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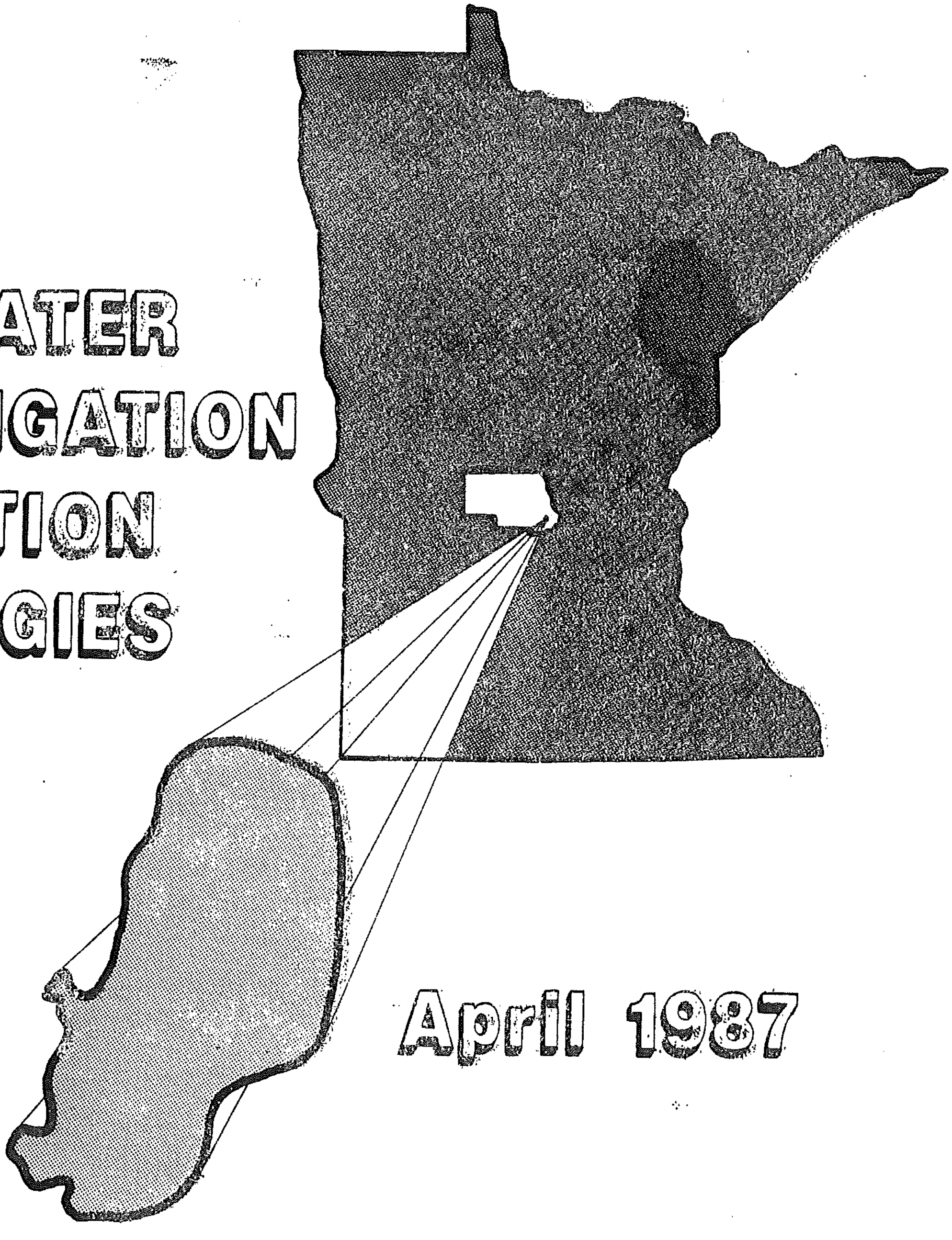
BEAVER LAKE

(Stearns County, 73-23)

HIGH WATER INVESTIGATION MITIGATION STRATEGIES



April 1987

Minnesota Department of Natural Resources
Division of Waters

HIGH WATER INVESTIGATION

AND

MITIGATION STRATEGIES

FOR

BEAVER LAKE

BASIN #73-23P

STEARNS 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 effects and mitigation strategies for high water problem basins. 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

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INTRODUCTION

Beaver Lake is located in southeastern Stearns County, Minnesota, approximately 60 miles northwest of the Twin Cities metropolitan area. The lake is about 7 miles southwest of the City of St. Cloud, and most of its area is within Section 6 of Township 122 North, Range 28 West (Plate 1).

Beaver Lake is one of over 50 landlocked lakes within glaciated terrain in Minnesota that are currently experiencing high-water level problems. These lakes 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.

Beaver Lake is situated in outwash sand and gravels within the St. Croix moraine complex. During the early 1980's, the lake level began to rise after heavy rainstorms, and by June 14, 1984, the lake water level was at elevation 1115.7' or 2.8' above the Ordinary High Water Level (OHW elevation 1112.9', NGVD, 1929)[1] which resulted in the flooding of several structures.

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 a high-water level problem lake. 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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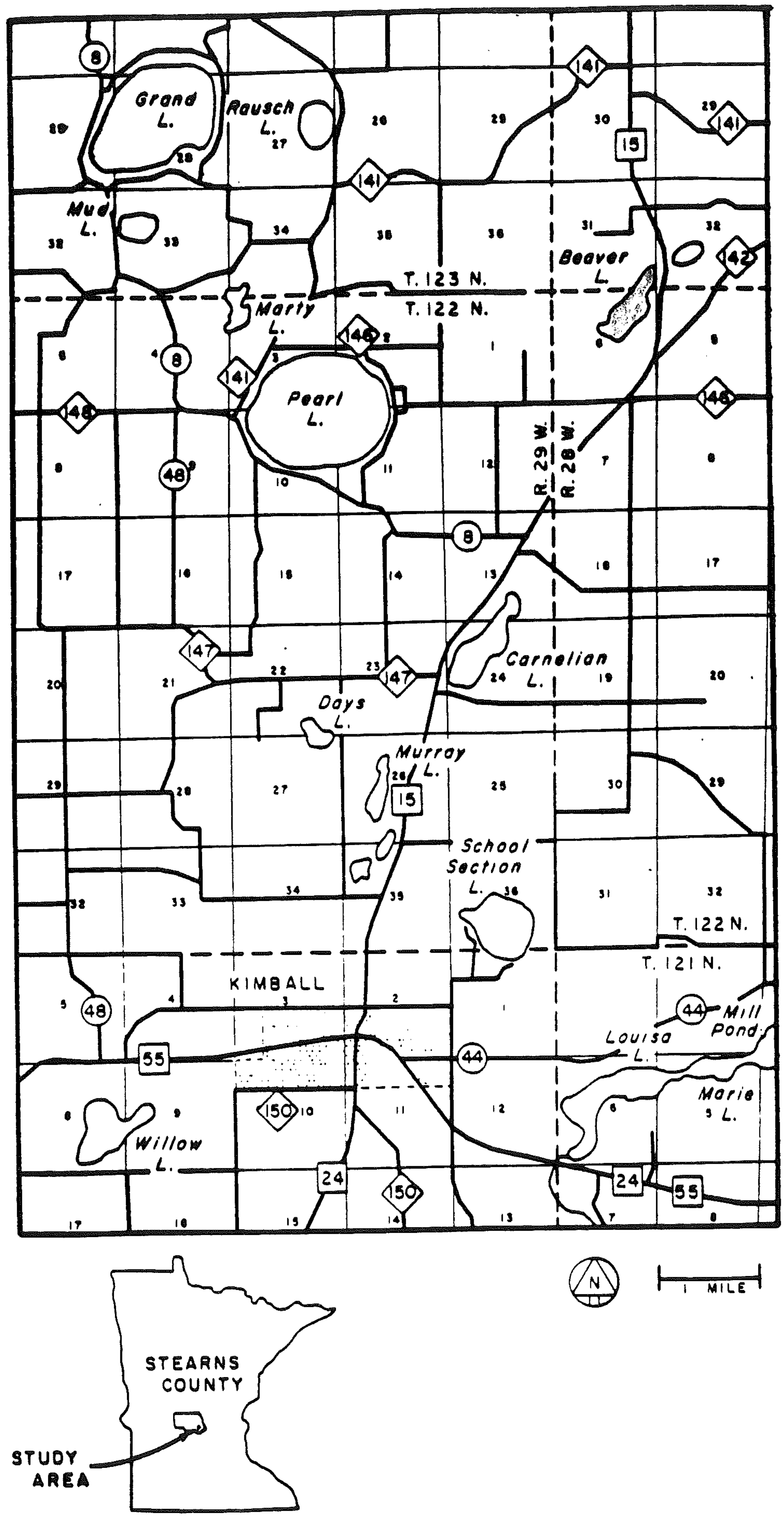
[1] National Geodedic Vertical Datum of 1929 is used for all elevations included in this report.


Grand L.
Rausch L.
Mud L.
Marty L.
Pearl L.
Beaver L.
Carnelian L.
Days L.
Murray L.
School Section L.
KIMBALL
Louisa L.
Mill Pond
Marie L.
Willow L.
T. 123 N.
T. 122 N.
T. 121 N.
R. 29 W.
R. 28 W.
STEARNS COUNTY
STUDY AREA
N
1 MILE

SUMMARY AND CONCLUSIONS/RECOMMENDATIONS

Water Level Data (See Part 1)

-In November of 1986 Beaver Lake was at elevation 1115.68, an elevation 2.78' above the lakes ordinary high water elevation of 1112.9'. Beaver Lake's water level reacts to both surface (above ground) runoff and ground water inflow.

-There is a correlation between the area's annual precipitation and Beaver Lake's water level. During the last 5-year period, there has been an excess of 30.38" 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 problem.

-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 lake were to rise to elevation 1121.6', 22 additional structures would be flooded with 1986 assessed market values totalling $607,550. At this elevation, it is estimated a minimum $506,660 of damage would occur.

-Methodologies do not exist which can predict what Beaver Lake's maximum elevation will be in the future. The major factor on limiting potential increases in lake levels would be if the lake should reach its natural runout elevation of 1119.7'.

-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 Beaver Lake will: 1) rise to elevation 1116.4' by December 1, 1987; or 2) rise to elevation 1116.2' by December 1, 1991. Conversely, there is a one-percent probability the lake will: 1) fall below elevation 1112.8' by December 1, 1987; or 2) fall below elevation 1110.3' by December 31, 1991. There is a 50% probability (a 50/50 chance) that Beaver Lake will be at elevation 1115.1' on December 1, 1987 and elevation 1114.2' in December of 1991.

Mitigation Strategies (See Part II)

-The flood protection standards for new development in Stearns County's current flood plain ordinance do not apply to the Beaver Lake shoreline because a flood delineation is not currently shown for the lake on the County's current flood plain zoning map. The County must properly regulate new development adjacent to the lake's shoreline. The County can 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 1118.7' (3' above the highest known water level). It is recommended that the County adopt a flood protection elevation of 1120'. This will insure that all new development is above Beaver Lake's natural runout elevation; and

2) A provision should be added which requires elevated road access to new construction to the minimum flood protection elevation established by the County (presently 1118.7' and recommend at 1120.0').

-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 area of Stearns County. A structure and/or its contents can be insured. Landowners or renters adjacent to Beaver Lake should explore purchasing flood insurance, especially those located below elevation 1120.0'.

-Landowners can take emergency measures to protect existing development. The safest method is either relocating a structure to natural ground above elevation 1120' or elevating a structure at its existing site on fill to a minimum recommended flood protection elevation of 1120'. Emergency protection measures, such as filling, sandbaggin, 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 Corp 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 Legislation. Local interests should explore these programs and the requirements for an acceptable local sponsor to submit the application.

-At the request of Stearns County, the Corps of Engineers is investigating the possibility of a federally cost-shared flood control project on Beaver Lake. The information in this report will be made available to the Corps of Engineers to assist in their study effort. Local interests should participate in this study effort to the degree possible. Should a federally cost-shared project be feasible, local interests must designate a "local project sponsor" acceptable to the Corps of Engineers.

-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 authorites 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

would affect the lake basin proper. The reader is encouraged to read the remainder of this report. The Department of Natural Resources will assist local interests in the degree possible in implementing future flood loss reduction measures.

PART 1

GEOLOGIC SETTING

Beaver Lake is located in medium to coarse outwash sands and gravels within the St. Croix moraine complex. To the northwest and southeast of the lake are areas where red till of the St. Croix moraine is exposed at the surface (Plate 2). The outwash is 80-100 feet thick near the lake, and thins to less than 20 feet in thickness near the areas of exposed till. The outwash is underlain by older gray till associated with the Wadena Lobe.

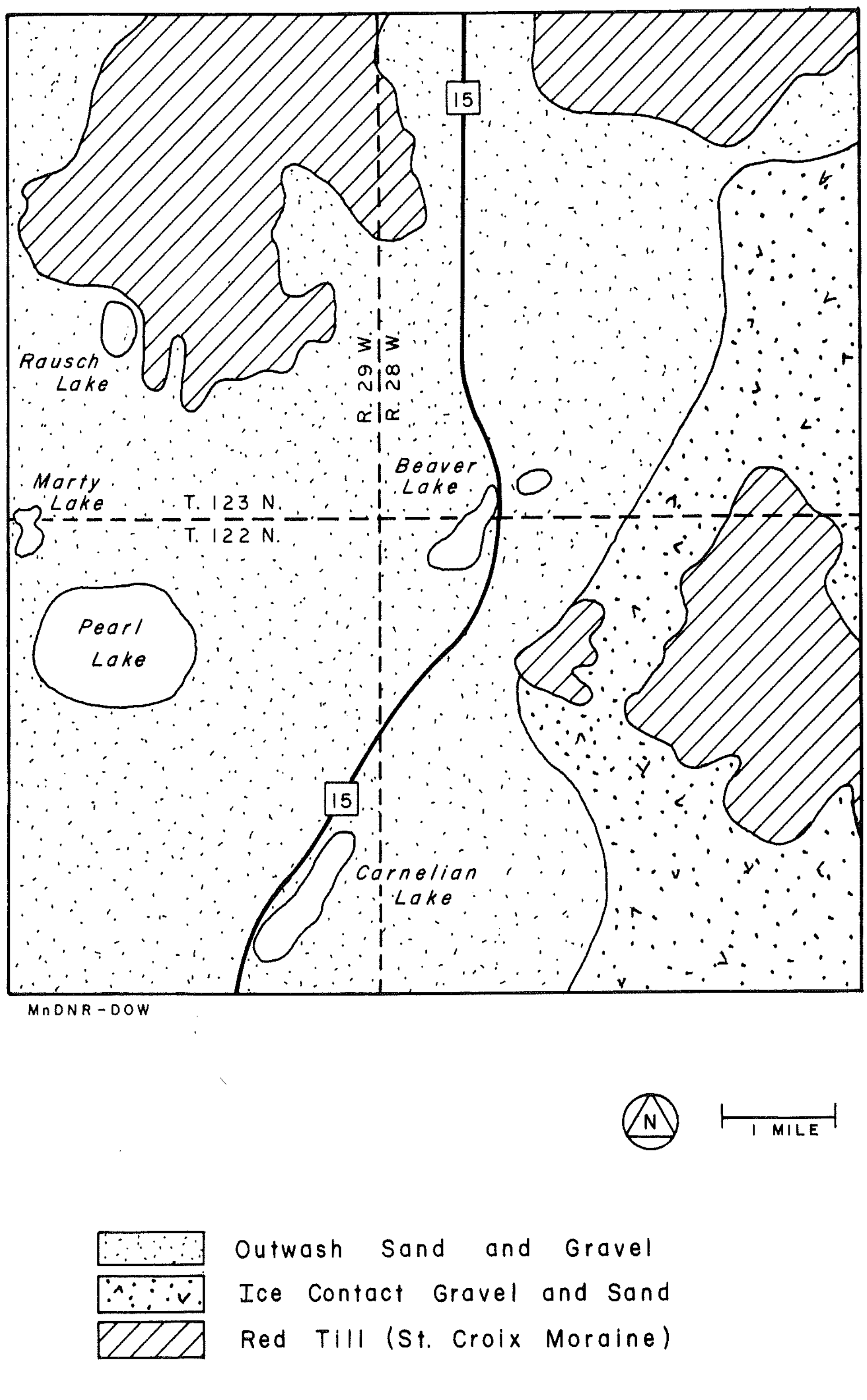
SOILS

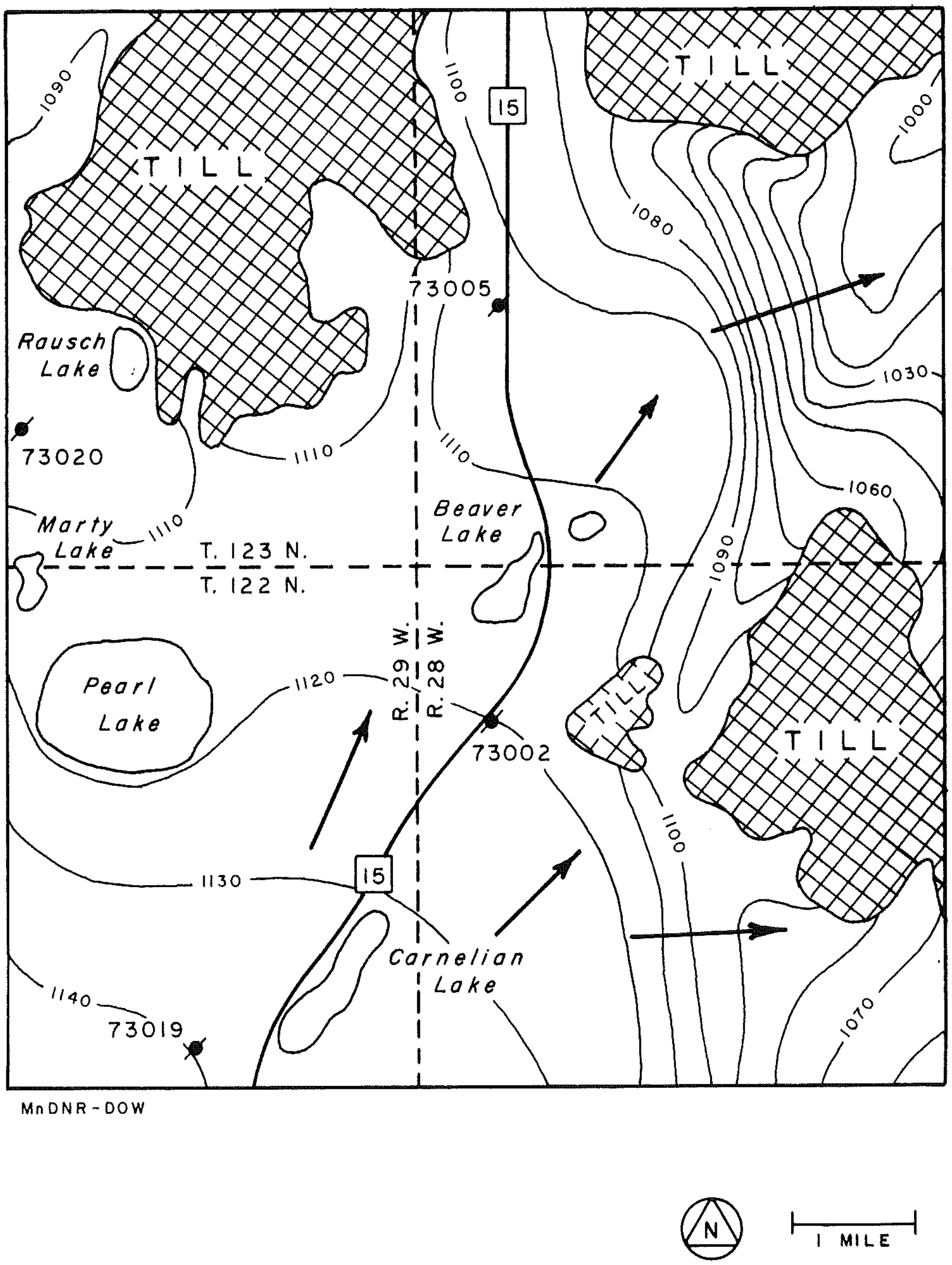
Soils in the area are developed over the sand and gravel parent material and contain varying proportions of silt and clay in the upper 1-4 feet. The soils typically contain loam, silt loam, clay loam, or sandy loam in the upper 1-4 feet underlain by coarse sand and gravel. Both organic and mineral wetland soils are present in the wetlands west of the lake. The lakeshore and lake bottom sediments are primarily sand (80%) with some muck (20%). A more detailed explanation of the soil types and characteristics is included in Appendix A.

HYDROGEOLOGIC SETTING

The local direction of ground water flow in the outwash is to the northeast towards the Mississippi River (Plate 3). The lake is hydrologically connected to the outwash aquifer, and is part of the ground water flow system. Fine-grained lake sediments will slow down the lake-ground water interaction somewhat, but the lake is still basically a reflection of the water table within the outwash aquifer. The water table gradient in the vicinity of the lake is approximately 0.001 based on observation well readings.

The lake is a ground water "flow-through" lake, with seepage to the lake on its southwest side, and seepage from the lake and from wetland No. 73-26W (northeast of Beaver Lake across Highway 15) to the northeast. A <u>rough</u> calculation of the amount of ground water flowing through the lake (under the wet Fall of 1986 conditions) using the above gradient, permeability derived from transmissivity maps by Lindholm (1980), and assuming a 25 feet depth of flow yields 15,000 cubic feet of water per day (112,200 gallons) or 0.3 cubic feet of water per second (cfs).


15
Rausch Lake
R. 29 W.
R. 28 W.
Marty Lake
T. 123 N.
T. 122 N.
Beaver Lake
Pearl Lake
15
Carnelian Lake
MnDNR-DOW
N
1 MILE
Outwash Sand and Gravel
Ice Contact Gravel and Sand
Red Till (St. Croix Moraine)



—1130— Water Table Elevation Contour, Summer 1984

73002 Observation Well (DNR Network)

General Ground Water Flow Direction

WATERSHED

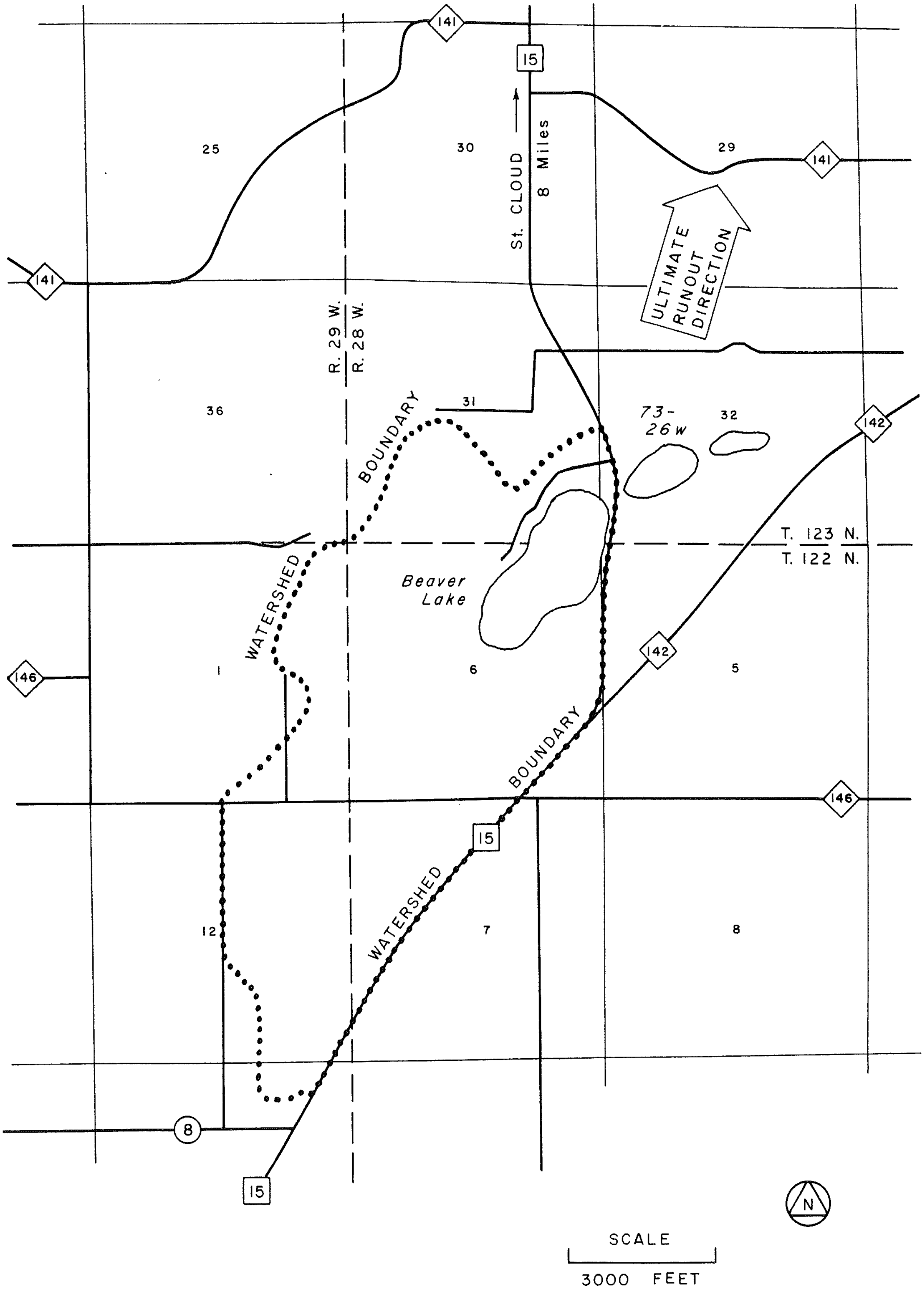
The total watershed area for Beaver Lake is approximately 1,386 acres (Plate 4). The watershed of 1,386 acres minus the lake water surface area of about 158 acres equals 1,228 acres or a total watershed area to lake area ratio of 8:1. However, a closer examination of the total watershed area reveals that there are about 580 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 648 acres, and therefore, the effective watershed to lake area ratio is about 4.1 to 1.

This effective watershed to lake area ratio of about 4.1 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 the area has been experiencing periods of above normal precipitation it is not surprising to see a rise in the lake's water level.

From the available data, it would appear that Beaver Lake has been experiencing above normal lake water levels due primarily to above normal precipitation which results in increased surface water runoff together with increased net groundwater flow into the lake.

