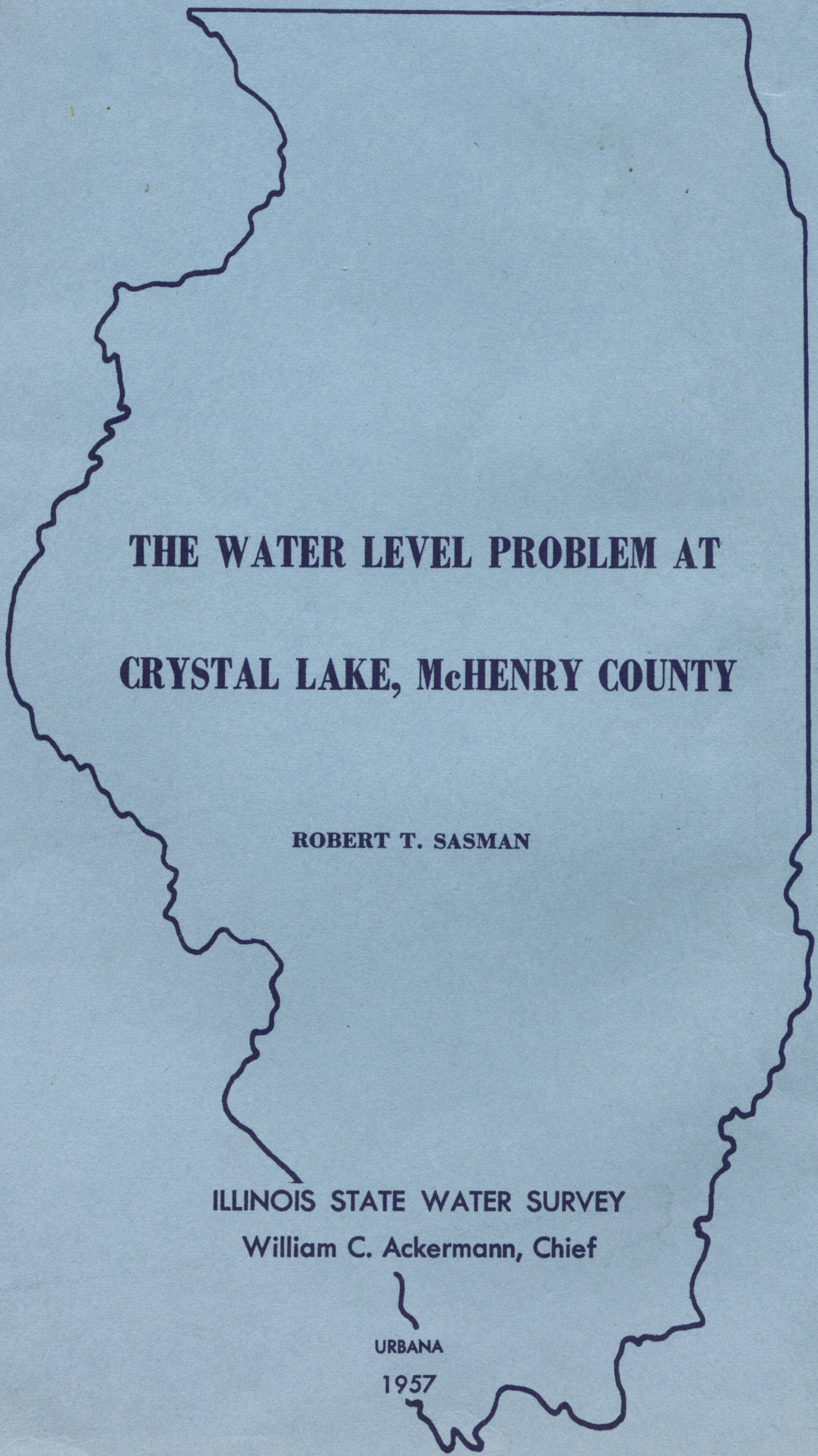
REPORT OF INVESTIGATION 32
STATE OF ILLINOIS
William G. Stratton, Governor
DEPARTMENT OF REGISTRATION AND EDUCATION
Vera M. Binks, Director



THE WATER LEVEL PROBLEM AT CRYSTAL LAKE, McHENRY COUNTY

ROBERT T. SASMAN

ILLINOIS STATE WATER SURVEY
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114

THE WATER LEVEL PROBLEM AT CRYSTAL LAKE, MC HENRY COUNTY

BY

ROBERT T. SASMAN

SUMMARY

The report discusses a number of factors which apparently contribute to excessive fluctuations of the level of Crystal Lake, McHenry County, Illinois. Annual fluctuations of more than four feet have been recorded, with an average of approximately two and one-half feet during the past sixteen years.

Crystal Lake is located in southeastern McHenry County in northern Illinois. It is bordered on the east and south shores by the City of Crystal Lake and the Village of Lakewood, respectively. The unincorporated communities of North Shore and Crystal Vista border the north and west shores, respectively. The unincorporated community of Crystal Gardens is adjacent to Crystal Vista and is an integral part of the area.

The lake has a surface area of approximately 234 acres at spillway crest elevation and has an indefinite watershed area of approximately 4.8 square miles.

Crystal Lake is connected to the shallow ground-water aquifer in the West Chicago and Marseilles Outwash deposits of the glacial drift. Because the lake is associated with this aquifer, it is directly affected by shallow ground-water movement through the area and by precipitation and evapotranspiration from the lake surface as well as from the surrounding land. Other factors which may have some effect on the lake level are storm sewers, sanitary sewers, and municipal and domestic pumpage in adjacent communities. Records obtained in this area show that periods of low lake levels are generally accompanied by precipitation deficiencies and low ground-water levels. Annual evapotranspiration losses may exceed two feet.

The eventual development of a satisfactory method of reducing evaporation might be one method of maintaining a more stable lake level. Other measures to stabilize the lake level might be: (1) adequate drainage into the lake of some of the swampy areas in the vicinity, (2) diversion of excess flow from nearby Kishwaukee River into Crystal Lake, and (3) pumpage into the lake from wells, provided sufficient capacity can be developed.

TABLE OF CONTENTS

ILLUSTRATIONS

INTRODUCTION

SCOPE OF REPORT

Water level fluctuations at Crystal Lake of one to four feet per year and averaging approximately two and one-half feet per year have been observed since the start of systematic records in 1940. A number of early records indicate fluctuations of similar magnitude at least as far back as 1914.

As a result, numerous inquiries from local residents and civic organizations in the vicinity of Crystal Lake prompted the Department of Registration and Education to request the State Water Survey Division to conduct an investigation of the factors relating to the fluctuation of the water levels This report is a presentation of the investigation and includes a discussion of possible methods of maintaining the lake at a level most favorable to its present uses.

ACKNOWLEDGMENTS

The investigation was completed under the administration of William C. Ackermann, Chief of the Illinois State Water Survey, and under the direction of H. F. Smith, Head of the Engineering Subdivision.

The section on evaporation was prepared by W. J. Roberts of the Engineering Subdivision.

The section on geology was prepared by J. E. Hackett of the Illinois State Geological Survey. In addition, considerable geological information regarding the area was received from Mr. Hackett as well as from Dr. G. B. Maxey, Head of the Subdivision of Ground-Water Geology and Geophysical Exploration of the State Geological Survey.

The investigation was started under the direction of H. E. Hudson, Jr., former Head of the Engineering Subdivision, and the early collection and analysis of data was performed by Mr. Hudson and F. X. Bushman, formerly of the Engineering Subdivision.

Other members of the Survey staff, past and present, aided in the collection of data used in the preparation of this report.

Mr. Fred Morgan, Superintendent of the City of Crystal Lake Park District, has been responsible for the collection of data regarding lake levels and precipitation since 1940.

The firm of Baxter and Woodman, Civil and Sanitary Engineers, Crystal Lake, Illinois, collected much of the data regarding ground-water levels in the area between 1950 and 1954.

Since 1954, E. J. O'Neil has been responsible for the collection of the data. In addition Mr. O'Neil and O. L. Beber, Members of the Village Board, Lakewood, Illinois have aided considerably in field investigations and collection of basic data.

The assistance of the Lake Preservation Council, Inc., of Crystal Lake in supplying data and constructive suggestions during the final preparation of this report is also gratefully acknowledged.

Acknowledgment is also made to the industries in the area which have their own ground-water supplies, the municipal officials of Crystal Lake and Lakewood, the Crystal Lake Herald, well drillers and well owners, who have been very helpful in supplying technical and historical data.

DESCRIPTION OF AREA

LOCATION

Crystal Lake is located in southeastern McHenry County, in northeastern Illinois (Fig. 1). The lake covers parts of Section 1, Township 43 North, Range 7 East and Section 6, Township 43 North, Range 8 East, Third Principal Meridian (Fig. 2). The City of Crystal Lake adjoins the lake to the east and northeast; the Village of Lakewood adjoins the lake along the south shore. Approximately 430 residences are located in the unincorporated communities of North Shore, Crystal Vista and Crystal Gardens. North Shore and Crystal Vista border the north and west shores of the lake, respectively. Although Crystal Gardens does not border the lake, it is contiguous to Crystal Vista and an integral part of the area under consideration.

WATERSHED

Much of the land in the vicinity of the lake is low and swampy, making it difficult to define definite boundaries of the watershed. Some of these swampy areas may also discharge partially into other drainage systems. As estimated from United States Geological Survey topographic maps and outlined in Figure 2, the watershed of the lake is approximately 4.8 square miles.

