LAKE ST. CLAIR

PHYSICAL AND HYDRAULIC CHARACTERISTICS[1]

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LAKE ST. CLAIR
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1. INTRODUCTION

Lake St. Clair is a shallow basin that serves as a connecting water body between the St. Clair and Detroit Rivers. It forms the midsection of the Lake Huron outflow system, which also includes the St. Clair and Detroit Rivers.

2. PHYSICAL CHARACTERISTICS

The lake is about 42 km (26 mi) long and 39 km (24 mi) wide, with a surface area of 1,100 km^2 (430 mi^2), as shown in figure 1. The maximum natural depth of the lake is 6.4 m (21 ft) and the average depth is about 3.4 m (11 ft). A dredged 8.2-m (27-ft) navigation channel bisects the lake, running in a northeast-southwest direction between the St. Clair Cutoff in the St. Clair River delta and the head of the Detroit River. In general, the water moves in the same direction (northeast to southwest) from the St. Clair River to the Detroit River. The lake drains about 12,400 km^2 (4,800 mi^2) of land drainage area with three major tributaries--the Clinton River in Michigan and the Sydenham and Thames Rivers in Ontario. However, the St. Clair River provides by far most of the water supplied to the lake; the average difference between the flows in the St. Clair and Detroit Rivers is only about 3 percent. Two distinct areas of Lake St. Clair are the main body of the lake, laying south and west of the St. Clair River delta, and the northern Anchor Bay area, which is very shallow. The maximum depth in Anchor Bay seldom exceeds 3.0 m (10 ft) and most of it is only about a meter (a few feet) deep. Because it is so shallow, the lake has no commercial harbors.

3. HYDRAULIC CHARACTERISTICS

3.1 Water Levels

Elevation of Lake St. Clair has an average water level of about 174.74 m (573.30 ft), which varies seasonally from a winter low of about 174.47 m (572.40 ft) to a summer high of about 174.92 m (573.90 ft) per month, with somewhat larger extremes (lower and higher) for shorter periods. Periodic long-term low and high mean annual water levels produced by below-normal and above-normal water supplies vary from about 174.09 m to 175.46 m (571.15 ft to 575.65 ft), respectively. The range of seasonal variation in monthly levels is with 0.30 to 0.60 m (1.00 to 2.00 ft).

3.2 Lake Circulation

Lake St. Clair is relatively small and shallow, and responds quickly to wind and temperature changes. Wind forces, along with the flow-through

