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SUMMARY OF GREAT LAKES WEATHER AND ICE CONDITIONS, WINTER 1977-78

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Ann Arbor, Michigan
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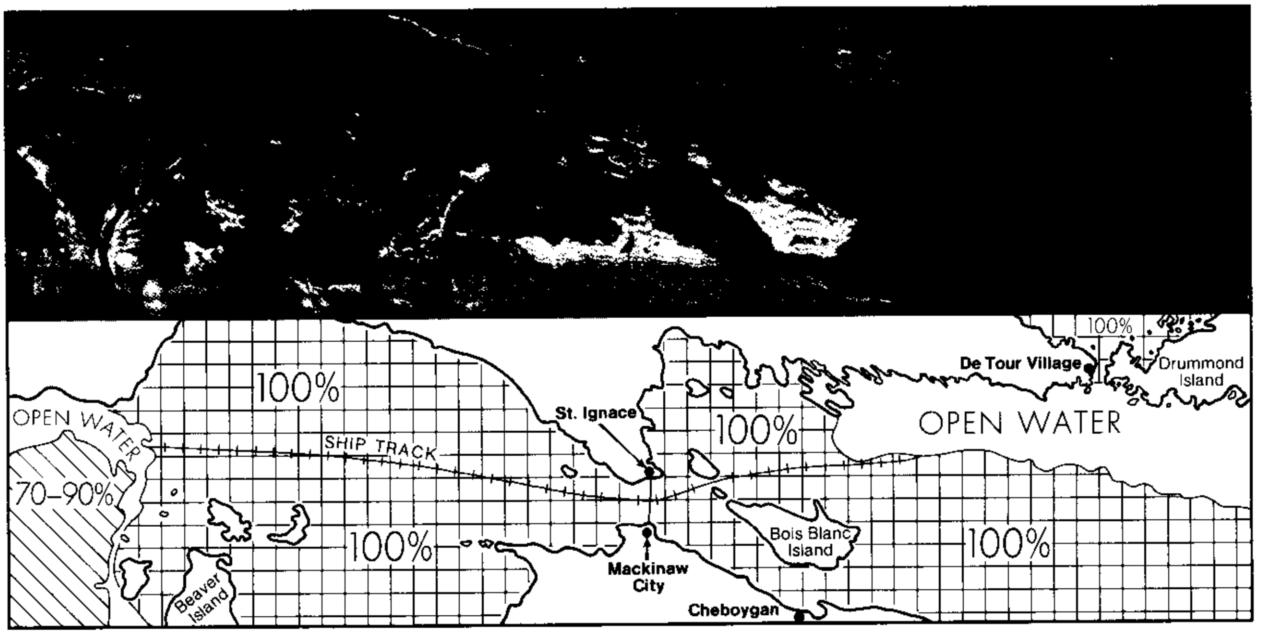
False color side Looking airborne radar image of Straits of Mackinac for February 21, 1978.



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December 1979

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SUMMARY OF GREAT LAKES WEATHER AND ICE CONDITIONS, WINTER 1977-78*

The winter of 1977-78 was the 12th coldest since 1850. The north-westerly flow aloft during this winter directed anticyclonic centers to the west and south of the Great Lakes Region, bringing the greatest negative air temperature departure from normal ever recorded on the southern lakes. Ice began forming in the shallows of the Great Lakes in late November. Lake St. Clair was virtually frozen over by early January. The remainder of the Great Lakes neared maximum areal ice extent from mid-February to early March: Lake Superior was 82 percent ice covered, Lake Michigan 52 percent, Lake Huron 89 percent, Lake Erie 100 percent, and Lake Ontario 57 percent. Spring breakup began in mid-March. The bulk of the ice was gone by April 26, but ice was observed as late as May 11 in eastern Lake Erie.

A shipping strike in fall 1977, combined with an early winter, provided the catalyst to create massive traffic tie-ups in the St. Lawrence Seaway in December. A total of 138 shipping companies participated in extended season operations, and shipping on the upper lakes continued throughout the season without interruption. The demands placed on Coast Guard icebreakers were the greatest ever, and total cargo tonnage assisted was about double the previous season.

1. INTRODUCTION

R. A. Assel

This report on the 1977-78 winter weather and ice conditions is the second coordinated report to combine the activities of the various NOAA components responsible for monitoring Great Lakes ice conditions. The participating units are the National Weather Service (NWS), the Environmental Research Laboratories, and the National Environmental Satellite Service (NESS). In addition, part of the ice-cover data was analyzed by DeWitt and Associates under NOAA Contract No. 03-79-B01-105.

Most geographic locations referenced in this report are shown in figure 1. The winter of 1977-78 marked the second year of below-normal temperatures and extensive ice covers on the lakes. Ice began forming in the shallow areas of the Great Lakes in late November. Maximum areal ice extent on individual Great Lakes occurred between mid-February and the first week in March. On Lakes Superior, Huron, and Erie maximum ice extent in 1977-78 was about the same as it had been in the benchmark winter of 1976-77. On Lake Michigan ice cover was much less in 1977-78 than it had been in 1976-77. However, on Lake Ontario the ice this winter was more extensive than during any of the previous 15 winters. The spring breakup period began in mid-March, and by the end of April the bulk of the ice was gone from the lakes.

*GLERL Contribution No. 206.

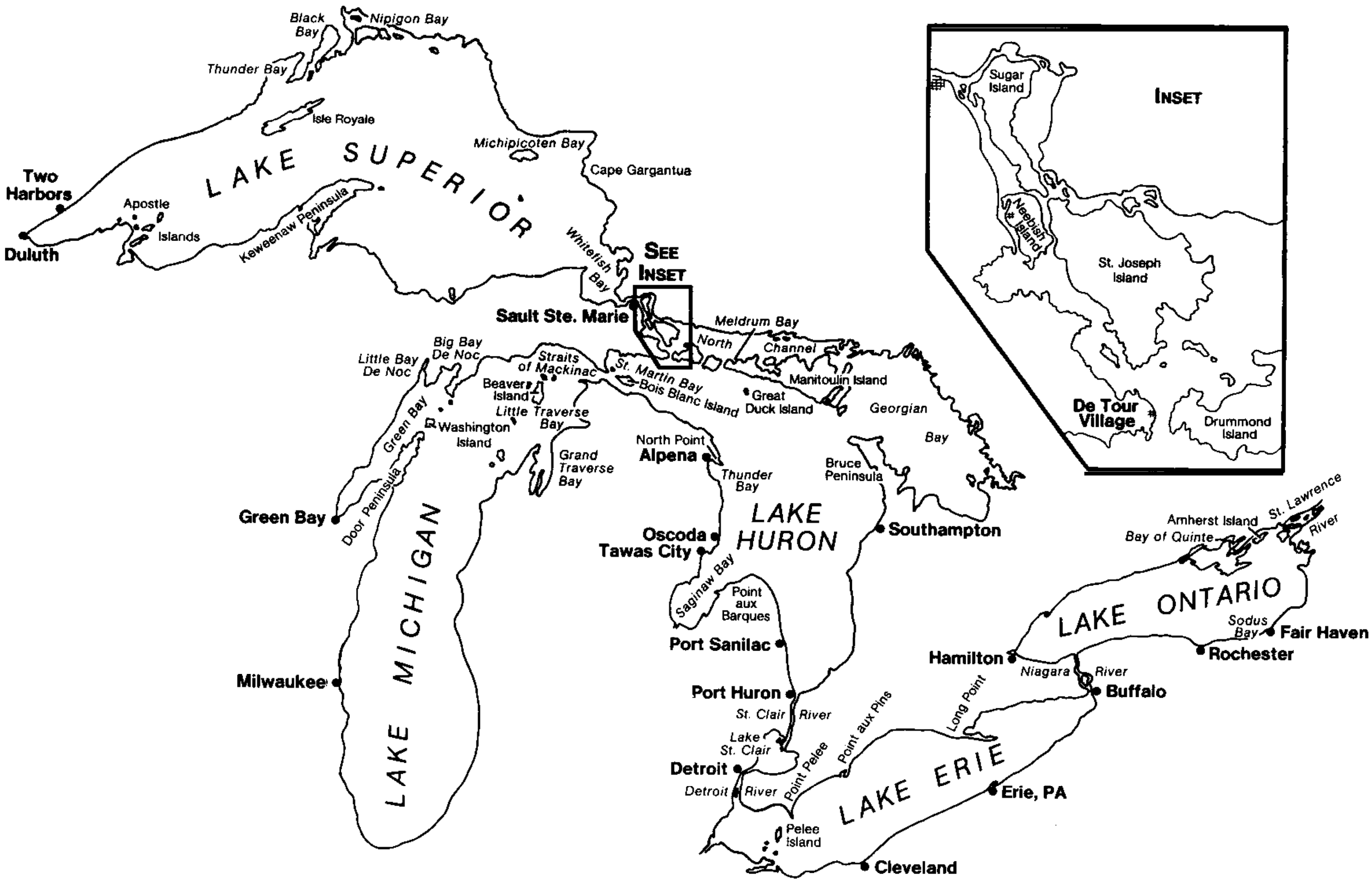

Figure 1.--Geographic location chart for the Great Lakes.

Supplementary wind data, synoptic surface weather charts, and lake bottom topography charts are given in the appendices of this report so that the reader can better understand the bathymetric and meteorological factors affecting ice cover on the Great Lakes.

Winter shipping activity reached a new record as 138 shipping companies participated in the extended navigation season and the total tonnage of vessels assisted by the Coast Guard increased by 50 percent over the old record set the previous winter. Shipping continued on the upper lakes throughout the winter.

2. SUMMARY OF METEOROLOGICAL CONDITIONS

F. A. Keyes

2.1 Synoptic Study of the Winter

Winter 1977-78 will go into the record books as one of the coldest across the southern lakes region, owing in large part to an extremely cold February. Monthly mean temperatures were progressively farther below normal throughout the winter across the majority of the Great Lakes, with maximum departures in February (table 1).

The upper air pattern for winter 1977-78 was very similar to that of the previous winter. That winter a large area of intense cyclonic activity persisted over the Pacific Ocean and a strong ridge was nearly stationary over Western North America, creating blocking highs over the Canadian Arctic. The differences this winter were: (1) the ridge was a little further north and east; (2) there was a strong subtropical jet across the Southern United States and Northern Mexico as compared to a weak subtropical jet during winter 1976-77; and (3) when short waves moved through the ridge at intervals of approximately 5 days, they moved eastward and intensified the long wave trough just to the east of the Great Lakes Region (figs. 2*a*-2*e*).

Before November 1977, there was little indication of how severe the winter was going to be. The 3 preceding months had averaged below normal, but no definite cooling pattern had been set. Cold, below-normal temperatures moved into the lake region in late November, with readings (degrees Fahrenheit) falling below zero across the upper lakes and into the teens across the lower lakes. Following this cold snap, temperatures moderated through mid-December as a series of low-pressure centers and areas of high pressure of Pacific origin moved across the region. Temperatures fluctuated below and above normal over all the area until the second week in January. Some sub-zero (degrees Fahrenheit) readings were reported over the upper lakes region around Christmas and New Year's Day. Then on the 15th and 16th of January, a strong cold front moved through. This was followed by a large area of Arctic high pressure, which moved southeastward out of Saskatchewan and drifted south of the Great Lakes.

Table 1.--*Monthly mean temperature departures from normal (°C)*

Station	November	December	January	February	March	April	Mean
Thunder Bay, Ont.	1.1	-0.6	-1.8	-1.1	-0.4	-0.7	-0.6
Duluth, Minn.	-0.2	-1.7	-1.8	-0.9	1.2	-0.2	-0.6
Marquette, Mich.	0.4	-0.8	-0.3	-0.6	0	-1.6	-0.5
Sault Ste. Marie, Mich.	0.8	-0.2	-1.9	-2.3	-1.7	-1.7	-0.5
Lake Superior Basin	0.5	-0.8	-1.4	-1.2	-0.2	-1.1	-0.7
Green Bay, Wis.	-0.4	-1.6	-2.3	-3.8	-1.9	-1.9	-2.0
Milwaukee, Wis.	0.3	-0.8	-2.2	-3.4	-0.9	-1.2	-1.4
Chicago, 111.	0.1	-2.1	-4.7	-5.9	-2.4	-1.1	-2.7
Muskegon, Mich.	0.2	-1.3	-2.5	-4.9	-1.9	-0.3	-1.8
Lake Michigan Basin	0.05	-1.4	-2.9	-4.5	-1.8	-1.2	-2.0
Alpena, Mich.	-0.1	-0.6	-0.9	-2.3	-0.9	-2.4	-1.2
Detroit, Mich.	0.2	-1.7	-2.8	-5.7	-2.9	-1.2	-2.4
Lake Huron Basin	0.05	-1.2	-1.8	-4.1	-1.9	-1.8	-1.8
Toledo, Ohio	0.8	-1.8	-4.5	-8.5	-4.0	-1.5	-3.3
Cleveland, Ohio	2.1	-0.6	-3.8	-6.2	-2.1	-0.7	-1.9
Buffalo, N.Y.	1.9	-0.05	-1.8	-4.9	-2.2	-1.3	-1.4
London, Ont.	0.6	-0.6	-2.8	-6.1	-4.1	-1.6	-2.4
Lake Erie Basin	1.3	-0.8	-3.2	-6.4	-3.1	-1.2	-2.2
Toronto, Ont.	1.1	-0.1	-2.3	-1.7	-1.1	-0.9	-0.8
Rochester, N.Y.	1.7	0.05	-0.6	-4.8	-1.8	-1.4	-1.1
Lake Ontario Basin	1.4	-0.05	-1.4	-3.3	-1.4	-1.2	-1.0

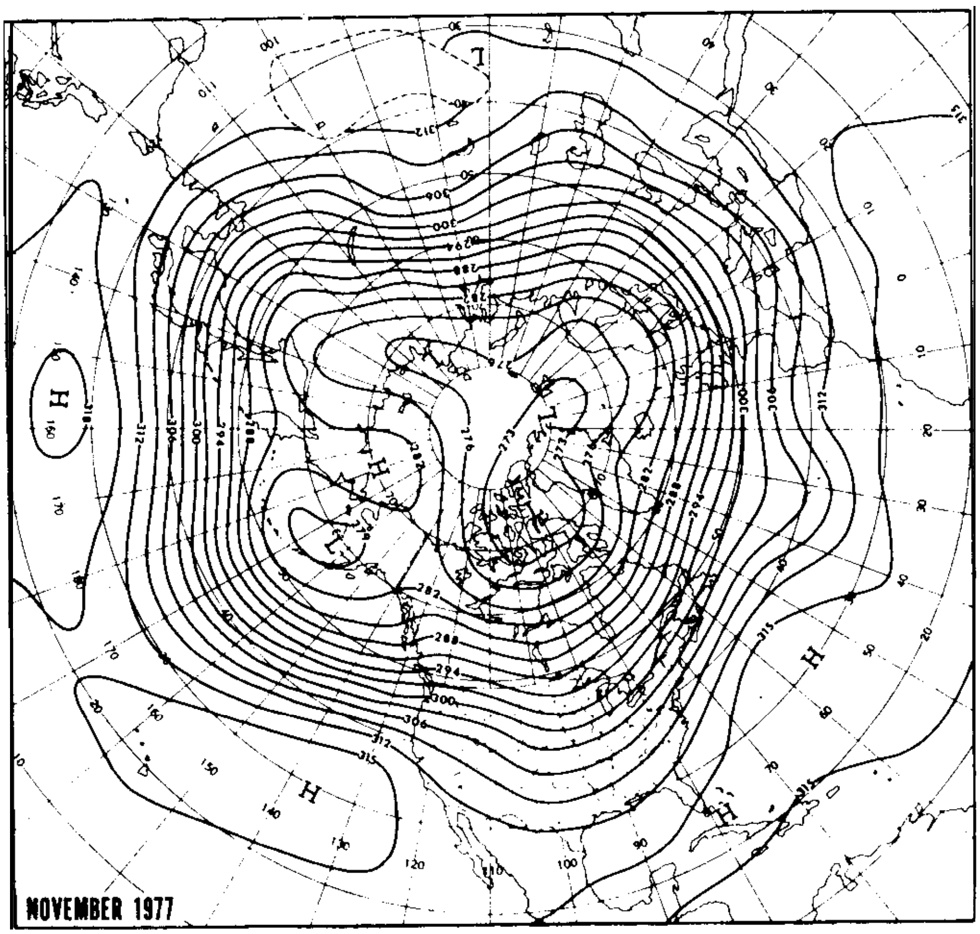

Figure 2a.--Mean 700 mb contours for November 1977.

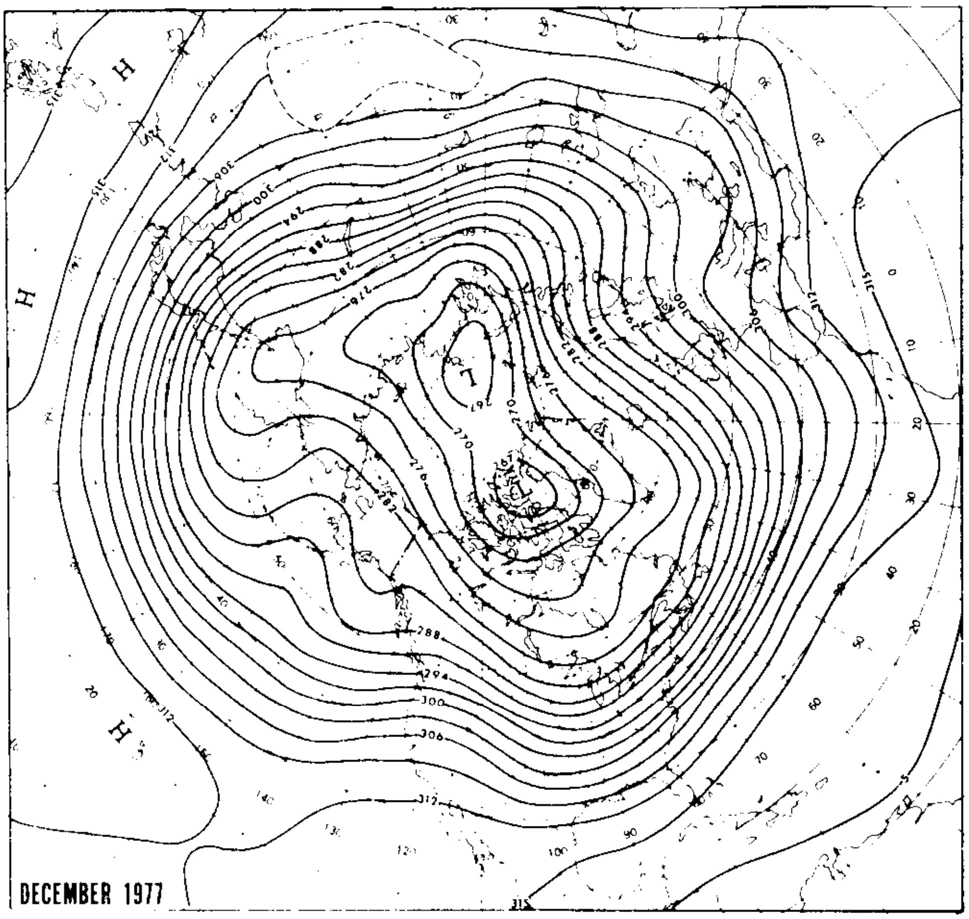

Figure 2b.--Mean 700 mb contours for December 1977.

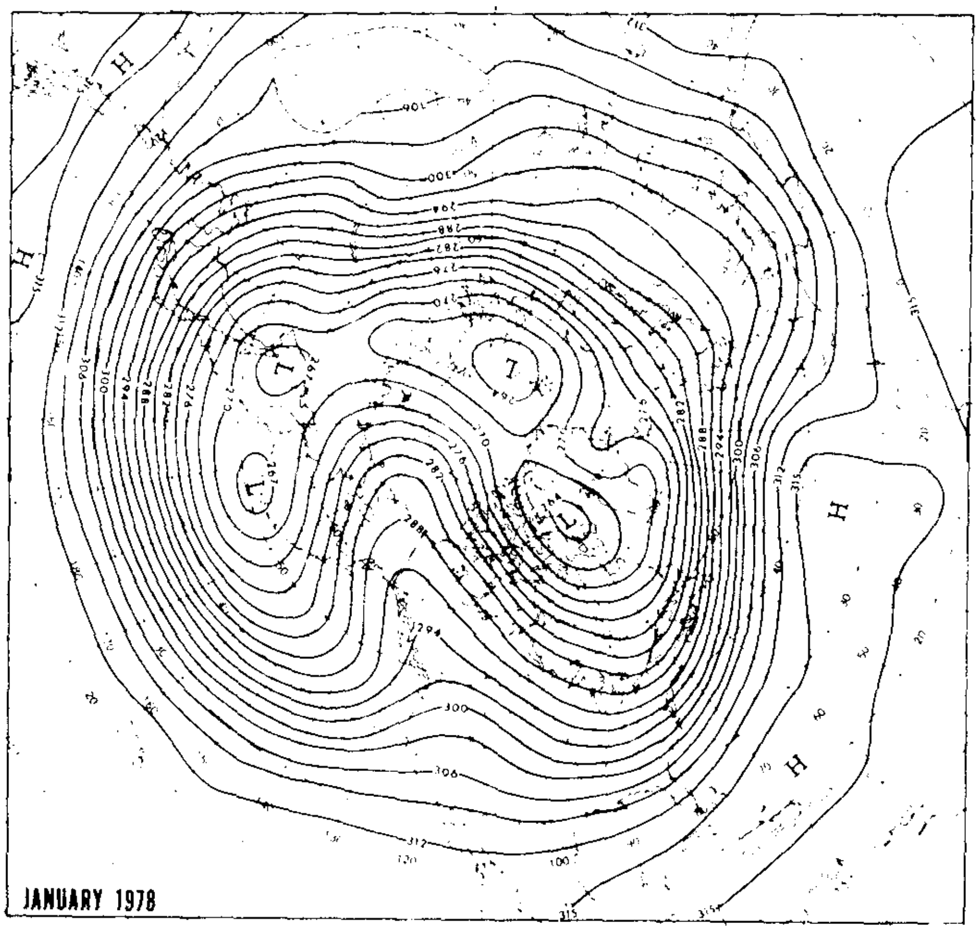

Figure 2c.--*Mean 700 mb contours for January 1978.*

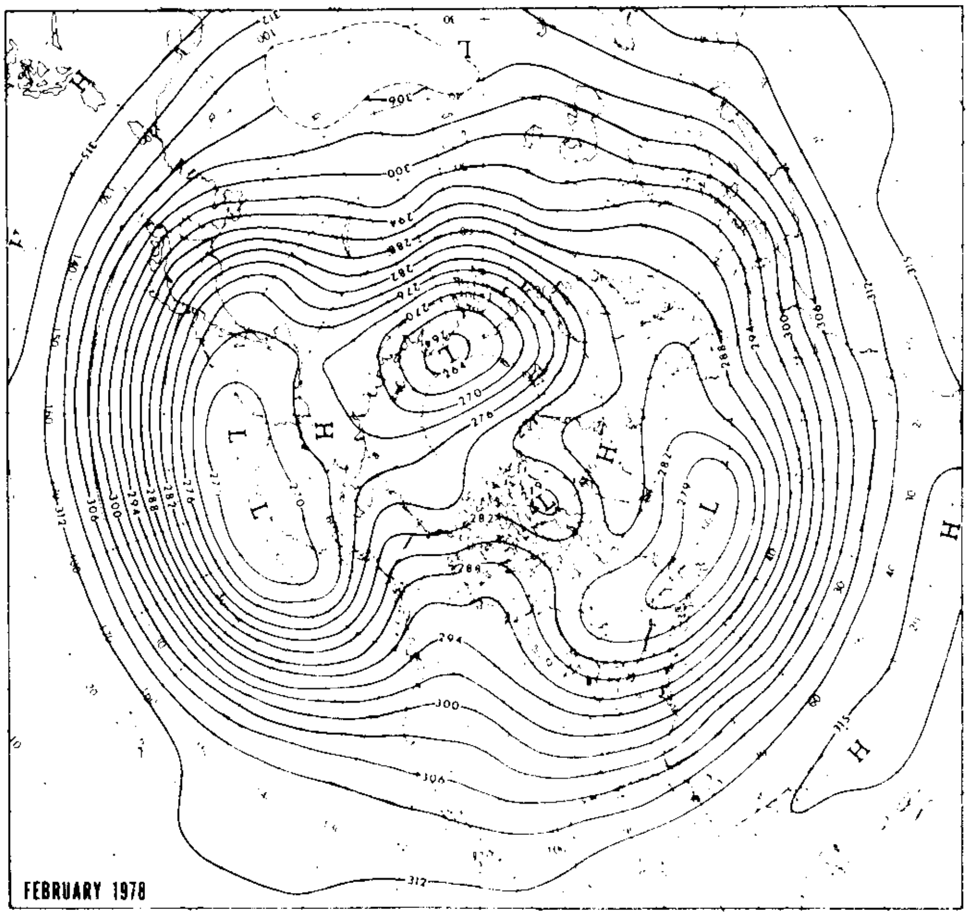

Figure 2d.--*Mean 700 mb contours for February 1978.*

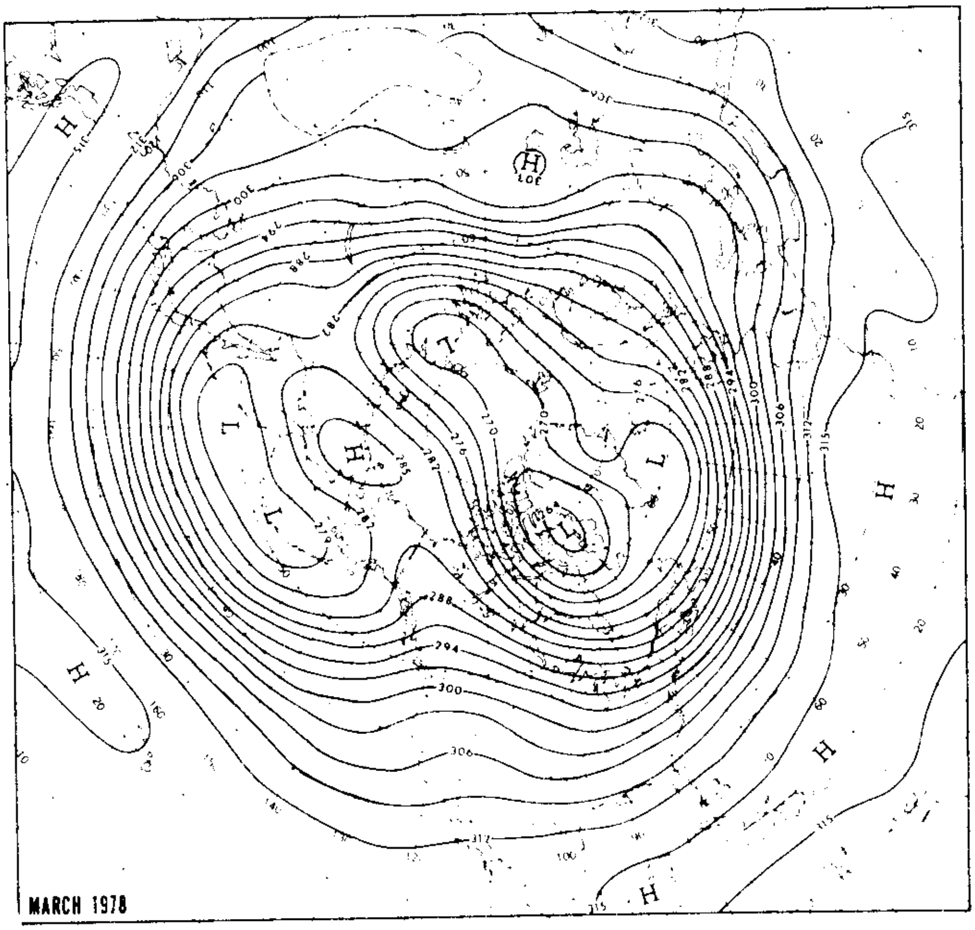

Figure 2e.--*Mean 700 mb contours for March 1978.*

Since the Great Lakes are relatively warm compared to the overlying air during winter, they provide a large heat source, which readily modifies wintertime air masses. As the cold air moves across the lakes, it is rapidly warmed and moistened and its pressure lowered. For this reason, very few cold high-pressure centers pass directly over the lakes. This year, the northwesterly flow aloft directed the majority of the high centers to the west and south of the Great Lakes Region, thus bringing the greatest negative departure from normal to the southern lakes region.

On the 25th and 26th of January, a major winter storm moved northeastward over the western lower lakes, bringing blizzard conditions to the majority of the Great Lakes. This storm was the worst blizzard on record in the Ohio Valley. The lowest pressure reported was 957.6 mb (28.28 inches) at Cleveland, Ohio. Lowest sea level pressure records were recorded by dozens of cities in the Ohio Valley and the Great Lakes Region, for example Detroit, Mich., [959.7 mb (28.34 inches)] and Toledo, Ohio [964.8 mb (28.49 inches)].

Wind gusts approached hurricane force over a wide area and exceeded it near the storm center. Cleveland recorded a record peak of 71 kn and Erie, Pa., 67 kn. Accompanying these strong winds were very cold temperatures and snow, which resulted in severe wind chill factors and mountainous drifts that paralyzed transportation for days.

This storm was followed by another series of cold Arctic high-pressure areas that drifted to the north and south of the lakes region through the first 3 weeks of February. These cold highs kept temperatures across the Great Lakes well below normal over the majority of the region. Monthly temperature departures of 4.4°-6°C (7.9°-10.8°F) below normal were common, with Toledo reporting a departure of -8.5°C (-15.3°F) for the month. (See table 1.)

During late February and early March the upper atmospheric ridge over the West Coast began to flatten out and this allowed Pacific air to reach the lakes region. Although temperatures remained below normal during March over most of the area, the cold regime that had been holding over the Great Lakes was replaced by moderating temperatures, which allowed readings to return to 0°-7°C (30's and 40's°F).

2.2 Freezing Degree-Days (FDD's)

The concept of degree-day accumulations is useful in forecasting a wide range of phenomena: the use of heating fuel, the maturation of crops, etc. The growth of freshwater ice is closely correlated with accumulation of freezing degree-days (FDD's) (Richards, 1963; Snider, 1974; and Assel, 1976). Calculations of FDD's are sensitive to minor changes in computational procedures, especially in the southern lakes region. The method used in this report is to begin accumulating FDD's on the first day on which one or more FDD's occur (a mean temperature of less than 0°C). For example on a day with a mean temperature of -3°C, 3 FDD's are accumulated, and on a day with a mean temperature of +2°C, -2 FDD's are accumulated. FDD's continue to accumulate throughout, the winter. If at any time the running sum of FDD's becomes negative, the accumulation begins again when the next FDD occurs.

Figures 3*a*-3*l* show comparisons of long term normal FDD curves (solid lines) versus the winters of 1976-77 (light dashed line) and 1977-78 (heavy dashed lines) at 12 Great Lakes cities. Table 2 gives maximum FDD's accumulated for the 1976-77 and 1977-78 winters.

2.3 Comparison With Previous Winters

In order to be able to compare winters across the Great Lakes, Snider (in Quinn et *al.*, 1978) developed a winter severity index. This index comprises the mean temperatures for November through February and for Duluth, Minn.; Sault Ste. Marie, Mich.; Detroit, and Buffalo, N.Y. The mean temperatures are averaged together to obtain a single number.

Table 3 gives a listing of the 12 coldest winters since 1850. Each winter is characterized as late (L), intermediate (I), or early (E), according to the timing of its coldest period. In 8 of the 12 winters the coldest part of the winter occurred in February; in 3 the cold weather was evenly distributed throughout the winter; and in only 1 did the major part of the cold weather come in the first part of the winter. The winter of 1977-78 was the 12th coldest since 1850. with the coldest part of the winter occurring during February.

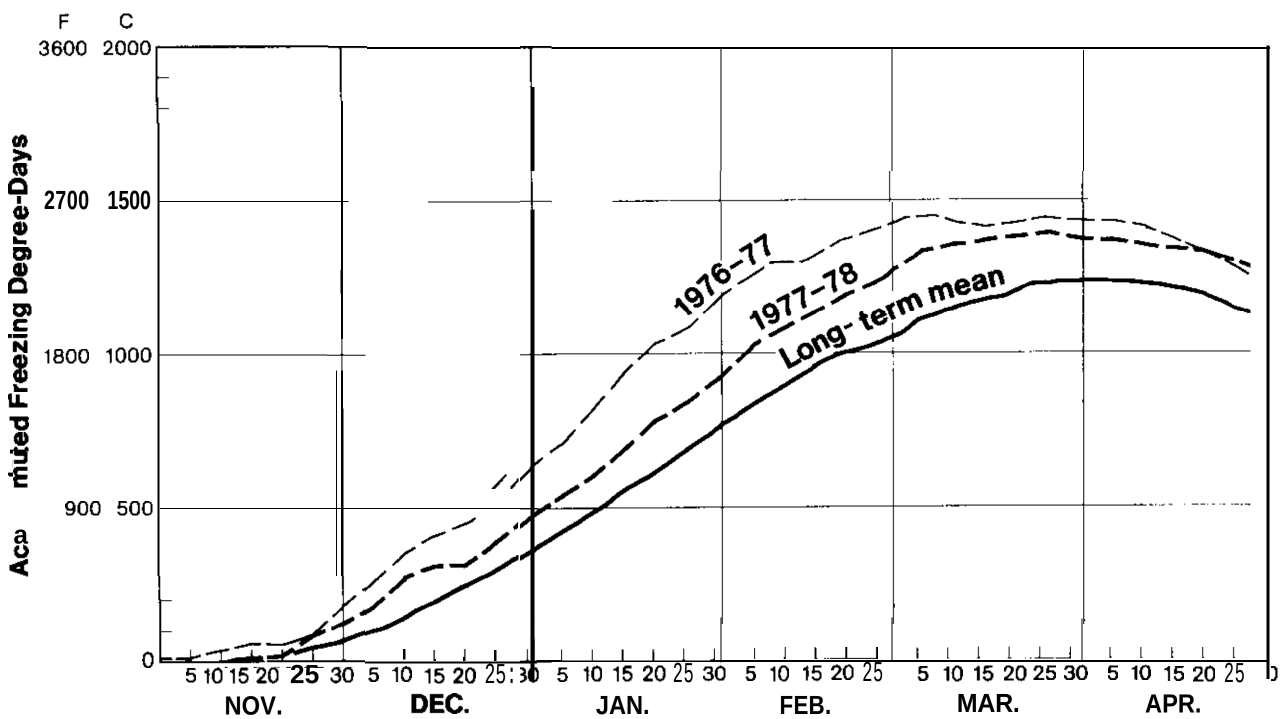

Figure 3*a*.--*Freezing degree-day accumulations, Duluth, Minn.*

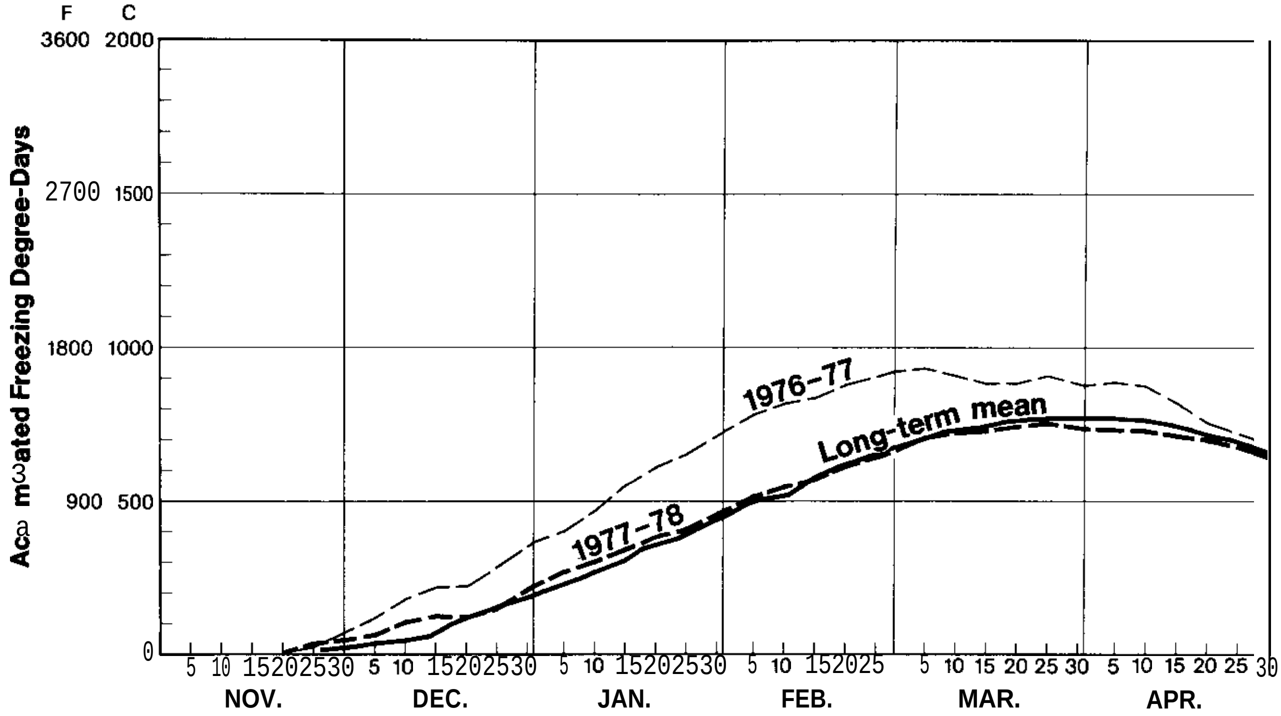

Figure 3b.--Freezing degree-day accumulations, Marquette, Mich.