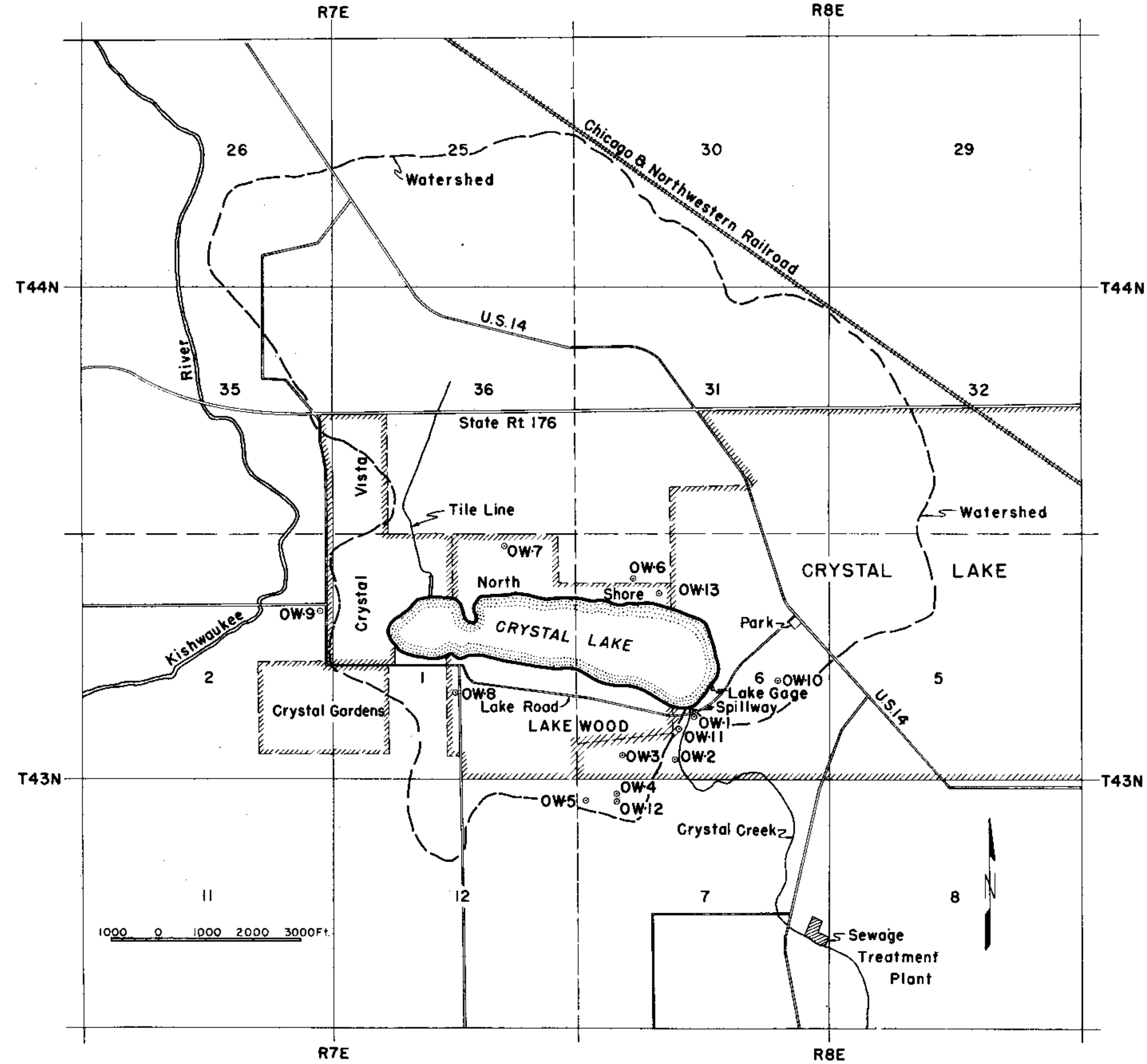

FIGURE 2 CRYSTAL LAKE WATERSHED

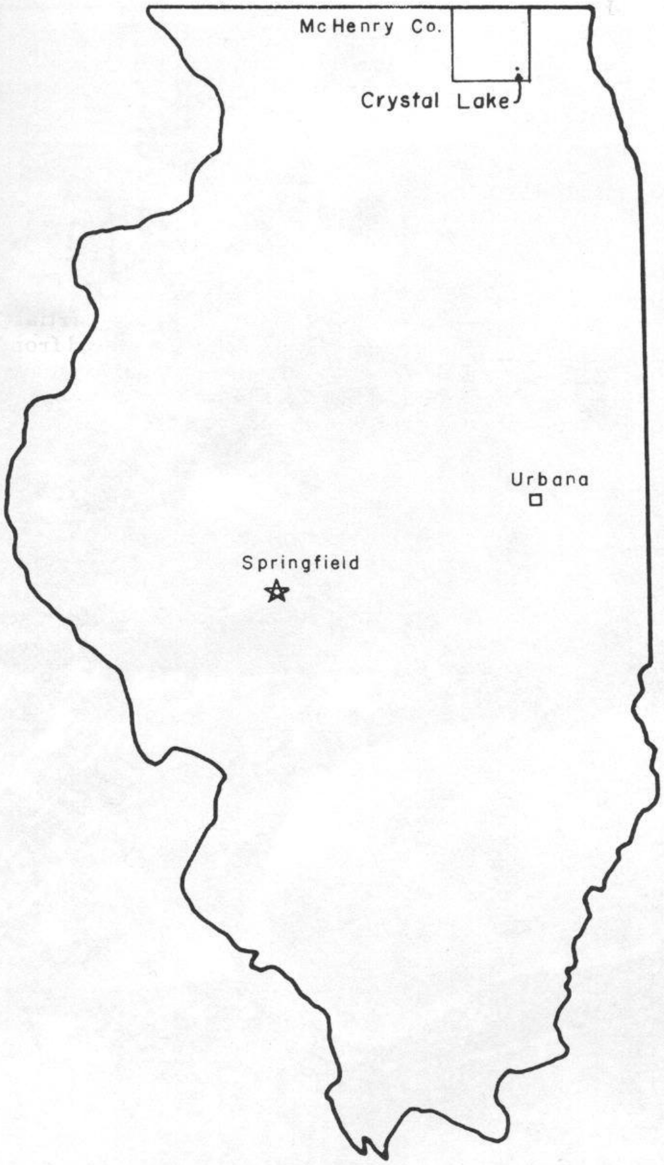

FIGURE 1
MAP OF ILLINOIS, SHOWING CRYSTAL LAKE AND MC HENRY COUNTY

The land surrounding the lake is comparatively flat, with an elevation of approximately 895 feet mean sea level at Lakewood and 900 feet at the City of Crystal Lake. There is no more than approximately 10 feet difference in elevation within a half mile of the lake. In general, the land is higher to the north than to the south of the lake.

The only identifiable tributary entering the lake is an unnamed ditch near the northwest corner. This ditch carries practically no surface runoff, but serves as an outlet for a tile system (Fig. 3) which drains a considerable area north of the lake. On August 3, 1949, the flow from the tile was calculated to be 1,230,000 gallons per day. The flow undoubtedly varies considerably and sufficient records have not been kept to determine an average flow.

FIGURE 3
TILE OUTLET NEAR NORTHWEST SHORE OF CRYSTAL LAKE

The only surface drainage into the lake is from the area immediately adjacent to the shoreline and from a few small ditches.

Surface discharge from the lake is by Crystal Creek, which starts at the spillway, near the southeast corner of the lake. The creek flows generally in a southeasterly direction about five miles to its junction with the Fox River, downstream from the Algonquin Dam in McHenry County.

The Kishwaukee River, rising to the northwest of the lake, flows southward to within about one-half mile of Crystal Lake and then turns westward. At its closest course to the lake, the river is actually only a small stream and is reported to go dry during periods of deficient precipitation.

CRYSTAL LAKE

The lake is oblong in shape and is approximately 1500 feet wide by 6800 feet long. A small peninsula is located on the north shore near the west end of the lake. The rest of the shoreline is generally smooth and regular.

The surface area of the lake varies considerably with the water level, covering about 234 acres at spillway crest elevation. This measurement was determined by means of an aerial photograph of Crystal Lake, dated 1954, and furnished by the United States Department of Agriculture (Fig. 4). A previous report[(1)] indicated an area of 249.8 acres in 1837 and 237.3 acres in 1911.

As reported by the Illinois Division of Waterways in 1950[(2)], maximum depth of the lake was 42 feet below spillway crest elevation (Fig. 5). The average depth of the main body of the lake is about 25 feet. Much of the area at the east and west ends of the lake has a depth of less than 10 feet. It can be noted that the slope of the bottom of the lake increases considerably with depth, especially below a depth of about 10 feet. It should also be noted that a lowering of the lake level of less than 10 feet results in considerable exposed shoreline (Figs. 6 and 7).

FIGURE 4

AERIAL VIEW OF CRYSTAL LAKE AND VICINITY

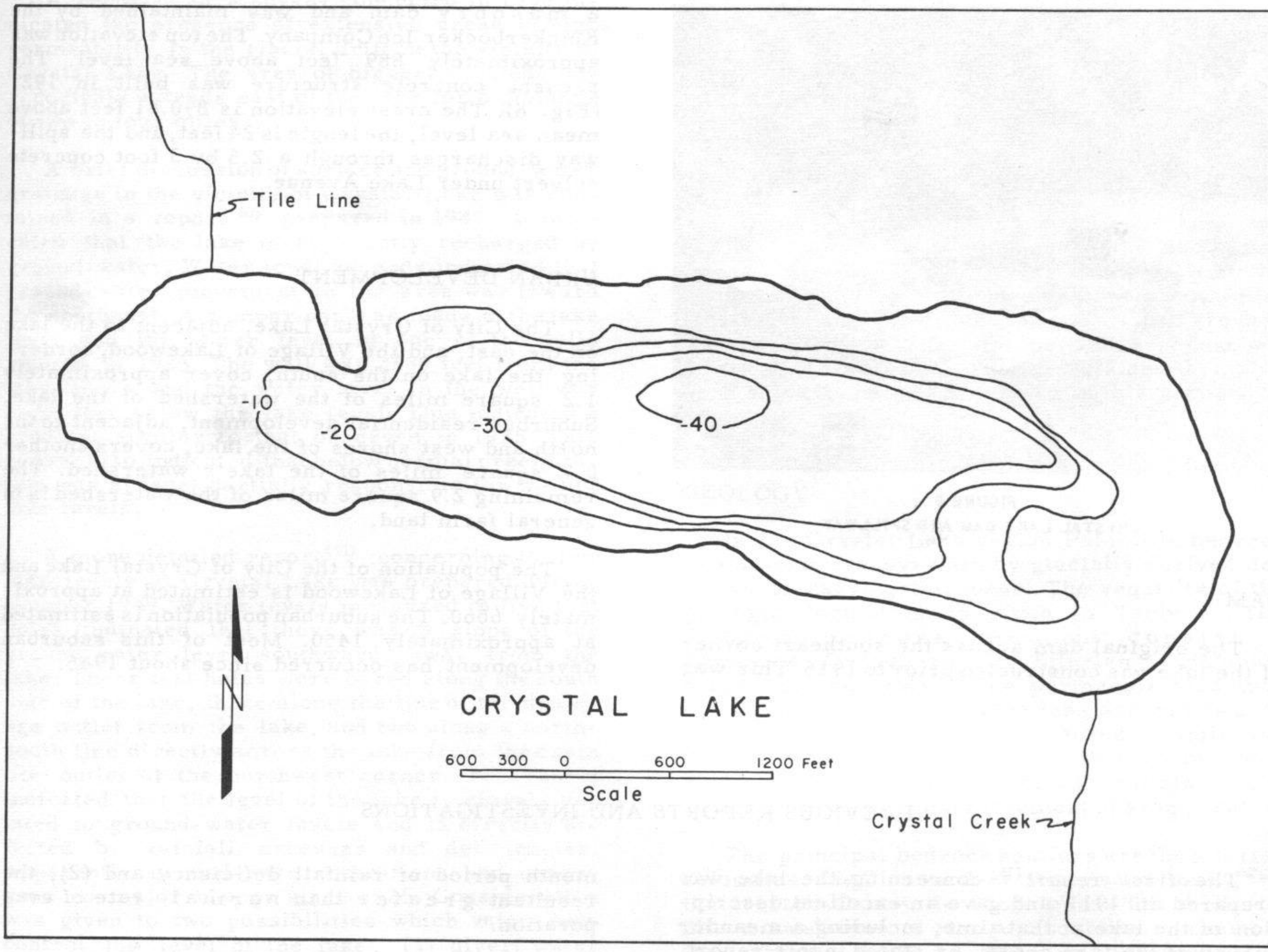

FIGURE 5
DEPTH CONTOUR MAP OF CRYSTAL LAKE

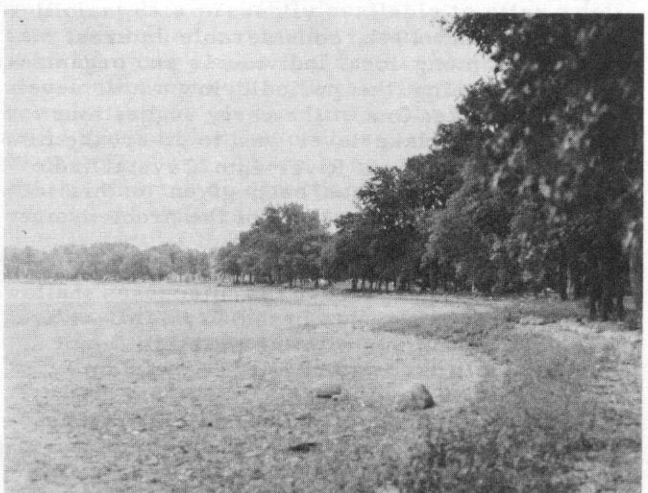

FIGURE 6
SOUTHEAST SHORE OF CRYSTAL LAKE, JULY 25, 1956

FIGURE 7
SOUTH SHORE OF CRYSTAL LAKE, JULY 25, 1956

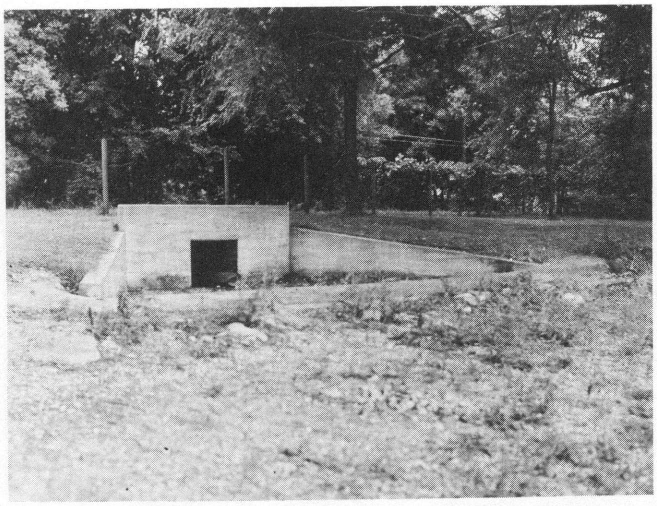

FIGURE 8
CRYSTAL LAKE DAM AND SPILLWAY

DAM

The original dam across the southeast corner of the lake was constructed prior to 1915. This was a masonry dam and was maintained by the Knickerbocker Ice Company. The top elevation was approximately 889 feet above sea level. The present concrete structure was built in 1921 (Fig. 8). The crest elevation is 890.81 feet above mean sea level, the length is 24 feet, and the spillway discharges through a 2.5 by 3 foot concrete culvert under Lake Avenue.

URBAN DEVELOPMENT

The City of Crystal Lake, adjacent to the lake on the east, and the Village of Lakewood, bordering the lake on the south, cover approximately 1.2 square miles of the watershed of the lake. Suburban residential development, adjacent to the north and west shores of the lake, covers another 0.7 square miles of the lake's watershed. The remaining 2.9 square miles of the watershed is in general farm land.

The population of the City of Crystal Lake and the Village of Lakewood is estimated at approximately 6660. The suburban population is estimated at approximately 1450. Most of this suburban development has occurred since about 1945.

PREVIOUS REPORTS AND INVESTIGATIONS

The first report(1) concerning the lake was prepared in 1911 and gave an excellent description of the lake at that time, including a meander survey of the lake shore. As stated in this report, the original lake area was surveyed in 1837 and covered 249.8 acres. At the time of this report, the area was 237.32 acres. It can be seen from these two surveys that the area of the lake was subject to change even at those early dates.

