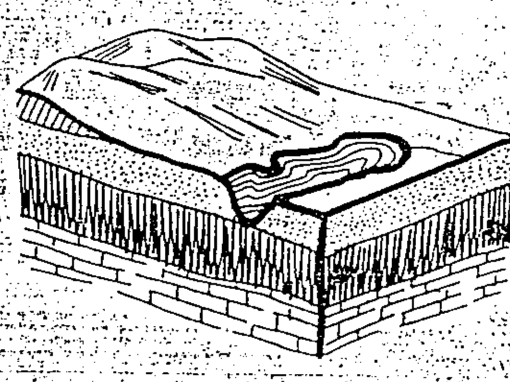
final report

CRYSTAL LAKE WATERSHED

Resources Management Study



BY
BAUER ENGINEERING, INC.
20 North Wacker Drive
Chicago, Illinois 60606

MARCH 1975

BAUER ENGINEERING, INC.

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March 13, 1975

Mr. Robert Walker
City Manager
City of Crystal Lake
121 North Main Street
Crystal Lake, Illinois 60014

Dear Mr. Walker:

In accordance with our contract with you, we are pleased to submit herewith our final report on the Crystal Lake Watershed Management Study. This report expands upon our earlier draft report and presents what we believe to be a comprehensive program for watershed management capable of protecting and enhancing the water resources of Crystal Lake.

The recommendations we make are more demanding than would commonly be made for most watersheds. However, we find these needed to cope with the environmental management requirements of the situation. If further justification is called for, we find it in the unique recreational and aesthetic potentials of Crystal Lake, which are now being eroded in the absence of adequate management measures.

By choice, we have taken a tempered conservative approach on the side of environmental protection, which we believe is in the best interests of Crystal Lake residents. We would be happy to discuss our findings and recommendations and the rationale behind our proposed action program with the Council, its agents and other interested parties at convenient times and places.

We wish to thank you for your cooperation and assistance in the undertaking of the efforts; also for that of Mr. James Mann, Planning Director and other members of the City staff. We also want to thank the Mayor, Mrs. Arlene Fetzner, the members of the City Council, the Chairman of the Planning Commission, Mr. Don Gaul, and the other members of the Planning Commission for their time, effort and invaluable insights.

We have enjoyed working with the City in this effort and have found the tasks challenging and rewarding. If and when you desire to move ahead with implementation of our recommendations, we would welcome the opportunity to assist you.

Sincerely,

Clint J. Keifer
President

CJK/JL:sk
Enclosure

final report

CRYSTAL LAKE WATERSHED
Resources Management Study

by

BAUER ENGINEERING, INC.
20 North Wacker Drive
Chicago, Illinois 60606

MARCH 1975

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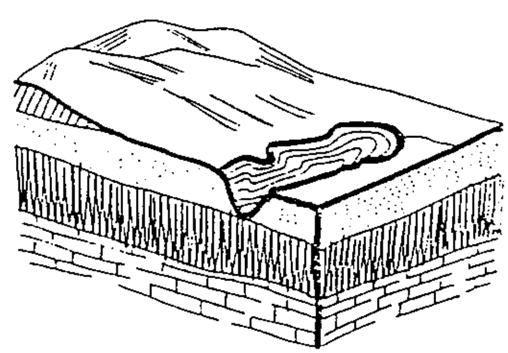
PURPOSE AND RECOMMENDATIONS



PURPOSE AND RECOMMENDATIONS

The purpose of this report is to suggest to the City of Crystal Lake ways and means of regulating the growth of the City while at the same time preserving the quality of the lake water and the natural beauty of the lake and its surroundings.

Crystal Lake is an unusual lake in that its waters are renewed laterally, from underground sources, rather than from streams flowing across the surface of the watershed and emptying into the lake from above. Because of this circumstance, it is necessary to think of new real estate developments in somewhat different terms than those appropriate to more usual lake conditions. The paving process that accompanies so much of modern urban expansion shortens the time interval between the fall of rain and the arrival of the rainwater at the lake; in absence of paving, the water percolates through the soil and subsequently travels through the aquifer formed underground by glacial outwash and till.

The watershed area from which Crystal Lake is recharged is approximately 5.0 square miles in extent -- a smaller area than that covered by the surface watershed drainage. If, because of the conversion of farmland and grassed open space to impermeable surface, stormwater would be allowed to flow directly into Crystal Lake, the quality of water in the lake would inevitably be impaired. On the other hand, if polluted stormwater were to be diverted from the basin and watershed recharge areas, recharge of the lake would be radically reduced.

Protection of recharge conditions can be realized only through the quality of land use practices. More than 75 percent of the natural surface drainage watershed recharge area is at present lightly developed or undeveloped, so the opportunity to control land use still exists. The critical water quality management need is limitation of the fertility of Crystal Lake to reduce excessive growth of algae and other aquatic vegetation. The basic problem is the lake's inability to purge itself of each year's new supply of nutrients on which this vegetation thrives. Phosphorus, nitrogen and other micro-nutrients accumulate from year to year. Not only must the recurrent supply of them be suppressed, but the reservoir of past deposits on the lake bottom must be neutralized.

Our recommendations are that the City (1) protect Crystal Lake aquifer recharge conditions, (2) improve the quality of surface and sub-surface discharges to the lake, and (3) reduce accumulated nutrients in the lake.

The following performance guidelines are proposed:

1. The natural groundwater flow hydraulics of the Crystal Lake watershed shall be preserved. Thus, present groundwater levels must be maintained.

2. Urban developments shall be designed to preserve present natural drainage patterns and local groundwater recharge conditions. In essence, this requires that all drainage systems be designed to recharge to the groundwater locally. No surface drainage systems flowing directly to Crystal Lake shall be allowed.

3. Stormwater management systems for developed areas shall be designed to protect the quality of surface and groundwater discharges.

4. Development intensities and associated local area drainage design shall be restricted to those plans with natural surface drainage management systems capable of complete local recharge of the 100-year design storm.

5. Natural areas of runoff detention and groundwater recharge shall be protected from urban development through dedication or acquisition.

6. Water supply systems using only the bedrock aquifers shall be required for all urbanized areas of the watershed where sewage collection systems are to be provided.

7. Leak-tight designs shall be used in sanitary sewer construction to minimize stormwater and groundwater infiltration.

8. Septic tank disposal systems shall be prohibited in the outwash soils area, with the exception of existing farming activities.

Five environmental management units are identified, each with different land use management recommendations. The five are:

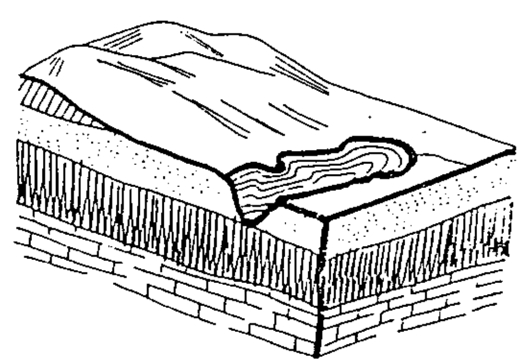
1. Marsh-wetlands
2. Shallow water table outwash
3. Deep water table outwash
4. Morainal
5. Existing urbanized area

It is our opinion that the marsh-wetland and the shallow water table outwash units should be withheld from urbanization through public acquisition, dedication or preservation as agricultural areas. In the deep water table outwash area, we would allow a maximum development intensity of 20 percent. We would set aside the morainal areas for very low intensity estate types of development. And in the presently developed area we would eliminate septic tank discharges and institute other management practices to reduce water-borne nutrient supply and enhance local groundwater recharge opportunities.

We would implement these regulations with the help of funds from three sources -- local, State and Federal governments. Bonds can be issued by local governments and special districts, revenue sharing funds and sales tax revenues are available to municipalities and townships, the State has power to acquire open space for public use and the Crystal Lake watershed is eligible to share Federal money set aside for open space acquisition, wastewater treatment and community development innovations.

Chapter I

INTRODUCTION:
A FRAMEWORK FOR PLANNING



CHAPTER I

INTRODUCTION

A FRAMEWORK FOR PLANNING

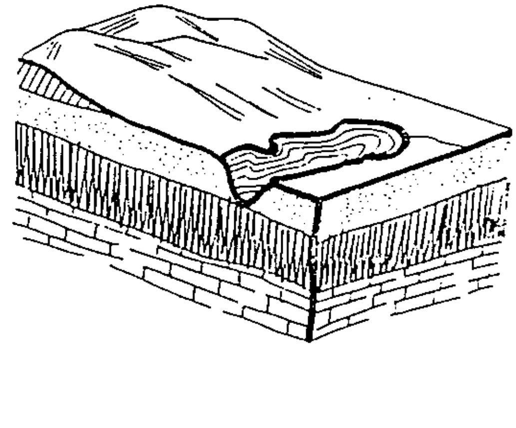
The City and surroundings of Crystal Lake are on the rural-urban fringe of the Chicago Metropolitan area. As shopping centers and parking lots supplant fields and woodland, the urban-rural balance weighs increasingly to the city side. To many, growth is desirable. However, the wish to preserve the small-town character, the natural resources and scenic beauty of the area is widespread. Many see controlled population growth as essential to achieve this end. Crystal Lake is at a crossroads; as the City continues to grow, it is faced with a decision. It can take measures now to insure that growth respects the ecological integrity of the area, on it can join the areas throughout the country that have allowed uncontrolled growth to pave and build over the countryside, transforming it to acres of look-alike houses, shopping centers and parking lots. By commissioning this study, the City has indicated which path it will take. Acting now, Crystal Lake can mitigate the environmental threats increased growth poses to the community.

This report focuses on the quality and quantity of water in Crystal Lake. According to residents and community officials, lake water quality has deteriorated in recent years; there are problems of cloudiness, occasional odors and excessive growths of algae and weeds. The quantity of water that feeds Crystal Lake has been a major source of concern ever since fluctuating water levels were first noted in the 1950s. Because the waters that replenish Crystal Lake come largely from underground shallow aquifer supplies, increased human use of these aquifers may decrease the amount of water available to recharge the lake. Both the quality and the quantity of water available within the watershed to feed the lake are intimately related to human activities. The intention of this study is to formulate appropriate watershed management policies for the Crystal Lake watershed to protect the lake and preserve the environmental integrity of the entire drainage basin.

Geology and climate are the immutable foundations on which other environmental elements -- hydrology, soils and natural vegetation -- are built. As the watershed's natural system is scrutinized, constraints and opportunities for human activities emerge and the extent and effects of present development on the natural system become apparent. The interplay among the natural environment, the urbanized environment, and man gives rise to a variety of management opportunities. From these opportunities, a watershed management plan has been formulated. The watershed has been divided into environmentally similar sections. For each section, compatible land uses are suggested. Specific developmental guidelines are given. These guidelines can be applied basin-wide. Monitoring methods and devices are specified so changes in the quality or quantity of water feeding Crystal Lake can be gauged and problems corrected before they become nuisances. Implementation and financing opportunities are presented.

Chapter II

THE NATURAL ENVIRONMENT: A BASIS FOR PLANNING



CHAPTER II

THE NATURAL ENVIRONMENT: A BASIS FOR PLANNING

The natural environment comprises individual elements interacting one with another. Each element -- geology, relief, climate, drainage patterns, soils, natural vegetation and wildlife -- gives rise to its own set of considerations. As each set is brought to bear on the others, management choices must be made. Depending on these choices, the resources of the environment provide opportunities for or limitations on human activities.

Location of the Study Area

Crystal Lake, located in central southeastern McHenry County, Illinois, 50 miles from Chicago, is within what may be considered the Chicago Metropolitan Area (Figure II-1). Its distance from the city, however, places it in the rural-urban fringe -- an area still predominantly rural but with rapidly growing population.

The study area for this report on Crystal Lake is the watershed of the lake itself, the area from which water is gathered to replenish the lake. The watershed was bounded (Figure II-2) by assuming that surface drainage patterns would follow the regional topography, as depicted by the 10-foot contour intervals used on the U.S.G.S. Quadrangle (1:24,000). More detailed definition of the boundaries would require an examination of larger scale maps indicating 1-or-2-foot contour intervals. In other words, the watershed presented here, though valid for conceptual planning is not exact.

For the purposes of this study, the area beyond the northeastern drainage basin boundary inside the dashed line in Figure II-2 is included

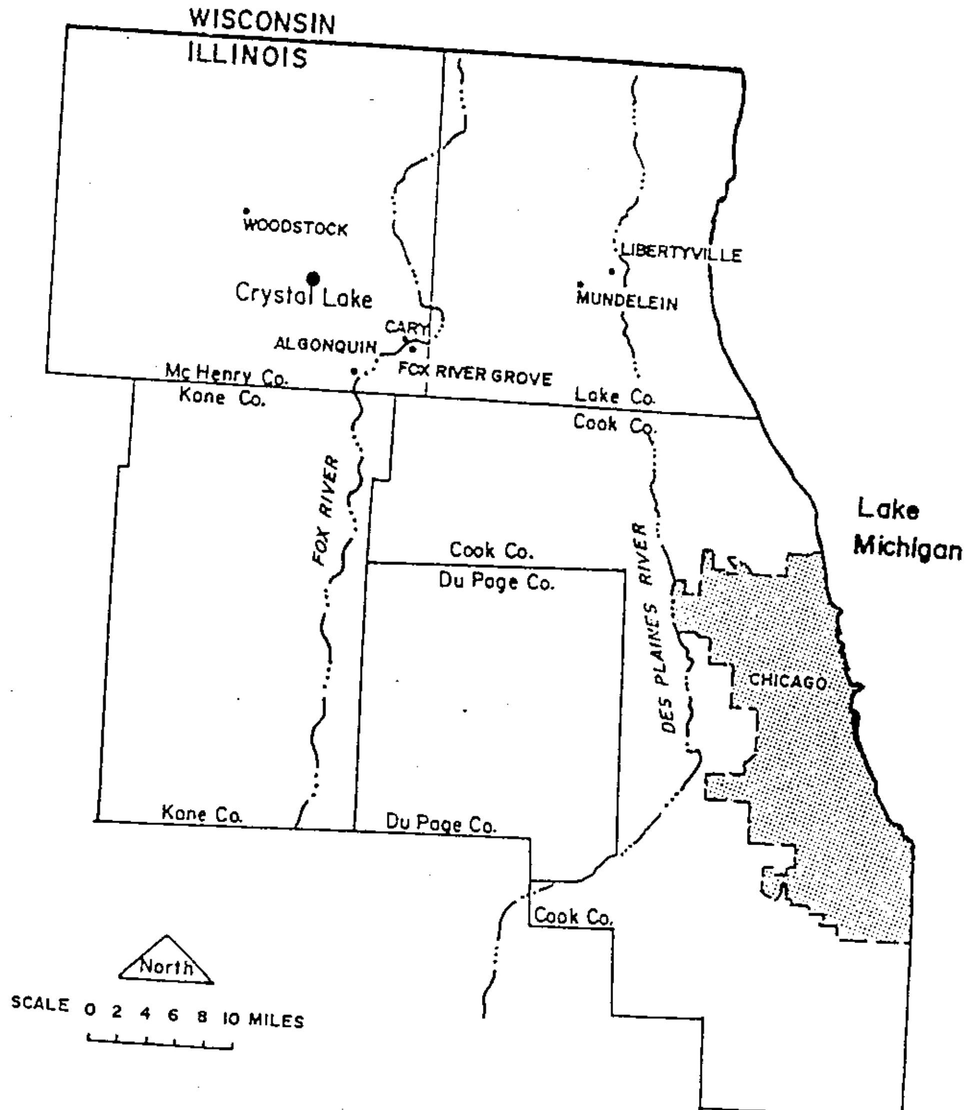


Figure II-1

CHICAGO METROPOLITIAN AREA — REGIONAL SETTING

Figure II-2 CRYSTAL LAKE WATERSHED

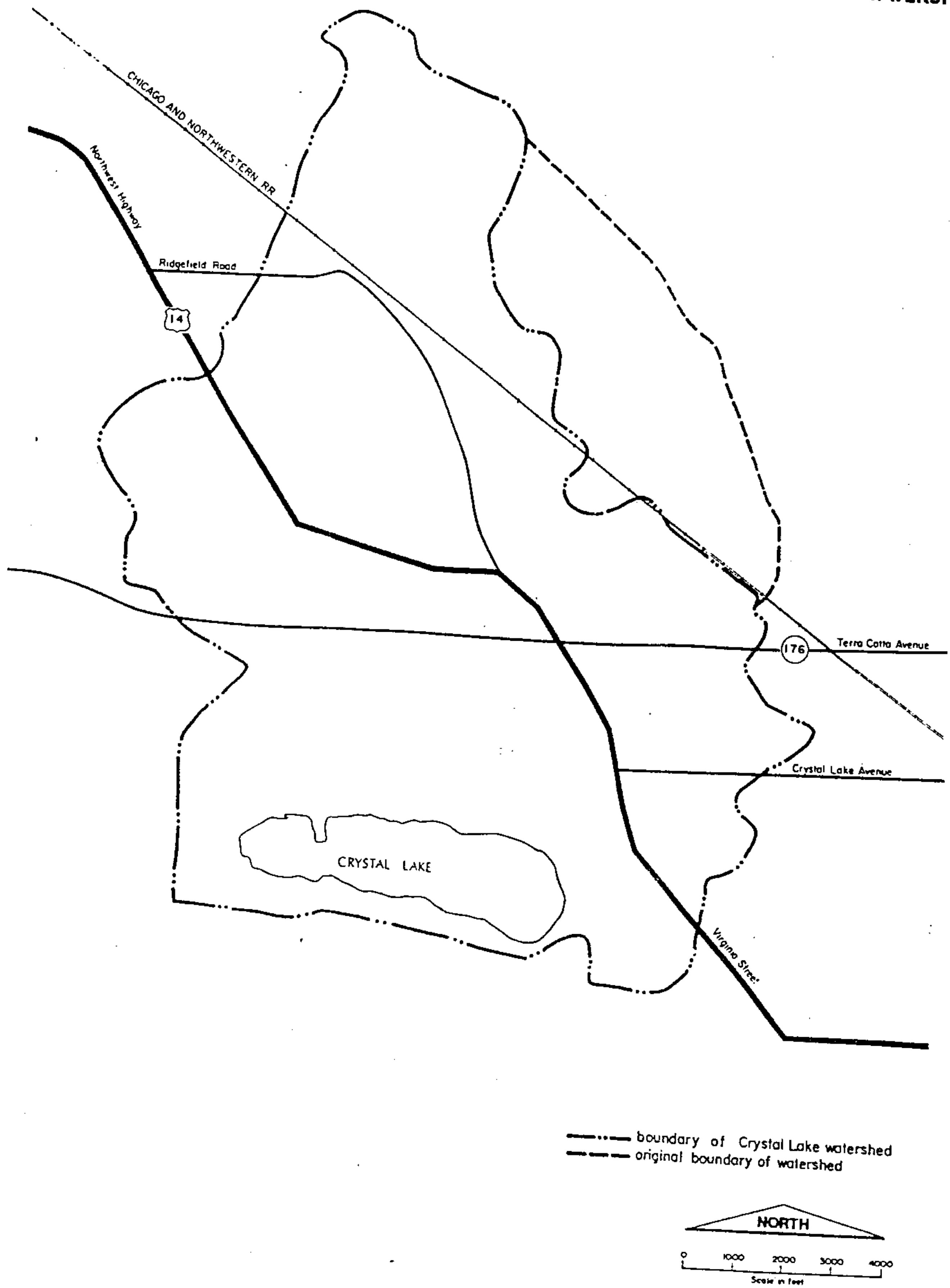
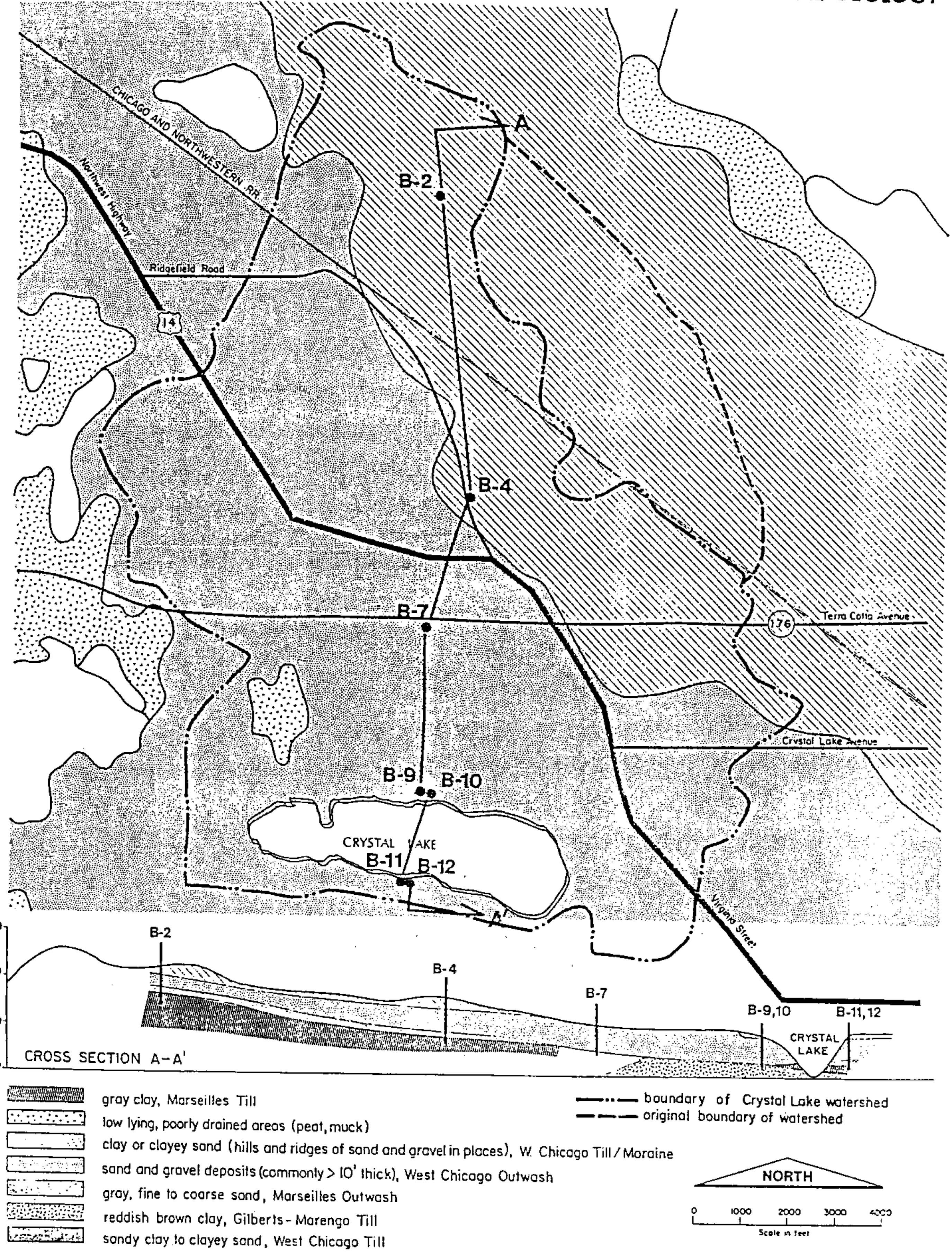


Figure II-3 SURFICIAL GEOLOGY



in the Crystal Lake watershed, but whether that area is really a part of the watershed is questionable. Here a tile drain was installed to correct a situation created by construction of the railroad. The roadbed formed an artificial watershed divide. To relieve the blockage caused by this divide, the tile drain was introduced. It carries water away from the lake.

The southern shore of Crystal Lake approximately demarcates the southern boundary of the study area. The watershed extends north, east and west of the lake, encompassing approximately 5 square miles altogether. To the west is the watershed of the Kishwaukee River and to the east the watershed of the Fox River, into which the Crystal Lake watershed drains via Crystal Creek.

The City of Crystal Lake is the major urban concentration in the watershed. This principally residential community occupies much of the lakeshore. Except for the community of Ridgefield in the northwestern section and scattered new subdivisions and planned unit developments elsewhere, the remaining study area is largely agricultural and open land.

Highway routes 14 and 176 (Terra Cotta Avenue) and the Chicago and North Western railroad traverse the area. They have attracted commercial and light industry facilities.

Geology

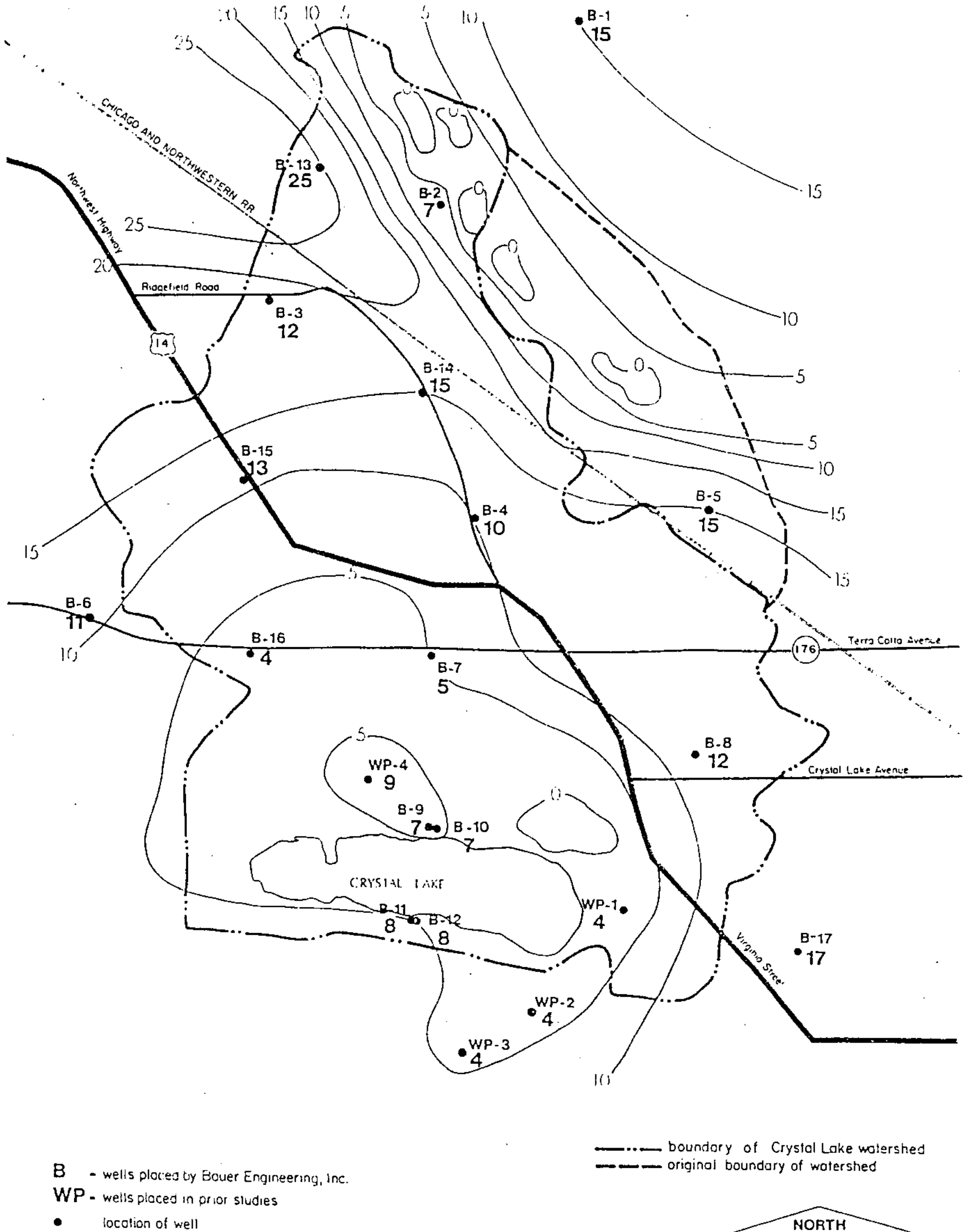
The geological formations that underlie the watershed are composed of strata formed at two widely disparate geological times. The older, lower strata (bedrock) are ancient, formed during the Cambrian, Ordovician and Silurian epochs. The Cambrian is the oldest; the others occurred consecutively later. Many hundreds of millions of years of the geological record are not represented in the Crystal Lake area; Silurian beds are directly overlain by glacial deposits formed during the Ice Age, or Pleistocene, a recent geological epoch (see stratagraphic table, Appendix A). These deposits reach maximum thicknesses of more than 250 feet; near Crystal Lake they are 200 feet deep. A fuller discussion of glacial geology can be found in Sasman (1957).[1]

There were several advances and retreats of ice sheets during Pleistocene; the resultant glacial deposits are complex. The deposits at Crystal Lake were formed during the last glacial advance and retreat -- the Wisconsinan. In terms of geological time, the deposits are young; they have not assumed rock-like characteristics, but tend to be more unconsolidated material.

Glacial deposits are of two sorts: till and outwash. Till is unsorted and unstratified material -- a mixture of silt, clay, sand and gravel. The landscape formed from till can be either undulating plains or pronounced ridges. The latter are called moraines. Outwash deposits, carried and deposited by streams of meltwater flowing from the ice-sheet, are well sorted, stratified sands and gravels most of which are permeable to water occasionally interbedded with lenses of clay (which are impermeable.

Both outwash and till are represented in the watershed. Figure II-3 is a generalized map of the glacial or surficial geology. The till, which is found in the northeastern section of the area, is a moraine; the outwash, to the south and west, contains deposits of organic peat and muck. These deposits formed in surface depressions where stagnant water accumulated, vegetation decayed, and swamp conditions developed.

Figure II-3A WELL LOCATIONS



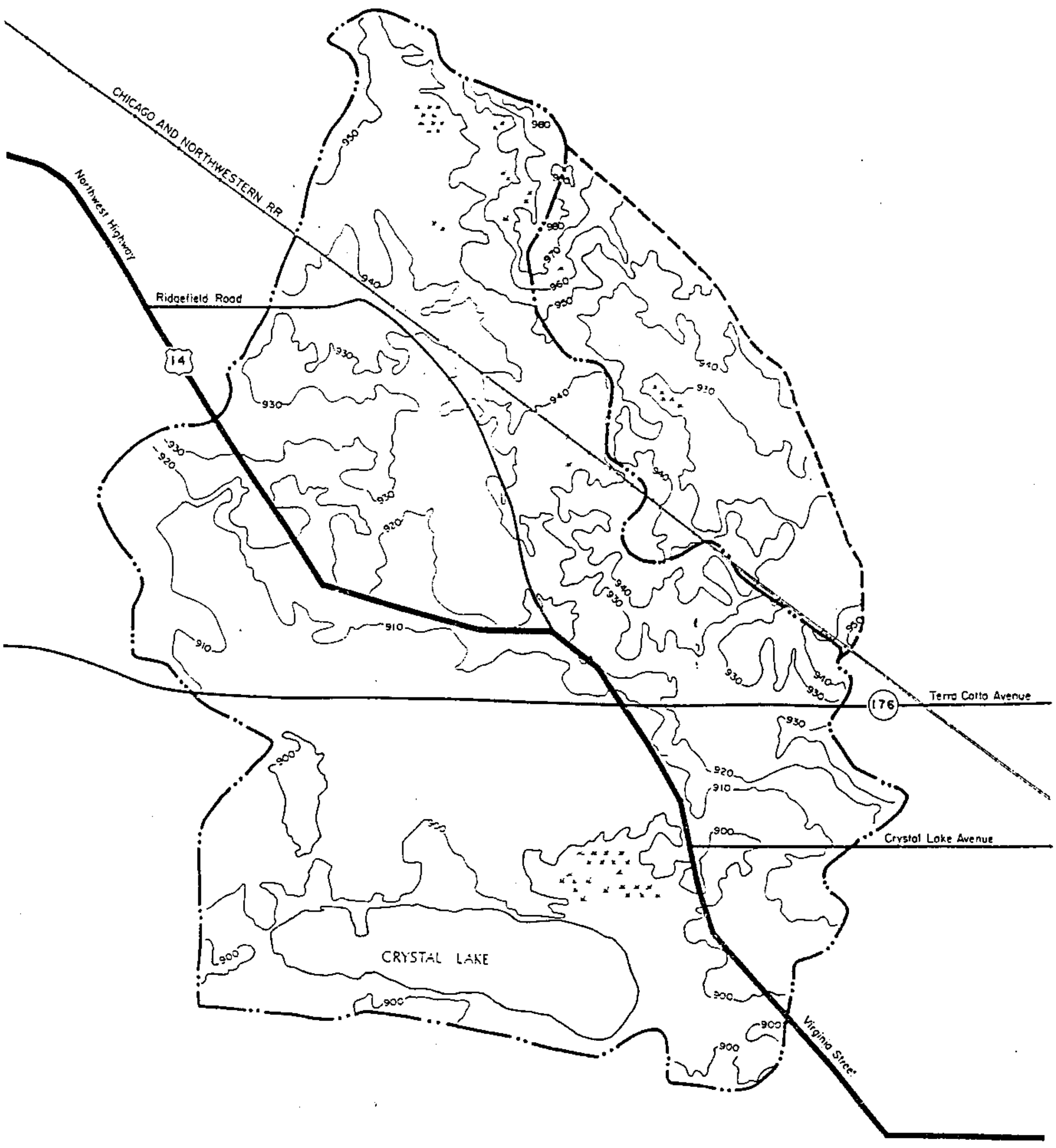
B - wells placed by Bauer Engineering, Inc.
WP - wells placed in prior studies
• location of well
4 depth to water in well
20 — isopleth of depth to water table (feet) for July-Aug 1974 (average of 3 weeks)

The glacial deposits in the Crystal Lake area correlate with a widespread ice advance in Illinois, known as the West Chicago and the Marseilles glacial episodes of the Wisconsinan period. Description of the geological data must be general because the glacial geology of the Crystal Lake area has never been studied in detail. To supplement existing information, well drilling data were used. Locations of the wells are shown in Figure II-3A. The cores of four of the wells, running roughly north to south through the area, were studied to make the cross-section of glacial deposits shown in Figure II-3. The moraine and outwash deposits are evident in both the map and the section, but deposits beneath these are seen only in the section. Both north and south of the lake shore, at depths of 30-35 feet, fine grained till was encountered. It appears that the lake bottom may be situated in these semi-permeable deposits, rather than in the permeable outwash as some earlier reports indicated. Beneath the outwash in the center of the watershed is the Marseilles Till and tills from the Gilberts-Marengo deposits. Both of these are rich in silt and clay.