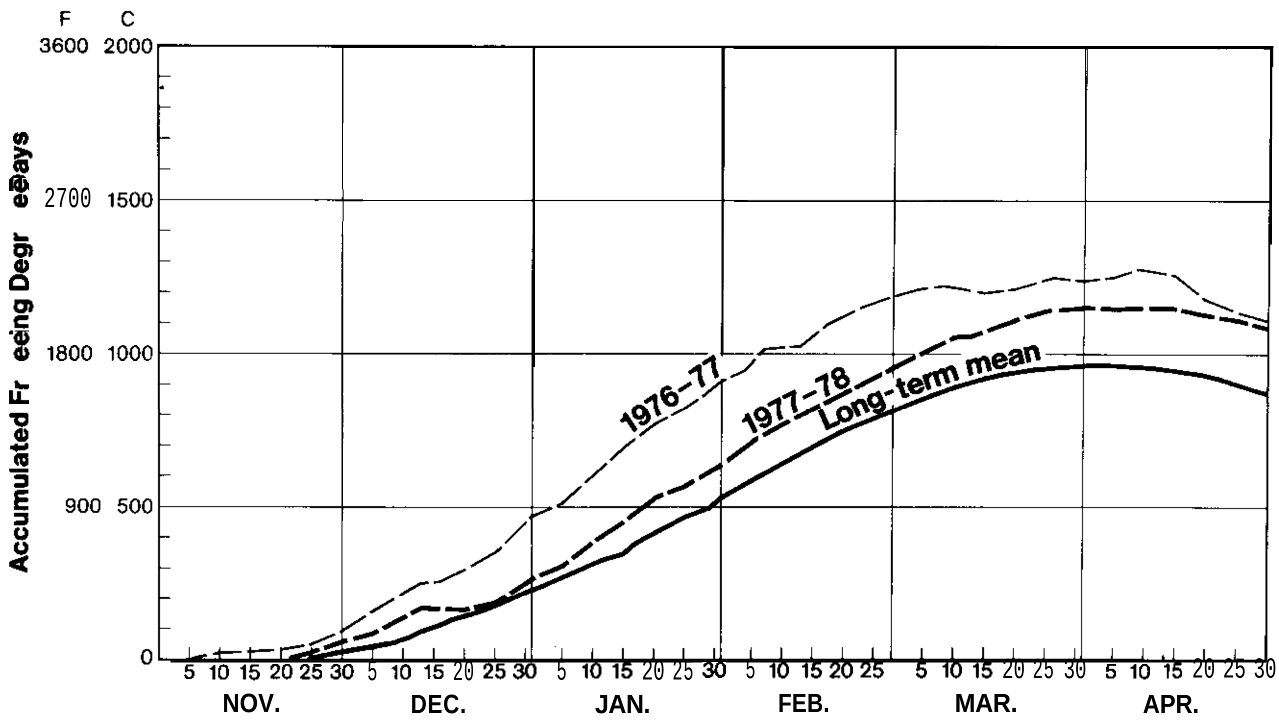

Figure *k--Freezing degree-day accumulations, Sault Ste. Marie, Mich.*

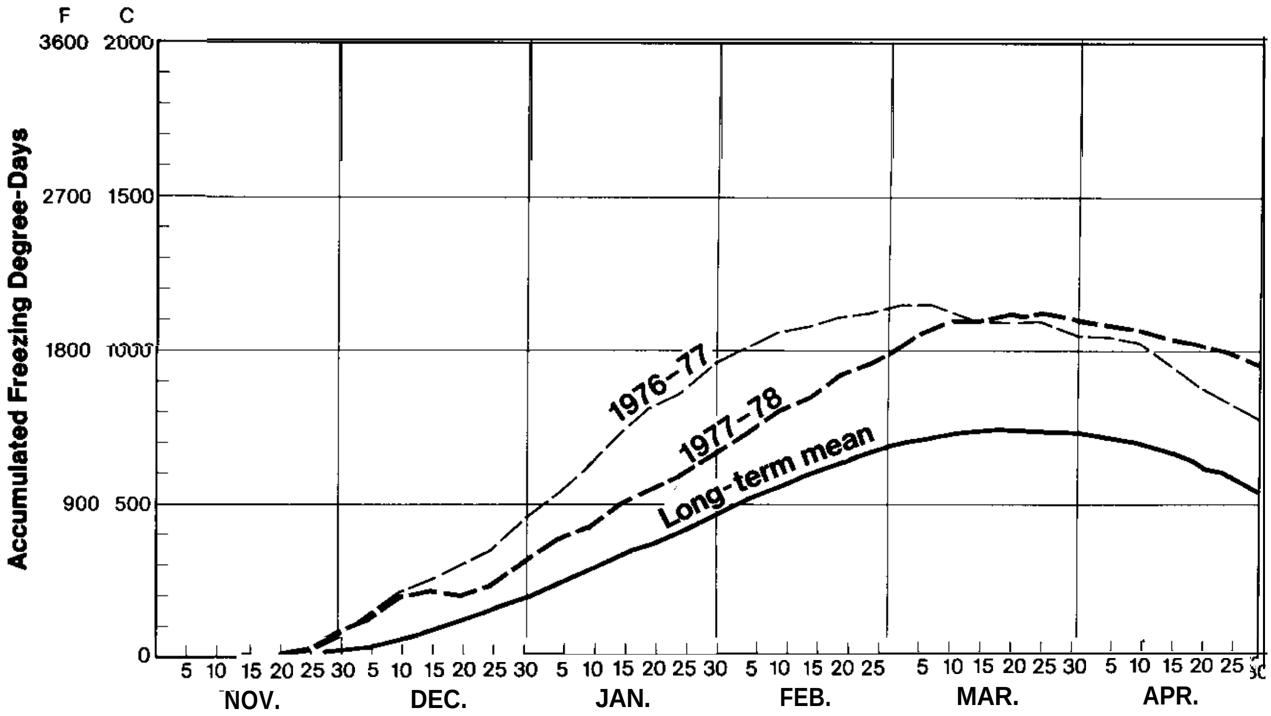

Figure 3d.--*Freezing degree-day accumulations, Green Bay, Wis.*

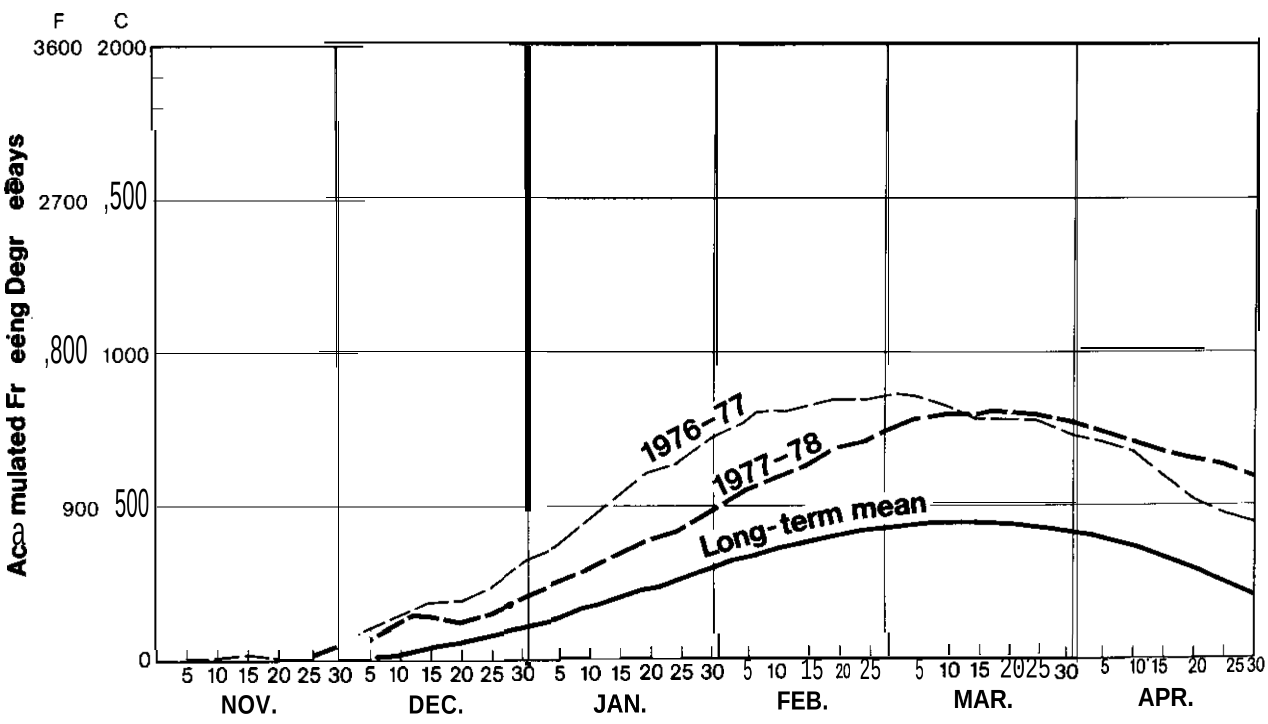

Figure 3e.--*Freezing degree-day accumulations, Milwaukee, Wis.*

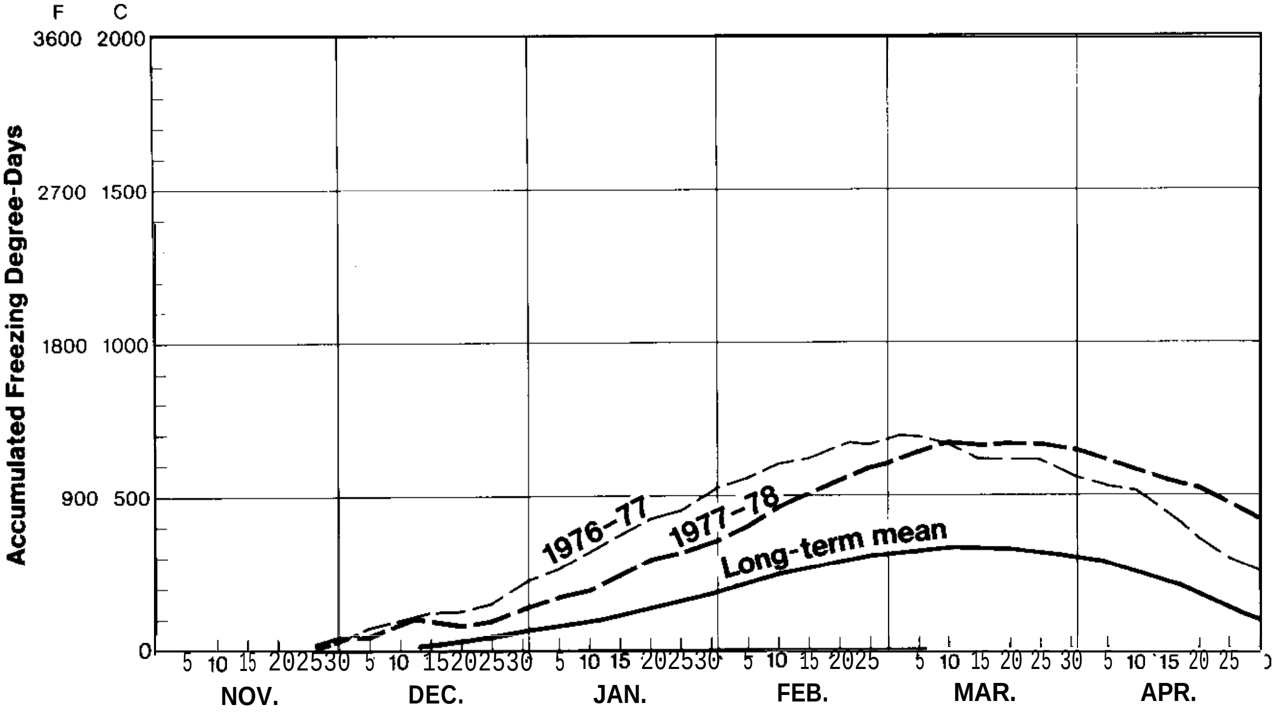

Figure 3*f*.--*Freezing degree-day accumulations, Muskegon, Mich.*

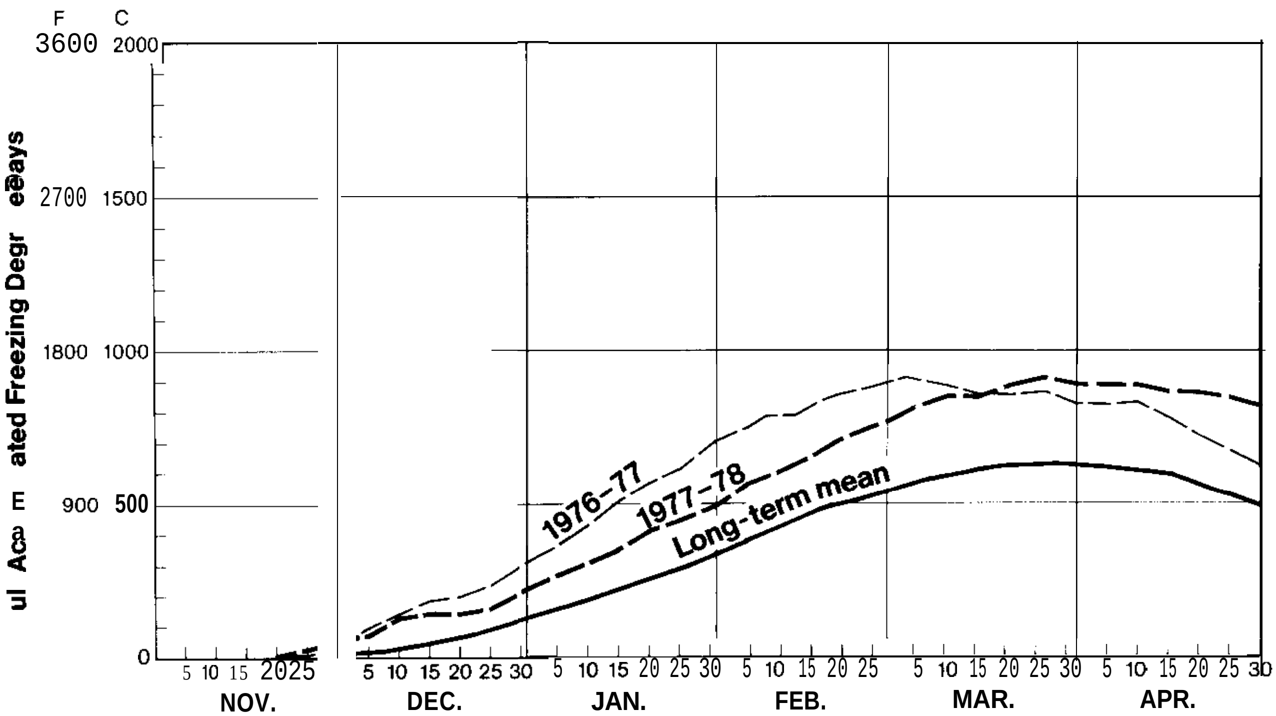

Figure 3*g*.--*Freezing degree-day accumulations, Alpena, Mich.*

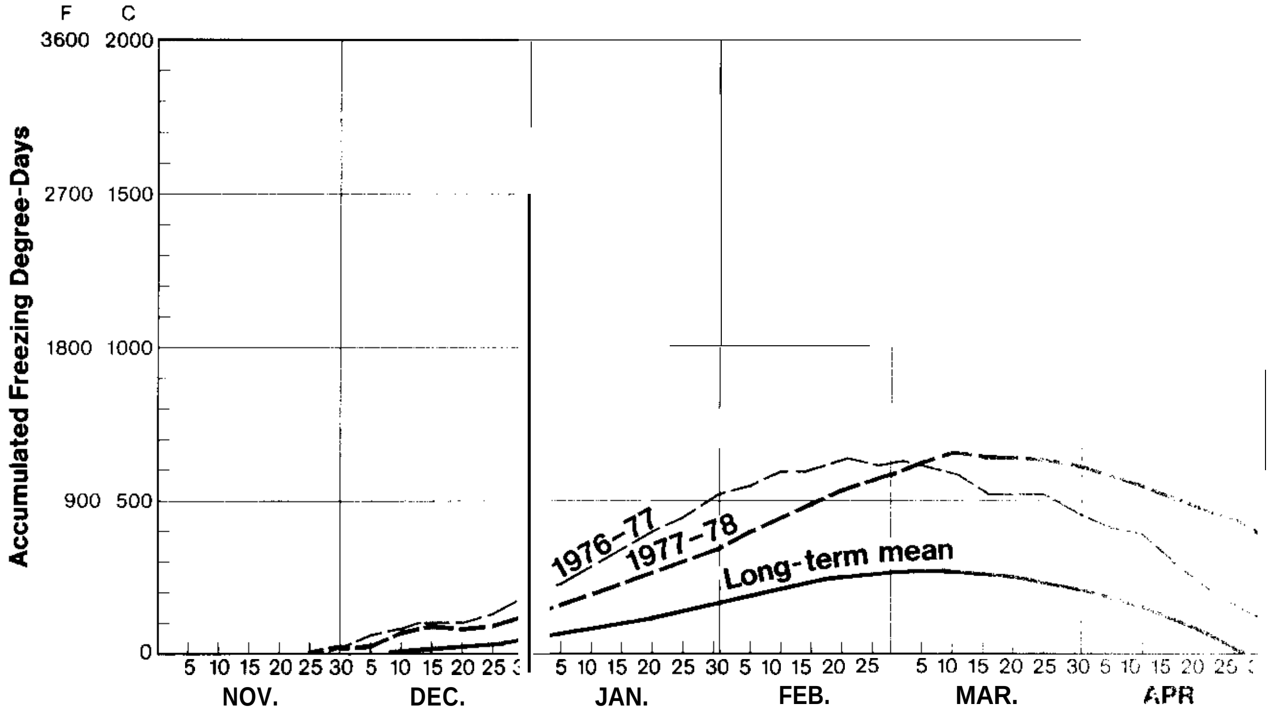

Figure 3h.--*Freezing degree-day accumulations, Detroit, Mich*

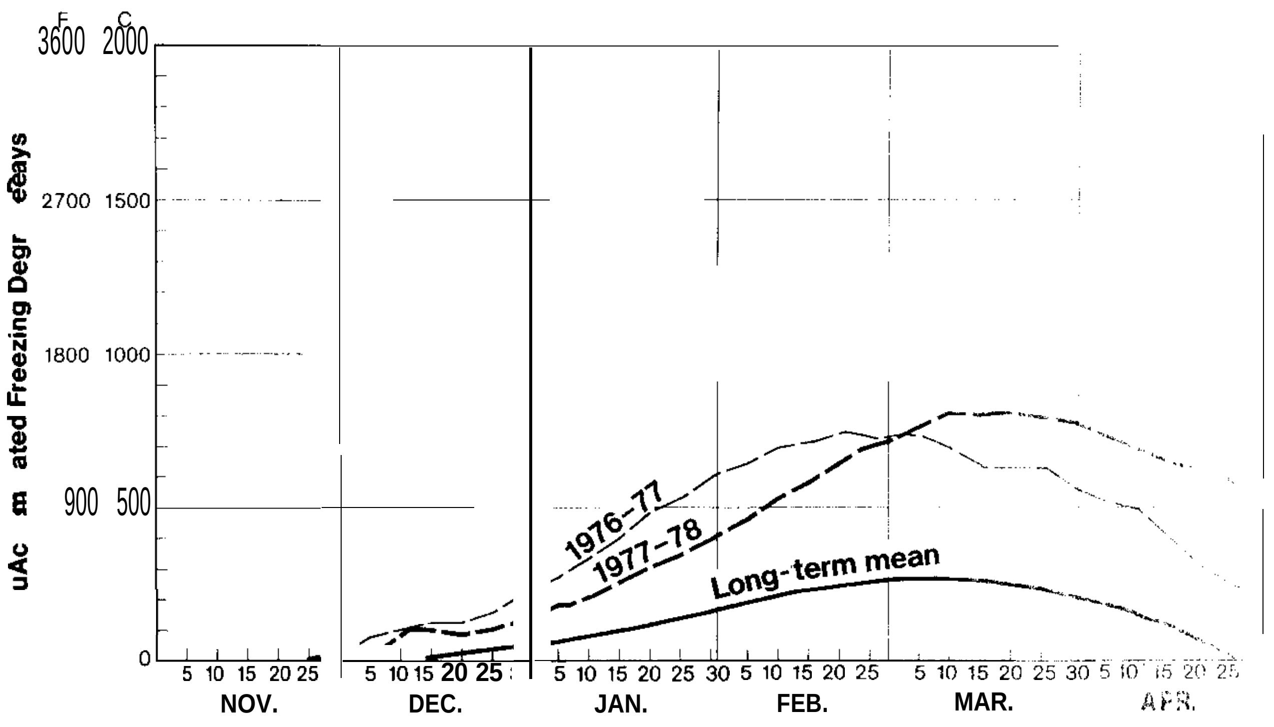

Figure 3i. --*Freezing degree-day accumulations, Toledo, Ohio*

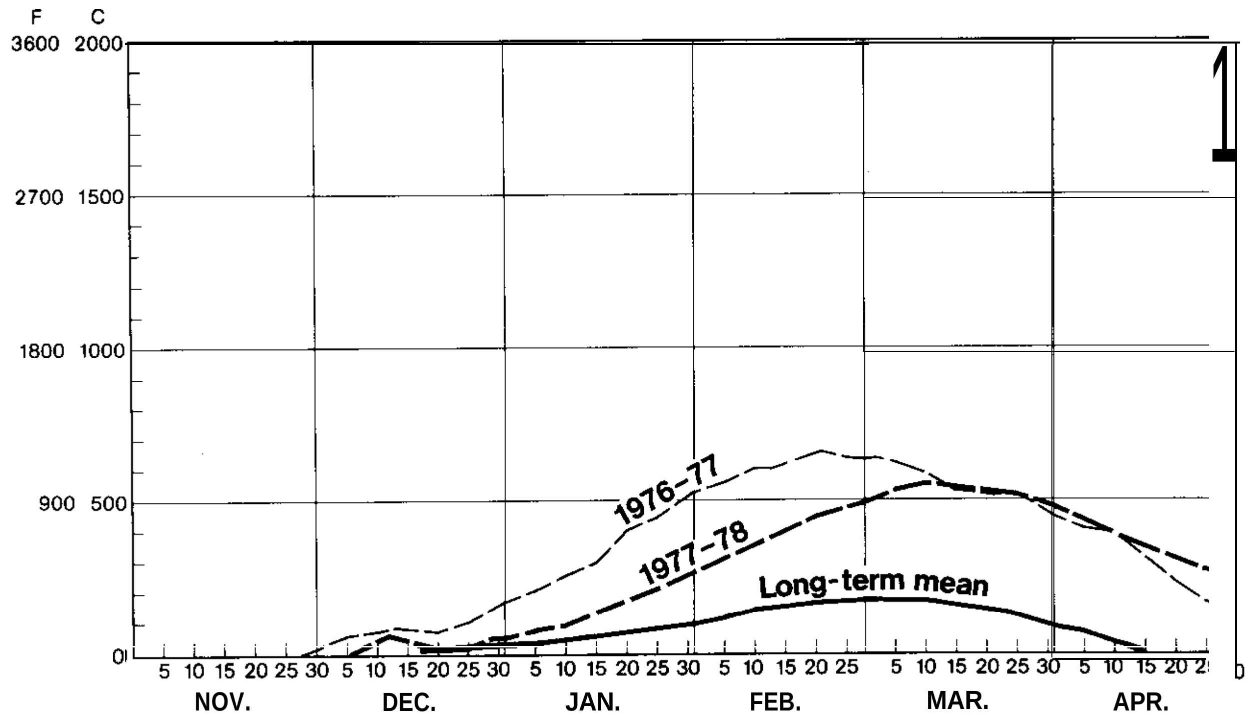

Figure 3j.--Freezing degree-day accumulations, Cleveland, Ohio.

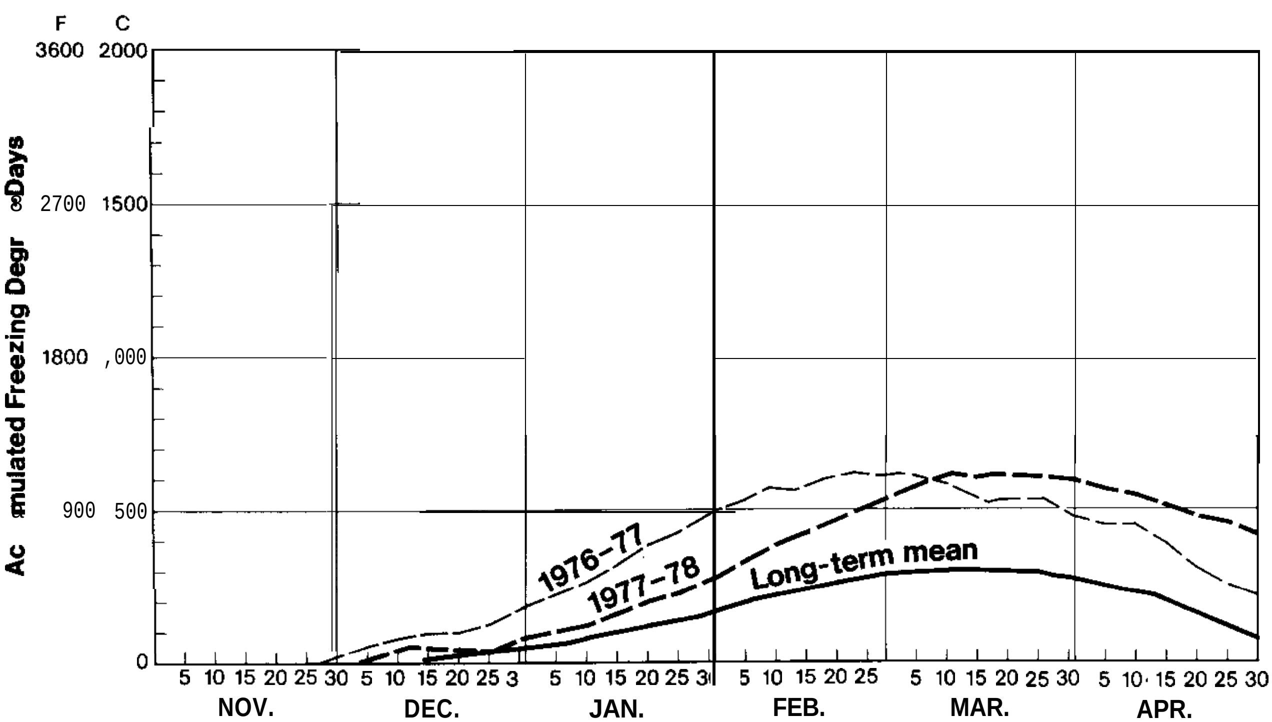

Figure 3k.--Freezing degree-day accumulations, Buffalo, N.Y.

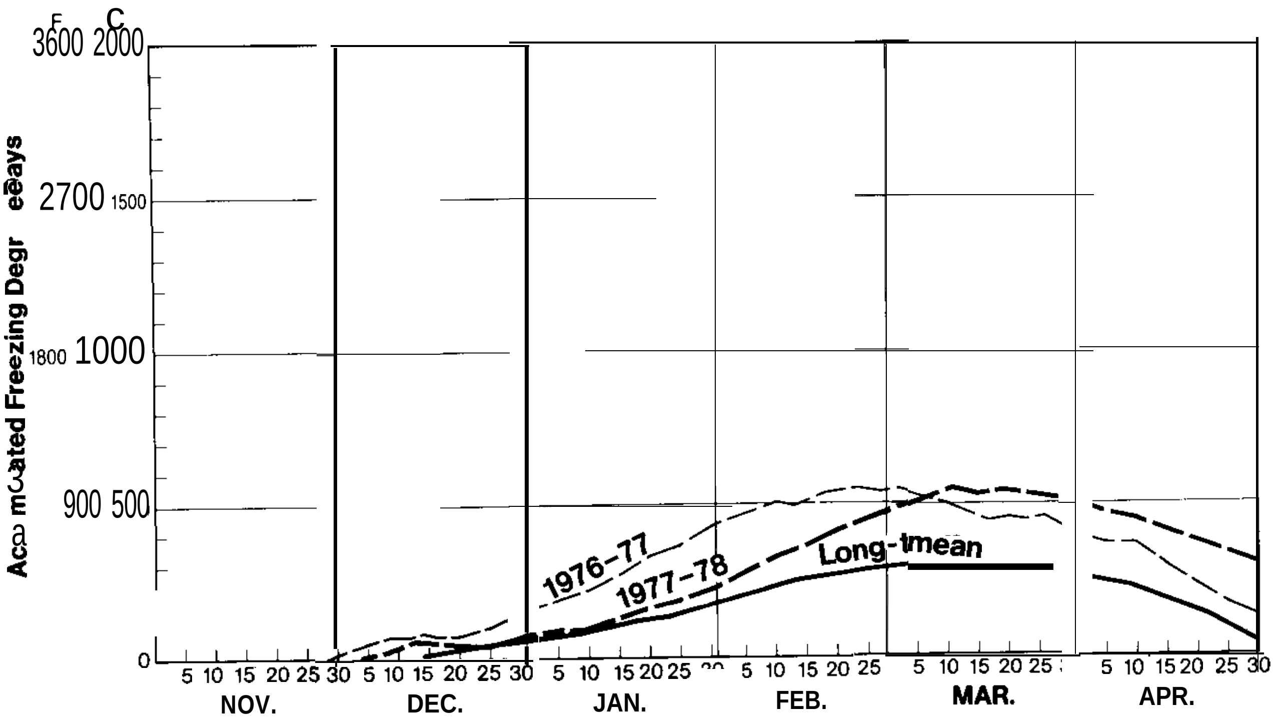

Figure 31.--*Freezing degree-day accumulations, Rochester,* N.Y.

Table 2.--*Maximum accumulated freezing degree-days for the 1976-77 and 1977-1978 winters*

Station	1976-77 (°F)	1976-77 (°C)	1977-78 (°F)	1977-78 (°C)
Duluth, Minn.	2612	1451	2514	1397
Marquette, Mich.	1680	933	1354	752
Sault Ste. Marie, Mich.	2243	1246	2056	1142
Green Bay, Wis.	2082	1157	2013	1118
Milwaukee, Wis.	1534	852	1388	771
Muskegon, Mich.	1211	673	1137	632
Alpena, Mich.	1628	904	1621	901
Detroit, Mich.	1129	627	1132	629
Toledo, Ohio	1317	732	1418	788
Cleveland, Ohio	1135	631	913	507
Buffalo, N.Y.	1069	594	1098	610
Rochester, N.Y.	949	527	987	548

Table 3.--*The 12 coldest winters since 1850*

Rank	Winter	November-February mean temp., °C	November-January mean temp., °C	Character
1	1874-75	-9.0	-6.5	L[1]
2	1903-04	-7.9	-6.2	L
3	1976-77	-7.7	-8.2	E[2]
4	1872-73	-7.5	-7.5	I[3]
5	1855-56	-7.5	-6.0	L
6	1919-20	-7.4	-7.0	L
7	1880-81	-7.3	-7.2	I
8	1917-18	-7.2	-6.8	L
9	1856-57	-7.0	-7.0	I
10	1892-93	-6.8	-5.8	L
11	1962-63	-6.5	-6.3	L
12	1977-78	-6.0	-4.5	L

[1] Late

[2] Early

[3] Intermediate

3. SUMMARY OF ICE CONDITIONS

R. A. Assel, B. H. Dewitt, and J. Wartha

3.1 Data Collection Platforms and Processes

Primary sources of ice-cover information used to document the 1977-78 Great Lakes ice cover include: visual aerial ice reconnaissance, side looking airborne radar (SLAR), and satellite imagery. Ice charts are the end result of interpretation of these data. Ice charts depicting ice distribution and concentration, as well as size and age of floes, were received at the Great Lakes Environmental Research Laboratory (GLERL) throughout the winter from the Ice Navigation Center, Cleveland, and Ice Forecasting Central, Ottawa, Ont. Interpretations of ice conditions made from NOAA-5, and Geostationary Operational Environmental Satellite (GOES) imagery were received from NESS in Washington, D.C. SLAR imagery and ice charts based on it were received from the Ice Navigation Center, Cleveland. In addition to these primary data, weekly and daily surface reports of ice conditions and thickness were received from observers for GLERL and the U.S. Coast Guard.

3.1.1 Visual Aerial Ice Reconnaissance

Trained ice observers for the United States Coast Guard and the Canadian Department of the Environment record visually observed ice conditions on the Great Lakes periodically during winter.

U.S. Coast Guard aircraft used for visual ice reconnaissance include the Grumman HU-16 Albatross and smaller fixed wing craft and rotary (helicopter) aircraft. Flights are made from Chicago, Ill.; Detroit; and Traverse City, Mich. Canadian aircraft used to support visual aerial ice reconnaissance include a Douglas DC-3 and a Lockheed Electra L188C.

3.1.2 Side Looking Airborne Radar

The National Aeronautics and Space Administration Lewis Research Center, in cooperation with the U.S. Coast Guard and NOAA, has developed a SLAR system for ice surveillance on the Great Lakes. The system, mounted aboard a HC-130B aircraft operating out of Cleveland, operates in the X-band at a frequency of 9.245 GHz (3.245-cm wave length). Flight altitude for SLAR missions is 3.35 km (11,000 ft) with an average ground speed of 280 kn. Flights are made regularly over all of the Great Lakes with the exception of Lake Ontario. The advantage of SLAR over visual reconnaissance and satellite imagery is its all-weather capability and ability to "see" through clouds. Schertler *et al*. (1975) give a history of the development of the current system.

3.1.3 Satellite Imagery

NOAA-5 and GOES-l satellite imagery were used in ice-cover documentation. The NOAA-5 satellite represents the second generation of operational satellites in the National Environmental Satellite Service. The orbit is near polar and Sun synchronous so the satellite always crosses the Equator at the same local solar time, in this case 0830 and 2030. This orbit is a typical polar orbit, providing a twice-daily thermal infrared image and a one-time visible band image of an area.

This type of orbital coverage permits detection of changes at 12-h intervals for dynamic snow and ice events. Cloudiness commonly reduces these observations, but in most of the United States it is possible to secure at least one cloudless view per week. The primary sensor for hydrologic use aboard NOAA-5 is the Very High Resolution Radiometer (VHRR), dual channel scanner (visible, 0.6-0.7 μm; infrared, 10.5-12.5 μm).

The VHRR images of the Great Lakes presented here have been specially processed to improve their quality and to rectify and correct the distortions due to Earth curvature, Earth rotation, and spacecraft roll-attitude errors. This rectification and correction was accomplished by using an algorithm developed by Legeckis and Pritchard (1976) in which the digital tape data are rerun and reformatted. The corrected tape is then processed through a Digital Muirhead Device to prepare new images. Standard NESS snow and ice enhancement programs were applied to the tapes to bring out details of the snow and ice areas.

The GOES images were prepared from Visible Spin Scan Radiometer (VISSR) negatives stored at NOAA's Environmental Data and Information Service. Tapes were not archived for GOES/VISSR images. The GOES images presented here have not been enhanced or rectified. North-south foreshortening is noticeable in images taken in higher latitudes, such as those of the Great Lakes.

3.2 General Description

The ice cycle that occurs on the Great Lakes each winter can be divided into three phases (Rondy, 1976): a cooling phase, an ice formation phase, and a breakup or fragmentation phase. In brief, the cooling phase starts in fall as air temperatures drop below water temperatures and the water begins to lose heat. Ice formation starts after fall overturn is completed and a stable water density gradient enables rapid cooling to take place in the surface layer. During the ice formation phase, both stable and dynamic ice is formed. Even though the net energy balance of the lake is negative during this time, i.e., the water mass is losing heat, rapid and extensive changes in ice extent and thickness can occur owing to wind- and current-induced ice movement, upwelling of warmer waters, and even midwinter thaws on some portions of the Great Lakes. The breakup period begins when the energy balance of the ice cover becomes positive and may be well defined and short if a warming trend starts and is persistent, or it may drag on as cold and warm periods alternate in frequency and intensity in spring.

A set of 21 composite ice charts and 31 satellite images illustrate the distribution and concentration of ice cover during the 1977-78 winter. (See figs. *4a*-*4u* and *5a*-*5ee*.) The composite ice charts were prepared at weekly

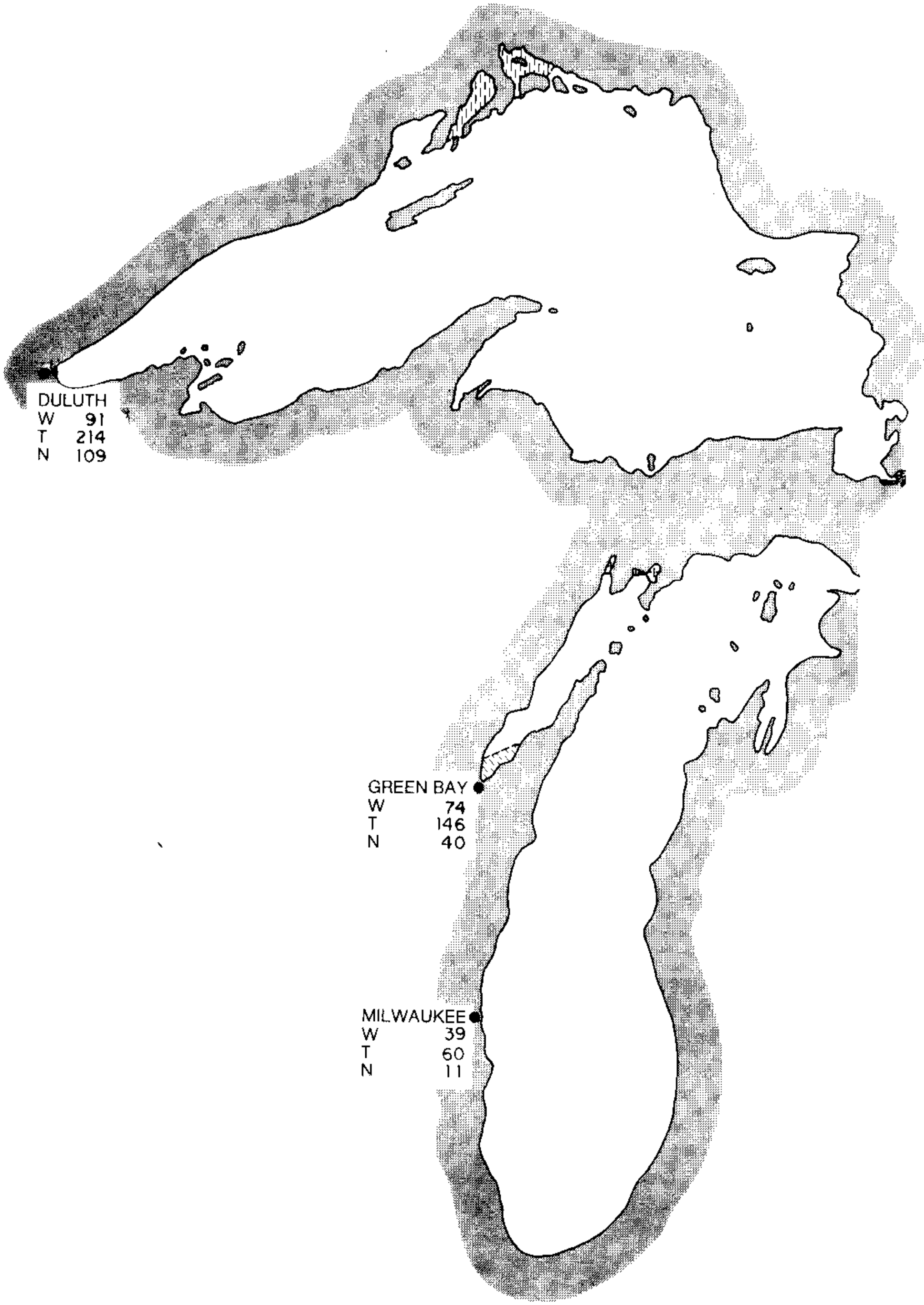

Figure 4a.--*Composite ice chart for December 7, 1977.*

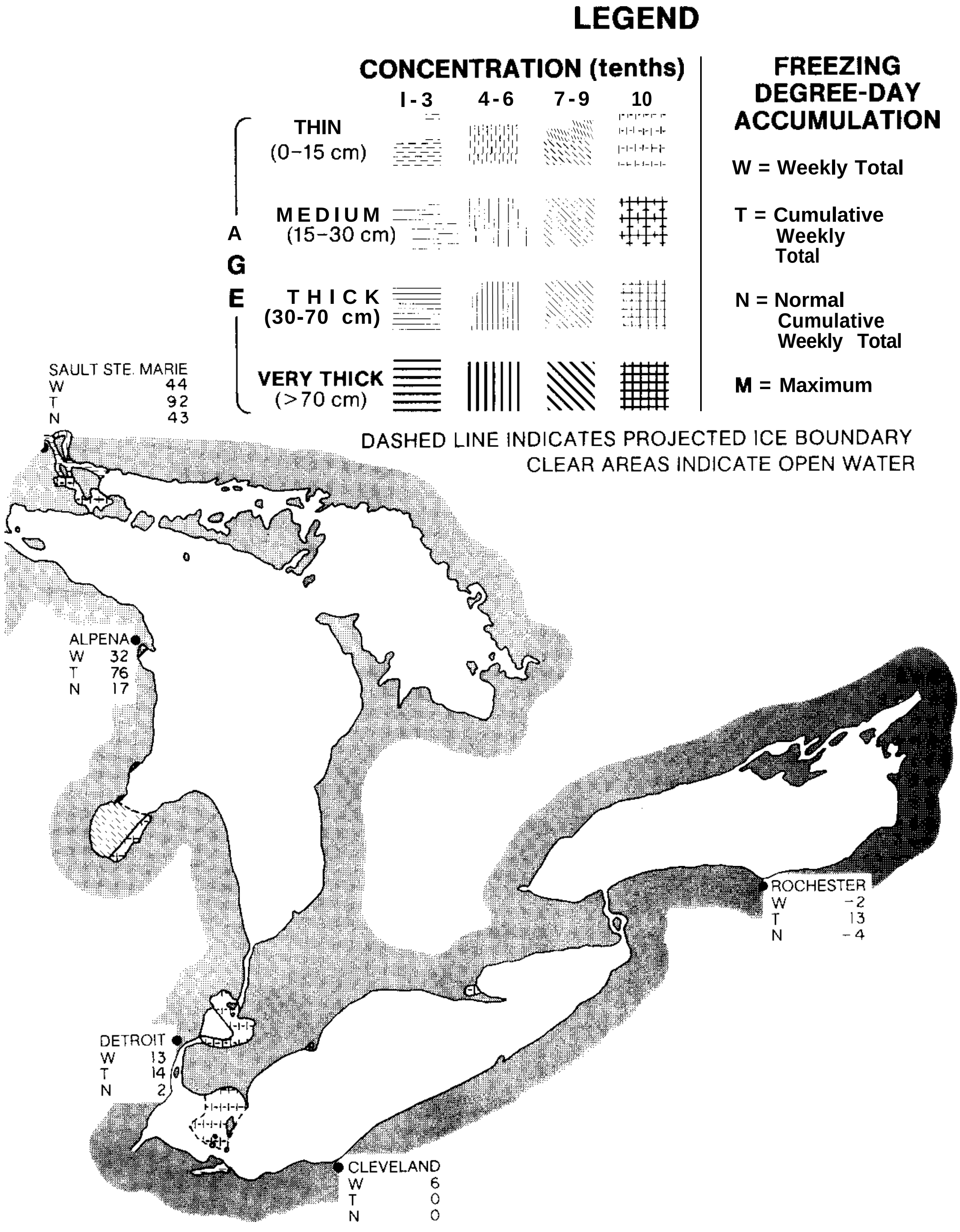

Figure *4a.--Composite ice chart for December 7, 1977 (con.)*

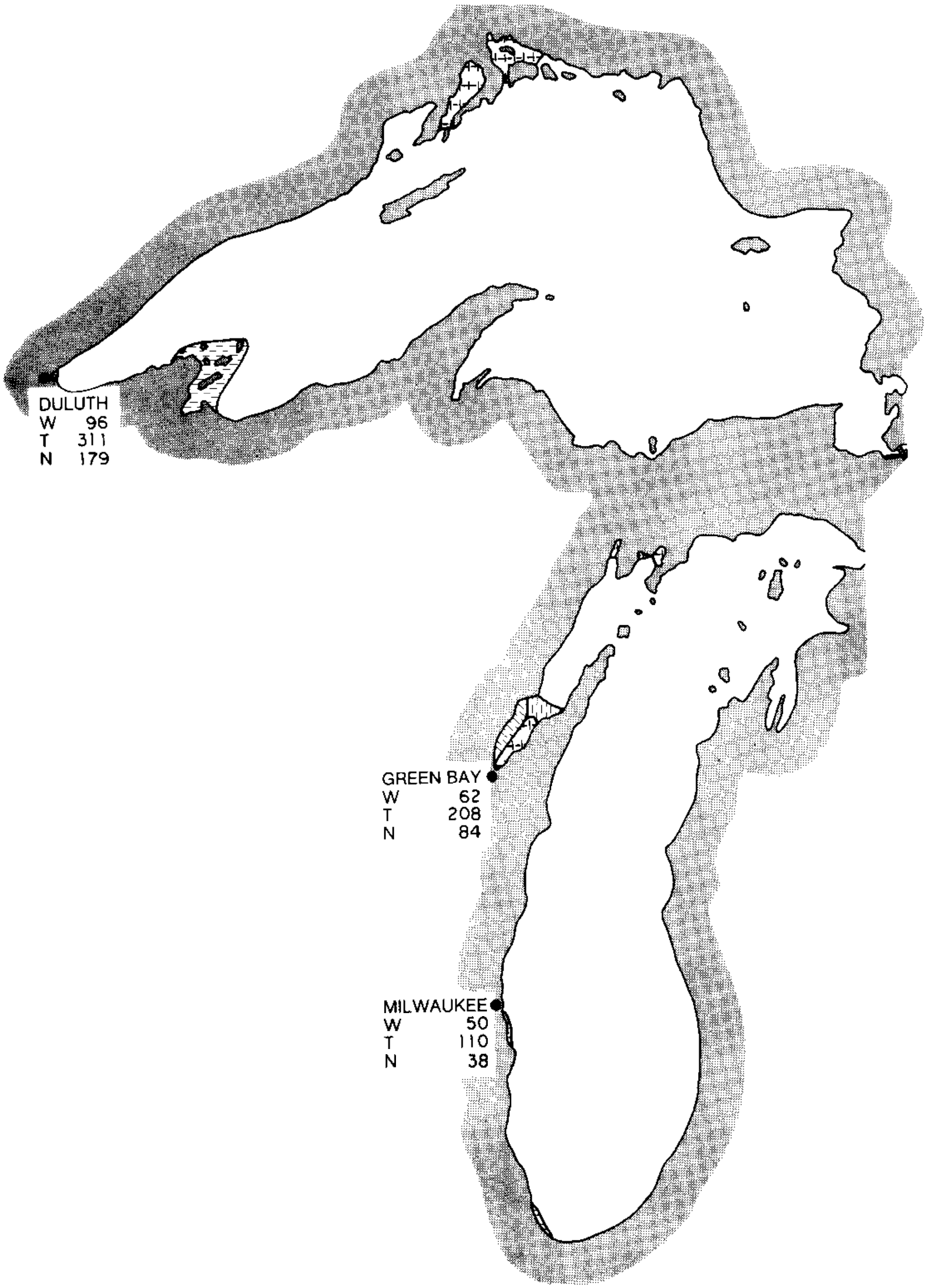

Figure 4b.--Composite ice chart for December 14, 1977.

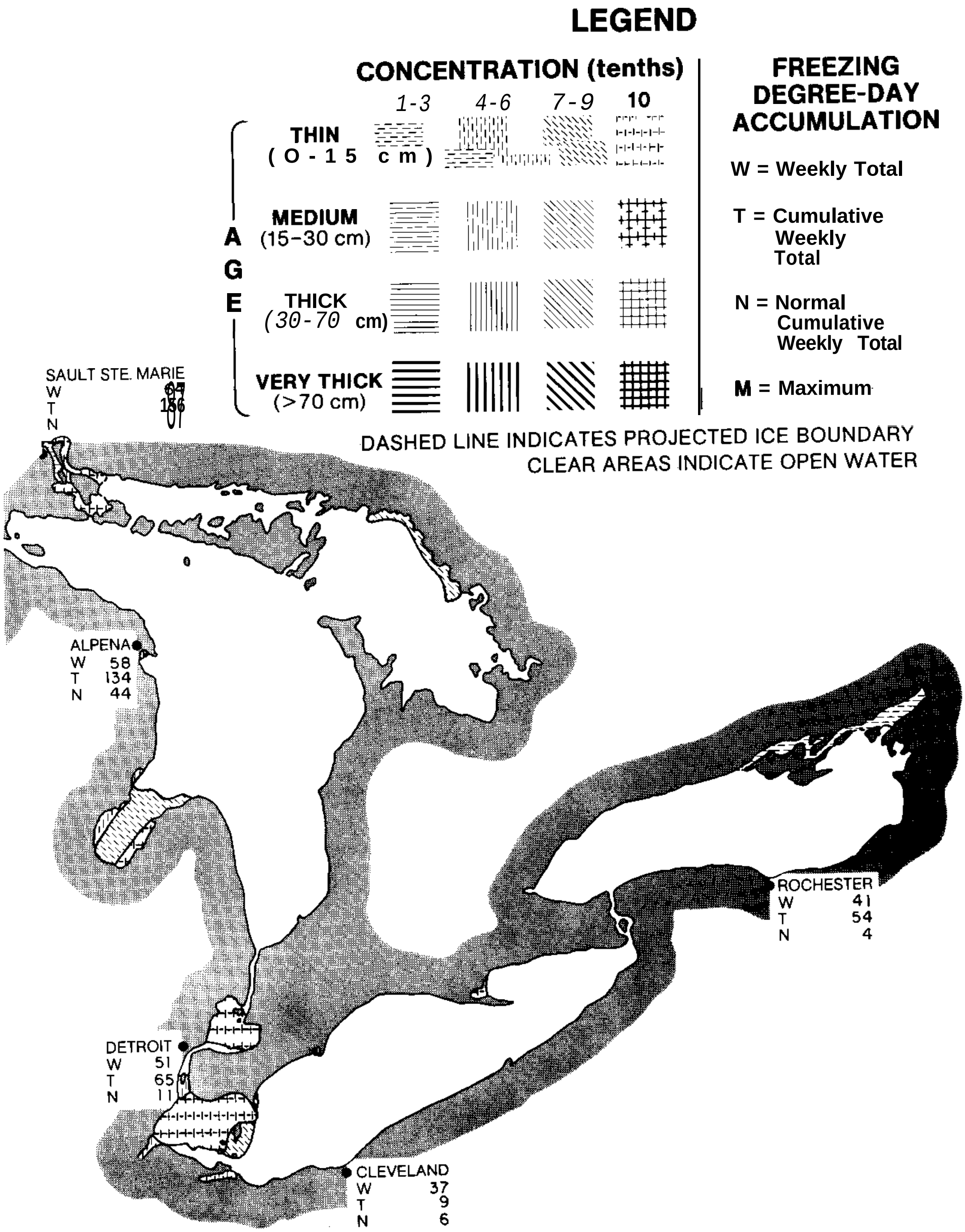

Figure 4b.--Composite ice chart for December 14, 1977 (con.).

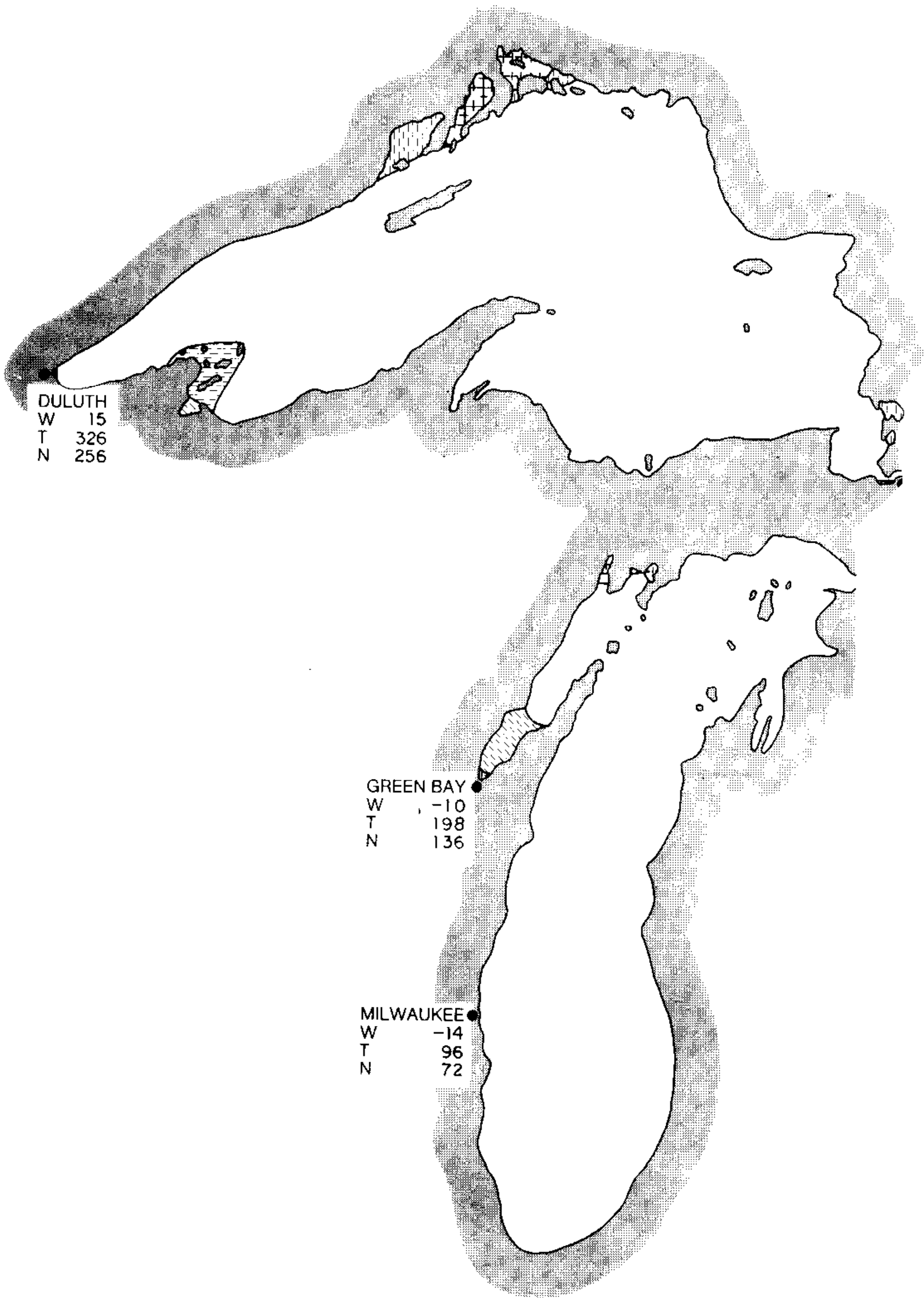

Figure 4c.--*Composite icechart* or *December> 21, 1977.*

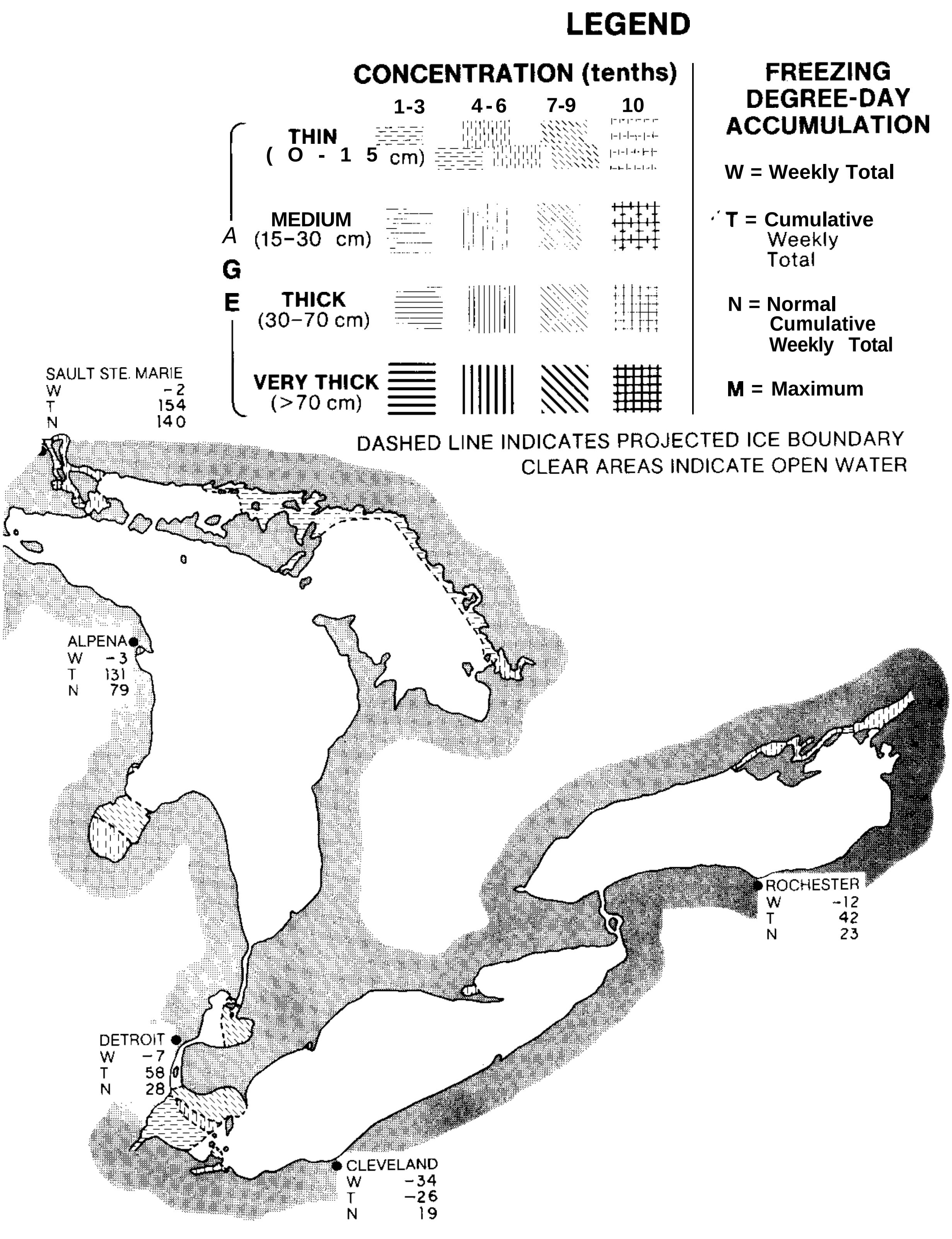

Figure 4c.--Composite ice chart for December 21, 1977 (con.).

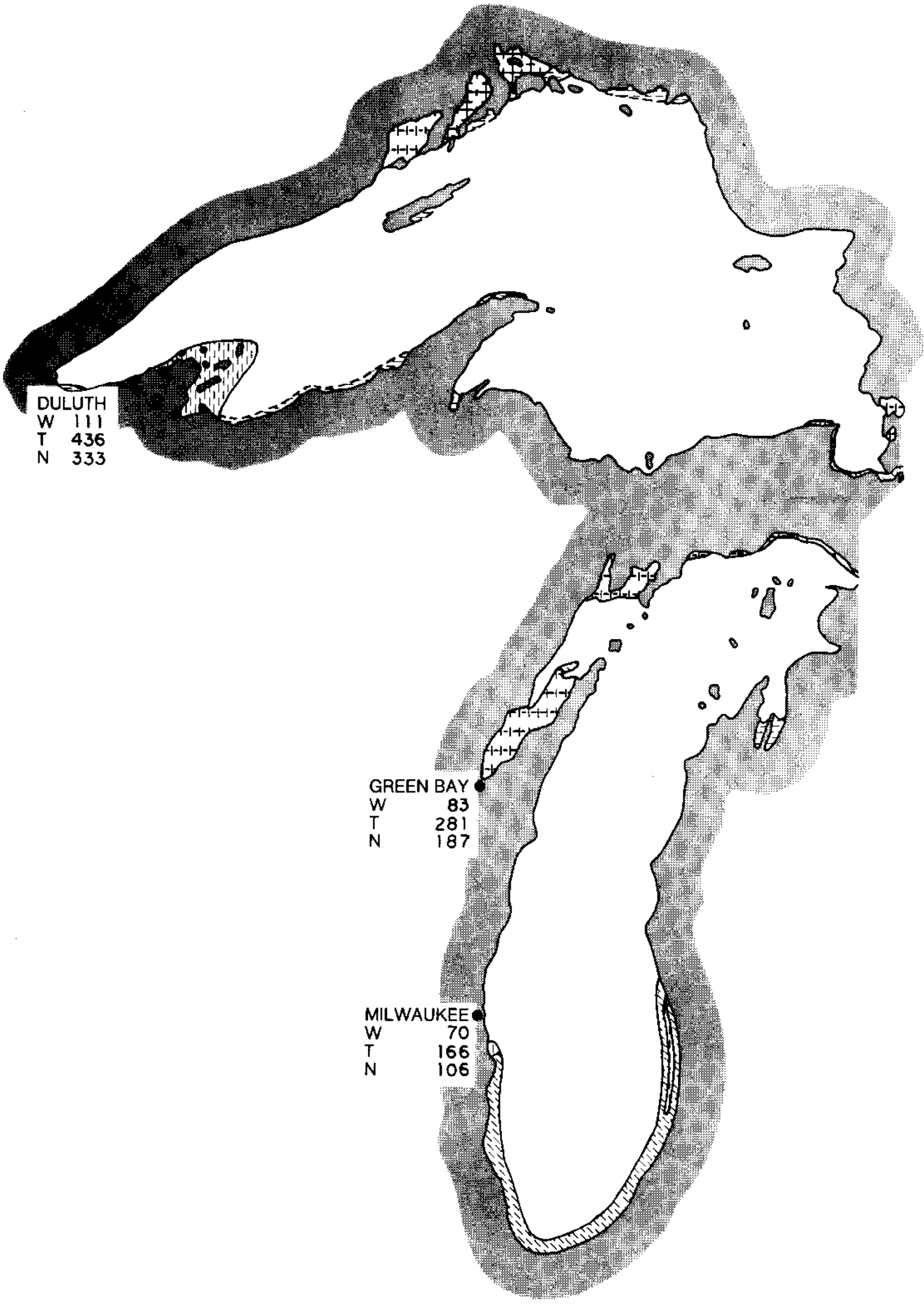

Figure 4d.--Composite ice chart for December 28, 1977.