According to this report, the peninsula which protrudes into the lake near the west end of the north shore was not there at the time of the original survey, but was there at the time of the second survey. No explanation is given for this change in the shoreline.

According to a survey(3) made in 1925, shallow ground-water levels had a downward gradient of approximately 16 feet per mile from the lake level toward the east. This survey was limited to two wells, located 280 and 2680 feet from the lake shore.

In 1935, a report(4) was prepared which included a study of shallow ground-water levels in the Crystal Lake area. Water levels were measured in at least 15 wells located west, south and east of the lake. These records indicate that ground-water movement in the area at that time was toward the southeast, somewhat parallel to the surface drainage.

A letter(5) written in 1940 stated that the chief factors contributing to low lake levels were believed to be: "(1), the past twelve- to eighteen-month period of rainfall deficiency and (2), the resultant greater than normal rate of evaporation."

Among the recommendations of this letter were the installation and operation of lake level and precipitation gages and the continued observation of the flow in the Lakewood storm sewer.

Data regarding lake levels and precipitation from gages installed soon after this letter was prepared are discussed elsewhere in this report.

In 1940 and 1941, considerable interest was evidenced among local individuals and organizations concerning the periodic low water levels in Crystal Lake. One of the early suggestions for controlling the lake level was to divert the flow of the Kishwaukee River into Crystal Lake.(6) Some consideration has been given to this idea in most of the investigations of the problem since 1941.

A report(7) prepared in 1947 discusses shallow ground-water resources in the Crystal Lake area and deals primarily with the possibilities of developing additional water wells in the vicinity.

Another report(8) prepared in 1947 discusses the geology of the area, with special emphasis on the glacial drift material above the bedrock in the vicinity of Crystal Lake. A bedrock surface map accompanying this report defines a bedrock valley which runs in an easterly direction across the southern end of the lake and the City of Crystal Lake.

A report[9] of a survey conducted in 1948 indicated the presence of extensive areas of high permeability in the glacial drift in the vicinity of Crystal Lake. The area of highest permeability reportedly extends east of the lake for a distance of two to four miles.

A brief discussion of surface and ground-water drainage in the vicinity of Crystal Lake was contained in a report[10] prepared in 1949. It indicated that the lake is apparently recharged by ground-water. Water level records indicated that ground-water movement in the area was toward the southeast. A comparison was made of the lake level and the water level in one of the wells studied in 1925. The well was 2680 feet from the lake shore and the water level in the well was eight feet below the lake level. This indicated a gradient similar to that observed in 1925. This report also indicated that below normal precipitation was at least partially responsible for the low lake levels.

A more detailed report[11] concerning the low lake levels at Crystal Lake was prepared during October 1949. Water levels measured in five test holes indicated that there was a slope of the ground-water level southward, away from the lake. These test holes were bored along the south side of the lake, three along the line of the drainage outlet from the lake, and two along a north-south line directly across the lake from the drain tile outlet at the northwest corner. The report indicated that the level of the lake is closely related to ground-water levels and is directly affected by rainfall excesses and deficiencies. Apparently ground-water conditions had undergone no major change since 1925. Consideration was given to two possibilities which might help control the level of the lake: (1) divert water from the Kishwaukee River into the lake and (2) lower the weir and maintain a lake at about elevation 888 or 88.5 feet above mean sea level.

A report[2] prepared in 1950 discussed most of the problems covered in previous reports and included considerably more detail on many of the problems. This report stated: "There is not sufficient data presently available to offer a definite conclusion as to the reasons for the fluctuation of water levels at Crystal Lake. The meager information on water levels prior to 1940 does not show definitely whether presently existing conditions are a repetition of those which have existed in earlier years. There is not definite factual data on the amount or direction of ground-water flow nor is the information on surface inflow sufficiently factual to make comparisons between past and present surface inflow. . . ."

As a result of these conclusions, it was recommended in the report that a more detailed study be made of all the problems which might have an effect on the water level in the lake.

CURRENT INVESTIGATION

The current investigation by the State Water Survey was begun in 1950 with the drilling of 13 observation wells (Fig. 2) to obtain additional data necessary to understand the problem. These data were needed to supplement the information which the Survey already had on hand from its previous investigations.[4, 7, 10, 11]

Because the fluctuation in water level of Crystal Lake appeared to be due to many complex and interrelated factors, data concerning the geology and hydrology are included in the current investigation. Various opinions have been expressed in recent years as to the cause of the fluctuation in the water level of Crystal Lake, such as the construction of sewers, development of new wells, lack of precipitation, evaporation and ground-water movement. These factors and their possible effect on the water level of Crystal Lake have also been studied and are presented in this report.

GEOLOGY

In the Crystal Lake region Paleozoic bedrock formations are overlain by glacially derived deposits of varying thickness. The sequence of the geologic formation is given in Table 1. The Paleozoic bedrock formations consist of Cambrian, Ordovician, and Silurian sandstones, dolomites and shales. The permeable sandstone and fissured dolomite formations are widely used as aquifers in northeastern Illinois while the thicker relatively impermeable shale formations, such as the Maquoketa, act as confining beds, restricting the vertical movement of ground water.

The principal bedrock aquifers are the Silurian dolomites, the Glenwood-St. Peter sandstones, and the Ironton-Galesville sandstones. The thick Mt. Simon sandstone is also a productive aquifer but the extreme depth to the formation, generally poorer mineral quality, and higher water temperature make it less desirable as a source of ground water than the more shallow bedrock aquifers.

The Pleistocene glacial drift everywhere overlies the Paleozoic bedrock in the Crystal Lake area. The thickness of glacial drift cover is variable due to the uneven nature of both the land surface and the buried bedrock surface. Drilling records show that the thickness of glacial drift in the Crystal Lake region ranges from about 120 feet to more than 270 feet. At Crystal Lake the thickness of glacial drift is estimated to be about 210 feet.

The glacial deposits have resulted from several advances and retreats of continental glaciers into the Crystal Lake region. The ice advances are recorded by deposition of glacial tills (unsorted mixtures of clays, silt, sand, gravel and boulders in various proportions) either plastered on the surface beneath the ice as the ice moved into the area or dumped as a residue as the ice wasted from the region. Meltwater from the huge ice sheets sorted the rock debris and deposited sand and gravel outwash either as widespread valley train and outwash flat deposits or as scattered discontinuous deposits closely associated with the ice. Where meltwater was ponded, fine sand, silt, and clay were deposited in the quiet water.

TABLE 1
GENERALIZED GEOLOGIC COLUMN
IN CRYSTAL LAKE AREA

SYSTEM	SERIES, GROUP OR FORMATION	THICKNESS (FT) MIN - MAX	COMPOSITION
	PLEISTOCENE	120 - 270	GLACIAL TILL AND WATER LAID SAND, GRAVEL, SILT, AND CLAY
SILURIAN	NIAGARAN	100 - 400	GRAY DOLOMITE WITH CHERTY ZONES; SOME GREEN AND RED SHALES
ORDOVICIAN	MAQUOKETA	100 - 200	GREEN TO BROWN SHALES WITH DOLOMITE BEDS
	GALENA	150 - 225	BUFF DOLOMITE, SLIGHTLY CHERTY
	PLATTEVILLE	75 - 125	GREY MOTTLED BUFF DOLOMITE
	GLENWOOD	25 - 60	SANDSTONE WITH SANDY DOLOMITE AND SHALE BEDS
	ST. PETER	175 - 275	FINE TO COARSE INCOHERENT WHITE TO PINK SANDSTONE; CHERTY AND SHALEY AT BASE
CAMBRIAN	TREMPEALEAU	0 - 75	DOLOMITE
	FRANCONIA	50 - 100	SANDSTONE, SHALE AND DOLOMITE
	IRONTON	25 - 75	INCOHERENT TO DOLOMITIC SANDSTONES WITH SOME RED AND GREEN SHALES
	GALESVILLE	100 - 150	FINE TO COARSE INCOHERENT SANDSTONE
	EAU CLAIRE	400 - 480	SANDY SHALE TO SHALEY SANDSTONE WITH DOLOMITE BEDS
	MT. SIMON	1500 - 2000	INCOHERENT SANDSTONE WITH RED AND GREEN SHALE BEDS
PRE CAMBRIAN			GRANITE AND OTHER CRYSTALLINE ROCKS

The early glacial history of the Crystal Lake region is obscure due to the removal of the evidence of the earlier ice advances by later ice advances and due to burial by glacial debris of the later advances. The late glacial history is, however, more clearly understood. The events which are of significance to the geologic setting of Crystal Lake are as follows:

During the Tazewell substage of the Wisconsin Glacial Stage the region was occupied by glacial ice which constructed a series of morainal deposits to the west. The Tazewell moraines mark lines of readvance of the ice after slight recessions and are progressively younger to the east. The last of the Tazewell ice advances, the Marseilles ice advance, built a wide morainal deposit the eastern edge of which is about 3/4 miles west of Crystal Lake (Fig. 9). During the construction of the moraine, meltwater was released westerly through channels in the ice bound area. Some of these drainage channels were on the ice surface while others were subglacial. Within these channels, sands and gravels were deposited often in direct contact with morainal ice. West of Crystal Lake, the Kishwaukee River occupies one of these morainal drainage channels in its westerly course through the hilly topography of the Marseilles moraine.

When the Marseilles ice abandoned its morainal position and by melting retreated easterly out of the Crystal Lake region, an extensive outwash plain was formed east of the Marseilles moraine and west of the melting ice front.[12]

The next glacial advance into the Crystal Lake region was during the Cary substage. Ice of the Cary glaciation overrode the outwash plain deposited by the melting of the Marseilles ice to advance into the region to about the present site of the City of Crystal Lake where it halted to

