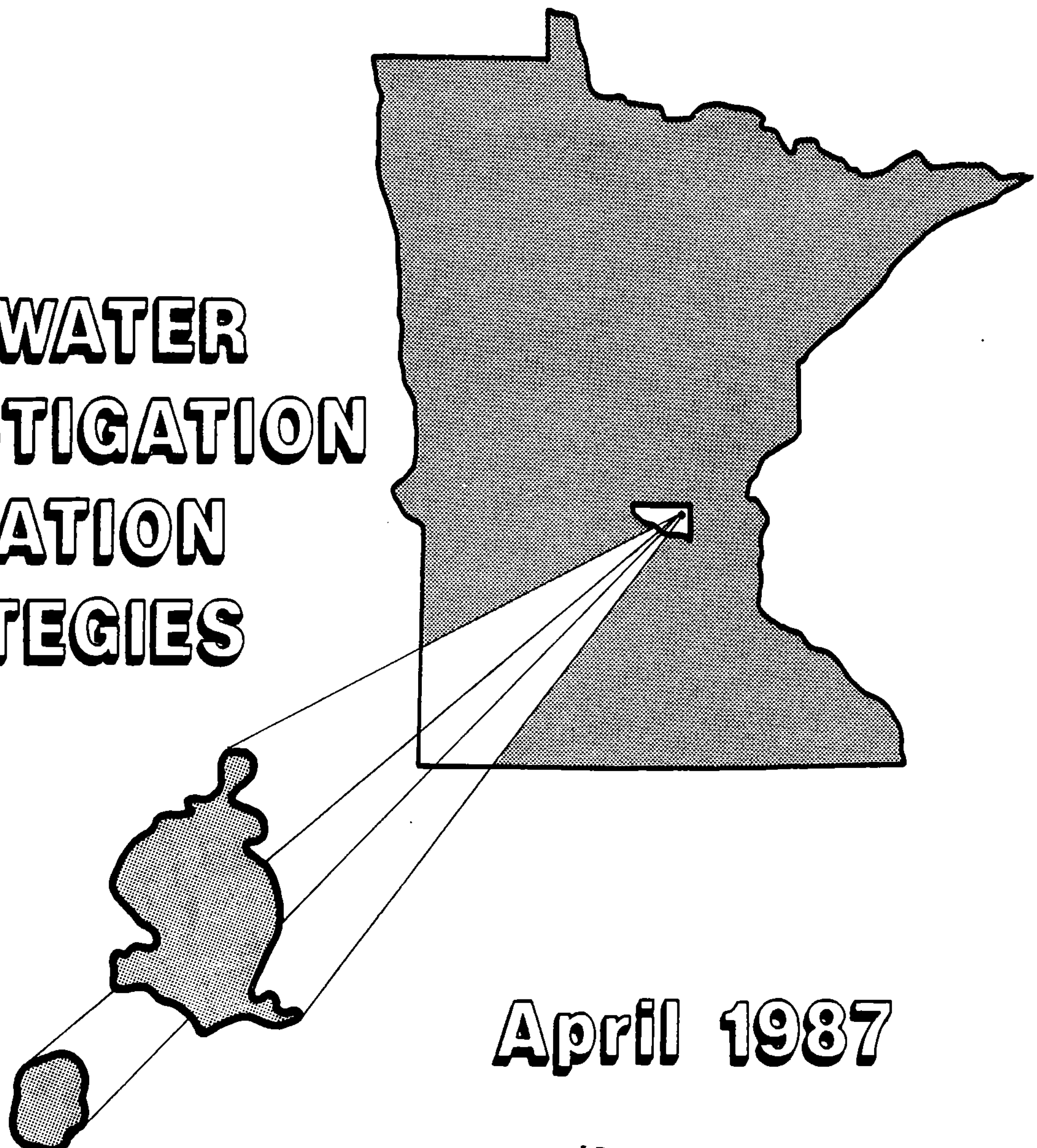
HELENE & DIANN LAKES

(Sherburne County, 71-45 & 71-46)



HIGH WATER INVESTIGATION MITIGATION STRATEGIES

April 1987

Minnesota
Department of Natural Resources
Division of Waters

HIGH WATER INVESTIGATION

AND

MITIGATION STRATEGIES

FOR

HELENE AND

DIANN LAKES

BASINS #71-45W AND 71-46P

SHERBURNE COUNTY

Minnesota Department of Natural Resources

Division of Waters

April 1987

Through an agreement between the Department of Natural Resources and the United States' Federal Emergency Management Agency (FEMA), a study was conducted to determine flood loss reduction strategies for high water problem lakes. The work that provides the basis for this publication was supported by funding under a cooperative agreement with the Federal Emergency Management Agency. The substance and findings of that work are dedicated to the public. The author and publisher are solely responsible for the accuracy of the statements, and interpretations contained in this publication. Such interpretations do not necessarily reflect the views of the Federal Government.

ACKNOWLEDGEMENT

This report was prepared under a Hazard Mitigation Assistance Grant from the Federal Emergency Management Agency with matching funds from the Department of Natural Resources, Division of Waters. This report would not have been possible without the special assistance of the Sherburne County Assessors Office.

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INTRODUCTION

Helene and Diann Lakes are located in northeastern Sherburne County, Minnesota, approximately 50 miles northwest of the Twin Cities metropolitan area. These lakes are 2 miles north of the City of Zimmerman, and most of their lake surface is within Sections 31 and 32 of Township 35 North, Range 26 West (Plate 1).

Helene and Diann Lakes are two of over 50 landlocked lakes within glaciated terrain in Minnesota that, in recent years, have been experiencing high water level problems. These lakes generally have no active natural outlets for surface water outflow and are susceptible to large natural water level fluctuations. The duration of these fluctuations is usually on the order of years and is dependent on long-term climatic trends. These lakes typically have small watershed-to-lake area ratios, usually less than 5 to 1.

Helene and Diann Lakes are located in surficial outwash sands of the Anoka Sand Plain. In recent years these lakes began to rise after heavy rainstorms. Except during periods of extreme high water levels, Diann Lake will drain into Helene Lake which is normally at a lower water surface elevation in respect to sea level datum. This evaluation indicates that during periods of high water, Diann and Helene Lakes will equalize in elevation, as was the case on February 23, 1987, when each basin was at elevation 966.60'. Both lakes, should they continue to rise, would eventually drain or run out to the southwest at elevation 968.6'.

This report addresses both Diann Lake and Helene Lake because they equalize at high water levels and eventually show the same runout elevation. This report is intended as a resource document to assist landowners and the local unit of government in terms of long range planning, developing flood loss reduction or mitigation strategies and in obtaining assistance in dealing with high water level problem lakes. In addition, this report will include background data on the watershed setting, geology, soils, climatology, fish and wildlife, water quality, historic water levels, and land use and existing development.

The report which follows is divided into 4 parts: Summary and Conclusions, Part 1, Part 2 and Appendices. Part 1, through the presentation and analysis of watershed, geologic, precipitation, water level and other data, will identify the source of the problem, project future conditions and identify the potential impact of continued rising water levels. Part 2 will identify mitigation options and implementation strategies. The Appendices will provide additional background data to be used by landowners and local, state and federal officials.

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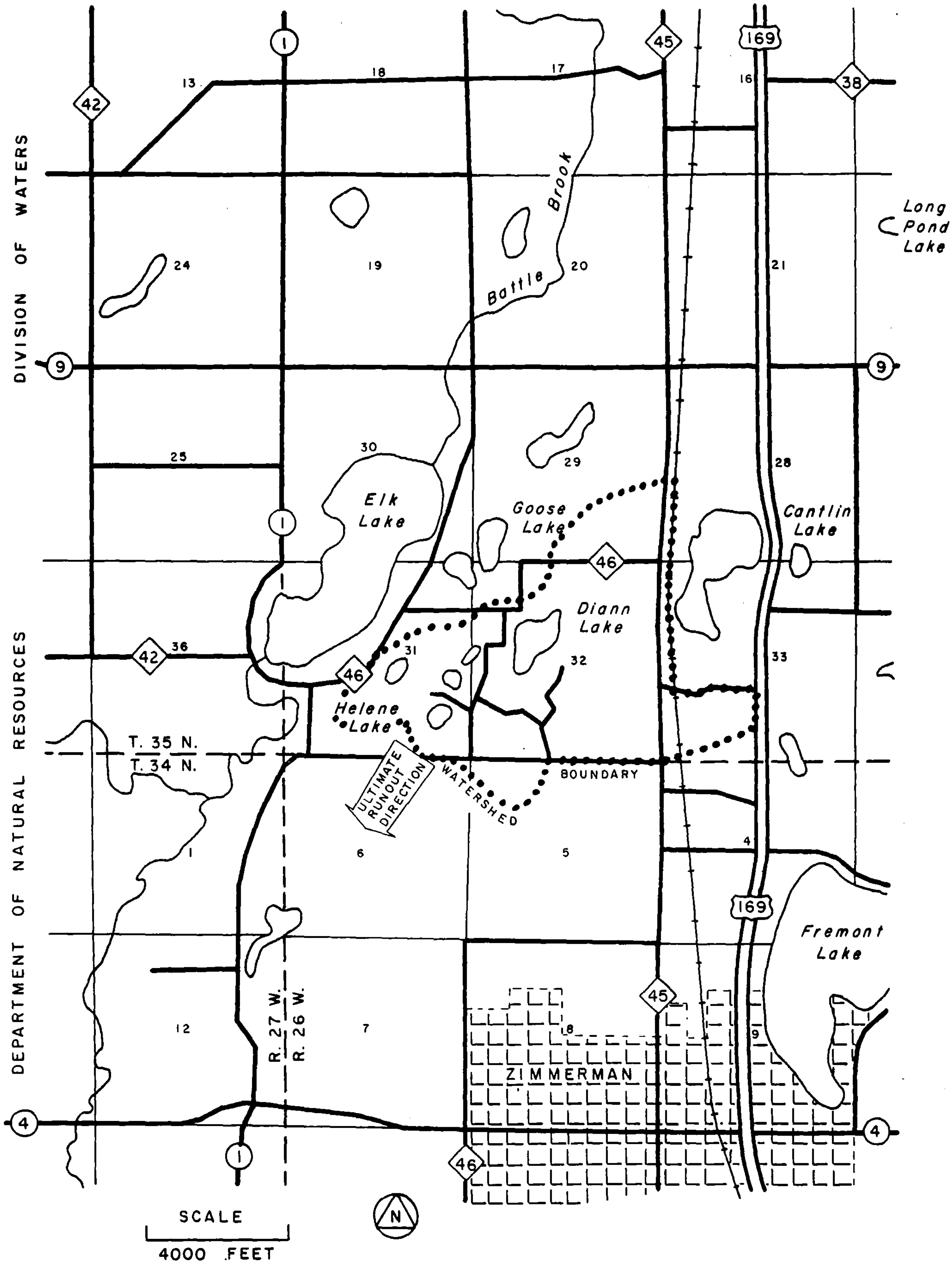
[1]National Geodetic Vertical Datum of 1929 is used for all elevations included in this report.

PLATE 1


DIVISION OF WATERS
DEPARTMENT OF NATURAL RESOURCES
Battle Brook
Long Pond Lake
Elk Lake
Goose Lake
Diann Lake
Cantlin Lake
Helene Lake
Fremont Lake
ZIMMERMAN
T. 35 N.
T. 34 N.
R. 27 W.
R. 26 W.
ULTIMATE RUNOUT DIRECTION
WATERSHED BOUNDARY
SCALE
4000 FEET
N

SUMMARY AND CONCLUSIONS/RECOMMENDATIONS

Water Level Data (See Part 1)

-In February of 1987, Diann and Helene Lakes were both at elevation 966.60'. On this date, Diann Lake was 1.2' above its Ordinary High Water Level of 965.40' and Helene Lake was 1.6' above its Ordinary High Water Level of 965.0'. Diann and Helene Lakes react to both surface and ground water inflow.

-There is a correlation between the area's annual precipitation and Diann and Helene Lake's water levels. During the last 5-year period, there has been an excess of 25.80" of precipitation above the normal annual precipitation for this general area. This has resulted in significant surface and ground water inflow and caused the current high water problems.

-This area in the past has experienced alternating wet and dry periods of varied duration. The current period may continue for several more years resulting in still higher water levels.

-If the lakes were to rise to elevation 971.95', 16 additional structures would be flooded with 1987 assessed market values totalling $248,300. At this elevation, it is estimated a minimum $207,025 of damages would occur.

-Methodologies do not exist which can predict what Diann and Helene Lakes maximum elevation will be in the future. The major factor on limiting potential increases in lake levels would be if the lakes should reach their ultimate runout elevation of 968.60'.

-Methodologies do exist which can calculate the probabilities of future water levels considering the long-term impact of above or below normal precipitation (i.e., both increases and decreases in water levels). There is a one-percent probability that Diann and Helene Lakes will: 1) rise to elevation 967.5' on December 1, 1987; or 2) will exceed elevation 967.60' on December 31, 1991. Conversely, there is a one-percent probability the lake will: 1) fall below elevation 964.8' by December 1, 1987; or 2) fall below elevation 963.5' on December 31, 1991. There is a 50% probability (a 50/50 chance) that Diann and Helene Lakes will be at elevation 966.6' on December 1, 1987 and elevation 966.6' in December of 1991.

Mitigation Strategies (See Part II)

-The flood protection standards for new development in Sherburne County's current flood plain ordinance do not apply to the Diann and Helene Lake's shoreline because a flood delineation is not currently shown for these lakes on the County's current flood plain zoning map. The County must properly regulate new development with its existing state-approved shoreland regulations with two recommended revisions, as follows:

1) New development within the lake's shoreland district must be elevated, at a minimum to elevation 969.6' (3' above the highest known water level). It is recommended that the County adopt a flood protection

elevation of 970.1'. This will insure that all new development is above Diann and Helene Lakes' potential 100-year flood level; and

2) For all new development a provision should be added which requires an elevated road access to the minimum flood protection elevation established by the County (presently 969.6' and recommend at 970.1').

-The County should develop a strategy to address the inundation of sewage treatment systems and wells, as well as the abandonment of flooded structures. The DNR will work with the County in formulating and implementing joint actions where appropriate.

-Flood insurance is available to all landowners and renters in the unincorporated areas of Sherburne County. A structure and/or its contents can be insured. Landowners or renters adjacent to Diann and Helene Lakes should explore purchasing flood insurance.

-Landowners can take emergency measures to protect existing development. The safest method is either relocating a structure to natural ground outside of the floodplain or elevating a structure at its existing site on fill to above the flood protection elevation. Emergency protection measures, such as filling, sandbagging, diking, etc., will require a permit from the County. A design professional should be contacted in advance to insure the flood protection measure will function properly.

-State and federal cost-sharing programs may be available to assist landowners and/or local governmental bodies in dealing with a high water problem. These programs include the U.S. Army Corps of Engineers' flood control authorities, Small Cities Development Block Grant Program, Section 1362 or the Federal Flood Disaster Protection Act of 1973 and the State's Flood Loss Reduction Program. Local interests should explore these programs and the requirements for an acceptable local sponsor to submit the application.

-Comprehensive basinwide solutions to high water problems are best implemented when a local entity or interest group takes the lead role. The legislature has established special taxing procedures and quasi-governmental authorities (e.g., lake improvement districts/watershed districts) which can be used to deal with high-water type problems. Landowners and local governmental bodies should: 1) define their respective roles in dealing with the existing high water problem; and 2) if necessary, use the special taxing procedures and/or quasi-governmental authorities to implement feasible basinwide solutions.

The report which follows goes into greater detail on the issues of water level data and mitigation measures (including additional recommendations). Part II also presents in detail state permit requirements for future actions which would affect a lake basin proper. The reader is encouraged to read the remainder of ths report. The Department of Natural Resources will assist local interests in the degree possible in implementing future flood loss reduction measures.

HELENE AND DIANN LAKES AREA

GEOLOGIC SETTING

Helene Lake and Diann Lake are located in surficial outwash sands of the Anoka Sand Plain. In the areas of these lakes, the outwash consists predominantly of gray medium sand. The saturated thickness of the outwash is approximately 60 feet at Helene and Diann Lakes. The outwash is underlain by red-brown sandy till. The total thickness of glacial drift is around 100 feet. The glacial drift is underlain by partially eroded Cambrian Mount Simon Sandstone.

SOILS

The area surrounding these lakes, as well as areas which are now flooded by lake water but were mapped by the Soil Conservation Service, are covered almost entirely by sandy soils of the Zimmerman Series. The soils were developed from outwash sands that have been sorted by wind and water action. The soils are very permeable, and have poor moisture holding capacity. There are also a few small areas of marsh soils and peat.

HYDROGEOLOGIC SETTING

The outwash sands are part of the Anoka Sand Plain Aquifer which covers much of Sherburne, Isanti and Anoka counties. These lakes are "outcrops" of the water table within the aquifer and are hydrologically connected to the ground water flow system of the aquifer. In the areas of the lakes, the local direction of ground water flow in the surficial aquifer is from west to east towards Elk Lake.

These lakes are ground water "flow-through" lakes, with ground water inflow occurring along their eastern shores, and ground water outflow occurring along their western shores. The inflow and outflow gradients were measured directly by a mini-piezometer at several locations around the lakes in August, 1986. Outflow gradients on the western shores of Helene and Diann Lakes were .02. Extending these measured gradients across the entire western shore of the lake, using published aquifer transmissivity values (Lindholm, 1980), and assuming a 5' flow depth for Helene and a 10' flow depth for Diann, a <u>rough</u> calculation of ground water outflow from the lakes is 40,000 cubic feet of water per day or 0.5 cubic feet of water per second (cfs) from Helene and 150,000 cubic feet of water per day or 1.7 cubic feet of water per second (cfs) from Diann. A similar rough calculation of ground water outflow from Cantlin Lake yields 50,000 cubic feet of water per day of 0.6 cubic feet of water per second (cfs). Ground water inflow to the lakes probably equals or exceeds ground water outflow.

WATERSHED

The total watershed area for Helene Lake which includes Diann and Little Diamond (Little Diann) Lakes is approximately 1,077 acres (Plate 1). The watershed of 1,077 acres minus the lake water surface areas of about 145 acres equals 932 acres or a total watershed area to lake area ratio of about 6 to 1. However, a closer examination of the total watershed area reveals that there are about 150 acres of smaller depressed areas or subwatersheds which also store runoff water and recharge the groundwater. These subwatersheds reduce the amount of the total watershed to about 782 acres and, therefore the effective watershed to lake area ratio is about 5 to 1.

This effective watershed to lake area ratio of about 5 to 1 is generally considered adequate to maintain lake levels during periods of normal precipitation. During periods of below normal precipitation the lake level would probably drop in elevation and during periods of above normal precipitation it would be expected to see a rise in elevation. Since, in recent years, the area has been experiencing periods of above normal precipitation it is not surprising to see a rise in the lake water levels.

From the available data, it is apparent that the Helene/Diann closed basin (no outlet) system is experiencing above normal lake water levels due to above normal precipitation which results in increased surface water runoff together with increased net groundwater flow into the lakes.

A field survey completed on April 27, 1987, indicates that Diann Lake waters flow through a culvert in the west road at elevation 966.74' and into the lake's west bay. From the west bay, the water flows south through a roadway culvert at elevation 966.05' into Helene Lake. Helene Lake will ultimately flow westerly overland into Little Diamond (Little Diann) Lake somewhere between elevation 960.0' and 968.6' and the entire system will ultimately outlet over the low point in the road south of Helene Lake at elevation 968.6' (See Plate 1).

WATER QUALITY
(HELENE LAKE)

There is very little water quality information available for Helene Lake. Prior to 1987, the lake had never been surveyed by the Department of Natural Resources. The lake's water quality is assumed to be typical of lakes in the area. In the 1987 survey (which included bathymetry on only two transects), the maximum depth of Helene was found to be 18 feet.

Helene Lake is assumed to be a moderately hardwater lake. Aquatic vegetation is abundant in the littoral zone, and photosynthesis produces enough oxygen to prevent winterkill in most years. It is suspected that if the lake's level is lowered, winterkill would become more frequent.

Water clarity was measured in May, 1987 and was 8 feet. This suggests that Helene Lake is not severely nutrient enriched.

WATER QUALITY
(DIANN LAKE)

There is very little water quality information available for Diann Lake. Lake surveys by the Department of Natural Resources were completed in 1959 and 1987. The lake's water quality is assumed to be typical of shallow lakes in the area. In 1959, the maximum depth of Lake Diann was cited as 5 feet, in the spring of 1987 the maximum depth was 9 feet (local residents state that the lake had come down more than a foot prior to the 1987 survey). The lake is thus entirely littoral.

Diann Lake has been described as a moderately hardwater lake. Aquatic vegetation is abundant over the entire area of the lake. Especially during low water years the weeds cannot maintain oxygen concentrations sufficient to prevent winter kill.

Water clarity measurements available are: July 1959 = 5.0' and May 1987 = 6.5'. Because these measurements are from different seasons, they cannot be used to show trends in water clarity. They do however, suggest that Diann Lake is not severely nutrient enriched.

FISH AND WILDLIFE

The Minnesota Department of Natural Resources, Fisheries Section, has not developed any historical fisheries data pertaining to Helene Lake. A recent fisheries lake survey (May 6, 1987) indicates that the lake does not contain a significant population of game fish. Five trap nets were set at various locations and 383 black bullheads and two black crappies were netted. No northern pike nor largemouth bass were caught, however, the local residents report that these two speices are part of the lake's fish population. The 1987 survey also indicates that fish winterkills do occur and if the lake water is lowered, the winterkills would become more intense.

The Minnesota Department of Natural Resources' Fisheries Lake Survey Report (dated 1959) classifies Diann Lake in ecological and management terms as Centrarchid (Bass/Panfish). A recent survey (dated 1987) indicates the fish population of the lake includes black crappies, sunfish, black bullheads, fathead and shinner minnows and stickle backs. The lake is quite shallow (9' maximum depth) and suffers major winter kills (low oxygen content) every 5 or 6 years. Even during winters with normal snow cover and normal water levels some winter kill will occur within the fish population. After a major winter kill, some bullheads will survive but virtually all game fish will die. It is for this reason that Diann Lake is not considered a good fishing lake.

The Department of Natural Resources has not performed wildlife field surveys for Helene or Diann Lakes. However, the lakes and their riparian areas do provide important habitat for a large number of wildlife species. Of the approximately 290 species of birds regularly found in the Lake States, 100 inhabit wetlands and another 80 are attracted to wetland edges. Of the 67 mammalian species in the Lake States, 6 have wetland habitats and approximately 40 other mammals are associated with or attracted to wetland edges. Reptiles and amphibians show a similar dependence on wetland habitats.

Wildlife such as gulls, terns, loons, pelicans, grebes, coots, cormorants, ducks, geese, swans, eagles, osprey, as well as other species of birds, use lakes for feeding and migrational resting areas. Shallow lakes and shallow portions of deeper lakes together with their riparian areas, provide important feeding, breeding, nesting and brooding habitat for a great variety of bird species including herons, egrets, bitterns, rails, cranes, hawks, snipe, sandpipers, kingfishers, warblers, sparrows, and pheasants, as well as ducks, geese and swans.

In addition, mink, muskrat, beaver, otter and water shrew also rely on lake and wetland habitats. Their riparian areas provide habitat for a variety of species of mammals such as raccoons, hares, weasles, moles, shrews, fox and deer.

Appendix B contains a more detailed presentation of water quality, fish and wildlife management, development history, and other information.

PRECIPITATION

Long Range Normal Annual Precipitation Average (St. Cloud data 1893-1986) = 26.84"

Normal Annual Precipitation (current trends) 1961-1986 = 31.27" (Plates 2 and 3)

Actual Annual Precipitation:

1982-1986

1982 = 34.74"
1983 = 36.58"
1984 = 38.86"
*1985 = 33.76"
1986 = 38.21"

5-year period, yearly average precipitation = 36.43"/year

Excess above normal precipitation for 5-year period (current trends) = 25.80"

1977-1986

1977 = 39.00"
1978 = 30.73"
1979 = 35.40"
1980 = 23.87"
1981 = 27.66"
1982 = 34.74"
1983 = 36.58"
1984 = 38.86"
*1985 = 33.76"
1986 = 38.21"

10-year period yearly average precipitation = 33.88"/year

Excess above normal precipitation for 10-year period (current trends) = 26.11"

A more in-depth discussion of climatological data is contained in Appendix C.

*The St. Cloud precipitation total for the month of November, 1985 was used for this report.