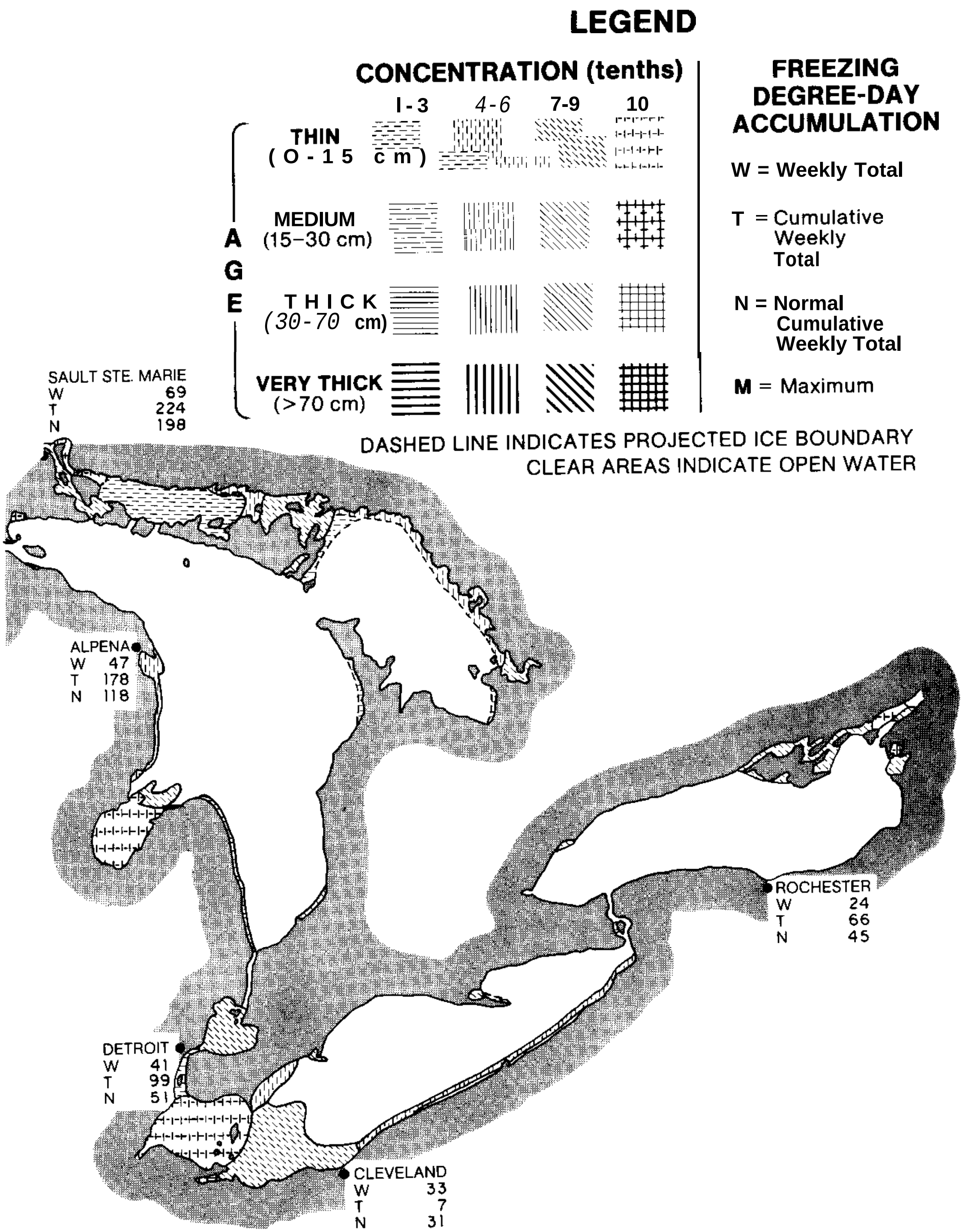

Figure 4d.--Composite ice chart for December 28, 1977 (con.).

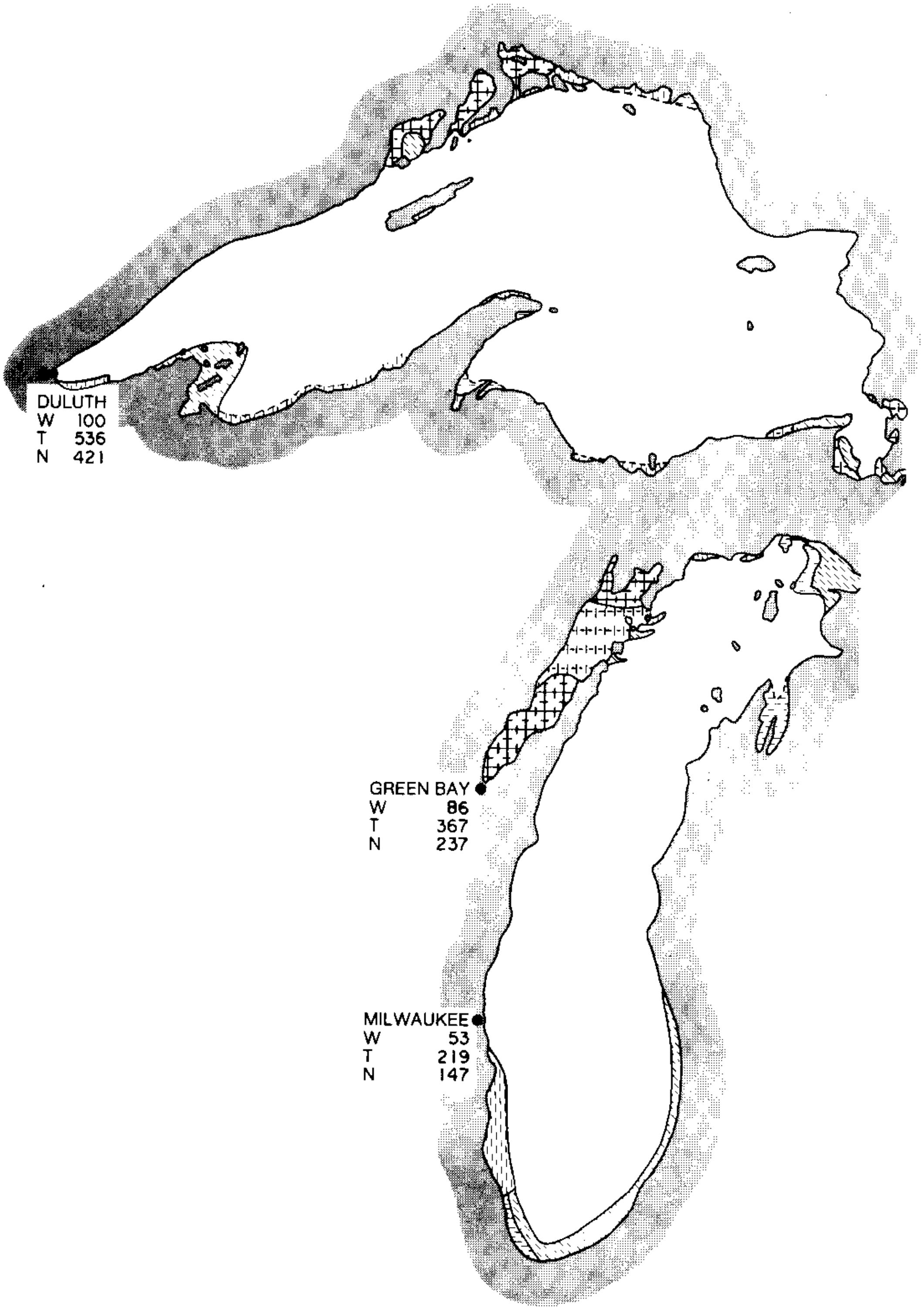

Figure 4e.--*Composite ice chart for January 4, 1978.*

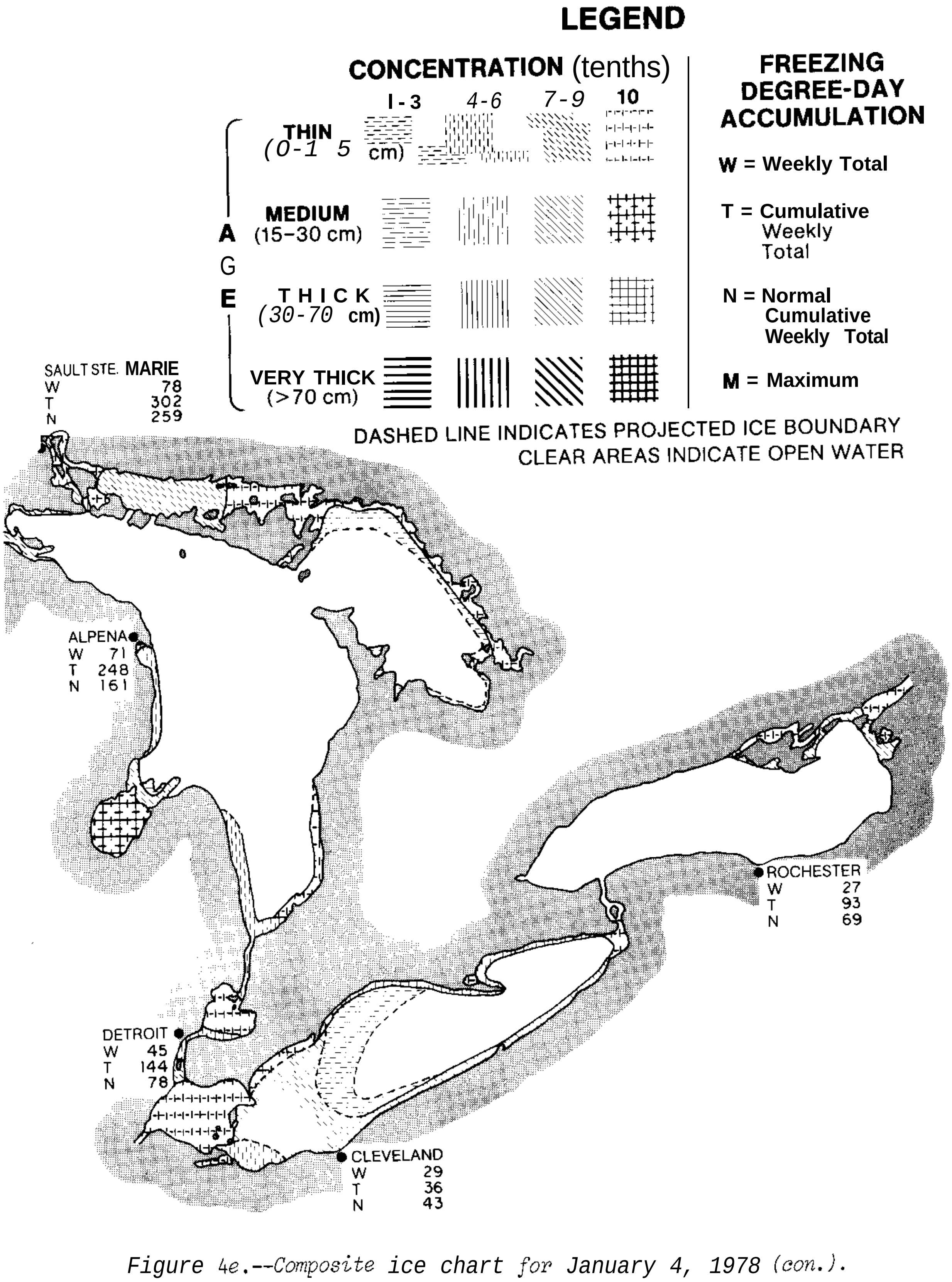

Figure 4e.--Composite ice chart for January 4, 1978 (con.).

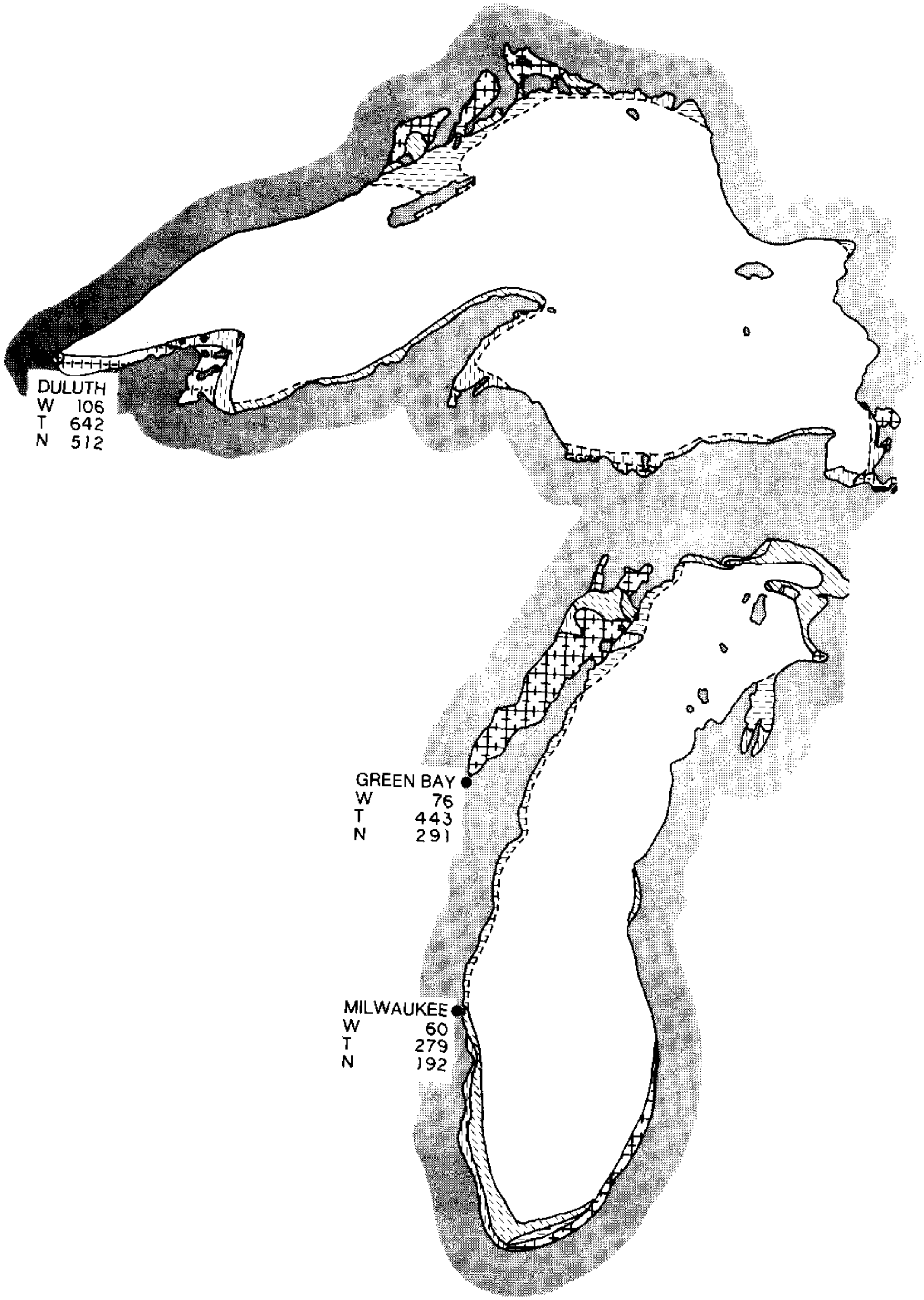

Figure 4f.--*Composite ice chart for January 11, 1978.*

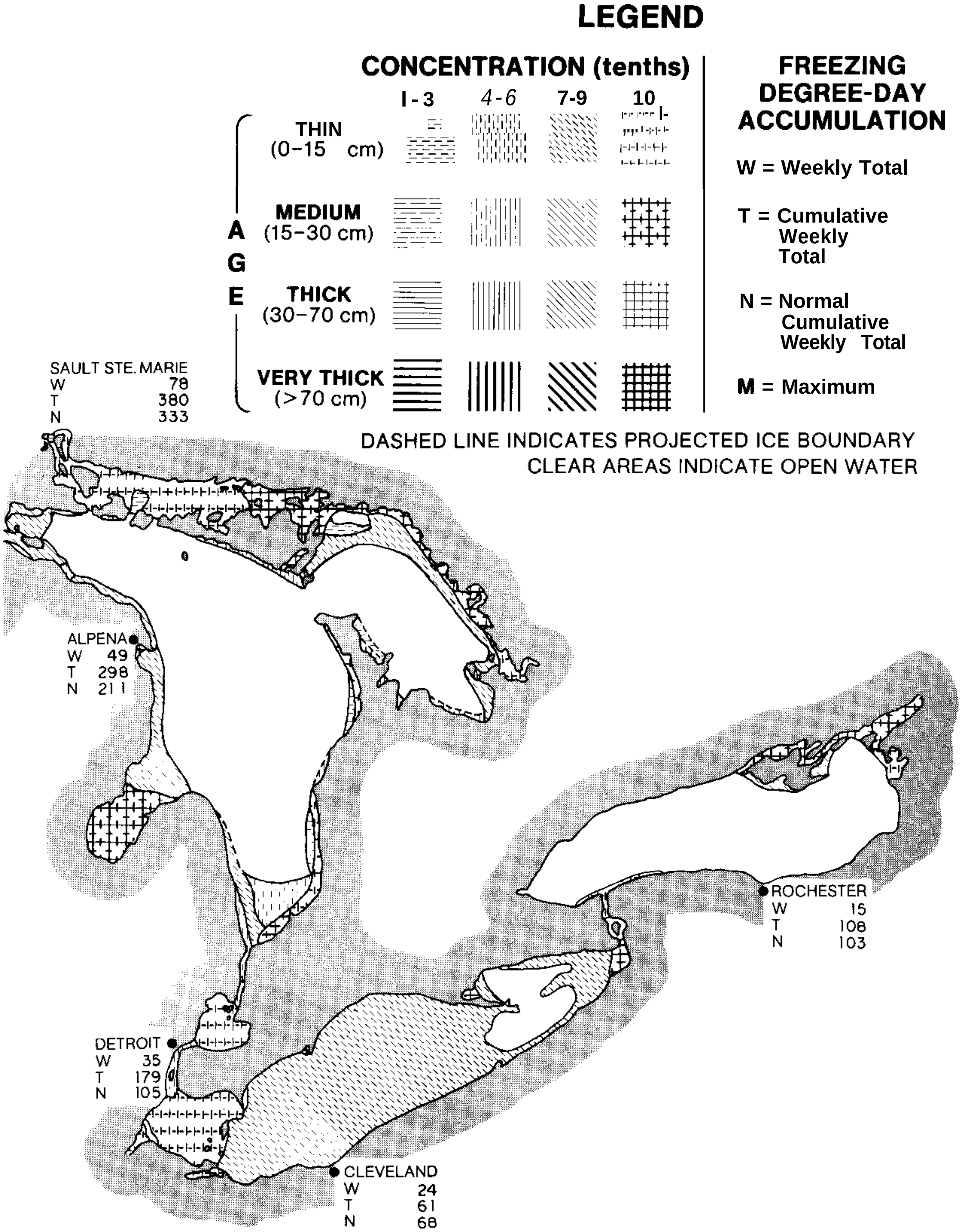

Figure 4f.--Composite ice chart for January 11, 1978 (con.).

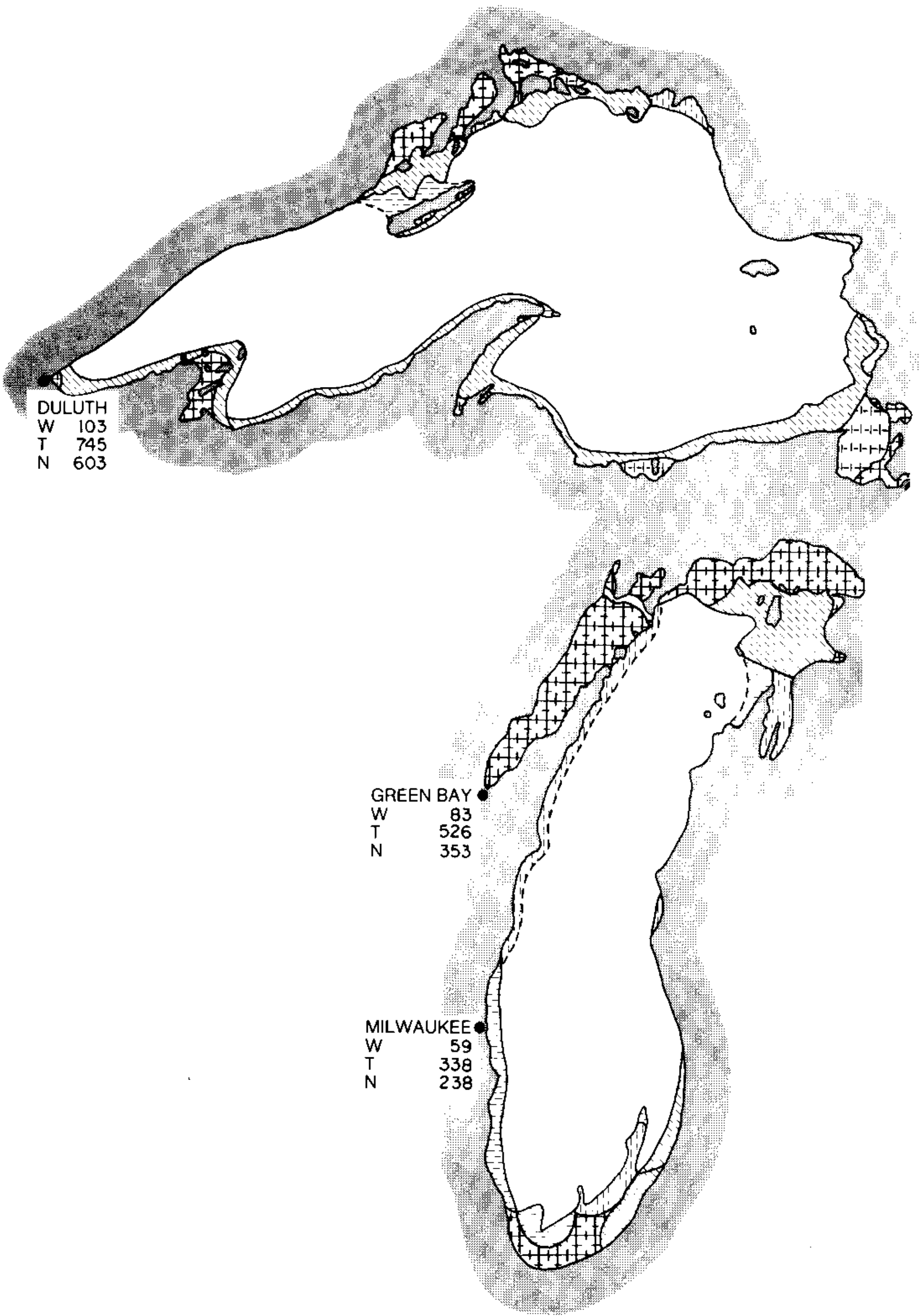

Figure 4g.--*Composite ice chart for January 18, 1978.*

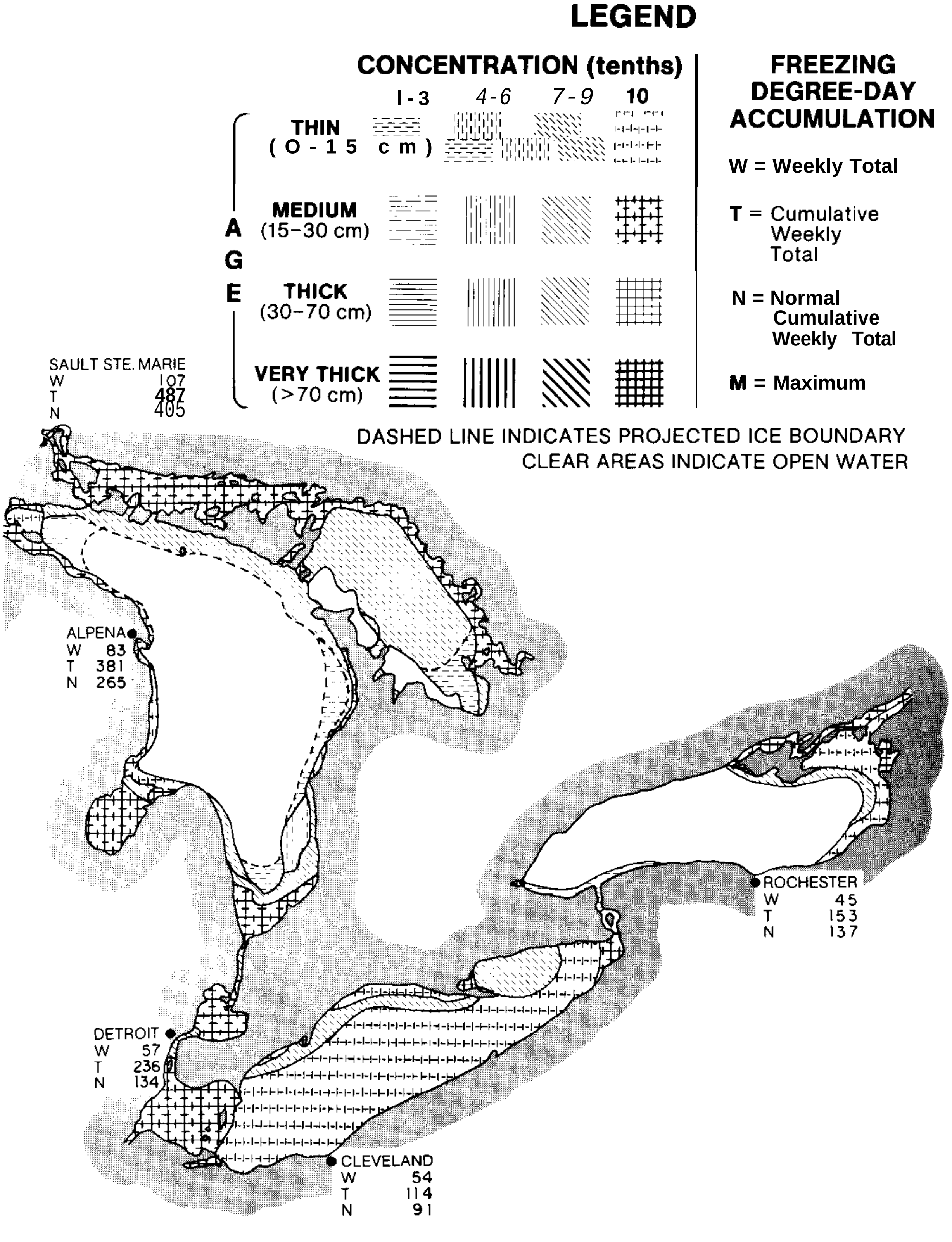

Figure 4g.--*Composite ice chart for January 18, 1978 (con.).*

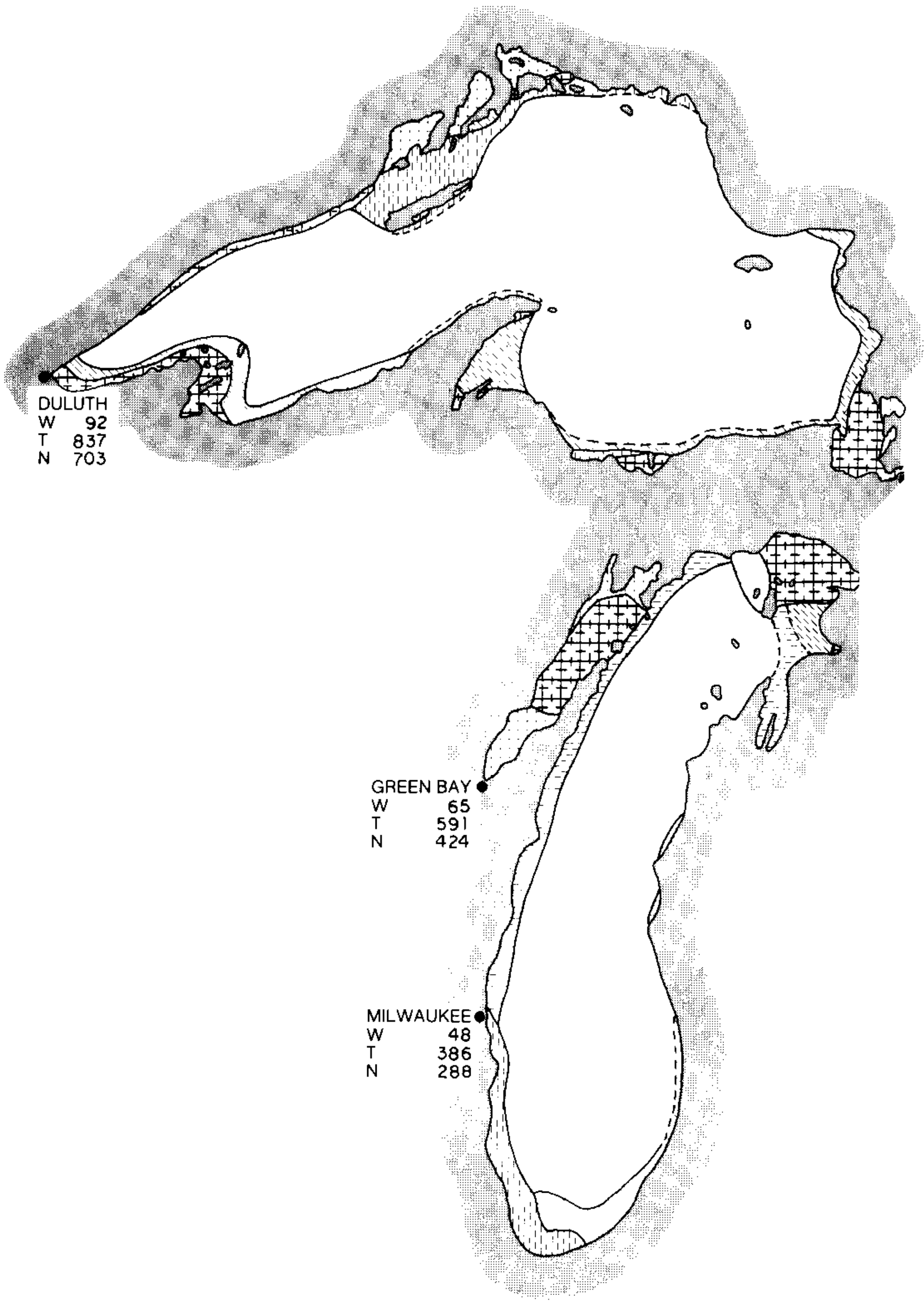

Figure 4h.--*Composite ice chart for January 25,* 1978.

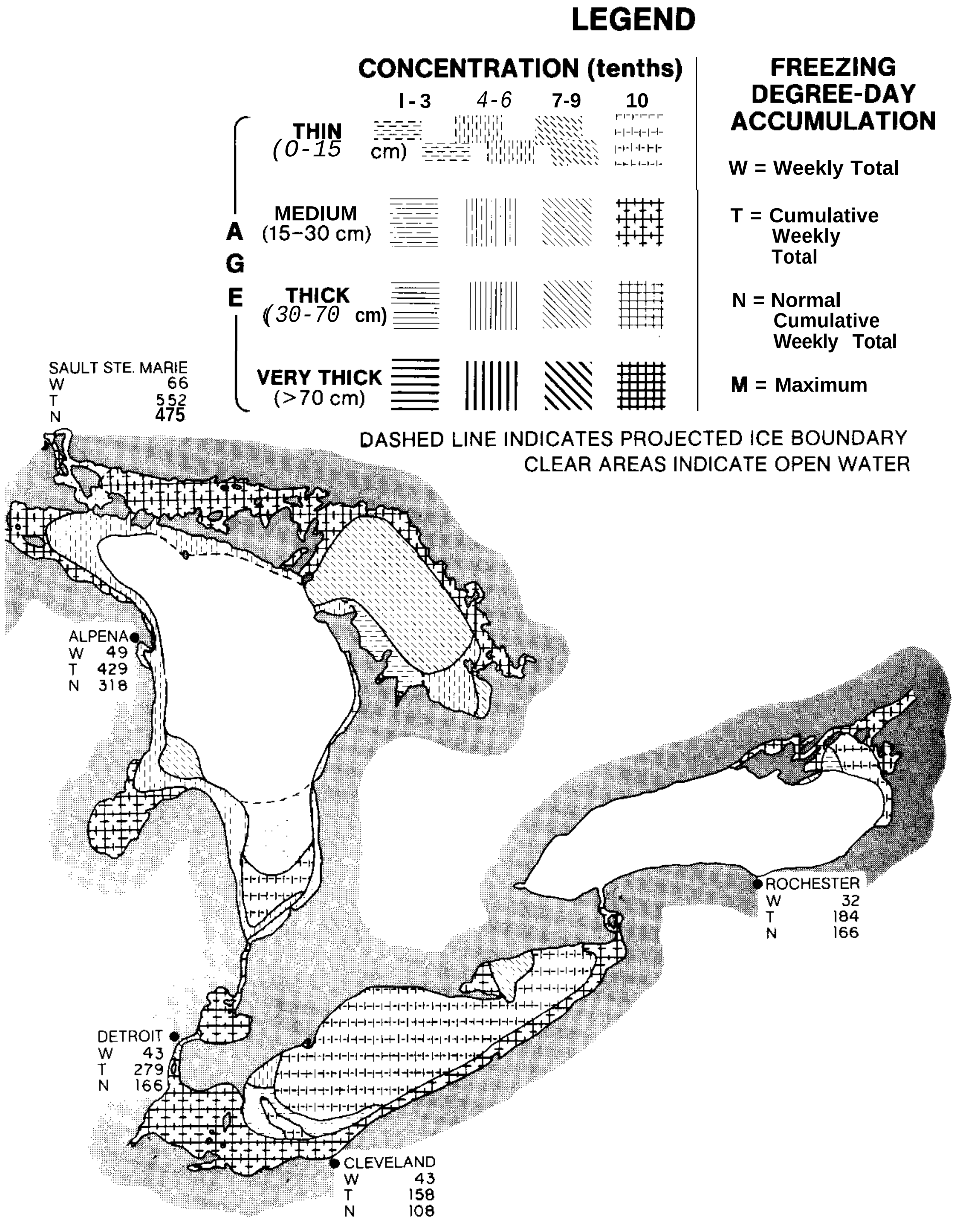

Figure 4h.--Composite ice chart for January 25, 1978 icon.).

