

No. 000311



EPA Region 5 Records Ctr.



207513

REMEDIAL INVESTIGATION
FOR THE
E. H. SCHILLING LANDFILL
Remedial Investigation/Feasibility Study

Prepared for :
Aristech Chemical Corporation

For Submittal to:
United States Environmental Protection Agency Region V
and
Ohio Environmental Protection Agency

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1.0 INTRODUCTION

A Remedial Investigation (RI) of the E. H. Schilling Landfill located in Hamilton Township, Lawrence County, Ohio has been conducted under the Administrative Order by Consent V-W-87-C-008 between respondents Aristech Chemical Corporation and E.H. Schilling and Sons, Inc., and the US Environmental Protection Agency (US EPA) and Ohio Environmental Protection Agency (OEPA). The RI was performed by Law Environmental under contract to Aristech Chemical Corporation. Metcalf and Eddy, under subcontract to Jacobs Engineering Group, Inc., performed oversight services for the US EPA. The RI field activities commenced in February 1988 and required approximately sixteen months to complete. The RI field work included sampling and analysis of leachate, surface and ground water, sediments, soil, landfill waste and air.

1.1 Project Scope

The Administrative Order established the following project objectives:

- o "To determine fully the nature and extent of the threat, if any, caused by the release or threatened release of hazardous substances, pollutants or contaminants from the E. H. Schilling Landfill site (Remedial Investigation -RI)."

- o "To evaluate alternatives for the appropriate extent of remedial action to prevent or mitigate the migration or the release or threatened release, if any,

of hazardous substances, pollutants, or contaminants from the E. H. Schilling Landfill site (Feasibility Study - FS)."

The RI/FS for the E.H. Schilling site was designed to be accomplished in three phases. Phase I of the RI was a comprehensive work effort characterizing the landfill and its environmental impacts. This phase consisted of the following tasks:

- TASK 1 - Description of the Current Situation
- TASK 2 - Preparation of the Phase I Work Plan
- TASK 3 - Phase I Site Investigation
- TASK 4 - Phase I Site Investigation Analysis

Phase II of the RI consisted of filling any data gaps identified in Phase I considering possible remedial technologies for the site. The tasks for Phase II were:

- TASK 5 - Preparation of the Phase II Work Plan
Quality Assurance Project Plan - Phase II
- TASK 6 - Phase II Site Investigation/Analysis
- TASK 7 - Remedial Investigation Report

The Feasibility Study is the phase III portion of the overall study. The tasks for the FS are:

- TASK 8 - Description of Current Situation
- TASK 9 - Preliminary Remedial Technologies
- TASK 10 - Development of Alternatives

- TASK 11 - Initial Screening of Alternatives
- TASK 12 - Evaluation of the Alternatives
- TASK 13 - Preliminary Report
- TASK 14 - Final Report

This RI report is submitted in fulfillment of Phases I and II (Tasks 1-7). In addition a site Risk Assessment has been performed and included in this report. The field and analytical work were performed in accordance with the following documents:

<u>DOCUMENT</u>	<u>AGENCY APPROVED DATE</u>
Phase I RI Work Plan	October, 1987
Phase I RI Management Plan	October, 1987
Phase I RI Health & Safety Plan	October, 1987
Phase I RI Sampling Plan	October, 1987
Phase I RI Quality Assurance Project Plan (QAPP)	April, 1988
Phase II RI Work Plan	February, 1989
Phase II RI Quality Assurance Project Plan	February, 1989

Due to site-specific conditions encountered during the Phase I site investigation, minor work scope modifications were required. Prior to implementation, all modifications were approved by US EPA/OEPA.

1.2 Site Background

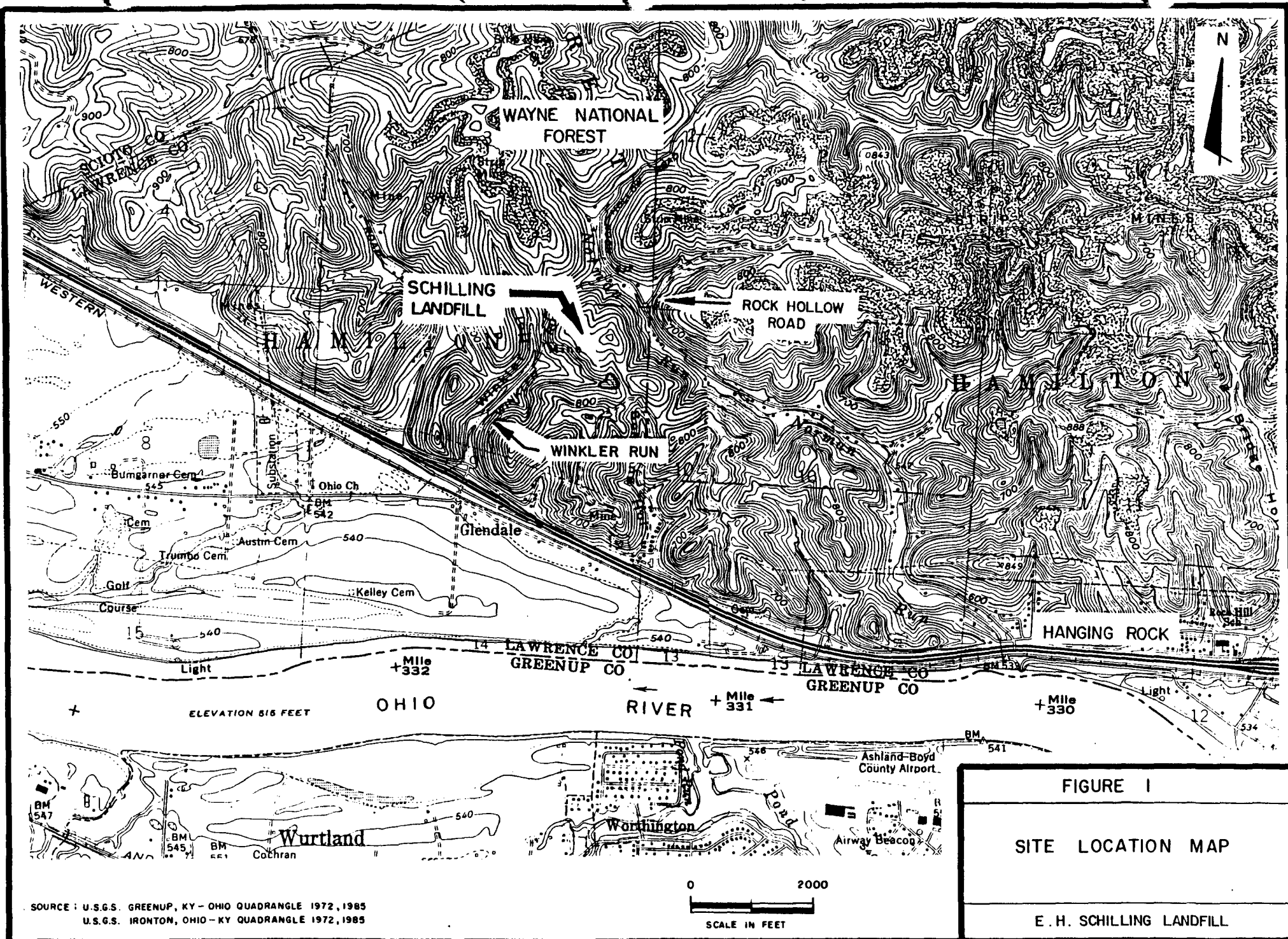
1.2.1 Site Location and Description

The E. H. Schilling Landfill is located approximately four miles northwest of the city of Ironton in the Northeast Quarter Section 9, Township 1 North, Range 19 West in Hamilton Township, Lawrence County, Ohio in south-central Ohio near the Ohio River as shown in Figure 1.

The landfill occupies approximately three acres of land on a larger land tract owned by Earl H. Schilling and is situated in a valley draw incised into the west slope of a ridge separating Winkler Hollow (west of the site) from Schilling Hollow (east of the site), 0.8 miles north of the Ohio River and about 0.5 miles north of US Route 52. The only major boundary of note is that of the Wayne National Forest, which extends north-south approximately four hundred feet east of the site. Figure 2 depicts the landfill in relation to other features within the study area. The waste is contained in the valley draw by a steeply sloping earthen dam.

1.2.2 Historical Framework

The landfill began receiving waste in January 1969, developed largely in part as an exclusive landfill for the Dow Chemical plant in Hanging Rock and Aristech Chemical plant in Haverhill. In August 1971 the landfill became licensed by Lawrence County to accept non-hazardous dry industrial waste. Other waste generators of record include Ashland Oil Company (Kyova Pipe Company), Associated Metals and Metallurgical Corporation, Matlack, Inc. and Roy McGovney Construction, Inc. A variety of wastes including solids, liquids and sludges were disposed of in the valley draw that is now the landfill.



SOURCE : U.S.G.S. GREENUP, KY - OHIO QUADRANGLE 1972, 1985
 U.S.G.S. IRONTON, OHIO - KY QUADRANGLE 1972, 1985

FIGURE I

SITE LOCATION MAP

E. H. SCHILLING LANDFILL

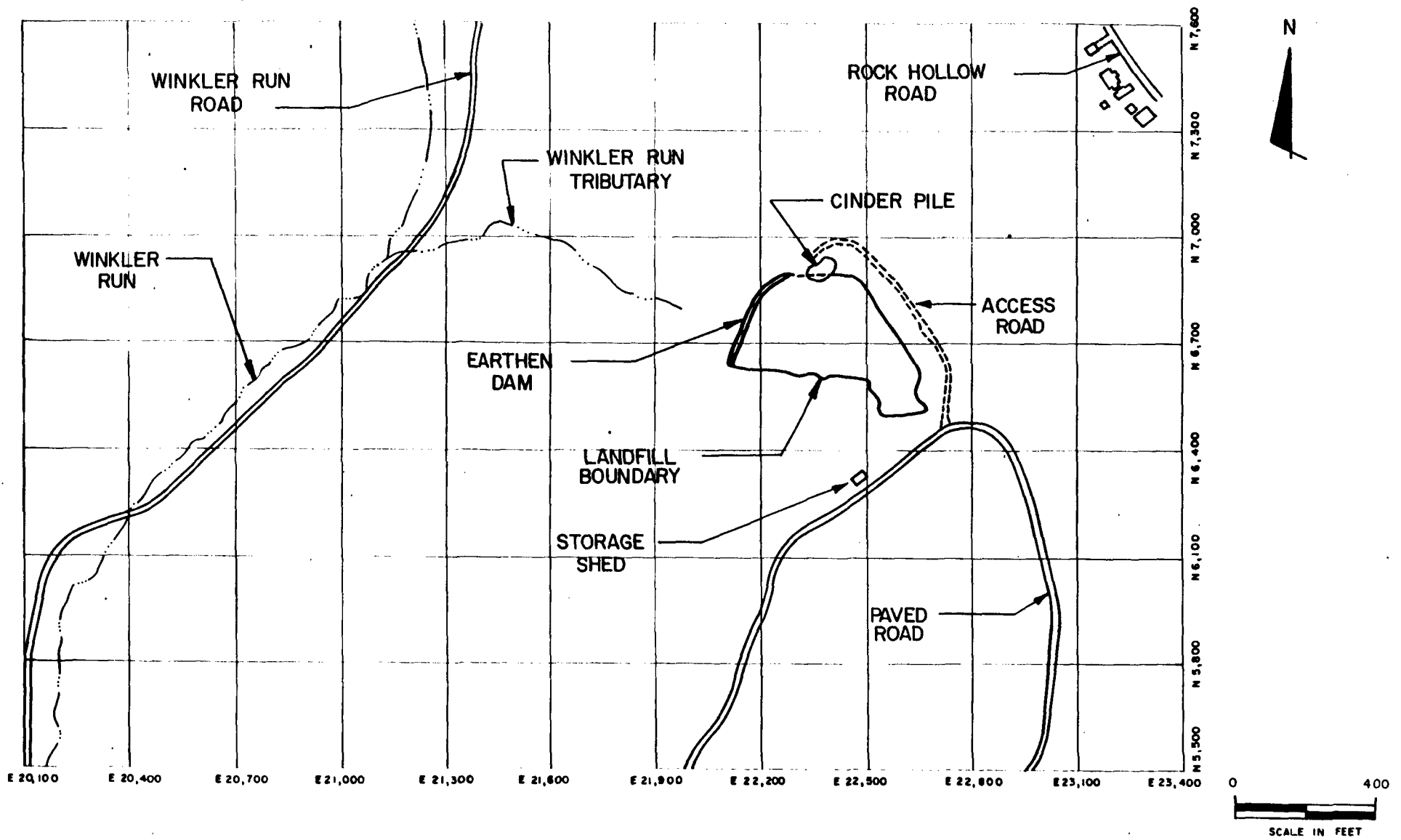


FIGURE 2

STUDY AREA FEATURES

E.H. SCHILLING LANDFILL

The site ceased operations in July 1980. The US EPA and OEPA have been involved in preliminary site studies and limited data collection efforts since 1979. An OEPA letter dated February 23, 1983, identified a number of listed hazardous materials as being present in leachate, surface water, and soil samples collected at the base of the earthen dam. Active leachate seeps were noted at several points along the base of the landfill earthen dam.

The E.H. Schilling Landfill was evaluated by using the CERCLA Hazard Ranking System (Mitre Model) in 1982, and it received a score of 40.37. The model data were revised in 1983, resulting in a score reduction to 34.6. The site was ranked number 520 on the National Priorities List (40 CFR 300, Appendix B, Page 829, July 1, 1986). Detailed RI/FS studies were required pursuant to CERCLA Section 105.

1.2.3 Historical Aerial Photographs

Historical aerial photographs include black-and-white photographs from 1966 and 1971 and color photographs from 1984. Excerpts from the US EPA files on aerial photography pertaining to the landfill area are provided below.

A photograph taken on October 25, 1966 shows the east half of the future landfill site. Natural drainage patterns were noted as being to the west within the steep-sided valley of the site boundary.

