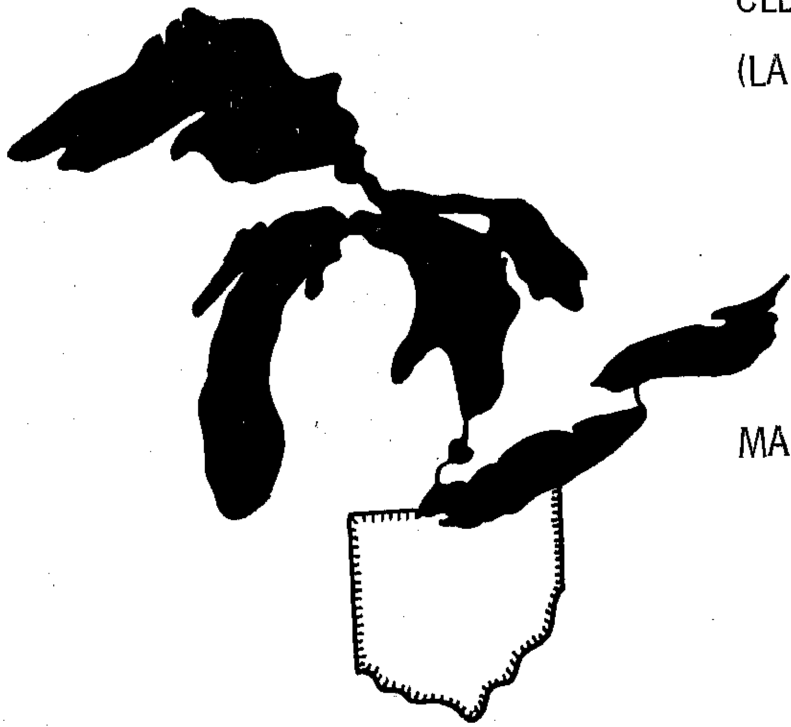
CLEAR TECHNICAL REPORT NO. 245

(LAKE ERIE TAT CONTRIBUTION NO. 20)



LAKE ERIE INTENSIVE STUDY: MAIN LAKE SEDIMENT CHEMISTRY - 1979

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COLUMBUS, OHIO

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1979 LAKE ERIE MAIN LAKE SURFACE SEDIMENT SURVEY

SUMMARY

Data from the 1979 main lake surface sediment survey indicates that some metals are highly concentrated offshore from tributary mouths near major industrial areas. Lead, nickel, copper, silver, vanadium, mercury, zinc, cadmium and chromium show elevated levels offshore from the Detroit River. Mercury is also high along the Pennsylvania/New York shoreline. Zinc and cadmium show high concentrations off Cleveland and Erie, Pennsylvania. Chromium is also high near Buffalo.

In addition, 14 of the elements show very high concentrations at Station 1, which is located offshore from the Welland Canal. It is suggested that high sediment levels here are caused by ships using this anchorage area prior to or following passage through the canal.

Data analysis shows that parts of the central and eastern basins have the highest mean concentrations of elements in the sediments. These areas correlate generally with the known sediment sinks in Lake Erie. Thus, it appears that many metals which are sedimented in the western basin may be re-distributed along with the sediments to sinks in the central and eastern basins.

METHODOLOGY

Sediment samples were collected from 80 main lake stations (Figure 1) during the summer of 1979 by the U.S. Environmental Protection Agency, Region V. One core was taken at each station except where prevented by unsuitable bottom conditions. Analytic work was done by the EPA's Central Regional Laboratory. The top 10 cm of each core were homogenized and analyzed for 19 elements. The remaining material from some of the cores was also analyzed as a second sediment layer. However, because these data are incomplete and inconsistent regarding depth, they are not included in this report.

Concentrations reported by EPA are given in Table 1, expressed as mg kg^{-1} dry weight except as noted. The values were plotted onto main lake station maps, from which contour maps were prepared to show the distribution of the elements in the main lake sediments (Figures 2-17).

Statistical analysis of the data was limited by the lack of comparable historical data for main lake sediments and by the nature of the survey, i.e., only one core per station. In addition, data were unavailable for 11 stations (3, 4, 8, 11, 23, 34, 40, 50, 51, 82 and 85). In some cases, the values reported were known to be higher than actual values; these data were not included in the mapping or data analysis. A cluster analysis was used to group like areas of the lake sediments together on the basis of 9 elements for which a complete data set was available.

RESULTS AND DISCUSSION

Aluminum (Figure 2) is a major constituent of the natural sediment input to the lake. Illite is the dominant clay mineral in Lake Erie, forming a very fine-grained sediment transported to deep sink areas. Aluminum is fairly well distributed throughout the lake, with somewhat higher concentrations in the central and eastern basins.

Titanium (Figure 3) is closely related to aluminum in the sediments. It is distributed fairly evenly except in the eastern basin, where there are high concentrations in the sink area and at Station 1, located offshore from the Welland Canal.

Iron (Figure 4) is the most abundant element found in main lake sediments. Concentrations of Fe are affected by the condition of overlying water, decreasing as Fe is released from the sediment during periods of anoxia. High concentrations were found in the central and eastern basins.

Manganese (Figure 5) shows a somewhat spotty distribution. It also is released from the sediments under anoxic conditions. Fairly high levels are found in parts of the central basin, with very high concentrations between the central and eastern basins and at Station 1.

Lead (Figure 6), one of the important industrial metals, shows a characteristic pattern of distribution: higher concentrations near the mouth of the Detroit River, in deep sink areas of the central and eastern basins, and at Station 1.

Nickel (Figure 7) shows elevated levels off the Detroit River and in the western basin, in much of the central basin, and at Station 1.

Mercury (Figure 8), with higher concentrations in the western basin, demonstrates the re-distribution of surface sediments from the Detroit River area eastward. There are high concentrations also in the eastern basin, along the Pennsylvania/New York shoreline, and, to a lesser degree, off Cleveland.

Zinc (Figure 9) shows elevated levels off the Detroit River and in the western basin generally, and at Station 1. Somewhat higher concentrations are found near Cleveland and Erie, Pennsylvania.

Copper (Figure 10) has its highest concentrations off the Detroit River and in the western basin generally, as well as at Station 1.

Molybdenum (Figure 11) shows higher concentrations in the central and eastern basin areas and at Station 1.

Silver (Figure 12) was reported in the sediments only in areas off the Detroit River and in the central basin.

Barium (Figure 13), Cobalt (Figure 14) and Vanadium (Figure 15) show high concentrations off the Detroit River, in the central and eastern basins, and at Station 1.

Chromium (Figure 16) has very high levels off the Detroit River and at Station 1, with fairly high levels generally in the western basin and near Buffalo.

Cadmium (Figure 17) was reported off the Detroit River, off Cleveland and Erie, Pennsylvania, and in the central basin.

Beryllium, Tin and Boron were reported in the sediments only at Station 1.

The results of a cluster analysis, using 9 elements for which a complete data set was available, are given in Table 2. For the most part, the analysis is dominated by Al and Fe, the most abundant components of the lake sediments. Except for Cluster No. 1, the groups show a general ordered increase in mean concentrations of the elements. Cluster No. 1 includes Station 1, with its high concentrations of 5 of these elements in conjunction with relatively low levels of Al and Fe.

The areas of the lake corresponding to Cluster No. 4 (highest mean concentrations) are located in the central and eastern basins. Fairly high concentrations (Cluster No. 3) are found in the middle portion of the western basin, and in the central and eastern basins. Moderate levels (Cluster No. 2) are located in parts of all 3 basins. Low concentrations (Cluster No. 1) are found in the northeast part of the central basin and at Station 1 (Figure 18).

Figure 19 shows the general sediment deposition pattern determined for Lake Erie. The light areas represent depositional zones for fine-grained silt and clay particles and organic matter, especially in the deep areas of the central and eastern basins. In general, the depositional zones correspond to the areas of highest element concentrations. In addition, the large non-depositional area in the northeastern part of the central basin correlates well with the low concentration area derived from the cluster analysis.

CONCLUSIONS

1. High concentrations of heavy metals are found in the main lake sediments offshore from tributaries draining major industrial areas.

2. High concentrations of 14 elements are found in Station 1 sediments; this is the anchorage area for the Welland Canal.

3. Areas of highest mean concentrations for 9 elements correspond generally to Lake Erie depositional zones, especially the deep

sink areas in the central and eastern basins; elements sedimented in western Lake Erie may thus be transported eventually to the central and eastern basin sink areas.

TABLE 1

LAKE ERIE SURFACE SEDIMENT SURVEY, 1979
(Mg/Kg Dry Weight)