Topography

One of the most direct effects of the geological history of an area is the form of the land. As is true for the State of Illinois as a whole, the topography of McHenry County and the Crystal Lake area affords little variation. In the watershed area, elevation of the land lies between 890 and 970 feet above sea level (Figure II-4). Land overlying the outwash deposits tends to be very gently sloping -- almost flat. The highest areas, in the northeastern section, are formed on the morainal deposits. The uphill trend of slope is extremely gentle in the south, gradually becoming steeper toward the northeast.

Figure II-4 TOPOGRAPHY



boundary of Crystal Lake watershed
original boundary of watershed

900 elevation in feet above Mean Sea Level
marsh

NORTH

0 1000 2000 3000 4000
Scale in feet

The level outwash areas undulate gently, but in the morainal area the relief is complex, with ridges pitted and contoured by many small depressions and hummocks not evident on the small-scale topographic map (Figure II-2). The demarcation between the outwash and the moraine occurs at approximately 930 feet. The peat and muck deposits are in a depression in the southwestern section bounded by the 900-foot contour. Crystal Lake itself lies below the same contour.

Climate

Climate influences the amount of moisture that the Crystal Lake watershed intercepts from the atmosphere and determines both the absolute and the net amounts of precipitation received. Of the total (absolute) amount of rain falling in the watershed, some is transpired by plants, some is evaporated back into the atmosphere from land and water surfaces. These combined evapo-transpiration losses must be subtracted from total precipitation in estimating net precipitation.

There is no official U.S. Weather Bureau observation station at Crystal Lake. Weather conditions registered at the station at Marengo, 13 miles west of Crystal Lake, were chosen as most nearly representative of the study area.

McHenry County has a continental climate typical of the north-central region of the United States. Temperature variation between summer and winter is great. Rainfall is evently distributed, with a summer (July) maximum. Relatively rapid interchanges of high and low pressure systems, typical in northeastern Illinois, bring frequent, short-period changes in temperature, cloudiness, humidity, and wind direction.

Table II-1 below shows monthly precipitation.

Table II-1

Mean Monthly Temperature at Marengo
1931 - 1960

Month		J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Daily Maximum	(°F)	31	33	43	59	71	81	86	84	76	64	47	34	59
Mean Daily Minimum	(°F)	14	16	25	36	47	57	61	60	52	41	29	18	38
Mean Daily Temp.	(°F)	22.5	24.5	34.0	47.5	59.0	69.0	73.5	72.0	64	52.5	38.0	26.0	48.5

Source: U.S. Weather Bureau Observation Station at Marengo, Illinois, 1931-1960.

Precipitation, averaged on a monthly basis, is shown in Table II-2 below.

Table II-2

Mean Monthly Precipitation at Marengo
1931 - 1960

Month	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Monthly Total (inches)	1.84	1.41	2.31	2.81	3.55	3.89	3.43	3.35	3.13	2.55	2.15	1.81	32.23
Mean Monthly Snowfall (inches)	8.7	6.1	6.3	.8	-	-	-	-	-	T	2.2	7.5	31.6

T = Trace

Source: U.S. Weather Bureau Observation Station at Marengo, Illinois.

Most of the summer precipitation in and around the study area falls during short-duration showers or thunderstorms. Of the thirty-five or forty thunderstorms that occur annually, more than half are in June, July and August. Variations in rainfall amounts have been shown to be correlated with lake fluctuations, as will be discussed later in this report.

In the 30-year record at Crystal Lake the highest annual precipitation was 47 inches in 1972, 14.15 inches more than the average. The lowest annual precipitation was 22 inches in 1946 and 1958, 10.85 inches less than the average. The average annual total is just over 32 inches.

Annual water losses due to evapo-transpiration average 24 to 27 inches in northeastern Illinois. Evapo-transpiration is a complicated phenomenon -- a result of the interactions of precipitation, temperature and vegetation -- that occurs over land. Over water, simply evaporation occurs, and it accounts for the loss of approximately 30 inches a year from the surface of Crystal Lake. The resultant average annual recharge to Crystal Lake can be calculated only by considering the size of the lake (240 acres) and the estimated total groundwater drainage area tributary to the lake (3,200 acres). The appropriate equation gives an annual average recharge flow of 2,144 acre-feet from the tributary drainage area and 41 acre-feet from the lake. The total recharge flow, therefore, is 715 million gallons annually.

The preceeding discussion on climate sets out the basic patterns of atmospheric moisture inputs into the natural system. However, meteorological data is only one of the dynamics in the natural hydrological system in the Crystal Lake drainage basin.

Hydrology

Rainfall is only one of two sources of water for the Crystal Lake drainage basin. The other is the underground aquifers. The hydrological processes discussed below are surface runoff, infiltration, groundwater flow and subsurface drainage.

Net precipitation can enter the hydrological system in two ways. First, if soils and rock strata are relatively impermeable, water concentrates in rivers and stream channels, to flow through the watershed according to the lay of the land. This is known as surface runoff. Second, in more porous and permeable rocks and soils, water percolates through the soil layer and the geological strata until it reaches the surface of saturated strata. This surface is known as the water table. Strata able to absorb the water but allow its subsurface lateral movement are called aquifers. In most areas both processes operate. However, in the Crystal Lake watershed there is very little surface runoff. The generally flat topography, the permeable glacial deposits, and a continuous shallow aquifer mean that most water falling on the watershed infiltrates to the subsurface. For this reason the exact aquifer recharge boundary and the dynamics of the system are obscure. The well-drilling program was undertaken to help clarify these issues.

A watershed is an area in which the surface flows of water, resulting from the topographic configuration of the land, have one point of exit in common. One watershed is separated from another by a ridge of higher land - a watershed divide - which causes different directions of flow and different points of exit. The exit flow to the Crystal Lake watershed is Crystal Creek, which flows out of the southwestern corner of the lake. However, the subsurface sources of the Crystal Lake water supply are obscure, with the exception of an unnamed ditch near the lake's northwestern corner. Although it carries very little surface runoff, the ditch is an outlet for a tile drainage system to be described later in this report. Thus the lake itself is the largest feature of surface runoff in the area. It is approximately 1500 feet wide (north-south) and 6800 feet long (east-west). The surface area varies, depending upon water level, but it is generally about 240 acres.[2/]

Water flows into Crystal Lake are, for the most part, contained in shallow aquifers. It may be expected that the aquifer recharge area is not coterminous with the watershed defined as the surface drainage area in Figure II-2. In the well-drilling program, measurements were made to establish the elevation of the groundwater table at various locations to determine the general direction of subsurface flow.

Measurements of groundwater table elevations were made by gauging the levels of water in the wells on three separate occasions (Table II-3). An average elevation of the groundwater table was obtained, enabling the mapping of its topography. The mapped slopes indicate the directions of subsurface flow; from these, the divides of the aquifer recharge area can be estimated. Contours of the water table elevation, the directions of flow, and the watershed boundary are shown in Figure II-5. It can be seen that the boundaries of the aquifer recharge area and the surface do not coincide, the aquifer boundary being approximately 3,200 acres smaller. Directions of groundwater flow indicate that, to the west of the aquifer recharge boundary, infiltrated water recharges the Kishwaukee River; to the east of the aquifer, water bypasses Crystal Lake, going directly to Crystal Creek.

A rough estimate of the volume of the watershed resources was made by computing precipitation versus evapotranspiration (see Climate). However, determination of the volume of the watershed runoff can best be estimated from stream discharge gauges for which a reasonable period of record exists. The Crystal Lake watershed does not have a recording gauge that measures flow to Crystal Creek, nor is Crystal Creek itself gauged at any point. However, streamflow records are available for a number of neighboring streams. Table II-4 presents the streamflow characteristics for six watersheds in the general regional area. Annual average discharges range from 7.4 to 10.1 inches per year. Based on these streamflows, regional rainfall-evapotranspiration

Table II-3

Groundwater Monitoring Results

Well No.	Ground Surface Elevation (fr. above MSL)	Groundwater Surface Elevation (ft. above MSL)		
		1st wk in July	3rd wk in July	1st wk in August
B-1	857	842	844	841
B-2	963	958	957	954
B-3	928	917	916	916
B-4	925	916	914	914
B-5	942	927	928	927
B-6	909	899	898	898
B-7	907	903	902	902
B-8	904	893	892	892
B-9	900	893	893	893
B-10	900	893	893	893
B-11	900	892	892	892
B-12	900	892	892	891
B-13	943	918	-	-
B-14	928	911	915	914
B-15	922	910	909	909
B-16	905	-	901	900
B-17	902	-	884	885
WP-1	890	886	886	886
WP-2	891	887	887	887
WP-3	896	893	892	891
WP-4	909	900	899	900
Kishwaukee River at Lucas Road		904	904	904
Kishwaukee River at Ballard Road		889	888	888

Figure II-5 GROUNDWATER FLOW PATTERNS

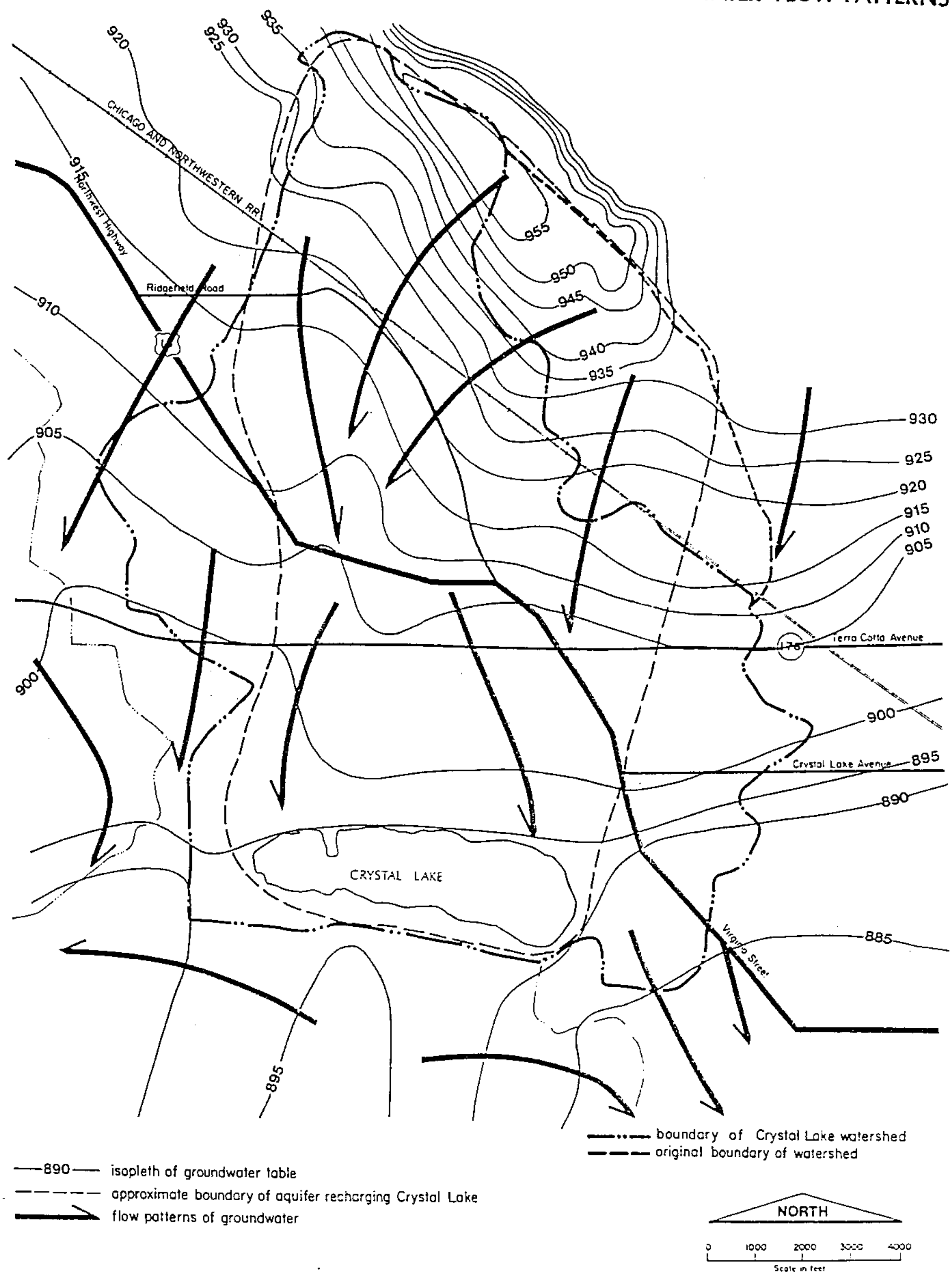


Table II-4

Streamflow Characteristics of Selected Watersheds
Near Crystal Lake in Northeastern Illinois (since 1940)

Watershed & Gaging Station	Drainage Area (sq.mi.)	Col.1 Ave. Flow (in/yr)	Col.2 Low Flow (in/yr)	Col.3 5-Yr Low Flow (in/yr)	Col.4 Col.1-Col.2 (in/yr)	Col.5 Col.1-Col.3 (in/yr)
Kishwaukee R. at Belvidere	525	7.5	2.7	6.4	4.8	1.1
South Branch Kishwaukee R. at Fairdale	386	7.7	2.3	6.3	5.4	1.4
Rock River at Rockton	6,290	7.9	4.3	7.1	3.6	0.8
Boone Creek near McHenry	15.3	10.1	6.0	9.3	4.1	0.8
Salt Creek near Arlington Hts.	32.5	9.4	2.8	-	6.6	-
Fox River at Algonquin	1,364	7.4	1.8	6.1	5.6	1.3
	Average	8.3			5.0	1.1

conditions, and the permeable soil conditions in the Crystal Lake watershed, a runoff figure of 8.0 inches per year was determined, which will be used for the purposes of this study. This figure may be subject to considerable error; to facilitate future work on the hydrology of the lake, it may be advisable to install a stream discharge gauge at Crystal Creek's outflow point from Crystal Lake.

Groundwater is seen to be the major source of water feeding Crystal Lake; but, as mentioned above, rainfall may not be the sole supply of groundwater recharge in the area. In certain situations, rock strata may come to the surface, receive rainfall recharge in one area, and conduct the water by underground flow to a different area, thereby providing a subsurface supply of water obtained from another watershed. The well-drilling program has clarified the sources of water supply to Crystal Lake.

Four major aquifér systems underlie northeastern Illinois. The shallowest aquifer is found in the glacial material and represents the groundwater flows discussed above. The older, solid bedrock strata that underly the glacial drift house three aquifer systems: the shallow bedrock aquifer (Silurian), the deep bedrock aquifer (Ordovician-Cambrian), and the deeper bedrock aquifer (Lower Cambrian).

The shallow glacial drift aquifer is recharged by local precipitation and provides recharge supplies to Crystal Lake. The results of the monitoring and the well-drilling program have provided new information on the characteristics of the aquifer. Drill holes just north of Crystal Lake encountered a thick section of sand and gravel down to about 35 feet. To the south of the lake, sand and gravel were encountered to depths of approximately 25 feet. These sand and gravel deposits are part of the West Chicago-Marseilles outwash described earlier.

Of significance is that both to the north and south of the lake fine-grained material -- clay and silt, with some gravels -- was encountered at depths of 30-35 feet. The material is apparently till. If, as it appears, the till is continuous below the lake at these depths, the lake bottom may be situated in these semi-permeable materials, rather than in the more permeable outwash that earlier reports indicated. Such a condition means that more groundwater movement will occur through the sides of the lake than through its bottom. In addition, this clay layer isolates the shallow aquifer, recharged by local precipitation, from the deeper bedrock aquifer. Thus it can be concluded that the Silurian bedrock aquifer, which is the first or shallowest bedrock aquifer, is recharged from precipitation falling in areas away from the Crystal Lake watershed and does not itself supply recharge to the lake.

The sand and gravel outwash deposits that comprise the shallow aquifer range in thickness from 25 to 35 feet; Table II-5 summarizes the estimated characteristics and dimensions. The total volume of water held in storage represents the equivalent of one year's recharge from average rainfall conditions.

Table II-5
Shallow Aquifer Characteristics

Characteristic	Value
Volume	4.0×10^9 ft.^{3}
Porosity (voids)	25%
Water Holding Volume	1.0×10^9 ft.^{3}
Water available in storage (May, 1974)	0.25×10^9 ft.^{3}
Hydraulic gradient (slope)	.004
Permeability	36 ft/day
Time of groundwater flow from farthest part of aquifer away from Crystal Lake	approximately 400 days

The shallow bedrock aquifer is found in Silurian dolomite directly underlying the glacial drift. Its fissured nature makes it a good aquifer; it presently serves as the major water supply of the City of Crystal Lake and surrounding development. Wells developed in these strata are capable of yielding water at the rate of up to 1000 gallons per minute. However, the yield is not consistent throughout the aquifer and is controlled by the number of fractures and solution cavities in the formation.3/

The deep bedrock aquifer is composed of two systems. The upper system is found in the Galena-Platteville dolomite of Ordovician age and the lower is in Cambrian sandstones Franconia and Ironton-Galesville formations. The latter of these is the most productive aquifer; the others have small to moderate yields.

The deeper bedrock aquifers have been pumped for many years and are found in sandstones of the Mt. Simon formation of lower Cambrian age. Wells with yields exceeding 700 gpm are not uncommon.4/

Based on total pumpage in 1962, the contribution of each source is 11 percent from glacial drift wells, 37 percent from shallow dolomite wells, and 52 percent from deep sandstone wells. Leakage from the shallow dolomite aquifers constitutes approximately one-fourth of the pumpage from deep sandstone wells.5/

In summary, the hydrology of the Crystal Lake watershed is characterized by subsurface drainage in the shallow aquifer in glacial drift. The system is recharged by a local net rainfall of about 8.0 inches per year. The subsurface water recharge area of 3,200 acres is somewhat smaller than the surface watershed. A clay layer separates the shallow glacial drift aquifer from the shallow bedrock aquifer, the latter receiving recharge outside the Crystal Lake watershed.

Lake recharge flows can be calculated as follows. An 8-inch watershed recharge rate during average years for the 3,200-acre watershed recharge area represents a total potential annual inflow to Crystal Lake of 700 million gallons. An additional 15 million gallons comes from the excessive rainfall reaching the surface of the lake over the evaporation that occurs from the lake surface. As will be explained in the next chapter, construction of the Crystal Lake Drainage District tile system may have increased the total drainage area tributary to the lake by 500 acres. Such an addition would increase average annual recharge flows to approximately 800 million gallons. Because the total fall of the lake at normal surface elevation is approximately 1,000 million gallons, the water in the lake is replaced approximately once every 1.25 years. This is a relatively modest rate, but not an uncommon one. It does present, however, a need for careful management of pollutant loadings. An 800 million gallon average annual flow represents an equivalent daily flow average of 2.2 million gallons. Discharge of this flow from Crystal Lake occurs via two or more separate routes. When lake surface levels are normal, a large portion of the total outflow is discharged through the outlet weir to Crystal Creek. Some flow also escapes to Crystal Creek via the sandy subsurface materials that border the lake to the south and southeast. Flow may also escape via the groundwater route to the Kishwaukee River. It is believed that a major fraction of total outflow occurs via groundwater outflow, as evidenced by the fact that during dry periods the lake elevation is below the spillway and hence no direct overflow discharge to Crystal Creek occurs. Groundwater and excess lake surface evaporation must, therefore, release the watershed inflow, which would, under drought conditions, still constitute at least 50 percent of normal recharge levels.

Soils

Soil, a mixture of inorganic geologic materials and organic matter supplied by vegetative decay, represents a thin layer developed on top of the geological underpinnings of an area. Soil is the basis of the terrestrial life-support system. Soil development is a slow process, dependent upon the nature of the parent geological materials, the climate, the depth of the groundwater table, and the type of vegetation present.

The relatively small study area contains a wide variety of soils,[6/] which are mapped and described completely in Appendix A. For the purposes of this report, five categories were established.

One soil property identified above is the nature of the parent materials. Soils with a high clay or silt content (small particle size) allow only slow percolation of water; sandy or gravelly (large particle size) soils allow rapid infiltration to the groundwater supply.

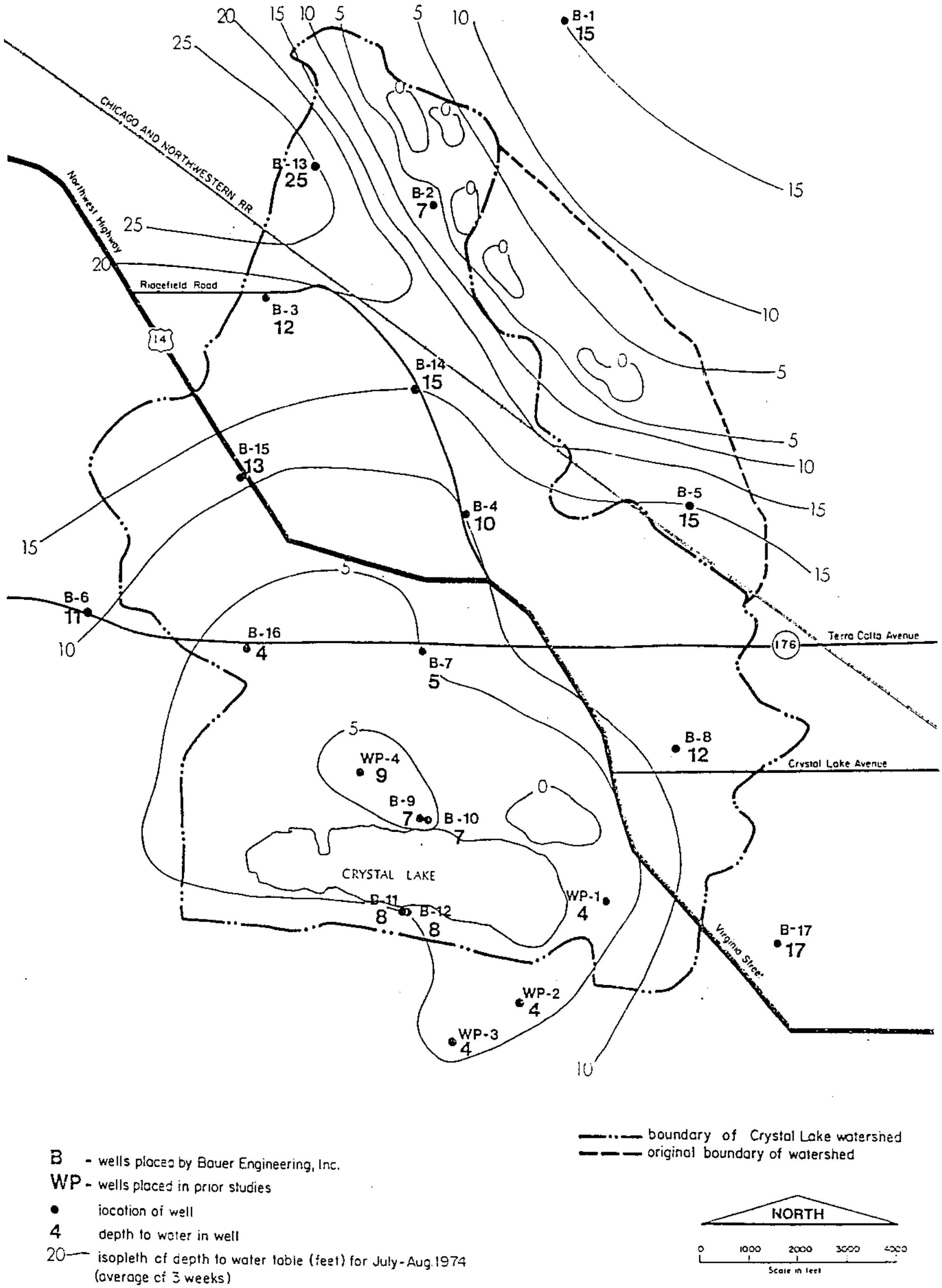
Outwash and moraine, the major deposits directly underlying the watershed, supply a different parent material for soil development. The outwash, which tends to sand and gravel materials, allows the development of a porous soil. However, occasionally lenses of clay are formed in the outwash; on these, tighter, less porous soils will develop. Where moraine is the parent material, a great variety of soil types are found. Because moraine contains silt, clay, sand and gravel, both porous and non-porous soils develop. Peat and muck, representing a small portion of glacial deposits in the watershed, give rise to incompletely formed soils that are difficult to distinguish from the deposits on which they are formed. Because these deposits are composed largely of decayed vegetation, the resultant soils have very little mineral content and extremely high organic levels. The soils are, in fact, highly porous, but because they occur in low-lying depressions are almost always wet.

A second component used to develop the soil categories is depth of the water table beneath the soil surface. The resultant drainage properties of the soil depend upon this factor as well as upon inherent qualities due to parent material.

By using the topographic may (Figure II-4) and the elevations of the water table (Table II-5), the depth of the water table could be calculated for each well location. Figure II-6 shows these locations in relation to contours indicating generalized depth to water table throughout the study area. Around Crystal Lake the water table is shallow; it comes to the surface as standing water in the lake itself and in a marsh area on the northeastern shore of the lake. In the northwestern corner of the watershed, the land rises. Although it would seem that the water table would be deeper here, in fact it becomes shallow and, again, occurs as standing water in various marshy pockets.

The depth to water table is instrumental in soil drainage. A high water table may impede drainage in a soil with good potential permeability. The outwash deposits, for example, tend to make for porous, permeable soils, but in the southern portion of the watershed, near the lake, the high water table results in poorly drained soils.

Figure II-6 WELL LOCATIONS AND DEPTH TO WATER TABLE



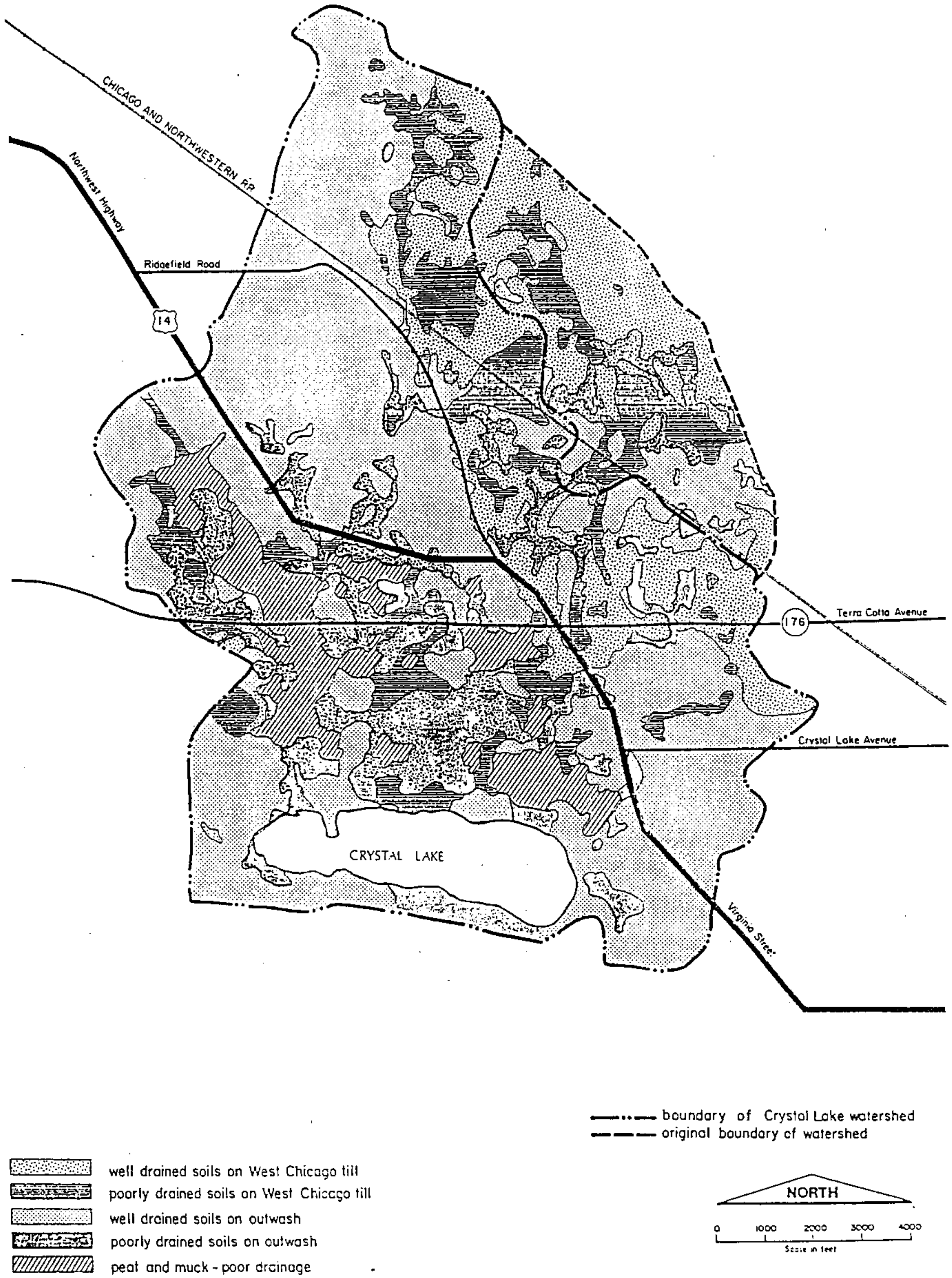
On the basis of the above criteria, the soils were grouped into the following categories:

Soil Category	Percent of Study Area
1. Well to moderately well drained soils on West Chicago till (moraine).	16 percent
2. Very poorly, poorly and imperfectly drained soils on West Chicago till (moraine).	12 percent
3. Well to moderately well drained soils on outwash.	54 percent
4. Very poorly, poorly and imperfectly drained soils on outwash.	13 percent
5. Peat and muck - very poorly drained.	5 percent

Figure II-7 shows the distribution of these soil categories.

1. Well to moderately well drained soils (on West Chicago till moraine). There may be some local deposits of clay in the till parent material, but it is generally sandier than typical tills. These soils are so permeable that water moves quickly through them to recharge the aquifers; there may be little time and opportunity for the soil to purify the waters. The potential for contamination of the groundwater supply by concentrated sources of pollutants is therefore considerable.

Figure II-7 SOIL MANAGEMENT UNITS



Management policies should protect these areas from land uses that could create such a hazard. The fact that these soils are located in the morainal country may counteract their good vertical drainage because the slopes and steeper areas may allow lateral drainage to occur. The high water table in this area may be a further impediment to vertical drainage. The implications are especially severe for domestic septic tank absorption field systems.

