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Measurement of Sediment
Loads in St. Clair and Detroit
Rivers

By:

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NWRI Contribution No. 87-15

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**MEASUREMENT OF SEDIMENT LOADS IN
ST. CLAIR AND DETROIT RIVERS**

**by
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MANAGEMENT PERSPECTIVE

The total contaminant load in a river consists of dissolved contaminants carried by the water as well as contaminants carried by the suspended sediments and sediments moving on the river bed. The proportion carried by sediments can sometimes be quite significant.

This report details the measurement of the suspended and bed sediment transport in the St. Clair and Detroit Rivers, which, in conjunction with another study of contaminant concentrations, will provide data on the total contaminant loading and the proportion carried by each component.

PERSPECTIVE DE GESTION

La charge totale des contaminants d'une rivière englobe les contaminants dissous transportés par les eaux mêmes, les contaminants charriés par les sédiments en suspension et les sédiments qui se déplacent sur le lit du cours d'eau. La proportion charriée par les sédiments peut parfois être très importante.

Ce rapport donne en détail les mesures du transport des sédiments en suspension et des sédiments de fond dans les rivières Ste-Claire et Detroit qui, conjointement à celles d'une autre étude sur les concentrations de contaminants, devraient fournir des données sur la charge totale de contaminants et la proportion des contaminants charriés par chaque composante du système

ABSTRACT

A field measurement of sediment loads in the St. Clair and Detroit Rivers was carried out as a part of the Upper Great Lakes Connecting Channels Study related to the contaminants transport in these rivers. Three transects in the St. Clair River and two transects in the Detroit River were sampled for bed load, suspended load, average flow velocity and flow rate. The measured data indicate that the sediment transport in these rivers is controlled by the sediment supply rather than the carrying capacity of the flows. The data collected in this study are being used to calculate the division of the total contaminant load among water, the suspended sediment and bed sediment.

RÉSUMÉ

Des mesures sur le terrain des charges sédimentaires des rivières Ste-Claire et Détroit ont été effectuées dans le cadre de l'étude sur les canaux reliant les Grands lacs d'amont portant sur le transport des contaminants dans ces cours d'eau. La charge du lit, la charge de matières en suspension, la vitesse moyenne de l'écoulement et le débit ont été échantillonnés dans trois sections de la rivière Ste-Claire et deux de la rivière Detroit. D'après les données mesurées, le transport des sédiments dans ces rivières est régi par l'apport en sédiments plutôt que par la capacité de transport des eaux. Les données recueillies dans cette étude sont utilisées pour calculer la répartition de la charge totale de contaminants dans les eaux, des matières en suspension et des sédiments du fond.

1.0 INTRODUCTION

As part of the Upper Great Lakes Connecting Channels Study, a field measurement of sediment transport was conducted in the St. Clair and Detroit Rivers during the spring of 1986. The objective of the field measurement was to quantify the bed load and suspended load sediment transport rates and the associated contaminants loadings so that they can be compared with contaminant loadings in the dissolved phase.

The only reported measurement of sediment load in the St. Clair River is the one carried out by Duane (1967) which was done in 1965 by sampling only one cross-section. Duane's observations hinted that the sediment transport in the St. Clair River could be supply limited. However, no attempt was made in that study to verify this opinion. In the present study, sediment load measurements were carried out at three different cross-sections in the St. Clair River and two different sections in the Detroit River. In addition, equilibrium sediment transport rate (capacity transport rate) calculations were carried out for these sections for the purpose of testing the hypothesis that the sediment load in the St. Clair River could be supply limited. The details of the field measurement of sediment load and the computation of equilibrium sediment loads are outlined in this report.

2.0 DESCRIPTION OF SELECTED CROSS-SECTIONS AND FIELD PROCEDURES

The cross-sections selected for the present study are indicated in two location maps shown in Figs. 1 and 2. Fig. 1 is for the St. Clair River and Fig. 2 is for the Detroit River. Cross-section 1 is downstream of the Black River confluence and it is near the tunnel for the Grand Trunk Western Railroad. This cross-section is referred to in this report as the Imperial Oil Transect. Cross-section 2 is downstream of Dow Chemical and it is referred to here as the Sun Oil Transect. The third cross-section is at Port Lambton and it is called

the Port Lambton Transect. The two cross-sections in the Detroit River are called the Rouge River Transect and the Gross Ile Transect. The Rouge River Transect is just downstream of the River Rouge confluence and it is upstream of Fighting Island. The Gross Ile Transect is a divided channel around the Grosse Ile Island. This cross-section, therefore, spans two channels, namely, Trenton Channel and the Ballards Reef Channel.

Except for the Port Lambton Transect, all the other four transects were sampled from a barge called SEA TRUCK (see photo in Fig. 3). The Port Lambton Transect was sampled from the CSS ADVENT (see photo in Fig. 4). In the case of SEA TRUCK the position of the boat was determined using a sextant. In the ADVENT, a radar device was used to measure the distance of the boat from the banks. In each case, the boat was positioned at a number of stations in a transect and measurements of depth of water, velocity, suspended sediment concentration and the bedload transport rates were made. The total number of measurement stations varied from transect to transect, ranging from 8 to 10.

The depth of water was measured using an echo sounder. The depth average flow velocity at a measurement station was determined by measuring velocities at two points, located at 0.2 and 0.8 times the total flow depth from the water surface and averaging the two velocities. The velocity at a point is measured using the Price current meter (see photo in Fig. 5). The depth integrated suspended sediment concentration was measured using a U.S. P72 suspended sediment sampler (see photo in Fig. 6). The sampler was traversed up and down the full water depth at a fairly constant rate. The sampling time varied between 30 to 100 secs. The sample volume collected ranged between 300 cc and 1000 cc. An Arnhem bedload sampler (Fig. 7) was used to collect the bedload sediment samples. An underwater video camera, mounted about 30 cm above the Arnhem sampler, enabled the operation of the sampler to be viewed on a TV monitor onboard. This is the first time that an Arnhem sampler has been fitted with such a video system. With this video system, it was possible to ensure a proper deployment and removal of the Arnhem sampler

as well as a proper orientation of the sampler with the flow during sampling. This feature was very useful when operating from a small launch on a fast flowing river such as the St. Clair where maintaining the launch at a fixed position required both anchoring and engine power and was sometimes rather difficult. The sampling time was maintained constant at 15 min. The size of the opening of the Arnhem sampler is: width = 3 inches (7.62 cm) and height = 2 inches (5.08 cm).

Samples collected by the suspended sampler and the bedload sampler were analyzed in the laboratory using the standard procedures. The suspended sediment concentration was calculated as milligrams per litre. The bedload sediment collected in the Arnhem sampler was dried and weighed. The calculations of bedload was then carried out by considering weight of the material collected in the sampler, sampler width and the efficiency of the sampler. On some bedload samples, size analysis was also performed.

The locations of the measurement stations and their coordinates in terms of longitudes and latitudes for all the transects are shown in Figs. 8 to 12.

3.0 RESULTS AND DISCUSSION

The results of the measurements are summarized in Tables 1 to 5 for the five transects. In these tables, the flowrate, suspended load and bedload computed for panels between measurement stations are given together with the total values for the whole transect. For the computation of these loads, certain assumptions have to be made. First of all, the measurement stations in a particular transect do not all lie in one plane (see Figs. 8 to 12). This is because of the drifting of the boat when it was anchored. This problem was worse for SEA TRUCK than for ADVENT. In performing the computation of loads, the measurement stations were shifted in the longitudinal direction so that they all lie in a single plane perpendicular to the flow direction. Secondly, the depth, velocity, suspended sediment concentration and bedload

transport rate were assumed to vary linearly between the measurement stations. Thirdly, the suspended sediment concentration at the banks were assumed to be equal to the values corresponding to the measurement stations nearest to the banks. Finally, the bedload transport rate at the banks were assumed to be zero.

From Tables 1 to 3 corresponding to the St. Clair River, it can be seen that the suspended load varies only slightly between transects. These values range between 2500 to 3000 metric tonnes per day. The same cannot be said for the bedload. It shows large variations between transects with the greatest jump between the Imperial Oil Transect and the Sun Oil Transect. It also shows an increasing trend in the downstream direction. The bedload transport rate at the Imperial Oil Transect is 0.67 metric tonnes per day while the same for the Sun Oil and Port Lambton transects are 3 and 3.6 metric tonnes per day respectively.

The data for the Detroit River (Tables 4 and 5) show much higher suspended load in the Detroit River than in the St. Clair River. The Detroit River values are more than double the values of the St. Clair River. Bedload transport rate, on the other hand, is much less. It also shows a decreasing tendency in the downstream direction. Bedload transport rate at gross Ile transect is about 1/30th of the value at Port Lambton of the St. Clair River. The grain size distribution of bedload material collected by the Arnhem sampler had been analyzed for a representative sample in each transect. The resulting grain-size distribution curves for all the transects are shown in Figs. 13 to 18. The median size of this material in the St. Clair River varies between 0.31 and 0.34 mm whereas the same in the Detroit River varies between 0.40 and 0.145 mm.

4.0 CAPACITY TRANSPORT RATES

The video pictures from the underwater camera attached to the Arnhem sampler showed clearly that a majority of the bottom area of the

St. Clair and Detroit Rivers was fully armoured with surface layer consisting of coarse gravel and cobble size particles. Occasional patches of sand layer were observed, mainly at the Port Lambton Transect. It was also noticed from the video pictures that the armour layer is stable and that the material forming the bed does not move. The material that is being transported as bedload and suspended load can be classified as fine sand and they have to come from upstream sources. Duane (1967) concluded that the nearshore bottom and the beaches of lower Lake Huron formed the primary source of sediment for the St. Clair River. Other minor sources of sediment could be from tributary and other inflows. Bank erosion does not appear to be a significant source of sediment in these rivers.

The armoured nature of the stream bed suggests that the measured sediment load is supply dependent, i.e., the flow has a greater capacity to transport than the availability of the sediment for transport. Equilibrium transport rate (capacity transport rate) calculations were carried out for the St. Clair River to get an idea of the maximum sediment transport rate that can be expected in the river. For this computation, information on bed shear stress is needed. For this, the flow predictions of Advanced Scientific Computing Ltd., carried out for the Ontario Ministry of the Environment (Ref. (2)) were used. These predictions were carried out using a three-dimensional turbulence model for a flowrate of 5500 m³/s in the St. Clair River between the Blue Water Bridge and Port Lambton. The characteristics of flow as predicted by the model for the three transect locations are summarized in Tables 6 to 8.

