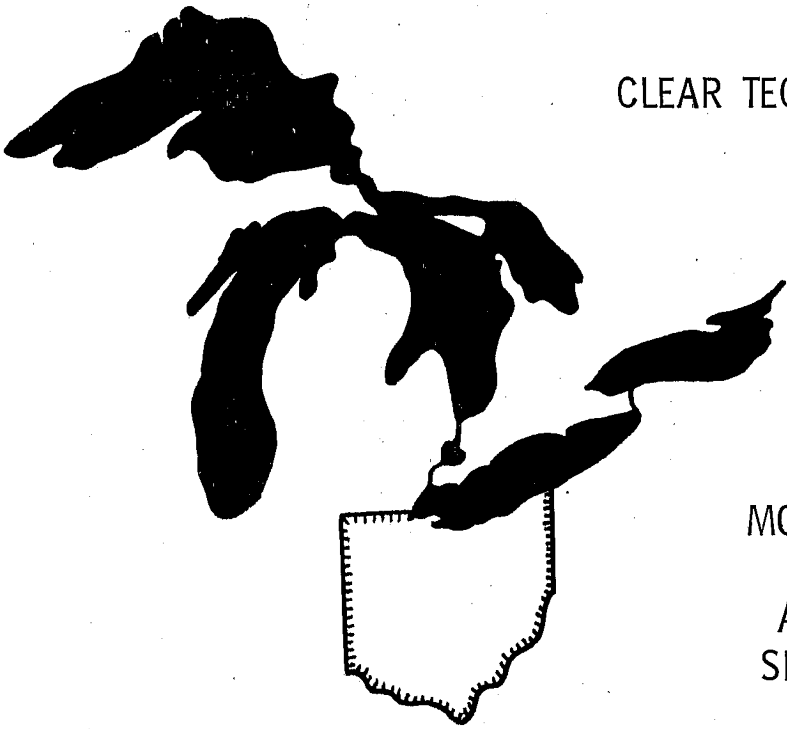

CLEAR TECHNICAL REPORT NO. 101

MONITORING OF TOXIC METALS IN LAKE ERIE SEDIMENTS AT DREDGE DISPOSAL SITES SERVING ASHTABULA HARBOR

by

Lester J. Walters, Jr.
Department of Geology
Bowling Green State University

Prepared for

U.S. Environmental Protection Agency
Environmental Research Laboratory-Duluth
Large Lakes Research Station
Grosse Ile, Michigan

THE OHIO STATE UNIVERSITY
CENTER FOR LAKE ERIE AREA RESEARCH
COLUMBUS, OHIO
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Bowling Green State University

Department of Geology
Bowling Green, Ohio 43403
Telephone (419) 372-2886

October 16, 1978

Dr. C. E. Herdendorf, Director
Center for Lake Erie Area Research
The Ohio State University
484 W. 12th Ave.
Columbus, Ohio 43210

Dear Eddie:

Enclosed is my project completion report for the Ashtabula Dredge Disposal project. This report should be assigned CLEAR Technical Report No. 101 (per our conversation last week). I am sorry that it has taken so long to get this to you, but it took some time for Laura Fay, the boat crew, and me to resolve our questions concerning the labeling and location of the samples collected in April.

I am working on the Cruise 2 and 3 water analyses and will be reporting some results to Laura soon. My full-time assistant is beginning to be very effective, thus we should see some progress soon.

Sincerely,

Les

Lester J. Walters, Jr.
Associate Professor

LJW/cp
Enclosure

Monitoring of Toxic Metals in Lake Erie Sediments at Dredge Disposal Sites Serving Ashtabula Harbor

Project Completion Report

by

Lester J. Walters, Jr.
Department of Geology
Bowling Green State University
Bowling Green, Ohio 43403

27 September 1978

Submitted to

The Center for Lake Erie Area Research, Ohio State University in completion of PO No. RF325980 and The U.S. Environmental Protection Agency, Large Lakes Section, Grosse Isle, Michigan

ABSTRACT

Detailed depth profiles for concentration of As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, and Zn showed that these toxic metals are nearly uniformly distributed in sediment cores on dredge spoils collected in April 1978. Cores collected in May, September, and October show increased degrees of surface enrichment for all metals except Sb. Cores collected at the disposal site used prior to spring 1978 showed surface enrichment for Cd, Cr, Cu, Ni, Pb, and Zn. Hg and Sb did not show surface enrichment. Analyses of control cores from the Ashtabula area indicated that the distribution of polluted sediments is highly variable. Further, sediment cores from the open lake stations in the central basin suggest that surface enrichment of toxic metals is not confined to the dredge spoils and nearshore environments, but is also found in the open lake sediments.

