BOTTOM SEDIMENT EVALUATION

Little Scioto River

Marion, Ohio

Ohio EPA
Division of Water Quality Planning and Assessment
Ecological Assessment Section
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SEDIMENT SUMMARY

Sediment samples were collected from the Little Scioto River and Scioto River by the Ohio EPA during 1988 (3 samples analyzed for metals and semivolatile organic priority pollutants) and from the Little Scioto River and North Rockswale Ditch in 1991 (8 samples analyzed for volatile and semivolatile organic priority pollutants and RCRA metals). These samples were collected to assess levels of contaminants present in stream sediments in the vicinity of the Baker Wood Preserving Co., Berwind Railway Service Co., Marion WWTP, Marion active and abandoned landfills, combined sewer overflows and an American Water Works surface water intake.

- Fifteen polycyclic aromatic hydrocarbons (PAH) were identified and quantified (Table 1 and 3) in the Little Scioto River study area. PAH values ranged between 0.43 ppm and 550 ppm, with the highest concentrations occurring between RM 5 and 7.

- To determine the relative severity of contamination in the Little Scioto River, PAH ratios were calculated based upon a comparison of Little Scioto River sediment data to Black River sediment data (Table 2). The Black River was used as a contaminated reference site for comparison because the lower six miles have a fish consumption advisory and primary contact advisory (Ohio Department of Health 1983) based upon the presence of high concentrations of PAHs in the sediments; there is also a high incidence of fish tumors in this segment. Ratios were calculated for total PAH compounds as well as for 15 commonly analyzed PAH parameters. Both methods gave comparable results. Ratios greater than one, indicating a sediment PAH concentration greater than that reported for Black River sediment (Baumann 1982) was reported at RM 5.80 (RM 6.5 had a ratio of nearly 1). These data suggest that the Little Scioto River from RM 6.5 to at least RM 5.8 is equal to or more contaminated than the Black River contaminated reference site.

- Five of the PAH compounds identified in Little Scioto River sediment have been identified as possible human carcinogens: benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, chrysene, and dibenzo(a,h)anthracene.

- Little Scioto River maximum values for 4 PAH compounds (phenanthrene, fluoranthene, benzo(a)pyrene, and benzo(a)anthracene) were significantly higher than maximum sediment values associated with areas of epizootics of neoplasia in fish (letter from Dr. Paul Baumann to Jeff DeShon, Ohio EPA); see Appendix 3.

- The contamination of Little Scioto River sediments with PAH compounds is significant since the sediments between at least RM 6.5 and 5.8 have benzo(a)pyrene concentrations at the highest levels ever observed in published data by a U.S. Fish and Wildlife Service expert (Pers. comm. Paul C. Baumann 1988). This compound is a known mammalian carcinogen with a high carcinogenic potency.

- Three semivolatile organic compounds (excluding PAHs) were quantified in sediment samples collected from the Little Scioto River and one compound was identified in Scioto River sediment (Tables 1 and 4). Di-n-butyl phthalate was measured at most of the stations sampled; the highest value was 110 ppm.

- Four volatile organic compounds were detected in sediment collected by the Ohio EPA during 1991 (1988 samples were not analyzed for volatiles). Methylene chloride and carbon disulfide were detected at most sampling locations, with maximum concentrations of 2,800 ppb and 260 ppb, respectively. Acetone was measured at 3,750 ppb in the Little Scioto River sediment from Holland Rd (Tables 1 and 6).

- Nine heavy metal parameters were detected in the sediment from the Little Scioto River (Tables 1 and 5). Generally, the highest metal concentrations in sediment were measured in the Little Scioto River between RM 6.6 and 2.7. This segment receives discharges of wastewater from the Marion WWTP, several industrial dischargers and combined sewer overflows.

- Using sediment evaluation criteria developed by Kelly and Hite (1984), the following chemicals and areas are considered highly elevated to extremely elevated above background conditions:

  Cadmium - Little Scioto River at RM 6.6 and 2.7
  Chromium - Little Scioto River from RM 6.6 to 2.7
  Lead - Little Scioto River from RM 6.6 to 2.7, North Rockswale Ditch at RM 0.5
  Mercury - Little Scioto River from RM 6.6
  Zinc - Little Scioto River from RM 6.5 to 2.7, Scioto River at RM 176.7

- Severe biological degradation exists in the Little Scioto River downstream from RM 6.5. Major sources of degradation appear to be sediments contaminated with heavy metals and PAH organic compounds, combined sewer overflows, numerous industrial discharges and effluent from the Marion WWTP.