Beaver Lake is considered to be land-locked because the Unnamed Wetland No. 73-26W it flows into has no active outlet. Beaver Lake outlets at the Beaver Lake Resort into a 24 inch concrete culvert under State Highway 15. The upstream invert of the culvert is 1114.72 feet and the downstream end is at 1113.97 feet. However, the driveway for the resort presently controls outflow at elevation 1115.33 feet or about 2.43 feet above the OHW. The water from this culvert drains into a small pond adjacent to the east side of Highway 15 and overflows northeast into Unnamed Wetland No. 73-26W, a 45 acre, type 5 wetland. The surface water elevation of this wetland in the fall of 1986 was approximately 3 feet below that of Beaver Lake. This wetland has no known outlet, although it appears that if the pond would rise to elevation 1119.7 feet it would outlet to the north and would eventually drain into either Luxemburg or Johnson Creeks (See Plate 4).

DEPARTMENT OF NATURAL RESOURCES DIVISION OF WATERS



WATER QUALITY

Water quality information on Beaver Lake is located in the files of the Minnesota Department of Natural Resources (lake surveys in 1939 and 1948) and the Minnesota Pollution Control Agency (1981 water quality survey). The lake's water quality is typical of the lakes in the area.

Beaver Lake can be described as a relatively clear, moderately nutrient rich, hardwater lake. A healthy variety of aquatic vegetation aids in the maintenance of adequate oxygen levels in all but the deeper layer (hypolimnion). The chemical and biological indicators of nutrient enrichment measured in 1981 have not changed from the 1939 and 1948 surveys, yet the Secchi disk depth improved from 6 feet in both 1939 and 1948 to 8.9 feet in 1981. Thus the transparency of Beaver Lake has improved in recent times, most likely due to the greater volume of higher quality water entering the lake.

FISH AND WILDLIFE

The Minnesota Department of Natural Resources' Fisheries Lake Survey Report taken from the (PIC) Planning and Information Center data base classifies Beaver Lake in ecological and management terms as Centrarchid (Bass/Panfish). The most common fish populations of the lake includes rock bass, largemouth bass, sunfish, crappies, yellow perch, northern pike, white sucker, golden shiner and black bullhead. The area fisheries manager reports that this type of lake is suitably manageable for large mouth bass, panfish and northern pike. The size and weight of many of the fish in Beaver Lake are below average, however, some fish of each of species are well above the average. The area fisheries manager reports that there is no known large spawning areas but natural reproduction does occur and accounts for the lake's fish population since no stocking has occurred in recent decades.

The Department of Natural Resources' files do not contain wildlife information pertaining to Beaver Lake . However, information supplied by the area wildlife manager indicates that Beaver Lake is a relatively shallow lake, with an extensive shallow bay on the south end. This shallow bay is a good wetland and brushland habitat for aquatic furbearing animals such as mink, muskrat, beaver, and raccoons. The lake is also used as a staging area for migrating waterfowl, and does have some waterfowl production present during the summer. There are also other non-game birds present such as terns, gulls, herons, egrets, red wing blackbirds, yellowheaded blackbirds, etc. The surrounding area of eastern Stearns, western Sherburne, and northeastern Wright counties have been known to provide habitat for Trumpeter Swans. Whether or not any Trumpeter Swans use Beaver Lake for nesting is not well known. The general area is also used by larger animals such as deer and fox, along with other game birds such as pheasant and grouse. Site specific information is not well known since there has not been a wildlife survey completed on Beaver Lake.

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

PRECIPITATION

The State Climatology Office reports that the average number of annual rain days for the St. Cloud area is 111. It actually rained 110 days in the St. Cloud area during 1986, which is normal. However, the area experienced more rain days in the higher 3 precipitation categories listed below which accounted for above normal total precipitation in 1986.

MEAN RAIN DAYS	MEAN PRECIPITATION CATEGORIES IN INCHES*	1986 ACTUAL RAIN DAYS
50	0.1 - 0.49	68
15	0.5 - 0.99	20
5	1.0 and above	7

*Trace amounts of precipitation less than .1" are not included.

St. Cloud Area

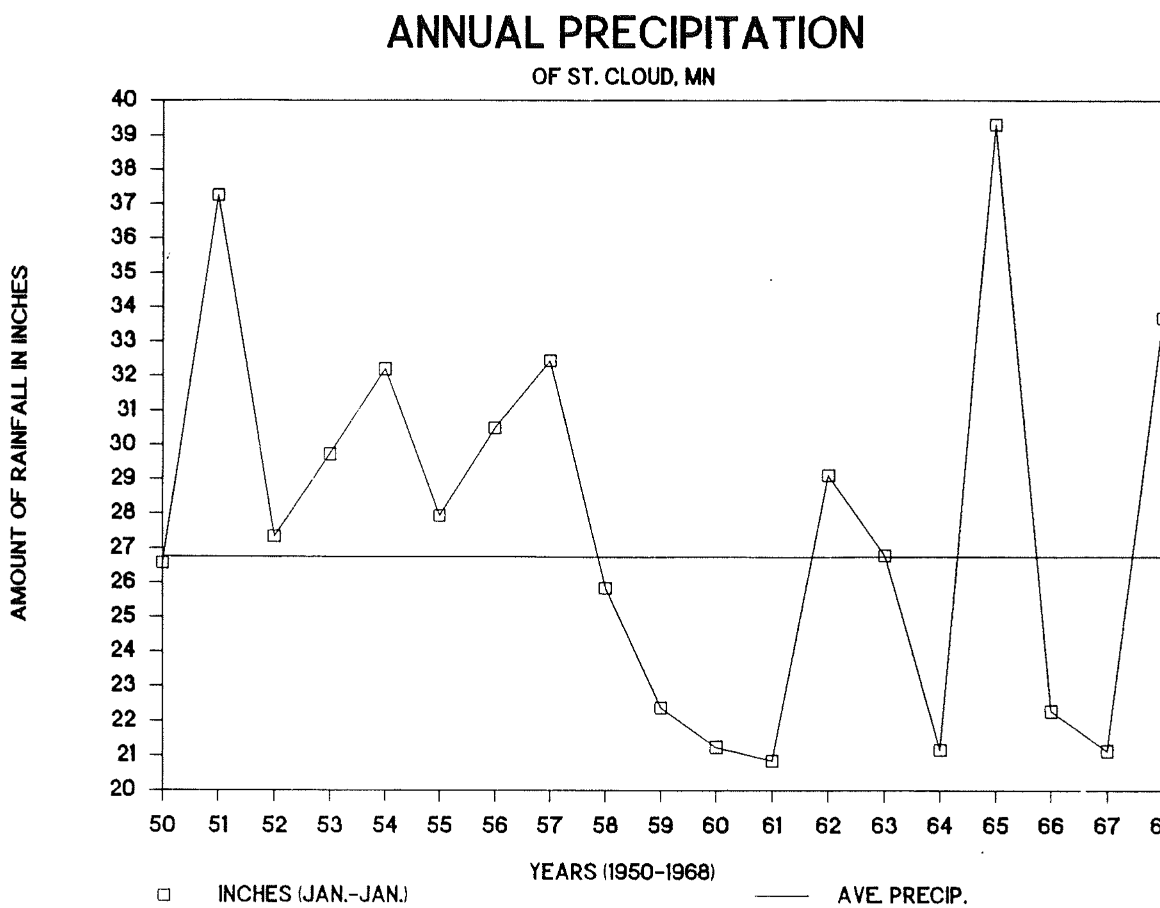
Long Range Normal Annual Precipitation Average (1893-1986) = 26.84"

Normal Annual Precipitation (current trends) 1951-1980 = 27.72" (Plates 5 and 6)

Actual Annual Precipitation:

1982-1986		1977-1986	
1982 = 30.46"		1977 = 35.59"	
1983 = 36.18"		1978 = 27.91"	
1984 = 33.20"		1979 = 31.18"	
1985 = 34.41"		1980 = 26.34"	
1986 = 34.73"		1981 = 23.00"	
		1982 = 30.46"	
5-year period, yearly average precipitation	= 33.79"/yr.	1983 = 36.18"	
		1984 = 33.20"	
		1985 = 34.41"	
		1986 = 34.73"	
Excess above normal precipitation for 5 year period	= 30.38"	10-year period, yearly average precipitation	= 31.30"/yr.
		Excess above normal precipitation for 10-year period	= 35.80"

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


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
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23
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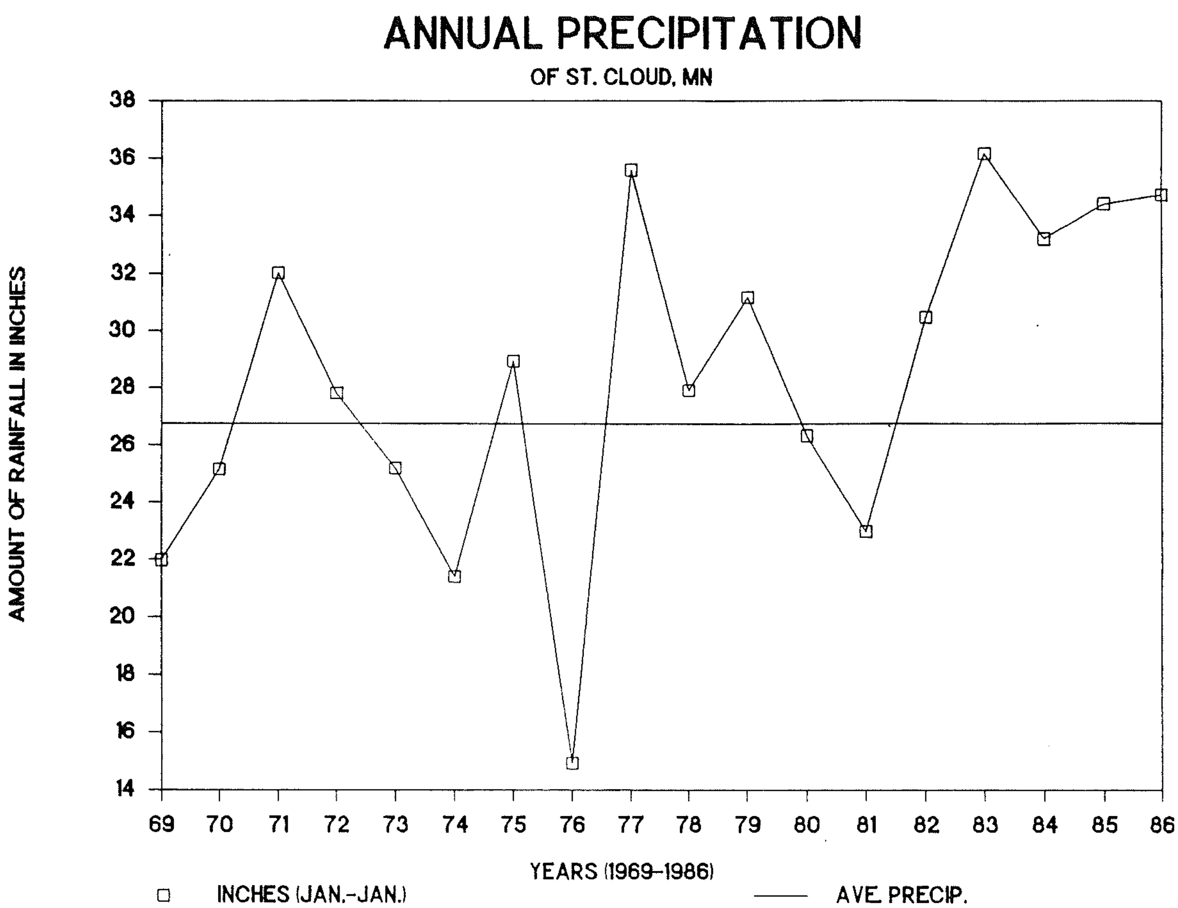
50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68
YEARS (1950-1968)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
38
36
34
32
30
28
26
24
22
20
18
16
14
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS (1969-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.

WATER LEVEL HISTORY

The Department of Natural Resources' Beaver Lake file contains seventeen fairly reliable surface water elevations dated from July 8, 1948 through November 14, 1986 (see Chart 1 and Table 1 below). 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, the area received an additional 30.38 inches of precipitation over the normal annual precipitation of 27.72 inches. The water level of the lake (1115.68') in November, 1986 is about 2.78' above the lake's Natural Ordinary High Water Mark (1112.9') 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 7 and 8). These long-term precipitation variations could continue into the future and Beaver Lake's water surface elevation will respond accordingly. Because above normal periods of precipitation of longer duration than the current period have occurred in the past, the current period may continue for several more years resulting in continued increasing lake levels.

Chart 1

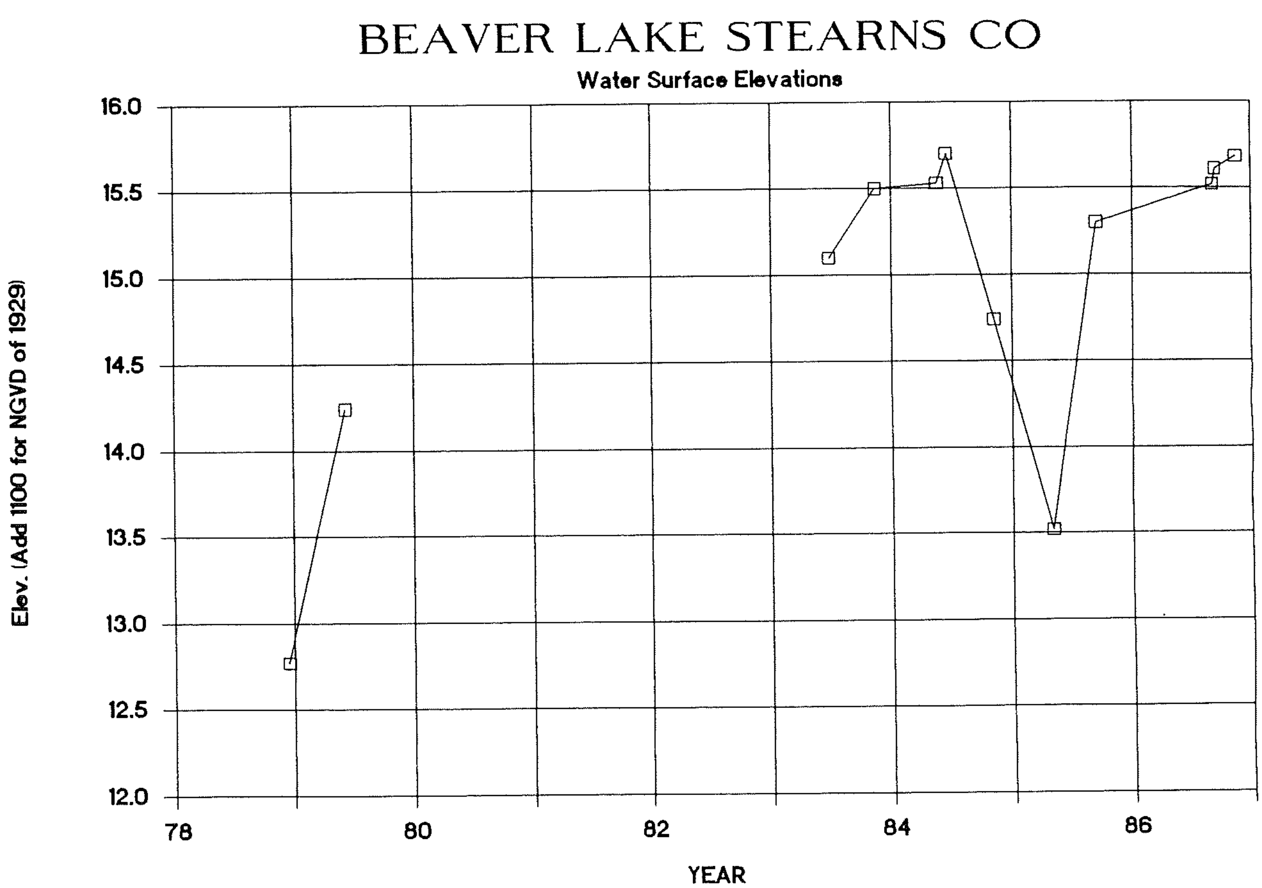
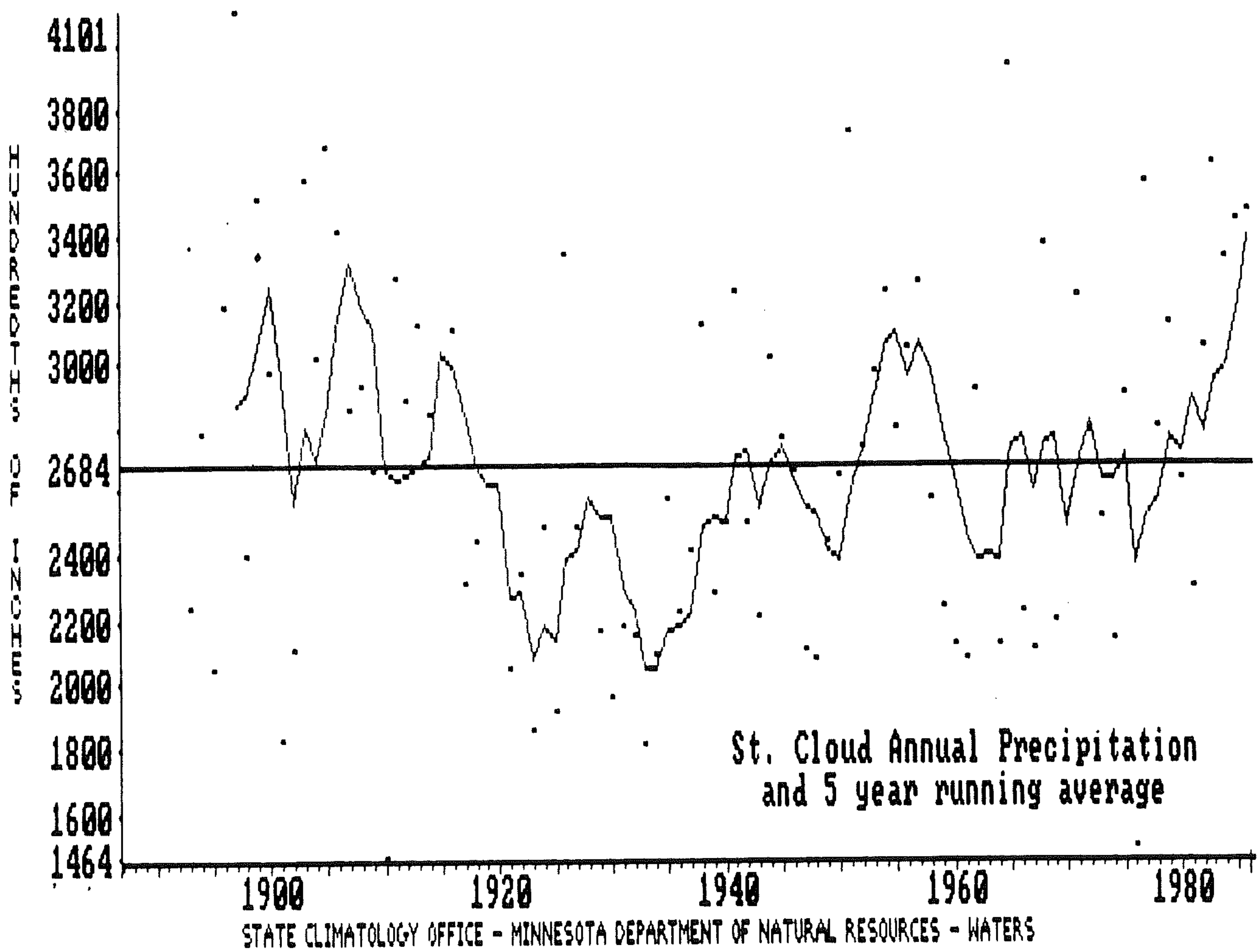


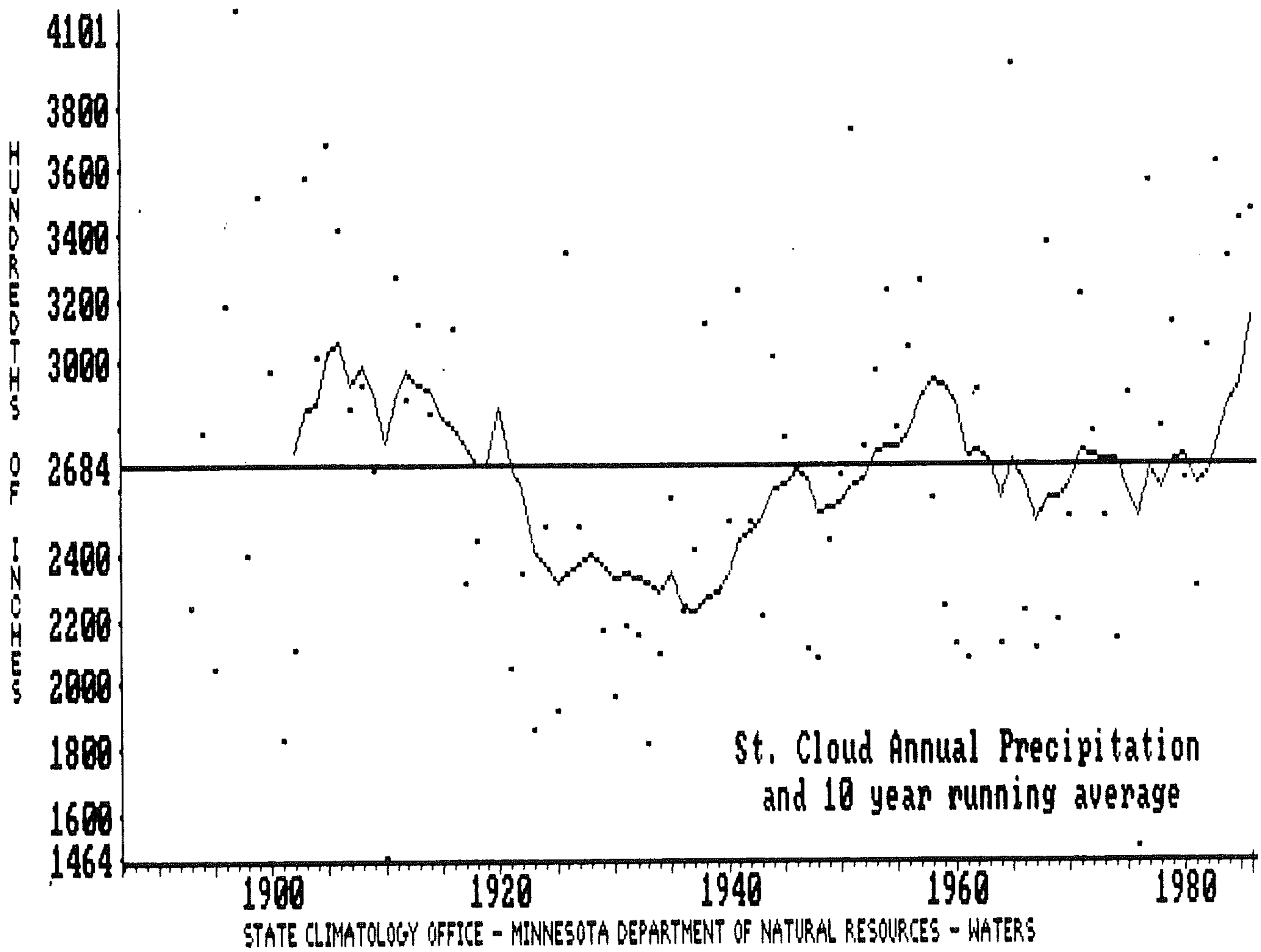
Table 1

WATER LEVEL HISTORY

Date	Water Level	Source
7/8/48	1110.7	Sounding Map
8/19/57	1112.4	Sounding Map
[1] 1965-1968	1113.7	Beaver Lake Resort Owner
[1] 1972	1113.9	Beaver Lake Resort Owner
1974	1114.0	USGS Quadrangle Map
12/13/78	1112.77	DOW Field Survey
6/5/79	1114.24	DOW Field Survey
6/23/83	1115.1	Measured by Area Hydrologist
11/10/83	1115.5	Measured by Area Hydrologist
5/17/84	1115.53	Measured by Area Hydrologist
6/14/84	1115.7	Measured by Area Hydrologist
11/6/84	1114.74	DOW Field Survey
March 1985	1113.52	Measured by Area Hydrologist
9/12/85	1115.30	Measured by Area Hydrologist
9/3/86	1115.52	DOW Field Survey
9/10/86	1115.61	DOW Field Survey
11/14/86	1115.68	Measured by Area Hydrologist

[1] Estimated peak level for this period.


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 5 year running average
STATE CLIMATOLOGY OFFICE - MINNESOTA DEPARTMENT OF NATURAL RESOURCES - WATERS


HUNDREDTHS OF INCHES
4101
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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 level (OHW)[2] for Beaver Lake has 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 20, 1978 and September 10, 1986, and the subsequent analysis indicated the OHW to be at elevation 1112.9.

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 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

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[2] According to Minnesota Statute 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.

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 governmental 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 the lake will go up or down. What we have seen so far is that Beaver Lake responds closely to precipitation. Precipitation patterns historically have fluctuated significantly in this area and have recently been in a very wet long term cycle. No one can predict with certainty whether this will continue.

The probability of different scenarios of future water level conditions can be estimated from historical precipitation data and groundwater 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 level. 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 storage routes them through the lake using the previous months lake level 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 groundwater 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 Beaver Lake, the WATBUD model was calibrated for the period April 1985 through December, 1986 using monthly precipitation from St. Cloud and pan evaporation data from Becker. The initial lake level of 1115.7' recorded November 14, 1986 was used with monthly time series precipitation data from the 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 the lake level would be above elevation 1116.4' on December 1, 1987 and a one-percent probability the lake will exceed elevation 1116.2' on December 31, 1991. These elevations are still many feet below the run-out. Conversely, probabilities exist which state the liklihood the lake elevation may fall. There is a one-percent probability the lake may fall below elevation 1112.8' by December 1, 1987 and a one-percent probability the lake may fall below elevation 1110.3' by December 31, 1991. The modeling results also suggest a 50-percent probability (a 50/50 chance) that the lake will be at elevation 1115.1' on December 1, 1987 and 1114.2' 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 and are not cyclical. 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 increases was also computed for the 24 hour and 10 day, 100-year duration storm events. Assuming the same initial condition lake elevation of 1115.7', the 100-year, 24 hour duration event of 5.7 inches of precipitation would result in a lake level increase of 1.6 feet to elevation 1117.3' and the 100-year, 10 day runoff of 7.2 inches would result in a lake level increase of 2.8 feet to elevation 1118.5'.