PLATE 2

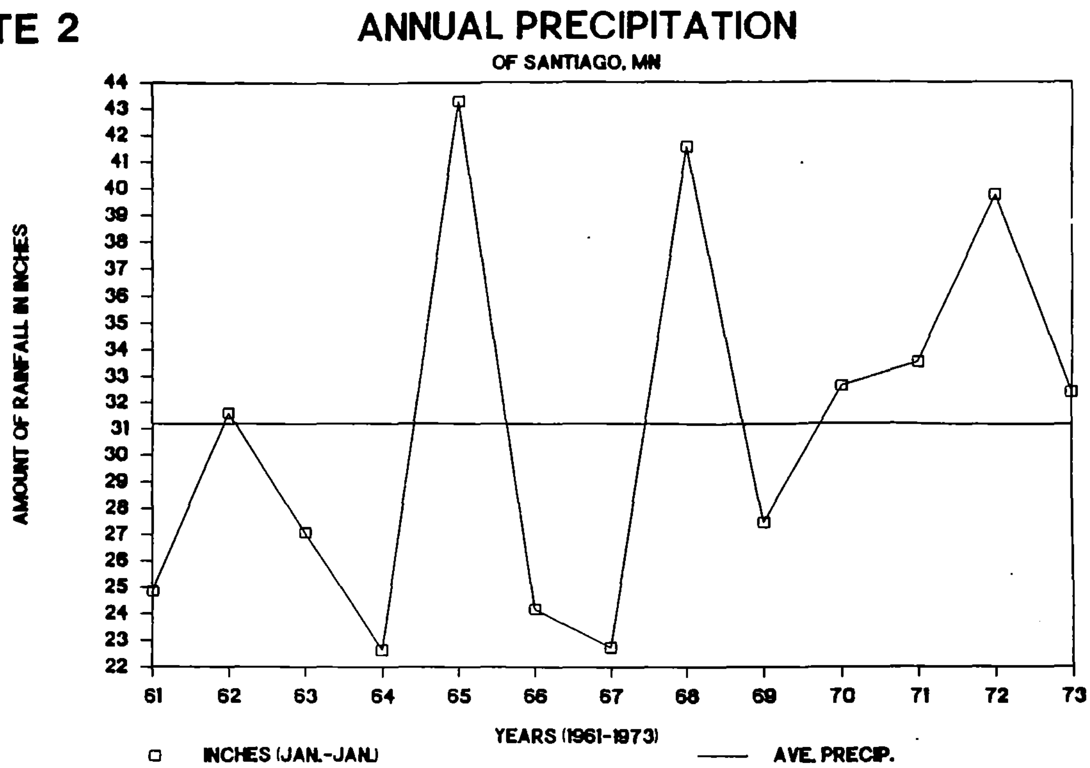
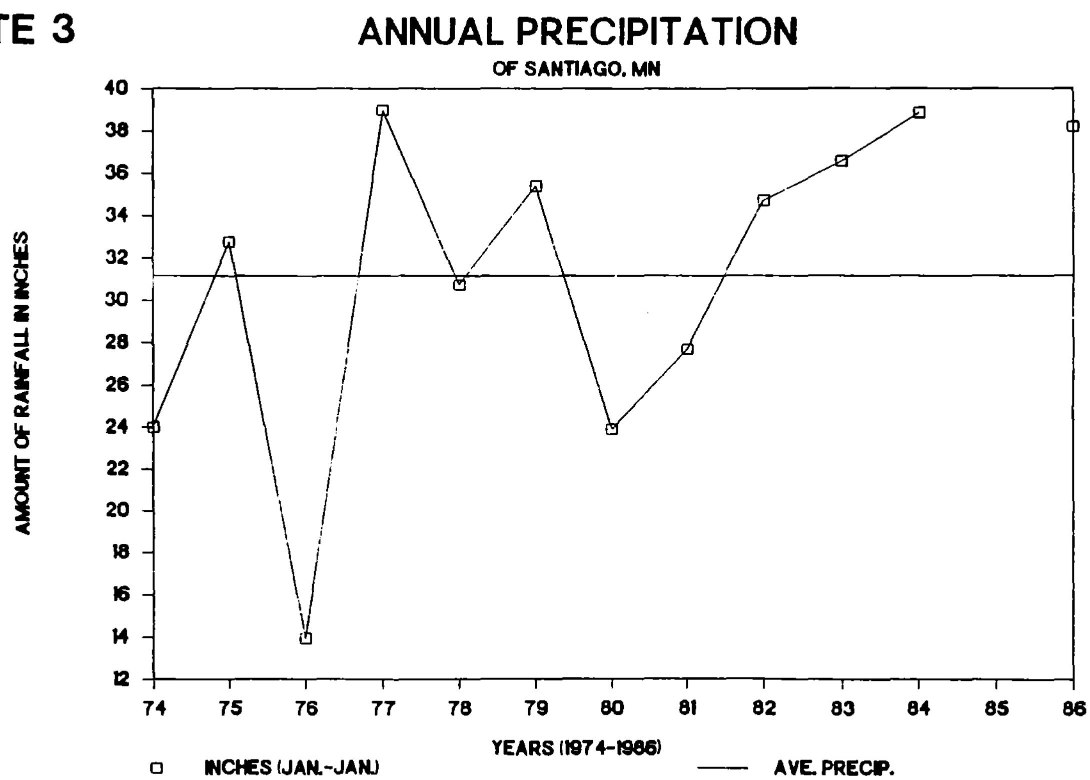


PLATE 3



WATER LEVEL HISTORY
(HELENE LAKE)

The Department of Natural Resources' Helene Lake file contains six fairly reliable surface water elevations dating from April 3, 1985 through April 27, 1987 (See Chart 1 below and Table 1 on the following page). The available precipitation and lake level data indicate a correlation between the area's annual precipitation and the lake's water level. From 1982 through 1986 (last 5 years), the area has received an additional 24.80 inches of precipitation over the normal annual precipitation of 31.27 inches. The water level of the lake at 966.60' on February 23, 1987 was about 1.6' above the lake's Natural Ordinary High Water Level of 965.0' and is presumably due to several years of above normal precipitation.

It should also be noted that the precipitation patterns in this area are characterized by alternating wet and dry periods of varied duration (Plates 4 and 5). These long-term precipitation variations could continue into the future and Helene Lake's water surface elevation will respond accordingly. Because above normal periods of precipitation of longer duration than the current period (recent years) have occurred in the past, the current period may continue for several more years resulting in continued increasing lake levels.

CHART 1

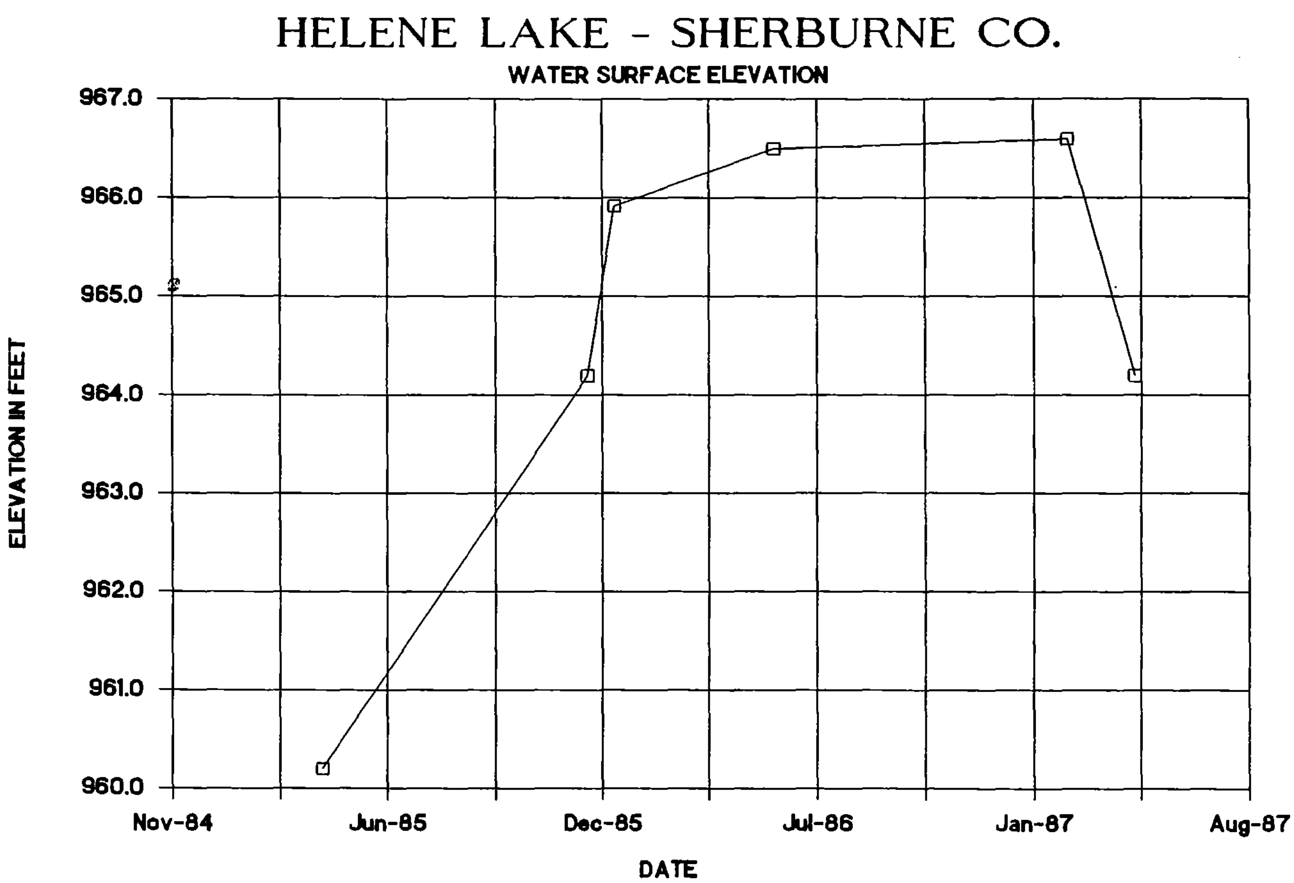


Table 1

WATER LEVEL HISTORY
(HELENE LAKE)

Date	Water Level	Source
4/3/85	960.20	DOW Field Survey
12/5/85	964.20	DOW Field Survey
12/30/85	965.92	U.S. Army Corps of Engineers
5/28/86	966.50	DOW Field Survey
2/23/87	966.60	U.S. Army Corps of Engineers
4/27/87	964.20	DOW Field Survey

WATER LEVEL HISTORY
(DIANN LAKE)

The Department of Natural Resources' Diann Lake file contains eight fairly reliable surface water elevations dating from 1961 through April 27, 1987 (See Chart 1a below and Table 1a on the following page). The available precipitation and lake level data indicate a correlation between the area's annual precipitation and the lake's water level. From 1982 through 1986 (last 5 years), the area has received an additional 25.80 inches of precipitation over the normal annual precipitation of 31.27 inches. The water level of the lake at 966.60' on February 23, 1987 was about 1.2' above the lake's Natural Ordinary High Water Level of 965.4' and is presumably due to several years of above normal precipitation.

It should also be noted that the precipitation patterns in this area are characterized by alternating wet and dry periods of varied duration (Plates 4 and 5). These long-term precipitation variations could continue into the future and Diann Lake's water surface elevation will respond accordingly. Because above normal periods of precipitation of longer duration than the current period (recent years) have occurred in the past, the current period may continue for several more years resulting in continued increasing lake levels.

CHART 1a

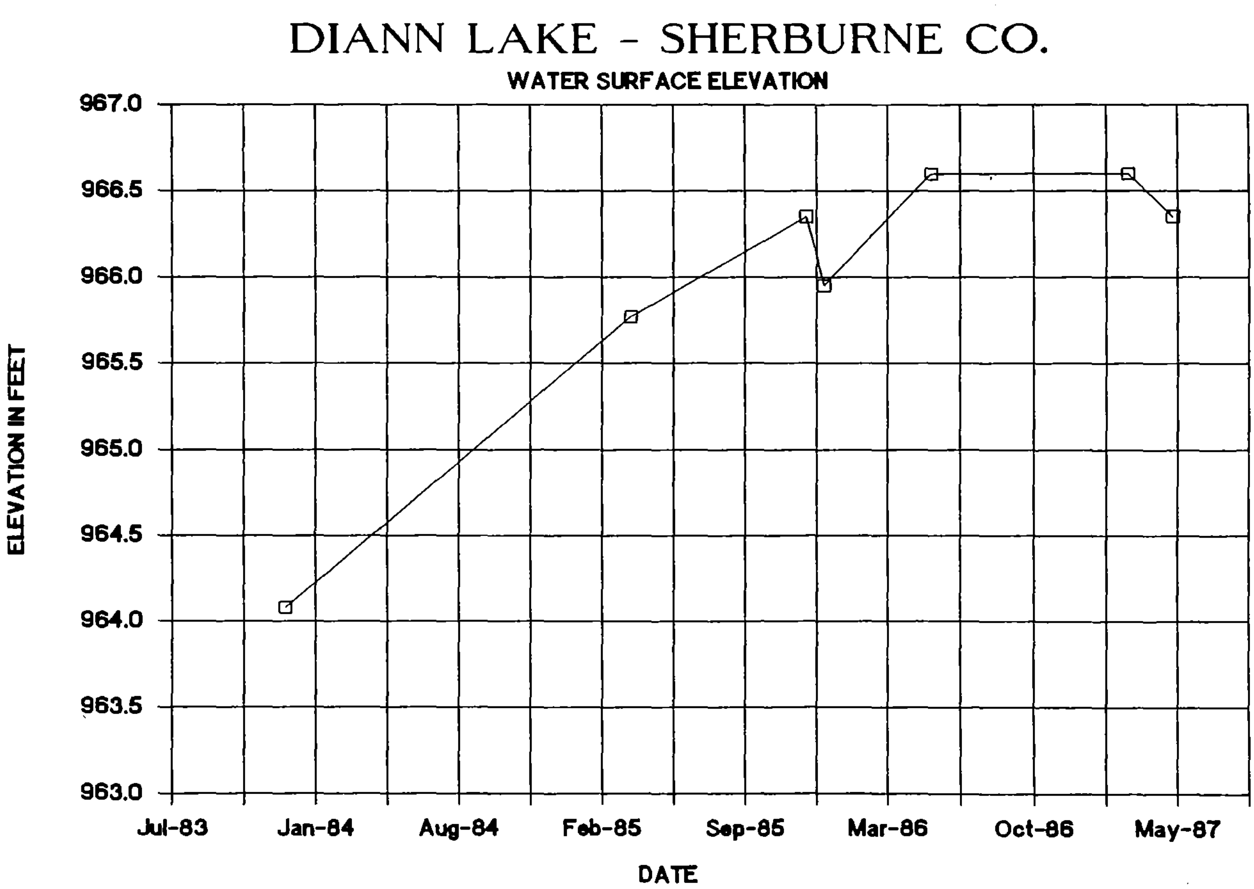


Table 1a

WATER LEVEL HISTORY
(DIANN LAKE)

Date	Water Level	Source
1961	958.0	USGS Quadrangle Map
12/8/83	964.08	DOW Field Survey
4/3/85	965.77	DOW Field Survey
12/5/85	966.35	DOW Field Survey
12/30/85	965.95	U.S. Army Corps of Engineers
5/28/86	966.60	DOW Field Survey
2/23/87	966.60	U.S. Army Corps of Engineers
4/27/87	966.35	DOW Field Survey

PLATE 4

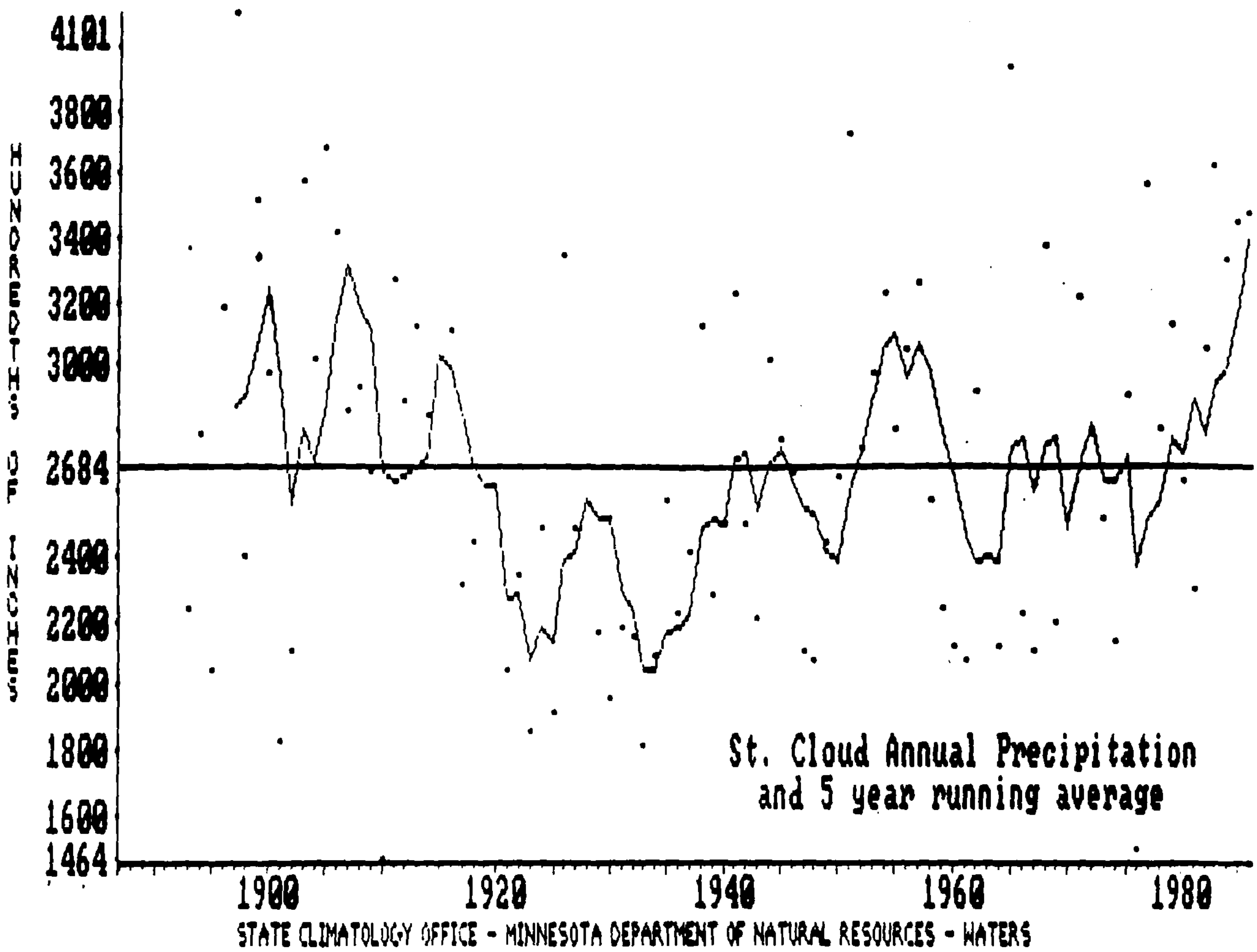
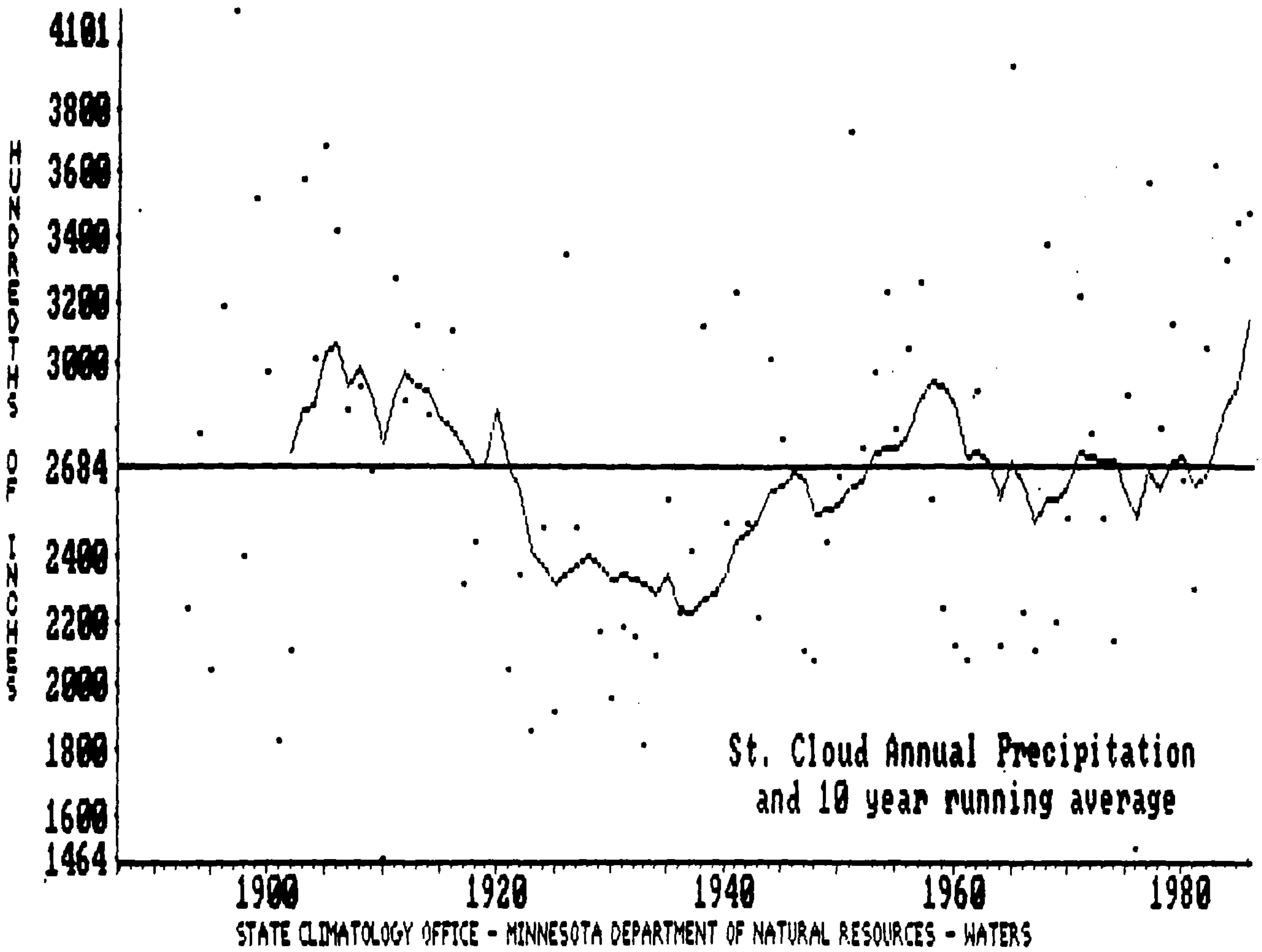

4101
3800
3600
3400
3200
3000
2684
2400
2200
2000
1800
1600
1464
HUNDREDTHS OF INCHES
St. Cloud Annual Precipitation
and 5 year running average
1900
1920
1940
1960
1980
STATE CLIMATOLOGY OFFICE - MINNESOTA DEPARTMENT OF NATURAL RESOURCES - WATERS

PLATE 5


HUNDREDTHS OF INCHES
4101
3800
3600
3400
3200
3000
2684
2400
2200
2000
1800
1600
1464
1900
1920
1940
1960
1980
St. Cloud Annual Precipitation
and 10 year running average
STATE CLIMATOLOGY OFFICE - MINNESOTA DEPARTMENT OF NATURAL RESOURCES - WATERS

ORDINARY HIGH WATER LEVEL (OHW)

The Ordinary High Water Levels (OHW)(2) for Helene and Diann Lakes have been determined by the Department of Natural Resources, Division of Waters in accordance with Minnesota Statute § 105.37, Subdivision 16. OHW data were obtained from field surveys completed on December 11 and 15, 1983, and the subsequent analyses indicate the OHW's to be at elevation 965.0' for Helene Lake and 965.4' for Diann Lake.

OHW General

Resource management and riparian rights pertaining to an inland lake are dependent upon identification and establishment of that lake's Ordinary High Water (OHW) elevation. The OHW is coordinated with the upper limit of the lake basin and defines the elevation (contour) on the lakeshore which delineates the boundary of public waters. Identification of the OHW comes from an examination of the bed and banks of a lake to ascertain the highest water level where the presence and action of water has been maintained for a sufficient length of time to leave recoverable evidence. The primary evidence used to identify the OHW of a lake consists of vegetational and physical features found on the banks of the lake.

Because trees are the most predominant and permanent expression of upland vegetation they are used as OHW indicators wherever suitable species and sites can be located. Particular attention must be given to the species of upland growth selected for consideration. In general, willow, cottonwood and most ash are very water tolerant; maples and elms tolerant; and most birch intermediately tolerant and oak intolerant. The less tolerant trees make the best indicators but factors in addition to species also have to be considered such as age, the slope of ground, the effect of water and ice action on the shoreline and the physical condition and growing characteristics of the trees. Water dependent vegetation such as cattails will follow lake levels as they rise and fall and therefore provide little evidence as to the lakes OHW, except in cases where more permanent vegetation does not exist.

Physical features searched for include soil characteristics, beachlines, beach ridges, scarp or escarpment (more prominent scarp can often be found in the form of the undercutting of banks and slopes), ice ridges, natural levees, berms, erosion, deposition, debris, washed exposed shoreline boulders, high water marks, movement of deposits as a result of wave action, top and toe of bank elevations as well as water levels. Caution is taken to be aware that many of

[2] According to Minnesota Statutes Section 105.37, Subdivision 16, "Ordinary High Water Level" means the boundary of public waters and wetlands, and shall be an elevation delineating the highest water level which has been maintained for a sufficient period of time to leave evidence upon the landscape, commonly that point where the natural vegetation changes from predominantly aquatic to predominantly terrestrial. For watercourses, the Ordinary High Water Level shall be the elevation of the top of the bank of the channel. For reservoirs and flowages the Ordinary High Water Level shall be the operating elevation of the normal summer pool.

the listed geomorphological features may take a long time to develop and also that several sets of these features may be found. That is, a lake likely will have more than one stage where the action of water has left recoverable evidence however only the stage coordinated with the upper limit of a basin are used to assist in identifying the OHW level. As an extreme example, water level stages resulting from the drought years of the 1930's certainly were the result of natural conditions extending over a number of years, but the resulting recoverable evidence is of no use in OHW determinations.

ANTICIPATED FUTURE LAKE LEVELS - PROBABILITIES

The problem facing landowners and government bodies for land-locked lakes is to respond to high water problems when there is no specific formula which tells us exactly when and how much a lake will go up or down. What we have seen so far is that lake level fluctuations for Diann and Helene Lakes have been closely related to how much precipitation falls in the immediate area. Precipitation patterns historically have varied significantly in this area and currently the pattern is on the upswing. No one can predict with certainty whether this will continue into the next six months, year, five-years, etc.

The probability of different scenarios of future water level conditions can be estimated from historical precipitation data and ground water and lake level data. The DNR, Division of Waters has used a water budget computer model with a long term series of monthly precipitation to determine probabilities of anticipated lake levels for the end of one and five year periods. Each end of period anticipated level was computed using the specific period or slice of historic precipitation (1 year or 5 years) and the known December 1, 1986 lake levels. By using all of the specific periods within the precipitation record, a series of anticipated lake levels is developed and then statistically analyzed to assign probabilities to the range of computed levels.

The in-house water budget computer model "WATBUD" computes net monthly inflow and outflow volumes and then storage routes them through the lakes using the previous month's lake levels for initial conditions. The inflows consist of precipitation and runoff computed from precipitation using a constant coefficient. Outflows consist of evaporation and any discharge from an outlet. A constant monthly ground water seepage rate may be an inflow or outflow and together with the rainfall-runoff coefficient are used as calibration parameters to provide a balanced water budget.

At Diann/Helene Lake, the WATBUD model was calibrated for the period January, 1986 through February, 1987 using monthly precipitation from the St. Cloud and pan evaporation data from Becker. An initial starting water surface elevation of 966.6', recorded for both lakes on February 3, 1987, was used with monthly time series precipitation data from St. Cloud precipitation record (1893 to 1986) to compute the specific one and five year period anticipated lake level series.

The modeling results indicate that there is a one-percent probability that these lakes would rise above elevation 967.5' on December 1, 1987 and a one-percent probability these lakes will exceed elevation 967.6' on December 31, 1991. These elevations are still lower than the runout elevation of 968.6'. Conversely, probabilities exist which state the likelihood these lakes elevation may fall. There is a one-percent probability these lakes may fall below elevation 964.8' by December 1, 1987 and a one-percent probability these lakes may fall below elevation 963.5' on December 31, 1991. The modeling results also suggest a 50-percent probability (a 50/50 chance) that these lakes will be at elevation 966.6' on December 1, 1987 and 966.6' in approximately 5-years.

The above-noted modeling concerned itself with longer periods of total precipitation and did not attempt to determine the impacts of major storm events which occur relatively quickly. A management plan for an area must consider the impact of these storm events because of their severe nature and there is little or no time to react to them.

The probability of lake level increase was also computed for the 24 hour and 10 day duration 100-year storm events. Assuming the same initial starting water surface elevation of 966.6' for both lakes, the 100-year, 24 hour duration event of 5.7 inches of precipitation would result in a lake level increases of 1.0 foot to elevation 967.6' and the 100-year, 10 day runoff of 7.2 inches would result in a lake level increases of 2.5 feet to elevation 969.1'. Under the latter conditions, these lakes would be 0.5 foot above the runout elevation of 968.6'.