- During the 1988 and 1991 sampling events and during three other macroinvertebrate surveys dating back to 1974, the banks and bottom of the Little Scioto River between RM 6.6 and 5.8 were observed to be heavily saturated with a black material with a creosote odor. Disturbance of the bottom sediments released an oily substance which created an extensive rainbow sheen on the surface of the water.

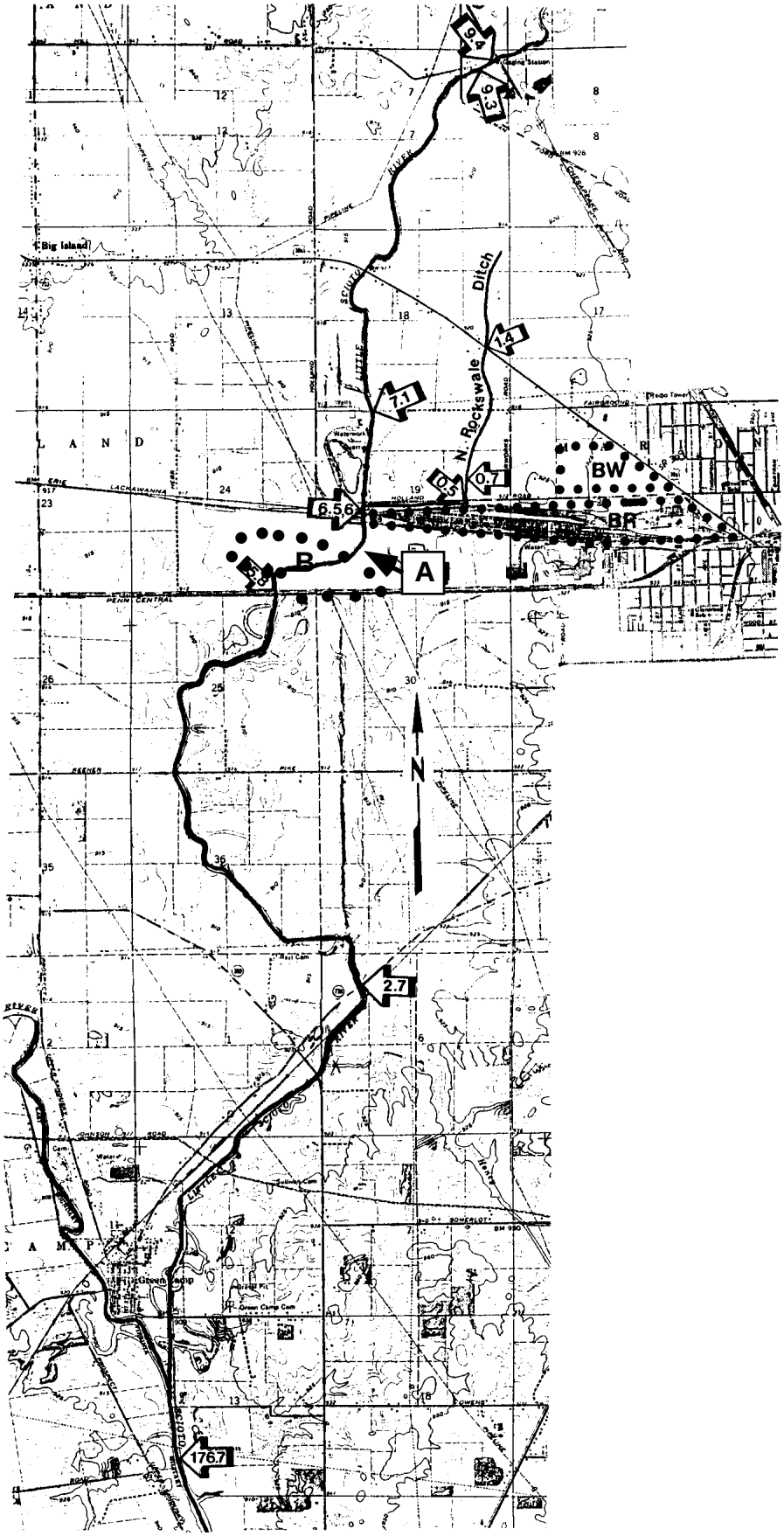

Figure 1. Map of the Little Scioto River study area showing Ohio EPA sediment sampling locations from 1988 and 1991. BW = Baker Wood; BR = Berwind Railway hazardous waste sites; A=Marion WWTP; B= Marion Landfill.