Evidences of waste disposal and landfill activity are indicated in the March 21, 1971 photograph. A considerable amount of solid waste had been dumped onto the headwall of the valley below the paved road. A small building had been constructed on the north side of the road southwest of the landfill (the building is still present).

Two color photographs (one plan and one oblique view) were taken on June 9, 1984 nearly four years after closing of the landfill. The areal extent of the landfill had expanded considerably since 1971. The landfill cap is clearly evident along with a scar/clearing in the woods east of the site which was used as the soil borrow area. The earthen dam on the west side of the landfill is also visible. Rust-colored leachate seeps were noted in the central portion of the site.

1.2.4 Previous Investigations and Sampling

The first known sampling conducted at the Schilling Landfill was performed by the OEPA on October 30, 1979. At this time, two separate leachate springs were sampled along with a "downstream" water sample at an unspecified location. Various volatile organic constituents and metals were detected. The results are tabulated in Table 1. Precise sampling locations are uncertain.

TABLE 1
SUMMARY OF CHEMICAL ANALYSES
OCTOBER 30, 1979 (1)

COMPOUND	UNITS	LEACHATE SPRING	LEACHATE SPRING	DOWNSTREAM (2)
Acetone	ug/l	280,000	1,120,000	416,000
Benzene	ug/l	700	500	700
N-Octane	ug/l	600	500	200
Phenols	ug/l	240	180	18
Arsenic	ug/l	11	12	
Barium	ug/l	400	300	
Cadmium	ug/l			5
Lead	ug/l			42

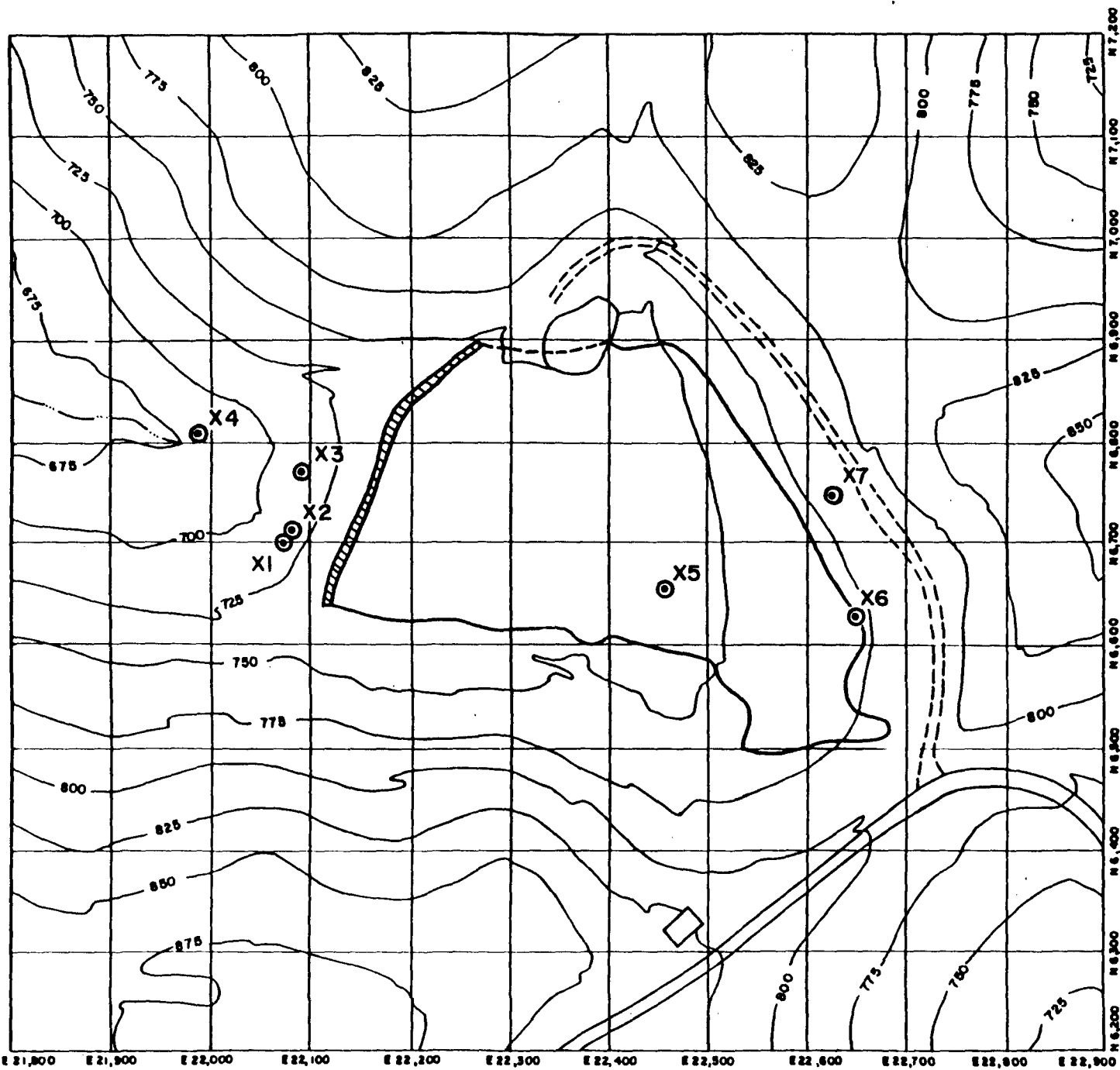
(1) Sampling by Ohio EPA.

(2) Precise sampling location is uncertain.

Under the direction of the US EPA, a site visit was made on October 30, 1980 by the Field Investigation Contractor, Ecology and Environment, Inc. Seven samples were collected for analysis. These samples included: a soil sample from the toe of the earthen dam (sample number X1 as shown on Figure 3); a leachate sample (X2) collected near the aforementioned soil sample; another leachate sample collected in a different area of the dam (X3); a leachate sample in the valley at the base of the dam (X4); an "oily clay" sample from the base of the highwall along the eastern side of the landfill (X5); and two leachate samples collected in the vicinity of the oily clay (X6 and X7). Table 2 provides a listing of sample descriptions and analytical results. Several volatile organics of phthalate and pyrene derivatives were found. Two pesticides, Aldrin and Heptachlor, and PCB-1242 were also detected.

Surface water samples were also collected by the US EPA on October 10, 1980 from (1) Winkler Run immediately upstream of its point of intersection with the tributary from the landfill area, and (2) downstream of the point of intersection (downstream samples were collected in duplicate). Results are shown in Table 2.

The OEPA made a landfill site visit on June 30, 1982 for the purpose of sampling leachate or runoff from the site. A leachate sample collected below the earthen dam contained various organic solvent constituents. Leachate seeps were reported on the highwall above the fill area emanating from beneath piles of ash material. Similar constituents were detected in a leachate sample from this area. A soil sample was also collected at this location. A summary of chemical analyses is given in Table 3.



LEGEND




-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  APPROXIMATE US EPA SAMPLING LOCATION (10/30/80)



FIGURE 3

PREVIOUS U.S. EPA SAMPLING LOCATIONS

E. H. SCHILLING LANDFILL

TABLE 2
SUMMARY OF CHEMICAL ANALYSES
OCTOBER 30, 1980 (1)

COMPOUND	SOIL AT	LEACHATE	LEACHATE			HIGHWALL	HIGHWALL	WINKLER RUN	WINKLER RUN	WINKLER RUN
	DAM (mg/g)	BELOW DAM (ug/l)	BELOW DAM (ug/l)	LEACHATE (ug/l)	OILY CLAY (ug/l)	LIQUID (ug/l)	(COMP.) (ug/l)	DOWNSTREAM (ug/l)	DOWNSTREAM (2) (ug/l)	UPSTREAM (ug/l)
	X1(*)	X2	X3	X4	X5	X6	X7			
Acenaphthene	ND	ND	ND	ND	1900	ND	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	ND	3100	ND	ND	ND	ND	ND
Napthalene	ND	ND	ND	ND	230	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	110/330	160	230	ND	3200	ND	ND	440	12	ND
Di-n-butyl phthalate	27/50	61	41	ND	9400	ND	ND	ND	ND	ND
Di-n-octyl phthalate	ND	ND	ND	ND	ND	ND	ND	19	ND	ND
Diethyl phthalate	ND/500	ND	ND	ND	1700	ND	ND	ND	ND	ND
Dimethyl phthalate	ND	ND	ND	ND	370	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND/7400	ND	ND	ND	3800	ND	ND	ND	ND	ND
Benzo(a)pyrene	ND/6300	ND	ND	ND	1100	ND	ND	ND	ND	ND
3,4-benzofluoranthene	ND/350	ND	ND	ND	1300	ND	ND	ND	ND	ND
Acenaphthylene	ND	ND	ND	ND	1000	ND	ND	ND	ND	ND
Anthracene	ND/960	ND	ND	ND	5400	ND	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND/4500	ND	ND	ND		ND	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	780	ND	ND	ND	ND	ND
Dibonzo(a,h)anthracene	ND/1900	ND	ND	ND		ND	ND	ND	ND	ND
Ideno(1,2,3-cd)pyrene	ND/2500	ND	ND	ND		ND	ND	ND	ND	ND
Pyrene	ND/2200	ND	ND	ND	2600	ND	ND	ND	ND	ND
Aldrin	ND	ND	ND	ND	56	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	ND	ND	ND	150	ND	ND	ND	ND	ND
PCB-1242	40	ND	ND	ND	9540	ND	ND	ND	ND	ND
Phenol	NA	ND	ND	ND	NA	ND	ND	ND	ND	ND
Aluminum								3600	53	425
Barium								50	<10	50
Beryllium								2	<2	<2
Cobalt								44	<10	<10
Iron								16500	92	808
Nickel								37	<20	20
Manganese								4650	<10	2170
Zinc								82	47	26
Boron								252	<10	32
Calcium								44000	<100	32700
Magnesium								29700	<100	19300
Sodium								29800	<100	6720

ND - Not Detected

NA - Not Applicable

(1) - Sampling by US EPA

(2) - Duplicate Sample

(*) - Denotes sampling location as shown in Figure 3

TABLE 3
SUMMARY OF CHEMICAL ANALYSES
JUNE 30, 1982 (1)

COMPOUND	UNITS	DAM LEACHATE	SOIL FROM HIGHWALL
Toluene	ug/l	200	
Ethylbenzene	ug/l	70	
Cumene	ug/l	60	594
N-Octane	ug/l	ND	ND
Acetone	ug/l	ND	ND
Benzene	ug/l	<0.0001	ND
Phthalates	ug/l	ND	ND
Styrene	ug/l	ND	ND
Vinyl Toluene	ug/l		158
Diphenyl Ether	ug/l		275
Biphenyl	ug/l		
Substituted Phenols	ug/l		
Nitrogen Ammonia	ug/l	4,230	
Arsenic	ug/l	<10	
Barium	ug/l	300	
Cadmium	ug/l	<5	
Chromium	ug/l	40	
Cobalt	ug/l	<30	
Lead	ug/l	<25	
Mercury	ug/l	<.5	
Phenol	ug/l	58	

ND - Not Detected
(1) - Sampling by Ohio EPA.

On February 10, 1983, the OEPA again collected samples at the site. The sampling included: (1) a leachate sample from within the landfill area; (2) a surface water sample from Winkler Run, upstream from the point of intersection with the Winkler Run tributary; (3) a surface water sample from Winkler Run downstream from this point of intersection; and (4) a surface water sample from a drainage ditch flowing from a suspected area of an abandoned coal drift mine. No solvents were detected at this time. Table 4 shows the chemical analyses of these samples.

1.3 Nature and Extent of the Problem

Polynuclear Aromatic Hydrocarbons (PAH's) were the principal contaminants identified in previous sampling efforts. Heavy metals generally were present only in low concentrations. During past US EPA and OEPA sampling, PCB's were detected in two samples and two pesticides (Aldrin and Heptachlor) in one sample.

Various media, including waste, soil, leachate, surface water and sediments, ground water and air, were sampled as part of the RI. Due to the comprehensive sampling and analysis effort, more volatile organic and semi-volatile compounds were detected than during previous EPA samplings. Landfill waste and leachate samples exhibited the higher contaminant concentrations and greatest number of chemical constituents as would be expected. Ground water and surface water showed the lower of contamination.

TABLE 4
SUMMARY OF CHEMICAL ANALYSES
FEBRUARY 10, 1983 (1)

COMPOUND	UNITS	LEACHATE	WINKLER RUN UPSTREAM	WINKLER RUN DOWNSTREAM
pH		7.3	4.8	6.0
T.D. Solids	mg/l	559	141	229
TKN Nitrogen	mg/l	2.16	<.06	0.44
Nitrogen Ammonia	mg/l	1.81	<.05	0.28
Chloride	mg/l	79	<10	13
Cyanide	mg/l	<.01	<.01	<.01
Arsenic	ug/l	<10	<10	<100
Barium	ug/l	<200	<200	<200
Cadmium	ug/l	<1	<1	<1
Chromium	ug/l	<30	<30	<30
Iron	ug/l	35,600	60	4270
Lead	ug/l	<5	<5	<5
T.O.C.	mg/l	35	<6	<6
C.O.D.	mg/l	91	<6	<6
Phenol	ug/l	15	3	<4
Solvents		ND	ND	ND

ND - Not Detected

(1) - Sampling by Ohio EPA.

1.4 Remedial Investigation Summary

1.4.1 Initial Project Meeting

A meeting and site visit was held on January 20, 1988, prior to approval of the QAPP (approved April, 1988). The meeting was convened at the Aristech Chemical Corporation plant in Haverhill, Ohio. The meeting was attended by representatives of the following organizations:

- o Aristech Chemical Corporation, a consenting party to the Administrative Order
- o Law Environmental, consultant to Aristech Chemical Corporation
- o Woolpert Consultants, surveying subcontractor to Law Environmental
- o US Environmental Protection Agency
- o Ohio Environmental Protection Agency
- o Metcalf & Eddy, Inc., US EPA oversight subcontractor

Phase I RI goals, requirements and procedures were discussed at the meeting. After the meeting, the attendees adjourned to the site to inspect the study area and to verify proposed monitoring well, test boring, sampling and support facility locations. The proposed sampling and testing locations were staked in the field with the oral approval of US EPA and OEPA representatives on site.