STATION NO.	Ag	Al	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sn	Ti	V	Zn	Oil & Grease	Phenols
1	3 K*	5800	87	210	3	2 K	39	180	75	13000	.005	2800	80	59	140	180	1600	160	380	320	.13
2	3 K	15000	80 K	91	1 K	2 K	5 K	36	16	23000	.02	710	13	30 K	30	100 K	200	28	79	390	.10
3	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3	---	---	---	---	---	---
4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
5	3 K	12000	80 K	41	1 K	2 K	7	15	13	24000	.01	340	10 K	30 K	30	100 K	82	16	72	360	.15
6	3 K	15000	80 K	65	1 K	2 K	10	23	22	31000	.03	450	11	30 K	30	100 K	110	23	94	720	.32
7	3 K	14000	80 K	65	1 K	2 K	12	35	28	30000	.1	460	13	30 K	42	100 K	83	31	150	870	.30
8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
9	3 K	24000	80 K	130	1 K	2 K	18	46	36	43000	.03	990	24	30 K	37	100 K	170	46	160	310	.41
10	3 K	24000	80 K	110	1 K	2 K	6	54	37	38000	.03	770	36	30 K	53	100 K	200	52	130	660	.38
11	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	3 K	16000	80 K	68	1 K	2 K	5 K	33	26	25000	.01	690	21	30 K	30	100 K	210	36	73	170	.14
13	3 K	11000	80 K	99	1 K	2 K	5 K	40	30	20000	.01	930	26	30 K	57	100 K	230	41	110	280	.16
14	3 K	20000	80 K	100	1 K	2 K	6	44	33	33000	.04	960	30	30 K	54	100 K	160	43	130	540	.21
15	3 K	25000	80 K	110	1 K	2 K	11	47	29	41000	.1	820	39	46	59	100 K	250	52	110	1620	.38
16	3 K	10000	80 K	63	1 K	2 K	8	27	18	23000	.01	450	22	30 K	48	100 K	100	22	71	570	.61
17	3 K	22000	80 K	150	1 K	2 K	14	51	45	41000	.02	1100	35	49	60	100 K	210	48	140	50	.56
18	3 K	21000	80 K	100	1 K	2 K	8	44	29	37000	.03	870	33	30 K	54	100 K	210	42	110	270	.40
19	3 K	13000	80 K	68	1 K	3	7	40	33	26000	.1	910	16	47	58	100 K	160	11	110	140	.47
20	3 K	15000	80 K	71	1 K	2 K	6	36	24	27000	.004	530	28	30 K	34	100 K	230	34	79	230	.72
21	4	14000	80 K	74	1 K	2 K	5 K	34	27	28000	.01	560	16	42	38	100 K	130	32	71	150	.25
22	3 K	12000	80 K	62	1 K	3	5 K	48	42	30000	.1	460	10 K	34	60	100 K	53	28	220	820	.34
23	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
24	3 K	6900	80 K	28	1 K	2 K	5 K	16	12	13000	.005	160	10 K	30 K	30	100 K	70	19	53	160	.30
25	5	18000	80 K	96	1 K	2 K	8	46	31	30000	.01	690	27	55	52	100 K	150	43	61	440	.30
26	6	15000	80 K	94	1 K	3	7	42	31	28000	.02	950	26	60	48	100 K	99	39	77	490	.21
27	6	7500	80 K	44	1 K	2 K	5	20	15	12000	.03	270	12	41	30	100 K	100	22	50 K	410	.24
28	5	15000	80 K	93	1 K	2 K	5	40	29	27000	.01	610	22	48	35	100 K	320	39	71	490	.16
29	3 K	17000	80 K	100	1 K	2 K	5 K	40	26	17000	.01	680	15	30 K	30	100 K	340	41	68	280	.24
30	3 K	13000	80 K	53	1 K	2 K	5 K	31	22	13000	.01	480	19	30 K	30	100 K	160	29	64	630	.56
31	3 K	12000	80 K	55	1 K	2 K	5 K	37	20	12000	.01	370	10 K	30 K	30	100 K	130	29	68	480	.27
32	3 K	7200	80 K	32	1 K	2 K	5 K	25	19	16000	.005	360	10 K	31	30	100 K	81	21	156	350	---
33	3 K	17000	80 K	73	1 K	2 K	5 K	42	35	28000	.1	430	18	49	611	100 K	93	46	160	750	.44
34	---	---	---	---	---	---	---	---	---	---	.003	---	---	---	---	---	---	---	---	310	---
35	3 K	11000	80 K	91	1 K	2 K	6	34	27	31000	.001	660	19	58	32	100 K	35	25	130	380	.21
36	3 K	20000	80 K	110	1 K	2 K	8	49	37	34000	.02	540	28	64	60	100 K	140	48	140	760	.71
37	3 K	24000	80 K	130	1 K	2 K	11	45	37	39000	.01	660	31	36	52	100 K	180	52	130	370	.56
38	3 K	21000	80 K	110	1 K	2 K	11	45	35	35000	.01	520	27	50	51	100 K	170	49	120	230	.30
39	3 K	15000	80 K	84	1 K	2 K	5 K	36	27	24000	.004	550	17	30 K	33	100 K	160	35	73	760	.14
40	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
41	3 K	18000	80 K	110	1 K	2 K	9	45	37	35000	.01	550	32	42	57	100 K	110	42	140	310	.43
42	4	21000	80 K	130	1 K	2 K	17	48	36	37000	.01	560	39	65	77	100 K	98	48	130	930	.38
43	3 K	21000	80 K	120	1 K	2 K	16	48	39	38000	.02	570	38	61	77	100 K	66	48	150	2980	.43
44	3 K	7400	80 K	49	1 K	3	6	30	34	19000	.04	520	15	30 K	64	100 K	67	23	150	1090	.41
45	3 K	11000	80 K	57	1 K	2 K	6	33	21	23000	.01	370	26	30 K	53	100 K	140	30	83	1110	.20
46	3 K	19000	80 K	100	1 K	2 K	5 K	38	29	32000	.02	460	23	30 K	36	100 K	150	41	120	350	.33
48	3 K	14000	80 K	110	1 K	2 K	5 K	35	23	25000	.01	1200	29	30 K	31	100 K	160	38	74	190	.21
49	3 K	14000	80 K	76	1 K	2 K	5 K	42	30	25000	.001	470	28	30 K	53	100 K	79	34	110	280	.42
50	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
51	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
52	3 K	15000	80 K	79	1 K	2 K	5 K	44	32	27000	.01	470	26	31	62	100 K	100	38	130	670	.60
53	3 K	14000	80 K	78	1 K	2 K	5 K	41	31	26000	.004	420	26	30 K	58	100 K	89	34	120	730	.80
54	3 K	13000	80 K	69	1 K	2 K	9	40	31	22000	.02	360	28	32	67	100 K	110	25	120	600	.63
55	3 K	8500	80 K	42	1 K	2 K	7	24	26	18000	.01	400	23	30 K	30	100 K	84	23	61	220	1.37
56	8	12000	80 K	58	1 K	3	5 K	73	46	23000	.1	460	22	72	110	100 K	130	37	180	170	.16
57	3 K	15000	80 K	72	1 K	2 K	6	66	44	29000	.1	560	16	37	78	100 K	130	40	170	970	.23
58	3 K	15000	80 K	92	1 K	2 K	8	56	42	29000	.1	520	27	42	80	100 K	73	37	170	---	.20
59	4	18000	80 K	110	1 K	3	9	51	59	35000	.02	630	28	59	100	100 K	42	43	230	1360	.31
60	3 K	13000	80 K	69	1 K	3	5 K	120	71	27000	---	450	21	43	100	100 K	120	32	260	1510	.15
61	8	14000	80 K	68	1 K	3	5 K	78	61	26000	.02	440	25	74	120	100 K	96	41	220	590	.47
62	3 K	6000	80 K	35	1 K	2 K	5 K	78	31	23000	---	690	19	43	54	100 K	48	22	210	---	---
63	3 K	13000	80 K	99	1 K	2 K	12	46	28	35000	.04	740	29	30 K	52	100 K	170	37	100	1020	.20
64	5	13000	80 K	60	1 K	4	8	44	23	27000	.1	490	19	30 K	44	100 K	150	33	86	1320	.34
65	3 K	10000	80 K	43	1 K	2 K	8	35	19	22000	.03	440	18	30 K	40	100 K	82	26	77	170	.65
66	3 K	11000	80 K	45	1 K	2 K	5 K	36	17	19000	.05	370	11	30 K	30	100 K	63	24	79	260	.56
67	3 K	16000	80 K	100	1 K	2 K	13	55	49	31000	.1	670	29	36	85	100 K	82	36	190	380	.26
68	3 K	13000	80 K	63	1 K	2 K	5 K	43	28	26000	.04	490	24	30 K	52	100 K	71	30	110	650	.18
73	3 K	17000	80 K	110	1 K	2 K	12	48	38	34000	.03	660	25	60	66	100 K	10	41	140	340	.49
74	3 K	8400	80 K	31	1 K	2 K	8	31	17	16000	.02	340	15	30 K	38	100 K	120	26	57	300	.27
75	3 K	8300	80 K	28	1 K	2 K	5 K	27	26	20000	.01	710	14	30 K	30	100 K	100	23	62	240	.14
78	3 K	16000	80 K	84	1 K	2 K	5 K	39	29	16000	.01	430	14	52	37	100 K	150	40	100	380	.64
79	3 K	13000	80 K	59	1 K	2 K	5 K	33	23	13000	.004	640	10 K	30 K	30	100 K	200	32	60	700	.32
80	3 K	10000	80 K	37	1 K	2 K	5 K	31	22	18000	.01	540	26	30 K	44	100 K	180	30	64	300	.29
81	3 K	19000	80 K	100	1 K	2 K	11	57	44	32000	.1	550	27	30 K	67	100 K	120	40	170	340	.45
82	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
83	3 K	9000	80 K	44	1 K	2 K	5 K	32	16	19000	0.0	400	19	30 K	44	100 K	140	28	64	460	.25
84	3 K	9600	80 K	99	1 K	2 K	5 K	73	51	23000	.1	500	20	41	67	100 K	110	35	180	1170	.17
85	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
86	3 K	13000	80 K	47	1 K	2 K	9	25	22	24000	.01	480	19	30 K	40	100 K	110	35	67	60	.10
87	3 K	7400	80 K	23	1 K	2 K	5 K	27	19	14000	.01	500	19	30 K	30	100 K	200	23	50	80	.17

*K denotes that the actual value is known to be less than the reported value.

TABLE 2

LAKE ERIE 1979 SEDIMENT SURVEY

CLUSTER MEANS (mg/kg dry weight)

CLUSTER NO.	AL	BA	CR	CU	FE	MN	HG	TI	VA
1	10,391	65	44	25	14,091	639	0.01	287	40
2	10,113	54	39	26	21,125	498	0.03	111	28
3	15,303	83	46	34	28,970	601	0.04	123	35
4	22,556	121	48	36	38,778	762	0.03	173	49