POTENTIAL STRUCTURAL DAMAGES

To determine the impact of potential continued increases in water levels, descriptive base data were collected for certain structures along the shoreline of Diann and Helene Lakes. These base data were collected in December of 1985. While the potential maximum elevation of Diann and Helene Lakes is unknown, it was felt surveying structures within an approximate 5-6' vertical elevation above elevation 965.95' would identify those structures most immediately subject to flood damage.

The example below shows a generic fact sheet that was completed for each structure surveyed. The elevations provided were determined from instrument surveys. Plate 6 on the following page shows the location of each structure surveyed. Appendix D contains the actual fact sheet for each structure surveyed with a numerical index to match the location map.

EXAMPLE

Structure number: Doe, John
Name : R.R. 1
Address : City, MN 55312

Legal Description: Lake Subdivision
N½, Sec. 24, Twp. 122, R. 29
Lot 2

Floor Elevation : 972.49'
Ground Elevation: 967.49'

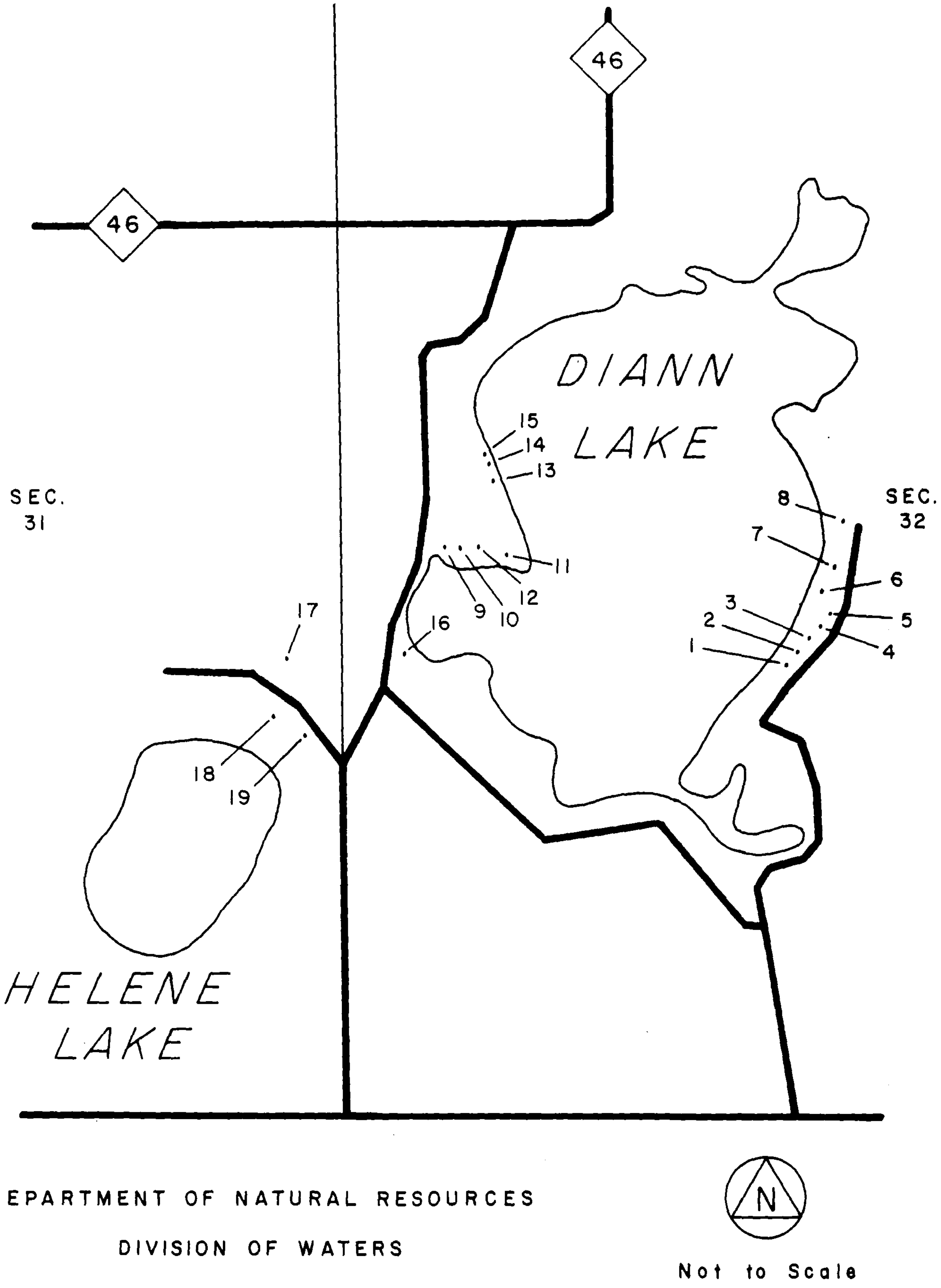
Basement : Yes
Walkout : Yes

Assessed Market Value
Building Value : $25,300.00
Land : $15,200.00

Total Value : $40,500.00

STRUCTURE PHOTO PROVIDED

PLATE 6



DEPARTMENT OF NATURAL RESOURCES

DIVISION OF WATERS

Potential structural losses for Diann and Helene Lakes can be viewed from two different viewpoints:

> First - Once water enters a structure (e.g., in the walkout level) for an extended period of time (e.g., over a winter season), the structure has minimal or no monetary value. The rationale being the structure's habitability to the owner is seriously in question and, on the competitive real estate market, the structure would be most likely unsellable. In effect, the structure's useful and economic life has ended. The loss to the landowner would be the structure's fair market value prior to the water entering the structure. Table 2 tabulates the total assessed market values per incremental increase in water levels. The total loss for all newly damaged structures between elevations 965.95' and 971.95' would be $248,300.
>
> Second - The actual loss to the landowner could be viewed as the physical damage to the structure caused by the water. This assumption is premised upon the water receding at some future date and the landowner could fix the damage and re-occupy the structure. Table 2 tabulates the estimated actual damage to each structure by incremental 1' increase in lake levels. At elevation 971.95', an estimated $207,025 of structural damage would occur. The reader is cautioned that the damage figures are taken from generalized assumptions and are applicable for basinwide planning purposes only.

The decision making process to take corrective measures can include the analysis of the degree of risk exposure, the anticipated benefits (losses prevented) and the cost of corrective measures. The data presented thus far should aid landowners and local officials in assessing the degree (probability) of risk exposure. Special references should be given to the discussion on anticipated future lake levels on pages 17 and 18 and the site specific surveyed elevations found in Appendix D. Basinwide solutions to a given problem (e.g., a lake outlet) often-times are based upon the total dollars worth of anticipated benefits (losses prevented). Table 2 was provided to show the estimated losses which could occur should the lake continue to rise.

Again, potential loss figures provided here were from generalized assumptions and the intent was to not provide exact projected damages for individual structures. Potential damages per individual structure would have to be determined after a site-specific investigation. Pages 29-33 in Part II do provide suggested site-specific protection measures and general construction guidelines which could be followed.

Table 2
Potential Increases in Flood Losses
By
Incremental Increases in Water Levels

	Structure Number as Shown on Location Map	Market Value of Building[2]	First Floor Level	Walkout Level[3]	Ground Level at Base of Crawlspace or Basement	Potential Damages/ Row Totals: Market Value	Potential Damages/ Row Totals: Actual Damages[4]	Potential Damages/ Cumulative Row Totals: Market Value	Potential Damages/ Cumulative Row Totals: Actual Damages[4]
Structures below elevation 965.95 presently flooded[1]	18	$ 500	965.92	N/A	N/A				
New damages between elevation 965.96 and 966.95	5	$16,600	973.39	N/A	N/A	$16,600	$ 3,320	$ 16,600	$ 3,320
New damages between elevation 966.96 and 967.95	19	$19,400	974.37	967.37	N/A	$81,200	$27,615	$ 97,800	$ 30,935
	15[5]	28,400	972.49	N/A	967.49				
	8	16,900	974.65	967.65	N/A				
	1	16,500	968.99	N/A	967.68				
New damages between elevation 967.96 and 968.95	9	$ 7,400	969.65	N/A	968.07	$23,300	$30,965	$121,100	$ 61,900
	6	9,000	973.65	N/A	968.45				
	12	6,900	968.66	N/A	N/A				
New damages between elevation 968.96 and 969.95	10	$ 5,000	968.96	N/A	N/A	$64,800	$51,525	$185,900	$113,425
	2	16,300	970.38	N/A	969.02				
	4	25,300	970.83	N/A	969.16				
	13	7,700	969.72	N/A	N/A				
	14	10,500	969.72	N/A	N/A				
New damages between elevation 969.96 and 970.95	11	$ 6,000	970.75	N/A	N/A	$31,800	$43,650	$217,700	$157,075
	3	25,800	971.33	N/A	970.13				
New damages between elevation 970.96 and 971.95	7	$30,600	978.53	971.53	N/A	$30,600	$49,950	$248,300	$207,025

Note: Structures #16 and #17 were above the study elevation, and therefore are not included in the potential damages table.

[1] Diann/Helene Lakes' water surface elevation was 965.95' in December of 1985, which was the time the structure elevation data were collected.
[2] 1987 assessed market value supplied by County Assessor.
[3] With the exception of #5, all other structures main floor elevation was estimated by adding 7' to the walkout floor elevation.
[4] A) Estimated damage for walkouts followed the recommendations of the National Flood Insurance Program's Loss Adjustment staff by: 1) assuming 20% damages when flood water was up to 1' in depth in a structure; 2) assuming an additional 55% damage when the flood water was greater than 1' in depth but less than the floor level of the main habitable floor; and 3) assuming total damage, or an additional 25% damage, when water reaches the main habitable floor.

B) Estimated damage for crawlspace/basements followed the recommendations of the National Flood Insurance Program's Loss Adjustment staff by: 1) assuming 25% damages when flood water was up to 1' in depth in a structure; and 2) assuming total damage, or an additional 75% damage, when water reaches the main habitable floor.

C) The figures provided do not include the additional costs for removal and disposal of flooded/abandoned structures, providing replacement water supply and waste treatment systems or abandonment of flooded wells according to health department standards.

The reader should be cautioned these figures do not include any allowance for contents damage because of the uncertainty whether contents would be removed prior to damage to the structure. If an adjustment is to be made for contents damage, the author recommends a 20% adjustment to each figure provided.

[5] Twenty-five percent additional damages will occur when water enters any structure with a second level above elevation 971.95'. The first structure where this would occur is #15 at elevation 972.49'. See column "First Floor Level".

PART II

FLOOD HAZARD MITIGATION - INTRODUCTION

A broad definition of flood hazard mitigation is those actions taken by individuals and governmental bodies to prevent future flood losses. Prevention of future losses can pertain to existing structures already at risk as well as future development which, if built improperly, will be subject to flood damage. Individual strategies by the landowner should also consider properly insuring oneself against financial, catastrophic loss.

Part II will emphasize those structural and nonstructural hazard mitigation actions which will prevent future losses. These actions will generally include flood insurance, local government land use regulations, lake level control structures (especially state permit requirements) and site-specific flood protection techniques (i.e., flood proofing). There will also be a discussion of: 1) potential non local cost-sharing programs to assist in constructing hazard mitigation measures; and 2) institutional frameworks for implementing these measures.

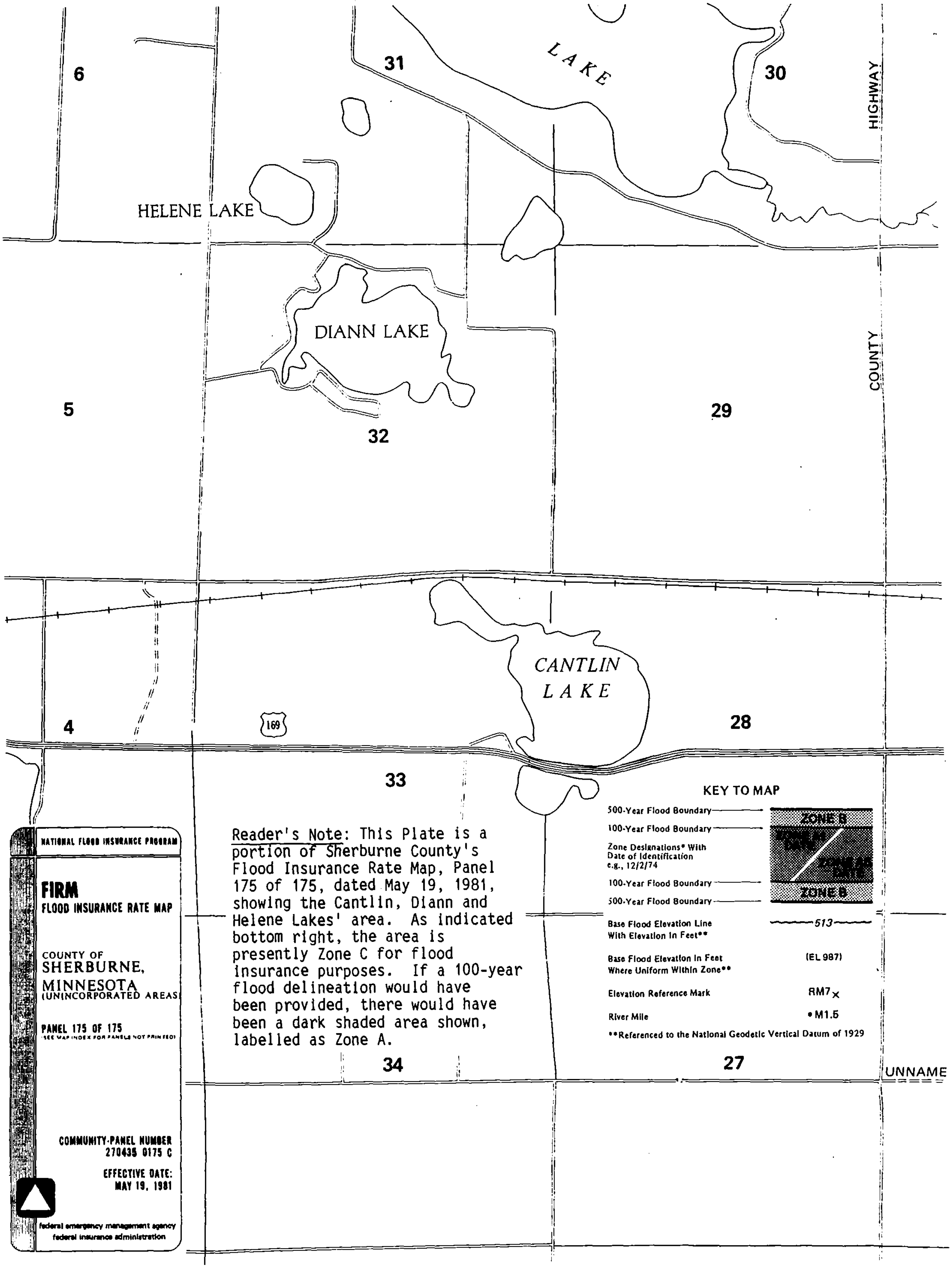
FLOOD INSURANCE

Landowners adjacent to Diann and Helene Lakes can purchase flood insurance through Sherburne County's eligibility in the National Flood Insurance Program (NFIP). Actually, <u>all</u> property owners and renters in the unincorporated areas Sherburne County can purchase flood insurance <u>regardless of whether or not the property is located in an identified flood hazard area</u>. This latter point must be stressed because a review of Sherburne County's Flood Insurance Rate Map (Plate 7) indicates a flood hazard delineation has <u>not</u> been provided for Diann and Helene Lakes. The significance of a lack of a flood hazard delineation will be discussed in greater detail on Pages 28 and 29 for the discussion on local government land use regulations.

the decision to purchase flood insurance should be based primarily on the probability that a structure and/or its contents will be flooded. The decision making process must also take into consideration the provisions of the standard flood insurance policy which identifies amongst other things:

- When losses are covered (i.e., a general condition of flooding exists);
- Items covered and not covered;
- The removal of a flood damaged structure from a site;
- A "loss in progress" (5-day waiting period); and
- Special loss adjustment for continuous lake flooding.

PLATE 7



Reader's Note: This Plate is a portion of Sherburne County's Flood Insurance Rate Map, Panel 175 of 175, dated May 19, 1981, showing the Cantlin, Diann and Helene Lakes' area. As indicated bottom right, the area is presently Zone C for flood insurance purposes. If a 100-year flood delineation would have been provided, there would have been a dark shaded area shown, labelled as Zone A.

Table 3 identifies the amount of flood insurance coverage available via the NFIP. Sherburne County has been in the Regular Program since March 1, 1979 so, for residential structures, $185,000 of coverage is available for a structure and 60,000 for contents. Questions pertaining to flood insurance premiums (i.e., costs) should be referred to the NFIP toll-free at 1-800-638-6620. It should be noted that all areas not now mapped as having a flood delination on the Flood Insurance Rate Map are considered "Zone C" for flood insurance rating purposes. Zone C has the cheapest flood insurance premium costs. The reader is also cautioned that if contents coverage is desired it must be specifically requested.

Table 3

	Emergency Program	Regular Program	
	Total Amount Available Basic Coverage	Additional Limits	Total Coverage Available
Residential Buildings - Single Family	$35,000	$150,000	$185,000
Residential Contents	10,000	50,000	60,000
Other Residential Buildings	100,000	150,000	250,000
Small Business - Buildings	100,000	150,000	250,000
Small Business - Contents	100,000	200,000	300,000
Other Nonresidential Buildings	100,000	100,000	200,000
Other Nonresidential Contents	100,000	100,000	200,000

The most important factors in determining whether flood insurance will cover a loss are:

1) Is the water body experiencing a "general condition of flooding"? A general condition of flooding is defined in the standard flood insurance policy as:

   -"A general and temporary condition of partial or complete inundation of normally dry land areas from:
      a. The overflow of inland or tidal waters;
      b. The unusual and rapid accumulation or runoff of surface waters from any source;
      c. Mudslides (i.e., mudflows) which are proximately caused by flood, as defined above and are akin to a river of liquid and flowing mud on the surface of normally dry land areas, as when earth carried by a current of water and deposited along the path of the current.

   -The collapse or subsidence of land along the shore of a lake or other body of water as a result of erosion or undermining caused by waves or currents of water exceeding the cyclical levels which result in flood, as defined above.

-Sewer (drain) backup, which is covered only if it is caused by flood, as defined above."

2) Was an insured structure and/or its contents damaged by direct surface water contact during a general condition of flooding?

Land-locked lakes with no outlets do not react to high water like streams/rivers and waterbodies with outlets. The latter, generally go up and down fairly quickly (days or weeks) and there is little question that a general and temporary condition of flooding has occurred. Lakes such as Diann and Helene can increase and decrease in elevation very slowly over a period of years. While the NFIP will judge each land-locked lake with a high water problem individually, a general condition of flooding has been determined to exist on Diann and Helene Lakes.

It must be pointed out that a flood insurance policy only covers a structure and its contents. The Department of Natural Resource's experience with the NFIP claims adjustment process indicates that surface water must come into direct physical contact with an insured structure during a general condition of flooding before the loss will be eligible for reimbursement. Seepage losses due to water table fluctuations during a general condition of flooding will not be reimbursed. The following is a general description of items covered and not covered (specific questions on coverage should be referred to the above-noted NFIP toll-free number):

> A building and its contents may be insured. Almost every type of walled and roofed building that is principally above ground can be insured. In most cases, this includes mobile homes, but not travel trailers or converted buses. Gas and liquid storage tanks, wharves, piers, bulkhead, crops, shrubbery, land, livestock , roads, machinery or equipment in the open and motor vehicles are among the types of property which are not insurable.

There is a 5-day waiting period for a flood insurance policy to take effect. A loss which occurs during the 5-day waiting period after a policy has been taken out is considered a "loss in progress" and will not be covered by the NFIP. This is a critical factor. The reader may wish to refer back to the Part 1, pages 17 and 18 for the discussion on anticipated water surface elevations.

The discussion on anticipated water surface elevations stresses two important facts. First, no one can predict a maximum water surface elevation for Diann and Helene Lake. If these lakes should continue to rise, a dampening effect would occur as they reach their runout elevation at elevation 968.60'. If the cause is the lake reacting only to long-term, above normal precipitation, then the assumption would be as these lakes rise slowly (e.g., 1-2' per year) a landowner would have sufficient advance warning to purchase flood insurance and meet the 5-day waiting period before a loss occurs.

The second important factor to consider is that Diann and Helene Lakes can react quickly to high intensity rainfall events (i.e., the 100-year 24 hour and 100-year, 10-day rainfall events). These high intensity rainfall events do occur randomly over time with little or no advance warning to the landowner. If these rainfall events were to occur, there would likely be insufficient time for a landowner to purchase a flood insurance policy and meet the 5-day waiting period.

The previous section on anticipated lake levels indicates that at a starting lake elevation of 966.60' Diann and Helene Lakes would bounce 1.0' upward during a 100-year, 24 hour rainfall event and 2.5' upward to elevation 969.1' for a 100-year, 10-day rainfall event. Landowners should refer to Appendix D which provides actual lowest floor elevations for adjacent shoreland development.

The NFIP has recently adopted special provisions to deal with continuous lake flooding situations. These provisions are provided below for the reader's information.

> W. Continuous Lake Flooding: Where the insured building has been flooded continuously for 90 days or more by rising lake waters and it appears that a continuation of this flooding will result in damage reimbursable under this policy to the insured building of the building policy limits plus the deductible, the Insurer will pay the Insured the building policy limits without waiting for the further damage to occur if the Insured signs a release agreeing (i) to make no further claim under this policy, (ii) not to seek renewal of this policy, and (iii) not to apply for any flood insurance under the National Flood Insurance Act of 1968, as amended, for property at the property location of the insured building. If the policy term ends before the insured building has been flooded continuously for 90 days, the provisions of this paragraph (W) still apply so long as the first building damage reimbursable under this policy from the continuous flooding occurred before the end of the policy term.

It should also be noted that the DNR has had discussions with the NFIP about whether a flood insurance policy will reimburse a landowner for the cost of removing a damaged structure from a site. Under most situations the answer is yes. A determining factor is that the cost of removal, in combination with the reimbursement for all covered losses, does not exceed the limits of structural coverage. If a landowner is considering purchasing flood insurance, the issue of maintaining additional coverage for removal of a damaged structure should be kept in mind.

A discussion on basement coverage will be provided here because there are structures with "walkout" basements adjacent to Diann and Helene Lakes. In the early 1980's, the NFIP reduced coverage to basement areas to cover primarily damage only to the structural components (e.g., foundation walls, floors, etc.) and limited contents. There would no longer be coverage for finishing materials on walls and floors and most contents. A basement was defined, though, as a space subgrade <u>on all four sides</u>. Therefore, a walkout basement is not subgrade on all four sides and does not meet the definition of a "basement". The coverage reductions do not apply to structures with walkout lower levels.

This section was intended to provide background information on the NFIP and information relevant to lake flooding situations. Specific questions should be referred to the NFIP. Flood insurance can be purchased through any licensed insurance agent or broker who can write property insurance in Minnesota. Landowners contemplating purchasing flood insurance should locate an insurance agent familiar with the NFIP.

LOCAL GOVERNMENT
LAND USE REGULATIONS

Proper enforcement of land use regulations for new development is the cornerstone of a hazard mitigation program. New development includes not only new construction but also modifications, additions to and repair of existing construction. Sherburne County, by virtue of its eligibility in the NFIP, must properly regulate new development in flood prone areas to insure continued eligibility in the NFIP for all citizens in the unincorporated area of the County.

As noted earlier, the current Flood Insurance Rate Map for Sherburne County does not show a flood delineation (i.e., Zone A) for Diann and Helene Lakes. This means that: 1) technically, Sherburne County does not now have to apply the provisions of its flood plain ordinance to new development bordering Diann and Helene Lakes; and 2) the NFIP, while making flood insurance available to property owners, places no minimum development standards to be met by the County when regulating new development on Diann and Helene Lakes.

The obvious question is what prudent course of action should Sherburne County take when regulating new development adjacent to Diann and Helene Lakes? Sherburne County must continue to properly enforce its state-approved shoreland management regulations adopted pursuant to Minnesota Statute, Chapter 105. The basic regulatory components of the County's shoreland regulations relevant to flooding potential on a land-locked basin include:

- The County must specify a lowest floor or flood protection elevation. In the absence of a 100-year flood level, all new structures and additions/modifications/ substantial repairs of existing structures must be elevated with the lowest floor (including basement) to 3' above the highest known water level. On Diann and Helene Lakes, this lowest floor elevation would be 966.6' + 3' or 969.6', NGVD-1929;

- On-site water supply and sewage treatment systems must be designed so as not to be impaired/contaminated during times of flooding. These systems, at a minimum, must be designed to elevation 969.6'; and

- New subdivisions, prior to approval by the County, must be reviewed to insure the area is suitable for the proposed use including a consideration of the potential for flooding. Each newly created lot must have a building site and a location for on-site utilities at or above elevation 969.6'.

The basic issues as to whether a flood delineation should be added to the County's Flood Insurance Rate Map (FIRM) are essentially three-fold:

1) A flood delineation would provide a notification to potential purchasers of existing property that the area is flood prone (and the potential magnitude of the flooding) and that the purchase of flood insurance may be advisable;

2) Flood insurance in a mapped Zone A (approximate 100-year flood plain) would be <u>mandatory</u> for all federally insured, financed or regulated mortgages, grants, etc., thus protecting the investment of the public at large. Otherwise, a landowner may default on a mortgage if a non insured loss were to occur; and

3) Would the delineation of an approximate Zone A on the FIRM better facilitate the future regulation of new development adjacent to Helene and Diann Lakes?

The latter of the above-noted three issues will be discussed first. It is the Department of Natural Resources' opinion that the County's current shoreland zoning and subdivision regulations will adequately regulate new development on Diann and Helene Lakes with the adoption of two additional provisions: 1) an elevated road access requirement; and 2) a flood protection elevation above 969.6' which provides additional freeboard or safety factor. These issues will be discussed below.

The rationale for using 969.6' is that in the absence of any studies of projected high water levels, 3' above the highest known water level is reasonable for most basins (but not necessarily land-locked basins). Aside from the flood plain mapping/ordinance issue, the County must assess whether using elevation 969.6' under its current shoreland regulations is a proper long-term strategy for regulating new development.

It is the Department's recommendation that the County use a minimum elevation of 970.1' for regulating new development adjacent to Diann and Helene Lakes. The previous section on Anticipated Water Levels indicates that Diann and Helene Lakes would bounce 2.5' upward to elevation 969.1' assuming a 10-day, 100-year rainfall event and a starting water surface elevation of 966.6' (May 1986 conditions). Adding one-foot of freeboard or safety factor to elevation 969.1' gives a flood protection level of 970.1'.

Adding a flood delineation on the County's FIRM would primarily act as a consumer awareness device for potential purchases of property and would also better protect the investment of federal dollars in mortgages, subsidized flood insurance, etc. The County has the authority to properly regulate new development with its current shoreland regulations, in the absence of a flood delineation and the jurisdiction of its flood plain ordinance. Adding a flood delineation on the FIRM would have to be premised on the selection of a flood elevation which best serves the public's interest. The decision will be left to the Federal Emergency Management Agency, with local input.