1.4.2 Phase I Site Investigation Summary

As previously stated, the Phase I RI was a comprehensive work effort to characterize the site and define the nature and extent of contamination. The site field investigation began on February 18, 1988, with air sampling. On February 24, 1988, a radiological survey and

extensive geophysical surveys were initiated . The radiological survey was intended as a safety precaution to determine if radioactive emissions were occurring from the landfill. The geophysics data were used largely to verify the limits of the landfill approximated from prior aerial photography and site reconnaissance. Magnetic anomalies indicating potential buried metallic objects within the landfill were also identified. Drilling activities commenced on March 16, 1988, and continued to May 25, 1988. During this time period many other activities such as geologic mapping, rock coring and packer testing, streamflow data, soil testing, etc. were performed.

Various environmental media were sampled in and around the landfill vicinity. Two sampling rounds were performed as part of the Phase I RI. The first round of sampling was conducted in late April for landfill waste, leachate, surface soils, surface water and sediments and in early June for ground water. A second round of sampling was performed in mid-December for ground water, leachate and surface water. Table 5 provides a summary of the media samples; the number of samples collected; the sample locations; the parameters analyzed; the type of investigation; the data type; the US EPA method used and analytical detection limits required to achieve the stated goals. Table 6 presents the Contract Laboratory Program (CLP) Target Compound List (TCL) parameters for analyses performed.

1.4.3 Phase II Site Investigation Summary

A Phase II RI was performed to fill data gaps from the Phase I investigation. Field work was conducted during the week of March 6, 1989, and consisted of four basic tasks: (1) additional surface soil sampling and analysis to delineate the extent of soil contamination;

TABLE 5
 REMEDIAL INVESTIGATION PROGRAM SUMMARY
 E. H. SCHILLING LANDFILL

MEDIA TYPE	TYPE OF INVESTIGATION	SAMPLE LOCATIONS	SAMPLING DATE	NO. OF SAMPLES COLLECTED	PARAMETERS ANALYZED	
<u>PHASE I RI</u>	WASTE	SOURCE IDENTIFICATION	FIGURE 9: LW	4/27/88 *	9	CLP TCL
			BO-01	4/24/88	2	CLP TCL
			BO-05	4/23/88	2	CLP TCL
	LEACHATE	SOURCE IDENTIFICATION	FIGURE 9: LS	4/27/88	5	CLP TCL
				12/13/88	5	CLP TCL
	BENTHOS	ASSESSMENT	FIGURE 11: BE	6/7-8/88	6 IN REPLICATE	MACROINVERTEBRATES
	AIR	ASSESSMENT	FIGURE 12: HV-1	2/15/88	1	TSP, HEAVY METALS, VOC'S
				5/24/88	1	TSP, HEAVY METALS, VOC'S
				8/4/88	5	TSP, HEAVY METALS, VOC'S
				10/12/88	5	TSP, HEAVY METALS, VOC'S
				1/26/89	5	TSP, HEAVY METALS, VOC'S
	GROUND WATER	ASSESSMENT	FIGURE 16: MW **	6/7-8/88	13	CLP TCL
				MW ***	12/13-14/88	13
	SURFACE WATER	ASSESSMENT	FIGURE 11: SW	4/25-26/88	6	CLP TCL
				12/12/88	6	CLP TCL
SEDIMENT	ASSESSMENT	FIGURE 11: SW	4/25-26/88	6	CLP TCL	
SOIL	ASSESSMENT	FIGURE 19: SS	4/25-26/88	19	CLP TCL	
<u>PHASE II RI</u>	ASSESSMENT	FIGURE 19: SS	3/7/89	16	CLP TCL	
GROUND WATER	ASSESSMENT	FIGURE 16: MW-01B	3/7/89	1	TOTAL & DISSOLVED METALS	
			MW-03A	3/7/89	1	TOTAL & DISSOLVED METALS
			MW-07A	3/7/89	1	TOTAL & DISSOLVED METALS

* SAMPLES LW-05 AND LW-09 WERE COLLECTED ON 5/20/88

** WELLS MW-01A, MW-02A AND MW-04A CONTAINED INSUFFICIENT WATER FOR SAMPLING

*** WELLS MW-01A AND MW-02A CONTAINED INSUFFICIENT WATER FOR SAMPLING; WELL MW-04A CONTAINED SUFFICIENT WATER FOR VOC ANALYSES ONLY

TABLE 6
CONTRACT LABORATORY PROGRAM
TARGET COMPOUND LIST

<u>SUBSTANCE</u>	<u>CAS Number</u>
VOLATILES	
1. Chloromethane	74-87-3
2. Bromomethane	74-83-9
3. Vinyl Chloride	75-01-4
4. Chloroethane	75-00-3
5. Methylene Chloride	75-09-2
6. Acetone	67-64-1
7. Carbon Disulfide	75-15-0
8. 1,1-Dichloroethene	75-35-4
9. 1,1-Dichloroethane	75-35-3
10. Trans-1,2-dichloroethene	150-60-5
11. Chloroform	67-66-3
12. 1,2-Dichloroethane	107-06-2
13. 2-Butanone	78-93-3
14. 1,1,1-Trichloroethane	71-55-6
15. Carbon Tetrachloride	56-23-5
16. Vinyl Acetate	108-05-4
17. Bromodichloromethane	75-27-4
18. 1,1,2,2-Tetrachloroethane	79-34-5
19. 1,2-Dichloropropane	78-87-5
20. Trans-1,3-dichloropropene	10061-02-6
21. Trichloroethene	79-01-6
22. Dibromochloromethane	124-48-1
23. 1,1,2-Trichloroethane	79-00-5
24. Benzene	71-43-2
25. Cis-1,3-dichloropropene	10061-01-5
26. 2-Chloroethyl vinyl ether	110-75-8
27. Bromoform	75-25-2
28. 2-Hexanone	591-76-6
29. 4-Methyl-2-pentanone	108-10-1
30. Tetrachloroethene	127-18-4
31. Toluene	108-88-3
32. Chlorobenzene	108-90-7
33. Ethyl benzene	100-41-4
34. Styrene	100-42-5
35. Xylenes (total)	

TABLE 6 (continued)
 CONTRACT LABORATORY PROGRAM
 TARGET COMPOUND LIST

SUBSTANCE	CAS Number
SEMI-VOLATILES (BNA)	
36. Phenol	108-95-2
37. Bis(2-chloroethyl) ether	111-44-4
38. 2-Chlorophenol	95-57-8
39. 1,3-Dichlorobenzene	541-73-1
40. 1,4-Dichlorobenzene	106-46-7
41. Benzyl Alcohol	100-51-6
42. 1,2-Dichlorobenzene	95-50-1
43. 2-Methylphenol	95-48-7
44. Bis(2-chloroisopropyl) ether	39638-32-9
45. 4-Methylphenol	106-44-5
46. N-nitroso-dipropylamine	621-64-7
47. Hexachloroethane	67-72-1
48. Nitrobenzene	98-95-3
49. Isophorone	78-59-1
50. 2-Nitrophenol	88-75-5
51. 2,4-Dimethylphenol	105-67-9
52. Benzoic Acid	65-85-0
53. Bis(2-chloroethoxy) methane	111-91-1
54. 2,4-Dichlorophenol	120-83-2
55. 1,2,4-Trichlorobenzene	120-82-1
56. Naphthalene	91-20-3
57. 4-Chloroaniline	106-47-8
58. Hexachlorobutadiene	87-68-3
59. 4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7
60. 2-Methylnaphthalene	91-57-6
61. Hexachlorocyclopentadiene	77-47-4
62. 2,4,6-Trichlorophenol	88-06-2
63. 2,4,5-Trichlorophenol	95-95-4
64. 2-Chloronaphthalene	91-58-7
65. 2-Nitroaniline	88-74-4
66. Dimethyl phthalate	131-11-3
67. Acenaphthylene	208-96-8
68. 3-Nitroaniline	99-09-2
69. Acenaphthene	83-32-9
70. 2,4-Dinitrophenol	51-28-5

TABLE 6 (continued)
 CONTRACT LABORATORY PROGRAM
 TARGET COMPOUND LIST

SUBSTANCE	CAS Number
71. 4-Nitrophenol	100-02-7
72. Dibenzofuran	132-64-9
73. 2,4-Dinitrotoluene	121-14-2
74. 2,6-Dinitrotoluene	606-20-2
75. Diethylphthalate	84-66-2
76. 4-Chlorophenyl phenyl ether	7005-72-3
77. Fluorene	86-73-7
78. 4-Nitroaniline	100-01-6
79. 4,6-Dinitro-2-methylphenol	534-52-1
80. N-nitrosodiphenylamine	86-30-6
81. 4-Bromophenyl phenyl ether	101-55-3
82. Hexachlorobenzene	118-74-1
83. Pentachlorophenol	87-86-5
84. Phenanthrene	85-01-8
85. Anthracene	120-12-7
86. Di-n-butylphthalate	84-74-2
87. Fluoranthene	206-44-0
88. Pyrene	120-00-0
89. Butyl benzyl phthalate	85-68-7
90. 3,3-Dichlorobenzidine	91-94-1
91. Benzo(a)anthracene	56-55-3
92. Bis(2-ethylhexyl)phthalate	117-81-7
93. Chrysene	218-01-9
94. Di-n-octyl phthalate	117-84-0
95. Benzo(b)fluoranthene	205-99-2
96. Benzo(k)fluoranthene	207-08-9
97. Benzo(a)pyrene	50-32-8
98. Indeno(1,2,3-cd)pyrene	193-39-5
99. Dibenzo(a,h)anthracene	53-70-3
100. Benzo(g,h,i)perylene	191-24-2

TABLE 6 (continued)
 CONTRACT LABORATORY PROGRAM
 TARGET COMPOUND LIST

SUBSTANCE	CAS Number
PESTICIDES/PCBs	
101. Alpha-BHC	319-84-6
102. Beta-BHC	319-85-7
103. Delta-BHC	319-86-8
104. Gamma-BHC (Lindane)	58-89-9
105. Heptachlor	76-44-8
106. Aldrin	309-00-2
107. Heptachlor Epoxide	1024-57-3
108. Endosulfan I	959-98-8
109. Dieldrin	60-57-1
110. 4,4'-DDE	72-55-9
111. Endrin	72-20-8
112. Endosulfan II	33213-65-9
113. 4,4'-DDD	72-54-8
114. Endosulfan Sulfate	1031-07-8
115. 4,4'-DDT	50-29-3
116. Endrin Ketone	53494-70-5
117. Methoxychlor	72-43-5
118. Chlordane	57-74-9
119. Toxaphene	8001-35-2
120. AROCLOR-1016	12674-11-2
121. AROCLOR-1221	11104-28-2
122. AROCLOR-1232	11141-16-5
123. AROCLOR-1242	53469-21-9
124. AROCLOR-1248	12672-29-6
125. AROCLOR-1254	11097-69-1
126. AROCLOR-1260	11096-82-5

TABLE 6 (continued)
CONTRACT LABORATORY PROGRAM
TARGET COMPOUND LIST

<u>SUBSTANCE</u>	<u>CAS Number</u>
METALS	
127. Aluminum	
128. Antimony	
129. Arsenic	
130. Barium	
131. Beryllium	
132. Cadmium	
133. Calcium	
134. Chromium	
135. Cobalt	
136. Copper	
137. Iron	
138. Lead	
139. Magnesium	
140. Manganese	
141. Mercury	
142. Nickel	
143. Potassium	
144. Selenium	
145. Silver	
146. Sodium	
147. Thallium	
148. Vanadium	
149. Zinc	
150. Cyanide	

(2) installation of shallow piezometers in the eastern portion of the landfill to investigate a linear zone of leachate generation; (3) analysis of samples from three wells for total and dissolved metals and (4) a residential well survey in Schillingville and a portion of Rock Hollow.

1.5 Report Organization

A large volume of technical data and information has been developed for the Schilling Landfill in response to the remedial investigation effort. Section 1.0 of this report has provided a brief overview of the RI including a historical perspective of the project. Section 2.0 introduces the specific investigative phases that comprise the RI and the field methods employed. Physical characteristics of the study area are provided in Section 3.0, as determined from literature searches and field testing/analysis. A detailed examination of the nature and extent of contamination is discussed in Section 4.0 for all media types. Sections 5.0 and 6.0 deal with the fate and transport of contamination and the assessment of risks associated with this contamination.

Detailed descriptions of test procedures and data are provided in the Appendices. Also, the Appendices contain calculations, computer printouts, etc., to support the report text.

1.6 Work Plan Scope Modifications

The original Work Plan documents dated October 1987, were subjected to minor modification as a result of site-specific conditions encountered in the field, in order to improve the quality of the data needed to complete the site investigation analysis and to furnish additional information for use in the feasibility study. Specifically, five limited scope

changes to the original Work Plan were implemented with the concurrence of the Agencies. The concurrence was obtained either by oral authorization from the oversight contractor representative, verbal, or written authorization from US EPA and/or OEPA representatives. These changes are discussed below.

1.6.1 Hydrogeologic Investigation Modifications

Two changes in the scope of work pertain to the hydrogeologic investigation.

During the drilling of monitoring well MW-02B, a cross-connection between the adjacent boreholes (02A and 02B) was observed. As the borehole in progress for MW-02B was advanced, water was blown to the surface at MW-02A under considerable pressure. After consultation with the US EPA Region V Remedial Program manager, it was decided to abandon the MW-02A borehole by pressure grouting. The borehole for what had been well MW-02B was renumbered MW-02A and utilized as the shallow well for that respective cluster. A new monitoring well MW-02B was advanced to provide deep water-bearing zone monitoring.