Table 1. Little Scioto River, North Rockswale Ditch and Scioto River **sediment** PAH, semivolatile and volatile organic compounds and metals contamination, 1988 and 1991 (see Tables 3-6 for data sources).

Parameter	Range
PAH (ppm)	
Acenaphthene	0.43-150
Anthracene	0.58-360
Benzo(a)anthracene	1.0-185
Benzo(b)fluoranthene	20J-215
Benzo(k)fluoranthene	2.27-213.2
Benzo(a)pyrene	1.01-141.1
Benzo(ghi)perylene	1.01-144.1
Dibenzo(a,h)anthracene	33.3
Chrysene	1.35-305
Fluoranthene	4.94-550
Fluorene	18.3-200
Indeno(1,2,3-cd)pyrene	1.03-156
Naphthalene	22.9-70
Phenanthrene	0.76-470
Pyrene	3.16-405
SEMIVOLATILE COMPOUNDS (ppm) (Excluding PAH compounds)	
Di-n-butyl phthalate	40J-110
Dibenzofuran	75
Bis(2-ethylhexyl) phthalate	3.1
2,4-Dinitrotoluene	0.35
VOLATILE COMPOUNDS (ppb)	
Toluene	140
Methylene chloride	15J-2800
Acetone	80J-3750J
Carbon disulfide	25-260
METALS (ppm)	
Arsenic, Total	9.49-11.2
Barium, Total	27.8-82.2
Cadmium, Total	<1.0-4.39
Chromium, Total	5.4-680
Copper, Total	40-83
Lead, Total	<10-213
Mercury, Total	<0.10-0.45
Nickel, Total	23-44
Zinc, Total	187-760

J = less than limit of practical quantitation but greater than zero

Table 2. Summary of PAH sediment contamination in the Little Scioto River, 1988 and 1991.

Stream River Mile (Location)	Year	Total PAH (ppm)	'Total' PAH Ratio [1]	'Commonly Analyzed' PAH Ratio [1]
Little Scioto River				
9.42 (Hillman Ford Rd.)	1991	Not Detected	-	-
9.33 (Hillman Ford Rd.)	1991	Not Detected	-	-
7.15 (American Water Works)	1991	**105**	**0.08**	**0.09**
6.60 (Holland Rd.)	1991	**180**	**0.14**	**0.16**
6.60 (Holland Rd.) *Duplicate*	1991	Not Detected	-	-
6.5 (Holland Rd.)	1988	***1,208.9***	***0.96***	***0.98***
5.80 (State Route 95)	1991	***3,235***	***2.52***	***2.32***
2.7 (State Route 739)	1988	**97.6**	**0.08**	**0.08**
North Rockswale Ditch				
1.42 (State Route 309)	1991	Not Detected	-	-
0.67 (200 meters upst. Holland Rd.)	1991	Not Detected	-	-
0.53 (Holland Rd.)	1991	**20**	**0.01**	**0.02**
Scioto River				
176.75 (0.5 mile dnst. L. Scioto R.)	1988	**17.54**	**0.01**	**0.01**

[1] PAH ratio calculations were based on comparing data from the Little Scioto River to a PAH contaminated segment of the Black River where a high incidence of fish tumors have been documented. A ratio greater than 1 indicates a sediment PAH concentration greater than that reported for Black River contaminated sediment.

$$\text{Total PAH Ratio} = \frac{\text{Total L. Scioto River PAH concentration}}{\text{Total Black River PAH concentration (1253.7 ppm)}}$$

$$\text{Commonly Analyzed PAH Ratio} = \frac{\text{15 'Common' L. Scioto River PAH concentrations}}{\text{15 'Common' Black River PAH concentrations (1151.4 ppm)}}$$

Commonly analyzed PAHs: acenaphthene, acenaphthylene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, 2-methylnaphthalene, naphthalene, phenanthrene, pyrene.