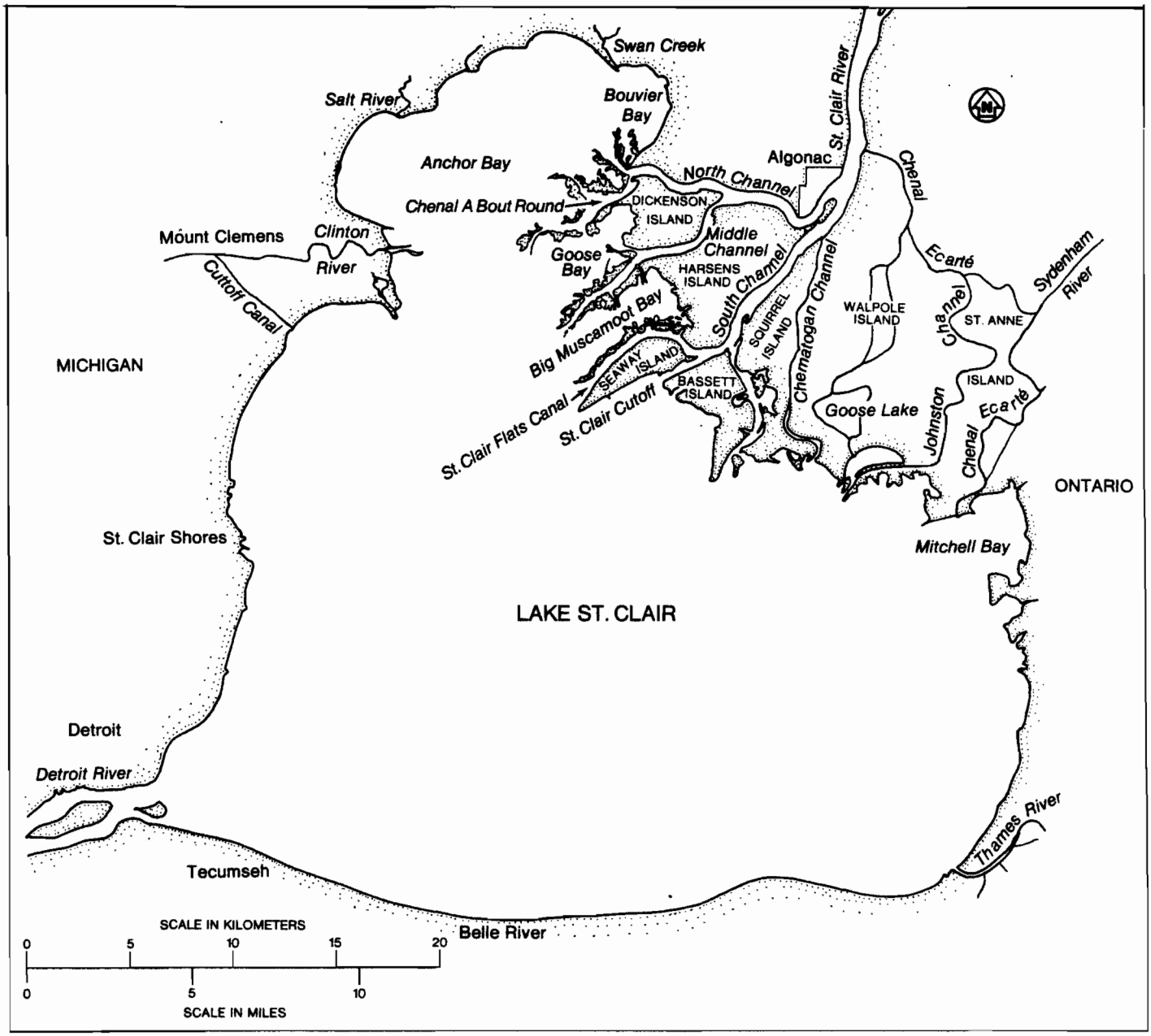

FIGURE 1.--*Lake St. Clair.*

pattern from the St. Clair River, determine the lake's circulation pattern. Lake circulation in relation to the prevailing wind conditions for the eight cardinal wind directions is shown in figures 2 and 3. Figure 2 shows the movement of surface currents from a physical model developed by Ayers (1964). These physical model results are based on a 1:10,000 horizontal and 1:16 vertical scale model of the lake, with wind input provided by an electric fan. Arrows on the current symbols denote direction only, without implying relative velocities. Designation of current symbols is shown in the figure. The origin of water in the surface circulation is identified for primary sources, namely, the St. Clair River (excluding Chenal Ecarte), separately for Chenal Ecarte (includes the Sydenham River), and the Clinton River. The fourth source, designated by the term "water left by previous wind," indicates currents that cannot be attributed to prevailing wind forces. Occasional subsurface escapement of water is indicated for Anchor Bay (west and southwest winds). These laboratory results are supported only qualitatively by actual field observations in Ayers' report, but field observations on Lake St. Clair are insufficient to verify fully the results from either the physical model or the numerical model shown in figure 3 for the same wind conditions. Figure 3 is based on the Great Lakes Environmental Research Laboratory (GLERL) numerical circulation modeling system developed for the Great Lakes, including Lake St. Clair, by Schwab *et al.* (1981). The model was verified against extensive current meter measurements in Lake Michigan (Schwab, 1983) and is used in the operational "Pathfinder" trajectory prediction system developed at GLERL (Schwab *et al.*, 1984). The numerical circulation model is a rigid-lid (nondivergent), two-dimensional model for well-mixed lakes. The model is based on the vertically integrated shallow water equations and includes Coriolis effects, but neglects nonlinear acceleration terms and horizontal diffusion of momentum. The calculated currents are vertically averaged over the depth of the water column. In real lakes, the surface currents can differ from the vertically averaged currents because of wind-induced shear near the surface and temperature stratification. These effects may be significant in deep lakes, but should be minimized in shallow Lake St. Clair. The lake's circulation pattern, indicated in the figure by solid and dashed lines, corresponds to the positive and negative stream functions, respectively, which also generally correspond to the origin of water from the St. Clair River delta; solid lines normally indicate outflow from the North and Middle Channels, while dashed lines normally show water originating from various branches of the South Channel. The results from the physical and numerical models frequently disagree, but since neither model can be fully verified, representative results from both models are included.