At the direction of the US EPA Region V Remedial Program Manager, the design of monitoring wells MW-06A and MW-07A were modified while work was in progress. The approved Sampling Plan called for a Type III design for these and all other shallow wells of the two well clusters at the site. The Type III wells have an outer steel casing seated through the soil and into rock, and the well is screened within the first water-bearing rock zone. While drilling at the MW-06 location, a considerable thickness of saturated unconsolidated deposits (alluvium, and colluvium) was encountered. Due to the proximity

of MW-06A and MW-07A to the Winkler Run tributary arising downhill of the landfill's earthen dam, it was decided that these wells should be of Type II design and screened within the unconsolidated valley floor deposits, to determine if contaminants were present in the ground water. Type II wells do not have an outer steel casing. The deep wells of each cluster at the MW-06 and MW-07 locations ('B' wells) were installed as Type III wells screened within the uppermost water-bearing rock zone.

A borehole originally designated as MW-06B was cored to a depth of 93.5 feet below grade, into the second bedrock water-bearing sandstone, prior to the Agency's decision to alter the well design at MW-06 and MW-07. Due to the excessive depth of MW-06B for use in the new plan (i.e. one shallow unconsolidated soil Type II well and one upper bedrock Type III well), the borehole was capped and welded shut. A shallower MW-06B was drilled. The borehole was renamed MW-06 core to reflect the change.

1.6.2 Geotechnical Scope Modifications

Two scope changes were implemented with regards to the geotechnical studies performed at the site.

Section 2.9.3 of the Sampling Plan dictated that borehole geophysical logging would be performed in the eight soil test borings in the earthen dam for the purpose of obtaining strength parameters for the materials of construction. However, the boreholes collapsed, preventing the geophysical logging. This condition and an alternative means to collect the data were described in letters transmitted to US EPA and OEPA by Aristech Chemical Corporation, dated May 5, 1988 and June 22, 1988. The amended scope of work that was

approved by the Agencies called for undisturbed (UD) soil sampling and vane shear testing of dam materials, which were performed.

Nine hand auger borings were originally planned for the landfill waste sampling (Section 2.1.3.4 of the Sampling Plan). However, only seven of the nine borings could be completed by this method because difficult subsurface conditions were encountered. The water table at boring LW-05 located at N 6900, E 22400 on the site grid was high and caused the borehole to repeatedly collapse. The hand auger would not penetrate the large blocks of plastic waste and other debris at LW-09 (N 6700, E 22200). A truck-mounted drill rig using hollow stem augers and a split-spoon sampler was required to sample waste at these two locations, so that sampling requirements set forth in the Sampling Plan could be fulfilled.

1.6.3 Benthos Investigation Modifications

A slight modification to the benthos investigation scope of work was required due to site conditions. Field sampling was to take place at six designated surface-water stations located throughout the study area. Low flow conditions were noted during the June sampling at station SW-01/BE-01. With the concurrence of the on-site US EPA oversight subcontractor, the actual benthos sampling area was relocated approximately 22 feet south of the originally planned site.

2.0 STUDY AREA INVESTIGATION

Aristech Chemical Corporation retained Law Environmental to furnish remedial investigation and feasibility study technical consulting services. Subcontractor support to the remedial investigation data collection effort was provided by the following firms:

<u>Organization</u>	<u>Responsibility</u>
Triangle Aerial Mapping, Inc.	Topographic mapping
Lambert, Inc.	Test borings, drilling and well installation
CompuChem Laboratories, Inc.	Chemical analyses
Woolpert Consultants, Inc.	Surveying
E. H. Schilling & Sons, Inc.	Grading and meteorological station construction

2.1 Topographic Mapping

In March 1987 an aerial photographic survey was conducted of the landfill and the immediate study area to obtain topographic control and delineate site features. The following quality control standards were met:

Film type	Panchromatic
Negative scale	1:1200 (+/- five percent)
Flight line orientation	Parallel north-south runs, true compass guided
Overlap	55% to 65%, averaging 60%
Sidelap	15% to 40%, averaging 30%

Print alignment	Drift does not impact more than 10% of a print width for any three consecutive frames
Tilt	Does not exceed 3° for a single frame or 1° for the completed mission
Negative/Print quality	Free of stains, blemishes and scratches.

Two topographic site maps were developed from the aerial photography, as outlined below:

<u>Maps</u>	<u>Coverage</u>	<u>Format</u>	<u>Contour Interval</u>	<u>Scale</u>
Plate	Study Area	48 in. x 60 in.	5.0 feet	1 in. = 60 ft.
Plate	Landfill	36 in. x 48 in.	2.0 feet	1 in. = 20 ft.

These maps were used initially in preparation and scoping of the Work Plan documents. The site maps include area topography, surface water features, buildings, utilities and vegetation cover outline. A site coordinate system was established for horizontal control, utilizing a one-hundred foot square grid pattern. Topographic data are referenced to the National Geodetic Vertical Datum (NGVD) of 1929.

To address the needs of this RI report, a set of base maps on an 8 1/2 x 11 inch format were established. Three map scales were selected: 1 inch = 400 feet, 1 inch = 300 feet, and 1 inch = 150 feet. The contour interval displayed on maps was reduced to 25 feet to minimize clutter. In addition, another set of base maps to the same three scales was developed without topographic control to further minimize clutter on the drawings. Figure

2 (following page 4) is an example of the 1 inch = 400 feet scale base map showing study area features without topographic control.

2.2 Contaminant Source Investigation

The contaminant source investigative program was developed to best characterize the waste materials within the landfill while minimizing the threat to health and life of on-site workers during the field work. The program focused on the use of geophysical surveys, leachate and soil/waste sampling. Also a review of known waste inventories was made to support the investigation.

2.2.1 Geophysical Surveys

Geophysical surveys were conducted during the period February 24 through March 3, 1988, by Law Environmental personnel at the landfill site. This work was conducted in conformance with the Sampling Plan.

Geophysical surveys were used to define the thickness and areal extent of the landfill and to aid in characterization of landfill waste. The depth to the bottom of the landfill was investigated using seismic refraction (SR) and electrical resistivity (ER) soundings. The general shape of the landfill was delineated using electromagnetic (EM) methods. The material within the landfill was characterized by using magnetic (MG) and EM surveys. EM techniques were used to measure electrical conductivities, and find areas of metallic interference. Electrical conductivity of the subsurface is primarily dependant upon the type and amount of pore fluid and lithology. Greater saturation and porosity typically yield higher conductivities. More conductive pore fluid also yields higher conductivities.

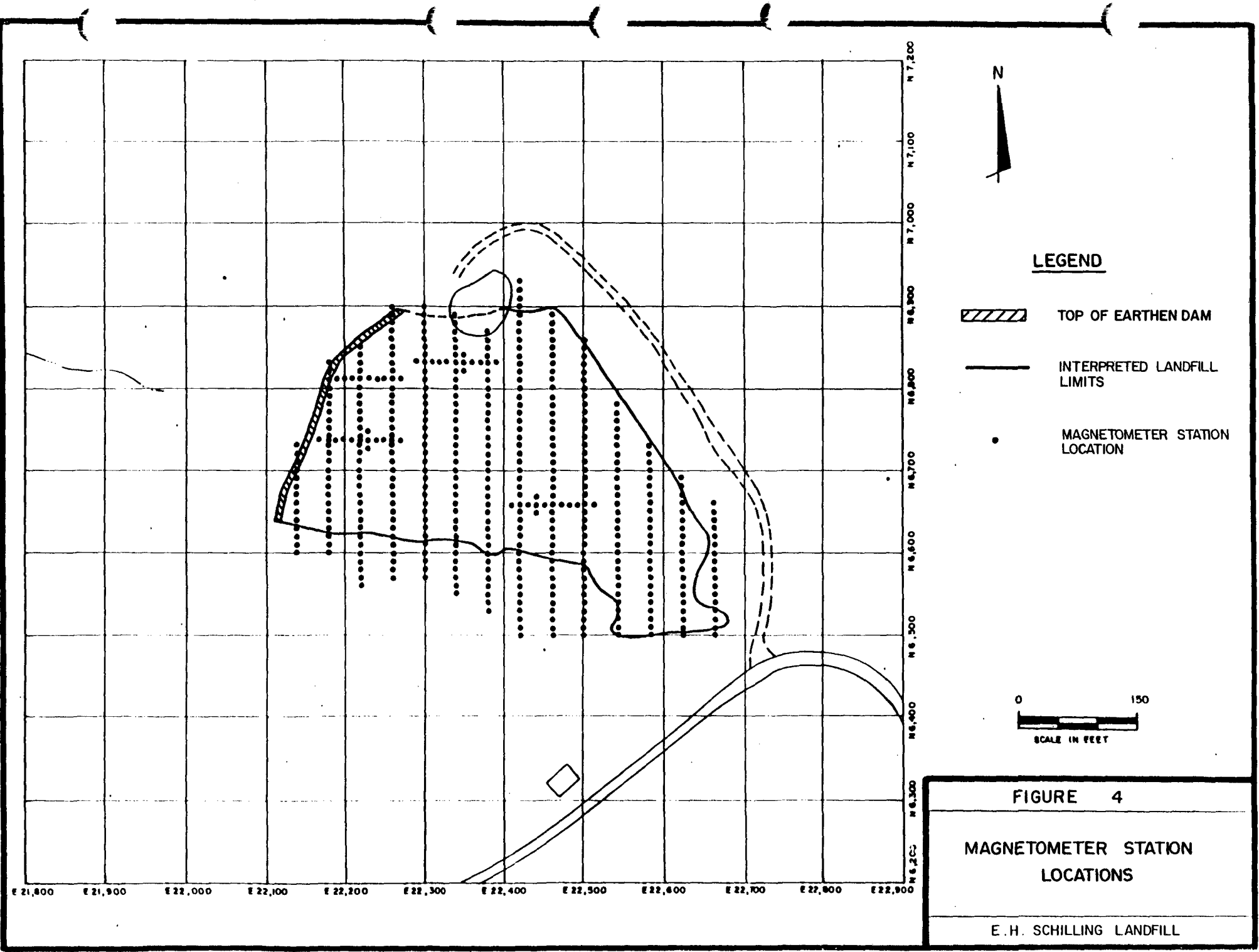
Clays and silts typically are more conductive than sands. Other parameters may affect subsurface conductivities, such as presences of metallic objects and temperature variations. In a landfill environment, areas of higher conductivity often indicate the presence of leachate or contaminated ground water. The MG survey helped identify zones with concentrations of ferromagnetic material. Horizontal control for all geophysical survey work was maintained by the established site grid coordinate system.

The following sections outline the field procedures and survey locations of the various geophysical studies. Interpretation of results is provided in Section 3.6.1 (Landfill Characteristics).

2.2.1.1 Magnetic Survey (MG)

The purpose of the MG survey was to help outline locations of metallic objects. A standard magnetic survey was conducted using a Geometrics G-816 portable proton precession magnetometer. The primary traverse lines were laid out forty feet apart in a north-south orientation with magnetometer readings taken every ten feet (Figure 4). Data points were collected at more than 400 points.

The earth's magnetic field is commonly measured in gammas. A gamma is a unit of magnetic intensity which is 10^{-5} oersteds or $(1/4) \times 10^{-3}$ ampere-turns per meter. One oersted is the field which would exert a force of 1 dyne on a unit magnetic pole. The natural magnetic field in the midwestern states is typically in the 55,000 gamma range (DeBremaecker, 1985).



LEGEND




-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  MAGNETOMETER STATION LOCATION



FIGURE 4

**MAGNETOMETER STATION
LOCATIONS**

E. H. SCHILLING LANDFILL

The earth's naturally occurring magnetic field may vary with time. Both diurnal variations and magnetic storms may occur. Diurnal variations are daily fluctuations of the magnetic field, typically less than 40 gammas, and are commonly related to tidal motion of the ionosphere. Magnetic storms are rapid, irregular fluctuations in the earth's magnetic field, typically greater than 50 gammas, commonly associated with sunspot activity. To check on these natural occurrences, each survey line had a base station where measurements were taken immediately before and after completing the survey on that line. The base stations were located at the south end of each survey line, outside the actual landfill area (as interpreted by the EM survey) in what was considered a background area. The values measured south of the landfill were about 55,000 gammas. Each base station closed to within a few gammas and the total daily drift measured at the primary base station was about 15 gammas. The drift, well within normal values, was compensated for in the data.

2.2.1.2 Electromagnetic (EM-31) Conductivity Survey

The purpose of the EM-31 survey was to determine the horizontal extent of the landfill. Two separate survey patterns were conducted as required by the Sampling Plan; long, parallel survey lines were used to map the apparent conductivity of the landfill material, and short, radial survey lines were used to further define the outer boundary of the landfill.

A Geonics EM-31 instrument was used to continuously record both the out-of-phase (apparent conductivity) and the in-phase components of the electromagnetic field (see Appendix A1 for description). The in-phase signal indicates the presence of buried metal or other highly conductive materials, and the out-of-phase signal indicates areas of higher

or lower apparent conductivity. The instrument was used in the vertical dipole mode, with a nominal depth of penetration of approximately 20 feet.