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 Beaver Lake. These base data were collected in September of 1986, when the lake was at elevation 1115.61'. While the potential maximum elevation of Beaver Lake is unknown, it was felt surveying structures within an approximate 5-6' vertical elevation above elevation 1115.61' 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 are in Mean Sea Level Datum, 1929 Adjustment, and were determined from instrument surveys. Plate 9 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
N 1/2, Sec. 24., Twp. 122, R. 29
Lot 2

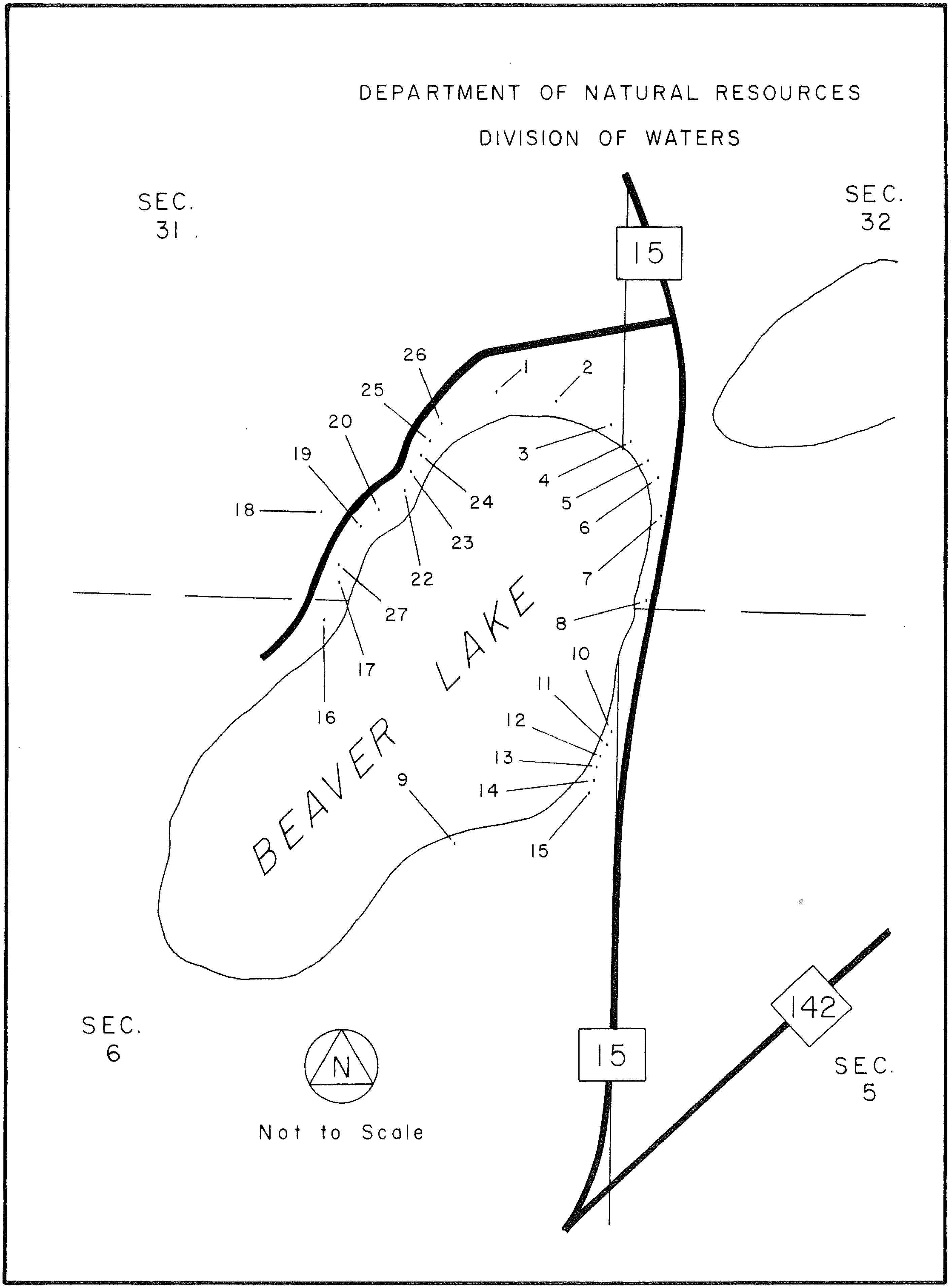
Floor Elevation : 1135.41
Ground Elevation : 1130.12

Basement : Yes
Walkout : Yes

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

Total Value : $40,500.00

STRUCTURE PHOTO PROVIDED


DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS
SEC. 31
SEC. 32
SEC. 6
SEC. 5
15
15
142
BEAVER LAKE
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2
3
4
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N
Not to Scale

Potential structural losses for Beaver Lake 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 1115.62' and 1121.61' would be $607,550.

> 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 1121.61', an estimated $506,660 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 reference should be given to the discussion on anticipated future lake levels on pages 19 and 20 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 31-34 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
Structures below elevation 1115.61 presently flooded[1]	7A	$ 500	1112.80+/-	N/A	N/A				
	7	1,000	1114.14	N/A	N/A				
	13[5]	40,200	1122.46	1115.26	N/A				
	2	300	1115.30	N/A	N/A				
	12	13,000	1122.59	1115.59	N/A				
New damages between elevations 1115.62 and 1116.61	26	33,800	1122.75	1115.75	N/A				
	6	11,300	1118.21	N/A	1116.30	$ 89,700	$ 47,765	$ 89,700	$ 47,765
	9	700	1116.46	N/A	N/A				
	25	44,600	1123.57	1116.57	N/A				
New damages between elevations 1116.62 and 1117.61	24	43,500	1123.75	1116.75	N/A				
	13A	4,600	1120.23	N/A	1117.0				
	8	100	1117.13	N/A	N/A	$149,050	$ 84,345	$238,750	$132,110
	20	50,500	1124.22	1117.22	N/A				
	1	11,550	1117.24	N/A	N/A				
	5	38.900	1119.78	N/A	1117.60				
New damages between elevations 1117.62 and 1118.61	23	43,500	1124.78	1117.78	N/A				
	19	38,300	1120.41	N/A	1117.8				
	3	39,200	1124.81	1117.81	N/A				
	10	38,200	1125.22	1118.22	N/A	$272,200	$119,440	$510,950	$251,550
	22	45,900	1125.30	1118.30	N/A				
	11	8,900	1125.56	1118.56	N/A				
	16	38,900	1120.20	N/A	1118.6				
	14	19,300	1124.54	N/A	1118.6				
New damages between elevations 1118.62 and 1119.61	4	9,300	1120.18	N/A	1118.8	$ 9,300	$ 98,960	$520,250	$350,510
New damages between elevations 1119.62 and 1120.61	27	4,400	1120.54	N/A	N/A	$ 4,400	$101,900	$524,650	$452.410
New damages between elevations 1120.62 and 1121.61	17	38,200	1125.40	N/A	1121.4	$ 82,900	$ 54,250	$607,550	$506,660
	18	44,700	1121.58	N/A	N/A				

[1] Beaver Lake's water surface elevation was 1115.61' in September of 1986, which was the time the structure elevation data were collected.
[2] 1986 assessed market value supplied by County Assessor.
[3] With the exception of #13, the main floor elevation of all other structures 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 amin 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 1121.61'. The first structure where this would occur is #13 at elevation 1122.46'. 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, catastropic 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 Beaver Lake can purchase flood insurance through Stearns County's eligibility in the National Flood Insurance Program (NFIP). Actually, all property owners and renters in the unincorporated areas of Stearns County can purchase flood insurance regardless of whether or not the property is located in an identified flood hazard area. This latter point must be stressed because a review of Stearns County's Flood Insurance Rate Map indicates a flood hazard delineation has not been provided for Beaver Lake. The significance of a lack of a flood hazard delineation will be discussed in greater detail on Pages 29-31 for the discussion on local government land use regulations.

Obviously, the decision to purchase flood insurance will 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;
- temoval of a flood damaged structure from a site;
- a "loss in progress" (5-day waiting period); and
- special loss adjustment for continuous lake flooding.

Table 3 identifies the amount of flood insurance coverage available via the NFIP. Stearns 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 Beaver 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 Beaver Lake.

It must be pointed out that a flood insurance policy only covers a structure and its contents. 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 19 and 20 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 Beaver Lake. If the lake should continue to rise, a dampening effect would occur as the lake reaches its runout elevation at elevation 1119.7'. If the cause is the lake reacting only to long-term, above normal precipitation, then the assumption would be as the lake rises 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 Beaver Lake 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 1115.7' Beaver Lake would bounce 1.6' upward during a 100-year, 24 hour rainfall event and 2.8' upward to elevation 1118.5' for a 100-year, 10-day rainfall event. Landowners should refer to Appendix D which provides actual lowest floor elevations for adjacent shoreland development. It is the author's recommendation that, at a minimum, any landowner with a structure below elevation 1120' (slightly above runout elevation 1119.7') should purchase flood insurance.

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 of the number of structures with "walkout" basements adjacent to Beaver Lake. 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. Stearns 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 Stearns County does not show a flood delineation (i.e., Zone A) for Beaver Lake. This means that: 1) technically, Stearns County does not now have to apply the provisions of its flood plain ordinance to new development bordering Beaver Lake; 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 Beaver Lake.

The obvious question is what prudent course of action should Stearns County take when regulating new development adjacent to Beaver Lake? Stearns 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 can specify a flood protection elevation. In the absence of a 100-year flood level, all new structures and additions/modifications/ substantial repairs of existing construction must be elevated with the lowest floor (including basement) to 3' above the highest known water level. On Beaver Lake, this is elevation 1115.7' + 3' or 1118.7', 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 1118.7'; 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 above elevation 1118.7'.

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 mandatory 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 Beaver Lake?

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 Beaver Lake with the adoption of two additional provisions: 1) an elevated road access requirement; and 2) a flood protection elevation above 1118.7' which provides additional freeboard or safety factor. These issues will be discussed below.

The rationale for using 1118.7' 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 1118.7' under its current shoreland regulations is a proper long-term strategy for regulating new development.

The County must look to the long-term because the economic life of new residential construction can be on the order of 60-80 years. With the documented cyclical nature of water levels and precipitation in this area, what might the maximum water level be in the next 60-80 year period? The answer to this question is unknown. What is known is that if new development is built to elevation 1118.7' (which is still below the lake's runout), and this level is exceeded during the life of the development, the ramifications will be severe. Considering the above, a proper course of action for the County would be to provide additional freeboard (or safety factor) above elevation 1118.7'.

It is the Department's recommendation that the County use a minimum elevation of 1120.0' for regulating new development adjacent to Beaver Lake. The previous section on Anticipated Water Levels indicates that Beaver Lake would bounce 2.8' upward to elevation 1118.5' assuming a 10-day, 100-year rainfall event and a starting water surface elevation of 1115.7' (September 1986 conditions). Elevation 1118.5' exceeds the 1-year and 5-year, 1-percent high water probabilities established using the DNR's in-house water budget model for longer term events. Elevation 1118.5' is still below Beaver Lake's natural runout elevation of 1119.7' so caution must be maintained. Because there is no physical condition which would prevent Beaver Lake from rising above 1115.7' immediately prior to a 100-year, 10-day rainfall event, additional freeboard or safety factor is warranted. The Department of Natural Resources recommends a minimum flood protection/lowest floor elevation of 1120.0' or an elevation slightly above the natural runout. Considering the significant damages that would occur if a structure is subjected to long-term inundation, this additional 1.3' of freeboard above elevation 1118.7' is warranted.

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.

The DNR makes the following recommendations:

1) At a minimum, the County must use elevation 1118.7' as a flood protection elevation when regulating new developments/subdivisions within the shoreland district of Beaver Lake. The County should add a provision to its shoreland ordinance requiring elevated road access to all new development/subdivisions at an elevation no lower than elevation 1118.7' on Beaver Lake;

2) The DNR urges the county to consider adopting a flood protection elevation of a minimum of 1120.0' into its shoreland regulations (instead of 1118.7') for regulating new development/subdivisions in the shoreland district of Beaver Lake.

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 1118.7'. The Department of Natural Resources strongly encourages a local flood protection level for Beaver Lake of 1120.0' at a minimum.

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 10 and 11 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 1118.7' (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 10 and 11 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 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.

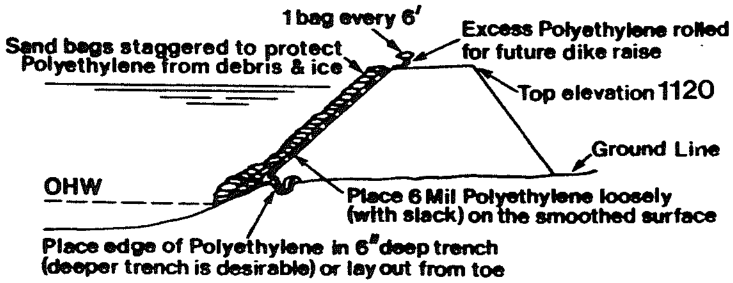
PL TE 10
FLOOD PROTECTION MEASURES

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

GENERAL DESIGN CONSIDERATIONS

EARTHEN LEVEE



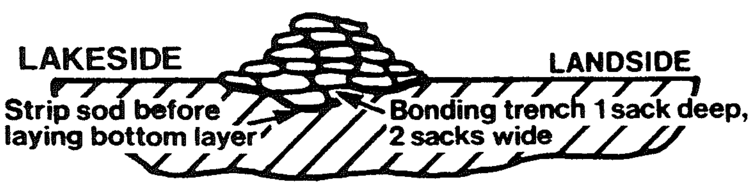
SECTION

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

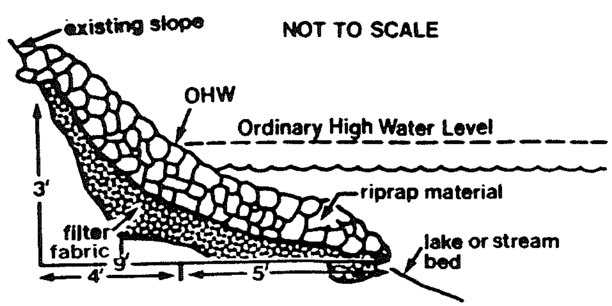


SECTION

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



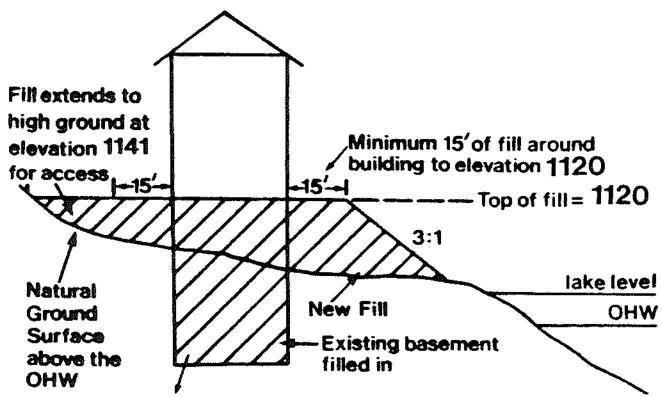
- Natural rock riprap 12" in diameter or larger
- Finished side slope no steeper than 3:1 (3' horizontal to 1' vertical)
- A transitional layer of filter fabric is required to be placed between the slope or embankment material and the riprap.

PLATE 11

FLOOD PROTECTION MEASURES

TYPE OF PROTECTION

ELEVATED STRUCTURE (PERMANENT)



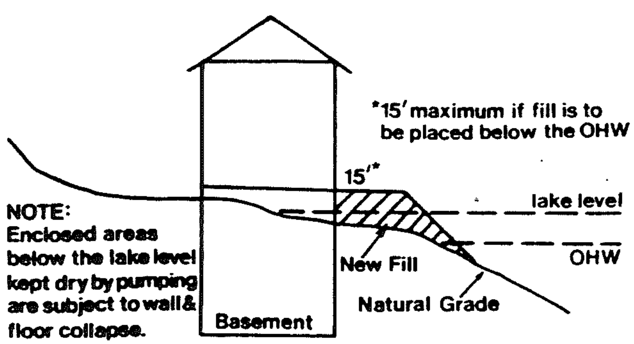
NOTE: Enclosed areas below the lake level intentionally kept dry by pumping are subject to wall and floor collapse.

GENERAL DESIGN CONSIDERATIONS

- Stabilized fill elevation underneath and 15' around the structure is at elevation 1120 at a minimum.
- 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

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



- The top of fill elevation should be elevation 1120
- 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.

RESOURCE MANAGEMENT -
THE DIRECT ROLE OF THE STATE

The preceeding 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 Beaver Lake. 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. Beaver Lake has been identified as a public water (Basin 23P) in the Protected Waters Inventory for Stearns County and, thus, falls 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 1112.9', the Ordinary High Water Elevation (OHW) for Beaver 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 below the OHW to protect a structure; or

- Placement of any shoreline protection measure which does not 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.
    (Minnesota Statutes Sections 105.41 and/or 105.42).

A DNR permit would be required: 1) to lower the lake below 1112.9'; or 2) to control the lake at an elevation above 1112.9', when:

1) Water is pumped 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 Beaver Lake 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 Beaver Lake. The Department's experience in similar flooding situations indicates that implementation of mitigation strategies is most successful when a local unit of government (i.e., 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. At the request of Stearns County, the Corps of Engineers has conducted a small projects initial appraisal investigation for flood control on Beaver Lake. This cursory analysis of the flood problem found that potential damages warrant further analysis by the federal government. In July of 1987 the Corps of Engineers received funding to perform a more in-depth evaluation of the flooding problem, potential solutions and the cost and benefits of alternate approaches to reduce potential damages. The Corps of Engineers has estimated this further evaluation will be completed probably by spring or early summer of 1988.

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 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 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 Leigslative 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. The DNR will provide cities and counties with information regarding eligibility and the application process sometime around August 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 land-locked 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 land-locked 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 <u>at the time of loss</u> are eligible for the program. As mentioned, the program is <u>competitive</u> 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
300 South Wacker Drive, 24th Floor
Chicago, Illinois 60606
ATTN: Flood Hazard Mitigation Officer

IMPLEMENTATION AUTHORITIES

The immediately preceeding 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 Stearns 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. The County Board at one time considered the formation of a LID, but the proposal was turned down.

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

<u>Watershed Districts</u>

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 Water Resources Board. 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 Water Resources Board
500 Lafayette Road
St. Paul, MN 55101
Phone: (612) 296-2840

Alstad Series

The Alstad series consists of deep, somewhat poorly drained, moderately permeable soils on ground and end moraines. The soils formed in noncalcareous, loamy glacial till. Slopes range from 1 to 4 percent.

Alstad soils are similar to Brainerd soils and adjacent on the landscape to Cushing, Nokay, and Prebish soils. Unlike Alstad soils, Brainerd soils do not have an argillic B horizon; they have fragic characteristics in the lower B and C horizons. Cushing soils are in more sloping areas. Nokay and Prebish soils are in depressions and drainageways.

Biscay Series

The Biscay series consists of deep, poorly drained soils on outwash plains and stream terraces. Permeability is moderate in the upper part and rapid in the lower part. The soils formed in loamy material overlying calcareous sandy outwash. Slopes range from 0 to 2 percent.

Biscay soils are similar to Mayer and Regal soils and are adjacent on the landscape to Estherville, Mayer, and Osakis soils. Mayer soils have fee carbonates in the upper part and are in positions on the landscape similar to those of Biscay soils. Regal soils have an upper loam mantle that is less than 20 inches thick. Osakis and Estherville soils are in higher positions on the landscape.

Cushing Series

The Cushing series consists of deep, well drained, moderately slowly permeable soils on ground and end moraines. The soils formed in noncalcareous, loamy glacial till. Slopes range from 2 to 40 percent.

Cushing soils are adjacent to Alstad, DeMontreville, Nokay, Prebish, and Jewett soils. DeMontreville and Jewett soils are in positions on the landscape similar to those of Cushing soils. Alstad soils are in less sloping areas. Prebish and Nokay soils are in depressions and drainageways.

Cylinder Series

The Cylinder series consists of deep, somewhat poorly drained soils. Permeability is moderate in the upper part and very rapid in the underlying material. The soils are on outwash plains and on stream terraces. They formed in glacial outwash consisting of a loamy mantle underlain by sandy material. Slopes range from 0 to 2 percent.

Cylinder soils commonly are adjacent to Biscay, Dakota, Estherville, and Fairhaven soils. Biscay soils are lower on the landscape than Cylinder soils, and Dakota, Fairhaven, Estherville soils are higher.

Dakota Series

The Dakota series consists of deep, well drained soils. Permeability is moderate in the upper part and rapid in the lower part. The soils are on outwash plains, stream terraces, and valley trains. They formed in glacial outwash consisting of a loamy mantle over sandy material. Slopes range from 0 to 6 percent.

Dakota soils are similar to Ridgeport soils and commonly are adjacent on the landscape to Biscay, Cylinder, Estherville, and Fairhaven soils. Ridgeport soils formed in sandier material and do not have an argillic horizon. Biscay and Cylinder soils are in lower positions on the landscape. Estherville and Fairhaven soils are in positions similar to those of Dakota soils.

Darfur Series

The Darfur series consists of deep, poorly drained, moderately rapidly permeable soils that formed in stratified loamy and sandy outwash. The slopes range from 0 to 2 percent.

Darfur soils are similar to Isan soils and commonly are adjacent to Dassel, Litchfield, and Ridgeport soils. Isan soils are not stratified and do not have fine textural bands in the profile. Also, they are leached more deeply than Darfur soils. Dassel soils are in depressions and drainageways. Litchfield and Ridgeports soils are in higher positions on the landscape.

Typical pedon of Darfur coarse sandy loam, 130 feet west and 20 feet north of the southeast corner of sec. 19, T 125 N, R 28 W.

Dickman Series

The Dickman series consists of deep, well drained soils. The soils have moderately rapid permeability in the upper part and rapid permeability in the underlying material. They are on outwash plains and stream terraces. They formed in loamy material 12 to 20 inches thick and in the underlying sandy outwash. Slopes range from 0 to 6 percent.

Dickman soils are similar to Estherville soils and commonly are adjacent on the landscape to Dickinson, Duelm, and Hubbard soils. Dickinson soils have a loamy mantle more than 20 inches thick. They and Dickman soils are in similar positions. Estherville soils have free carbonates at a depth of 15 to 24 inches. Hubbard soils have coarser textures below a depth of 10 inches than Dickman soils, and they are in similar positions. Duelm soils are downslopes.

Typical pedon on Dickman sandy loam, 0 to 2 percent slopes, 2,260 feet south and 2,100 feet west of the northeast corner of sec. 32, T 127 N, R 34 W.

Dorset Series

The Dorset series consists of deep, well drained soils. Permeability is moderately rapid in the upper part and rapid in the lower part. The soils formed in a loamy mantle over sandy sediment on outwash plains, valley trains, and kames. Slopes range from 2 to 25 percent.

Dorset soils are adjacent on the landscape to Biscay, Cylinder, and Dakota soils. Biscay and Cylinder soils are in lower positions than Dorset soils, and Dakota soils are in less sloping areas.

Typical pedon of Dorset sandy loam, 2 to 8 percent slopes, 1,520 feet east and 740 feet south of the northwest corner of sec. 36, T 123 N, R 28 W.

Estherville Series

The Estherville series consists of deep, somewhat excessively drained soils. Permeability is moderately rapid in the upper part and rapid in the lower part. The soils are on outwash plains and stream terraces. They formed in loamy material and in the underlying calcareous, sandy outwash (fig. 10). The slopes range from 0 to 25 percent.

Estherville soils are similar to Dickman and Osakis soils and commonly are adjacent on the landscape to Hawick, Osakis, and Regal soils. Unlike Estherville soils, Dickman soils do not have free carbonates to a depth of 60 inches or more. Osakis soils have mottle in the lower part of the B horizon and the C horizon. Hawick soils and Estherville soils are in similar positions on the landscape. Regal soils are downslope.

Typical pedon of Estherville sandy loam, 2 to 6 percent slopes, 2,560 feet west and 20 feet south of the northeast corner of sec. 23, T 122 N, R 29 W.

Estherville-Hawick Complex, 2 to 6 Percent Slopes

This map unit consists of somewhat excessively drained Estherville soil and excessively drained Hawick soil. The areas vary in shape and range from 10 to 200 acres in size.

Estherville soils makes up about 55 percent of the map unit, and Hawick soil makes up about 35 percent. The soils are gently undulating. Estherville soil is in lower lying positions on toe slopes and in swales and on longer, smooth side slopes. Hawick soil is on more sloping, convex knolls and ridges. The individual areas of the soils are so intricately mixed or so small that it was not practical to map them separately at the scale used in mapping.

Fairhaven Series

The Fairhaven series consists of deep, well drained soils. Permeability is moderate in the upper part and rapid in the lower part. The soils are on outwash plains and valley trains. They formed in a loamy mantle and the underlying sandy glacial outwash. The slopes range from 0 to 6 percent.

Fairhaven soils are similar to Dakota soils and commonly are adjacent to Biscay, Cylinder, and Estherville soils. Fairhaven and Dakota soils formed in similar material, but Dakota soils have an argillic horizon. Fairhaven soils and Estherville soils are in similar positions on the landscape. Biscay and Cylinder soils are downslope.

Typical pedon of Fairhaven loam, 0 to 2 percent slopes, 360 feet east and 130 feet south of the northwest corner of sec. 7, T 122 N, R 28 W.

Hawick Series

The Hawick series consist of deep, excessively drained, very rapidly permeable soils on outwash plains and stream terraces. The soils formed in sandy outwash. Slopes range from 2 to 40 percent.

Hawick soils are similar to and are adjacent to Estherville soils. Estherville soils have a loamy mantle 10 to 20 inches thick. They and Hawick soils are in similar positions on the landscape.

Typical pedon of Hawick loamy sand, 6 to 12 percent slopes, 350 feet north and 2,290 feet west of the southwest corner of sec. 7, T 126 N, R 32 W.

Histosols and Haplaquolls, Ponded

This map unit consists of level, organic and mineral soils in shallow ponds, sloughs, and undrained closed depressions that are filled with water throughout most of the year. Some of the areas go dry late in summer or in years of drought, but most areas have open water during the growing season. The vegetation in the shallower parts and around the edges in an area consists of cattails, reeds, hedges, and other water-tolerant plants.

Included in this mapping are areas of sandy, loamy, organic, and calcareous mucky lake sediments. Open water normally covers the central part of a mapped area.

Most areas are left undeveloped. The areas generally are excellent habitat for wildlife. They provide nesting, mating, and escape areas for waterfowl, furbearers, and upland game.

This map unit was assigned to capability subclass VIIw.

