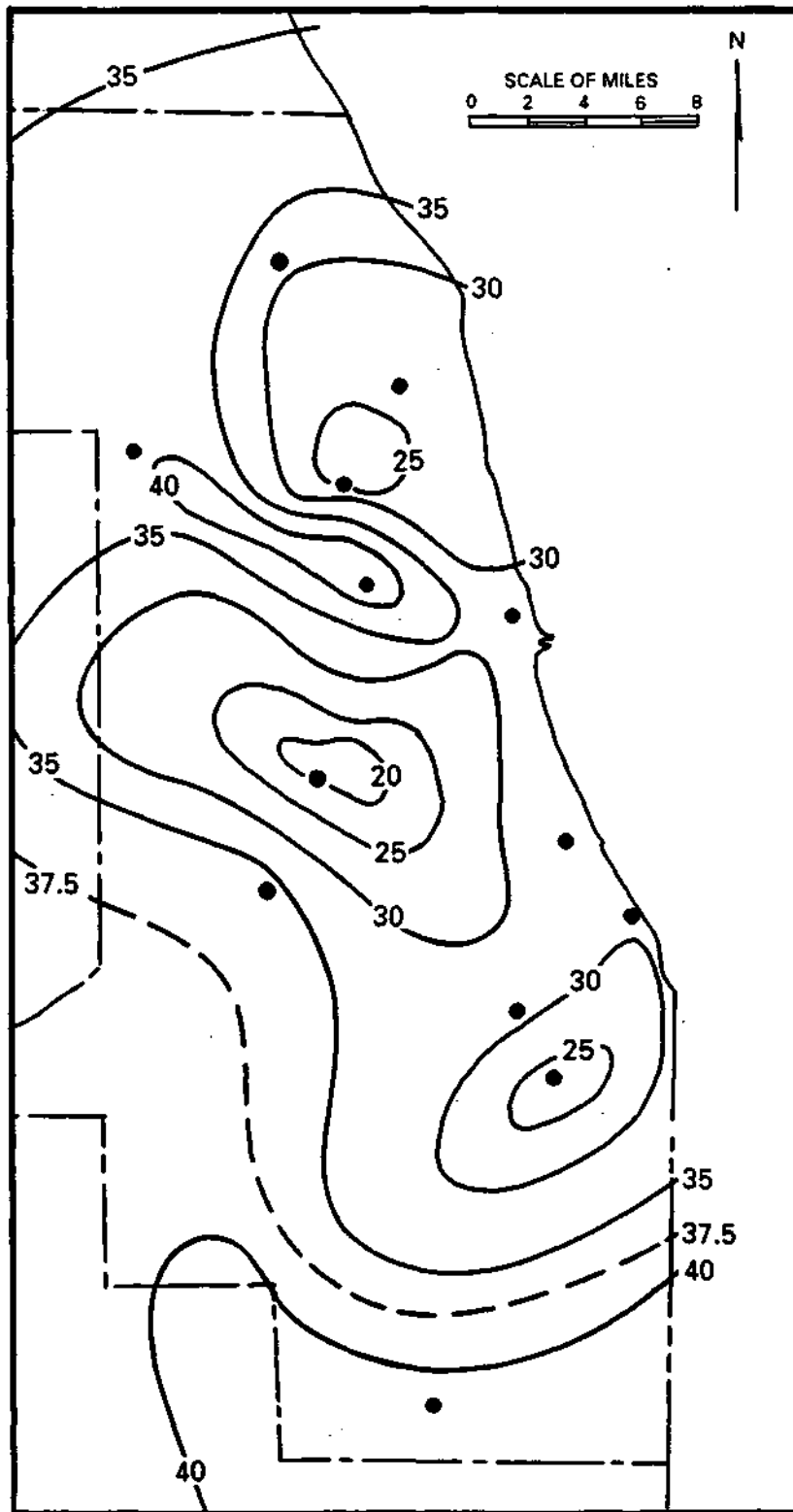


Figure 1. 1987 Water Year precipitation pattern (inches) from original records. Dots indicate rain gauge sites.