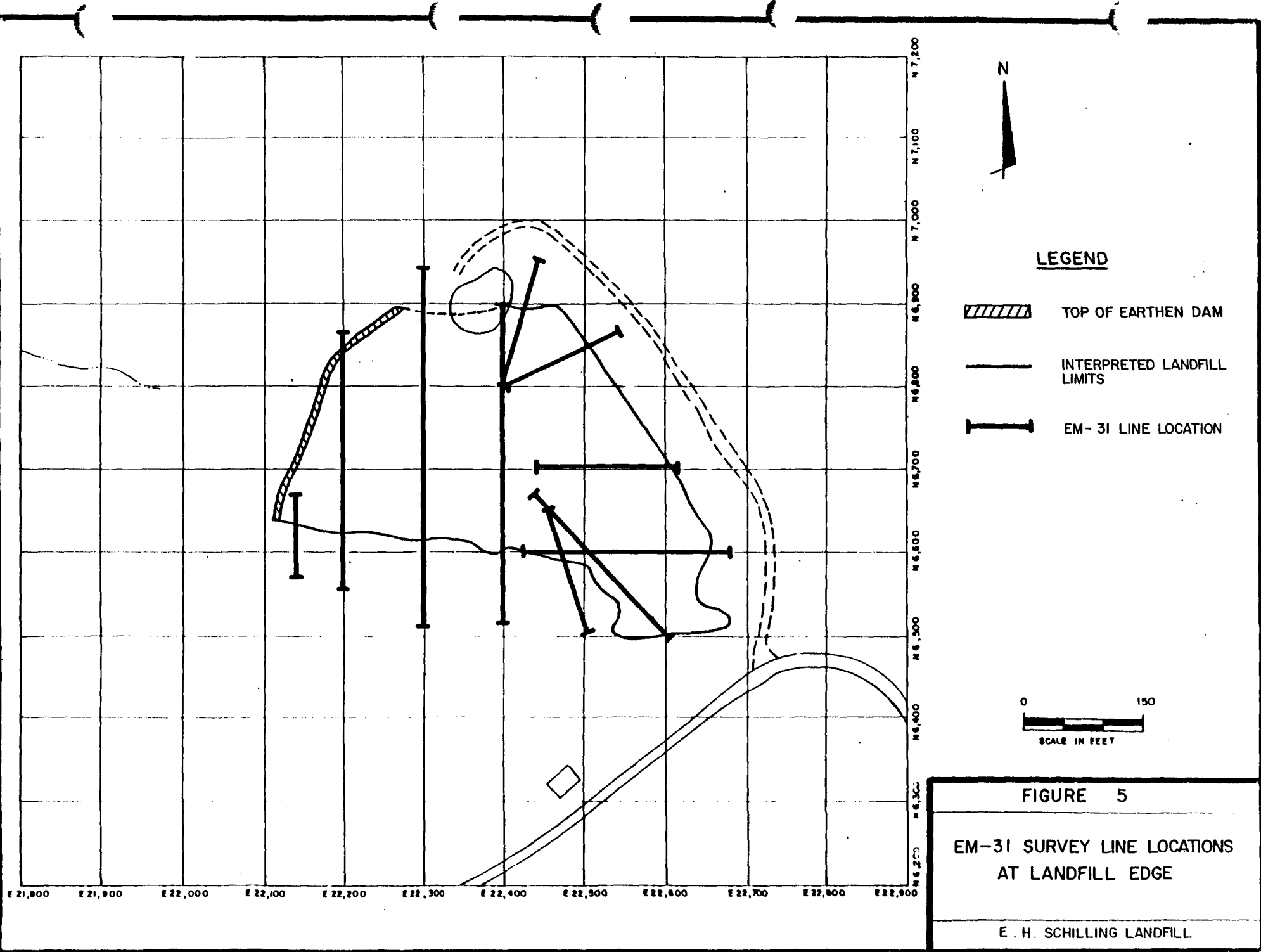
Apparent conductivity is typically measured in millimhos/meter. A millimhos/meter is the conductivity for which a meter cube offers a resistance of one ohm between opposite faces, and is the reciprocal of an ohm-meter.

To outline the landfill edge, a survey was conducted consisting of 10 short radial profile lines with a total of 2700 linear feet of coverage. The locations of these survey lines are shown in Figure 5.

To map the apparent conductivity of the landfill, 27 survey lines (consisting of approximately 7800 linear feet of continuous EM-31 profiling) were utilized. These survey lines (shown in Figure 6) were parallel to the long axis of the landfill and were twenty feet apart. The edge of the landfill was interpreted from both the in-phase response and by the increase of apparent conductivity values.

2.2.1.3 Electromagnetic (EM-34) Conductivity Survey

An EM-34 survey was conducted to delineate areas of differing electrical conductivities. The EM-34 has a greater depth of penetration than the EM-31. Measurements were made every 25 feet on survey lines 40 feet apart, running parallel to the long axis of the landfill. Every other line of the EM-31 landfill survey was used for the EM-34 survey (Figure 7). The EM-34 instrument offers coil separations of 10, 20, and 40 meters for various depths of penetration. In the horizontal dipole mode, the depth of penetration is approximately



LEGEND




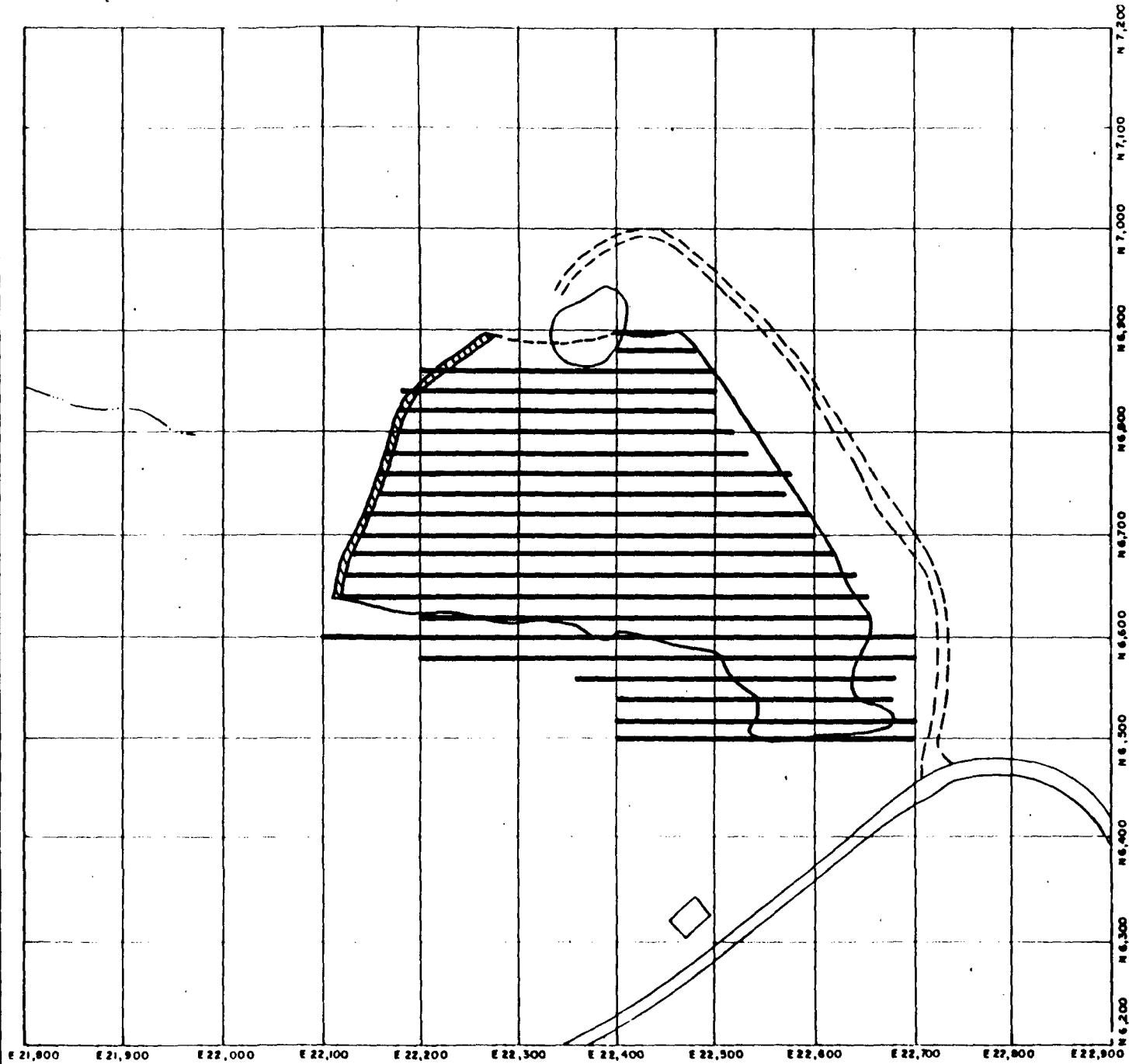
-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  EM- 31 LINE LOCATION



FIGURE 5

**EM-31 SURVEY LINE LOCATIONS
AT LANDFILL EDGE**

E. H. SCHILLING LANDFILL



LEGEND




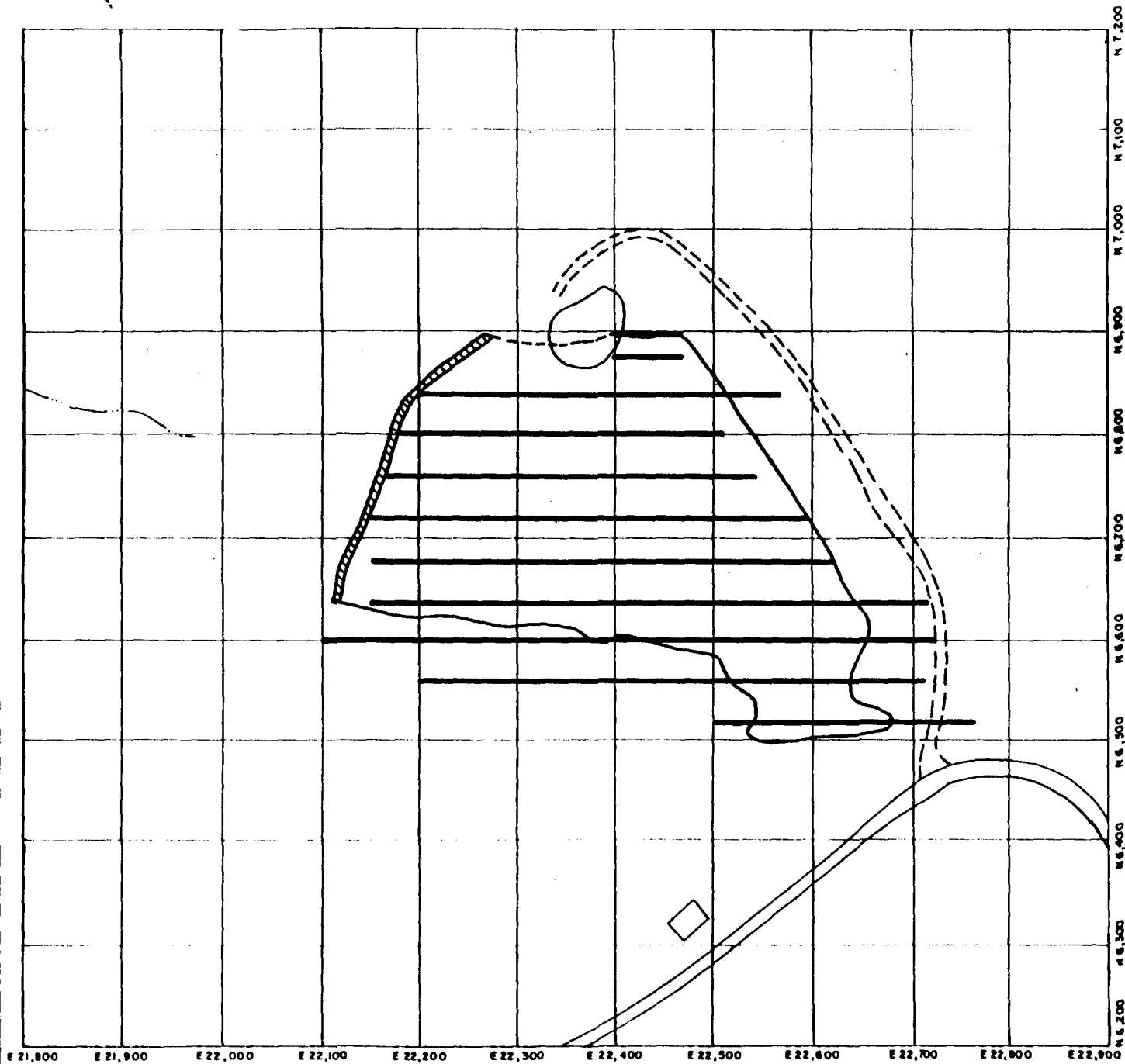
-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  EM-31 LINE LOCATION



FIGURE 6

**EM-31 SURVEY LINES-PARALLEL
WITH 20 FOOT SEPARATION**

E. H. SCHILLING LANDFILL



LEGEND




-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  EM-34 LINE LOCATIONS



FIGURE 7

**EM-34 SURVEY LINE
LOCATIONS**

E. H. SCHILLING LANDFILL

0.75 times the coil separation, and 1.5 times for the vertical dipole mode. Measurements were made both in the horizontal and the vertical dipole modes, yielding nominal depths of penetration of about 15 meters (50 feet) and 30 meters (100 feet), respectively. Measurements at 217 stations along approximately 3400 feet of survey lines were made in each dipole mode.