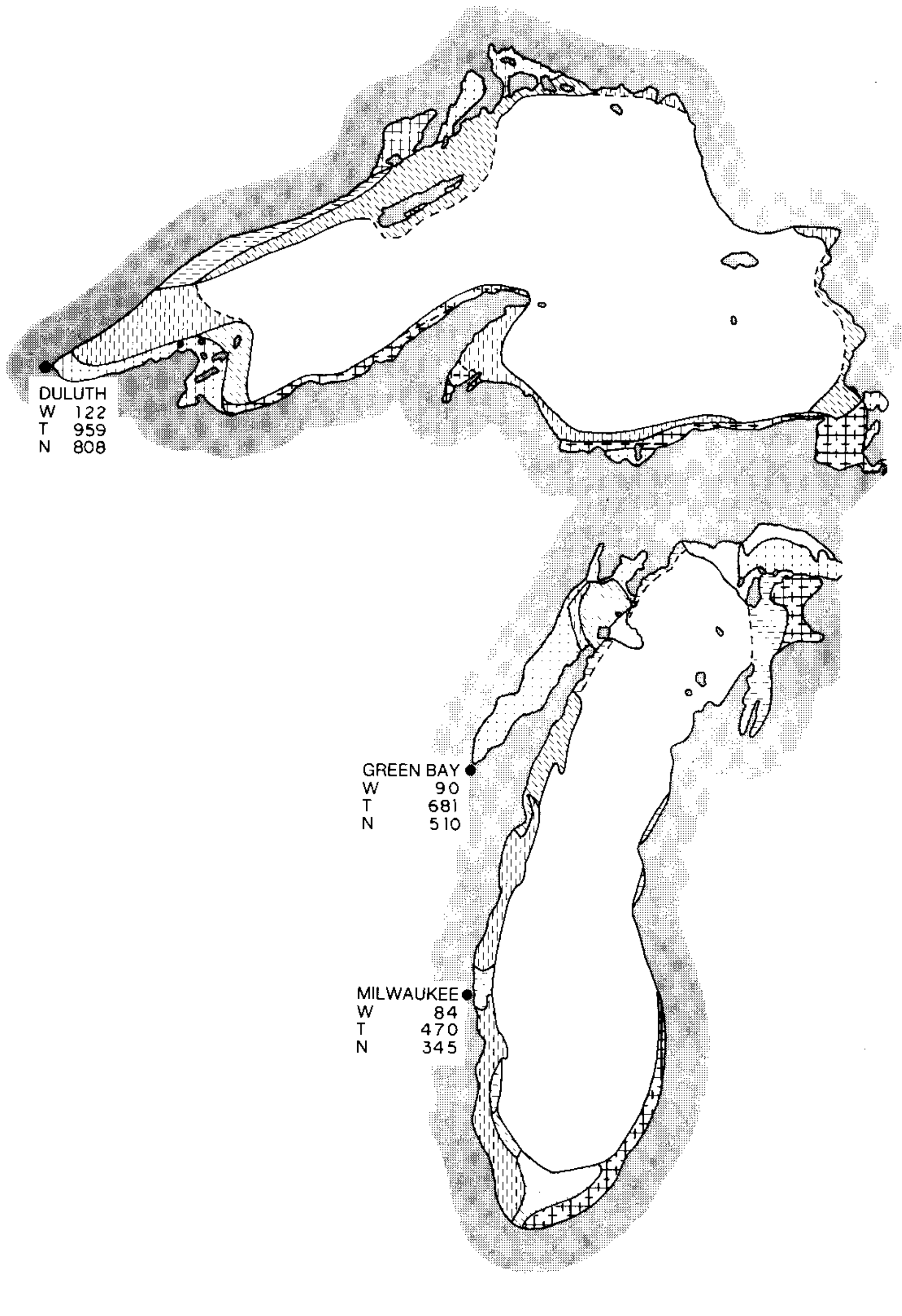

Figure 4i.--*Composite ice chart for February 1, 1978.*

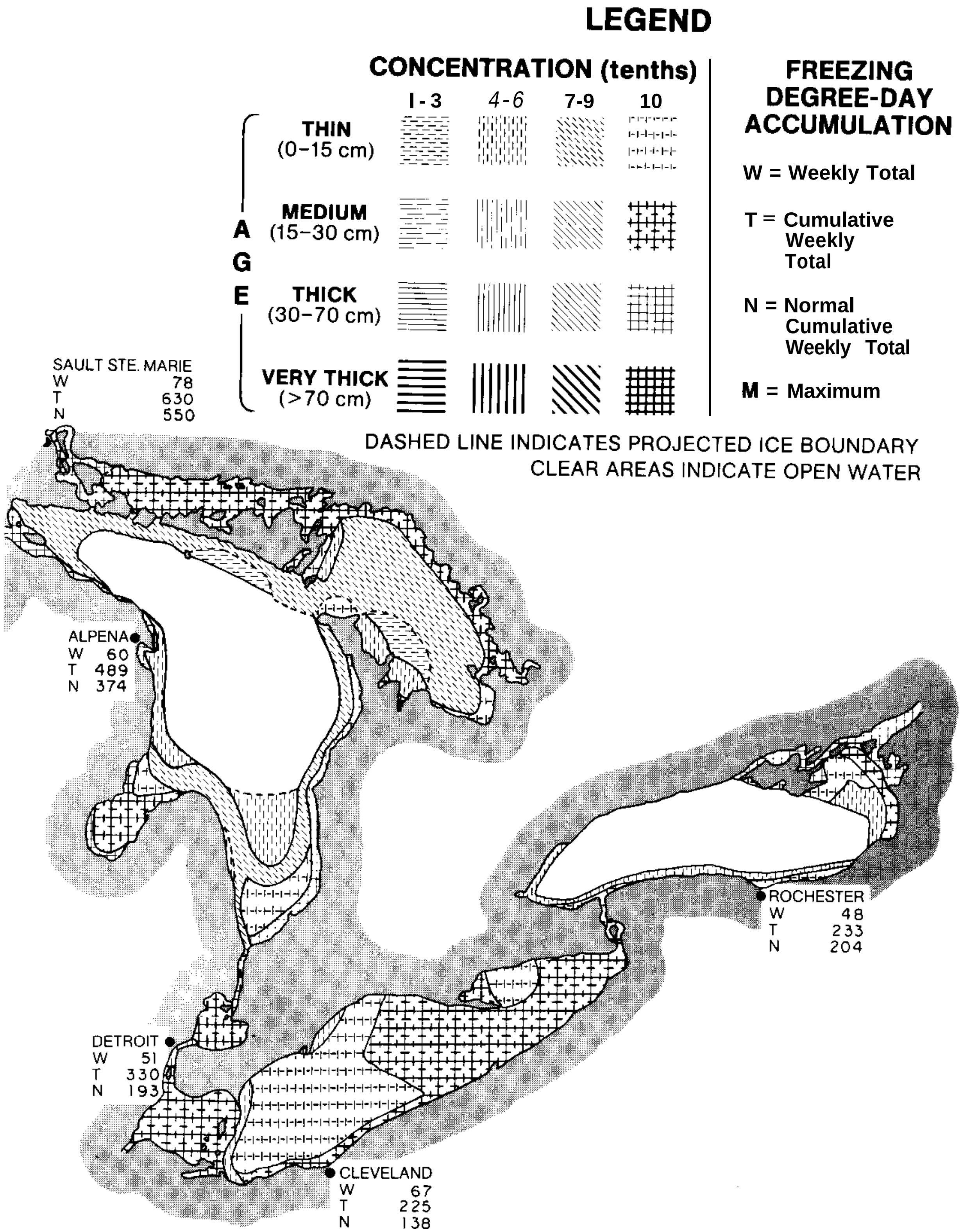

Figure 4i.--*Composite ice chart for February 1, 1978 (con.).*

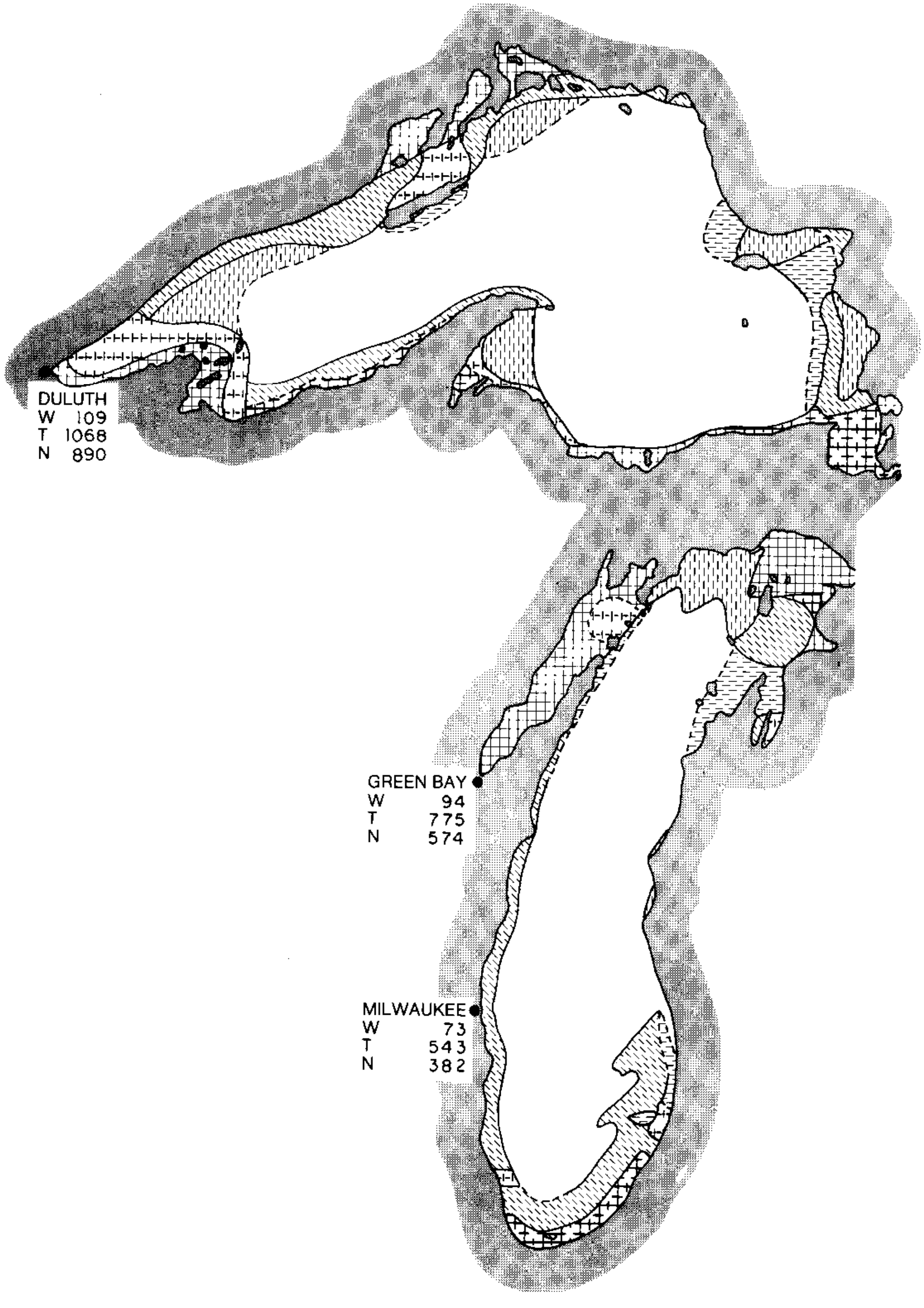

Figure 4j.--*Composite* ice *chart for February 8, 1978.*

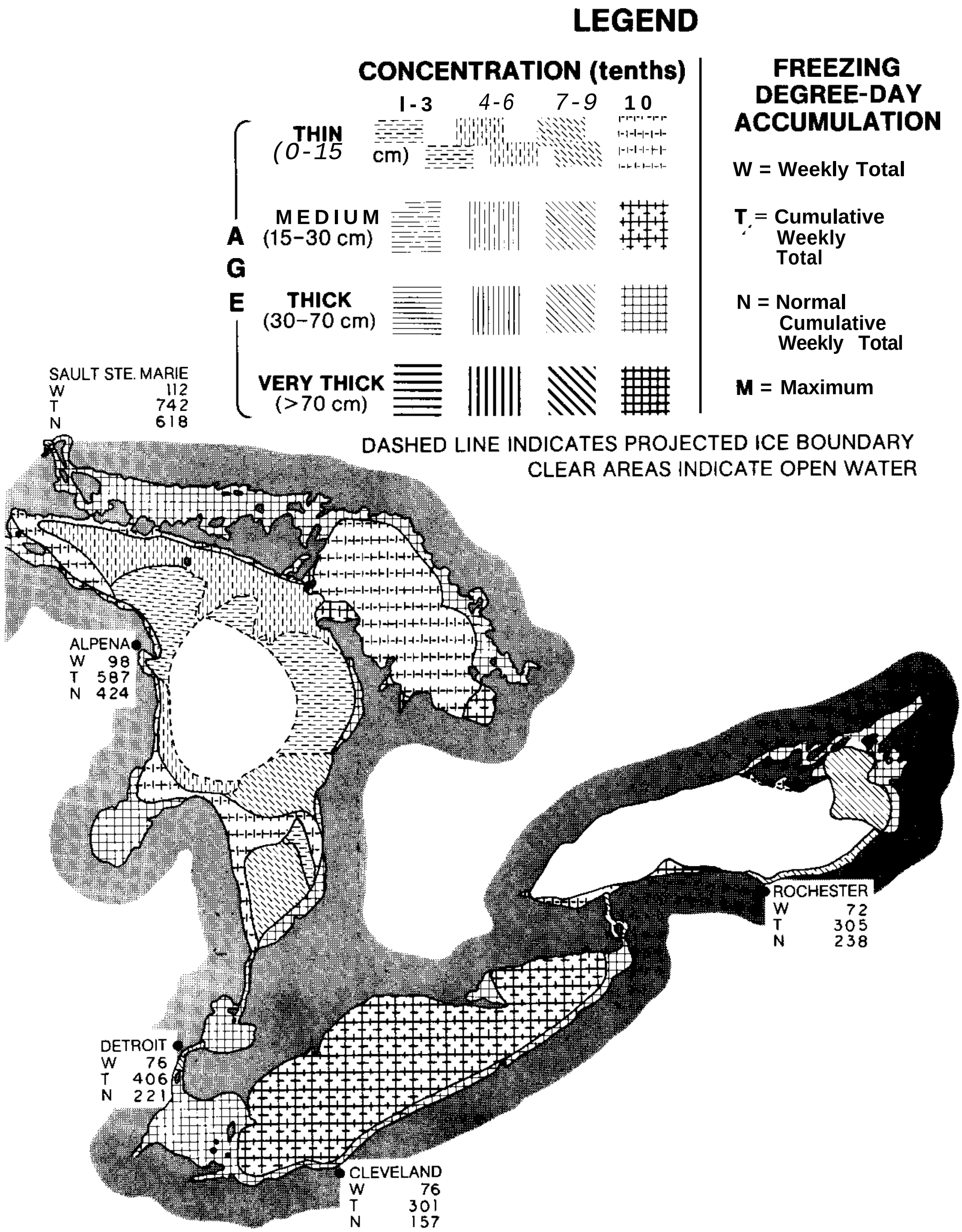

Figure 4j.--*Composite ice chart for February 8, 1978 (con.).*

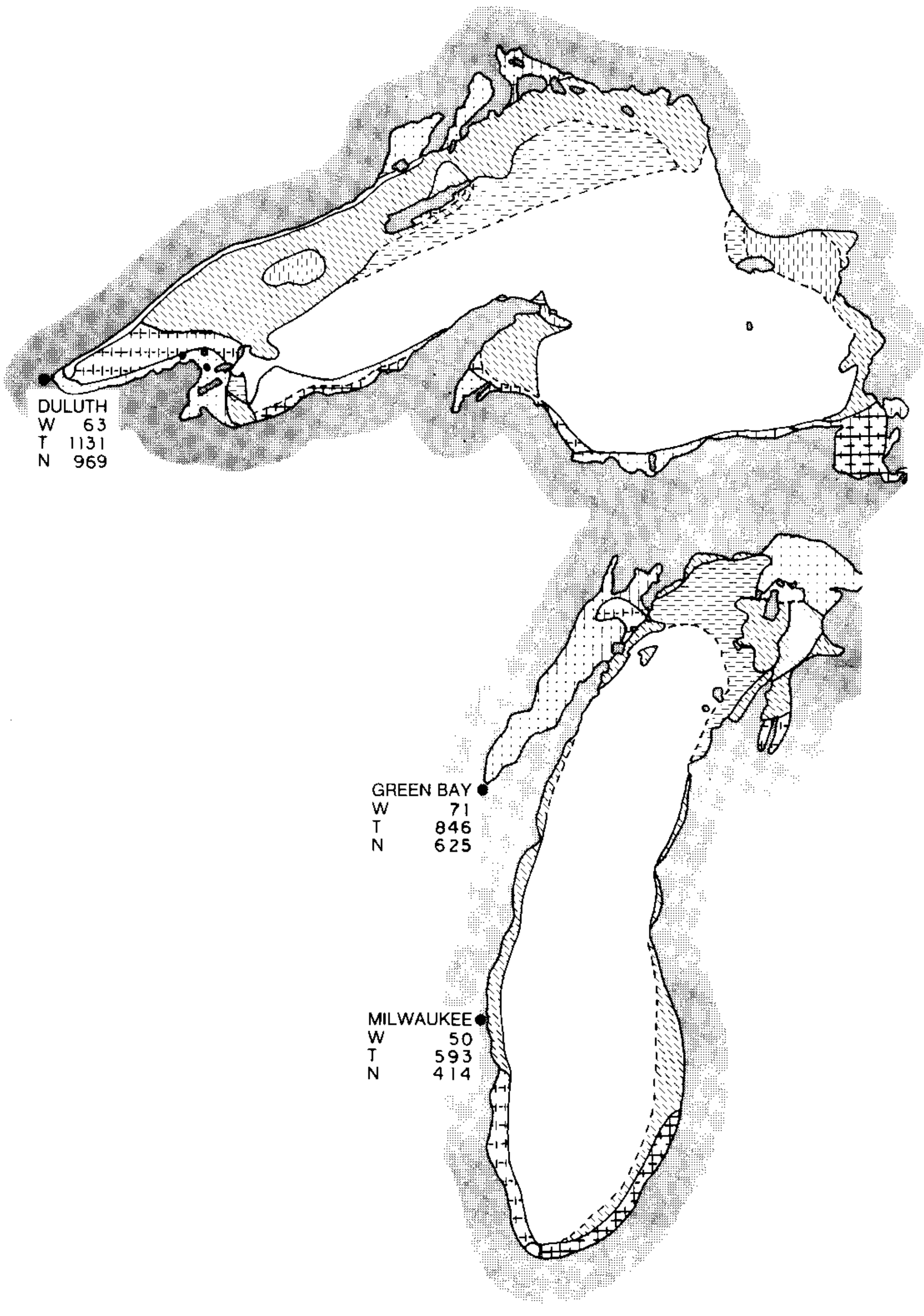

Figure 4k.--*Composite ice chart for February 15, 1978.*

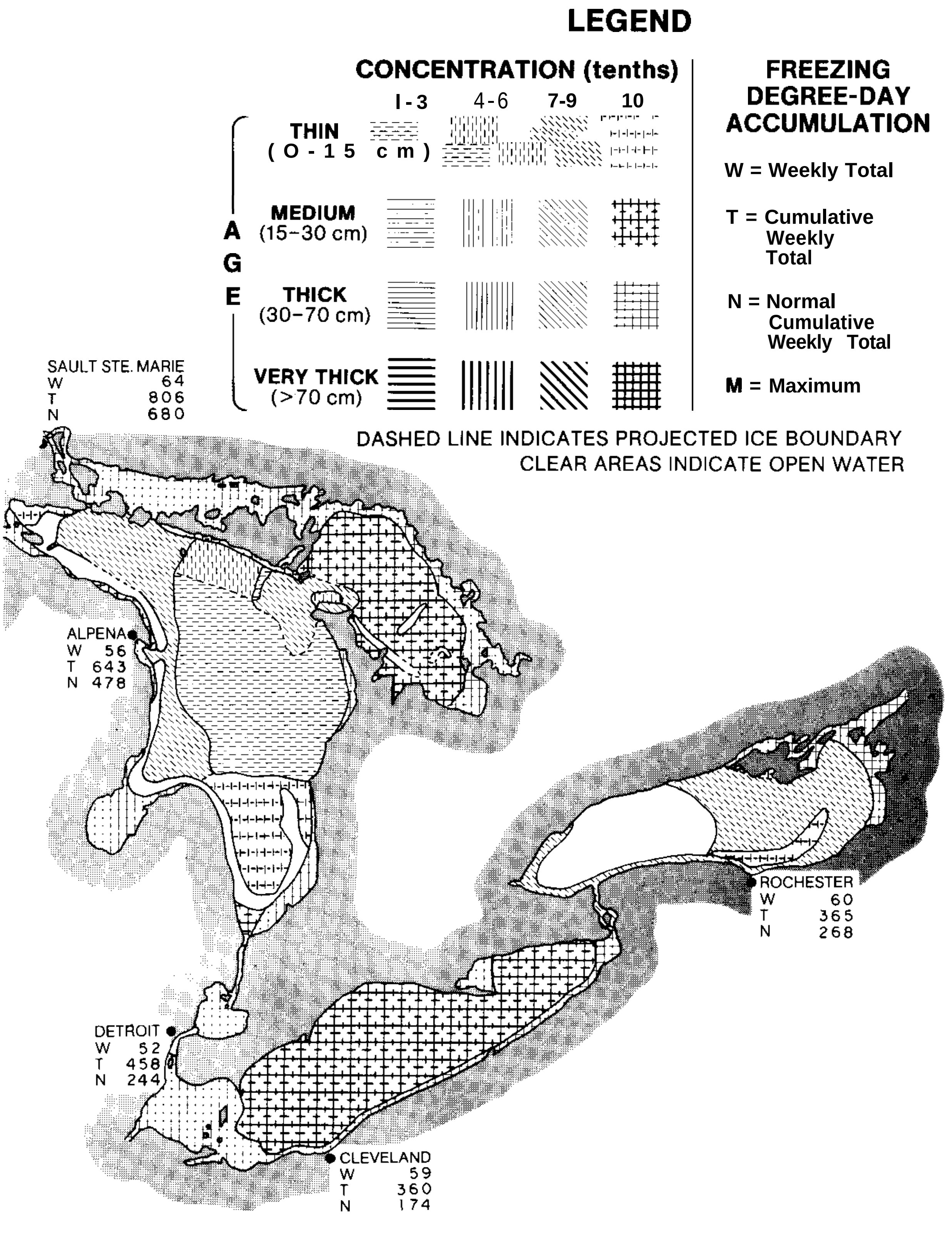

Figure 4k.--*Composite ice chart for February 15, 1978 (con.).*

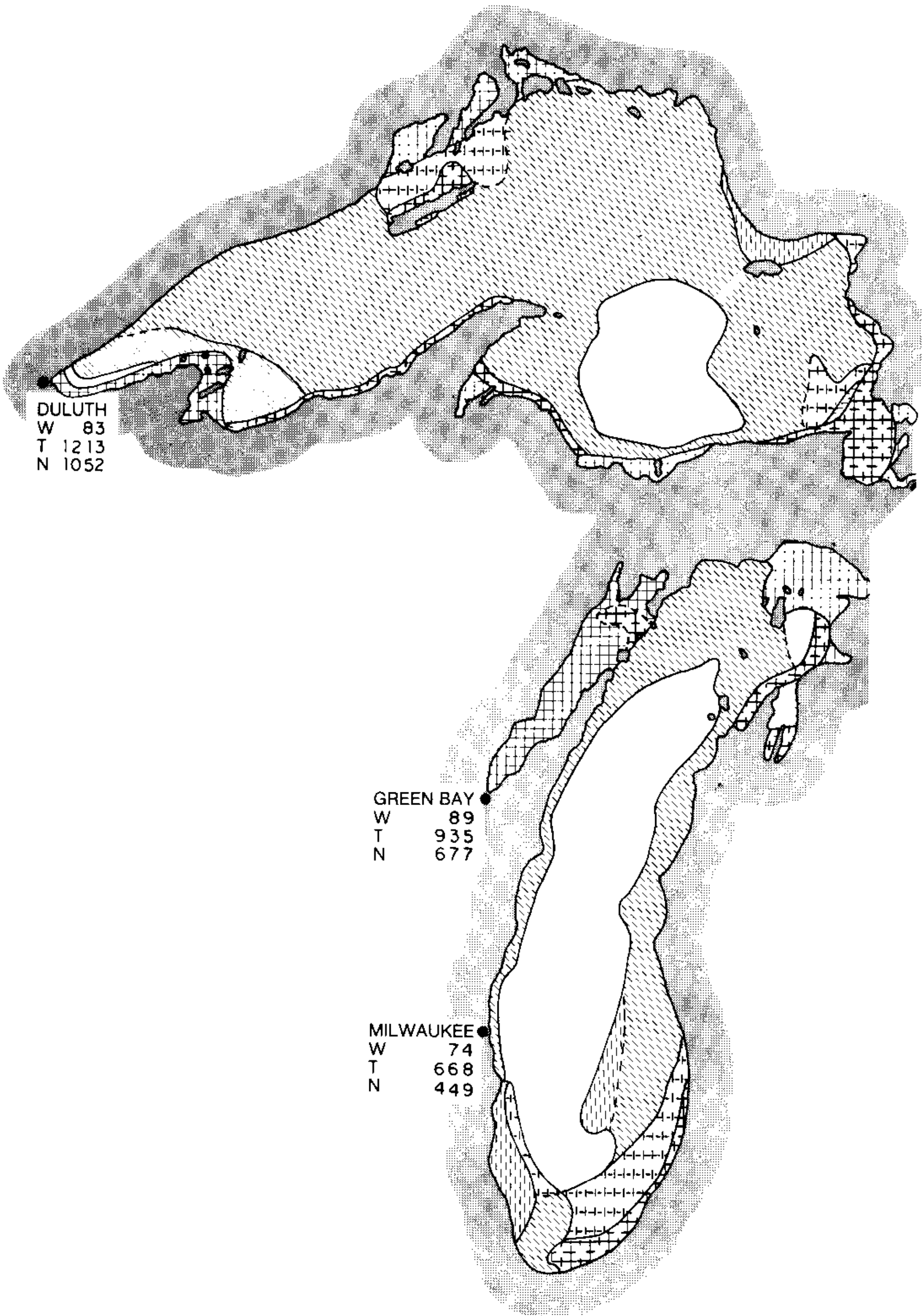

Figure 41.--*Composite ice chart for February 22, 1978.*

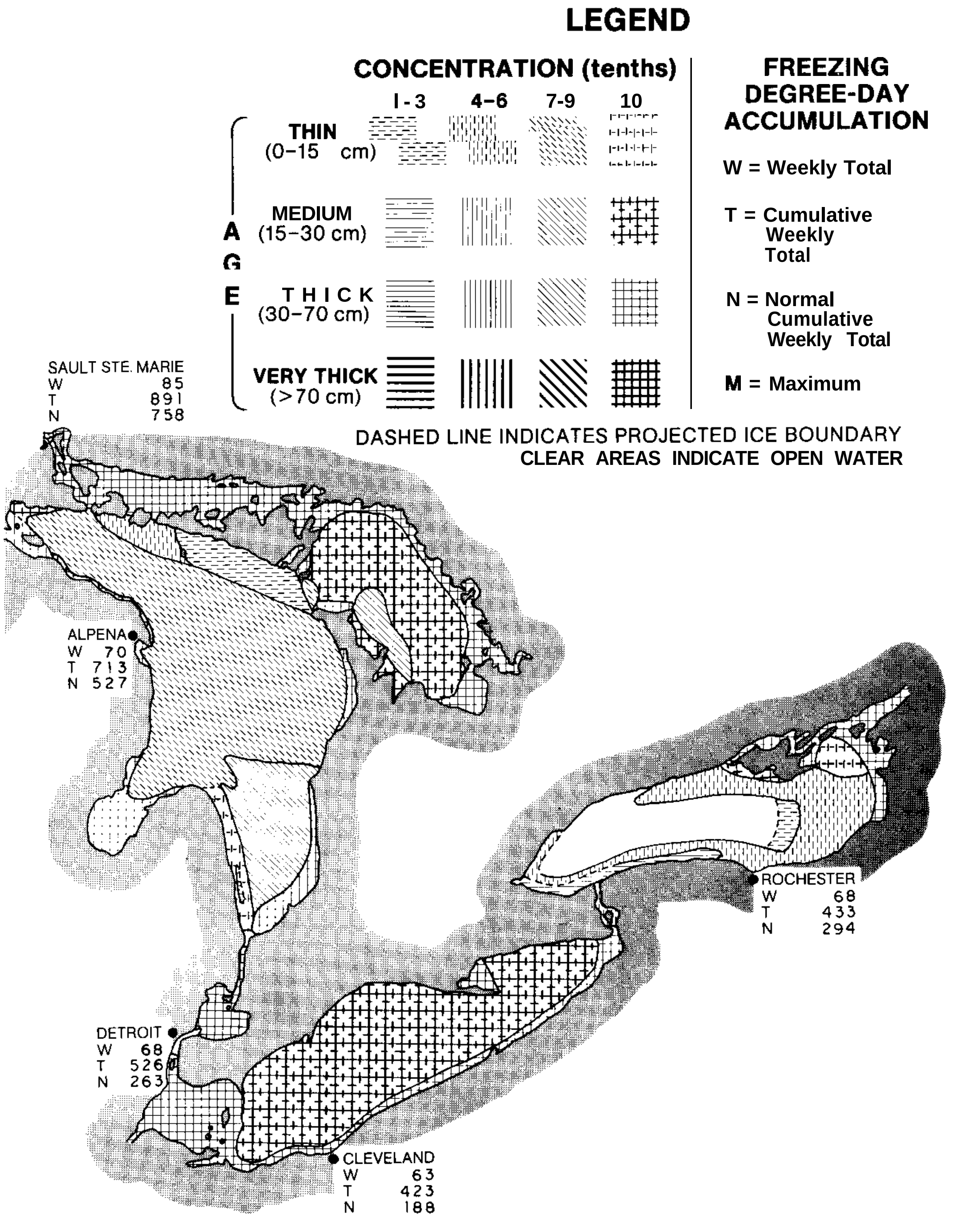

Figure 41.--*Composite ice chart for February 22, 1978 (con.).*

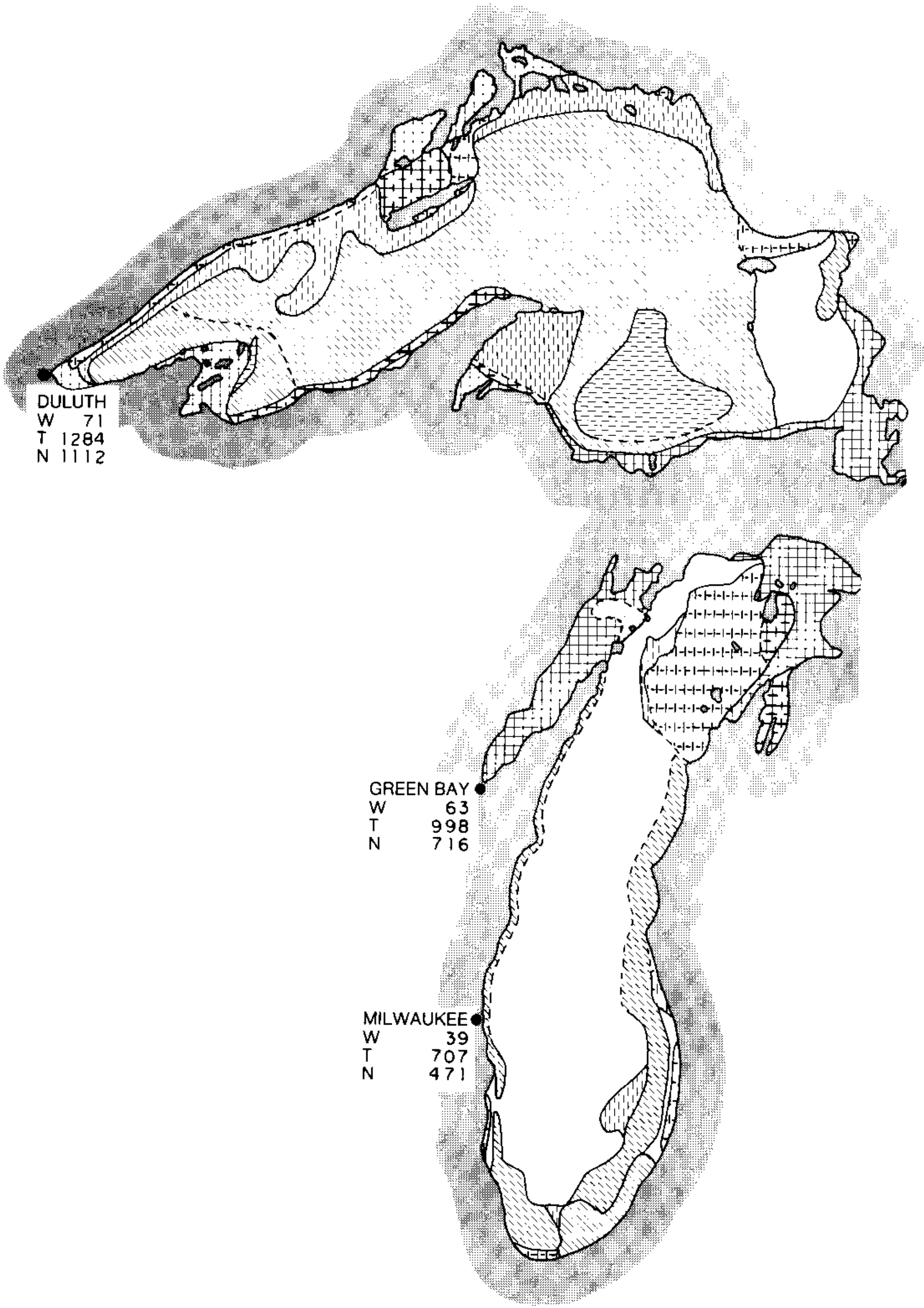

Figure 4m.--Composite ice chart for March 1, 1978.

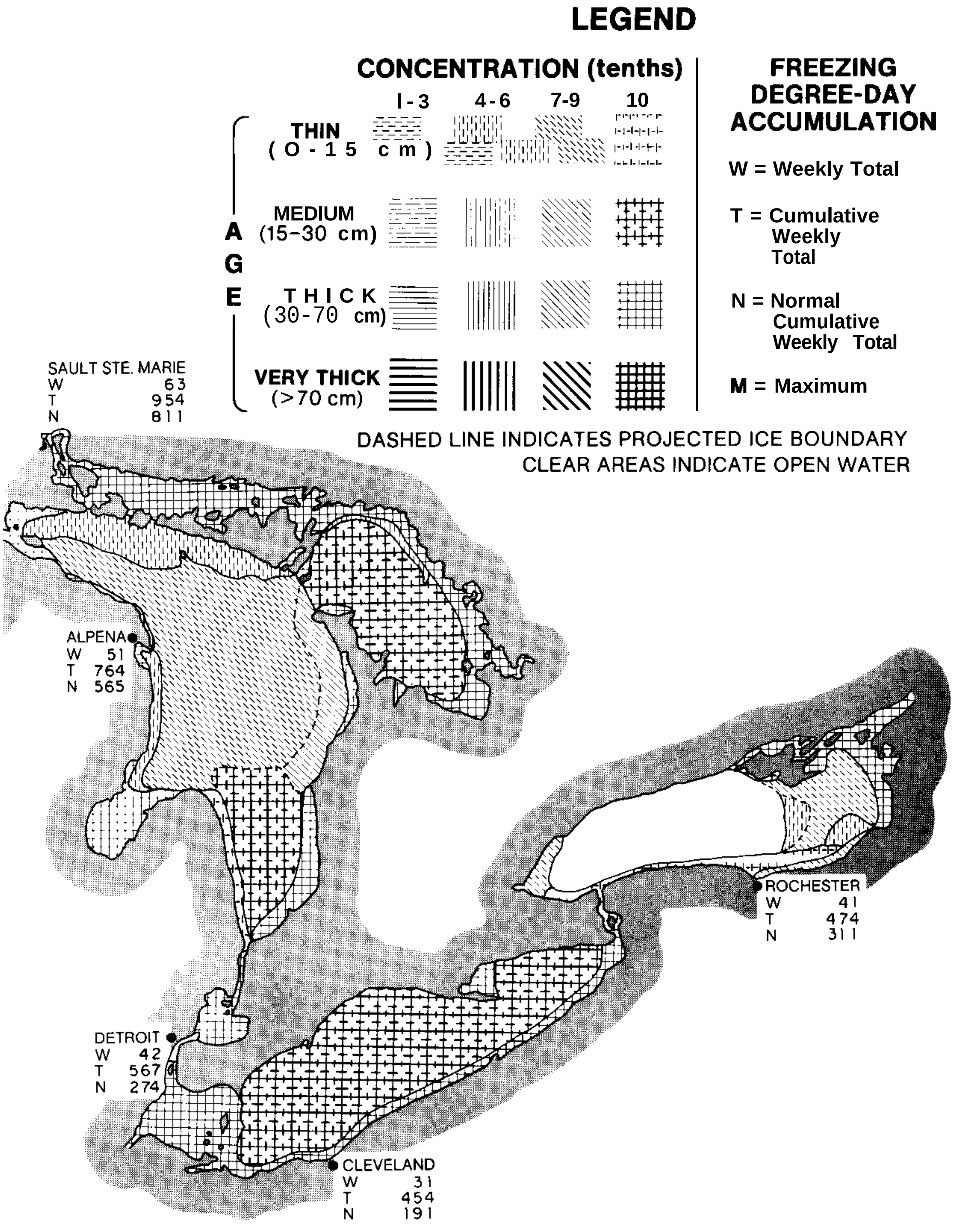

Figure 4m.--Composite ice chart for March 1, 1978 (con.).

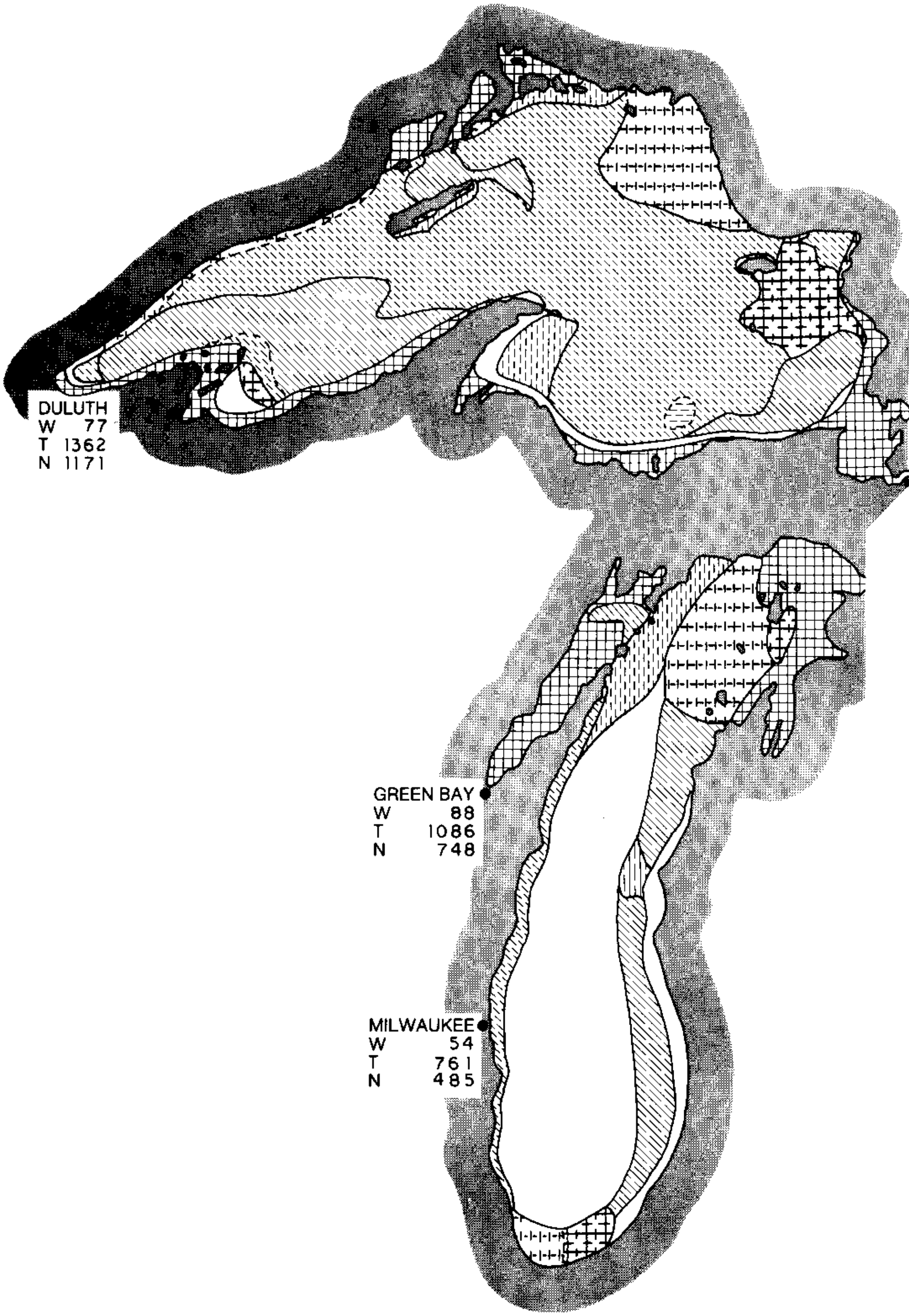

Figure 4n.--*Composite ice chart for March 8, 1978.*

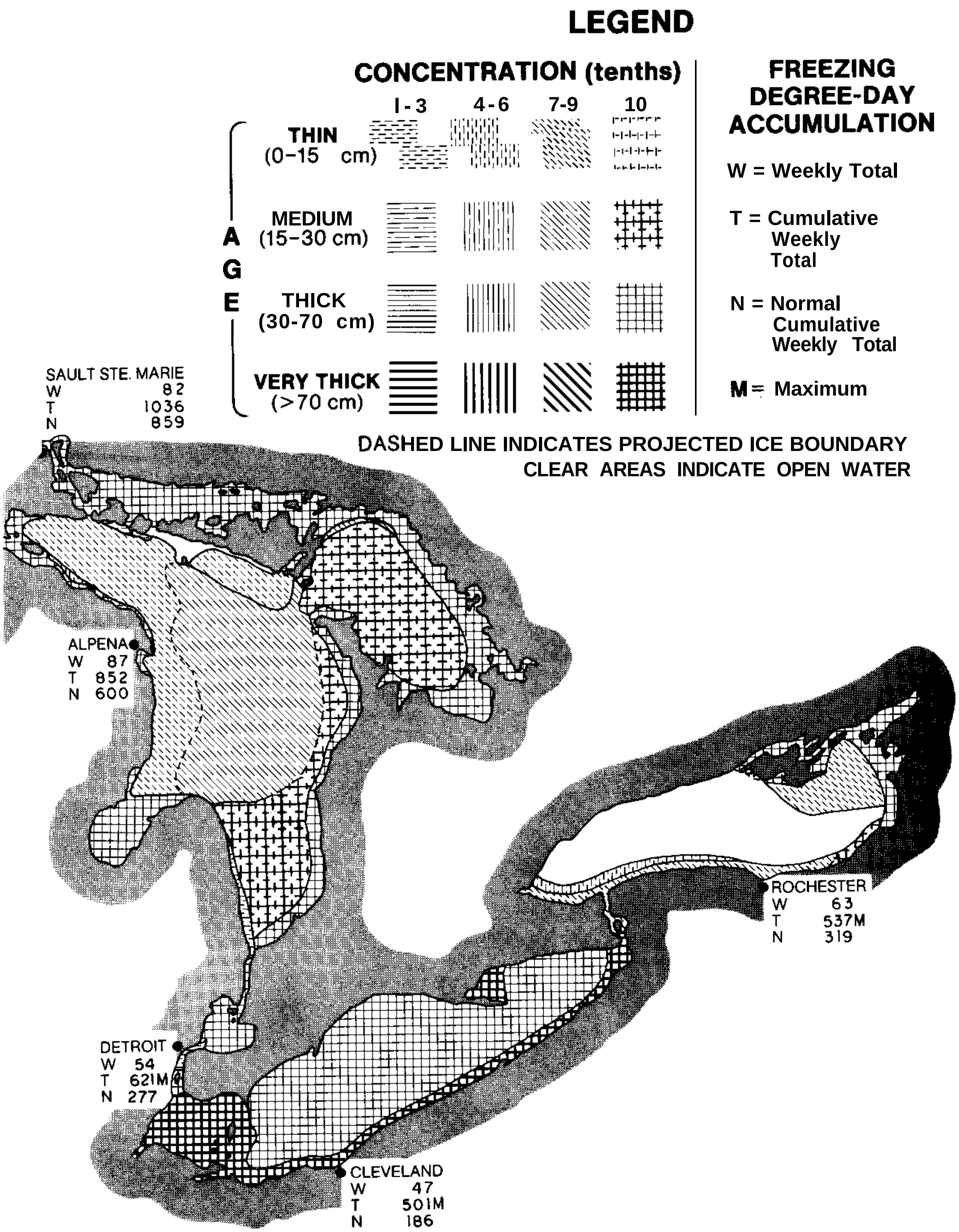

Figure 4n.--*Composite ice chart for March 8, 1978 (con.).*

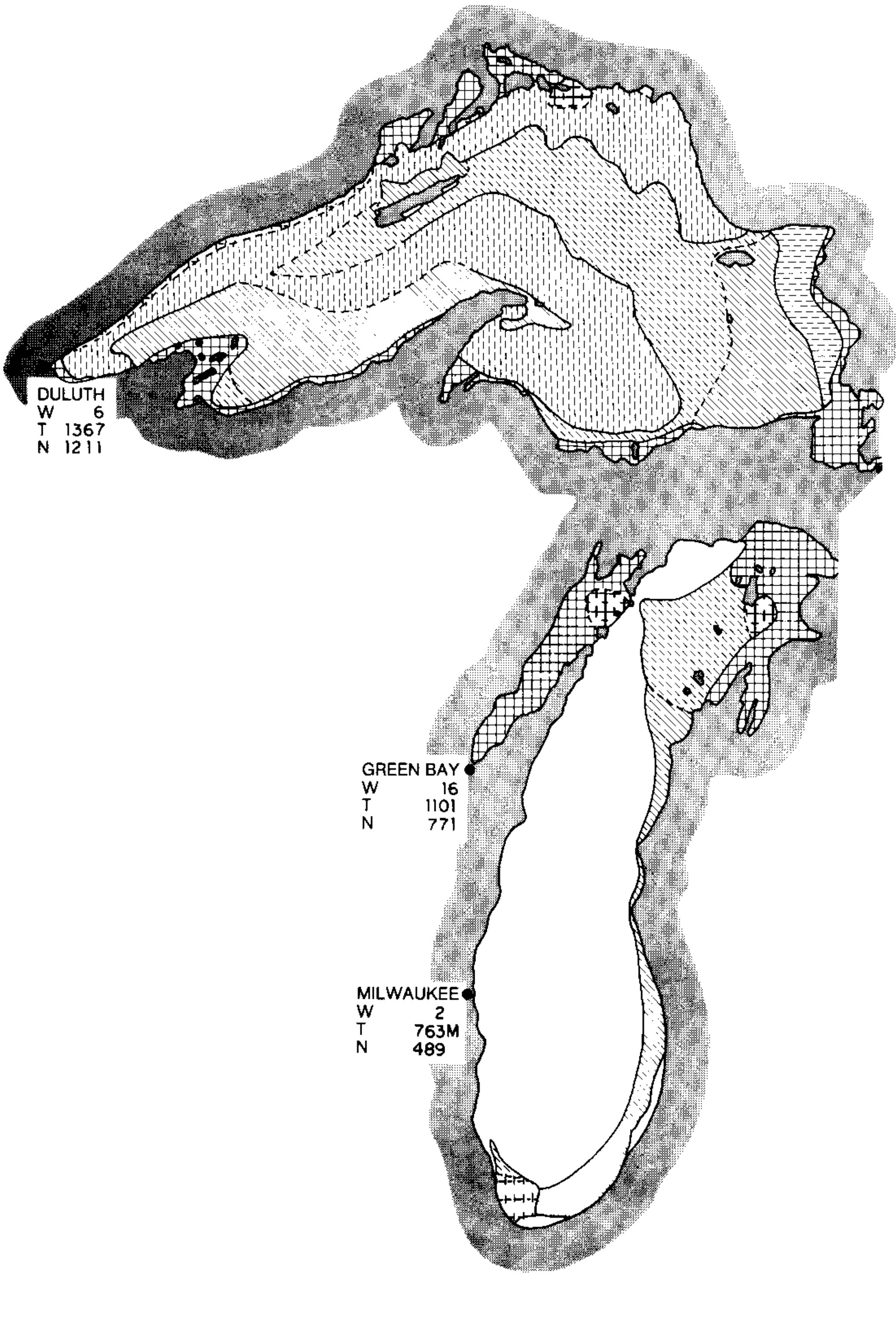

Figure 4o.--*Composite ice chart for March 15, 1978.*

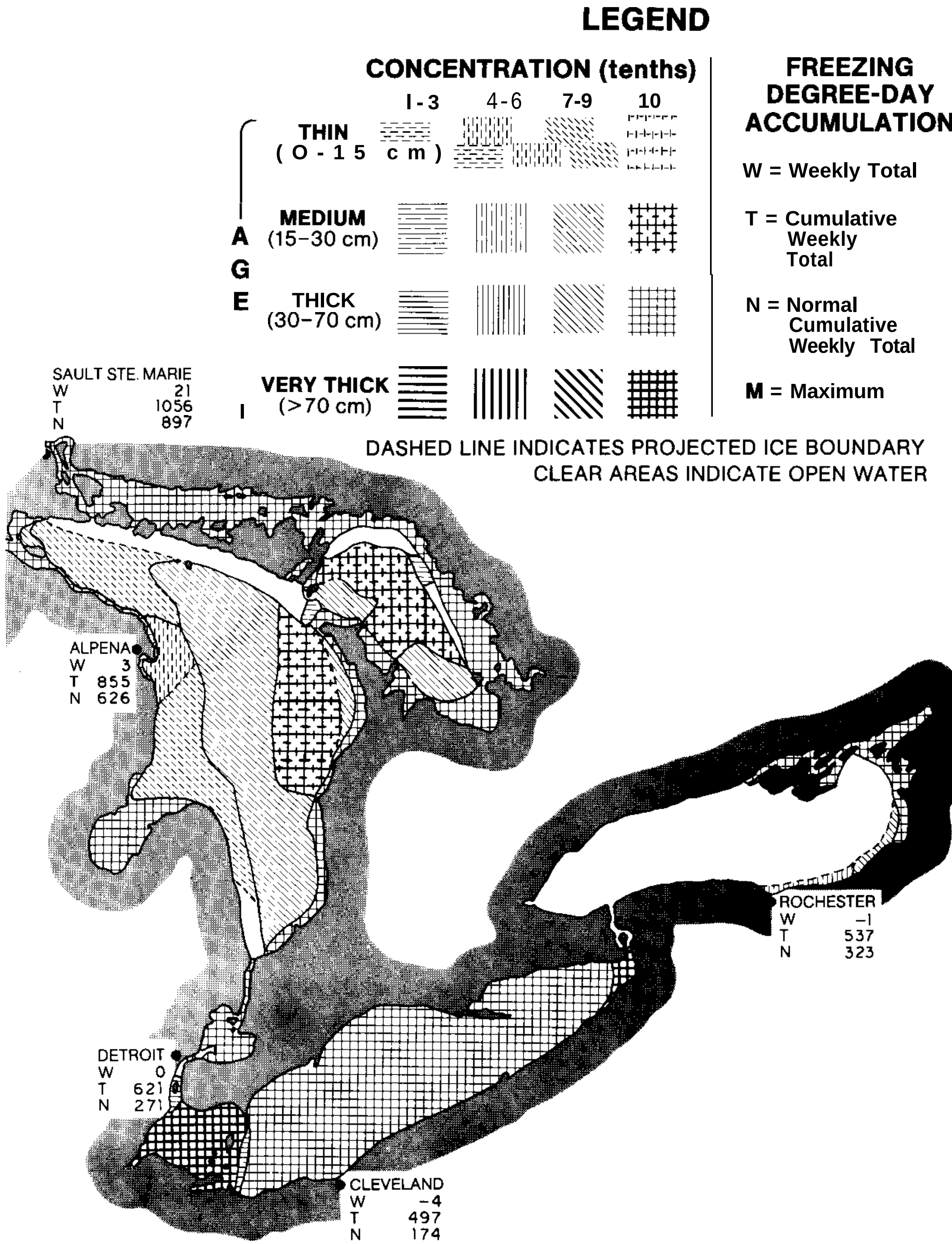

Figure 4o.--*Composite ice chart for March 15, 1978 (con.).*

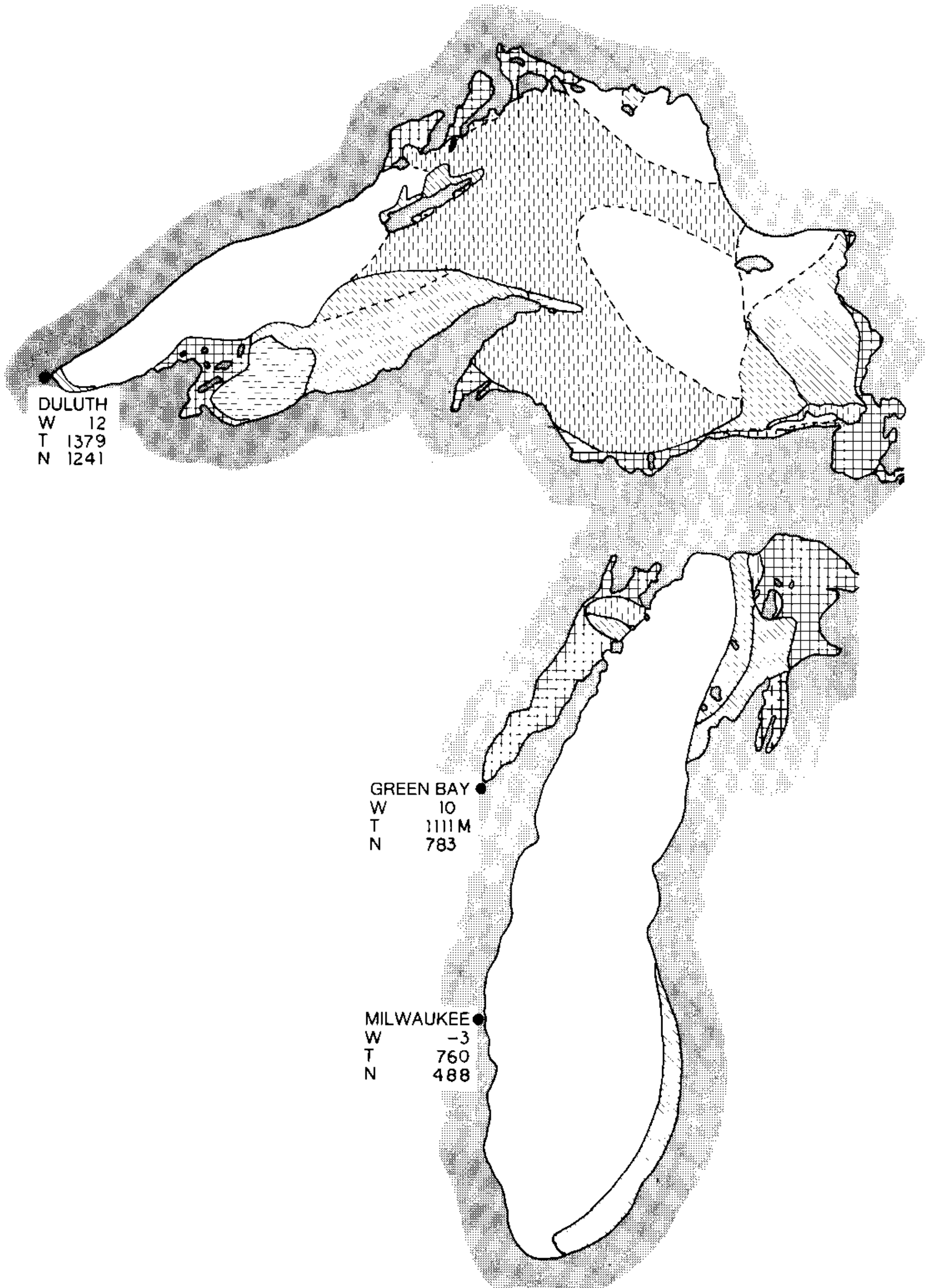

Figure 4p.--*Composite ice chart for March 22, 1978.*

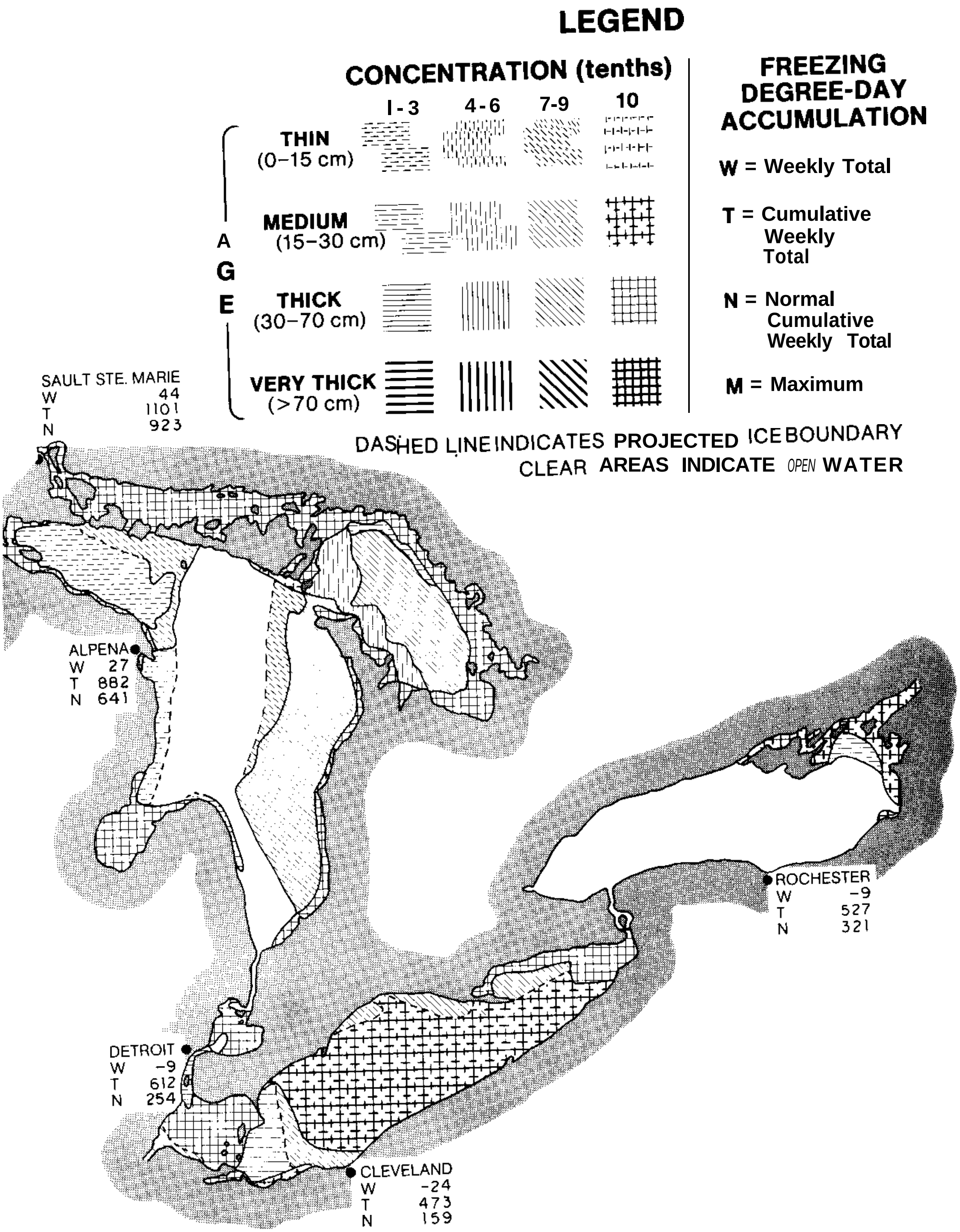

Figure 4p.--Composite ice chart for March 22, 1978 icon.).