Litchfield Series

The Litchfield series consists of deep, moderately well drained and somewhat poorly drained, moderately rapidly permeable soils on glacial outwash plains and on stream terraces. The soils formed in stratified sandy and loamy outwash. Slopes range from 1 to 3 percent.

The Litchfield soils in this survey have more medium and coarse sand than is defined for the Litchfield series. This difference, however, does not affect the use or behavior of the soils.

Litchfield soils are similar to Duelm soils and commonly are adjacent to Darfur, Dassel, and Ridgeport soils. Duelm soils do not have banding in the outwash material. Darfur and Dassel soils are in lower positions on the landscape than Litchfield soils. Ridgeport soils are in higher positions.

Typical pedon of Litchfield loamy sand, 2,640 feet west of the southeast corner of sec. 19, T 125 N, R 28 W.

Nokay Series

The Nokay series consists of deep, somewhat poorly drained soils on drumlins and ground moraines. Permeability is moderately slow. The soils formed in noncalcareous, loamy glacial till. Slopes range from 0 to 2 percent.

Nokay soils are adjacent on the landscape to Alstad, Brainerd, Pomroy, and Prebish soils. Alstad and Brainerd soils are more sloping and higher positions than Nokay soils. Pomroy soils are also in higher drainageways.

Typical pedon of Nokay fine sandy loam, 2,560 feet west and 95 feet south of the northeast corner of sec. 29, T 124 N, R 38 W.

Osakis Series

The Osakis series consists of deep, moderately well drained soils. Permeability is moderate or moderately rapid in the upper part and rapid in the lower part. The soils are on outwash plains and stream terraces. They formed in 12 to 20 inches of loamy material and in the underlying sandy outwash. Slopes range from 0 to 2 percent.

Osakis soils are similar to Estherville soils and commonly are adjacent on the landscape to Estherville and Regal soils. Estherville soils do not have mottles in the lower part of the B horizon and the C horizon. They are upslope from Osakis soils. Regal soils are downslope.

Typical pedon of Osakis loam, 240 feet north and 2,550 feet east of the southwest corner of the sec. 33, T 127 N, R 35 W.

Prebish Series

The Prebish series consists of deep, very poorly drained soils on drumlin fields and on ground and end moraines. Permeability is moderately slow. The soils formed in modified, noncalcareous, loamy glacial till. Slopes range from 0 to 1 percent.

Prebish soils are similar to Corunna soils and are adjacent on the landscape to Alstad, Brainerd, Growton, and Nokay soils. Unlike prebish soils, Corunna soils have a C horizon, at a depth of 26 to 50 inches, that is mildly alkaline and moderately alkaline. Alstad and Brainerd soils are more sloping than Prebish soils. Growton and Nokay soils are on higher lying flats and on the rim of depressions.

Typical pedon of Prebish sandy loam, depressional, 190 feet south and 25 feet west of the center of sec. 6, T 125 N, R 28 W.

Prebish-Nokay Complex

This map unit consists of level to nearly level Prebish and Nokay soils in slightly concave depressions, potholes, and drainageways on glacial moraines. The areas vary in shape and range from 4 to 40 acres in size. This map unit is about 45 percent Prebish soil and 35 percent Nokay soil.

Prebish soils is in the concave center of depressions; it is very poorly drained it is subject to ponding. Nokay soil is on narrow edges, small rises, and the upper parts of drainageways, and it is somewhat poorly drained. The Nokay soils are so intricately mixed or so small that it was not practical to separate them in mapping.

Regal Series

The Regal series consists of deep, poorly drained soils. Permeability is moderate in the loamy mantle and rapid in the underlying material. The soils are on outwash plains or stream terraces. They formed in loamy material overlying sandy outwash. Slopes range from 0 to 2 percent.

Regal soils are similar to Biscay and Mayer soils and commonly are adjacent to Osakis and Estherville soils. Biscay and Mayer soils are deeper to sand and gravel than Regal soils. Osakis and Estherville soils are in higher positions on the landscape.

Typical pedon of Regal loam, 1,080 feet south and 20 feet east of the northwest corner of sec. 11, T 122 N, R 32 W.

Ridgeport Series

The Ridgeport series consists of deep, somewhat excessively drained soils on outwash plains and valley trains. Permeability is moderately rapid. The soils formed in stratified loamy and sandy outwash. Slopes range from 0 to 6 percent.

Ridgeport soils are similar to Dakota and Dickman soils and are adjacent on the landscape to Biscay, Dassel, Estherville, Fairhaven, and Litchfield soils. Dakota soils have a loamy mantle that is 20 to 40 inches thick over sand and gravel, and they have a fine-loamy argillic B horizon. Dickman soils have more sand in the B horizon than Ridgeport soils and do not have an argillic depressions. Dassel, Estherville, and Fairhaven soils are in positions on the landscape similar to those of Ridgeport soils. Litchfield soils are downslope.

Typical pedon of Ridgeport sandy loam, 0 to 2 percent slopes, 923 feet east and 165 feet north of the southwest corner of sec. 35, T 123 N, R 29 W.

Rifle Series

The Rifle series consists of deep, very poorly drained soils. Permeability is moderate and moderately rapid. The soils are in bogs or potholes on outwash plains and ground moraines. They formed in partly decomposed herbaceous organic deposits. Slopes are less than 2 percent.

Rifle soils are adjacent on the landscape to Cathro, Markey, and Seeleyville soils. Cathro and Markey soils have loamy or sandy underlying material at a depth of 51 inches or less. Seeleyville soils have a dominantly sapric material in the subsurface and bottom tiers. All of these soils are in positions on the landscape similar to those of Rifle soils.

Typical pedon of Rifle mucky peat, 1,000 feet west and 1,800 feet north of the southeast corner of sec. 17, T 125 N, R 29 W.

Rifle Mucky Peat

This is a nearly level, very poorly drained soil in concave swales and depression on outwash plains and ground moraines. The areas vary in shape and range from 30 to about 200 acres in size. This soils is subject to ponding.

Seeleyville Series

The Seeleyville series consists of deep, very poorly drained soils. Permeability is moderately rapid to moderately slow. The soils are in postglacial lake basins. They formed in highly decomposed herbaceous material. Slopes range from 0 to 2 percent.

Seeleyville soils are similar to Muskego soils and commonly are adjacent to Cathro and Markey soils. Muskego soils have limnic sediment at a depth between 12 and 52 inches. Cathro and Markey soils are in positions on the landscape similar to those of Seeleyville soils.

Typical pedon of Seeleyville muck, 660 feet north and 2,245 feet west of the southeast corner of sec. 20, T 124 N, R 35 W.

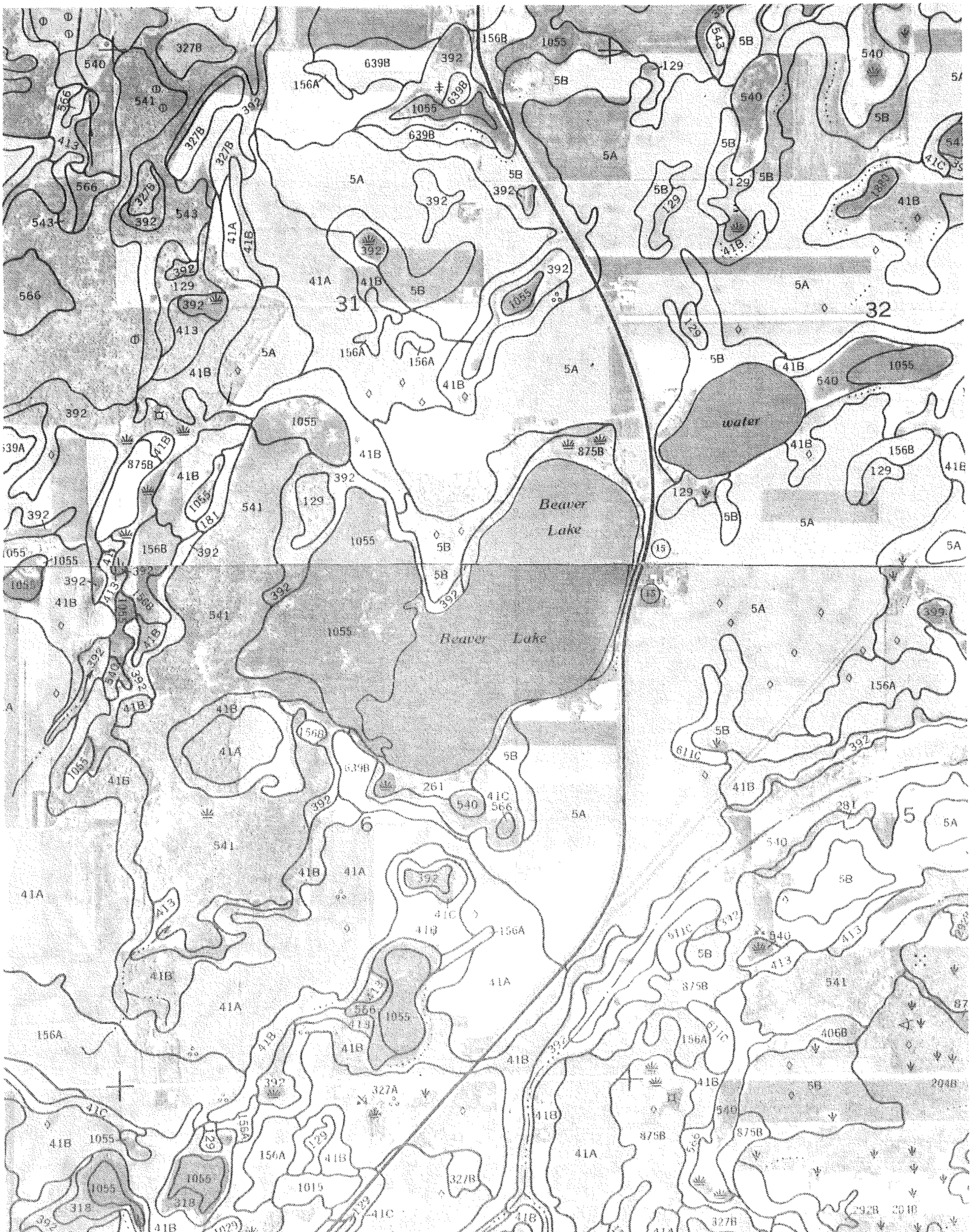
Seeleyville Muck

This is a nearly level, very poorly drained soil in depression on uplands. The area vary in shape and range in size from 10 to 200 acres. This soil is subject to ponding.

For more detailed information, see the Soil Conservation Service Soil Survey of Stearns County, Minnesota dated May, 1985.

APPENDIX A

SOIL TYPES AND CHARACTERISTICS


Beaver Lake
Beaver Lake
water
31
32
6
5

Soil Survey of Stearns County - Beaver Lake

# on Map	Soil Classification	% Slope	Series
292B	Alstad Sandy Loam	1-4	Alstad
392	Biscay Loam		Biscay
204B	Cushing Sandy Loam	2-8	Cushing
204C	Cushing Sandy Loam	8-15	Cushing
129	Cylinder Loam		Cylinder
5A	Dakota Loam	0-2	Dakota
5B	Dakota Loam	2-6	Dakota
281	Darfur Coarse Sandy Loam		Darfur
327A	Dickman Sandy Loam	0-2	Dickman
327B	Dickman Sandy Loam	2-6	Dickman
406B	Dorset Sandy Loam	2-8	Dorset
41A	Estherville Sandy Loam	0-2	Estherville
41B	Estherville Sandy Loam	2-6	Estherville
41C	Estherville Sandy Loam	6-12	Estherville
875B	Estherville-Hawick Complex	2-6	Estherville-Hawick Complex
156A	Fairhaven Loam	0-2	Fairhaven
156B	Fairhaven Loam	2-6	Fairhaven
611C	Hawick Loamy Sand	6-12	Hawick
1055	Histosols and Haplaquoll, Ponded		Histosols and Haplaquolis, Ponded
181	Litchfield Loamy Sand		Litchfield
413	Osakis Loam		Osakis
873	Prebish-Nokay Complex		Prebish-Nokay Complex
566	Regal Loam		Regal
639B	Ridgeport Sandy Loam	2-6	Ridgeport
	Rifle		Rifle
541	Rifle Mucky Peat		Rifle Mucky Peat
	Seelyeville		Seelyeville
540	Seeleyville Muck		Seelyeville Muck

Alstad Series

The Alstad series consists of deep, somewhat poorly drained, moderately permeable soils on ground and end moraines. The soils formed in noncalcareous, loamy glacial till. Slopes range from 1 to 4 percent.

Alstad soils are similar to Brainerd soils and adjacent on the landscape to Cushing, Nokay, and Prebish soils. Unlike Alstad soils, Brainerd soils do not have an argillic B horizon; they have fragic characteristics in the lower B and C horizons. Cushing soils are in more sloping areas. Nokay and Prebish soils are in depressions and drainageways.

Biscay Series

The Biscay series consists of deep, poorly drained soils on outwash plains and stream terraces. Permeability is moderate in the upper part and rapid in the lower part. The soils formed in loamy material overlying calcareous sandy outwash. Slopes range from 0 to 2 percent.

Biscay soils are similar to Mayer and Regal soils and are adjacent on the landscape to Estherville, Mayer, and Osakis soils. Mayer soils have fee carbonates in the upper part and are in positions on the landscape similar to those of Biscay soils. Regal soils have an upper loam mantle that is less than 20 inches thick. Osakis and Estherville soils are in higher positions on the landscape.

Cushing Series

The Cushing series consists of deep, well drained, moderately slowly permeable soils on ground and end moraines. The soils formed in noncalcareous, loamy glacial till. Slopes range from 2 to 40 percent.

Cushing soils are adjacent to Alstad, DeMontreville, Nokay, Prebish, and Jewett soils. DeMontreville and Jewett soils are in positions on the landscape similar to those of Cushing soils. Alstad soils are in less sloping areas. Prebish and Nokay soils are in depressions and drainageways.

Cylinder Series

The Cylinder series consists of deep, somewhat poorly drained soils. Permeability is moderate in the upper part and very rapid in the underlying material. The soils are on outwash plains and on stream terraces. They formed in glacial outwash consisting of a loamy mantle underlain by sandy material. Slopes range from 0 to 2 percent.

Cylinder soils commonly are adjacent to Biscay, Dakota, Estherville, and Fairhaven soils. Biscay soils are lower on the landscape than Cylinder soils, and Dakota, Fairhaven, Estherville soils are higher.

Dakota Series

The Dakota series consists of deep, well drained soils. Permeability is moderate in the upper part and rapid in the lower part. The soils are on outwash plains, stream terraces, and valley trains. They formed in glacial outwash consisting of a loamy mantle over sandy material. Slopes range from 0 to 6 percent.

Dakota soils are similar to Ridgeport soils and commonly are adjacent on the landscape to Biscay, Cylinder, Estherville, and Fairhaven soils. Ridgeport soils formed in sandier material and do not have an argillic horizon. Biscay and Cylinder soils are in lower positions on the landscape. Estherville and Fairhaven soils are in positions similar to those of Dakota soils.

Darfur Series

The Darfur series consists of deep, poorly drained, moderately rapidly permeable soils that formed in stratified loamy and sandy outwash. The slopes range from 0 to 2 percent.

Darfur soils are similar to Isan soils and commonly are adjacent to Dassel, Litchfield, and Ridgeport soils. Isan soils are not stratified and do not have fine textural bands in the profile. Also, they are leached more deeply than Darfur soils. Dassel soils are in depressions and drainageways. Litchfield and Ridgeports soils are in higher positions on the landscape.

Typical pedon of Darfur coarse sandy loam, 130 feet west and 20 feet north of the southeast corner of sec. 19, T 125 N, R 28 W.

Dickman Series

The Dickman series consists of deep, well drained soils. The soils have moderately rapid permeability in the upper part and rapid permeability in the underlying material. They are on outwash plains and stream terraces. They formed in loamy material 12 to 20 inches thick and in the underlying sandy outwash. Slopes range from 0 to 6 percent.

Dickman soils are similar to Estherville soils and commonly are adjacent on the landscape to Dickinson, Duelm, and Hubbard soils. Dickinson soils have a loamy mantle more than 20 inches thick. They and Dickman soils are in similar positions. Estherville soils have free carbonates at a depth of 15 to 24 inches. Hubbard soils have coarser textures below a depth of 10 inches than Dickman soils, and they are in similar positions. Duelm soils are downslopes.

Typical pedon on Dickman sandy loam, 0 to 2 percent slopes, 2,260 feet south and 2,100 feet west of the northeast corner of sec. 32, T 127 N, R 34 W.

Dorset Series

The Dorset series consists of deep, well drained soils. Permeability is moderately rapid in the upper part and rapid in the lower part. The soils formed in a loamy mantle over sandy sediment on outwash plains, valley trains, and kames. Slopes range from 2 to 25 percent.

Dorset soils are adjacent on the landscape to Biscay, Cylinder, and Dakota soils. Biscay and Cylinder soils are in lower positions than Dorset soils, and Dakota soils are in less sloping areas.

Typical pedon of Dorset sandy loam, 2 to 8 percent slopes, 1,520 feet east and 740 feet south of the northwest corner of sec. 36, T 123 N, R 28 W.

Estherville Series

The Estherville series consists of deep, somewhat excessively drained soils. Permeability is moderately rapid in the upper part and rapid in the lower part. The soils are on outwash plains and stream terraces. They formed in loamy material and in the underlying calcareous, sandy outwash (fig. 10). The slopes range from 0 to 25 percent.

Estherville soils are similar to Dickman and Osakis soils and commonly are adjacent on the landscape to Hawick, Osakis, and Regal soils. Unlike Estherville soils, Dickman soils do not have free carbonates to a depth of 60 inches or more. Osakis soils have mottle in the lower part of the B horizon and the C horizon. Hawick soils and Estherville soils are in similar positions on the landscape. Regal soils are downslope.

Typical pedon of Estherville sandy loam, 2 to 6 percent slopes, 2,560 feet west and 20 feet south of the northeast corner of sec. 23, T 122 N, R 29 W.

Estherville-Hawick Complex, 2 to 6 Percent Slopes

This map unit consists of somewhat excessively drained Estherville soil and excessively drained Hawick soil. The areas vary in shape and range from 10 to 200 acres in size.

Estherville soils makes up about 55 percent of the map unit, and Hawick soil makes up about 35 percent. The soils are gently undulating. Estherville soil is in lower lying positions on toe slopes and in swales and on longer, smooth side slopes. Hawick soil is on more sloping, convex knolls and ridges. The individual areas of the soils are so intricately mixed or so small that it was not practical to map them separately at the scale used in mapping.

Fairhaven Series

The Fairhaven series consists of deep, well drained soils. Permeability is moderate in the upper part and rapid in the lower part. The soils are on outwash plains and valley trains. They formed in a loamy mantle and the underlying sandy glacial outwash. The slopes range from 0 to 6 percent.

Fairhaven soils are similar to Dakota soils and commonly are adjacent to Biscay, Cylinder, and Estherville soils. Fairhaven and Dakota soils formed in similar material, but Dakota soils have an argillic horizon. Fairhaven soils and Estherville soils are in similar positions on the landscape. Biscay and Cylinder soils are downslope.

Typical pedon of Fairhaven loam, 0 to 2 percent slopes, 360 feet east and 130 feet south of the northwest corner of sec. 7, T 122 N, R 28 W.

Hawick Series

The Hawick series consist of deep, excessively drained, very rapidly permeable soils on outwash plains and stream terraces. The soils formed in sandy outwash. Slopes range from 2 to 40 percent.

Hawick soils are similar to and are adjacent to Estherville soils. Estherville soils have a loamy mantle 10 to 20 inches thick. They and Hawick soils are in similar positions on the landscape.

Typical pedon of Hawick loamy sand, 6 to 12 percent slopes, 350 feet north and 2,290 feet west of the southwest corner of sec. 7, T 126 N, R 32 W.

Histosols and Haplaquolls, Ponded

This map unit consists of level, organic and mineral soils in shallow ponds, sloughs, and undrained closed depressions that are filled with water throughout most of the year. Some of the areas go dry late in summer or in years of drought, but most areas have open water during the growing season. The vegetation in the shallower parts and around the edges in an area consists of cattails, reeds, hedges, and other water-tolerant plants.

Included in this mapping are areas of sandy, loamy, organic, and calcareous mucky lake sediments. Open water normally covers the central part of a mapped area.

Most areas are left undeveloped. The areas generally are excellent habitat for wildlife. They provide nesting, mating, and escape areas for waterfowl, furbearers, and upland game.

This map unit was assigned to capability subclass VIIw.

Litchfield Series

The Litchfield series consists of deep, moderately well drained and somewhat poorly drained, moderately rapidly permeable soils on glacial outwash plains and on stream terraces. The soils formed in stratified sandy and loamy outwash. Slopes range from 1 to 3 percent.

The Litchfield soils in this survey have more medium and coarse sand than is defined for the Litchfield series. This difference, however, does not affect the use or behavior of the soils.

Litchfield soils are similar to Duelm soils and commonly are adjacent to Darfur, Dassel, and Ridgeport soils. Duelm soils do not have banding in the outwash material. Darfur and Dassel soils are in lower positions on the landscape than Litchfield soils. Ridgeport soils are in higher positions.

Typical pedon of Litchfield loamy sand, 2,640 feet west of the southeast corner of sec. 19, T 125 N, R 28 W.

Nokay Series

The Nokay series consists of deep, somewhat poorly drained soils on drumlins and ground moraines. Permeability is moderately slow. The soils formed in noncalcareous, loamy glacial till. Slopes range from 0 to 2 percent.

Nokay soils are adjacent on the landscape to Alstad, Brainerd, Pomroy, and Prebish soils. Alstad and Brainerd soils are more sloping and higher positions than Nokay soils. Pomroy soils are also in higher drainageways.

Typical pedon of Nokay fine sandy loam, 2,560 feet west and 95 feet south of the northeast corner of sec. 29, T 124 N, R 38 W.

Osakis Series

The Osakis series consists of deep, moderately well drained soils. Permeability is moderate or moderately rapid in the upper part and rapid in the lower part. The soils are on outwash plains and stream terraces. They formed in 12 to 20 inches of loamy material and in the underlying sandy outwash. Slopes range from 0 to 2 percent.

Osakis soils are similar to Estherville soils and commonly are adjacent on the landscape to Estherville and Regal soils. Estherville soils do not have mottles in the lower part of the B horizon and the C horizon. They are upslope from Osakis soils. Regal soils are downslope.

Typical pedon of Osakis loam, 240 feet north and 2,550 feet east of the southwest corner of the sec. 33, T 127 N, R 35 W.

Prebish Series

The Prebish series consists of deep, very poorly drained soils on drumlin fields and on ground and end moraines. Permeability is moderately slow. The soils formed in modified, noncalcareous, loamy glacial till. Slopes range from 0 to 1 percent.

Prebish soils are similar to Corunna soils and are adjacent on the landscape to Alstad, Brainerd, Growton, and Nokay soils. Unlike prebish soils, Corunna soils have a C horizon, at a depth of 26 to 50 inches, that is mildly alkaline and moderately alkaline. Alstad and Brainerd soils are more sloping than Prebish soils. Growton and Nokay soils are on higher lying flats and on the rim of depressions.

Typical pedon of Prebish sandy loam, depressional, 190 feet south and 25 feet west of the center of sec. 6, T 125 N, R 28 W.

Prebish-Nokay Complex

This map unit consists of level to nearly level Prebish and Nokay soils in slightly concave depressions, potholes, and drainageways on glacial moraines. The areas vary in shape and range from 4 to 40 acres in size. This map unit is about 45 percent Prebish soil and 35 percent Nokay soil.

Prebish soils is in the concave center of depressions; it is very poorly drained it is subject to ponding. Nokay soil is on narrow edges, small rises, and the upper parts of drainageways, and it is somewhat poorly drained. The Nokay soils are so intricately mixed or so small that it was not practical to separate them in mapping.

Regal Series

The Regal series consists of deep, poorly drained soils. Permeability is moderate in the loamy mantle and rapid in the underlying material. The soils are on outwash plains or stream terraces. They formed in loamy material overlying sandy outwash. Slopes range from 0 to 2 percent.

Regal soils are similar to Biscay and Mayer soils and commonly are adjacent to Osakis and Estherville soils. Biscay and Mayer soils are deeper to sand and gravel than Regal soils. Osakis and Estherville soils are in higher positions on the landscape.

Typical pedon of Regal loam, 1,080 feet south and 20 feet east of the northwest corner of sec. 11, T 122 N, R 32 W.

Ridgeport Series

The Ridgeport series consists of deep, somewhat excessively drained soils on outwash plains and valley trains. Permeability is moderately rapid. The soils formed in stratified loamy and sandy outwash. Slopes range from 0 to 6 percent.

Ridgeport soils are similar to Dakota and Dickman soils and are adjacent on the landscape to Biscay, Dassel, Estherville, Fairhaven, and Litchfield soils. Dakota soils have a loamy mantle that is 20 to 40 inches thick over sand and gravel, and they have a fine-loamy argillic B horizon. Dickman soils have more sand in the B horizon than Ridgeport soils and do not have an argillic depressions. Dassel, Estherville, and Fairhaven soils are in positions on the landscape similar to those of Ridgeport soils. Litchfield soils are downslope.

Typical pedon of Ridgeport sandy loam, 0 to 2 percent slopes, 923 feet east and 165 feet north of the southwest corner of sec. 35, T 123 N, R 29 W.

Rifle Series

The Rifle series consists of deep, very poorly drained soils. Permeability is moderate and moderately rapid. The soils are in bogs or potholes on outwash plains and ground moraines. They formed in partly decomposed herbaceous organic deposits. Slopes are less than 2 percent.

Rifle soils are adjacent on the landscape to Cathro, Markey, and Seeleyville soils. Cathro and Markey soils have loamy or sandy underlying material at a depth of 51 inches or less. Seeleyville soils have a dominantly sapric material in the subsurface and bottom tiers. All of these soils are in positions on the landscape similar to those of Rifle soils.

Typical pedon of Rifle mucky peat, 1,000 feet west and 1,800 feet north of the southeast corner of sec. 17, T 125 N, R 29 W.

Rifle Mucky Peat

This is a nearly level, very poorly drained soil in concave swales and depression on outwash plains and ground moraines. The areas vary in shape and range from 30 to about 200 acres in size. This soils is subject to ponding.

Seeleyville Series

The Seeleyville series consists of deep, very poorly drained soils. Permeability is moderately rapid to moderately slow. The soils are in postglacial lake basins. They formed in highly decomposed herbaceous material. Slopes range from 0 to 2 percent.