PROTECTING NEW/EXISTING STRUCTURES

As mentioned in the previous section on local land use regulations, new construction and additions, modifications to and repair of existing structures must be protected against potential flood damage. The minimum protection level pursuant to local shoreland regulations is 969.6. The Department of Natural Resources encourages a local flood protection level for Diann and Helene Lakes' of 970.1'.

The most prudent method of protecting new and existing development in a potentially long duration flooding event is to elevate the building site on properly compacted fill. The lowest floor (including crawl spaces, basements, and other enclosed areas), must not extend below the identified flood protection level, even if continuous fill is placed around the structure to the identified flood protection level. Standard flood proofing techniques for enclosed spaces below the flood protection level generally are not recommended in flood plains for land-locked basins. This is due to the long duration of flooding and associated saturated soil conditions. Although flood proofing of spaces is generally not recommended when flooding is long-duration, more detailed information is available in the report "Flood Proofing Regulations" which has been adopted into the State Building Code.

Taking emergency action to protect existing development presents a particular problem to the landowner and the community. Because these activities require structural modifications to structures, grading/filling, alteration to shoreline vegetation, etc., a development permit will be required from the local unit of government. The County would review the proposal so as to insure neighboring properties are not affected and the lake resource protection standards are met (e.g., setbacks, flood protection, vegetation removal, etc.)

Plates 8 and 9 provide a number of potential emergency protection measures. The decision to employ any given measure will depend on the site-specific flooding situation. These emergency protection measures are presented here so as to inform the reader of the general design factors which must be considered. The reader is cautioned that an engineer or architect and the local building code official should be consulted prior to the design of emergency flood protection measures.

Except for the following two situations, a landowner may choose the protection level for <u>emergency protection measures</u>.

1) A structure has been damaged to 50-percent of its market value at the time of loss and the landowner wishes to repair the damage; or

2) The emergency protection measures would equal or exceed 50-percent of the structures market value.

For the two above situations, the structure, at a minimum, must be protected to elevation 969.6' (or to a higher elevation if the County wishes to adopt one).

The reader is requested to pay special attention to the discussion of levees and filling around structures on Plates 8 and 9 on the following pages. Levees are temporary measures and should not be considered as a permanent solution. In no case should a structure protected by a levee be used for human occupancy. This is especially true when the top of the levee is higher than 1-2' above the lowest floor level. A sudden collapse of the levee or overtopping can cause structural failure to the supporting walls, inundating the building with little warning and causing serious damage. All damageable items should be removed from potentially damaged areas and provisions should be made to allow water to enter the building (to equalize water pressure inside and out) should the levee fail.

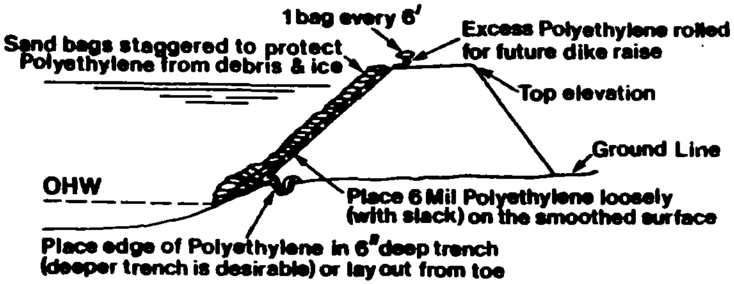
Secondly, fill could be placed around an existing building to keep surface water away. It is likely that the fill material adjacent to the building will become saturated because of the potentially long duration of the high water and the porosity of the soil. Water pressure will likely build on the outside walls at an elevation equal to the lake level. Any attempt to keep the area inside the building dry by pumping will create differential pressures inside and outside of the building's walls. This could lead to wall and floor collapse and, in no case, should the building be used for human occupancy. A design professional should be consulted prior to pumping the inside of a structure to determine if

PLATE 8
FLOOD PROTECTION MEASURES

The following information is being presented to stress the importance of following prudent design and permit review procedures prior to installing emergency or permanent protection measures. Design guidelines assisted by a qualified professional are not only cost effective (e.g., the measure will work as designed and will not be over or under-designed), but protect the investment of the landowner. Community permit review will insure consistency with local land use controls which were designed to avoid haphazard, unregulated shoreline encroachment that will have adverse impacts on adjoining landowners, long term property values and the lake resource.

TYPE OF PROTECTION

EARTHEN LEVEE



SECTION

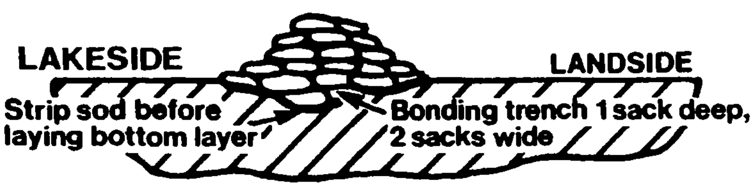
GENERAL DESIGN CONSIDERATIONS

These criteria are guidelines for construction of temporary levees. The criteria are not for permanent protection and not intended for long term exposure to high water.

- Site Preparation: Remove topsoil and vegetation on the foundation of the levee. This material can be stockpiled and used for cover of the levee.
- Construction Materials and Placement: The preferred material is clay as it is relatively impervious if compacted properly. The material should be placed in layers not exceeding 9 inches and compacted with four to six passes of a roller. Impervious material such as sand or sandy-clay can be used. This material requires a flatter side slope than clay. Place material in layers not more than 12 inches, and compact with not less than two passes of a roller.
- Side Slope (minimum):
  Clay - 1 vertical on 2½ horizontal
  Sand - 1 vertical on 3 horizontal (lakeward)
  1 vertical on 5 horizontal (landward)
- Top Width: Clay - 8 feet
  Sand - 10 feet
- Interior Drainage: Pumping will always be required for removal of seepage and rainfall behind the levee. The amount of pumping depends on the foundation soils, the levee material and the drainage area behind the levee.
- Slope Protection: Protection is needed on the lakeward side of the levee to prevent erosion from wave action. The preferred protection is a layer of rock riprap 12 inches in diameter with a filter underneath (filter cloth, poly sheeting). Protection of the toe of the levee and foundation is critical for areas of high wave action. A second method of protection is reinforced polyethylene sheeting weighted with sandbags.
- Placement in Water: Construction of earthen levees in water is not recommended. A temporary sandbag levee can be constructed and the area behind pumped. Then the earthen levee can be constructed behind the sandbag levee.

*Each project should be analyzed and designed by an engineer competent in earthen structure construction.

SANDBAGGING

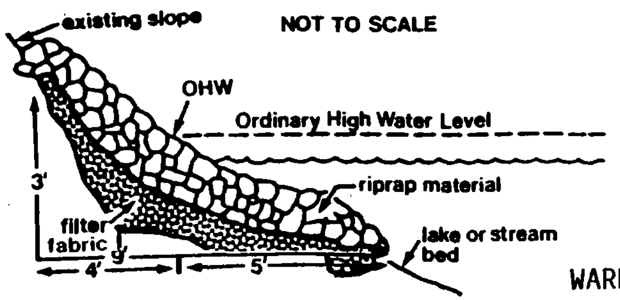


SECTION

A sandbag levee provides temporary protection from short term rises in lake elevations.

- Site Preparation: Remove topsoil and vegetation. Dig a bonding trench to key in the levee to the foundation.
- Construction Materials and Placement: Sand or predominantly sandy or gravelly material should be used. Woven plastic sandbags are preferred if the levee is long term, as burlap bags will deteriorate over time. Bags should be filled ½ full, lapped when placed, and tamped tightly in place. The bags should be staggered when placing to prevent gaps through the levee.
- Cross Section: The base width should be 3 times the height, as a minimum. The top width should be sufficient to add additional bags to raise the levee if needed. A maximum height of 3 feet is recommended.
- Seepage Barrier: Polyethelyne sheeting may be incorporated into the lakeward face of the levee to reduce seepage. Placement is similar to placement on an earthen levee.
- Interior Drainage: Pumping will be required for removal of seepage and rainfall behind the levee. Sandbag levees will seep more than earthen levees, as the material is pervious and the cross section is not as wide.
- Placement in Water: If the levee is placed in the water, it is important to monitor the levee for settlement, erosion under the levee and excessive seepage.

RIPRAP: NATURAL SHORELINE OR FILL EMBANKMENT PROTECTION



- Natural rock riprap 12" in diameter or larger
- Finished side slope no steeper than 3:1 (3' horizontal to 1' vertical)
- A transitional layer of filter fabric is required to be placed between the slope or embankment material and the riprap.

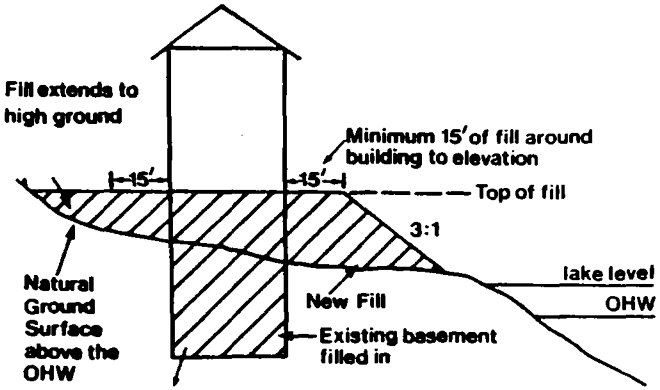
WARNING: Fill placed below the Ordinary High Water Level may require a permit.

PLATE 9

FLOOD PROTECTION MEASURES

TYPE OF PROTECTION

ELEVATED STRUCTURE (PERMANENT)

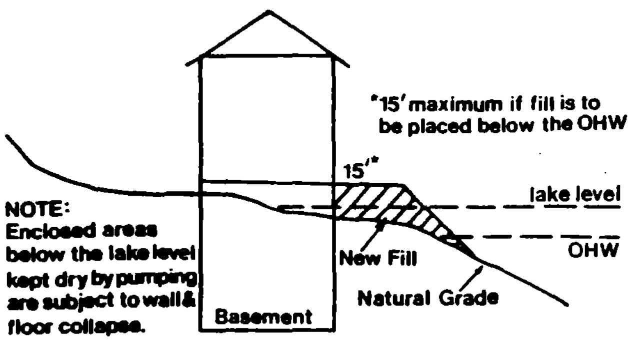


NOTE: Enclosed areas below the lake level intentionally kept dry by pumping are subject to wall and floor collapse.

GENERAL DESIGN CONSIDERATIONS

- Stabilized fill elevation underneath and 15' around the structure
- Fill selection and placement shall recognize the effects of saturation from flood waters on slope stability, uniform and differential settlement and scour/wave action.
- Fill material would be preferably granular and free-graining, placed in compacted layers.
- The minimum.distance from any point of the building perimeter to the top of the edge of the fill slope shall be 15'.
- Side slope sections of fill areas should be anticipated to experience wave action and must be properly riprapped or otherwise protected.
- The area to be filled shall be properly cleared of trees, brush, debris or other growth which the building officials considers unstable as a foundation material.

PERMANENT FILLING AROUND STRUCTURE



- The side slope of the fill area shall be properly protected by a method of protection as outlined above.
- Pumping lower level enclosed areas may result in hydrostatic pressure levels being higher on the outside of the walls as compared to the inside of the walls. This pressure differential can cause walls to collapse or floors to buckle.

WARNING: Fill placed below the Ordinary High Water Level may require a permit.

the structure can tolerate differential pressures against its walls and floors. A safer alternative may be to fill the inside area of the building with granular material (a permanent loss of a lower level) or to allow water to enter into and equalize inside the lower level.

RESOURCE MANAGEMENT -
THE DIRECT ROLE OF THE STATE

The preceding sections in Part II indicate that the federal government plays the primary role in providing flood insurance and local government is actively involved in regulating development adjacent to Diann and Helene Lakes. The State, pursuant to Minnesota Statutes Chapter 105, regulates directly those actions affecting the course, current or cross section (i.e., the bed) of public waters and protected wetlands, as defined in Minnesota Statutes Section 105.37, Subd. 14. Diann and Helene Lakes' has been identified as a public water (Basins 71-46P and 71-45W, respectively) in the Protected Waters Inventory for Sherburne County and, thus, fall under the jurisdiction of Minnesota Statutes Section 105.42.

A common response to rising lake levels is to: 1) artificially control the lake's level by constructing an outlet or pumping; 2) protecting existing structures by constructing temporary levees, placing fill around structures or elevating structures on-site with fill; and 3) constructing shoreline erosion protection measures. Pursuant to Minnesota Statutes Section 105.42, a state permit is required for the following specific activities below elevation 965.4', the Ordinary High Water Elevation (OHW) for Diann Lake and below elevation 965.0' which is the OHW for Helene Lake (this is not an all inclusive list of state permit requirements):

- Any action which would attempt to control the lake to prevent it from returning to its OHW;

- Any fill or obstruction placed <u>below the OHW</u> to protect a structure; or

- Placement of any shoreline protection measure which <u>does not</u> meet the following criteria:

  Riprap shall be natural rock 12" in diameter or larger;

  The finished side slope shall be no steeper than 3:1 (3' horizontal to 1' vertical);

  A transitional zone or layer of gravel, small stone or fabric is placed between the slope or embankment material and the riprap; and

  The shore protection measure does not extend more than 5' horizontally lakeward of the OHW.

A DNR permit would be required: 1) to lower the lake below its OHW; or 2) to control the lake at an elevation above its OHW, when:

1) Water is <u>pumped</u> in excess of 10,000 gallons a day or 1,000,000 gallons a year; or

2) The OHW of another public water or protected wetland is affected.

State Rules for managing public waters and protected wetlands do allow for controlling a land-locked waterbody up to 1.5' below its OHW when its in the public's interest to do so. State Rules balance the public's interest in protecting a public resource in a natural condition versus a landowner's (or group of landowners) right to alter a statewide resource to protect existing development. This balancing of interests is paramount for any activity which changes the course, current or cross section of protected wetlands and public waters.

The following statements are excerpts from DNR Rules which address the above-noted "balancing of interests" concept:

Goals, Objectives and Standards

-Maintain natural flow and natural water level conditions to the maximum extent feasible;

-Encourage the construction of small upstream retarding structures for the conservation of waters in natural waterbasins and watercourses consistent with any overall plans for the affected water;

-Limit the artificial manipulation of water levels except where the balance of affected public interest clearly warrants the establishment of appropriate controls and it is not proposed solely to satisfy private interests;

-The project will involve a minimum of encroachment, change or damage to the environment including but not limited to fish and wildlife habitat, navigation, water supply, storm water retention and agricultural uses;

-Adverse effects on the physical and biological character of the waters shall be subject to feasible and practical measures to mitigate the effects;

-Where no natural or artificial outlet exists and the lake is for all practical purposes "landlocked", the control elevation shall not be more than 1½ feet below the ordinary high water mark; and

-Justification has been made of the need in terms of public and private interests and the available alternatives, including the impact on receiving waters and public uses thereof, through a detailed hydrologic study.

Those considering any action which would alter the course, current or cross-section of Diann and Helene Lakes' should contact the DNR area hydrologist in St. Cloud at: DNR-Division of Waters, 3725 12th Street North, P.O. Box 370, St. Cloud, MN 56302, Phone: (612) 255-4278.

IMPLEMENTING MITIGATION MEASURES/INTRODUCTION

This report up until now has attempted to provide landowners and local government officials with the resource management information necessary to judge which mitigation strategies would be most successful on Diann and Helene Lakes. The Department of Natural Resources' experience in similar flooding situations indicates that implementation of mitigation strategies is most successful when a local unit of government below the level of state and federal government takes the lead role. The remainder of this report will emphasize: 1) those non-local funding programs which may be available to assist local interests; and 2) institutional arrangements (both governmental and quasi-governmental) which are available to secure funding or direct mitigation strategies.

COST-SHARING ASSISTANCE

This section will give an overview of the non local funding sources that the Department of Natural Resources is aware of and have used to alleviate flooding problems in Minnesota. Some of these funding sources have been used more successfully than others, while potential funding sources (i.e. programs) are still under consideration at the state and federal level.

U.S. Army Corps of Engineers/Flood Control Assistance

The U.S. Army Corps of Engineers has two primary authorities for providing technical and financial assistance for constructing local flood control measures. Flood control measures can consist of "structural" measures, such as levees, dams, lake outlet structures, pumping stations, etc., and "non-structural" measures, such as flood proofing structures, acquisition/relocation of structures, etc. The two primary federal funding authorities are:

1) Small Projects - Continuing Authorities Program. This is an ongoing program established by Congress to provide a more timely response to local flood control, erosion and navigational problems. Funding decisions are made directly by the Corps of Engineers through established review procedures without direct congressional approval on a project-by-project basis. By virtue of the small projects connotation, federal financial assistance is limited to $5,000,000 or less for each project; and

2) Congressionally Authorized Projects. The federal government, via the Corps of Engineers, can participate in "large" flood control projects where the federal cost would exceed $5,000,000. The study and funding mechanism is time consuming and requires direct congressional approval at each stage of each project.

The Small Projects, Continuing Authorities Program has been successful in assisting many Minnesota communities. Two recent successful projects are the Lake Pulaski outlet and the City of Halstad ring levees. Lake Helene and Lake Diann were included in a Section 205 Flood Control Study conducted by the Corps of Engineers for Cantlin Lake. One of the alternatives examined would have resulted in a drain pipe from Cantlin to Diann to Helene and would have outleted into Elk Lake. This proposal appeared to be economically feasible and would have protected existing residential development on all three lakes. This alternative is no longer under consideration, however, because of potential adverse impacts on the Lake Diann Bog and concerns about water quantity and quality from the property owners abound Elk Lake. It appears as though no additional Corps of Engineers studies to reduce the damages caused by high water levels at Lake Diann and Lake Helene will be conducted.

It must also be noted that all federal assistance will be premised upon an acceptable local sponsor and non-federal cost-sharing. Generally, the local sponsor must provide the lands, easements and rights-of-way necessary to construct the project or approximately 35% of the total project, whichever is greater. A political entity must sponsor the project and eventually enter into contractual agreements to insure all guarantees and cost-sharing commitments are met (the reader should refer to the next section on institutional arrangements).

If local interests should desire further Corps of Engineers' flood control assistance, a written request should be submitted to: Flood Plain Management and Small Projects, Planning Division, St. Paul District Corps of Engineers, St. Paul, Minnesota 55101-1479. The Corps of Engineers will conduct an initial appraisal and assess federal interest and potential economic feasibility.

SMALL CITIES DEVELOPMENT PROGRAM

The Small Cities Development Program (SCDP) is the state-administered portion of the U.S. Department of Housing and Urban Development Community Block Grant Program. The SCDP is a competitive program for smaller general purpose local units of government to provide a suitable living environment and expanding economic opportunities, primarily for persons of low to moderate income. It must be stressed that the program is competitive and that application requests have traditionally exceeded the grant monies available.

This program is designed to address a broad range of community development needs, including: 1) housing grants to rehabilitate local housing stock; 2) public facilities grants; and 3) comprehensive grants, comprising a combination of housing and public facilities grants or other economic development components. Smaller general purpose local units of government, defined as cities and towns with populations under 50,000 and counties with populations under 200,000 can apply for SCDP grant funds.

The SCDP has been used successfully by a number of Minnesota communities to alleviate flooding problems. Examples include:

- St. Vincent Township, Kittson County: purchase of the right-of-way to construct permanent flood control levees, designed and cost-shared by the Corps of Engineers;

- City of Argyle: acquisition and relocation/demolition of flood prone structures, as part of an overall Corp of Engineers' permanent levee project. Approximately one-dozen structures will be acquired and relocated from the flood plain, as they could not be included within a levee system which will protect the City; and

- City of Austin: acquisition and relocation/demolition of approximately 75 frequently flooded structures.

It should be noted that use of the SCDP appears most probable (i.e., the application becomes more competitive) as the amount of non SCDP matching funds increases. Therefore, it is in the local sponsor's best interest to attempt to package a number of assistance programs if possible. This not only reduces the cost to the sponsoring local government/individual landowners but oftentimes one grant program can be used as offsetting matching funds for another grant program.

The SCDP is administered by the state's Department of Energy and Economic Development. An annual application cycle has been established. Currently, applications are due by the end of January. Potential applicants should contact the Department of Energy and Economic Development immediately so they can be notified of the deadline for submitting future applications. To qualify for funding, an applicant must meet one of the three following federal objectives:

-Benefit low and moderate income people;

-Eliminate slum or blight; or

-Eliminate threats to public health and safety.

Inquiries should be addressed to:

Department of Energy and Economic Development
Division of Community Development
9th Floor, American Center Building
150 East Kellogg Boulevard
St. Paul, Minnesota 55101
Phone: (612) 296-5005

State Assistance Programs

Until the 1987 Legislative Session, there were no ongoing statewide financial assistance programs designed specifically to alleviate flooding problems. Prior to 1987, the state had acted with emergency funds with cost-sharing projects to respond to high water problems. An example was the $250,000 made available in 1986 by the Governor through the Legislative Advisory Committee. These funds were made available on a competitive basis to respond to ongoing high water problems. As expected, the requests for assistance outweighed the funds available (on the order of 2:1, for projects totalling $2.3 million).

During the 1987 Legislative Session, the Department of Natural Resources sponsored a bill to cost-share local flood loss reduction programs. As proposed and passed, the State Flood Loss Reduction Act can cost-share up to a 50/50 match with a local government sponsor to implement flood loss mitigation measures (both structural and non-structural). The primary benefit is that increased state funding levels are now available for advance mitigation measures on a priority basis. The legislation would consider funding projects which alleviate lake flooding problems. Applications will be available from the respective DNR area hydrologists on or about November 15, 1987. Technical guidance will be available to assist in formulating and evaluating damage reduction strategies.

The Standard Flood Insurance Policy

The State of Minnesota has encouraged the National Flood Insurance Program, primarily through the standard flood insurance policy, to fund advance hazard mitigation measures. The thought being that the NFIP will pay for insured losses as structures adjacent to landlocked basins are flooded (many of which sustain severe damage or near total loss). It is reasoned that, with the generally gradual rise of flood waters on landlocked basins and the likelihood the water will continue to rise, it would be prudent and cost-effective to either relocate a potentially damaged structure from the site or elevate it in place. As the NFIP would be a primary beneficiary of these actions (i.e., reduced insurance payments), the state suggested the NFIP should consider bearing part of the cost for advance mitigation measures.

Unfortunately, the federal legislation for the National Flood Insurance Program prevents federal participation in these advance mitigation measures. This may be short-sighted, but the NFIP by legislation is presently put in a reactionary mode of only being able to pay for eligible, insured losses as they occur. The only ongoing hazard mitigation program currently administered by the Federal Emergency Management Agency is Section 1362 of the Flood Disaster Protection Act of 1973.

The Section 1362 Program, which is strictly a voluntary program, is reactionary in nature because damages must have already occurred prior to the submittal of an application to FEMA. This competitive, nationwide program is designed to acquire and relocate/demolish frequently flooded or severely damaged structures and to return the flood plain to an "open space" nature.

The program is of limited application to lake flooding situations and is too complex to discuss in any great detail in this report. It must be stressed though that only those structures covered with a flood insurance policy at the time of loss are eligible for the program. As mentioned, the program is competitive nationwide where application requests have far outweighed the funds appropriated by Congress. Section 1362 applications become more competitive as matching funds are proposed in the application.

Further information on the FEMA's Section 1362 Program can be secured from:

Federal Emergency Management Agency
175 West Jackson Blvd., 4th Floor
Chicago, Illinois 60606
ATTN: Flood Hazard Mitigation Officer

IMPLEMENTATION AUTHORITIES

The immediately preceding section dealt with non local funding sources for cost-sharing hazard mitigation measures. A focal point of this discussion was that a local sponsoring authority is necessary to enter into formal (contractual) arrangements with potential funding agencies. Generally, aside from the actions of individual landowners, basinwide mitigation strategies require at least one political entity to take the lead role if for no other reason than to secure the necessary funding.

The authorities and obligations for implementing comprehensive or basinwide mitigation strategies (and the securing of local or matching funds) does not lie solely with municipalities or counties, as the case may be for incorporated and unincorporated areas, respectively. State legislation has provided for establishing special purpose quasi-governmental districts or special taxing authorities which may be used for implementing mitigation strategies.

Experience has shown that city and county governments have been willing to take varying degrees of active participation in solving local high water problems. Therefore, the remainder of this section will discuss how existing local authorities, special districts and special taxing authorities can be used for implementing hazard mitigation measures.

Local Government Capabilities

Municipal and county government can: 1) appropriate general funds for hazard mitigation measures; and 2) act as a local sponsoring agency. It is totally at the discretion of the respective governmental body to determine their degree of participation. This is a local matter. The Department of Natural Resource's experience has shown that some governmental bodies have been hesitant to appropriate community-wide funds to benefit a select group of landowners (e.g., landowners in flood prone areas).

To bypass the issues of uniform local tax rates and providing community-wide funds for a select category of landowners, most counties, including Sherburne County, can establish "subordinate service districts" pursuant to Minnesota Statutes Chapter 375. Subordinate service districts, once established, allow a county to provide additional governmental services only within that service district. Importantly, the revenues to fund these additional government services come only from within the subordinate service district.

Subordinate service districts are initiated either by a resolution of the county board or by petition to the county board signed by ten percent of the qualified voters within the portion of the county proposed for the subordinate service district. The reader should refer to Minnesota Statute, Chapter 375 for a more detailed explanation of subordinate service districts.

Lake Improvement Districts

Pursuant to Minnesota Statutes Chapter 378, a lake improvement district (LID) is a local unit of government established by resolution of the county board. A LID provides the opportunity for greater landowner involvement in lake management activities by actions initiated at the local level of government.

As with the following discussion on the establishment of watershed districts, there is no upper or lower size limit for the area which may be included in a LID. Establishing a LID versus a watershed district is a matter of weighing the pro's and con's of each approach. Each lake improvement district may be delegated different levels of authority by the county board depending upon existing problems and proposed activities. It does allow those [landowners] closest to the situation to directly seek solutions to their problem. A county board may grant powers to LID to, amongst other things:

- -Acquire, construct and operate a dam or other lake control structure;
- -Undertake research projects;
- -Conduct programs of water improvement and conservation;
- -Construct and maintain water and sewer systems;
- -Serve as local sponsors for state and federal projects or grants; and
- -Provide and finance governmental services.

To finance LID projects, services and general administration, a county may:

- -Assess costs to benefitted properties;
- -Impose service charges;
- -Issue general obligation bonds;
- -Levy an ad valorem tax solely on property within the LID boundaries; or
- -Any combination of the above.

The minimum guidelines and requirements for the formation of a LID are contained in (Minnesota Rules Part 6115.0920 - 6115.0980). These rules provide specific guidance on the content and issues to be addressed by the petition or county board resolution.

Specific questions pertaining to lake improvement districts can be directed to:

Minnesota Department of Natural Resources
Division of Waters
500 Lafayette Road, Box 32
St. Paul, MN 55155-4032
Phone: (612) 296-4800

Watershed Districts

Watershed districts are independent units of government established pursuant to Minnesota Statutes Chapter 112. Watershed districts are initiated following a formal petition to the state's Board of Water and Soil Resources. Once established, watershed districts can have broad powers including (but not limited to):

- -Control or alleviation of damage by flood waters;

- -Imposition of preventative or remedial measures for the control or alleviation of land and soil erosion and siltation of watercourses or bodies of water affected thereby; and

- -Regulating improvements by riparian landowners of the beds, banks and shores of lakes, streams, and marshes by permit or otherwise in order to preserve the same for beneficial use.