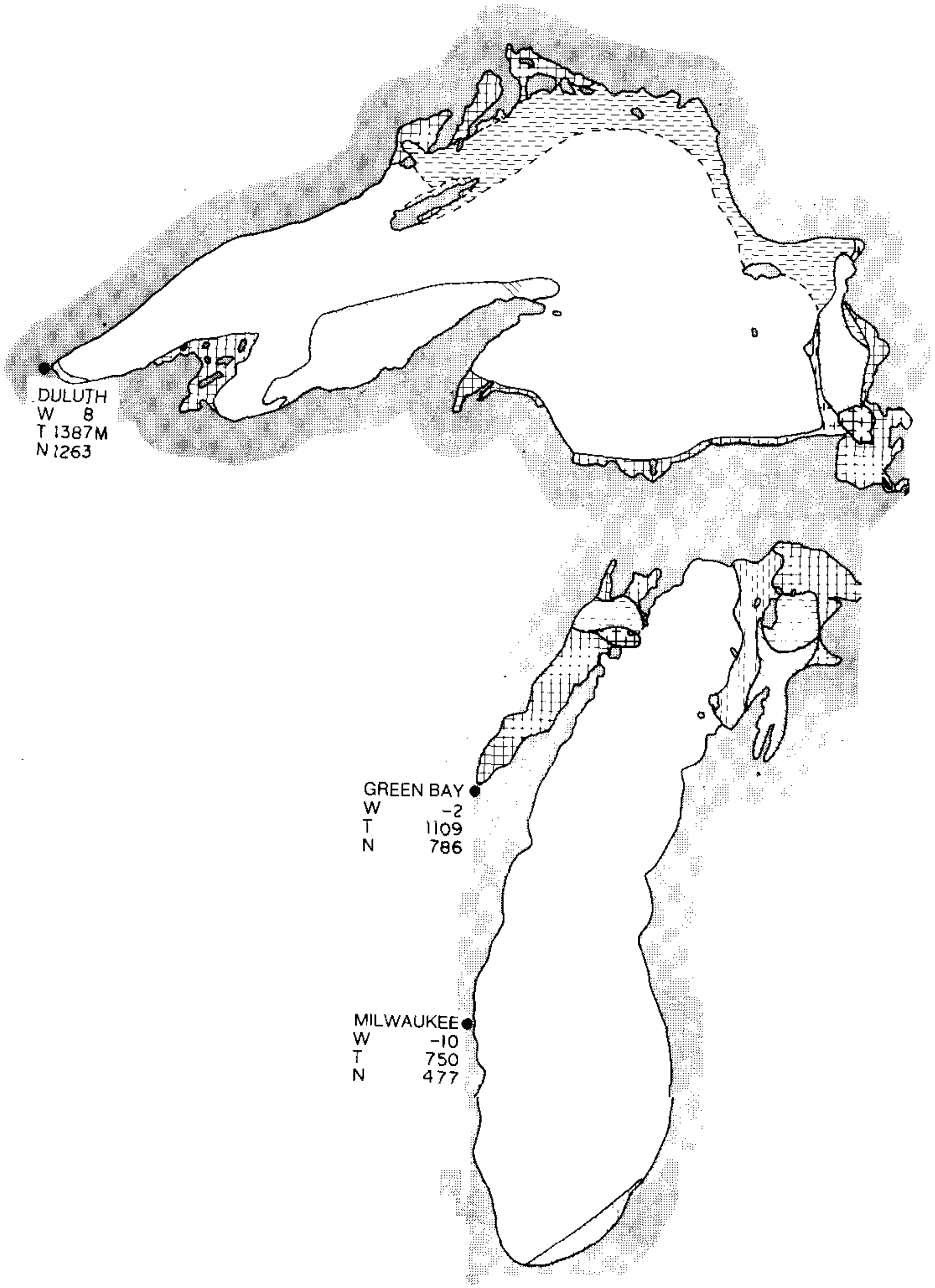

Figure 4q.--*Composite ice chart for March 29, 1978.*

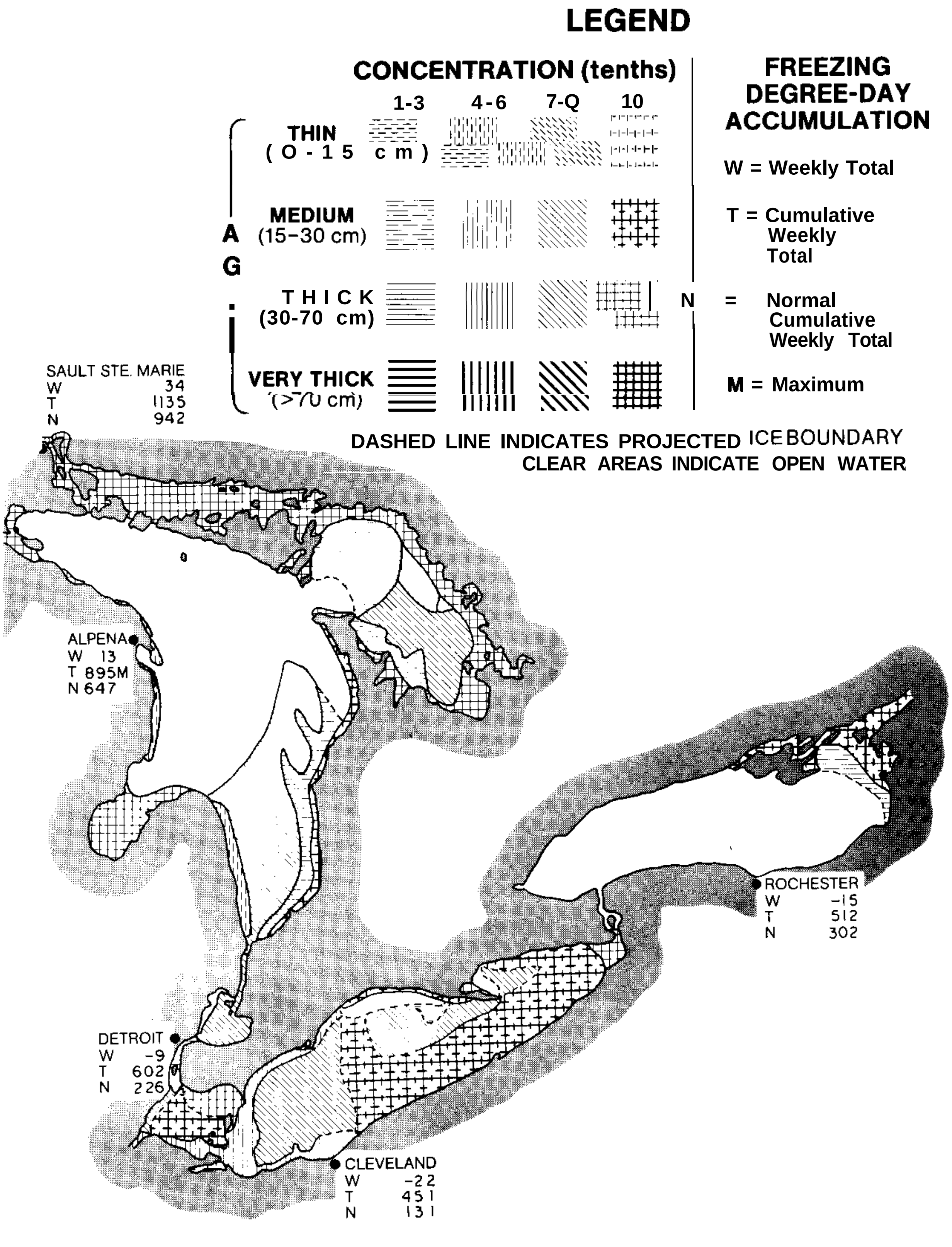

Figure 4q.--*Composite ice chart for March 29, 1978 (con.).*

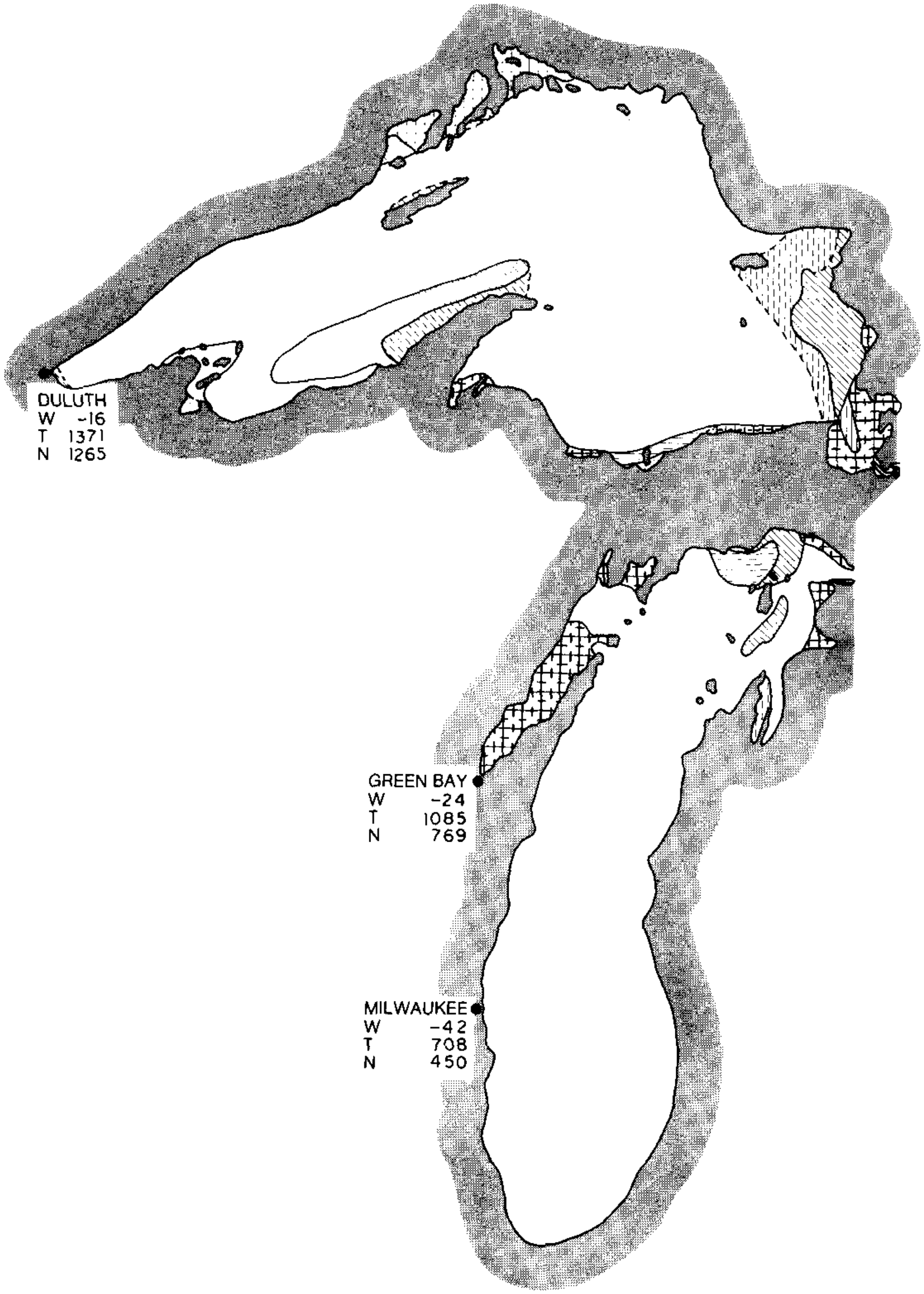

Figure 4r.--*Composite* ice chart for *April* 5, 1978.

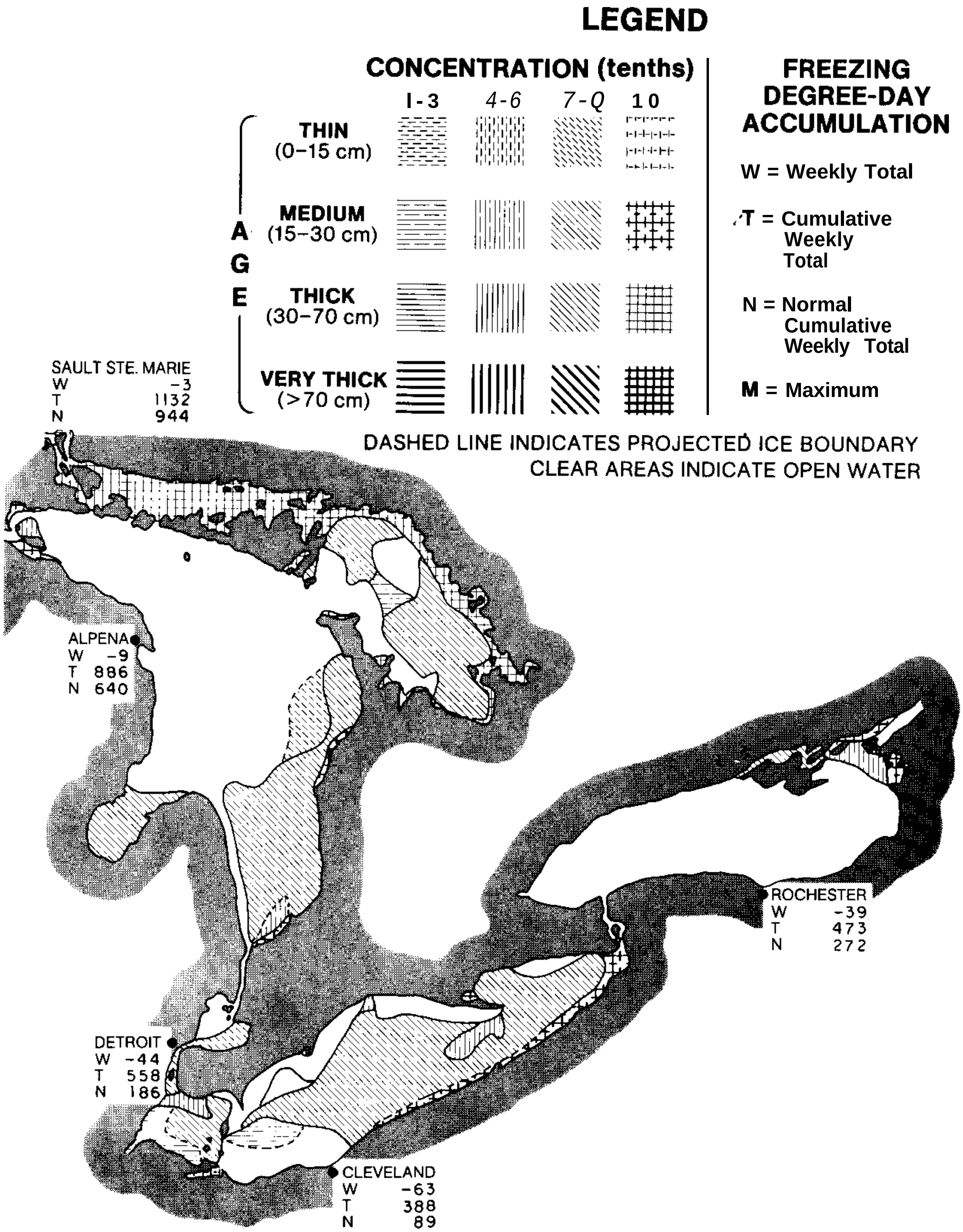

Figure 4r.--*Composite ice chart for April 5, 1978 (con.).*

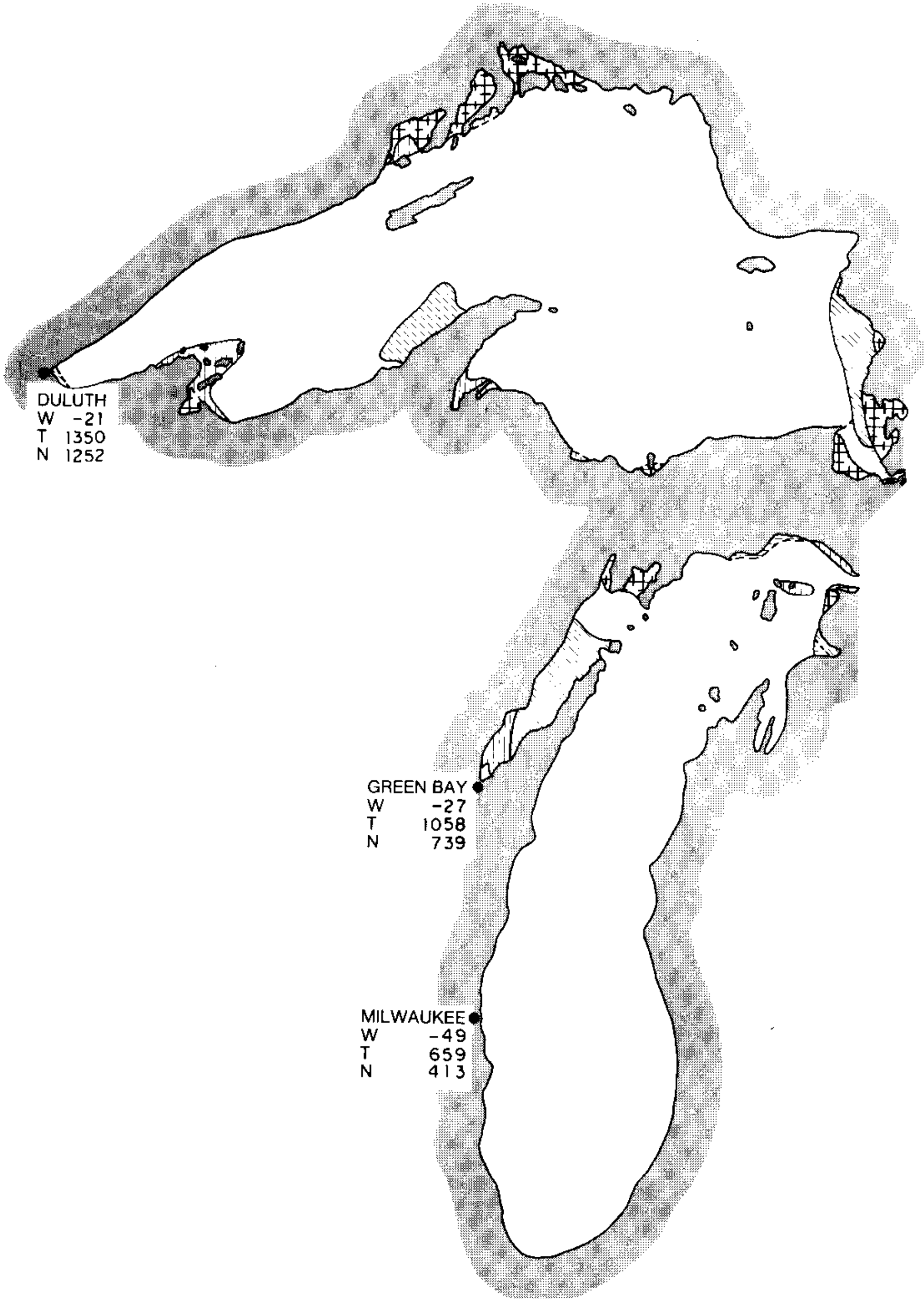

Figure 4s.--*Composite* ice chart for April 12, 1978.

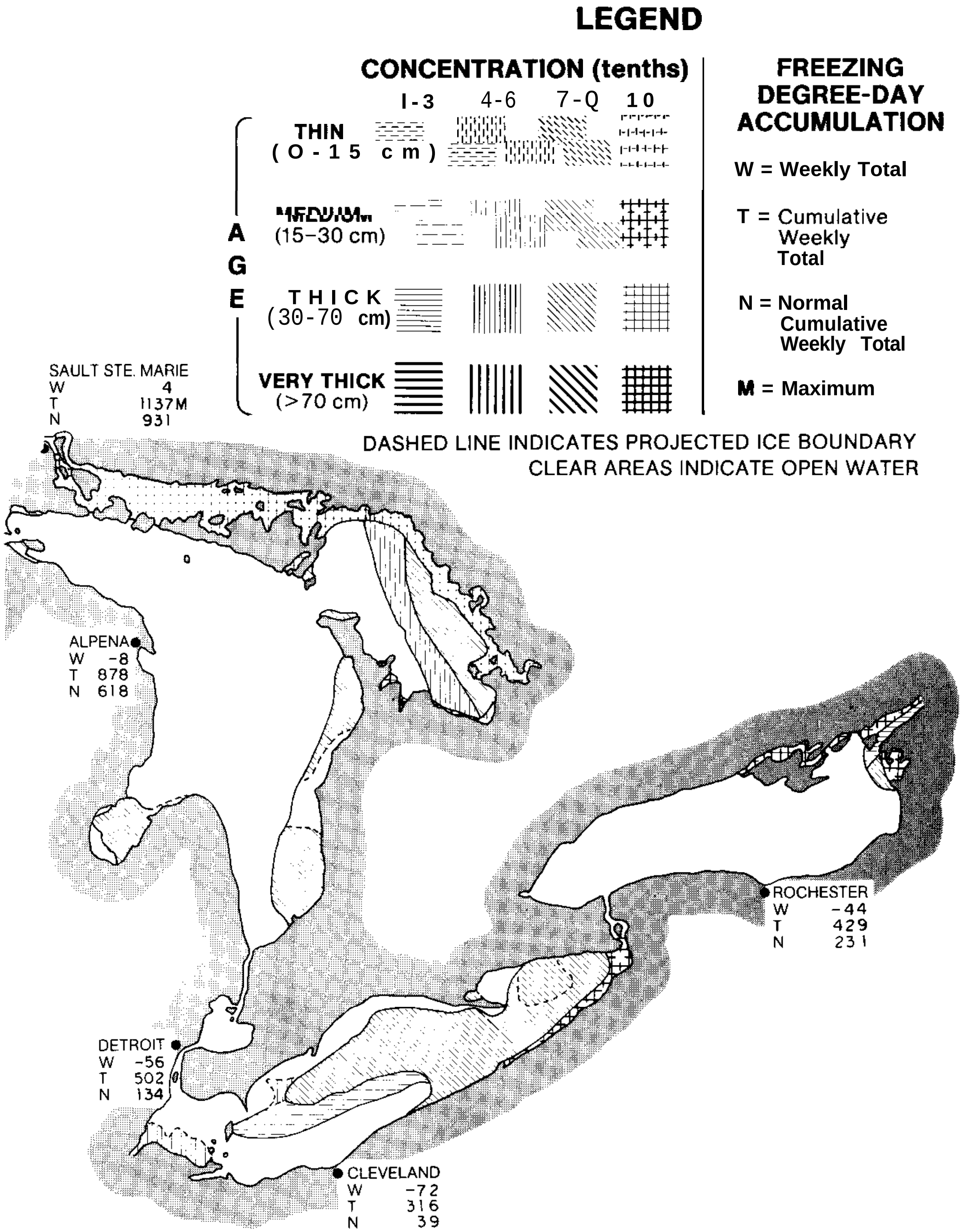

Figure 4s.--*Composite ice chart for April 12, 1978 icon.).*

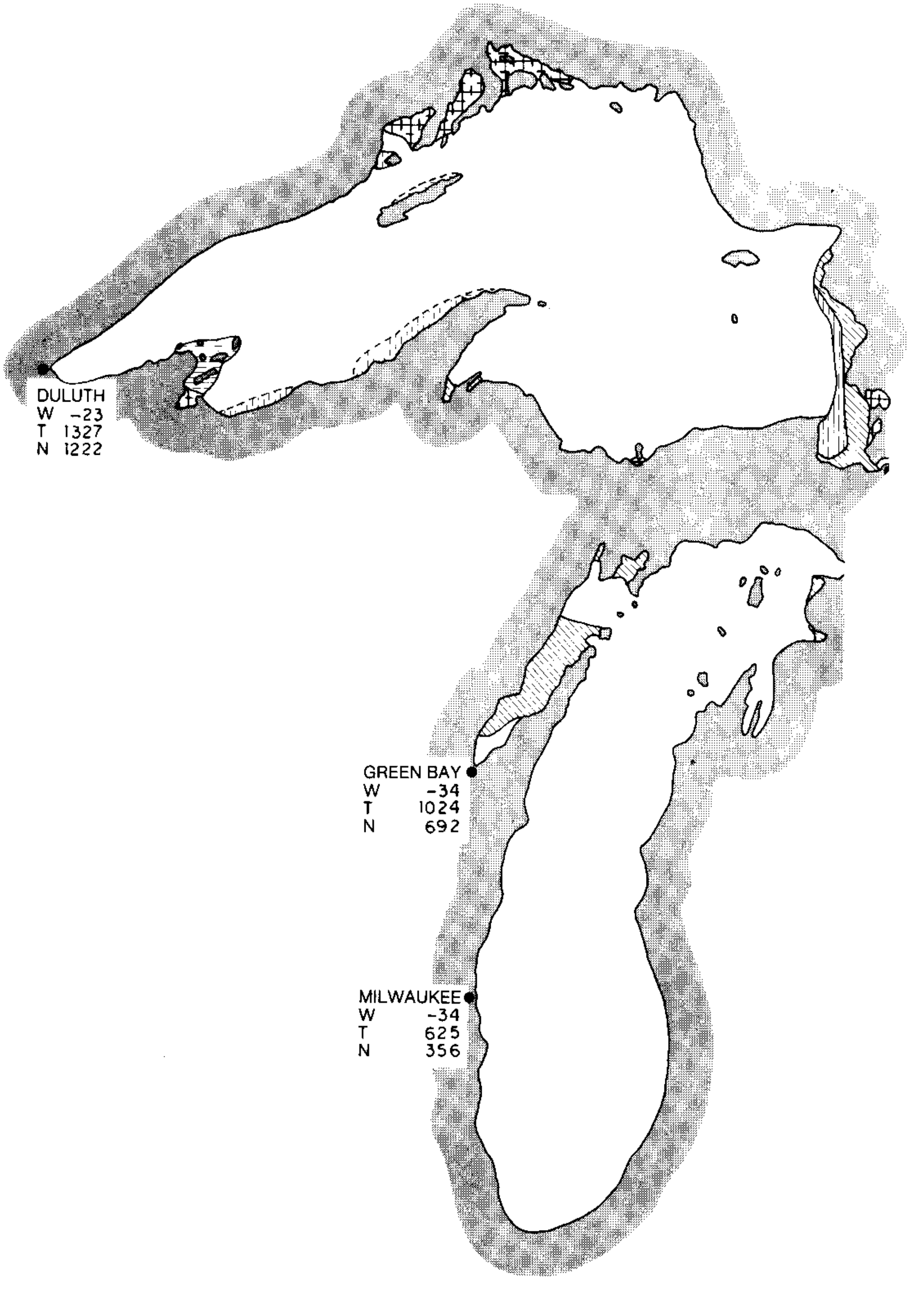

Figure 4t.--*Composite ice chart for April 19, 1978.*

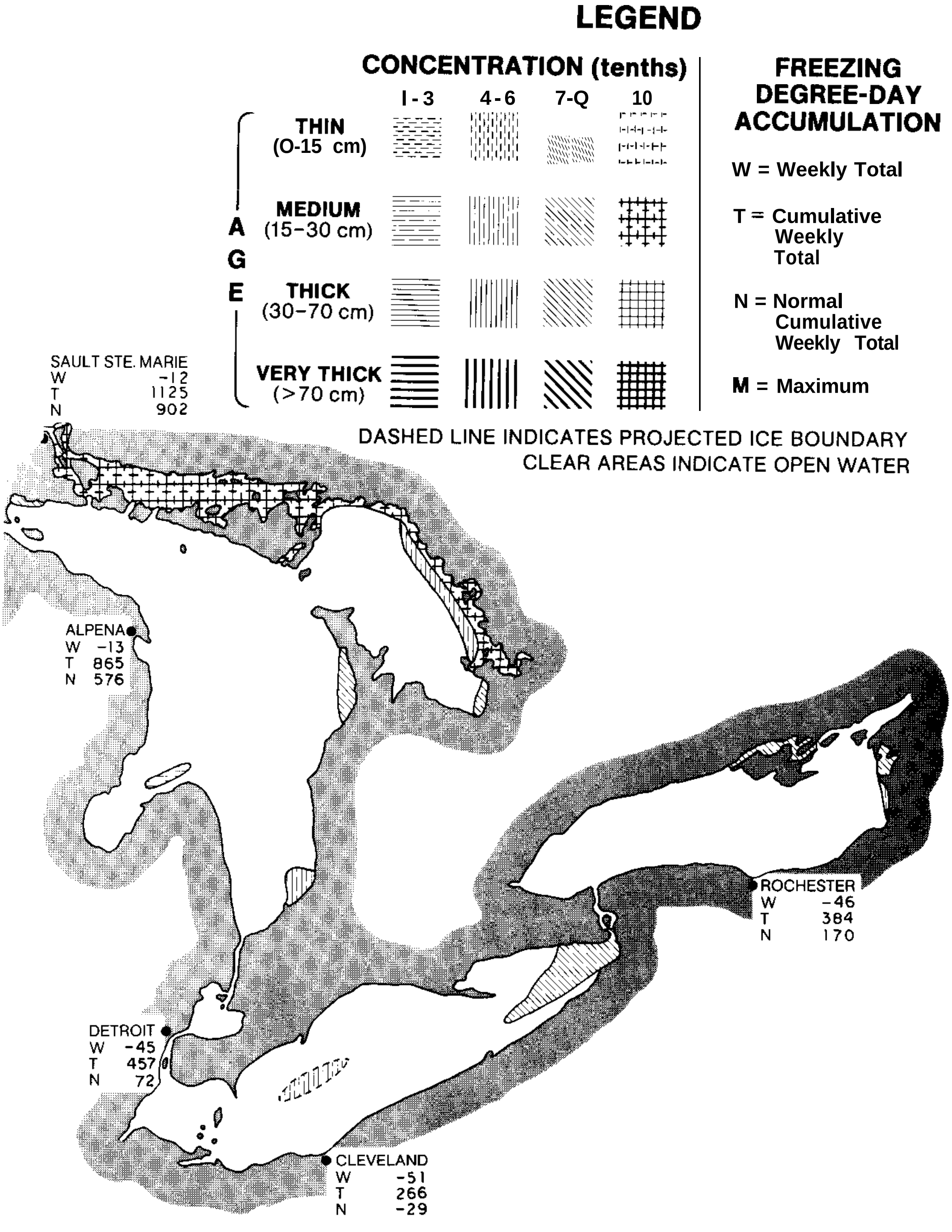

Figure 4t.--Composite ice chart for April 19, 1978 Icon.).

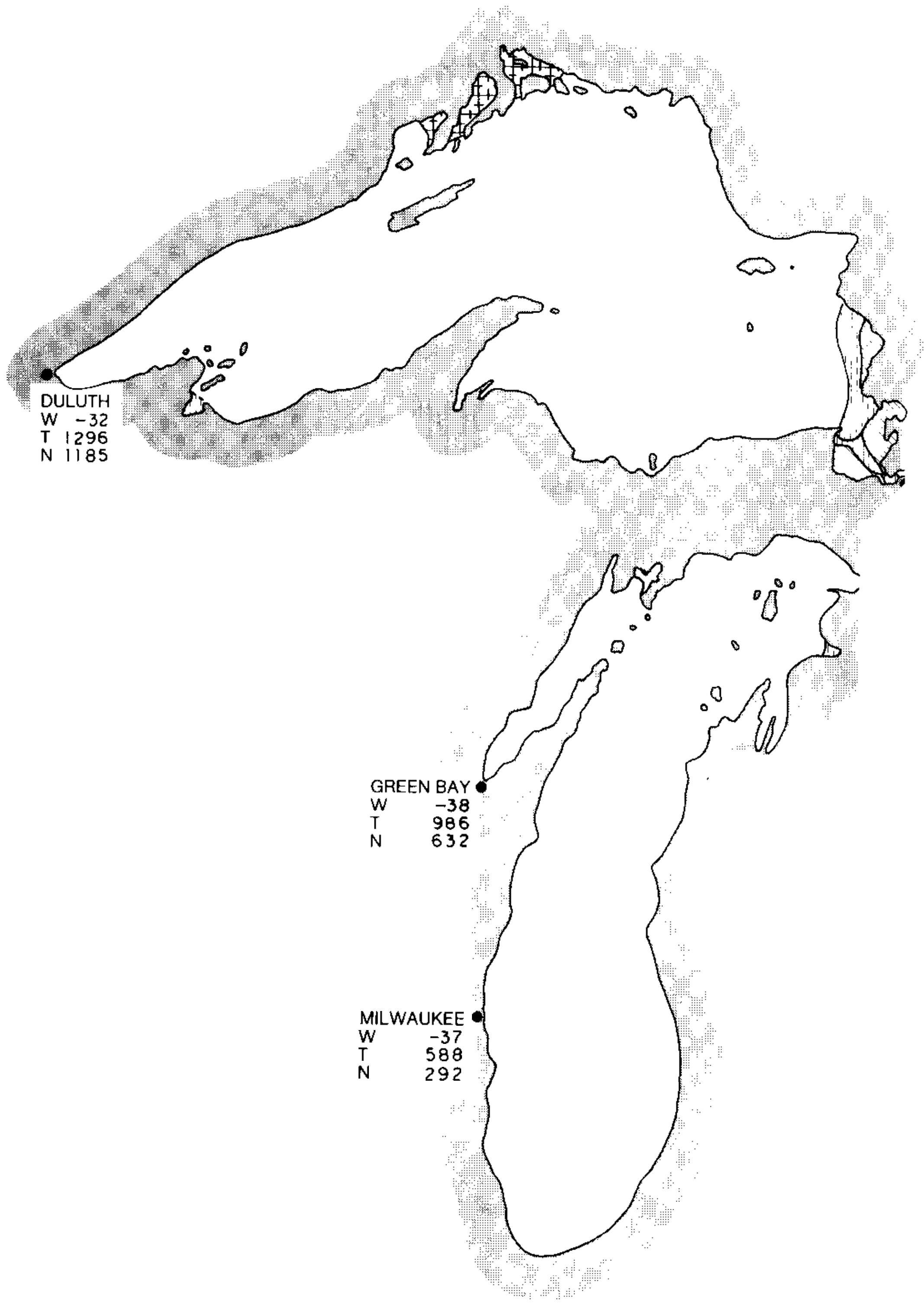

Figure 4u.--*Composite ice chart for April 26, 1978.*

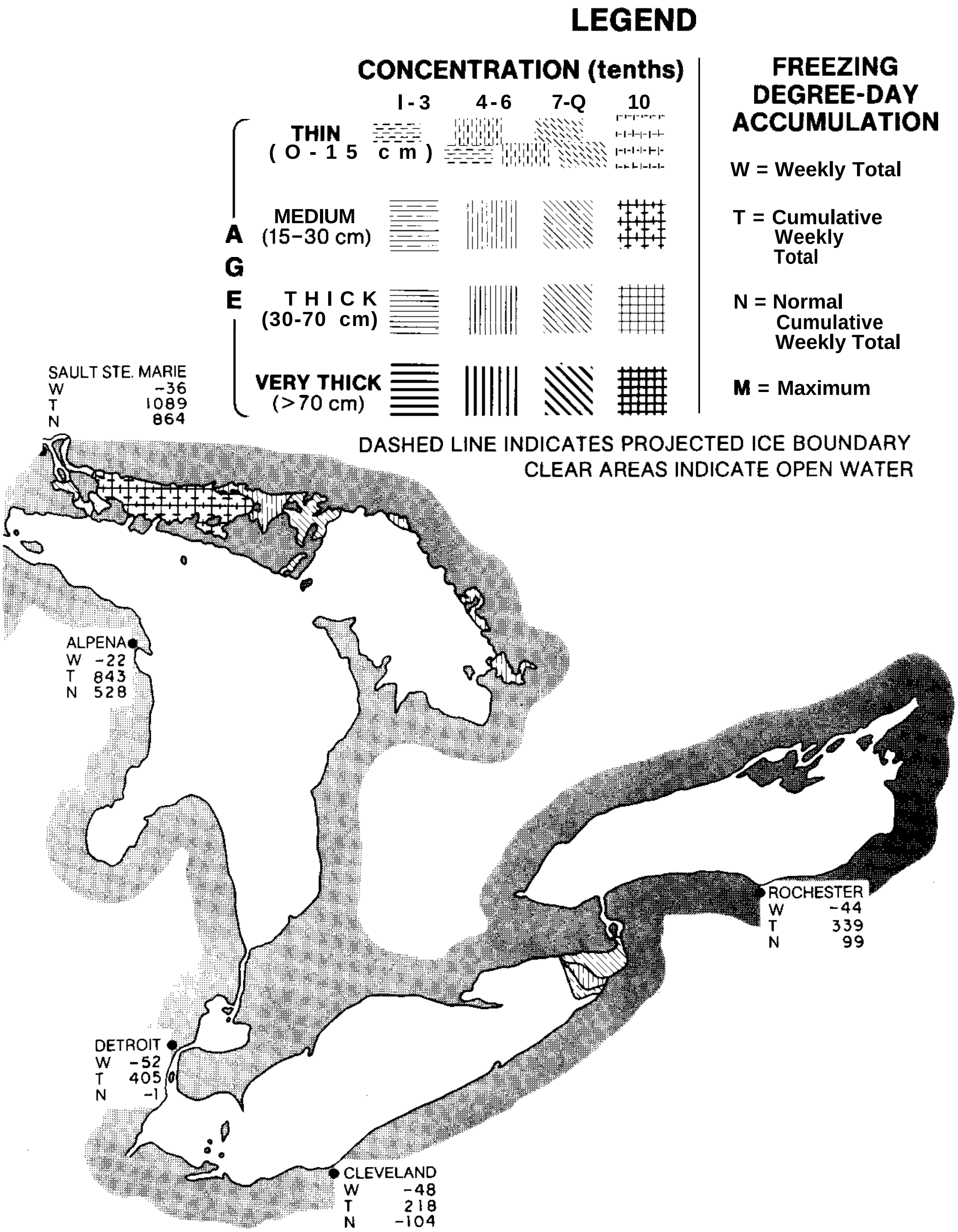

Figure 4u.--Composite ice chart for April 26, 1978 icon.).

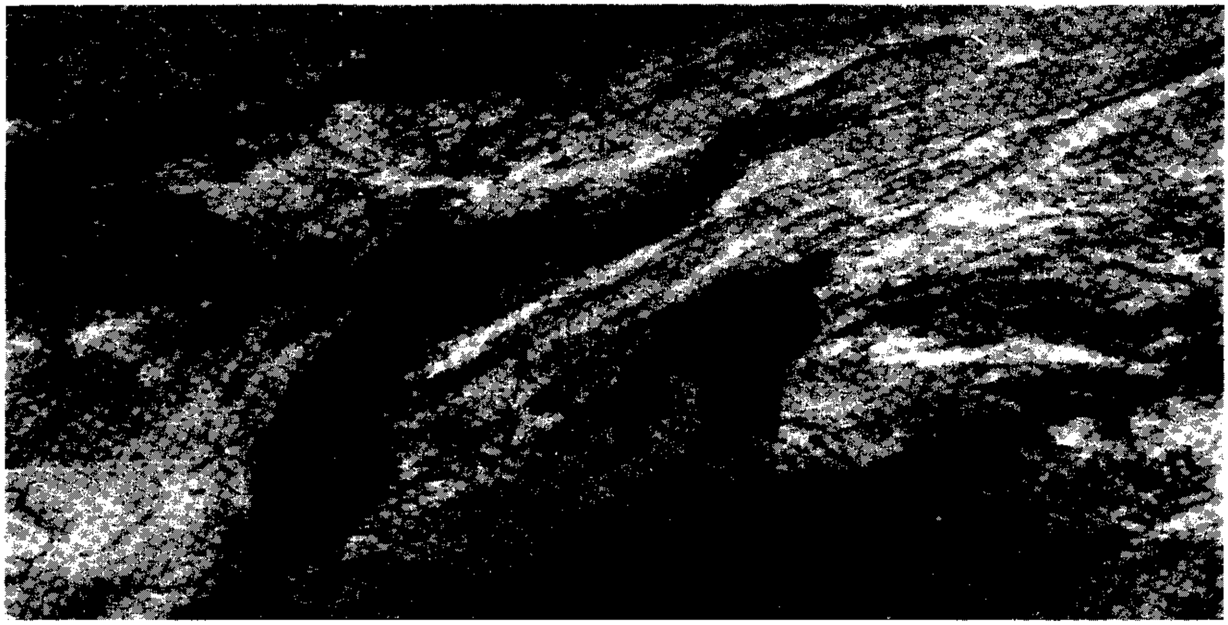

Figure 5*a*.--*GOES VISSR (visible) image for December 23, 1977.*

Figure 5*b*.--*GOES VISSR (visible) image for January 2, 1978.*

Figure 5c.--*GOES VISSR (visible image for January 3, 1978*

Figure 5d.--*GOES VISSR (visible image fo January 11, 1978*

Figure 5e.--*NOAA-5 VHRR (visible) image for January 15, 1978.*

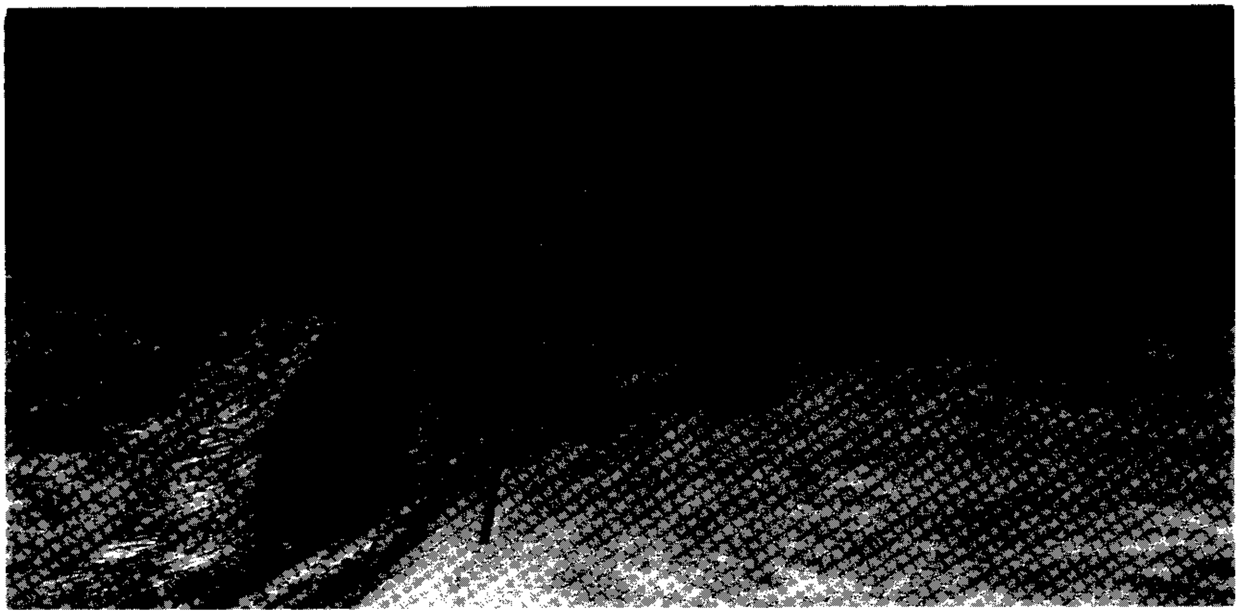

Figure 5f.--GOES VISSR (visible) image for January 17, 1978.

Figure 5g.--GOES VISSR (visible) image for January 18, 1978.

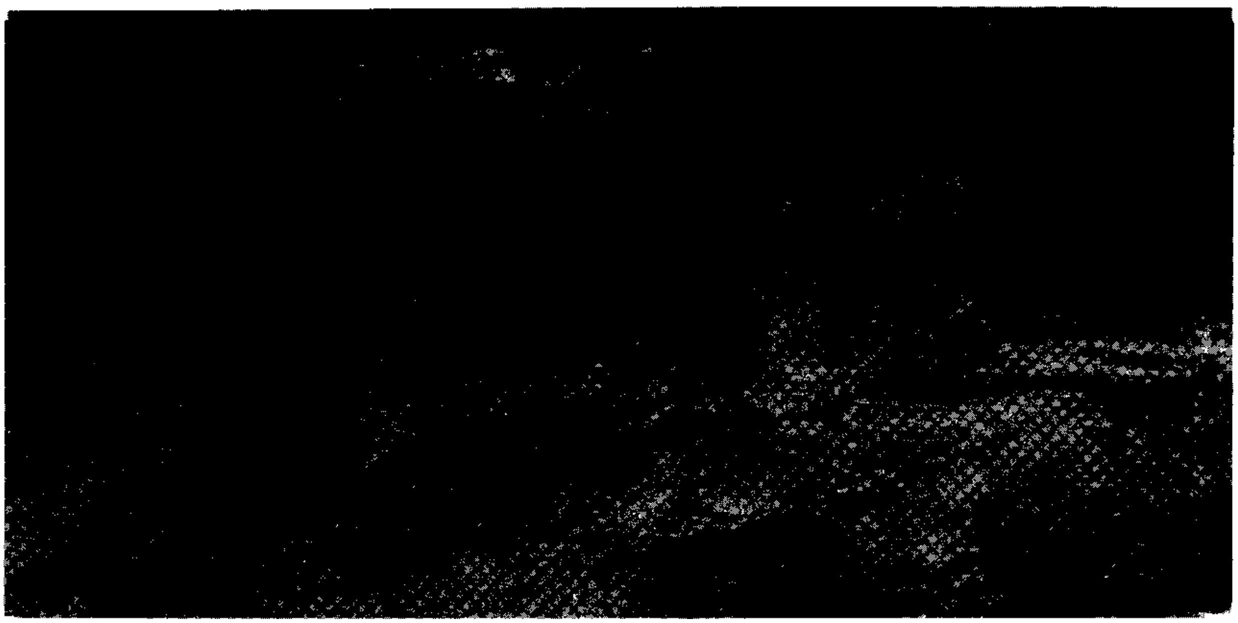

Figure 5h.--GOES VISSR (visible) image for January 22, 1978.

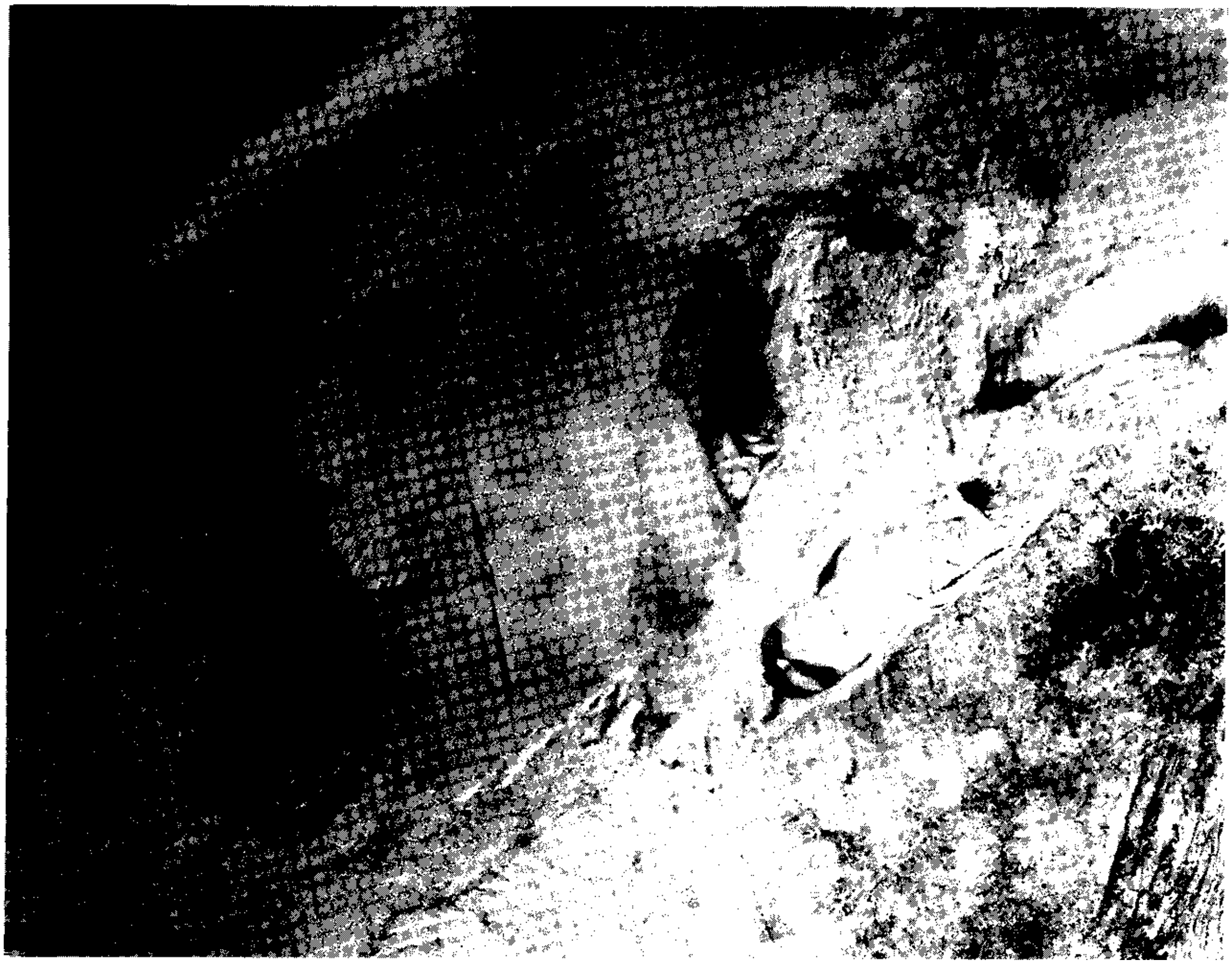

Figure 5i.--NOAA-5 VHRR (visible) image for January 23, 1978.