Table 1. Raingage locations in Cook County and northeastern Illinois.	
Raingages Used in Accounting Procedure	
Glenview (MWRD)	South WPP (CC)
Skokie Northside STP (MWRD)	Roseland WPP (CC)
MWRD Office (MWRD)	Chicago O'Hare Airport (NWS)
West Southwest STP (MWRD)	Chicago University (NWS)
Calumet STP (MWRD)	Midway 3 SW (NWS)
Mayfair WPP (CC)	Park Forest (NWS)
Springfield WPP (CC)	
Additional Raingages Used in Analysis	
Antioch (NWS)	Jardine WPP (CC)
Waukegan (NWS)	Wheaton (NWS)
McHenry (NWS)	Aurora (NWS)
Marengo (NWS)	Joliet/Brandon Road Dam (NWS)
Barrington (NWS)	Channahon/Dresden Island (NWS)
Chicago Botanical Garden (NWS)	Peotone (NWS)
Elgin (NWS)	
MWRD = Metropolitan Water Reclamation District	
CC = City of Chicago	
NWS = National Weather Service	
STP = Sewage Treatment Plant	
WPP = Water Purification Plant	

District of Greater Chicago (MWRD). Three different recording raingage types are used, while the Park Forest site (NWS) is a standard 8-inch non-recording device. The NWS raingages at Chicago O'Hare Airport and the University of Chicago are of the weighing-bucket type, while that at Midway 3 SW is a Fischer-Porter, measuring only to the nearest one-tenth of an inch (the weighing-bucket type measure to the nearest one-hundredth). The remainder of the gages, operated by CC and MWRD, are of the tipping-bucket type. The spatial distribution of these raingages is given in Figure 2.

Hourly precipitation data from NWS raingages for the 1987 Water Year were obtained from Hourly Precipitation Data, Illinois, published by the National Climatic Data Center (NCDC). Daily precipitation for Park Forest and for the other daily NWS sites used in the analysis (Table 1) were acquired from Climatological Data, Illinois, also published by NCDC. Hourly precipitation values for the MWRD and CC raingages were provided by NIPC. It should be noted here that some data from the 1987 Water Year were missing. The gage at West Southwest STP was out-of-service from 1 July 1987 through 30 September 1987; Mayfair WPP was down from 1 August 1987 through 31 August 1987; Glenview was out-of-order 15 September 1987 through 22 September 1987; Skokie Northside STP was missing on 14 August 1987; and, Chicago University was down 29 June 1987 through 30 June 1987. In addition to correcting questionable data, the procedure used here replaces missing values with estimates using available surrounding information.