4. ICE EFFECTS

Ice conditions in Lake St. Clair react quickly to wind and temperature changes. Because it is relatively shallow, the lake has a limited capacity to store heat; consequently, its ice cover forms and melts quickly. The lake usually becomes ice covered by the end of January. During the period of greatest ice cover, the ice is usually fast and thick in the bays and protected areas, with heavy consolidated ice floes of brash and cake ice in the middle of the lake. The stability of the ice cover in the lake is very sensitive to wind forces (speed and direction). This may present a problem in

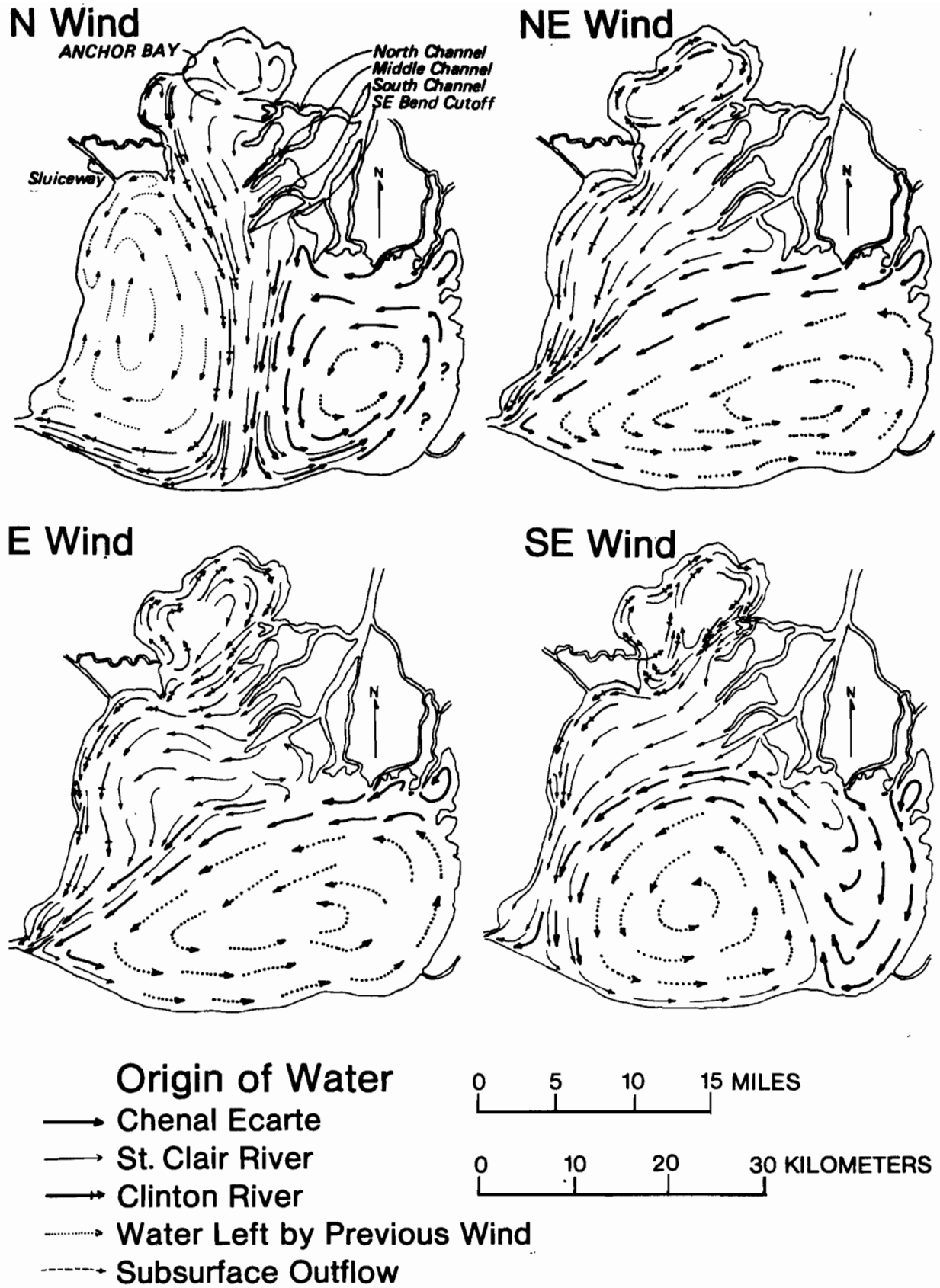

FIGURE 2.--*Lake St. Clair surface water movements under various wind stresses from Ayers' (1964) physical model.*