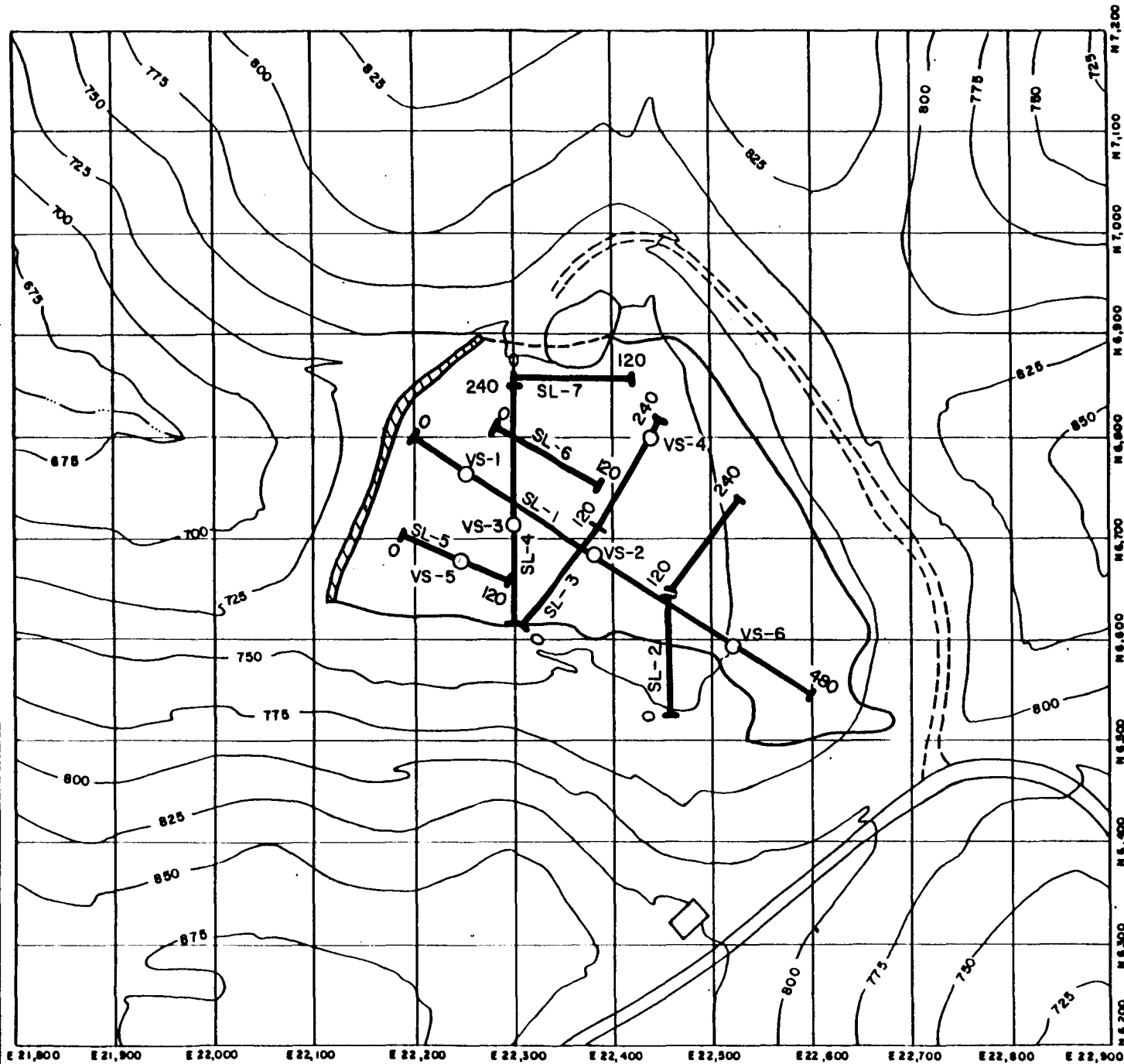
2.2.1.4 Electrical Resistivity (ER) Vertical Soundings

The purpose of the ER survey was to enhance the interpretation of the EM survey and assess the depth of the landfill especially along the seismic survey lines. Six ER vertical soundings were conducted. Their locations were referenced to the seismic refraction survey lines and are indicated in Figure 8.

Resistivity is typically measured in ohm-meters. An ohm-meter is the resistivity of a meter cube which offers a resistance of one ohm to the flow of current between opposite faces.

2.2.1.5 Seismic Refraction Survey

A Geometrics ES-1225 twelve-channel digital seismograph was used to investigate the depth of the landfill. Seismic data were recorded both on paper and digitally on a Zenith 183 portable computer. Figure 8 shows the locations of the seismic refraction survey lines. Seismic data were collected on profile lines, each 120 feet long. A typical profile line consisted of 12 geophones and 5 hammerpoints. The hammerpoints were at the center and each end of the spread and, where feasible, at 60 feet off each end of the spread. These hammerpoint locations provide the appropriate coverage and detail necessary for shallow



LEGEND



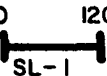

-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  SEISMIC REFRACTION SURVEY LINE
-  ELECTRICAL RESISTIVITY VERTICAL SOUNDING LOCATION



FIGURE 8

**ELECTRICAL RESISTIVITY
AND SEISMIC REFRACTION
SURVEY LOCATIONS**

E. H. SCHILLING LANDFILL

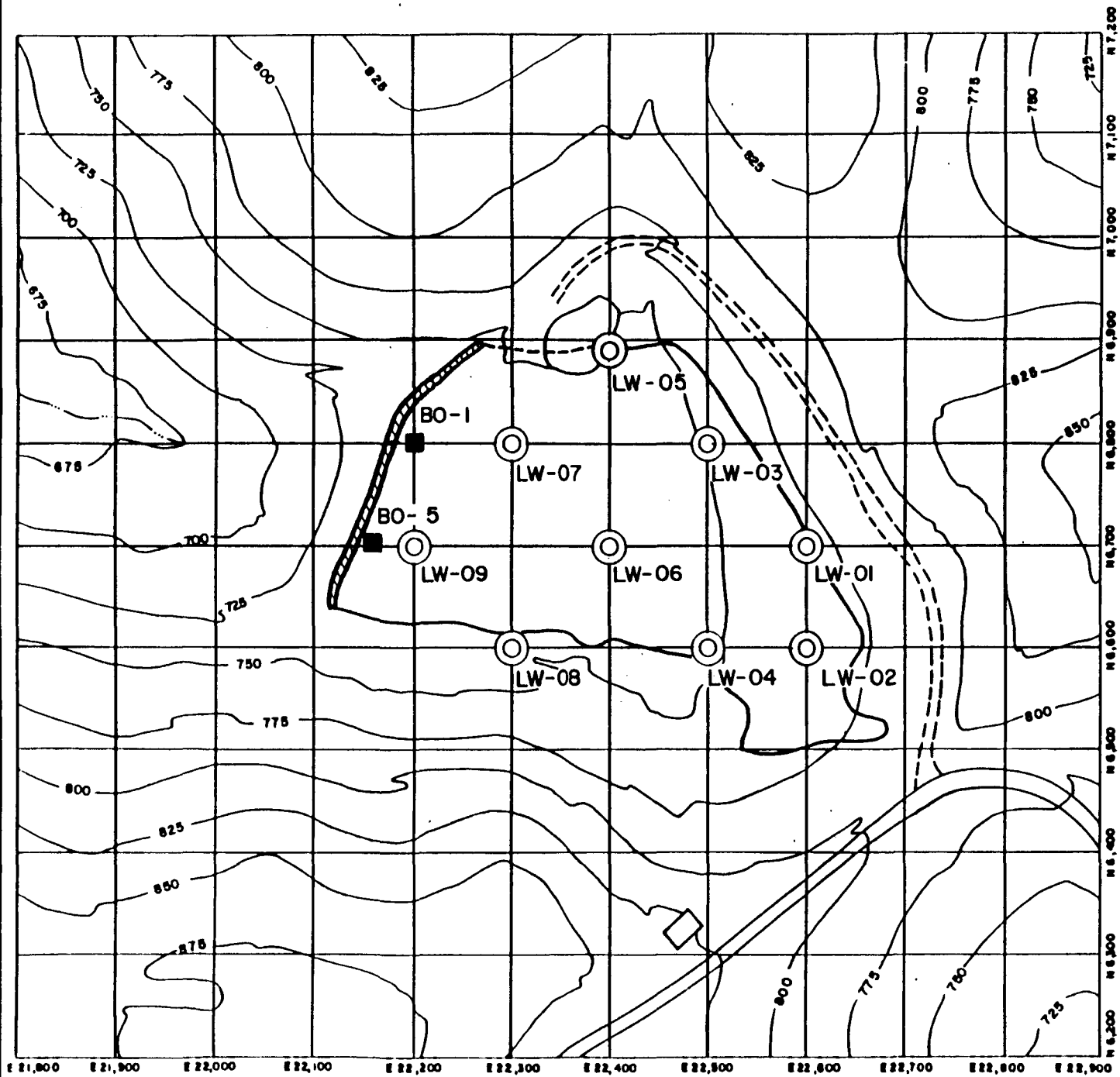
seismic refraction surveys. The energy source was a 12-pound hammer striking a metal plate on the ground. Seismic velocities were measured in feet per second.

2.2.2 Waste Sampling and Analysis

Nine locations were selected within the landfill limits to collect samples of the near surface landfill wastes. The selected locations are shown Figure 9.

A stainless steel hand auger was used for sample acquisition. At each location a boring was advanced through the landfill cap (usually one to two feet in thickness) to a depth sufficient to extract the appropriate soil/waste volume to fill the sample containers. In general, auger depths were limited to one to two feet below the cap. Waste material was removed from the auger bucket into a stainless steel bowl and composited for each boring. Compositing was a two-step procedure: first, the waste was mixed very gently (to minimize volatilization) and the volatile organic containers filled; next, the remaining material was thoroughly mixed prior to filling the semi-volatile, metals and cyanide sample jars.

The waste sampling was performed on April 27, 1988. Subsurface conditions encountered at LW-05 and LW-09 precluded sampling by the hand auger method. At LW-05, shallow water conditions caused the borehole to continuously collapse preventing withdrawal of waste materials. Shallow auger refusal (depth of 1 to 1.5 feet) was encountered in ten separate boring attempts in the vicinity of LW-09 and therefore sampling efforts were discontinued. Due to sampling difficulties at these two locations, an alternative method approved by US EPA was used in which a drill rig fitted with hollow stem augers drilled



LEGEND





-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  LW-01
LANDFILL WASTE SAMPLING LOCATION
-  BO-01
SOIL TEST BORING LOCATION



FIGURE 9

**LANDFILL
SAMPLING LOCATIONS**

E. H. SCHILLING LANDFILL

through the cap and a split-spoon sampler driven into the underlying waste until a sufficient sample volume was extruded. This work was performed on May 20, 1988.

In conjunction with the earthen dam evaluation, two soil test borings were drilled on the landfill side of the earthen dam (borings BO-01 and BO-05, Figure 9). Continuous split-spoon soil sampling was maintained to provide detailed lithologic information of the subsurface. Waste material was encountered in each of these borings at various depths. With approval from the onsite EPA oversight contractor, the following samples were retained for analysis:

Boring: BO-01	Depth Interval: 10.5 - 13.5 ft.
	19.5 - 22.5 ft.
Boring: BO-05	Depth Interval: 13.5 - 16.0 ft.
	26.0 - 30.0 ft.

All waste samples were submitted to CompuChem Laboratories for CLP TCL analysis. Sampling and analysis was performed in accordance with the April 1988 QAPP.

2.2.3 Leachate Sampling and Analysis

Active seeps were sampled as part of the contaminant source investigation. Only liquid (no soil/sediment) was collected at each chosen location. Where flow volume was small, a shallow depression was made with a decontaminated trowel to allow liquids to accumulate. Sampling was performed twice during the remedial investigation.

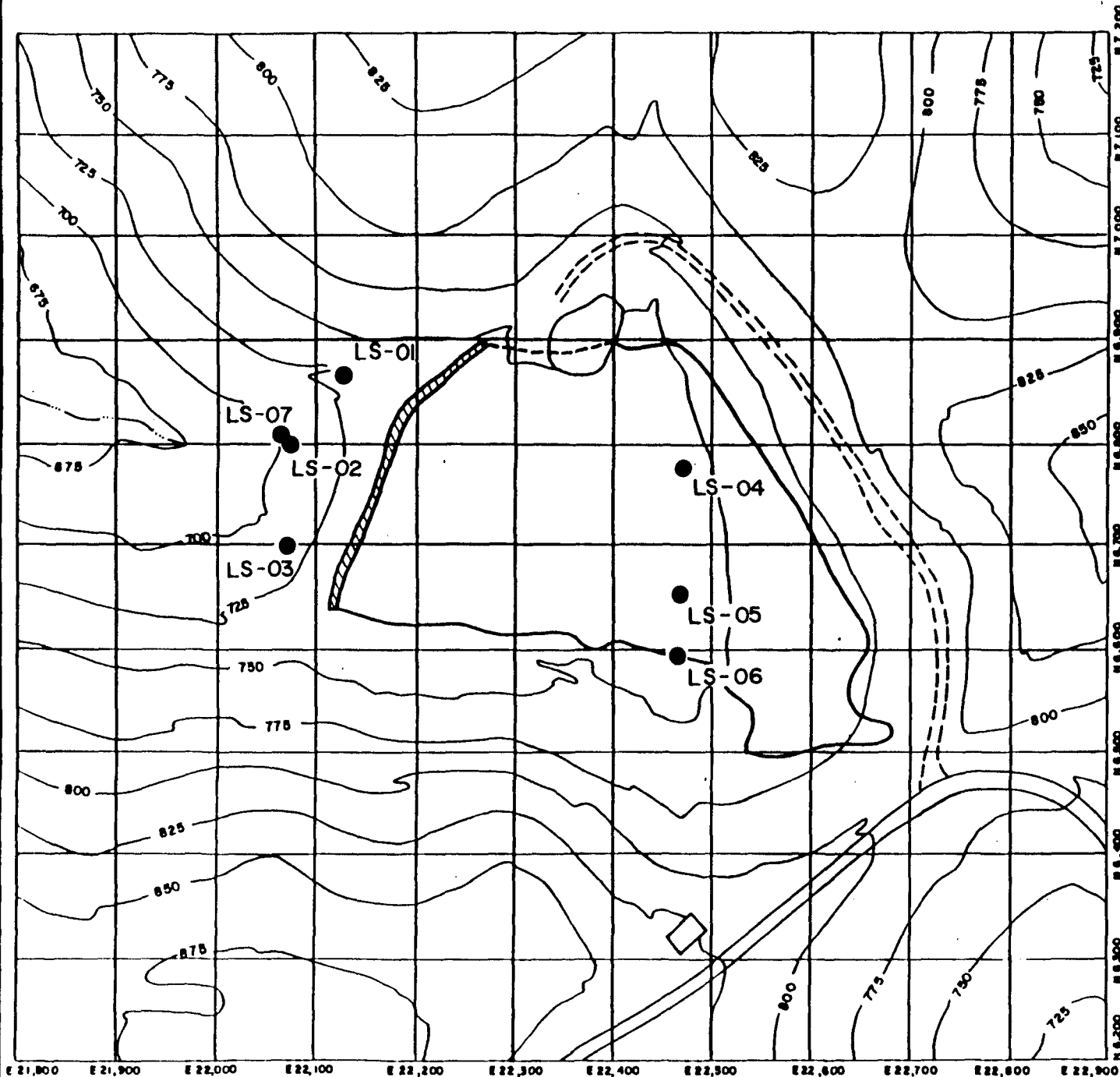
During the initial sampling on April 27, 1988, five locations designated LS-01 through LS-05 were selected (with approval from the onsite EPA oversight contractor) as shown on Figure 10. Five samples were again collected during the second round of sampling conducted on December 13, 1988. Due to low flow volumes at LS-02 and LS-05, slightly different locations were selected for sampling (Figure 10; LS-07 and LS-06, respectively). All sampling and analysis was done in accordance with the approved QAPP.