These tables also contain prediction of total sediment load, calculated using the equations of Ackers and White (1973, and the ratio between the suspended load and total load using the concept of Einstein (1950). From these two, the two component loads suspended load and the bedload are computed and shown in the last two columns of Tables 6 to 8. From these calculations, it can be seen that the capacity transport

rates for both suspended load and the bedload are much higher than the measured values.

From the Imperial Oil Trnsect, the capacity suspended load is almost four times as high as the measured load while the capacity bedload is close to 150 times as high as the measured value. The capacity transport rate shows a decreasing trend along the length of the river which is reasonable because the slope of the river goes down on the downstream direction.

5.0 SUMMARY AND CONCLUSIONS

It is quite obvious from the measured data and the calculated capacity transport rates that the sediment transport in the St. Clair River is controlled by the supply of sediments from upstream. At present, the transport rate is very much below what the river can carry.

The increase in bedload between the Imperial Oil Transect and the Sun Oil Transect is rather mysterious. The data indicate that there is some source of sediment somewhere between the two transects. However, the likelihood of such a sediment supply from tributaries or bank erosion between the two transects is rather remote.

The data from this report are being used to calculate the division of the total contaminant load among the water, the suspended sediment and the bed sediment. It is possible that this ratio can change if any upstream developments lead to any significant increase in sediment supply.

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TABLE 1

Sediment Transport Measurements in the St. Clair River

Imperial Oil Transect

Date: 7th May 1986 Water Temperature: 6°C Total Width = 520 metres D₅₀ : 0.31 mm

Station No.	Lateral Distance from American Side (in metres)	Depth of Flow (in metres)	Average Flow Velocity (in m/s)	Depth Averaged Suspended Sediment Concentration in (mg/L)	Bed Material Collected in Arnhem Sampler (in gm/min)	Flowrate in Different Panels (in m ³ /s)	Suspended Load in Different Panels (metric tonnes/day)	Bedload in Different Panels in (kg/day)
1	45	10.4	0.849	6	0	117.0	30.33	0
2	150	10.5	1.263	6	0.0779	1158.1	600.67	117.8
3	255	10.3	1.263	3	0.1267	1510.5	587.28	269.0
4	309	10.7	1.440	3	0.0591	496.7	128.74	64.2
5	330	10.5	1.199	3	0.0254	419.6	108.76	24.3
6	375	14.0	1.339	8	0.0596	699.5	332.40	36.7
7	400	13.3	1.336	4	0.1592	456.4	236.60	52.5
8	430	12.2	1.422	4	0.0196	527.5	182.30	51.5
9	465	11.5	1.399	4	0.0441	585.0	202.18	21.4
10	490	11.1	1.140	5	0.0471	358.6	139.42	21.9
						94.9	20.50	13.6
Total for the Section					0.6187	6424.0	2569.18	671.1

Flowrate value from U.S. Army Corps of Engineers: 6371m³/s

TABLE 2

Sediment Transport Measurements in the St. Clair River

Sun 011 Transect

Date: 8th May 1986		Water Temperature: 6°C		Total Width = 653 metres		D ₅₀ : 0.34 mm		
Station No.	Lateral Distance from American Side (in metres)	Depth of Flow (in metres)	Average Flow Velocity (in m/s)	Depth Averaged Suspended Sediment Concentration in (mg/L)	Bed Material Collected in Arnhem Sampler (in gm/min)	Flowrate in Different Panels (in m ³ /s)	Suspended Load in Different Panels (metric tonnes/day)	Be load in Different Panels in (g/day)
1	90.0	9.40	0.968	5	0.1229	204.7	88.43	106.2
2	172.5	10.96	1.014	6	0.4315	832.3	395.51	399.1
3	315.0	11.12	1.174	6	0.1424	1721.1	892.22	85.2
4	330.0	10.68	1.277	4	0.3971	200.4	86.57	77.7
5						938.1	445.79	735.2
6	398.0	10.96	1.273	7	0.7291	1341.8	753.55	802.2
7	510.0	10.03	1.090	6	0.0170	305.3	145.08	17.9
8	540.0	10.18	1.004	5	0.0450	315.8	177.35	51.2
9				12	0.2437	25.6	17.69	22.23
10	600.0	4.22	0.458	8	0.0438			
Total for the Section				2.1725	5885.1	3002.19	3037.0	

Flowrate value received from U.S. Army Corps of Engineers: 6371 m³/s

TABLE 3

Sediment Transport Measurements in the St. Clair River

Port Lambton Transect

Date: 27th May 1986			Water Temperature: 11°C		Total Width: 654 metres		D ₅₀ : 0.310 mm	
Station No.	Lateral Distance from American Side (in metres)	Depth of Flow (in metres)	Average Flow Velocity (in m/s)	Depth Averaged Suspended Sediment Concentration in (mg/L)	Bed Material Collected in Arnhem Sampler (in gm/min)	Flowrate in Different Panels (in m ³ /s)	Suspended Load in Different Panels (metric tonnes/day)	Bed Load in Different Panels in (t/day)
1	45	6.75	0.698	7	0.0177	53.0	32.00	7.7
2	195	10.58	1.006	5	0.0330	1107.4	574.08	73.1
3	295	12.60	1.009	4	0.0577	1167.7	454.00	87.1
4	345	16.38	1.034	4	0.1513	740.1	255.78	100.3
5	395	16.35	1.075	4	2.1249	862.8	298.18	1392.6
6	475	15.52	0.963	4	0.0477	1299.0	448.93	1568.6
7	545	13.03	0.855	4	0.4607	908.3	313.91	341.6
8	595	4.85	0.166	21	0.0305	217.0	234.36	235.8
						7.0	12.70	14.7
Total for the Section				2.9235	6362.3	2623.94	3621.5	

Flowrate value received from U.S. Army Corps of Engineers: 6343 m³/s

TABLE 4

Sediment Transport Measurements in the Detroit River
Rouge River Transect Upstream of Fighting Island (upstream of LaSalle)

Date: 13th May 1986		Water Temperature: 8°C		Total Width = 825 metres		D ₅₀ : 0.280 mm		
Station No.	Lateral Distance from American Side (in metres)	Depth of Flow (in metres)	Average Flow Velocity (in m/s)	Depth Averaged Suspended Sediment Concentration in (mg/L)	Bed Material Collected in Arnhem Sampler (in gm/min)	Flowrate in Different Panels (in m ³ /s)	Suspended Load in Different Panels (metric tonnes/day)	Bedload in Different Panels in (g/day)
1	90	7.35	0.542	10	0.0149	90.24	77.97	12.9
2	185	13.75	0.809	8	0.0102	680.23	528.95	22.9
3	255	14.21	0.747	40		762.44	1581.00	
4	315	12.50	1.216	15		786.18	1528.33	51.5
5	360	11.08	0.764	10	0.0205	525.69	567.75	40.5
6	450	11.15	0.825	12	0.0264	797.28	757.73	90.1
8	615	12.45	0.838	12	0.0343	1622.36	1682.06	74.7
10	713	4.55	0.476	26	0.0451	547.28	898.41	48.5
Total to the Section					0.1514	5872.34	7758.42	347.1

Flowrate value received from U.S. Army Corps of Engineers: 6371 m³/s

TABLE 5

Sediment Transport in the Detroit River

Grosse Isle Transect, Gross Isle Split (Trenton Channel + Ballards Reef Channel)

Date: 15th May 1986

Total Widths: Trenton Channel: 450 m; Ballards Reef Channel: 1950 m; Total 2400 m

Station No.	Lateral Distance from Trenton (in metres)	Depth of Flow (in metres)	Average Flow Velocity (in m/s)	Depth Averaged Suspended Sediment Concentration in (mg/L)	Bed Material Collected in Anhem Sampler (in gm/min)	Flowrate in Different Panels (in m ³ /s)	Suspended Load in Different Panels (metric tonnes/day)	Bedload in Different Panels in (g/day)
1	30	7.12	.567	11	.0024	30.28	28.78	0.7
2	75	6.55	.547	8	.0029	171.32	140.62	2.3
3	165	6.32	.564	11	.0035	321.72	264.07	5.6
4	300	8.15	.752	30	.0046	642.69	1356.10	10.5
5	360	6.46	.522	11	.0065	279.20	494.51	6.4
						75.57	72.11	5.6
	Lateral distance from Gross Isle			Subtotal	.0199	1521.08	2166.20	31.1
6	480	3.16	.453	10	.0048	171.78	148.42	22.3
7	870	8.33	.462	9		1025.05	841.36	
8	1350	8.28	.399	20	.0026	1823.40	2284.36	64.2
9	1575	8.20	.433	48		668.43	1963.58	
				Total	.0273	332.87	1380.48	14.2
						5542.61	8784.40	31.8

Flowrate value received from U.S. Army Corps of Engineers: 6315 m³/s

TABLE 6
Equilibrium Transport Rates for the St. Clair River
Imperial Oil Transect

Total Width: 546.7 m; Flowrate 5500 m³/s; Flow patter computed by Advanced Scientific Computing Ltd., Waterloo, using a 3D Model