Seeleyville soils are similar to Muskego soils and commonly are adjacent to Cathro and Markey soils. Muskego soils have limnic sediment at a depth between 12 and 52 inches. Cathro and Markey soils are in positions on the landscape similar to those of Seeleyville soils.

Typical pedon of Seeleyville muck, 660 feet north and 2,245 feet west of the southeast corner of sec. 20, T 124 N, R 35 W.

Seeleyville Muck

This is a nearly level, very poorly drained soil in depression on uplands. The area vary in shape and range in size from 10 to 200 acres. This soil is subject to ponding.

For more detailed information, see the Soil Conservation Service Soil Survey of Stearns County, Minnesota dated May, 1985.

APPENDIX B

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

STORET RETRIEVAL DATE 87/05/20 PGM=ALLPARM

73-0023
45 24 15.0 094 14 45.0 3
LAKE. BEAVER 10 M S OF ST. CLOUD
27145 MINNESOTA STEARNS
AREA: 61.5 HECTARE M 070317
MEAN DEPTH: - M MAX DEPTH: 8.2 M
21MINNL 810829 07010203 HQ
0000 FEET DEPTH

/TYPA/AMBNT/LAKE

INDEX
MILES

INITIAL DATE				81/06/30	81/06/30	81/06/30	81/06/30	81/06/30	81/06/30	81/06/30	81/06/30
INITIAL TIME				1010	1010	1010	1010	1010	1010	1010	1010
MEDIUM				WATER	WATER	WATER	WATER	WATER	WATER	WATER	WATER
DEPTH-FT(SMK)				0	3	6	9	13	16	19	22
00000	LAB	IDENT.	NUMBER	129306							
00010	WATER	TEMP	CENT	21 5	21 5	21 0	21 0	20.0	19.0	18.5	18.0
00011	WATER	TEMP	FAHN	70 7$	70.7$	69 8$	69.8$	68.0$	66.2$	65.3$	64.4$
00029	FIELD	IDENT	NUMBER	101							
00078	TRANSP	SECCHI	METERS	2.70							
00080	COLOR	PT-CO	UNITS	10							
00098	VSAMPLOC	DEPTH	METERS	00	1 00	2 00	3.00	4 00	5.00	6.00	7 00
00300	DO		MG/L	9 8	9 8	9 6	8 8	9.4	7.9	6.2	2.8
00301	DO	SATUR	PERCENT	108 9$	108.9$	106.7$	97 8$	102.2$	84.0$	65.3$	29.5$
00403	LAB	PH	SU	8 2							
00410	T ALK	CACO3	MG/L	150							
00605	ORG N	N	MG/L	640							
00610	NH3+NH4-	N TOTAL	MG/L	060							
00612	UN-IONZD	NH3-N	MG/L	004$							
00619	UN-IONZD	NH3-NH3	MG/L	005$							
00625	TOT KJEL	N	MG/L	700							
00630	NO2&NO3	N-TOTAL	MG/L	01K							
00665	PHOS-TOT		MG/L P	047							
32211	CHLRPHYL	A UG/L	CORRECTD	9 90							
32218	PHEOPHTN	A	UG/L	01K							
81903	DPTH BOT	AT SITE	FEET	27 0							

PIC DATA

PHYSICAL CHARACTERISTICS FOR LAKE: BEAVER

Lake Type: Panfish Lake (Centrarchid)
Dominant Forest/Soil Type: DECID/SAND
Size of Lake: 158 Acres
Maximum Depth: 27.0
Shorelength: 2.6 Miles

Secchi Disk Reading (water clarity): 6.0 feet (1948) and 8.9 feet (1981)
Lake Contour Map Number: C0784 (available at cost from Documents Division)
(Phone: 612-297-3000)

DEVELOPMENT CHARACTERISTICS FOR LAKE: BEAVER

Shoreland Zoning Classification: Recreational Development
Public Accesses in 1983: 0

Development	Seasonal Homes	Permanent Homes	Total Homes
1967	4	5	9
1982	13	21	34

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

	Number Issued	Number Denied
Permit Types		
Encroachment	1	0
Shore Protection	1	0
General Appropriation Permits	0	0

GILL NETS No. of sets: 1 Gill net survey date: 8/1/78

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
White Sucker	3	3.0	5.80	5.80
Northern Pike	10	10.0	22.10	22.10
Yellow Perch	12	12.0	3.00	3.00
Largemouth Bass	1	1.0	0.30	0.30
Rock Bass	2	2.0	1.70	1.70

TRAP NETS   No of sets: 3   Trap survey date: 8/1/78

Species	# Fish	# Per Set	Total Pounds	Pounds Per Set
White Sucker	3	1.0	5.00	1.67
Golden Shiner	2	0.7	0.10	0.03
Black Bullhead	26	8.7	28.50	9.50
Northern Pike	2	0.7	3.30	1.10
Yellow Perch	16	5.3	2.50	0.83
Largemouth Bass	1	0.3	0.40	0.13
Geen Sunfish	1	0.3	0.10	0.03
Pumpkinseed Sunfish	12	4.0	1.50	0.50
Bluegill Sunfish	102	34.0	14.00	4.67
Rock Bass	1	0.3	0.10	0.03
Black Crappie	4	1.3	1.50	0.50
Hybrid Sunfish	3	1.0	1.20	0.40

***Fish Stocking Data is not available.

APPENDIX C

CLIMATOLOGICAL DATA

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	0.05	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	20.85
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	6.66	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

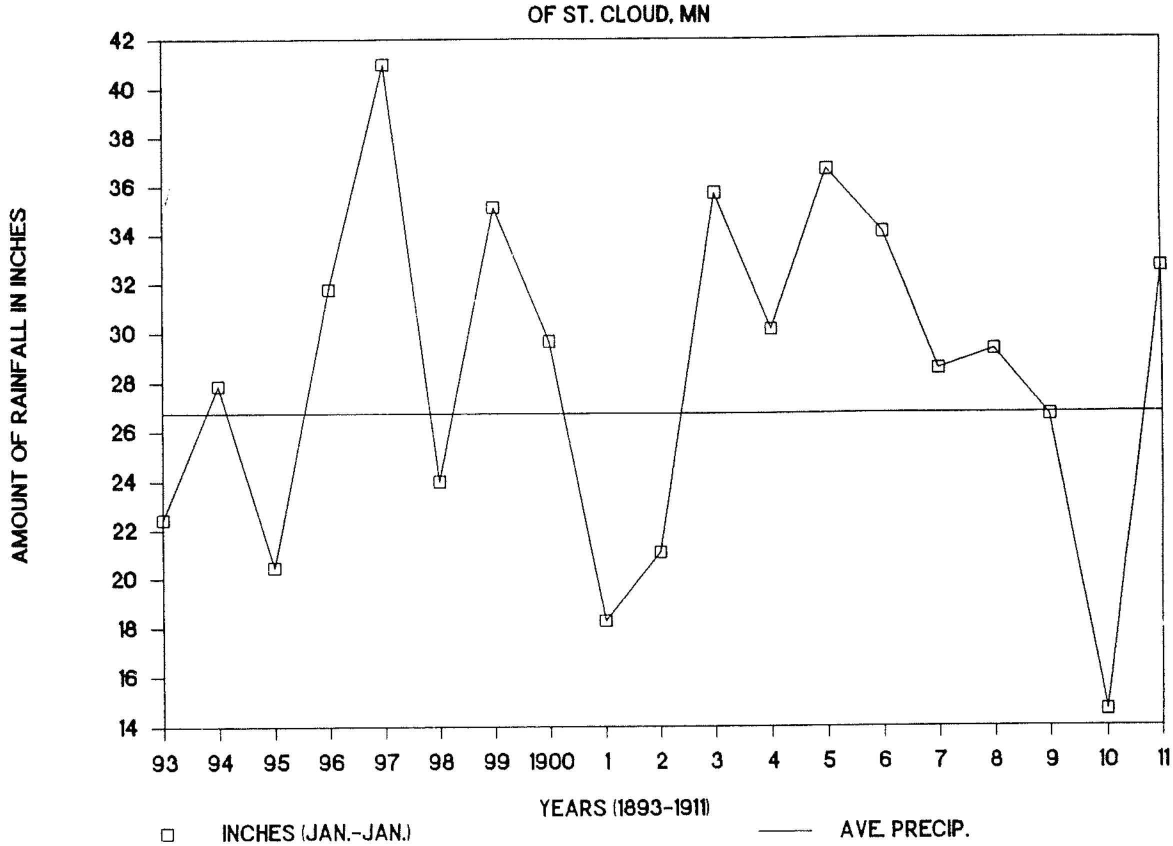
Note: Values in hundredths of inches; 'm' = missing; 'e' = estimated; '####' is the National Weather Service Coop Station Number.

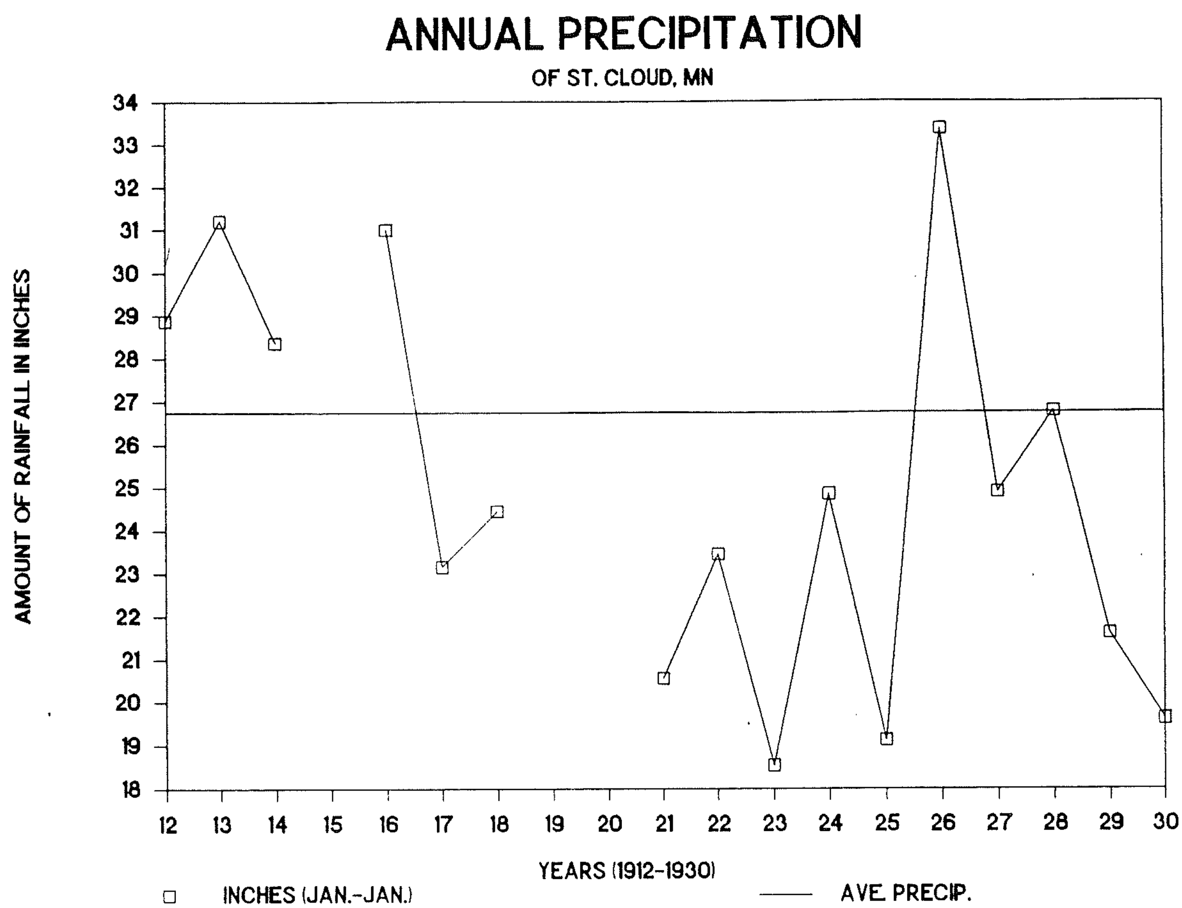
All data were supplied to this State Climatology Office by the National Climate Data Center, NOAA, Asheville, NC, 28801. "Certified Data" can only be supplied by NCDC directly.

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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12
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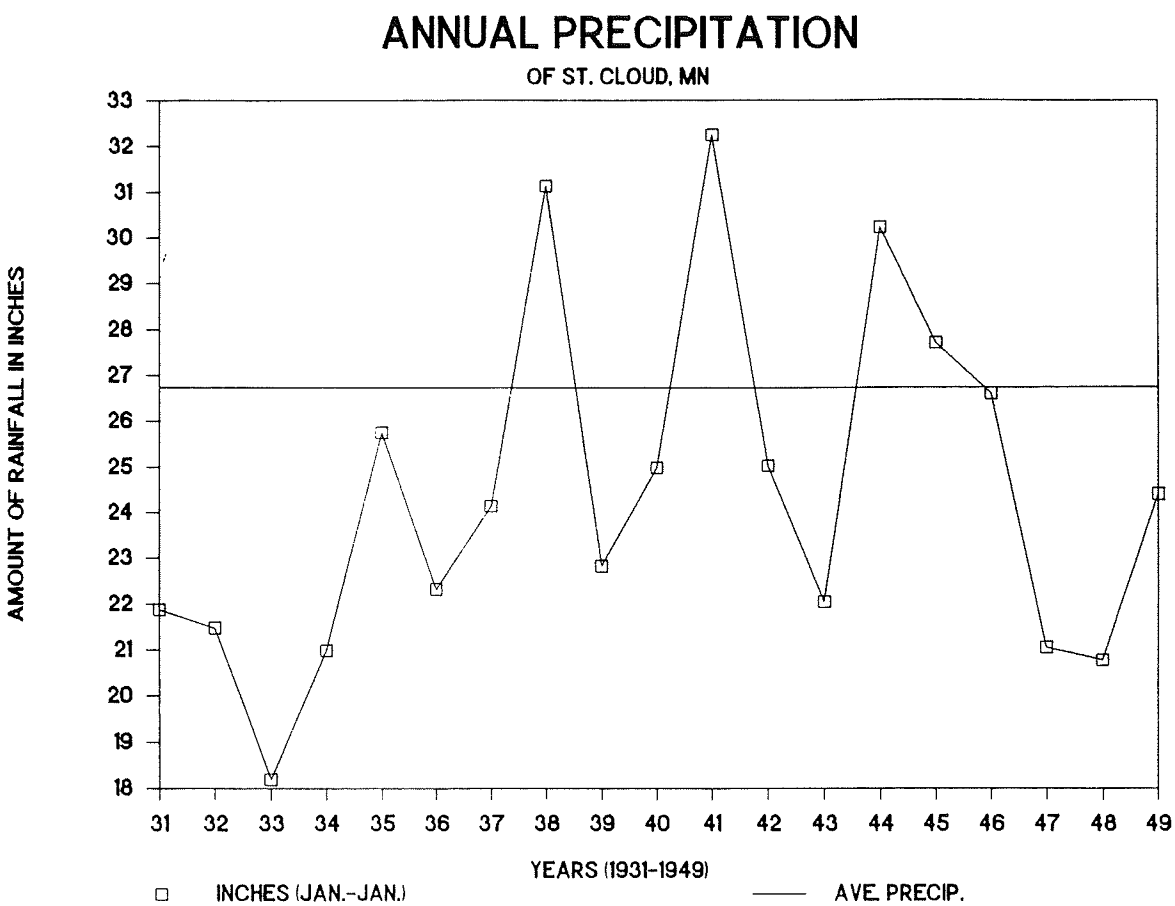
YEARS (1912-1930)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
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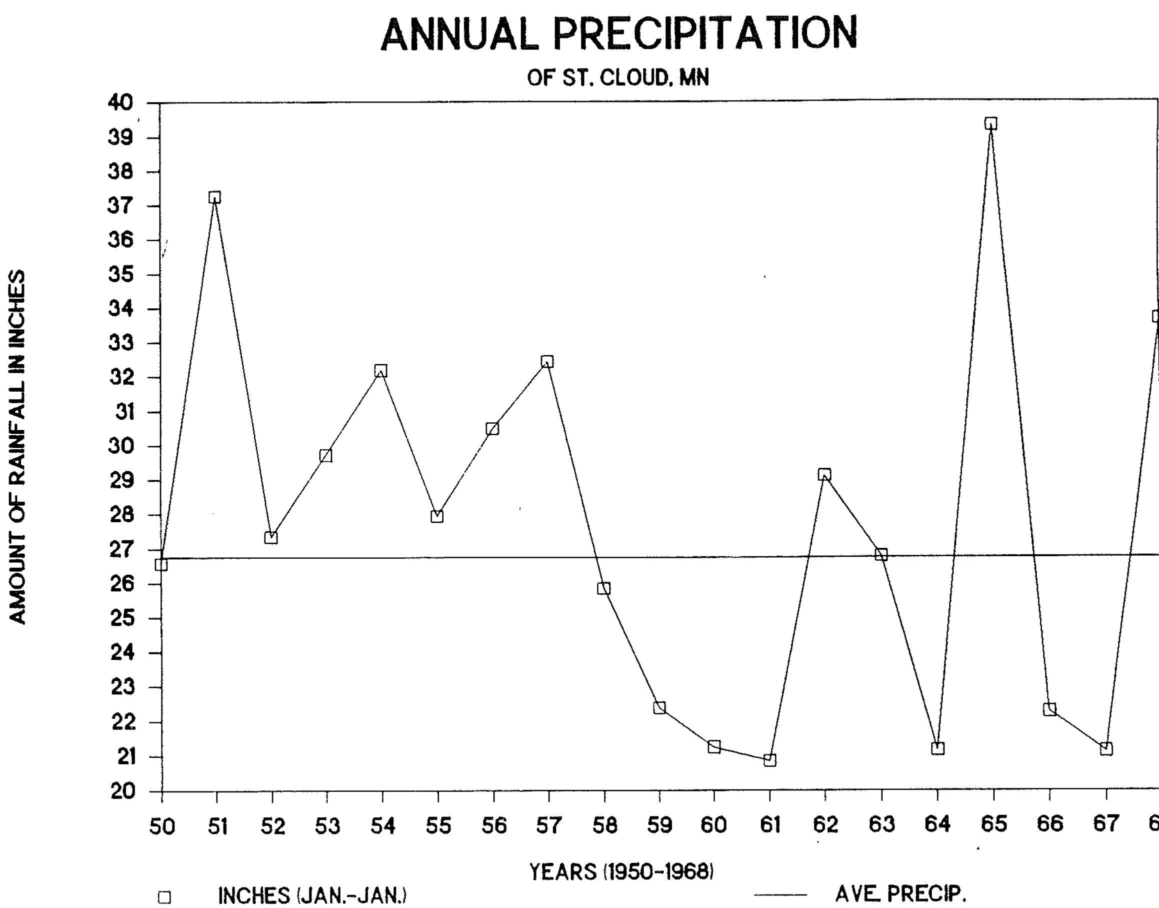
31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49
YEARS (1931-1949)
INCHES (JAN.-JAN.)
AVE. PRECIP.



ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
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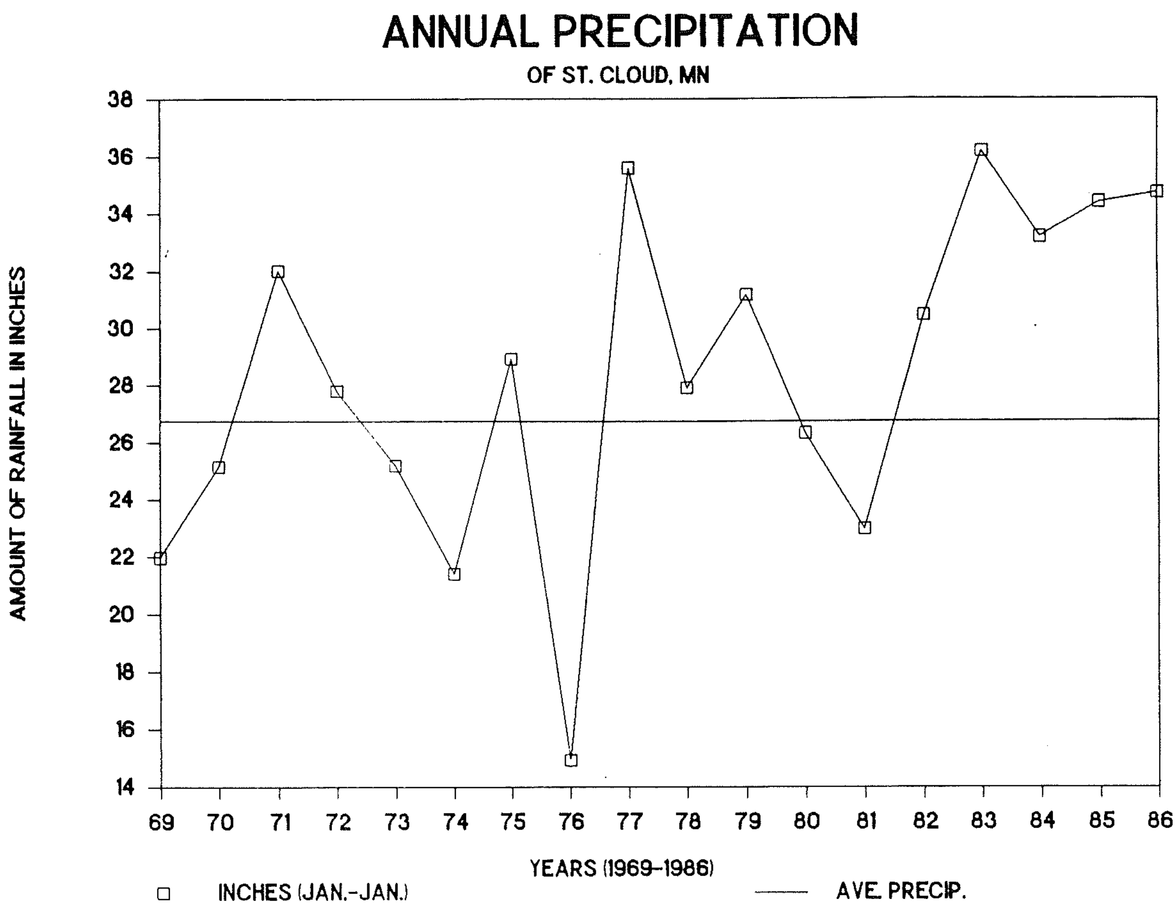
50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68
YEARS (1950-1968)
INCHES (JAN.-JAN.)
AVE. PRECIP.


ANNUAL PRECIPITATION
OF ST. CLOUD, MN
AMOUNT OF RAINFALL IN INCHES
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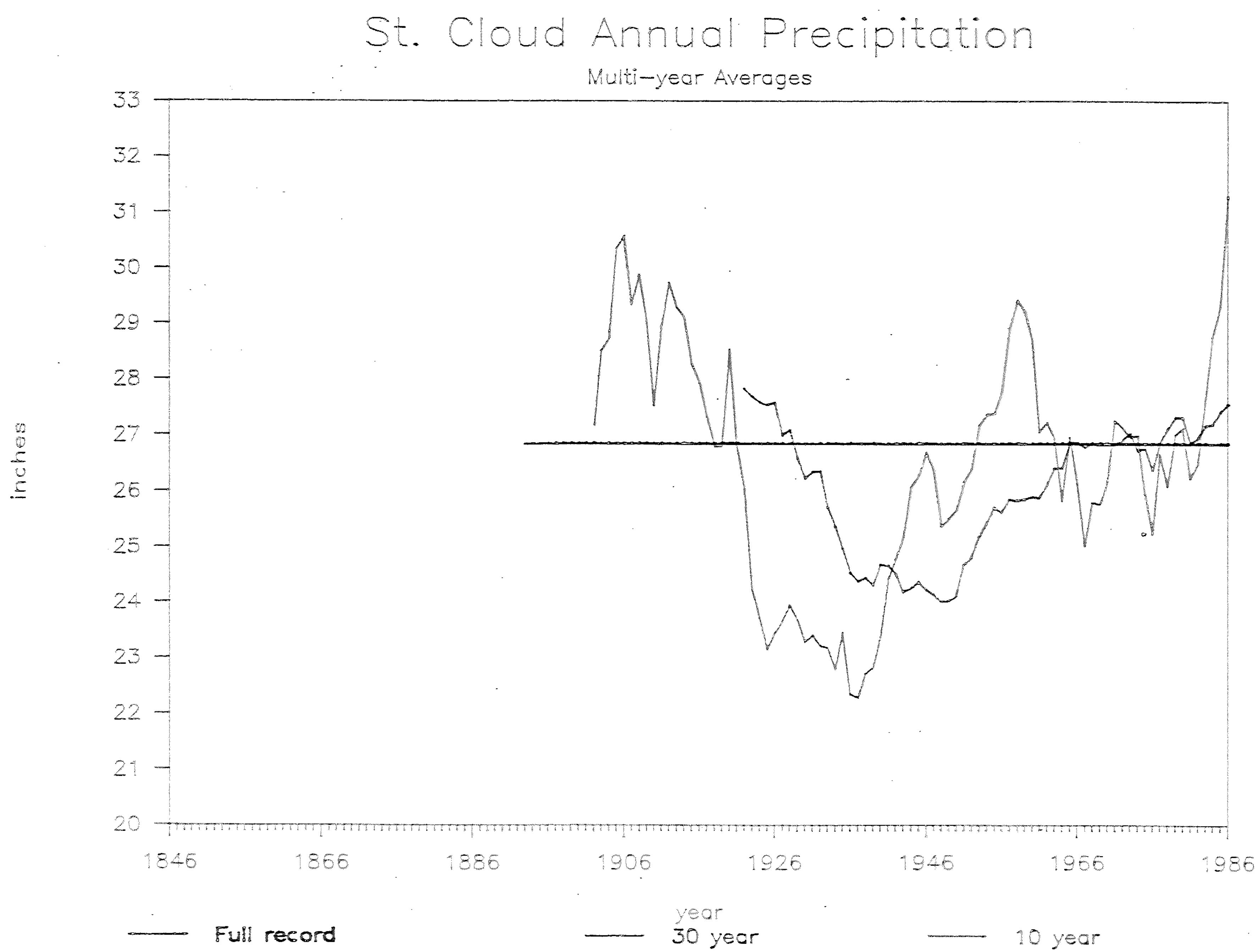
69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86
YEARS (1969-1986)
INCHES (JAN.-JAN.)
AVE. PRECIP.