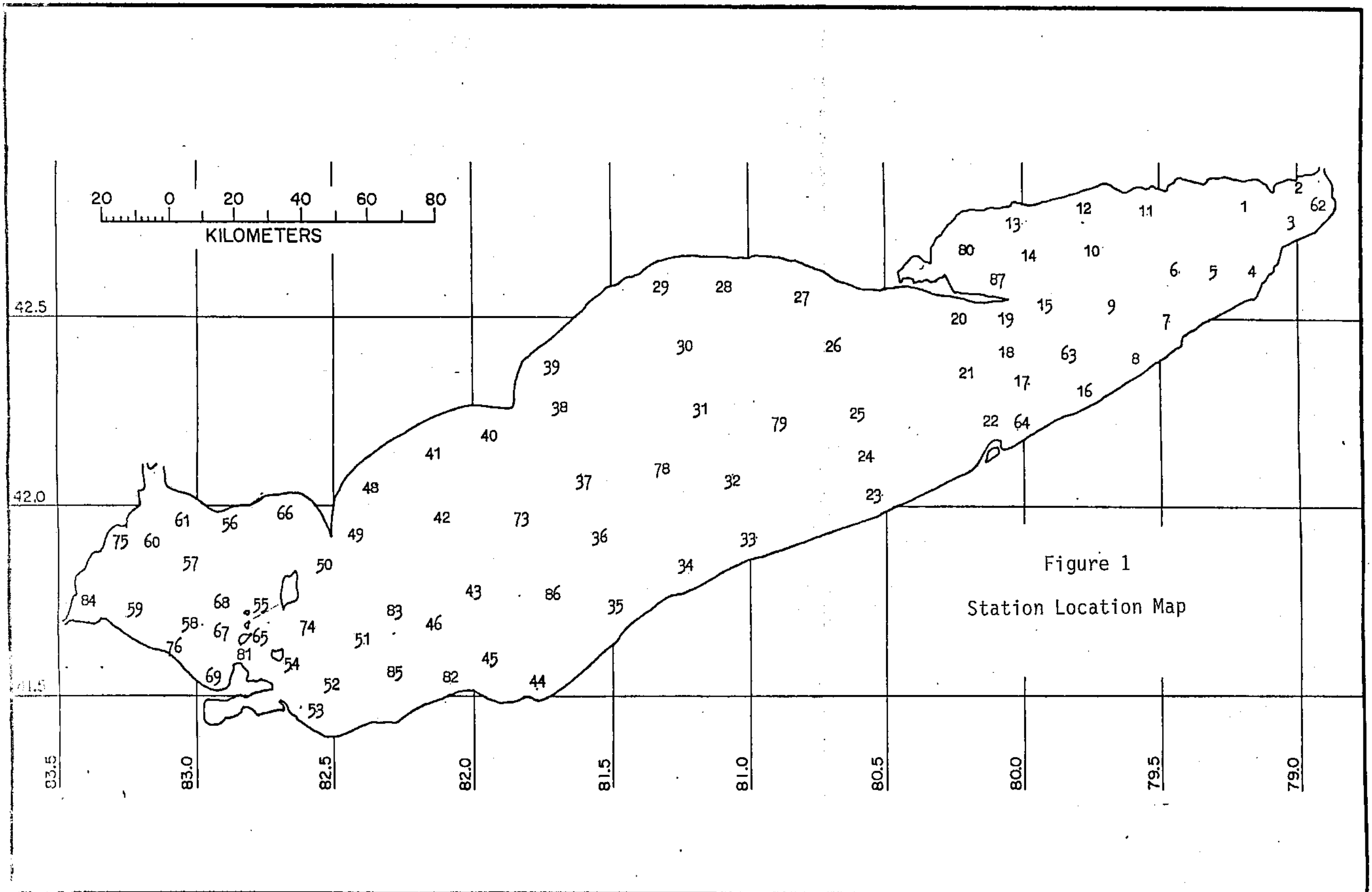

Figure 1

Station Location Map

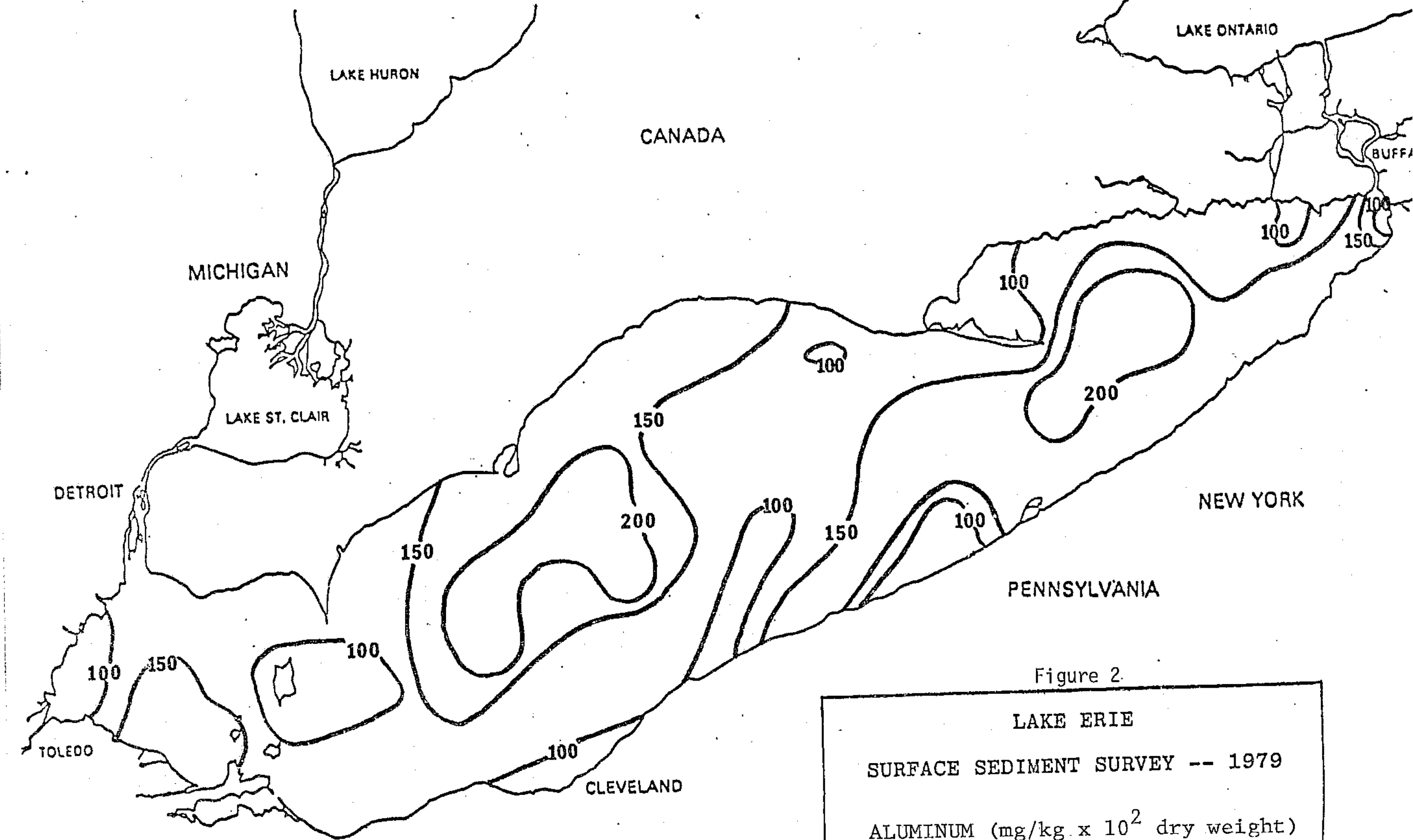

Figure 2

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

ALUMINUM (mg/kg x 10^2 dry weight)

Contour Interval = 50

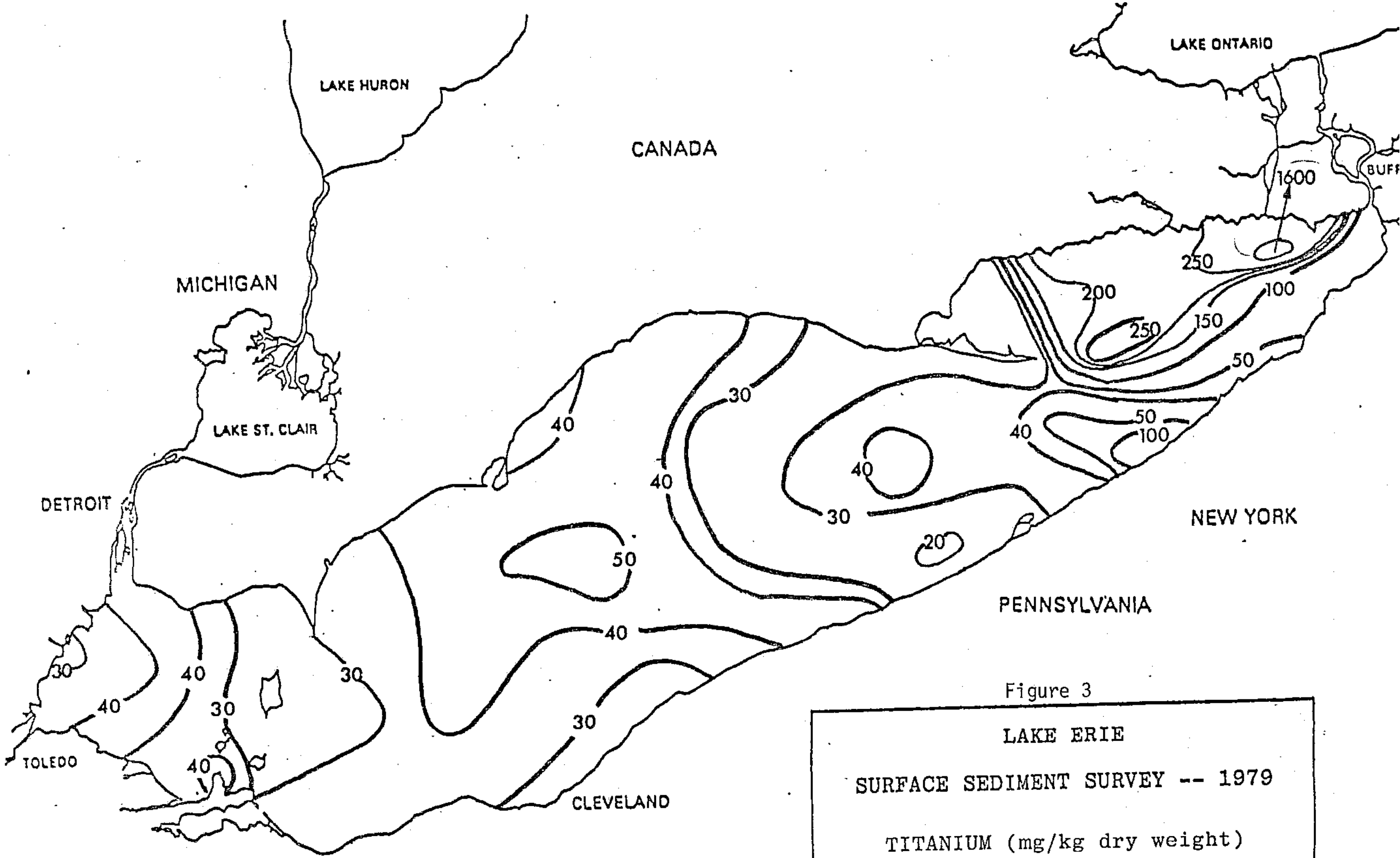

Figure 3

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

TITANIUM (mg/kg dry weight)

Contour Interval = 10

CI = 50 in Eastern Basin

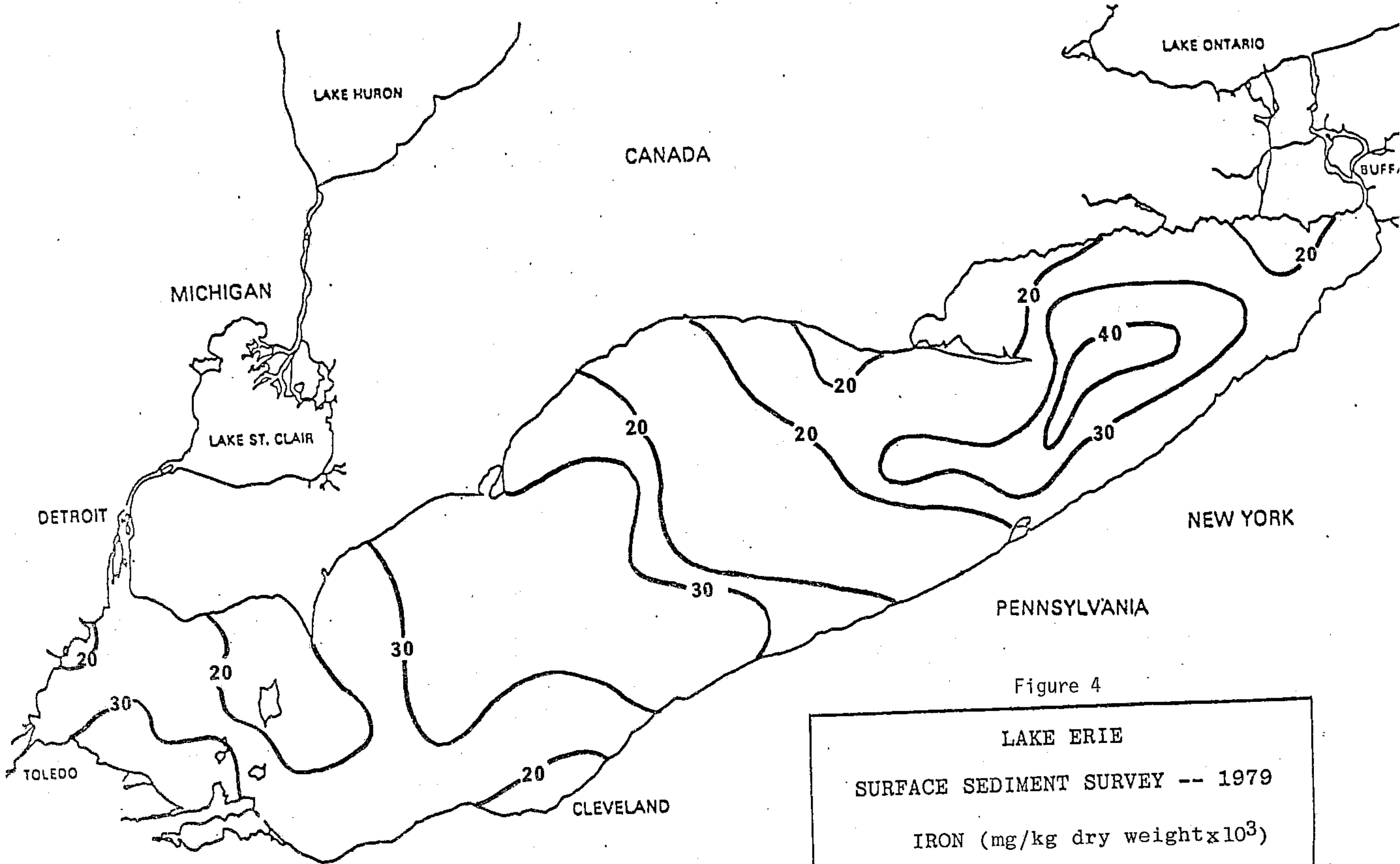

Figure 4

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

IRON (mg/kg dry weight x 10^3)