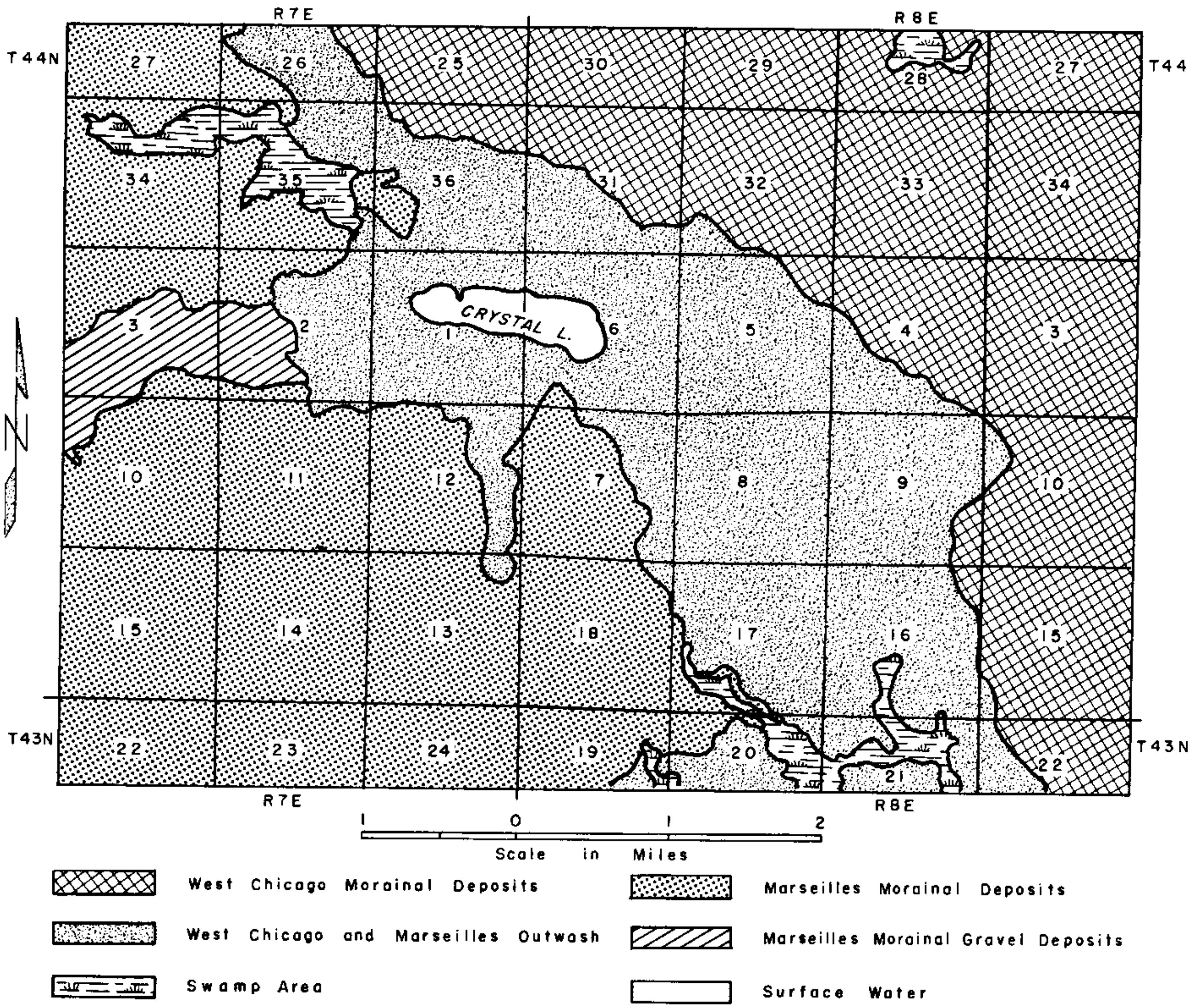

FIGURE 9 GEOLOGIC OCCURRENCE AT CRYSTAL LAKE

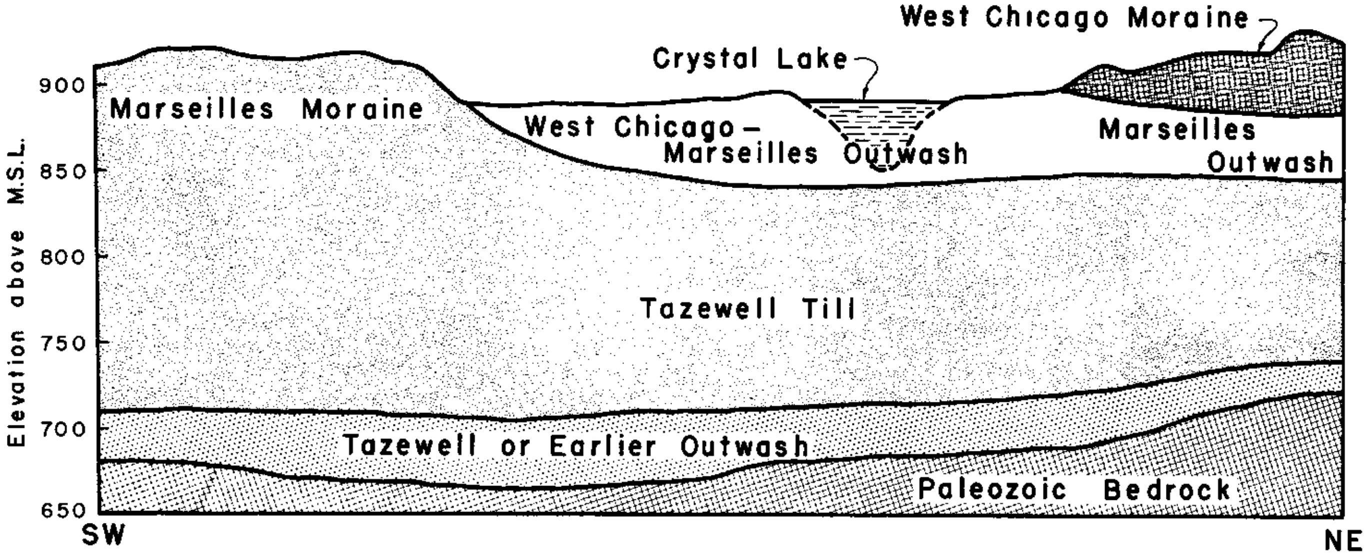

FIGURE 10 DIAGRAMMATIC CROSS SECTION OF GLACIAL DEPOSITS

build the West Chicago moraine. At its morainal position the West Chicago ice contributed outwash into the low-lying area between the ice front and the Marseilles moraine on the west. In this restricted area West Chicago outwash was deposited directly on the Marseilles outwash. With the melting of the ice from the West Chicago moraine the glacial history of the Crystal Lake area was essentially completed.

As shown in Figures 9 and 10, Crystal Lake occupies a shallow depression in the surface of the West Chicago-Marseilles outwash deposits between the Marseilles moraine on the west and the West Chicago moraine on the east. The generally permeable nature of the outwash materials constituting this outwash plain is demonstrated by the lack of development of any organized drainage system in this area. Water falling as precipitation on the outwash plain is so quickly removed by infiltration through the permeable surface materials that runoff is not sufficiently concentrated to erode drainage channels in this surface.

Drilling records of water wells in the vicinity of Crystal Lake show that the West Chicago-Marseilles outwash deposits attain a thickness of more than 60 feet. The drilling records show that the outwash materials vary locally in thickness and character of materials. Locally the outwash is thin or may consist largely of silty sand and is consequently of relatively low transmissibility. At other locations the outwash materials are thicker or may consist largely of clean coarse sand and gravel. In such areas the transmissibility of the outwash is relatively high, that is, satisfactory for the development of municipal and industrial wells.

The deeper water wells in the vicinity of Crystal Lake penetrate a thick section of low permeable glacial till underlying the West Chicago-Marseilles outwash. The glacial till deposits locally exceed a thickness of 150 feet and were probably largely deposited as a result of the Tazewell glaciation. Between the glacial till and the surface of the underlying Paleozoic bedrock, widespread deposits of Tazewell or earlier glacial outwash are commonly present. These basal outwash deposits are the source of ground water for the deep sand and gravel wells in the vicinity of Crystal Lake.

The geologic conditions described above allow for certain interpretation of hydrologic relationships in the Crystal Lake area. The lack of natural surface drainage into Crystal Lake and the position of the lake completely within the permeable West Chicago-Marseilles outwash deposit require that the lake level be maintained by ground water under water-table conditions. The thick deposit of relatively impermeable Tazewell glacial till which underlies the West Chicago-Marseilles outwash restricts the movement of ground water between this aquifer and the deeper Tazewell or earlier outwash (Fig. 10) and bedrock aquifers. The thick glacial till of low permeability forms a relatively impermeable barrier through which ground-water movement is probably so slow that for all practical purposes the upper aquifer functions as an independent unit. Consideration of all known geologic factors indicates that hydrologic connection is to be expected between the sand and gravel aquifer beneath the till and the bedrock aquifers which immediately underlie it. The deeper bedrock aquifers are overlain by the relatively impermeable Maquoketa shale and constitute a third hydrologic unit.

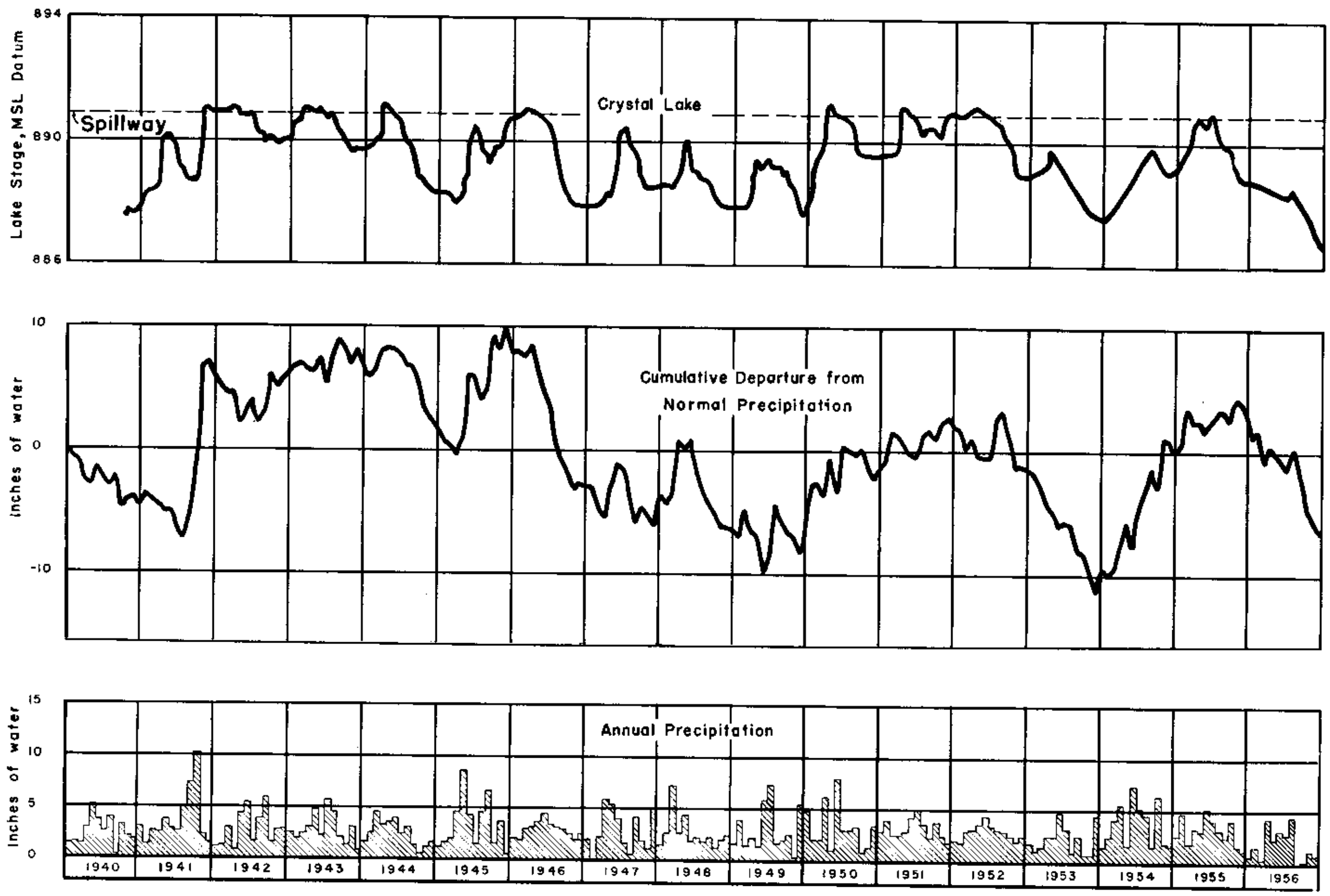

FIGURE 11 LAKE LEVEL AND PRECIPITATION DATA AT CRYSTAL LAKE

HYDROLOGY

Lake Levels

In October 1940, a gage was installed on the east shore of the lake (Fig. 2) so as to permit accurate measuring of the lake level (Fig. 11). This gage has been maintained and operated by the superintendent of the City of Crystal Lake Park District. Water levels have been measured and recorded at irregular monthly intervals through 1952. Since that date, measurements have been taken at less frequent intervals, but often enough to record major fluctuations of the lake level.

Prior to the time of installation of the gage in 1940, records from several sources indicate that the lake was considerably below the level of the present spillway for various periods as far back as 1914. In October of that year, the lake level was at elevation 889 or 1.81 feet below the level of the present spillway. Other lake stages recorded prior to 1940 were 890.42 in March 1921, 888.5 in October 1925 and 890.43 some time in 1927. A picture taken of the lake on August 23, 1934 (Fig. 12) reveals that considerable expanse of beach was exposed; the elevation at that time was 887.23. Unless otherwise indicated, the lake level and ground-water elevations in the present report are in feet above mean sea level.

During the fifteen year period that the lake level gage has been in operation at Crystal Lake, the water level has been at or above spillway elevation only eleven times for a total period of about 33 months. The longest period the level was above spillway was from mid-November 1951 through mid-June 1952. The shortest period was for a few days in mid-April 1955. The longest period the level has been below spillway was from mid-May 1946 through March 1950, a period of 46 1/2 months.

Lake levels have fluctuated from 0.37 feet above the spillway to 4.11 feet below the spillway. The highest recorded level was in April 1950; the lowest level was in January 1957. Figures 6 and 7 show the lake about 3 feet below spillway in July 1956. Figure 13 shows the lake in 1942 during one of the periods when the level was at or near spillway elevation.

Generally, the lake stage reaches a high during the spring or early summer and a low during the fall or early winter. However, annual peak levels have been recorded in August and November, and annual low stages in February and March.

