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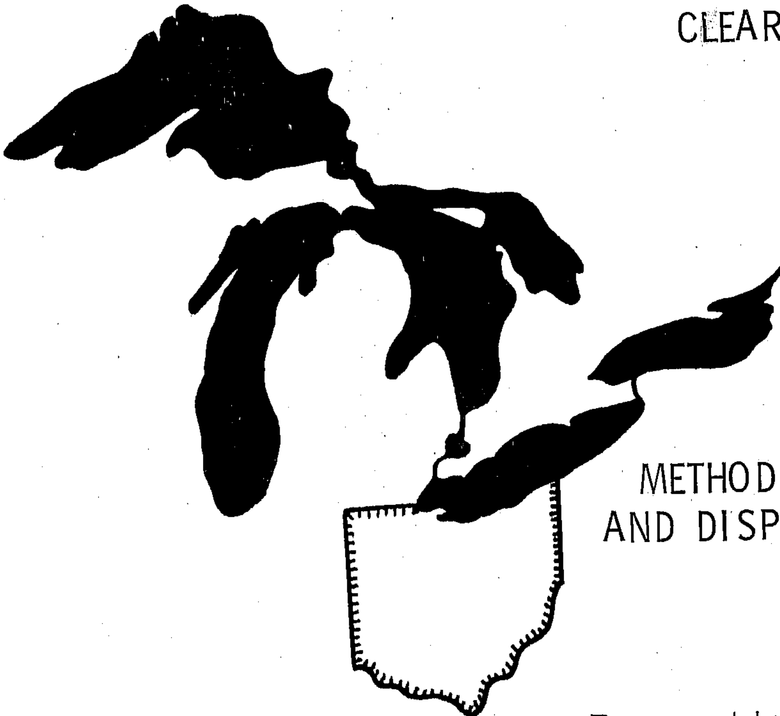

METHODS OF SEDIMENT DREDGING AND DISPOSAL IN THE GREAT LAKES

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METHODS OF SEDIMENT DREDGING AND DISPOSAL IN THE GREAT LAKES

Introduction

Dredging is defined as the process of removing materials from underwater and their subsequent disposal. The process includes two operations: (1) excavation of the materials and (2) conveyance to and release of the materials at the disposal site. Equipment for dredging operations on the Great Lakes are of two types: (1) mechanical and (2) hydraulic. Dipper and clamshell dredges are mechanically operated, while hopper and pipeline dredges are hydraulically operated. Mechanical dredging requires auxiliary equipment, consisting of scows and tugs, to receive the dredged materials and transport them to the disposal site. Hydraulic dredges combine the digging and disposal operations in one piece of equipment (U. S. Army Corps of Engineers, 1969).

1.2 Equipment

Dipper Dredges

Dipper dredges are used for heavy duty excavations. Their main feature is a power operated dipper stick with a bucket at its end which can be moved forward, vertically and horizonally from boom. This type dredge is especially useful for "new work" dredging and breaking up hard compacted material, including some types of ledge rock. The dredge is held in position by forward and stern spuds. During operation, the boom is swung around to empty the bucket into a scow. Rates of dredging depend on the size of the dipper bucket, nature of the material, and depth of the cut. Rates in the Great Lakes have been reported as high as 400 cubic yards/hour (U. S. Army Corps of Engineers, 1969).

Dredging operations can be classed in two general categories: (1) maintenance and (2) new work dredging. Maintenance dredging comprises the removal of soft and easily excavated sediments deposited since the last dredging. It is generally required annually in the commercially more important harbors and less frequently in harbors for ligh-draft recreational craft. New work dredging is employed to improve a harbor area or channel by widening or deepening. This type of dredging removes materials, ranging from limestone to compacted clays, which were deposited in older geologic times. In performing new work dredging some small amounts of very recently deposited material is also removed. New work dredging is performed by the Corps of Engineers only when authorized and funded by Congress.

1.2.2 Clamshell Dredges

Dredges of this type consist of a clamshell bucket suspended by cables from a forward extending boom which can swing about the bow of the dredge. Clamshell dredges are most commonly used to excavate soft or cohesive underwater materials. They are especially useful for deep digging and for dredging in close quarters alongside structures. Maintenance dredging in winding river channels is usually done with clamshell dredges. Spuds or anchors are used to position and maneuver these dredges. Like dipper dredges, the dredged material is usually loaded onto a scow. Large clamshell dredges with 12 cubic yard buckets excavate up to 400 cubic yards/hour when excavating soft, light-weight material. Approximately 20 percent of all dredging done in the Great Lakes is accomplished by clamshell dredges (U. S. Army Corps of Engineers, 1969).

1.2.3 Pipeline Dredges

Pipeline dredges excavate bottom materials with a revolving cutter surrounding the intake end of a suction pipe. The cutter and suction pipe are mounted on a ladder frame hinged at the forward end of the dredge for vertical movement. A pumping unit sucks up material at the intake end of the suction pipe and discharges the material through a trailing pipeline to the disposal site. These dredges are generally equipped with two stern spuds and forward anchors to swing the hull around one of the stern spuds. By alternately raising each of the spuds, the dredge excavates transversely across the area to be cut and "walks" forward into the cut. Pipeline dredges are used most frequently for dredging sandy, clayey, or silty bottoms which have sufficient depths of cut for economical operation. Generally, these dredges are designated by the diameter of the discharge pipe; sizes range from small 6-inch portable dredges to mammoth 36-inch dredges over 100 feet in length. Pipeline dredges usually contain their own power unit, but some are electrically driven with shore current. Rates of output depend on many factors: (1) horsepower of the pumping and cutter head machinery, (2) length of pipeline, (3) elevation of disposal site, (4) use of booster stations and (5) nature of the material.

1.2.4 Hopper Dredges

Hopper dredges are essentially self-propelled ships. The dredging apparatus consists of one or more dredging pumps located in each hold which are provided with a suction pipe leading out through the side of the hull to a flexible connection that permits raising and lowering the external portion of the suction pipe, which is equipped with a drag head at its intake (Figure 1). Pumping goes on while the dredge is underway a slow speed and while the drag heads slide over the sediments to be dredged. The dredgings are discharged into the hoppers where they settle. Fine material and excess water overflow at the top of the hoppers. Dredging continues until an economical load has been accumulated in the hoppers. At this time, the pumps are shut down, and the dredge itself transports its load to the disposal site. Hopper dredges are not equipped with cutter heads and work well only in uncompacted sediments. They are particularly efficient in removing a thin layer of sediment covering extensive areas. Hopper dredges in use on the Great Lakes range in capacity from 920 to 2,700 cubic yards (Table 1). The rate of performance depends upon the length of time required to fill the hoppers, and on the speed and length of travel of the vessel to and from the disposal site. Normally, the hoppers are emptied by opening doors at their bottom while the dredge passes over the disposal site. However, in recent years most of the hopper dredges in the Great Lakes have been equipped with piping through which they can pump out the hoppers to an on-shore or in-lake disposal site. These dredges tie up to a mooring, and connect their discharge pipes to a pipeline through which the dredgings flow to a disposal area that would otherwise be inaccessible to the dredges.

Presently the U. S. Army Corps of Engineers operates 16 hopper dredges in the coastal and inland waterways of the United States. Four of these maintain authorized project depths on the Great Lakes: the Hoffman, Lyman and Markham operated by the Buffalo District and the Hains operated by the Detroit District. Hopper dredges presently do about 75 percent of the approximately ten million cubic yards of annual maintenance dredging on the Great Lakes (U. S. Army Corps of Engineers, 1969).

1.3 Corps of Engineers Dredges Operating in Great Lakes

1.3.1 Hoffman. This dredge was designed by the Marine Division of the Philadelphia District, Corps of Engineers and launched from the Pusey and Jones Shipyard, Wilmington, Delaware in 1942. In 1947 she was transferred to the Buffalo District where deepening the harbors on Lake Erie has been her principal concern.

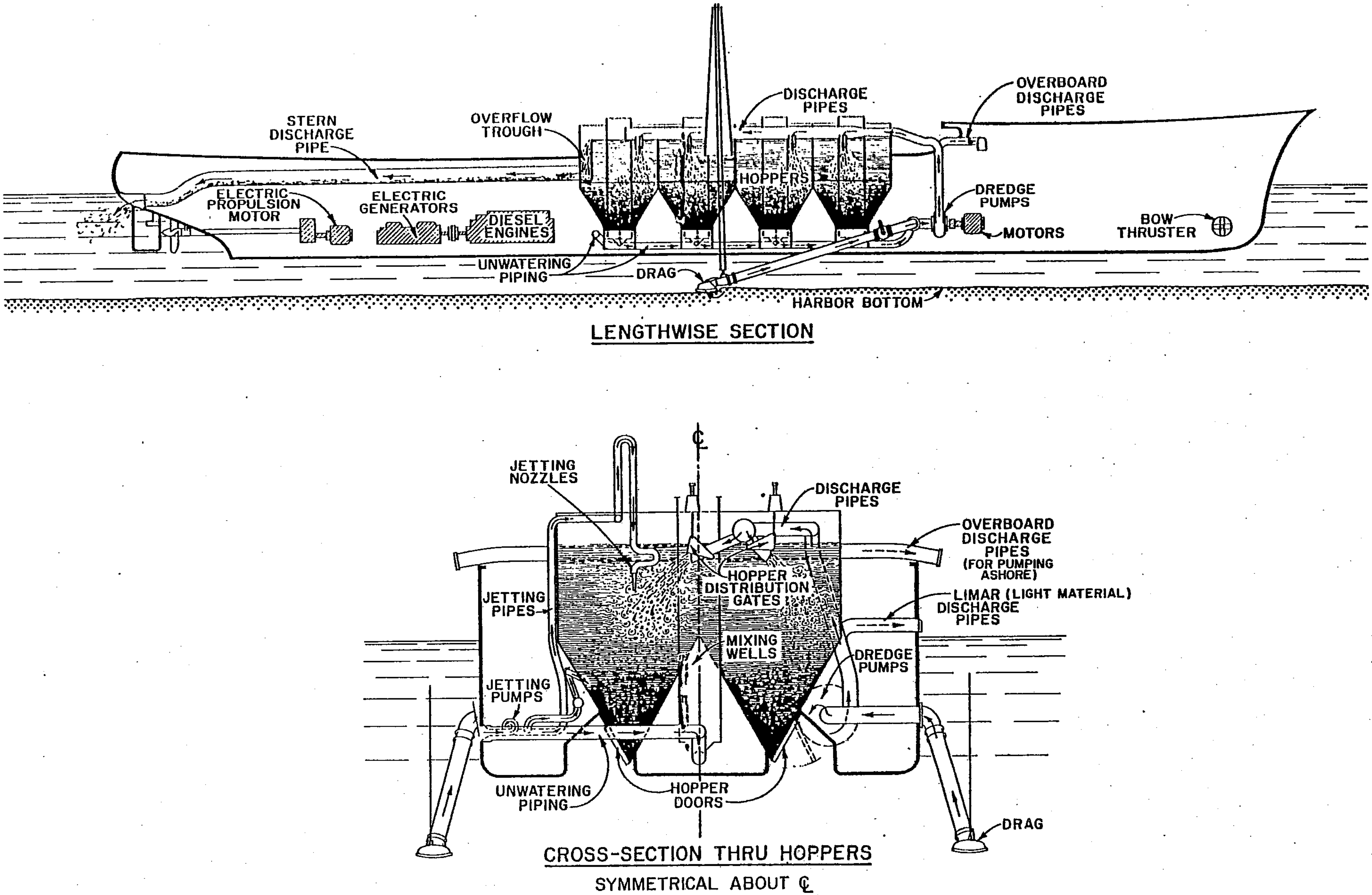

Figure 1. OPERATIONAL SKETCH OF HOPPER DREDGE

TABLE 1

PHYSICAL CHARACTERISTICS OF THREE ARMY CORPS HOPPER DREDGES

Physical Characteristics	Lyman	Hoffman	Markham
Length, overall	225 ft. 10.5 in.	215 ft. 10.5 in.	339 ft. 6 in.
Beam	40 ft. 4 in.	40 ft. 4 in.	62 ft.
Draft, light	9 ft. 8 in.	9 ft. 8 in.	–
Draft, loaded	12 ft. 10 in.	12 ft. 10 in.	19 ft.
Displacement, loaded	2,134 long tons	2,134 long tons	7,800 tons
Hoppers	4	4	8
Hoppers, capacity	920 cu. yds.	920 cu. yds.	2,700 cu. yds.
Max. dredging depth	35 ft.	35 ft.	43.5 ft.
Total propelling power	1,400 hp.	1,400 hp.	5,200 hp.
Total pumping power	410 hp.	410 hp.	2,000 hp.
Suction pipe diameter	18 in.	18 in.	23 in.
Suction pipe length	40 ft.	60 ft.	54 ft.
Speed, light	14 mph	14 mph	17 mph
Speed, loaded	13 mph	13 mph	14 mph
Ave. Daily performance	10,000 cu. yds.	10,000 cu. yds.	30,000 cu. yds.
Crew, officers & men	43	43	54
Launched	1945	1942	1959
Height, keel to bridge	–	–	65 ft.
Bow thruster	–	–	150 hp.
Power, twin diesels	–	–	4,250 hp. each
Propellers, 4 blades	–	–	13 ft. diameter