Contour Interval = 10

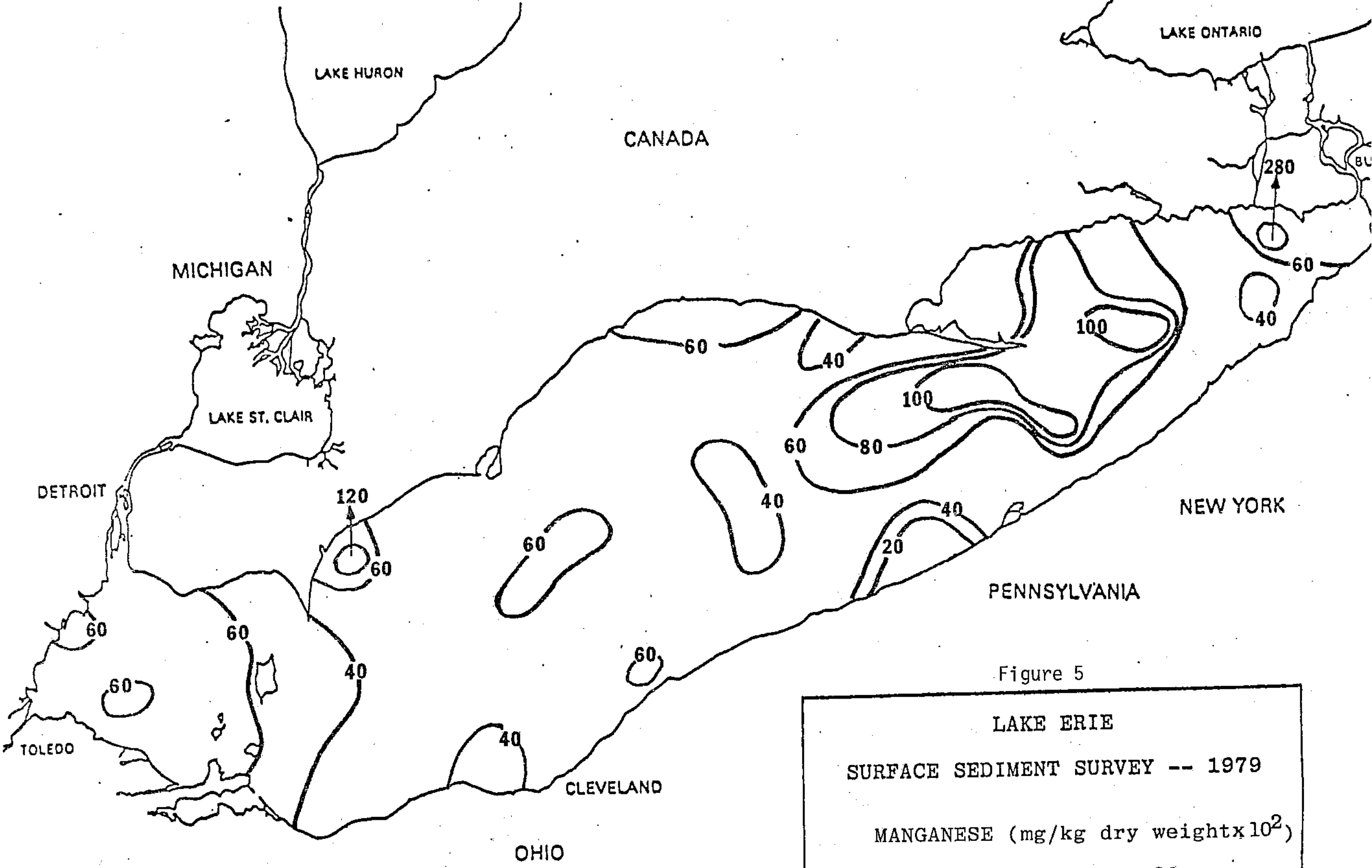

Figure 5

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

MANGANESE (mg/kg dry weight x 10^2)

Contour Interval = 20

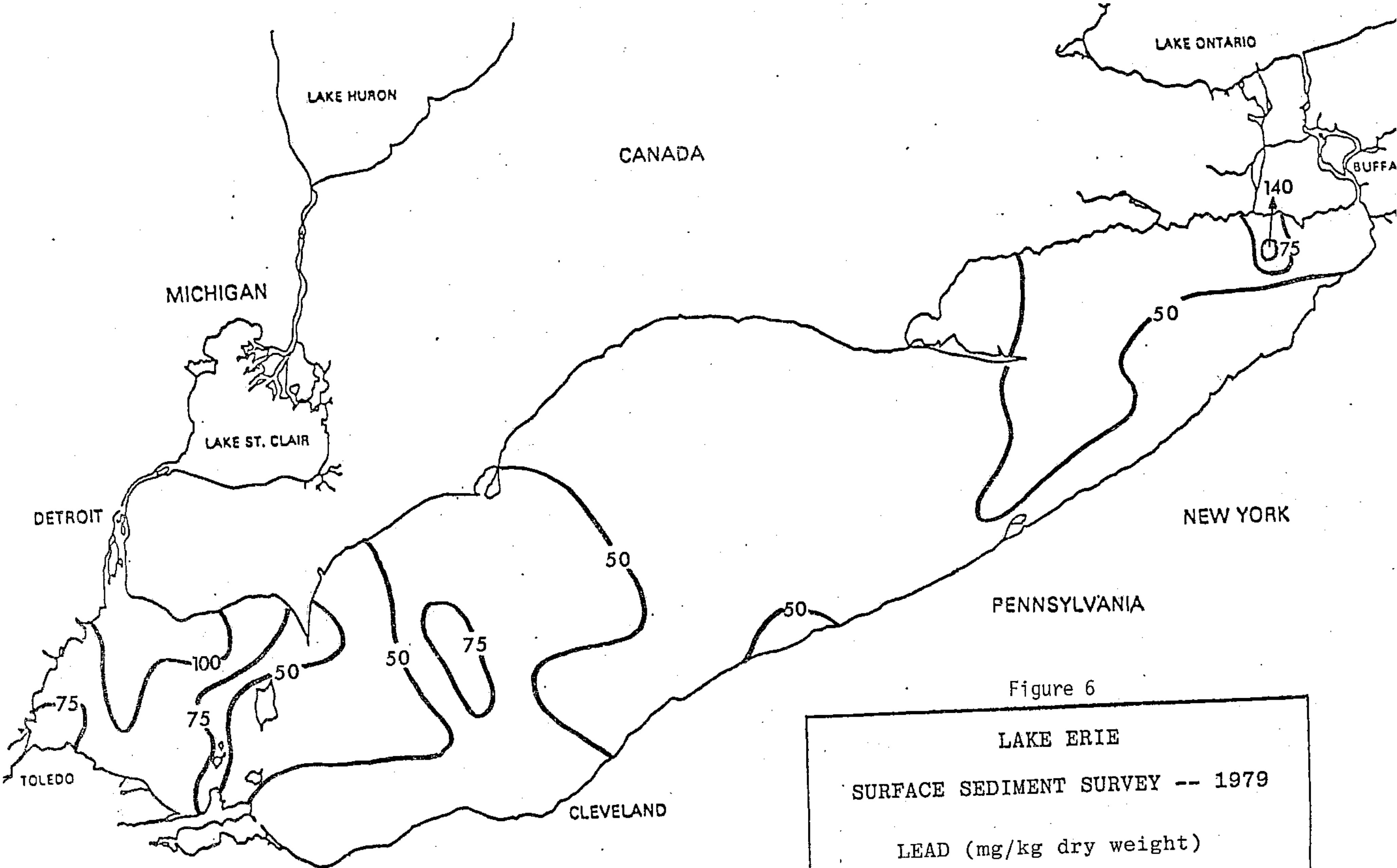

Figure 6

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

LEAD (mg/kg dry weight)

Contour Interval = 25

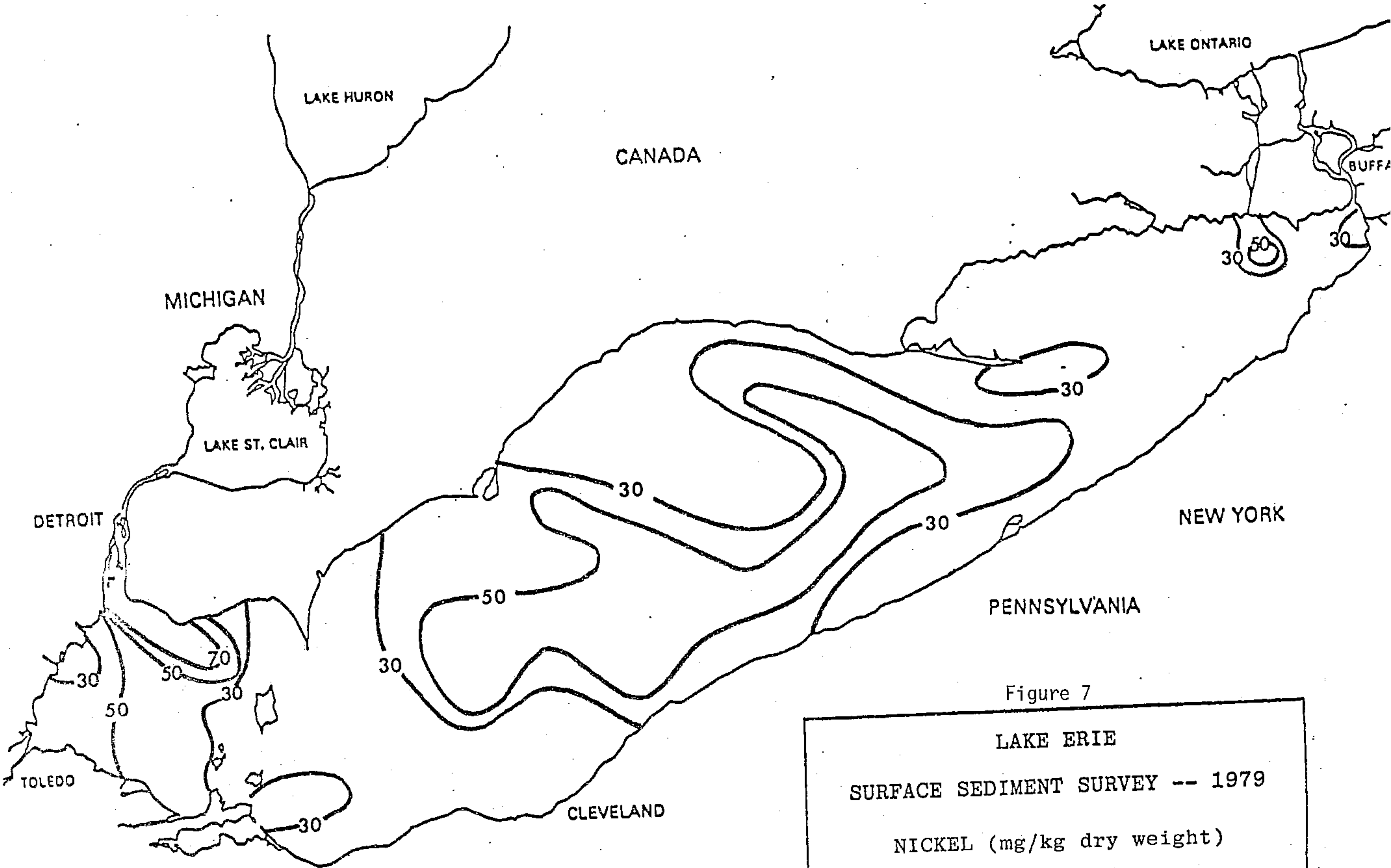

Figure 7

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

NICKEL (mg/kg dry weight)