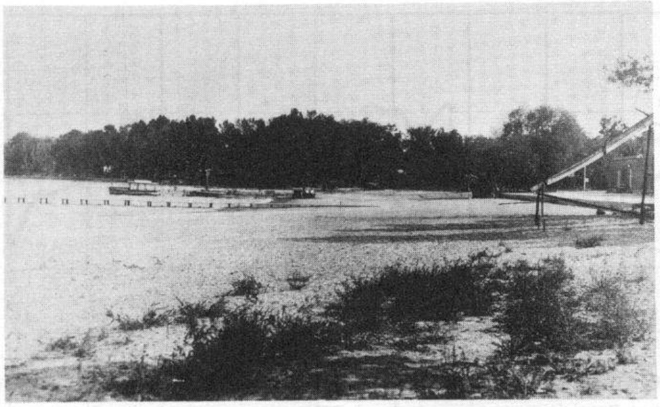

FIGURE 12 CRYSTAL LAKE, AUGUST 23, 1934

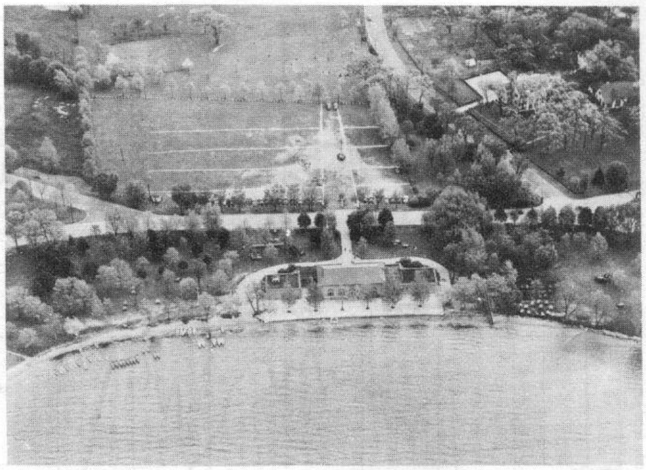

FIGURE 13 CRYSTAL LAKE, 1942

Artificial Drainage

It is not within the scope of this report to fully investigate the design and carrying capacity of the various sewer systems in the Crystal Lake area. However, since some local opinion indicates that the flow in the Lakewood storm and sanitary sewers plays a major role in determining the level of the lake, some study has been made of these sewers. Since there have been no major complaints regarding the storm sewer for the City of Crystal Lake, no study has been made of this system. If it is similar to the storm sewer in Lakewood, it likely has a similar effect on ground-water levels in the area which it serves. The flow in the sanitary sewers of both Lakewood and the City of Crystal Lake is combined and metered at the treatment plant. Therefore, the excess flow from either one of these sewers cannot be readily determined.

Sanitary Sewers

The Lakewood sewer system (Fig. 14) was installed about 1940. The flow accumulates at the Everett Avenue lift station, southeast of the lake, and is pumped up to the McHenry Avenue sewer, part of the City of Crystal Lake system The entire system discharges at the City of Crystal Lake treatment plant.

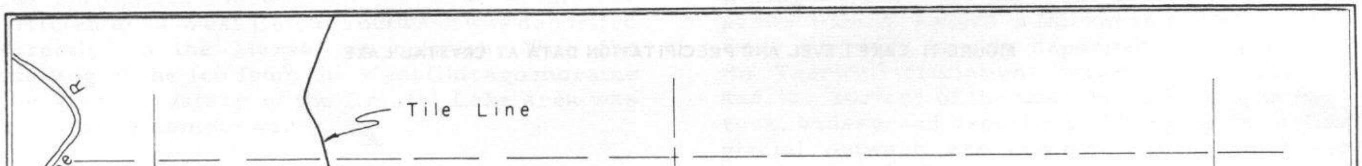

FIGURE 14 LAKEWOOD SANITARY SEWER SYSTEM

A continuous record of the flow in the sanitary sewer has not been made. In 1942, the flow in the Lakewood sewer averaged 5140 gallons per day. This represented a flow of approximately 40 gallons per day per person.

In February 1956, the metered flow at the treatment plant for the sanitary sewers of both Lakewood and the City of Crystal Lake averaged 497,000 gallons per day, or approximately 75 gallons per day per person. The maximum flow at the treatment plant was reported to be about 900,000 gallons per day.

The flow at the treatment plant reportedly is considerably heavier than average during periods of heavy rain. On February 24, 1956, the flow was 835,000 gallons. On this same date, a one-inch rain was measured at the Crystal Lake rain gage at the east end of the lake. However, during February, the lake level was approximately two feet below spillway and it had maintained about the same level since early November 1955. Thus, it would appear that some surface runoff or ground water enters the sanitary sewer, at least during periods of heavy precipitation and high ground saturation. However, the average flow does not appear excessive for the population served by the system. Although the sanitary sewer apparently carries excessive flow during periods of heavy precipitation, the average flow indicates a rather insignificant effect on ground-water levels over extended periods of time.

Lakewood Storm Sewer. A storm sewer system for the Village of Lakewood was installed prior to 1930, to drain the marshy land for housing development. This system serves approximately 0.2 square miles of the watershed of the lake. The original plans for this system apparently have been misplaced or destroyed, and therefore the location of much of the sewer system is not definitely known at the present time. The main interceptor line parallels the sanitary sewer interceptor line (Fig. 14), and both run in an easterly direction roughly parallel to the south shore of the lake. West of Crystal Creek, the sewer runs southeastward and discharges into the creek about a mile southeast of the lake. Laterals extend north and south from the interceptor line, but the exact extent and location of some of these laterals are unknown.

The storm sewer lies approximately two feet lower than the sanitary sewer. This is evidenced in several manholes along the interceptor line, where the sanitary sewer crosses above the laterals of the storm sewer. This is further confirmed by village officials.

Some reports indicate that laterals of the storm sewer extend out into the lake along the south shore. A reconnaissance of the shore line in August 1956, with the lake more than two feet below spillway, revealed no evidence of the sewer system.

On August 8, 1956, the flow in Crystal Creek, below the storm sewer outlet, was measured. This location is also below the sewer outlet from the National Grain Yeast Corporation. At the time of measurement, the flow in the storm sewer could not be accurately determined, but it was estimated to be a rather small percentage of the total flow in the creek. Numerous observations at sewer manholes and the outlet have not revealed high flows during periods of normal or deficient precipitation.

Considering the storm sewer installation from another viewpoint, the primary purpose of the sewer, as stated previously, was to drain the marshy area south of the lake for development of Lakewood. Since this purpose has been accomplished it is possible that the sewer contributes to some lowering of the ground-water level in the area which it drains.

Suburban Sewers. In the subdivisions west and north of the lake, there are no municipal sewers and most of the water withdrawn from the ground is returned through domestic septic tanks. Therefore, these areas probably have little or no effect on the ground-water aquifer and lake level.

Ground-Water Withdrawal

Geologic and hydrologic data indicate that there is little possibility of hydrologic interconnection between the West Chicago and Marseilles Outwash deposits and aquifers near the base of the glacial drift or in the bedrock. From available records, the highest water level in any bedrock well has been at least 37 feet below the lowest level of the lake. Therefore, wells in these deeper aquifers probably have little or no effect on the lake level and will not be discussed in this report.

Municipal. Two old wells originally supplied water for the City of Crystal Lake. A 64-foot dug well provided water from 1898 until 1913. This well penetrated West Chicago morainal deposits and may have been connected with the West Chicago and Marseilles Outwash. In 1913, a well was dug to a depth of 32 feet. This well was located 2685 feet from the lake, in a city park. It was finished in the West Chicago and Marseilles Outwash, the same aquifer with which the lake is associated. Since 1930, the well served only as a supplementary source and it has not been in use since 1943.

The present municipal water supply is obtained from five wells, three of which are finished in dolomite and sandstone aquifers in the bedrock. Municipal wells No. 3 and 4 have depths of 48 and 57 feet, respectively, and are finished in the West Chicago and Marseilles Outwash. They are located in the park near the site of the old 32-foot dug well. Both wells were drilled in 1948 and served as part of the municipal supply until 1953, after which they were not used until March 1956. These two wells have been pumped considerably since March, which might partially account for the extremely low lake level during the latter part of 1956.

Since the old municipal wells have been used only to a limited extent after 1930 and since wells No. 3 and 4 have been used only between 1948 and 1953 and after March 1956, it appears that pump-

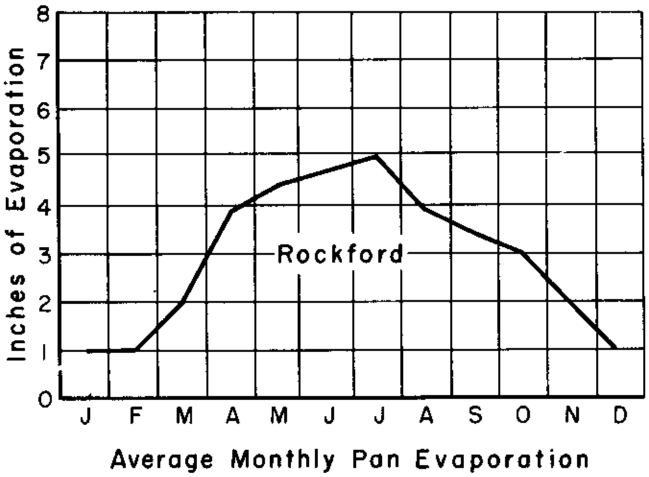

FIGURE 15 EVAPORATION AT ROCKFORD, ILLINOIS

age from these wells has not been a major factor affecting the water level of Crystal Lake.

Private. The Village of Lakewood and the unincorporated areas of North Shore, Crystal Vista and Crystal Gardens do not have public water supplies. Domestic supplies are obtained from relatively shallow sand points finished in the West Chicago and Marseilles Outwash.

On the basis of a population of approximately 2100 and an average consumption of 50 gallons per day per person, the Village of Lakewood and the suburban areas withdraw approximately 105,000 gallons per day from the shallow aquifer by these private domestic wells.

Industrial. There is only one major industry in the Crystal Lake area which obtains water from wells finished in the shallow drift. The National Grain Yeast Corporation has four wells, three of which are finished in West Chicago morainal deposits and one which is finished in Maquoketa shale at 319 feet and obtains water from the Silurian dolomite above the shale. The three shallow wells have depths of 60, 62, and 65 feet. The dolomite well is the newest of the four wells and provides most of the water for the company. The 62-foot well is pumped regularly, but is used only as a supplementary source of water. The other two shallow wells provide only limited quantities of water. Total pumpage in 1947 was estimated at 400,000 gallons per day. These wells are about one and three-quarter miles from Crystal Lake. Since most of the water is obtained from the dolomite, there is probably little effect on water levels in the West Chicago and Marseilles Outwash.

Precipitation

There is no official United States Weather Bureau precipitation station in the Crystal Lake area. However, the superintendent of the City of Crystal Lake Park District has measured precipitation with a non-recording rain gage since 1940 (Fig. 11). Based on the 15 year period from 1940 through 1954, the average annual precipitation is 32.95 inches. Average monthly precipitation varies from a low of 1.76 inches in February to a high of 4.29 inches in June.

The highest measured annual precipitation occurred in 1941, with 43.60 inches. The highest monthly precipitation occurred in October 1941, with 10.17 inches. The lowest measured annual precipitation occurred in October 1941, with 10.17 inches. The lowest measured annual precipitation occurred in 1946, with 22.22 inches. The lowest monthly precipitation has been zero, which occurred in February 1947 and September 1956.

Based on the average monthly precipitation for the 15 years, the cumulative monthly departure from normal has been calculated (Fig. 11). The longest period of cumulative departure above normal occurred from October 1941 through February 1945, a period of 45 months. The longest periods of cumulative departure below normal occurred from June 1948 through May 1950 and from October 1952 through September 1954, periods of 24 months each. The highest cumulative departure above normal occurred in November 1945, with 9.87 inches. The lowest cumulative departure below normal occurred in November 1953, with 11.52 inches.

The nearest official United States Weather Bureau precipitation station is located at Marengo, Illinois, thirteen miles west of Crystal Lake. At the end of 1955, 100 years of records were available.

The average annual precipitation for this 100 year period was 32.92 inches. This compares very closely with the 15 year average at Crystal Lake of 32.95 inches.

Evapotranspiration

In August 1950, the State Water Survey established a Class A United States Weather Bureau type evaporation pan near Rockford, Illinois. This is approximately the same latitude as Crystal Lake but 38 miles west of the lake.

Records of monthly evaporation, shown in Figure 15, indicate that the greatest evaporation takes place during July and that evaporation for the six warmest months, April to September inclusive, averages 25.38 inches.

In April 1953 an automatic evaporation recorder was installed adjacent to the pan at the Rockford Evaporation Station. Data obtained from this instrument can be correlated with the pan observations. It has yielded data on water losses during the winter months, when the Weather Bureau type pan cannot be used. Three years of records at that station indicate that monthly evaporation during December, January and February averages 1 inch; during March and November, 2 inches; and during October, approximately 3 inches.

If the averages of the two records are added, an average yearly evaporation of 36.14 inches is obtained. Experience has shown that, for lakes and reservoirs, evaporation losses are approximately 70 per cent of those from adjacent Weather Bureau type pans. Applying this correction to the 36.14 inches gives a total of 25.30 inches of evaporation annually for lakes in northern Illinois.

FIGURE 16

WEEKLY WATER LEVEL RECORDER, OBSERVATION WELL NO. 11

Comparison of the Rockford evaporation records with those of surrounding states indicates that a maximum monthly evaporation at this latitude seldom exceeds 6 inches and is probably nearer 5 inches, and that the average monthly evaporation during the growing season is about 4.25 inches.

Although a study has not been made of dry land evapotranspiration losses in this investigation, research projects [13] have established that large quantities of water are transpired by vegetation and the land surface, especially during the growing season. As much as 7000 gallons per acre per day may be used by crops in the evapotranspiration process. This loss is equivalent to approximately one-fourth inch per acre a day.

Ground-Water Levels

In 1950, a series of 13 observation wells was constructed for the State Water Survey at various sites around the lake to observe the fluctuation and movement of the ground water in the West Chicago and Marseilles Outwash. The wells were arranged to obtain data regarding the ground-water level in all directions from the lake. Specific sites of the wells were determined by the availability of the site under consideration.