2. Very poorly, poorly and imperfectly drained soils on West Chicago till (moraine). These soils are found in association with the well drained soils described above, being of the same parent material. They are, with the exception of the peat and muck areas, the most poorly drained soils in the watershed. Local deposits of clay are more frequent in this category and the potential for aquifer recharge, and, therefore, contamination, is minimal. The high water table in this area is a prime contributor to the drainage problems of these soils.

3. Well to moderately well drained soils on outwash. These soils are generally located in the western, and to a lesser extent, southeastern sections of the Crystal Lake watershed. The sand and gravel nature of the parent material makes these the soils with the greatest infiltration rates. Thus they hold the greatest potential for groundwater recharge and the greatest danger of groundwater contamination. In the southern area of the watershed, the high water table negates the inherent drainage advantages of these soils.

4. Very poorly, poorly, and imprefectly drained soils on outwash. This unit consists primarily of scattered areas in the outwash that are locally underlain by clay. The unusually sandy nature of the till deposits

previously discussed gives these soils, even though they are on outwash, relatively less potential than well-drained soils on moraine for aquifer recharge and contamination. Because of the relatively flat topography, water on the surface tends to pond and remain for some time after a storm -- a condition which is aggravated in areas of high water table.

5. Peat and muck. These soils are derived from partly decomposed vegetation, such as sedges, reeds, and rushes, and some mineral matter that accumulated in poorly-drained depressions in post-glacial time. The topographic positions of these soils and the fact that some of the areas contain water for most or all of the year indicate the presence of a high groundwater table. Surface drainage may also accumulate in these areas. They occur mainly in level or depressional areas, though may occasionally be found on slopes where the soil is kept saturated by lateral drainage. Undrained areas generally remain as natural marshes. These highly organic soils are capable of holding a great deal of water and, in doing so, expanding their bulk. When the soil is drained and dried, it may shrink. This presents danger for construction.

Glacial materials tend to produce fertile soils and all of the soils in the study area have agricultural potential. However, some soils on slopes need protection from erosion, perhaps by permanent forest cover.

Natural Vegetation, Wildlife and Amenities

Over a hundred years of farming in McHenry County has replaced most of the natural vegetation. In some areas, however, the natural vegetation rests undisturbed, in others a natural oak-hickory forest has regrown in unfarmed fields. The areas of natural vegetation and the wildlife that finds sanctuary there are clues to the original ecosystem of the area. As such, they are valuable natural study areas. Preserving the scenic variety of the landscape and the rural character of the community should also be considered when formulating watershed management policies.

Field inspections of the watershed revealed four unique areas: (1) a marsh-wetland, (2) an oak-hickory forest, (3) an open oak-hickory woodlot, and (4) Crystal Lake itself. Figure II-8 locates areas 1, 2, and 3.

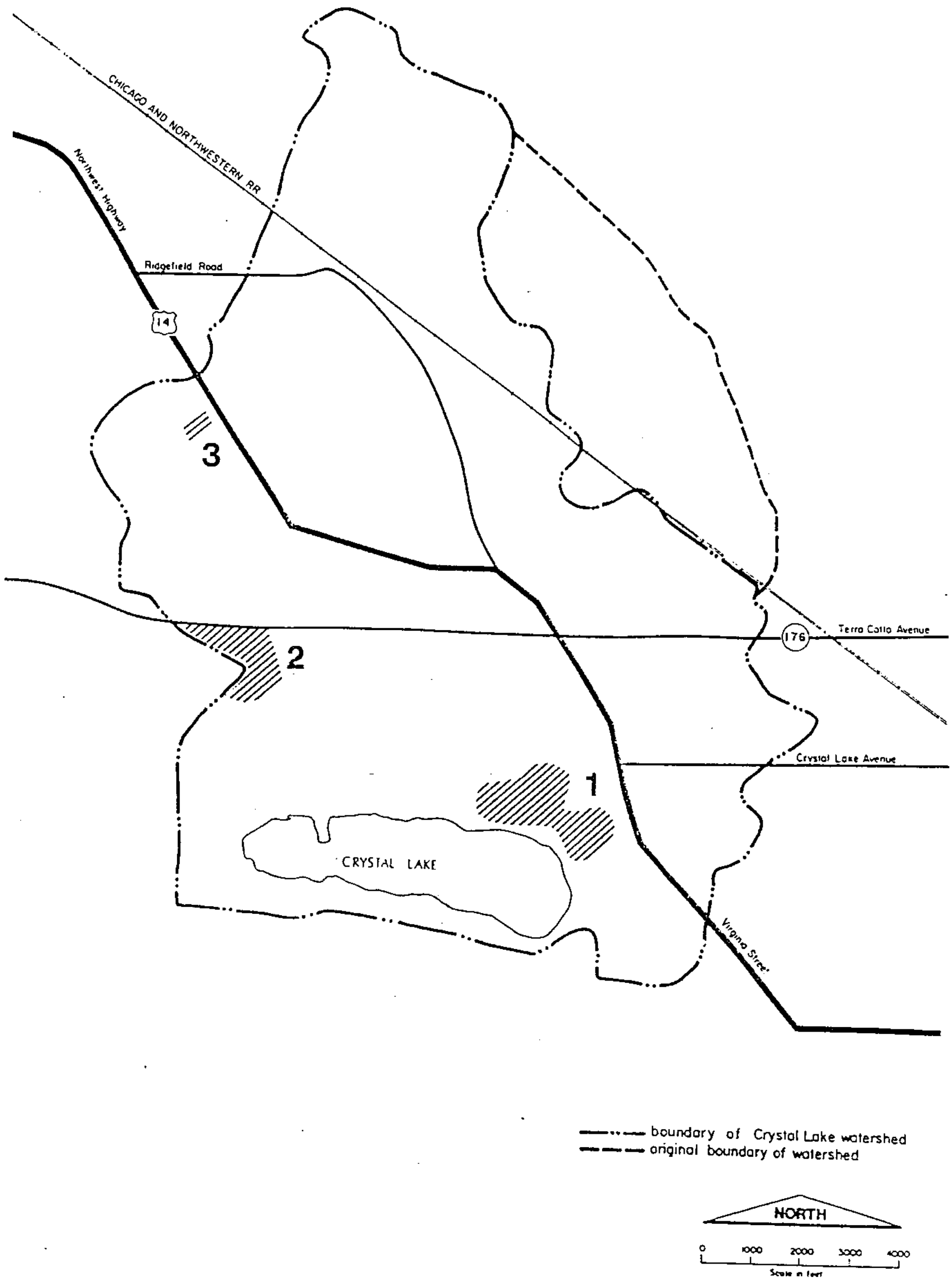
(1) Marsh-wetland Area

Wetlands stabilize storm runoff by retaining it until the ground is capable of absorbing it. They function as fire breaks, and as outdoor laboratories for students and scientists, while providing a habitat for waterfowl and wildlife. The 100-acre marsh in the watershed is the only true wetland ecosystem within the study area -- a fact in itself justifying its preservation.

The dominant grass is reed canary grass. Great bulrushes (sedges), cattails, weeping willows, cottonwood, quaking aspen, and box elder are also present. Pheasants, red wing blackbirds, marsh wrens, goldfinches, chicken sparrows, and an occasional muskrat inhabits the marsh.

The area north of North Shore Drive appears drier than the southern portion, suggesting a difference in water table level or drainage conditions. Although the box elder suggest that the natural succession of species has been disturbed, the entire area represents a fairly good marsh environment worthy of preservation.

Figure II-8 NATURAL AREAS



(2) Oak-hickory Forest

Hickory and willow trees are interspersed among an abundance of oaks -- black, red and pin. The forest has a good understory, including cherry and members of the rose family. Some sumac around the margins of the stand suggest disturbance, but basically this is a good example of a mature forest. It should be protected.

(3) Open Woodlot of Oak-hickory Type

This site is predominantly oak, with some shag bark hickory. The lot is mature, with some oaks over 100 years old. As there is no significant understory, the trees grow without competition. The maturity and stability of the site make it valuable; it should remain undisturbed.

(4) Crystal Lake

Crystal Lake and the marsh-lagoon at its northeastern corner are good habitats for fish and waterfowl. Sport fishing is generally considered good, with bass and northern pike the most common catches. The lake was last stocked in October, 1968, when, according to the Illinois Division of Fisheries, fish included: large-mouth bass, rock bass, white crappie, northern pike, war-mouth bass, yellow perch, pumpkinseed sunfish, black and yellow bullhead, white sucker, northern brook silver sides, blunt nose minnow, banded killfish, golden shiner, and carp.

The remaining wooded areas in the watershed are predominantly scattered trees clusteredaround residences and farm houses. No natural prairies remain. Some small wet depressions support cattails and sedges, adding interest and diversity to the landscape.

Blue-winged teal, greenwinged teal, mallards, coots, and wood ducks are the most common watershed fowl. At times, tintails, Canada geese, black duck, canvas back, and scaup may also be present.[7/]

Within Nunda Township is a large resident deer population. Most are concentrated in the wooded areas around the northeastern boundary of the watershed and farther east, outside of the study area.

To the west of the watershed's northern tip are the remains of a large natural marsh. The surrounding area contains muskrat and beaver.[8/]

Crystal Lake residents want to retain the region's rural and natural flavor -- from the rolling agricultural fields to the hills and slopes of the northeastern morainal region. Development decisions should be in accordance with this work.

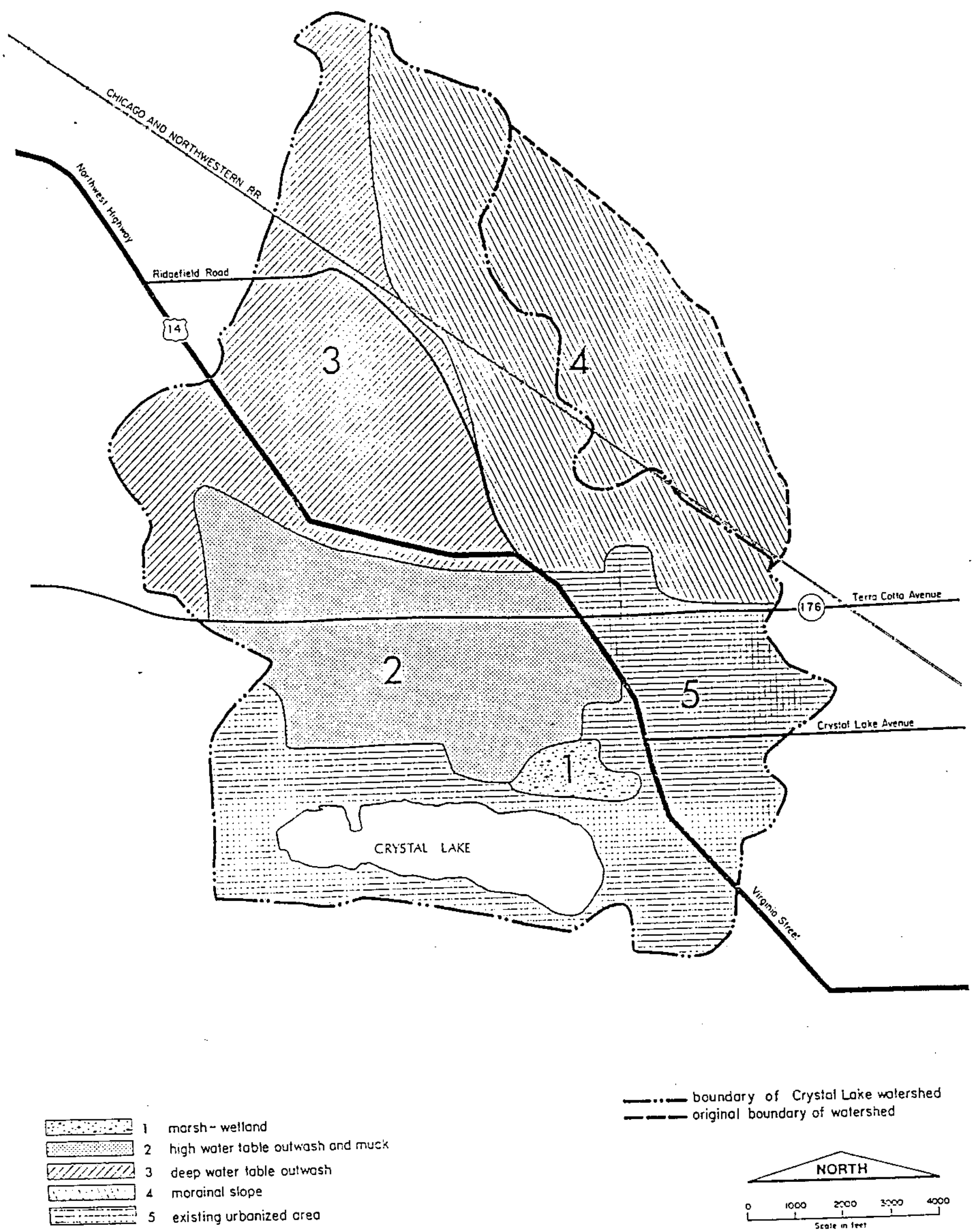
Environment Management Units

On the basis of the foregoing discussion of the various environmental elements -- geology, topography, climate, hydrology, soils, natural vegetation and wildlife -- five environmental units were determined. These are watershed subareas where natural elements fall together to produce a series of criteria that demand similar management techniques. The five units are (1) marsh-wetland area, (2) high water table outwash area, (3) low water table outwash area, (4) morainal slope area, and (5) existing urbanized area (Figure II-9).

Marsh-Wetland

This area is located on the outwash deposits, but it is low-lying, in a depression below 900 feet close to the lake. Here the water table

Figure II-9 ENVIRONMENTAL MANAGEMENT AREAS



is so high it reaches the surface, producing standing water and creating marsh conditions. Muck soils with high organic content have developed. The area acts as an overspill of the lake. Drainage is not advisable because the concommitant disturbances to the watershed hydrology would be severe. The organic soil is unsuitable for construction, because it shrinks and swells with moisture variations. Thus, the marsh-wetland, although valuable for its wildlife and plants, has little merit for development. It should be managed as a natural area.

High Water Table Outwash

This area, occupying the southwestern and south central areas of the watershed, is underlain by outwash and, in the western section, peat and muck deposits. Topographically the land is level to very gently sloping; the area lies below 910 feet. The muck deposits have produced organic soils; the low-lying land encourages these areas to remain wet. The height of the water table (generally shallower than five feet) impedes drainage through the outwash; even potentially well-drained outwash soils tend to be water-logged. Drainage is seriously impeded on soils developed on outwash that includes clays. Such soil drainage problems are most highly developed to the south of Terra Cotta Avenue. Between Terra Cotta Avenue and Route 14 are some areas of limited soil, but because the groundwater table is deeper, the conditions are less serious, particularly along Route 14. The natural vegetation and rural landscapes reinforce the advisable management choice: open space acquisition or continued agricultural use.

Deep Water Table Outwash

Outwash deposits are combined with gently sloping land in this northwestern and central area of the watershed. The land lies approximately below the 930-foot contour, except in the extreme north where it rises to above 940 feet. Water table depths, ranging from approximately 25 to 15 feet, allow optimum infiltration on the typically well-drained outwash soils. The soils are so permeable and porous that there may be too little time for the natural filter of the soil to remove impurities. This area offers controlled developmental opportunities. The soils are not suited for septic tanks and their rapid infiltration -- threatening the groundwater -- is a development hazard.

Morainal Slope Area

The topography of the morainal area reflects the highly-variable deposits. A ridge landform, rising above the 970-foot contour, is pocked with depressions and hummocks. The water table tends to be high, especially at the top of the ridge; standing water occurs in several small depressions. From the diverse glacial materials have developed a variety of soils. Those developed on the sand or gravel components of the till are well drained. Others are poorly drained clay soils. Soil drainage problems occur in the depressional areas. This highly diverse area should be developed with great care. Generalization is difficult; each section should be examined, separately should development be a possibility.

Existing Urbanized Area

The remainder of the watershed has already been urbanized. Specific recommendations for its management are made in Chapter V.

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[1]Sasman, Robert T., The Water Level Problem at Crystal Lake, Mc Henry County. Urbana: Illinois State Water Survey, 1957.

[2]Ibid p. 7.

[3]Csallany, Sandor and Walton, W.C., Yields of Shallow Dolomite Wells in Northern Illinois: Illinois Water Survey Report Inv. 46. Urbana: Illinois State Water Survey, 1963, p. 4.

[4]Walton, W.C. and Csallany, Sandor, Yields of Deep Sandshore Wells in Northern Illinois: Illinois Water Survey Report Inv. 43. Urbana: Illinois State Water Survey, 1962, p.7.

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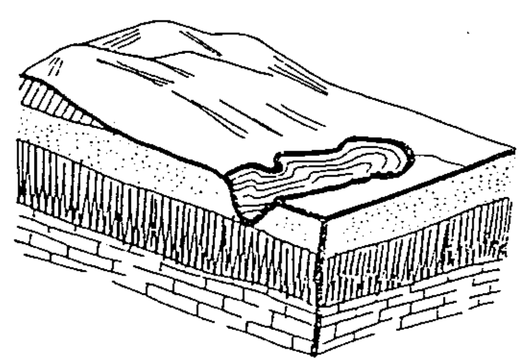
[7]Mr. Tom Kwak, Mc Henry County District Biologist, Illinois Department of Conservation, personal communication, August 14, 1974.

[8]Mr. Kenneth V. Fiske, Executive Director, Mc Henry County Conservation District, personal communication, June 18, 1974.

Chapter III

WATER RESOURCE MANAGEMENT CONDITIONS



CHAPTER III

WATER RESOURCE MANAGEMENT CONDITIONS

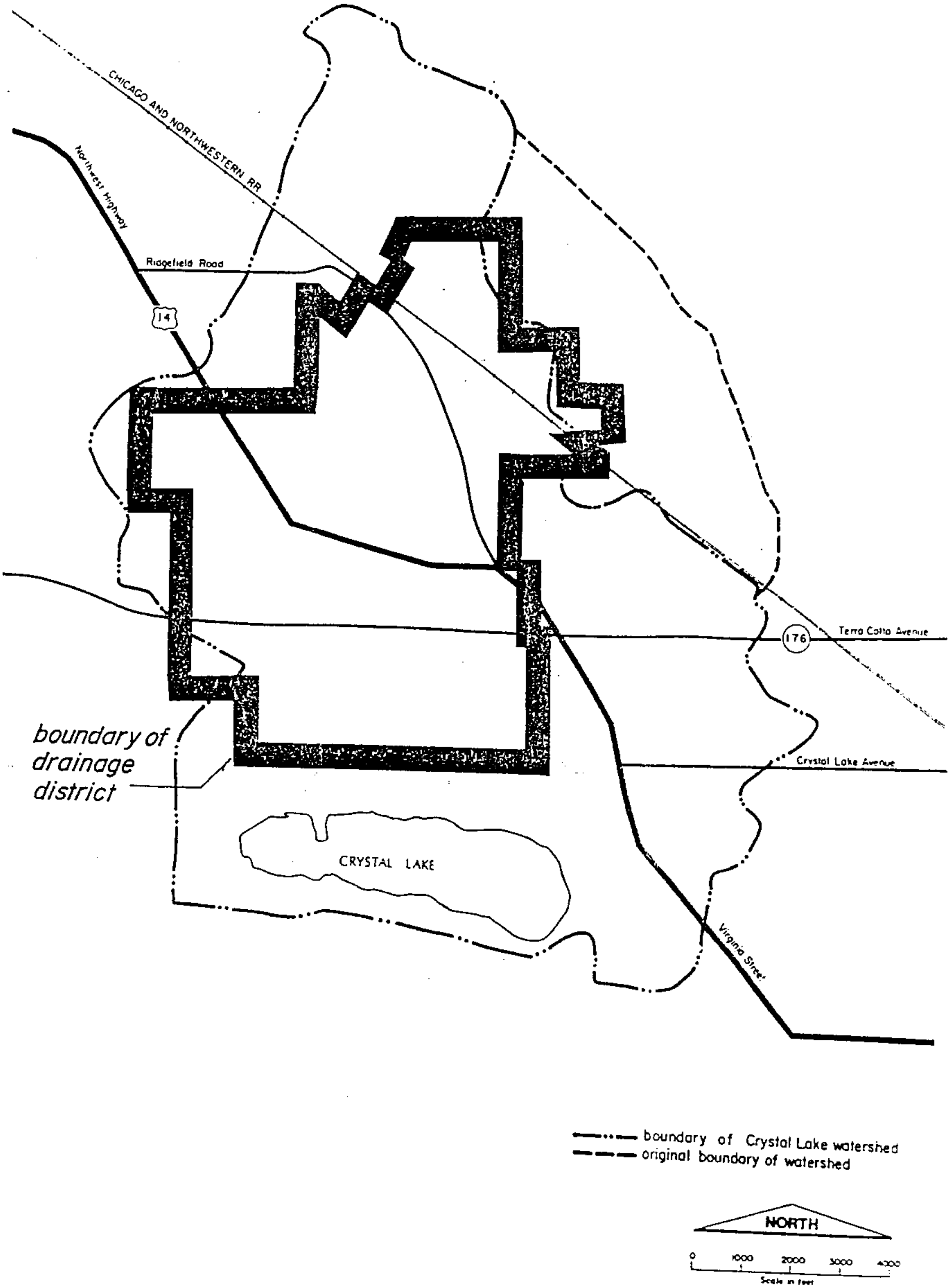
This chapter addresses two considerations that affect and are affected by water resource management decisions in Crystal Lake -- water quantity and quality. Each characteristic is discussed independently as it relates to both the natural and man-made states of the watershed.

Watershed Adjustments

Man has altered the natural recharge and hydraulic characteristics of the Crystal Lake watershed. The first adjustment was a farm tile drainage system created in 1917 by the Crystal Lake Drainage District. The system, shown in Figure III-1, drains an area of about 1,300 acres and has increased the rate of groundwater flow to Crystal Lake. The service area of the District, however, extends beyond the natural groundwater divide, and has also increased the area tributary to the lake by 500 acres. The drainage system also affects water quality, as will be discussed later in this chapter.

Surface and subsurface tile outlets, constructed to improve drainage in the northeastern part of the watershed, are a second significant adjustment. These outlets allow some of the natural recharge flows from a 585-acre area along the watershed's north-eastern edge to be diverted out of the drainage basin to the east (see Figure II-2). The total amount of flow lost from this diversion is unknown. It is apparent, however, that the indiscriminate whittling away of the natural recharge areas by actions designed to alleviate local drainage problems can lead to disastrous consequences.

Figure III-1 CRYSTAL LAKE DRAINAGE DISTRI(



Lake Level Fluctuations

Annual fluctuations in the elevation of Crystal Lake are of great concern to lake-users. Recorded variations range from a low of 887 feet to a high of 891 feet. The study conducted by the Illinois Water Survey[1/] after a period of low lake levels in the mid-1950s reported a strong correlation between precipitation deficiencies and lake surface decline. This study observed that the known low water periods of 1925, 1934, 1940 and 1949 occurred during periods of deficient rainfall. Figure III-2 depicts this relationship. Fluctuations in lake surface elevation between 1940 and the present are graphed on Figure III-3 for those years when the lake level was below the spillway elevation.

When lake levels are above the spillway, the added factor of discharge rate over the weir must be considered. This would tend to change the slope of the straight-line correlation between lake level fluctuation and precipitation. The conclusion drawn from these date is that lake level drop is a direct result of precipitation deficiency.

Crystal Lake has no recording gauge. Some lake outflow is lost as underflow. Thus, an analysis of runoff conditions at measured gauging stations for other regional watersheds during the dry years in Crystal Lake provides the basis for developing a quantitative relationship between runoff variations and annual precipitation. This information provides an approximation of the quantitative relationship between annual aquifer recharge to Crystal Lake and lake surface elevations. Figure III-4 presents the relationship, which shows the effect of precipitation deficiencies on runoff conditions for the six gauged watersheds shown previously in Table II-4. Figure III-5 presents

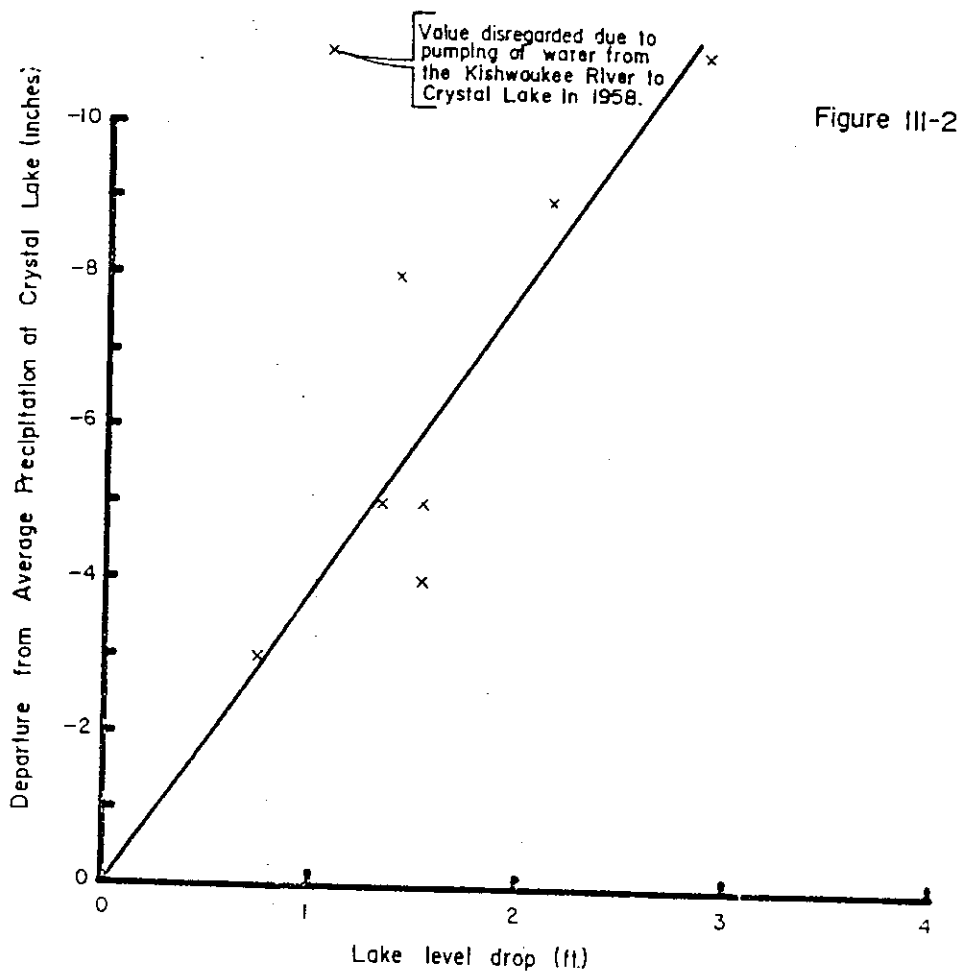
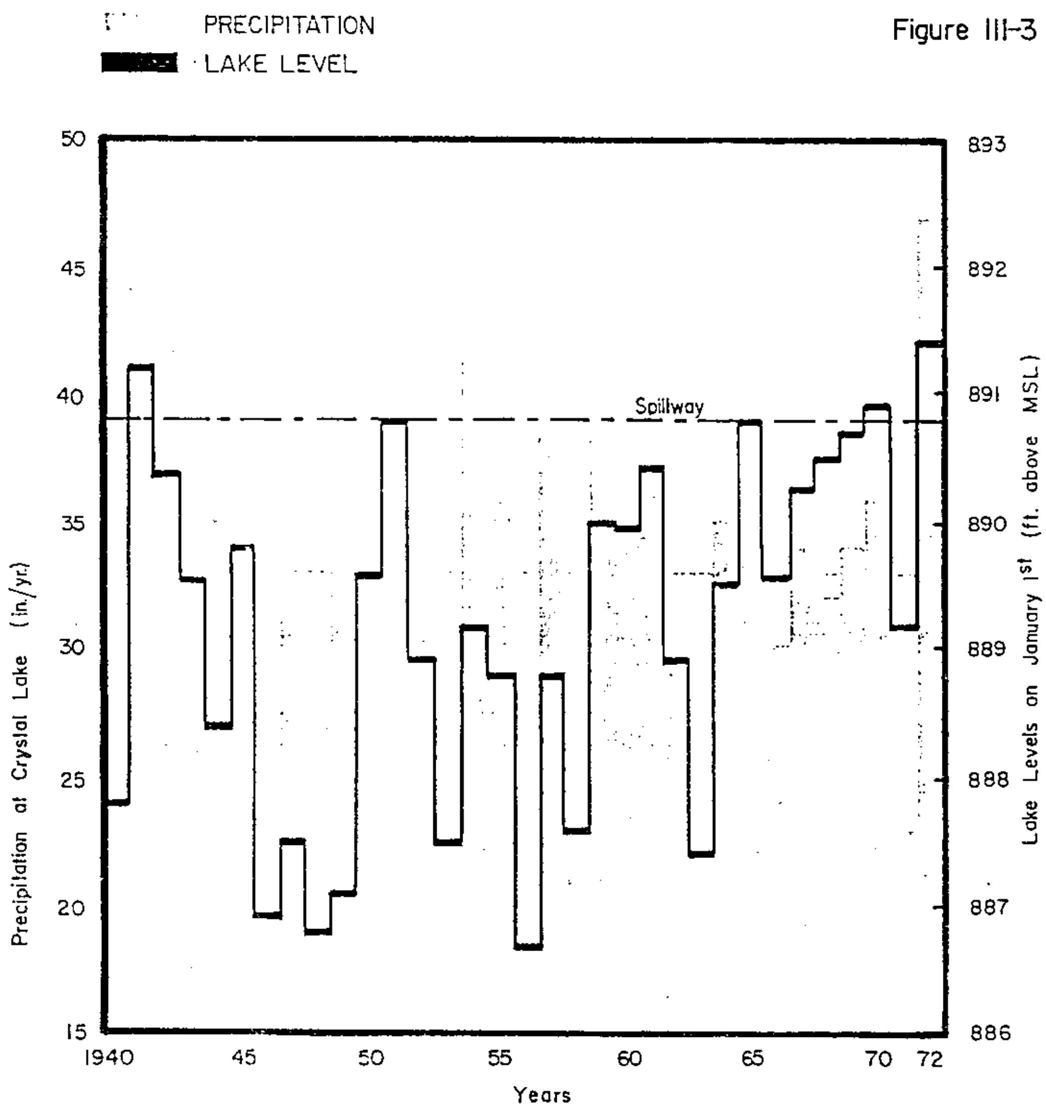


Figure III-2

EFFECT OF DEFICIENCY IN PRECIPITATION ON CRYSTAL LAKE SURFACE LEVELS BELOW SPILLWAY ELEVATIONS

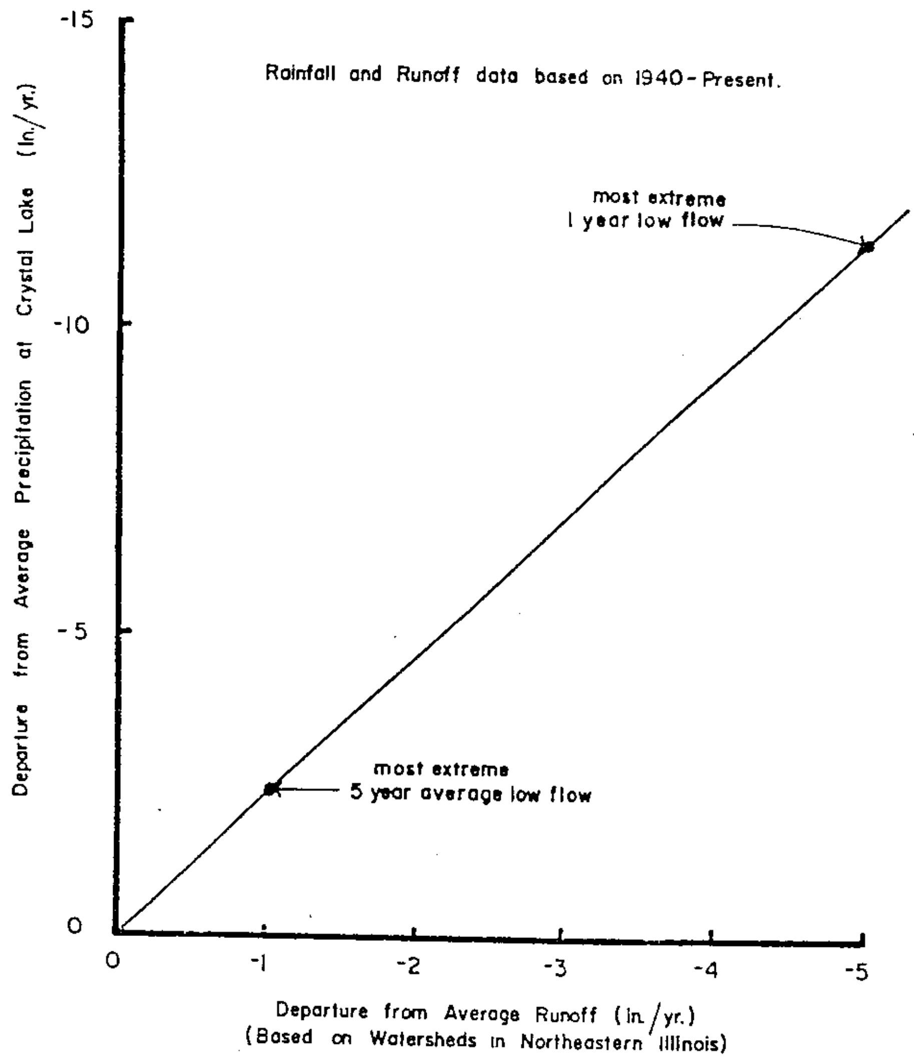
YEAR	DEPARTURE FROM AVERAGE RAINFALL	LAKE LEVEL DROP (FT.)
1944	-5"	1.3
1946	-11"	2.9
1948	-3"	0.7
1954	-8"	1.4
1956	-9"	2.1
1958	-11"	1.0
1962	-4"	1.5
1963	-5"	1.5