Station No.	Distance from U.S. Side (m)	Depth in metres	Velocity in m/s	Shear Velocity in m/s	Q_s/Q_T^*	Q_T^{**} kg/m.s	Q_s kg/m.s	Q_B kg/m.s
1	17.2	3.22	0.589	.037	0.9725	0.0156	0.0152	.00043
2	51.4	8.42	0.875	.047	0.9891	0.107	0.1058	.0012
3	85.3	10.26	0.998	.053	0.9910	0.202	0.2002	.0018
4	119.1	9.94	1.042	.055	0.9906	0.257	0.2546	.0024
5	153.0	10.19	1.061	.056	0.9909	0.278	0.2755	.0025
6	187.0	10.42	1.076	.057	0.9910	0.297	0.2943	.0027
7	221.0	10.29	1.072	.057	0.9909	0.292	0.2893	.0027
8	254.8	10.47	1.081	.057	0.9911	0.303	0.3003	.0027
9	289.0	10.83	1.096	.058	0.9914	0.321	0.3182	.0028
10	323.2	11.84	1.113	.058	0.9921	0.336	0.3334	.0027
11	357.5	11.90	1.111	.057	0.9921	0.331	0.3284	.0026
12	391.8	12.09	1.119	.058	0.9923	0.342	0.3394	.0026
13	426.2	12.90	1.129	.058	0.9927	0.348	0.3455	.0025
14	460.6	11.12	1.067	.055	0.9916	0.274	0.2717	.0023
15	495.1	7.57	0.640	.049	0.4878	0.133	0.1314	.0016
16	529.7	3.17	0.578	.036	0.9721	0.0136	0.0132	.0004
					$\sum Q_i dz$ kg/s	131.26	130.1146	.1450
					$\sum Q_i dz$ in metric tonnes/day	11340.9	11241.9	39.0

* Using Einstein's definition of bedload

** Using Ackers & White equations

TABLE 7

Equilibrium Transport Rates for the St. Clair River

Sun Oil Transect

Total Width: 695.7 m; Flowrate 5500 m³/s; Flow pattern computed by Advanced Scientific Computing Ltd., Waterloo, using a 3D Model

Station No.	Distance from U.S. Side (m)	Depth in metres	Velocity in m/s	Shear Velocity in m/s	Q_s/Q_T^*	Q_T^{**} kg/m.s	Q_s kg/m.s	Q_b kg/m.s
1	25.8	4.85	0.446	0.0313	0.9799	.0017	0.0017	0.00003
2	76.6	8.19	0.677	0.0411	0.9877	.028	0.0277	0.00034
3	125.0	9.30	0.766	0.0450	0.9891	.054	0.0534	0.00059
4	171.7	9.89	0.836	0.0485	0.9897	.086	0.0851	0.00089
5	217.1	9.78	0.882	0.0511	0.9896	.115	0.1138	0.00120
6	261.7	9.95	0.922	0.0531	0.9897	.144	0.1425	0.00150
7	305.4	10.41	0.951	0.0543	0.9901	.165	0.1634	0.00163
8	348.5	10.55	0.982	0.0559	0.9903	.193	0.1911	0.00187
9	391.0	10.41	0.999	0.0570	0.9901	.211	0.2059	0.00209
10	432.9	10.15	0.998	0.0572	0.9899	.212	0.2099	0.00214
11	474.5	10.18	0.998	0.0571	0.9899	.211	0.2089	0.00213
12	515.6	10.20	0.993	0.0569	0.9899	.207	0.2049	0.00209
13	556.4	10.01	0.972	0.0559	0.9897	.187	0.1851	0.00193
14	596.7	9.49	0.917	0.0533	0.9892	.143	0.1415	0.00154
15	636.6	8.23	0.782	0.0467	0.9877	.064	0.0632	0.00079
16	676.1	1.95	0.413	0.0322	0.9513	.0017	0.0016	0.00008
					$\sum Q_i dz$ kg/s	85.801	84.9246	1.877
					$\sum Q_i dz$ in metric tonnes/day	7413.2	7337.4	75.8

* Using Einstein's definition of bedload.

** Using Ackers & White equations

TABLE 8

Equilibrium Transport Rates for the St. Clair River

Port Lambton Transect

Total Width: 612.4 m; Flowrate 5500 m³/s; Flow pattern computed by Advanced Scientific Computing Ltd., Waterloo, using a 3D Model

Station No.	Distance from U.S. Side (m)	Depth in metres	Velocity in m/s	Shear Velocity in m/s	Q_s/Q_T^*	Q_T^{**} kg/m.s	Q_s kg/m.s	Q_b kg/m.s
1	19.8	1.92	0.409	.0280	0.9556	.00095	.00091	.00004
2	59.3	7.02	0.628	.0353	0.9872	.0160	.0158	.00020
3	98.5	9.96	0.748	.0423	0.9908	.0417	.0413	.00038
4	137.5	10.42	0.793	.0425	0.9912	.0586	.0581	.00052
5	176.3	10.62	0.825	.0442	0.9914	.0735	.0729	.00063
6	215.0	11.17	0.861	.0458	0.9918	0.917	.0910	.00075
7	253.6	12.80	0.909	.0475	0.9928	.1174	.1166	.00085
8	291.9	15.50	0.938	.0477	0.9940	.1284	.1276	.00077
9	330.2	15.44	0.929	.0473	0.9940	.1222	.1215	.00073
10	368.3	14.12	0.925	.0477	0.9935	.1240	.1232	.00081
11	406.1	13.64	0.932	.0485	0.9932	.1320	.1311	.00090
12	443.9	14.24	0.925	.0480	0.9935	.1250	.1242	.00081
13	481.5	14.04	0.863	.0449	0.9934	.0856	.0850	.00056
14	518.9	12.03	0.754	.0437	0.9924	.0417	.0414	.00032
15	556.3	7.13	0.529	.0312	0.9875	.00462	.0046	.00006
16	593.7	1.26	0.253	.0205	0.9352	.0000	.0	0
					$\sum Q_i dz$ kg/s	44.410	44.172	1.238
					$\sum Q_i dz$ in metric tonnes/day	3837.0	3816.46	0.56