To generate spatial patterns, the hourly data at Jardine WPP

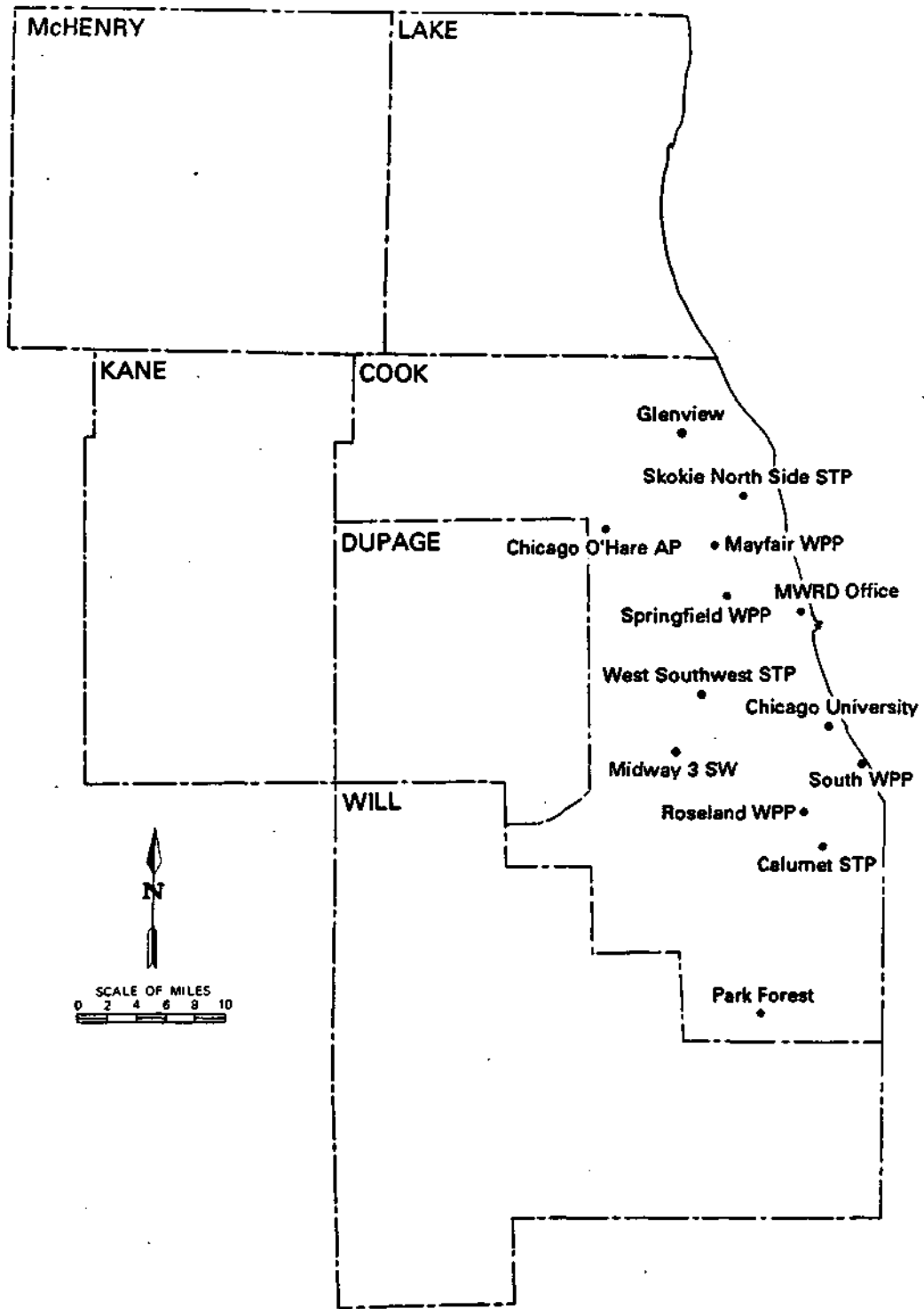


Figure 2. Raingage sites used by the accounting procedure.

(CC) and the daily data at the NWS sites in northeastern Illinois (Table 1) were utilized in addition to the thirteen stations used for water diversion purposes. All stations are shown in Figure 3.

EVALUATION OF PRECIPITATION DATA FOR THE 1987 WATER YEAR

Hourly precipitation data for each of the recording (hourly) raingages were organized chronologically with stations as the columns and year/month/day/hour as the rows. This data matrix was used to first check for possible time inconsistencies, and then for dividing the data into storm periods. For this study and its predecessors, a storm was defined as a rain period separated from preceding and succeeding precipitation by six hours or more at all stations. This definition was used successfully by Huff (1967) for an area of similar dimensions in central Illinois, by Vogel (1986) for defining extreme storm events in the Chicago area, and by Vogel (1988, 1989, 1990) for defining storms for the 1984-1986 Water Years.