Figure III-3



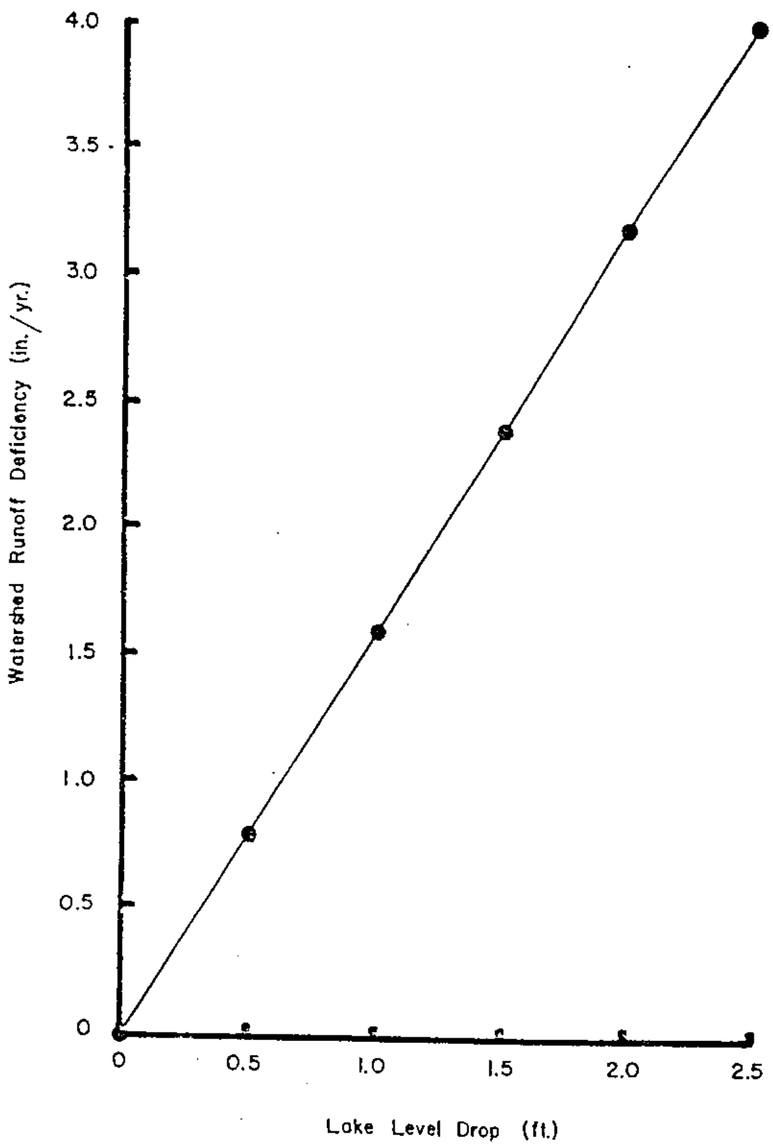
ANNUAL LAKE LEVEL FLUCTUATIONS
FOR CRYSTAL LAKE

Figure III-4



EFFECT OF DEFICIENCY
IN PRECIPITATION ON RUNOFF

Figure III-5



ESTIMATED RELATIONSHIP BETWEEN
WATER RUNOFF DEFICIENCY
AND LAKE LEVEL ELEVATION

an estimated relationship for Crystal Lake surface elevation declines as a function of runoff deficiencies from the normal level of eight inches per year.

The lake surface-lake recharge relationship is important to watershed management decisions, because diversion of wastewater derived from shallow aquifer supplies, from sewer infiltration and from stormwater collection and diversion can reduce recharge flows by an equal amount. A runoff deficiency of one inch (12 percent of normal flow) would reduce lake surface levels by 0.7 feet; a four-inch deficiency would reduce the level by 2.5 feet. For the 3,700-acre groundwater recharge area, deficiencies of one inch and 4 inches are equivalent to 100 and 400 gallons per year, respectively. An annual flow of 100 million gallons represents the water usage and wastewater discharge of 2,800 people. It is quite apparent that urban resource management decisions that do not protect watershed flows can seriously affect water levels in Crystal Lake.

Impacts of Urban Utilities On Hydrological System

Aquifer recharge deficiency is a major determinant of lake level drop. It is not the only one. With urban development have come facilities for water supply, sanitary wastewater, and stormwater drainage. The impacts of these municipal utilities -- their effects on the natural hydrological system and their implications for future growth-related utilities decisions -- are discussed below.

Water Supply

Of the more than 18,000 persons living in the study area, approximately 15,000 receive water from the City of Crystal Lake municipal water supply. In 1973, water usage was 603 million gallons[2/]; 14 percent of this was used by industry.[3/] Net combined commercial and residential water consumption was 1.43 million gallons per day. Thu per capita consumption for 1973 computes to nearly 100 gallons daily.

The City of Crystal Lake draws all of its municipal water supply from wells drilled into the dolomite bedrock aquifer. Because, as was discussed previously, this aquifer is recharged from areas away from the Crystal Lake watershed, recharge to Crystal Lake is not affected.

The total available treated water supply capacity for the Crystal Lake municipal system in 1975 will be 5.6 mgd.[4/] In cases where the largest city well is out of service, water supply capacity will still be 3.5 mgd.[5/] This should serve the normal domestic needs of more than 20,000 persons.

Individual wells furnish water for the remaining 3,000 people in the watershed. Most of these wells draw from the shallow glacial aquifer, and serve the rural areas. Urbanized areas with shallow wells include Ridgefield, Crystal Vista northwest of the lake, the residential estates in the northeast corner of the watershed, a mobile home park on Country Club Road, the North Shore Homes, and approximately 50 homes in Lakewood. Applying the per capita consumptic rate derived from municipal users, the total water usage from the shallow wells is estimated to be 0.2 to 0.3 mgd.

McHenry County College, presently under construction along U.S. 14 near Lucas Road, will be supplied by wells finished in bedrock.

The ultimate water usage at this facility is expected to be no more than .05 mgd.[6/]

Figure III-6 shows the areas served by each type of water supply source; water usage quantities are contained in Table III-1. From the table it is apparent that the shallow local aquifer that recharges Crystal Lake is not used appreciably for water supply. Because most areas that pump from the shallow aquifer also use septic tank sewage disposal systems, little water is diverted from the watershed due to water supply and wastewater facilities.

Compared with other parts of the Chicago metropolitan area, southeastern McHenry County makes relatively slight withdrawals from the dolomite regional bedrock aquifer. Available information indicates that this aquifer can furnish considerable, yet undetermined, additional supplies in the future. Water supply is therefore not a basis for limiting development in the foreseeable future if the bedrock aquifer is used.

Sanitary Wastewater Systems

Nearly every residence or business in the study area that is served by the municipal water supply system hooks up to the municipal sanitary sewer system, which serves both Crystal Lake and Lakewood residences. Fifty homes in Lakewood are excepted, having sanitary sewers but private wells. Figure III-6 located the areas served by particular wastewater systems; Table III-1 presented their estimated discharges. North Shore homes, Ridgefield, Crystal Vista, the mobile home park, residential estates and rural areas discharge through septic systems. For the total watershed area, septic system discharges total

Figure III-6 WATER MANAGEMENT UTILITIES

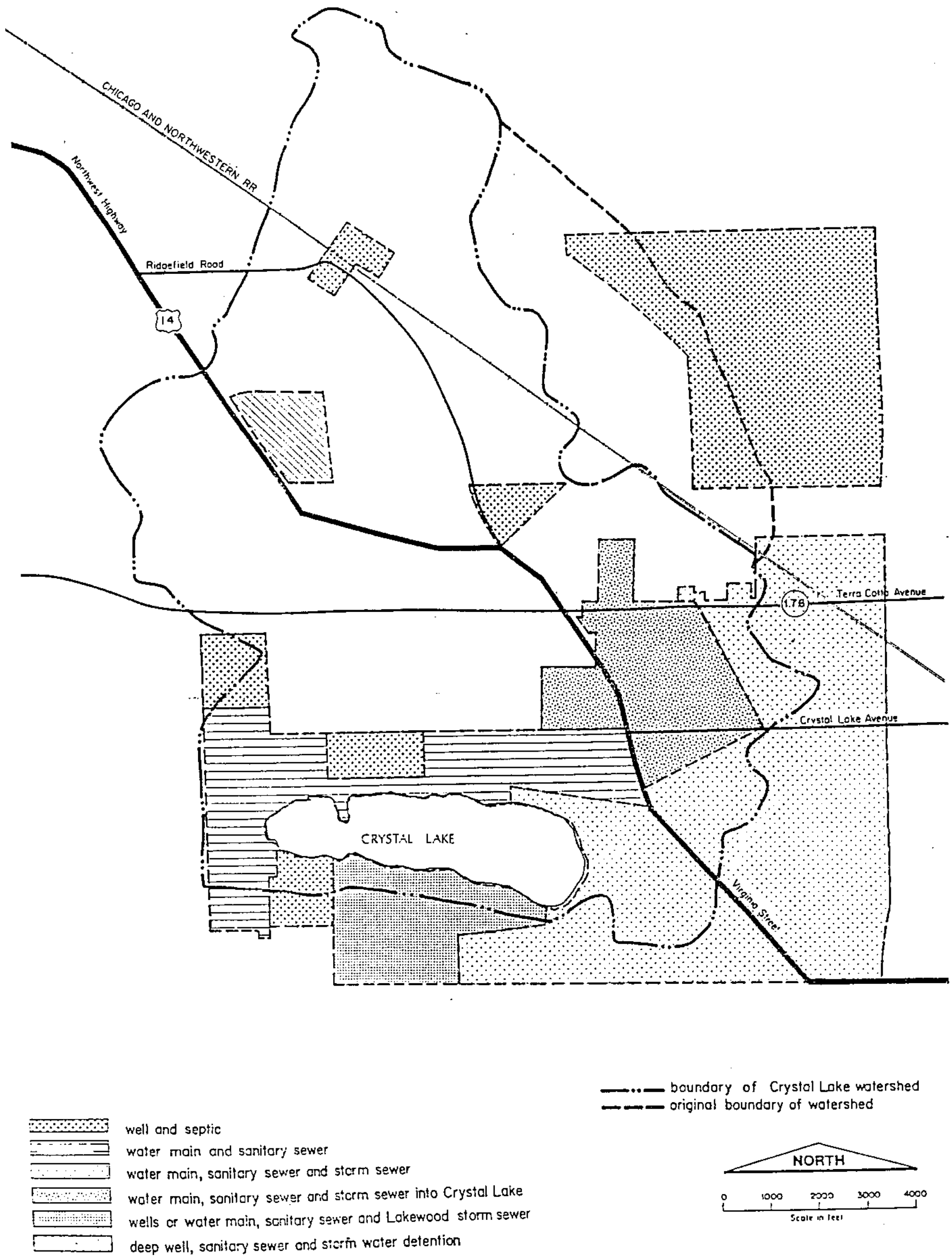


Table III-1

Inventory of Present Water Usage

and Sanitary Wastewater Discharges

Area	Water Supply (MGD) Municipal[a]	Water Supply (MGD) Private Well	Wastewater (MGD) Sewers[b]	Wastewater (MGD) Septic
Crystal Lake (total)	1.43	-	2.90	-
Shallow aquifer	-	.07	-	0.15
Lakewood (total)	.075	.015	.09	-
Shallow aquifer		.005		-
North Shore Homes	-	.04	-	.04
(Crystal Vista)	-	.01	-	.01
Ridgefield	-	.01	-	.01
Mobile Home Park	-	.02	-	.02
Residential Estates in NE (total)	-	.08	-	.08
Shallow aquifer	-	.02	-	(.02)
Rural	-	.01	-	.01
TOTAL	1.43	.25	2.9	.32
Total using shallow aquifer		.19		.24

[a] City of Crystal Lake dolomite bedrock aquifer supply

[b] City of Crystal Lake sewage treatment collection and treatment system

only about 0.24 mgd. From May, 1973 to May, 1974 the average metered flow in the Crystal Lake sewage treatment plant was 2.9 mgd.[7/] The quantity of wastewater discharged locally within the watershed recharge area is, therefore, extremely small compared with that conducted in the Crystal Lake collection system and discharged to Crystal Creek downstream of Crystal Lake.

Groundwater and stormwater infiltration represent a major portion of the wastewater collection system annual flows. Based on the difference between annual water supply pumpage (619 million gallons) and total annual wastewater treatment plant flows (1055 million gallons), total infiltration is estimated at 431 million gallons per year, or roughly 43 percent of the total flow. This difference represents an average equivalent daily flow of 1.2 million gallons.

Not all of this infiltration affects the groundwater flow into Crystal Lake. Presently not more than five percent of the units serviced by sanitary sewer system are within the watershed recharge area. Assuming an areal proportional relationship, it can be estimated that (.05 x 1.2 =).06 might be lost through sanitary sewers. After sanitary sewers now under construction in the City along the north shore of the lake are completed, infiltration into sanitary sewers may increase somewhat. Future expansion of sewer service to new areas could lead to significant watershed recharge loss.

Stormwater Drainage

Stormwater drainage will be considered separately for urban and rural areas. Most of the Crystal Lake watershed area is rural (approximately 68 percent). Due to the natural percolative capacity of the soils, surface drainage facilities are minimal. Field surveys with less than 24 hours after large rains and interviews with local resident confirm that streamflow runoff in the watershed is negligible. While a very small percentage of rainfall ponds in low depressional areas, nearly all rainfall not lost through evapotranspiration infiltrates into the soil. A portion of this infiltrated water reappears when it is discharged through the 24-inch tile outlet from the Crystal Lake Drainage District near the northwest corner of the lake. The remainde. of the infiltrated water is used to recharge the shallow groundwater aquifer.

The maximum discharge rate through the Drainage District tile outlet is 1 mgd. Community residents have noted that occassionally, dur very large rains, water attempting to flow out the tile has backed up, flooding agricultrual lands and overtopping streets in the North Shore area. This flood water then flowed directly overland to the lake, damaging some homes.

The urbanized portion of the watershed drains to the lake by both conventional storm sewers and surface runoff from a thin strip of developed area bordering the lake. Figure III-6 also showed the areas served by storm sewers. Most of the City of Crystal Lake and the Vill of Lakewood have storm sewers that discharge to Crystal Creek downstr of the lake.

One outlet from the Crystal Lake storm sewer system flows directly into a bog northeast of the lake, draining 200 acres of urban residential land. The developed area that drains directly to the lake through surface drainage is estimated at 70 acres. At present, very little of the watershed is served by storm sewers that divert stormwater away from the lake. However, this situation could change as additional areas urbanize.

Future decisions on stormwater system design pose a serious technical dilemma: when stormwater is diverted downstream around the lake, the total volume of potential recharge water is lessened; when stormwater drainage is emptied into the lake, water quality may be affected. Storm sewer flows from typical urbanized areas can represent up to half of the total watershed runoff from these areas. Extended to a large portion of the watershed, the impact on lake recharge would be devastating. The other dimension -- stormwater quality -- is equally threatening to the lake water quality. This is discussed in the following section.

Water Quality Management

In the past, more residents were concerned with protecting lake levels and flows than with water quality, because lake levels problems are readily evident, engendering intense public reaction. Water quality degradation is a gradual process; with time, lake users forget how clean the waters once were. The problem of water quality is, nonetheless, equally important.

Water Quality Studies

Relevant baseline data for water quality or the sources of inflow to Crystal Lake are sparse. Historical data have largely been restricted to bacteriological and grass chemical analyses. These are not relevant in assessing the lake's critical water quality problem - the inflow and accumulation of nutrients, which accelerates the process of eutrophication.

A comprehensive program of water quality analyses was undertaken in 1973 and 1974 by the NALCO Chemical Company under a study contract with the Crystal Lake Park District. Various lake locations were sampled monthly; the influent surface waters were analysed for chemical, nutrient, physical, and biological conditions. The intent of the study was to develop baseline water quality data on the lake and to identify existing problems. Appendix C summarizes the NALCO study results.

As part of the Crystal Lake Watershed Study, Bauer Engineering conducted analyses of groundwater quality. The purpose was twofold: to identify possible difference in quality conditions for different land use areas, and to serve as a basis for estimating the contribution to the lake of nutrients present in the groundwater flow. The results of this work are presented in Appendix C and are discussed in the sections of this chapter that address septic tank discharges and watershed nutrient budgets.

One additional source of water quality data is a study of the Crystal Lake Drainage District outlet, conducted by the Illinois EPA in the spring and summer of 1973. A summary of the data obtained in this study is presented in Appendix C. These data are discussed in the agricultural and rural runoff section of this chapter.

Water Quality Conditions

Poor water quality conditions in Crystal Lake are largely associated with increased nutrient enrichment. This increased enrichment -- the net accumulation in the lake ecosystem of phosphorus, nitrogen, and other micro-nutrients -- results from the lake's inability to purge itself of each year's new supply of nutrients. During the summer months, increased enrichment reduces visibility and contributes to the lake's green color -- both caused by increased algal growths. Typically, summer visibility is less than two feet. This is dramatic contrast to the 1836 report by Ziba Beardsley that the lake had, "water clean as crystal."[8/] As the lake clouds, its appeal to users diminishes. Increased nutrient enrichment stimulates the growth of aquatic weeds in shallow areas and interferes with boating and recreation.

Motorboating stirs up sediments on the lake's bottom, contributing to reduced clarity and high suspended solids levels. This is most severe on summer weekends when activity is at its peak. Stirring up these sediments can also lead to an increased solubilization of phosphorus and nitrogen, which will accelerate algal production.

Two types of algae are present in Crystal Lake -- single cell and filamentous (see Appendix C for a description of the specific algae species found in the lake). The single cell algae generally float freely in the water and give the lake its characteristic summer green. Filamentous algae often grow attached to shoreline areas and docks, appearing as concentrated masses floating on the lake's surface.

Algal masses, moved by wind and waves, create acute localized nuisances. As these massed decompose, odors develop and oxygen is depleted, which can kill fish and other aquatic life. In the past, winds have blown accumulated floating algae onto the Crystal Lake Park District beach, closing the area to bathers.

Algal growth is an annual cyclical process, beginning in early spring after the lake's surface is freed of ice. At this time the lake is well-mixed from bottom to top; nutrients rising from the bottom are in their soluble forms, readily available for synthesis into algal cells. With increasing solar radiation and lake temperatures, algal cells multiply through the process of photosynthesis, which uses up the available nutrients plus carbon dioxide in fixed relationships until one of these basic components is exhausted. The exhausted element then becomes the controlling or limiting factor in algal production. In a particular aquatic system any one of the three -- nitrogen, phosphorus, or the carbon supply -- can be the controlling factor.

In the early fall, as solar radiation decreases and lake temperatures decline, the algae begin to die. The dead algae and other aquatic species settle to the bottom of the lake, where they decompose and release their stored nutrients. Turnover of the lake the following spring recirculates the liberated nitrogen and phosphorus throughout its full depth, releasing abundant nutrients for a new cycle of algal growth. The annual recirculation of nutrients stored in the bottom sediments often is significantly greater than the annual inflow of nutrients from the watershed. As a result, significant reductions in annual nutrient additions usually take many years to register observable reductions in algal activity.

Lake Eutrophication

The NALCO study data provide a basis for a general assessment: Crystal Lake is in transition from an oligotrophic (clean water) lake to an eutrophic (nutrient enriched) one. The polluted water algae -- numerous both in species and number -- and the moderately high chlorophyll a concentrations found in the lake, are the bases for this conclusion. Crystal Lake contains a varied algae population typical of clean water lakes. However, most numerous species are those typically found in eutrophic (enriched) waters -- the blue-green algae. Blue-green algae account for 80 percent of the total algae population at all locations in July. In October their concentration is greater than 90 percent.

The chlorophyll a concentration is a measure of algal biomass. The range of mean summer concentration in the higher water levels (epilimnion) can be used as an indicator of trophic stage of a lake: oligotrophic, 0-4 mg chlorophyll a/m^3; eutrophic; 10-100 mg chlorophyll a/m^3.[9/]

Crystal Lake chlorophyll a concentrations ranged from a high of 20 mg/m^3 in May to a low of 2 mg/m^3 in October, with a midsummer concentration of about 5 mg/m^3. It appears that the mean concentration would lie in the transition zone between oligotrophic and eutrophic (sufficient samples were not obtained to compute a valid mean).

Sources of Pollution

Crystal Lake receives nutrients and other contaminants from four basic sources:

1. Discharge of private septic disposal systems
2. Runoff from agricultural and rural areas
3. Stormwater runoff from urbanized areas
4. Atmospheric discharge occurring with rainfall

Because the Crystal Lake sewage treatment plant discharges into Crystal Creek downstream of the lake, municipal wastewater effluent does not contribute to the Crystal Lake water quality problem.

Septic Tank Discharges. Approximately 700 individual septic tank disposal systems operate within the watershed. Some of these -- concentrated along the shoreline on the lake's north side -- have been operating for many years.

If all of the nutrient discharges from septic tanks reached Crystal Lake, a major eutrophication problem would develop. The total phosphorus and nitrogen content of the 700 septic systems amounts to about 7,000 and 28,000 pounds per year, respectively (10 lbs. of phosphorus and 400 lbs. of nitrogen per residence). Fortunately, however, the soil system naturally removes most of these and other constituents in the effluent when the systems are located in proper soils environments.

The results of the groundwater quality monitoring study provide one basis to assess the amount of nutrients that reaches the lake from developed septic tank areas. Table C-4, Appendix C, shows the groundwater concentrations of soluble phosphorus and nitrogen in different watershed areas.

The soluble phosphorus concentrations at different sampling times fluctuate considerably, making meaningful interpretations difficult. The highest phosphorus levels were obtained in the rural watershed.

Presented below are estimated ranges in phosphorus and nitrogen discharging from the watershed to Crystal Lake. The estimates were derived from analysis of the groundwater nutrient data for the local areas where septic systems are concentrated and for the total watershed area using the septic tank land area ratio to the whole.

Total Soluble Phosphorus	40 to 120 lbs. per year (.06 to .18 lbs, per dwelling
Total Nitrate Nitrogen	50 to 550 lbs. per year (.07 to .80 lbs. per dwelling

It must be emphasized that these results are based on a number of gross assumptions and should be used only as order-of-magnitude estimates. Other studies have reported much higher levels of contribution by shoreline septic tank systems near residential lakes.[10/] Measurement of the actual direct contribution of septic disposal systems to Crystal Lake water quality problems is a difficult task, due to the diffuse nature of septic system discharges and the variable performances of individual installations. However, experience shows that where numerous septic installations develop with urbanization of recreation lakes' shorelines, water quality problems associated with increased algae production have materialized. Degradation of Lake Tahoe in California is the classic example.

Agricultural and Rural Runoff. Runoff from undeveloped and agricultural lands is another contributor of nutrients and other pollutants to the lake. Rural runoff pollutant loadings, which usually occurs with surface runoff, are the largest source. However, because the watershed is relatively flat and the soils are moderately to highly permeable, there is little direct surface runoff to surface watercourses. Thus fewer pollutants are conveyed to the lake from rural runoff then in most watersheds.

Contaminants from rural areas reach Crystal Lake principally through the groundwater and the farm drainage system serving the Crystal Lake Drainage District. The District drainage system consists largely of tile underdrains; this surface discharge to this system should be lessened, as most discharges receive the benefit of percolation through the soil. However, a field study of the District drain conducted by the Illinois Environmental Protection Agency in 1973 (see Appendix C) indicated that nutrient discharges varied appreciably, depending on watershed runoff conditions. Significant concentrations of nitrogen and phosphorus were recorded on a number of occasions. Phosphorus levels in particular were significantly high for discharges to a recreational lake: at times 0.5 to 0.30 mg/l.

Samples taken and analyzed by Bauer Engineering during the summer of 1974 (Appendix C, Table C-4) showed typical phosphorus levels of .126 to .152 mg/l in the drainage ditch upstream of the outlet pipe to Crystal Lake. These results compare favorably with the results obtained by the EPA survey. The sampling results indicate that the drain tile effluent frequently exceeds the State of Illinois water quality standard of 0.05 mg/l of phosphorus for surface flows entering recreational lakes.

These results indicate that some direct surface drainage may be reaching the outlet. This could be due to drainage from the sod farm and from possible surface inlets into the tile system at upstream locations. No attempt was made to inspect the condition of the tile drain, but, because of its age, breaks and indiscriminate topping by surface connections are expected.

One area where surface runoff of this drainage outlet may be contaminated is along a shore stretch through the sod farm south of Terra Cotta Avenue. Here the drain has been rebuilt as an open channel. Periodic flooding has been reported; soil erosion and fertilizer washing off from adjacent agricultural land is likely.

Percolation through the soil is the most effective treatment to remove sediments, nutrients (phosphorus and nitrogen), and organic and toxic substances. Under controlled application rates and aerobic soil conditions, the physical, chemical and biological processes of the soil system can remove virtually all of the phosphorus, suspended solids, organic and toxic substances, as well as most of the nitrogen present in land runoff.

As discussed previously, the concentration of selected contaminants determined during the groundwater water quality monitoring study were analyzed to evaluate present watershed runoff pollutant contributions to Crystal Lake. Based on the groundwater sampling data obtained in this study (Appendix C, Table C-4, concentrations of 0.05 mg/l for phosphorus and 1.0 mg/l for nitrogen were estimated as the nutrient groundwater discharges from the rural and agricultural portions of the watershed. For the eight inches of average annual watershed runoff, this represents an annual contribution of 0.10 lbs/acre for phosphorus and 2.0 lbs/acre for nitrogen.

The above nutrient estimate represents a relatively low phosphorus and nitrogen runoff to Crystal Lake from agricultural and rural runoff. By comparison, phosphorus and nitrogen runoff from watersheds with significant direct surface runoff are typically in the range of 0.4 lbs/acre for phosphorus and 6 to 10 lbs/acre for nitrogen. If the low nutrient runoff characteristics of the watershed are to continue, direct surface runoff must be prevented by preserving watershed runoff infiltration conditions.

Urban Stormwater Runoff. Urban runoff as a major source of nutrients and contaminants to lakes and streams only recently has been given adequate attention. There is a growing recognition that the nutrients, sediments and toxic substance in urban runoff must be removed, if the water in urban streams and lakes are to be clean enough for a full range of recreational and aquatic uses.

The sources of urban runoff pollutants include: dust fall, precipitation, leaching from vegetation, street litter, lawn and garden fertilizers, dead vegetation, plus tire wear, gasoline combustion products and motor oil discharge from automotive vehicles.

Studies have shown that a good municipal street sweeping program, where streets are cleaned weekly, removes up to 60 percent of the debris that otherwise would wash from the streets to local waterways during storms. However, even with a good street cleaning program, the level of contaminants that reaches local waterways is unacceptable.

Of the 1,400 urbanized acres in the Crystal Lake watershed, 270 drain directly to the lake through a storm sewers and overland flow. An estimated 20 percent of the urban area is streets and parking. These areas produce most of the direct runoff from storms and are the source of most urban runoff contaminants reaching Crystal Lake.

Extensive studies of pollutant concentrations in urban runoff from various cities around the country are the basis for estimating the amounts of contaminants reaching Crystal Lake. Table III-2 summarizes the average concentration of nutrients observed in each of these studies and estimates the concentrations expected for the Crystal Lake study area. Included are results of a study of runoff quality for discharges from the northeast area storm sewer that flows to Crystal Lake.

Annual stormwater runoff from urbanized portions of the watershed is estimated to be about 20 percent of annual rainfall. For the 33 inches of average annual precipitation, the total runoff per acre would be approximately 180,000 gallons per year. Based on the above runoff estimates, Table III-2 estimates the total annual amounts of nitrogen and phosphorus contributed by surface runoff per urban acre.

Urban runoff that percolates into the ground in pervious areas has greatly-reduced nutrient content, due to the filtering and chemical and biological processes of the soil. As a result, the amounts of nutrients reaching Crystal Lake from groundwater runoff originating in urban areas are relatively insignificant compared with that resulting from surface runoff.

Table III-2

Annual Nutrient Budget for Crystal Lake

Source Area	Unit	Amount Per Unit		Number of Units	Total Amount	
		Phosphorus	Nitrogen		Phosphorus	Nitrogen
Urban Runoff	Acre	0.75	4.5	270	202	1,215
Watershed Groundwater	Acre	0.10	2.0	2,400	240	4,800
Drainage District Tile	Acre	0.20	4.0	1,300	260	5,200
Precipitation	Acre	0.20	8.0	240	48	1,920
Septic Tanks	D.U.	0.18	0.8	700	120	(550)*
			TOTAL		750	13,685

*Appears to be unrealistically low.

Precipitation. Significant concentrations of both phosphorus and nitrogen are present in rainfall. Total annual contributions falling on the surface of Crystal Lake are estimated to be 0.2 lbs. of phosphorus and 8 lbs. of nitrogen per acre of lake surface.

Nutrient Budget

An approximate estimate of the total nutrient loading to Crystal Lake from the various identified sources is presented in Table II-2. Of particular interest in this table is the fact that three sources (urban runoff, watershed groundwater and the drainage district outlet) contribute relatively equal amounts of phosphorus. Septic tanks contribute about half the amount of each of the above sources. However, it must be emphasized that the level of accuracy of the septic tank contributions could be off by as much as 100 percent. Most of nitrogen inflow to the lake is indicated as coming from groundwater and the drainage district outlet.

It would be desirable to estimate the rate at which nutrients are being accumulated in Crystal Lake. But the absence of any reasonable method of estimating lake discharges to Crystal Creek precludes the possibility of estimating nutrient outflow. Consequently, it is impossible at the present time to develop a total nutrient budget.

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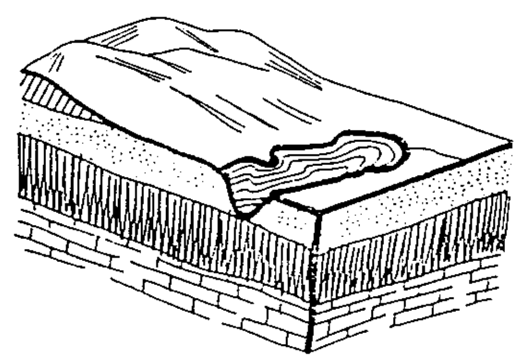
Chapter IV

MANAGEMENT OPPORTUNITIES



CHAPTER IV
MANAGEMENT OPPORTUNITIES

The previous two chapters have attempted to provide insight into the elements of the natural environment and existing watershed conditions, and to assemble data requisite to identification of watershed management needs and to determination of alternatives capable of satisfying those needs. In this chapter the critical needs are identified, after which the applicability and economic efficiency of selected alternative management systems and technologies are reviewed.

Management Needs

The principal watershed management needs made apparent by the study can be divided into two categories for purposes of discussion:

1. Watershed recharge protection
2. Water quality improvement

These are by no means independent. Management choices in one most often have major consequences in the other.