Contour Interval = 20

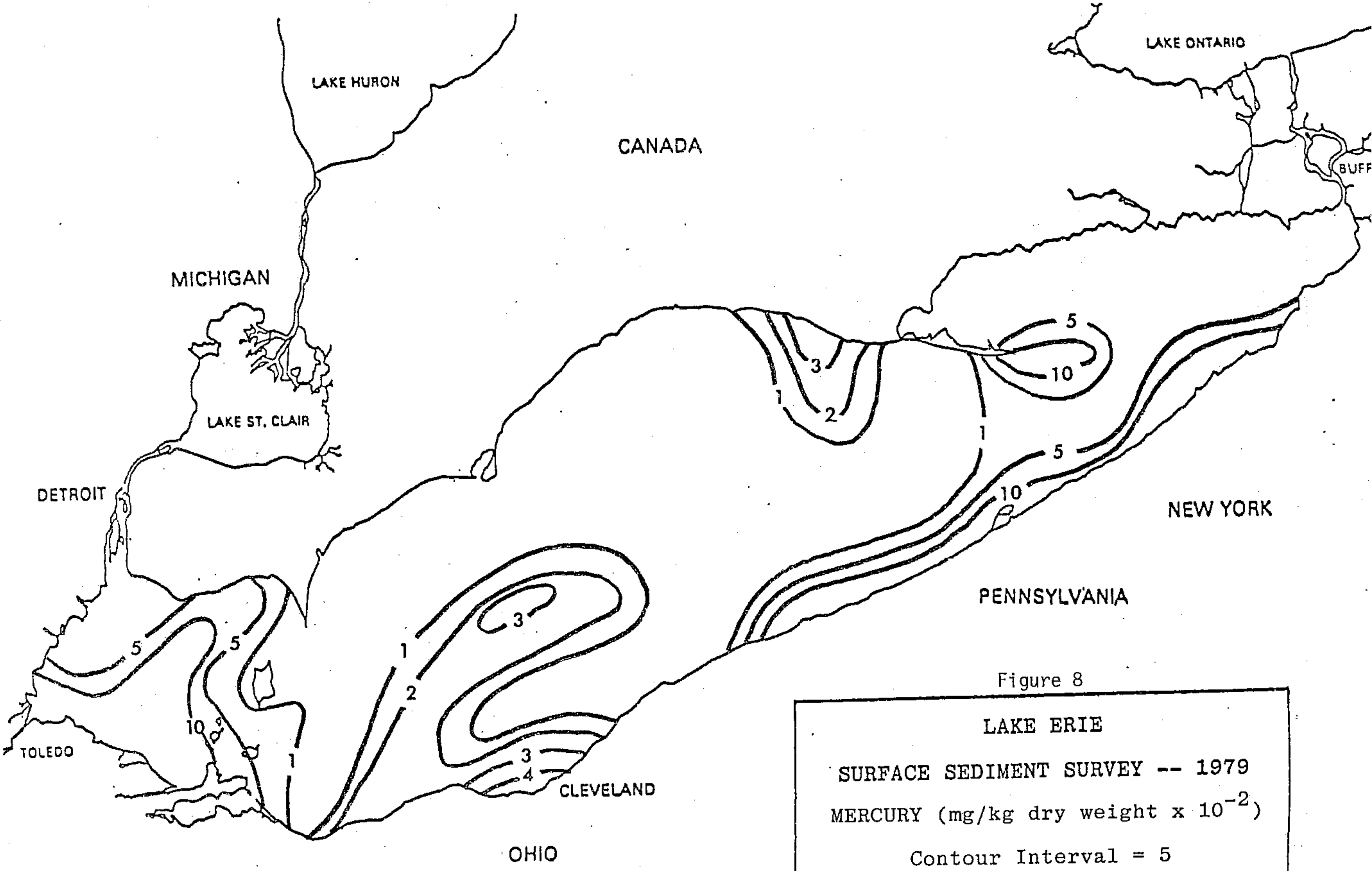

Figure 8

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

MERCURY (mg/kg dry weight x 10^{-2})

Contour Interval = 5

CI = 1 in Central Basin

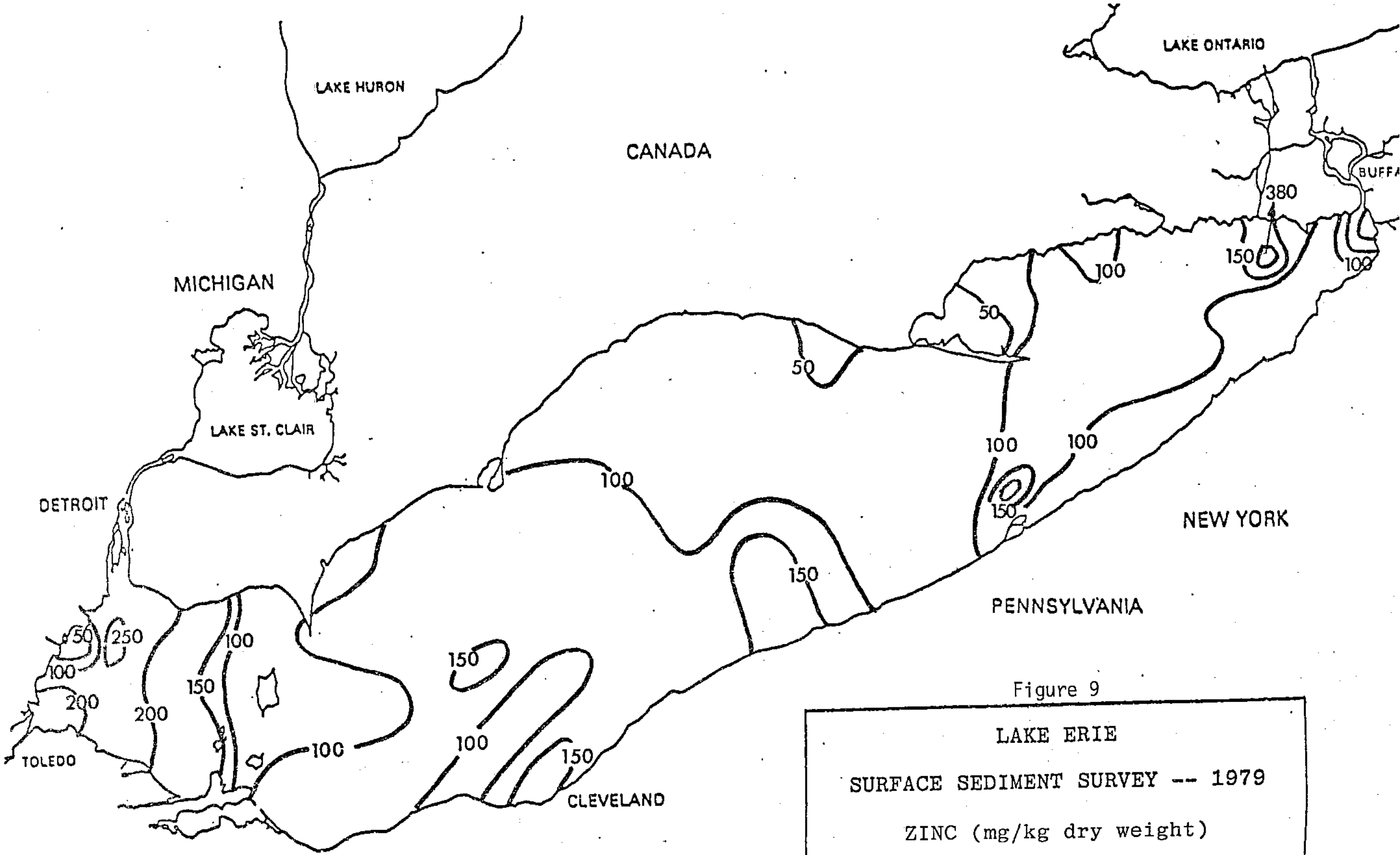

Figure 9

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

ZINC (mg/kg dry weight)