* Using Einstein's definition of bedload

** Using Ackers & White equations

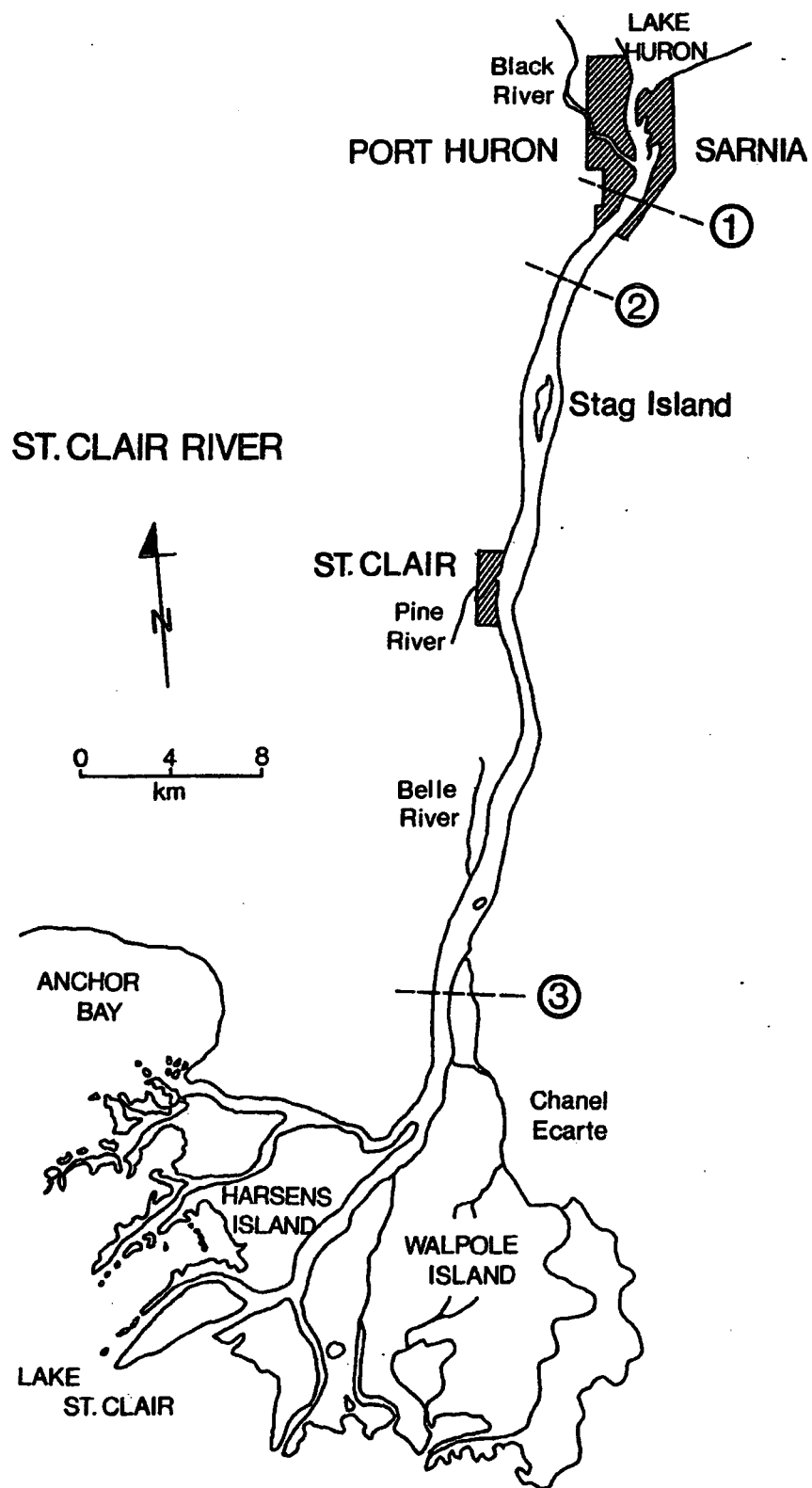


Fig.1 Location of sampled transects in St.Clair River

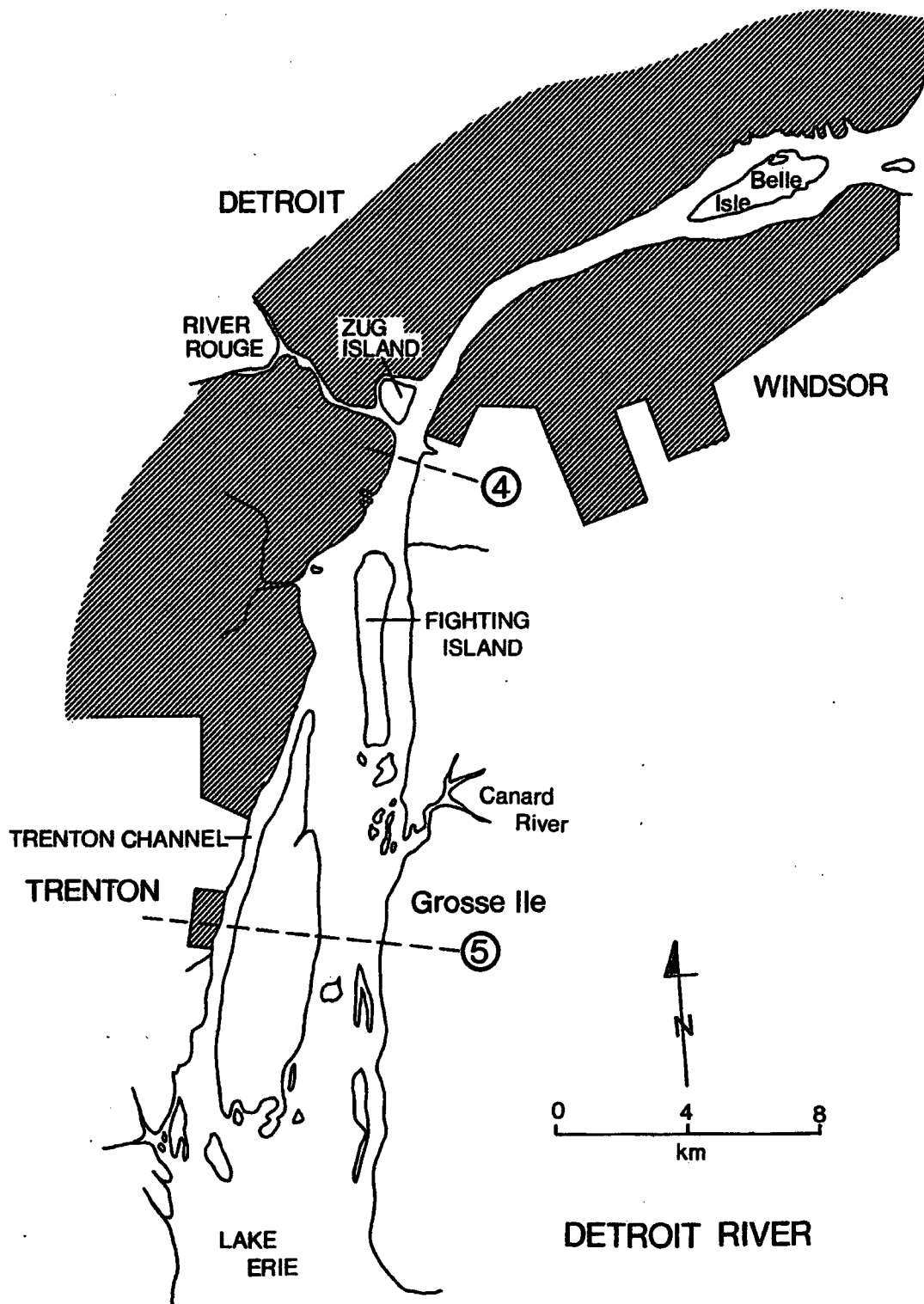


Fig. 2 Location of sampled transects in Detroit River.

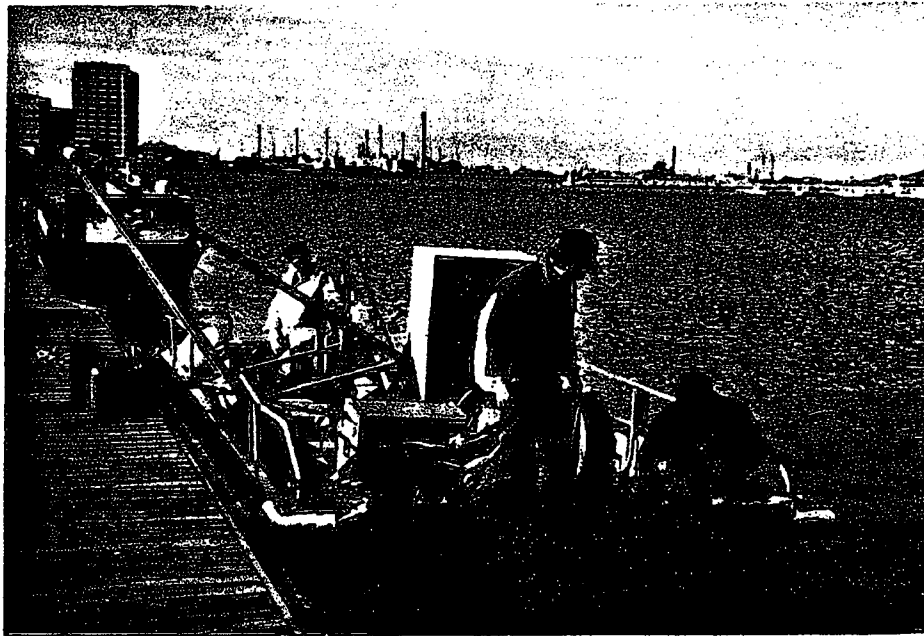


Fig. 3. The Sea Truck.



Fig. 4. The Advent.



Fig. 5. Price Current Meter.

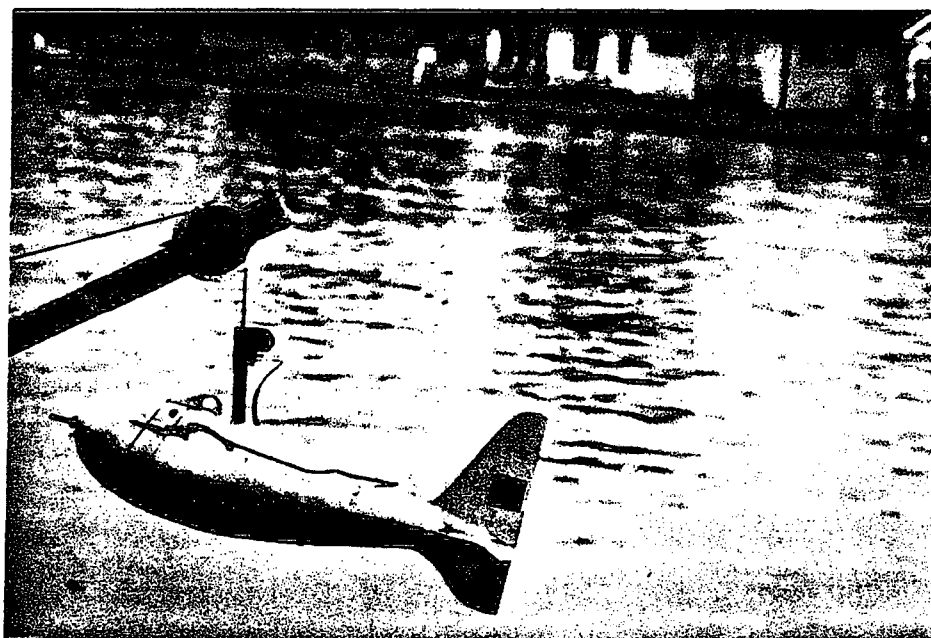


Fig. 6. Depth-Integrating Suspended Sediment Sampler.

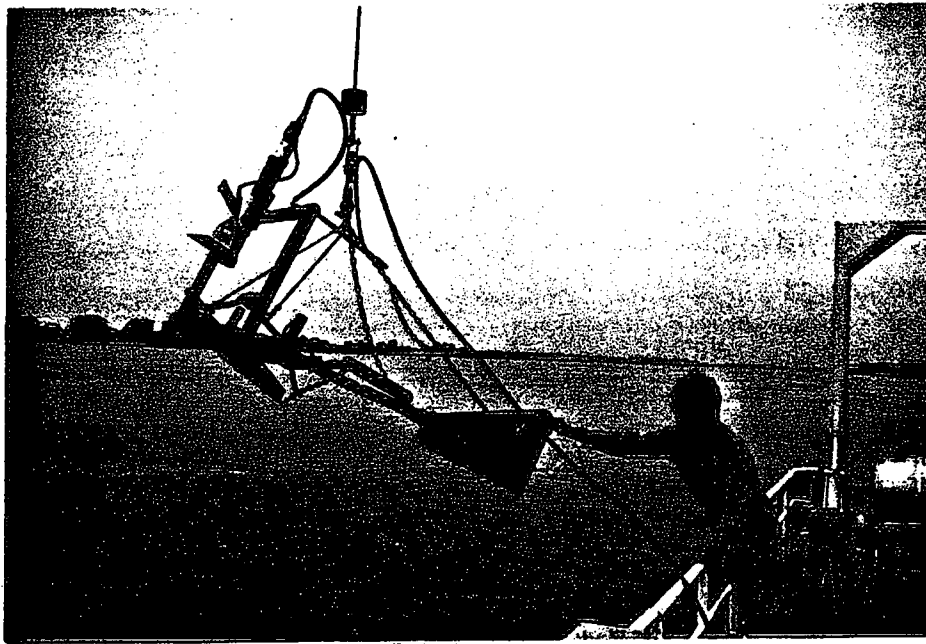


Fig.7. Arnhem Bedload Sampler.