Overall, 107 individual storms were defined for the 1987 Water Year. These were then plotted using all available data, and isohyetal patterns were drawn for each. The NWS sites were given the most weight when defining isohyetal patterns, because of the exposure problems previously noted for the MWRD and CC sites (see Vogel, 1988, for a complete description of the problems at these raingage sites). After a generalized precipitation pattern was obtained for each storm, a corrected storm total was estimated at

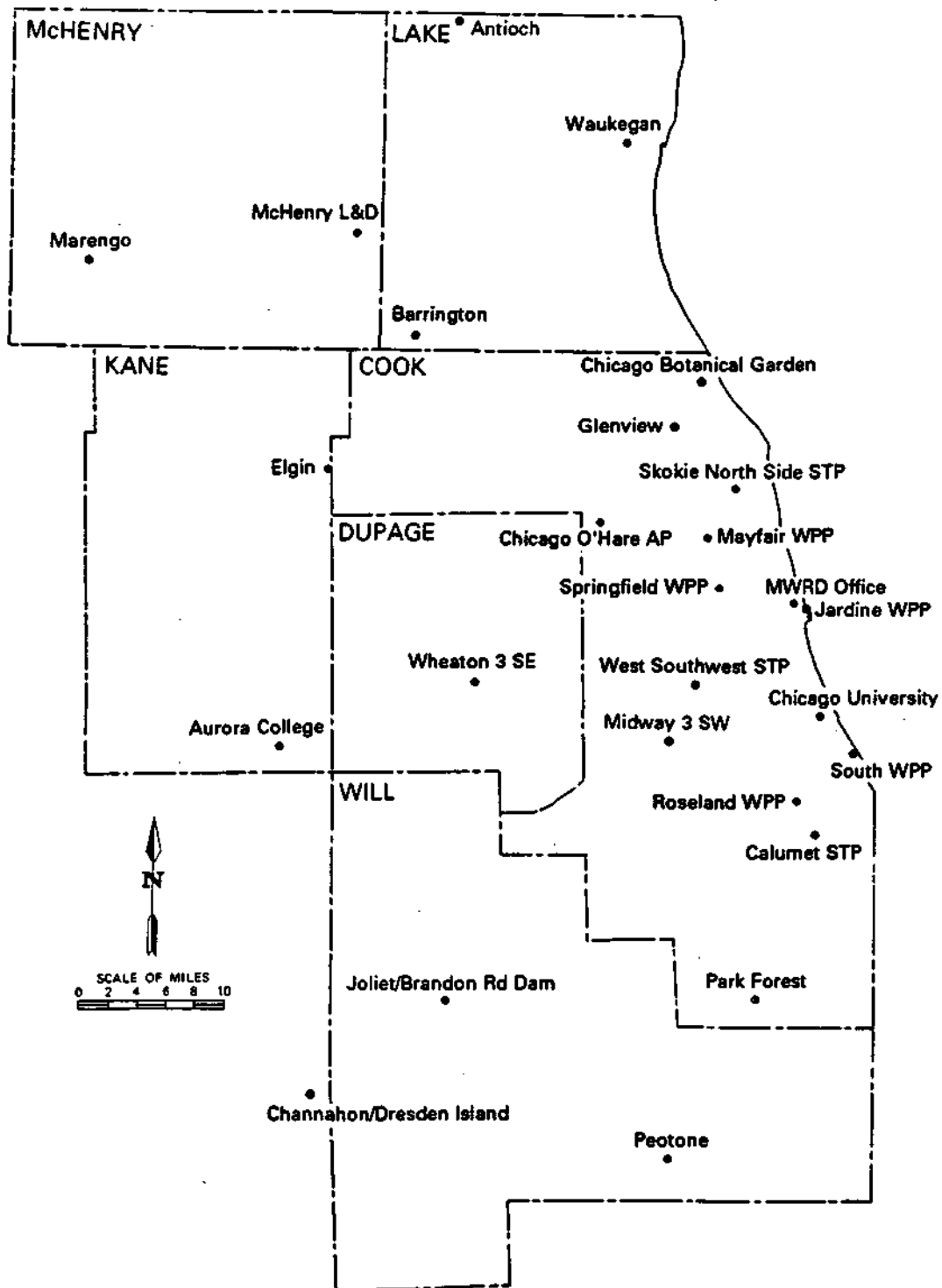


Figure 3. Raingage sites used in northeastern Illinois.

each site deemed questionable for that storm by using the isohyetal pattern. The corrected storm totals were then distributed into hourly values using the existing hourly percentage breakdown of the uncorrected precipitation at the sites in question. The hourly breakdown at the nearest neighboring station was used instead in those cases where missing data were replaced.