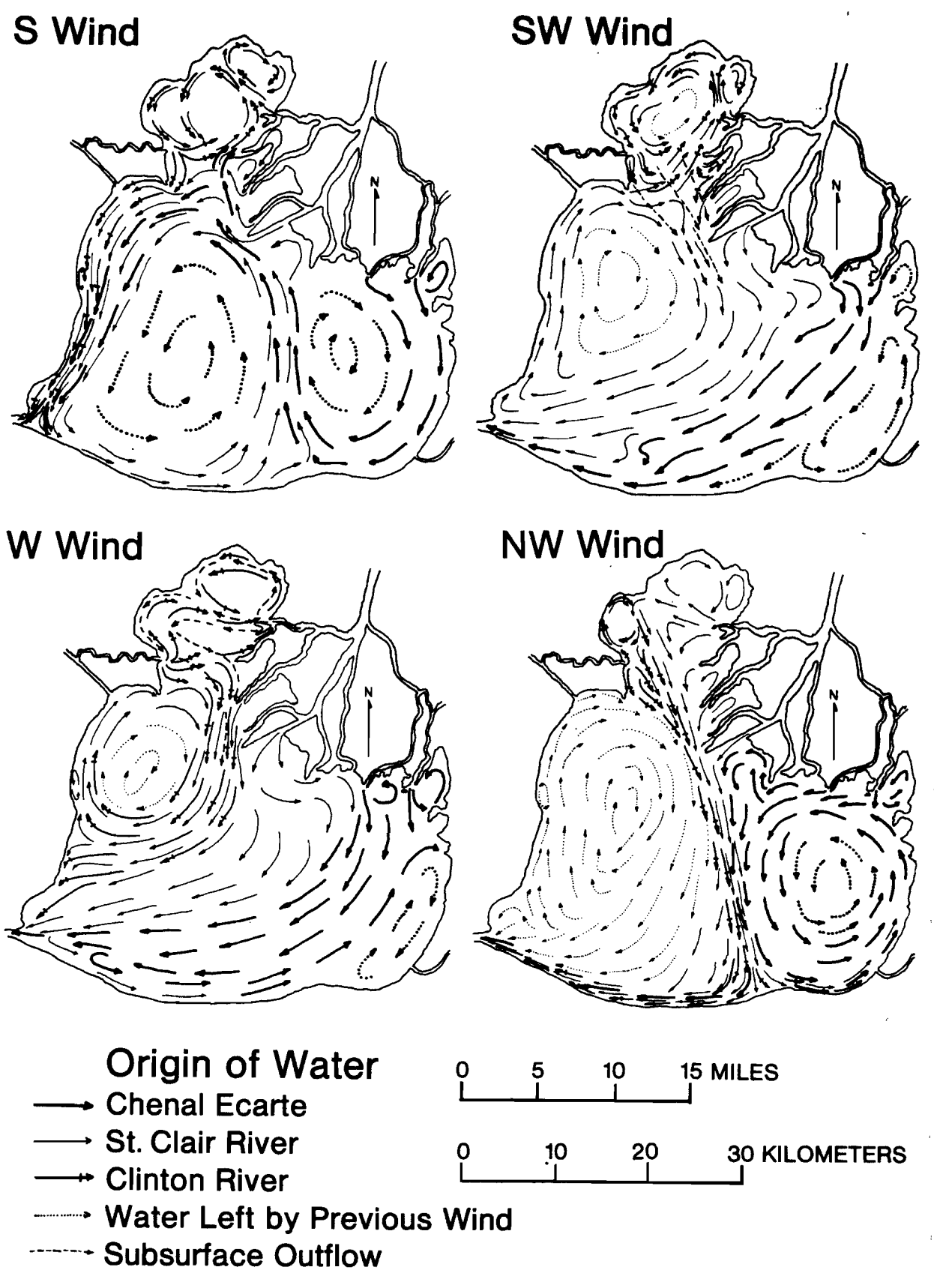

FIGURE 2.--*Lake St. Clair surface water movements under various wind stresses from Ayers' (1964) physical model (cont.).*