INTRODUCTION

The effect of dredge spoil disposal on the quality of lake bottom sediments is a matter of concern to the people living around and using the Great Lakes. Heqvy metal concentrations were monitored in a dredge disposal site used by the U.S. Army Corps of Engineers in April 1978 for sediment from the Ashtabula Harbor area.

The concentration of toxic metals in the sediment of the central basin of Lake Erie have been investigated by Stith (1973), Ritchie _et al_. (1973), Sweeney _et al_. (1974), Walters _et al_. (1974), Rosengrant (1975), Kemp and Thomas

(1976) and Walters (1977). Ritchie *et al.* (1973) showed that significant heavy metal loadings to Lake Erie were caused by open lake disposal of spoils from Ashtabula Harbor. Sweeney *et al.* (1974) showed that the deposition of dredge spoils from the Cleveland Harbor and Cuyahoga Rivers reduced the quality of the surficial sediments in the dumping grounds. Walters *et al.* (1974) and Rosengrant (1975) found that heavy metals were usually enriched in the surficial sediments of the central basin. However, Walters (1977) showed that the concentration levels of the surficial sediments in the central basin of Lake Erie were usually much less than those in western Lake Erie. The major source of polluted sediments in the central basin was identified as the Cleveland area (Rosengrant, 1974; and Walters, 1977).

Although most of the research on toxic metals has concerned the levels of mercury, several authors have also investigated other toxic metals. Wilson (1978) summarized the current state of toxic metal research in western Lake Erie and concluded that the sediments have a large capacity for holding and retaining As, Cd, Cr, Cu, Hg, Ni, Pb, Sb, and Zn. The occurrences of these elements was monitored by the present study.

METHODS

The sediment cores were collected by the crew of the R/V HYDRA and were frozen on-board the ship. The cores were collected with a 2 inch ID gravity corer using CAB plastic core liners. Table 1 lists the sampling locations for the cores used in the study.

The frozen cores were sectioned in the laboratory into 2 cm intervals (0-16 cm), 4 cm intervals (16-40 cm), and 10 cm intervals (40 cm to total depth). The frozen cores and plastic liner were sectioned using a hacksaw. After sawing, the cut surface was scraped to remove residue from the plastic liner and saw blade.

The samples were digested for mercury analysis using the standard nitric-sulfuric acid-permanganate digestion procedure which is described by Wolery (1973) and is modified after those of Hatch and Ott (1968) and Iskander et al. (1972). Two additional digestion procedures were used for the remaining metals. First Cd, Cr, Cu, Ni, and Zn were determined after digesting the sample with 1) hydrogen peroxide 2) hydrochloric acid, and 3) hydroxylamine-hyrochloride-hydrochloric acid (Wolery, 1973). Secondly, As, Pb, and Sb were determined after digestion with ultrapure nitric acid using the procedure of Wilson (1978, p. 18) which was developed because severe interference by the chloride was observed with the arsenic determination. One gram of sediment was evaporated over heat with 2 ml concentrated ultrapure nitric acid. This step was repeated. Then 25 ml of 4 N ultrapure nitric acid was added to the sample, stirred, and centrifuged. The supernate was taken for analysis.

All heavy-metal analyses were performed using a Perkin-Elmer 603 atomic absorption spectrophotometer. A 3-slot Boling-type burner was used with an air-acetylene flame to analyze for elements in relatively high concentrations as found in sediment samples. Argon or nitrogen was used with HGA-2100 graphite furnace accessory unit to determine lower concentrations of metals. When using the graphite furnace, all samples were analyzed two or three times and the results averaged. A cold-vapor FAAS technique as described by Kovacik (1972, pp. 15-22) and Wolery (1973, pp. 78-80) was employed for the analysis of mercury. Data was normalized to a one-gram dry sample. Equipment, standard conditions, and matrices used in atomic absorption analyses are described for all nine elements in Table 2. The atomic absorption conditions were those recommended by Perkin-Elmer (1976 a; and 1976 b).

RESULTS AND DISCUSSION

The analytical results for 11 sediment cores collected from the new dump site which was used in April 1977 are listed in Table 3. Values for arsenic are not shown for the cores collected in April and May because these samples were digested with hydrochloric acid. The resulting presence of chloride in the sample solution caused extreme interference with the arsenic determination by graphite furnace. The later samples were digested with nitric acid only prior to arsenic analysis and yielded valid results. Table 4 lists the results observed for Cores from the old dump site which had been used prior to 1977. Analytical results for the control cores are listed in Table 5. The average concentration (Table 6) of Cd, Cr, Ni, Pb, Sb, and Zn in the sediment cores from the new dump site showed a significant decrease during the sampling period (5/17/77 to 10/10/77). The concentrations of these metals approached the values observed for the open lake stations (32, 33, and 78). This decrease in metal concentration was concomitant with a decrease in water content of the sediment (58% to 47%).