Data source: U. S. Army Corps of Engineers, Buffalo District

Working on a vacuum cleaner principal, the Hoffman operates 24 hours a day, six days a week from mid-March until mid-December when lake ice prevents dredging. She is self-contained, highly mobile, and works in almost all kinds of weather. The hopper dredge is the most efficient type of dredge in areas where there is a relatively small amount of material spread over a large area and since the Hoffman's transfer to Buffalo many improvements in equipment and technique have greatly increased efficiency and capability. The latest improvement is a hopper pumpout system which permits the material in the hppers to be pumped to shore disposal areas.

1.3.2 Lyman. This dredge was designed by the Marine Division of the Philadelphia District Corps of Engineers and launched from the Dravo Corporation Shipyard, Wilmington, Delaware, in 1945. In 1954 she was transferred to the Buffalo District where she performs the same duties as the Hoffman.

1.3.3 Markham. This dredge was designed by the Marine Division of the Philadelphia District of the Corps. The pride of the Army Engineers workhorse fleet, she was launched from Avondale Marine-ways Shipyard, New Orleans, Louisiana, in 1959. She was the first Army Engineer hopper dredge to sail the International Waterway from her training grounds in Louisiana, along the Atlantic Coast, through the Gulf of St. Lawrence and into the Great Lakes. She was commissioned in Cleveland Harbor in May of 1960 and assigned to deepening portions of the Connecting Channels in western Lake Erie. Operating like other Corps dredges, the Markham has broken all previous dredging records for any similar type vessel on the Great Lakes (U. S. Army Corps of Engineers, 1971).

1.3.4 Hains. This dredge is assigned to the Detroit District, Corps of Engineers. She is of similar vintage and design as the Hoffman and performs similar operations.

1.4 Disposal Techniques

1.4.1 Open Lake Disposal

Past dredging in the Great Lakes required the disposal of dredged materials in the open lake areas designated by the Corps of Engineers. In general, areas were selected as close to the harbor as possible and of sufficient depth to preclude interference or obstruction to navigation. Disposal areas in the proximity of intakes for public water supply or recreational beaches were avoided. Figures 2 through 6 are maps prepared by the U. S. Army Corps of Engineers (1969) of each of the Great Lakes which