Watershed districts are suited to resolving multiple water resource issues over a large area. As noted earlier, there is no upper or lower limit on the geographic area which may be included in a watershed district. Establishment of a watershed district requires development of an overall plan, adoption of formalized rules for operation of business and preparation of yearly reports.

Questions concerning watershed districts should be directed to:

Minnesota Board of Water and Soil Resources
90 West Plato Blvd.
St. Paul, MN 55107
Phone: (612) 296-2840

APPENDIX A

SOIL TYPES AND CHARACTERISTICS


LAKE
BATTLE
GOOSE
LAKE
CANTLIN
LAKE
DIANN
LAKE
Little Diann
Lake
HELENE
LAKE
GREAT
NORTHERN
30
29
28
31
32
33

SOIL SURVEY FOR CANTLIN, DIANN, AND HELENE LAKES

MAP SYMBOL	SOIL CLASSIFICATION	% SLOPE
Af	Alluvial land, frequently flooded	
Ba	Beach sand	
BrB	Braham loamy fine sand	2-6
BrB2	Braham loamy fine sand, eroded	2-6
BrC2	Braham loamy fine sand, eroded	6-12
ChB	Chetek sandy loam	2-6
ChB2	Chetek sandy loam, eroded	2-6
ChC	Chetek sandy loam	6-12
ChC2	Chetek sandy loam, eroded	6-12
Du	Dundas loam	
EgC	Emmert gravelly loamy sand	6-12
EgE	Emmert gravelly loamy sand	12-35
EIB	Emmert loamy sand	2-6
EIB2	Emmert loamy sand, eroded	2-6
EIC	Emmert loamy sand	6-12
EIC2	Emmert loamy sand, eroded	6-12
EIC3	Emmert loamy sand, severely eroded	6-12
EmD	Emmert and Chetek soils	12-18
HaB	Hayden fine sandy loam	2-6
HaB2	Hayden fine sandy loam, mod. eroded	2-6
Is	Isanti loamy fine sand	
LsA	Lino loamy fine sand, loam substratum	0-2
Lw	Loamy wet land	
Ma	Marsh	
Pa	Peat and muck, deep	
Pc	Peat and muck, shallow, over loam	
Pd	Peat and muck, shallow, over sand	
Pn	Peat-Lino complex	
ZfE	Zimmerman fine sand	
ZmA	Zimmerman loamy fine sand	0-2
ZmA2	Zimmerman loamy fine sand, wind eroded	0-2
ZmB	Zimmerman loamy fine sand	2-6
ZmB2	Zimmerman loamy fine sand, eroded	2-6
ZmC	Zimmerman loamy fine sand	6-12
ZmC2	Zimmerman loamy fine sand, eroded	6-12

Alluvial land, frequently flooded (Af) is similar to Alluvial land except that it is frequently flooded.

Beach Sand

Beach sand (Ba) consists of nearly level or gently sloping areas of loose sandy material along some of the lakes in the county. These areas are generally not used for agriculture.

Braham loamy fine sand, 2 to 6 percent slopes (BrB).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of their original surface layer through wind erosion. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were spots of a deep sandy soil and small areas in shallow swales where the surface layer is fine sandy loam.

This soil is suited to most crops commonly grown in the county. Yields are fair. Low moisture-holding capacity and low natural fertility are the major limitations. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is cropland. The rest is oak forest or permanent pasture.

Braham loamy fine sand, 2 to 6 percent slopes, eroded (BrB2).

Between one-third and two-thirds of the original surface layer of this soil has been removed by wind erosion. On slight rises on the crests of slopes, the surface layer is lighter colored in places and the sand appears looser because some of the fine silt and clay particles have blown away. The topography is gently sloping or undulating. Slopes are generally short. Included in mapping were deep sandy spots and small areas in shallow swales where the surface layer is thin and is fine sandy loam in texture.

This soil is suited to most crops commonly grown in the county. Yields are fair. Low moisture-holding capacity and low natural fertility are the major limitations. Increasing fertility, conserving moisture, and controlling erosion are the main management needs. Most of the acreage is cropland.

Braham loamy fine sand, 6 to 12 percent slopes, eroded (BrC2).

This soil has a surface layer slightly thinner and slightly lighter colored than that in the profile described for the series. Between one-third and two-thirds of the original surface layer is gone and the sandy subsoil has been turned up in plowing. The topography is sloping or rolling. Slopes generally are short and complex. Included in mapping were sandy spots on side slopes where the sand is more than 48 inches thick.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are the major limitations. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Most of the acreage is cropland.

Chetek sandy loam, 2 to 6 percent slopes (ChB).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but some spots on the crests of slopes have lost between 3 and 6 inches of the original surface layer through wind and water erosion. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards in cultivated areas. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland, part of it is oak forest, and the rest is permanent pasture.

Chetek sandy loam, 2 to 6 percent slopes, eroded (ChB2).

This soil has lost between 3 and 6 inches of its original surface layer through wind and water erosion. In spots on the crest of slopes most of the original surface layer is gone, the dark reddish-brown subsoil has been turned up by plowing, and gravelly material is exposed. The topography is gently sloping or undulating. Slopes generally are short.

This soil is suited to most crops commonly grown in the county. Yields are fair. Both wind and water erosion are hazards. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, and increasing fertility are the main management needs. Most of the acreage is cropland.

Chetek sandy loam, 6 to 12 percent slopes (ChC).

Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. The topography is sloping or rolling. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, increasing fertility, and supplying organic matter are the main management needs in cultivated areas. Most of the acreage is oak forest or permanent pasture. Only a small acreage is cropland.

Chetek sandy loam, 6 to 12 percent slopes, eroded (ChC2).

This soil has lost between 3 and 6 inches of its original surface layer through erosion. In spots on the crests of the slopes, most of the original surface layer is gone, the reddish-brown subsoil has been turned up in plowing, and gravelly material is exposed. There are a few rills on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Low moisture-holding capacity and low natural fertility are serious limitations. Controlling erosion, conserving moisture, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland.

Dundas loam (Du).

In virgin areas this soil has a surface layer slightly thinner and slightly darker colored than that in the profile described for the series. Virgin areas are uneroded, and cultivated areas are only slightly eroded. The gradient is 0 to 4 percent. Included in mapping were small areas where the topography is undulating. In these areas the low spots are wetter than is typical for this soil and the crests of slopes are better drained.

This soil is well suited to most crops grown in the county but is likely to compact if worked when wet. It is not suited to alfalfa. Establishing and maintaining stands of alfalfa without drainage, fertilization, and the application of lime is likely to be difficult. Wetness is the major limitation. Adequate drainage and a cropping system that increases fertility, supplies organic matter, and preserves tilth are the main management needs. Most of the acreage is cropland, part of it is woodland, and the rest is permanent pasture.

Emmert gravelly loamy sand, 6 to 12 percent slopes (EgC).

Most of this soil is uncultivated and uneroded. A small acreage is slightly or moderately eroded, and on the crests of the slopes in cultivated areas, most of the original surface layer is gone and gravelly spots are exposed. The topography is sloping or rolling. Slopes generally are short and complex.

This soil is suitable for meadow, pasture, and woodland, but it is too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a serious hazard. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is either oak forest or permanent pasture.

Emmert gravelly loamy sand, 12 to 35 percent slopes (EgE).

This soil consists mainly of uneroded virgin areas but includes a small acreage that has been eroded. On the crests of slopes in cultivated areas, the original surface layer is gone and the gravelly or cobbly subsoil is exposed. The topography is moderately steep to very steep. Slopes generally are short and complex.

This soil is suitable for woodland but is too steep and too droughty to be suitable for either cropland or pasture. At best, the yield of pasture grasses is poor. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. Most of the acreage is either oak forest or permanent pasture.

Emmert loamy sand, 2 to 6 percent slopes (ElB).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through wind and water erosion. In these spots, the present surface layer is brown and the gravelly loamy sand subsoil is exposed. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping was approximately 60 acres where the surface layer is gravelly and is very shallow over gravel.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are serious limitations. Wind erosion is a hazard. Nevertheless, much of the acreage is cropland. The rest is either oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Emmert loamy sand, 2 to 6 percent slopes, eroded (EIB2).

Between one-third and two-thirds of the original surface layer of this soil has been removed by wind or water erosion, and the rest has been mixed with the subsoil in plowing. On the crests of slopes, more than two-thirds of the original surface layer is gone and the subsoil has been turned up in plowing. A few small areas of gravelly or cobbly material are exposed. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs.

Emmert loamy sand, 6 to 12 percent slopes (EIC).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but spots on the crests of slopes have lost more than a third of the original surface layer through water erosion and the subsoil has been turned up in plowing. The topography is sloping or rolling. Slopes generally are short.

This soil is marginal for cultivated crops. Yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Most of the acreage is either oak forest or permanent pasture. Only a small acreage is cropland.

Emmert loamy sand, 6 to 12 percent slopes, eroded (EIC2).

Erosion has removed between one-third and two-thirds of the original surface layer from this soil, and plowing has mixed the rest with material from the subsoil. On the crests of slopes, more than two-thirds of the original surface layer is gone and the subsoil has been turned up in plowing. A few small gravelly or cobbly spots are exposed. Rills are common on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is marginal for cultivated crops. Yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs.

Emmert loamy sand, 6 to 12 percent slopes, severely eroded (ElC3).

Erosion has removed more than two-thirds of the original surface layer from this soil, and plowing has mixed the rest with gravelly material from the subsoil. The present surface layer is gravelly loamy sand. All of the original surface layer is gone from the crests of some slopes, and either gravelly material or a pavement of cobblestones and gravels is exposed. Rills are common on side slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, and woodland, but it is too droughty to be suitable for cropland. Yields of cultivated crops are very poor. Very low moisture-holding capacity and low natural fertility are the major limitations. The erosion hazard is severe. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation.

Emmert and Chetek soils, 12 to 18 percent slopes (EmD).

The solum of these soils is thinner than that in the profile described for either Emmert loamy sand or Chetek sandy loam. Virgin areas are uneroded, and cultivated areas are only slightly eroded. The topography is moderately steep or hilly. Slopes are complex.

These soils are suitable for meadow, pasture, or woodland, but they are too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Erosion is a hazard. Cultivated field should be seeded to permanent vegetation. Most of the acreage is either oak forest or permanent pasture. Only a small acreage is cropland.

Hayden fine sandy loam, 2 to 6 percent slopes (HaB).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, part of the original surface layer is gone and the rest has been mixed with material from the subsoil in plowing. In a few places where the glacial till joins the sand plain, the till is covered with a thin mantle of sandy material. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were soils that have a sandy cap less than 18 inches thick.

This soil produces good yields and is suited to all crops grown in the county. There is a slight erosion hazard in cultivated areas. Controlling erosion, preserving tilth, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture.

Hayden fine sandy loam, 2 to 6 percent slopes, moderately eroded (HaB2).

Between one-third and two-thirds of the original surface layer of this soil has been removed by erosion, and on the crests of slopes the yellowish-brown subsoil is exposed. In a few places where the glacial till joins the sand plain, the till is covered with a thin mantle of sandy material. The topography is gently sloping or undulating. Slopes generally are short. Included in mapping were soils that have a sandy cap less than 18 inches thick.

This soil produces good yields and is suited to all crops grown in the county. There is a slight erosion hazard in cultivated areas. Controlling erosion, preserving tilth, increasing fertility, and supplying organic matter are the main management needs. Most of the acreage is cropland. The rest is woodland or permanent pasture.

Isanti loamy fine sand (Is).

In many places this soil has a thin layer of peat or muck on the surface. The slope range is 0 to 1 percent. Included in mapping were areas of very poorly drained coarse sand.

If adequately drained, this soil can be used for most crops grown in the county, but it is generally not suitable for alfalfa. Yields are poor or fair. Poor drainage and low fertility are the major limitations. Controlling excess surface water and improving internal drainage are the main management needs. Most of the acreage is undrained and supports aquatic grasses, sedges, and willows. Only a small part is drained and suitable for cropland.

Lino loamy fine sand, loamy substratum, 0 to 2 percent slopes (LsA).

This soil has a black surface layer. Virgin areas are uneroded, and cultivated areas are slightly eroded. Included in mapping were areas where the surface layer is very dark grayish brown.

This soil is suited to most crops grown in the county, but alfalfa stands are short lived. Excessive wetness and low fertility are the major limitations. The main management needs are adequate internal drainage, measures that increase fertility, and a cropping system that adds organic matter to the soil and helps to prevent wind erosion. Drained areas are likely to be susceptible to wind erosion. Much of the acreage is cropland, but a significant acreage is covered with trees and brush.

Loamy Wet Land

Loamy wet land (Lw) consists of dark-colored, poorly drained or very poorly drained soil material. It occurs as depressions and nearly level areas. The slope range is 0 to 2 percent. The surface layer ranges from loam to silty clay loam in texture. In places it is capped with a thin layer of peat. The material is moderately deep or deep over gray till, red till, a mixture of red and gray till, lacustrine silt, or outwash, depending on location.

The moisture-holding capacity of this land type varies but for the most part is moderate to high. The movement of air and water is moderate or moderately slow; it is restricted by a high water table. The organic matter content is high, and natural fertility is moderate. The reaction is acid to alkaline.

If adequately drained, much of this land type is suited to most crops grown in the county. Some areas are not suitable for alfalfa, and in others alfalfa is likely to be short lived. The soil material is likely to compact if worked when wet. Wetness is the major limitation. Controlling excess surface water, improving internal drainage, supplying organic matter, and preserving tilth are the main management needs. Much of the acreage is undrained and supports aquatic grasses, sedges, and willows. The drained areas are cropland or pasture.

Marsh

Marsh (Ma) consists of areas that are covered with water most of the year. The slope range is 0 to 1 percent. The vegetation consists of aquatic grasses, sedges, and cattails.

Peat and muck, deep (Pa).

These soils are more than 42 inches thick. They occur in bogs and along streams and are frequently flooded.

If adequately drained, these soils are suitable for cropland and vegetable gardens. Wetness, low fertility, and the hazard of summer frost are the major limitations. Wind erosion is likely to be a hazard in cultivated areas. Controlling excess surface water, improving internal drainage, controlling wind erosion, and supplying fresh organic matter are the main management needs. Adequate controls are needed to keep drained areas from becoming too dry. Most of the acreage is undrained and supports aquatic grasses and sedges. Part of the undrained acreage is native pasture. Only a small acreage is drained and cropped.

Peat and muck, shallow, over loam (Pc).

These soils are 12 to 42 inches thick. They occur in slight depressions within or adjacent to the till areas in the county.

If adequately drained, these soils are suitable for cropland or vegetable gardens. Wetness, low fertility, and the hazard of summer frost are the major limitations. Wind erosion is likely to be a hazard in cultivated areas. Controlling excess surface water, improving internal drainage, controlling wind erosion, and supplying fresh organic matter are the main management needs. Most of the acreage is undrained and supports aquatic grasses and sedges. Part of the undrained acreage is native pasture. Only a small acreage is drained and cropped.

Peat and muck, shallow, over sand (Pd).

These soils are 12 to 42 inches thick. They occur in depressions in sandy areas, and also along streams that have low banks and overflow frequently.

If adequately drained, these soils are suitable for cropland or vegetable gardens. Wetness, low fertility, shallowness over sand, and the hazard of late-summer frost are the major limitations. Wind erosion is likely to be a hazard in cultivated areas. Controlling excess surface water, improving internal drainage, supplying fresh organic matter, and controlling wind erosion are the main management needs. Stabilizing and maintaining ditchbanks are problems. Most of the acreage is undrained and support aquatic grasses and sedges. Part of the undrained acreage is native pasture. Only a small acreage is drained and cropped.

Peat-Lino complex (Pn).

This complex consists of broad areas of peat and many small islands of sandy soils that are deep, dark-colored, and poorly drained or very poorly drained.

It occurs mainly in the broad, level areas along the St. Francis River and is frequently flooded. Peat makes up 50 percent or more of the complex. Ordinarily, the peat is shallow over sand. The islands of sandy soils range from half an acre to 5 acres in size. For a description of these soils, refer to "Lino Series".

The movement of air and water is ordinarily restricted by a high water table but would be moderate to rapid if the soils were drained. The organic matter content is high, and natural fertility is low. The reaction is medium acid. The moisture-holding capacity of peat is high, and that of the sandy soils is low.

If this complex were drained, it would be suited to most crops grown in the county, except alfalfa. Wetness, the hazard of flooding, and low fertility are the major limitations. Controlling excess surface water and improving internal drainage are the main management needs. Most of the acreage is undrained. The vegetation consists mainly of marsh grasses, cattails, and sedges. Some of the sandy islands support trees and brush. If the soils dry out enough that farm machinery can be used, the marsh grasses are cut for hay.

Zimmerman fine sand, 12 to 25 percent slopes (ZfE).

Virgin areas of this soil are uneroded, but cultivated areas have lost as much as two-thirds of their original surface layer through erosion. Most of the original surface layer is gone from the crests of slopes, and loose sand is exposed. A few rills have been cut on side slopes. Blowouts and dunes are common near the Sand Dunes State Forest. The topography is moderately steep or steep. Slopes generally are short.

This soil is suitable for woodland but is too steep and too droughty to be suitable for cropland. Very low moisture-holding capacity is the major limitation. The erosion hazard is severe. About half the acreage is oak forest or permanent pasture. The rest is cropland.

Zimmerman loamy fine sand, 0 to 2 percent slopes (ZmA).

Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where the soil is faintly mottled below a depth of 36 inches.

Most of the common crops can be grown on this soil, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Nevertheless, much of the acreage is cropland. The rest is oak forest or permanent pasture. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Zimmerman loamy fine sand, 0 to 2 percent slopes, wind eroded (ZmA2).

Between one-third and two-thirds of the original surface layer of this soil has been removed or shifted by wind erosion. The present surface layer is slightly browner than the subsoil; the change in color is ordinarily at a sharp line at the base of the plow layer. On slight rises the sand appears looser, because some of the fine silt and clay particles have blown away. There are some drifts of sand and a few blowouts. Included in mapping were spots where the soil is faintly mottled below a depth of 36 inches.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Zimmerman loamy fine sand, 2 to 6 percent slopes (ZmB).

Virgin areas of this soil are uneroded, and cultivated areas are only slightly eroded. Included in mapping were spots where there are slight accumulations of wind-shifted sand. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion is a hazard. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs. Most of the acreage is oak forest or permanent pasture. The rest is cropland.

Zimmerman loamy fine sand, 2 to 6 percent slopes, eroded (ZmB2).

Between one-third and two-thirds of the original surface layer of this soil has been removed or shifted by wind erosion. The present surface layer is slightly browner than the subsoil; the change in color is ordinarily at a sharp line at the base of the plow layer. In spots on slight rises or on the crests of slopes, the present surface layer is lighter colored and the sand is looser because some of the fine silt and clay particles have blown away. Drifts of sand are common, particularly along fence lines and road ditches. There are a few blowouts, mainly near the Sand Dunes State Forest. The topography is gently sloping or undulating. Slopes generally are short.

This soil can be used for most crops commonly grown in the county, but yields are poor. Very low moisture-holding capacity and low natural fertility are the major limitations. Wind erosion and damage to seedlings by sandblasting are hazards. Nevertheless, most of the acreage is cropland. Conserving moisture, increasing fertility, and controlling wind erosion are the main management needs.

Zimmerman loamy fine sand, 6 to 12 percent slopes (ZmC).

Virgin areas of this soil are uneroded. Most of the cultivated acreage is only slightly eroded, but in spots on the crests of slopes, more than a third of the original surface layer has been removed. In these eroded spots the sand is looser and the material is generally lighter colored. There are a few blowouts, mainly near the Sand Dunes State Forest. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pasture, or woodland, but it is too droughty and too steep to be suitable for cropland. Very low moisture-holding capacity and low fertility are the major limitations. Wind erosion is a hazard. Cultivated fields should be seeded to permanent vegetation. Most of the acreage is oak forest or permanent pasture. The rest is cropland.

Zimmerman loamy fine sand, 6 to 12 percent slopes, eroded (ZmC2).

Wind erosion has removed or shifted between one-third and two-thirds of the original surface layer of this soil. The present surface layer is slightly browner than the subsoil; the change in color is generally a sharp line at the base of the plow layer. The crests of slopes have lost most of the original surface layer, and some are very sandy. Blowouts are common particularly near the Sand Dunes State Forest. Drifts of sand are common also. Rills have been cut on the steeper slopes. The topography is sloping or rolling. Slopes generally are short.

This soil is suitable for meadow, pastures, or woodland, but it is too droughty and too erodible to be suitable for cropland. Yields of cultivated crops are very poor. Nevertheless, most of the acreage is cropland. Very low moisture-holding capacity and low natural fertility are the major limitations. Conserving moisture, increasing fertility, and controlling erosion are the main management needs. Cultivated fields should be seeded to permanent vegetation.

For more detailed information, see the Soil Conservation Service Soil Survey of Sherburne County, Minnesota dated February, 1968.

APPENDIX B

BACKGROUND DATA ON WATER QUALITY, FISH AND WILDLIFE AND DEVELOPMENT HISTORY

PIC DATA

PHYSICAL CHARACTERISTICS FOR LAKE: HELENE

Dominant Forest/Soil Type: Not Available
Size of Lake: 21 Acres
Maximum Depth: NA
Shorelength: NA
Median Depth: NA

Secchi Disk Reading (water clarity): NA
Lake Contour Map is not available.

DEVELOPMENT CHARACTERISTICS FOR LAKE: HELENE

Shoreland Zoning Classification: NOT AVAILABLE
Public Accesses in 1986: 0

Fish Information Not Available.

Permit Information Not Available.

PHYSICAL CHARACTERISTICS FOR LAKE: DIANN

Dominant Forest/Soil Type: NOT AVAILABLE
Size of Lake: 101 Acres
Maximum Depth: NA
Shorelength: NA
Median Depth: NA

Secchi Disk Reading (water clarity): NA
Lake Contour Map is not available.

DEVELOPMENT CHARACTERISTICS FOR LAKE: DIANN

Shoreland Zoning Classification: NATURAL ENVIRONMENT
Public Accesses in 1986: 0

Fish Information Not Available.

PERMIT DATA FOR LAKE DIANN

SUMMARY OF DNR PERMIT APPLICATIONS ISSUED OR DENIED AS OF JUNE 1986 FOR LAKE: DIANN

Permit Types	Number Issued	Number Denied
Public (Protected) Waters Permits Excavation	1	0
General Appropriation Permits	0	0

APPENDIX C

CLIMATOLOGICAL DATA

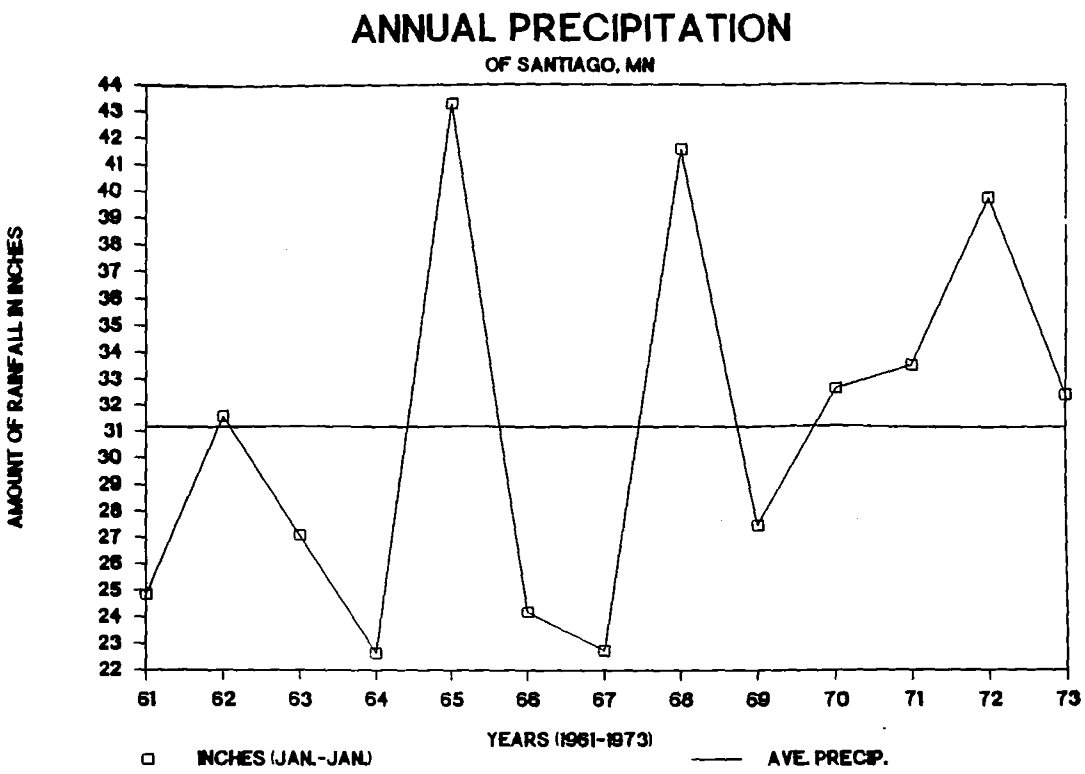
Santiago 3E, MN Monthly Precipitation

####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
7502	1959	m	m	m	m	m	m	m	m	m	1.78	m	1.74	m
7502	1960	m	0.10	m	1.87	m	2.80	m	m	1.87	0.38	1.56	0.59	m
7502	1961	0.5	0.49	0.96	2.55	3.97	2.96	4.03	2.03	2.96	2.32	1.74	0.78	24.84
7502	1962	0.81	1.83	1.76	1.13	6.81	3.14	6.48	3.76	4.72	0.52	0.49	0.14	31.59
7502	1963	0.35	0.40	1.41	3.35	4.95	3.47	1.32	5.56	3.95	0.55	0.81	0.94	27.06
7502	1964	0.19	0.14	1.96	3.21	4.71	1.19	1.02	5.59	2.07	0.38	1.12	1.06	22.64
7502	1965	0.98	1.62	4.56	3.23	7.70	3.54	4.68	5.60	5.74	1.42	2.32	1.91	43.30
7502	1966	0.83	0.81	1.37	2.04	1.86	2.82	6.27	4.46	1.11	1.10	0.56	0.95	24.18
7502	1967	3.48	1.87	0.22	1.06	1.49	7.77	2.14	2.25	0.69	1.07	0.00	0.70	22.74
7502	1968	0.89	0.39	1.47	5.05	3.97	5.55	1.75	4.65	8.46	5.69	1.25	2.46	41.58
7502	1969	2.33	0.62	0.49	3.34	1.99	2.31	5.57	2.32	2.56	2.39	0.92	2.61	27.45
7502	1970	0.65	0.39	1.80	4.09	3.25	4.33	4.07	2.35	1.83	5.87	3.36	0.61	32.60
7502	1971	1.62	2.24	1.06	2.18	2.52	3.86	3.40	3.39	2.47	6.82	3.05	0.91	33.52
7502	1972	1.61	1.03	1.42	2.51	3.46	4.26	11.93	4.95	2.03	3.65	1.12	1.80	39.77
7502	1973	1.17	0.34	2.09	1.51	5.28	3.29	3.38	4.35	3.52	4.03	1.99	1.45	32.40
7502	1974	0.07	1.63	0.87	2.12	3.42	4.31	3.35	1.99	1.75	1.16	2.53	0.80	24.00
7502	1975	3.42	0.52	1.62	3.67	3.22	5.61	1.54	5.76	3.11	1.41	2.76	0.14	32.78
7502	1976	1.22	1.43	1.07	0.45	1.63	3.90	1.93	1.03	0.39	0.19	0.20	0.51	13.95
7502	1977	0.93	1.72	4.29	2.57	3.76	3.25	2.89	8.11	2.97	3.19	3.21	2.11	39.00
7502	1978	0.13	0.07	0.82	4.58	3.18	3.04	6.17	6.07	4.26	0.35	0.64	1.42	30.73
7502	1979	1.50	2.38	3.22	0.79	5.79	8.13	2.64	5.03	0.83	4.76	0.23	0.10	35.40
7502	1980	1.10	0.96	0.69	0.39	1.24	5.52	1.45	6.02	5.70	0.70	0.07	0.03	23.87
7502	1981	0.23	1.46	0.85	3.55	1.46	6.32	3.06	4.62	1.13	3.50	0.40	1.08	27.66
7502	1982	2.80	0.09	1.82	1.02	4.34	2.77	4.56	2.29	5.09	4.44	3.15	2.37	34.74
7502	1983	1.04	0.19	2.83	2.89	2.20	8.12	2.19	3.41	4.97	3.25	4.10	1.39	36.58
7502	1984	0.67	0.93	0.96	3.88	3.26	9.28	2.50	4.20	4.10	6.84	0.30	1.94	38.86
7502	1985	0.49	0.29	2.58	2.88	2.65	5.21	2.86	4.02	8.87	1.54	1.43	0.94	m
7502	1986	0.54	0.98	1.09	5.87	2.52	3.38	7.44	5.55	7.50	0.65	2.16	0.53	38.21

Note: Values in hundredths of inches: 'm' = missing; 'e' = estimated; '####" is the National Weather Service Coop Station Number.