The metal concentrations observed in the sediment cores were highly variable for those cores collected in May. However, the degree of surface enrichment increased in the cores collected in September and October. Likewise the amount of variability within the cores decreased so that a smoothly decreasing concentration-depth profile was observed for those cores collected later in the sampling season.

Comparisons of the concentrations of toxic metals observed at the old dump site (Table 4), new dump site (Table 3) and control site (Table 5) with the concentration observed at the open lake stations (Table 5; Walters, 1977; and Rosengrant, 1975) showed that all cores collected in the Ashtabula near-shore area were enriched in metals. The degree of enrichment suggested that the Ashtabula area was not the only source of polluted sediments but rather the impact of input from Cleveland and the Cuyahoga River (Sweeney et al. 1974) spread northeast along the United States shoreline by littoral drift.

The changes observed in the concentration of toxic metals determined in the sediment cores from the Ashtabula area can be explained by at least two mechanisms. First the polluted sediments deposited as dredge spoil are rapidly transported away from the disposal site by the northeast trending littoral drift, which would result in the sediments from the Cleveland area having the most impact on the sediment quality at Ashtabula. Secondly, the concentration depth profiles may be controlled by a process of diffusion toward and across the sediment-water interface as the dredge spoil is dewatered. However, the latter process seems unlikely considering the strong binding power of the sediment for these toxic metals (Wilson, 1978).

ACKNOWLEDGEMENT

I thank Dr. Jack Zapatowsky, Dave Gruet, Dennis Naylon and the crew of the R/V HYDRA for collecting the sediment cores. This work was supported by the USEPA, Contract grant R804612-01.

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Table 1. Sample locations for cores at dredge disposal and control sites in the Ashtabula area.

Sample Station	Latitude	Longitude
New dump site	41 57 00	80 48 30
Old dump site	41 56 24	80 45 54
Control site	41 55 54	80 46 54
32	42 04 54	81 00 42
33	41 55 54	80 55 00
78	42 07 00	81 15 00

Table 2. Summary of atomic absorption conditions and specifications.

METAL	EQUIPMENT	STANDARD CONDITIONS					MATRIX
		Gas	Standards (ppb)	Detection Limit (ppb)	(nm)	Temperature Char-Atomize (°C)	
Ag	Flame	Acetylene Air	100, 200, 500	2.0	328.1	N.A.*	HNO_3
	Furnace	N_2	20, 50, 100	0.02		400°-2700°	
As	Furnace	Ar	10, 20, 50	0.3	193.7	250°-2700°	HNO_3
Cd	Flame	Acetylene Air	100, 200, 500	1.0	228.8	N.A.	HCl
	Furnace	Ar or N_2	2, 5, 10	0.01		250°-2100°	
Co	Flame	Acetylene Air	2000, 5000, 10000	10.0	240.7	N.A.	HCl
	Furnace		50, 100, 200	0.1		1000°-2700°	
Cr	Flame	Acetylene Air	2000, 5000, 10000	3.0	357.9	N.A.	HCl
	Furnace	Ar	100, 200, 500	0.07		1100°-2700°	
Cu	Flame	Acetylene Air	2000, 5000, 10000	2.0	324.7	N.A.	HCl
	Furnace	Ar or N_2	100, 200, 500	0.1		900°-2700°	

*N.A. - Not applicable

Table 2. Continued

METAL	EQUIPMENT	Gas	Standards (ppb)	Detection Limit (ppb)	(nm)	Temperature Char-Atomize (^{o}C)	MATRIX
Hg	Cold-vapor Flameless	Air	2, 5, 10	0.007	253.7	N.A.*	HNO_3-H_2SO_4
Ni	Flame	Acetylene Air	2000, 5000, 10000	5.0	232.0		HNO_3
	Furnace	Ar or N_2	50, 100, 200	0.4		1000^{o}-2700^{o}	
Pb	Flame	Acetylene Air	2000, 5000, 10000	10.	217.0		HNO_3
	Furnace	N_2 or Ar	20, 50, 100, 200	0.05		700^{o}-2300^{o}	
Sb	Furnace	N_2 or Ar	100, 500, 700	0.3	217.6	900^{o}-2700^{o}	HNO_3
Se	Furnace	N_2 or Ar	200, 500, 1000	0.5	196.0	350^{o}-2700^{o}	HNO_3
Zn	Flame	Acetylene Air	2000, 5000, 10000	1.0	213.9		HNO_3
	Furnace	N_2		0.004		500^{o}-2500^{o}	