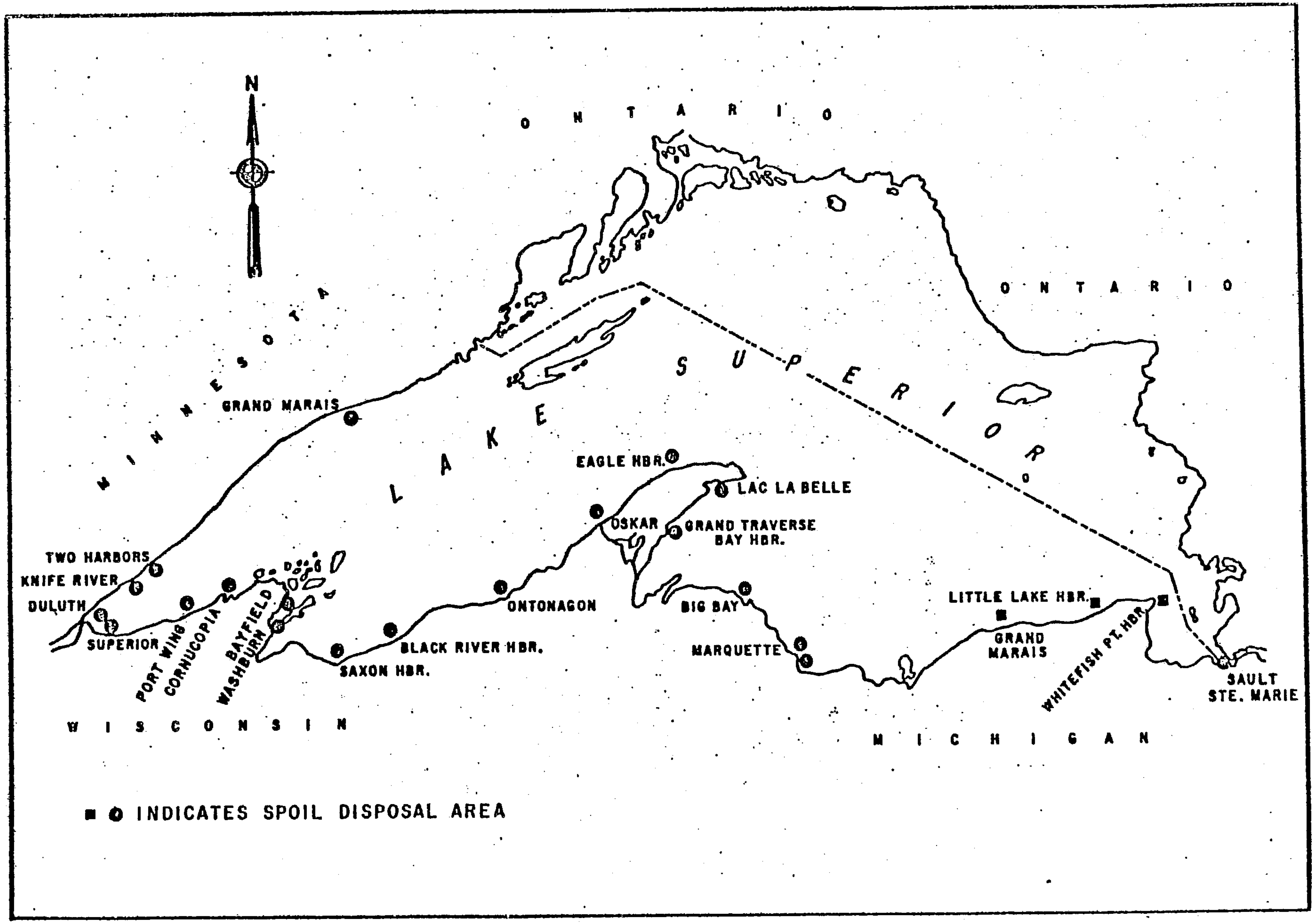

Figure 2. Disposal Areas on Lake Superior

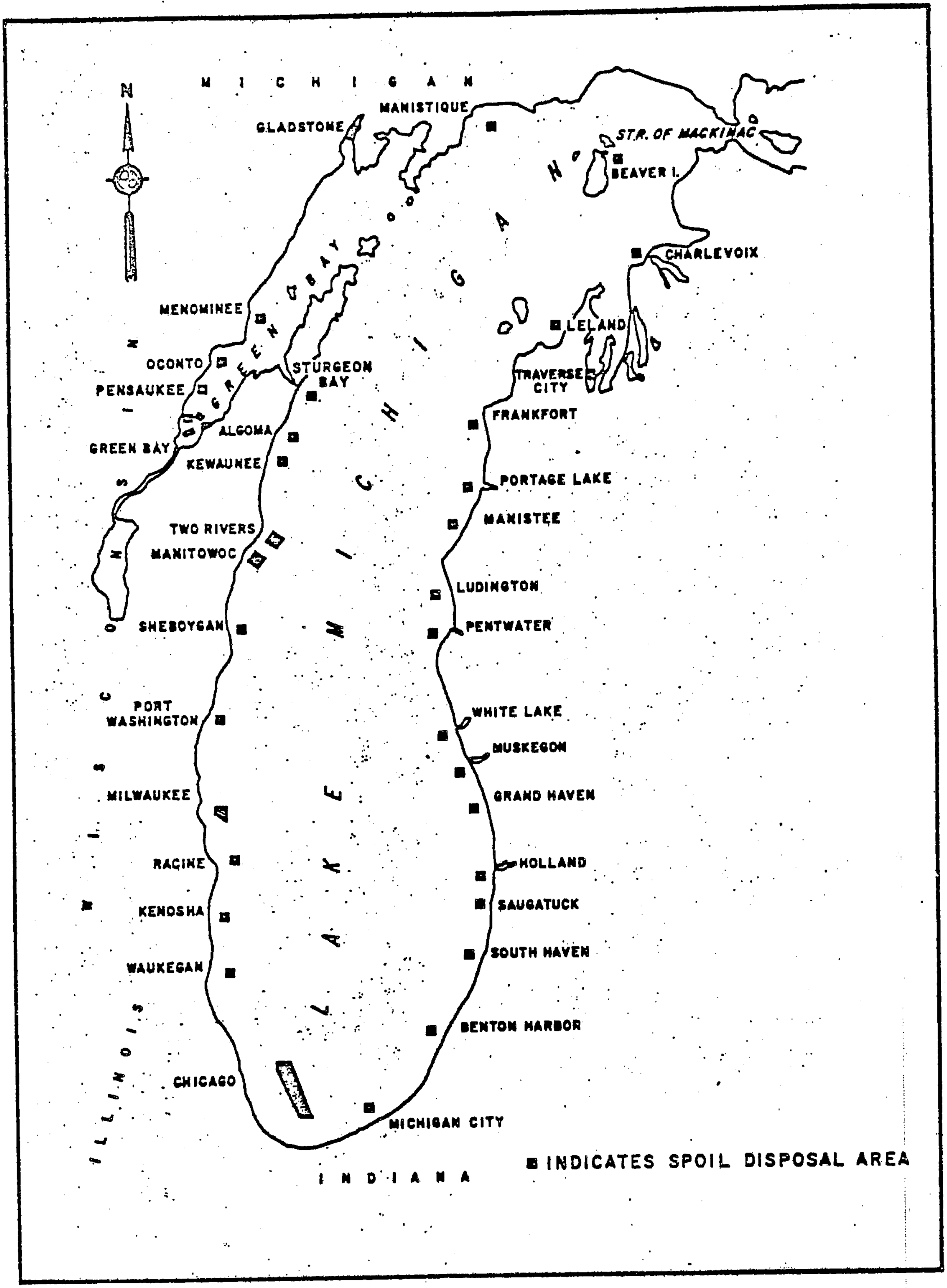

Figure 3. Disposal Areas on Lake Michigan

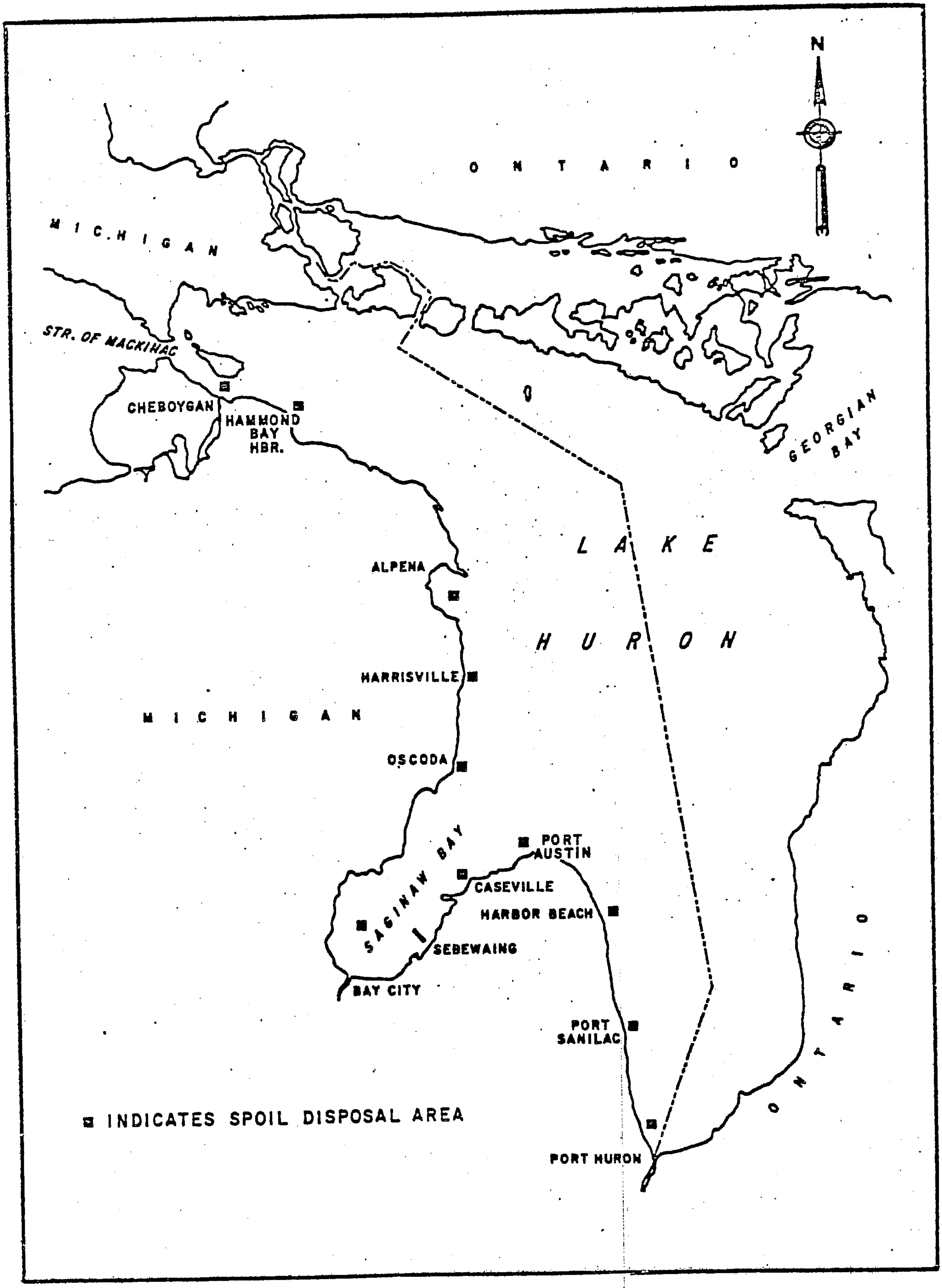

Figure 4. Disposal Areas on Lake Huron

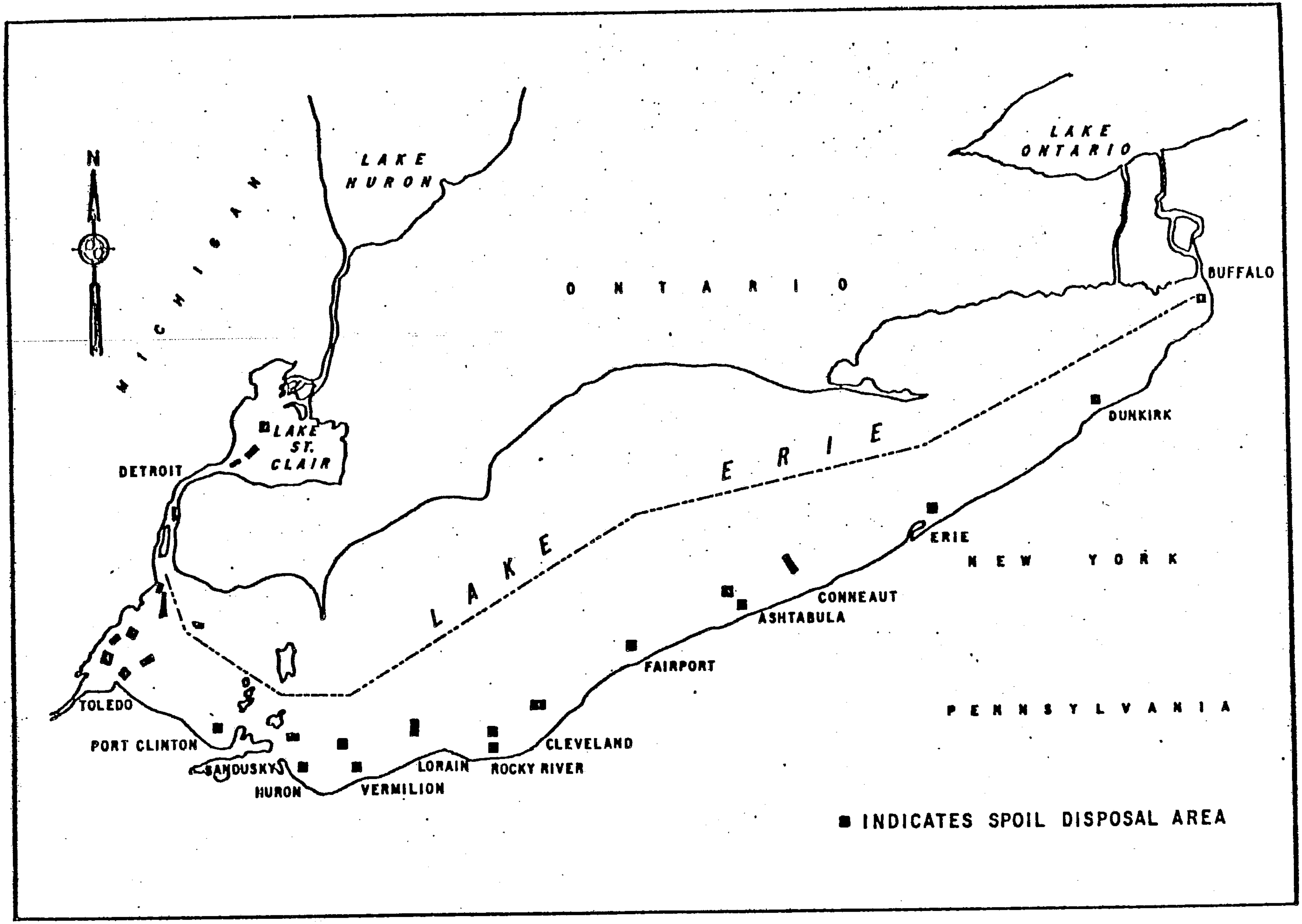

Figure 5. Disposal Areas on Lake Erie

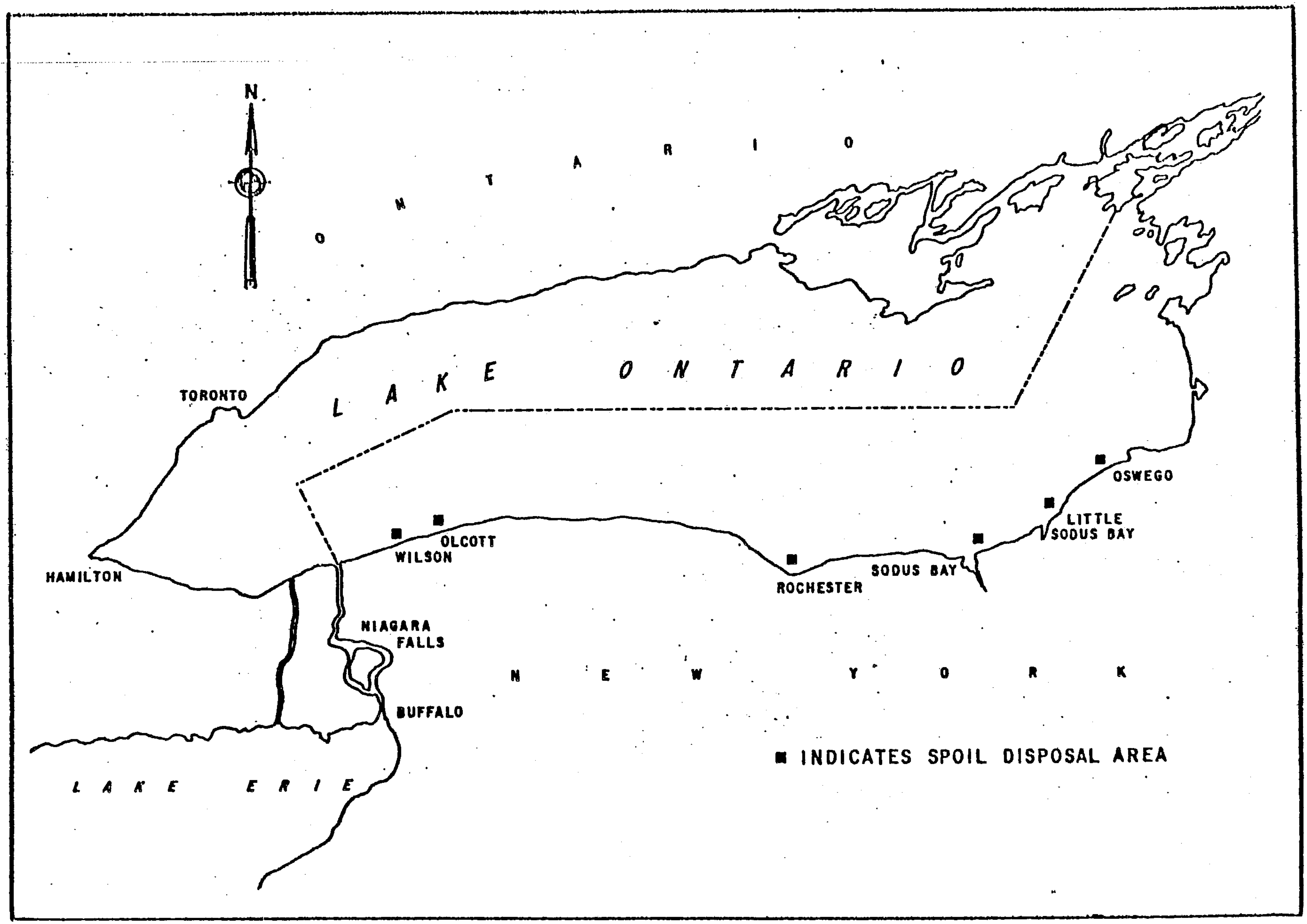

Figure 6. Disposal Areas on Lake Ontario

show, to scale, areas within which dredges or scows disposed of dredged materials.