IMPERIAL OIL TRANSECT

STATION POSITIONS

STATION NUMBER	LATITUDE N.	LONGITUDE W.
1	42° 57' 33.5"	82° 25' 32.0"
2	42° 57' 29.5"	82° 25' 29.7"
3	42° 57' 27.0"	82° 25' 26.0"
4	42° 57' 26.5"	82° 25' 24.7"
5	42° 57' 25.0"	82° 25' 24.2"
6	42° 57' 24.0"	82° 25' 23.0"
7	42° 57' 23.0"	82° 25' 22.5"
8	42° 57' 23.0"	82° 25' 21.0"
9	42° 57' 23.1"	82° 25' 19.0"
10	42° 57' 23.3"	82° 25' 17.5"

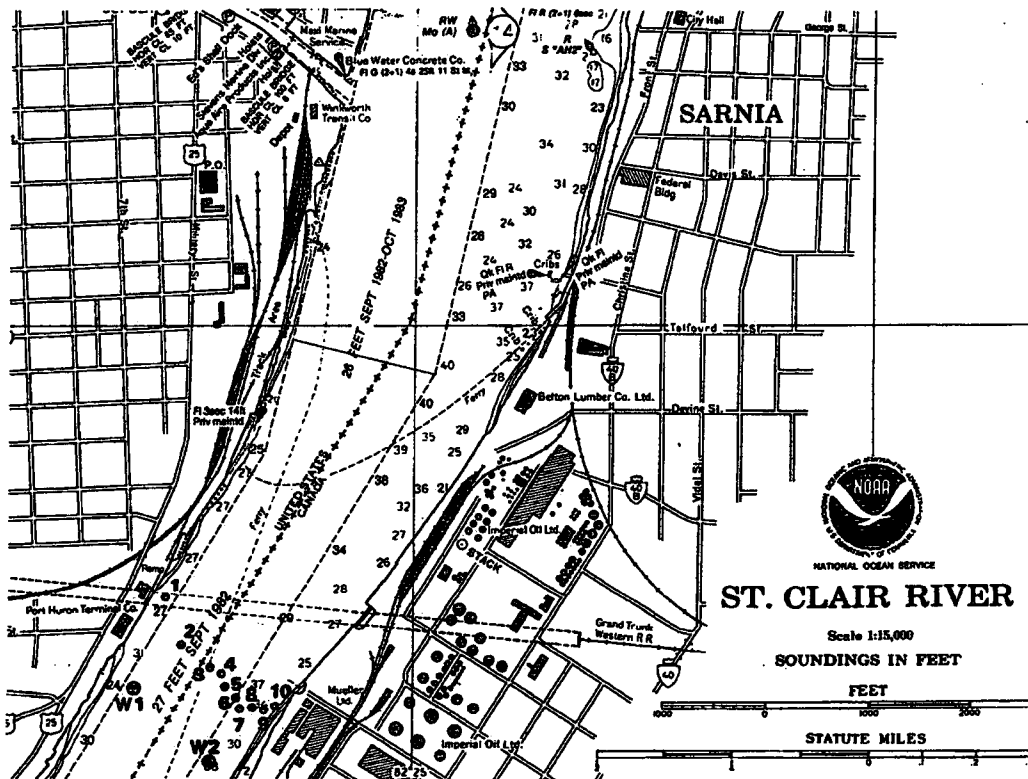
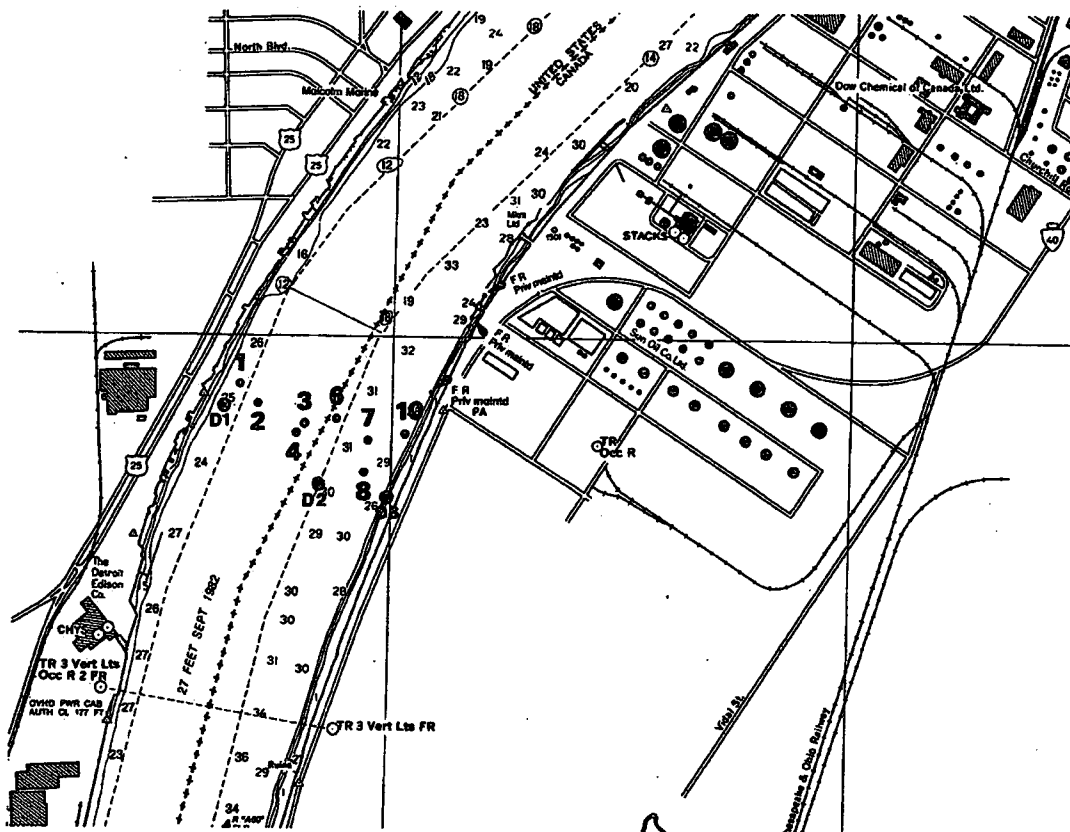


Figure 8. Sampling stations at the Imperial oil Transect

SUN OIL TRANSECT

MAY 8, 1986



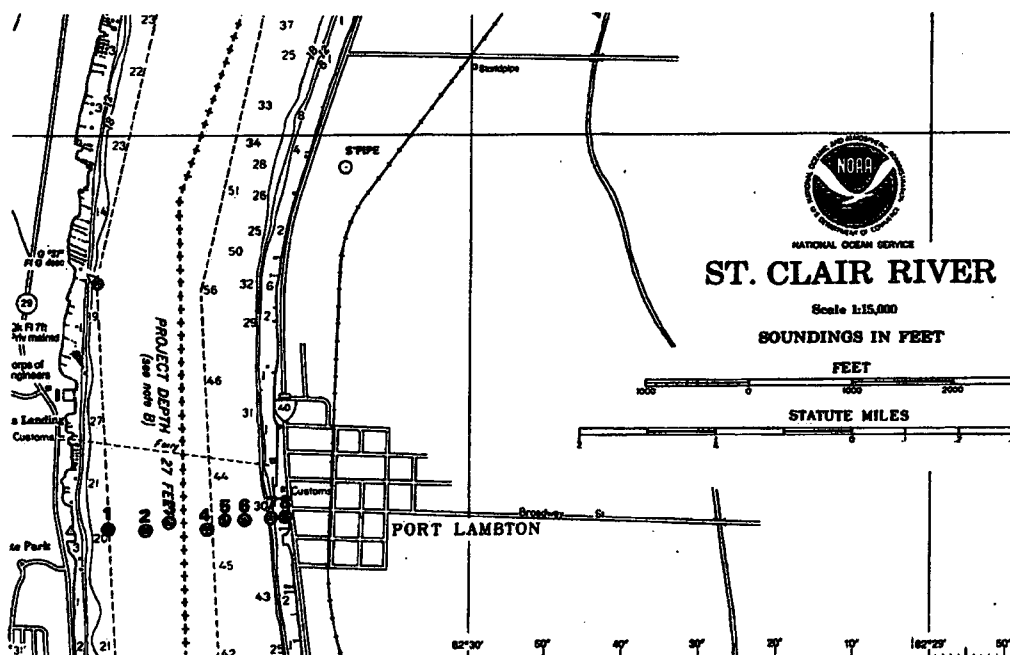
SUN OIL TRANSECT

STATION POSITIONS

STATION NUMBER	LATITUDE N.	LONGITUDE W.
1	42° 55' 55.1"	82° 27' 19.8"
2	42° 55' 55.8"	82° 27' 17.1"
3	42° 55' 51.2"	82° 27' 10.6"
4	42° 55' 51.1"	82° 27' 11.2"
6	42° 55' 52.0"	82° 27' 08.0"
7	42° 55' 49.8"	82° 27' 02.4"
8	42° 55' 47.9"	82° 27' 02.8"
10	42° 55' 50.3"	82° 26' 57.8"

Figure 9. Sampling stations at the Sun oil Transect

MAY 27, 1986



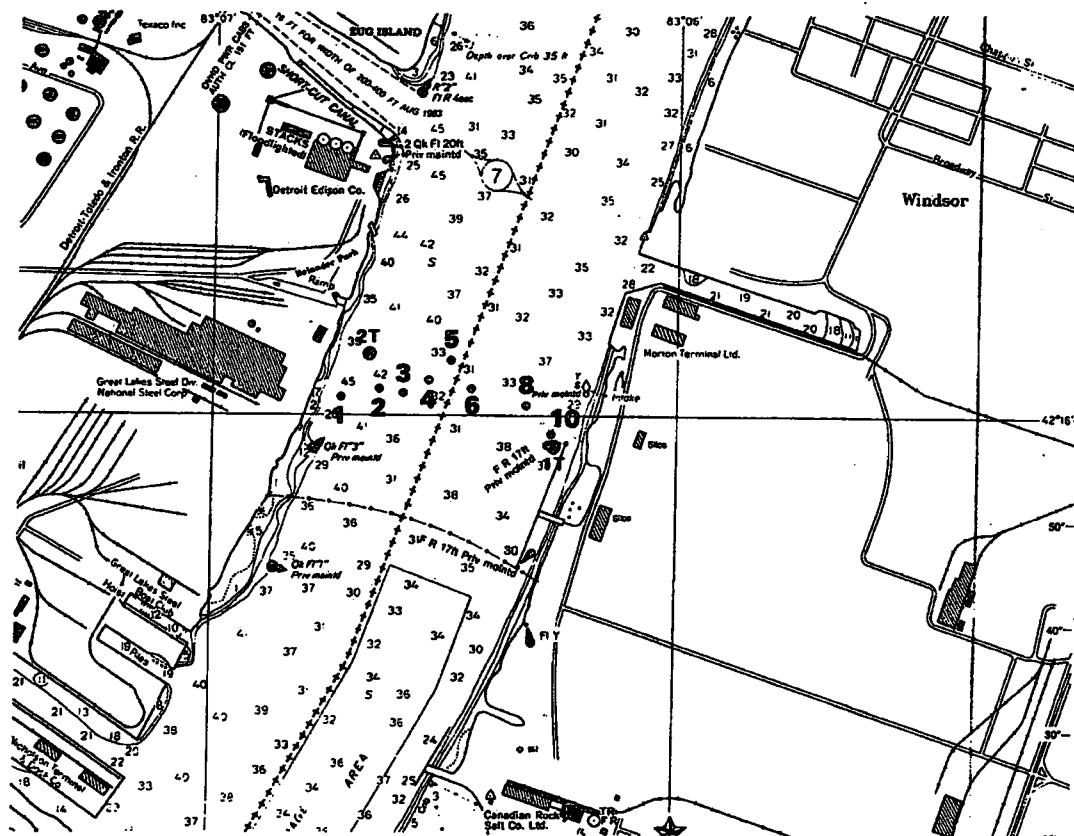
STATION POSITIONS

STATION NUMBER	LATITUDE N.	LONGITUDE W.
1	42° 39' 22"	82° 30' 47"
2	42° 39' 22"	82° 30' 42"
3	42° 39' 23"	82° 30' 39"
4	42° 39' 22"	82° 30' 34"
5	42° 39' 23"	82° 30' 32"
6	42° 39' 23"	82° 30' 29"
7	42° 39' 23"	82° 30' 26"
8	42° 39' 24"	82° 30' 24"

Figure 10. Sampling stations at the Port Lambton Transect.