*N.A. - Not applicable

Table 3. Heavy metals in sediment cores from dredge disposal site used in spring 1978

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
NEW DUMP SITE CORE 1 COLLECTED 5/17/77											
0.0	2.0	57		3.0	44	39	.19	47	49	.45	170
2.0	4.0	46		3.0	42	37	.18	44	53	.78	180
4.0	6.0	48		3.6	48	40	.16	44	49	.73	190
6.0	8.0	49		2.9	46	36	.22	40	44	.79	220
8.0	10.0	50		3.7	54	47	.28	40	53	.85	330
10.0	12.0	49		3.2	55	41	.30	40	52	.97	400
12.0	14.0	48		3.4	59	42	.29	40	48	.82	410
14.0	16.0	54		3.6	67	46	.44	46	59	.71	390
20.0	24.0	48		3.2	56	45	.27	41	51	.50	470
28.0	32.0	41		1.6	34	32	.17	33	35	.60	190
NEW DUMP SITE CORE 2 COLLECTED 5/17/77											
0.0	2.0	60		3.1	41	38	.18	40	45	.70	160
2.0	4.0	52		3.3	47	42	.21	45	51	.68	210
4.0	6.0	52		3.2	53	45	.26	41	50	.77	260
6.0	8.0	45		2.6	44	37	.19	33	41	.74	230
8.0	10.0	48		2.8	56	40	.26	40	44	.81	300
10.0	12.0	53		3.0	67	44	.39	41	49	.68	320
12.0	14.0	54		3.7	160	48	.48	47	54	.62	380
14.0	16.0	52		3.7	78	48	.36	44	58	.79	450
20.0	24.0	45		2.8	52	38	.25	36	45	.77	390
28.0	32.0	43		1.5	32	34	.23	32	36	.56	220

Table 3. Cont.

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
NEW DUMP SITE CORE 3 COLLECTED 5/17/77											
0.0	2.0	49		2.5	40	36	.19	41	39	.86	190
2.0	4.0	42		2.4	39	32	.15	36	34	.79	180
4.0	6.0	48		3.3	58	48	.30	41	53	.91	360
6.0	8.0	45		2.8	61	40	.25	40	44	.97	410
8.0	10.0	52		2.3	55	36	.28	37	39	1.07	290
10.0	12.0	51		2.9	83	42	.47	44	50	.92	370
12.0	14.0	47		2.5	105	41	.50	42	46	.77	380
14.0	16.0	47		2.4	150	38	.45	42	45	.73	340
20.0	24.0	51		3.0	63	46	.31	40	55	.86	470
28.0	32.0	51		2.9	53	44	.30	39	50	.68	510
36.0	40.0	43		1.9	36	34	.19	32	37	.63	290
NEW DUMP SITE CORE 1 COLLECTED 9/4/77											
0.0	2.0	76	.48	1.8	34	39	.19	36	47	.53	200
2.0	4.0	57	.64	1.9	42	50	.14	44	49	.40	420
4.0	6.0	60	.70	1.9	44	51	.28	40	53	.40	440
6.0	8.0	56	.52	1.3	37	46	.22	33	43	.17	320
8.0	10.0	52	.39	1.1	36	37	.15	28	32	.18	250
10.0	12.0	41	.41	.74	35	35	.13	28	32	.21	200
12.0	14.0	41	.43	.94	34	41	.21	30	35	.10	170
14.0	16.0	43	.37	.57	22	35	ND	27	33	ND	140
16.0	20.0	45	.37	.72	22	35	.17	28	40	.11	170
24.0	28.0	46	.41	.43	16	31	.35	25	32	.05	120
32.0	36.0	44	.74	.33	15	36	.19	25	37	.13	130
40.0	43.0	25	.48	.16	11	16	.08	17	14	.05	58

Table 3. Cont.