1.4.2 Offshore and Alongshore Diked Disposal

Prior to 1967, materials from maintenance dredging in the Great Lakes were rarely deposited in diked areas to create new land. Generally, the fine sediment dredged from harbors, particularly harbors polluted with industrial wastes, seldom provides a satisfactory fill because of its hygroscopic nature and its lack of shear strength.

However, maintenance dredgings from the Rouge River at Detroit and the Maumee River in Toledo have been deposited in diked disposal areas since the 1960 and 1961, respectively. River Rouge spoil is deposited in the Grassy Island disposal area, located in the Detroit, 4.5 miles downstream from the lower end of the dredging project. Three separate diked enclosures are used at Toledo. Two of the areas are land disposal sites adjacent to the dredging area and the third is in Maumee Bay near the mouth of the Maumee River Estuary. Grassy Island does not provide for regular discharge of the effluent because of its large ponding area, whereas, the Toledo areas are equipped with overflows for runoff of excess water.

From 1948 to 1952, maintenance dredgings from the Cuyahoga River were deposited in the area now occupied by the Burke Lakeport Airport at Cleveland, Ohio. The City of Cleveland also placed municipal wastes in the same area. The mixed fill was found to be unsuitable as a base for the runways. It was necessary to excavate portions of the fill and replace it with suitable materials.

In 1967, as part of an experimental study by the U. S. Army Corps of Engineers (1969) alongshore diked disposal areas were constructed at Buffalo, New York, and Cleveland, Ohio, to receive portions of the maintenance dredging spoil. An existing diked area at Indiana Harbor, Indiana, was also used at the same time as part of this study.

In 1969, an offshore diked disposal area was completed in Green Bay. It is being used for new work dredgings from a project to deepen the outer channel and for disposal of maintenance dredgings from the outer sections of the channel.

1.4.3 Landfill Disposal

In the past, practically all landfills were constructed of new work dredgings. These materials, deposited in past geologic times, contain few man-induced wastes other than those included in recent sediments overlying the older deposits. Landfills with these dredgings usually have been suitable for beneficial uses. The U. S. Army Corps of Engineers (1969) found no record of a landfill consisting of polluted maintenance dredgings alone in the Great Lakes area.

1.5 Quantities of Material Dredged

1.5.1 Past dredging records compiled by the U. S. Army Corps of Engineers (1969) provide a good history of dredging operations from 1933 to the present, but earlier records are incomplete. Figures 7 through 11 are bar graphs showing the yearly volumes (1933-1968) of dredging in each of the Great Lakes and connecting channels and Table 2 gives quantities of dredgings by harbor for 1972 and 1973 (U. S. Environmental Protection Agency, 1973). These data include only dredging by the Corps of Engineers. In addition, local industries have dredged the area between the Federal channels and the unloading piers and in private slips and channels. Data on such dredging are not readily available, but the volume is estimated to be less than 10 percent of that dredged by the Corps.

At present, it is unlikely that further deepening of harbors and connecting channels by new work dredging will occur in the near future. Almost all major harbors are now improved to accomodate the size of vessel which can pass through the ship locks on the St. Lawrence River, the Welland Canal or the St. Mary's River. The new Poe Lock, completed in 1968 at Sault Ste. Marie, Michigan, can pass vessels larger than any now navigating the Great Lakes. Under study at the present time are proposals to construct additional locks on the St. Lawrence River and new canals linking Lakes Ontario and Erie to relieve congestion and provide capacity for additional shipping. These projects, if authorized and constructed, are likely to include ship locks of larger size than those now available. Vessels larger than those now in use are being planned, and there will be a growing demand for deeper and larger harbors.

1.5.2 Estimates of future annual maintenance dredging requirements are difficult to make because of the variations in the present quantities dredged. Also, it is expected that current efforts by regulatory agencies may result in a reduction in the volume of