For the 1987 Water Year, the largest cumulative storm correction (Table 2 and Figure 4) occurred at Mayfair WPP (19.74 inches) in the north central part of the Chicago region. The large increase is partially explained by the fact that data at this site were missing for August 1987, which was a very wet month. The second-highest correction was at West Southwest STP (19.25 inches) in the western portion of the region. This correction is substantially due to the site being inoperative during all of July-September 1987. Corrections during this period were made to closely follow the nearby Midway 3 SW site. Two other large corrections occurred at Skokie Northside STP (17.51 inches), which was missing data on one day, and at Calumet STP (16.44 inches), a site which has consistently underestimated precipitation during all recent Water Years (e.g., Vogel, 1988, 1989). Other corrections of note occurred at the MWRD Office site (7.15 inches) and at Glenview (7.00 inches). All other corrections were 5.17 inches (Roseland WPP) or less. A few corrections were made at three of the four NWS raingages (Chicago O'Hare excluded). Chicago University and Midway 3 SW appeared to be low on a few occasions, while Park Forest was modified slightly. These adjustments were the smallest except for Springfield WPP, a reliable station which was lowered slightly.

Table 2. Cumulative corrections and percent changes for the gages used in the accounting procedure for the 1987 Water Year

Raingage Site	Cumulative Correction (inches)	Percent Change
Glenview	+7.00	+18.1
Skokie NorthsideSTP	+17.51	+40.7
MWRD Office	+7.15	+18.4
West Southwest STP	+19.25	+49.7
Calumet STP	+16.44	+43.4
Mayfair WPP	+19.74	+45.0
Springfield WPP	-0.39	-0.9
South WPP	+4.17	+11.3
Roseland WPP	+5.17	+13.4
Chicago O'Hare	0.00	0.0
Chicago University	+1.61	+4.5
Midway 3 SW	+3.67	+9.4
Park Forest	+0.68	+1.5

Figure 5 is a companion to Figure 4 and shows the corrections on a percentage change basis. The pattern is similar, with the largest percentage changes at West Southwest STP (49.7 %), Mayfair WPP (45.0%), Calumet STP (43.4%), and Skokie Northside STP (40.7%). All others were 18 percent or less. Considering both of these figures and Table 2, the results are not necessarily consistent with those found for the other Water Years due to the preponderance of missing data during wet periods (e.g., August 1987) at some sites. Also, Mayfair WPP and Skokie Northside STP were adjusted upward so as to better fit the patterns established by Chicago O'Hare and Springfield WPP, both of which have been considered