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
NEW DUMP SITE CORE 2 COLLECTED 9/4/77											
0.0	2.0	67	.20	3.5	42	53	ND	58	55	.026	230
2.0	4.0	57	.19	3.2	50	55	ND	48	47	ND	330
4.0	6.0	54	.21	2.9	54	56	ND	57	56	.005	330
6.0	8.0	53	.26	2.9	50	56	ND	37	110	.024	310
8.0	10.0	44	.13	1.8	31	34	.09	23	32	.039	160
10.0	12.0	42	.17	1.7	34	37	.46	19	34	.046	170
12.0	14.0	37	.12	1.3	27	33	.12	40	30	.041	130
14.0	16.0	43	.12	1.2	20	39	.21	38	41	.085	140
16.0	20.0	43	.12	1.2	18	34	.21	30	46	ND	140
24.0	28.0	47	.11	.74	13	35	.16	27	42	ND	130
32.0	36.0	39	.12	.62	15	26	.18	20	30	.029	92
40.0	49.0	27	.06	.26	8.4	20	.06	13	19	.017	54
NEW DUMP SITE CORE 3 COLLECTED 9/4/77											
0.0	2.0	73	1.3	1.3	39	40	.29	44	49	.092	200
2.0	4.0	56	.67	1.2	43	44	.23	43	21	.030	360
4.0	6.0	55	1.9	1.4	43	50	.26	39	50	.26	410
6.0	8.0	53	.54	1.1	42	49	.22	43	40	.002	360
8.0	10.0	50	.78	.98	34	42	.14	34	22	.063	270
10.0	12.0	44	1.05	.67	30	35	.12	30	30	<.002	210
12.0	14.0	41	1.9	.59	33	39	.15	30	35	<.002	190
14.0	16.0	42	2.1	.45	23	35	.16	28	35	<.002	130
16.0	20.0	42	3.2	.33	18	29	.18	28	38	.063	140
24.0	28.0	48	2.0	.85	15	29	.23	39	44	<.002	180
32.0	36.0	46	3.5	.61	15	37	.25	28	39	.056	160
40.0	43.0	31	.08	.39	11	21	ND	23	21	.12	87

Table 3. Cont.

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
NEW DUMP SITE CORE 1 COLLECTED 10/10/77											
0.0	2.0	76	.15	2.0	37	47	.18	36	47	<.002	230
2.0	4.0	47	.16	1.3	22	38	.22	28	89	.069	150
4.0	6.0	44	.081	.88	22	30	.21	23	36	.041	140
6.0	8.0	46	.089	.77	17	35	.29	27	39	.004	170
8.0	10.0	38	.067	.32	12	22	ND	19	25	<.002	100
10.0	12.0	41	.094	.43	15	28	.13	25	33	.043	130
12.0	14.0	43	.109	.69	13	31	.25	25	37	<.002	140
14.0	16.0	36	.10	.54	11	28	.18	21	26	.085	110
16.0	20.0	35	.067	.45	11	21	.13	22	24	.025	100
20.0	24.0	27	ND	.34	9.8	18	.08	18	17	.013	68
NEW DUMP SITE CORE 2 COLLECTED 10/10/77											
0.0	2.0	82	ND	3.8	42	52	.32	52	50	.17	220
2.0	4.0	62	ND	3.3	41	46	.30	49	46	<.002	240
4.0	6.0	53	ND	1.9	30	43	.21	38	42	<.002	180
6.0	8.0	48	ND	.99	17	35	.23	30	45	.034	190
8.0	10.0	32	ND	.35	8.1	14	.16	13	38	<.002	85
10.0	12.0	39	ND	.57	15	24	.13	25	28	.068	130
12.0	14.0	37	ND	.63	11	23	.15	21	30	.035	130
14.0	16.0	36	ND	.57	15	24	.14	26	33	.11	130
16.0	20.0	38	ND	.71	17	28	.14	30	35	<.002	150
24.0	26.0	32	ND	.38	11	17	.07	22	22	.073	77

Table 3. Cont.

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
NEW DUMP SITE CORE 3 COLLECTED 10/10/77											
0.0	2.0	78	.107	3.3	44	55	.31	57	57	.032	210
2.0	4.0	54	.049	2.2	28	50	.28	30	49	.29	180
4.0	6.0	45	.062	1.6	23	42	.31	53	50	.13	160
6.0	8.0	44	.116	1.1	22	32	.20	30	39	.033	110
8.0	10.0	45	.070	.89	15	35	.26	25	45	.57	150
10.0	12.0	36	.051	.52	14	24	.16	32	29	.43	81
12.0	14.0	41	.14	.74	15	33	.24	39	40	.74	95
14.0	16.0	43	.14	.67	18	41	.25	21	46	.65	160
16.0	20.0	37	.15	.54	11	34	.19	20	33	.11	120
20.0	22.0	42	.10	.54	15	27	.14	26	31	.32	120

Table 4. Heavy metals in sediment cores from dredge disposal site used in spring 1978