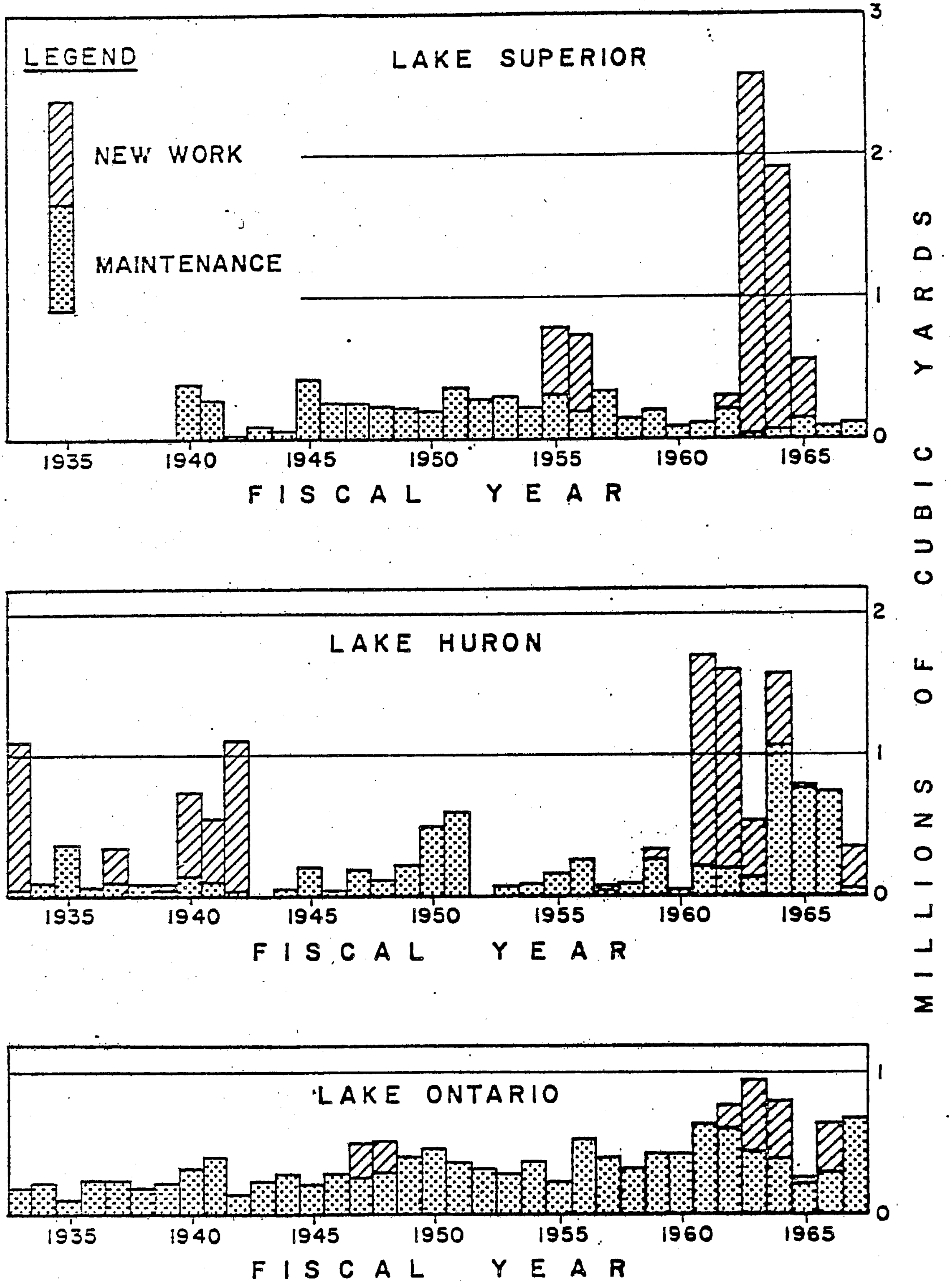

Figure 7. Dredging in Lakes Superior, Huron and Ontario
By Corps of Engineers

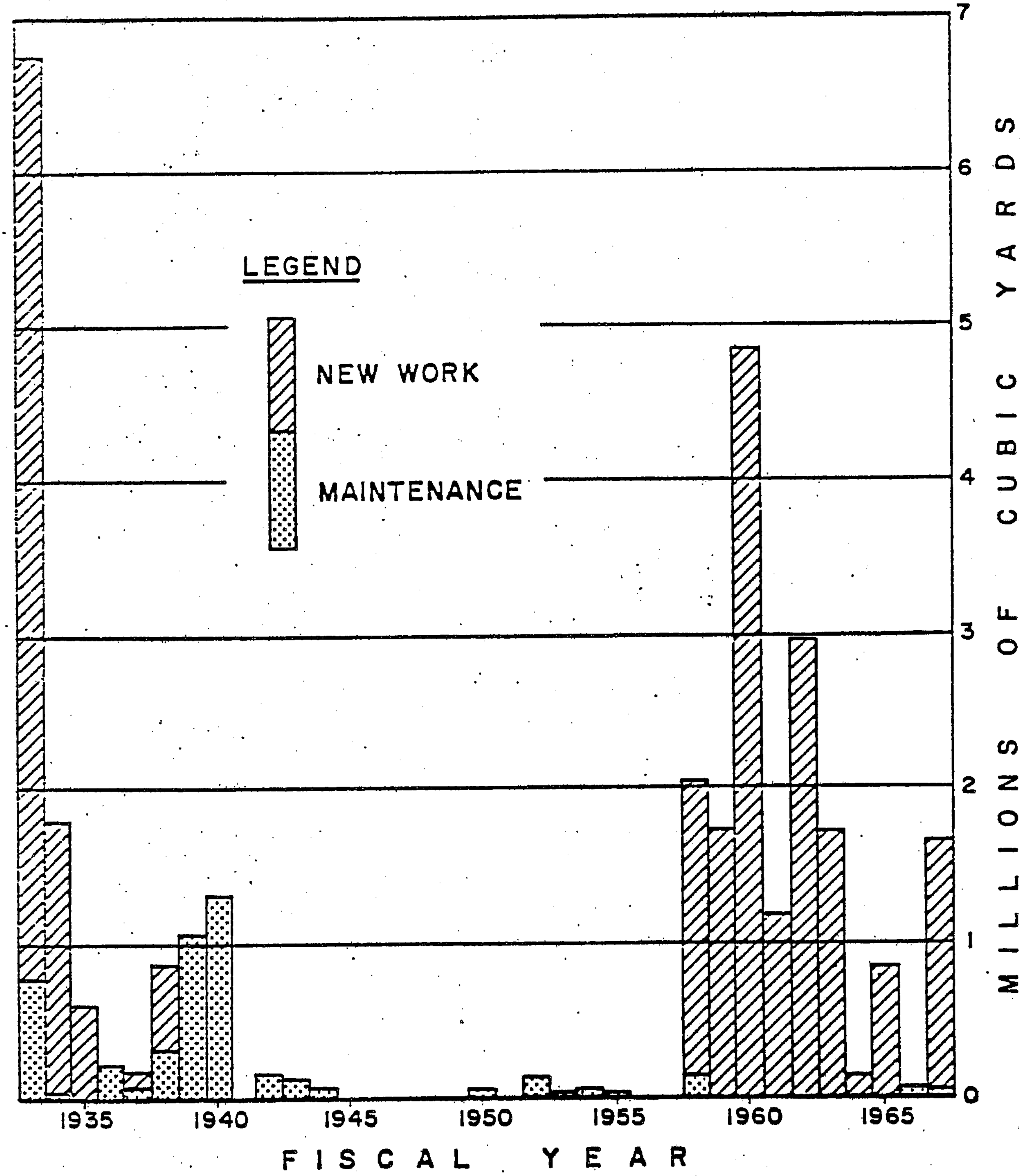

Figure 8. Dredging in St. Mary's River By Corps of Engineers

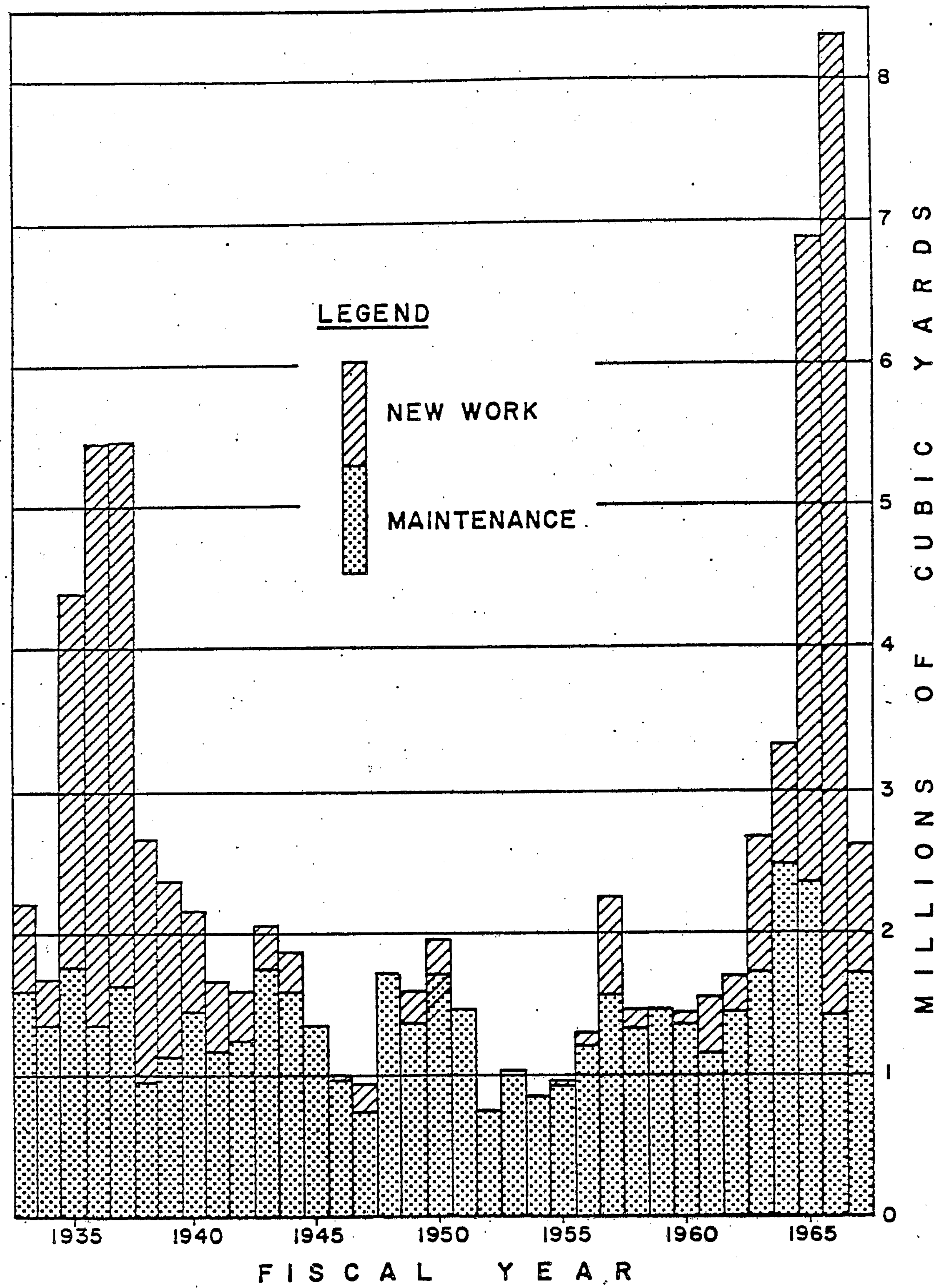

Figure 9. Dredging in Lake Michigan By Corps of Engineers

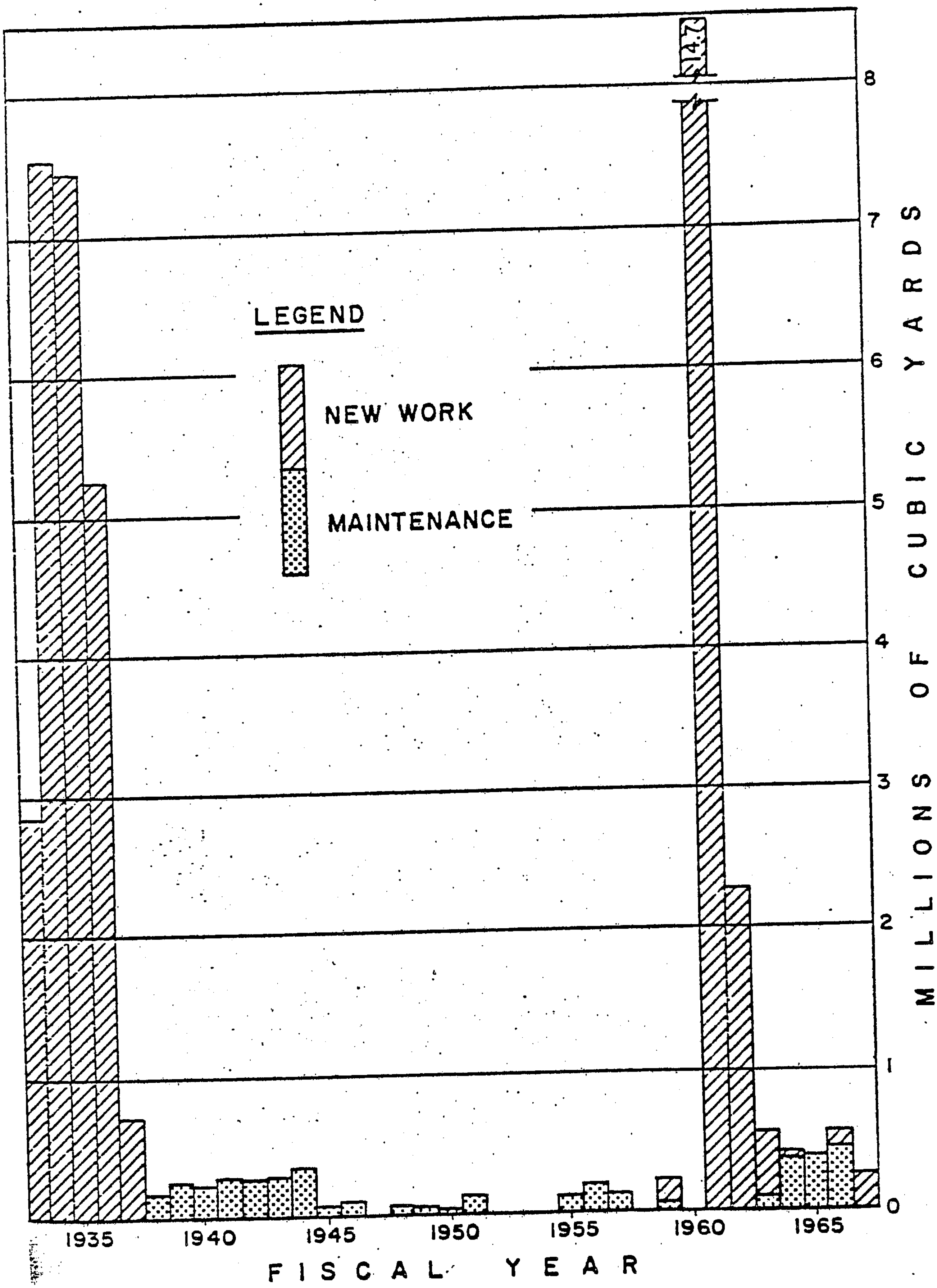

Figure 10. Dredging in Lake St. Clair and St. Clair River By Corps of Engineers

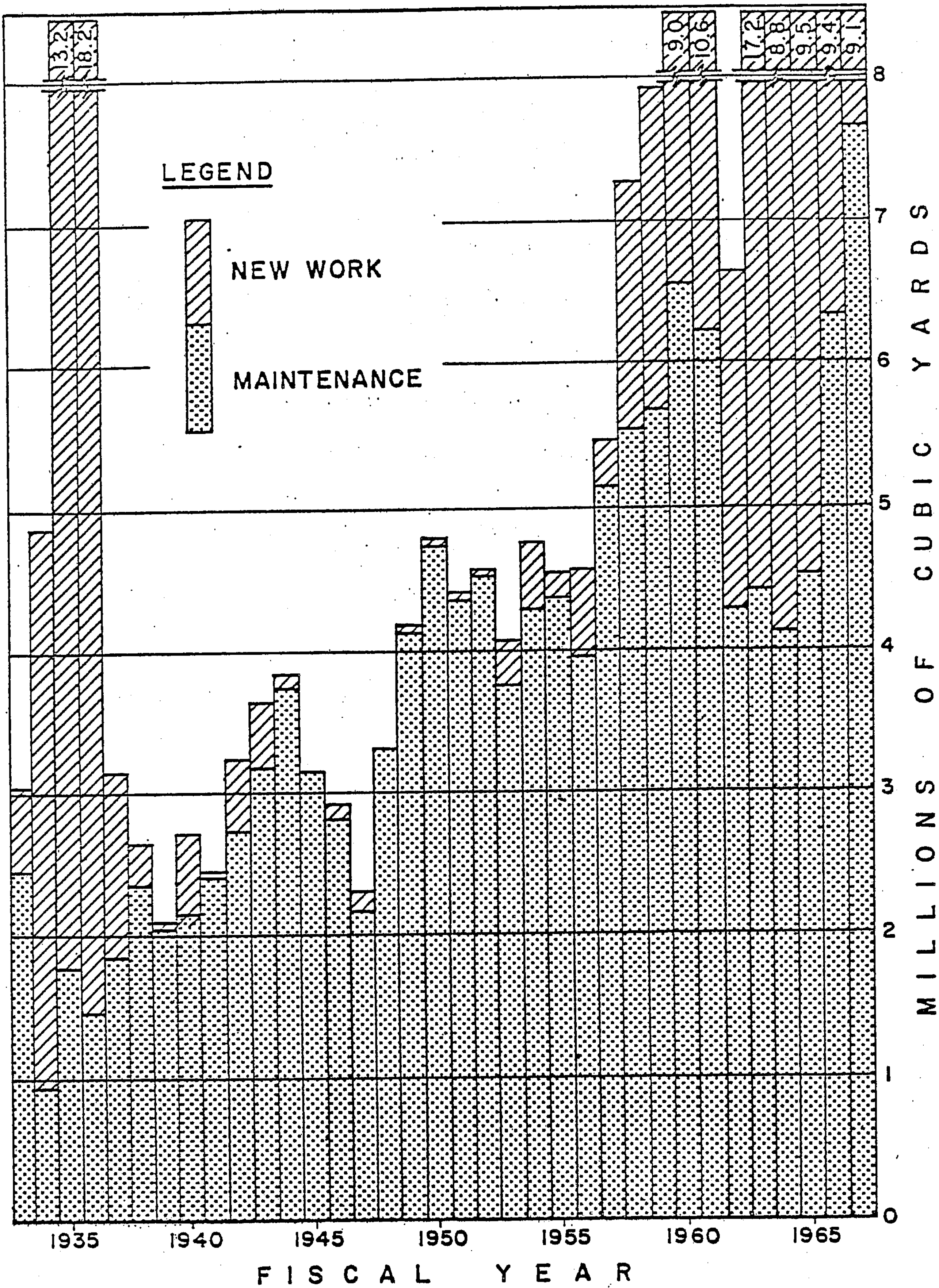

Figure 11. Dredging in Lake Erie and Lower Detroit River Including Rouge River By Corps of Engineers