Watershed Recharge Protection

Two facets of watershed recharge must be considered in the management of Crystal Lake. First is the need to conserve present recharge flows, and second is the desire to preserve the natural regulation of lake recharge flow rates arising from the hydrogeologic characteristics of the shallow sand and gravel aquifer. Reduction of flow to the lake could result from some management systems that might be applied to development of the watershed for urban and rural activities. Improperly managed drainage and sanitary sewer installations are the two principal threats to be guarded against. Depletion of local water resources often follows expedient introduction of new land uses which bring with them problems and in their train short-sighted "solutions" that solve nothing. In the case of Crystal Lake, loss of natural flow would intensify an already deficient natural recharge of the lake. This in turn would further aggravate periodic water level deficiencies and reduce the rate of hydraulic flow-through that is responsible for purging the lake of nutrient inputs.

Land Use Controls. Protection of recharge conditions to satisfy the dual conservation requirements for total flow and flow rate regulation can only be effectuated through control of land use practices. Present site drainage recharge conditions in the undeveloped portions of the watershed must not be disturbed by excessive conversion of land to impervious surfaces, which require positive surface drainage outlets for storm runoff.

Other utility systems (sanitary sewer and water supply) required by new developments also must be planned, designed and installed so as to be consistent with watershed groundwater preservation standards. The possibilities of excessive infiltration and diversion of water supply withdrawals by sanitary sewer systems are of particular concern. Chapter VI is devoted to the formulation of specific design requirements and site evaluation procedures that will assure compatibility of development proposals.

Fortunately, at least 75 percent of the natural surface drainage watershed recharge area is currently undeveloped or relatively undeveloped for urban uses. The opportunity remains, therefore, to effectively manage most of the watershed recharge area.

For the portion of the watershed that is urbanized, only limited local improvements in recharge conditions are possible. These can be achieved, largely, in individual lots, where site drainage could be managed in such a way that a greater amount of runoff would be stored and infiltrated into the ground. In the storm sewered areas, the opportunity exists of conveying the storm sewer flows to an area where it would be recharged to the ground.

Flow Augmentation. Even with the attainment of watershed recharge conservation, the long-term natural cyclical process of precipitation excesses and deficiencies will lead to periodic problems with lake level maintenance unless outside supplies can be obtained to augment natural recharge conditions during extended drought periods. Flow augmentation during normal precipitation periods would also be beneficial as it would help to increase the nutrient purging capacity of the lake by increasing out-flow to Crystal Creek.

Water Quality Management

The critical water quality management need is limitation of the fertility of Crystal Lake to reduce the excessive growth of algae and other aquatic vegetation. There must be a diminution of available nutrients present in the photic zone (region where photosynthetic activity takes place) of the lake at the time of year when this activity takes place. Phosphorus and nitrogen are the principal nutrients to be controlled. Even after renewal of nutrient supplies is suppressed, the nutrients accumulated in the past will still circulate internally and may have to be purged or immobilized to permit rapid recovery of water quality. Experiences with a number of eutrophic lakes where influent nutrient sources have been drastically reduced indicate that ten or more years may be required for significant improvement in water quality.

Water Quality Criteria. Present watershed nutrient discharges to Crystal Lake exceed levels that can be safely assimilated without occurrence of nuisance conditions and accelerated eutrophication. Phosphorus and nitrogen concentrations in surface and subsurface flows into the lake should be reduced to the following levels:

<u>Phosphorus:</u> Total combined organic and soluble concentrations should be less than 0.05 mg/l and preferably as low as 0.01 mg/l.

<u>Nitrogen:</u> Total concentration in all forms should be less than 1.0 mg/l and as close to 0.1 mg/l as possible.

Present nitrogen and phosphorus concentrations in the tile drain and storm sewer flows exceed the maximum tolerable concentration levels by a factor of about 2 to 1. Present groundwater concentrations are about at the maximum acceptable level.

Crystal Lake has a mean depth of 7.5 meters. Its annual phosphorus loading is 0.11 g/m^2 and its annual nitrogen loading is 6.4 g/m^2. These loadings are in excess of the permissible loadings for nitrogen and phosphorus as determined by Vollenweider in his study of thirty lakes (see Table IV-1). Studies by Sawyer[1/] of seventeen lakes indicate that if, at the time of spring overturn, concentrations of inorganic phosphorus and nitrogen exceed 0.01 and 0.3 mg/l, respectively, a lake may be expected to produce excessive growths of nuisance algae. The discharge criteria proposed for Crystal Lake appear to be stringent enough to protect the lake water quality.

<u>Source Reduction.</u> Reduction of nutrient influx will require attention to the principal existing sources, which include:

Table IV-1

Specific Nutrient Loading Levels for Lakes[a]

Mean Depth up to:	Permissible Loading, up to:		Dangerous Loading in Excess of:	
	N	P	N	P
5 m	1.0	0.07	2.0	0.13
10 m	1.5	0.10	3.0	0.20
50 m	4.0	0.25	8.0	0.50
100 m	6.0	0.40	12.0	0.80
150 m	7.5	0.50	15.0	1.00
200 m	9.0	0.60	18.0	1.20

(Expressed as Total Nitrogen and Total Phosphorus in $g/m^2/yr$)

[a] R.A. Vollenweider, Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Organ. for Econ. Co-operation and Dev., Dir. for Sci. Aff., Paris, France, 1968.

1. The agricultural drain
2. The City's storm sewer
3. Shoreline septic tanks
4. Watershed non-point sources contributing to groundwater contamination

Other efforts are required to prevent the emergence of new sources of nutrients or expansion of existing sources.

In-Lake Nutrient Reduction. A program to reduce the accumulated available nutrients in the lake's bio-system is required if significant improvements in water quality are to be achieved within the immediate future. The present high level of nutrient enrichment and the poor nutrient outflow dynamics of the lake leave no escape from such measures. Periodic removal or immobilization of in-lake nutrients may be necessary if inflow of nutrients from the watershed cannot be reduced to acceptable levels.

Management Alternatives

Management choices for dealing with the water quality management needs of Crystal Lake fall into three categorical action areas:

1. Point of origin (on-site) controls
2. Lake influent treatment
3. In-lake controls

As indicated previously, the reasonable alternatives for dealing with the quantity and dynamics of recharge flows are largely limited to local area land use and drainage management techniques. The one exception is the possibility of flow augmentation from outside water supply sources.

Point of Origin Controls

Techniques that can be employed to reduce nutrient discharges from watershed land use activities include the following:

- reduction in frequency and amounts of surface stormwater discharges
- improved erosion control practices
- better housekeeping practices (frequent street sweeping and proper private property maintenance)
- improved practices of lawn fertilizer use (use of smaller amounts and slow release varieties)
- selection of agricultural crops with low erosion and nutrient leaching potential
- controlled use of fertilizers on agricultural soils
- elimination of septic tank discharges

All of the above controls should be considered as elements of a comprehensive program to reduce nutrient discharge from watershed land use activities.

Land Influent Treatment

Point sources of flow (the agricultural drain and storm sewer discharges) are subject to possible treatment before discharge to the lake. Various kinds of physical-chemical or biological systems are possible candidates for the job. Specific systems that could be considered are:

- a physical-chemical treatment plant using lime precipitation and filtration for phosphorus and sediment reduction
- a land treatment system using irrigation or overland flow system to remove phosphorus, nitrogen and sediment
- a lagoon-marsh natural treatment system to remove nitrogen, phosphorus and sediment

For the Crystal Lake situation, the land treatment and lagoon-marsh systems offer the greatest potential for a number of reasons.

First, the low concentrations of allowable nutrients in the effluent cannot be achieved with available physical-chemical plants but can be with the other two systems. Second, land treatment and marsh-lagoon systems are less expensive to construct and operate than physical-chemical systems and can be integrated readily into the open space program for the area immediately north of the lake. Both land treatment[2/] and special natural biological systems such as the lagoon-marsh[3/] techniques are being given widespread attention at the present time due to their high performance and low cost.

In-Lake Controls

A number of schemes have been developed to limit the availability of nutrients already present in the Crystal Lake ecosystem. Although lake sediments appear to be the key source of nutrients within eutrophic lakes, the complex nutrient pathways are poorly understood. Nevertheless, numerous in-lake control techniques have been aimed at sediments, the water and the biota itself. Used alone, these techniques provide rapid but usually only temporary relief from the effects of overfertilization. Among the possible technqiues are: dredging for nutrient control, nutrient inactivation/precipitation, dilution/flushing, biotic harvesting, selective discharge, sediment exposure and desiccation, lake bottom sealing.[4/]

Dredging for Nutrient Control

Because lake sediments are an important potential nutrient sources, the removal of these sediments can in many cases reverse or retard eutrophication. This has happened in shallow lakes burdened with man-made sediments such as long-term sewage inflows. In some cases, the side effects of dredging outweigh the advantages. This is true in cases where agitation of bottom sediments increase the rate of nutrient release drastically or where return waters from the dredge spoils carry a high nutrient load.

Nutrient Inactivation/Precipitation

Nutrient inactivation can be accomplished by changing the form of a nutrient to make it unavailable to plants, removing the nutrient from the photic zone, or preventing the release or recycling of potentially available nutrients within the lake. Nutrient inactivation is most readily accomplsihed at this time by limiting the availability of phosphorus. Various combinations of sorption, precipitation, and physical entrapment of soluble phosphorus forms can do the job. Precipitation and removal of suspended solids reduces nutrient levels as well. Agents utilized for sorption or coagulation include metal ion additives (iron, aluminum), ion exchange resins, zeolities, polyelectrolytes, aerobic lake mud, flyash, powdered cement and clay.

Dilution/Flushing

This technique reduces nutrient levels by replacing nutrient-rich waters with nutrient-poor waters and flushing out phytoplankton. Nutrient dilution has been attempted using two procedures: (1) pumping water out of the lake to allow nutrient-poor water to enter and (2) routing additional nutrient-poor waters into the lake. The first technique was utilized at Snake Lake, Wisconsin, where pumped water was disposed of at a land disposal site; the water eventually cleansed itself and returned to the groundwater system. Three pitfalls of this technique must be avoided, however; the dilution water must have a lower concentration of the limiting nutrient than the original water, or must be deficient enough in another nutrient to create a nutrient-deficient environment, or must be so employed as not to leach nutrients from bottom deposits back into the lake.

Biotic Harvesting

A significant amount of nutrients in a lake are tied up in plants and animals. Significant reductions in nutrient levels can be achieved by the systematic harvesting of the plant and animal life. At present, algae are best removed with strainers, although in the Snake Lake project the land treatment system filtered out algae. Macrophytes (aquatic plants) may be harvested as well, although the overall utility of doing so is at present inconclusive. Fish are another nutrient harvesting agent, and initial studies indicate that fish harvesting could produce a significant reduction of nutrients. In general, however, little conclusive work has been done to verify the theoretical significance of biotic harvesting.

Selective Discharge

This technique increases the amount of dissolved oxygen throughout a lake and/or increased nutrient outputs from a lake by releasing anaerobic, nutrient-rich waters from the thermocline or hypolimnion of the lake. This is done through outlet controls or the use of pipes extended to the bottom of the lake. However, these selective discharge techniques can cause oxygen sag downstream unless reaeration is provided for the effluent.

Sediment Exposure and Desiccation

Reservoir drawdown exposes nutrient-rich sediments and can subsequently reduce the sediment oxygen demand and increase the oxidation state of the surface layer, thereby retarding the movement of phosphorus from the sediments. Nutrient release may also be curbed by the physical stabilization of the upper flocculent zone of sediments. However, agricultural studies indicate that lake sediment desiccation can accelerate microbial conversion of nutrients from organic to inorganic forms. Final resolution of this inconsistency remains in the future.

Lake Bottom Sealing

Instead of removing nutrient-rich sediments from a lake, it is possible to suppress the transport of nutrients from the sediments to the lake waters by physically retarding exchange or by increasing the capacity of the sediments to hold the nutrients. Available for this purpose are a variety of bottom coverings ranging from plastic sheeting and rubber liners to types of mineral soil coverings including sand, flyash, clays, hydrous metal oxides and gels.

Flow Augmentation

Flow augmentation during drought and normal precipitation periods can produce significant water quality and lake level stabilization benefits as discussed previously. Alternative sources of water supply to accomplish this would include:

1. the regional bedrock aquifer
2. the Kishwaukee River
3. renovated wastewater

Of the three sources named, only the renovated wastewater would likely be available for use during extreme drought periods. The Kishwaukee River typically drys up during droughts, and public pressures to conserve the deeper bedrock aquifer supplies for potable use would prevent the use of this supply for lake recharge augmentation. The treated wastewater, however, would be a dependable supply that would be politically acceptable to outside interests.

To make the introduction of wastewater to the lake an acceptable environmental action would require an extremely high level of treatment prior to release of the water to the lake. Adequate treatment must be provided to reduce nitrogen, phosphorus, residual organics and other constitutents to levels compatible with lake water quality conditions. Precautions to obtain complete removal of possible pathogenic bacteria and viruses must also be taken.

FOOTNOTES

1. C. N. Sawyer, "Fertilization of Lakes by Agricultural and Urban Drainage," Journal New England Waste Works Association, Volume 51, 1943.

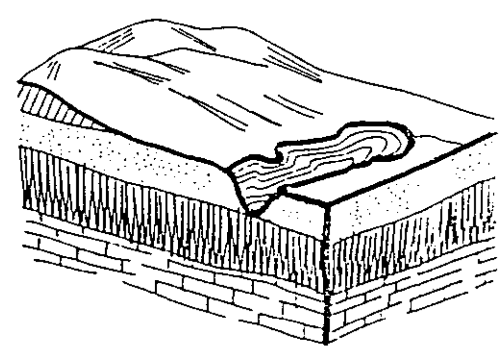
2. C. E. Pound and R. W. Crites, "Wastewater Treatment and Reuse by Land Application," U. S. Environmental Protection Agency, Office of Research and Development, Washington, D.C., August, 1973.

3. G. M. Woodwell, et. al., "Experimental Eutrophication of Terrestrial and Aquatic Ecosystems," Annual Report, U. S. Atomic Energy Commission, Brookhaven National Laboratory, February, 1974.

4. R. C. Dunst, et. al., "Survey of Lake Rehabilitation Technqiues and Experiences," Technical Bulletin No. 75, Wisconsin Department of Natural Resources, Madison, Wisconsin, 1974.

Chapter V

RECOMMENDED WATERSHED MANAGEMENT PLAN



CHAPTER V

RECOMMENDED WATERSHED MANAGEMENT PLAN

The previous chapters disclosed the relationship between the natural environmental system and rural and urban development activities. Management needs to protect and enhance the quality of the lake's water resources were identified. Environmental opportunities and alternative means of achieving the needs were described. This chapter recommends a comprehensive management plan to adequately protect and revitalize the water resources of Crystal Lake.

Plan Formulation Objectives

The watershed management policy recommendations and the action programs presented in this chapter stem from three principal objectives:

1. To protect Crystal Lake aquifer recharge conditions-- both the quantity and the controlled discharge rate -- and to preserve the naturally-regulated flow dynamics of the aquifer feeding the lake.

2. To improve the quality of surface and subsurface discharges to the lake by limiting nutrients and other contaminants.

3. To reduce the amounts of accumulated in-place nutrients contained in the lake's sediments, which, when recirculated annually, produce excessive growths of phytoplankton and other aquatic plants.

4. To regulate urban and rural watershed land use practices so that they will be consistent with optimum water resource protection.

Watershed Management Policies Criteria

This section recommends management policies and criteria to protect the natural hydrological and water quality management system of the Crystal Lake watershed from harmful effects of urbanization. The intent is to provide performance guidelines for use in reviewing development plans, designating land use management areas, and specifying service utilities systems. The proposed policies are:

1. The natural groundwater flow hydraulics of the Crystal Lake watershed shall be preserved. Thus, present groundwater levels must be maintained.

2. Urban developments shall be designed to preserve present natural drainage patterns and local groundwater recharge conditions. In essence, this requires that all drainage systems be designed to recharge to the groundwater locally. No surface drainage systems flowing directly to Crystal Lake shall be allowed.

3. Stormwater management systems for developed areas shall be designed to protect the quality of surface and groundwater discharges.

4. Development intensities and associated local area drainage design shall be restricted to those plans with natural surface drainage management systems capable of complete local recharge of the 100-year design storm.

5. Natural areas of runoff detention and groundwater recharge shall be protected from urban development through dedication or acquisition.

6. Water supply systems using only the bedrock aquifers shall be required for all urbanized areas of the watershed where sewage collection systems are to be provided.

7. Leak-tight designs shall be used in sanitary sewer construction to minimize stormwater and groundwater infiltration.

8. Septic tank disposal systems shall be prohibited in the outwash soils area, with the exception of existing farming activities.

Action Program

The action program integrates a variety of elements to protect the integrity of the Crystal Lake watershed and, where necessary, to rehabilitate the lake itself. The required action areas and program elements include:

Land Development Controls

Prevention of urbanization in selected sensitive management areas.

Controlled urbanization of other less-sensitive watershed recharge areas.

Utilities Management Standards

Regulation of sewer, water,and drainage systems to conserve watershed and other water resources.

Restorative Activities

Implementation of specific treatment programs to improve the quality of present stormwater and agricultural drainage discharges to lake.

Implementation of a program to remove those accumulated nutrients in the lake's bio-system that are recirculated annually.

Flow Augmentation

Provision of imported supplemental lake recharge flows during extended draughts when the lake levels are low.

Environmental Management Practices

Institution of improved watershed management practices for fertilizer application and erosion control for rural and urban areas.

Environmental Monitoring

Institutionof a long-range watershed and lake monitoring program to evaulate program accomplishments and to improve understanding of water quality and hydrologic con- conditions, trends, and environmental relationships.

Land Development Controls

In Chapter II, the watershed was classified into five environmental management units. These are now identified as management zones:

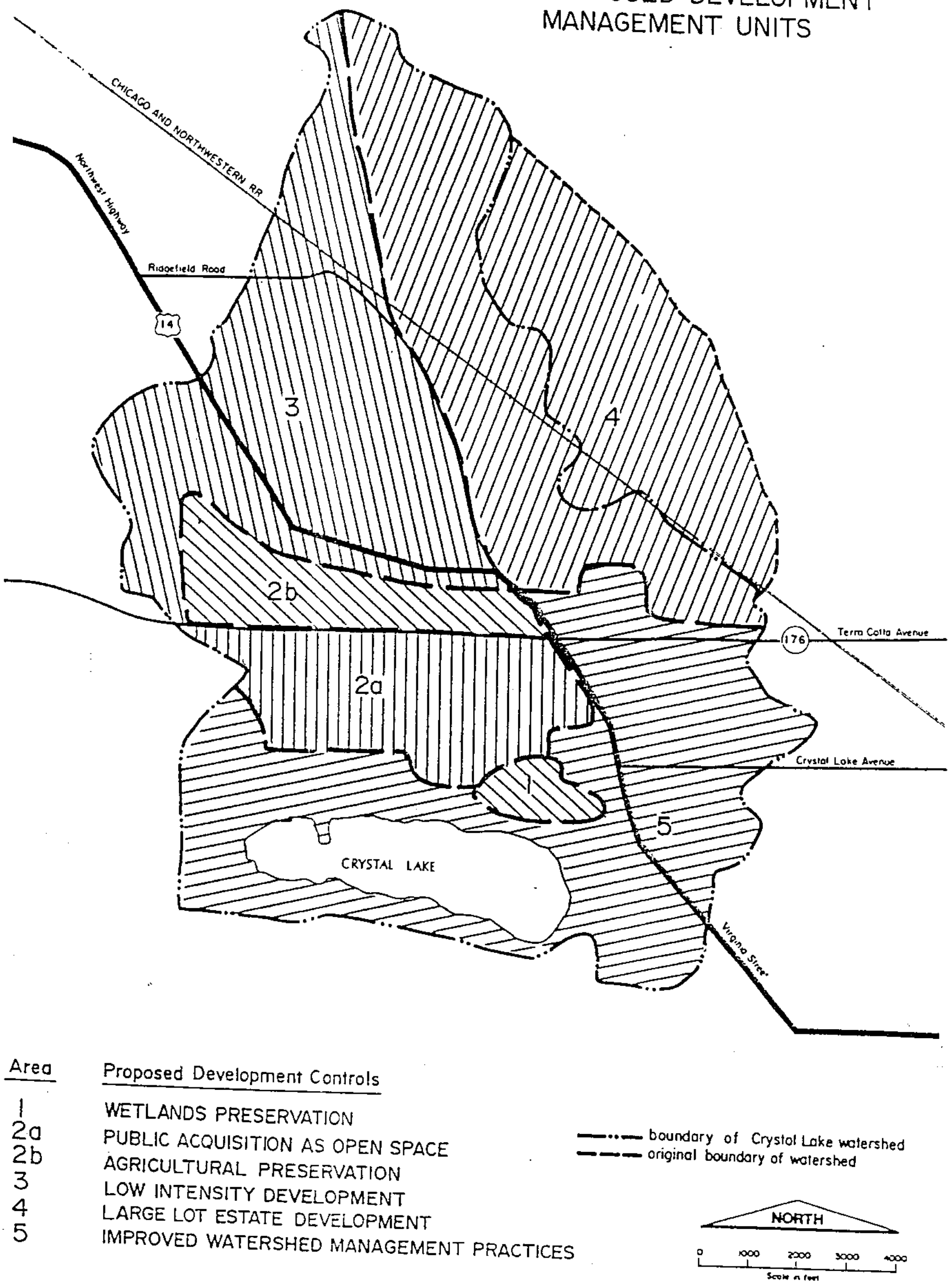
1. Marsh-wetlands
2. Shallow water table outwash
3. Deep water table outwash
4. Morainal
5. Existing urbanized area

Figure V-1 locates these zones, the boundaries of which were determined from analyses of soil types, soil permeability, groundwater elevations and topography, as well as cultural and environmental conditions. Recommended land use restrictions, with the justification for each, are proposed below.

Marsh-wetland. The marsh-wetland area is a vital hydrological adjunct to Crystal Lake. It is an overspill area. Because the water holding capacity of its soil and vegetation is so high, it serves as a "sponge" that controls water quantity. In passing through the marsh, the water is filtered by the vegetation and so improved in quality. Any attempt to drain and fill the marsh would seriously disrupt the hydrological balance of the area. Besides, as a specimen ecosystem of the marsh-wetland type, it has value as an outdoor laboratory. Its assemblage of vegetation is the natural habitat for wetland wildlife. The City should protect this area from urbanization.

Shallow Water Table Outwash. This management area expands outward from the north shoreline of Crystal Lake. Throughout this strip of about 718 acres, the water table is typically only three to four feet below the surface. The soil types include peat and muck, poorly drained tills, poorly drained outwash and well drained outwash.

Figure V-1 PROPOSED DEVELOPMENT MANAGEMENT UNITS



Area	Proposed Development Controls
1	WETLANDS PRESERVATION
2a	PUBLIC ACQUISITION AS OPEN SPACE
2b	AGRICULTURAL PRESERVATION
3	LOW INTENSITY DEVELOPMENT
4	LARGE LOT ESTATE DEVELOPMENT
5	IMPROVED WATERSHED MANAGEMENT PRACTICES

Urbanization would likely produce irreversible negative impacts on Crystal Lake. If urbanization were permitted, positive drainage facilities would be necessary to lower the water table or to carry runoff away from the developed area to protect building foundations. Such procedures would require a direct surface outlet to Crystal Lake, which is not recommended. A direct surface outlet would allow conveyance of urban runoff pollutants directly to the lake, shortening the flow time for recharge to the lake, which now occurs indirectly underground. The result would be an increase in runoff peaks and a reduction in storage volume of recharge flows needed for flow augmentation during droughts. The preponderance of poorly drained soils compounds the problem of developing drainage facilities capable of controlling pollutant discharges and surface runoff.

Because this area is unsuited for urbanization, as much of it as possible should be preserved as publicly owned open space or kept in agricultural use. The Park District owns a 108-acre parcel and is attempting to acquire the 202-acre tract west of that acreage. The remaining 610 acres are in private ownership. The specific land management proposal for this area is that the remaining 393 acres of open land south of Terra Cotta Road be acquired by the City or Park District. The 271 acres north of Terra Cotta should be preserved in private agricultural use through public acquisition or development rights.

Deep Water Table Outwash. This area comprises approximately 1,000 acres of relatively permeable surface soils overlying highly permeable sands and gravels. The water table is typically at least ten feet below the surface; the topography is relatively flat. The underlying sands and gravels are a critical recharge unit of the Crystal Lake system. Controlled urbanization is possible here, but the amount of land covered with impervious surfaces must be restricted in order to preserve the existing subsurface recharge pattern.

The range of soil percolative capacities expected from most soils in this area (0.6 to 2.0 inches/hour) leads us to recommend that no more than 20 percent of the land be covered with impervious surfaces. Such a restriction would allow a density of about three single family detached housing units per gross acre. Within this 20 percent limit, natural drainage systems are capable of achieving recharge of all surface runoff locally. Within this limit, the soils can filter potential pollutants from the runoff of developed areas. However, specific local drainage design techniques will be required to eliminate the need for stormwater piping systems. These techniques are presented in the following chapter on Watershed Development Standards.

A development intensity of 20 percent is the minimum level at which public sewer and water facilities can be justified economically. A public sewer system is required to prevent possible contamination of the sand and gravel aquifer recharging Crystal Lake.

Morainal. Intensive urbanization of the morainal area -- the rolling terrain along the northeast edge of the watershed -- would pose potentially severe environmental problems, including soil erosion. Stormwater now discharges to numberous localized sinks; the water eventually percolates into the ground. Even moderate urbanization is likely to upset this delicate drainage system. Because such disruptions would necessitate a positive stormwater drainage system, continuation of the present low intensity zoning classification of the area (one dwelling per two-three acres) is recommended. Limiting development to large lot estates will preserve the natural beauty and diversity of the landscape. Even with low intensity development, development site and highway drainage must be carefully collected and recharged to preserve the present recharge conditions.

The nature of the morainal soils and the distance of groundwater movement to Crystal Lake make the morainal region acceptable for on-site sewage disposal systems if development is limited. The water supplies can be drawn from the local shallow aquifer because, after filtering through the soil, the flows will return to the same aquifer. On-site waste disposal systems for individual parcels must be based upon suitable on-site conditions as determined by the County and State Health Department.

Selected morainal sub-areas could be developed at higher densities if on-site investigations establish adequate infiltration capacities, suitable slope conditions, and groundwater depths capable of meeting the drainage requirements set by the Watershed Management Standards (see Chapter VI). Public sewer and water would be mandatory for higher density areas.

Existing Developed Area

Only limited opportunities exist to improve on-site groundwater recharge in the existing fully developed area. Nevertheless, significant reduction in nutrient and other pollutant discharges can be effected. To this end, the watershed management program for this area must be directed at improved housekeeping practices, including:

- restricted use and practices for lawn fertilizer application
- maintenance of vegetated ground covers
- frequent street sweeping
- controlled use of salt for road de-icing in winter

Septic tank systems in all developed areas with densities greater than one dwelling per acre must also be eliminated early from the lower portion of the watershed and as soon thereafter as possible from the presently urbanized areas away from the lake.

Collection and treatment of the storm sewer flows from the urban area that discharges to the lake also should be pursued as an early action project. The treated storm sewer flows must be returned to the lake, or preferably recharged to the groundwater, within the watershed.

When practicable within the urbanized area, on-site drainage modification should be encouraged to increase the amount of stormwater that is recharged to the groundwater. This can be accomplished through site regrading to retain runoff in sculptured temporary detention-recharge areas that are compatible with site usage. Redirection of roof and parking area drainage into grassed open areas instead of directly to street gutters also should be encouraged. These measures can help to increase local recharge and also help to improve the quality of urban runoff.

Utilities Management Standards

Recommended measures for water, sewer, and drainage systems are detailed in the following chapter on Watershed Development Standards.

Restorative Actions

Corrective actions are necessary to reduce the nutrients entering Crystal Lake due to man's disruptions of the natural watershed systems. Nutrient sources include the agricultural drain that flows into the lake at its western end, the storm sewer system that discharges into the east end of the lake, and the septic tank disposal systems of shoreline residences. The accumulated nutrients that are recycled annually through the lake's sediments must also be removed or immobilized. The following sections discuss specific restorative measures.

Agricultural Drain Discharges. To reduce the nutrients and sediments in the drain tile, improved drainage area management practices should be imposed and a sediment trap-treatment lagoon constructed at the system's lower end. If these steps to not adequately reduce pollutants, supplemental land application may be necessary.

Proposed management practices to improve drainage include: elimination of direct surface inlets, replacement of broken tile lines and regulation of fertilizer-use practices. The tile system should be carefully inspected to locate specific problems. Then flows should be measured and additional water quality tests conducted to refine estimates of the tile system flows and seasonal variations in nutrient discharges.

The present open drain located within the sod farm should be enlarged to form the sediment trap-treatment lagoon. Constructed as a combination marsh-lagoon biological system, the lagoon would filter or settle out the sediments and nutrients in the drain tile flows. If waters were detained sufficiently long, soluble nutrients will be absorbed by marsh plants or converted to phytoplankton. The lagoon system will discharge waters through a grass filtration area and so remove the suspended phytoplankton before they reach the lake.

It is impossible to predict exactly how much the nutrient level would be reduced by these actions. A 50 to 80 percent reduction appears reasonable. With additional information gained from long-range monitoring of the lake's nutrient fluxes, it will be possible to determine if greater nutrient reductions are expectable. Additional reductions could be achieved by irrigating suitable lands with lagoon effluent. As the waters infiltrated the soil, the nutrients would be filtered or adsorbed and made available to crops or vegetation.

Urban Storm Sewer Flows. Waters collected by the storm sewer system serving 270 acres in the City of Crystal Lake should be treated prior to their discharge to Crystal Lake. We recommend that this flow, which averages about 48 million gallons per year, be intercepted, pumped to a land application area for treatment, and then returned to the lake. The land application site could be integrated with the farm drain site if similar designs are selected for both.

A storage lagoon with a capacity of about 12 million gallons (36 acre-feet) would be constructed to hold the intercepted stormwater. Thus, irrigation waters could be released at controlled rates and stored during the winter when the ground is frozen. A pumping station, designed for a flow of approximately 30 cubic feet per second (cfs), would operate in conjunction with a small temporary detention basin designed to hold waters released from the outlet sewer. The temporary basin could detain all of the excess storm runoff from the 30-cfs pumping station during all but the largest storms. Because the system would have limited treatment capacity, waters released to the lake would be only a small percentage of the total annual flow. In all cases, initial runoff -- the highly polluted "first flush" -- would be captured. Chapter III emphasized the significance of urban storm sewer discharges as pollution sources.

Lake Restoration. Removing of nutrients flowing into Crystal Lake will only gradually improve the water quality, for nutrients accumulated on the lake's bottom will continue to circulate in large amounts. Excessive growths of blue-green algae and other nuisance aquatic plants and organisms will continue. Because the surface outflow from Crystal Lake is so small, the lake is unable to purge itself of accumulated nutrients. Recovery may be slow. To accelerate the recovery rate, we proposed a system for selective removal, treatment and return of treated flows to the lake. The nutrient-rich lake waters would be pumped to the land application site identified for the agricultural and storm drain treatment systems. Nutrients present in the soluble and particulate form (as algae and other aquatic organisms) would be removed by the soil system and used for sod or field crops. The renovated water would be collected by sub-surface drains and returned to the lake. As discussed in Chapter IV, this technique has been utilized at Snake Lake, Wisconsin with good success.

A preliminary assessment of application site possibilities indicates that about 250 million gallons of water could be recirculated annually. Operations would continue from May through October at an average pumping rate of 2.2 million gallons per day. Each year, approximately 25 percent of the lake's volume and 30 percent of the average annual flow would be recirculated.

Because only a portion of the annual flow leaves the lake via the overflow surface outlet, the treatment system should more than double the annual amounts of nutrients purged from the lake. Within five to ten years of system operation, available nutrients should be reduced substantially.

Flow Augmentation

Even effective land use controls and utilities systems designed to conserve watershed recharge flows will not insure Crystal Lake of a stable lake level. Long-range variations in local rainfall will cause cyclical fluctuations of the lake surface. To resolve this problem, watershed flows can be augmented during extended droughts. Treated wastewater provides a sustained augmentation source, available when rainwaters are not.