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
OLD DUMP SITE CORE 1 COLLECTED 4/1/77											
0.0	2.0	84		4.1	44	27	.32	55	57	.51	220
2.0	4.0	64		3.6	44	25	.34	49	54	.46	210
4.0	6.0	60		3.1	43	22	.25	44	47	.58	210
6.0	8.0	64		4.0	51	25	.28	51	62	.48	230
8.0	10.0	63		3.9	60	23	.35	49	62	.45	330
10.0	12.0	67		3.9	66	26	.35	52	65	.46	290
12.0	14.0	57		4.5	63	24	.41	52	69	.71	370
14.0	16.0	60		4.5	65	27	.51	53	74	.47	410
16.0	20.0	63		5.1	69	30	.37	54	82	.41	460
20.0	24.0	55		3.9	62	22	.35	48	62	.54	470
24.0	28.0	49		3.6	50	21	.34	46	58	.71	450
28.0	32.0	46		3.1	43	18	.28	45	52	.60	320
32.0	36.0	46		2.6	36	39	.31	39	44	.65	300
36.0	40.0	53		3.3	47	49	.32	46	56	.54	350
40.0	43.5	45		1.7	47	31	.23	32	37	.43	160
OLD DUMP SITE CORE 2 COLLECTED 4/1/77											
0.0	2.0	72		3.4	39	38	.015	47	54	.54	200
2.0	4.0	57		4.9	59	44	.024	44	73	.36	440
4.0	6.0	57		2.9	38	32	.015	39	46	.70	180
6.0	8.0	60		3.7	40	40	.037	42	57	.58	270
8.0	10.0	65		5.3	53	56	.023	45	75	.72	370
10.0	12.0	62		5.2	54	46	.020	47	73	.80	360
12.0	14.0	57		4.3	50	45	.044	40	64	.67	350
14.0	16.0	61		3.9	42	46	.047	46	58	1.02	270
16.0	20.0	56		4.2	67	52	.062	49	70	.68	460
20.0	24.0	59		4.4	69	52	.095	46	70	.81	500

Table 4. Cont.

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
24.0	28.0	53		4.1	60	52	.038	44	61	.98	550
28.0	32.0	59		4.8	75	66	.077	54	79	.72	730
32.0	36.0	49		2.5	45	41	.046	38	44	.62	360
36.0	40.0	47		2.5	42	39	.040	33	40	.50	250
40.0	46.0	52		2.5	46	46	.037	35	43	.62	250

Table 4. Cont.

Top cm	Bot cm	H_2O percent	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
OLD DUMP SITE CORE 1 COLLECTED 5/17/77										
0.0	2.0	82	3.7	52	46	.001	51	58	.51	120
2.0	4.0	68	3.8	46	43	.028	47	56	.50	110
4.0	6.0	64	4.5	59	49	.002	52	62	.69	130
6.0	8.0	65	6.5	86	66	.008	49	87	1.0	200
8.0	10.0	60	5.1	76	60	.029	48	77	.89	440
10.0	12.0	57	4.9	72	56	.055	49	71	.98	480
12.0	14.0	57	4.3	63	53	.077	49	66	.95	360
14.0	16.0	62	3.9	61	50	.049	47	56	.52	310
20.0	24.0	57	2.5	44	41	.062	36	47	.71	180
28.0	32.0	57	2.4	33	38	.12	36	56	.65	190
36.0	40.0	56	.9	21	31	.11	30	41	.66	140
50.0	60.0	58	.6	20	26	.045	30	30	.57	100
OLD DUMP SITE CORE 2 COLLECTED 5/17/77										
0.0	2.0	73	3.5	52	47	.095	52	62	.68	230
2.0	4.0	58	3.5	61	49	.099	52	63	.75	250
4.0	6.0	64	4.0	81	62	.15	55	83	.79	460
6.0	8.0	69	3.6	86	62	.18	52	86	.51	520
8.0	10.0	65	3.4	79	61	.18	53	74	.81	530
10.0	12.0	60	2.0	54	46	.11	42	57	.68	410
12.0	14.0	62	2.1	59	56	.15	46	62	.83	430
14.0	16.0	76	2.0	64	52	.12	45	59	.63	390
20.0	24.0	51	.75	39	32	.11	33	39	.64	160
28.0	32.0	58	1.5	31	32	.18	33	52	.96	180
36.0	40.0	59	.85	18	24	.11	29	35	.80	120

Table 4. Cont.

Top cm	Bot cm	H_2O percent	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
OLD DUMP SITE CORE 3 COLLECTED 5/17/77										
0.0	2.0	64	4.0	57	42	.17	55	62	.68	220
2.0	4.0	59	4.4	65	45	.22	51	68	.77	370
4.0	6.0	63	5.8	82	57	.23	55	96	1.15	490
6.0	8.0	61	5.1	73	52	.25	51	89	.71	420
8.0	10.0	61	3.7	59	39	.19	47	64	.68	340
10.0	12.0	66	3.4	60	36	.18	46	58	.67	350
12.0	14.0	64	2.9	52	30	.22	40	53	.56	300
14.0	16.0	67	3.0	59	31	.15	40	60	.53	280
20.0	24.0	59	2.1	44	39	.19	34	52	.30	200
28.0	32.0	59	1.5	27	35	.24	34	63	.30	200
36.0	40.0	59	.86	23	28	.17	32	42	.64	140
50.0	60.0	42	.40	17	20	.071	26	23	.59	87

Table 5. Heavy metals in sediment cores from control sites used for comparison with dredge disposal sites.