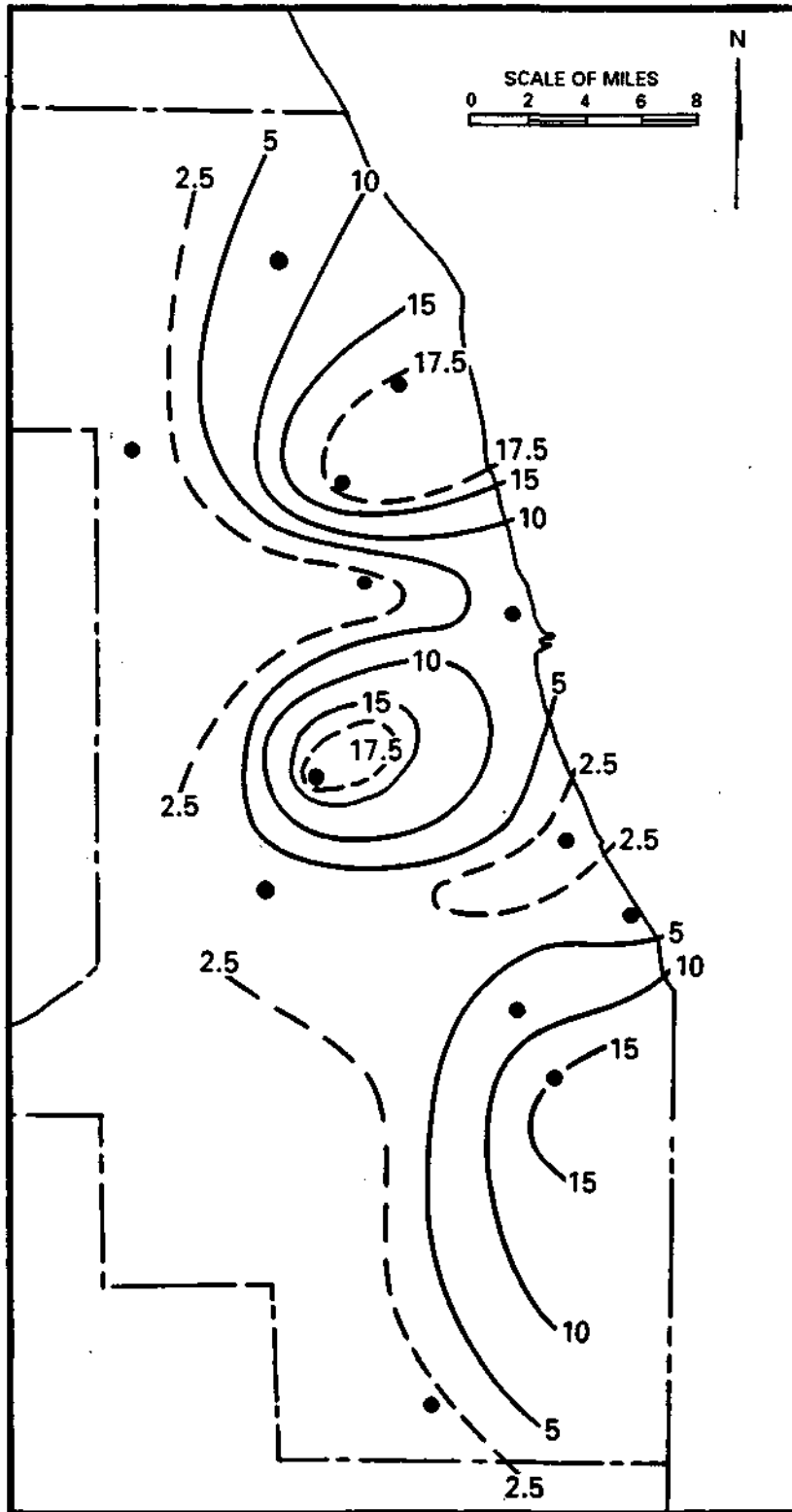


Figure 4. Cumulative storm corrections (inches) for the 1987 Water Year.