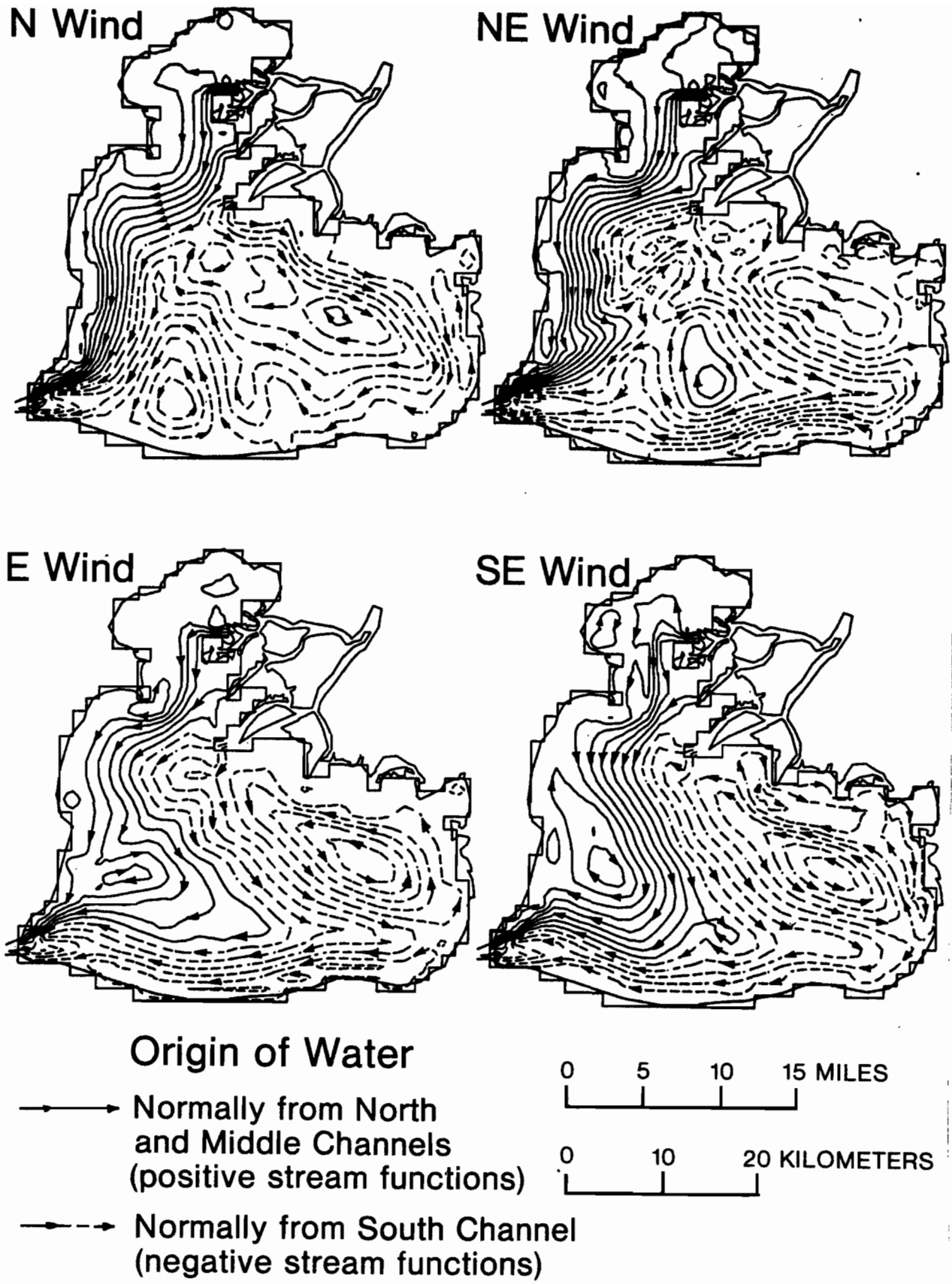

FIGURE 3.--*Lake St. Clair vertically averaged water movements under various wind stresses from the numerical model developed by Schwab* et al. *(1981).*