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
CONTROL SITE 1 CORE 1 COLLECTED 4/2/77											
0.0	2.0	64		4.1	54	54	ND	45	64	.54	370
2.0	4.0	64		4.0	53	52	.020	45	59	.59	340
4.0	6.0	55		4.1	54	53	.047	44	62	.69	350
6.0	8.0	54		4.2	55	56	.061	46	62	.80	360
8.0	10.0	56		3.9	51	50	.044	42	57	.61	320
10.0	12.0	55		4.8	62	58	.035	48	68	.73	390
12.0	14.0	53		4.5	57	58	.045	44	63	.71	390
14.0	16.0	50		4.5	56	58	.052	43	64	.60	390
16.0	20.0	47		3.2	43	48	.038	36	55	.61	300
20.0	24.0	50		2.4	38	45	.019	36	53	.61	230
24.0	28.0	50		3.5	47	52	.054	39	57	.63	310
28.0	32.0	45		1.0	21	29	.024	28	33	.41	140
32.0	36.0	47		3.2	44	47	.033	36	52	.53	300
36.0	42.0	46		2.0	31	39	.024	32	44	.44	210
CONTROL SITE 1 CORE 2 COLLECTED 4/2/77											
0.0	2.0	68		3.8	53		.023	39	55	.48	340
2.0	4.0	60		4.0	56	54	.045	40	53	.62	360
4.0	6.0	62		4.5	63	63	.041	44	58	.31	420
6.0	8.0	59		3.8	53	51	.041	38	53	.44	340
8.0	10.0	60		3.4	46	50	.056	35	51	.39	320
10.0	12.0	49		1.4	23	32	.037	28	40	.57	160
12.0	14.0	50		.95	19	29	.038	28	39	.52	150
14.0	16.0	43		.80	17	28	.036	25	35	.49	130
16.0	20.0	48		.88	19	29	.034	30	38	.42	140
20.0	24.0	53		1.16	21	31	.068	31	43	.55	160

Table 5. Cont.

Top cm	Bot cm	H_2O Percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
24.0	28.0	51		.97	19	28	.053	30	38	.32	140
28.0	32.0	46		.89	19	27	.056	28	37	.49	150
32.0	36.0	47		2.1	35	38	.024	32	44	.74	230
36.0	40.0	47		1.06	18	29	.035	28	41	.52	170
40.0	51.0	30		.42	12	13	.007	21	12	.46	62
STATION 32 CORE 1 COLLECTED 9/29/77											
0.0	2.0	91	ND	1.3	37	36	.35	50	55	.72	160
2.0	4.0	53	ND	.79	55	21	.12	24	28	.32	85
4.0	6.0	41	ND	.26	15	14	.13	22	11	.047	47
6.0	8.0	41	ND	.18	15	17	.06	25	11	.068	47
8.0	10.0	41	ND	.22	15	14	.04	25	9.6	.13	48
10.0	12.0	42	ND	.35	16	18	.27	25	12	.15	48
12.0	14.0	37	ND	.42	14	17	.04	25	14	.25	44
14.0	16.0	31	ND	.45	12	16	.02	22	15	.43	37
16.0	20.0	32	ND	.38	12	18	.03	22	15	.44	38
24.0	28.0	30	ND	.53	11	14	.02	20	14	.34	34
32.0	36.0	34	ND	3.8	12	18	.05	22	15	.29	40
40.0	50.0	32	ND	.50	5.4	15	.02	14	15	.23	27
STATION 33 CORE 1 COLLECTED 9/29/77											
0.0	2.0	76	.34	4.2	64	71	.22	48	76	.028	330
2.0	4.0	72	.33	3.7	64	72	.22	46	73	.044	390
4.0	6.0	73	.18	2.2	41	57	.27	37	48	<.002	250
6.0	8.0	48	.091	.44	13	22	.11	21	18	.078	71
8.0	10.0	43	.056	.29	13	17	.05	20	11	.040	52
10.0	12.0	54	.093	.33	14	24	.06	25	20	.041	66
12.0	14.0	53	.065	.38	13	21	.04	21	12	.077	56
14.0	16.0	41	.22	.38	13	16	.06	23	9.6	.053	51

Table 5. Cont.