St. Cloud Annual Precipitation
Multi-year Averages
33
32
31
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29
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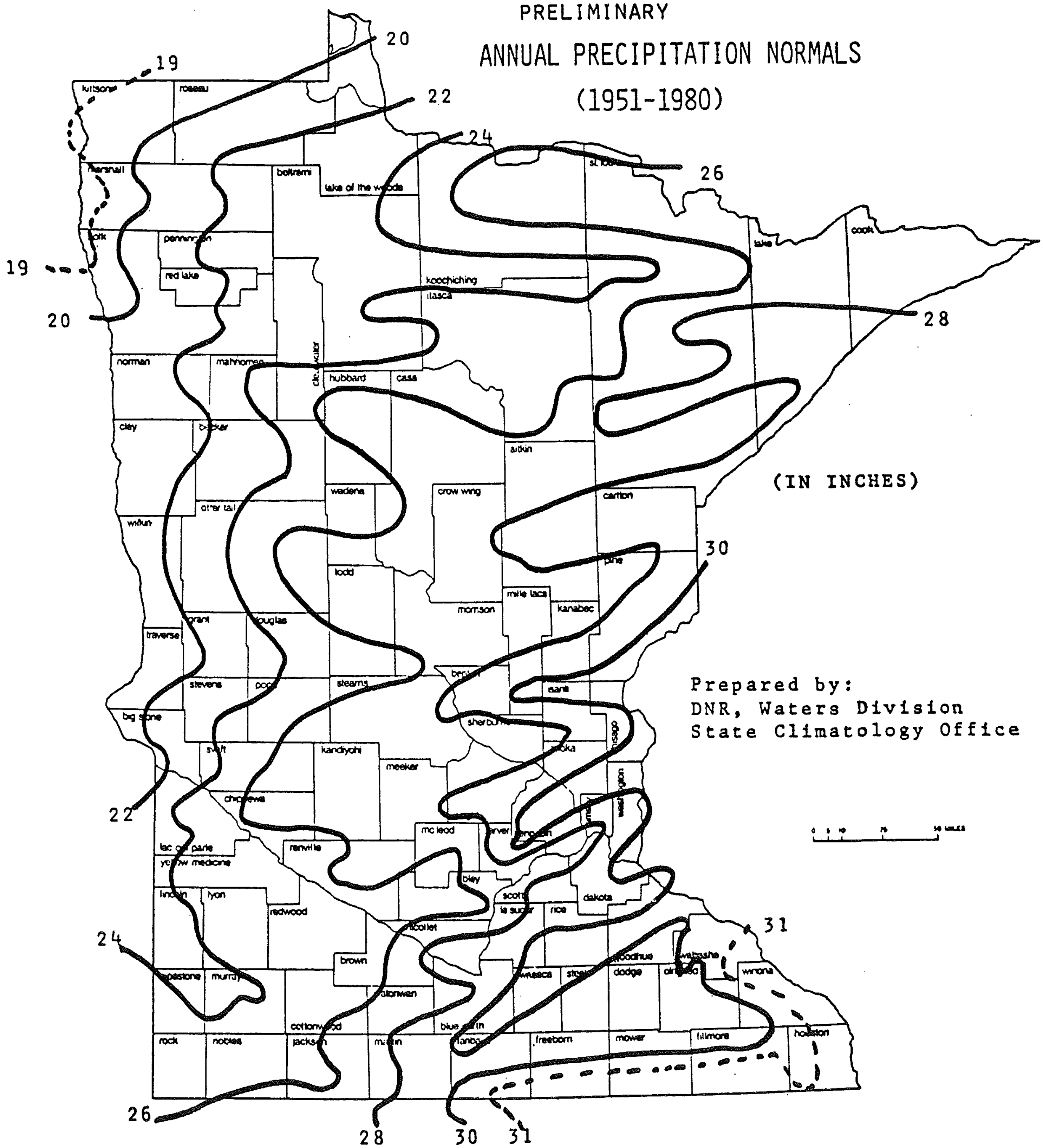
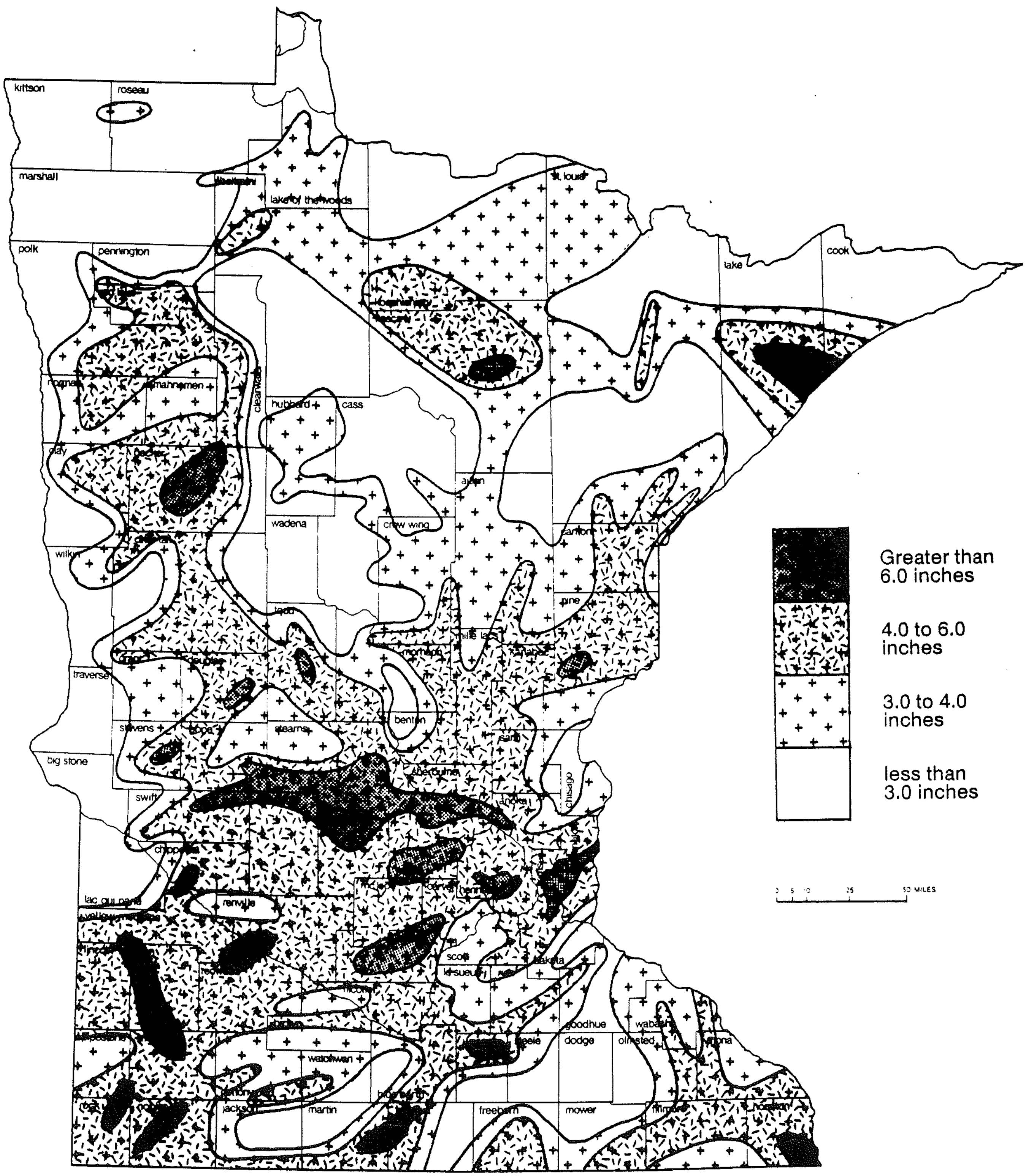
27
26
25
24
23
22
21
20
inches
1846
1866
1886
1906
1926
1946
1966
1986
year
Full record
30 year
10 year

PRELIMINARY
ANNUAL PRECIPITATION NORMALS
(1951-1980)



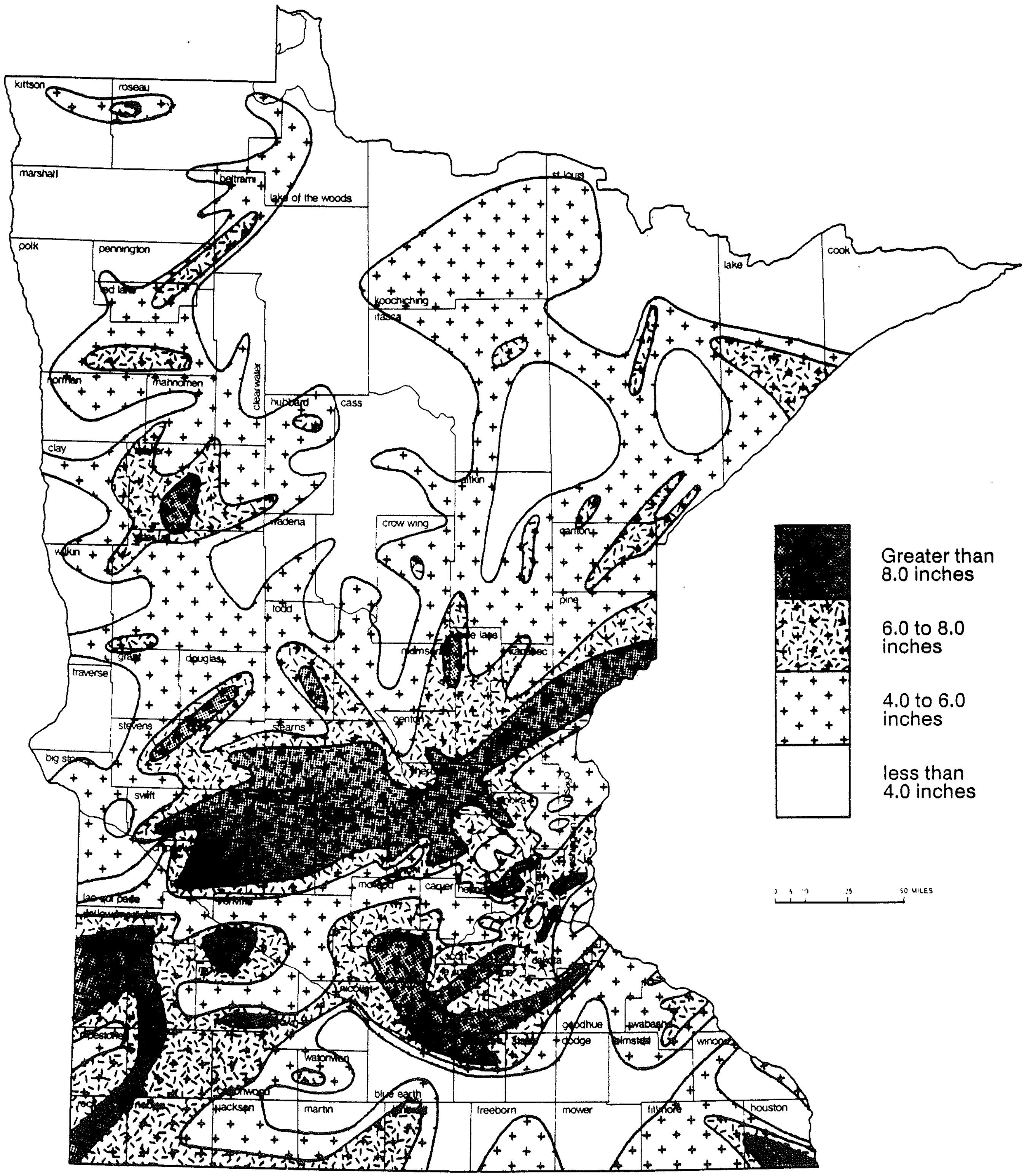
Prepared by:
DNR, Waters Division
State Climatology Office

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



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

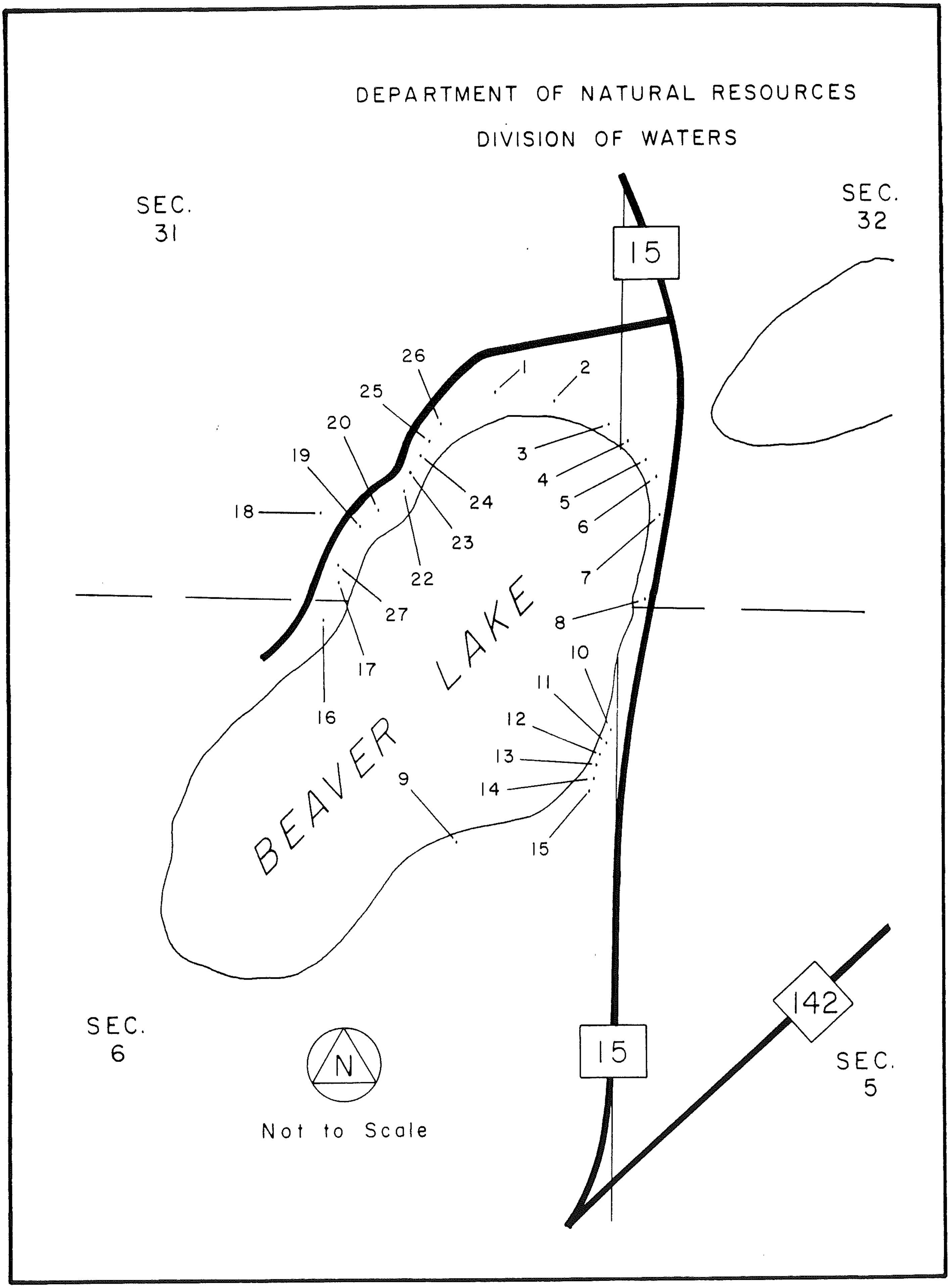
AVERAGE ANNUAL DEPARTURE FROM NORMAL PRECIPITATION FOR 1982 - 1986 (5 YEARS)



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

APPENDIX D

FACT SHEET FOR EACH POTENTIALLY DAMAGED STRUCTURE


DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS
SEC. 31
SEC. 32
SEC. 6
SEC. 5
15
142
BEAVER LAKE
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N
Not to Scale

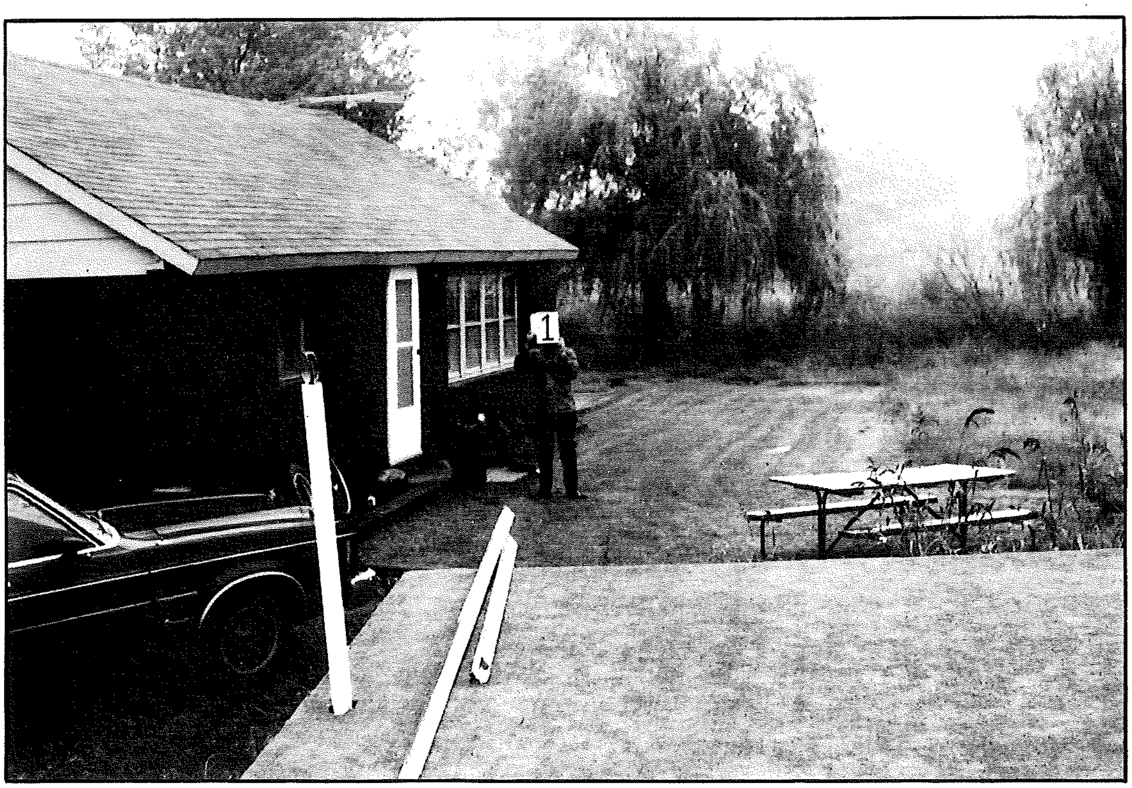
BEAVER LAKE STEARNS CO.

Structure Number :	1
Name :	Weber, Mary
Address :	P.O. Box 187 St. Cloud, MN 56301-0187
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 21
Walkout/1stFl Elev. :	1117.24
Ground Elevation :	1116.6
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$11,550.00
Land :	$15,600.00
Total :	$27,150.00

Flood Insurance :	NO



BEAVER LAKE STEARNS CO.

Structure Number : 2
Name : Lommel, N.
Address : R.R. 1
Kimball, MN 55353-9801

Legal Description : Sec. 31, Twp. 123, R. 28, .43 A. W. 100 ft. (when measured on shoreline), of Lommel Survey 469-10 Govt. Lot 1. (TR #1 of DB 363 P 373).

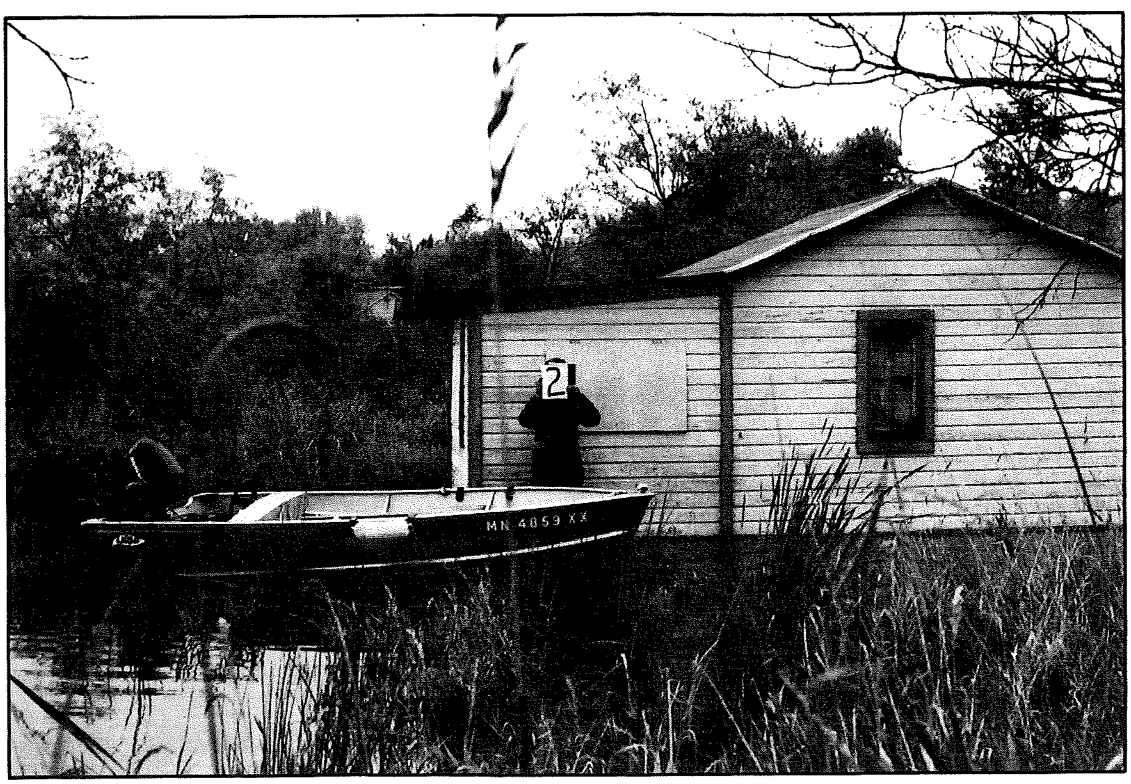
Walkout/1stFl Elev. : 1115.30
Ground Elevation : 1114.7

Basement : NO
Walkout : NO

Market Value

Buildings :	$300.00
Land :	$3,300.00
Total :	$3,600.00

Flood Insurance : NO



BEAVER LAKE STEARNS CO.

Structure Number : 3
Name : Lommel, L.
Address : Rt. 1 Box 47
Kimball, MN 55353-9801

Legal Description : Sec. 31, Twp. 123, R. 28, .50 A. FR .50 A. of Lot 1 Sec. 31 and FR part of Lot 1 Sec. 32.

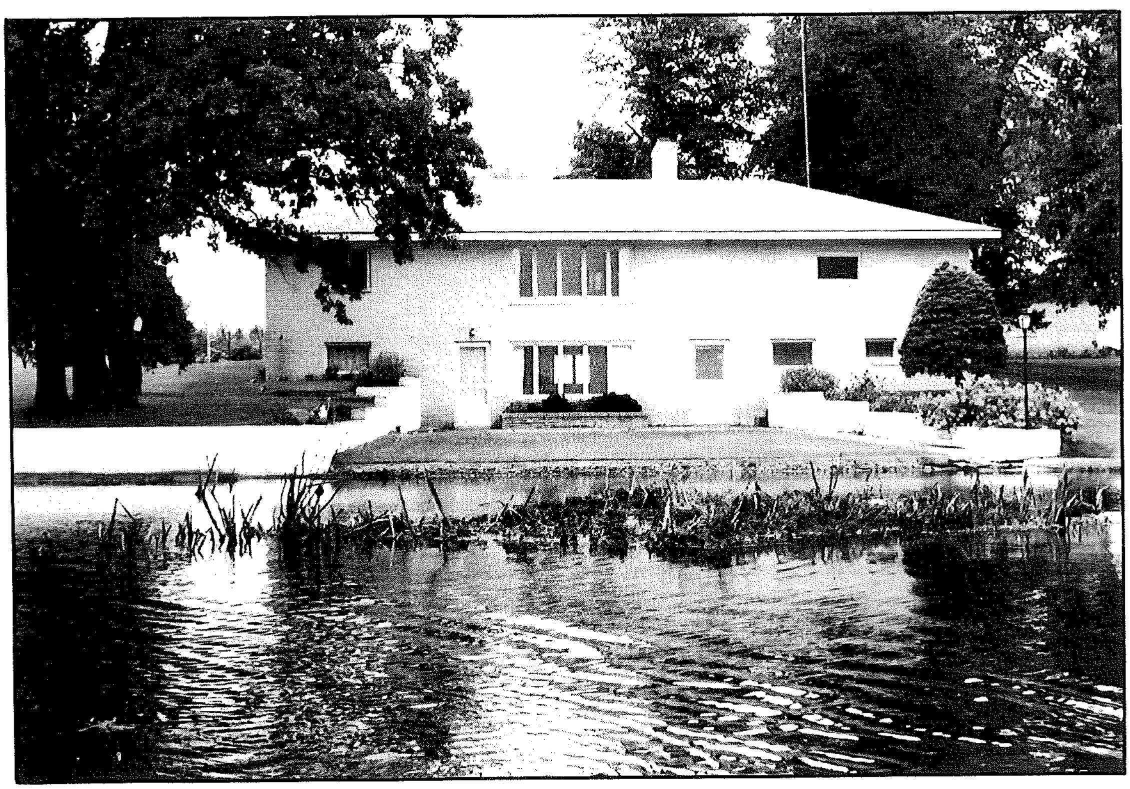
Walkout/1stFl Elev. : 1117.81
Ground Elevation :

Basement : YES
Walkout : YES

Market Value

Buildings : $39,200.00
Land : $12,600.00
Total : $51,800.00

Flood Insurance : NO



BEAVER LAKE STEARNS CO.

Structure Number :	4
Name :	Rahe, J. & J.
Address :	Rt. 1 Box 44 Kimball, MN 55353-9801
Legal Description :	Sec. 32, Twp. 123, R. 28, .50 A. of Govt. Lot 1 Sec. 31 and Govt. Lot 1 Sec. 32 on N.E. shore of Beaver Lake 134 ft. Frontage.
Walkout/1stFl Elev. :	1120.18
Ground Elevation :	1118.8
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$9,300.00
Land :	$14,700.00
Total :	$24,000.00

Flood Insurance : NO

BEAVER LAKE STEARNS CO.