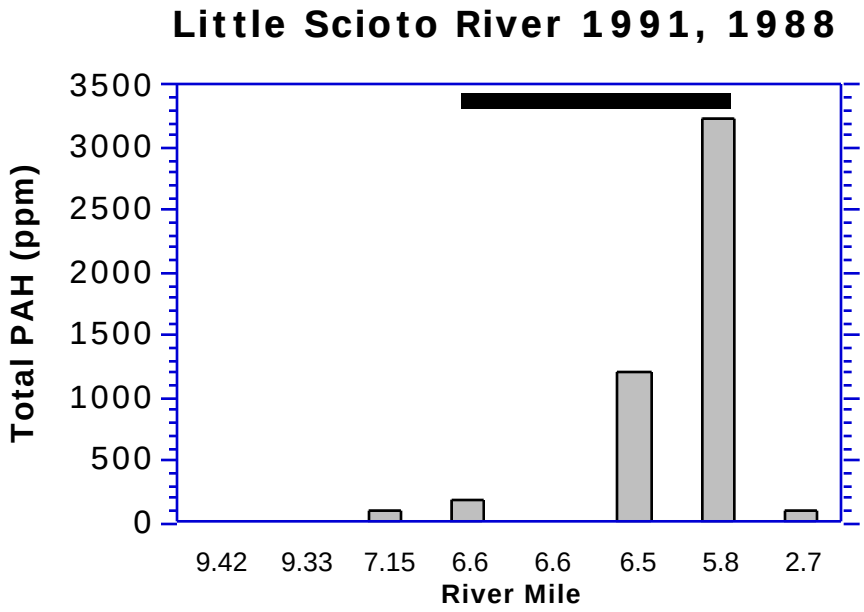

Figure 2. Summary of sediment PAH levels in the Little Scioto River during 1988 and 1991. The black bar represents an area which encompasses the North Rockswale Ditch discharge, Berwind Railway property, Marion WWTP effluent discharge, combined sewer overflows, old Marion landfill and active Marion landfill. Baker Wood Preserving Co. is located 0.5 miles east of North Rockswale Ditch. RM 6.6D is a duplicate sample of RM 6.6

Table 3. PAH contaminant levels in sediment collected from the Little Scioto River and North Rockswale Ditch, Marion, Ohio. QA criteria were not established for the Ohio EPA sediment samples - results of Ohio EPA data cannot be assumed.

PAH

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppm)
Little Scioto River					
9.42 (Hillman Ford Rd.)	1991	B1018266 (Betz)	Grab	All PAHs	Not Detected (Limit of Practical Quantitation = 10ppm)
9.33 (Hillman Ford Rd.)	1991	B1018265 (Betz)	Grab	All PAHs	Not Detected (Limit of Practical Quantitation = 5ppm)
7.15 (Amer. Water Works)	1991	B1018269 (Betz)	Grab	Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Chrysene Fluoranthene Indeno(1,2,3-cd)pyrene Pyrene	15J 10J 25 15J 20J 5J 15J
6.60 (Holland Rd.)	1991	B1018271 (Betz)	Grab	Benzo(a)anthracene Benzo(b)fluoranthene Benzo(ghi)perylene Chrysene Fluoranthene Phenanthrene Pyrene	15J 20J 10J 15J 50 40J 30J
6.60 (Holland Rd.) *Duplicate of Lab Number B1018271*	1991	B1018272 (Betz)	Grab	All PAH	Not Detected (Limit of Practical Quantitation = 20ppm)
6.5 (Holland Rd.)	1988	01189 (OEPA)	Grab	Acenaphthene Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(ghi)perylene Benzo(k)fluoranthene Chrysene Dibenzo(a,h)anthracene Fluoranthene Fluorene Indeno(1,2,3-cd)pyrene Naphthalene Phenanthrene Pyrene	14.8 66.8 44.7 141.1 144.1 213.2 119.5 33.3 78.4 18.3 156.0 22.9 88.3 67.5

Table 3.Continued.