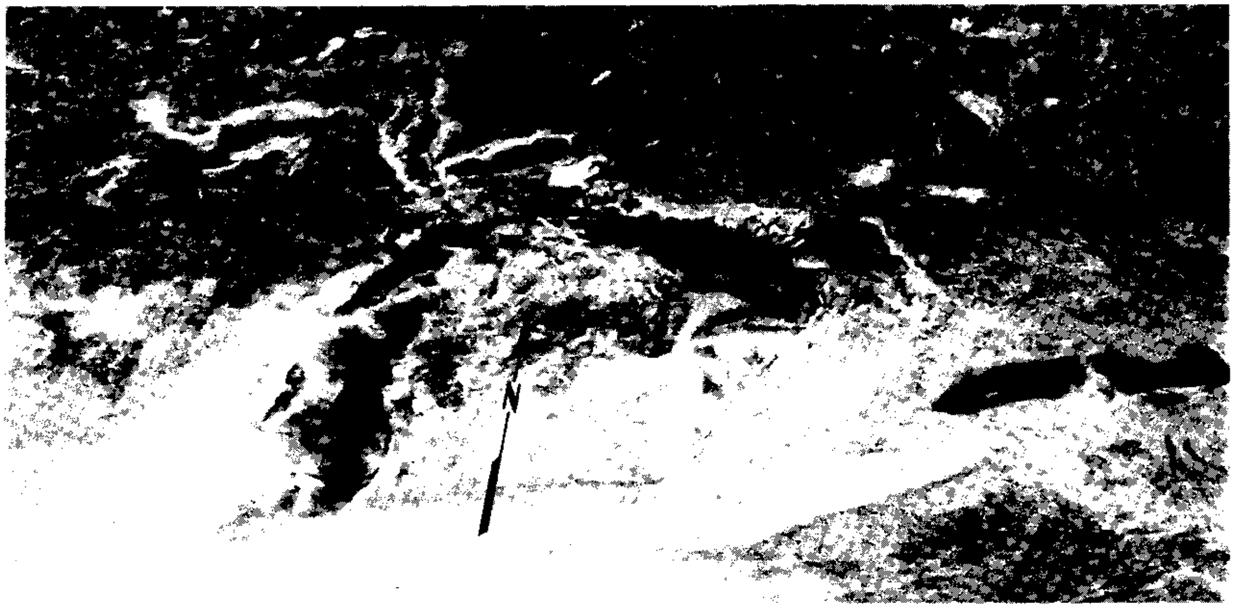

Figure 5j.--*GOES VISSR (visible) image for February 3, 1978.*

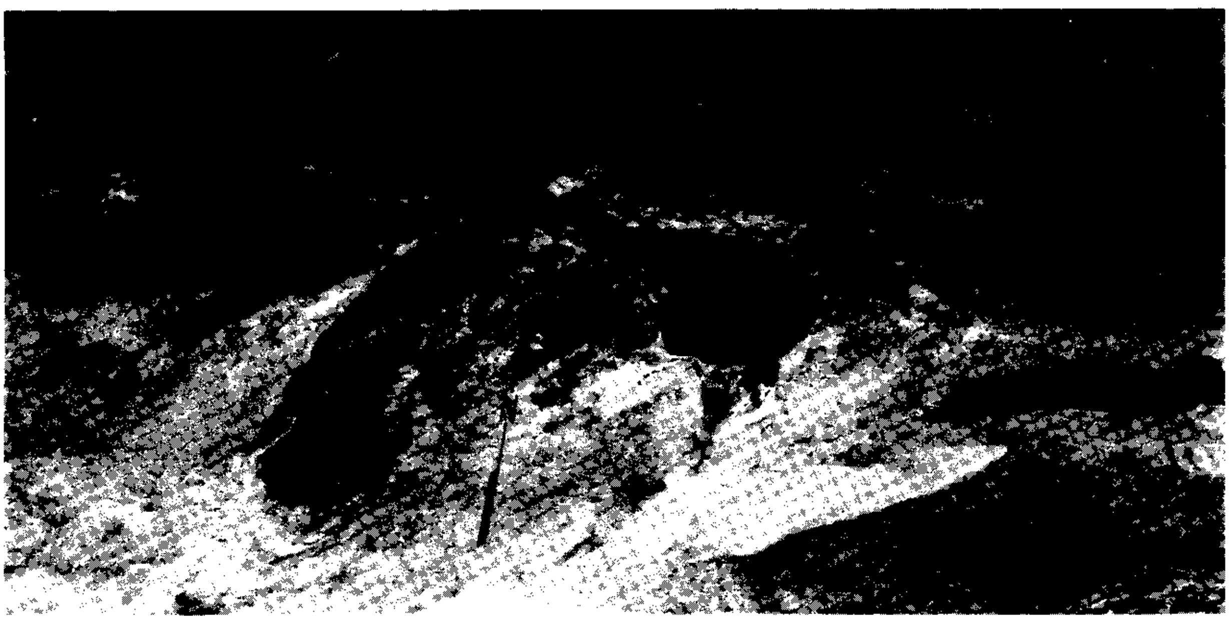

Figure 5k.--*GOES VISSR (visible) image for February 9, 1978.*

Figure 51.--*NOAA-5 VHRR (visible) image for February 10, 1978.*

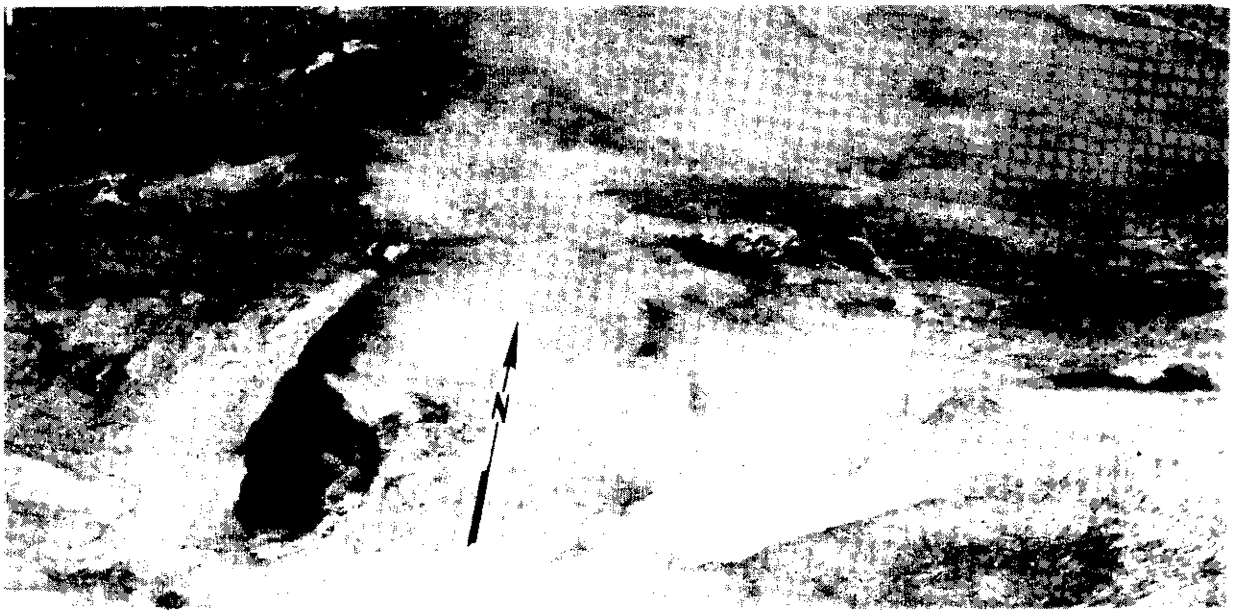

Figure 5m. - [illegible] VISSR (visible) image for February 12, 1978.

Figure 5n. - [illegible] VISSR (visible) image for February 13, 1978.

Figure 5o.--*GOES VISSR (visible image for February 14, 1978*

Figure 5p.--*GOES VISSR visible image for February 15, 1978*

Figure 5q.--*NOAA-5 VHRR (visible) image for February 19, 1978.*

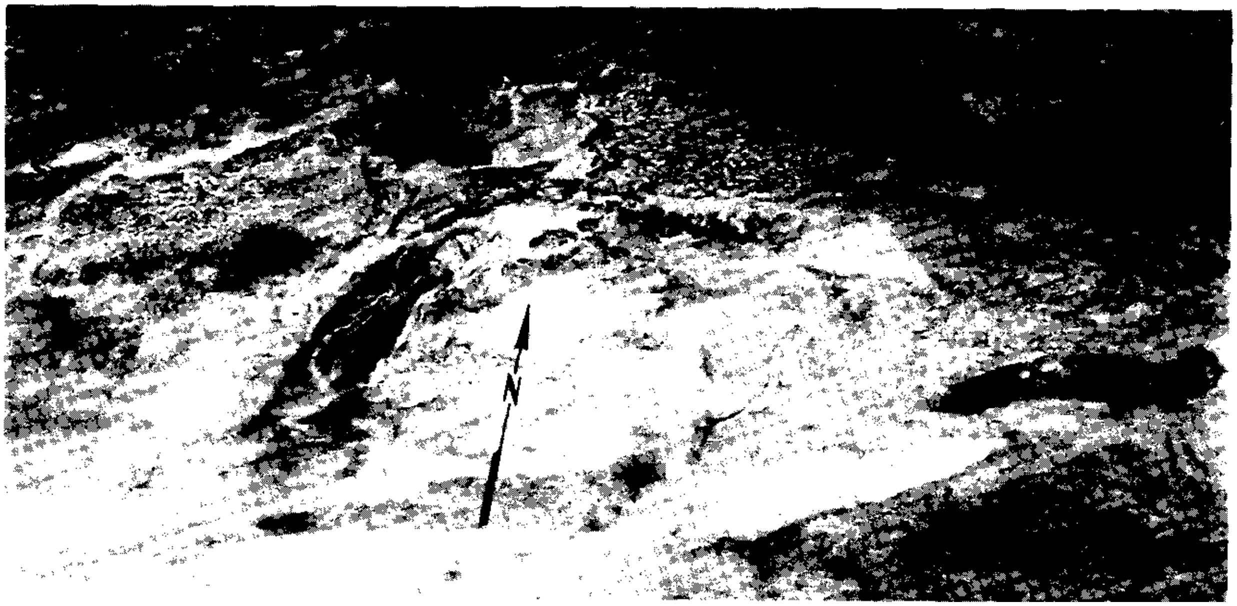

Figure 5r.--*GOES VISSR (visible) image for February 28, 1978.*

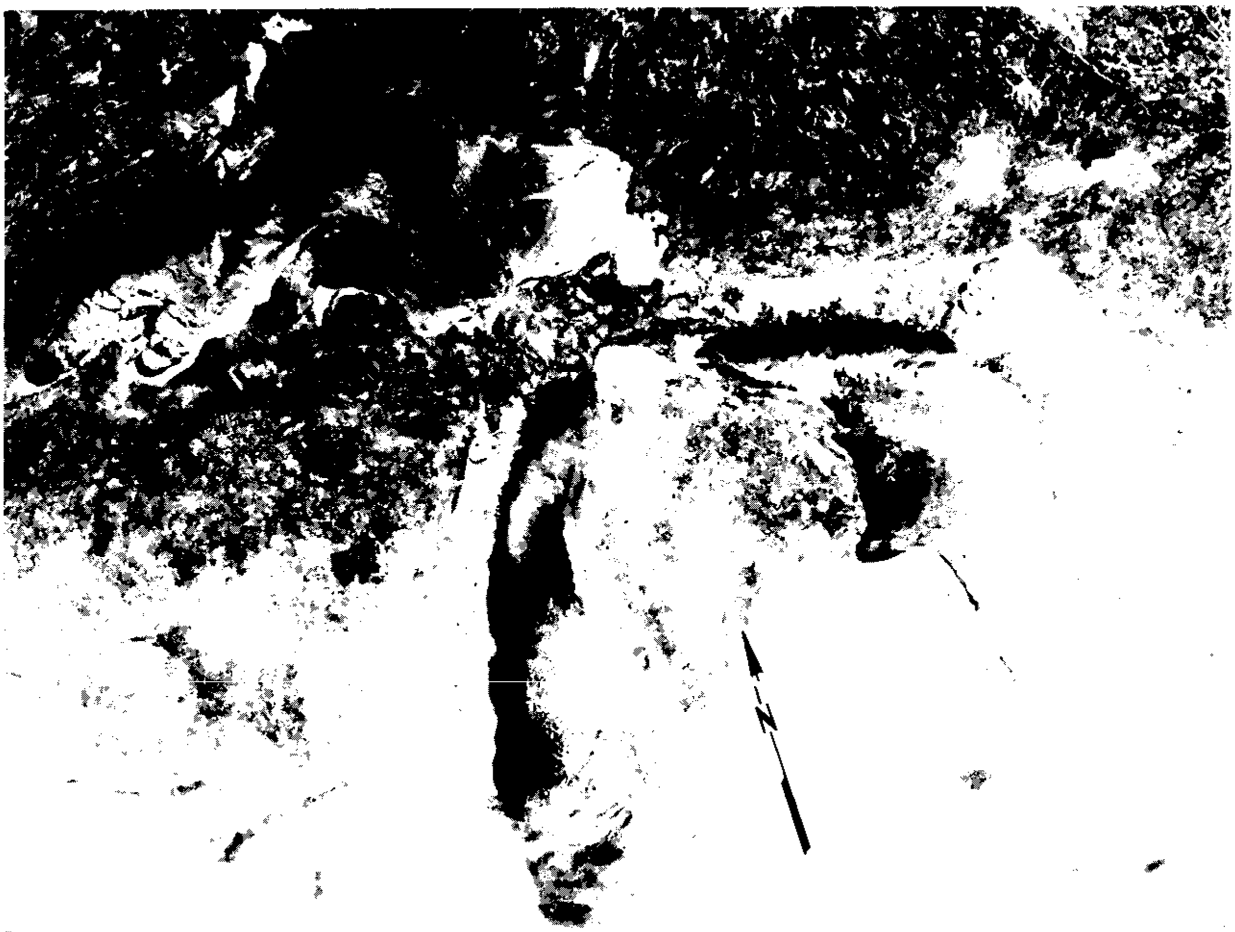

Figure 5s.--*NOAA-5 VHRR (visible) image for March 3, 1978.*

Figure 5t.--*GOES VISSR (visible) image for March 8, 1978.*

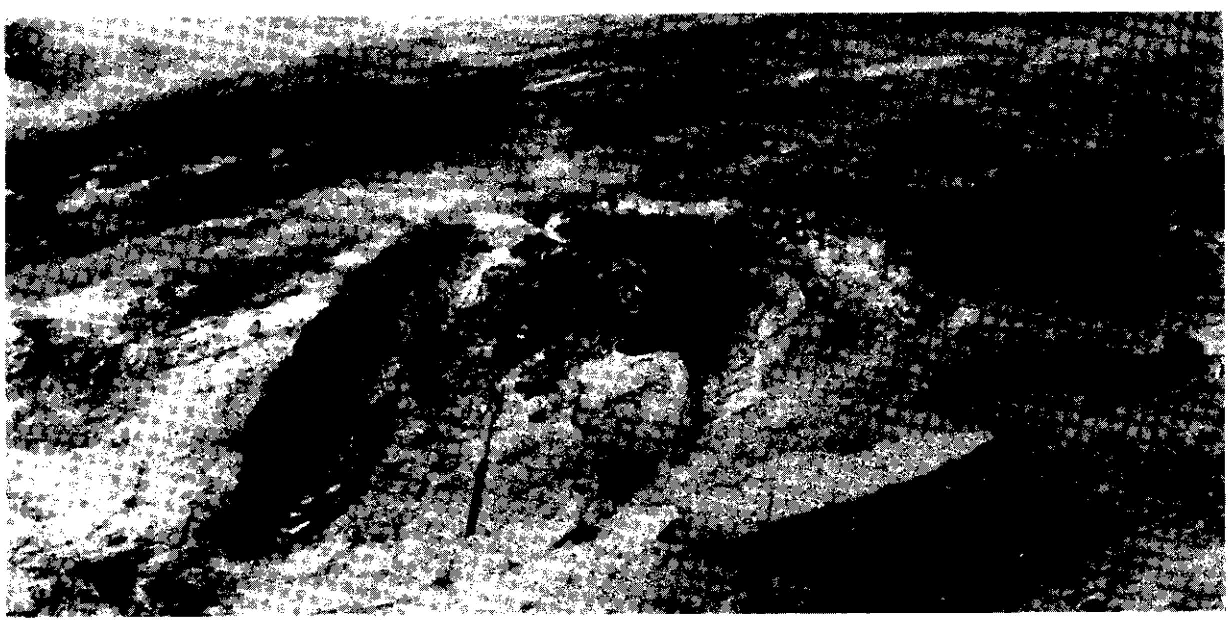

Figure 5u.--*GOES VISSR (visible) image for March 9, 1978.*

Figure 5v.--GOES VISSR (visible) image for March 12, 1978.

Figure 5w.--NOAA-5 VHRR (visible) image for March 20, 1978.

Figure 5x.--GOES VISSR (visible) image for March 24, 1978.

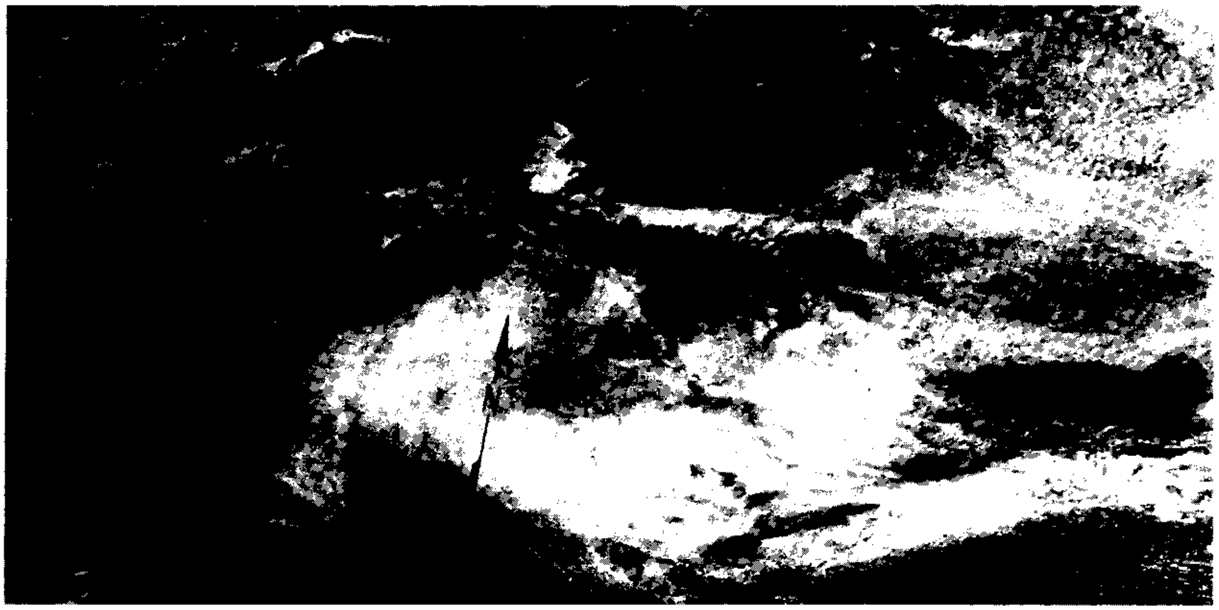

Figure 5y.--GOES VISSR (visible) image for March 29, 1978.

Figure 52.--NOAA-5 VHRR (visible) image for March 30, 1978.

Figure 5aa.--GOES VISSR (visible) image for April 2, 1978.

Figure 5bb.--GOES VISSR (visible) image for April 8, 1978.

Figure 5cc.--*NOAA-5 VHRR (visible) image for April 17, 1978.*

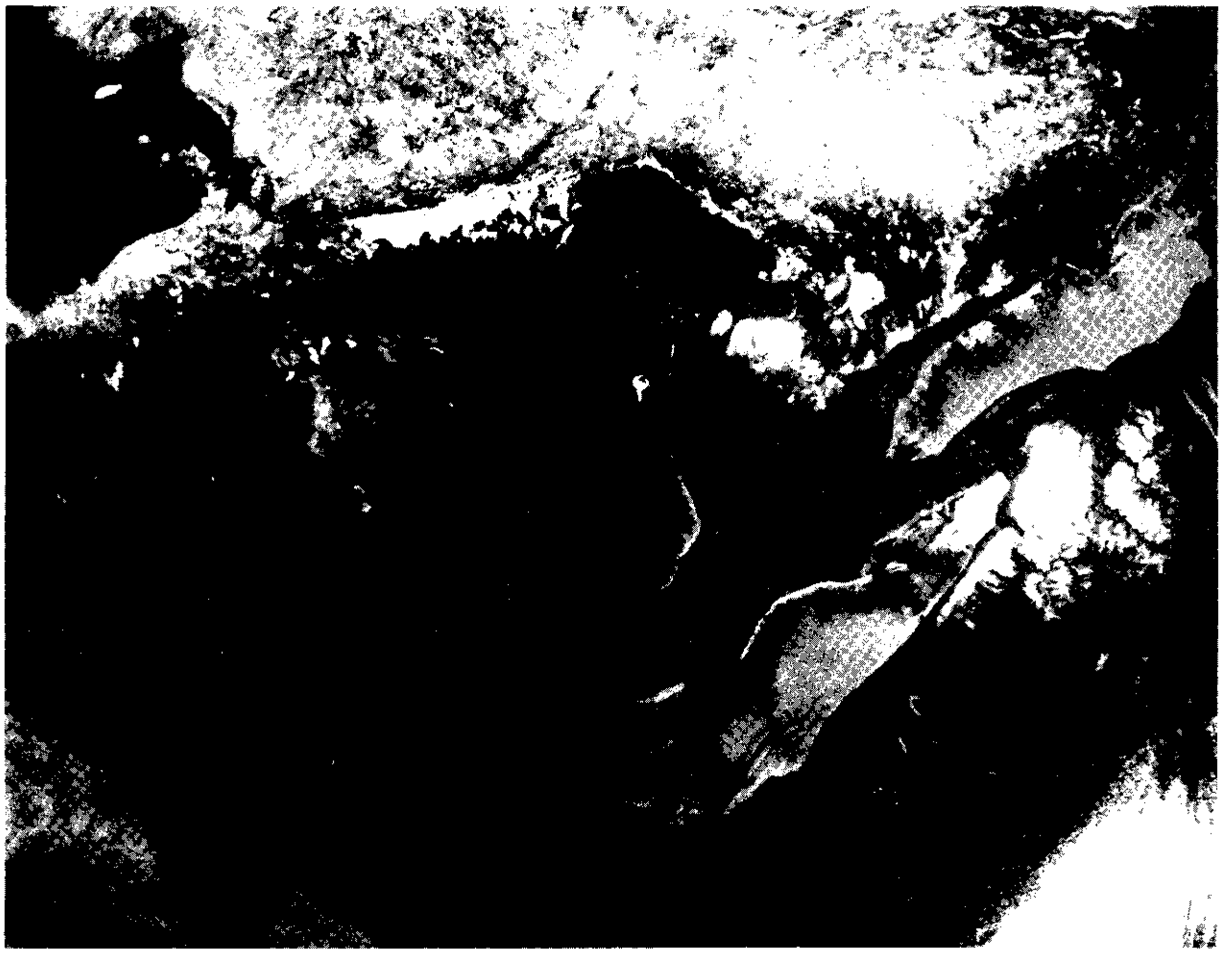

Figure 5dd.--NOAA-5 VHRR (visible) image for April 22, 1978.

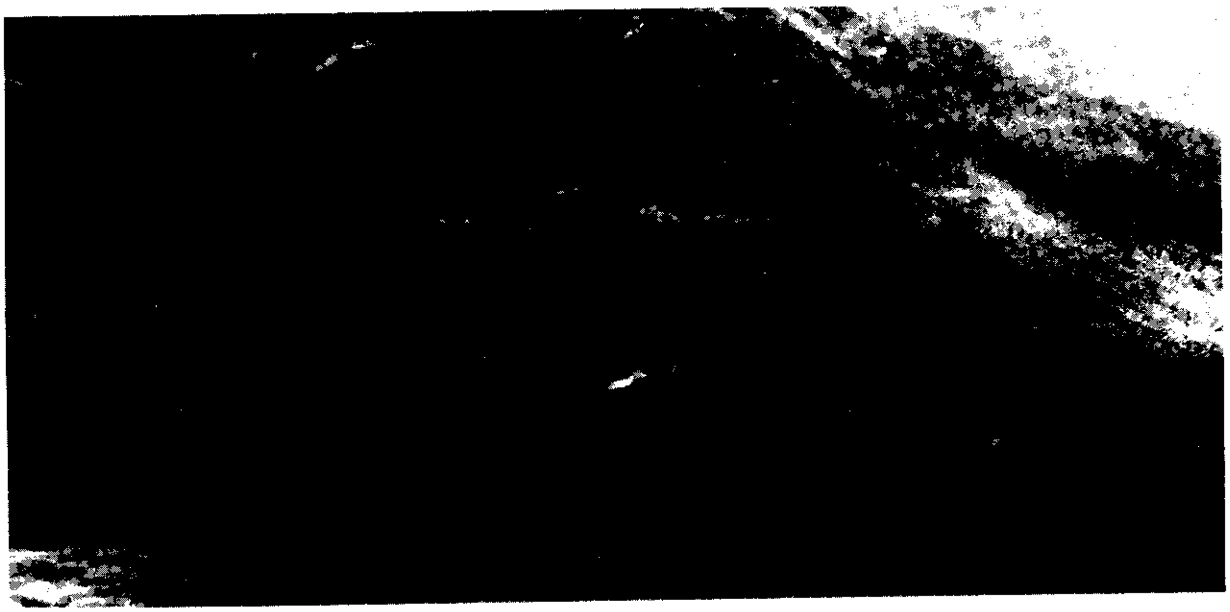

Figure 5ee.--*GOES VISSR (visible) image for April 30, 1978.*

intervals; each chart provides an estimate of the synoptic ice conditions for Wednesday of that week. In the preparation of each chart, it was necessary to critically evaluate available source data described in section 3.1. During this evaluation process, it was interesting to note a considerable day-to-day change in the ice cover during a single weekly period. However, a study of synoptic weather charts and wind data verified that the changes in ice cover logically responded to the strong winds associated with storm passage. Consequently the weekly ice charts, which it will be recalled represent synoptic ice conditions for a given date during the week and not average ice conditions for the week, do not always reflect progressive continuity during the winter season.

FDD's, which progressively accumulate during the winter season, are plotted on each ice chart for eight representative locations. FDD's are useful to define winter severity (Assel and Quinn, 1979, and Rondy, 1971) and they have also been correlated with ice thickness and extent (Assel, 1976, and Rogers, 1976). However, it should be noted that numerous other variables are involved in the formation, extent, and decay of ice on the Great Lakes and that FDD's provide only one index for gaging the potential for ice formation and winter severity. Other factors, such as water depth, storm passage, and lake bottom topography, are discussed later in this report and documented in the appendices. The FDD's given on the composite ice charts were calculated from daily NWS weather observations, and they provide a summary of (1) the current FDD total in the week ending on the date of each chart, (2) the total accumulation of FDD's for the season, and (3) the climatological normal accumulation up to and including the date of each chart. Because of the conversion of the original data from degrees Fahrenheit to degrees Celsius, the summary FDD's on the ice charts in some instances are inconsistent owing to rounding off.

3.2.1 Fall Cooling Phase

Each lake goes through an isothermal stage twice each year, usually in April or early May, and again in December. At these times the lake is isothermal at 4°C. The heat content associated with this temperature can be taken as the base heat content of the lake.

Any excess or deficiency above or below this base heat content has been absorbed from or lost to the atmosphere since the last isothermal stage. Average air temperatures, integrated over periods of several months, have been found to give useful indications of the water's heat content.

Several different methods of integrating air temperature have been used. The most useful attempt so far, incorporating a "decay factor" to give greater weight to more recent data, is calculated as follows:

$$S_m = \frac{\Delta T_m + S_{m-1}}{2}$$

where

S_m is the heat storage factor at the end of a month,

AT_m is the departure from normal of the average air temperature for the month, and

S_{m-1} is the heat storage factor at the end of the previous month.

The physical meaning of the heat storage factor cannot be precisely defined. It approximates the excess heat, sensible and latent, of a unit water mass within the epilimnion.

At the end of August 1977, the heat storage factor was negative for Lake Superior and positive elsewhere. The same pattern was observed in September. By the end of October, however, the heat storage factor became negative everywhere. November temperatures were near normal to above normal, providing a moderating trend, and heat storage factors at the Soo and Buffalo reversed themselves from the previous month and became positive. With below-normal air temperatures in December, heat storage factors were once more on the decline. As a result of moderating temperatures in November and generally higher temperatures throughout the cooling period compared to fall 1976, the fall 1977 cooling period was relatively mild. Heat storage factors for fall 1977 are summarized in table 4.

3.2.2 Ice Formation and Breakup Phases

Winter 1977-78 produced ice in various shallow protected areas of the Great Lakes in late November and early December. Lake St. Clair was virtually frozen over by early January. The remainder of the Great Lakes neared maximum areal ice coverage in late February and early March. Spring breakup on all lakes started in mid-March. In general, open-water areas first appeared lakeward of the western shores of the Great Lakes and expanded east. The bulk of the ice was gone by April 26. Areas of ice on that date included the southeastern shore of Lake Superior, Big Bay de Noc and Little Traverse Bay in Lake Michigan, the North Channel and Georgian Bay in Lake Huron, and the Buffalo vicinity in eastern Lake Erie.

3.2.3 The Ice Cycle on Lake Superior

Freeze-up on Lake Superior began in the shallow areas of Whitefish Bay and Duluth Harbor and in the northern inlets of Nipigon and Black Bays (fig. *4a).* By mid-December (fig. *4b)* ice was also forming in shallow waters around the Apostle Islands. One week later fast ice covered Black and Nipigon Bays and ice was beginning to cover Thunder Bay (figs. *4c* and *5a*).

Toward the end of the month air temperatures were averaging at or below -10°C. In response to this cold weather, ice grew along the shore between the Apostle Islands and the Keweenaw Peninsula as well as along the shores of Whitefish Bay. In addition, Thunder Bay became covered with fast ice (fig. *4d*).

Table 4.--*Heat storage factor at month's end (°C)*

City	August	September	October	November	December
Duluth, Minn.	-0.99	-0.83	-0.70	-0.46	-1.10
Green Bay, Wis.	0.34	0.34	-0.36	-0.41	-1.02
Chicago, Ill.	0.40	0.17	-0.36	-0.41	-1.27
Sault Ste. Marie, Mich.	-1.81	-1.38	-1.11	0.11	0.14
Detroit, Mich.	0.58	0.71	-1.10	-0.44	-1.09
Buffalo, N.Y.	0.35	0.45	-0.31	0.80	0.37

During the next 2 weeks, ice formed along the coast between Duluth and the Apostle Islands and also west of Whitefish Point. Ice also grew rapidly in Keweenaw Bay and the area between the Canadian shore and Isle Royale (figs. 4e, 4f, and 5d). Around mid-January air temperatures were averaging -15°C and lower. Thus by January 18 the entire southern perimeter of the lake was ice covered (figs. 4g and 5f). In addition, Whitefish Bay had become completely covered for the first time this season. Over the northern portion of the lake, broken floes covered the area between Isle Royale eastward to St. Ignace Island.

A major storm passed over the Great Lakes on January 25 and 26. The 2 weeks after the passage of this storm, air temperatures averaged below normal, and consequently by February 1 ice had grown around virtually the entire perimeter of the lake (fig. 4i). One week later, on February 8 (figs. 4j and 5k), considerable ice had formed over the western and northwestern areas of the lake as well as along the eastern shore.

By mid-February the surface waters of Lake Superior had cooled sufficiently to allow ice formation over the northern and western sections of the lake (fig. 4k). West and northwest winds produced leads along the northwestern shore. Moreover, this persistent flow gradually pushed the ice edge east and southeast toward the interior of the lake.

By February 22 (fig. 4l) the interior of Lake Superior was 70-100 percent ice covered with the exception of a 32-km- (20-mile-) wide clear area to the east of the Keweenaw Peninsula where the waters of the lake are deepest. A thin but solid bridge of ice also connected the Canadian shore and Isle Royale.

During the next 10 days average daily air temperatures ranged from -4°C to -15°C at Duluth, and to -13°C at Sault Ste. Marie. This cold weather caused the ice to continue to consolidate and thicken (fig. 4*m*). Between March 3 and March 8 the lake reached its maximum ice coverage. As can be seen in figs. 4*n*, 5*s*, and 5*t*, the interior of the lake was covered with 70-100 percent thin ice. Broken to consolidated medium ice covered the eastern portion of the lake while thick fast ice covered all bay areas and ringed the entire southern coastline. In addition, open and refrozen leads could be seen east of the Keweenaw Peninsula, in Beaver and Ciiequamegon Bays, and parallel to the shore from Isle Royale to Duluth. These leads formed as a result of southwesterly and northwesterly winds from February 28 to March 5. In all, 82 percent of the surface of the lake was ice covered.

Warmer weather between March 8 and March 15 caused a rapid decrease in the concentration of the interior ice (figs. 4*o* and 5*v*). During the next week, winds with westerly components in the west end of the lake and winds with northerly and easterly components in the east end of the lake had cleared the ice from the northwestern shores, had compacted some of it along the Keweenaw Peninsula, and had created large open-water areas in the eastern lake basin (fig. 4*p*). The ice in the lake interior continued to decrease over the week ending March 29 (figs. 4*q*, 5*x*, and 5*y*). However, fast ice still covered Whitefish Bay and the three bays north of Isle Royale. Westerly winds from March 27 to 29 caused floes to consolidate west of the Keweenaw Peninsula and along the eastern shore.

By the first week in April ice-cover concentration and extent in Whitefish Bay, around the Keweenaw Peninsula, and along the northern and eastern shores had decreased from the previous week (figs. 4*r* and 5*aa*). Nipigon and Black Bays still contained fast ice, however.

By mid-April ice around the Apostle Islands began to dissipate (figs. 4s and 5*bb*). Ice was also melting in Whitefish Bay and was decreasing in thickness in Nipigon and Black Bays (fig. 4*t*).

One week later, on April 26, the lake was virtually ice free with the exception of the bays and the area of compacted floes along the eastern shore (fig. 4*u*). Although the ice along the eastern shore had vanished by May 1, ice was still discernible in Whitefish Bay and the three bays north of Isle Royale.

Thus the ice season lasted from December to May, with the maximum coverage occurring in the first week in March.

3.2.4 The Ice Cycle on Lake Michigan

The freeze-up on Lake Michigan began in late November. By December 7 ice partially covered the southern portion of Green Bay as well as the Bays de Noc (fig. 4a). Ice grew steadily in these areas through December. Toward the end of the month ice also began to appear along the extreme northern edge of the lake as well as along portions of the perimeter (figs. *4d* and 5*a*). Ice was visible over the deep areas of Green Bay on January 2 and subsequently drifted northeastward owing to southwest winds on January 3 (figs. 5*b* and 5*c*). On the morning of January 4 air temperatures dropped to -18°C at Green Bay, Wis. As a result, even the deep areas of Green Bay froze over (fig. 4e). Ice also grew rapidly between the Straits of Mackinac and Beaver Island. On January 11 ice in Green Bay broke up slightly in response to 4 days of westerly winds. These winds also pushed the ice away from the western shore and out to midlake. This ice either melted or congregated along the eastern shore (figs. 4f and *5d).*

In mid-January mean air temperatures around Lake Michigan averaged nearly -10°C. As a result, ice grew rapidly over the southern and eastern portions of the lake (figs. 4g and 5*f*). Considerable ice coverage is also visible between the Straits of Mackinac and Beaver Island. On January 22 and 23 ice along the southern border of Lake Michigan was transported northward by southerly winds (figs. *5k* and 5*i*).

During January 25 and 26 a major storm passed over the Great Lakes Region. The cyclonic flow around this storm produced strong (greater than 20 kn) north and west winds over Lake Michigan. The immediate effect of these winds was the removal of the ice west of Beaver Island (fig. *4k).* Low air temperatures the week following the storm produced an increase in ice concentration along portions of the western shore and in the south end of the lake (fig. 4i). However, persistent westerly and northwesterly winds pushed this ice across the lake and onto the southeast coastline by February 8 (fig. 4j). Ice on the southeastern shore on February 12 (fig. *5m)* was subsequently moved southwest as a result of northeasterly winds on February 13 (fig. 5*o*), and southwesterly winds congregated ice in the northern areas of the lake on February 15 (figs. *4k* and 5*p*).

After February 15 a 7-day period of light surface winds and low air temperatures produced ideal ice formation conditions across the lake. As a result, on February 22 (fig. 4*l*) fast ice covered both Green Bay and the Straits of Mackinac out to Beaver Island. Fast ice could also be seen adhering to the southeastern shoreline, while a broad band of broken ice covered the eastern one-third of the lake. The maximum extent of ice for the season was reached at this time, with 52 percent of the lake ice covered.

The below-freezing air temperatures that had prevailed for over 2 months finally ended during the first half of March. As a result, signs of ice breakup began to appear. (See figs. 4*n* and 5s.) As the warmer weather continued through March, the ice cover became more susceptible to wind action. For example, the 7-day period of westerly winds that began on March 14 produced a large shore lead along the western shore (fig. 4o). On March 25 and 26 a storm passed south of the lake, producing 15-20 kn northerly winds. Much of the ice west of Fox and Beaver Islands (fig. 5*x*) was cleared by these winds (fig. 5*y*). In addition it continued the breakup of ice over the deep areas of Green Bay (fig. 4q).

By April 5 ice breakup had proceeded to the point that open water was visible at the Straits of Mackinac and the southern portion of the lake was ice free (figs. 4*r* and *5bb).* Ice still remained, however, over the southern portion of Green Bay. Two weeks later, Green Bay, Little Traverse Bay, and Sturgeon Bay still contained ice (figs. 4*t* and 5*cc*). Three days later, on April 22, Green Bay was ice free except for fast ice near Gladstone, Mich., and a few floes in the south (fig. 5*dd*). By April 30 Lake Michigan was virtually ice free (fig. 5*ee*).

3.2.5 The Ice Cycle on Lake Huron

Ice formation on Lake Huron was already well begun by December 7 (fig. 4*a*), with Saginaw Bay 70-90 percent covered and portions of the St. Marys River completely covered, although with thin ice. Air temperatures continued at or below freezing for the next week. By December 14 ice was reported covering the St. Joseph Channel of the St. Marys River and shore ice was forming in northeast Georgian Bay (fig. 4*b*).

Beginning on December 15 a 6- to 8-day period of easterly winds and near-freezing air temperatures was observed at Sault Ste. Marie and Alpena, Mich. Similar conditions may have existed in the vicinity of Saginaw Bay, where a reduction of ice coverage was observed between the second and third weeks of December (figs. *4b* and 4*c*), but ice continued to form along the entire eastern perimeter of Georgian Bay and in the North Channel near Manitoulin Island.

Colder weather initiated ice growth along most of the coastline of the lake by the beginning of January (figs. 4*e* and 5*c*). In addition, ice concentrations of 70-100 percent also covered Saginaw Bay and the North Channel. During the next 2 weeks, ice growth increased as minimum air temperatures frequently fell below -18°C (-0.4°F). On January 11 (fig. 5*d*) fast ice could be detected in southern Lake Huron from Port Huron, Mich., to Goderich, Ont., and on January 15 (fig. 5*e*) new ice could be seen in northern Saginaw Bay and from Port Huron to Harbor Beach, Mich. Westerly winds reported at Alpena and Sault Ste. Marie on January 15 transported the ice offshore and produced leads from Alpena to Standish, Mich., and from Harbor Beach to north of Port Huron. By January 18 Georgian Bay contained 70-90 percent ice cover and the North Channel, 100 percent. Fast ice at Port Huron had widened, and new ice was adhering to the northern part of this ice. Moreover, a rapidly widening band of shore ice now completely encircled the lake (figs. 4g and 5*g*).

Although a major storm passed directly over the lake on January 25 and 26, little change in the ice cover was discernible (fig. 4*h*). However, after the passage of the storm, low air temperatures the next 4 weeks caused further ice formation. By February 3 Georgian Bay was 100 percent ice covered (fig. 5*j*), with a refrozen lead along the northern shore. Five days later, on February 8, only the interior of Lake Huron was still ice free. The remainder of the lake was between 10 and 100 percent ice covered (figs. 4*j* and 5*k*).

The marked effect of wind direction on ice movement is illustrated for February 10-19 in figs. *4k* and 5*l* to *5q.* During this period, persistent westerly winds on February 9 and 10 transported the ice offshore (fig. 5*l*), forming leads parallel to the coast near the Straits of Mackinac, Sturgeon Point, and Harbor Beach. South winds produced similar ice transport and leads from Port Huron to north of Saginaw Bay on February 15 (figs. 4k and 5p). Likewise, westerly winds on February 18 compressed the ice in Georgian Bay and from Harbor Beach to Port Huron against the eastern shore (fig. 5q).

As the cold weather continued, ice concentrations in the open expanses of the lake increased (fig. 4l), and on February 28 the iake reached its maximum coverage for the season (fig. 5r). Approximately 89 percent of the lake was then frozen over with the addition of new ice south of Manitoulin Island. The interior of the lake contained 70-100 percent thin to medium ice, while the remainder had 100 percent medium to thick ice.

This maximum coverage was short lived, however, as westerly winds on March 1 moved the ice from the western shore eastward (figs. 4m and 5s). In addition, a lead formed along the northern shore of Georgian Bay between the fast ice adhering to the land and mobile ice covering the rest of the bay. The lake remained in this configuration through March 8 (fig. 4n).

A 2-week warming trend began on March 10. The mild weather and winds gradually caused the interior ice either to move over to the eastern shore or to dissipate entirely, as shown in figs. 4p, 5w, and 5x. Ice over the western portion of the lake and over areas of Georgian Bay was also rapidly deteriorating.

During the last third of March significant changes in the ice cover included the reduction of ice extent on the western shore from the straits to Saginaw Bay and along the western shore of the Bruce Peninsula (figs. 4p and 4q).

During the first week in April ice rapidly melted in Georgian and Saginaw Bays and along the eastern shoreline (figs. 4r and 5bb). Fast ice still covered the North Channel. By April 17 (fig. 5cc) most of the lake ice had melted with the following exceptions: ice in lower Saginaw Bay, the fast ice in the North Channel, and ice along the eastern perimeter of Georgian Bay. By April 26 only the small inlets in Georgian Bay and most of the North Channel were ice covered (fig. 4u). The only remaining ice on April 30 (fig. 5ee) was in the North Channel.

3.2.6 The Ice Cycle on Lake St. Clair

Lake St. Clair already had considerable ice coverage by the first week in December (fig. 4a). With persisting cold weather, the lake was virtually frozen over by December 14 (fig. 4b). This condition was only temporary, however, as a subsequent period of milder air temperatures and moderate southwesterly winds broke up and pushed the thin ice over to the Canadian side of the lake (figs. 4c and 5a).

By the end of December cold weather had returned so that by January 4 Lake St. Clair was once again 100 percent ice covered (figs. 4e and 5c). The lake remained ice covered for the next 60 days.

After the first week of March a warming trend began over the Great Lakes. This warm weather eventually produced a small opening in the thick ice near the head of the Detroit River (figs. 4*n* and 5*u*). This small opening grew wider and extended northward as air temperatures remained well above freezing (fig. 40). By March 29, thawing and westerly winds had cleared the entire western edge of the lake (figs. 4*q* and 52). One week later only the southeastern portion of the lake had ice cover (fig. 4*r*).

Lake St. Clair, after having some ice cover for at least 126 days (December 7 to April 12), was finally free of ice on April 12 (figs. 4s and 5*cc*).

3.2.7 The Ice Cycle on Lake Erie

As on the other Great Lakes, ice formation on Lake Erie was well begun by the second week in December. As can be seen in fig. 4*b*, the western basin of the lake was nearly 100 percent covered with thin ice [0-15 cm (0-6 inches)]. From December 13 to 24, numerous low-pressure systems passed to the west of the Great Lakes. The passages of these systems caused higher temperatures and southeasterly and southwesterly winds, which broke up this ice cover and congregated it along the Canadian side of the lake (figs. 4*c* and 5*a*).

Low air temperatures by the end of the month caused rapid ice growth. As can be seen in fig. 4*d*, the entire western basin was once again completely frozen over by December 28. In addition, a slender ice ribbon had grown all along the southern shore of the lake. Ice could also be seen forming over the area from Kelleys and the Pelee Islands eastward to Cleveland. These islands hindered ice from moving into the western end of the lake.

During the first week of January a combination of low air temperatures and westerly and southwesterly winds promoted ice formation and movement eastward toward the interior of the lake (figs. 4*e* and 5*c*). By January 11 only the deep part of the eastern section of the lake was relatively free of ice (figs. 4f and 5*d*). The rest of the lake was either completely frozen over or from 70 percent to 90 percent ice covered.

Lake Erie would probably have been 100 percent ice covered by mid-January if it were not for southwesterly and northerly winds on January 15 and 17, respectively. These winds broke up the thin interior ice and pushed it both east and south, producing the leads seen in figs. 5e and 5*g*.

About a week later, on January 22 and 23 (figs. *5k* and 5*i*), ice located in the lead between the western ice field and the larger eastern ice field could be seen moving eastward in response to southerly and southwesterly winds.

During January 25 and 26 strong westerly and southwesterly winds that accompanied an intense storm produced a large lead to the east of the islands (fig. *4k).* After the storm passed, daily mean air temperatures didn't rise above -5°C for about a month. As a result, Lake Erie became virtually frozen over by February 3 (fig. 5j) and remained so until the second week in March. Occasionally during this period, leads would form along the island barrier and refreeze. In addition, on February 14 (fig. 5o) a second lead formed in an arc from Port Stanley, Ont., on the north shore to Fairport, Ohio, on the southern shore. Then between the second and third week in March, in response to mild air temperatures and strong winds, the lead east of the islands became much wider and ice broke up along the northern shore (figs. 4p and 5w). By March 29 all ice was in a rapid state of decay, with many leads visible along the Canadian shore and south and east of Kelleys and the Pelee Islands (figs. 4q and 52).

For the next 2 weeks, as air temperatures remained in the 0°-15°C range, ice decay became more extensive. As can be seen in fig. 4r, the ice east of the islands had dissipated along both the northern and southern shores. The remainder of the lake was covered by 70-90 percent rotten ice. One week later, on April 12, the western basin was nearly free of ice except for broken floes along the southern shore. Meanwhile, ice over the interior of the lake continued to melt west to east (fig. 4s). From April 11 to 18 strong westerly and southwesterly winds prevailed over the lake. These winds moved this remaining ice over to the east end of the lake, producing an ice "plug" there (figs. 4t and 5cc). Although the remainder of the lake was ice free by April 26 (figs. 4u and 5dd), this plug melted very slowly and was still observed as late as May 11.

3.2.8 The Ice Cycle on Lake Ontario

The ice season on Lake Ontario began on December 14, when ice formed around Prince Edwards Peninsula and Wolfe Island (fig. 4b). The ice grew gradually in these areas through the end of the month and into the second week of January since air temperatures averaged near freezing through that period. By mid-January the lake had cooled sufficiently to allow ice to form in the relatively shallow eastern portion and also along the southwestern shore (figs. 4g and 5e).

Much of the shore ice disappeared on January 25 because of southwesterly winds associated with the major storm that passed over the Great Lakes on January 25 and 26 (fig. 4h). As was the case for other lakes, low air temperatures after the storm passage produced rapid ice growth over the lake. As can be seen in figs. 4i and 5j, a narrow ribbon of ice extended along the entire southern shoreline, while ice in the eastern basin grew thicker (15-30 cm). By February 15, thin ice had grown westward into the interior of the lake. On that date, the lake was 57 percent ice covered, its maximum extent for the season (figs. 4k and 5p). This coverage lasted only a short time, however, as westerly and southwesterly winds on February 18 and 19 pushed the ice from the western section of the lake into the eastern half. These winds also removed the new ice from around the shore (fig. 5q).

A 2-week period of persistent southwesterly winds prevailed over the area after February 15. These winds gradually moved the thin interior ice eastward and packed it into the eastern basin (figs. 4l and 4m). This general ice configuration can also be seen through the first week in March (figs. 4*n* and 5t).

A considerable warming trend began on March 10. This trend initiated a rapid deterioration of ice, especially along the southwestern coastline and over the eastern basin. Thus, by mid-March most of the lake was ice free, although fast ice remained along the southeastern and eastern shorelines and around the island areas (fig. 40).

Westerly and southwesterly winds moved ice from along the southern shore to the northeastern shore on March 22 (figs. 4*p* and 5*x*). Although air temperatures remained above freezing for the remainder of the month and into April, the compacted floes and shore ice over this area of the lake melted very slowly (fig. 4*t*). They are discernible in the satellite image for April *17* (fig. 5*cc*).

Lake Ontario finally became ice free on April 22 (fig. 5*dd*), having had ice for at least 129 days (since December 14).

3.3 Comparisons With Previous Winters

Table 5 compares percent maximum ice extent for winter 1977-78 and for those given by Quinn *et al*. (1978) for the Great Lakes during the past 15 winters. From table 5, it can be seen that the 1977-78 maximum ice extent was only exceeded by six winters for Lake Superior, two winters for Lake Michigan, and one winter for Lake Huron. No winters for Lake Ontario had greater ice extent. No comparison is made for Lakes Erie and St. Clair as they freeze over most winters. Table 5 also contains the mean and standard deviations of maximum ice extent for the past 16 winters on the Great Lakes. Defining as normal the mean plus or minus one standard deviation, we can classify the 1977-78 winter as having above-normal ice extent for Lakes Huron and Ontario and normal extent for Lakes Superior and Michigan.

4. SUMMARY OF LAKE COMMERCE

D. E. Boyce

Year-around navigation was resumed on the Great Lakes during the 1977-78 ice season after an official break during the previous season. It was not accomplished without difficulty, however. There was a high level of shipping during the extended part of the season due to an earlier strike. Coast Guard forces were very active and logged a 50-percent increase in mission miles to assist commercial traffic (table 6).

4.1 Fall Season

On August 1, 1977, about 18,000 members of the United Steelworkers of America went on strike against the iron ore mines and pellet processing plants in Minnesota and Upper Michigan. Production was virtually halted by

Table 5.--Comparison of maximum percent ice extent on the Great Lakes: 1977-78 and previous winters

Winter	Superior, percent	Michigan, percent	Huron, percent	Erie, percent	Ontario, percent
1962-63	95	80	97	98	51
1963-64	31	13	32	91	12
1964-65	90	40	60	NA	10
1965-66	60	15	29	NA	15
1966-67	88	46	80	90	12
1967-68	90	30	50	98	10
1968-69	40	15	50	80	10
1969-70	80	30	50	95	17
1970-71	48	27	45	92	10
1971-72	95	45	70	95	20
1972-73	55	20	60	95	20
1973-74	70	20	65	95	25
1974-75	30	25	45	80	16
1975-76	40	20	50	95	20
1976-77	83	90	89	100	38
1977-78	82	52	89	100	57
Mean	67	36	60	93	21
Standard deviation	24	23	20	6	15
1977-78 – Mean	+ 15	+ 16	+ 29	+ 7	+ 36
1977-78 ice cover	normal	normal	above	NA	above

NA = Not applicable.

Table 6.--*Summary of Great Lakes icebreaking assistance*

Winter	Operation, hours in assistance	Mission distance		Tonnage of vessels assisted		Cargo tons carried	
		Miles	Kilometers	Long tons	Metric tons	Long tons	Metric tons
1970-71	4080	14,101	22,562	3,452,708	3,508,967	2,520,152	2,560,470
1971-72	2446	11,765	18,824	3,617,431	3,675,310	2,276,384	2,312,806
1972-73	1341	9,494	15,190	2,076,701	2,109,928	1,470,995	1,494,531
1973-74	3872	12,807	20,491	3,115,605	3,165,455	1,681,127	1,708,025
1974-75	2575	11,275	18,040	5,788,909	5,881,532	3,662,653	3,721,255
1975-76	2775	11,586	18,538	4,553,832	4,626,693	2,937,083	2,984,076
1976-77	5942	23,131	33,810	6,284,304	6,384,853	4,556,724	4,629,632
1977-78	6863	32,322	51,715	11,994,519	12,186,431	9,507,274	9,659,390

the strike, and some lake boats were laid up within a few days. Others were scheduled to sail up the St. Lawrence River to pick up cargoes from Quebec mines.

The march of early winter storms dropped 5 cm (2 inches) of snow on Buffalo on December 2. On the morning of December 4, the mercury had slipped to -22.2°C (-8°F) in Green Bay, breaking the old record of -20°C (-4°F) set in 1893. Water temperatures in the Great Lakes were well below the lo-year average and even below 1976 levels. Because of the heavy weather, fears were mounting that some foreign vessels might be trapped in the Great Lakes for the winter. On December 2 there were 158 ships above St. Lambert, Que.; the St. Lawrence Seaway was officially closed to inbound traffic.

The cold weather and high winds associated with the frequent storms in early December rapidly removed heat from all of the lakes. An ice watch calling for ice to form in the northern Great Lakes and Green Bay was issued on December 7.