2.3 Radiological Investigation

No radiological data had been previously obtained from the site. The approved October 1987 Sampling Plan required a radiological investigation be performed as a safety precaution before initiating the Phase I Remedial Investigation site work. The radiological data collection was to consist of a check for gamma radiation over the landfill area proper. Alpha and beta measurements were to be performed in any areas of the landfill lacking a clay cap. Any areas measuring two to three times the background radiation of 10 micro-Roentgens per hour (uR/hr) were to be further investigated, as stated in Subtask 3.h of the Administrative Order Statement of Work.

The investigation was performed with an Eberline ESP-2 instrument equipped with an Eberline SPA-6 detector. The instrument was set to read directly. The instrument's alarm was set at twenty uR/hr in order to provide prompt warning to personnel operating the equipment.

A grid-controlled site walk-over was employed to obtain gamma radiation data at the locations illustrated on Figure 11. Background readings were obtained at the site office



LEGEND




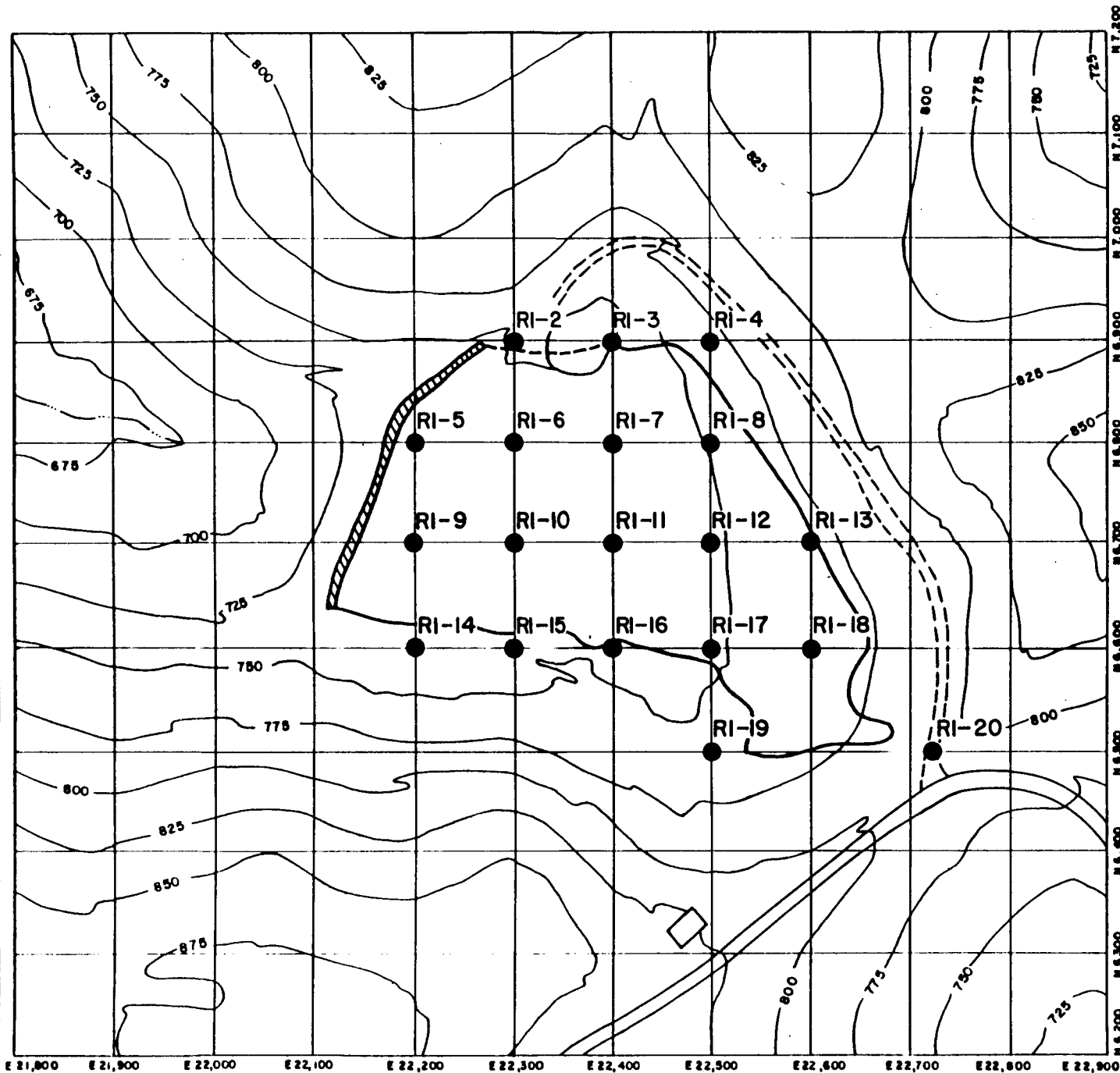
-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  LS-01
LEACHATE SAMPLING LOCATION






FIGURE 10

LEACHATE SAMPLING LOCATIONS

E. H. SCHILLING LANDFILL



LEGEND

-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  RI-2 RADIOLOGICAL SAMPLING LOCATION

BACKGROUND SAMPLES

- RI-1 SITE OFFICE
- RI-20 ACCESS ROAD

NOTE: RI-1 IS LOCATED OFF OF THE MAP COVERAGE AREA AT APPROXIMATE COORDINATES N 4080 E 22,900



FIGURE 11

RADIOLOGICAL SAMPLE LOCATION MAP

E.H. SCHILLING LANDFILL

(RI-1) and along the access road leading to the landfill (RI-20). Eighteen station location (grid intersection) measurements were taken.

The Sampling Plan required measuring gamma, alpha, and beta radiation. However, the entire landfill surface had a cap and no waste was exposed. The cap material is composed of sand containing varying amounts of silt and clay, as well as silt and clay containing sand. There is sufficient silt and clay in the cap to prevent the detection of alpha and beta radiating from the landfill. The fine grained material prevents detection of alpha and beta radiation. The oversite contractor agreed to this conclusion and only gamma radiation values were measured.

The survey was performed February 24, 1988, before site work began. A follow-up gamma survey was conducted on May 18, 1988, after site work had been completed and the landfill cap had been traversed many times by heavy equipment. The results of the surveys are included in Table 7 for the two survey dates.

No measured values exceeded the limit of 10 uR/hr. Readings from the two background stations of RI-1 and RI-20 were 4.6 uR/hr and 6.1 uR/hr, respectively, for both dates. Landfill readings varied from 4.3 uR/hr to 8.8 uR/hr. The highest values were measured at stations RI-2 and RI-3, adjacent to the cinder pile. No additional radiological investigations were required based on these measured values.

TABLE 7
RADIOLOGICAL INVESTIGATION SUMMARY

PHASE I RI

INSTRUMENT: Eberline ESP-2, Serial No. 0464.

DETECTOR: Eberline SPA-6, Serial No. 253

Units Of Measurement In Micro-Roentgens Per Hour (uR/h)

SAMPLING POINT NO.	LOCATION	INSTRUMENT READING	
		FEBRUARY 24, 1989	MAY 18, 1989
RI-1 (BACKGROUND)	PROJECT OFFICE FRONT LAWN	4.6	4.6
RI-2	N 6900 E 22300	8.5	8.5
RI-3	N 6900 E 22400	8.7	8.8
RI-4	N 6900 E 22500	6.2	6.2
RI-5	N 6800 E 22200	5.5	5.5
RI-6	N 6800 E 22300	5.0	5.1
RI-7	N 6800 E 22400	4.7	4.7
RI-8	N 6800 E 22500	5.1	5.1
RI-9	N 6700 E 22200	5.0	5.0
RI-10	N 6700 E 22300	5.4	5.4
RI-11	N 6700 E 22400	4.3	4.5
RI-12	N 6700 E 22500	5.2	5.2
RI-13	N 6700 E 22600	4.9	4.9
RI-14	N 6600 E 22200	5.2	5.2
RI-15	N 6600 E 22300	4.5	4.5
RI-16	N 6600 E 22400	4.4	4.3
RI-17	N 6600 E 22500	4.9	4.8
RI-18	N 6600 E 22600	4.7	4.6
RI-19	N 6500 E 22500	5.1	5.1
RI-20 (BACKGROUND)	N 6500 E 22720	6.1	6.1

NOTE: SCALE FACTOR OF 1 WAS USED FOR ALL MEASUREMENTS

2.4 Benthic Macroinvertebrate Investigation

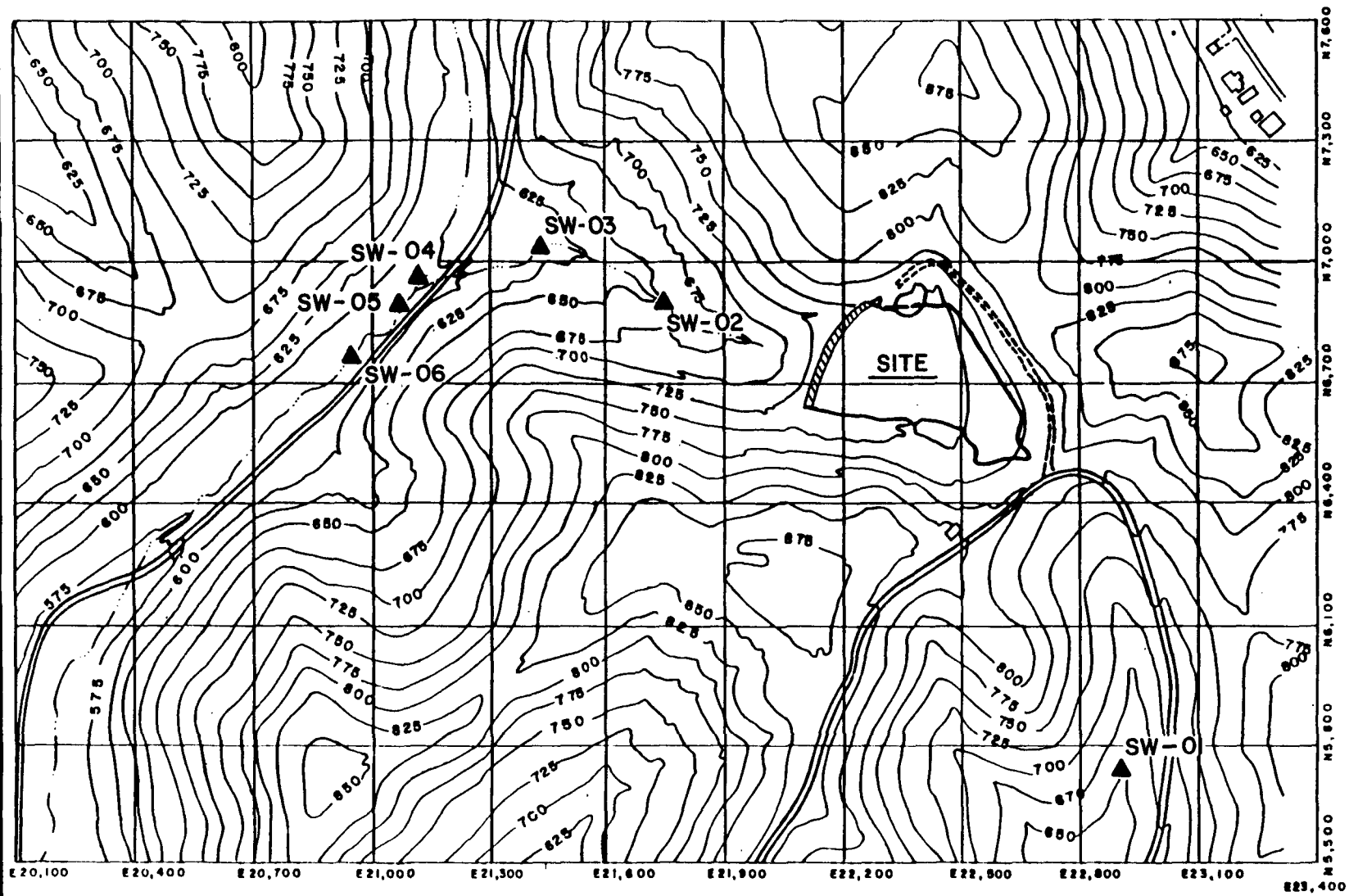
2.4.1 Objectives

A quantitative and qualitative benthic macroinvertebrate sampling program utilizing six sampling stations was established and performed by Law Environmental. Benthic macroinvertebrate communities are composed of animals that inhabit the bottom sediments of lakes, streams, estuaries and marine waters. In freshwater systems they include insects, annelids, mollusks, flatworms, roundworms, and crustaceans. The benthic macroinvertebrate community is sensitive to environmental changes and thus can be a useful tool for detecting these changes. The benthic macroinvertebrate sampling program for the landfill was designed as a one-time investigation. The sampling program's objective was to survey the benthic macroinvertebrate communities associated with the intermittent stream systems adjacent to the landfill to determine if impacts had occurred. The benthic macroinvertebrate communities were evaluated for quantity and types of organisms.

Physical-chemical environmental information was collected at each of the six sampling stations to supplement the qualitative and quantitative macroinvertebrate sampling program. These parameters included air temperature; stream characterization data (velocity, depth, width, and substrate type); and water quality (pH, conductivity and temperature).