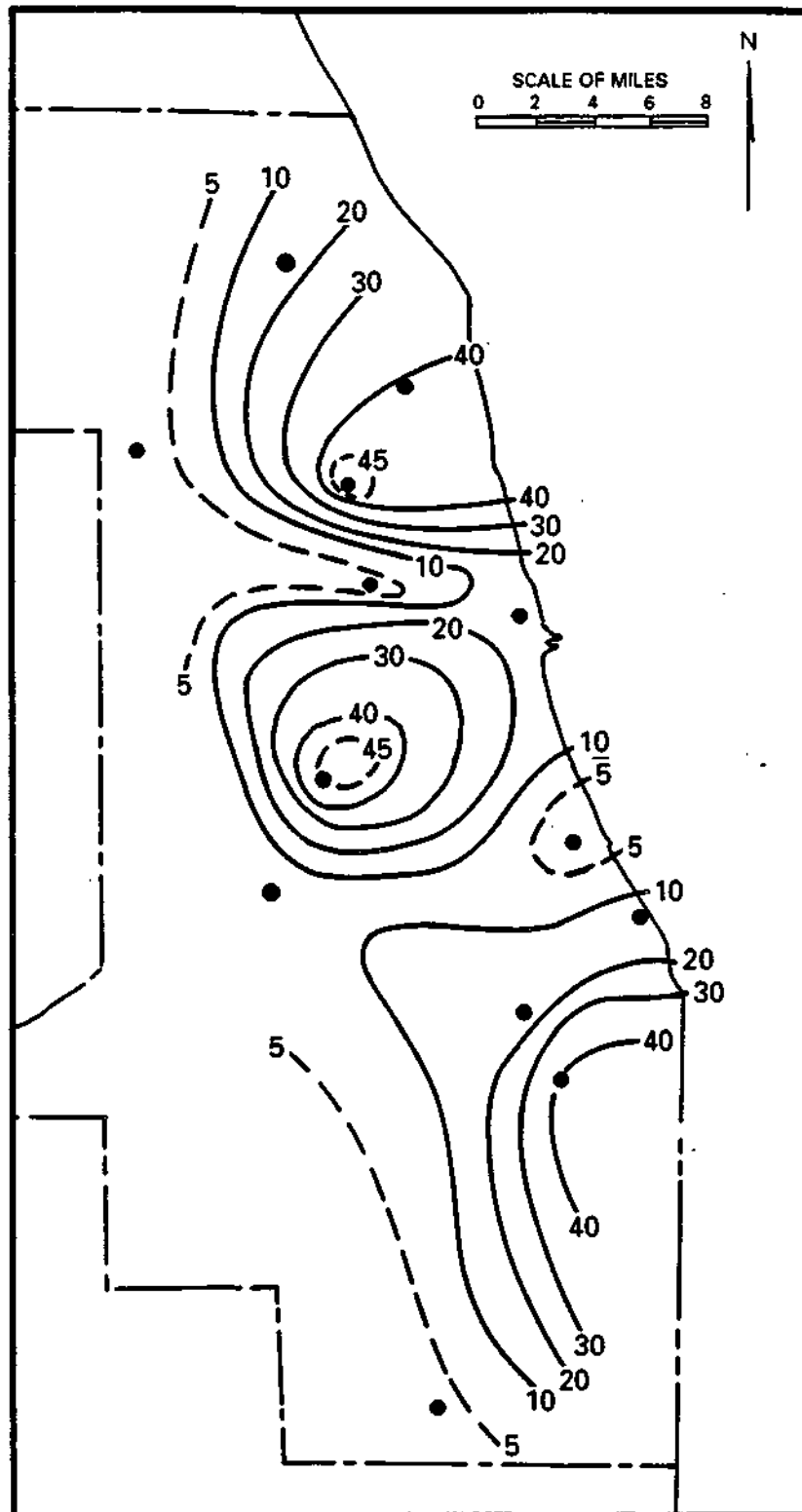


Figure 5. Percentage change of precipitation from original 1987 Water Year records.

reliable sites in past Water Years.

The final, adjusted 1987 Water Year pattern for the Chicago area is given in Figure 6a, with the new, general pattern for northeastern Illinois given in Figure 6b. Two general maxima now exist, one over the southern portion of the region dominated by Park Forest, and the second in the north central area stretching from southwest of Springfield WPP to Skokie Northside STP. General minima are now found along the southern Lake Michigan shoreline, spreading westward, and over the northernmost portion of the region.

SUMMARY

Data from raingages used in an accounting procedure for Lake Michigan water diversion into Illinois were analyzed for the 1987 Water Year (1 October 1986 through 30 September 1987). As was the case for the 1984-1986 Water Years, some of the raingages were found to have underestimated the precipitation which fell. Using a procedure devised by Vogel (1988) for the 1984 Water Year, adjustments were made to the original data and corrected patterns were developed. Also, estimates were made at those sites where data were missing during the water year. The adjusted data have been provided to the Northeastern Illinois Planning Commission in both floppy disk and hard copy formats.