Contour Interval = 50

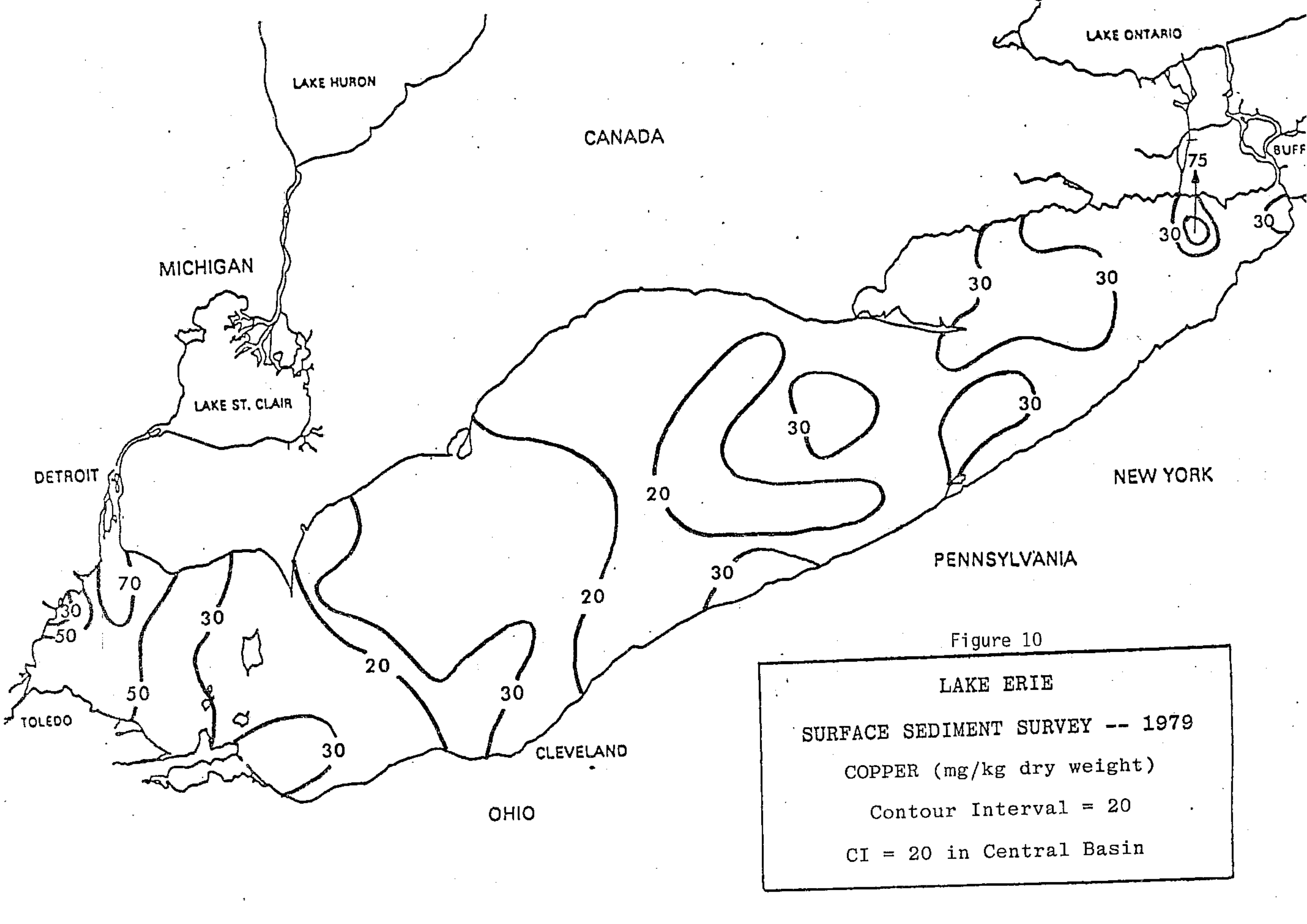

Figure 10

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

COPPER (mg/kg dry weight)

Contour Interval = 20

CI = 20 in Central Basin

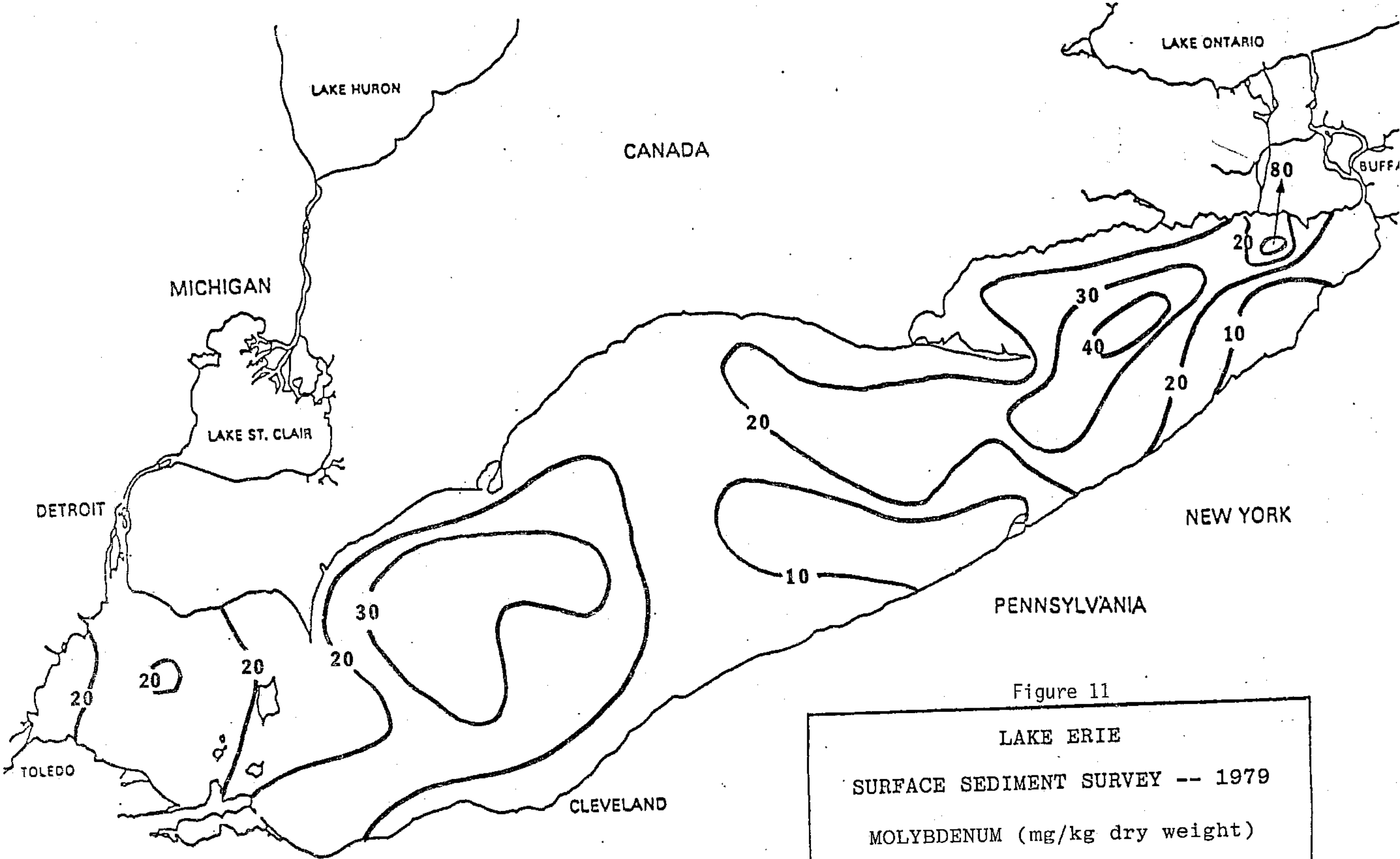

Figure 11

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

MOLYBDENUM (mg/kg dry weight)

Contour Interval = 10

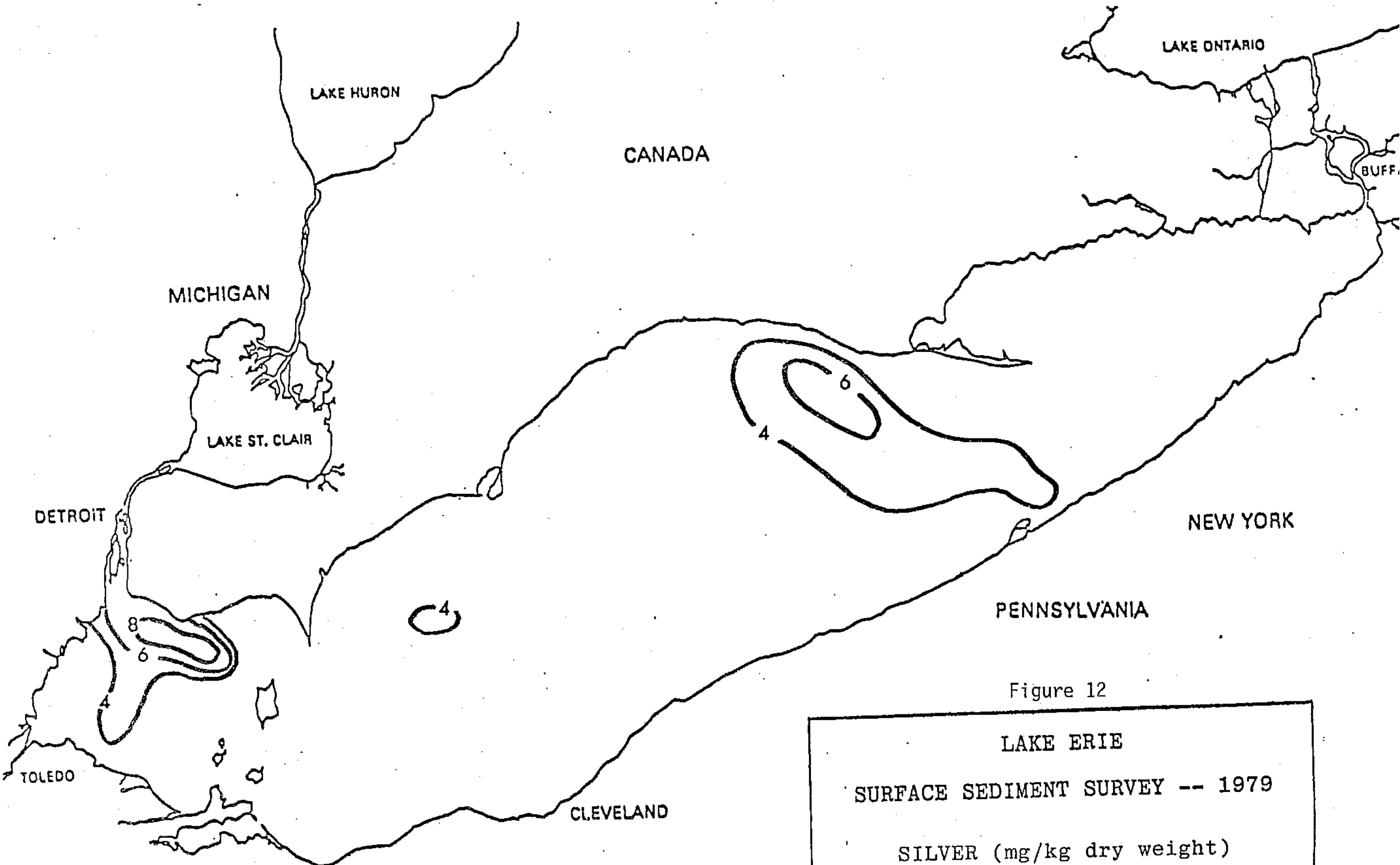

Figure 12

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

SILVER (mg/kg dry weight)