All data was supplied to this State Climatology Office by the National Climate Data Center, NOAA, Asheville, NC, 28801. 'Certified Data' can only be supplied by NCDC directly.

State Climatology Office, Minnesota Department of Natural Resources - Waters, Jim Zandlo at (612) 296-4214.


ANNUAL PRECIPITATION
OF SANTIAGO, MN
AMOUNT OF RAINFALL IN INCHES
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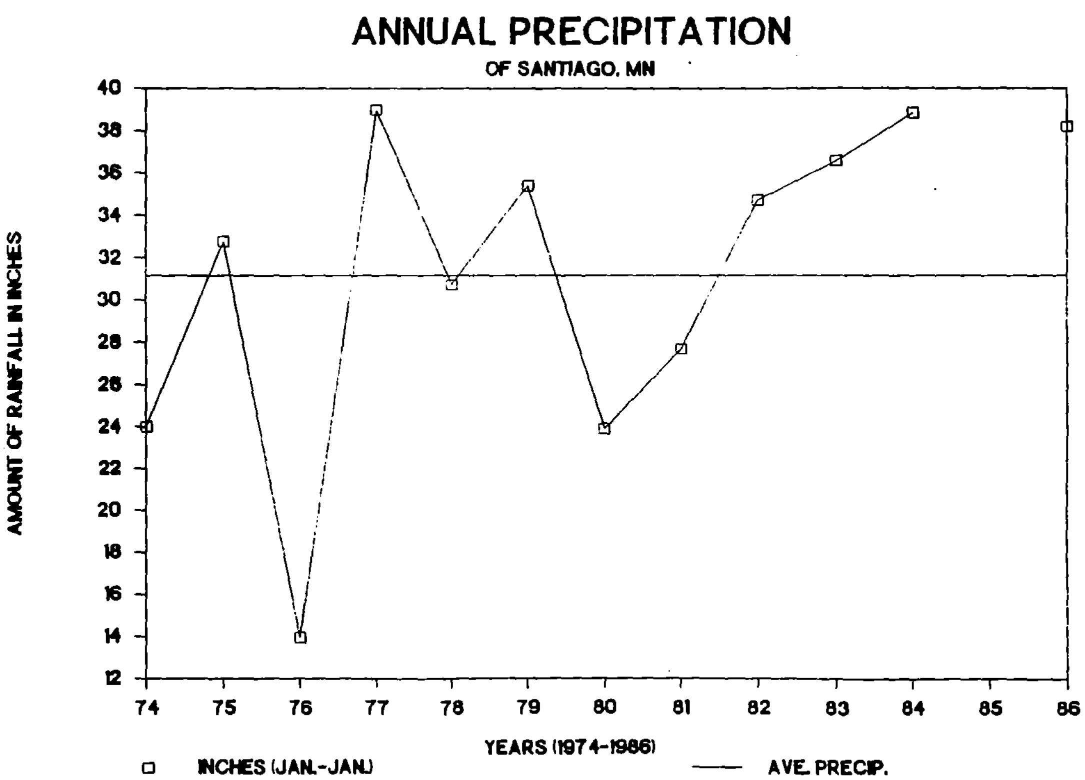
YEARS (1961-1973)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF SANTIAGO, MN
AMOUNT OF RAINFALL IN INCHES
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YEARS (1974-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.

St. Cloud WSO Airport, MN Monthly Precipitation

####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
7294	1887	0.90	1.01	0.14	m	m	m	m	m	m	m	m	m	m
7294	1888	m	m	1.60	m	m	m	m	m	m	m	m	m	m
7294	1890	m	m	m	m	m	m	m	2.20	m	m	m	m	m
7294	1893	1.00	0.90	0.90	5.74	2.62	0.54	3.67	2.41	0.81	1.68	0.81	1.36	22.44
7294	1894	0.81	0.00	2.55	4.93	8.54	4.15	0.51	0.90	2.12	1.95	0.72	0.69	27.87
7294	1895	0.48	0.70	0.24	2.30	3.99	2.55	3.16	2.28	3.84	0.00	0.94	0.00	20.48
7294	1896	1.05	0.18	3.05	6.31	2.57	5.00	2.32	1.66	2.59	4.30	2.76	0.00	31.79
7294	1897	2.75	1.40	4.53	1.56	1.96	6.77	12.81	2.48	4.18	1.69	0.60	0.28	41.01
7294	1898	0.00	1.78	1.75	0.32	2.96	3.73	1.83	3.34	2.28	4.17	1.85	0.00	24.01
7294	1899	0.30	1.05	2.22	2.22	3.79	2.78	4.51	7.91	0.95	7.94	1.10	0.36	35.14
7294	1900	0.27	0.45	1.40	0.81	0.20	2.05	4.28	9.28	7.12	2.39	0.58	0.86	29.69
7294	1901	0.42	0.00	1.34	2.00	1.21	4.67	2.38	1.54	3.25	0.76	0.50	0.23	18.30
7294	1902	0.30	0.00	0.35	0.88	2.79	2.92	4.75	2.32	2.19	1.63	1.53	1.43	21.09
7294	1903	0.20	0.33	2.75	3.74	5.46	1.28	10.53	2.64	5.20	2.80	0.25	0.55	35.73
7294	1904	0.35	0.18	1.06	1.37	2.95	3.89	5.87	6.00	3.02	5.01	0.08	0.39	30.17
7294	1905	0.49	0.36	0.60	2.06	5.47	7.42	5.41	6.96	3.38	3.13	1.41	0.00	36.69
7294	1906	1.20	0.26	1.03	1.68	6.50	7.61	3.17	3.42	4.33	3.22	1.15	0.54	34.11
7294	1907	1.80	0.78	0.75	0.21	3.53	5.05	2.22	3.55	5.15	1.67	3.57	0.26	28.54
7294	1908	0.29	0.69	1.44	3.21	6.77	6.82	2.55	1.60	2.74	1.64	1.09	0.47	29.31
7294	1909	1.56	1.21	0.14	1.57	3.34	4.84	3.08	2.43	4.06	0.71	2.10	1.63	26.67
7294	1910	0.65	0.46	0.18	1.52	1.90	1.85	0.63	3.90	2.53	0.47	0.31	0.24	14.64
7294	1911	0.55	0.37	0.87	2.19	5.86	5.28	3.33	3.56	3.41	4.87	1.65	0.75	32.69
7294	1912	0.26	0.10	0.28	2.96	9.68	2.29	5.23	4.79	1.78	0.68	0.01	0.82	28.88
7294	1913	0.42	0.37	0.48	2.91	4.26	3.05	9.49	2.61	4.12	2.27	1.23	0.00	31.21
7294	1914	0.88	0.35	0.95	2.42	2.79	8.35	0.90	3.37	6.49	1.59	0.23	0.05	28.37
7294	1915	0.33	1.29	0.54	2.83	3.97	m	4.26	1.62	3.41	2.62	2.13	0.70	m
7294	1916	2.16	0.37	1.38	1.92	5.86	6.04	3.21	4.65	2.98	1.71	0.00	0.74	31.02
7294	1917	1.85	1.09	2.98	2.69	1.02	4.65	3.35	2.61	1.39	1.04	0.05	0.44	23.16
7294	1918	0.48	0.27	0.72	1.79	4.14	1.64	4.43	3.21	0.84	3.23	2.99	0.72	24.46
7294	1919	0.30	2.22	1.17	2.53	2.85	5.30	3.83	2.10	0.80	2.18	m	0.42	m
7294	1920	1.61	0.66	3.14	1.53	4.61	10.56	0.75	0.89	3.87	2.62	m	0.76	m
7294	1921	0.29	0.00	0.80	1.21	2.07	3.18	2.86	1.70	6.10	0.80	1.02	0.52	20.55
7294	1922	1.88	2.94	1.39	1.25	2.01	4.50	0.86	1.16	0.74	2.37	4.16	0.20	23.46
7294	1923	1.42	0.25	0.20	2.66	2.49	5.17	3.26	1.00	0.93	0.42	0.57	0.17	18.54
7294	1924	0.14	0.35	0.95	3.26	1.80	5.17	1.49	4.76	4.63	0.76	0.52	1.04	24.87
7294	1925	0.39	0.37	0.34	2.16	1.07	4.96	4.63	1.29	2.46	0.44	0.50	0.51	19.12
7294	1926	0.98	0.44	0.89	0.08	0.98	4.67	4.31	7.22	10.72	1.22	1.53	0.32	33.36
7294	1927	0.41	0.31	1.73	3.31	2.98	3.04	2.74	2.18	2.55	1.97	1.93	1.75	24.90

####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
7294	1928	0.40	0.88	0.39	2.31	1.34	3.61	4.62	5.28	4.28	2.15	0.81	0.71	26.78
7294	1929	0.93	0.50	1.19	1.40	2.10	1.19	2.37	1.97	6.60	2.11	0.67	0.57	21.60
7294	1930	0.82	0.96	0.73	0.59	3.61	2.89	2.17	1.46	3.10	1.43	1.78	0.08	19.62
7294	1931	0.07	1.35	1.30	0.96	1.81	2.94	1.37	2.65	1.56	3.54	4.02	0.31	21.88
7294	1932	1.02	0.26	0.73	1.16	4.32	3.55	3.94	2.52	0.78	1.46	1.51	0.23	21.48
7294	1933	0.48	0.27	0.84	0.46	4.22	1.96	5.75	0.42	1.36	1.46	0.54	0.43	18.19
7294	1934	0.74	0.06	0.82	0.25	1.01	3.89	1.30	1.84	6.12	2.83	1.32	0.82	20.99
7294	1935	0.89	0.27	1.28	2.02	1.97	4.41	4.02	6.30	0.90	2.18	0.57	0.95	25.76
7294	1936	0.79	1.10	1.30	2.25	4.05	0.80	0.94	4.98	2.15	0.54	1.89	1.53	22.32
7294	1937	1.04	0.76	0.37	3.18	5.72	2.43	2.43	5.12	1.26	1.03	0.49	0.33	24.16
7294	1938	0.41	0.64	2.07	3.62	6.80	4.29	4.87	2.84	3.16	0.34	1.43	0.67	31.14
7294	1939	1.26	1.20	0.27	1.96	2.72	6.91	2.74	3.17	1.39	1.22	0.00	m	m
7294	1940	0.26	0.84	1.93	2.48	2.21	2.84	3.39	3.61	1.07	2.66	3.14	0.57	25.00
7294	1941	0.86	0.95	0.72	2.08	5.23	6.19	1.23	5.83	5.02	3.28	0.01	0.86	32.26
7294	1942	0.02	0.26	1.94	1.87	4.47	3.21	3.45	3.28	4.89	0.38	0.16	1.11	25.04
7294	1943	0.77	0.67	1.61	0.87	6.18	2.90	3.16	1.36	0.68	2.30	1.54	0.01	22.05
7294	1944	0.63	1.37	1.07	3.48	5.11	5.57	5.19	3.67	2.55	0.07	1.11	0.41	30.23
7294	1945	0.87	1.29	2.07	1.91	2.08	6.58	4.22	1.96	3.06	0.33	1.60	1.74	27.71
7294	1946	0.43	1.14	0.64	1.00	4.41	5.73	1.86	0.77	4.19	4.24	1.35	0.85	26.61
7294	1947	0.31	0.23	0.63	4.40	2.38	3.55	1.75	2.90	1.63	1.10	2.15	0.03	21.06
7294	1948	0.16	1.42	1.89	2.09	0.32	4.38	2.86	2.89	2.13	0.51	1.74	0.39	20.78
7294	1949	1.61	0.21	1.76	0.97	2.04	3.77	5.93	1.43	2.34	2.28	1.13	0.94	24.41
7294	1950	2.12	0.31	2.44	3.32	5.54	1.33	1.72	0.46	1.79	3.76	1.98	1.80	26.57
7294	1951	0.35	2.76	2.41	2.26	2.87	7.85	4.73	4.95	2.75	3.14	1.54	1.65	37.26
7294	1952	1.33	0.70	1.97	0.92	2.25	9.08	3.40	6.95	0.07	0.07	0.47	0.13	27.34
7294	1953	0.92	1.61	1.19	3.52	2.83	9.34	2.01	3.86	0.99	0.51	1.55	1.40	29.73
7294	1954	0.49	0.57	1.62	5.31	4.46	6.90	3.13	2.94	3.96	2.23	0.38	0.21	32.20
7294	1955	0.57	1.58	0.73	1.17	0.88	2.90	8.00	5.43	2.10	1.99	1.26	1.35	27.96
7294	1956	1.01	0.22	1.13	2.01	2.69	5.46	4.79	7.55	1.88	1.08	2.34	0.33	30.49
7294	1957	0.40	1.10	2.03	0.90	4.58	8.54	2.07	6.35	3.88	0.94	1.28	0.38	32.45
7294	1958	0.69	0.23	0.69	2.03	2.05	2.25	2.63	6.95	4.97	1.44	1.75	0.16	25.84
7294	1959	0.20	0.58	0.10	0.34	5.70	2.42	2.64	4.36	2.20	1.85	0.30	1.69	22.38
7294	1960	0.92	0.09	0.75	1.81	4.29	2.68	2.35	4.47	1.71	0.32	1.31	0.55	21.25
7294	1961	0.07	0.38	0.57	2.18	2.77	2.60	3.15	2.58	2.96	2.11	0.68	0.80	20.35
7294	1962	0.67	1.40	1.12	1.13	8.01	2.93	6.20	3.21	3.71	0.19	0.44	0.13	29.14
7294	1963	0.43	0.40	1.39	2.91	5.79	2.51	2.04	5.90	3.40	0.60	0.76	0.66	26.79
7294	1964	0.18	0.04	1.22	3.31	3.62	1.30	1.71	5.66	1.38	0.19	0.98	0.58	21.17
7294	1965	0.48	0.91	3.43	3.44	6.78	6.43	4.66	4.65	4.94	0.94	1.55	1.11	39.32
7294	1966	0.70	1.17	1.53	1.66	2.22	3.18	3.51	4.67	0.95	1.41	0.49	0.79	22.28
7294	1967	1.99	0.75	0.39	1.05	0.82	7.00	0.59	4.72	1.43	1.14	0.14	1.12	21.14
7294	1968	0.86	0.21	1.17	4.51	2.80	6.98	1.95	2.13	4.74	5.80	0.58	1.95	33.68

####	YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
7294	1969	2.52	0.69	0.47	3.48	2.16	2.27	2.81	2.16	1.71	1.29	0.38	2.04	21.98
7294	1970	0.24	0.18	1.05	3.01	2.52	3.43	3.26	1.73	1.66	5.10	2.73	0.24	25.15
7294	1971	0.86	1.53	0.31	1.66	3.86	6.49	2.28	2.79	3.12	6.16	2.56	0.39	32.01
7294	1972	0.55	0.47	1.56	1.59	3.30	1.91	7.26	4.94	1.64	2.54	0.74	1.31	27.81
7294	1973	0.52	0.31	1.40	1.65	2.89	2.92	2.94	4.27	2.80	3.13	1.64	0.73	25.20
7294	1974	0.09	0.83	0.88	1.16	3.26	4.36	2.25	3.20	1.97	1.58	1.29	0.54	21.41
7294	1975	2.39	0.40	1.75	3.69	3.02	5.78	0.21	4.83	2.27	1.08	3.24	0.28	28.94
7294	1976	0.85	0.83	1.78	0.92	0.93	4.84	1.92	0.60	1.37	0.44	0.14	0.31	14.93
7294	1977	0.58	0.98	3.03	3.17	3.57	3.48	4.27	6.10	2.34	2.93	3.74	1.40	35.59
7294	1978	0.19	0.17	0.81	3.49	3.20	6.04	4.43	2.88	4.59	0.14	0.95	1.02	27.91
7294	1979	1.28	1.67	3.02	0.74	5.17	6.34	1.21	4.88	1.58	4.36	0.62	0.31	31.18
7294	1980	1.17	0.84	0.76	0.48	1.62	6.06	1.28	7.01	5.99	0.71	0.20	0.22	26.34
7294	1981	0.44	1.10	1.05	3.29	1.40	6.65	1.92	0.00	1.26	4.40	0.45	1.04	23.00
7294	1982	0.97	0.13	1.75	0.97	3.91	2.53	3.90	3.37	4.38	4.52	2.31	1.72	30.46
7294	1983	0.61	0.13	2.60	1.57	2.39	9.52	2.21	3.48	6.55	3.09	3.11	0.92	36.18
7294	1984	0.67	0.87	0.65	4.16	2.02	8.11	2.94	2.57	3.39	5.84	0.17	1.81	33.20
7294	1985	0.43	0.23	1.70	3.83	2.81	5.28	2.80	4.57	9.48	1.28	1.43	0.57	34.41
7294	1986	0.72	0.83	0.89	5.55	2.36	3.75	7.54	5.18	6.03	0.49	1.05	0.35	34.74

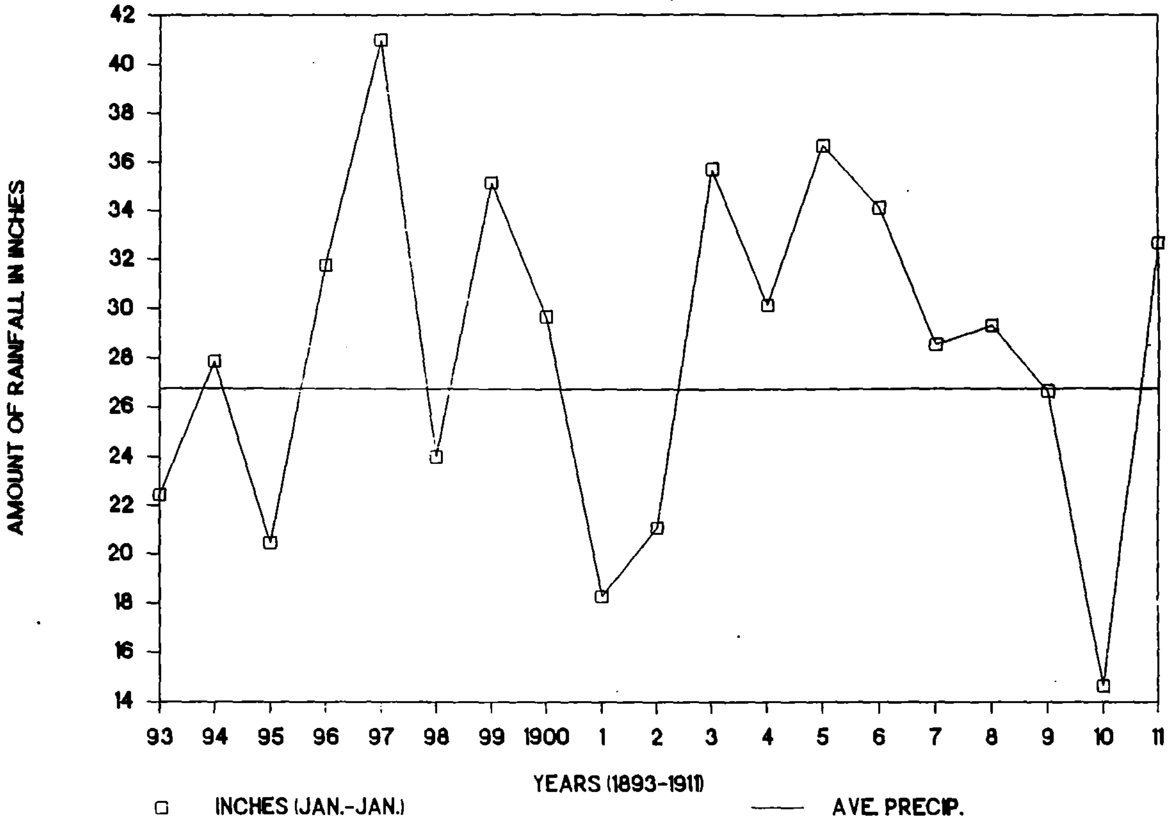
Note: Values in hundredths of inches; 'm' = missing; 'e' = estimated; '####' is the National Weather Service Coop Station Number.

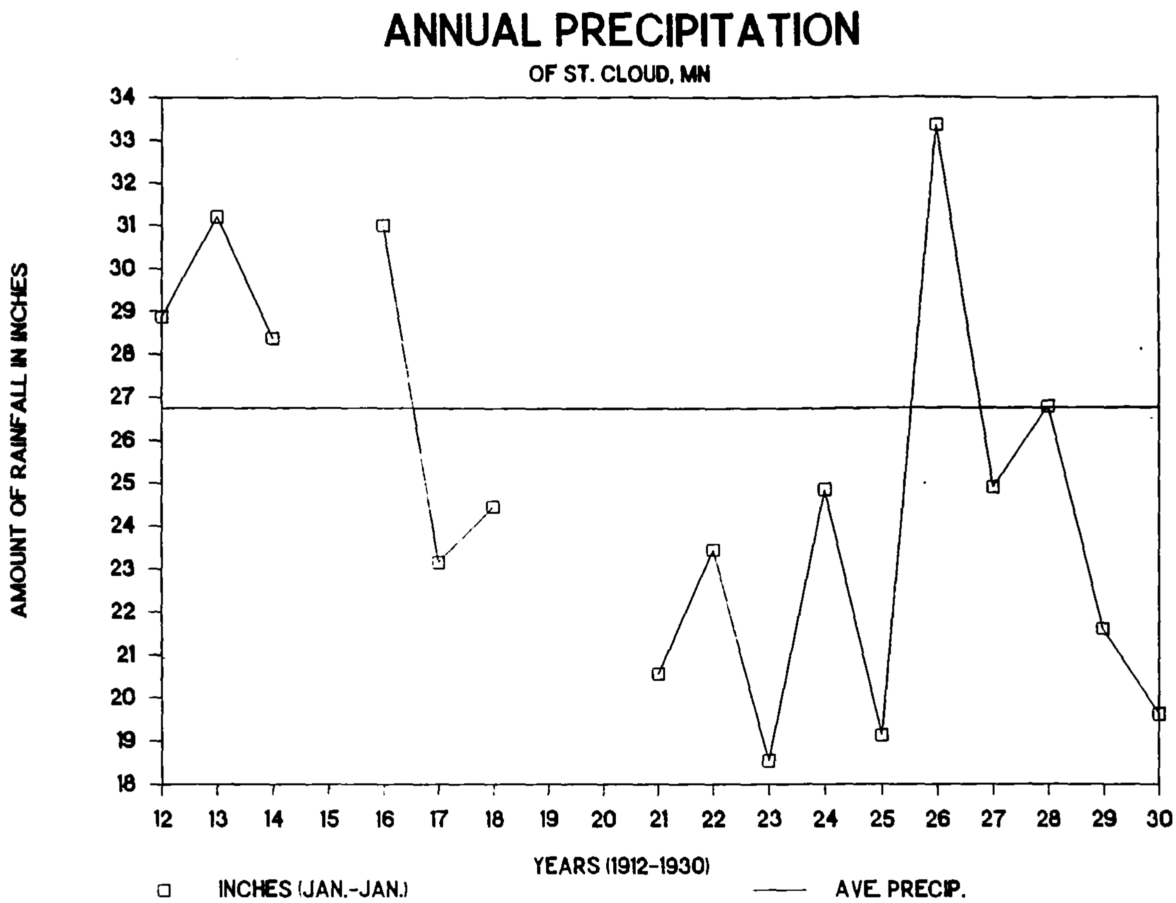
All data were supplied to this State Climatology Office by the National Climate Data Center, NOAA, Asheville, NC, 28801. "Certified Data" can only be supplied by NCDC directly.

State Climatology Office, Minnesota Department of Natural Resources - Waters, Jim Zandlo, (612) 296-4214.