The Coast Guard-NOAA Ice Navigation Center in Cleveland opened on December 10. The first icebreaking assists were performed on December 11. The Coast Guard cutter *Kaw* had a busy first day; she worked six domestic ships and five salties (foreign ships) in the Detroit River. The buoy tender *Mariposa* assisted the *Saguenay* in Sandusky Bay, and the *Bramble* helped the *Leadale* in Saginaw Bay.

The first and the largest Coast Guard casualty of the ice season occurred on December 13. The major icebreaker *Westwind* went hard aground off De Tour Reef at the lower end of the St. Marys River. It took several days of lightering and hauling by Coast Guard vessels and commercial assistance to get her off. About 605,600 liters (160,000 gal) of fuel had to be off-loaded in the process. And when she finally did ease off the reef, she slid backwards and hit the icebreaker *Mackinaw,* which was behind her. Because of the loss of the *Westwind* for duty in the lakes, the Coast Guard ordered her sister ship, the *Northwind*, from her home port of Baltimore to the Great Lakes for the season. In addition the *Mariposa* and the *Ojibwa* were each lost for a week while thrust bearings and seals were replaced in mid-December. And in the St. Lawrence Seaway both a British ship and a Liberian vessel were aground and thus required assistance that same week. The *Fort William* ran into a sand bar while working in a thick fog in western Lake Erie.

The St. Lawrence Seaway was scheduled to close for the season at midnight, December 15. However, as the deadline approached, 60 ships were still above Montreal, Que., and the waterway remained open on a day-to-day basis to allow them to exit if possible. Very cold weather at mid-month produced large clouds of steam over the river, and navigation was halted several times because of low visibility. The seasonal removal of navigation aids, the placement of ice booms, and a shortage of pilots also contributed to delays.

4.2 Extended Season

December 15 has traditionally marked the beginning of "extended season" navigation on the Great Lakes. The cutter *Kaw* chalked up an assist on that day. Earlier, two fishing vessels, the *Karen Lee* and the *Sally Ann* from Sandusky, Ohio, had become trapped in Lake Erie ice. They had been operating in shallow water close to South Bass Island, too shallow in fact for any of the Coast Guard's fleet to reach them. Several residents of the island came to their aid, however. They used their chain saws to cut through 183 m (200 yd) of ice so the stranded vessels could reach deeper waters. The *Kaw* took over from there and escorted them back to home port.

The last few steelworkers' locals settled their strikes on December 17, and shippers made immediate plans to make up for lost time. The weather moderated almost in sympathy. Although a storm moved through the midwest, this time very mild air came with it. On December 17 the thermometer soared to 15.5°C (60°F) in Chicago, tossing out the old record of 12.8° (55°F) set in 1877. As usual it was short lived, and colder weather with 7.6-17.8 cm (3-7 inches) of snow fell on northern Illinois and the Lake Ontario shores of New York State during the next 3 days. On December 20, 40-kn winds and 3.7- to 4.6-m (12- to 15-ft) waves on southern Lake Michigan battered the tug American *Viking* and her two barges in tow. One barge broke loose, eventually capsized, and grounded near Holland, Mich.

Daily icebreaking continued on Lake Erie and the Detroit River throughout December. By the end of the month, 105 direct assists had been logged by the Coast Guard. Only two of them were in the northern lakes. The main concern was getting the salties out of the Great Lakes and the St. Lawrence River system before severe ice conditions forced the closing of the river until spring. Forces on both sides of the international boundary joined in the effort. A period of mild weather the week before Christmas also contributed. The Swiss freighter St. *Cergue*, the last commercial vessel to leave, exited on December 28. The last ship to actually transit the river was the Coast Guard icebreaker *Westwind* on her way to Montreal for shipyard repairs; she arrived on December 26.

As the new year dawned across the Great Lakes, the tough ice caused the first damage to merchant vessels. The tanker *Jupiter* was damaged in Lake Erie and the *Leon Falk*, Jr., in Superior Harbor. The most costly accident of the winter occurred on January 4; the *Irving Olds* was transiting the Livingston Channel south of Grosse Isle when she encountered a heavy ridge of ice and stopped short. Because the *Armco*, directly behind her, was unable to stop, she hit her. The *Irving Olds* suffered some shaft damage, and the *Armco* was damaged above the waterline near her anchor. Repairs were estimated at about a quarter of a million dollars. During the mid-month other vessels sustained ice damage in Lake Erie, including the *J. Burton Ayers* and the *Paul Thayer*. The *Falk* was also damaged in Lake St. Clair, and the *Saturn* reported damage in Lake Michigan.

Very cold weather dominated the middle 2 weeks of January. Frequent snows also fell over the lakes. The Chicago area picked up 12.7-25.4 cm

(5-10 inches) on the 14th. By the 21st, seasonal record snowfalls had already been posted in Cleveland. As a result, ice thickened sufficiently to make regular icebreaking necessary on the St. Marys River by January 10. By far the worst conditions still prevailed on Lake Erie. The tanker Jupiter got stuck off of Erie on January 10. The *Ojibwa* set out from Buffalo to help, but she only got about 4.8 km (3 mi) before getting beset herself in 0.9-m 1.5-m (3- to 5-ft) ridged ice. The *Northwind* freed both ships.

By mid-January the only way to move ships on Lake Erie "as by convoy. One convoy formed in the Detroit River headed for Cleveland. It consisted of the *Cliffs Victory, Joseph Frantz, William G. Mather, Robert C. Norton, Crispin Oglebay,* and *J. Burton Ayers.* With the exception of the *Ayers,* which remained in Pelee Passage, they managed to get to the crib just outside Cleveland before getting beset. Meanwhile another convoy of ships left Cleveland on January 15, upbound. The *Northwind*, accompanied by the *Mariposa* and *Bramble,* escorted the *McKee Sons, Falk, William Synder, A. H. Ferbert*, and *Champlain.* Strong northwesterly winds had put the ice field under heavy pressure and after 12 h of work one ship had only moved 6,401 m (7,000 yd). Winds eased the following day. The convoy made it through Pelee Passage--the most dangerous bottleneck--and moved steadily to Detroit.

The *Northwind* returned to near Cleveland and spent 3 days assisting downbound ships. The most powerful of the group, the *Cliffs Victory,* reached Cleveland on January 22. For awhile, the Coast Guard *Ojibwa* helped the major icebreaker, but then she suffered hull damage while hacking through the ice and flooded her engine room. She "as towed to Cleveland. Little change in ice conditions occurred during the next 2 days.

Coast Guard aid "as still needed. Food supplies ran low on merchant vessels, and a *Coast* Guard helicopter delivered a fresh load. A helicopter "as also called on to transport a young seaman from the *Joseph Frantz* after he was injured in a fall. After day and night struggles against the windrowed ice, the *Mather* made it to Cleveland on January 24. Late the following day the *Frantz* "as escorted to Cleveland, and early on the 26th the *Norton* and *Oglebay* docked.

The *Northwind* had proceeded to Southeast Shoal to free the Ayers when an unprecedented "white hurricane" struck Lake Erie. This storm struck suddenly and fiercely about dawn. The *Northwind* reported winds of 80 kn, with gusts to 90 kn, at 9:00 a.m. The temperature "as -9.4°C (15°F) and visibility 91 m (100 yd) in snow. The *Ayers* measured 98-kn winds nearby at 7:oo a.m. A dock bridge in Cleveland was blown down by the icy blasts. The storm center passed northward between Cleveland and Erie. Record low pressures were established at Cleveland [957.6 mb (28.28 inches)] and at both Detroit and Erie [959.7 mb (28.34 inches)]. Winds of over 50 kn were still reported by the *Northwind* 12 h later, and gales continued for another day after that. Finally, late on January 28 the *Northwind* freed the Ayers from Pigeon Bay and escorted her to Lorain Harbor. Although there were no casualties to ships in the storm on Lake Erie, the Great Lakes Maritime Academy's training vessel *Allegheny* iced up and rolled over in the gales at Traverse City.

In an unrelated incident on January 26, the *Charles M. Beeghly* grounded at Johnson Point on the St. Marys River. With Coast Guard assistance, she moved on to De Tour Passage after lightering. Damage was estimated at $160,000.

Traffic gradually dwindled throughout January. About four dozen ships were still operating at the beginning of the month, but the number had dropped to less than half that by the end of the month. The main problem area outside of Lake Erie was the St. Marys River. High water flows through the Soo Canal from Lake Superior appeared to be causing unusually large accumulations of ice along the ice edge. Engineers measured ice up to 4.6 m (15 ft) thick at the edge. Because of one-way traffic patterns in the river, when the West Neebish Channel was closed for the winter on January 20, 26 vessels were awaiting transit. With the addition of the *Northwind* and the Canadian icebreaker *Griffon* to the forces in the river, the backlog was cleared by the end of the month.

Ice cover continued to expand and become more stable because of very cold conditions in February. Shipping continued to gradually withdraw for the year. By the end of the month, traffic was reduced to eight or more United States vessels and two Canadian vessels. The last traffic into upper Green Bay at Little Bay de Noc was on February 22, when the *Wilfred Sykes* loaded ore pellets.

In spite of the decline in ship traffic during February, icebreaking assists continued high. The Coast Guard logged over 150 direct icebreaking assists during the month. Most of these were in the St. Marys River, where assistance was necessary to transit the area at all. But this season only a few requests for Coast Guard assistance were made in Green Bay because commercial assistance was available. Two U.S. Steel Corporation ships reported damages during the month. The *Presque Isle* was damaged on the 21st, and $40,000 damage was reported in a collision between the *John G. Munson* and the *Northwind*. On February 13 the Coast Guard lost the services of the *Km* because of hull cracks and rudder damage.

Improved sailing conditions in March brought an increase in ship traffic, but problems to shoreline structures continued. The *Blough* resumed ore shipping to Lake Erie with a load of pellets to Conneaut, Ohio, on March 23. The next day the *Munson* arrived in Lorain, Ohio, with taconite. About 45 commercial vessels were sailing by March 31. Heavy snowmelt in northern Ohio caused some flooding problems along Lake Erie, and a number of Coast Guard ships were dispatched to harbors from Vermilion, Ohio, to Ashtabula, Ohio, from March 16 to 21 to break up ice at the river mouths. No heavy rains accompanied the snowmelt, so serious flooding threats ended by month's end.

The St. Lawrence Seaway officially opened on schedule in early April. On April 3 the French vessel *Hermine* entered the Montreal-Lake Ontario section upbound. The first downbound ship was the *J. N. McWatters*. The Welland Canal opening on March 30 saw the *Tarantau* pass through. Ice on parts of the seaway ranged from 76.2 to 91.4 cm (from 30 to 36 inches) deep at the opening, but forces in both Canada and the United States worked to keep the track open. "Operation Open Buffalo" started on March 27.

As usual, the hard spring ice of the lakes took its toll of ships. The *Munson* sustained about $40,000 worth of rudder damage in Whitefish Bay on March 27. On April 20, the *Buckeye* sustained $30,000 damage while operating in the St. Marys River. Nine other vessels reported much smaller amounts of damage during the remainder of April.

The number of operating ships jumped to about 75 during the first week of April. The Arctic icebreaker *Westwind* returned to the lakes from Montreal when the seaway opened, allowing the *Northwind* to return to Baltimore, Md., on April 7.

4.3 summary

During winter 1977-78 there was heavy ice cover on the Great Lakes, but in spite of that the level of shipping traffic was high during most of the year. For the second year in a row, severe winter weather created very heavy ice conditions. November was mild, but without exception the remaining 5 months were colder than normal throughout the lakes. A strike at mines and processing plants delayed fall shipping until winter. Because of this combination of circumstances, a total of 138 shipping companies participated in the extended season operations. Foreign shipping on the Great Lakes set a new record for the St. Lawrence Seaway. The increased tonnage coupled with an early winter created massive traffic tie-ups in the river system in December. The last vessels did not reach the ocean until after Christmas--the latest the seaway has ever been open. In spite of the severe midwinter conditions, shipping on the upper lakes continued throughout the season without interruption.

The demands placed on Coast Guard icebreakers were the greatest ever because of ice and heavier than usual traffic. Total cargo tonnage assisted was about double that of the previous season. It was a year of challenge for all involved, but a year that was met with determination and dedication. It was yet another landmark year in Great Lakes ice history.

5. ACKNOWLEDGMENTS

Icebreaking data and casualty information were supplied by the Ninth Coast Guard District, Cleveland. Ice information was derived from records of the NWS Forecast Office, Ann Arbor, Mich., and the Ice Navigation Center, Cleveland. Additional information was obtained from the Center for Archival Collections at Bowling Green, Ohio. George Leshkevich assisted in the preparation of illustrations appearing in section 3. The data in appendices A and C were provided by Jenifer Wartha. VHRR images were supplied by Dave Forsyth, and the local climatological data in appendix C were obtained from the National Climatic Center in Asheville, N.C. Stanley Schneider of NESS offered advice and criticism for portions of section 3. The manuscript was typed by Michele Head and Barbara Lawton, and edited by Jeanne Kelley.

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7. Appendix A. LAKE BOTTOM TOPOGRAPHY

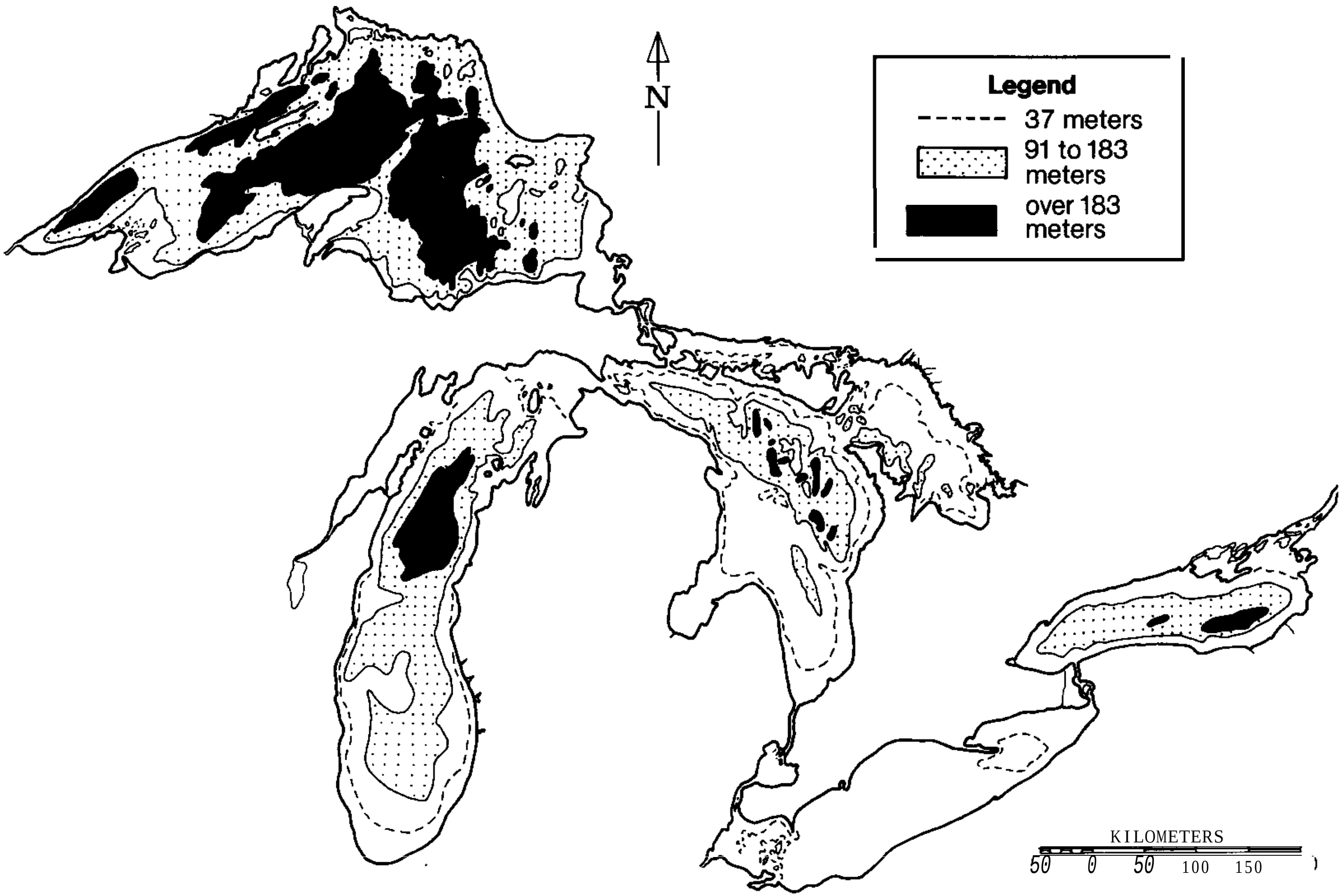

Figure 6.--*Lake bottom topography (after figure 3 in Snider, 1974).*

8. Appendix B. SURFACE WEATHER MAPS

8.1 Cold Outbreak (January 15-16)

8.2 Severe Storm (January 25-26)

8.3 Severe Storm Southern Lakes (March 25-26)

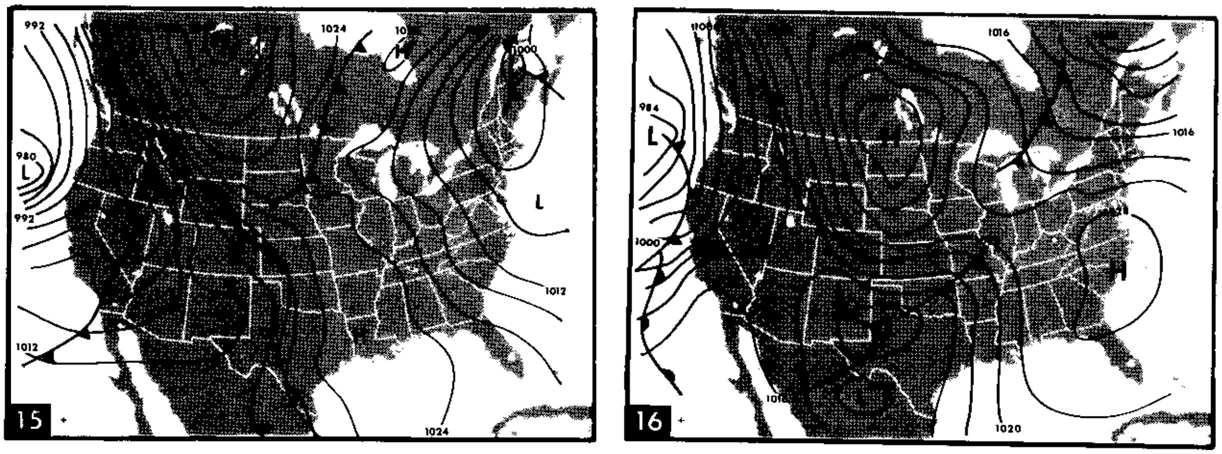

Figure 7a.--*Cold air outbreak on January 15-16.*

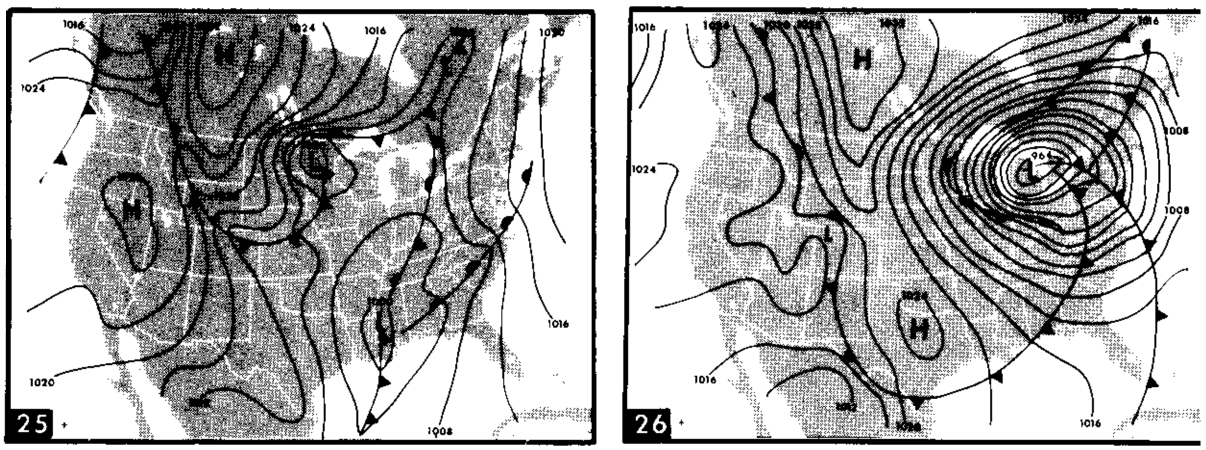

Figure 7b.--*Severe storm on January 25-26.*

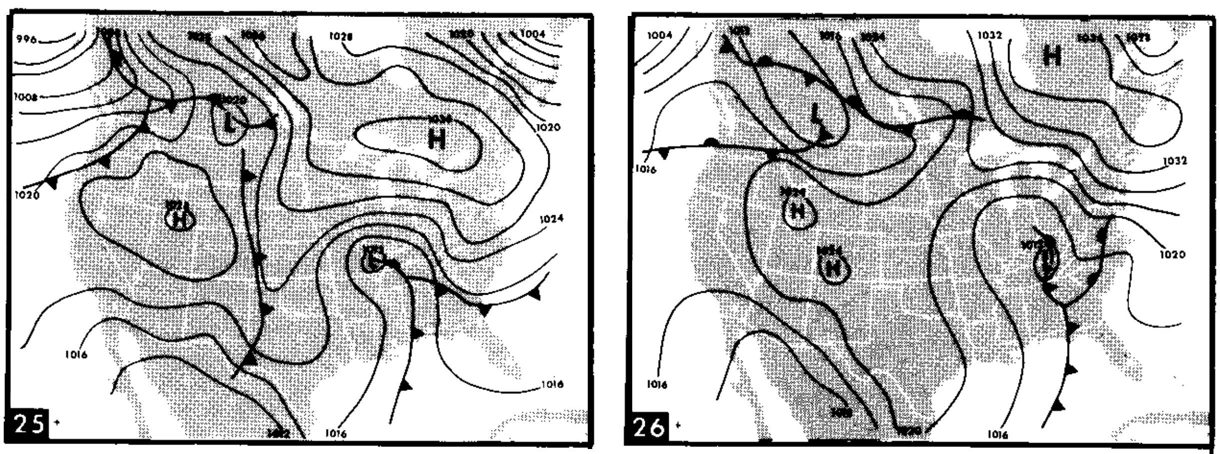

Figure 7c.--*Severe storm on southern lakes on March 25-26.*

9. Appendix C. DAILY AIR TEMPERATURE AND WIND SPEED AND DIRECTION

9.1 Duluth, Minn.

9.2 Sault Ste. Marie, Mich.

9.3 Grand Rapids, Mich.

9.4 Chicago, Ill.

9.5 Milwaukee, Wis.

9.6 Green Bay, Wis.

9.7 Alpena, Mich.

9.8 Flint, Mich.

9.9 Buffalo, N.Y.

9.10 Erie, Pa.

9.11 Cleveland, Ohio

9.12 Toledo, Ohio

9.13 Detroit, Mich.

9.14 Rochester, N.Y.

9.15 Syracuse, N.Y.

Table 7a.--*Daily air temperature and wind speed and direction, Duluth, Minn.*

	DECEMBER			JANUARY			FEBRUARY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	-4.4	W	8.0	-18.9	W	8.0	-21.7	NW	7.0
2	-10.6	W	11.0	-13.3	W	11.0	-21.7	W	6.0
3	-16.1	NY	9.0	-12.8	S	7.0	-21.7	E	3.0
4	-15.0	E	5.0	-12.2	NW	6.0	-12.8	W	3.0
5	-12.8	W	4.0	-8.9	N	6.0	-17.2	NW	12.0
6	-16.1	W	11.0	-5.0	NE	9.0	-18.3	N	8.0
7	-16.1	NW	2.0	-10.0	NW	6.0	-10.0	N	8.0
8	-11.1	S	6.0	-21.1	NW	15.0	-6.7	NE	12.0
9	-18.3	NW	14.0	-25.6	NW	15.0	-7.2	N	6.0
10	-26.7	W	7.0	-22.2	W	11.0	-8.9	W	9.0
11	-22.2	E	7.0	-16.1	W	12.0	-12.2	W	8.0
12	-7.2	SE	4.0	-15.0	SW	2.0	-6.1	NY	10.0
13	-3.9	W	5.0	-13.3	N	8.0	-7.9	N	7.0
	-6.1	SW	2.0	-10.0	N	2.0	-8.9	W	8.0
14	-3.3	E	7.0	-14.4	W	7.0	-11.7	W	10.0
15	0.0	NE	16.0	-20.0	NW	10.0	-13.9	W	6.0
17	1.7	NE	22.0	-19.4	E	2.0	-12.2	W	10.0
18	1.7	E	10.0	-10.6	S	.6	-12.2	SW	3.0
19	-1.7	SW	6.0	-18.9	NW	8.0	-12.5	SE	2.0
20	-5.0	NW	11.0	-18.3	NW	4.0	-11.7	N	4.0
21	-8.3	NW	15.0	-17.8	SW	5.0	-12.2	SW	2.0
22	-8.9	S	3.0	-13.3	S	10.0	-7.8	S	4.0
23	-11.1	W	9.0	-7.2	S	10.0	-3.9	W	8.0
24	-15.6	W	11.0	-6.7	SW	8.0	-3.9	E	2.0
25	-22.8	W	14.0	-9.4	N	3.0	-8.9	W	8.0
26	-20.0	W	13.0	-15.6	NW	16.0	-11.7	W	5.0
27	-21.1	SW	7.0	-15.0	NW	17.0	-15.D	E	.7
28	-11.1	W	10.0	-16.7	NW	14.0	-12.2	NY	4.0
29	-13.3	W	5.0	-17.2	NW	11.0			
30	-13.3	W	6.0	-18.3	W	9.0			
31	-16.1	NW	10.0	-17.2	W	9.0			

	MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	-15.6	SW	2.0	-.6	W	8.0	2.2	NE	3.0
2	-15.6	NY	2.0	-2.2	E	17.0	6.7	NE	1.0
3	-13.3	W	8.0	1.1	E	4.0	11.7	E	3.0
4	-12.8	W	6.6	3.9	W	6.0	8.9	NE	13.0
5	-11.7	SW	2.3	.6	NE	6.0	7.8	E	10.0
6	-11.1	N	1.0	7.8	E	4.0	6.1	E	9.0
7	-9.4	S	1.0	3.3	W	6.0	9.4	E	14.0
8	-3.3	SW	8.0	.6	E	14.0	7.8	E	6.0
9	1.7	SW	8.0	.6	E	8.0	8.9	W	11.0
10	0.0	SW	3.0	3.9	W	2.0	13.3	S	11.0
11	1.1	W	6.1	1.1	W	7.0	15.0	W	7.0
12	0.0	E	1.C	3.9	SW	7.0	7.2	NE	8.0
13	-1.7	NE	9.″	0	W	11.0	11.7	N	8.0
	-2.2	NY	5.0	3.9	W	9.0	12.8	NE	6.0
14	-10.0	SW	3.0	3.3	NY	4.0	11.1	E	10.0
15	-7.2	W	7.0	2.2	E	4.0	15.0	E	8.0
17	-7.2	W	5.0	5.9	E	11.0	17.2	E	5.0
18	-.6	SW	lC.E	3.3	NE	16.0	19.4	SW	5.0
19	-1.7	W	8.0	5.0	N	8.0	20.6	SW	7.0
20	0.0	S	4.0	0.0	NE	6.0	10.0	NW	8.0
21	2.2	SW	5.0	1.1	E	11.0	11.7	E	4.0
22	2.2	W	10.0	5.0	E	9.0	14.4	E	7.0
23	-5.0	NY	9.0	2.2	NE	12.0	16.1	SE	5.0
24	-8.3	E	5.0	6.7	NE	14.0	18.3	E	5.0
25	-3.9	E	6.0	7.2	E	7.0	20.6	E	6.0
26	0.0	E	3.0	9.4	E	3.0	21.1	SE	6.0
27	7.2	W	4.0	11.7	SE	3.0	19.4	NE	1.0
28	1.1	W	10.0	11.7	E	1.0	16.7	NE	6.0
29	1.1	W	2.0	4.4	NE	15.0	13.3	E	7.0
30	8.3	E	3.0	2.8	E	9.0	13.9	W	3.0
31	5.0	NE	7.0				9.4	NE	6.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7b.--*Daily air temperature and wind speed and direction, Sault Ste. Marie, Mich.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	1.1	SW	4.0	-8.3	N	5.0	-12.8	W	4.0	-9.4	W	7.0	-6.7	W	12.0	2.2	W	12.0
2	-2.8	SW	10.0	-14.4	W	5.0	-16.1	W	5.0	-12.8	NY	1.0	-5.6	E	4.0	5.3	W	10.0
3	-5.0	W	10.0	-16.1	N	3.0	-19.4	NE	1.0	-6.7	NY	6.0	-1.7	E	13.0	5.6	W	5.0
4	-8.9	E	2.0	-8.3	SW	4.0	-20.6	E	6.0	-10.6	W	6.″	-.6	N	3.C	7.2	E	4.0
5	-9.4	NE	9.0	-11.7	NE	5.0	-14.4	N	6.E	'8.9	S	3.0	1.7	W	6.C	10.0	N	3.0
6	-9.4	N	9.0	-11.7	E	12.0	-16.7	N	9.0	-6.7	W	3.″	0.0	E	14.0	10.6	NY	2.0
7	-10.0	NY	7.0	-6.7	E	11.0	-13.9	NW	4.0	-9.4	W	2.0	6.0	W	12.0	10.t	E	6.0
8	-11.1	E	10.0	-10.0	NW	9.0	-10.6	N	3.0	-7.2	NW	1.0	-3.3	NW	6.0	8.9	E	9.0
9	-12.2	N	11.0	-19.4	NW	17.0	-11.1	W	7.r:	-8.9	NY	6.0	-3.3	E	3.0	7.8	SW	6.0
10	-18.3	NE	3.0	-11.1	NW	20.0	-7.2	W	4.0	-3.3	W	6.C	0.0	E	12.G	9.4	W	5.0
11	-99.0	E	5.0	-7.2	W	13.0	-10.0	W	8.C	1.7	S	3.0	1.7	W	6.E	12.8	E	7.0
12	-6.1	SE	8.0	-8.9	E	4.0	-5.0	W	12.0	1.7	W	3.i	.5	S	2.0	11.1	E	5.0
13	-1.1	E	7.0	-13.3	NE	6.0	-8.9	N	4.0	1.7	SE	2.0	.6	W	11.0	7.8	NE	8.0
14	1.1	W	2.0	-17.8	N	6.0	-15.0	SE	2.0	1.7	E	2.0	1.0	W	12.0	10.0	NE	8.0
15	1.1	SE	3.0	-16.7	W	5.0	-6.7	S	8.C	.6	W	7.0	.6	NW	9.0	16.1	E	3.0
16	1.7	E	12.0	-15.0	NW	2.0	-10.0	S	3.0	-1.7	E	5.0	-1.7	NW	4.0	16.1	E	.5
17	0.0	E	16.0	-18.9	NE	2.0	-9.4	SW	6.0	-5.6	SW	3.0	2.8	W	2.0	15.0	W	8.0
18	-1.1	E	13.0	-16.1	NE	2.0	-13.9	W	6.0	-2.8	W	4.0	3.9	E	1C.0	14.4	W	5.0
19	1.1	E	11.0	-13.9	NW	3.0	-14.4	SE	.4	-.6	E	6.0	5.6	E	9.0	19.4	SW	3.0
20	.6	E	11.0	-13.9	NE	6.0	-10.6	N	2.0	-.6	N	5.0	2.8	N	9.0	13.3	W	4.0
21	-1.7	E	6.0	-11.7	NE	.2	-15.6	W	5.0	2.8	N	2.0	-.6	NW		7.2	NW	7.0
22	-2.8	E	4.0	-12.2	S	3.0	-11.1	W	4.0	2.8	E	4.0	3.3	SE	2.0	12.8	S	2.0
23	-2.2	SW	4.0	-2.8	S	7.0	-7.8	W	4.0	1.7	W	6.0	4.4	E	7.C	15.i	E	4.0
24	-3.3	SW	4.0	-2.2	SW	5.0	-4.4	W	3.″	-5.0	S	6.3	7.8	NE	5.0	16.1	W	2.0
25	-9.4	W	8.0	-8.9	NE	4.0	-6.7	NW	6.5	-2.8	W	16.0	9.4	N	2.0	19.4	S	2.0
26	-16.7	S	1.0	-7.2	N	15.0	-10.0	NW	6.0	0.0	E	8.0	8.3	NY	5.0	19.4	SE	3.0
27	-22.2	NE	4.0	-10.6	NW	13.0	-9.4	S	2.0	1.7	SW	2.C	8.3	W		22.2	S	2.0
28	-12.8	SW	3.0	-10.6	NW	11.0	-10.0	W	3.0	6.1	W	10.0	8.9	W	6.0	22.2	S	3.0
29	-11.7	SW	9.0	-12.2	NW	9.0				1.1	NW	12.0	5.0	NW	7.″	21.7	E	6.0
30	-9.4	SW	4.0	-14.4	E	4.0				.6	SW	2.0	-1.1	NW	10.0	18.9	E	6.0
31	-10.0	E	1.0	-10.0	W	6.0				13.9	E	11.0				12.2	W	6.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7c.--*Daily air temperature and wind speed and direction, Grand Rapids, Mich.*

	DECEMBER			JANUARY			FEBRUARY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	2.2	SW	10.0	-3.9	N	6.0	-8.9	S	5.0
2	3.3	SW	17.0	-9.4	SW	12.0	-10.0	W	4.0
3	-2.2	W	6.0	-8.9	SW	8.0	-15.0	NE	4.0
4	-3.9	NE	2.0	-6.1	S	7.0	-14.4	E	4.0
5	-1.7	NE	13.0	-3.3	NE	7.0	-8.9	NY	6.1
6	-3.3	W	11.0	-1.1	E	8.0	-16.7	N	8.0
7	-6.1	N	9.0	2.2	E	8.0	-15.6	NY	4.0
8	-10.0	N	7.0	-3.9	W	13.0	-13.3	NE	2.0
9	-9.4	W	15.0	-10.6	W	20.0	-8.3	NY	3.0
10	-11.7	SW	4.0	-10.0	W	15.3	-10.6	SW	6.0
11	-11.7	E	6.0	-7.8	SW	12.0	-10.0	SW	7.0
12	-2.2	SW	13.0	-9.4	S	5.0	-7.2	SW	6.0
13	2.8	S	9.0	-5.0	N	8.3	-8.3	NE	11.0
14	2.2	SE	2.0	-10.6	N	10.3	-10.6	W	2.0
			6.0	-12.2	SW	5.0	-6.1	S	lF.0
15 lb	2.2 4.4	ss	9.0	-12.2	S	6.0	-7.8	S	10.0
17	5.0	W	13.0	-11.7	N	11.0	-8.3	S	8.0
18	2.8	SE	3.0	-10.0	NW	2.0	-10.6	SW	5.0
19	3.3	E	5.0	-6.1	N	7.0	-15.6	S	4.0
20	-1.1	E	8.0	-6.1	N	11.0	-11.1	S	2.0
21	-4.4	E	11.0	-9.4	W	5."	-10.6	NW	5.0
22	-2.2	SE	11.0	-8.3	S	11.0	-11.7	SW	5.0
23	.6	E	12.0	-6.7	S	11.0	-10.6	SW	4.0
24	0.0	S	7.0	-5.3	S	8.0	-2.2	S	8.0
25	-8.3	W	15.0	-1.7	NE	6.0	-1.7	W	10.0
26	-11.1	SW	10.0	-4.4	W	21.0	-12.2	W	6.6
27	-11.1	SW	10.0	-5.6	W	16.1	-6.1	S	5.0
28	-8.9	S	8.0	-5.0	W	lC.0	-4.4	SW	2.1
29	-3.9	SE	6.0	-5.0	W	10.C			
30	-16.7	NE	2.0	-8.9	S	8.0			
31	-7.2	NE	9.0	-8.9	S	10.0			

	MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	-9.4	NY	6.0	10.0	W	16.0	5.0	W	11.0
2	-12.8	E	3.0	.6	E	13.0	7.8	W	7.0
3	-5.7	NY	5.0	7.2	=	10.0	9.4	NE	3.0
4	-10.6	W	7.0	8.3	W	3.0	8.9	E	16.0
5	-8.9	S	8.0	6.1	S	2.0	6.1	NE	10.0
6	-6.7	SE	2.0	7.2	E	6.0	11.1	NY	4.0
7	-9.4	NE	6.0	10.0	W	11.0	12.2	E	10.0
8	-7.2	NE	8.0	5.0	NE	10.0	15.6	S	7.0
9	-8.9	SW	4.0	3.3	E	12.0	11.7	SW	15.0
10	-3.3	SW	3.0	11.1	S	4.0	12.8	W	7.0
11	1.7	S	2.0	6.1	W	13.0	16.1	S	13.0
12	1.7	SW	2.0	8.9	SW	15.0	17.8 8	S	7.0
13	1.7	SE	8.0	5.P	W	15.0	15.6	E	7.0
14	1.7	W	6.0	4.4	W	10."	13.3	NE	7.0
	.6	W	7.0	2.8	NW	7.0	13.9	NE	12.0
15 lb	-1.7	SW	8.0	4.4	NY	4.0	15.0	NE	8.0
17	-5.5	W	8.0	6.1	NE	11.0	16.1 1	W	4.0
18	-2.8	S	11.0	6.1	E	15.0	12.8	W	9.0
19	-.6	W	12.0	10.6	N	5.0	18.9	W	7.C
20	-.6	SE	7.0	5.0	NY	5.0	16.1	W	8.0
21	2.R	W	8.0	7.8	NY	6.0	11.1	NE	5.0
22	2.8	SW	5.0	7.8	E	4.0	13.9	SE	5.0
23	1.7	NY	6.0	7.2	E	9.0	17.2	SE	3.0
24	-5.0	NE	14.0	11.1	NE	lE.0	19.4	SW	.7
25	-2.8	NE	19.0	9.4	NE	13.J	20.0	SW	3.0
26	0.0	NE	11.0	11.1	NE	5.0	23.3	S	4.0
27	1.7	W	4."	13.3	NY	4.0	25.0	S	5.0
28	6.1	SW	10.C	11.7	W	4.0	24.4	S	6.0
29	1.1	NY	8.3	13.3	SW	3.0	25.6	S	6.0
30	.6	S	4.0	6.7	N	6.0	23.3	SW	7.0
31	13.9	S	8.0				19.4	W	6.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7d.--*Daily air temperature and wind speed and direction, Chicago, Ill.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	3.3	SW	12.0	-8.3	W	6.0	-11.7	S	4.0	-7.2	NW	4.0	9.0	W	7.0	4.4	N	15.0
2	-.6	SW	12.0	-15.6	SW	12.0	-12.8	W	6.0	-7.8	E	6.0	1.1	NE	15.3	5.6	N	9.0
3	-5.6	W	7.0	-11.7	S	6.0	-12.2	N	2.0	-7.8	NW	10.0	12.2	E	6.0	8.5	NE	6.0
4	-3.9	NE	5.0	-2.8	S	9.0	-10.0	SE	6.0	-11.1	W	10.0	10.0	SW	5.0	6.7	NE	15.0
5	-.6	N	12.0	1.1	E	5.0	-10.6	NW	14.0	-11.1	S	10.0	8.3	E	3.0	5.0	N	9.0
6	-10.0	W	14.0	2.8	SE	7.0	-12.8	NW	13.0	-2.8	E	3.C	12.8	W	.4	7.8	NE	4.0
7	-13.9	SW	7.0	3.3	E	5.0	-10.6	NW	6.0	-2.8	NE	12.0	13.9	W	4.0	8.9	E	15.0
8	-7.8	E	3.0	-7.2	W	15.0	-9.4	NE	4.0	-2.8	N	16.0	5.0	N	11.0	10.0	S	9.0
9	-15.0	W	16.0	-18.9	W	18.0	-3.9	N	5.0	-2.8	SW	4.0	10.6	E	10.0	11.7	W	13.0
10	-17.2	SW	8.0	-17.2	W	12.0	-8.3	W	6.0	.6	SW	2.0	12.2	S	3.0	15.0	SW	5.c
11	-12.2	S	5.0	-13.3	SW	9.D	-8.9	SW	5.0	1.1	NE	2.0	10.C	SW	12.0	15.6	S	15.0
12	0.0	S	14.0	-10.6	W	1.0	-3.3	W	2.0	1.7	W	3.0	11.7	S	13.0	20.6	S	12.0
13	-1.1	S	9.0	-6.1	N	6.0	-4.4	NE	13.0	.6	SE	9.0	7.8	W	15.0	12.2	N	6.0
14	2.2	W	5.0	-7.8	N	11.0	-5.0	S	2.0	1.7	W	8.0	8.9	SW	7.0	I.8	N	13.0
15	1.7	S	11.0	-12.2	W	7.0	-9.4	SW	8.0	1.1	W	9.0	6.7	N	6.C	11.7	N	11.0
16	6.1	SE	11.0	-11.7	W	5.0	-13.3	SW	8.0	-1.7	W	10.0	4.4	N	8.0	12.8	N	9.0
17	5.6	SE	12.0	-7.8	NE	15.0	-12.8	SW	6.0	-2.8	W	10.0	6.1	NE	9.0	14.4	N	4.0
18	5.0	SW	6.0	-5.0	NE	6.0	-11.7	W	4.0	-1.1	S	13.0	11.7	E	13.0	19.4	N	2.0
19	3.5	NE	2.0	-5.0	N	9.0	-10.6	S	4.0	4.4	W	5.0	6.7	NY	8.0	21.1	SW	5.0
20	-1.7	W	9.0	-5.6	N	12.0	-8.3	E	3.0	5.0	SE	9.0	3.3	NY	11.0	17.8	W	6.0
21	-3.3	W	11.0	-10.0	W	9.0	-8.3	NW	7.0	4.4	W	10.0	4.4	N	9.0	8.9	NE	10.0
22	-4.4	S	13.0	-13.3	S	7.0	-10.0	S	6.0	8.9	SW	7.0	6.7	E	3.0	12.8	E	6.0
23	-1.7	S	10.0	-6.1	S	11.0	-5.0	SW	6.0	5.0	N	7.0	11.7	SE	9.0	14.4	E	5.0
24	-2.2	SW	7.0	-3.3	S	7.0	-.6	S	9.0	-.6	NE	20.0	12.2	E	5.0	16.7	NE	4.0
25	-13.3	W	15.0	-4.4	N	3.0	-3.3	W	11.0	-1.7	N	17.0	8.9	N	14.0	21.1	S	5.0
26	-13.9	W	10.0	-8.9	W	21.0	-7.2	W	6.0	0.0	N	10.0	9.4	N	11.0	25.6	S	7.0
27	-15.0	W	9.0	-15.9	W	14.0	-6.7	S	7.0	4.4	W	4.0	10.6	N	5.0	26.1	S	6.0
28	-9.4	SW	8.0	-12.8	W	12.0	-3.3	NW	2.0	8.3	SW	6.1)	13.3	N	.5	25.6	SE	5.0
29	-1.7	S	6.0	-14.4	W	9.0				3.3	N	7.0	12.8	N	4.0	26.7	S	8.0
30	-1.1	NE	2.0	-15.6	SW	7.0				6.1	SE	7.0	5.0	N	12.0	23.3	SW	8.0
51	-1.1	NE	9.0	-11.7	SW	9.0				18.3	S	11.0				23.9	SE	3.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table *Je.--Daily air temperature and wind speed and direction, Milwaukee, Wis.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	-.6	W	12.0	-8.9	NY	7.0	-12.2	W	5.0	-8.9		5.0	8.9	W	12.0	3.9	N	14.0
2	-3.9	SW	15.0	-15.0	W	11.0	-13.5	W	7.1	-10.6	SE	3.0	.6	NE	13.0	6.1	N	4.0
,	-7.2	W	8.0	-12.8	SW	6.0	-10.6	NW	4.0	-7.2	NY	8.0	5.0	E	7.0	6.1	E	3.0
4	-5.0	N	1.0	-6.7	SW	6.0		S	6.0		W	9.0	6.1	NY	8.0	6.7	NE	12.0
5	-1.1	N	10.0	-3.3	N	6.0	-10.6	NY	13.0	-12.2	SW	8.0	4.4	E	3.0		N	11.0
6	-9.4	W	17.0	.6	SE	6.0	-12.2	NY	15.0	-5.0	NY	4.0	7.2	E	3.0	8.3	NE	4.0
7	-12.2	W	8.0	1.1	SE	5.0	-8.3	NW	10.0	-2.8	NE	11.0	11.1	W	6.0	7.2	E	7.0
8	-8.3	SW	6.0	-7.2	W	15.0	-5.6	N	6.0	-5.0	NE	7.0	2.8	N	13.0	13.3	SW	11.0
9	-15.0	W	19.0	-18.3	W	14.0	-6.7	NW	7.0	-5.6	SW	9.0	3.9	E	13.6	11.7	W	14.0
10	-15.0	W	9.0	-18.3	W	14.0	-9.4	W	7.t	.6	W	2.0	9.4	SW	4.0	12.8	SW	4.0
11	-12.8	SW	4.0	-14.4	W	12.0	-6.7	W	8."	.6	S	4.0	5.6	W	11.0	15.6	SW	15.0
12	-2.2	S	12.0	-12.2	SW	4.0	-5.6	NW	5.0	C.3	S	2.0	9.4	SW	5.0	13.9	E	2.0
13	2.2	S	6.0	-6.1	N	11.0	-5.6	N	14.0	0.0	SE	7.0	7.2	W	15.0	6.1	N	24.0
1	l	W	6.0	-7.2	N	12.0	-6.7	W	4.0	1.7	NY	7.0	6.7	W	8.0	7.2	N	13.0
15	1.1 .6	WS	9.0	-11.1	W	8."	-9.4	SW	10.6	.6	W	5.0	4.4	N	4.0	10.0	N	14.0
16	3.9	SE	12.P	-10.6	W	7.0	-12.8	SW	9.0	-1.7	W	10.0	3.3	N	5.0	10.0	N	9.0
17	5.6	SE	14.0	-5.6	NE	14.0	-12.2	SW	9.0	.	W	10.0	2.8	NE	9.0	15.0	N	5.0
18	5.9	SW	3.0	-6.1	NW	5.1	-10.0	W	8.0	-2.8	S	14.0	4.4	E	16.0	19.4	W	6.0
19	2.2	SW	2.0	-5.6	N	1u.0	-11.7	SW	7.0	1.7	W	9.0	5.[illegible]	N	10.0	18.9	NE	6.0
20	.6	NW	7.0	-6.7	N	12.0	-9.4	S	2.L	1.1	SE	8.0	3.3	N	19.0	15.6	W	5.0
21	-2.2	W	11.0	-8.9	W	8. .	-7.6	NW	9.:	4.4	W	10.0	3.3	N	10.0	6.7	N	10.0
22	-4.4	SW	13.0	-12.2	SW	8.0	-10.6	SW	7.0	4.4	SW	3.0	3.3	NE	4.0	9.4	E	4.0
23	-3.3	SW	9.0	-5.6	S	11.0	-6.1	W	6.1	1.7	N	5.0	4.4	SE	11.0	11.7	NE	5.0
24	-3.9	SW	5.0	-3.3	SW	8.0	-1.7	SW	9.0	-3.3	N	19.0	7.2	NE	5.0	15.0	NE	3.0
25	-15.0	W	14.0	-6.1	NW	2.6	-2.2	W	10.C	-1.1	NE	19.0	6.7	N	14.0			7.0
26	-16.1	W	11.0	-6.7	W	22.0	-6.7	W	9.0	0.0	N	13.0	8.9	N	10.0			8.0
27	-16.7	W	11.0	-12.2	W	17.Q	-8.3	SW	6.0	3.9	SW	5.0	10.0	N	4.0		S	7.0
28	-10.6	SW	11.0	-11.7	W	13.3	-5.0	NY	6.[illegible]	7.2	W	16.0	10.6	SE	4.0		S	8.0
29	-5.6	N	2.0	-13.9	W	12.0				1.7	N	7.0	10.0	N	12.J		S	6.0
30	-2.8	N	9.0	-15.0	W	9.0				2.8	SE	6.0	3.3	N	15.t		SW	7.0
31	-1.7	E	5.0	-12.2	W	11.0				13.9	S	11.0						1.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADF
WD = WIND DIRECTION
WS = YIN" SPEED IN KNOTS
[illegible] DATA AVAILABLE