Contour Interval = 2

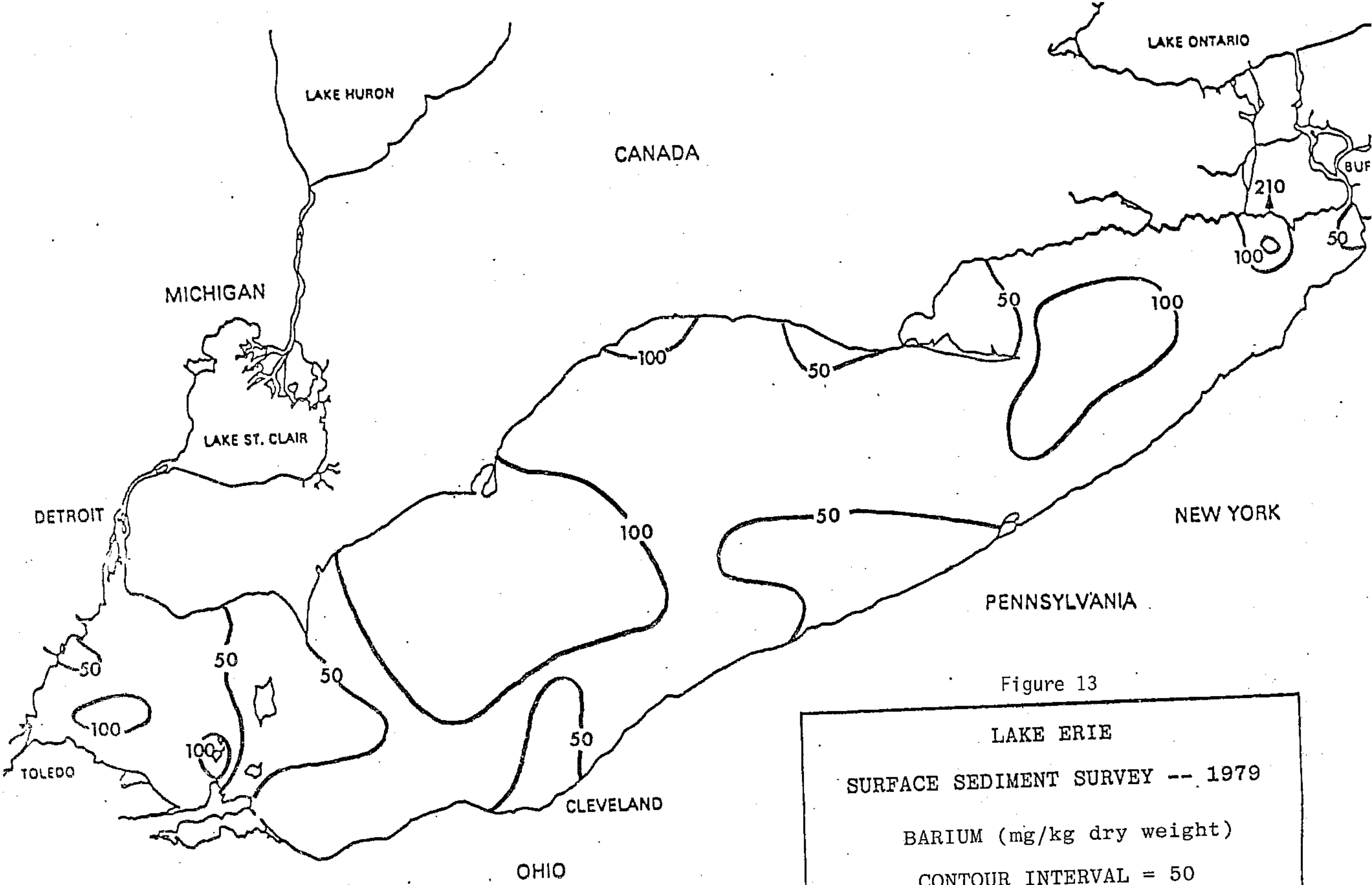

Figure 13

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

BARIUM (mg/kg dry weight)

CONTOUR INTERVAL = 50

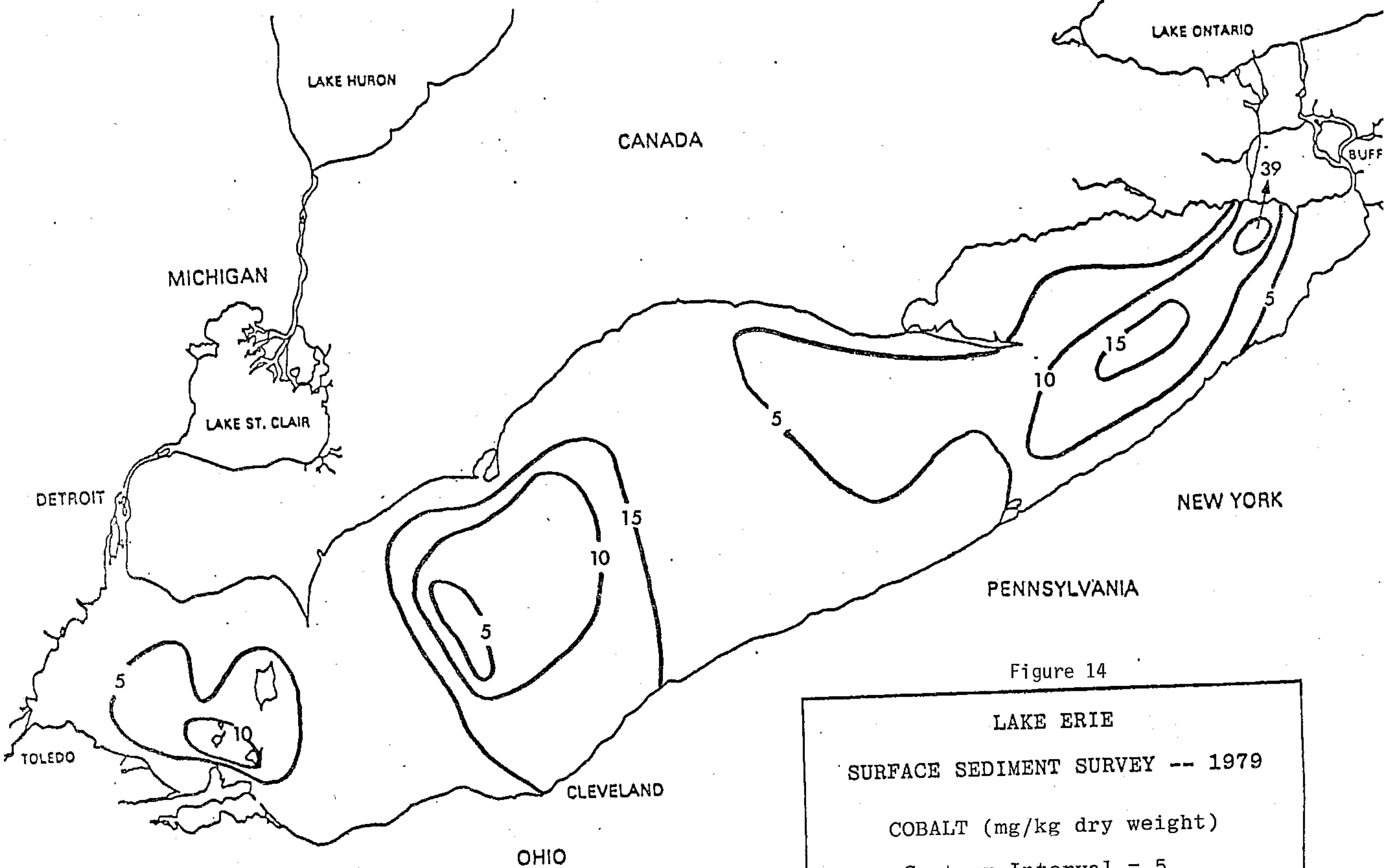

Figure 14

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

COBALT (mg/kg dry weight)

Contour Interval = 5

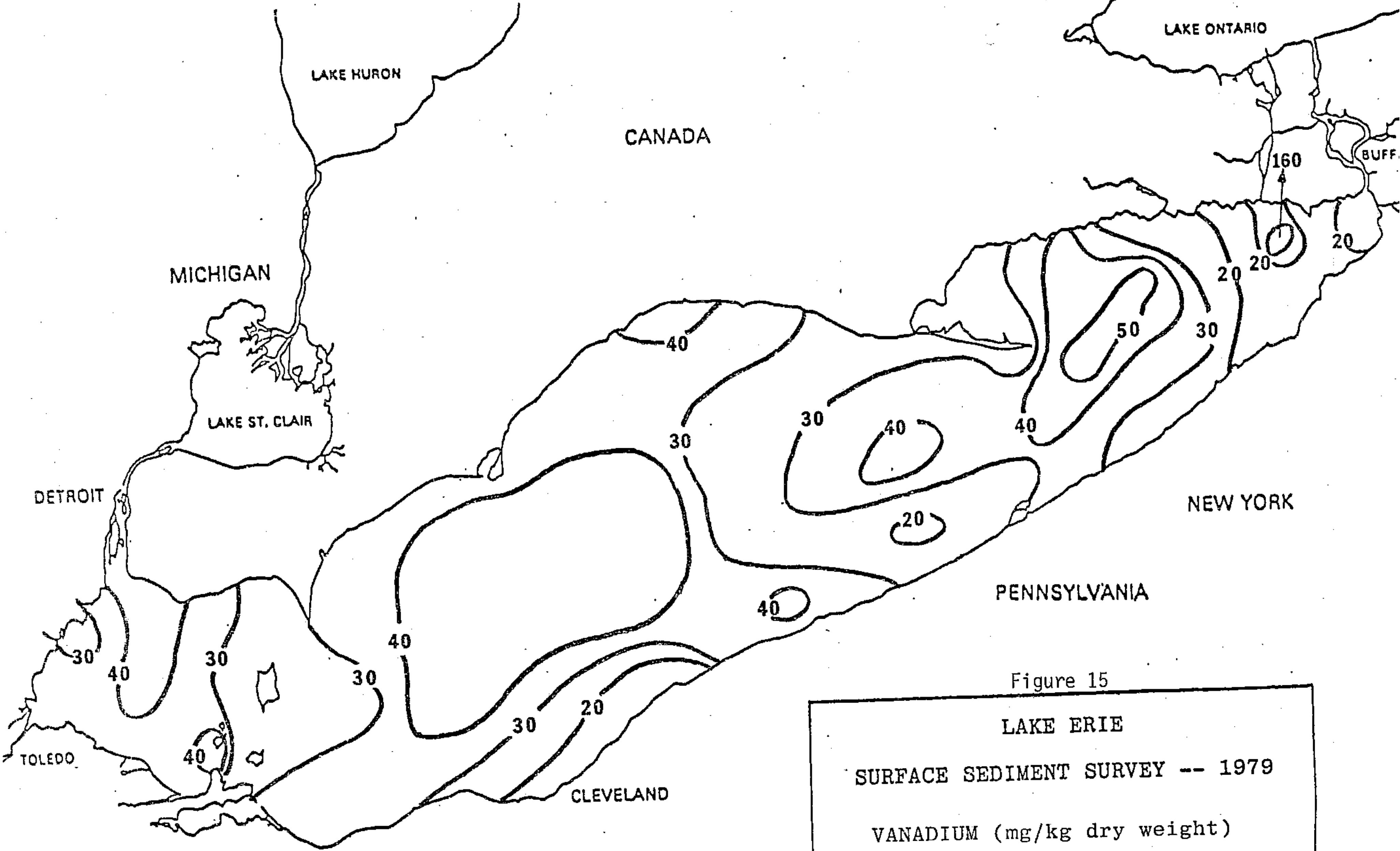

Figure 15

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

VANADIUM (mg/kg dry weight)