Ten of the observation wells were of the drive-point type of construction; that is, the well casings, with screened points on the bottom, were driven into the ground. These wells were cased with one and one-quarter inch diameter steel pipe. The top of each of these casings was fitted with a threaded cap. Depths of the drive points were from 12.5 to 31 feet. All of these wells were equipped with 42-inch long well points with 3 feet of exposed No. 12 slot screen.

Three wells were drilled to depths of 18, 23.6, and 46.1 feet. These wells were cased with 6-inch diameter steel pipe, the top of which was fitted with a flanged coupling. The 23.6 foot well was equipped with a 3-inch diameter brass jacket well point with 3 feet of exposed screen. The other two were equipped with 4-inch diameter brass jacket well points with 5 feet of exposed screen.

A definite numbering system for the observation wells was arranged in order to avoid any error in recording data (Fig. 2). In this report, the 10 one and one-quarter inch wells will be referred to as Observation Wells Nos. 1 through 10. The 3 six-inch wells will be referred to as Observation Wells Nos. 11, 12, and 13.

Weekly water-level recorders were installed in the six-inch observation wells (Fig. 16) and serviced each week. The depth of water in each of the one and one-quarter inch observation wells was measured weekly. The measurement of the water levels in the observation wells and the maintenance of two of the weekly recorders were discontinued in late 1954. Observation Well No. 11 continues in operation as a general check of ground-water levels in the West Chicago and Marseilles Outwash as compared to the level of the lake.

Hydrographs of each of the observation wells have been plotted depicting the range in water levels during the period 1950 to 1954 (Figs. 17-20). A comparison of these hydrographs shows a very close correlation between the levels in the wells. Water levels in all of the wells show definite seasonal variations, with relatively high levels in the spring and low levels in late summer and fall. During the four-year period, seasonal variations of from 1.3 to 5.7 feet were recorded.

A variation in water levels of a longer range was also observed during the four-year period. Water levels in 8 of the 13 wells were the highest in March and April 1951. In four of the wells, water levels were the highest in April 1952. Observation Well No. 11 reached the same peak level in both 1951 and 1952. With this well continuing in operation, a new high, 0.17 feet above the previous peak level, was recorded in June 1955.

During the period 1950 to 1954 the lowest recorded levels in all 13 wells occurred during late 1953 and early 1954. These levels were from 3.80 to 7.20 feet below the peak levels recorded in 1951 and 1952.

A correlation between lake levels and ground-water levels is shown by a comparison of the curve showing the lake stage (Fig. 11) and the curves showing the hydrographs of ground-water levels in the 13 observation wells (Figs. 17-20). These curves all show similar high and low trends, indicating a direct relationship between the lake and ground-water levels in the Crystal Lake area.

One of the lowest recorded lake stages since this investigation started occurred in January 1954. This was 3.26 feet below the spillway. Precipitation was also at its lowest during this period, with a cumulative deficiency of 11.52 inches in November 1953.