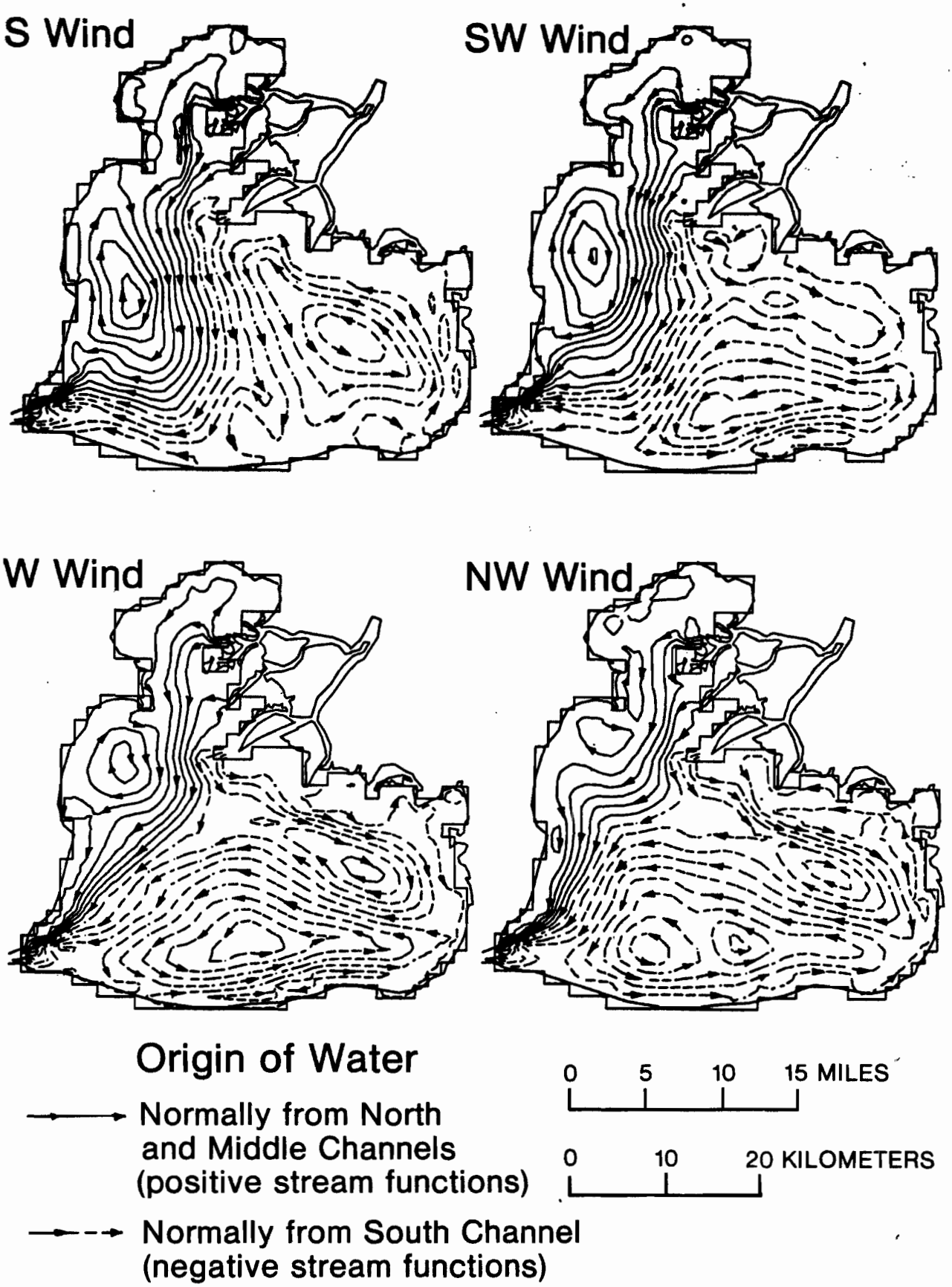

FIGURE 3.--*Lake St. Clair vertically averaged water movements under various wind stresses from the numerical model developed by Schwab* et al. *(1981) (cont.)*

maintaining an open water navigation channel during winter, because vessel tracks tend to close and entire ice sheets shift when the vessel channel is cleared. The area of Lake St. Clair at the head of the Detroit River is usually ice free because an ice bridge forms above the river head; however, this lake area fills with drift ice following storm breakup of the ice bridge. As the ice begins to melt, the breakup of the lake ice cover occurs quickly. Winds and currents move the drifting ice to the entrance of the Detroit River, where relatively strong river currents move it downstream. The lake is usually free of ice in March.

5. SUMMARY

Lake St. Clair connects the St. Clair and Detroit Rivers and forms the midsection of the Lake Huron outflow system through the St. Clair-Detroit Rivers. The lake is approximately 42 km (26 mi) long and 39 km (24 mi) wide, with a surface area of 1,100 km^2 (430 mi^2). Lake St. Clair is relatively shallow, with the maximum natural detph of about 6.4 m (21 ft) and the average depth of 3.4 m (11 ft). A dredged 8.2-m (27-ft) navigation channel bisects the lake in a northeast-southwest direction, running between the St. Clair and Detroit Rivers. Lake circulation is determined to a large extent by this flow-through pattern and the predominant winds. Average lake elevation is about 174.74 m (573.30 ft). The lake is normally ice covered during winter.

6. REFERENCES

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