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WATER CIRCULATION STUDY FOR CLINTON REEF MARINA PORT CLINTON, OHIO

by

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Prepared for

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General Considerations

Successful control of water quality within a boat basin depends on periodic exchanges of harbor water with the main body of water that the harbor serves. In flowing rivers, such as the Portage River, the problem is minimized because the river current will induce circulatory flow. The U. S. Army Corps of Engineers, Coastal Engineering Research Center points out that this is true even in off-river basins (Dunham and Finn 1974, p. 39). Wind tides, seiches, storm surges and other water level fluctuations are important factors in adequate water exchange in harbors. For single-entrance harbors, Coastal Engineering Research Center (CERC) recommends an average daily exchange of water equivalent to about one-third of the harbor's mean volume to prevent water stagnation (Dunham and Finn 1974, p. 40). Although such exchanges may penetrate only part of the harbor, CERC believes that sufficient diffusion occurs to maintain adequate water quality.

When water level fluctuations are small, special arrangements may be necessary to ensure adequate water exchange. Sometimes this can be done by providing a wide entrance, by adding a second entrance to the harbor, or by appropriately placed culverts so that wind-generated currents, feeble though they may be, move continuously through the harbor. CERC recommends a complete exchange of water every 10 days for adequate water quality control (Dunham and Finn 1974, p. 40).

Site Description

Clinton Reef Marina is located on the estuarine portion of the Portage River approximately one mile from the river's mouth at Lake Erie. Constructed adjacent to the left (north) bank of the river, the boat basin is an irregular rectangle approximately 1800 ft long and 500 ft wide (Figure 1). The surface area of the basin is somewhat less than 900,000 sq ft because of several land projections into the harbor. Mean water depth in the basin during the survey was nearly 7 ft, yielding a water volume of approximately 6,300,000 cu ft.

The boat basin has a single opening located near the center of the east-west breakwater which separates the basin from the river. The opening is about 170 ft with a mean depth of slightly over 7 ft, yielding a cross-sectional area of approximately 1200 sq ft. The marina breakwaters are of rubble mound construction faced with limestone rip-rap. No culverts are provided in the breakwaters.

Field Study

The primary objectives of the field study were to (1) determine if water circulation was occurring in the boat basin, (2) if circulation was present, to determine the dominant flow pattern, (3) measure the rate flow within the basin, (4) determine the volume of water entering and exiting the marina per unit time and (5) calculate the water exchange rate between the boat basin and the Portage River.

On May 9, 1987, a water circulation study was conducted in the boat basin at Clinton Reef Marina. Measurements were made

between 1000 and 1200 hours. On that day the wind was from the southwest at 10-15 mph. Southwest winds are the most common direction for the Port Clinton area (Verber 1959). The water level of western Lake Erie was falling at a rate of 0.07 ft/hr until about Noon as recorded at the Ohio Division of Natural Resources guage on South Bass Island. The maximum excursion of lake level for the 10 hours prior to the study was 0.5 ft.

Twenty-one (21) stations were selected throughout the boat basin to determine water depth and movement (Figure 1). At each station the depth was determined with a lead line lowered from an outboard motor boat. Water movements were monitored by placing packets of water soluble flourescein dye just under the water surface. The direction of dye movement was determined with a hand compass. At selected stations, particularly the harbor entrance, the time required for the dye patch to flow along a measured distance was determined. This information was later converted to current velocities in ft/sec (Table 1).

The results of these measurements show there is considerable water circulation in the boat basin under the conditions present during the field study. Figure 2 provides a generalized interpretation of the probable flow patterns which exist during periods of moderate southwest winds, a typical conditions throughout the main boating season. Circulation in the harbor consists of two gyres, one moving rapidly toward the NNE along the insdie of the outer wall. A shallow sediment bar has been deposited in this region as it slows down once it has entered the basin . The circulation then continues counterclockwise around

the eastern portion of the basin. The second gyre moves clockwise in the western portion of the basin, first along the inside of the outer wall and then east along the inner shore of the basin. Accumulations of debris were observed in the northeast and northwest corners of the basin. These are most likely areas where wind and current action have concentrated floating materials. In these corners, the currents change direction and most probably move to the subsurface, particularly the northeast corner, stranding the floating material.