To accomplish flow augmentation when natural flows are deficient, secondary or tertiary treated wastewater can be applied to the same application sites programmed for the surface drains and lake water treatment programs. During extended droughts, surface stormwater flows will decrease; withdrawals of lake water can be halted temporarily. Thus, most of the treatment site would be available to give complete tertiary treatment to applied wastewater.

Of all presently-available technology systems, irrigation of secondary or tertiary treated disinfected wastewater at low rates (2 to 3 inches per week) achieves the highest level of consistent nutrient, residual organics, and pathogen removal. The waters captured in the underdrainage from this system would be of adequate quality for direct discharge to the lake to augment the natural flow deficiencies.

The wastewater renovation system would probably operate only during periods when lake flow augmentation were needed. However, tertiary treatment costs using this system are expected to be substantially lower than those of a biological or chemical tertiary plant. As a result, it may be desirable to make maximum use of the treatment site for wastewater irrigation. Crystal Lake would benefit from the consequent increase in flows. Once the nutrient condition in the lake were sufficiently reduced, the lake recirculation system could be curtailed and more of the application site could be used for wastewater renovation.

Wastewater flows could derive from either the present Crystal Lake plant or the new facility proposed in the northwest part of the watershed. The treated wastewater would be pumped to the application area.

To ensure sufficient wastewater to compensate for natural flow deficiencies during severe drought years, the land treatment application site should be at least 100 acres. A 2-inch-per-week wastewater application rate for 30 weeks per year on a 100 acre site would provide 167 million gallons of renovated water to the lake. During an extreme drought year, natural flows could be increased by 20 to 30 percent with the addition of renovated wastewater.

Environmental Management Practices

Loss of nutrients to water supplies is the major source of eutrophication. Nitrogen and phosphorous appear as the two significant nutrients in the eutrophication process. Natural loss of these two elements to groundwater and streams has occurred under natural forest vegetation because plant uptake of available nutrient amounts does not seem to occur naturally.[1/] However, when vegetation is removed, losses in nitrogen increase 30-fold and phosphorous 10-fold.[2/] When vegetation is removed, soils erode. The two environmental degradation processes -- groundwater contamination and erosion -- are frequently found together.

Agricultural/Rural Practices. Two contributors to nutrient loss in current agricultural practices are the decreased density of crops, stemming from the tendency to cultivate row crops rather than small grains or pasture, and the constant application of artificial fertilizers. The loss of the nitrogen component of fertilizer is most common, but even the loss of one percent of 40 pounds of P_2O_5 per acre provides enough nutrients to eutrophy five acre-feet of water, or its equivalent of 60 inches of runoff.[3/]

Although no specific guidelines on rates or methods of fertilizer application or fertilizer types have been adopted by the State of Illinois, a report is currently being considered by the Illinois Pollution Control Board.[4/] Outlined below are considerations that have been found beneficial in managing nutrient loss from fertilizers.

1. Timing of application

In the midwest, where runoff is relatively low and native soil fertility is fairly high, the potential for nitrate pollution depends primarily upon the amount and distribution of precipitation. During the cropping season, soils dry to a depth of approximately three feet. As soils are dampened, dissolved nitrate moves down through the soil to be used subsequently by the crop. Some years, soils are dampened to a depth greater than six feet, placing some of the moisture too deep to be available to the crop. As this water continues downward to the groundwater supply, nutrients go with it. Applications must be tailored to each specific crop's needs. A crop's nutrient budget should be estimated and the fertilizer should be applied at times when the crop's rate of nutrient use is highest. Summer side-dressing (using several relatively smaller applications) is advisable for corn.[5/] Application should be avoided in the fall until the soil temperature at a depth of four inches is 50°F or less.

2. Areas of restraint

Fertilizer application areas should be set back from water bodies and stream channels to avoid direct contamination.

3. Nature of soil

Applications of fertilizer in the fall should not be made on sandy soils where the infiltration capacity is too high. Application of fertilizer on bare soil should be avoided, and on frozen soils with a greater than five percent slope.

4. Type of fertilizer

Slow-release fertilizers are recommended.

5. Cropping techniques

Cultivated row crops require more fertilizer than do small grains and hay rotations and they expose more bare soil, thus increasing the likelihood that phosphorous will be lost in surface runoff. A return to rotation has been suggested.

Agricultural erosion can be reduced by exercising caution on soils with a high erosion potential (see Appendix A) and by using cultivation techniques such as contour ploughing. Soils with erosion hazards on steeper slopes should be left forested or in pasture.

Urban Practices. Lawn fertilizers in housing developments threaten water bodies with increased nutrient loadings, particularly where stormwater is conveyed directly to water bodies. Most of the above five considerations can be applied to lawn fertilization techniques. In addition, grass clippings can be left on lawns. These allow nutrients to be released slowly as they decay, provide a protective cover against evaporation and sun-scorching, and improve the infiltration capacity of the cover, thus reducing runoff.

Maintaining vegetative cover and permeable surfaces in urban areas reduces stormwater runoff from impermeable paved surfaces. This is especially important on shoreline areas, where -- should vegetation be removed -- direct runoff, erosion and siltation of water bodies would occur.

The City should maintain a program of frequent sweeping of all streets. Streets should be cleaned at least once each two weeks, although a weekly schedule is preferable. Road areas that drain directly to the lake via surface runoff should be given special attention.

Construction Practices. Erosion hazards are high in construction areas. Constantly-exposed unvegetated soil is a target for runoff erosion. Runoff is exacerbated where topsoil is submerged beneath subsoil in excavation mounds. The results of erosion are particularly hazardous when vegetation is removed from steep slopes or shorelands. Practices that have proved instrumental in decreasing erosion and siltation at construction sites follow.

1. Sites should have soils, topography and drainage patterns suited to the site's intended use. Steep slopes and erodable soils should be scant.

2. Ground surfaces stripped of vegetation should be left bare for the shortest possible time. This may mean exposing mineral soil at only sections of a construction site at one time, and revegetating sections before uncovering others. A temporary vegetation cover should be maintained throughout construction. At excavation, topsoil should be separated from subsoil to accelerate regrowth of both temporary cover and final revegetation.

3. Storm runoff should be controlled, using sediment ponds to trap silt.

4. Cutting and filling should be kept to a minimum; the resultant slopes should not exceed an angle the soils can tolerate.

Environmental Monitoring

This and other studies should contribute to an understanding of the Crystal Lake water resources. Yet much remains to be quantified about nutrient fluxes, annual cyclical processes, long-term eutrophication trends, and hydrological conditions.

Although studies to date have provided baseline information against which to compare future data, some gaping holes remain. For the future, critical water quality questions remain: How fast is the lake aging? Is the lake getting cleaner? What level of nutrients can the lake safely assimilate? For the present, additional nutrient data and cost-effectiveness assessments are needed. With these additional data, design and implementation decisions for the corrective actions recommended in this study can be made.

To address those questions that remain unanswered and to assess the performance of initial management actions, Chapter VII recommends a program of water resources monitoring activities. In this way, the watershed planning program can adjust to unforeseen circumstances, to new information and understanding, and to changes in expectations.

Project Cost Estimates

Within the scope of this study, estimates of construction and operating cost for the principal recommended watershed management projects can only be developed at the preliminary "order of magnitude" level of detail. In the cost analysis, the assumption was made that the various projects would develop around the integrated use of a single

100-acre land application area that was acquired separately to prevent urbanization. The assumed site was located within the area now owned by the Park District and a portion of the sod farm that is proposed for open space acquisition.

The estimated construction cost for a system to recirculate nutrient-rich water from Crystal Lake through a land treatment area and then return the flows to the lake is $500,000. This includes the lake intake, pumping station, pipeline, irrigation system, underdrainage collection system and return pipeline. The annual operating and maintenance costs of recirculating 250 million gallons is $25,000.

The estimated incremental cost of collecting the storm sewer discharges and applying these flows to the same site is $400,000. This includes the cost of a flow regulation basin, pump station, storage lagoon and irrigation pump station. This system would utilize the irrigation and drainage system costed above for the recirculation system. The annual operating and maintenance costs for this system would be about $10,000.

The cost of a system to return treated wastewater from the present Crystal Lake sewage treatment plant is estimated at about $600,000. The operating and maintenance costs of pumping and applying this flow to the land application site would be about $150 per million gallons. During an extreme drought year when the system would be operated at full capacity, the total operating and maintenance cost would be about $25,000.

The construction cost of the agricultural drain improvements to create a sedimentation lagoon-marsh complex is estimated at approximately $200,000. Operation and maintenance costs would be minimal.

In analysis of the above costs, it was assumed that the 100-acre land application area would be set aside for this intended use and that conventional agricultural irrigation systems (wheel roll or fixed pivot) rotating rig) would be employed. This land could be used for agricultural activities the earnings of which could offset the operating and maintenance costs of the systems. A $100-per-acre agricultural profit would produce an annual income of $10,000.

Land usage decisions should be made in the detailed planning phase of the project implementation. The possibility exists that initially, or at some future date, the application site could be operated as a multipurpose recreation and irrigation area. This might require the installation of specialized solid set irrigation equipment which would add about $250,000 in project costs.

References

[1]Bormann, F.H., Likens, G.E., Fisher, D.W., and Pierce, R.S, (1968), Nutrient Loss Accelerated by Clearcutting of a Forest Ecosystem, Science, 159: 882-884.

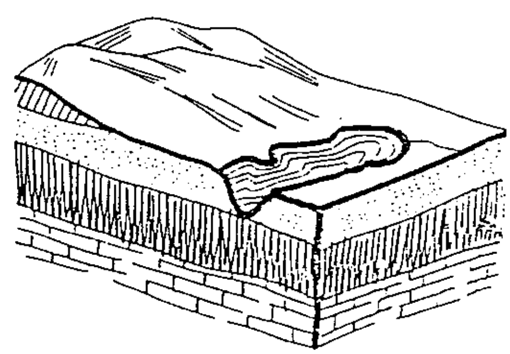
[2]Ibid.

[3]Frink, C.R., (1971), Plant Nutrients and Water Quality, Agricultural Science Review, 9, #2: 11-25.

[4]Nitrogen Task Force Center for the Biology of Natural Systems, Washington University, St. Louis (1974), Fertilizer Application Rates and Nitrate Concentrations in Illinois Surface Waters, Illinois Institute for Environmental Quality Document #74-38.

Chapter VI

WATERSHED DEVELOPMENT STANDARDS



CHAPTER VI

WATERSHED DEVELOPMENT STANDARDS

The land use and general utilities recommendations presented in the previous chapter provide only a general framework for watershed protection. This chapter translates the general objectives into specific operational criteria, evaluation procedures and design standards useful to the city in determining the acceptability of development proposals.

The watershed has been classified into five land management areas, each with its own capacity to achieve the objectives of the recommended watershed management plan. Within each of these units, localized conditions affecting the suitability of particular sites for urban development must be taken into account -- for example: soil infiltration capacity, ground slope, groundwater conditions and soil structural suitability for foundations and other urban structures.

Facilities Design Standards and Criteria

The basic objectives of the facilities design standards and criteria here presented are to improve the total quantity, rate, location and quality of watershed flows and so preserve the integrity of Crystal Lake. Deviations should be allowed only when special site conditions, extreme economic hardships or unique site management objectives are recognized by both the developer and the city. In such cases, the developer should be required to produce reasonable alternative means of achieving the stated objectives.

The specific management objectives are:

1. Direct surface discharge of watershed runoff to Crystal Lake, or to drainageways and storm sewers leading to the lake shall be eliminated where they exist and avoided in the future.

2. No surface or subsurface water resources originating within the Crystal Lake watershed and naturally tributary to the lake shall be diverted from the watershed prior to flowing through the lake.

3. Because the shallow aquifer at present regulates recharge flows to Crystal Lake, all stormwater drainage systems shall be designed to preserve the present undeveloped local recharge rates to this aquifer.

4. Surface and subsurface discharges to Crystal Lake shall meet the quality standards given in Chapter IV. Total phosphorus, the limiting nutrient affecting the lake, should be minimized as much as possible.

Drainage Systems

To achieve the water quality and recharge objectives of the watershed management plan, drainage facilities must be designed to make maximum use of drainage natural to the site. This will assure high levels of surface infiltration and promote three basic management objectives.

1. Local groundwater recharge.

2. Removal, by the soil system, of sediments, nutrients and other contaminants from surface runoff.

3. Reduction in the need for an area-wide sewer conveyance system with outlet to Crystal Lake.

To achieve maximum on-site groundwater recharge, natural surface drainage system designs should be required for all watershed drainage facilities. Special conditions -- threats to public safety, excessive ground slopes or special site usage conflicts -- should be the only exceptions In most cases, the maximum land use intensities proposed for the different management areas are highly compatible with natural surface drainage designs.

Facilities and techniques generally used in natural surface drainage designs include:

- grassed swales
- grassed waterways
- gradual slopes and broad vegetated areas to ease runoff conveyance
- shallow, sculptured, vegetated depressions and mounds to detain and direct runoff from impervious surfaces
- shallow grass-lined detention-percolation basins
- discharge of roof drainage onto pervious grassed surfaces
- discharge of parking area runoff overland onto pervious grassed surfaces
- discharge of road drainage to grassed roadside infiltration - conveyance swales

A natural drainage system design plan must address both the initial storm (expectable every one to two years) and the major storm. On-site infiltration rates and depression storage capacities can reasonably handle only the initial storms. Major storms, those that occur once in 100 years or less frequently, would necessitate an overflow conveyance system and area detention storage basins. Preserving existing natural detention areas and constructing additional facilities should allow overflows from all major storms to gradually percolate into the ground.

Figure VI-1 depicts the types of natural drainage design facilities and techniques proposed. Design criteria to evaluate the compatibility of local area development plans with the natural drainage design concept are presented below.

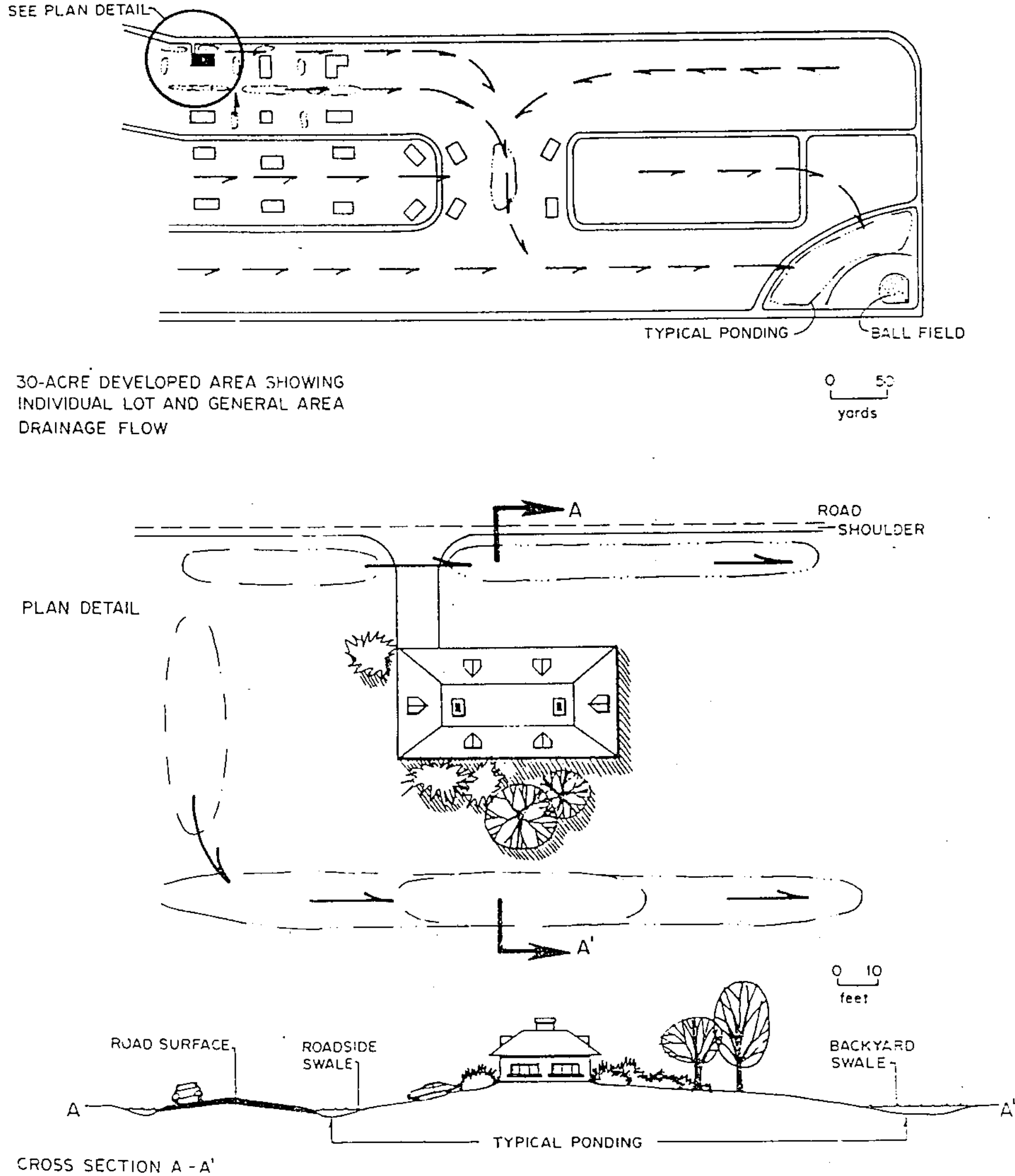
Design Criteria

1. Drainage from all impervious areas (roads, driveways, patios, roofs, etc.) shall be designed to discharge to pervious ground surfaces at controlled rates and with sufficient distribution to inhibit erosion.

2. Surfaces used for conveyance and recharge of impervious surface runoff shall be planted with sod or other ground cover, to control erosion and maintain ground infiltration capacity.

3. Roadside grassed drainage swales shall be used to collect road and driveway drainage, permiting recharge to the subsurface aquifer. Storage capacity should be sufficient so that rains falling during a one year-one hour (frequency-duration) storm will all infiltrate into the soil with no surface flow to major area detention facilities. Curbs, gutters, storm inlets and storm sewers shall be avoided where possible. Areas where road grades are too steep to control erosion of drainage swales and where excessive embankment cuts would be required are excepted.

Figure VI-1 STORMWATER DRAINAGE SCHEME FOR HOUSING DEVELOPMENT



4. Individual lots shall be graded so that runoff from impervious and adjacent pervious areas is conveyed away from buildings and other areas of high intensity use. To prevent erosion, grades shall be kept below 3 percent where the natural terrain does not require extensive earth moving.

5. Initial runoff management areas shall be designed to detain and recharge a one-year one-hour design storm (one-inch per hour), including flows from on-site impervious surface runoff.

6. Major storm runoff conveyance and detention-recharge facilities shall be designed for the 100-year design storm. The critical design storm shall be determined from the 100-year rainfall-duration curve (Appendix D, Figure D-1) and the infiltration capacities of the pervious runoff management areas.

7. Major storm detention-recharge areas shall be designed to recharge the 100-year design storage volume within five days.

8. The maximum 100-year design flooding depth of detention-recharge basins shall be three feet.

9. Conveyance channels to detention-retention basins shall be grassed waterways, where possible, with design flow velocities of two feet per second or less to protect recharge basins from frequent clogging. No direct discharge of storm sewers collecting direct runoff from paved surfaces shall be allowed.

10. Retention-recharge basins shall be designed with grassed bottoms and, where possible, used for recreation.

11. Detention-retention basins should be constructed with a free-draining depth from the base of the basin to the groundwater table of at least ten feet.

12. The infiltration rate used for the basin shall be that of the least permeable soil stratum. At least three soil borings shall be made at each basin, each to a depth of at least five feet below the water table. Sieve analyses and laboratory permeability tests shall be provided for each soil formation encountered. A minimum of three 24-hour infiltration tests (using the two ring method described in Appendix D) shall be taken at each infiltration basin site in the least permeable soil stratum.

Sanitary Sewerage

Sanitary sewers are recommended for all developments in the highly permeable sand and gravel outwash soils, in soils where discharge exceeds two population equivalents per acre (one dwelling unit per two acres), and in high-water-table areas (less than five feet to the surface.

The sand and gravel soils are too permeable to adequately treat septic tank discharges. In some areas of the country where urbanization has occurred on such soils, septic discharges have severely contaminated the groundwater.

Special design precautions must be taken to minimize water losses from infiltration to the sanitary sewer system from the shallow aquifer. The shallow groundwater zones pose the greatest infiltration hazards. If these areas are urbanized, special pressure or vacuum system designs should be considered. In the lower water table areas, special leak-tight gravity systems can be used. Design specifications should limit infiltration to less than four gallons per day per capita.

Technology and design chocies for low infiltration sanitary sewer systems include:

1. Use of gravity sewers with rubber or neoprene gasketed, O-ring joints, flexible joint manhole pipe connections and sealed manhole barred joints.

2. Use of shallow grinder pump pressure or vacuum collection and conveyance systems in areas of shallow water table.

Water Supply

Areas with public sewers should use the deeper regional aquifer as a water supply source. A public distribution system will be required. Drawing municipal water from the deeper regional aquifer, recharged primarily from outside the watershed will conserve the shallow aquifer that feeds Crystal Lake and thus prevent depletion of lake recharge flows. The shallow aquifer should be used in the low-density areas, where on-site waste disposal systems are permitted.

Techniques to conserve the public water supply include:

1. Specification in the sanitary code of low-water-usage plumbing fixtures (three-gallon toilets, low-usage shower heads).

2. Imposition of pricing policies that discourage unnecessary use.

3. Prohibition of once-through cooling in industrial and commercial facilities.

4. Restriction of system operating pressures to 45 psi.

Analysis of Development Proposals

To insure specific land development proposals are compatible with the general watershed management goals, policies and standards, the developer will be required to submit at the time of preliminary plat or annexation application, information about specific site characteristics, details of the development plan, and an impact assessment of the project.

Site Information Requirements

Specific site information required of the developer includes:

1. A topographic map of the site, at a scale of no smaller than one inch = 100 feet, showing one-foot contours.

2. Logs of soil borings taken to a depth of at least 20 feet and spaced relatively uniformly throughout the site. A minimum of four borings shall be drilled for a site up to five acres, with one additional boring furnished for each additional five acres.

3. Groundwater readings shall be taken for each boring at the time of drilling and 24 hours later. Readings shall be mapped.

4. A map of surface soil conditions, showing the areas and boundaries of each soil type, shall be provided. Where organic soils are encountered, the extent and depth of these deposits shall be mapped.

5. Soil percolation tests shall be performed for each soil type contributing more than 5 percent of the total site. The two-ring infiltration method shall be used. Appendix proposes specifications and procedures for conducting the infiltration tests.

6. Existing drainage conditions for the proposed development parcel and its relationship to area drainage patterns shall be analyzed. The analysis shall include:

a. A map* showing surface drainage patterns within the site, leaving the site and entering the site. All surface drainage areas should be identified.

b. A map locating the extent of all temporary surface runoff detention areas and other areas periodically flooded by surface or subsurface discharges.

c. Analysis of the amount of stormwater entering the site, retained within the site (infiltrated directly or retained as surface storage until infiltrated), and discharged from the site as surface flow for the following design storms:

1-year - 30 minute duration

1-year - 60 minute duration

10-year - 24 hour duration

100-year - 24 hour duration

(Appendix D, Figure D-1 presents rainfall frequency duration curves that can be used for this analysis.)

d. The disposition of all surface flow leaving the site for the storm frequencies identified in c above shall be analyzed to determine if and/or how the flow is recharged to the groundwater, leaves the Crystal Lake watershed as surface discharge, or flows to Crystal Lake via a surface drainage route.

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*All maps presented should be prepared at the same scale.

Development Plan Details

To allow the city to thoroughly assess a plan's compatibility with watershed water resource management objectives, design criteria, and facilities standards, the developer should be required to furnish the following information.

1. The percent of land that will be occupied by roads, parking, buildings, patios, walks, etc., for each type of land use area.

2. The general grading plan for the entire project area and typical grading plans for each type of land use area.

3. A preliminary engineering design plan of the proposed drainage facilities, including:

   - a plan map of the proposed drainage facilities showing sizes, locations, capacities, design velocities, grades, and critical elevations.

   - A description of the drainage management plan for each type of land use area.

   - A presentation of the analysis methods, design coefficients and calculations, and rationale used in developing the facilities plan.

4. A preliminary engineering design plan of proposed collection and trunk sanitary sewers, including:

   - A map showing the general sizes, depths and locations of sewer lines.

   - A description of proposed material types and construction methods.

   - Analysis of the expected rates and total amounts of infiltration, including design techniques to minimize infiltration.

5. A statement of the type and source of the proposed water supply system.

6. A description of the initial and final ground cover for the development.

7. A description of the techniques and procedures employed to control erosion and sediment runoff during construction.

Project Impact Assessment

The impact assessment shall analyze the potential impacts on-site and area-wide groundwater recharge and surface drainage conditions, address quantifiable changes in water resource conditions resulting from the proposed development and assess rainfall frequency conditions for those storms identified in 6c of the section "Development Plan Details." Specific analyses should include:

1. Amount, rate and location of surface flows accepted from upstream drainage areas.

2. Amount and rate of rainfall percolated directly in-site (excluding project recharge detention basins).

3. Amount and rate of runoff stored in recharge detention basins.

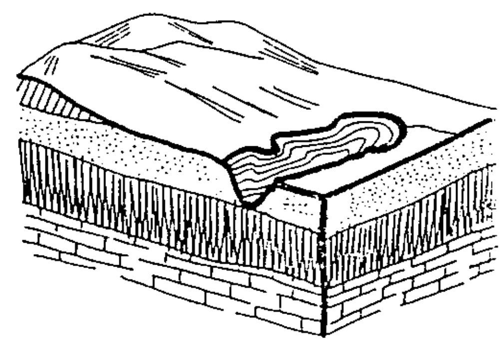
4. Amount, rate and location of surface discharge, if any.

5. Maximum depth, area of flooding and storage time for all recharge retention basins.

6. Annual average evapo-transpiration losses due to changes in vegetation and evaporation for permanent and temporary water impoundments.

Chapter VII

WATER RESOURCES MONITORING NEEDS



CHAPTER VII

WATER RESOURCES MONITORING NEEDS

A basic understanding of the principal environmental relationships between the Crystal Lake watershed and the lake itself is provided by this report. However, serious quantitative deficiencies in information remain, and these must be addressed as the recommended plan is implemented. Gathering the data will require periodic monitoring of the system. The result will be a continuous feedback of community attitudes and, in pace with that, a stream of adjustments to a new understanding of the environmental processes at play around the lake

Supplemental Baseline Data

The additional data needed falls into three environmental information categories:

1. watershed hydrology
2. nutrient budget
3. Crystal Lake physical and biological processes

Watershed Hydrology

Specific hydrological data must be obtained to enable accurate quantification of seasonal and long-term fluctuations in watershed hydrological conditions related to climatalogical changes. A relative study of surface discharge to Crystal Creek vs. underflow discharges through the sand and gravel aquifer must be made in order to asses the lake's capacity to purge itself of nutrients. Flow data for the agricultural tile drain are the sole means of quantifying its nutrient discharges and actual influence on drainage. Without that data, it will not be possible to design a nutrient removal treatment system for the drain.

Specific proposals for acquiring the needed hydrological data include:

1. Installation of a permanent flow recording guage on Crystal Creek just downstream of the overflow from the lake.
2. Installation of a temporary flow recording device at the outlet of the Crystal Lake Drainage District agricultural tile system. This device should be kept operating for a 3-to-5-year period.
3. Implementation of an extended period groundwater level monitoring program using the monitoring wells dug for this study and other selected wells. Monthly measurements should be made for a 3-to-5-year study period.
4. Reactivation of the rain gauge at the Crystal Lake Park District beach house. This gauge, which is not operating at present, should be repaired and kept in proper working order.

The City should seek cooperation and financial assistance from the Illinois Water Survey and the Division of Water Resources of the Department of Transportation in the placement and operation of the Crystal Creek monitoring gauge.

Nutrient Budget

A preliminary assessment of nutrient inputs to Crystal Lake was made in Chapter III. However, the assessment was based on only a few bits of water quality data. Specific hydrological flow data are missing. Furthermore, no estimate could be made of Crystal Lake nutrient outflow due to water quality and flow data deficiencies. Efforts should be made to complete an accurate assessment of nutrient inflow and outflow dynamics for the lake. To this end, we recommend the following additional studies:

1. A 12-month nutrient sampling program for the agricultural drain conducted on a bi-monthly frequency. This should be supplemental to a special sampling of nutrient runoff during and after major storms that cause surface flooding. For this special study, a 12-hour sampling frequency is proposed for a 3-to-4-day period during and following each of two to three major storms.
2. Analysis of Crystal Lake storm sewer discharges to the lake. Nutrient discharges during at least three to four storms should be studied, with hourly sampling during and after the storms. Either automatic sampling equipment or manual techniques can be used. Flow measurements of sewer discharges are also required during the sampling periods.
3. Additional baseline groundwater water quality data are desired to improve the reliability of nutrient additions from underflow to the lake. Monthly sampling of up to twelve well locations for a one-year period is recommended.
4. Sampling of discharges from Crystal Lake to Crystal Creek should be done on a weekly frequency schedule when the stage of the lake is sufficiently high to allow overflow. This study should last at least one year.

Crystal Lake Physical and Biological Processes

A number of additional baseline studies of Crystal Lake itself are needed to supplement the NALCO study results. These should include:

1. The photosynthetic activity zone and lower thermocline layer of the lake should be studied for a year, with readings taken at bi-monthly intervals to determine nutrient assimilation, sedimentation and recycling dynamics and phosphorus and nitrogen concentrations in soluble and solid (bio-mass) form. This will permit an analysis of seasonal fluctuations in available nutrients, in the amount of nutrients recirculated from bottom deposits, in the rate of biological activity at different times of the year.
2. A concentrated study of photosynthetic activity should be made through bi-monthly measurement of chlorophyll a during the months of April through October. This work would supplement the initial work done by NALCO.
3. Temperature and dissolved oxygen profiles of the lake at different depths should be obtained to establish depth of mixing and the biological activity rate of the bottom sedimentation zone.

Long Range Monitoring

Periodic reassessment of water quality and nutrient inflow conditions are a necessary part of the watershed management program. During the first ten to fifteen years of the management program, the frequency of comprehensive assessment should be at five year intervals. After a substantial improvement in lake quality conditions is realized, the interval of testing could be extended to ten years. Data from these periodic surveys, when compared to the baseline data, will allow quantitative assessment of trends in environmental conditions and status of the lake.

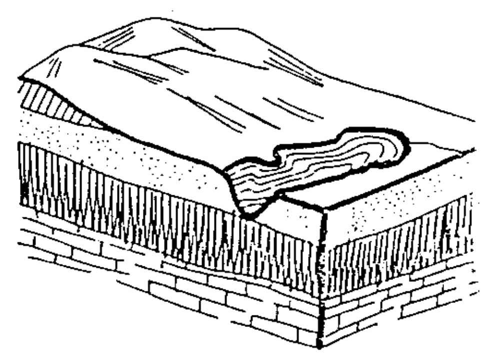
The periodic evaluations should be comparable in comprehensiveness to the baseline survey completed in the NALCO study.

Monitoring Costs

The projected cost of the additional baseline water quality studies proposed above is estimated to be between $25,000 and $35,000. Each five-year assessment in the monitoring testing and evaluation program is projected to cost about $25,000. The City should seek assistance from various interested State agencies in the funding of this work, for the results will be of significant value to State and national research and demonstration programs. Agencies that might fund this work include the Illinois EPA, the Illinois Water Survey, and the Division of Water Resources of the State Department of Transportation.

Chapter VIII

IMPLEMENTATION AND FINANCING OPPORTUNITIES



CHAPTER VIII

IMPLEMENTATION AND FINANCING OPPORTUNITIES

The Crystal Lake Watershed Control Program presents a number of implementation and financing problems. The basic problem is that the watershed itself includes a relatively large number of separate, and in many cases overlapping, governmental units. These include cities, townships and special districts, such as park districts and drainage districts, as well as the various County government agencies and county-wide special districts. The various jurisdictions are all governed by separate decision and policy-making bodies, each with individual goals and values. To resolve this basic problem will require an overall or centralized management and planning effort developed from a common set of basin management goals. The program should make optimum use of the varying jurisdictions' land use controls. It is imperative that the cooperative/coordinated approach be pursued.