ROUGE RIVER TRANSECT

MAY 13, 1986



ROUGE RIVER TRANSECT

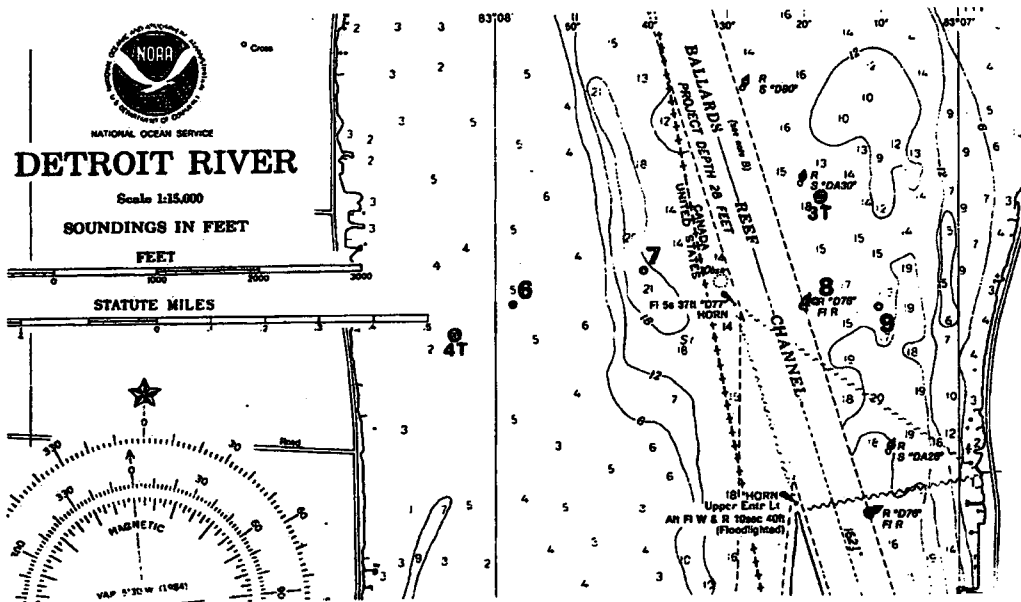
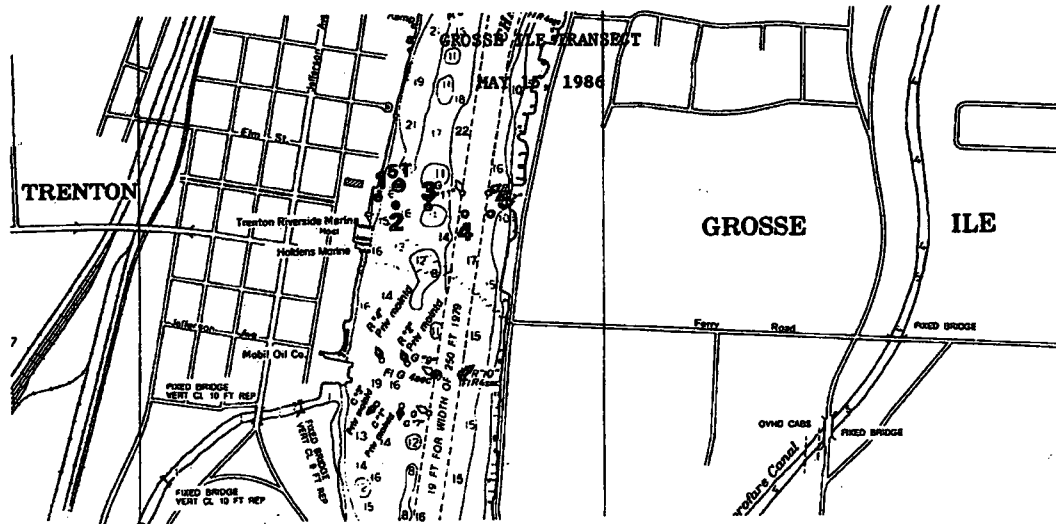
STATION POSITIONS

STATION NUMBER	LATITUDE N.	LONGITUDE W.
1	42° 16' 01.8"	83° 06' 43.2"
2	42° 16' 02.4"	83° 06' 38.5"
3	42° 16' 02.2"	83° 06' 35.1"
4	42° 16' 03.1"	83° 06' 32.1"
5	42° 16' 04.2"	83° 06' 29.6"
6	42° 16' 02.2"	83° 06' 26.7"
8	42° 16' 00.7"	83° 06' 20.2"
10	42° 15' 58.1"	83° 06' 16.4"

Figure 11 Sampling stations at the Rouge River Transect

GROSSE ILE TRANSECT

MAY 15, 1986



GROSSE ILE TRANSECT

STATION POSITIONS

STATION NUMBER	LATITUDE N.	LONGITUDE W.
1	42° 08' 31.2"	83° 10' 29.0"
2	42° 08' 30.5"	83° 10' 26.4"
3	42° 08' 30.2"	83° 10' 22.7"
4	42° 08' 29.1"	83° 10' 18.2"
5	42° 08' 29.7"	83° 10' 14.1"
6	42° 08' 33.8"	83° 07' 57.0"
7	42° 08' 32.0"	83° 07' 40.5"
8	42° 08' 28.0"	83° 07' 18.5"
9	42° 08' 27.8"	83° 07' 10.7"

Figure 12 Sampling stations at the Gross Ile Traverset

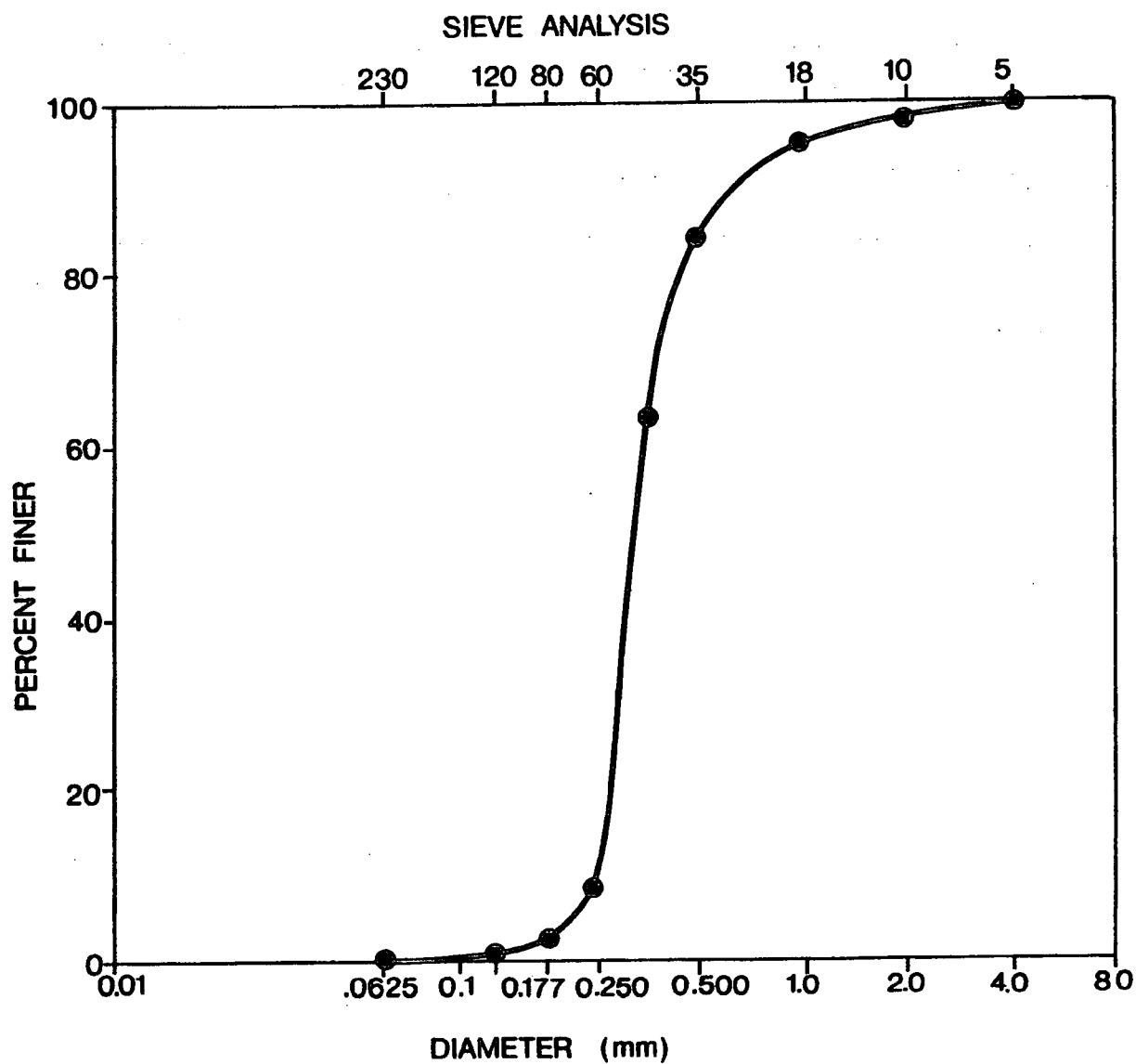


Fig.13. Grainsize distribution of bed load material collected at the Imperial Oil Transect in St. Clair River.