PAH

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppm)
Little Scioto River					
5.80 (State Route 95)	1991	B1018276 (Betz)	Grab	Acenaphthene	150
				Anthracene	360
				Benzo(a)anthracene	185
				Benzo(a)pyrene	125
				Benzo(b)fluoranthene	215
				Benzo(ghi)perylene	65
				Chrysene	305
				Fluoranthene	550
				Fluorene	200
				Indeno(1,2,3-cd)pyrene	60
				Naphthalene	70
				Phenanthrene	470
				Pyrene	405
2.7 (State Route 739)	1988	01188 (OEPA)	Grab	Anthracene	2.3
				Benzo(a)anthracene	4.3
				Benzo(a)pyrene	11.4
				Benzo(ghi)perylene	16.5
				Benzo(k)fluoranthene	21.3
				Chrysene	9.7
				Fluoranthene	6.3
				Indeno(1,2,3-cd)pyrene	18.6
				Phenanthrene	2.0
				Pyrene	5.2
North Rockswale Ditch					
1.42 (State Route 309)	1991	B1018267 (Betz)	Grab	All PAHs	Not Detected (Limit of Practical Quantitation = 10ppm)
0.67 (200 meters upstream Holland Rd.)	1991	B1018268 (Betz)	Grab	All PAHs	Not Detected (Limit of Practical Quantitation = 10ppm)
0.53 (Holland Rd.)	1991	B1018270 (Betz)	Grab	Phenanthrene	20J

Table 3.Continued.

PAH

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppm)
Scioto River					
176.75 (0.5 miles downstream L. Scioto River)	1988	01190 (OEPA)	Grab	Acenaphthene	0.43
				Anthracene	0.58
				Benzo(a)anthracene	1.0
				Benzo(a)pyrene	1.01
				Benzo(ghi)perylene	1.01
				Benzo(k)fluoranthene	2.27
				Chrysene	1.35
				Fluoranthene	4.94
				Indeno(1,2,3-cd)pyrene	1.03
				Phenanthrene	0.76
				Pyrene	3.16

J = less than limit of practical quantitation but greater than zero.

Table 4. Semivolatile organic compound contaminant levels (excluding PAH compounds) in sediment collected from the Little Scioto River, Scioto River and North Rockswale Ditch, Marion, Ohio. QA criteria were not established for the Ohio EPA sediment samples - results of Ohio EPA data cannot be assumed.

SEMIVOLATILE ORGANIC COMPOUNDS

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppm)
Little Scioto River					
9.42 (Hillman Ford Rd.)	1991	B1018266 (Betz)	Grab	Di-n-butyl phthalate	110
9.33 (Hillman Ford Rd.)	1991	B1018265 (Betz)	Grab	Di-n-butyl phthalate	63
7.15 (Amer. Water Works)	1991	B1018269 (Betz)	Grab	Di-n-butyl phthalate	55
6.60 (Holland Rd.)	1991	B1018271 (Betz)	Grab	Di-n-butyl phthalate	40J
6.60 (Holland Rd.) *Duplicate of Lab Number B1017271*	1991	B1018272 (Betz)	Grab	All compounds	None Detected
6.5 (Holland Rd.)	1988	01189 (OEPA)	Grab	All compounds	None Detected
5.8 (State Route 95)	1991	B1018276 (Betz)	Grab	Di-n-butyl phthalate Dibenzofuran	70 75
2.7 (State Route 739)	1988	01188 (OEPA)	Grab	Bis(2-ethylhexyl) phthalate	3.1
North Rockswale Ditch					
1.42 (State Route 309)	1991	B1018267 (Betz)	Grab	Di-n-butyl phthalate	97
0.67 (200 meters upstream Holland Rd.)	1991	B1018268 (Betz)	Grab	Di-n-butyl phthalate	70
0.53 (Holland Rd)	1991	B1018270 (Betz)	Grab	Di-n-butyl phthalate	90
Scioto River					
176.75 (0.5 miles downstream	1988	01190 (OEPA)	Grab	2,4-Dinitrotoluene	0.35

J = less than limit of practical quantitation but greater than zero.