Land use controls within the basin can be accomplished through four general techniques. First, cities and other jurisdictions can use their "police power" for the maintenance of the public welfare. These powers include zoning, building, and subdivision codes and public health regulations. Second, a city or regulating body can purchase a piece of property and all of the rights associated with that parcel in a fee simple acquisition. Third, a city or regulating body can purchase certain specified property rights associated with a piece of property or easement. Most common are scenic and access easements, and development and mineral rights. Finally, financial inducements, such as subsidies or preferential tax assessments, can be used to maintain or change existing land uses.

Institutional Approaches

The most direct way for Crystal Lake to implement a basin-wide management program is for the City to aggressively annex the rest of the unincorporated territory within the basin. The City of Crystal Lake could control development through building codes, zoning, subdivision, health, and natural hazard area regulations. A binding community master plan could guide overall development.

Crystal Lake can enforce development regulations indirectly. Certain unincorporated areas--primarily where developers needs the City to provide utilities and other services--may wish to annex to Crystal Lake. In such cases, the City can prescribe appropriate development regulations as a part of a preannexation agreement. This is praticularly true where public sewer and water services are necessary in high water table areas that preclude septic tanks. Amendments to the McHenry County Zoning Ordinance give the City zoning review powers in the 1.5 mile band around the corporate borders. Implementating a protested zoning amendment by the City of Crystal Lake would require a three-fourths majority vote to the County Board.

The watershed can be managed by establishing a special district encompassing all or significant parts of the basin. State statutes allow for various special purpose districts. Five might be employed for basin management: conservation, sanitary, park, river conservancy, and drainage districts. The first four are all formed by a majority vote of residents within the proposed district boundaries; drainage district formation requires acceptance by a majority of landowners. Tables VIII-1 and VIII-2 summarize revenue sources and capabilities of these districts.

The conservation district is the less-populated counties' equivalent to the forest preserve district. The emphasis of the conservation district is the preservation of public open space and such districts are restricted by statute to the acquisition and maintenance of such areas. Even if McHenry County grows to a size where a forest preserve district would replace the conservation district, the district would only gain financial flexibility in dealing with the same problems.

Drainage districts are limited exclusively to solving drainage problems within a specified area. The range of revenue sources is limited. There is no property tax levy, and the bulk of the revenue must come from users' fees and special assessments. There presently exists the Crystal Lake Drainage District, which encompasses 1300 acres in the central part of the watershed.

Park districts, as conservation districts, are limited by statute to acquiring and maintaining recreation and open space lands. However, park districts emphasize using the land for intensive recreational activities; recreation is their primary business. Park districts are relatively constrained in their financing

Table VIII-1

Capabilities of Local Governmental Units

Unit	Governmental Powers				Areas of Legal Involvement							
	Eminent Domain	Ability to Lease Property	Development Program	Zoning	Recreation	Open Space	Water Quality	Drainage	Water Supply	Provide Utility Services	Irrigation	Wildlife and Fish
Local Unit												
Municipality	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	No
Township	Yes	Yes	No	No	No	No	Yes	No	Yes	Yes	No	No
County	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No
Special District												
Conservation	Yes	Yes	No	No	Yes	Yes	No	No	No	No	No	Yes
Drainage	No	Yes	No	No	No	No	No	Yes	No	No	No	No
Park	Yes	Yes*	No	No	Yes	Yes	No	No	No	No	No	Yes
River Conservancy	Yes	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Sanitary	Yes	Yes	Yes	No	No	No	Yes	Yes	No	Yes	No	No

*Only if land is maintained for park and recreation uses or equivalent land substituted.

Table VIII-2

Revenue Sources

Allowable to Local Governmental Units

Local Units	Property Tax: Max. Rate w/o Referendum (%)	Property Tax: Max. Rate with Referendum (%)	Property Tax: Limit of Indebtedness	General Obligation Bonds	Special Assessment	Special Assessment Bonds	User Fees	Revenue Bonds	Share Sales Tax	Share Motor Fuel Tax
Municipality				Yes	Yes	Yes	Yes	Yes	Yes	Yes
Township		*		No	Yes	Yes	Yes	Yes	No	Yes
County				No	No	No	Yes	Yes	Yes	Yes
Special Districts										
Conservation District	.100	-	.5	Yes	No	No	Yes	No	No	No
Drainage District	-	-	****	No	Yes	Yes	Yes	Yes	No	No
Park District	.100	.255	5	Yes	No	No	Yes	Yes	No	No
River Conservancy District	.083	.750***	5	Yes	Yes	Yes	Yes	Yes	No	No
Sanitary District	.083	**	5	Yes	Yes	Yes	Yes	Yes	No	No

*Local unit taxing rates are very complex with separate rates for each function. The 1973 Illinois Revised Statutes and Supplement should be consulted for details for each item.

**Limited to 90 percent of uncollected assessments - greater indebtedness possible with approval of the County Circuit Clerk.

***.375 percent if district is over 25,000 population

****Rate can be increased to equal .02 percent of [illegible] capabilities, with their bonding capabilities tied directly to the assessed valuation. The Crystal Lake Park District includes all but the northwestern corner of the Crystal Lake watershed.

River Conservancy districts are the broadest in scope of the special districts. These districts can address almost any aspect of watershed management, including water quality, water supply, drainage, irrigation, public health and recreation. The financial resources are also broad: property tax levy, bonds, and assessments. The river conservancy district, in short, can do most anything necessary to preserve, protect and enhance a defined watershed area. Unfortunately, the Fox River Conservancy District has been declared unconstitutional by a lower court because the board of trustees of the district failed to meet the one man/one vote requirement. Even if this judgment is upheld, simple legislation could be enacted to change the organization of the board of trustees and re-establish the district.

The sanitary district was instituted to provide treatment and drainage of wastewater from developed areas. This remains their primary task, although various regulations regarding the extension of services have amounted to development regulations in areas of unfavorable environmental conditions. The sanitary district has varied sources of revenue, including tax levies, revenue and general obligation bonds, and user assessments.

A final approach is to attempt to coordinate all of the local governments and special purpose districts within the basin in a management effort. The need for such intergovernmental cooperation was recognized and encouraged by the new Illinois State Constitution. Article VII, Section 10 provides for very broad powers of cooperation:

> Units of local government and school districts may contract or otherwise associate among themselves, with the State, with other states and their units of local government and school districts, and with the United States to obtain or share services and to exercise, combine, or transfer any power or function, in any manner not prohibited by law or by ordinance. Units of local government and school districts may contract and otherwise associate with individuals, associations, and corporations in any manner not prohibited by law or by ordinance. Participating units of government may use their credit, revenues, and other resources to pay costs and to service debt related to intergovernmental activitites.

The City of Crystal Lake would be coordinator and planner in a cooperative, intergovernmental effort. Nine separate jurisdictions that can be used to advantage include: the City of Crystal Lake; the Village of Lakewood, McHenry County; the McHenry Conservancy District; the Crystal Lake Park District; and the four basin townships of Dorr, Algonquin, Grafton and Nunda. As mentioned earlier, the City of Crystal Lake has various police powers in the form of development regulations and the power to annex and provide services subject to compliance with these regulations. The County also exercises police powers relating to development--through soil utilization, flood plain, and zoning ordinances--and imposes health regulations and building codes which regulate development. The County can exert financial inducements for or against development through its taxing and assessment policies. The Crystal Lake Park District and McHenry County Conservancy District can maintain areas in a natural state by purchasing them for recreation. In the case of the park district, the emphasis is upon preserving open space. Townships frequently have excess funds available for general improvements in unincorproated areas, including parks, roads, and utilities. These various jurisdictions can be brought together through a program of mutually desirable goals, a cooperative financing program to bring about earlier action on land acquisition, and other appropriate cooperative actions.

Financing

Financing sources include: local governments and special districts, who can provide funds both individually and collectively; Federal funding, where appropriate; and State programs for local assistance (although these tend to be for more specific, short-duration programs).

Local Funding

The City of Crystal Lake has several options for generating funds for land acquisition and program implementation. One is to allocate part of its general operating funds. Similarly, part of the Federal revenue sharing monies could be allocated to a watershed management program. The City may also use special revenue sources. Revenue bonds, one method of generating funds for program implementation, might require a referendum and subsequent voter approval. Another special source is to earmark sales tax revenues for land acquisition. This technique has been used successfully in Boulder, Colorado to acquire extensive greenbelt lands around the city.

Other local agencies have independent sources of income that could be used. The local townships have both general funds and revenue sharing funds. The revenue sharing funds are frequently difficult to distribute effectively and have often been used for open space acquisition. For example, in Milton Township, DuPage County, three local park districts were given revenue sharing funds to purchase land.

The park districts can generate land acquisition funds through a corporate tax or revenue bonds. The limits on taxing rates and bonds are relatively generous and have been used to great advantage by other park districts in the region. The McHenry County Conservancy District has similar taxing and bonding powers intended to facilitate land acquisiton. The drainage district can use assessments and revenue bonds to aid in the financing of drainage works. Similarly, a sanitary district has use of tax levies, bonds and assessments to finance sewerage, sewage treatment facilities, and drainage works. The formation of a special river conservancy district would also include a means of financing aspects of the management program. In this case, funds available through taxes and bonds could be applied to a range of problems wider than simply land acquisition. The river conservancy district can address any program designed to maintain water quality within the watershed. Special treatment systems and runoff control programs could be financed with river conservancy district monies.

State Funding

The State of Illinois has an Open Space Land Acquisition Program administered by the Department of Conservation. This program provides a 50 percent reimbursement of local expenditures for open space acquisition. These funds are available to any governmental body with the power to acquire open space and/or recreational land. Five million dollars is being requested for fiscal year 1976 with a maximum of 10 percent of the total ($500,000) for any single project.

Federal Funding

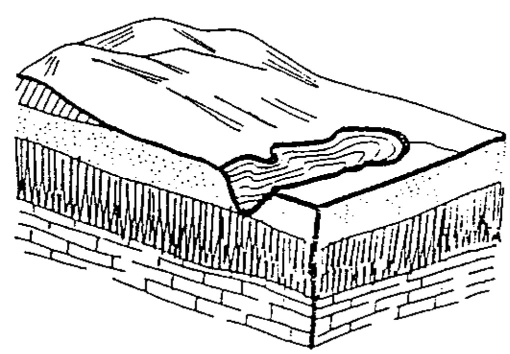
There are three appropriate sources of Federal funds for land acquisition. The first is the Bureau of Outdoor Recreation, authorized by the Land and Water Conservation Act of 1968 to provide matching funds for state and local jurisdictions for the acquisition and development of recreation areas. These funds are in the form of a 50 percent reimbursement of local expenditures. In fiscal year 1976 it is expected that 3.6 to 4.0 million dollars will be available to local governments in Illinois.

The second source is the Environmental Protection Agency, which provides funds to acquire land needed in land treatment systems--one of the proposed program elements. These funds would be distributed in the usual ratio of 75 percent Federal funds and 25 percent local funds.

A final potential source is the Housing and Urban Development (HUD) community development block grants. An overall watershed development program could be prepared as an "innovative project" under section 570.406 of the Title 24, HUD Federal regulations. The block grants emphasize programs that employ new techniques and procedures for community development and that are transferable to other similar situations.

Appendix A

SOILS AND GEOLOGY



APPENDIX A

SOILS AND GEOLOGY

Each of the five general soil management units described in Chapter II is composed of one or more specific soil types. Because the substrata of the types differ, the soils vary widely in suitability for many specific uses and in agricultural value. The nature of the subsoils and substrata is particularly significant in determining the drainage and moisture-supplying capability of most soils.

The most accurate and detailed information on the properties of various soil types comes from specific site investigations by the U.S. Soil Conservation Service. Before any construction is permitted, detailed soils analyses should be made on the site. For planning and policy formulation purposes, the information provided by the following table is appropriate. It summarizes the soils found in the Crystal Lake watershed and is keyed to the numbered soil types on the accompanying map, Figure A-1. Numbered soils on Figure A-1 are followed by a suffix (e.g., soil 103A), which indicates soil slope or unique soil conditions. These suffixes are explained in the key following Figure A-1.

The table indicates the relative suitability of each type of soil under different land use conditions. Suitability for conservation and productivity is based upon erosion hazard, wetness, slope, general fertility, and drainage. Suitability for urbanizing areas is dependent upon wetness hazards, flood potential, slope, limitations for foundations, depth to bedrock, erosion hazards, and limitations for the maintenance of grass, trees, and shrubs. Criteria that determine soil suitability for septic tank filter fields are soil permeability, percolation rate, groundwater level, depth to bedrock, flooding hazard, and slope. Soil wetness hazard is a criteria for suitability for most land uses, and generally refers to the depth at which soils saturated with water -- on either a permanent or a seasonal basis -- are encountered. Because of its wide applicability as a criterion, it is included for reference in this appendix.

The stratigraphical column in the Crystal Lake area is indicated in Table A-2. The oldest rocks are shown at the bottom of the page, the youngest at the top. Between the youngest Silurian rocks and the Pleistocene glacial deposits, no rocks of Mesozoic and Camozoic eras are represented. This inconformity is a gap of several hundred million years in the geological record.

Table A-1
McHenry County Soil Types/Land Use Suitability

Number	Soil Name	Material of Origin	Drainage Characteristics	Depth of Soil	Organic Matter Content	Permeability	Topography
23	Blount Silt Loam	Till	Imperfectly Drained (Few Moderately Drained)	2 - 3 1/2 ft	Low	Moderately Slow to Slow	Upland 1. - 5% Slope
57	Montmorenci Silt Loam	Silt Loam Till	Moderately Well- To Well-Drained	2 ft	Low	Moderate	Upland 1. - 6% Slope
67	Harpster Silty Clay Loam	Outwash Sediments, Till and Loess	Very Poor	1 - 4 ft	High	Moderate	Depressed Area 12% (Occasionally)
93	Rodman Gravelly Loam	Loamy Gravel Glacial Drift	Excessibly Drained	1 - 3 ft		Very Rapid	5 - 30% Slope
102	Lafiegue Loam	Outwash	Imperfectly Drained	3 1/2 ft (Loamy Sand) 5 ft (Sand)	High	Moderate	
103	Houghton Muck	Decomposed Vegetation	Very Poorly Drained	1 - 3 ft	High	Moderate to Rapid	Level and Depressed 12 - 18% Slope
104	Virgil Silt Loam	Till and Loess	Imperfectly Drained	30 - 40 inches thick	High	Moderate	Upland 3% Slope
132	Starks Silt Loam	Outwash Under Forest Vegetation	Imperfectly Drained	1 - 3 ft	Low	Moderately Slow	Level to Gently Sloping
134	Camden Silt Loam	Outwash Under Forest Vegetation	Well-Drained to Moderately Well-Drained	4 ft	Low	Moderate	Irregular Pattern 1 - 10% Slope
137	Ellison Silt Loam to Loam	Silt Loam and Loam Sediments		2 - 3 ft	Low	Moderately Rapid	Gently Sloping
148	Proctor Silt Loam	Medium Textured Outwash	Well-Drained to Moderately Well-Drained	1 - 3 ft	High	Moderate	0 - 7% Slope
149	Bienton Silt Loam	Medium Textured Outwash	Imperfectly Drained	1 - 3 ft	High	Moderate	Level to Gently Sloping
152	Drummer Silty Clay Loam	Loam or Loam Till	Poorly Drained	1 - 4 ft	High	Moderate	Level, Gently Sloping 0 - 3 %
191	Knight Silt Loam	Silt and Loam Deposits	Imperfectly to Poorly Drained	4 ft or more	High	Moderately Slow	Depressed Area
194	Morley Silt Loam	Loess Over Silty Clay Loam Till	Moderately Well-Drained to Imperfectly Drained	2 ft.	Low	Moderately Slow to Slow	Upland 4 - 20 % Slope

Table A-1 (cont.)

Number	Soil Name	Material of Origin	Drainage Characteristics	Depth of Soil	Organic Matter Content	Permeability	Topography
197	Troxel Silt Loam	Silt or Loam Deposits	Moderately Well-Drained to Imperfectly Drained	4 ft or more	High	Moderate	Depressed Area
198	Elburn Silt Loam	Loess	Imperfectly Drained	30 - 40 inches	High	Moderate	Depressed Area 30% Slope
206	Thorf Silt Loam	Silt of Loam	Poorly Drained	3 - 4 ft	Medium	Slow to Moderately Slow	Depressed Area
210	Lena Muck	Outwash	Very Poorly Drained	3 ft	High	Moderate	Depressed Area
219	Millbrook Silt Loam	Outwash	Imperfectly Drained	3 ft	Moderately High	Moderate	Depressed Area Gently Sloping
232	Ashkum Silty Clay Loam	Till or Loam	Poorly Drained	3 1/2 ft	High	Moderately Slow	Upland
290	Warsaw Silt Loam to Loam	Silt Loam	Well to Excessively Drained	2 - 3 1/2 ft	High	Moderately Rapid	1 - 10% Slope
297	Ringwood Silt Loam	Till	Well-Drained to Moderate	1 - 3 ft	High	Moderate	Upland 1 - 7% Slope
299	Nippersink Silt Loam	Loess over Loam Till	Well-Drained to Moderately Well-Drained	1 - 3 ft	Low	Moderate	Upland 12% Slope
310	McHenry Silt Loam	Loess on Sandy Loam Till	Well-Drained to Moderately Well-Drained	1 - 3 ft	Low	Moderate	Upland 1 - 12%
318	Lorenzo Silt Loam to Loam	Loam and Silt	Excessively Drained	12 - 24 inches	Moderately High	Moderately Rapid	1 - 20% Slope
323	Casco Silt Loam	Loam and Silt	Excessively Drained	12 - 24 inches	Low	Moderately Rapid	1 - 20% Slope
325	Dresden Silt Loam to Loam	Silt Loam	Well-Drained to Excessively Drained	2 - 3 1/2 ft	Low	Moderate Very Rapid	Depressed Area 1 - 10% Slope
327	Fox Silt Loam to Loam	Silt Loam	Well-Drained to Excessively Drained	2 - 3 1/2 ft	Low	Moderate Moderately Rapid	1 - 15% Slope
329	Will Silty Clay Loam	Outwash	Poorly Drained	2 - 3 1/2 ft	High	Moderate	Depressed Area 2 - 3% Slope

Table A-1 (cont.)

Number	Soil Name	Material of Origin	Drainage Characteristics	Depth of Soil	Organic Matter Content	Permeability	Topography
330	Peotone Silty Clay Loam	Outwash	Very Poorly Drained	3 - 4 ft	High	Moderately Slow	Depressed Area
342	Martherton Silt Loam to Loam	Outwash	Imperfectly Drained	2 - 3 1/2 ft	Moderately High	Moderate to Moderately Rapid	Depressed Area
343	Kane Silt Loam to Loam	Outwash	Imperfectly Drained	2 - 3 1/2 ft	High	Moderate to Moderately Rapid	Depressed Area 2 - 3% Slope
344	Harvard Silt Loam	Outwash	Well-Drained	1 - 3 ft 4 - 5 ft	Moderately Low	Moderate	6% Slope
347	Harpster Silt Loam	Outwash Till	Naturally Poor-Imperfect	1 - 4 ft	High	Moderate	Depressed
361	Lapeer Loam	Till	Well-Drained	3 ft or less	Low	Moderate to Moderately Rapid	Upland 5 - 18% Slope
363	Griswold Loam	Till or Loess	Well-Drained	3 ft or less	High	Moderate to Moderately Rapid	Upland 5 - 12% Slope

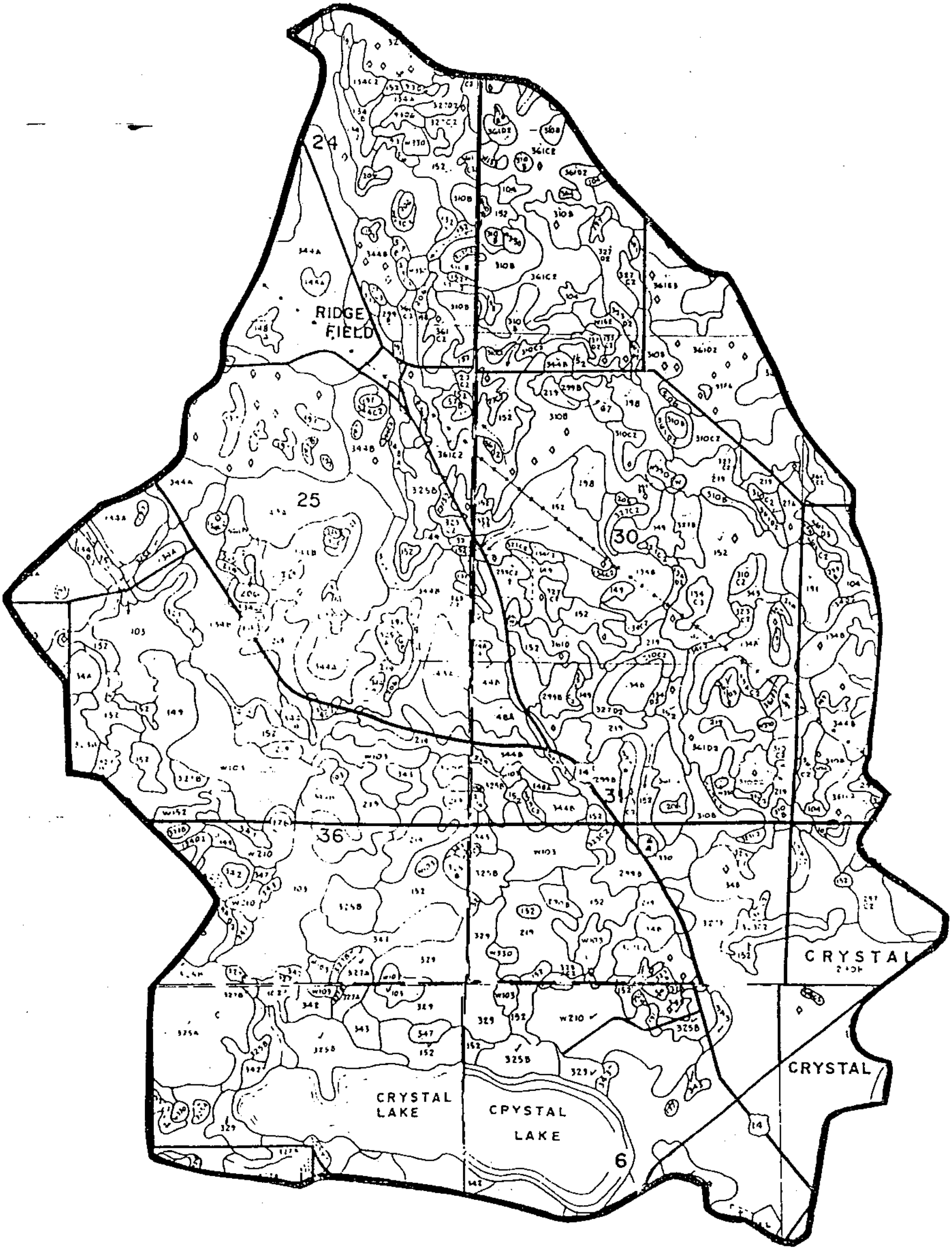


Figure A-1 CRYSTAL LAKE WATERSHED SOIL TYPES

Key to Soil Symbols in Figure A-1

A	0 - 2% Slopes
B	2 - 4% Slopes
C	4 - 7% Slopes
D	7 - 12% Slopes
E	12 - 18% Slopes
F	18 - 30% Slopes
2	Eroded
3	Severely Eroded
W	Wet

TABLE A-2

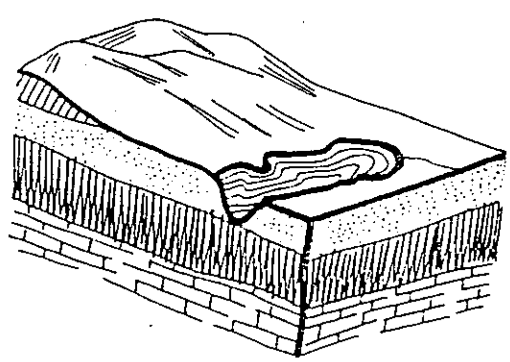
GENERALIZED GEOLOGIC COLUMN IN CRYSTAL LAKE AREA

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

SOURCE: SASMAN, ROBERT T., THE WATER LEVEL PROBLEM AT CRYSTAL LAKE, MCHENRY, ILLINOIS, URBANA: ILLINOIS STATE WATER SURVEY, 1957.

Appendix B

REGIONAL GROWTH



APPENDIX B
REGIONAL GROWTH

The Village of Crystal Lake was incorporated in 1837, only a year after the first white settlers replaced the Sauk and Fox tribes on the lake shores. Today, the village has become a city, the home for over 16,000 people; the profitable ice industry of the late 19th century has faded before commercial and industrial enterprises. As the city continues to grow and change, its past is left for historians. In planning for its future, more recent trends take precedence. In this section, the growth of the region will be examined by surveying change in population and land use.

Population

Located 49 miles northwest of Chicago in McHenry County, Crystal Lake is included in the Chicago Standard Metropolitan Statistical Area (SMSA). From 1960 to 1970 total SMSA population grew from 6,220,913 to 6,978,947 -- a 12.2 percent increase.[1/] Most growth was in areas outside the metropolitan center, as evidenced by a 35.3 percent growth increase outside Chicago compared with a 5.2 percent decrease in the population of the City itself.

The population in the City of Crystal Lake has grown steadily since 1900 (see Table B-1). Recent figures illustrate the current growth trend: steady and rapid. The population grew from 4,832 in 1950 to 8,314 in 1960, a 72 percent increase. By 1970 the population had reached 14,451, growing by an additional 74.9 percent. The growth rate in the City of Crystal Lake is nearly double that in most surrounding communities, as shown by Table B-2.

TABLE B-1

POPULATION OF CRYSTAL LAKE
1900-1970 2/

Year	Population	Change	
		Number	Percent
1900	950	-	-
1910	1242	292	30.2
1920	2249	1007	81.1
1930	3732	1483	65.9
1940	3917	185	5.0
1950	4832	915	23.4
1960	8414	3482	72.1
1970	14,451	6227	74.9

TABLE B-2

POPULATION COMPARISON
CRYSTAL LAKE, ILLINOIS 3/

Municipality	1950	1960	1950-60 % Change	1970	1960-70 % Change
Crystal Lake	4,832	8,314	72.1	14,451	74.9
McHenry	N/A	3,336	-	6,772	103.0
Woodstock	7,192	8,897	23.7	10,226	14.9
Carpentersville	1,523	17,424	1044.1	24,059	38.1
Barrington	N/A	5,434	--	7,701	41.7

NOTE: N/A - Not Available.

Growth in the townships surrounding the watershed are an additional indicator of regional growth. Here too, population has been on the rise, as seen in Table B-3.

TABLE B-3

POPULATION GROWTH

TOTAL TOWNSHIP AREA SURROUNDING THE WATERSHED 4/

(1850-1970)

Township	Year							
	1850	1860	1870	1930	1940	1950	1960	1970
Algonquin	1,455	1,987	2,157	5,424	5,424	9,483	20,759	31,948
Dorr	-	2,386	2,681	6,371	6,371	8,280	9,652	10,765
Grafton	446	1,073	2,681	1,379	1,379	2,471	4,022	5,018
Nunda	1,548	1,321	-	2,919	2,919	4,768	9,605	12,873

As these figures -- and those presented earlier -- reveal, following the growth spurt during initial settlement prior to the Civil War, growth has been greatest since World War II, continuing to the present.

A 1972 land survey indicated a population of 21,200 people in the Crystal Lake Planning Area (the city and 1.5 miles beyond), including 16,000 in Crystal Lake, 4,300 in the 1.5 mile unincorporated area, and an additional 900 persons in the Village of Lakewood.5/ Yet population increases between 1958 and 1970 have been so great that facilities previously planned to accommodate a 1980 population are no longer adequate. The message is clear: growth trends, current and projected, are an essential component of sound developmental planning.

Population Forecast

If current growth trends continue, the Crystal Lake region will steadily add to its numbers. A 1968 study by the Northeastern Illinois Metropolitan Area Planning Commission anticipated that 10.2 million people would make their homes in Cook, Du Page, Lake, Will, Kane and McHenry Counties by 1995. With present declines in the birth-rate, the figures were later reforecasted at 1 million fewer regional residents. Yet growth in McHenry County is anticipated to be extensive, as seen from Table B-4.

TABLE B-4

McHENRY COUNTY POPULATION FORECAST

Township	Year			
	1973	1980	1990	2000
Algonquin	35,210	47,000	61,000	82,500
Dorr	10,936	12,700	19,000	31,500
Grafton	5,262	6,000	8,500	11,500
Nunda	14,306	22,100	29,000	39,500
County Total	121,050	156,000	205,100	276,000

Source: Northeastern Illinois Metropolitan Planning Commission, Population and Employment Forecasts Policies and Summaries of Findings, May, 1974.

The most rapidly growing township will be Algonquin, increasing from a 1973 population of 35,210 to 47,000 by 1980. The expansion southeast of Crystal Lake will taper off slightly in 1990, then increase again to a projected 82,500 residents by the year 2000. Influencing this area growth might be the southeastern location of the Crystal Lake airport.

Seven thousand new residents will join Nunda Township by 1980. Although the northward expansion from the city will be slower than the anticipated Algonquin increase, it too will be steady. By 2000, Nunda's population will have grown to 39,500.

Dorr Township is expected to expand toward the northwest. In 1980, Dorr will have grown by 1,764 people and in 1990 by 6,300, to total 31,500 in the year 2000.

Growth is limited in Grafton Township. Poor soils in the southwest cannot support building foundations, nor are they suited for septic drainage fields. Inadequate water systems are an additional growth limitation. Yet despite these shortcomings, the 1980 project for Grafton Township reveals an increase of 738 residents. The 1990 increase is for 2,500 new dwellers, with the year 2000 increase set at 3,000, to total 11,500 residents.

Growth Summary

With improvements in transportation and the spread of the Chicago metropolitan area, the Crystal Lake region has grown both as a home for commuters and as self-contained commercial and industrial center. Currently about 4.5 percent of Crystal Lake's employment force commutes to white-collar jobs in Chicago's Central Business District, with 5.2 percent employed in other Chicago-based areas. Those working in McHenry County total 66.5 percent. Indicated by the small percentage commuting to Chicago are an increase in suburban-based businesses and an economic independence from the central city.

If the present rate of development remains constant, the next 10 to 15 years will mean considerable new development not only in Crystal Lake, but in the entire far west and northwest portions of the Chicago metropolitan area as well. Already proposed are a new town development near Aurora and the Elgin-Aurora freeway, both contributing to the potentially rich market for commercial, industrial, and residential development. A proposed commercial center near Elgin might be the next step in accommodating future growth.

The growth spurts early in the 20th century and again recently (1950 to 1970) might well indicate a yearning for a less congested way of life. Lest those moving to Crystal Lake recreate by their numbers the urban blight they fled, facilities -- for both life's necessities and pleasures -- must be planned to accomodate the increased growth.

Land Use

Land use has been surveyed by the City for the Crystal Lake Planning Area. As the area under study in this reporting reflects natural rather than political boundaries, watershed land use was also examined for this study. These land uses will be discussed individually; presented on the following page is a map showing existing land use.

Land Use - City of Crystal Lake

The first comprehensive plan for Crystal Lake was developed in 1957; the most recent in 1972. Since 1957 the population of Crystal Lake has more than doubled; commercial activities have increased threefold (from 33 to 99 acres); and parks and open lands have increased from 66 to 298 acres. A comparison of growth and land use from 1957 to 1972 for the Crystal Lake Planning Area is shown in Table B-5. In this 15-year period, the total developed area has doubled.