Structure Number : 5
Name : Desanto John and Carolyn
Address : Rt. 1 Box 45
Kimball, MN 55353-9801

Legal Description : Sec. 32, Twp. 123, R. 28, .41 A. Govt. Lot 1 com 1506.90 ft. S. W. 4 cor. S.E. on CL of old Hwy 257.15 ft. POB-SE on CL 125 ft. -R90D 141.30 ft. to Lk-N.W. 125 ft. -R90D147.20 ft. POB.

Walkout/1stFl Elev. : 1119.78
Ground Elevation : 1117.6

Basement : NO
Walkout : NO

Market Value

Buildings : $38,900.00
Land : $16,000.00
Total : $54,900.00

Flood Insurance : YES

BEAVER LAKE STEARNS CO.

Structure Number :	6
Name :	Buerman, Roman
Address :	Rt. 2 St. Joseph, MN 56374
Legal Description :	Sec. 32, Twp. 123, R. 28, .74 A. FR .74 A. of Lot 1.
Walkout/1stFl Elev. :	1118.21
Ground Elevation :	1116.3
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$11,300.00
Land :	$9,000.00
Total :	$20,300.00

Flood Insurance : NO

BEAVER LAKE STEARNS CO.

Structure Number :	7
Name :	Rahe, Ed
Address :	R.R. 1 Kimball, MN 55353-9801
Legal Description :	Sec. 32, Twp. 123, R. 28, .71 A. FR .71 A. of Lot 1.
Walkout/1stFl Elev. :	1114.14
Ground Elevation :	1113.7
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$1,000.00
Land :	$4,600.00
Total :	$5,600.00

Flood Insurance : NO

<u>BEAVER LAKE STEARNS CO.</u>

Structure Number :	7A
Name :	Rahe, Ed
Address :	R.R. 1 Kimball, MN 55353-9801
Legal Description :	The market value of all four cabins, buildings and land, are included with structure number 7.
Walkout/1stFl Elev. :	1112.80
Ground Elevation :	
Basement :	
Walkout :	

Market Value

Buildings :	
Land :	
Total :	$0.00

Flood Insurance :

<u>BEAVER LAKE STEARNS CO.</u>

Structure Number : 8
Name : Kenning, R.
Address : Bel Clare Acres
St. Cloud, MN 56301-9346

Legal Description : Sec. 32, Twp. 123, R. 28, .18 A., FR. .18 A. of Lot 1.

Walkout/1stFl Elev. : 1117.13
Ground Elevation : 1115.0

Basement : NO
Walkout : NO

Market Value

Buildings : $100.00
Land : $2,500.00
Total : $2,600.00

Flood Insurance : NO

BEAVER LAKE STEARNS CO.

Structure Number : 9
Name : Zieglmeier, Theo M.
Address : Rt. 3
St. Cloud, MN 56301-9803

Legal Description : Sec. 32, Twp. 123, R. 28, 130.04 A. S.W. 1/4 N.E 1/4 S.E. 1/4 N.W.1/4 and Lot 1 less N.E. 3.43 A. less S.E. 2.03 A.

Walkout/1stFl Elev. : 1116.46
Ground Elevation : 1116.3

Basement : NO
Walkout : NO

Market Value

Buildings : $700.00
Land :
Total : $700.00

Flood Insurance : NO

BEAVER LAKE STEARNS CO.

Structure Number : 10
Name : Weber,R.
Address : R.R. 1
Kimball, MN 55353-9801

Legal Description : Sec. 6, Twp. 122, R. 28, .51 A. that part of Govt. Lot 1 N. of A. L. DAF.BEG 1797.36 ft. N. of E 4 COR-N82D W. 43.33 ft. -N. 67 DW 60 ft. to Beaver Lake.

Walkout/1stFl Elev. : 1118.22
Ground Elevation : 1117.3

Basement : YES
Walkout : YES

Market Value

Buildings : $38,200.00
Land : $10,000.00
Total : $48,200.00

Flood Insurance : NO

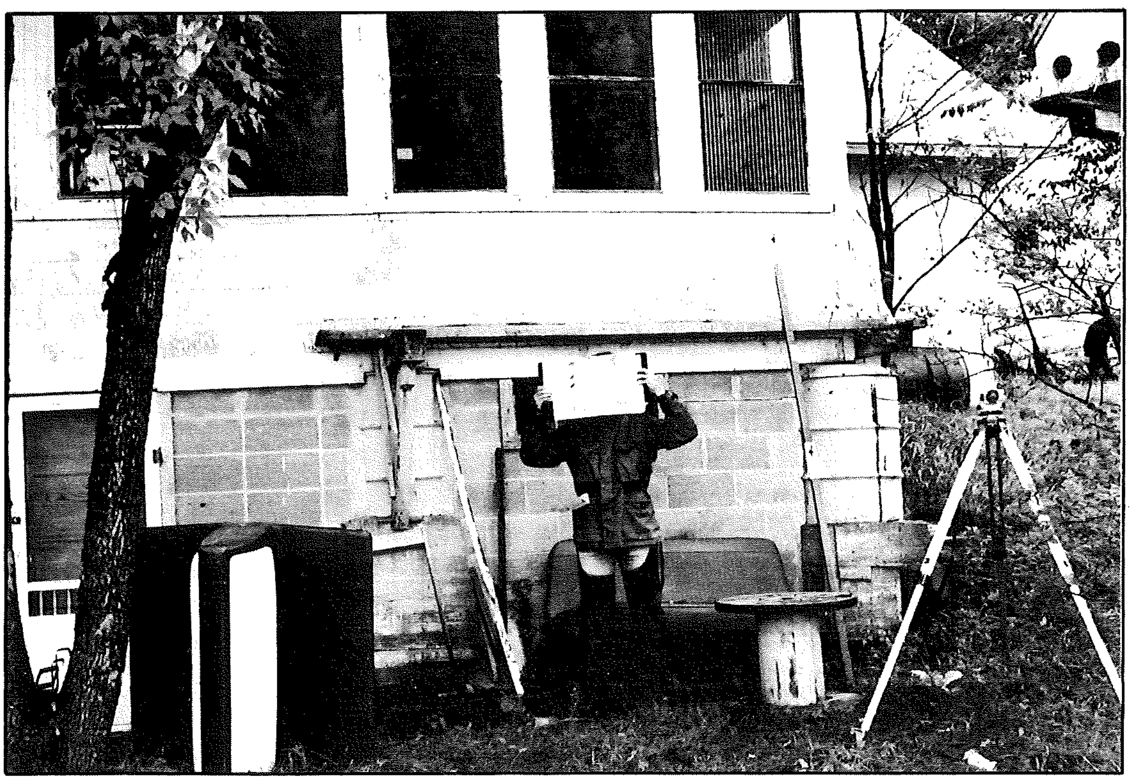
BEAVER LAKE STEARNS CO.

Structure Number :	11
Name :	Berscheid, A.
Address :	126 11th Ave. N. Waite Park, MN 56387
Legal Description :	Sec. 6, Twp. 122, R. 28, .16 A. S. 62.16 ft. of N. 448 ft. Pt. of Govt. Lot 1 bounded on E. by E. L. of Sec. and on W. by Beaver Lake.
Walkout/1stFl Elev. :	1118.56
Ground Elevation :	1118.4
Basement :	YES
Walkout :	YES

Market Value

Buildings :	$8,900.00
Land :	$7,800.00
Total :	$16,700.00

Flood Insurance : NO



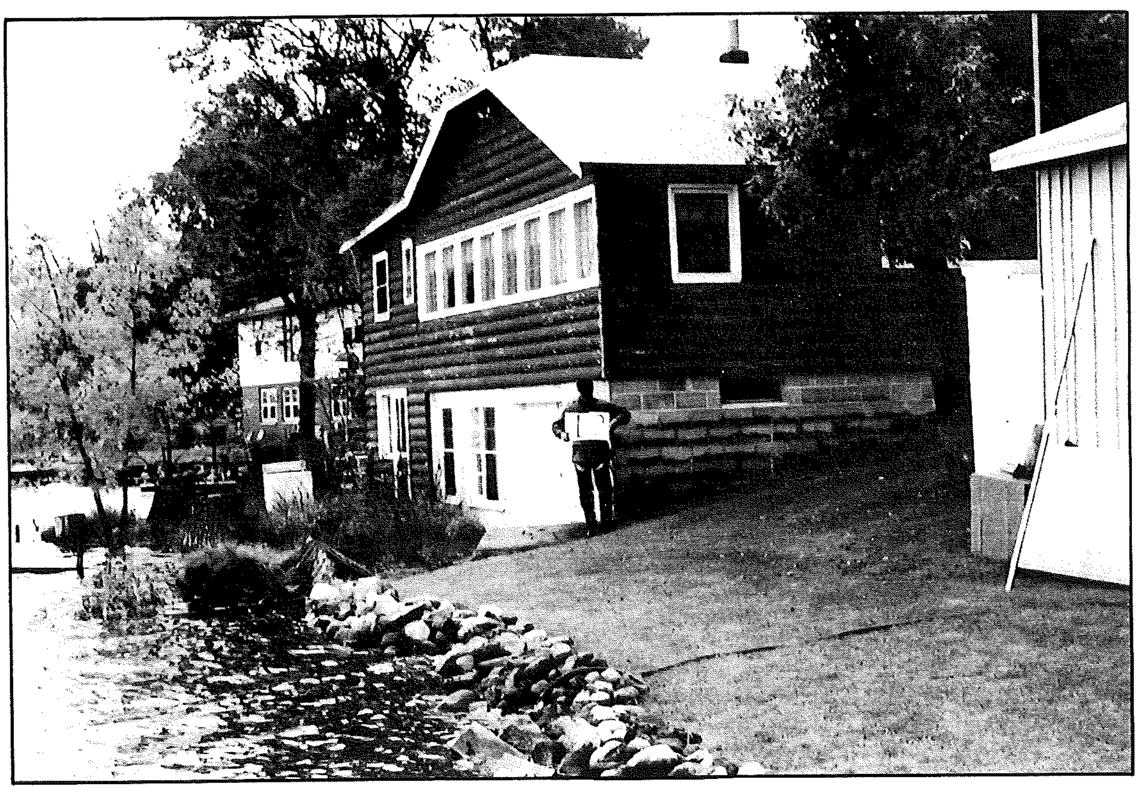
BEAVER LAKE STEARNS CO.

Structure Number :	12
Name :	Klug, Albert E.
Address :	837 20 Ave. N. St. Cloud, MN 56301-1449
Legal Description :	Sec. 6, Twp. 122, R. 28, .12 A. S. 50 ft. of N. 498 ft. of Lot 1.
Walkout/1stFl Elev. :	1115.59
Ground Elevation :	1115.5
Basement :	YES
Walkout :	YES

Market Value

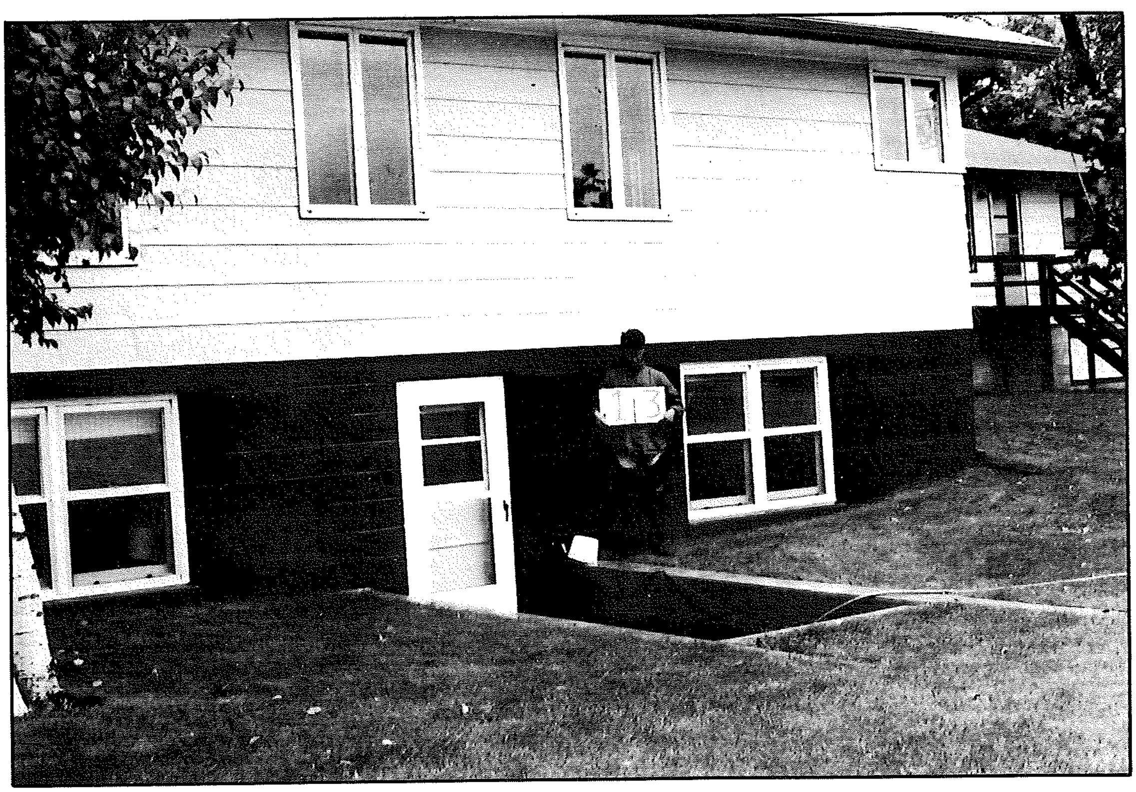
Buildings :	$13,000.00
Land :	$6,000.00
Total :	$19,000.00

Flood Insurance : NO



BEEVER LAKE STEARNS CO.

Structure Number :	13	
Name :	McGowan, Martin J.	
Address :	R.R. 1 Kimball, MN 55353-9801	
Legal Description :	Sec. 6, Twp. 122, R. 28, FR .27 A. of Lot 1.	
Walkout/1stFl Elev. :	1115.26	
Ground Elevation :	1117.0	
Basement :	YES	
Walkout :	YES	
Market Value		
Buildings :		$40,200.00
Land :		$10,800.00
Total :		$51,000.00
Flood Insurance :	NO	



BEAVER LAKE STEARNS CO.

Structure Number : 13A

Name : McGowan, Martin J.

Address : R.R. 1
Kimball, MN 55353-9801

Legal Description : Sec. 6, Twp. 122, R. 28, FR .27 A. of Lot 1.

Walkout/1stFl Elev. : 1120.23

Ground Elevation : 1117.0

Basement : NO

Walkout : NO

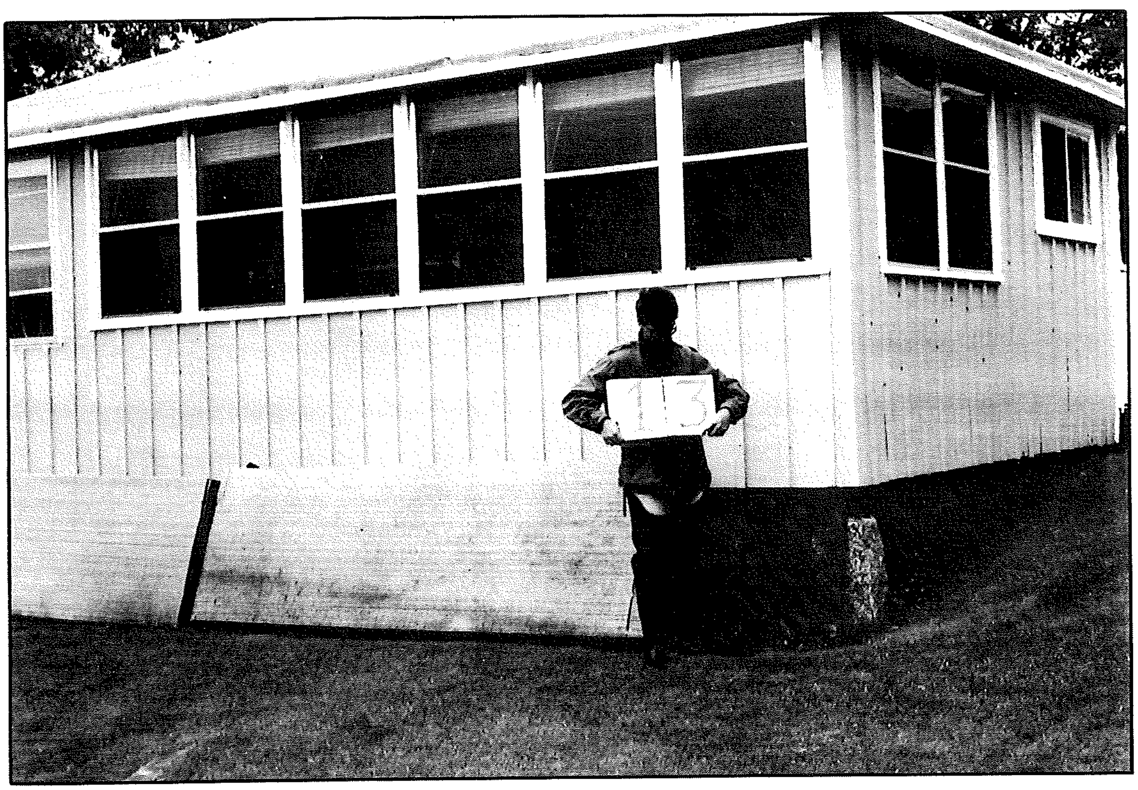
Market Value

Buildings : $4,600.00

Land : $10,000.00

Total : $14,600.00

Flood Insurance : NO



BEAVER LAKE STEARNS CO.

Structure Number : 14
Name : Moren, Alice M.
Address : 102 22nd Ave. So.
St. Cloud, MN 56301

Legal Description : Sec. 6, Twp. 122, R. 28, .23 A. S. 53.33 ft. of N. 637.99 ft. of Lot 1, As Per. DB 207 P 423.

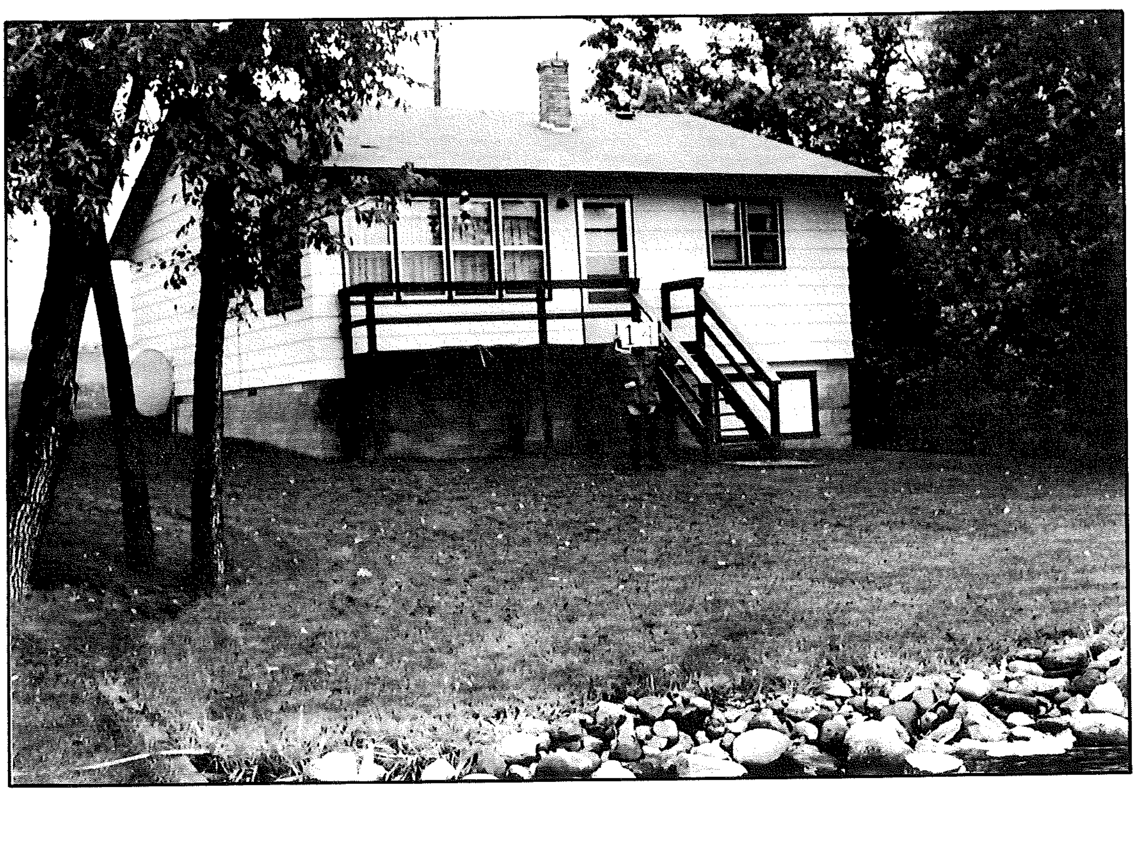
Walkout/1stFl Elev. : 1124.54
Ground Elevation : 1118.6

Basement : NO
Walkout : NO

Market Value

Buildings : $19,300.00
Land : $6,400.00
Total : $25,700.00

Flood Insurance : NO



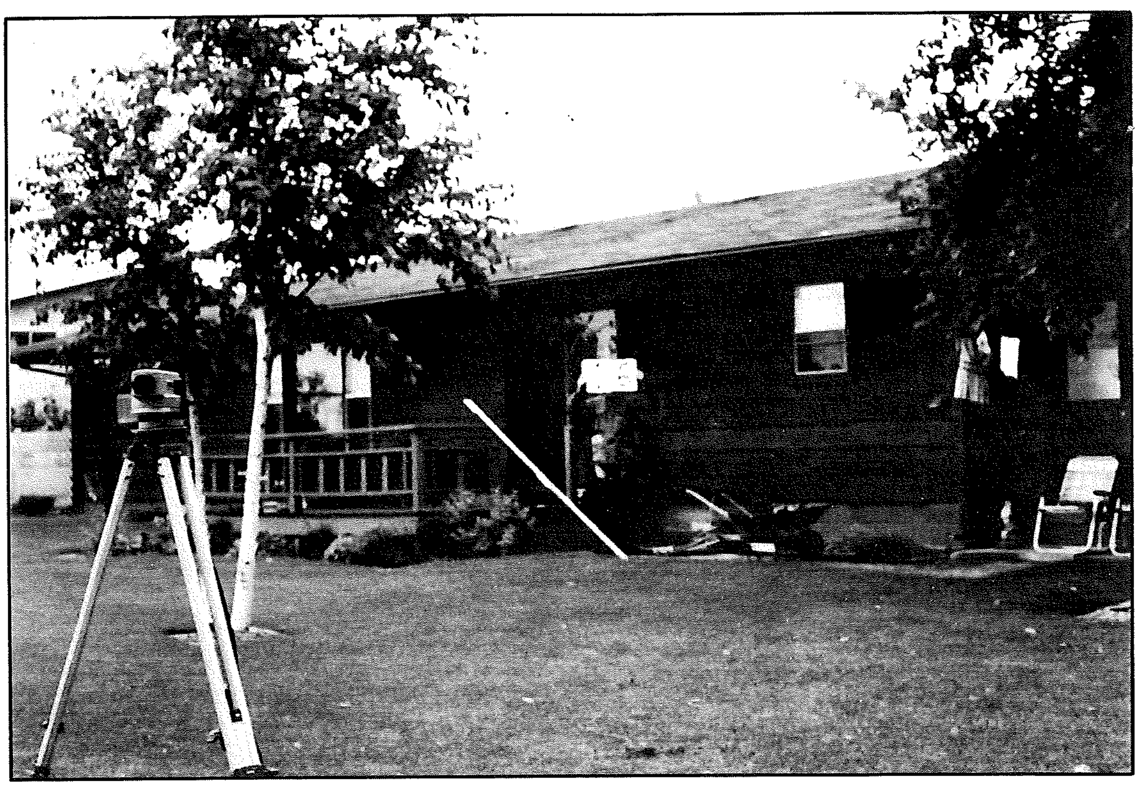
BEAVER LAKE STEARNS CO.

Structure Number :	15
Name :	Heid, Bertha
Address :	126 15th Ave. So. St. Cloud, MN 56301-3338
Legal Description :	Section 6, Twp. 122, R. 28
Walkout/1stFl Elev. :	--
Ground Elevation :	--
Basement :	--
Walkout :	--
Market Value	--
Buildings :	--
Land :	--
Total :	$0.00
Flood Insurance :	--

No Photo Available.

BEAVER LAKE STEARNS CO.

Structure Number :	16	
Name :	Hinkemeyer, Scott P.	
Address :	Rt. 1 Box 49 AA Kimball, MN 55353-9801	
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 5.	
Walkout/1stFl Elev. :	1120.20	
Ground Elevation :	1118.6	
Basement :	NO	
Walkout :	NO	
Market Value		
Buildings :		$38,900.00
Land :		$13,800.00
Total :		$52,700.00
Flood Insurance :	NO	



BEAVER LAKE STEARNS CO.

Structure Number :	17
Name :	Lommel, Louise
Address :	Rt. 1 Kimball, MN 55353-9801
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 7.
Walkout/1stFl Elev. :	1125.40
Ground Elevation :	1121.2
Basement :	YES
Walkout :	NO

Market Value

Buildings :	$38,200.00
Land :	$12,500.00
Total :	$50,700.00

Flood Insurance : NO

BEAVER LAKE STEARNS CO.