TABLE 2

QUANTITY OF MATERIAL DREDGED FROM GREAT LAKES HARBORS AND METHODS OF DISPOSAL DURING FISCAL YEARS 1972 AND 1973

Harbor	FY 1972			FY 1973		
	On Land	Open Water	Total	On Land	Open Water	Total
Arcadia	–	–	0	13,000	–	13,000
Au Sable	–	41,675	41,675	–	7,420	7,420
Charlevoix	–	5,200	5,200	–	–	0
Frankfort	–	30,191	30,191	–	23,132	23,132
Grand Haven	–	79,094	79,094	56,742	28,993	85,735
Grand Morais	–	–	0	–	60,000	60,000
Grand River	44,378	–	44,378	41,000	–	41,000
Harrisville	–	25,950	25,950	–	–	0
Holland	68,519	10,695	79,214	60,000	44,600	104,600
Inalnd Route	76,259	–	76,259	–	–	0
Leland	–	18,600	18,600	–	24,400	24,400
Little Lake	–	37,305	37,305	–	34,525	34,525
Ludington	–	24,742	24,742	–	33,230	33,230
Manistee	–	42,969	42,969	7,440	24,593	32,033
Monroe	127,260	–	127,260	136,229	–	136,229
Muskegan	–	55,009	55,009	–	54,000	54,000
Pentwater	–	37,010	37,010	–	35,000	35,000
Portage Lake	–	–	0	–	48,150	48,150
Rouge River	135,322	–	135,322	151,504	–	151,504
Saugatuck	–	41,980	41,980	–	37,100	37,100
Saginaw	86,944	–	86,944	87,943	69,262	157,205
South Haven	16,178	6,789	22,967	3,762	37,754	41,516
St. Clair River	–	26,337	26,337	–	8,800	8,800
St. Joseph	42,269	10,003	52,272	8,012	39,792	47,804
St. Mary's River	–	122,011	122,011	–	40,123	40,123
Toledo	1,273,181	103,841	1,377,022	513,013	165,611	678,692
Whitefish	–	23,327	23,327	–	33,500	33,500

Data Source: U. S. Environmental Protection Agency (1973) waste discharges which now end up as harbor sediments. While the volume of such discharges is large, it is generally only a small fraction of the dredging volume. Increased soil conservation practices may reduce the amount of sediment originating from soil erosion, but, up to the present, such practices have been implemented only at small watersheds. Table 3 shows the U. S. Army Corps of Engineers (1969) estimates for future annual maintenance dredging for the various harbors currently maintained by the Corps. The tabulated values do not reflect any reductions which may result from the aforementioned control measures.

2.2 Polluted Harbor Sediments

Sediments become polluted before, during, and after transport into harbors. In general, the sources of pollution can be categorized as municipal, industrial, and agricultural. Agricultural pollution derives from animal wastes and from the use of fertilizers and pesticides, whose residues are washed or leached into streams and other drainage channels. Some contamination of sediments and water must be ascribed to municipal wastewaters that are emptied into receiving waters as stormwater discharges, overflows of combined sewers, spillage from surcharged and broken sewers, and effluents from sewage treatment plants. Industrial wastewaters may be added along with municipal sewage or directly through industrial outfalls.

Little is known about the ability of sediments to sorb and hold specific pollutants except for recent work on the sorption of phosphorus and nitrogen on particulate matter. While phosphorus commonly exists in solution in different ionic forms, direct precipitation of phosphatic salts is probably of little importance as a mechanism for their removal in nature. However, removal of phosphorus by sorption appears to be a significant mechanism, with clay minerals, limestone, dolomite, and iron, all having capacities to remove phosphatic salts from solution. Experiments have shown that sediments have a great capacity to adsorb phosphorus, but to date the mechanics of anionic sorption have not been fully identified. Total nitrogen in a stream is the sum of nitrogen occurring as ammonia, nitrite, nitrate, and organic nitrogen. Fifty to ninety percent of the total nitrogen probably is precipitated as organic particles or sorbed on sediments as molecules. Ammonia (NH_3) is electrically neutral, but is a highly polar molecule, and is capable of being adsorbed on clay.

TABLE 3

ESTIMATED QUANTITIES OF FUTURE ANNUAL MAINTENANCE DREDGING

Lake or Connecting Channel	Name of Harbor or River Project	Future Annual Maintenance Dredging in 1,000 Cu. Yds.
Lake Ontario	Great Sodus Bay Harbor	40
	Oswego Harbor	80
	Rochester Harbor	360
	Other small projects	nil
		480
Lake Erie, Niagara and Detroit Rivers	Ashtabula Harbor	220
	Black Rock Channel & Tonawanda Harbor	100
	Buffalo Harbor	525
	Cleveland Harbor	1,220
	Conneaut Harbor	100
	Detroit River	800
	Dunkirk Harbor	20
	Erie Harbor	300
	Fairport Harbor	400
	Huron Harbor	200
	Lorain Harbor	300
	Monroe Harbor	240
	Rouge River	300
	Sandusky Harbor	600
	Toledo Harbor	1,400
	Other small projects	35
		6,760
Lake Huron, St. Mary's River	Au Sable Harbor	40
	Harbor Beach	30
	Saginaw River	600
	St. Mary's River	250
	Other small projects	100
		1,020

TABLE 3 (Con't.)

Lake or Connecting Channel	Name of Harbor or River Project	Future Annual Maintenance Dredging in 1,000 Cu. Yds.
Lake Michigan	Calumet Harbor and River	200
	Chicago Harbor and River	108
	Charlevoix Harbor	30
	Frankfort Harbor	32
	Grand Haven Harbor and River	100
	Green Bay Harbor	137
	Holland Harbor	105
	Indiana Harbor	151
	Kenosha Harbor	29
	Kewaunee Harbor	28
	Ludington Harbor	55
	Manistee Harbor	55
	Manistique Harbor	40
	Manitowoc Harbor	35
	Michigan City Harbor	48
	Milwaukee Harbor	70
	Muskegon Harbor	105
	Pentwater Harbor	70
	Portage Lake Harbor	40
	Racine Harbor	30
	Saugatuck Harbor	55
	Sheboygan Harbor	23
	South Haven Harbor	74
	St. Joseph Harbor	80
	Two Rivers Harbor	51
	Waukegan Harbor	32
	White Lake Harbor	60
	Other small projects	37
		1,880
Lake Superior	Duluth-Superior Harbor	150
	Ontonagen Harbor	80
	Keweenaw Waterway	40
		270

TABLE 3 (Con't.)

Lake or Connecting Channel	Name of Harbor or River Project	Future Annual Maintenance Dredging in 1,000 Cu. Yds.
Lake St. Clair, St. Clair River	Clinton River	20
	Lake St. Clair	200
	St. Clair River	200
	Other small projects	7
		427
	Total	10,837

Data Source: U. S. Army Corps of Engineers (1969)

Nitrite (NO_2^-) and nitrate (NO_3^-) may be transported by anionic sorption mechanisms, but they probably are transported as sorbed organic nitrogen compounds or as nitrogen in discrete organic particles (U. S. Army Corps of Engineers, 1969).

For the most part, sediments from upstream sources are deposited in river channels and inner harbors. In addition, sand is piled against the windward side of breakwalls by littoral drifts. During storm conditions, wind and wave action blow and wash sand particles over the breakwalls and into the relatively calm waters of the harbor, where they settle as shoals. These sediments are susceptible to pollution by watercraft in the harbors and waterways, as well as from municipal and industrial discharges.

The U. S. Environmental Protection Agency (1973) has identified the Great Lakes harbors containing major areas of polluted sediments. These harbors are listed in Table 4 and shown for each lake on Figures 12 through 16.

2.3 Techniques for Handling Polluted Sediments

The best control of pollution is at the source. Regulatory agencies are engaged presently in a concerted effort to require municipalities and industries to treat their wastewaters more intensively to decrease their pollutants. Control of land erosion could greatly reduce the contribution of agricultural pollution. Control at the source, whether municipal, industrial, or agricultural, will require time and funds. Estimates of how soon control measures at the source will result in the reduction of pollutants to an amount equal to the natural assimilation capacity of the receiving waters is only conjecture.

Therefore, alternate disposal methods must be considered; these include: (1) alteration in equipment and procedures used in connection with open lake disposal, (2) treatment of dredged materials to remove or stabilize pollutants to a degree that the sediments could be deposited into open lake disposal areas, and (3) disposal of dredgings in diked disposal areas. The following information on this alternative has been reported by the U. S. Army Corps of Engineers (1969).

2.3.1 Dredge Modifications. Spillage of dredgings from a loaded hopper often occurs during the trip to open lake disposal areas. The pitch and roll of the vessel causes a portion of the hopper contents to spill through the open overflow discharge pipe.

TABLE 4

GREAT LAKES HARBORS FOUND TO CONTAIN POLLUTED SEDIMENTS

LAKE SUPERIOR	Whitefish Harbor (northernmost 20 percent of area)
LAKE MICHIGAN	Frankfort Harbor (area in Lake Betsie)
	Grand Haven (from junction upstream)
	Holland Harbor (inner section, upper 33 percent of channel)
	South Haven Harbor (upper 33 percent of channel)
	St. Joseph Harbor (from C & O R. R. upstream, upper 50 percent)
	Traverse City Harbor (all)
LAKE HURON	Alpena Harbor (all)
	Bay Port Harbor (all)
	Caseville Harbor (from shoreline upstream)
	Clinton River Harbor (from turning basin disposal area upstream)
	Harbor Beach Harbor (all)
	Inland Route and Crooked River Channel (all)
	Lake St. Clair (all)
	Les Chenneaux Island Channel (all)
	Port Austin Harbor (33 percent of basin nearest to shore)
	Port Sanilac Harbor (all)
	Saginaw River (to point 6.5 miles off shore)
	Sebewaing River (from mouth outward)
LAKE ERIE	Bolles Harbor (all)
	Detroit River (east and west outer channel, lower Livingstone channel, lower 67 percent of Trenton channel and lower 50 percent of Amherstburg channel)
	Monroe Harbor (all)
	Port Clinton (all)
	Rouge River (all)
	Toledo (to 5 miles offshore)
LAKE ONTARIO	None

Data Source: U. S. Environmental Protection Agency (1973)