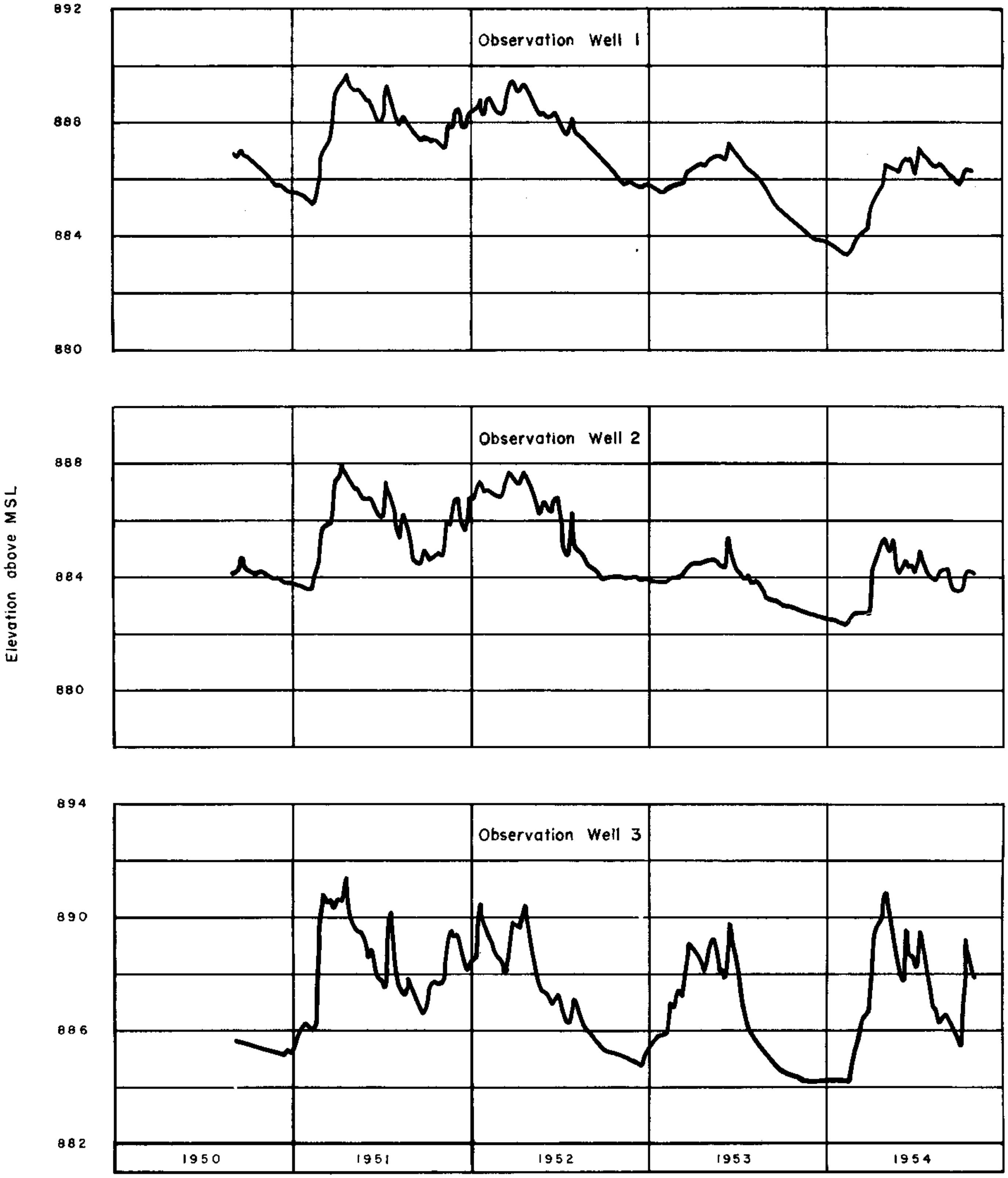

FIGURE 17

HYDROGRAPHS OF GROUND-WATER LEVELS AT CRYSTAL LAKE

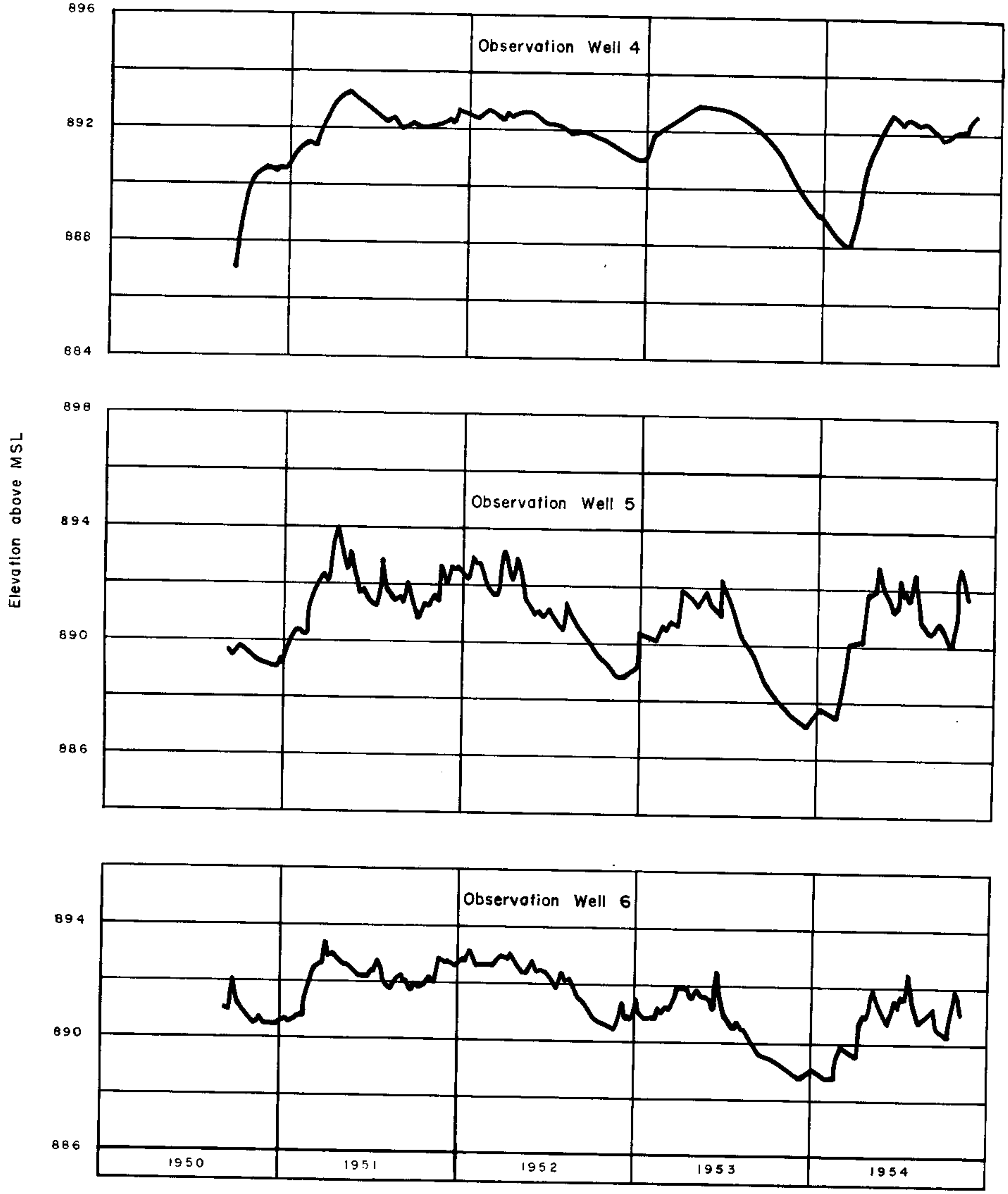

FIGURE 18

HYDROGRAPHS OF GROUND-WATER LEVELS AT CRYSTAL LAKE

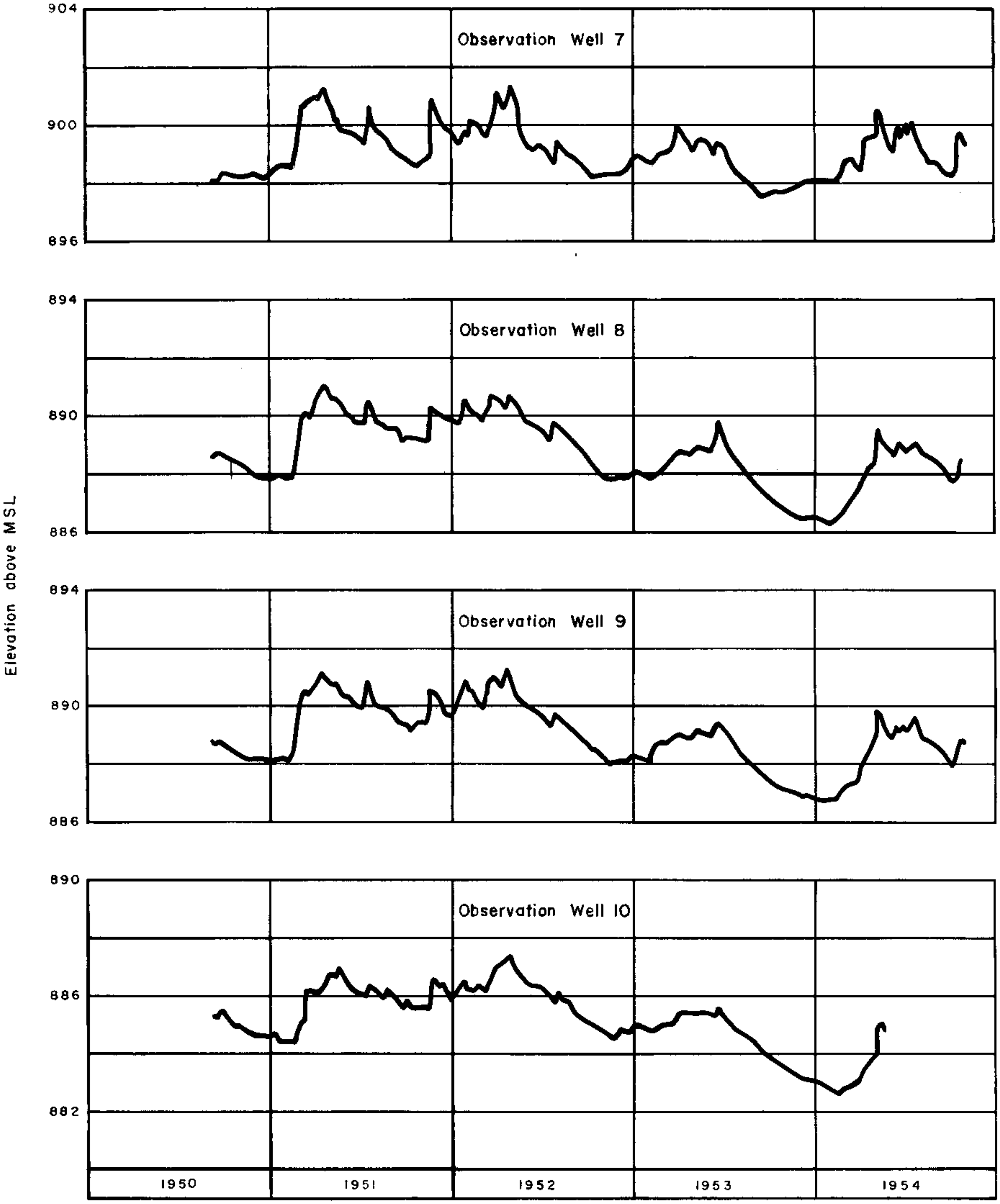

FIGURE 19

HYDROGRAPHS OF GROUND-WATER LEVELS AT CRYSTAL LAKE

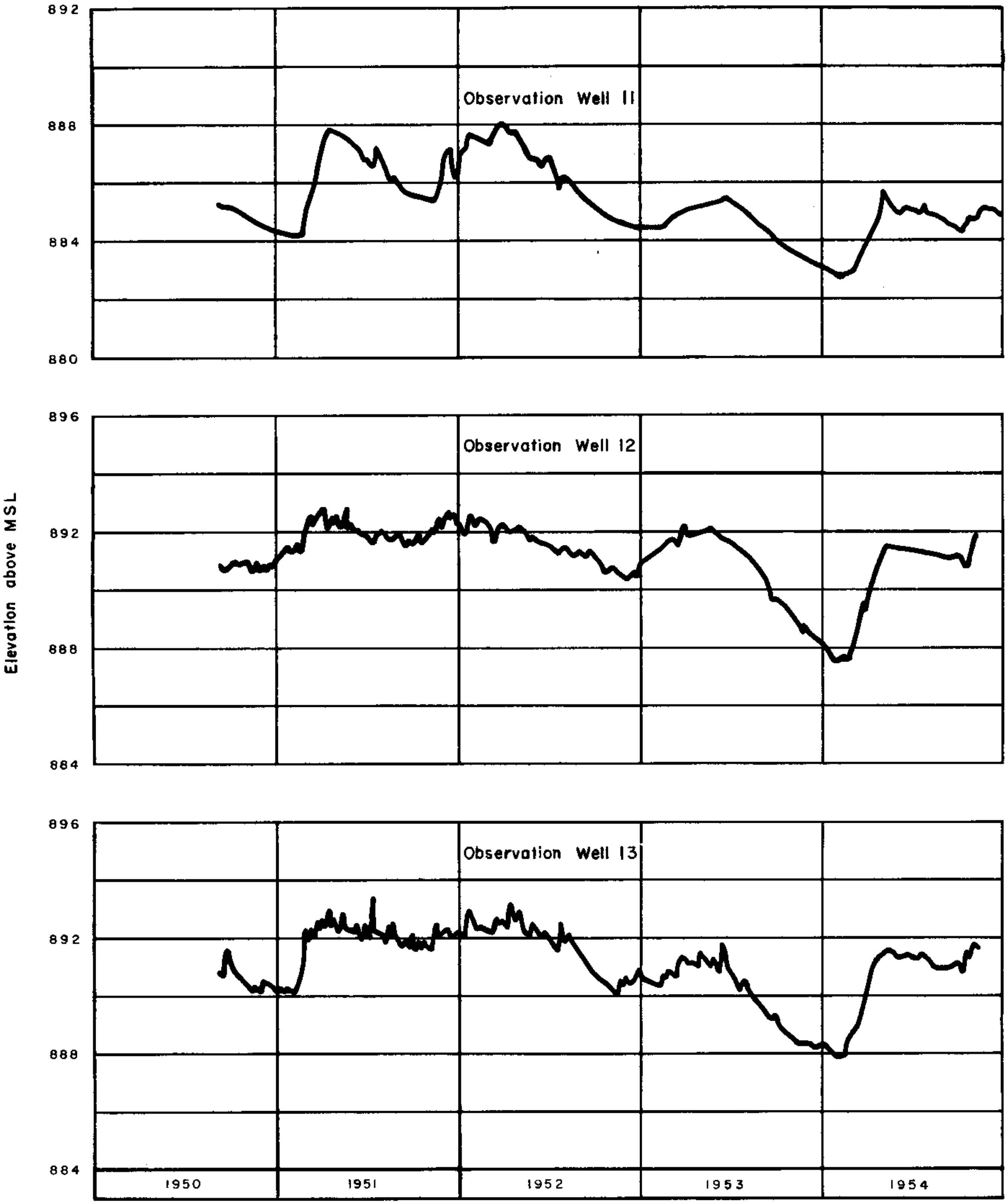

FIGURE 20

HYDROGRAPHS OF GROUND-WATER LEVELS AT CRYSTAL LAKE

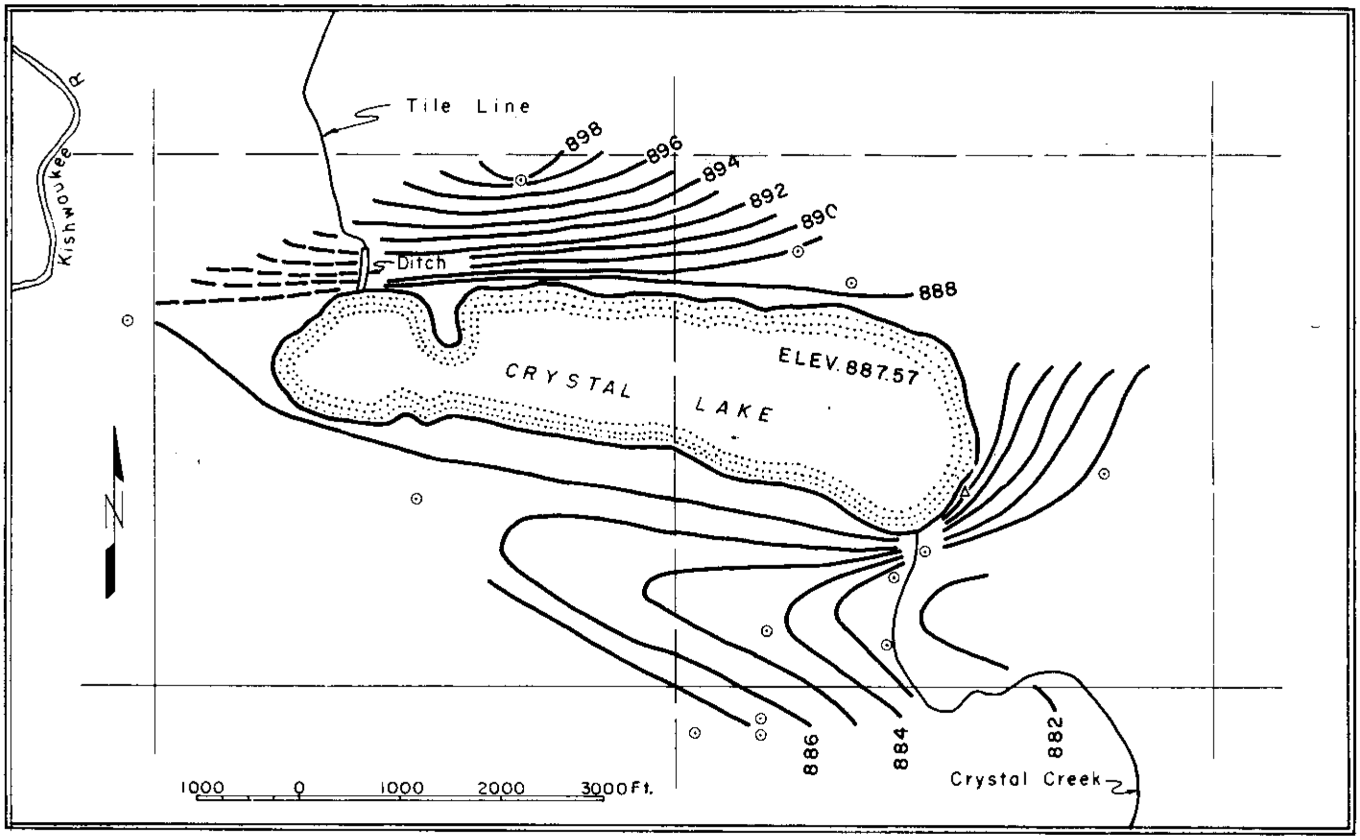

FIGURE 21 PIEZOMETRIC SURFACE AT CRYSTAL LAKE, JANUARY 6, 1954

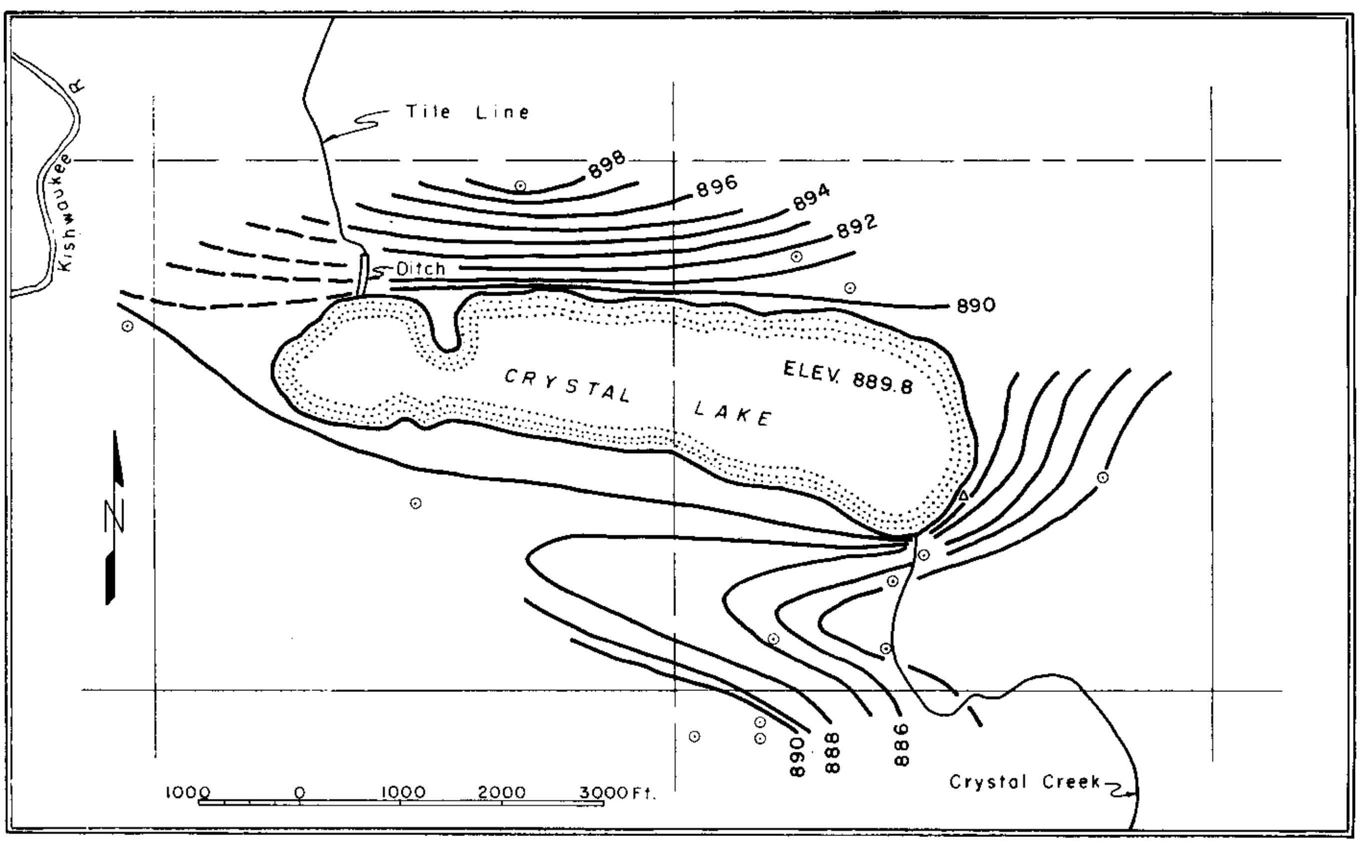

FIGURE 22 PIEZOMETRIC SURFACE AT CRYSTAL LAKE, AUGUST 25, 1954

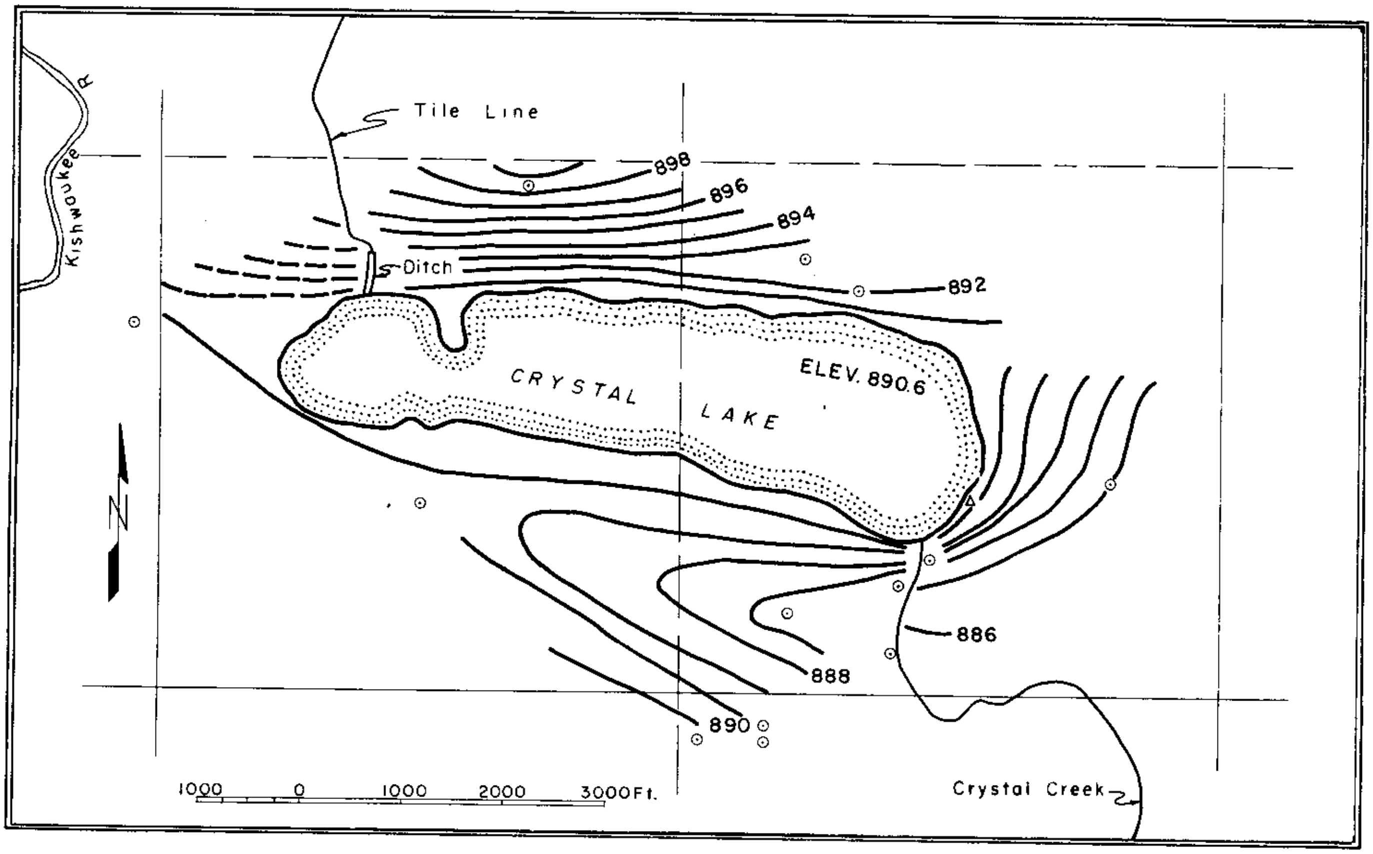

FIGURE 23 PIEZOMETRIC SURFACE AT CRYSTAL LAKE, JULY 24, 1952

DISCUSSION OF DATA

Records for the past fifteen years indicate a close correlation between lake levels and precipitation (Fig. 11). A comparison of the curve showing the cumulative departure from normal precipitation and the curve showing the lake stage shows a similar trend in high and low measurements. These curves show that the lake very seldom reaches spillway elevation unless the cumulative departure of precipitation has been above normal for at least a few months. Monthly departures below normal precipitation are also reflected in lake levels, although to a lesser extent.

A correlation is also noted between lake and ground-water levels. These levels all show similar trends, thereby indicating a direct relationship.

Based on data obtained regarding lake levels and ground-water levels in the West Chicago and Marseilles Outwash, a series of water level contour maps was prepared. Three maps (Fig. 21-23) were selected for inclusion in this report as being representative of the maps prepared. These three maps show conditions during periods of below normal, near normal and above normal precipitation, respectively, for the dates of January 6, 1954, August 25, 1954, and July 24, 1952.

A comparison of the maps shows a similar piezometric surface pattern for each of the three dates, with a high elevation across the north side of the lake and a low elevation, declining towards the southeast, across the south side of the lake. Considerable variation exists between the slope of the piezometric surface on the three maps.

On each of the maps, a rather steep slope exists between Observation Well No 1 and the lake shore. This tends to indicate an area of low transmissibility of the ground-water aquifer. This low transmissibility may be partially due to soil compaction in the vicinity of the spillway.

As evidenced by the three maps, the piezometric surface and the surface of the lake coincide. It appears that the lake is fed by ground water from the north and discharges into the ground-water aquifer to the south, with the subsurface drainage continuing to the southeast. Comparison of the geologic map and the piezometric map indicate that there may be secondary drainage of the aquifer to the southwest into the Kishwaukee River Valley. The fact that the lake and surrounding area are located on a glacial outwash plain adds additional emphasis to the interrelationship of the lake level and the ground-water aquifer. Therefore, conditions affecting ground-water levels have an effect on the lake and, conversely, conditions affecting the lake also cause changes in ground-water levels.

Of the artificial factors which have an effect on the lake level, the Lakewood storm sewer has received major consideration. The sewer has served the purpose of draining the once-swampy land south of the lake. However, during periods of deficient precipitation, with little or no flow in the sewer, the lake and ground-water levels have continued to lower. Therefore, it would appear that although the storm sewer may account for some of the water loss from the area, it is not primarily reponsible for the extended periods of extremely low lake levels.

In addition to the Lakewood storm sewer, the Crystal Lake storm sewer and the sanitary sewers of the two communities remove water from the area. However, currently available data indicate that this removal apparently is not a major contributing factor to the low lake levels.

Increased residential development in Lakewood and the subdivisions west and north of the lake has resulted in a considerable increase in the number of shallow sand point wells. The resultant withdrawal of ground water has probably had some effect on water levels, although a considerable amount of this withdrawal is undoubtedly returned to the same formation from which it is withdrawn, through septic tanks and other disposal means.

Continual increases in ground-water withdrawal from the West Chicago and Marseilles Outwash will undoubtedly affect water levels in that aquifer, with a resultant effect on the lake. Although a considerable portion of that withdrawal presently is returned to the same aquifer, the volume that is not being returned probably is increasing.

All data collected during this investigation point to lack of precipitation, evaporation from the lake surface and evapotranspiration from plant and land surfaces as the chief factors responsible for the periodic low levels of Crystal Lake.

Extended periods of deficient precipitation result in low water levels in the West Chicago and Marseilles Outwash and in the soil formations above that aquifer. Before the outwash can be recharged, the upper soil formations must first be saturated. This process often extends over a considerable period of time. Since the lake is directly connected to the outwash aquifer, recharge of the lake is likely to occur only slowly or during periods of considerable excess precipitation.