ANNUAL PRECIPITATION

OF ST. CLOUD, MN




ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
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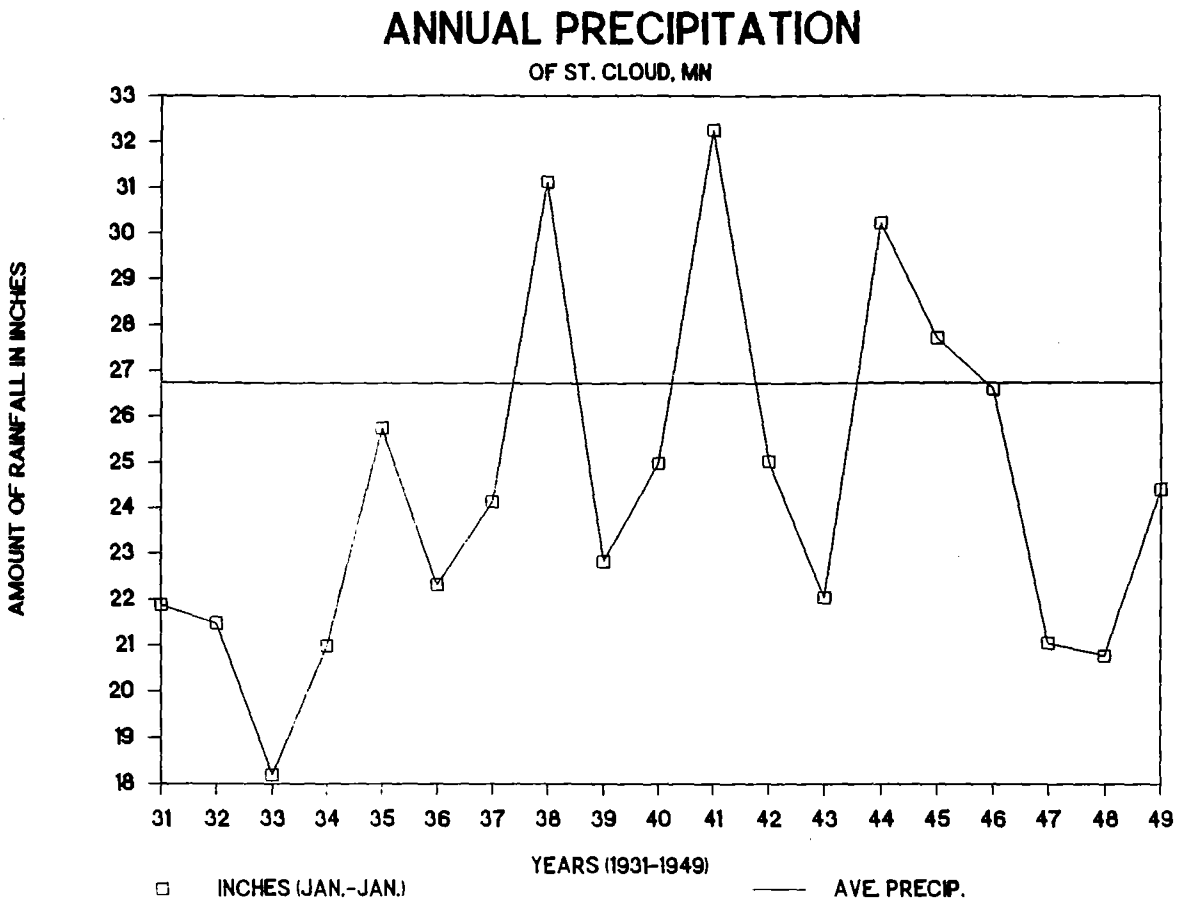
YEARS (1912-1930)
INCHES (JAN.-JAN.)
AVE. PRECIP.



ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
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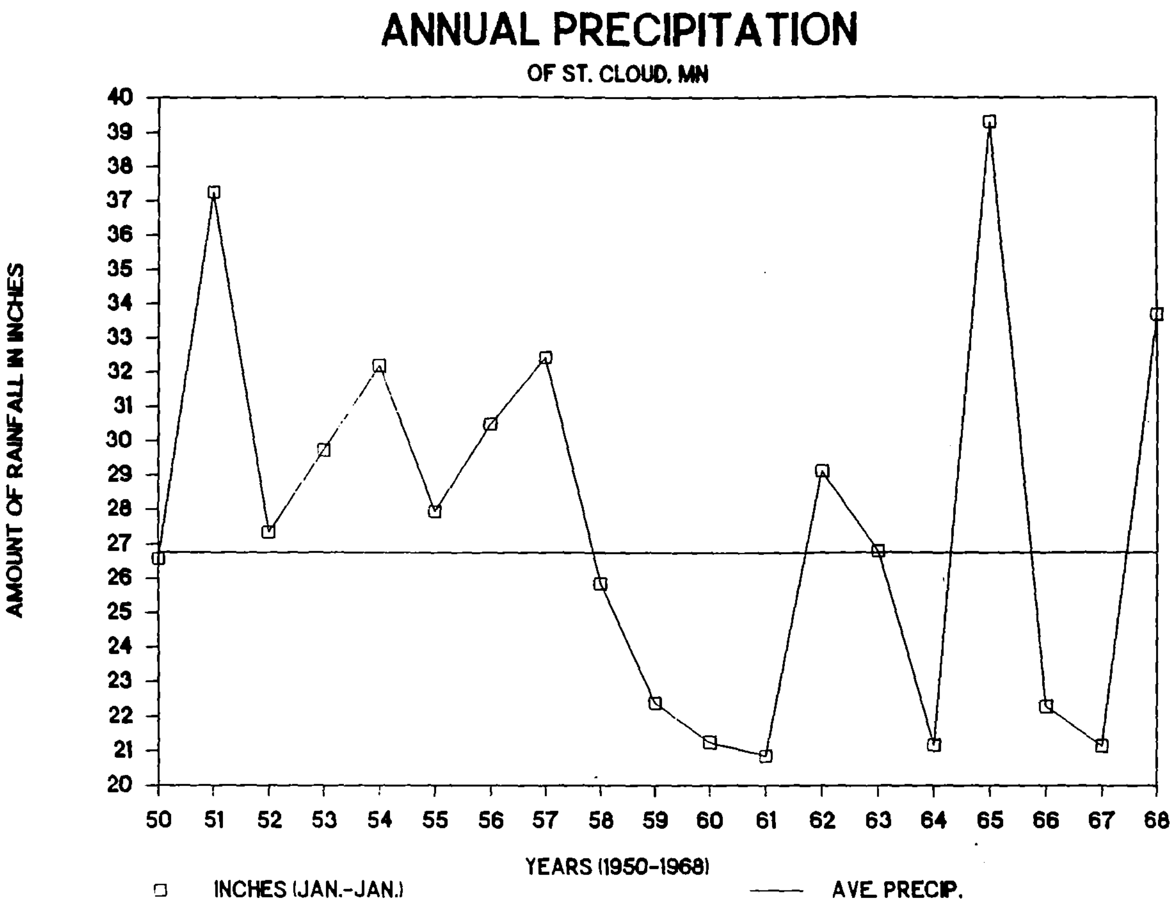
YEARS (1931-1949)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
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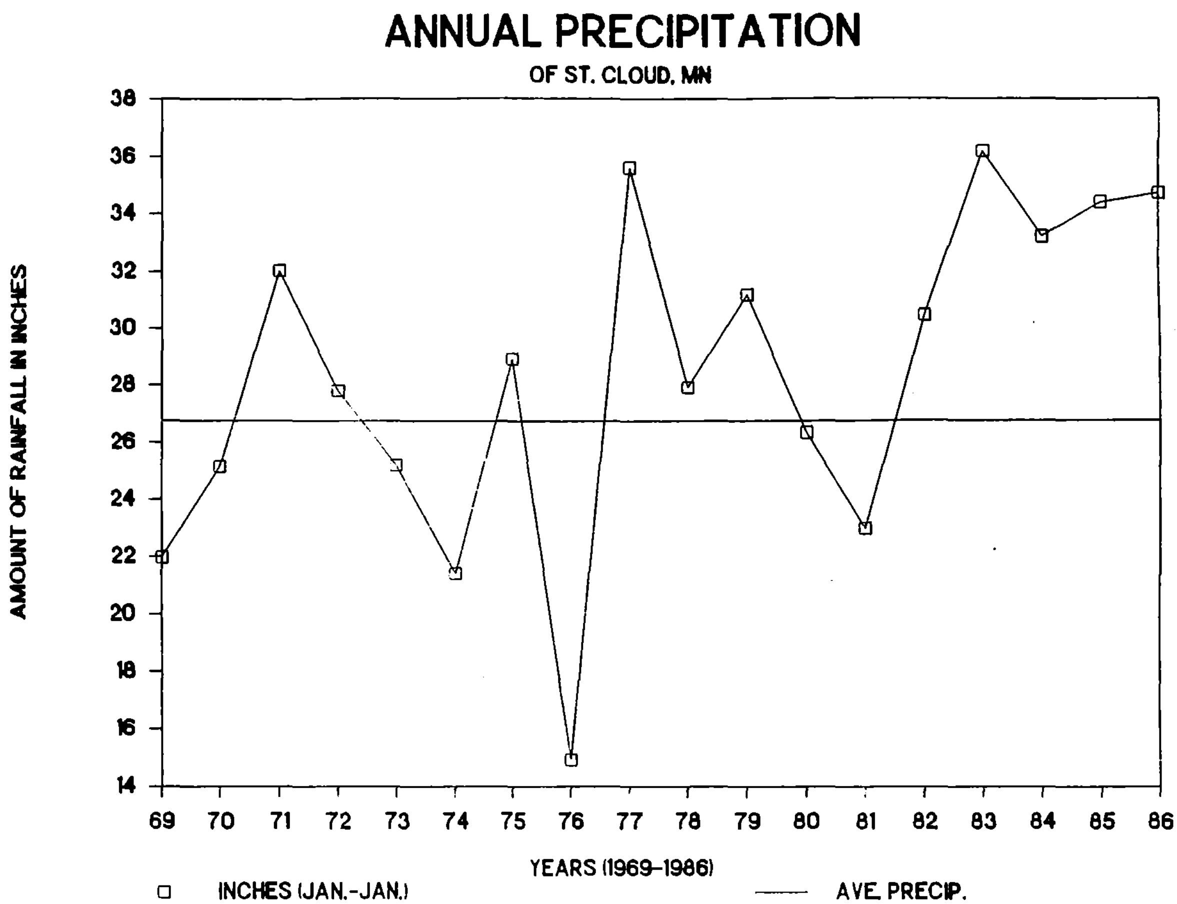
YEARS (1950-1968)
INCHES (JAN.-JAN.)
AVE. PRECIP.



ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
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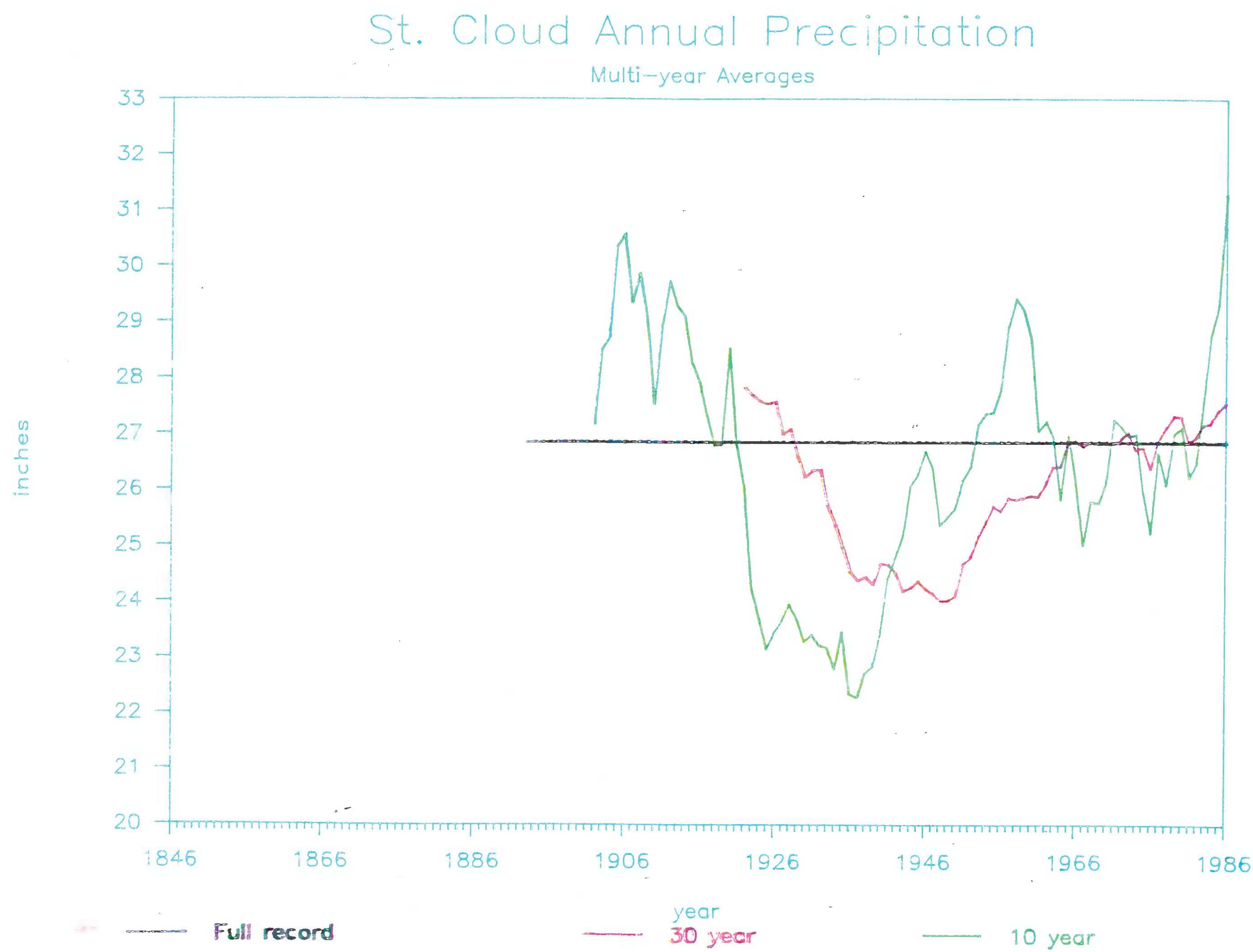
YEARS (1969-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.



St. Cloud Annual Precipitation
Multi-year Averages
inches
33
32
31
30
29
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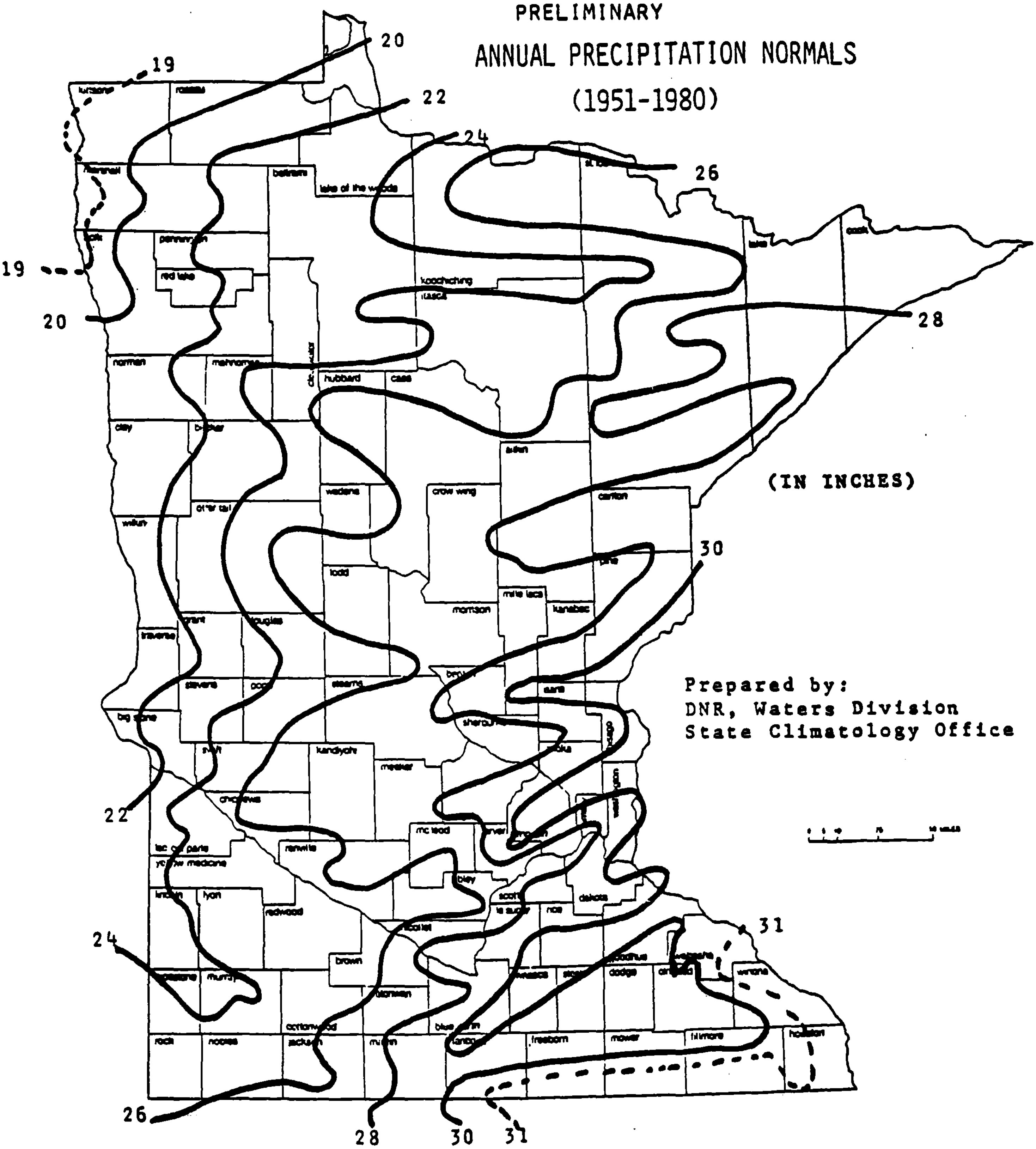
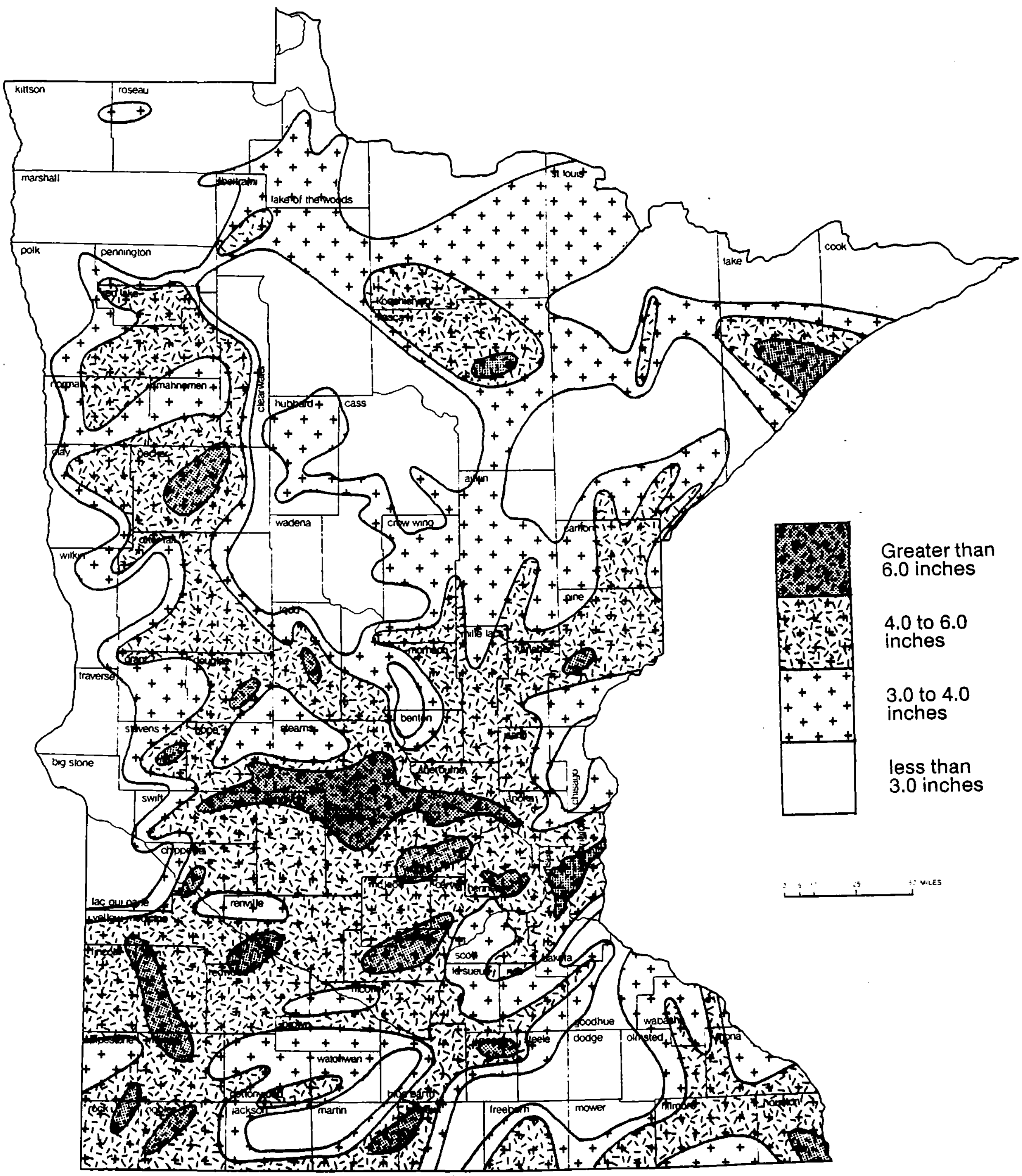
26
25
24
23
22
21
20
1846
1866
1886
1906
1926
1946
1966
1986
year
Full record
30 year
10 year

PRELIMINARY ANNUAL PRECIPITATION NORMALS (1951-1980)

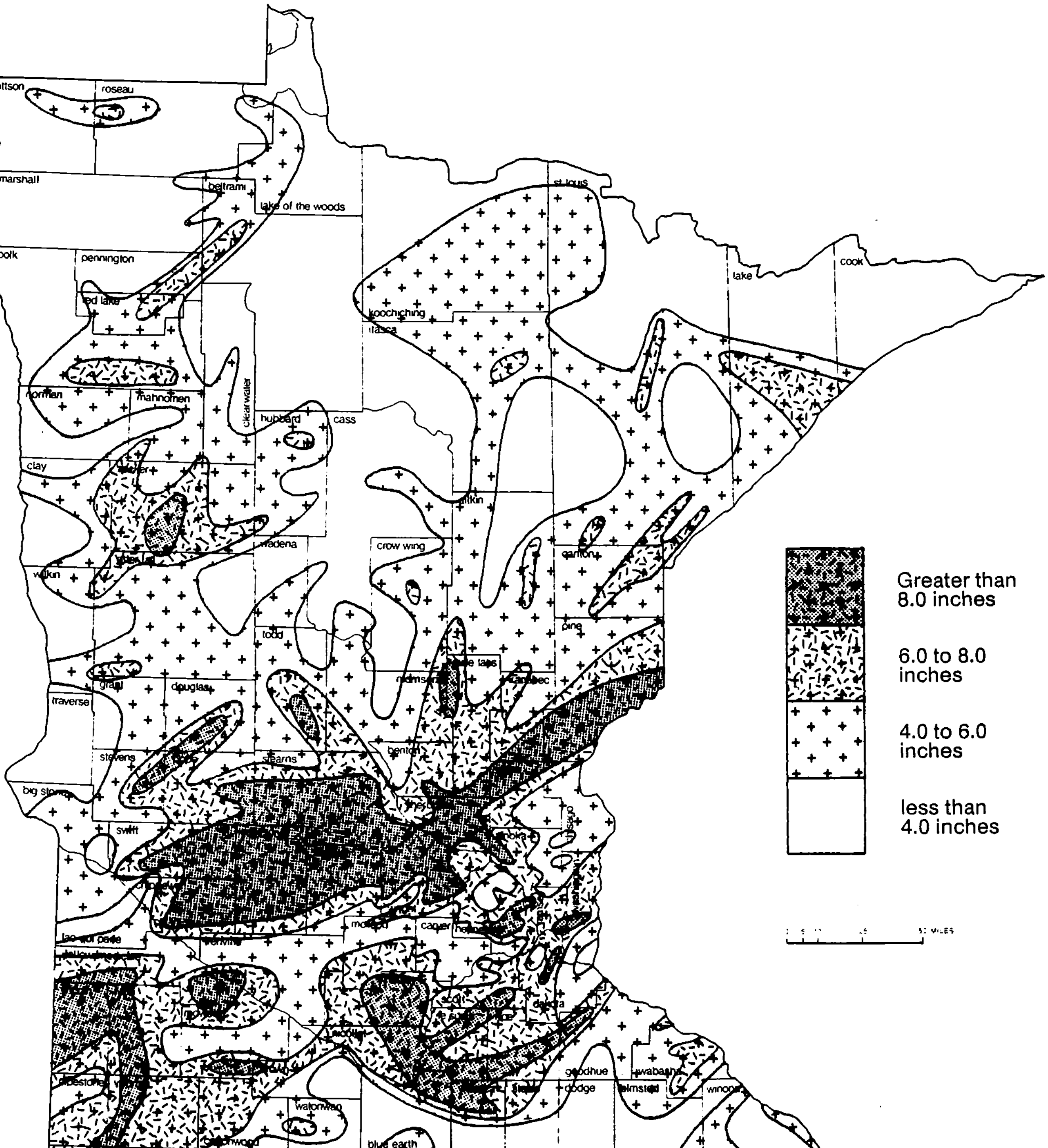


AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1977 - 1986 (10 YEARS)



Prepared by: DNR, Division of Waters, State Climatology Office

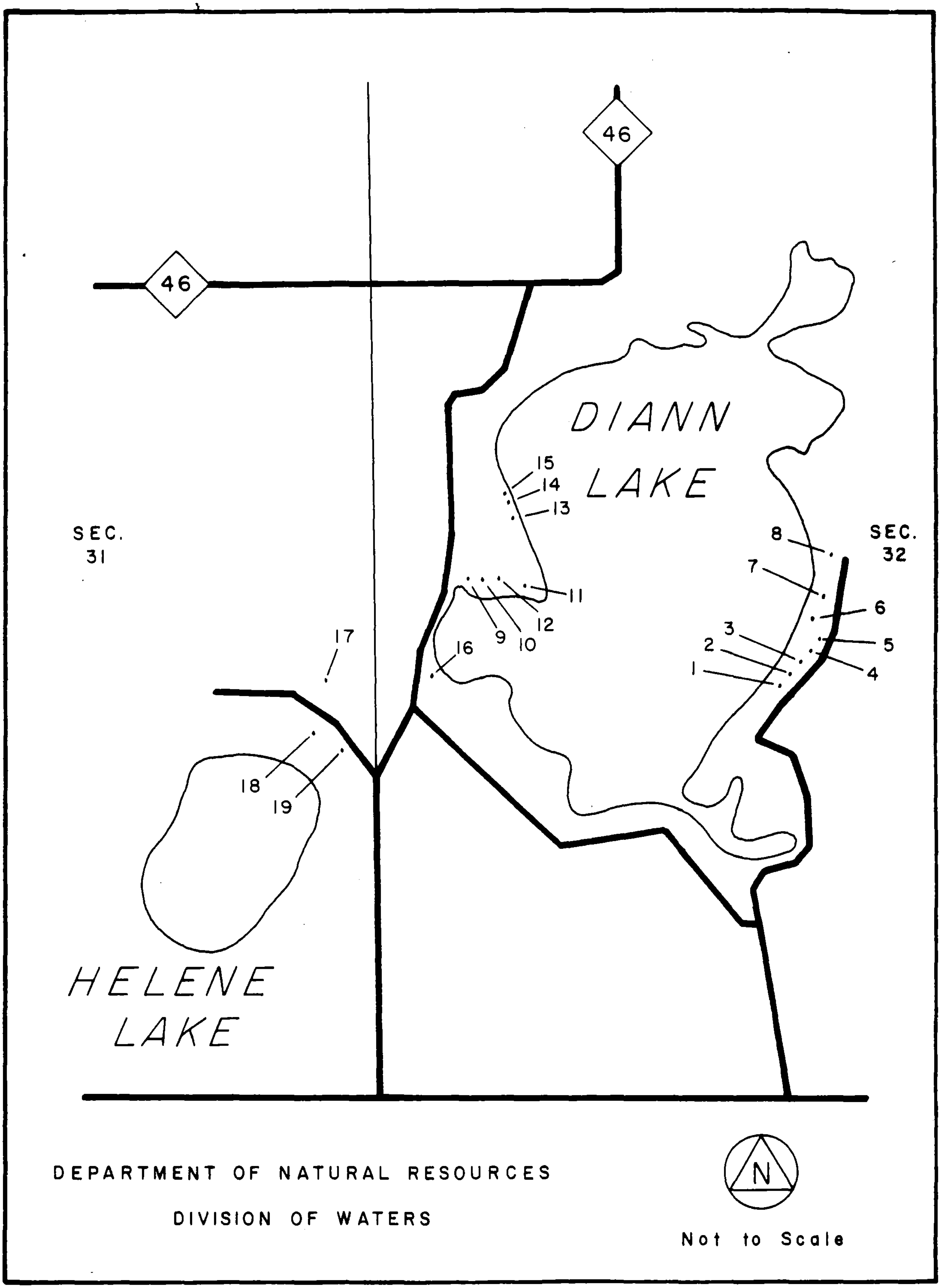
AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1982 - 1986 (5 YEARS)