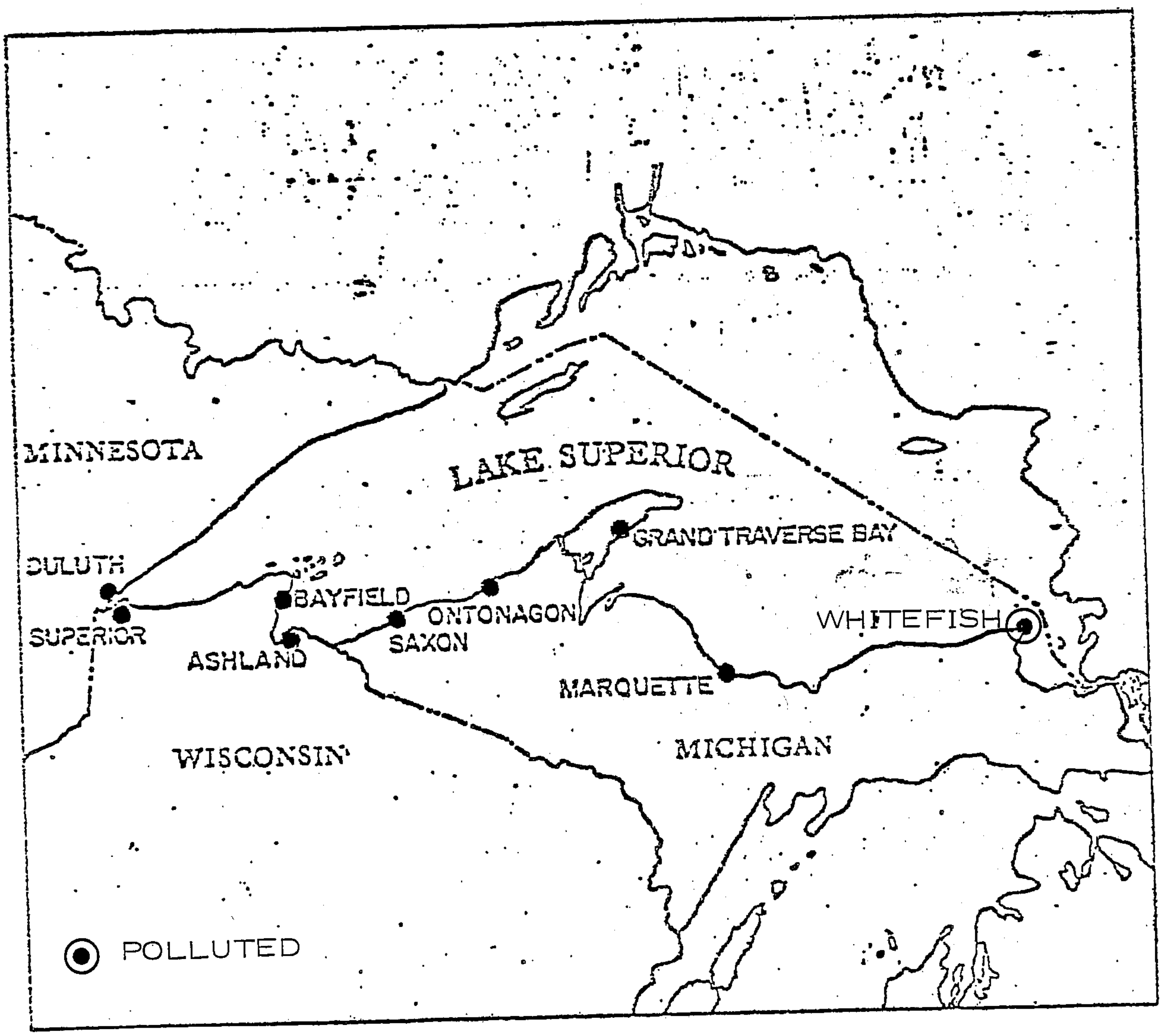

Figure 12. Polluted Harbors on Lake Superior

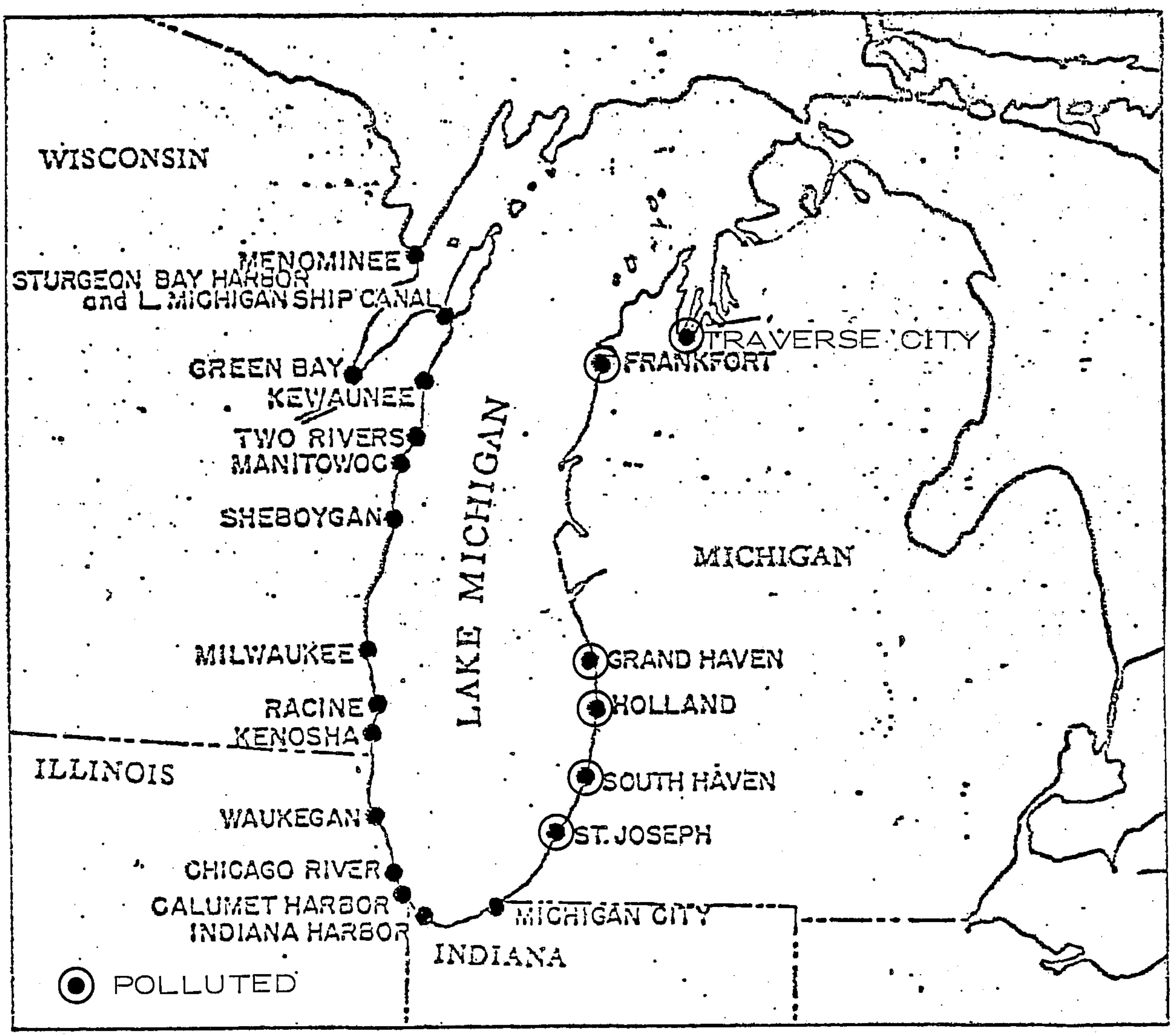

Figure 13. Polluted Harbors on Lake Michigan

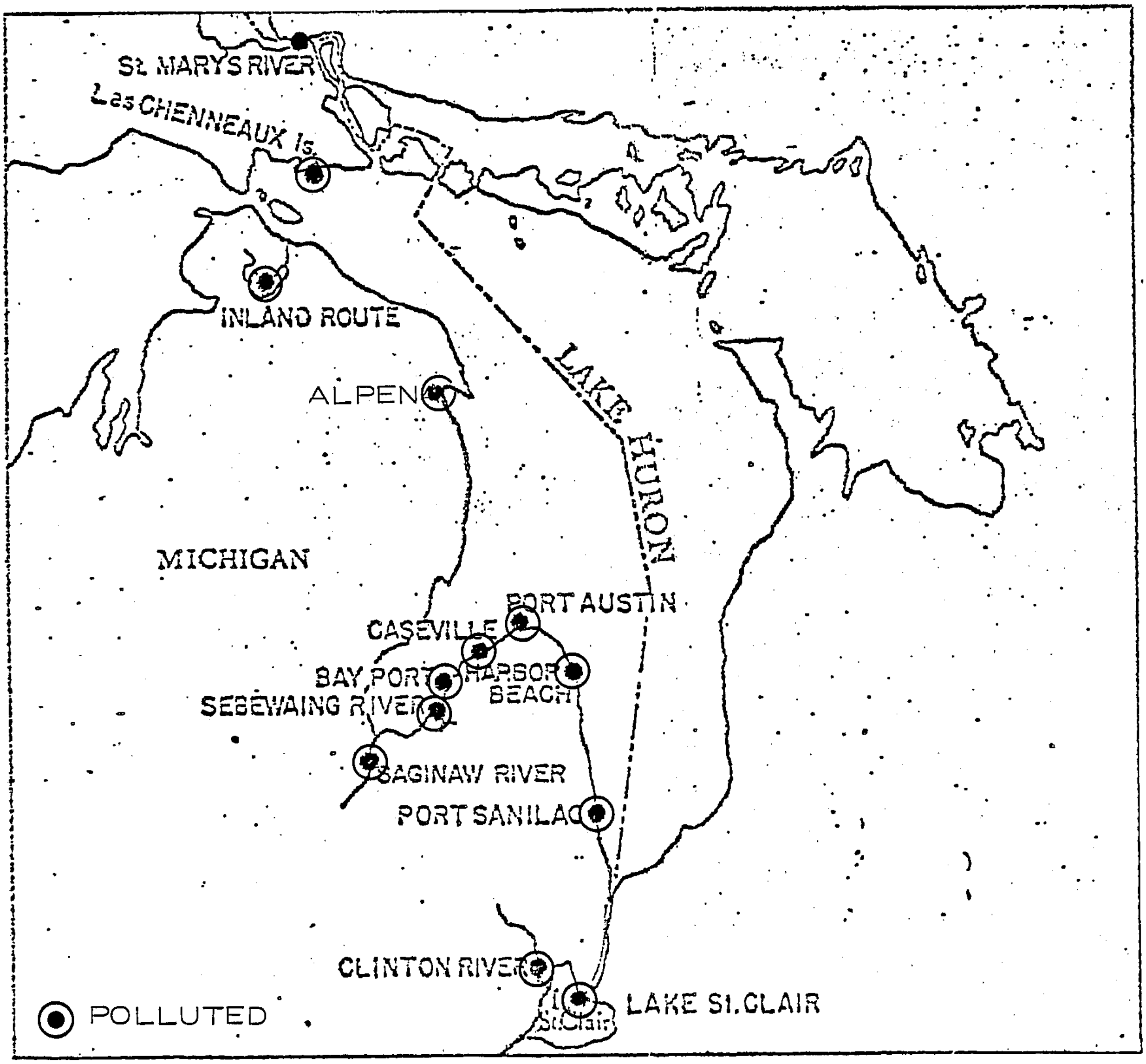

Figure 14. Polluted Harbors on Lake Huron

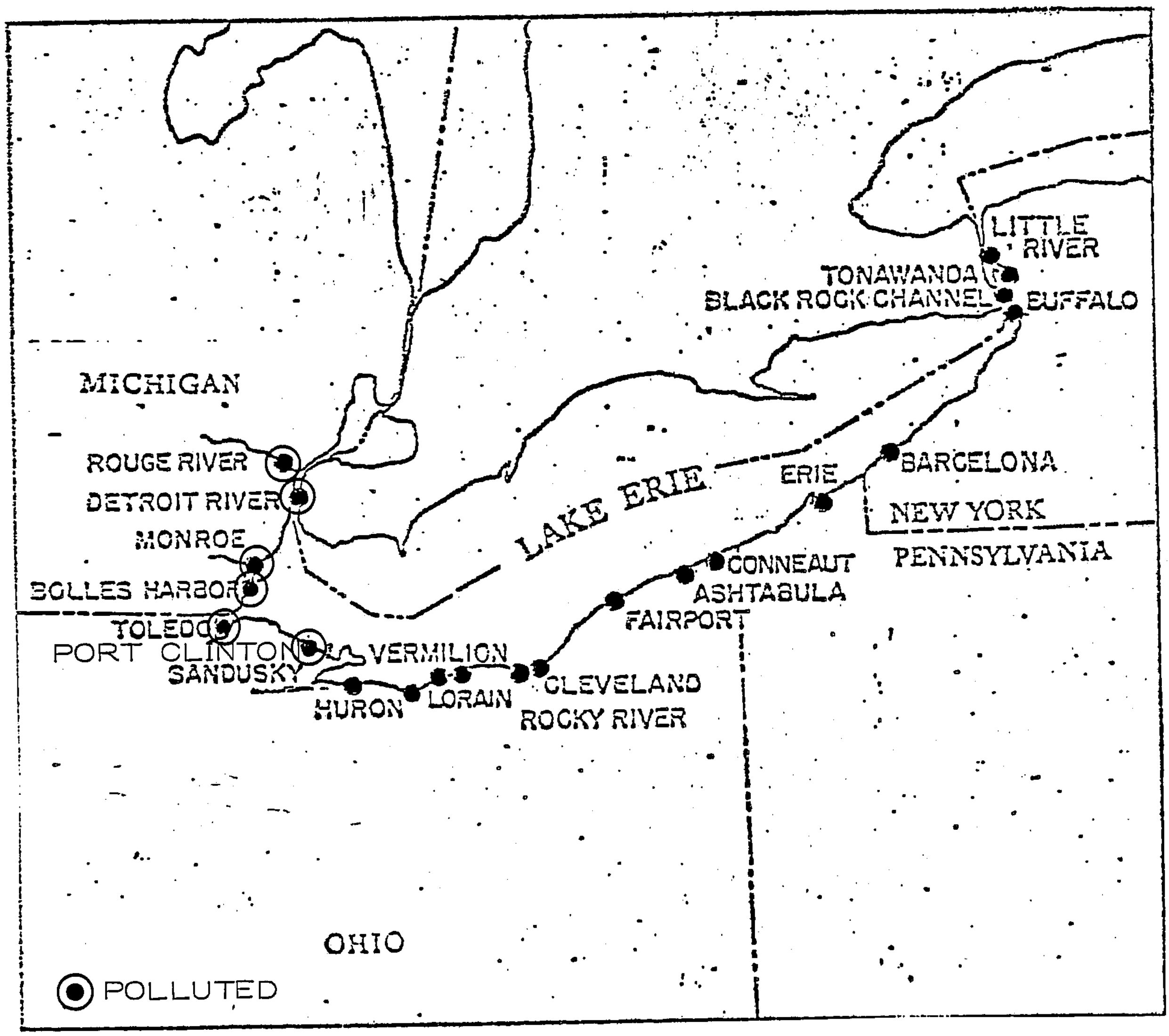

Figure 15. Polluted Harbors on Lake Erie

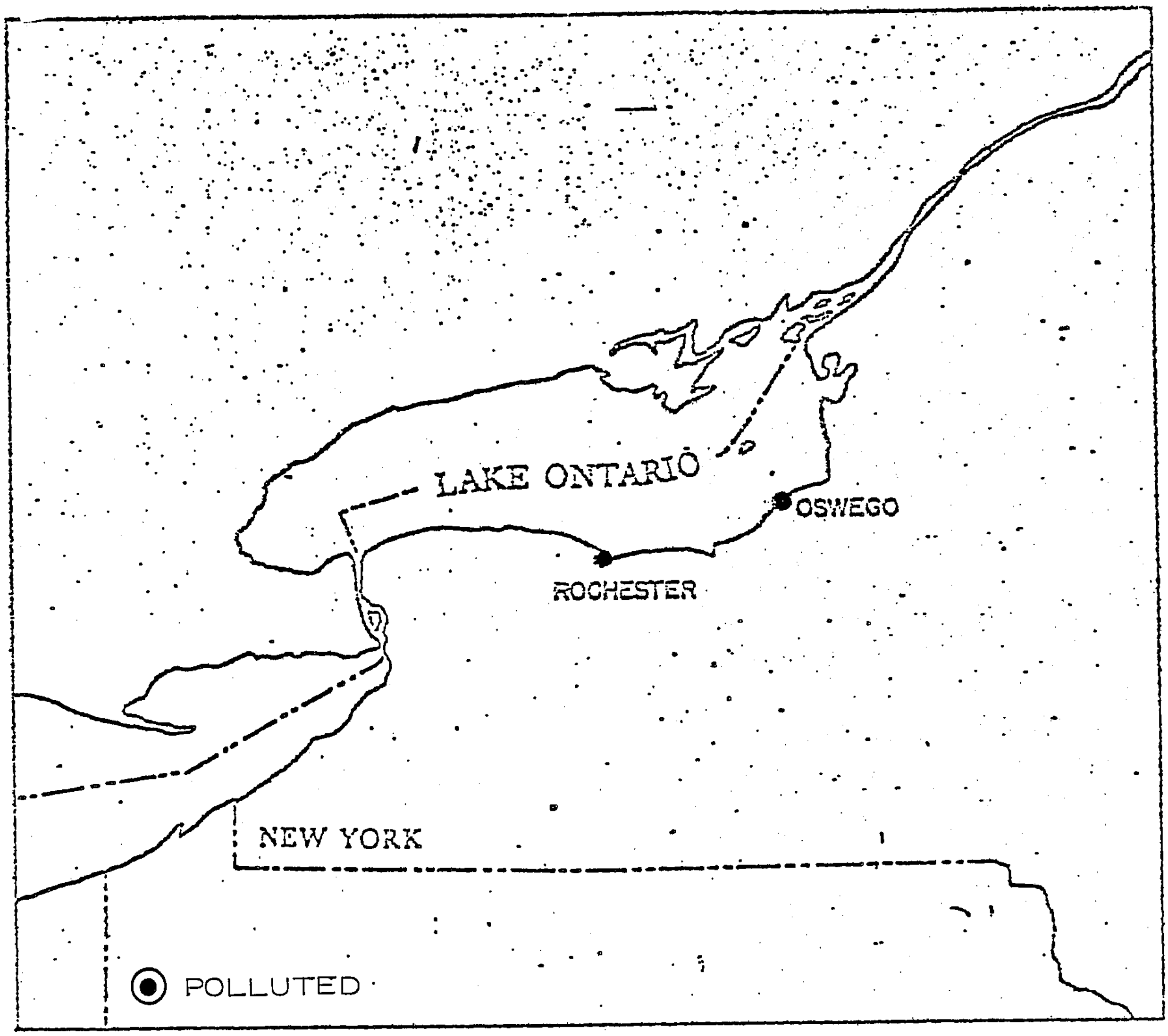

Figure 16. Polluted Harbors on Lake Ontario

The Philadephia District of the Corps of Engineers designed a temporary closure structure for the Markham class hopper dredge. To prevent discharge, a gate valve would be installed in the entrance of the discharge pipe. It was estimated that the cost of the installation would be about $4,600. A similar problem exists on the Lyman class dredge. The original equipment for this class vessel included a one-foot high weir gate which was used to increase the capacity of the hoppers. During modification of the hoppers a number of years ago, the weir gate was removed. It could be reinstalled at costs similar to those discussed above for the Markham class.

Consideration was given to modifying the Markham to reduce surface effects in the disposal area by discharging the dredgings at least 45 feet below the water surface. Philadelphia District designed a temporary "jury rig" structure to test the feasibility of the plan. A 24-inch diameter piping system could be installed in lieu of the existing starboard shore pumpout connection. A 65-foot section of piping could be lowered with a cargo boom after the vessel had come to a complete stop in the open lake disposal area. Spoil could be pumped from the hoppers while the vessel was stationary. The estimated cost of installing the temporary structure was $28,000. Additional operating costs for using this method would be $0.06 per cubic yard.

Disposal of dredgings from hopper dredges in open lake areas normally is accomplished while the vessel is in motion. To reduce surface effects, consideration was given to stopping the dredge before discharging the dredgings. Tests were conducted on the dredge Lyman during maintenance dredging operations at Rochester and Buffalo in 1968. Aerial photographs and water samples were taken to determine the effects of stationary disposal compared with disposal while the dredge was underway. Stationary disposal reduces the extent of surface effects; but the dredge is required to remain stationary for a period of time or move very slowly as it leaves the area. Further, stationary disposal does not eliminate the need for washout, and this would become the major source of surface effects. Accordingly, the washout would have to be delayed until the dredge returned to the dredging area. The additional costs for increased dredge cycle time would be about: (1) $0.11 per cubic yard for Lyman class dredges; and (2) $0.03 per cubic yard for the Markham.

The normal dredging procedure with hopper dredges is to continue loading for a short time after the hoppers are filled initially. As indicated previously, this procedure increases the volume of dredged sediments that can be contained in the dredge, but it also causes some of the dredgings to be discharged back into the waters behind the dredge. It was estimated that the increase in the cost of dredging without overflow would average about $0.05 per cubic yard, but it could be as much as $0.12 per cubic yard for projects where the disposal site is a long distance from the dredging area.