Whereas precipitation varies greatly from month to month and year to year, evaporation and transpiration take place at more uniform annual rates, regardless of the amount of precipitation. Thus the normal loss from evapotranspiration is considerably accentuated during extended periods of inadequate precipitation.

RECOMMENDATIONS

During the course of this investigation, several plans have been discussed which might aid in maintaining the lake at a more uniform level. It appears that there is no completely satisfactory solution to this problem. However, a number of steps might be taken which would reduce the extent of water level fluctuations.

As this report nears completion, additional investigation is being made of the tile drainage system north of the lake. There are numerous swampy areas around the lake which are wet even during periods of prolonged drought. Tile or open ditch drainage of some of these areas could add an appreciable volume of water to the lake.

For two lakes in the State of Indiana [14, 15] studies have been made concerning the possibility of pumping water into the lakes from wells. At Crystal Lake, where lake and ground-water levels coincide, this would undoubtedly involve a large volume of water. Pumpage would have to be from an aquifer below the West Chicago and Marseilles Outwash and possibly would have considerable effect on other nearby wells finished in the same aquifer. This approach to the problem does not appear to offer a feasible solution.

Although the Kishwaukee River has a very low flow during the summer and fall, excess flow during the spring or other periods of high rainfall might be stored by a small channel dam and diverted into the lake, but this involves complex legal procedures as well as considerable expense.

Dredging of the shallow shoreline around the lake would result in less exposed beach area with low lake levels. Since the lake and ground-water aquifer are directly connected, such dredging should not result in any additional water loss from the lake and would actually reduce evaporation. Material removed from the lake might be used as fill in raising and improving the shore.

Consideration might be given to the possibility of lowering the spillway from one to two feet, thereby establishing a new maximum lake level as well as a new shoreline. This new level would be more nearly the average elevation of the lake during the past 16 years. The additional beach area could be permanently maintained in a more desirable condition, thus reducing the area that is under water part of the time and exposed as mud and sand the rest of the time.

Experiments are being conducted in the use of non-toxic chemical films to reduce the rate of evaporation from the surface of a body of water. Considerable additional experimentation remains to be done before the effectiveness of this project on large bodies of water can be determined.

The Illinois State Water Survey has recently conducted studies on the effect of hexadecanol on the rate of evaporation of water from a 100,000-gallon concrete storage basin. Data showed a reduction of evaporation from 25 per cent to a maximum of 62 per cent over a 10-week period during the summer of 1956.

Such a reduction in evaporation may indicate the feasibility of reducing the normal evaporation losses from Illinois lakes. A saving of 1-foot of water depth, roughly a reduction in evaporation of 30 per cent, would seem possible if this treatment were applied to Crystal Lake. However, problems in application and attrition of the monolayer film on large water bodies still have to be worked out.

REFERENCES

1. Report of the Submerged and Shore Lands Legislative Investigating Committee, Vol. II, pp. 40-41, Illinois House of Representatives, 47th General Assembly, Springfield, Illinois, 1911.

2. Interim Report, Crystal Lake Water Levels at Crystal Lake, Illinois, Illinois Division of Waterways. Springfield, Illinois, March 1950.

3. Engineering Survey, Randolph-Perkins Company, Chicago, Illinois, October 1925. Unpublished.

4. A Survey of Ground-Water Resources in Illinois, Circular No. 18, Illinois State Water Survey, Urbana, Illinois, 1935.

5. Unpublished communication, September 1940.

6. Unpublished communication, March 1941.

7. Romine, H. E., "Report on Shallow Ground-Water Resources in Crystal Lake and Vicinity," Illinois State Water Survey, Urbana, Illinois, October 18, 1947. Unpublished.

8. Prescott, Gordon W., "Geological Report on the Ground-Water Possibilities at Crystal Lake," Illinois State Geological Survey, Urbana, Illinois, October 31, 1947. Unpublished.

9. Buhle, M. B., "An Electrical Earth Resistivity Survey at Crystal Lake, Illinois," Illinois State Geological Survey, Urbana, Illinois, June 1948. Unpublished.

10. Bushman, F. X., "Report of Water Table Conditions in the Vicinity of Crystal Lake, McHenry County," Illinois State Water Survey, Urbana, Illinois, March 18, 1949. Unpublished.

11. Hudson, H. E., Jr., and Bushman, F. X., "Engineering Study of Water Level Variations at Crystal Lake, McHenry County, Illinois," Illinois State Water Survey, Urbana, Illinois, October 24, 1949. Unpublished.

12. Powers, William E. and Ekblaw, George E., Glaciation of the Grays Lake Quadrangle, Circular 63, Illinois State Geological Survey, Urbana, Illinois, 1940.

13. Water, The Yearbook of Agriculture, The United States Department of Agriculture, Washington, D. C., 1955.

14. Report on the Feasibility of Maintaining a Higher Water Level in Bass Lake by Pumping Water from a Well or Wells, Indiana Department of Conservation, Indianapolis, Indiana, July 1956.

15. Report on Maintaining Level of Cedar Lake with Water from Wells, Indiana Department of Conservation, Indianapolis, Indiana, September 1956.