A subsequent visit to the boat basin on 13 May, a day with light to moderate northeast wind, indicated that under these conditions the debris accumulations in the northeast and northwest corners are dissipated. Only a very small accumulation of debris was observed on 13 May, and that was in the southeast corner.

River water appeared to be entering the boat basin primarily along the eastern side of the harbor opening. Surface flow rates here were measured at up to 0.17 ft/sec (Station 8). Harbor water appeared to be exiting on the western side of the opening, primarily as a subsurface flow. Surface dye packets showed only a slow drift toward the river here, while a weighted dye packet yielded movements up to 0.12 ft/sec toward the southwest (Station 10). These values seem reasonable when compared with open water currents in western Lake Erie. Herdendorf and Braidech (1972) found for 10 years of data that surface currents average 0.47 ft/sec and bottom currents average 0.25 ft/sec.

Considering that the harbor opening has a cross-sectional

area of approximately 1200 sq ft and assuming that during the study about half of that area contained inflowing currents and half contained outflowing currents (a reasonable assumption given the relatively uniform water level within the boat basin during the study and the exchange rates with the river from the current velocity data). Using the conservative value of 0.1 ft/sec inflow at Station 9 near the center of the opening, approximately 60 cu ft/sec of water was entering the boat basin, or 648,000 cu ft during the 3-hour study. The entire boat basin has a volume of about 6,300,000 cu ft. Thus, given the conditions that existed during the field study, enough river water enters the opening every 24 hours to completely replenish the water in the boat basin.

Conclusions

Water circulation in the Clinton Reef Marina appears to be adequate to maintain proper water quality within the boat basin. No serious evidence of stagnation has been observed within the basin. Current measurements and calculations of exchange reates show that river water completely replenishes harbor water every 1.2 days under moderate southwest wind conditions. This is considerably better than the Coastal Engineering Research Center recommendation of once every three (3) days for tidal areas and every ten (10) days for areas with small water level fluctuations. The good circulation pattern within the basin and the high exchange rate can be attributed to the wide opening (170 ft) and its orientation toward the direction of the prevailing wind (Figure 3).

References Cited

Dunham, J. W. and A. A. Finn. 1974. Small-craft harbors: design, construction, and operation. U. S. Army Corps of Engineers, Coastal Engineering Research Center, Spec. Rept. No. 2. 375 pp.

Herdendorf, C. E. and L. L. Braidech. 1972. Physical characteristics of the reef area of western Lake Erie. Ohio Dept. Natural Resources, Div. Geological Survey, Rept. Invest. No. 82. 90 pp.

Verber, J. L. 1959. Wind report for Sandusky, Ohio and adjacent Lake Erie. Ohio Dept. Natural Resources, Div. Shore Erosion. 28 pp.

TABLE

AND

FIGURES

TABLE 1. CURRENT MEASUREMENTS WITHIN THE CLINTON REEF MARINA BOAT BASIN ON 9 MAY 1987

Station	Time	Direction	Velocity (ft/sec)	Water Depth (ft)
1	1000	SW	----	7.0
2	1005	E	----	8.8
3	1010	E	----	8.5
4	1015	E	0.37	9.5
5	1025	ENE	----	3.0
6	1030	ENE	----	6.2
7	1035	ENE	----	10.0
8	1040	NE	0.17	5.5
9	1045	NE	0.11	9.0
10	1100	SW	0.12	6.3
11	1105	W	0.11	7.0
12	1110	W	0.08	5.0
13	1120	NW	----	8.0
14	1125	E	----	5.8
15	1130	SE	----	5.8
16	1135	S	0.07	7.2
17	1140	E	----	5.7
18	1145	E	----	6.8
19	1150	N	0.05	5.0
20	1150	W	0.15	6.2
21	1200	NE	----	7.3
			Mean	6.8