Top cm	Bot cm	H_2O percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
16.0	20.0	42	.20	.32	14	17	.05	21	10	<.002	50
24.0	28.0	47	.11	.40	11	17	.05	22	8.1	.064	48
32.0	36.0	38	.21	.31	13	18	.05	23	13	.17	53
40.0	50.0	37	.16	.24	13	19	.04	24	10	.023	54
STATION 78 CORE 1 COLLECTED 9/29/77											
0.0	2.0	87	ND	3.0	52	81	.21	ND	ND	.14	290
2.0	4.0	77	.30	2.0	41	58	.16	44	80	.099	220
4.0	6.0	70	.092	.99	23	33	.11	16	20	.038	130
6.0	8.0	74	.17	.84	18	33	.05	37	63	<.002	93
8.0	10.0	66	.13	.49	19	33	.07	14	17	<.002	82
10.0	12.0	61	.14	.48	22	26	.03	18	18	<.002	76
12.0	14.0	59	.15	.58	17	27	.02	32	15	<.002	77
14.0	16.0	54	.15	.52	19	28	.04	22	15	.042	77
16.0	20.0	59	.29	.41	23	31	.03	51	15	.15	79
24.0	28.0	57	.24	.41	21	28	.03	ND	15	<.002	77
32.0	36.0	57	.18	.46	19	30	.03	21	15	<.002	74
40.0	50.0	50	.090	.53	23	28	.03	23	14	<.002	79

Table 6. Average values for heavy metals in sediment cores from the Ashtabula Harbor dredge disposal sites and control sites.

Location*	Core	Date Collected	H_2O Percent	As ppm	Cd ppm	Cr ppm	Cu ppm	Hg ppm	Ni ppm	Pb ppm	Sb ppm	Zn ppm
ODS	1	4/1/77	58		3.7	53	27	.33	48	58	.53	312
ODS	2	4/1/77	58		3.9	52	46	.039	43	60	.69	369
NDS	1	5/17/77	49		3.1	51	41	.25	42	49	.72	295
NDS	2	5/17/77	50		3.0	63	41	.28	40	47	.71	292
NDS	3	5/17/77	48		2.6	68	40	.31	39	45	.84	379
NDS	1	9/4/77	49	.50	.99	29	38	.19	30	37	.21	262
NDS	2	9/4/77	46	.15	1.8	30	40	.19	34	45	.035	185
NDS	3	9/4/77	48	1.6	.82	29	38	.20	34	35	.058	225
NDS	1	10/10/77	43	.10	.77	17	30	.19	24	37	.028	134
NDS	2	10/10/77	51		1.3	21	31	.19	31	37	.050	153
NDS	3	10/10/77	47	.10	1.2	21	37	.23	33	42	.33	139
ODS	1	5/17/77	62		3.6	53	47	.041	44	59	.72	230
ODS	2	5/17/77	63		2.5	57	48	.13	45	61	.73	335
ODS	3	5/17/77	60		3.1	52	38	.19	43	61	.63	283
CS	1	4/2/77	53		3.5	48	50	.038	40	57	.61	314
CS	2	4/2/77	52		2.0	32	36	.040	32	42	.49	218
32	1	9/29/77	42	ND	.76	18	18	.096	25	18	.28	54
33	1	9/29/77	52	.17	1.1	24	31	.10	28	27	.052	122
78	1	9/29/77	64	.16	.89	25	36	.07	28	26	.040	113
NDS	Ave	4/1/77	58		3.8	52	36	.19	46	59	.61	340
NDS	Ave	5/17/77	49		2.9	61	41	.28	40	47	.76	322
NDS	Ave	9/4/77	48		1.2	29	39	.19	33	39	.10	224
NDS	Ave	10/10/77	47		1.1	20	33	.20	29	39	.14	142
OPEN LAKE	Ave	9/29/77	53	.16	.92	22	28	.088	27	24	.12	96

* NDS New dump site
ODS Old dump site
CS Control site
ND Not determined

Ashtabula Mtg. 21 Aug

Howard Zar	USEPA	312-353-3503
BARBARA TAYLOR	US EPA	312-353-2307
ANTHONY KIZLAUSKAS	USEPA	312-353-3576
John H. Cousins	ODNR	614-466-4768
KEN BURCH	USEPA WMB	(312) 353-2197
JOHN ALBRECHT	OEPA	(614) 466-9092
Ken Multerer	U.S. FWS	FTS 943-6923
Eddie Herdendorf	OSU	(614) 422-8949
Ralph J. Bernhagen	ODNR	614-466-4768
Ed. Duffield	OEPA	614-466-7427
PAUL LANG	COE	com - 716-876-5454 FTS 473-2175
J.A. FOLEY	COE	" 473-2225
Coe Emery	USFWS Columbus	231-3431
Richard P. Motta	OEPA, Land	466-8934
Eric Arge	ODNR	614-466-3558