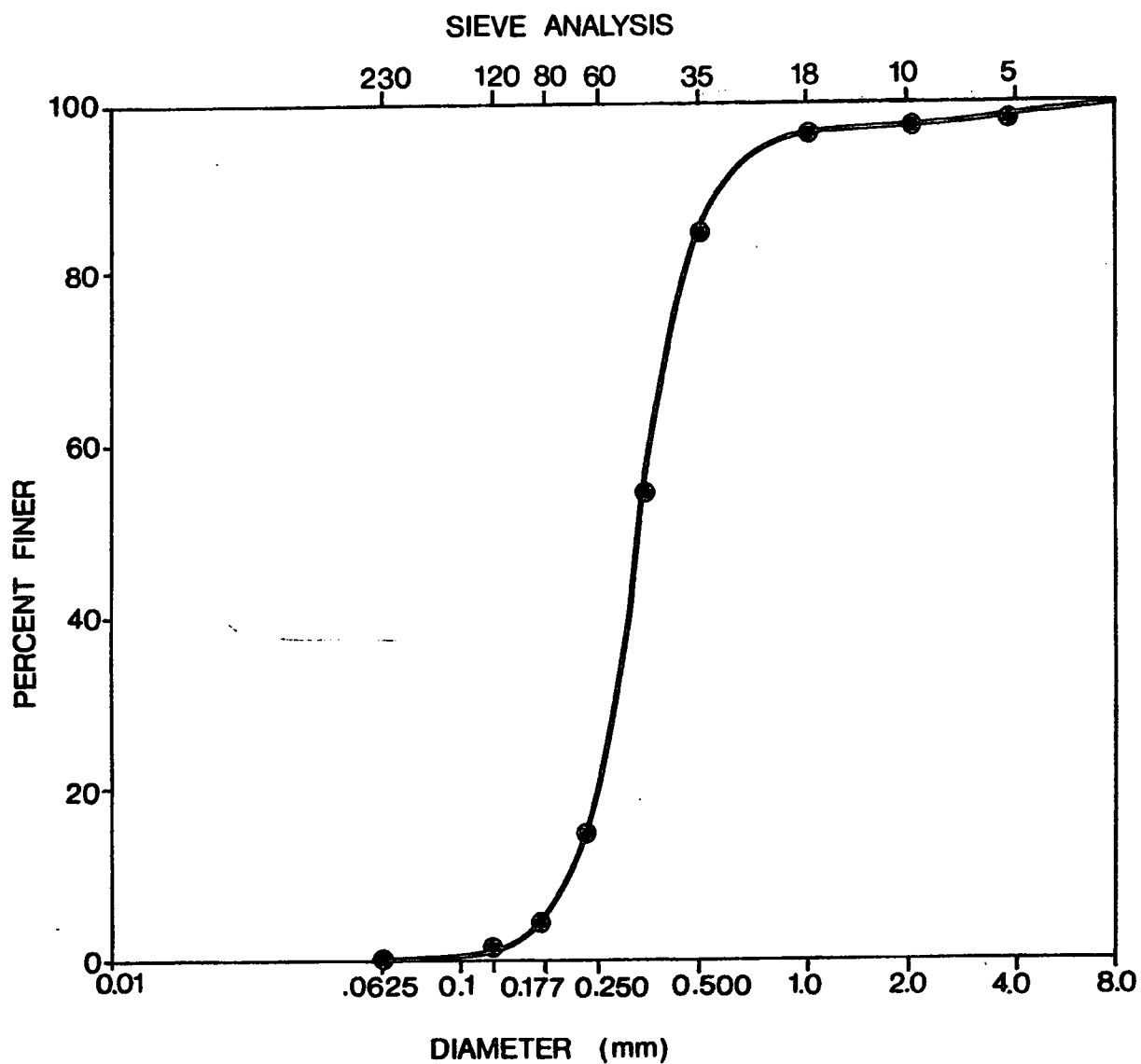


Fig.14. Grainsize distribution of bed load material collected at the Sun Oil Transect in St.Clair River.

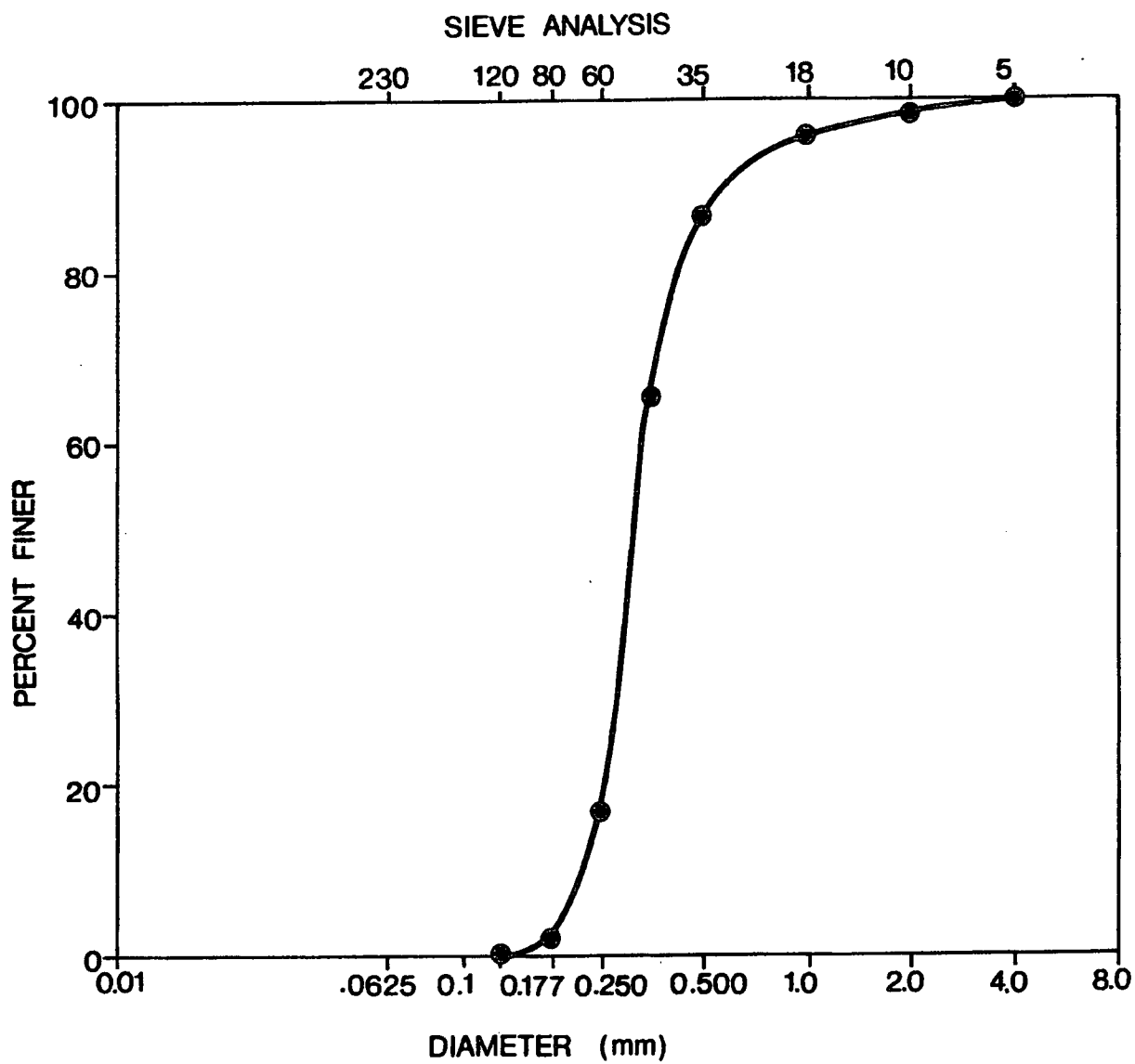


Fig.15. Grainsize distribution of bed load material collected at the Port Lambton Transect in St.Clair River.