Contour Interval = 10

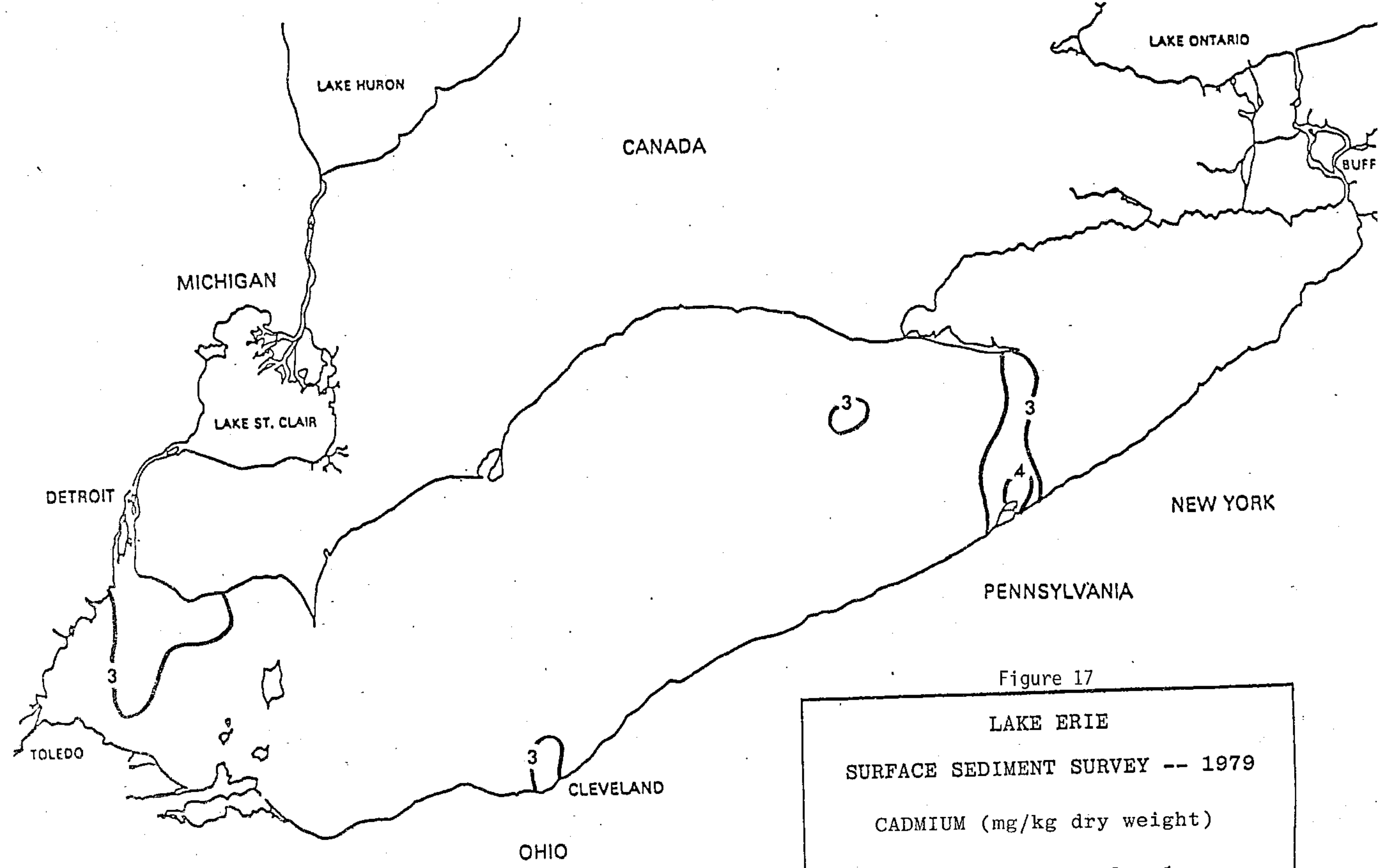

Figure 17

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

CADMIUM (mg/kg dry weight)

Contour Interval = 1

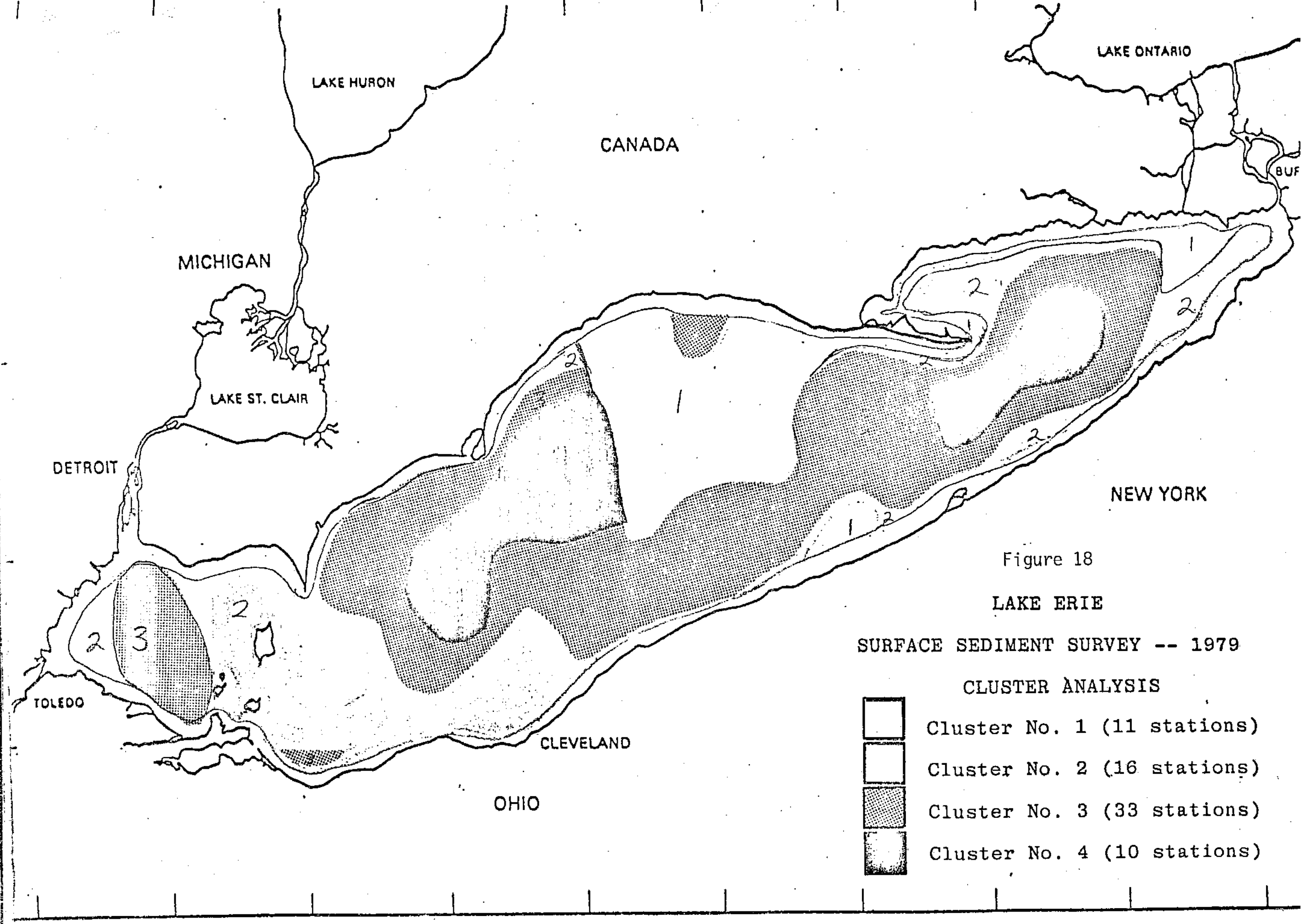

Figure 18

LAKE ERIE

SURFACE SEDIMENT SURVEY -- 1979

CLUSTER ANALYSIS

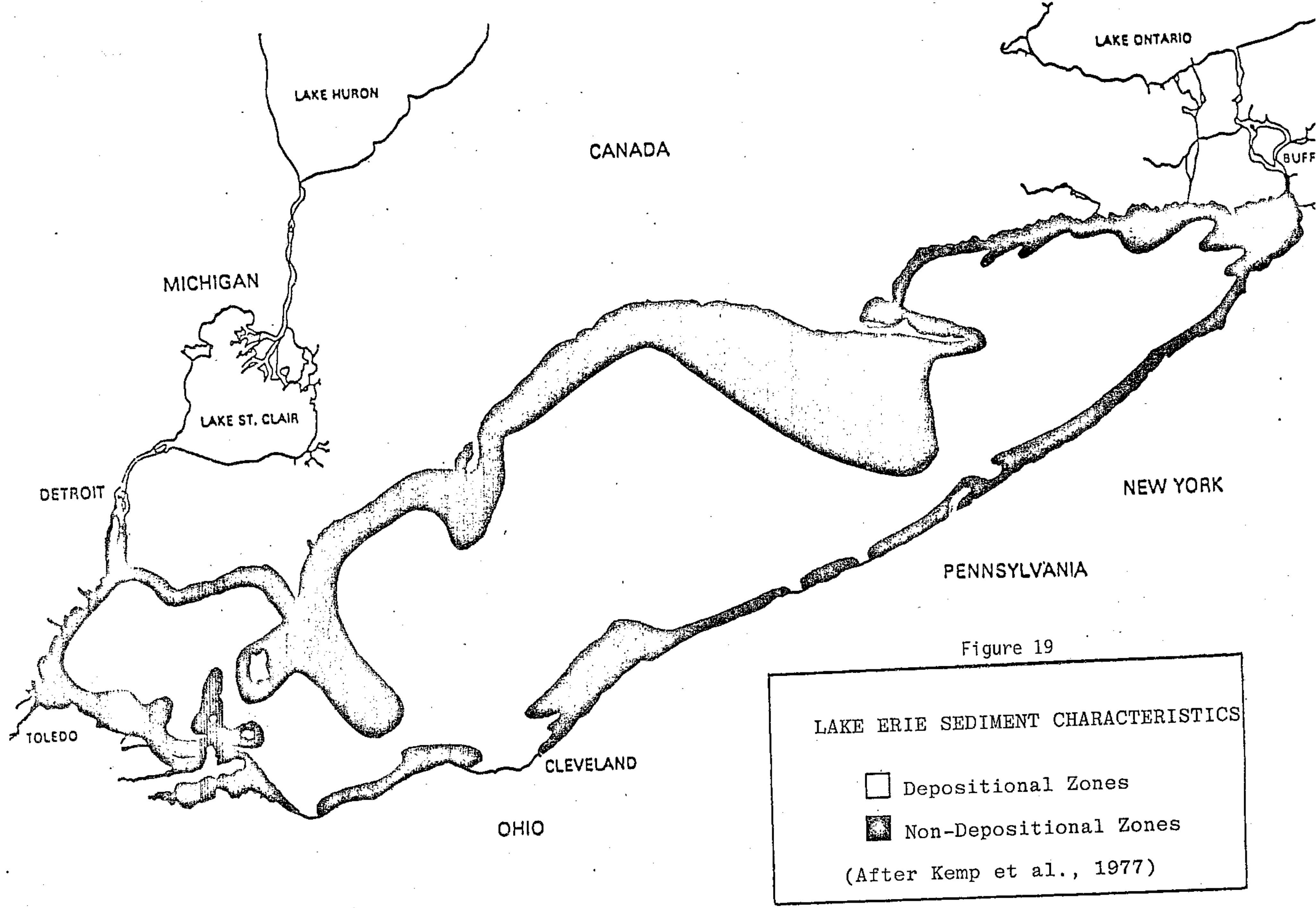
LAKE HURON
CANADA
LAKE ONTARIO
BUFF
MICHIGAN
LAKE ST. CLAIR
DETROIT
NEW YORK
PENNSYLVANIA
TOLEDO
CLEVELAND
OHIO
LAKE ERIE SEDIMENT CHARACTERISTICS
Depositional Zones
Non-Depositional Zones
(After Kemp et al., 1977)

Figure 19