While dredging Saginaw Bay, the pumping speed of the Markham was reduced after the hoppers were filled initially. The solids content of the overflow mixture was reduced from 18 to 12 percent by weight with no appreciable change in the cost of dredging. Similar tests were performed at Buffalo with the dredge Lyman, but the overflow solids content remained essentially the same as in the normal overflow. Additional tests would be required to determine the effects associated with the reduced pumping speed.

Recent modifications to dipper and clamshell dredging practices include the requirement that (1) scow pocket doors be fitted tightly to prevent leakage; (2) material spilled on the decks of scows during loading operations be washed off in the dredging area; and (3) free water in the scow pockets be spilled in the dredging area if it approaches the top of the scow pocket. To aid in the measurement of quantities dredged and to prevent spillage while moving to the disposal area, scows were leveled or trimmed before leaving the dredge. The above practices are expected to minimize surface effects from scows.

2.3.2 Treatment of Dredgings. Space requirements for complete treatment equipment preclude its on-board use or its assignment to auxiliary accompanying vessels. Among the possibilities of partial treatment methods requiring a limited amount of space, the following were considered for hopper dredges: (1) aeration; (2) flocculation; and (3) chlorination. Hopper dredges normally dispose of dredgings in the open lake, but pumping into diked areas appears to be becoming a more frequent and common practice.

2.3.3 Diked Disposal Areas. Treatment of supernatant from disposal areas prior to discharge back into waterways, has been considered by the Corps. They engaged the Dow Chemical Corporation to make a full scale field test at the Maumee River diked disposal area using the same chemicals as for the earlier tests on board the dredge Markham. The 30-acre Riverside spoil area was used for the field test. A two-acre corner was diked off to form a clarification pond. Supernatant from the main area was discharged into the clarification pond through a 250-foot long corrugated metal trough in which the chemicals were added. Before running the field test, many laboratory tests were run with different coagulants and aids and with a wide range of suspended solids. It was found that the flocculation was most effective with Purifloc C-31 when suspended solids were at a concentration of about 8,000 mg/l and very good at concentrations up to 20,000 mg/l. Above this level, the effectiveness decreased rapidly. Below the 8,000 mg/l level, effectiveness decreased also, but the addition of ferric chloride improved the flocculation. Ferric chloride alone was effective also, but produced a weak, light floc which settled slowly. At low concentrations of suspended solids, a combination of ferric chloride and Purifloc C-31 proved to be best.

The concentration of suspended solids in the water discharged into the coagulation pond was only 60 mg/l during the 48-hour field test at the disposal area. Chemicals used were 33 mg/l of ferric chloride and 7.5 mg/l of Purifloc C-31. Suspended solids were reduced to as little as 10 mg/l; phosphates decreased from 0.16 to 0.10 mg/l; coliform count dropped from 14,700 to 9,000 per 100 ml; and chemical oxygen demand and dissolved oxygen increased slightly. The cost of chemicals used was $0.01 per cubic yard of dredging. Dow Chemical Corporation believes that the concentration of suspended solids was too low for an optimum test. Actually, there should be little need for coagulation with so low a level of suspended solids. With higher concentrations, it is probable that the ferric chloride could be eliminated and the same results could be obtained using the same amount of polymer.

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