Table 5. Metal contaminant levels in sediment collected from the Little Scioto River, Scioto River and North Rockswale Ditch, Marion, Ohio during 1988 and 1991. NA = not analyzed. Sediment evaluations were based upon criteria in Kelly and Hite (1984). Evaluations with two letters (e.g. a and b) indicates that the reported less than value could be either non-elevated or slightly elevated.

METALS - mg/kg (ppm) dry weight

Stream River Mile (Location) Lab/Lab Number/Year	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Little Scioto River											
9.42 (Hillman Ford Rd.) Betz/ B1018266/ 1991	<10 a,b	33.8	<1.0 a,b	5.8 a	NA	<10 a	<0.10 a,b	NA	<10	<2.0	NA
9.33 (Hillman Ford Rd.) Betz/ B1018265/ 1991	<10 a,b	62.2	<1.0 a,b	6.8 a	NA	<10 a	<0.10 a,b	NA	<10	<2.0	NA
7.15 (American Water Works) Betz/ B1018269/ 1991	<10 a,b	67.2	<1.0 a,b	13.2 a	NA	25.5 a	<0.10 a,b	NA	<10	<2.0	NA
6.60 (Holland Rd.) Betz/ B1018271/ 1991	<10 a,b	82.2	**4.0** d	**680** e	NA	**213** e	**0.24** d	NA	<10	<2.0	NA
6.60 (Holland Rd.) Betz/ B1018272/ 1991 *(Duplicate of Lab Number B1018271)*	<10 a,b	60.8	**2.8** d	**150** e	NA	**138** e	**0.45** e	NA	<10	<2.0	NA
6.5 (Holland Rd.) OEPA/ 29189/ 1988	11.2 c	NA	1.8 c	**47.6** d	68 c	**170** e	NA	23	NA	NA	**187** d
5.80 (State Route 95) Betz/ B1018276/ 1991	<10 a,b	70.4	1.0 c	**39.2** d	NA	59.5 c	0.16 c	NA	<10	<2.0	NA
2.7 (State Route 739) OEPA/ 29190/ 1988	9.49 b	NA	**4.39** d	**134** e	83 c	**160** e	NA	44	NA	NA	**760** e
North Rockswale Ditch											
1.42 (State Route 309) Betz/ B1018267/ 1991	<10 a,b	27.8	<1.0 a,b	5.4 a	NA	12.4 a	<0.10 a,b	NA	<10	<2.0	NA
0.67 (200 m upst. Holland Rd.) Betz/ B1018268/ 1991	<10 a,b	33.8	<1.0 a,b	7.2 a	NA	14.2 a	<0.10 a,b	NA	<10	<2.0	NA
0.53 (Holland Rd.) Betz/ B1018270/ 1991	<10 a,b	45.2	1.4 c	35.2 c	NA	**97.4** d	0.11 c	NA	<10	<2.0	NA
Scioto River											
176.75 (0.5 m. dst. L. Sc.) OEPA/ 29188/ 1988	9.95 b	NA	1.43 c	29.5 c	40 b	53 c	NA	30	NA	NA	**187** d

a - non elevated; b - slightly elevated; c - elevated; d - highly elevated; e - extreme.

Arsenic: a <8.0, b ≥8.0, c ≥ 11; Cadmium: a <0.5, b ≥0.5, c ≥1.0; Mercury: a <0.07, b ≥0.07, c ≥0.10.

Table 6. Volatile organic compound contaminant levels in sediment collected from the Little Scioto River and North Rockswale Ditch, Marion, Ohio. NA = not analyzed.

VOLATILE ORGANIC COMPOUNDS

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppb)
Little Scioto River					
9.42 (Hillman Ford Rd.)	1991	NA	NA	Volatile compounds	NA
9.33 (Hillman Ford Rd.)	1991	B1018265 (Betz)	Grab	Carbon Disulfide Acetone Methylene chloride	260 80J 20J
7.15 (American Water Works)	1991	B1018269 (Betz)	Grab	Carbon Disulfide Methylene chloride	30 1,200
6.60 (Holland Rd.)	1991	B1018271 (Betz)	Grab	Acetone Methylene chloride	3,750J 750J
6.60 (Holland Rd.) *Duplicate of Lab Number B1018271*	1991	B1018272 (Betz)	Grab	All volatiles	Not Detected
5.80 (State Route 95)	1991	B1018276 (Betz)	Grab	Methylene Chloride	600
North Rockswale Ditch					
1.42 (State Route 309)	1991	B1018267 (Betz)	Grab	Acetone Carbon disulfide Methylene chloride	80J 150 2,800
0.67 (200m upstream Holland Rd.)	1991	B1018268 (Betz)	Grab	Carbon disulfide Methylene chloride	90 15J
0.53 (Holland Rd.)	1991	B1018270 (Betz)	Grab	Carbon disulfide Methylene chloride Toluene	25 65 140

J = less than limit of practical quantitation but greater than zero.