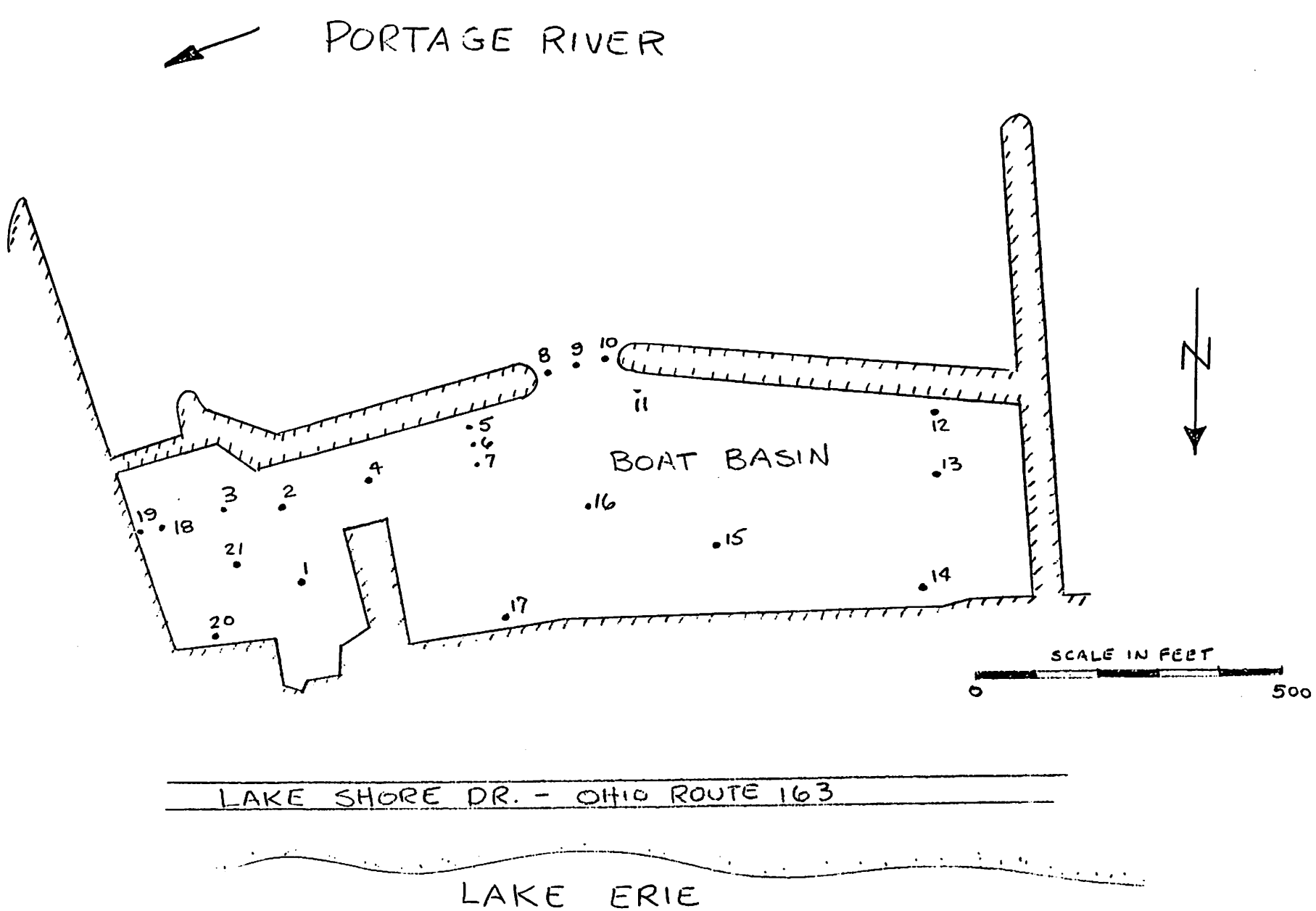

Figure 1. Location map of Clinton Reef Marina showing position of dye study and current measurement stations.