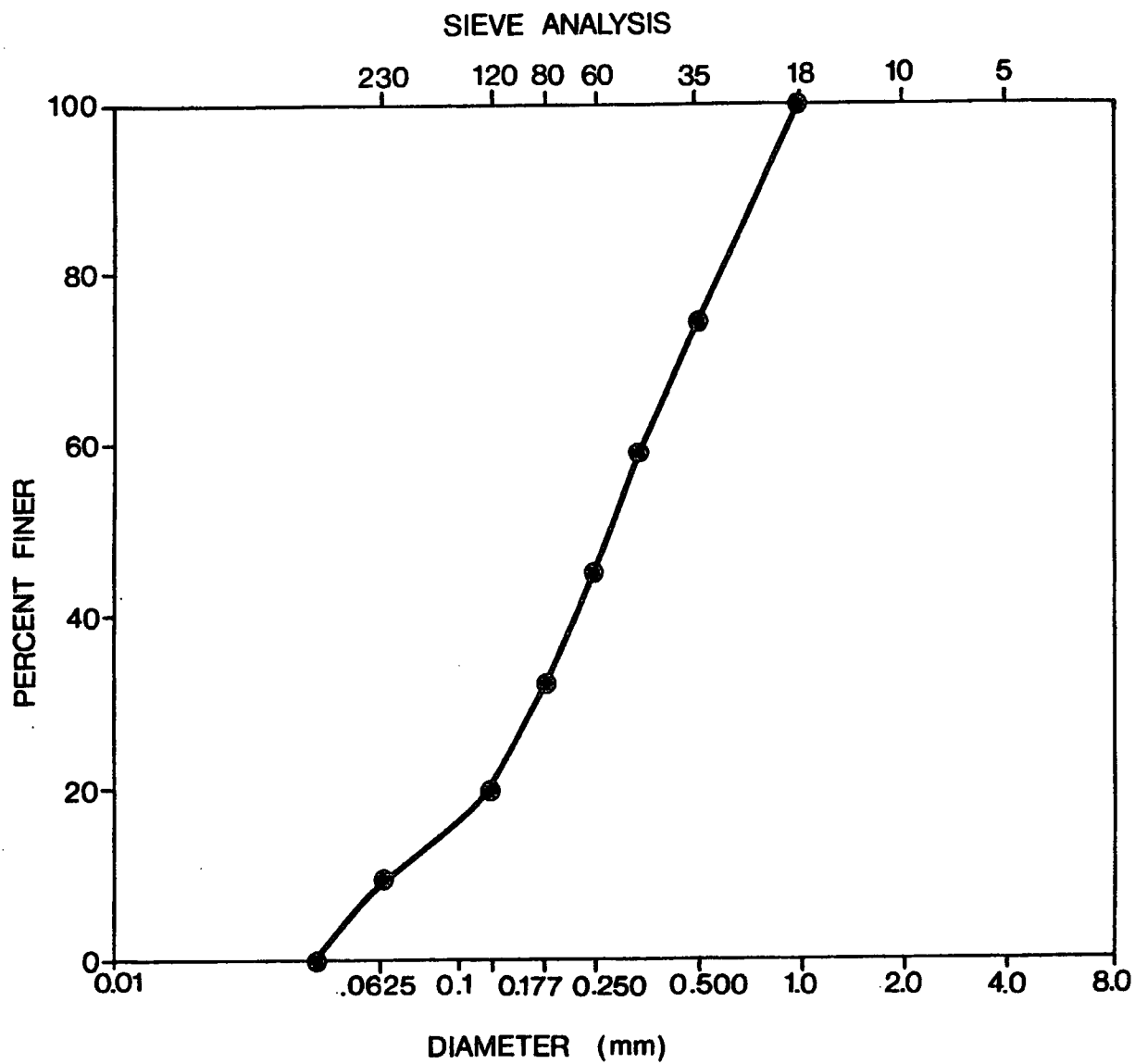


Fig.16. Grainsize distribution of bed load material collected at the Rouge River Transect in Detroit River.

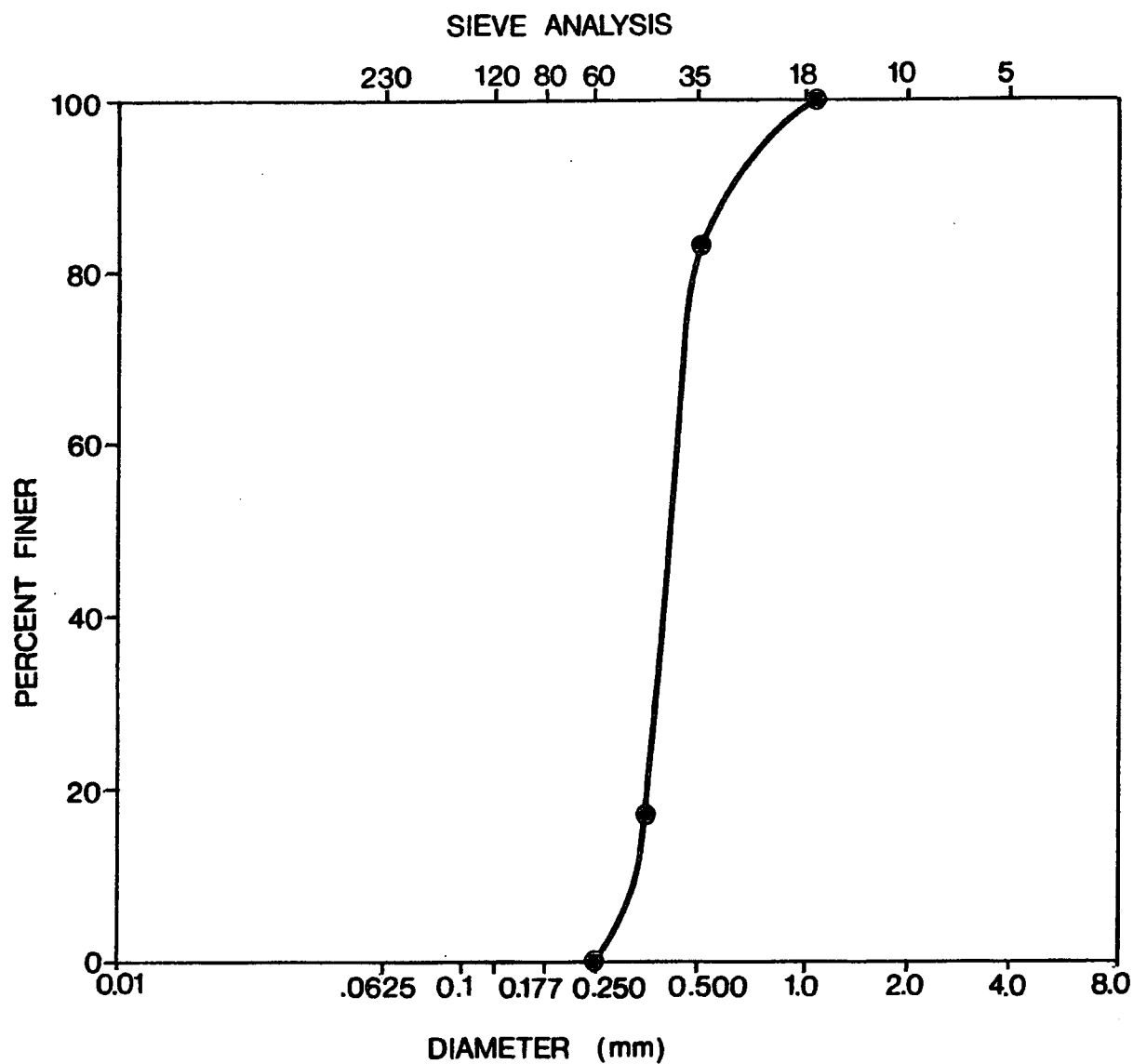


Fig.17. Grainsize distribution of bed load material collected at Trenton channel in Detroit River.

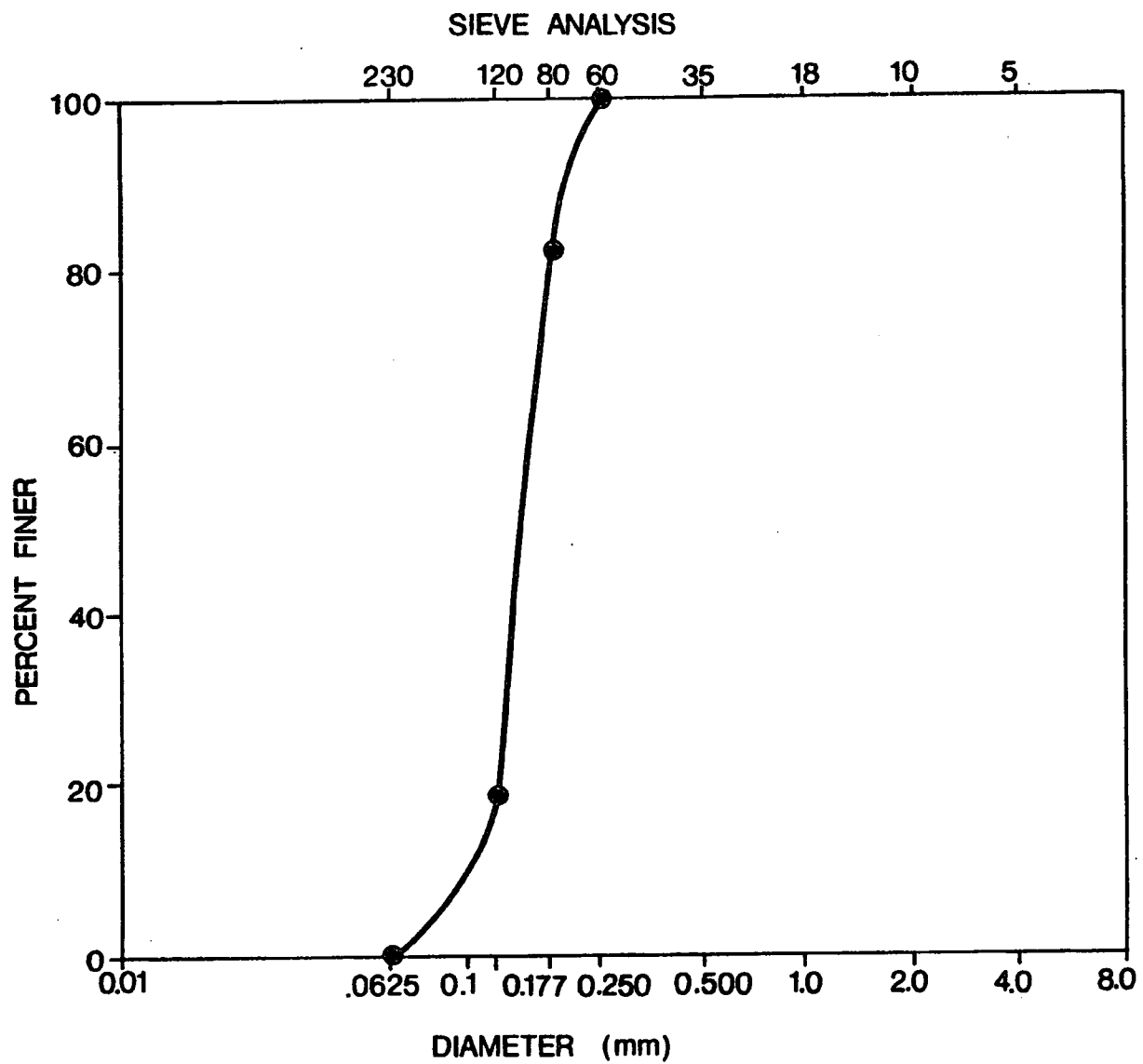


Fig.18. Grainsize distribution of bed load material collected at Ballards Reef channel in Detroit River.



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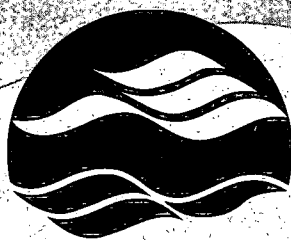
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