Figure B-1 EXISTING LAND USE

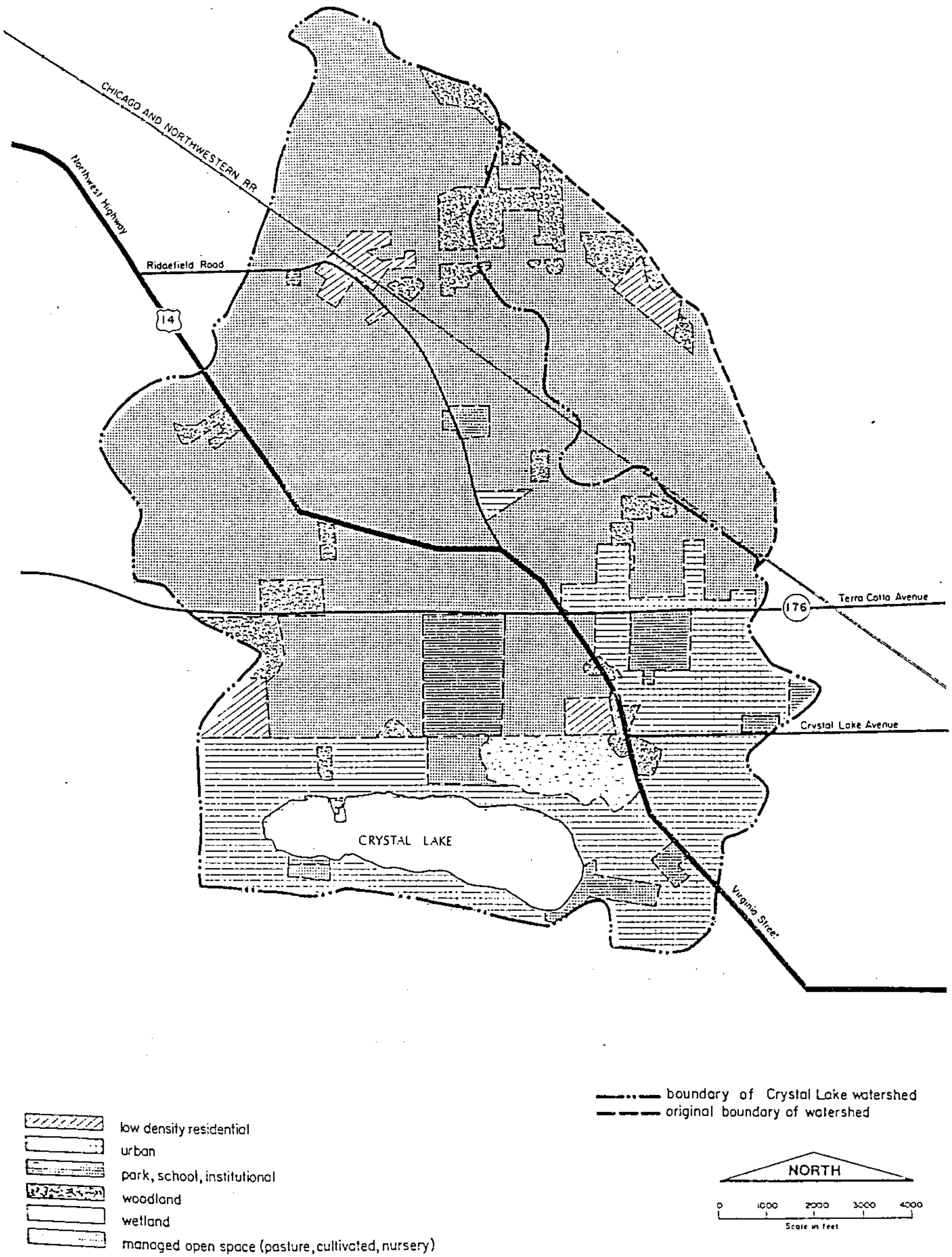


TABLE B-5

LAND USE 1957 AND 1972

CRYSTAL LAKE PLANNING AREA 6/

Land Use	1957 Acres	1957 Percent	1972 Acres	1972 Percent	1972* Acres Per 100 Persons
Single Family	555.59	45.12	956.52	40.91	6.58
Two Family	23.27	1.89	15.41	.63	0.11
Multiple Family	2.16	.18	43.90	1.85	0.30
RESIDENCE	581.02	47.19	1015.83	43.39	6.99
COMMERCE & PARKING	33.35	2.71	98.77	4.22	0.62
Railroads	48.78	3.96	39.69	1.70	0.25
Industry	90.20	7.32	106.67	4.57	0.67
INDUSTRY	138.98	11.28	146.36	6.27	0.92
Public Buildings	93.73	7.61	277.96	11.90	1.91
Parks & Open Space	66.18	5.37	296.24	12.65	2.04
PUBLIC & SEMI-PUBLIC	159.91	12.98	574.20	24.55	3.95
STREETS	318.20	25.84	504.04	21.57	3.15
TOTAL DEVELOPED	1231.46	100.00	2336.41	100.00	14.61
WATER	33.81		122.68		
VACANT	819.99		1129.02		
TOTAL AREA	2085.26		3588.11		

* Population January 1972 estimated to be 16,000 persons. Building permits for 1970 and 1971 were tabulated and added to the housing supply. A vacancy factor of 2 percent was deducted and the 1970 persons per household of 3.5 was used to estimate the current population.

New subdivisions have joined the residential areas in order to accommodate the growing population. Lots have been annexed around the lake to provide space for new residents. Large-scale residential complexes have generally been planned unit developments, which provide recreational open space facilities for residents. Most dwelling units now being built in Crystal Lake are multiple family apartments.

As in most communities, the commercial areas in Crystal Lake are located along major streets and highways. Most major commercial routes in Crystal Lake have undergone some form of extensive development. For example, Virginia Street is now almost entirely commercial from Main Street to Dole Avenue. U.S. Highway 14 has become exceedingly congested, with no relief to passing autos from the strip commercial development. Also intensely developed are State Highway 176 (Terra Cotta Avenue) from U.S. 14 to the Northwestern Railroad and the central business district. Shops, offices, financial institutions and public offices are housed within the central business district. The commercial development to the east appears as cluster-like formations extending along State Highway 31. Eventually, this land use pattern will produce a 3-mile long commercial street.

The industry in Crystal Lake has been located almost entirely outside of the city, due partly to the limited availability of good industrial sites within the city limits. Most of the new industries have located to the southeast, east, and northeast areas of the community. The newer residential areas are situated close to U.S. Highway 14, State Highway 176, and adjacent to the Chicago and Northwestern Railroad.

Crystal Lake residents are afforded numerous parks and open space lands, which total 13 percent of the developed area. Almost one-fourth of the total developed area is used for public buildings and open space, although some of the land once allotted for schools now sits unused.

Land Use - Crystal Lake Watershed

Land use in the surface watershed area of Crystal Lake consists of residential, open space/institutional, and agriculture. Together, these categories total 4,300 acres, as shown in Table B-6. Twenty-five percent of the watershed area has been developed.

TABLE B-6

LAND USE IN SURFACE WATERSHED AREA

Category	Acreage	Percent
Urban	810	19
Institutional, Parks, Schools	195	4
Residential, Low Density	100	2
Managed Open Space	2590	60
Woodland	280	7
Wetland	85	2
Crystal Lake	240	6
TOTAL	4300	100

The agricultural area north of the lake comprises 60 percent of the watershed. Here the land is cultivated for alfalfa, corn, soybeans, nursery stock, wheat and soil. It has been estimated that in 1960 the market worth of all crops and livestock exceeded $25,000,000.

At one time dairy farming was prevalent in this area. Where 20 dairy farms once operated, today there are three. Two are small farms, with about 30 cows; the third supports 60 to 70 cows. As urbanization increases, many farmers are either selling their land or cultivating less. Many feel it is only a matter of time before they are eliminated by new residential development.

Despite these urban growth trends in the watershed, the preservation of open space has not been neglected. The Crystal Lake Park District has provided its residents with two beautiful parks, one on the west end of the lake, and the other on the east end. The northern portion of the watershed has scenic open pastures, woodlands and nurseries. Aiding in the preservation of open areas is institutional development, which sets aside huge areas of land for multiple uses. The new McHenry County Junior College is one such example.

References

[1]City of Crystal Lake, Comprehensive Plan, 1972.

[2]U.S. Bureau of Census

[3]City of Crystal Lake, Comprehensive Plan, 1972.

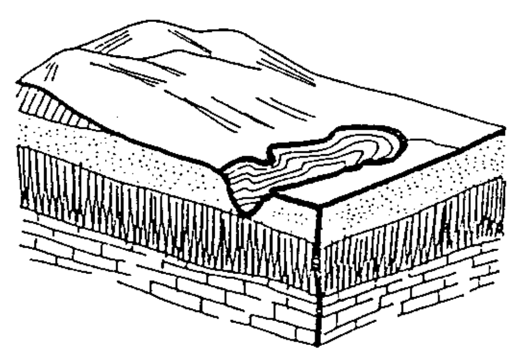
[4]U.S. Bureau of Census

[5]City of Crystal Lake, Comprehensive Plan, 1972.

[6]Ibid.

Appendix C

WATER QUALITY DATA



APPENDIX C

WATER QUALITY DATA

This appendix presents selected water quality data that were gathered or used substantially during this study. Data tables to follow are described below.

Table C-1 presents a summary of algae species and concentrations observed at various sampling locations in the lake during the NALCO study.

Table C-2 presents chlorophyll a concentrations at various locations in the lake observed in the NALCO study.

Table C-3 presents results of the Illinois EPA water quality study of the Crystal Lake Drainage District Tile System.

Table C-4 presents Bauer Engineering measurements of surface and groundwater quality conditions at Crystal Lake, July - September, 1974.

An analysis of algae conditions in Crystal Lake based on the data from the NALCO study follows.

Algae in Crystal Lake

One of the methods of determining the water quality in a body of water is the identification and enumeration of algae. There are many kinds of algae. These are classified in seven groups in families that characterize the several species within the group. Four of these groups are represented in Crystal Lake.

In order for algae to grow, they need specific quantities of nutrients and other life-sustaining elements. Phosphorus, nitrogen, and organic carbon are considered the primary nutritional requirements for algae. The nutritional condition of a water body is stated as its trophic condition. The trophic condition of a water body lies within the range of a clean water (oligotrophic) condition and a polluted water (eutrophic) condition. Excess levels of phosphorus, nitrogen, and organic material increase the nutritional content, thereby causing eutrophication to occur.

One can determine the trophic transition of water from the various kinds of species present and their quantity. The algae of Crystal Lake can be classified into four groups: clean water, surface water, diatoms, and blue-green algae. Clean and surface water algae with a few diatoms and a wide variety of species indicate an oligotrophic or clean water condition. A proliferation of diatoms and a large abundance of blue-green algae with two or three dominant species indicate a eutrophic condition. An assessment of the trophic transition can be made by monitoring the types and quantity of algae and the water quality over a period of several years. In most urban environments, the progression of water quality is toward eutrophication. Crystal Lake can be characterized as once an oligotrophic lake in transition to a eutrophic condition; eutrophication is taking place.

The eutrophication process in Crystal Lake has been detected by the number of algal species identified and their quantification. Data were collected in the NALCO study three times during the seasonal transitions in lake spring and early fall. The variety of species identified were numerous for all three samples taken throughout the time period. All four groups of algae were found at all sampling locations.

The most distinctive character of the algal population is the dominant character of the diatoms in the spring and the proliferation of blue-green algae in the summer and early fall. The Pennales are a group of diatoms that compose up to 78 percent of the algae population in May. Fragilaria crotonensis is the species of these diatoms that dominates up to 70 percent of the population. An over-abundance of diatoms indicates the onset of a eutrophic condition. They proliferate in the spring because the lower water temperatures offer more viable conditions. Their decomposition during the summer months increases the organic content of the water, increasing the nutritional levels.

As water temperatures increase during the summer and fall months, the blue-green algae become the most dominant group. The Cyanophyceae is the blue-green algae group that compose up to 95 percent of the population at some locations in the lake. Those species found in large quantity in Crystal Lake that belong to the blue-green algae group are Merismopedia tenuissima, Gomphosphaeria aponina, and Aphanocapsa pulchia.

The blue-green algae, generally characteristic of eutrophic conditions when over-abundant, represented 80 percent of the algae population at all locations during July and well over 90 percent at all locations in October. These blue-green algae blooms indicate a high organic enrichment.

The algal population during the summer months is relatively specific and is dominated by one group of algae. These algal conditions suggest a high nutrient level in the water; this encourages the eutrophic process. The nutrient levels in Crystal Lake seem to be increasing, supporting an algae population that has less variety and is becoming more abundant. These conditions indicate a eutrophic process and a slow degradation of water quality. The abundance of the diatoms in the spring and the proliferation of blue-green algae in the summer with a variety of other species suggest a water quality transition from a less eutrophic to a more eutrophic condition.

Table C-1a

Algal Taxonomy at Location #1*

From NALCO Lake Surveillance Report 1974

	Total Org/ml			Percent of Population		
	May 22	July 24	October 2	May 22	July 24	October 2
Bacillariophyta	17,619	8	43	83.60	0.08	0.3
Chlorophyta	822	804	434	8.99	7.24	3.2
Chrysophyta	19	30	2	0.20	0.27	0.0
Cryptophyta	545	994	402	5.96	8.95	2.9
Cyanophyta	99	9,269	12,855	1.07	83.44	95.6
Pyrrhophyta	2	4	-	0.02	0.04	-
Total Phytoplankton	9,106	11,109	13,726			

* Location 1 Center of Lake

Table C-1b

Algal Taxonomy at Location #4 *

From NALCO Lake Surveillance Report 1974

	Total Org/ml			Percent of Population		
	May 22	July 24	October 2	May 22	July 24	October 2
Bacillariophyta	225	41	57	33.85	0.19	0.7
Chlorophyta	113	1,053	402	17.00	4.98	5.0
Chrysophyta	179	8	-	26.94	0.04	-
Crystophyta	141	1,751	253	21.21	8.29	3.2
Cyanophyta	4	18,269	7,313	0.60	86.45	91.1
Pyrrhophyta	-	11	-	-	0.05	-
Englenophyta	2	-	-	0.30	-	-
Total Phytoplankton	664	21,133	8,025			

* Location 4 Gate #9

Table C-1c

Algal Taxonomy at Location #8*

From NALCO Lake Surveillance Report 1974

	Total Org/ml			Percent of Population		
	May 22	July 24	October 2	May 22	July 24	October 2
Bacillariophyta	7,202	15	79	80.23	0.09	0.4
Chlorophyta	994	872	449	11.03	5.16	2.3
Chrysophyta	283	-	5	3.13	-	0.0
Cryptophyta	372	1,008	229	4.13	5.97	1.2
Cyanophyta	117	14,987	18,541	1.29	88.69	96.1
Pyrrophyta	2	8	-	0.02	0.05	-
Euglenophyta	-	8	-	-	0.05	-
Total Phytoplankton	8,970	16,898	19,303			

* Location 8 Main Beach Area

Table C-2

Chlorophyll a Concentrations Measured at Crystal Lake
From NALCO Lake Surveillance Study 1974

	Location	Mean Concentrations of Chlorophyll a (mg/m^3) During the Year 1974				
		May 22	June 19	July 24	August 14	October 2
1.	Center of Lake	20.40	8.66	4.67	4.53	1.48
2.	Lake Influent Flow	5.20	1.35	5.20	8.40	9.33
3.	Lake Effluent Flow	16.80	9.60	7.60	6.80	1.25
4.	Gate No. 9	17.20	7.60	5.47	4.40	2.32
8.	Main Beach Area	18.53	8.53	4.67	8.93	1.52

Table C-3

Water Quality Data for Crystal Drainage District Tile System from Illinois EPA Survey, 1973

Location	Sample Date	BOD mg/l	Total Suspended Solids mg/l	pH	Fecal Coliform per 100 ml	Total Coliform per 100 ml	Phosphorus mg/l	Ammonia mg/l	Nitrate mg/l	Turbidity (JTU)
B-1	Tile Outlet to Crystal Lake[a]									
	2-14-73	0	1	-	<10	-	0.02	0.2	2.6	1.5
	3-14-73	-	2	7.6	80		0.06	0.25	2.6	1.5
	5-14-73	3	4	8.3	50		0.15	0.06	0.8	
	8-6-73	0	13	7.5	420	11,000	0.09	0.33	2.3	2
B-2	Inlet to Discharge Tile[b]									
	2-14-73	1	3	-	10	-	0.025	0.2	3.0	1.0
	3-14-73	-	2	7.5	110	-	0.06	0.27	2.7	1.6
	5-14-73	6	1	8.3	10	-	0.21	0.23	0.2	-
	8-6-73	0	9	7.4	420	10,000	0.08	0.37	2.4	2

[a] Sampling location was at the south end of the drainage tile at the point of discharge into Crystal Lake.

[b] Sampling location was at the north end of the drainage tile at the point where the open ditch feeds into the drainage tile.

Table C-4

Surface and Groundwater

Measurements for Crystal Lake Watershed

July-September 1974

Location	Date	PARAMETERS*							
		pH	Chloride	TDS	NO_3-N	NO_2-N	Total PO_4-P**	Soluable Ortho PO_4-P	Fecal Coliform
B-12	7/3/74	-	24	492	0.68		.216	1.16	< 1
	8/1/74	7.3	69	1302	0.82	0.08	.032	.008	< 1
	9/9/74	7.5	36	962	0.94	0.18	.158	<.005	<10
B-11	7/3/74	-	30	488	0.90		.060	0.61	10
	8/1/74	7.4	61	1410	0.97	0.08	.016	.008	< 1
	9/9/74	7.6	46	550	0.50	0.15	.084	<.005	<10
B-10	7/3/74	-	303	1572	0.70		.060	0.61	< 1
	8/1/74	6.8	1342	3602	0.83	0.05	.028	.008	5
	9/9/74	7.1	546	1542	0.53	0.10	.056	<.005	<10
B-9	7/3/74	-	26	392	0.80		.132	0.18	<10
	8/1/74	7.4	42	938	0.85	0.05	.080	.008	1
	9/9/74	7.8	22	558	0.62	0.10	.024	<.005	<10
B-8	7/8/74	-	94	494	0.52		1.564	2.10	<10
	8/1/74	7.4	191	1554	3.05	0.05	.040	<.003	4
	9/9/74	7.5	112	868	2.82	0.08	.680	<.005	<10
B-7	7/3/74	-	16	626	0.65		.120	.120	5
	8/1/74	7.3	34	1192	0.85	0.05	.016	.008	< 1
	9/9/74	7.7	25	668	0.71	0.05	.458	.005	100

* All measurements are in mg/l except for pH and fecal coliform. Fecal coliform is measured by organisms/100 ml

Table C-4 (continued)

Surfacé and Groundwater

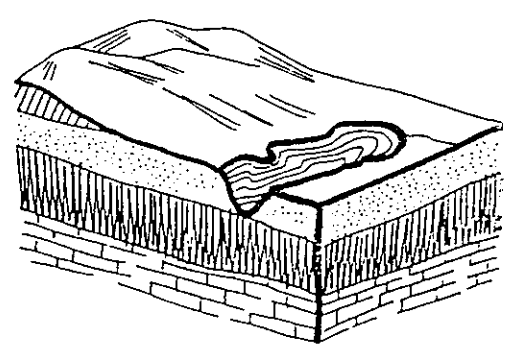
Measurements for Crystal Lake Watershed

July-September 1974

Location	Date	PARAMETERS*							
		pH	Chloride	TDS	NO_3-N	NO_2-N	Total PO_4-P**	Soluable Ortho PO_4-P	Fecal Coliform
B-3	7/3/74	-	21	1096	1.07		1.10	1.10	-
	8/1/74	7.4	22	1428	1.30	0.05	.008	< .003	-
	9/9/74	7.7	13	716	0.91	0.05	0.71	< .005	-
B-2	7/3/74	-	40	528	0.72		0.40	0.44	-
	9/9/74	7.7	13	716	0.91	0.05	0.28	< .005	-
WP-3	7/3/74	-	7	264	0.68	-	.64	-	-
WP-4	7/3/74	-	8	526	3.11	-	.012	-	< 1
	8/1/74	7.4	13	1226	4.75	.05	.008	< .003	2
	9/9/74	7.5	11	590	2.39	.16	.026	< .005	< 10
Tile Outlet	8/1/74	7.5	47	1306	3.85	.05	.008	< .003	500
	8/26/74	7.4	26	714	9.95	.10	.024	< .005	-
	9/9/74	8.0	26	650	3.00	.20	.026	< .005	280
Tile Inlet	8/26/74	7.4	27	694	3.84	.06	.15	< .005	-
	9/9/74	7.8	26	682	2.98	.20	.126	< .005	80
Storm Sewer	8/26/74								
	1st flash	8.4	-	632	1.65	.10	.04	< .005	13,000
	2nd flash	7.2	-	180	1.69	.06	.04	< .005	17,000

Appendix D

HYDROLOGY



APPENDIX D

HYDROLOGY

This appendix presents the hydrological information used in the site evaluation procedures presented in Chapter VI.

Figure D-1 presents rainfall intensity curves for storms of various frequencies of occurrence, ranging from one-year to one-hundred-year return frequencies.

Figure D-2 presents required on-site detention requirements as a function of soil infiltration capacities for a one-year design storm. This figure indicates the amount of storage that must be provided for the one-year storm frequency criteria proposed for on-site recharge of runoff through direct infiltration. Required storage is shown as a function of percent imperviousness and average infiltration capacity of the site soils. Infiltration capacity would be determined by field testing procedures.

Also included is a discussion of the recommended infiltration test technique and procedures.

Infiltration Test

Infiltration tests are conducted to measure the rate at which water is taken up by the soil. The infiltration measurement is concerned only with movement through the air-soil interface and not with movement through the soil, i.e. permeability and percolation.

The concentric ring infiltrometer (Figure D-3) consists of two concentric rings, 12 inches high. The inner one usually is about 9 inches in diameter and the outer one ranges from 14 to 36 inches in diameter (14 inches in a common size). These rings are inserted into the soil to be tested at the minimum depth necessary to prevent leakage from the rings. The two rings are then flooded to the same depth and maintained at that level. The inner ring is used to determine the infiltration rate, while the outer ring is used to decrease border effects on the inner ring. If only one ring were used, the border areas would take in more water, because there would be lateral motion of water as well as

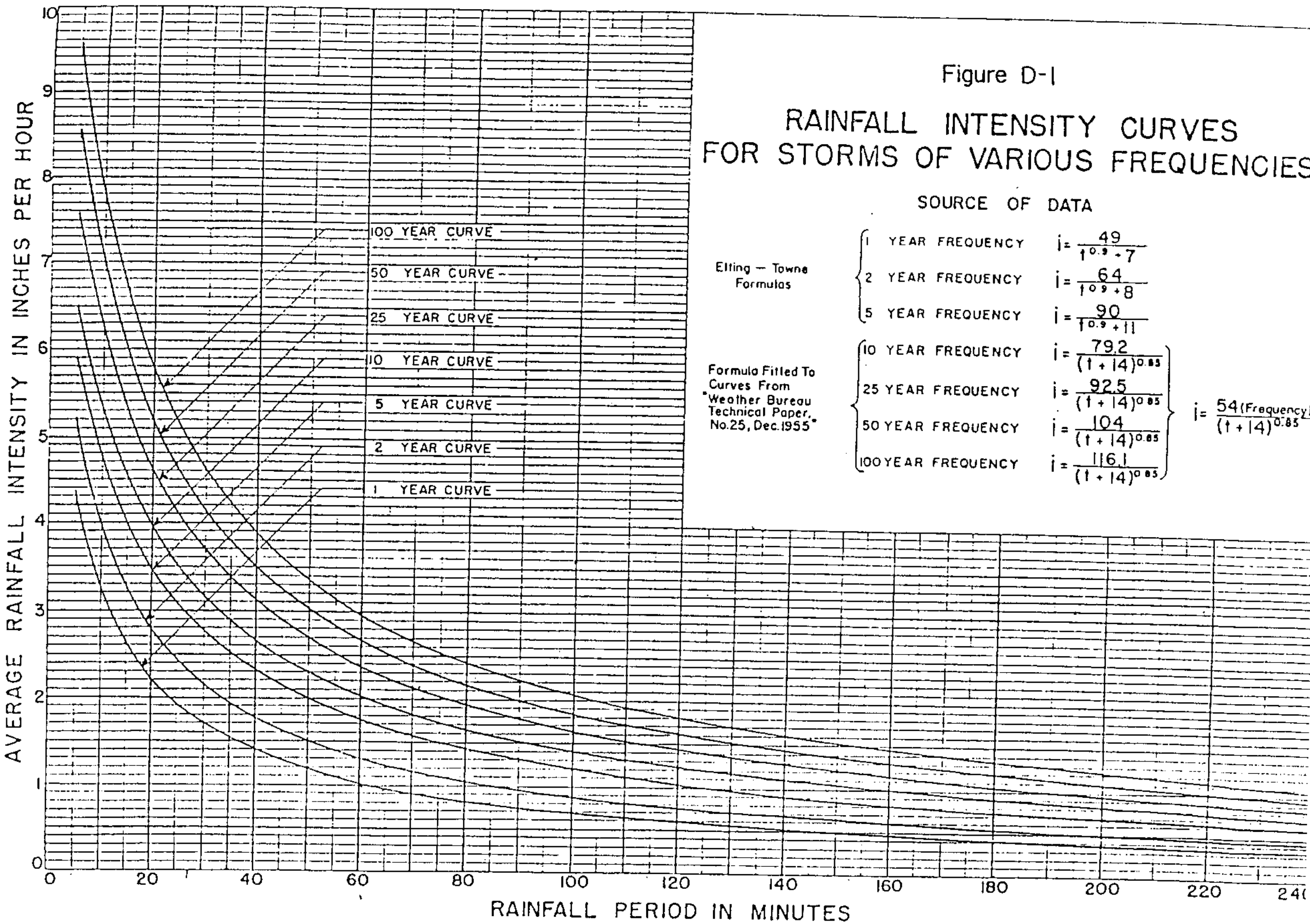
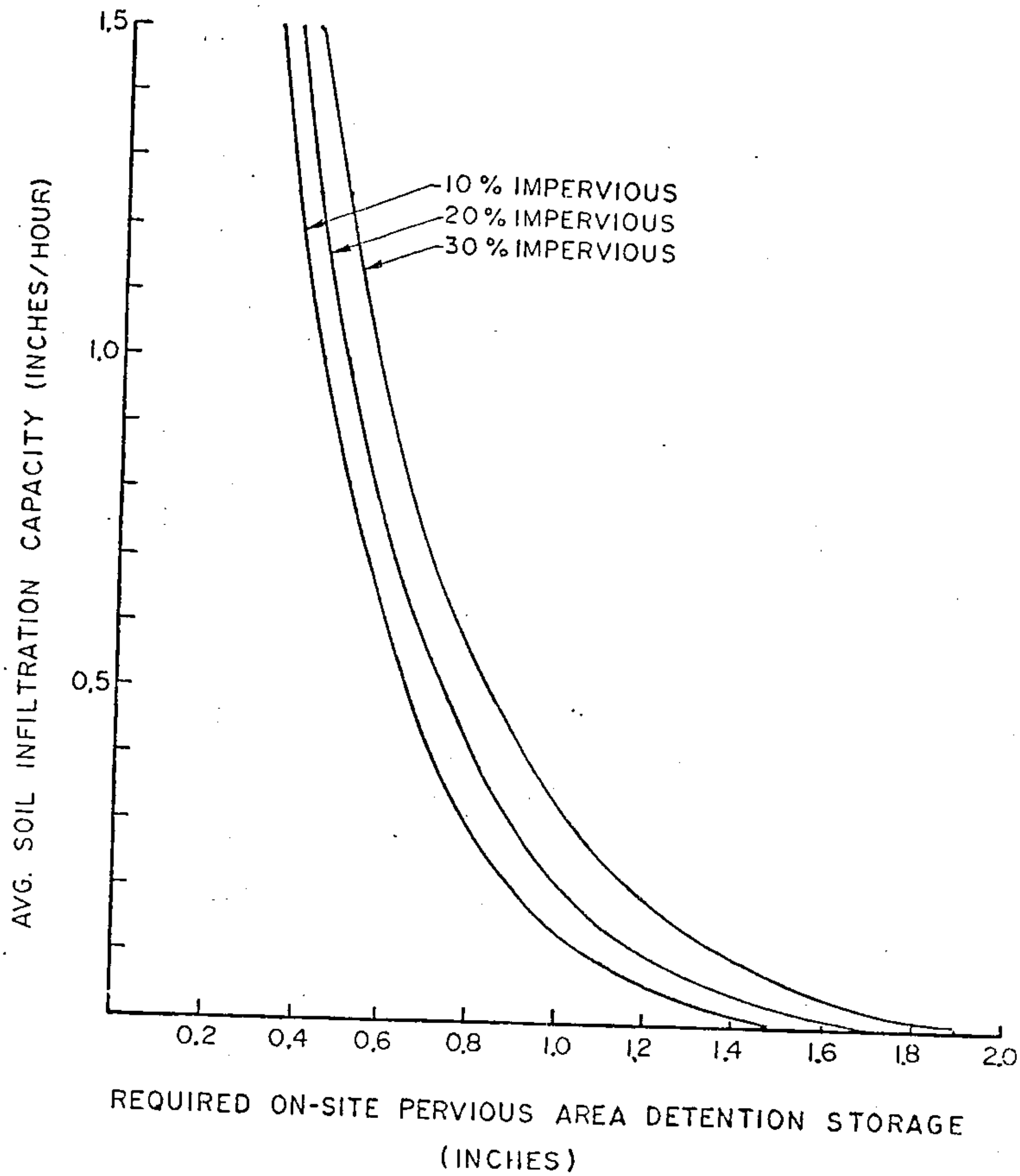


Figure D-1
RAINFALL INTENSITY CURVES
FOR STORMS OF VARIOUS FREQUENCIES
SOURCE OF DATA
Elting — Towne Formulas
1 YEAR FREQUENCY $i = \frac{49}{t^{0.9} + 7}$
2 YEAR FREQUENCY $i = \frac{64}{t^{0.9} + 8}$
5 YEAR FREQUENCY $i = \frac{90}{t^{0.9} + 11}$
Formula Fitted To Curves From "Weather Bureau Technical Paper, No.25, Dec.1955"
10 YEAR FREQUENCY $i = \frac{79.2}{(t + 14)^{0.85}}$
25 YEAR FREQUENCY $i = \frac{92.5}{(t + 14)^{0.85}}$
50 YEAR FREQUENCY $i = \frac{104}{(t + 14)^{0.85}}$
100 YEAR FREQUENCY $i = \frac{116.1}{(t + 14)^{0.85}}$
$i = \frac{54 (\text{Frequency})^{1/5}}{(t + 14)^{0.85}}$
100 YEAR CURVE
50 YEAR CURVE
25 YEAR CURVE
10 YEAR CURVE
5 YEAR CURVE
2 YEAR CURVE
1 YEAR CURVE
AVERAGE RAINFALL INTENSITY IN INCHES PER HOUR
0
1
2
3
4
5
6
7
8
9
10
RAINFALL PERIOD IN MINUTES
0
20
40
60
80
100
120
140
160
180
200
220
240

Figure D-2 RETENTION REQUIREMENTS FOR ONE-YEAR DESIGN STORM WITH VARIOUS INFILTRATION AND SITE IMPERVIOUSNESS



vertical motion. However, with two rings, the border effects are confined to the outer ring and measurements are taken only in the inner ring. Water is applied to the two rings from graduated burettes, and reading of the burettes at successive time intervals permits direct determination of rates and amounts of infiltration. Time intervals should be 15 minutes, 30 minutes, one hour, two hours, and four hours. From this data, a infiltration versus time curve can be prepared characterizing the particular soil. For each site several infiltration tests will have to be taken for each soil present.

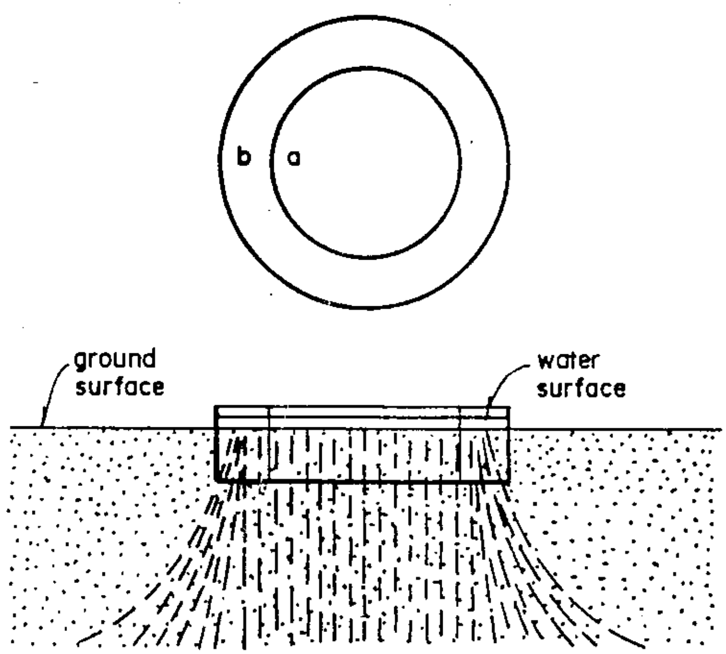


Figure D-3 TWO-RING INFILTROMETER