Prepared by: DNR, Division of Waters, State Climatology Office

APPENDIX D

FACT SHEET FOR EACH POTENTIALLY DAMAGED STRUCTURE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46
DIANN
LAKE
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SEC.
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HELENE
LAKE
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DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS
N
Not to Scale

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 1
Name: Monn, Otto

Assessment Number: 200-030-050050

Legal Description: Lake Diann Acres; Lt. 5, Bk. 5

Walkout/1sFl Elev.: 968.99
Ground Elevation: 967.68

Basement: No
Walkout: No

Market Value

Buildings: $16,500
Land: $ 6,000
Total: $22,500

DIANN LAKE - SHERBURNE COUNTY

Structure Number:	2
Name:	Wallace, Tim
Assessment Number:	200-0300-050090
Legal Description:	Lake Diann Acres; Lt. 9, Bk. 5
Walkout/1sFl Elev.:	970.38
Ground Elevation:	969.02
Basement:	No
Walkout:	No

Market Value

Buildings:	$16,300
Land:	$ 6,000
Total:	$22,300

DIANN LAKE - SHERBURNE COUNTY

Structure Number:	3
Name:	Rawley, Joseph
Assessment Number:	200-030-050100
Legal Description:	Lake Diann Acres, Lt. 10, Bk. 5
Walkout/1sFl Elev.:	971.33
Ground Elevation:	970.13
Basement:	No
Walkout:	No

Market Value

Buildings:	$25,800
Land:	$ 6,300
Total:	$32,100

DIANN LAKE - SHERBURNE COUNTY

Structure Number:	4
Name:	Lenz, Jeffrey J.
Assessment Number:	200-030-050110
Legal Description:	Lake Diann Acres, Lt. 11, Bk. 5
Walkout/1sFl Elev.:	970.83
Ground Elevation:	969.16
Basement:	No
Walkout:	No

Market Value

Buildings:	$25,300
Land:	$ 3,000
Total:	$28,300

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 5
Name: Ohr, Larry

Assessment Number: 200-030-050120

Legal Description: Lake Diann Acres, Lt. 12, Bk. 5

Walkout/1sFl Elev.: 973.39
Ground Elevation: 966.89

Basement: No
Walkout: Yes

Market Value

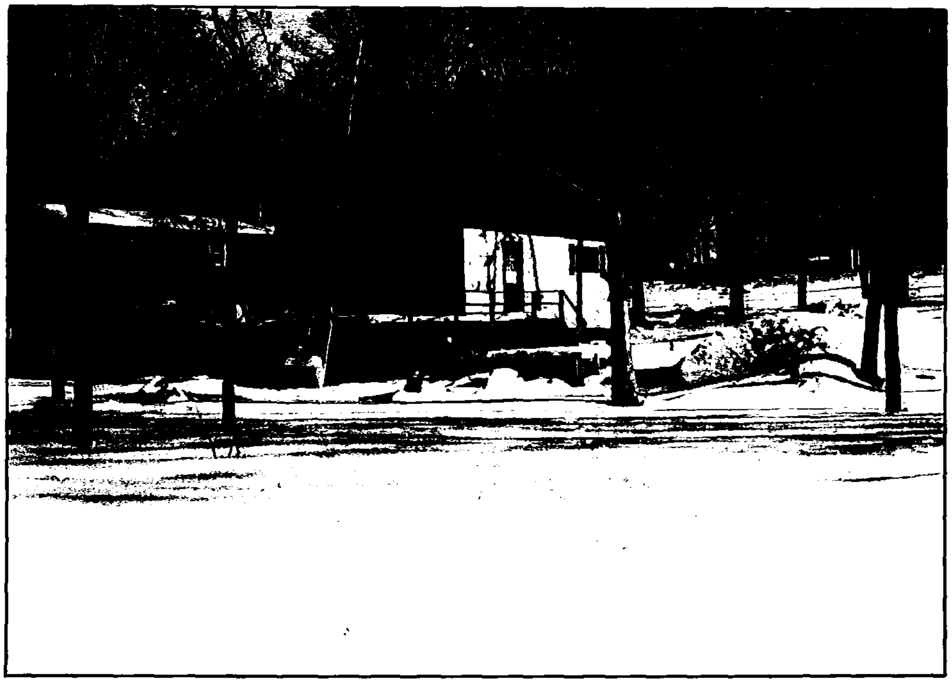
Buildings: $16,600
Land: $ 4,000
Total: $20,600

DIANN LAKE - SHERBURNE COUNTY

Structure Number:	6
Name:	Modderman, L & D
Assessment Number:	200-030-050150
Legal Description:	Lake Diann, Lt. 15, Bk. 5
Walkout/1sFl Elev.:	973.65
Ground Elevation:	968.45
Basement:	Yes
Walkout:	No

Market Value

Buildings:	$ 9,000
Land:	$ 8,400
Total:	$17,400



DIANN LAKE - SHERBURNE COUNTY

Structure Number: 7
Name: Lenz, Steven

Assessment Number: 200-030-050160

Legal Description: Lake Diann Acres, Lt. 16, Bk. 5

Walkout/1sFl Elev.: 971.53
Ground Elevation: 971.53

Basement: Yes
Walkout: Yes

Market Value

Buildings: $30,600
Land: $ 8,400
Total: $39,000

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 8
Name: Storie, Craig A.

Assessment Number: 200-030-050180

Legal Description: Lake Diann Acres, Lt. 19, Bk. 5

Walkout/1sFl Elev.: 967.65
Ground Elevation: 967.65

Basement: Yes
Walkout: Yes

Market Value

Buildings: $16,900
Land: $ 8,400
Total: $25,300

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 9
Name: Schultz, Rudolph

Assessment Number: 200-040-030010

Legal Description: Lake Diann Shores, Lt. 2, Bk. 3 + Lt. 1, Bk. 3

Walkout/1sFl Elev.: 969.65
Ground Elevation: 968.07

Basement: No
Walkout: No

Market Value

Buildings: $ 7,400
Land: $ 6,400
Total: $13,800

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 10
Name: Olson, Gloria

Assessment Number: 200-040-030030

Legal Description: Lake Diann Shores, Lt. 4, Bk. 3

Walkout/1sFl Elev.: 968.96
Ground Elevation: 968.40

Basement: No
Walkout: No

Market Value

Buildings: $ 5,000
Land: $ 5,000
Total: $10,000

DIANN LAKE - SHERBURNE COUNTY

Structure Number:	11
Name:	Frost, Lavonna
Assessment Number:	200-040-030050
Legal Description:	Lake Diann Shores, Lt. 5, Bk. 3
Walkout/1sFl Elev.:	970.75
Ground Elevation:	970.04
Basement:	No
Walkout:	No

Market Value

Buildings:	$ 6,000
Land:	$ 8,500
Total:	$14,500

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 12
Name: Larsen, William

Assessment Number: 200-040-030070

Legal Description: Lake Diann Shores, Lt. 7, Bk. 3

Walkout/1sFl Elev.: 968.66
Ground Elevation: 968.66

Basement: No
Walkout: No

Market Value

Buildings: $ 6,900
Land: $ 3,400
Total: $10,300

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 13
Name: Fitzsimmons, Ronald

Assessment Number: 200-040-030090

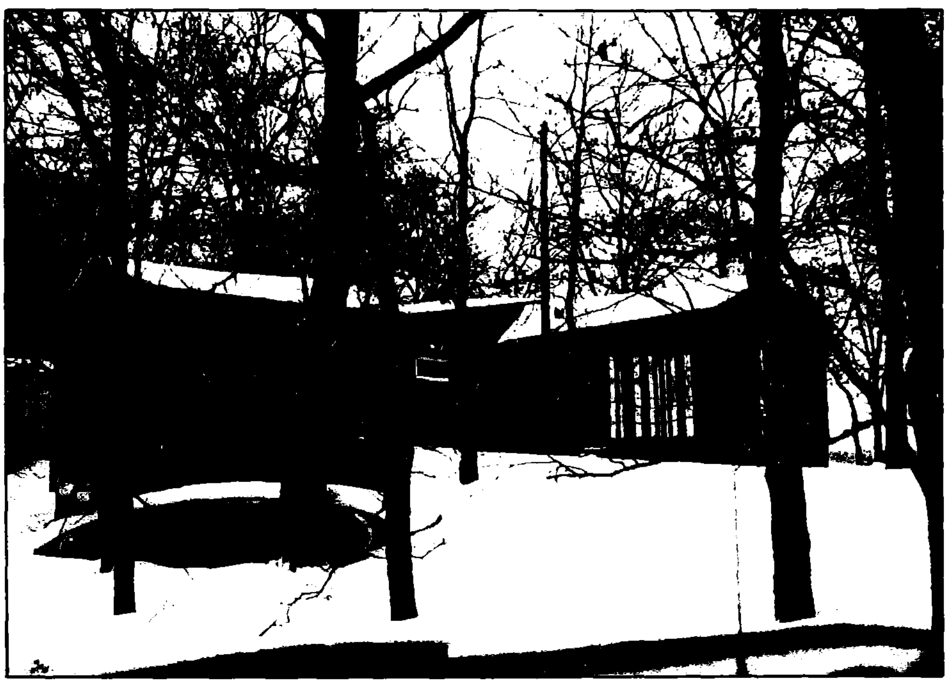
Legal Description: Lake Diann Shores, Lt. 8 & 9, Bk. 3

Walkout/1sFl Elev.: 969.72
Ground Elevation: 969.72

Basement: No
Walkout: No

Market Value

Buildings: $ 7,700
Land: $10,000
Total: $17,700

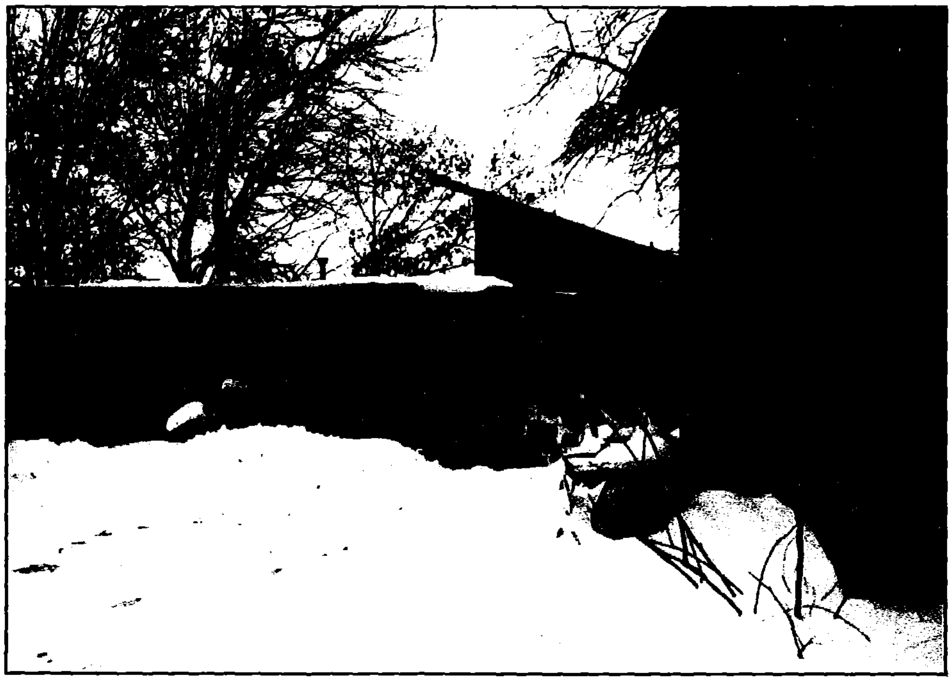


DIANN LAKE - SHERBURNE COUNTY

Structure Number:	14
Name:	Munson, Francis
Assessment Number:	200-040-030120
Legal Description:	Lake Diann Shores
Walkout/1sFl Elev.:	969.72
Ground Elevation:	969.72
Basement:	No
Walkout:	No

Market Value

Buildings:	$10,500
Land:	$ 6,300
Total:	$16,800



DIANN LAKE - SHERBURNE COUNTY

Structure Number:	15
Name:	Patten, Virgil
Assessment Number:	200-040-030130
Legal Description:	Lake Diann Shores
Walkout/1sFl Elev.:	972.49
Ground Elevation:	967.49
Basement:	Yes
Walkout:	No

Market Value

Buildings:	$28,400
Land:	$ 6,300
Total:	$34,700

DIANN LAKE - SHERBURNE COUNTY

Structure Number:	16
Name:	Cole, Darwin
Assessment Number:	200-040-010190
Legal Description:	Lake Diann Shores, Lt. 19, Bk. 1
Walkout/1sFl Elev.:	968.95
Ground Elevation:	968.95
Basement:	Yes
Walkout:	No

Market Value

Buildings:	$35,800
Land:	$13,900
Total:	$49,700

DIANN LAKE - SHERBURNE COUNTY

Structure Number: 17
Name: Smith, Bradley

Assessment Number: 200-060-030050

Legal Description: Forest Hills Addition, Lt. 5, Bk. 3

Walkout/1sFl Elev.: 968.95
Ground Elevation: 968.95

Basement: Yes
Walkout: No

Market Value

Buildings: $26,500
Land: $ 6,000
Total: $32,500

HELENE LAKE - SHERBURNE COUNTY

Structure Number:	18
Name:	Anderson, Laverne
Assessment Number:	200-060-010110
Legal Description:	Forest Hills Addition, Lt. 11, Bk. 1
Walkout/1sFl Elev.:	965.92
Ground Elevation:	965.92
Basement:	No
Walkout:	No

Market Value

Buildings:	$100
Land:	$500
Total:	$600

HELENE LAKE - SHERBURNE COUNTY

Structure Number:	19
Name:	Christopher, James
Assessment Number:	200-060-010060
Legal Description:	Lt. 6, Bk. 1
Walkout/1sFl Elev.:	967.37
Ground Elevation:	967.37
Basement:	Yes
Walkout:	No

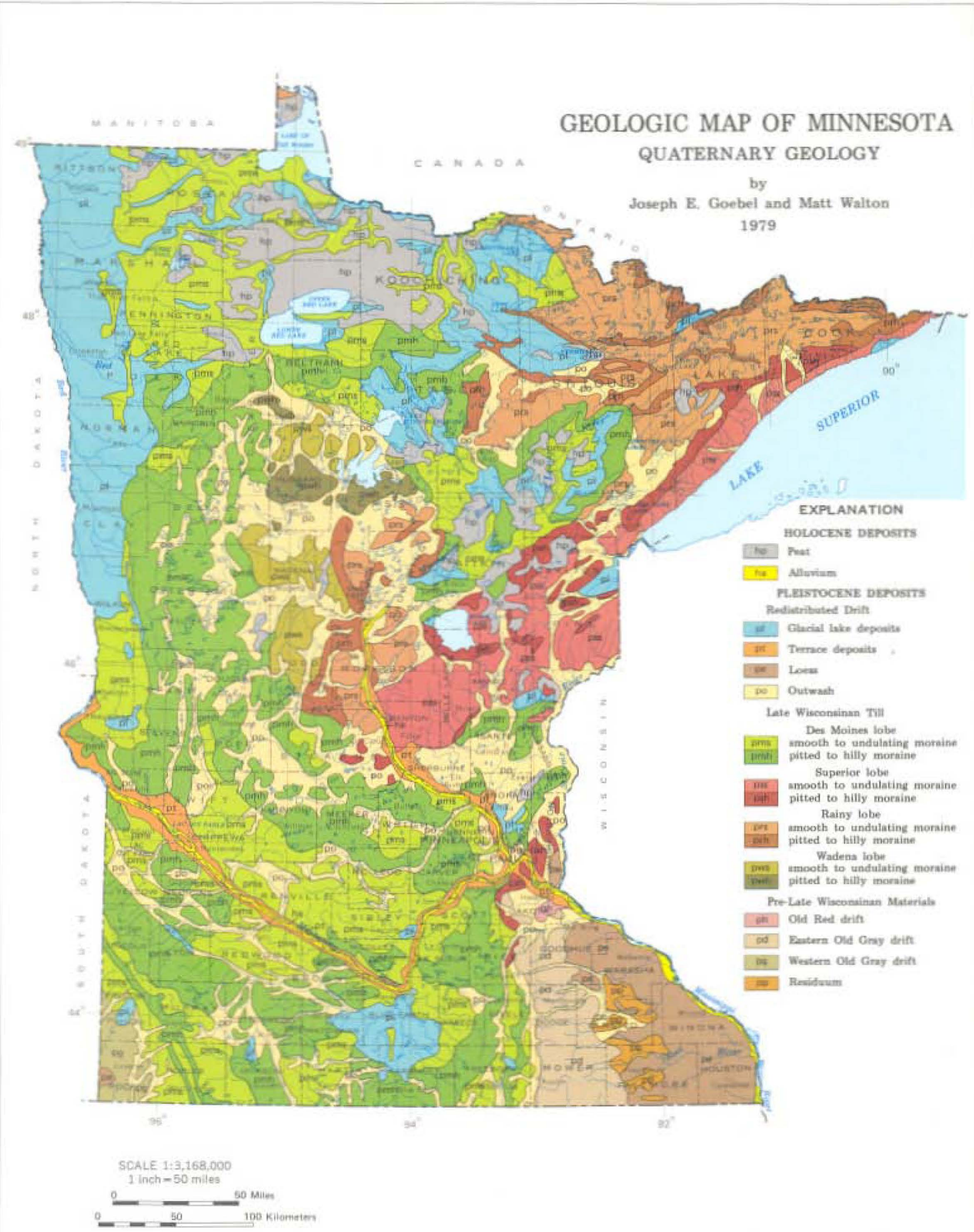
Market Value

Buildings:	$19,400
Land:	$ 4,200
Total:	$23,600

APPENDIX E

GEOLOGIC MAP OF MINNESOTA

Minnesota Geological Survey
University of Minnesota
Matt Walton, Director



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QUATERNARY GEOLOGY OF MINNESOTA

The Quaternary Period comprises the "Great Ice Age" or Pleistocene Epoch, which began about 2 million years ago and ended only about 10 thousand years ago. It also includes the Holocene or Recent Epoch, which spans the last 10 thousand years. By comparison with bedrock formations in Minnesota, which range from about 100 million to more than 3,500 million years in age, Quaternary formations represent only a very small part of the state's geologic history. However, glacial drift spread by Pleistocene ice sheets covers most of Minnesota and ranges to hundreds of feet in thickness, so that Quaternary geology is the major influence on topography, soils, water, and land uses–in short, the environment of Minnesota.

Quaternary geologic units are unconsolidated sedimentary materials deposited by water, wind and plant growth, and by glacial ice and meltwaters. This map portrays the distribution of Quaternary formations. Outcrops of bedrock, which are common only in the northeast and along larger river valleys in the south, are not shown on this map.

HOLOCENE DEPOSITS

hp PEAT—Accumulations of partially decayed vegetation, especially mosses, reeds and sedges, in wet, poorly-drained areas. Peat is valuable as an organic soil conditioner and chemical feedstock and as a potential energy resource. It is a very poor base for roads and other construction.

ha ALLUVIUM—Sand and gravel, locally interbedded with silt, clay and organic material, deposited on present floodplains. Sand and gravel deposits, copious shallow ground water and flat terrain make alluvial plains attractive for urban and industrial development, but they are flood-prone, and sensitive to pollution. They are valuable for agriculture and wildlife.

PLEISTOCENE DEPOSITS

There were four major ice advances in North America during the Pleistocene Epoch: the Nebraskan, Kansan, Illinoisan and Wisconsinan Glaciations. Each lasted tens of thousands of years and was followed by a warmer period when the ice melted. Each deposited sediments, called drift, over vast areas. Drift deposited during the last stage of the Wisconsinan Glaciation covers most of Minnesota and conceals evidence of older ice advances except in the southeast and southwest corners of the state.

Redistributed Drift

Some drift deposited by glaciers was quickly eroded, transported and redeposited by water and wind in lakes, on floodplains and on land beyond the margin of the ice.

pl GLACIAL LAKE DEPOSITS—Clay, silt and sand with local gravel bars and beaches deposited on the beds and margins of extensive lakes that existed when outlets for meltwater were blocked by ice or by glacial deposits which have now eroded away. Major glacial lakes were: Lake Agassiz in northwestern and north-central Minnesota, Lakes Upham and Aitkin northwest of Duluth, and Lake Minnesota south of Mankato. Due to the prevalence of fine silt and clay, glacial lake deposits present drainage and construction problems and tend to be poor ground-water sources. They form extensive areas of flat farmland, notably the Red River Valley.

pt TERRACE DEPOSITS—Stratified sand and gravel with some interbedded silt and clay occurring along stream valleys above the level of present floodplains. During glacial melting, stream-flow was larger than at present, and floodplains were built up by glacial sediments. Recent streams have cut into older floodplains leaving remnants as terraces. Terrace tops are commonly flat and well drained. They are attractive for residential and industrial development, but they also contain valuable sand and gravel resources.

pe LOESS—Eolian silt and fine sand blown from unvegetated drift exposed along major glacial streams. Loess is shown on the map for areas where it is commonly more than 2 meters (6.5 feet) thick. Excellent agricultural soils are formed in loess.

po OUTWASH—Sand, silt and gravel carried from glaciers by meltwater and spread over wide areas. The deposits are typically sorted into discontinuous and interfingering beds of silt, sand and gravel called stratified drift. Outwash plains have flat topography, sandy soils, and many gravel deposits. Shallow ground water is commonly abundant for irrigation.

Late Wisconsinan Drift Deposited Directly From Glaciers

The ice of each glaciation accumulated in northern Canada and moved southward in a complex series of tongue-like extrusions or lobes. Near the center of ice accumulation, the moving ice scoured the land surface down to hard bedrock and picked up a load of rock fragments and soil. Farther from the center the ice deposited this drift from its base. Areas of ice-scoured, exposed bedrock occur mainly in northeastern Minnesota; deposition predominated throughout the rest of the state. Drift deposited directly from ice is called till. In general, till is an unsorted mixture of all sizes of rock from boulders to clay and "rock flour." It tends to be stiff, stony and impervious. Till of different lobes differs in composition depending on the geology "upstream" along the path of the advancing ice.

Till deposited from the base of an ice lobe forms a smooth to undulating blanket called a ground moraine. Such till is stiff and compact; it yields little ground water.

Till deposited at ice margins or from stagnating masses of melting ice forms irregular pitted to hilly topography with many ponds and lakes. These landforms are called end moraines, recessional moraines and stagnation moraines. These deposits may contain pockets of sand, gravel and boulders with some local ground water.

pms / pmh DES MOINES LOBE TILL—Smooth to undulating moraine (pms) and pitted to hilly moraine (pmh). The Des Moines lobe is the most recent glacial lobe. It advanced through the Red River Valley into Iowa. Sublobes extended eastward into the St. Louis River basin and northeastward across Minneapolis and St. Paul, incorporating drift from earlier lobes. Des Moines lobe till is typically clay-rich. It is mainly composed of gray (olive-brown where oxidized) calcareous silt and clay, with lesser amounts of sand and gravel. Shale and limestone are diagnostic.

pss / psh SUPERIOR LOBE TILL—Smooth to undulating moraine (pss) and pitted to hilly moraine (psh). Ice of the Superior lobe moved out of the Lake Superior basin in several pulses, spreading westward across the Mille Lacs area and southward across the Minneapolis-St. Paul area. It interacted with the partly contemporaneous Rainy lobe along the Laurentian Divide. Superior lobe till is generally reddish-brown, sandy to stony, and non-calcareous; it contains abundant fragments of volcanic, granitic, gabbroic and metamorphic rocks, red sandstone and conglomerate. Where it incorporates earlier lake deposits, it is locally silty or clayey.

prs / prh RAINY LOBE TILL—Smooth to undulating moraine (prs) and pitted to hilly moraine (prh). The Rainy lobe moved southward into Minnesota along a broad front from Lake of the Woods almost to Lake Superior, where it met ice from the Lake Superior basin along the Laurentian divide and moved southwestward. It advanced to the vicinity of Little Falls overriding drift and perhaps encountering ice remaining from the earlier Wadena lobe. Part of the Rainy lobe drift area was later overridden by the St. Louis sublobe of the Des Moines lobe. Rainy lobe till is grayish brown (moderate brown where oxidized), non-calcareous and generally sandy with abundant fragments of granitic, metamorphic and greenstone volcanic rocks.

pws / pwh WADENA LOBE TILL—Smooth to undulating moraine (pws) and pitted to hilly moraine (pwh). The Wadena lobe was the earliest of the Late Wisconsinan glacial lobes. A large remnant of its till and outwash survives in northwest-central Minnesota in an area that was not overridden by any of the three later lobes. A large drumlin field indicates movement of ice from the north or a little east of north. Wadena lobe till is gray (yellowish brown where oxidized) and calcareous with fragments of igneous and metamorphic rocks, some limestone and little or no shale.

Pre-Late Wisconsinan Materials

At one time or another, prior to the Late Wisconsinan, all of Minnesota must have been covered by glaciers. Evidence is concealed beneath Late Wisconsinan drift except in the southwestern and southeastern corners of the state where there are deposits of weathered and stream-dissected drift that are older than Late Wisconsinan and could be Illinoisan or Kansan in age.

ph OLD RED DRIFT—Moderate to dusky-brown till and outwash found mainly in Dakota and southern Washington Counties. Fragments of gabbro, felsite and red sandstone are notable. Some exposures show a distinct weathered profile overlain by younger drift.

pd EASTERN OLD GRAY DRIFT—Moderate yellowish-brown weathered silty till and outwash. It contains fragments of igneous and metamorphic rocks, limestone and sandstone, but lacks shale. It appears to underlie Old Red Drift in southern Dakota County.

pg WESTERN OLD GRAY DRIFT—Dark-gray, strongly weathered, clayey, stream-dissected till and outwash with fragments of quartzite, granite and limestone.

pp RESIDUUM—Soils of uncertain age and origin, including some old weathered drift and loess, on weathered pre-Quaternary rocks.

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