REFERENCES

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Kelly, M.H. and R.L. Hite. 1984. Evaluation of Illinois stream sediment data: 1974-1980. Illinois Environmental Protection Agency, Div. of Water Pollution Control.

Ohio EPA. 1988. Biological and water quality study of the Little Scioto River watershed, Marion County, Ohio. Div. of Water Quality Planning and Assessment, July 15, 1988. pp 35.

Appendix 1

Semivolatile, Volatile and Heavy Metal Compounds Analyzed for Ohio EPA 1991 and 1988 Little Scioto River, North Rockswale Ditch and Scioto River Sediment Samples

1991 & 1988 - Bold type

1991 only - Italized type

1988 only - Thin type

METALS

Arsenic, Total
Barium, Total
Cadmium, Total
Chromium, Total
Copper, Total
Lead, Total
Mercury, Total
Nickel, Total
Selenium, Total
Silver, Total
Zinc, Total

SEMIVOLATILE COMPOUNDS

Acenaphthene
Acenaphthylene
Anthracene
Benzo (A) anthracene
Benzo(A) pyrene
Benzo(B) fluoranthene
Benzo(G,H,I) perylene
Benzo(K) fluoranthene
Benzoic acid
Benzyl alcohol
Benzylbutyl phthalate
Bis(2-chloroethoxy) methane
Bis(2-chloroethyl) ether
Bis(2-chloroisopropyl)ether
Bis(2-ethylhexyl) phthalate
4-Bromophenyl phenyl ether
4-Chloroaniline
4-Chloro-3-methyl phenol
2-Chloronaphthalene
2-Chlorophenol
4-Chlorophenyl phenyl ether
Chrysene
o-Cresol
p-Cresol
Dibenzo(A,H) anthracene
Dibenzofuran
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3'-Dichlorobenzidine
2,4-Dichlorophenol
Diethyl phthalate
2,4-Dimethylphenol
Dimethyl phthalate
Di-N-butyl phthalate
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Di-N-octyl phthalate
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Hexachloropentadiene
Indeno (1,2,3-CD) pyrene
Isophorone
2-Methyl-4,6-Dinitrophenol
2-Methylnaphthalene
Naphthalene
2-Nitroaniline
3-Nitroaniline
4-Nitroaniline
Nitrobenzene
2-nitrophenol
4-Nitrophenol
N-nitrosodiphenyl amine
N-Nitroso-N-propylamine
Pentachlorophenol
Phenanthrene
Phenol
Pyrene
1,2,4-Trichlorobenzene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

VOLATILE COMPOUNDS

Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
2-Butanone
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethylvinylether
Chloroform
Chloromethane
Dibromochloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
Trans-1,2-dichloroethene
1,2-Dichloropropane
cis-1,3-Dichloropropene
Trans-1,3-dichloropropene
Ethylbenzene
2-Hexanone
Methylene chloride
4-Methyl-2-pentanone
Styrene
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Vinyl chloride
Total Xylenes

APPENDIX 2

Raw Data

Appendix 2 Sampling Stations 1991

Sampling Station	Stream	River Mile
BASE-021	Little Scioto River	9.42
BASE-020	Little Scioto River	9.33
BASE-024	Little Scioto River	7.15
BASE-026	Little Scioto River	6.60
BASE-027 (Duplicate of BASE-026)	Little Scioto River	6.60
BASE-028	Little Scioto River	5.80
BASE-022	North Rockswale Ditch	1.42
BASE-023	North Rockswale Ditch	0.67
BASE-025	North Rockswale Ditch	0.53

Appendix 3

Letter from Dr. Paul Baumann