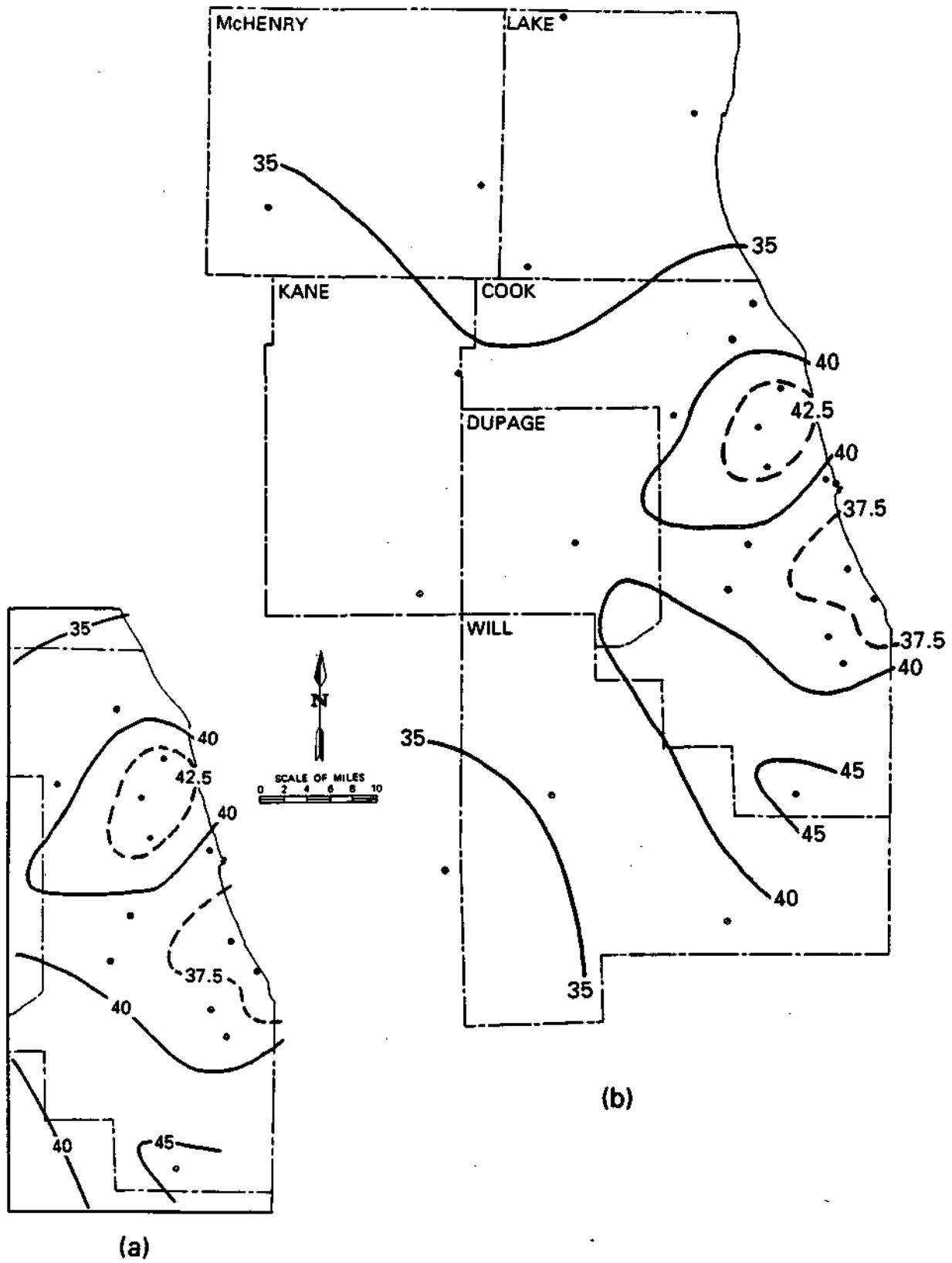


Figure 6. a) Revised 1987 Water Year precipitation pattern (inches).
 b) Revised pattern for northeastern Illinois (inches).

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