Structure Number :	18
Name :	Opatz, James A.
Address :	Rt. 1 Box 49 M Kimball, Mn 55353
Legal Description :	Sec. 31, Twp. 123, R. 28, 5.00 A. Part of Govt. Lot 2, Beg. at most W'LY corner of Lot 10 Beaver Lake Park W. PAR. to S. line to W. line of road POB - cont W. Par. to S. line to E. LI.
Walkout/1stFl Elev. :	1121.58
Ground Elevation :	1120.7
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$44,700.00
Land :	$7,500.00
Total :	$52,200.00

Flood Insurance : NO

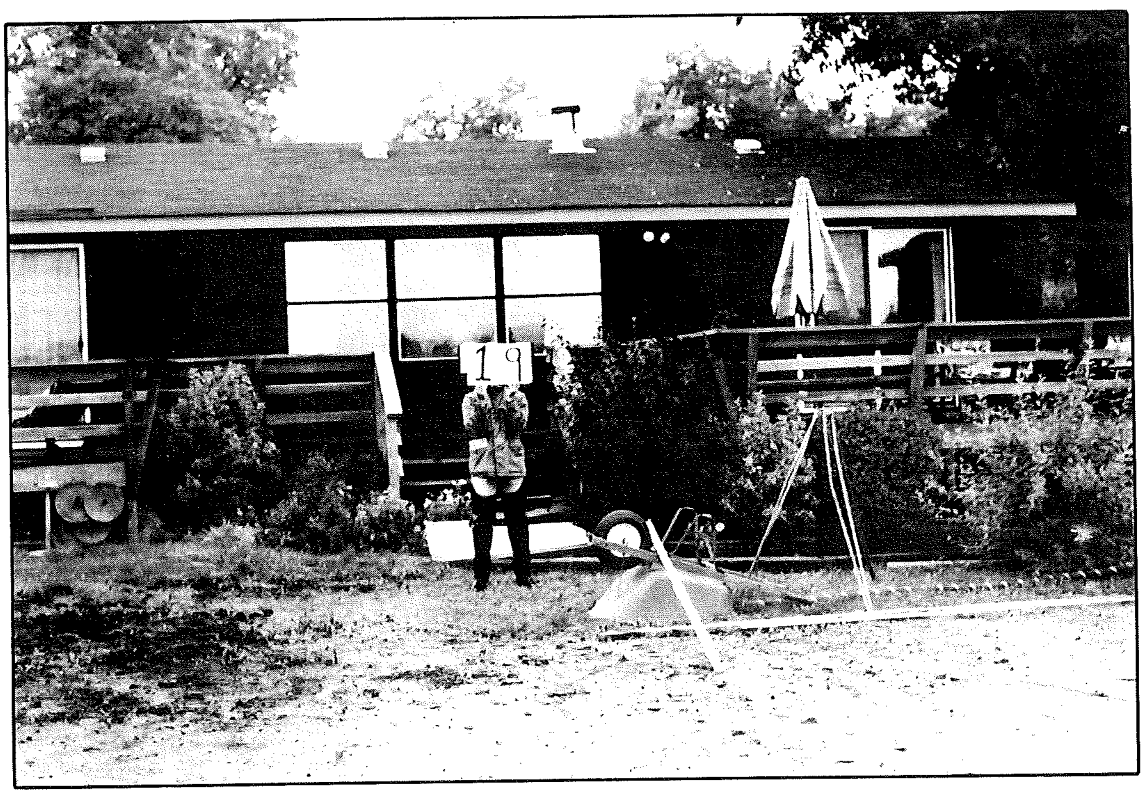
BEAVER LAKE STEARNS CO.

Structure Number :	19
Name :	Haselkamp, Robert C.
Address :	Rt. 1 Box 50 Kimball, Mn 55353-9712
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 11.
Walkout/1stFl Elev. :	1120.41
Ground Elevation :	1117.8
Basement :	YES
Walkout :	YES

Market Value

Buildings :	$38,300.00
Land :	$11,500.00
Total :	$49,800.00

Flood Insurance : NO



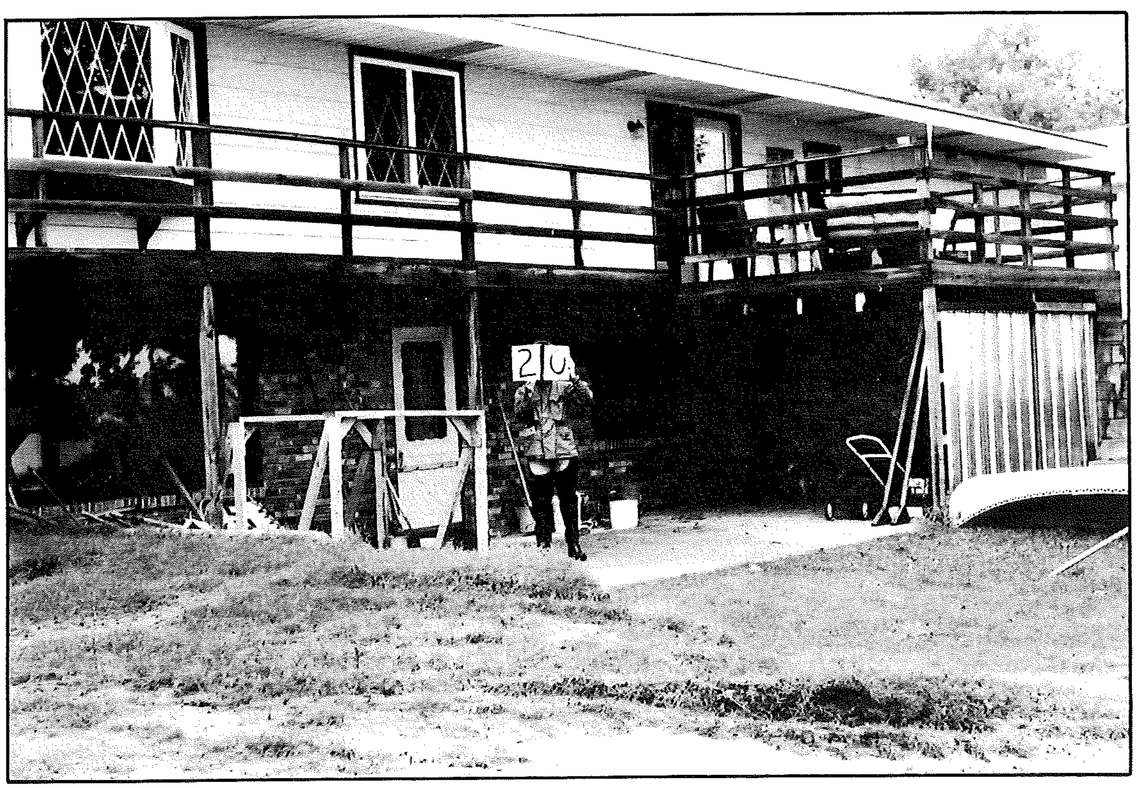
BEAVER LAKE STEARNS CO.

Structure Number :	20
Name :	Kunkel, Robert
Address :	Rt. 1 Box 51 Kimball, Mn 55353-9712
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 12.
Walkout/1stFl Elev. :	1117.22
Ground Elevation :	1117.0
Basement :	YES
Walkout :	YES

Market Value

Buildings :	$50,500.00
Land :	$17,300.00
Total :	$67,800.00

Flood Insurance : YES



BEAVER LAKE STEARNS CO.

Structure Number :	22
Name :	Renstrom, Gary A.
Address :	Rt. 1 Box 54 Kimball, MN 55353-9712
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 15.
Walkout/1stFl Elev. :	1118.30
Ground Elevation :	1117.9
Basement :	YES
Walkout :	YES

Market Value

Buildings :	$45,900.00
Land :	$11,500.00
Total :	$57,400.00

Flood Insurance : NO

BEAVER LAKE STEARNS CO.

Structure Number : 23
Name : Kirchoff, Jeffrey A.
Address : Rt. 1 Box 54 A
Kimball, Mn 55353

Legal Description : Sec. 31, Twp. 123, R. 28
Beaver Lake Park
Lot 16.

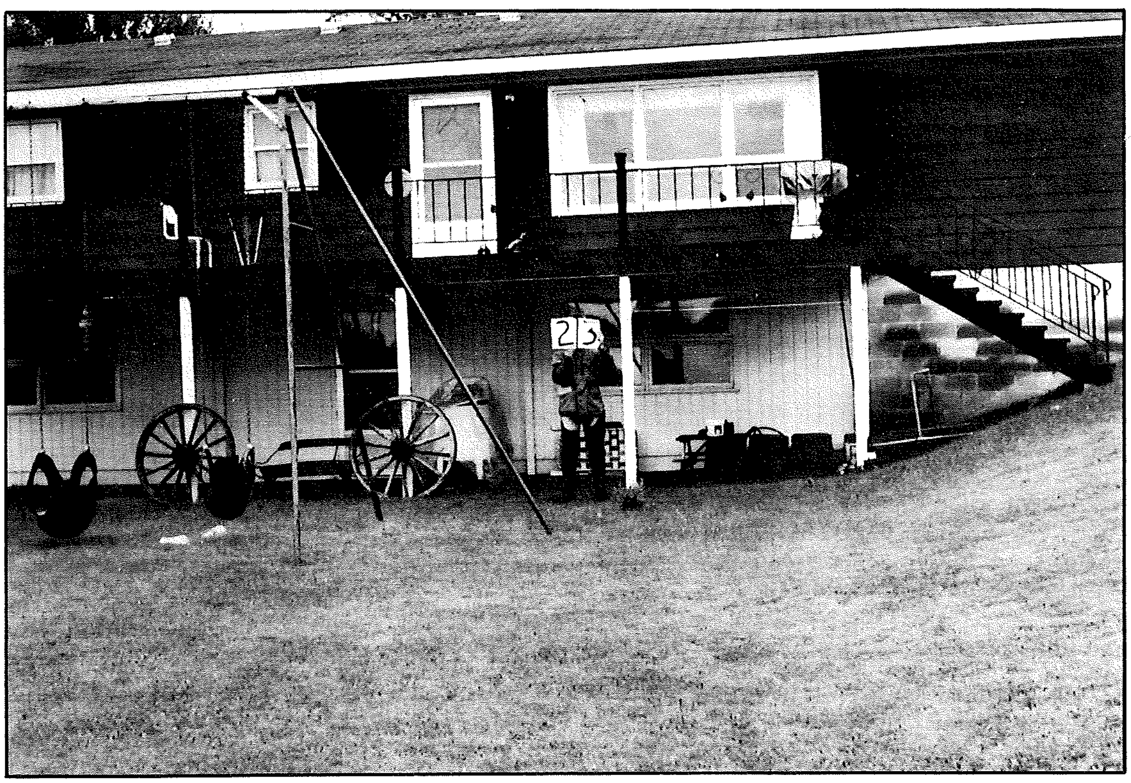
Walkout/1stFl Elev. : 1117.78
Ground Elevation : 1117.4

Basement : YES
Walkout : YES

Market Value

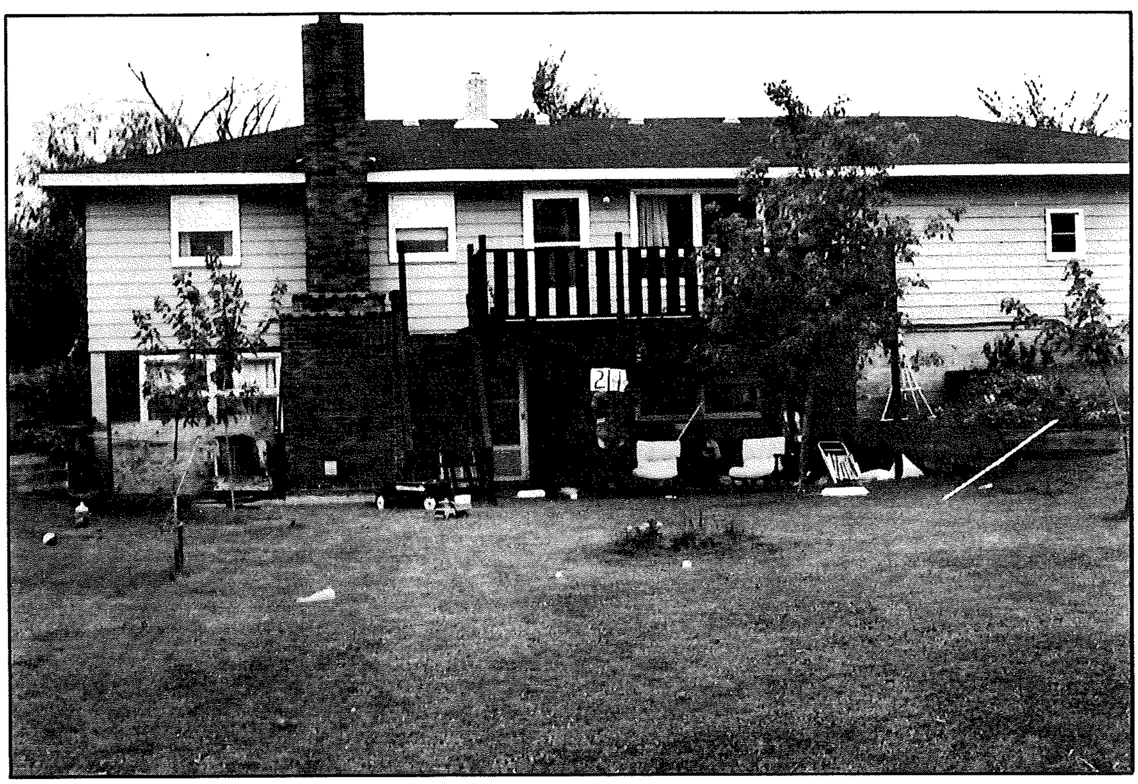
Buildings : $43,500.00
Land : $11,500.00
Total : $55,000.00

Flood Insurance : YES



BEAVER LAKE STEARNS CO.

Structure Number :	24	
Name :	Hammer, Steven J.	
Address :	Rt. 1 Box 54 A Kimball, MN 55353-9801	
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 17.	
Walkout/1stFl Elev. :	1116.75	
Ground Elevation :	1116.5	
Basement :	YES	
Walkout :	YES	
Market Value		
Buildings :		$43,500.00
Land :		$11,500.00
Total :		$55,000.00
Flood Insurance :	NO	



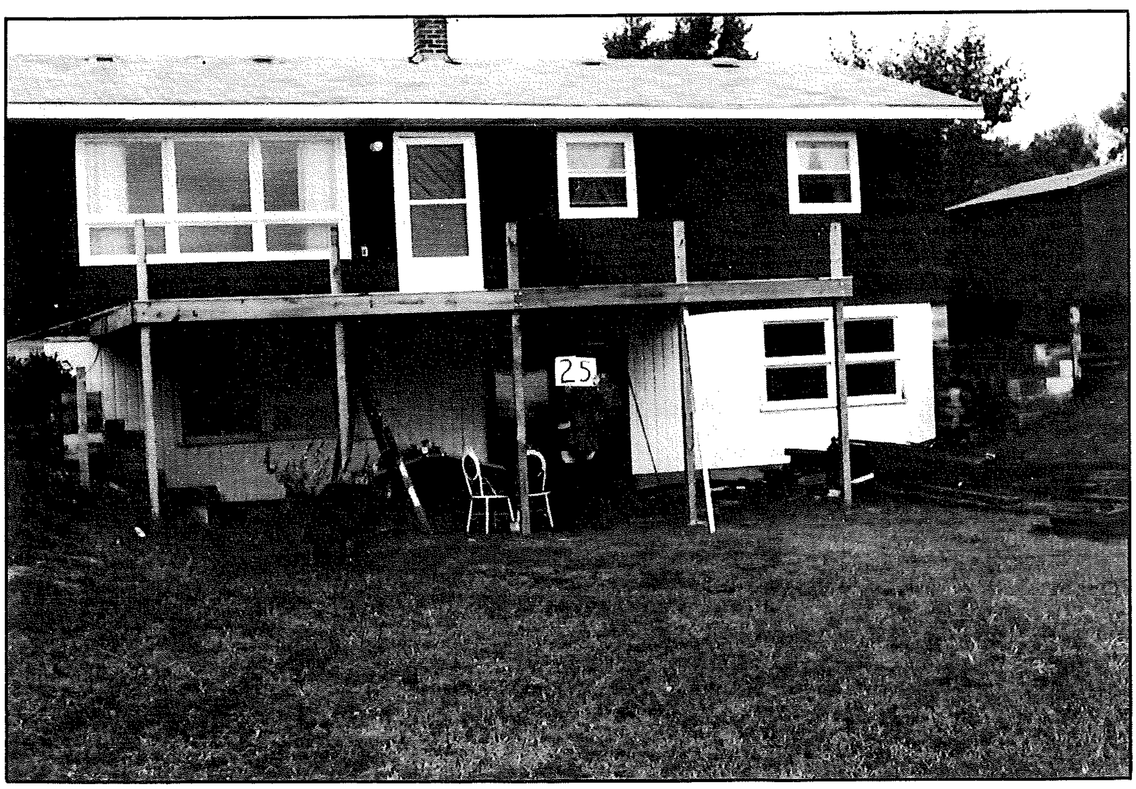
BEAVER LAKE STEARNS CO.

Structure Number :	25
Name :	Parker, Steven J.
Address :	Rt. 1 Beaver Lake Kimball, MN 55353-9801
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 18.
Walkout/1stFl Elev. :	1116.57
Ground Elevation :	1115.9
Basement :	YES
Walkout :	YES

Market Value

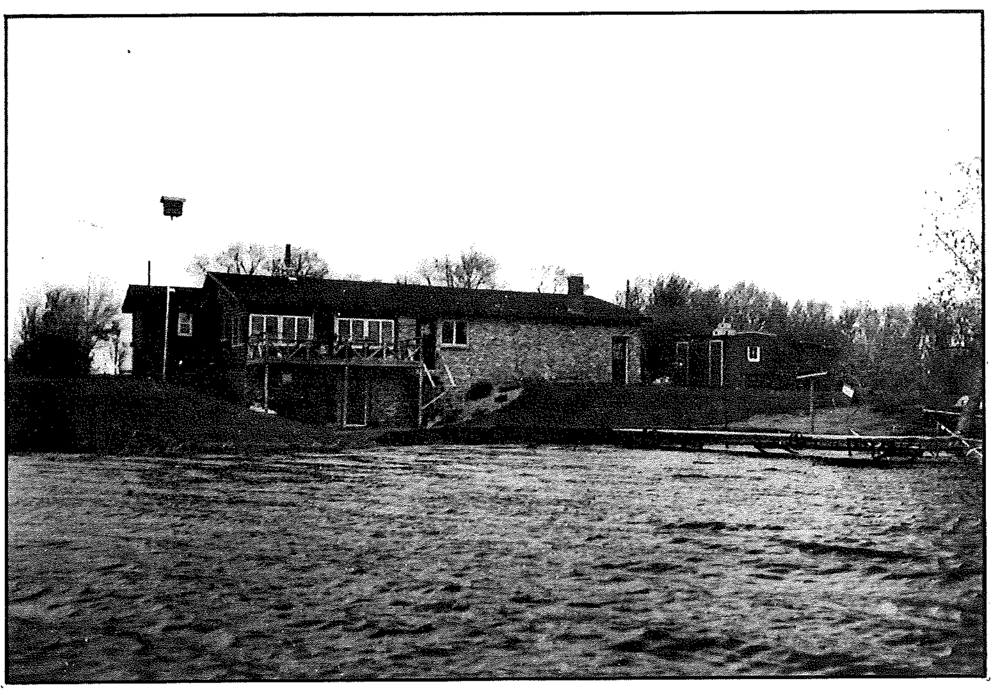
Buildings :	$44,600.00
Land :	$11,500.00
Total :	$56,100.00

Flood Insurance : NO



BEAVER LAKE STEARNS CO.

Structure Number :	26	
Name :	Mcstott, Bonnie	
Address :	Rt. 1 Box 55 C Kimball, MN 55353-9801	
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake park Lot 19.	
Walkout/1stFl Elev. :	1115.75	
Ground Elevation :	1115.6	
Basement :	YES	
Walkout :	YES	
Market Value		
Buildings :		$33,800.00
Land :		$16,500.00
Total :		$50,300.00
Flood Insurance :	NO	



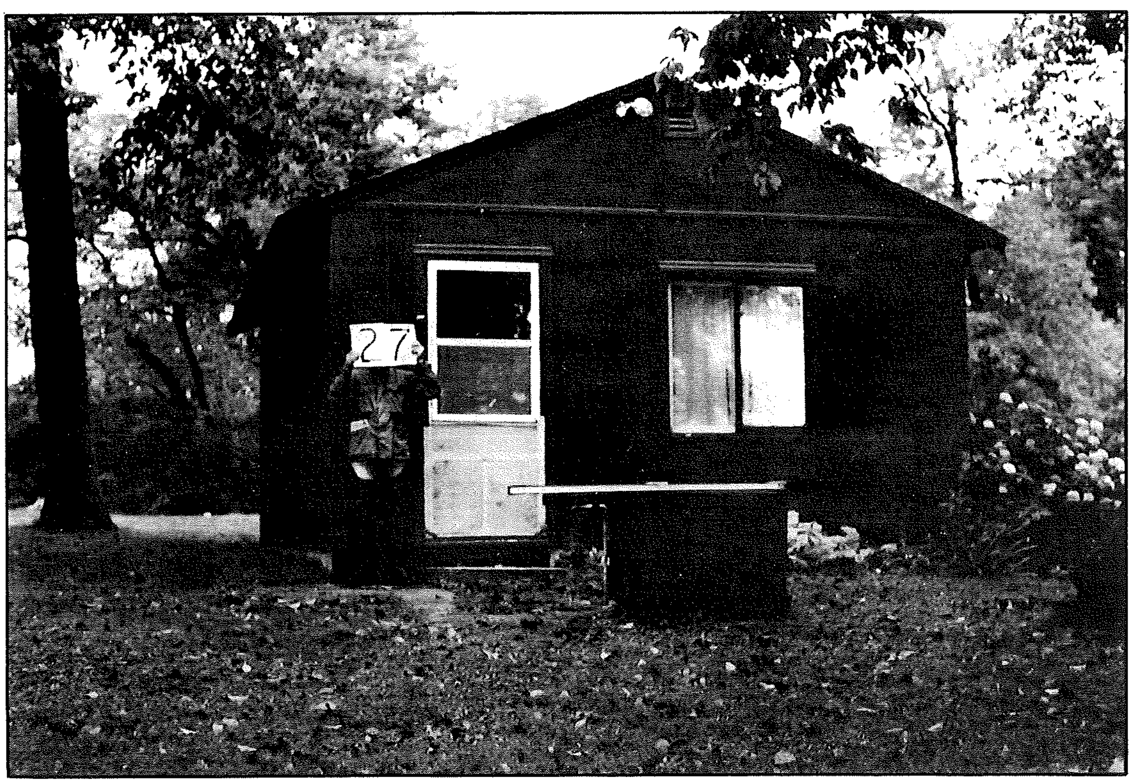
BEAVER LAKE STEARNS CO.

Structure Number :	27
Name :	Lommel, Gary
Address :	9220 Foxline Dr. Corcoran, MN 55340-9657
Legal Description :	Sec. 31, Twp. 123, R. 28 Beaver Lake Park Lot 8.
Walkout/1stFl Elev. :	1120.54
Ground Elevation :	1119.6
Basement :	NO
Walkout :	NO

Market Value

Buildings :	$4,400.00
Land :	$12,500.00
Total :	$16,900.00

Flood Insurance : NO



APPENDIX E

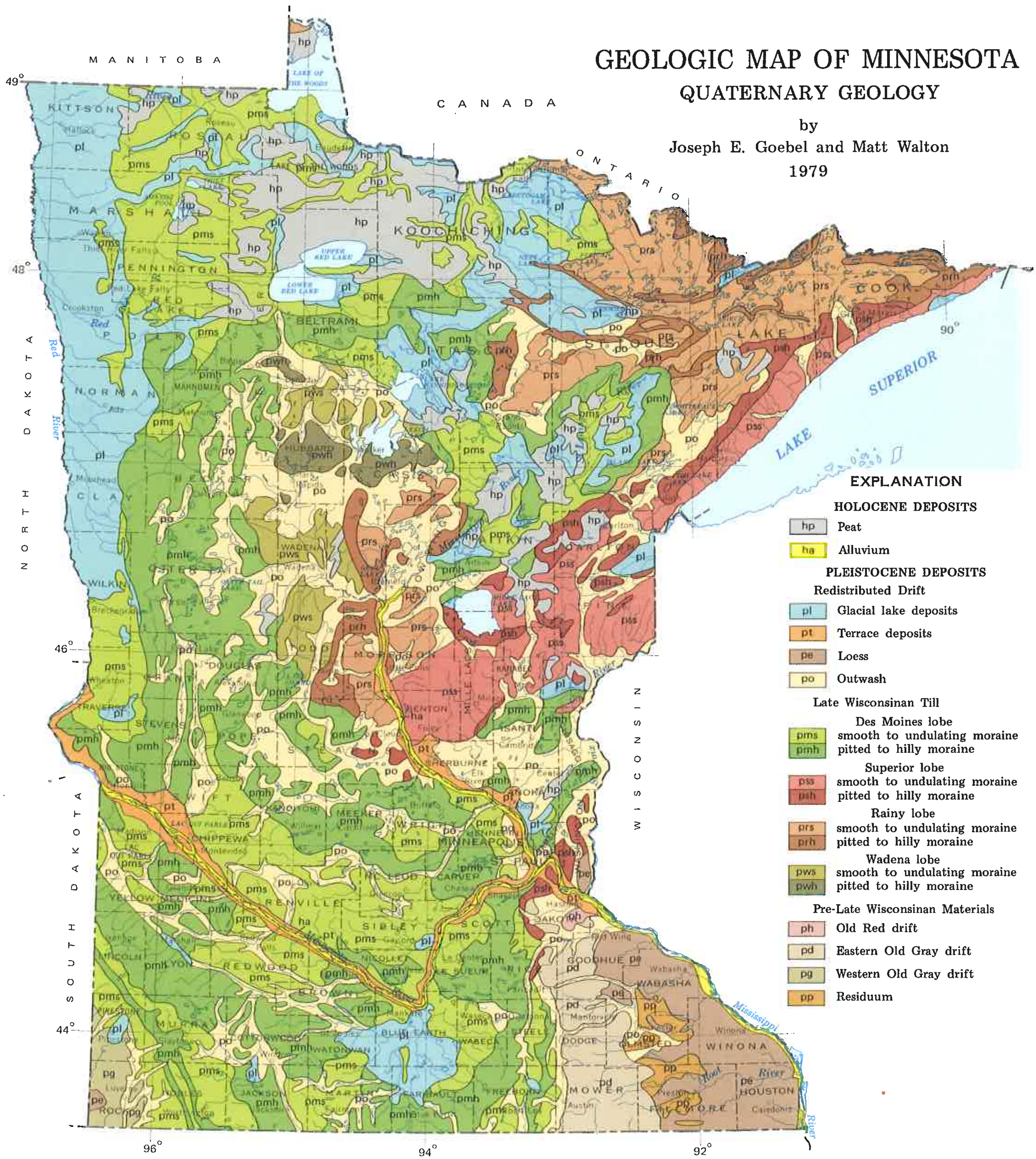
GEOLOGIC MAP OF MINNESOTA

Minnesota Geological Survey
University of Minnesota
Matt Walton, Director

GEOLOGIC MAP OF MINNESOTA

QUATERNARY GEOLOGY

by
Joseph E. Goebel and Matt Walton
1979



SCALE 1:3,168,000
1 inch = 50 miles

0 — 50 Miles
0 — 50 — 100 Kilometers

Published with the support of the Legislative Commission on Minnesota Resources

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 groundwater 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, streamflow 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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