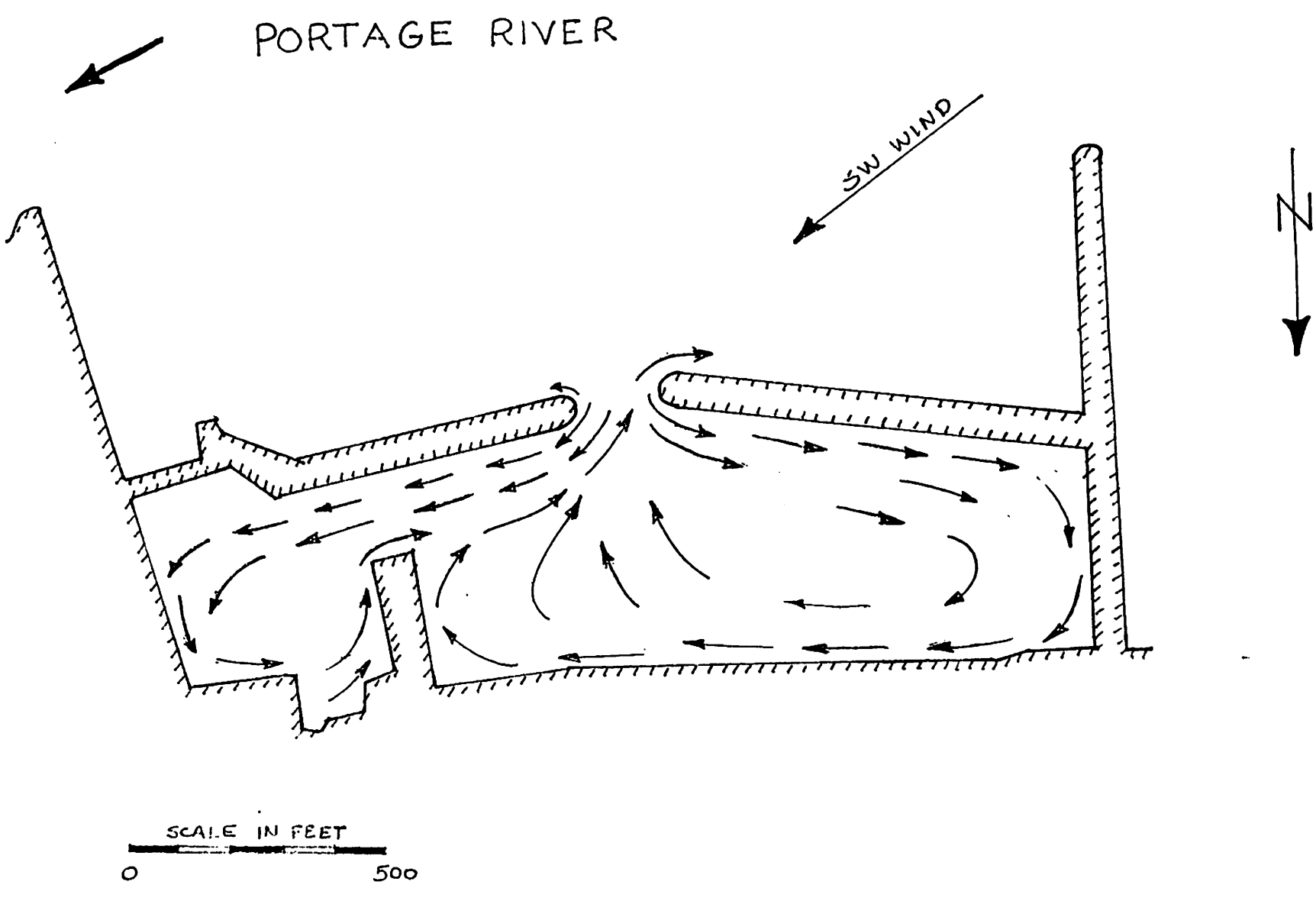

Figure 2. Water circulation pattern in the Clinton Reef Marina boat basin on 9 May 1987.