Table 7f.--*Daily air temperature and wind speed and direction, Green Bay, Wis.*

	DECEMBER TC	DECEMBER WD	DECEMBER WS	JANUARY TC	JANUARY WD	JANUARY WS	FEBRUARY TC	FEBRUARY WD	FEBRUARY WS	MARCH TC	MARCH WD	MARCH WS	APRIL TC	APRIL WD	APRIL WS	MAY TC	MAY WD	MAY WS
1	-1.7	W	10.0	-12.5	NW	10.0	-16.1	SW	5.″	-13.3	S	4.0	3.9	NW	13.0	5.9	N	8.0
2	-10.0	SW	13.0	-15.6	SW	11.0	-17.2	W	5.0	-13.9	S	3.0	-1.1	NE	15.0	7.2	NE	1.0
3	-13.9	SW	6.0	-13.9	SW	7.0	-17.2	N	4.0	-10.6	NY	9.0	2.8	E	5.8	9.4	S	3.0
4	-14.4	NY	1.0	-12.8	SW	5.0	-10.6	S	5.0	-13.9	SW	8.0	6.7	NY	7.0	8.3	NE	12.0
5	-3.9	N	10.0	-10.0	N	7.0	-13.3	NW	15.0	-16.1	S	7.0	4.4	NE	7.0	9.4	NE	15.0
6	-11.7	W	13.0	-2.2	SE	4.0	-15.6	MY	8.0	-11.7	W	1.0	3.9	E	6.0	8.9	NE	4.0
7	-18.3	S	6.0	-.6	SW	4.0	-10.0	N	7.0	-10.6	N	3.0	6.7	W	6.6	11.1	E	9.0
8	-10.0	NW	3.0	-8.3	NY	12.0	-1C.6	N	9.0	-11.1	S	4.0	.6	N	13.0	13.9	S	10.0
9	-12.8	W	15.0	-18.3	W	17.0	-10.6	NY	5.0	-6.1	S	11.0	1.7	E	11.0	11.1	W	10.0
10	-18.9	W	7.0	-18.3	W	13.0	-11.7	SW	5.0	-4.4	S	4.0	2.9	N	5.0	12.8	SW	8.0
11	-18.3	S	4.0	-18.3	SW	11.0	-10.6	SW	7.F	.6	SW	7.0	2.8	SW	11.0	17.2	S	15.0
12	-3.9	S	8.0	-17.2	S	6.0	-8.3	SW	6.0	-2.8	SE	2.0	8.3	SW	11.0	12.8	NE	5.0
13	1.7	S	6.0	-8.3	N	10.0	-8.3	N	10.0	-1.7	SE	7.0	5.″	W	15.C	6.7	N	19.0
14	.6	W	3.0	-7.8	N	11.0	-11.7	SW	5.C	.6	N	6.0	5.0	W	8.0	7.2	N	14.0
15	0.0	SE	7.0	-11.7	W	7.0	-9.4	SW	10.0	-1.7	W	4.0	3.9	NY	4.0	12.8	N	14.0
16	2.2	E	9.0	-11.7	W	6.0	-14.4	SW	8.0	-3.9	W	7.0	-1.1	NE	4.0	13.3	NE	6.0
17	3.9	E	14.0	-11.1	N	13.0	-13.9	SW	10.0	-6.1	W	9.0	3.9	NE	9.0	15.0	NY	3.0
18	2.8	NE	6.0	-9.4	NY	3.0	-13.3	W	4.0	-5.0	S	13.0	4.4	E	14.0	18.3	SW	6.0
19	1.7	SE	2.0	-11.7	N	8.0	-13.9	S	7.0	-1.1	W	10.0	3.9	N	10.0	18.3	SW	10.0
20	1.1	N	12.0	-10.0	N	9.0	-15.5	W	1.0	-1.1	SE	8.0	2.2	N	12.0	15.0	W	5.0
21	-1.7	N	9.0	-8.9	W	5.0	-10.6	NW	5.0	2.8	W	8.0	3.3	N	6.0	10.0	NE	7.0
22	-5.0	S	11.0	-12.8	S	12.0	-13.5	S	7.C	4.4	SW	6.0	5.6	SE	4.0	12.2	S	6.0
23	-2.8	SW	7.0	-6.1	S	13.0	-7.2	SW	7.P	0.0	NY	9.0	2.2	E	11.0	12.8	E	2.0
24	-7.8	NW	7.0	-5.6	SW	9.0	-3.3	S	4.0	-5.6	N	14.0	7.2	NE	10.0	17.2	S	3.0
25	-17.8	W	14.0	-10.0	NE	3.0	-5.6	NY	9.1	-3.5	N	16.0	7.8	N	12.0	18.9	S	5.0
26	-19.4	W	13.0	-6.1	NY	24.0	-8.3	W	8.0	0.0	N	12.0	9.4	N	5.0	23.9	S	7.0
27	-19.4	SW	10.0	-8.9	W	15.0	-12.8	S	5.0	2.2	SW	6.0	9.4	E	3.0	25.0	S	5.0
28	-10.6	SW	10.0	-11.1	W	12.0	-12.2	N	5.E	5.6	W	11.0	12.8	S	4.0	23.9	SW	3.0
29	-10.6	W	3.0	-14.4	SW	7.0				2.8	N	3.0	5.6	N	12.0	21.7	S	5.0
30	-11.1	NY	5.0	-18.3	SW	8.0				5.0	S	8.0	3.3	N	8.0	20.0	SW	8.0
31	-9.4	N	10.0	-15.0	W	10.0				6.7	E	7.0				18.9	W	1.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7g.--*Daily air temperature and wind speed and direction, Alpena, Mich.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	3.3	SW	5.0	-1.7	NE	6.E	-11.1	W	3.0	-10.0	W	8.0	2.8	W	11.0	3.9	NY	12.0
a	-2.2	SW	15.0	-11.7	SW	8.0	-12.8	W	4.0	-11.7	SW	2.0	-3.9	NE	7.0	5.6	NY	9.0
3	-3.3	SW	8.0	-11.1	SW	6.P	-18.3	NW	4.0	-7.2	NY	4.0	-.6	SE	10.0	6.1	N	1.0
4	-7.8	W	5.0	-8.9	SW	7.0	-18.9	SE	4.0	-11.1	W	7.0	1.7	NW	3.0	2.8	E	8.0
5	-6.1	N	11.0	-6.1	N	4.0	-10.6	N	2.0	-10.6	SW	4.0	3.3	W	6.0	6.7	NE	6.0
6	-6.1	NW	13.0	-4.4	E	9.0	-15.6	N	12.0	-11.7	N	1.0	.6	E	9.0	9.4	NY	4.0
7	-9.4	W	10.0	-.6	SE	8.0	-10.0	NY	11.0	-11.7	SE	2.0	2.8	W	10.0	7.2	E	4.0
8	-10.6	SE	6.0	-5.6	W	8.0	-11.7	N	5.0	-11.7	E	2.0	-1.7	NW	7.0	9.4	E	8.0
9	-6.7	NY	10.0	-15.6	NW	17.3	-13.9	W	5.0	-1.7	SW	6.0	-3.9	E	9.0	8.3	SW	9.0
10	-16.7	W	5.0	-10.6	W	16.0	-5.0	W	7.0	-3.9	E	3.0	1.7	E	9.0	8.9	SW	4.0
11	-17.2	S	3.0	-6.7	SW	12.0	-6.1	W	8.0	3.3	S	5.0	4.4	SW	8.0	13.3	S	11.0
12	-5.6	SE	7.0	-4.4	SW	2.0	-3.9	W	11.0	.6	N	1.0	4.4	SE	4.0	12.2	SE	5.0
13	1.1	S	7.0	-6.7	N	7.0	-8.9	N	6.0	2.2	SE	8.0	3.9	W	10.0	9.4	E	6.0
14	1.1	W	3.0	-13.9	N	11.0	-9.4	W	2.0	.6	NW	6.0	2.2	W	10.0	10.0	NE	5.0
15	.6	S	4.0	-15.0	W	7.0	-8.9	S	8.0	-4.4	N	5.0	1.7	W	9.0	12.8	NE	6.0
16	1.1 .	E	9.0	-13.9	W	3.0	-4.4	S	7.0	-7.2	E	6.(	0.0	NW	5.0	13.9	N	5.0
17	1.7	E	15.0	-15.6	N	3.0	-7.8	SW	7.0	-8.3	W	4.0	1.7	NE	1.0	18.3	N	2.0
1.9	.6	E	12.0	-13.3	NW	3.0	-9.4	W	6.0	-6.1	S	8.0	1.1	E	11.0	17.8	E	3.0
19	2.2	E	6.0	-9.4	NW	5.0	-14.4	SW	3.0	-2.2	W	15.0	2.9	E	7.0	21.7	SW	2.0
20	1.1	E	11.0	-10.0	N	10.0	-11.7	NY	1.0	-6.1	SE	9.0	.6	N	11.0	16.1	W	6.0
21	-3.9	SE	8.0	-11.1	NW	5.0	-12.8	NW	6.0	1.1	N	4.0	1.7	NW	10.C	10.6	N	4.0
22	-2.8	S	8.0	-11.1	S	5.0	-9.4	W	6.8	2.2	SW	3.0	1.7	SE	2.0	12.2	SE	5.0
23	-1.7	S	7.0	-2.8	S	9.0	-9.4	SW	7.0	-1.1	W	11.0	0.0	E	5.0	12.2	E	5.″
24	0.0	SE	7.0	-2.2	S	6.0	-2.2	SW	4.0	-9.4	NW	4.0	5.0	NE	4.0	15.0	E	3.0
25	-7.2	SW	14.0	-2.2	NE	4.0	-4.4	NY	6.L	-7.8	NE	8.0	7.2	N	8.0	17.6	E	1.0
26	-12.8	SW	11.0	-5.0	N	20.0	-7.8	W	7.1	-16.1	NE	11.0	5.6	N	5.0 .	18.9	S	2.0
27	-13.3	W	5.0	-9.4	W	14.1	-8.3	S	3.0	1.1	N	2.0	8.3	NW		23.3	SE	2.0
28	-9.4	S	8.0	-8.3	W	11.0	-8.9	NW	4.0	4.4	W	8.0	10.6	NW	7.0	22.8	E	4.0
29	-11.1	SW	4.0	-9.4	W	8.0				0.0	W	11.0	5.0	NW	9.0	22.2	E	5.0
30	-11.1	W	3.0	-8.3	SW	6.0				1.7	SW	5.0	1.7	NW	9.0	22.8	SE	3.0
31	-10.0	NE	2.0	-8.3	W	6.0				3.9	E	9.0				14.4	W	8.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7h.--*Daily air temperature and wind speed and direction, Flint, Mich.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	7.2	S	13.0	-7.2	N	6.0	-9.4	SW	6.0	-11.1	W	6.0	7.2	W	15.0	4.4	W	16.0
2	1.7	SW	18.0	-10.6	SW	11.0	-13.3	SW	5.0	-14.4	S	4.0	1.1	NE	9.0	6.7	NW	9.0
3	-1.7	W	7.0	-10.0	SW	9.0	-15.6	SW	2.0	-7.2	NW	4.0	3.9	E	9.0	7.2	N	2.0
4	-3.3	SW	3.0	-5.6	S	11.0	-17.8	SE	5.6	-12.8	W	12.0	8.3	W	2.0	7.2	NE	13.0
5	-1.7	N	14.0	-3.3	NE	5.0	-10.6	NY	3.0	-11.1	S	9.0	5.6	W	4.0	6.1	N	9.0
6	-4.4	W	15.0	-6.1	E	7.0	-13.3	NY	2.0	-7.8	S	3.0	5.6	E	12.0	10.6	N	6.0
7	-5.6	W	11.0	.6	E	8.0	-12.8	NW	9.0	-10.0	NE	4.0	9.4	W	12.0	10.6	E	7.0
8	-7.8	SE	8.0	-3.3	NY	8.0	-10.6	N	3.0	-8.3	NE	7.0	1.7	N	10.0	14.4	SE	9.0
9	-7.8	SW	16.0	-11.1	W	23.0	-11.1	W	4.0	-9.4	S	5.0	.6	E	9.0	11.1	SW	14.0
10	-15.0	S	6.0	-9.4	W	21.0	-10.0	SW	8.0	-4.4	SW	4.0	11.1	E	10.0	12.2	SW	9.0
11	-16.1	S	5.2	-8.3	SW	14.0	-9.4	SW	8.0	.6	S	4.0	10.6	SW	15.0	15.0	SE	13.0
12	-3.9	S	14.0	-9.4	S	6.0	-7.8	SW	8.0	0.0	W	3.0	9.4	S	15.0	12.9	SE	11.0
13	2.2	S	10.0	-5.0	N	10.0	-6.1	N	7.0	0.0	SE	8.0	6.7	W	15.0	15.6	E	10.0
			4.0	-10.6	N	13.0	-13.3	SW	4.0	3.3	W	7.0	5.0	W	10.0	13.3	NE	9.0
14 15	2.2 1.7	NY S	6.0	-15.0	SW	8.0	-8.3	S	11.0	.6	W	7.0	3.3	W	9.0	12.8	N	15.0
16	5.0	S	6.0	-12.2	S	7.0	-8.3	SW	9.0	-1.1	SW	6.0	3.9	NW	2.0	15.0	N	10.0
17			12.0	-12.8	N	12.G	-8.9	S	9.C	-5.6	W	7.0	4.4	NE	8.0	16.1	NW	5.0
18	2.8 3.3	SE	3.0	-7.8	NW	5.0	-11.1	SW	6.0	-3.3	S	15.0	6.1	E	14.0	20.2	W	4.0
19	3.3	E	4.0	-7.2	N	7.0	-15.6	SW	4.0	-1.1	SW	14.0	11.1	NE	4.0	19.4	SW	8.0
20			11.0	-6.1	N	14.0	-11.7	S	3.0	-1.1	SE	8.0	5.0	N	11.0	16.7	SW	8.0
21	-5.0 -.6	SE S	13.0	-11.1	W	7.0	-12.8	W	9.0	2.8	W	9.0	5.0	NW	9.0	12.2	N	6.0
22	-2.2	S	13.0	-12.2	S	9.0	-12.2	SW	6.0	1.7	S	7.0	6.70	E	1.0	12.8	SE	3.0
		S	13.0	-7.8	S	11.0	-11.1	S	7.C	2.2	W	6.0	8.3.	E	7.0	15.0	SE	2.0
24	0.6	S	9.0	-3.3	S	9.0	-3.3	S	9.0	-3.3	N	14.0		NE	1.0	17.8	NE	3.0
25	-7.2	W	18.0	-1.1	N	7.0	-3.3	W	10.0	-1.7	NE	16.0	8.9	NE	13.0	18.9	S	3.0
26	-12.2	SW	12.2	-2.2	W	17.0	-7.2	W	7.0	.6	NE	10.0	10.6	N	10.0	20.6	S	3.0
27	-12.2	SW	9.0	-6.1	W	19.0	-5.6	SW	6.0	1.1	NY	5.0	8.9	N	9.0	22.2	SE	4.0
28	-10.6	S	13.0	-7.8	W	13.0	-5.0	S	4.0	5.0	SW	10.0	10.0	NW	4.0	22.8	SE	6.0
29	-5.0	S	6.0	-2.3	W	11.0				0.0	W	9.0	11.1	N	4.0	23.9	SE	7.0
30	-5.6	N	3.0	-7.8	SW	9.0				1.1	S	7.0	4.4	N	6.0	23.9	S	8.0
31	-6.1	YE	4.0	-10.0	SW	10.0				8.3	SE	11.0				21.1	W	6.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7i.--*Daily air temperature and wind speed and direction, Buffalo, N.Y.*

	DECEMBER TC	DECEMBER WD	DECEMBER WS	JANUARY TC	JANUARY WD	JANUARY WS	FEBRUARY TC	FEBRUARY WD	FEBRUARY WS	MARCH TC	MARCH WD	MARCH WS	APRIL TC	APRIL WD	APRIL WS	MAY TC	MAY WD	MAY WS
1	10.0	SW	16.0	-4.4		8.0	-8.9	S	19.0	-1.7	NW	5.0	8.3	SW	15.0	1.7	W	12.0
2	-2.2	SW	23.0	-7.8	W	15.0	-8.3	S	8.E	-12.8	SW	10.0	.6	N	10.0	4.4	W	9.0
3	0.0	W	9.0	-8.3	W	17.0	-8.3	NW	2.6	-8.3	NE	5.0	.6	E	10.0	6.1	W	8.0
4	-2.2	W	9.0	-3.9	S	13.9	-15.0	S	4.0	-10.0	W	11.0	13.3	SW	6.0	6.1	E	12.0
5	-4.4	NE	15.0	0.0	SW	5.0	-15.0	NE	5.0	-10.6	SW	13.0	9.4	W	11.0	6.7	E	9.0
6	-5.6	N	12.0			9.3	-11.1	N	12.0	-9.4	SW	11.0	-1.1	E	10.0	6.1	SW	10.C
7	-5.6	W	12.0	0.0	NE	5.0	-7.2	N	14.0	-7.2	SW	5.0	5.6	W	11.0	9.4	SE	4.0
8	-5.6	S	7.0	3.3	S	13.0	-8.3	S	7.0	-7.2	NE	7.P	C.6	NV	12.0	11.7	SE	13.0
9	-3.9	SW	21.0	-7.8	W	17.0	-10.6	S	9.6	-6.1	S	6.C	1.1	NY	4.0	12.2	SW	15.0
10	-12.2	NW	8.0		W	19.5	-11.1	S	13.0	-.6	SW	5.0	10.0	E	8.0	7.8	W	12.0
11	-13.3	S	5.0	-8.3	SW	22.0	-8.3	S	17.0	-1.1	SW	7.0	11.1	SW	12.0	13.3	SW	7.0
12	-6.7	S	12.0		SW	13.0	-6.7	SW	17.0	1.7	MY	3.0	8.9	W	14.0	17.8	SE	7.0
13	3.3	S	11.0	-5.0		8.0	-16.7	NE	4.0	2.2	SE	4.0	8.9	SW	17.0	16.7	SE	9.0
14	4.4	S	2.0	-8.9	N	16.0	-8.9	N	7.0	5.0	S	16.0	3.9	W	13.0	13.3	E	9.0
15	2.2	W	6.0	-12.2	SW	12.0	-10.0	S	7.P	.6	W	11.0	2.2	W	11.0	13.3	NE	14.0
16	2.2	NE	4.0		SW	14.0	-6.7	S	8.0	-2.2	N	5.0	3.9	SW	6.C	13.3	NE	10.0
17	1.1	NE	16.0	-8.3	NE	9.U	-7.8	S	12.0	-3.9	N	1.0	E.3	SW	4.0	14.4	N	4.0
18	2.2	E	7.0		N	8.C	-10.6	SW	11.0	-5.3	SW	13.0	7.2	E	13.0	12.8	SW	7.0
20	1.1	E	10.0			2.i	-11.1	SW	9.0	-4.1	W	16.0	16.6	SF	13.0	15.6	SW	11.0
21	2.8	S	14.0	-7.8	NE	16.0	-10.0	S	3.0	0.0	SE	3.0	3.9	N	7.0	18.3	SW	13.0
	1.1	SW	6.0	-8.9	W	4.0	-1C.6	SW	9.3	7.2	SW	14.0	1.7	NW	10.0	11.7	W	7.0
22	-1.7	SW	18.0	-7.2	S	14.0	-11.7	W	10.0	3.3	W	12.P	3.3	W	7.0	14.4	SW	7.0
23	1.1	S	16.0		S	13.0	-8.9	SW	15.0	1.7	SW	10.0	6.1	N	1.0	17.8	S	4.0
24	3.9	S	13.0		S	12."	-4. .	SW	14.0	-3.9	N	7.6	8.3	MY	2.0	20.0	E	7.0
25	-2.2	SW	13.0		E	4.0	-3.9	W	2.i	-2.8	E	13.0	7.8	E	8.0	18.3	SW	9.0
26	-11.1	W	14.0	-3.9	S	19.0	-6.7	SW	8.[illegible]	2.2 .	E	11.0	8.9	NE	12.0	20.0	SW	7.0
27	-9.4	SW	10.0	-7.8	SW	25.0	-10.0	SW	9.'		W	3.0	e.3	N	7.0	23.3	SE	4.0
28	-10.6	S	13.0	-7.8	SW	12.0	-6.1	S	3.0	2.8	SW	15.0	10.[illegible]	W	5.0f	23.3	SE	2.6
29	-6.1	SW	10.0		W	8.1				1.1	W	10.0	8.3	W	8.0 .	24.4	S	3.0
30	-1.7	S	7.0	-8.3	SW	10.[illegible]				.6	SW	11.0	1.1	NW		23.3	S	4.0
31	-3.9	NE	9.0		SW	15.[illegible]				6.1	S	7.0				21.1	SW	13.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7j.--*Daily air temperature and wind speed and direction, Erie, Pa.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	R.9	SW	18.0	-2.8	SW	1.0	-10.6	SW	8.0	-10.0	W	6.P	8.3	SW	14.C	1.7	NY	11.0
2	2.8	SW	17.0	-8.3	W	15.0	-9.4	SW	5.0	-11.1	SW	3.0	0.0	N	8.0	5.6	W	9.0
3	.6	W	9.0	-8.9	W	12.0	-11.7	W	2.:	-6.7	N	4.0	5.9	SE	8.0	6.1	W	4.0
4	-1.7	SW	9.0	-6.7	S	15.0	-17.8	S	1.0	-11.7	W	15.L	11.1	S	9.0		E	10.0
5	-1.7	E	13.0	1.1	S	5.0	-11.7	N	3.C	-10.6	W	9.C	3.3	W	8.0	6.9	SE	4.0
6	-2.8	NW	16.0	.6	NE	5.0	-13.9	N	8.C	-10.6	W	3.6	4.4	SE	11.0	7.8	W	7.0
7	-6.1	W	18.0	2.2	SE	9.E	-12.8	W	7.0	-11.7	NE	3.0	7.2	W	10.0	10.6	N	4.0
8	-7.8	S	19.0	2.8	S	10.0	-10.6	SW	3.0	-6.1	NE	9.0	.6	W	7.C	13.3	S	19.0
9	-7.2	SW	21.0	-7.6	W	23.3	-11.7	SW	4.0	-6.1	SW	2.3	-1.1	NE	6.0	14.4	SW	13.0
10	-12.2	SW	15.0	-10.0	W	25.0	-11.7	SW	7.0	-3.9	SW	3.0	13.3	S	4.0	7.8	W	11.0
11	-12.2	SW	9.0	-10.0	SW	15.5	-8.9	SW	12.C	1.1	S	7.0	12.2	SW	12.0	13.3	S	10.0
12	-5.6	S	17.0	-9.4	SW	9.0	-6.1	W	11.0	.6	N	2.C	11.7	SW	12.0	17.2	S	12.2
13	3.9	S	13.0	-5.6	NE	8.0	-5.0	E	6.C	0.0	S	5.0	6.9	W	14.0	11.7	SE	4.0
14	5.0	SW	8.0	-7.8	N	16.'	-10.0	NE	7.3	5.1	S	14.0	3.9	W	12.0	11.7	SE	4.0
15	1.7	W	I.0	-11.1	W	10.0	-10.0	S	4.0	0.0	W	10.0	2.8	W	9.0	11.7	NE	9.0
16	5.0	SE	7.0	-10.6	SW	9.0	-5.E	SW	5.0	0.0	NE	3.0	1.7	W	4.0	11.1	NE	11.0
17	2.2	E	5.0	-9.4	NE	12.C	-9.4	W	7.1	-3.3	W	9.0	1.7	W	2.0	10.6	NY	3.0
18	5.6	SE	13.0	-7.2	N	6.0	-11.7	SW	4.L	-2.8	SW	11.0	7.9	SE	14.0	13.3	W	3.0
19	3.5	S	10.0	-7.6	NE	9.0	-11.7	SW	3.0	1.7	W	16.0	11.1	SE	15.0	16.7	NW	5.0
20			14.0	-7.2	NE	19.0	-10.6	S	2.0	1.7	S	8.0	3.3	W	6.0	22.0	SW	7.0
21	-1.7 2.8	SE SW	11.0	-10.0	W	4.0	-12.2	SW	4.0	6.7	SW	13.0	1.7	W	9.6	11.1	NY	6.0
22	-3.9	SW	17.0	-9.4	SW	7.C	-12.8	W	9.0	4.4	SW	9.0	2.2	W	4.0	11.7	NE	3.0
25	1.7	S	18.0	-9.4	S	10.P	-7.8	SW	8.0	1.1	W	4.0	3.3	NE	2.0	15.0	SW	2.0
24	3.3	S	12.0	-1.7	S	13.0	-3.9	SW	11.0	-4.4	NE	13.0	5.6	W	1.0	16.7	N	2.0
25	-2.2	SW	18.0	1.7	E	3.0	-2.2	SW	10.0	-2.2	E	11.0	5.0	NE	9.0	17.2	SW	4.0
26	-13.3	SW	16.0	-3.3	S	25.0	-6.1	W	7.U	2.8	SE	6.C	7.8	NE	11.0	17.2	W	1.0
27	-10.0	SW	13.0	-10.0	SW	19.0	-7.2	W	4.0	.6	W	5.0	6.7	N	2.0	20.0	NE	1.C
28	-11.1	SW	13.0	-9.9	SW	14.0	-6.1	SE	1.0	2.8	SW	11.0	6.1	SW	6.0	22.2	SE	4.0
29	-5.6	SW	13.0	-9.4	W	5.0				.6	W	8.0	9.4	W	6.0	22.8	S	3.0
30	0.0	S	9.0	-9.4	W	10.5				-.6	W	4.0	3.9	N	9.0	23.3	S	5.0
31	-1.7	NE	8.0	-11.7	SW	9.0				5.6	S	9.0				19.4	SW	8.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD 5 WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7k.--*Daily air temperature and wind speed and direction, Cleveland, Ohio*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	2.9	SW	16.0	-1.1	W	5.0	-11.7	SW	7.0	-7.8	N	8.0	12.2	W	15.0	4.4	N	9.0
2	3.9	SW	16.0	-8.3	W	14.0	-8.3	W	4.0	-10.6	S	2.0	2.2	NE	11.0	7.2	N	7.0
3	1.1	W	5.0	-10.0	SW	10.0	-10.6	N	1.0	-5.6	N	7.0	11.1	S	6.0	7.2	N	3.0
4	-1.7	SW	5.0	-5.6	S	12.0	-13.3	N	2.0	-8.3	NW	9.0	15.0	SW	9.0	10.0	E	14.0
5	1.7	NE	11.0	2.2	S	6.G	-9.4	N	4.0	-7.8	SW	9.G	7.2	N	5.0	9.4	SW	2.2
6	-7.8	W	11.0	1.7	E	3.0	-12.8	N	10.0	-5.0	W	1.0	10.0	SE	11.0	8.3	W	5.0
7	-11.7	SW	13.0	4.4	SE	4.0	-10.6	NY	11.0	-6.7	NE	7.0	12.8	W	10.0	10.0	E	5.0
		S	12.2	1.7	SW	5.0	-10.6	W	1.0	-3.9	N	9.0	2.2	N	7.0	16.1	S	12.0
9	-6.7	SW	19.0	-10.0	W	17.0	-10.0	W	2.0	-3.9	NW	1.0	3.3	NE	7.0	15.6	SW	15.0
10	-14.4	SW	12.0	-13.3	W	16.0	-10.0	SW	6.0	-2.2	SW	2.0	16.7	S	9.0	12.8	W	7.0
11	-15.0	SW	7.0	-11.1	SW	13.R	-8.9	SW	10.0	1.7	S	7.0	15.0	W	12.0	16.1	S	11.0
12	-3.9	S	14.0	-4.4	S	7.0	-5.6	W	5.0	0.0	N	6.0	12.2	SW	13.0	17.2	S	12.0
13	5.0	S	12.0	-5.9	NE	8.0	-5.0	NE	8.0	1.1	S	8.0	8.3	W	12.0	12.2	S	4.0
14	5.0	SW	3.0	-6.1	NE	15.0	-9.4	N	8.0	5."	S	13.0	6.1	NY	9.0	12.2	S	4.0
15	2.2	S	6.0	-10.6	W	10.P	-10.6	S	7.0	2.2	W	7.0	4.4	N	6.0	13.9	N	6.0
16	7.2	SE	6.0	-11.1	S	8.0	-3.9	SW	8.0	1.1	NY	4.0	6.3	NE	5.0	15.0	NE	9.0
17	7.8	SE	7.0	-6.1	NE	12.6	-8.9	W	8.0	-1.1	W	9.0	8.9	NE	5.0	15.0	NY	5.0
18	10.6	S	7.0	-6.7	N	7.0	-10.0	SW	4.0	-3.3	SW	13.0		SE	15.P	17.8	NY	2.2
19	5.0	SE	5.0	-7.8	NE	7.0	-10.0	SW	4.C	5.0	W	12.0	15.C	S	7.0	20.0	W	3.0
20	3.9	S	11.0	-6.1	NE	15.0	-10.0	NE	1.0	5.C	S	8.0	6.7	NY	6.0	21.7	SW	8.0
21	-2.2	SW	13.0	-8.3	W	7.3	-10.0	W	4.0	8.9	SW	12.0	2.9	NY	7.0	12.8	N	10.0
22	-5.3	SW	17.0	-11.1	SW	9.P	-10.6	NY	6.0	8.3	SW	11.0	3.9	N	3.0	11.1	NE	4.0
23	2.2	S	15.0	-10.0	S	16.0	-8.3	SW	8.0	3.9	N	4.0	6.1	S	6."	16.1	SE	3.0
24	3.9	S	11.0	-2.8	S	11.0	-2.2	SW	11.0	-1.7	NE	14.0	9.9	N	4.0	18.3	N	5.0
25	-2.8	W	16.0	2.8	E	3.0	.6	W	12.0	1.1	E	12.C	8.9	NE	11.0	18.3	W	2.0
26	-12.2	SW	14.0	-3.9	SW	24.0	-3.3	NY	7.0	6.7	E	4.0	10."	NE	12.0	20.0	E	2.0
27	-10.6	W	9.0	-10.6	W	20.0	-5.0	SW	6.0	2.2	NW	7.0	8.3	N	8.0	21.1	N	2.0
28	-9.4	SW	13.0	-10.0	SW	14.0	-4.4	NW	1.0	7.2	SW	11.0	8.9	NW	5.0	23.9	SE	4.0
29	-3.9	S	9.0	-8.9	W	8.0				2.8	NW	7.C	13.3	NY	5.0	24.4	SE	3.0
30	0.0	SW	6.0	-11.1	SW	8.0				2.2	NY	1.0	3.9	N	10.0	23.9	S	5.0
31	0.0	NE	7.0	-11.1	SW	8.3				12.8	S	9.6				21.1	SW	6.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
[illegible] DATA AVAILABLE

Table 71.--*Daily air temperature and wind speed and direction, Toledo, Ohio*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	6.7	SW	12.0	-2.8	NW	3.0	-13.3	SW	5.0	-13.0	N	8.?	IC.6	W	15.0	5."	N	8.0
2			13.0	-11.7	W	14.0	-12.2	W	5.0	-13.3	E	2.0	C.0	NE	11.0	7.8	NY	6.0
3	-3.9 1.7	SW W	4.0	-11.7	SW	9.0	-11.7	E	1.3	-7.8	N	6.0	8.9	E	7.0	7.8	N	5.0
4	-5.0	S	2.0	-8.3	SW	8.0	-15.0	E	3.0	-11.7	NW	3.0	10.6	W	6.0	8.3	E	16.0
5	-1.7	NE	12.0	1.1	S	4.0	-10.0	N	4.0	-11.7	SW	8.0	6.7	NW	1.0	7.2	NE	3.0
6	-9.4	W	13.0	0.0	E	4.0	-15.6	N	10.0	-6.7	NW	1.0	9.4	E	5.0	8.3	NY	6.0
7	-13.3	W	12.0	1.1	E	4.0	-14.4	NW	9.0	-10.0	E	7.0	12.2	W	11.0	7.8	E	8.0
8	-10.6	SE	8.0	-3.5	NY	9.0	-13.3	NW	4.0	-6.7	NE	11.0	6.1	E	6.0	14.4	S	7.0
9	-10.0	W	17.0	-12.6	W	17.0	-11.7	N	5.0	-8.3	SW	1.0	1.7	E	10.0	13.3	W	13.0
10	-17.2	SW	9.0	-13.3	W	16.0	-13.9	W	6.0	-5.0	W	3.0	13.9	S	5.0	13.9	W	9.0
11	-18.3	S	4.0	-12.8	W	10.0	-8.9	W	9.0	0.0	S	4.0	10.0	SW W	13.0	15.0	S	9.0
12	-5.0	S	9.0	-11.1	SW	3.0	-7.2	W	8.0	.6	N	4.0		"	10.0	18.3	S	11.0
13	3.3	S	7.0	-6.7	NE	7.0	-8.9	NE	7.0	-2.2	SE	7.0	6.1	W	12.0	15.0	S	9.0
			5.0	-9.4	N	10.0	-12.8	N	6.5	3.3	SW	8.0	6.1	W	10.6	11.7	E	7.0
14 15	2.2 .6	NY S	5.0	-11.7	W	9.0	-12.2	S	6.0	2.2	W	8.0	4.4	NY	8.0	11.7	NE	7.0
16	3.3	E	5.0	-11.7	SW	5.0	-8.3	SW	7.0	-.6	W	9.0	3.3	E	4.0	13.3	NE	9.0
17	3.9	E	7.0	-8.9	NE	13.0	-12.8	SW	7.0	-2.8	W	11.0	3.9	E	7.0	16.7	NY	7.0
18	3.9	SW	1.0	-8.9	N	4.0	-13.3	W	5.i	-2.8	SW	9.0	6.1	E	12.0	20.6	W	8.0
19	3.9	SE	3.0	-6.7	NE	10.0	-12.8	W	2.0	2.8	W	12.0	10.C	NE	5.0	21.1	W	6.0
		S	9.0	-6.7	NE	12.0	-13.3	S	1.0	0.0	SE	5.0	6.7	NY	10.0	19.4	NY	6.0
21	-5.0	SW	11.0	-10.0	W	8.0	-14.4	NW	5.0	6.1	W	10.0	3.3	N	8.F	11.7	N	4.0
22	-3.3	SW	11.0	-13.3	SW	8.0	-12.2	W	6.0	6.1	SW	9.0	4.4	E	5.0	11.7	E	5.0
23	1.7	SW	11.0	-12.2	S	5.0	-13.3	W	4.0	3.3	N	6.0	5.6	SE	6.0	12.8	E	3.0
24	.6	S	5.0	-6.7	S	5.0	-3.9	SW	10.0	-1.7	NE	15.0	9.4	E	6.0	18.9	NE	1.0
25	-7.2	W	16.0	-.6	NE	8.0	-1.7	W	11.0	-1.7	E	12.0	8.3	NE	11.0	19.4	S	1.0
			11.0	-6.1	W	15.0	-6.7	NY	8.0	.6	NE	8.0	11.7	NE	11.0	21.1	SE	2.2
26	-13.3	SW W	11.0	-11.1	W	12.0	-8.9	SW	6.0	1.7	NW	7.0	10.6	N	7.0	21.1	SE	2.0
28	-10.0	SW	9.0	-10.0	W	12.0	-8.3	W	1.0	5.6	SW	9.0	5.0	N	5.0	22.2	SE	2.0
29	-5.6	SW	5.0	-9.4	W	12.0				1.7	NW	8.0	12.8	W	5.0	23.3	S	5.0
30	-1.1	W	4.0	-12.2	W	9.0				0.0	SW	3.0	6.7	NE	6.0	24.4	SW	7.0
31	-1.7	E	7.0	-11.1	W	10.0				14.4	S	7.0				22.2	W	8.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table Jm.--Daily air temperature and wind speed and direction, Detroit, Mich.

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	7.8	SW	15.0	-3.3	N	8.0	-8.3	SW	16.0	-6.7	NW	10.0	8.9	W	15.0	4.4	N	7.0
2	3.3	SW	21.9	-9.4	SW	14.0	-6.7	W	5.0	-8.3	S	2.0	1.1	NE	11.0	8.3	NW	8.0
3	.6	W	8.0	-8.3	SW	10.0	-10.0	N	5.0	-6.1	N	6.C	3.3	E	9.0	8.9	NE	4.0
4	-1.1	W	6.0	-4.4	SW	12.0	-12.8	E	5.00	-8.9	NW	11.0	10.0	W	3.0	8.9	E	13.0
5	-1.1	NE	14.0	0.0	NE	.6	-10.0	N	12.0.	-7.2	SW	10.0	8.3	W	4.C	7.2	NE	7.0
6	-2.8	NY	11.0	-1.1	E	5.0	-13.3	N		-5.6	SW	1.0	5.6	E	9.0	10.0	N	4.0
7	-6.1	W	10.0	1.1	E	7.0	-10.0	NY	14.0	-6.7	NE	5.0	12.8	W	11.0	10.6	E	7.0
8	-5.6	SE	8.0	-1.7	NW	6.0	-7.8	N	5.0	-5.6	N	8.0	3.3	N	9.0	13.9	SE	9.0
9	-6.1	SW	17.0	-8.9	W	17.0	-6.7	N	6.0	-3.3	SW	...	1.1	E	9.0	13.9	SW	13.0
10	-12.2	SW	7.0	-8.9	W	17.0	-6.1	W	8.0	.6	NW	2.P	11.7	SE	7.0	13.9	W	7.0
11	-11.1	SW	4.0	-13.3	SW	15.0	-5.0	W	9.0	2.2	S	5.0	12.2	W	13.0	15.6	S	11.0
12	-3.3	S	13.0	-7.8	SW	5.0	-3.9	W	7.0	2.2	N	7.L	12.2	SW	12.0	16.7	S	12.0
13	3.3	S	9.0	-4.4	NE	9.0	-5.6	NE	6.0	-.6	SE	6.0	10.6	W	13.0	14.4	SE	10.0
14	3.9	NY	4.0	-7.8	N	14.0	-8.9	N	4.0	3.9	W	18.0	7.8	W	8.0	12.2	E	7.0
15	2.2	S	7.0	-10.6	W	8.0	-5.6	S	9.0	2.2	W	7.0	5.6	NW	8.0	12.8	N	10.0
16	4.4	E	7.0	-8.3	SW	8.0	-5.6	SW	11.0	1.1	W	8.00	5.0	N	6.0	14.1	NE	10.0
17	3.3	E	11.0	-8.9	NE	11.0	-8.3	SW	8.0	-2.8	NW	12.00	4.4	NE	12.0 .	17.2	N	7.0
18	4.4	SE	5.0	-5.6	N	9.0	-7.2	W	6.0	-1.7	SW	[illegible]	6.1	E		18.3	SE	2.0
19	...	SE	5.0	-3.9	NE	9.0	-8.3	NY	2.00	3.9	W	12.0	16.6	E	5.0	22.2	W	7.0
20	1.1	SE	7.0	-6.7	NE	14.0	-2.3	SE	6.0.	2.8	SE	7.6	6.77	N	11.0	21.1	SW	7.0
21	-3.9	SW	15.0	-5.6	W	7.0	-7.8	NY		6.1	W	11.0	5.P	N	10.0	12.8	N	9.0
22	-1.7	SW	13.0	-8.9	SW	10.0	-8.3	W	7.0	5.0	SW	8.0	5.0	E	1.0	13.3	E	4.0
23	-3.3	SW	16.0	-7.8	S	10.0	-7.2	SW	8.0	5.0	NW	8.L	6.1	E	7.1	16.7	SE	3.0
24	2.2	S	8.0	-2.8	S	10.0	-2.8	SW	9.0	-2.8	NE	13.0	7.8	E	6.0	20.0	NE	4.0
25	-5.0	W	16.0	0.0	N	8.0	-1.7	W	11.0	-1.7	NE	12.0	6.9	NE	10.0	20.6	S	1.0
26	-11.7	SW	14.0	-2.8	W	10.0	-4.4	NY	8.0	1.1	NE	9.0	11.1	N	10.0	23.9	S	3.0
27	-9.4	W	10.0	-6.7	W	13.0	-4.4	W	6.0	1.7	NW	8.0	1[illegible].6	N	9.	23.9	SE	5.0
28	-8.9	SW	13.0	-4.4	W	9.0	-3.9	SW	3.0	5.6	SW	11.0	12.8	NW	7.0	13.9	S	5.0
29	-3.3	SW	8.0	-7.2	W	9.0				2.8	NW	8.0	12.8	N	4.C	24.4	SE	7.0
30	0.0	W	3.0	-8.3	W	8.0				2.2	SW	5.C	5.0	NE	7.0	25.0	S	5.0
31	-.6	NE	5.0	-8.9	W	11.0				11.1	SE	8.0				22.8	W	7.0

TC = MEAN DAILY AIR TEMPERATURE IN DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

Table 7n.--*Daily air temperature and wind speed and direction, Rochester, N.Y.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	11.1	SW	10.0	-2.8	E	7.0	-7.8	W	14.0	-6.7	NY	5.0	10.0	W	4.0	1.7	W	13.0
2	11.1	SW	14.0	-5.6	W	15.0	-6.7	SW	6.0	-11.1	W	9.0	.6	NY	12.0	5.0	NY	9.0
3	.6	SW	7.0	-7.8	W	12.0	-11.7	W	3.0	-8.3	E	5.0	1.1	E	8.0	7.8	W	8.0
4	-1.7	W	9.0	-3.3	SW	10.0	-13.3	S	2.C	-7.8	W	13.6	15.3	S	6.0	5.6	NE	9.0
5	-1.7	NE	12.0	1.1	W	3.0	-16.7	E	5."	-11.1	W	12.0	5.0	W	14.C	8.3	E	9.6
6	-3.9	NY	10.0	-1.1	NE	8.0	-10.0	N	8.C	-8.5	W	-99.3	3.9	E	6.0	10.0	W	2.0
7	-5.6	W	15.0	1.1	E	6.3	-4.4	N	17.0	-8.3	W	7.0	6.7	W	12.0	11.7	S	3.0
8	-8.9	SE	3.0	6.1	S	10.0	-9.4	N	5.0	-7.8	SE	2.0	.6	W	14.C	12.8	SE	12.2
9	-3.3	SW	16.0	-5.0	W	22.6	-12.2	W	7.0	-6.1	SW	9.0	1.1	NW	6.0			13.0
10	-12.8	W	11.0	-11.1	W	19."	-11.7	W	7.C	-3.3	SW	1.0	6.7	E	7.0 .	11.1	SW W	14.2
11	-15.0	SW	4."	-7.2	W	19.0	-5.6	W	15.0	-1.7	SW	3.0	13.9	SW	9.0	13.9	W	6.0
12	-8.3	S	6.0	-5.0	SW	Il.0	-3.9	W	17.0	2.8	W	3.0	11.1	W	10.0	18.3	S	4.0
13	2.2	SE	5.0	-3.9	E	9.0	-4.4	NE	4.C	.6	SE	4.0	10.0	W	15.0	17.8	SE	8.0
		S	3.0	-6.7	N	16.0	-11.1	N	6.0	6.7	S	14.0	5.0	W	15.0	15.0	E	13.0
14 15	-15.6 2.8	W	7.0	-10.6	W	15."	-11.1	SW	4.0	1.7	W	11.0	3.3	W	12.0	14.4	NE	11.0
16	3.9	E	4.0	-6.7	W	12.0	-6.7	S	2.0	-1.1	N	4.C	5.6 0	NY	5.0	14.4	NE	8.0
17	1.1	E	11.0	-7.8	E	6.0	-8.3	W	8.0	-3.9	N	2.0	7.2 .	W	4.0	16.1	E	8.0
18	.6	E	10.0	-4.4	N	7.0	-11.1	SW	9.0	-2.2	SW	11.0		SE	7.0	16.1	W	5.0
19	1.1	E	8.0	-3.9	NE	1.0	-11.7	W	7.C	2.8	W	15.0	9.4	E	11.0	18.3	SW	8.0
20	1.7	SE	12.0	-5.6	NE	14.C	-9.4	SW	4.F	.6	SE	4.0	5.0	N	5.0		W	10.0
21	1.1	W	3.0	-7.8	W	7.0	-9.4	W	5.C	8.9	SW	12.0	3.3	W	10.0 .	21.3	W	11.0
22	-1.7	SE	11.0	-8.9	SW	9.1	-11.7	W	13.0	4.e	W	11.C	3.9	NY	7.0	15.0	W	6.0
23	1.1	S	12.0	-7.2	SW	9.0	-7.2	W	14.0	4.4	W	9.C	6.1	W	4.0	19.4	S	3.0
24	5.9	S	7.0	-2.2	S	9.0	-3.9	W	13.0	-1.1	NW	7.0	83	NW	5.0	21.1	E	4.0
25	-.6	W	14.0	3.9	E	4.0	-4.1	NW	1.0	-1.7	E	8.0	8.3	NE	6.0	20.6	W	6.0
26	-9.4	SW	12.0	-2.2	S	12.0	-6.7	W	11.0	1.7	E	11.0	9.4	NE	6.0	21.7	W	3.0
27	-8.3	SW	11.0	-5.6	SW	21.0	-6.7	W	ll.C	3.9	W	3.0	10.0	N	5.0	24.4	NE	1.0
28	-8.9	S	9.0	-6.7	W	IQ.0	-5.0	SW	3.0	4.4	W	12.0	10.0	NY	6.0	23.9	SE	2.0
29	-5.0	SW	8.0	-10.6	W	11.0				3	W	12.0	11.1	W	9.0	24.4	S	1.0
30	-.6	SW	5.0	-7.2	W	10.0				2.8	W	9.0	2.8	NY	11.0	25.6	E	2.0
31	-1.7	NE	8.0	-8.3	W	13.0				6.7	W	1.0				23.9	W	11.0

TC = WEAN D&IL" AIR TEMPERATURE IN DEGREES CENTIGRADE
WD 3 WIND DIRECTION
WS = WIND SPEED IN KNOTS
[illegible] DATA AVAILABLE

Table 7o.--*Daily air temperature and wind speed and direction, Syracuse, N.Y.*

	DECEMBER			JANUARY			FEBRUARY			MARCH			APRIL			MAY		
	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS	TC	WD	WS
1	8.3	E	4.0	-6.7	NE	7.2	-7.2	SW	15.2	-6.1	N	2.0	10.0	W	6.2	.6	W	13.0
2	4.4	SW	12.0		W	16.0	-7.8	SW	2.0	-10.0	W	9.0	-1.1	NY	15.0	4.4	W	10.0
3	2.2	SW	8.0	-5.0	SW	17.0	-10.6	N	5.0	-8.3	E	7.0	-.6	E	7.0	6.7	W	9.0
.	-1.1	SW	11.0	-5.2	S	8.0	-14.4	NE	1.0	-8.3	W	13.0	8.3	SE	a.0	5.6	NE	4.0
5	-3.3	NE	11.0	1.1	W	4.0	-18.9	E	6.0	-9.4	W	9.0	5.2	W	13.0	7.8	E	10.0
6	-2.8	W	7.0	-2.2	NW	4.0	-9.4	N	8.0	-6.1	W	14.0	3.9	SE	2.2	7.8	E	4.0
7	-6.7	W	13.0	0.0	E	8.0	-5.6	NY	11.0	-9.4	W	6.0	6.1	W	7.0	11.7	NY	3.0
		E	3.0	6.1	SE	15.0	-9.4	WY	8.0	-7.0	E	2.0	.6	W	14.0	12.8	SE	11.0
9	-2.8	SW	16.0	-2.2	W	20.0	-11.1	SW	4.0	-6.7	HE	4.0	0.0	NW	9.0	17.2	SW	8.0
10	-12.2	W	13.0	-11.7	W	21.0	-0.9	W	5.0	-3.9	W	4.0	3.3	E	7.0	10.6	W	11.0
		W	2.0	-8.9	SW	18.0	-6.7	SW	11.0	0.0	SW	4.0	12.2	N	1.0	12.2	SW	2.0
12	-16.7	E	7.0	-6.1	SW	9.0	-3.3	SW	15.0	2.8	W	5.0	10.0	W	7.0	16.1	E	6.0
13	-2.8	E	7.0	-4.4	E	8.0	-5.6	W	5.0	1.7	E	3.0	3.3	W	12.2	17.8	E	12.0
1.	2.8	NE	6.0	-7.2	NY	10.0	-9.4	W	6.0	7.2	S	10.0	3.3	W			E	15.0
15	1.7	W	7.0	-11.1	SW	9.0	-10.0	W	3.0	1.1	W	12.2	2.2	W	12.0	16.3	E	16.0
16	2.2	E	4.0	-6.7	SW	13.0	-7.8	NE	4.0	-2.2	W	6.0	5.6	NY	8.0	15.0	NE	7.0
17	-.6	NE	7.0	-6.7	E	6.0	-2.2	NY	3.0	-3.9	W	8.0		W	3.0	13.3	E	7.0
18	-2.2	E	12.0	-5.6	N	3.0	-1.2	W	4.0	-3.3	SW	10.0	5.6 7.2	E	B.O	13.9	NY	3.0
19	.6	E	9.0	-5.6	N	2.0	-11.1	W	8.0	1.7	W	11.0	7.8	E	11.0	15.6	W	3.0
20	1.1	E	12.0	-8.9	N	6.0	-8.3	NE	2.0	1.1	NE	1.0	5.0	W	2.2	20.0	SW	5.0
21	.6	E	3.0	-9.4	NY	8.0	-7.8	W	3.0	8.9	S	8.0	2.2	W	12.0	12.8	W	10.0
22	-1.1	SW	11.0	-8.3	SW	8.0	-9.4	W	12.2	2.8	W	7.2	2.8	W	8.0	13.9	W	5.0
25	.6	S	8.0	-9.4	SW	7.2	-5.0	W	13.0	5.0	W	7.0	6.1	W	5.0	17.8	SE	4.0
2.	2.2	SE	6.0	-8.3	SE	4.0	-2.8	SW	12.2	-2.2	NY	11.0	-2.2	NW	5.0	18.9	E	6.0
25	.6	W	11.0	2.2	E	8.0	-3.9	N	1.0	-2.8	NE	5.0	.6	N	5.0	18.3	W	4.0
26	-8.3	SW	16.0	0.0	S	11.0	-5.2	W	8.0	0.0	E	11.0	1.1	NE	5.0	21.1	NY	1.0
27	-8.3	6	8.0	-6.7	SE	19.0	-6.1	W	9.0	2.8	W	1.0	1.7	NY	6.2	21.7	E	4.0
28	-0.9	S	6.0	-7.8	W	12.0	-6.1	SW	5.0	3.9	SW	11.0	.6	W	8.0	22.8	N	1.0
29	-5.6	SW	9.0	-11.7	W	10.0				2.8	W			W	8.0	22.8	SE	3.0
30	0.0	S	4.0	-8.9	W	8.0				2.2	W	19.0	-2.8	W	12.0	25.9	E	3.0
31	-3.9	WY	6.0	-8.3	W	8.0				5.6	W	3.0				22.8	W	4.0

TC = MEAN DAILY AIR TEMPERATURE II DEGREES CENTIGRADE
WD = WIND DIRECTION
WS = WIND SPEED IN KNOTS
-99.0 = NO DATA AVAILABLE

GOVERNMENT ... ICE: 1980-O-677-402/501