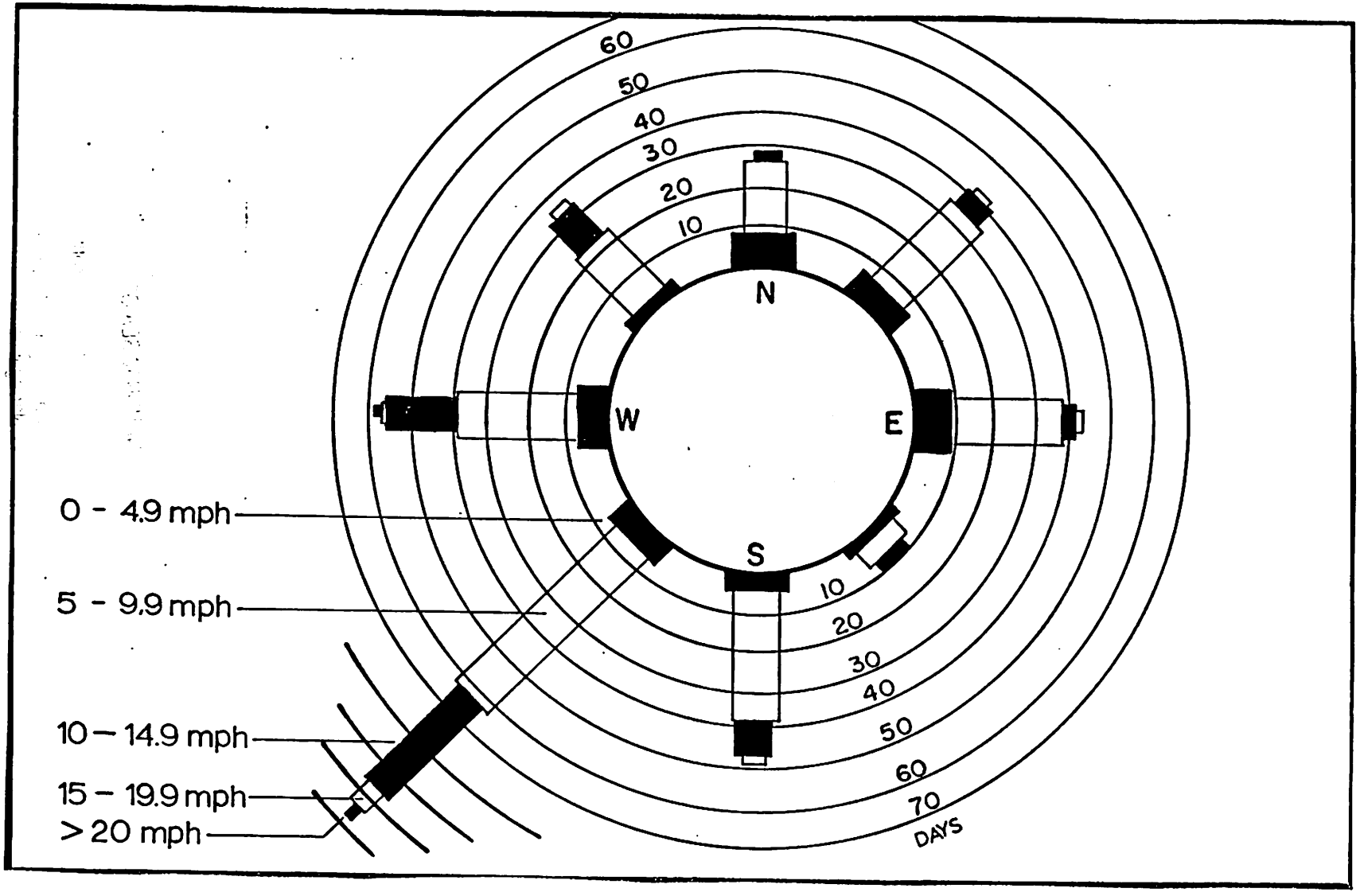

Figure 3. Average annual winds at Sandusky, Ohio, for ten years (1948-1957) (after Verber 1959).