2.4.2 Sample Program

The six approved sampling stations labeled BE-01 through BE-06 (shown in Figure 12 as SW-01 through SW-06) were sampled on June 7 to 8, 1988. Representative samples were collected to evaluate both benthic macroinvertebrate communities and physical-chemical water quality conditions. All collections were begun at the most downstream sample



LEGEND




-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  SW-01 SURFACE WATER (SW), SEDIMENT (SD) AND BENTHOS (BE) SAMPLING LOCATION



FIGURE 12
SURFACE WATER, SEDIMENT,
AND BENTHOS
SAMPLING LOCATIONS
 E. H. SCHILLING LANDFILL

station. This was done to prevent sediments or other dislodged materials from being carried downstream, possibly altering the next sample station. Personnel access to the sample stations was restricted to that required for collecting the samples along previously established routes.

2.4.3 Quality Assurance

The quality assurance objective was to accurately quantify the benthic macroinvertebrate community at each sample station. Due to the inherent species variability and the clumped, irregular distribution of organisms in benthic communities, samples at each station were collected in triplicate (US EPA, 1973 and APHA, 1985). A reference collection of verified specimens was used in addition to taxonomic literature so that correct identification of specimens was possible.

2.4.4 Benthic Sampling - Quantitative

A Wildco-Ekman, standard grab, tall version (Cat. No. 196-T) was used to collect the benthic macroinvertebrate samples. The Ekman grab was washed in an Alconox solution scrubbed with a stiff bristle brush and rinsed several times with tap water after completion of sampling at each station.

The Wildco-Ekman type of benthic grab is designed for sampling silt, muck and sludge in water with slow flows (APHA, 1985). The box-like part holding the sample has spring-operated jaws on the bottom that must be manually cocked. At the top of the grab are two hinged overlapping lids that maintain sample integrity during sample retrieval through the water column. The Ekman grab is constructed of solid brass with stainless steel springs and

cables. Grab chamber dimensions are six inches x six inches x nine inches; and the surface area sampled is 36 square inches. The Ekman grab for the purposes of this study was equipped with a metal handle five feet in length which incorporated the trigger mechanism. The triggering mechanism was loaded and locked prior to entering the stream proper. The grab was worked into the sediment to the maximum penetration depth, triggered, and inspected to determine that no foreign material had lodged in the jaws preventing complete closure. The grab was then placed into a three-gallon plastic wash bucket. The wash bucket bottom consisted of a brass wire cloth (US Standard No. 30 sieve size; 28 meshes per inch) reinforced with hardware cloth and attached to the bucket by a brass ring. The sampler was opened, locked in position, and the contents of the grab were allowed to spill into the bucket. Sample material remaining on the grab was washed into the bucket with a washing/dispensing bottle containing tap water. The grab was then removed from the wash bucket.

The wash bucket containing the sample was placed inside a larger five gallon plastic bucket approximately half full of tap water. The grab sample contained within the wash bucket was resuspended and agitated by hand to allow the smaller soil material to pass through the US Standard No. 30 sieve.

The material retained on the screen within the wash bucket was then transferred to a labeled one-quart plastic, wide-mouth, container. A plastic spatula and washing/dispensing bottle were used to assist in the transfer of material from the wash bucket to the sample container. The sample was preserved with a 10% buffered formalin solution. Since formalin tends to become acidic with storage and can cause damage to the preserved

specimens, sodium acetate was used as a buffer (Holme and McIntyre 1971). A biological stain, rose bengal, was also added to the formalin preservative to assist in the sorting and identification of the preserved specimens. The sample was then sealed as per chain-of-custody procedures, the container labeled, and the field data sheet completed.

2.4.5 Benthic Sampling - Qualitative

The qualitative catch per-unit-effort sampling program involved 10-minute searches of the stream reaches, 20 to 30 feet upstream and downstream of each sample station. The search involved over-turning gravel and rubble and collecting any organisms found. The organisms collected using this method were preserved and documented in the same fashion as those collected quantitatively.

2.4.6 Sorting and Identification

Laboratory sorting of the benthic macroinvertebrate samples followed procedures detailed in EPA (1973) and APHA (1985). Each sample was initially rough sorted by hand using a low power scanning lens and a white enamel pan filled approximately one-third full with water. The white enamel pan provided excellent contrast to the red stained organisms and greatly improved sorting efficiency.

The organisms were identified to the lowest practical taxon using available keys, and enumerated after sample sorting and identification was completed. Stereoscopic and compound microscopes were used for identification purposes. A macroinvertebrate laboratory bench sheet was used to record total number of individuals by taxonomic group.

2.4.7 Water Quality

Three water-quality parameters, pH, conductivity, and temperature, were collected at each station prior to collection of the benthic samples. A grab sample was collected with a clean plastic, one-quart container. Due to the limited water depth at many stations, the water samples included the water-surface layer. The sample was field analyzed for pH, conductivity and temperature.

A YSI Model 33 Conductivity-Salinity-Temperature meter was used to determine conductivity; an Orion Model SA 250 pH meter equipped with a Ross field combination pH electrode and temperature probe was used to determine pH and temperature. The methods used are detailed in "Methods for Chemical Analysis of Water and Wastes" (US EPA, 1983) and correspond to the following procedure numbers: pH - Method 150.1; conductivity - Method 120.1; and temperature - Method 170.1.

The instrumentation was calibrated several times each day using either certified standards or standards traceable to a certified standard; calibration was verified prior to analysis at each station. Documentation regarding calibration frequency was logged on an equipment calibration report form; corrections were made to the water-quality values when instrument drift was observed. Instrument probes were rinsed with distilled water between sample analysis to prevent cross contamination. Water-quality results and calibration information were recorded on the appropriate field-data sheets.

2.4.8 Data Treatment

As specified by the Sampling Plan, the diversity index was used for benthic macroinvertebrate data interpretation. Diversity incorporates two components, number of species (species richness), and the distribution of individuals among species. Diversity is a measure of the species richness in a community which takes into account the relative abundance of each species. The Shannon-Weaver index was used to calculate mean diversity. The formula used to calculate this index as presented by Lloyd et al. (1968), is:

$$d = \frac{C}{N} (N \log_{10} N - \sum n_i \log_{10} n_i)$$

where $C = 3.321928$ (converts base 10 log to base 2); N = total number of individuals; and n_i = total number of individuals in the i^{th} species.

The equitability index was also calculated to supplement data interpretations. Equitability evaluates the component of diversity due to the distribution of individuals among the species by comparing the number of taxa in the sample with a hypothetical number of taxa based on the mean diversity. The formula for equitability as presented in "Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents" (US EPA, 1973) is :

$$e = \frac{s'}{s}$$

where s = number of taxa in the sample, and s' = the tabulated hypothetical value.

2.4.9 Supplemental Characterization of Sample Stations

Supplemental information was obtained in an effort to provide as much pertinent information as possible regarding the environmental setting of each sample station. This included stream substrate type, water velocity, stream width (bank and wetted), and water depth.

Stream substrate type (physical composition of stream sediments) was determined by visual inspection in the field. Description of substrate size and characteristics followed those detailed by EPA (1973). Stream flow velocity was qualitatively estimated by placing a small object on the stream water surface, usually a plant leaf, and timing its movement over a known distance. Two stream widths, bank and wetted, were identified, measured and recorded. Both widths were determined with a field tape measure. The bank width was defined as the natural stream bed width. The wetted width was that portion of the bank width which was either inundated with water or the substrate was visually saturated. Water depth was measured and a range (minimum/maximum) reported since stream depths are not constant due to the irregularities associated with the stream bottom.

2.5 Meteorological Investigation

Meteorological data collection activities for the E.H. Schilling Landfill project have been accomplished over a twelve-month period in conformance with Section 5.3 of the approved October 1987 Sampling Plan. The data collection activities include the tabulation of historic meteorological data within a reasonable distance of the landfill area and the collection of on-site meteorological data for the landfill. These data serve a two-fold

purpose: (1) as input into air dispersion modeling, and (2) for use in estimating the site water balance.

2.5.1 Historical Data

Several sources of historical data were contacted and available data reviewed. Detailed historical data useful to analyses of the Schilling site were obtained from the National Climatic Data Center in Ashville, North Carolina, and from the Huntington, West Virginia National Weather Service station located at the Huntington airport approximately seventeen miles southeast of the landfill site. The historical meteorological data from these locations include hourly data on computer tapes and annual summary data. The Climatic Atlas of the United States (NOAA, 1983) was reviewed, but the Huntington, West Virginia station had more specific regional summaries. The Ashland-Boyd County Airport does not record significant meteorological data. The Portsmouth, Ohio City Health Department, Local Air Agency, uses the Huntington, West Virginia Airport station data. Supplemental precipitation data was obtained from a US Corps of Engineers monitoring station at the Lloyd Greenup dam on the Ohio River, approximately six miles southwest of the site.

Five years of hourly meteorological data is required as a data base for air dispersion modeling. The available data base from the Huntington, West Virginia, Airport is for the period of record 1975 through 1979 and has been obtained for this project on floppy disks. These data are in the appropriate computer format for use in air dispersion modeling, and include wind speed, wind direction, mixing height, temperature, and category of stability of the atmosphere.

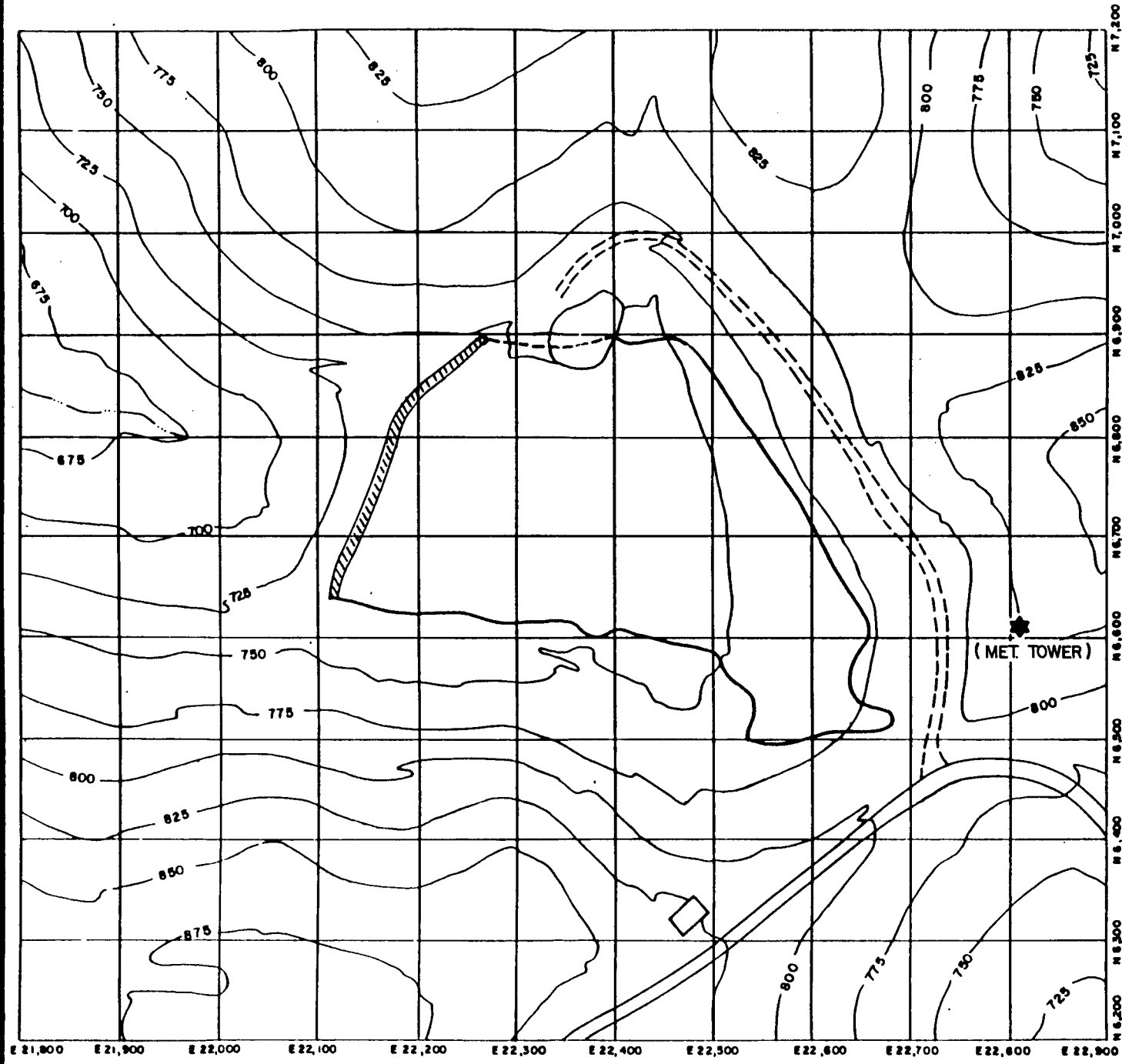
Additionally, annual summary reports published for the Huntington airport station were obtained for 1983 through 1987. The annual summary reports were used for the wind resultant direction data which were not initiated until 1984.

2.5.2 Site Meteorology

On-site meteorological data for the landfill site required the design and installation of a meteorological station. The station location with respect to the landfill is illustrated on Figure 13. The location was selected in a clearing east of the landfill in an area free from obstruction. The objectives of the meteorological study were to provide data needed for air modeling and to obtain input data for determining the site water balance. Wind speed, wind direction, temperature, and solar radiation are important input parameters utilized in air dispersion modeling. Precipitation, relative humidity, and solar radiation data are input parameters utilized for evaluating surface water runoff and evaporation.

A 10-meter high tower was installed, and automated meteorological monitoring equipment was placed in operation by Law Environmental on February 18, 1988. The installation is depicted in Figure 14.

The automated meteorological data acquisition and storage system consists of a microprocessor-based data collection system with cassette tape for data storage, wind speed and direction sensors, temperature and relative humidity sensors; a pyranometer (solar radiation sensor), and a tipping bucket precipitation gauge. The system is battery-powered, and a solar panel recharges the battery during daylight hours. Table 8 identifies the



LEGEND



-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS



FIGURE 13
METEOROLOGICAL TOWER LOCATION
E. H. SCHILLING LANDFILL

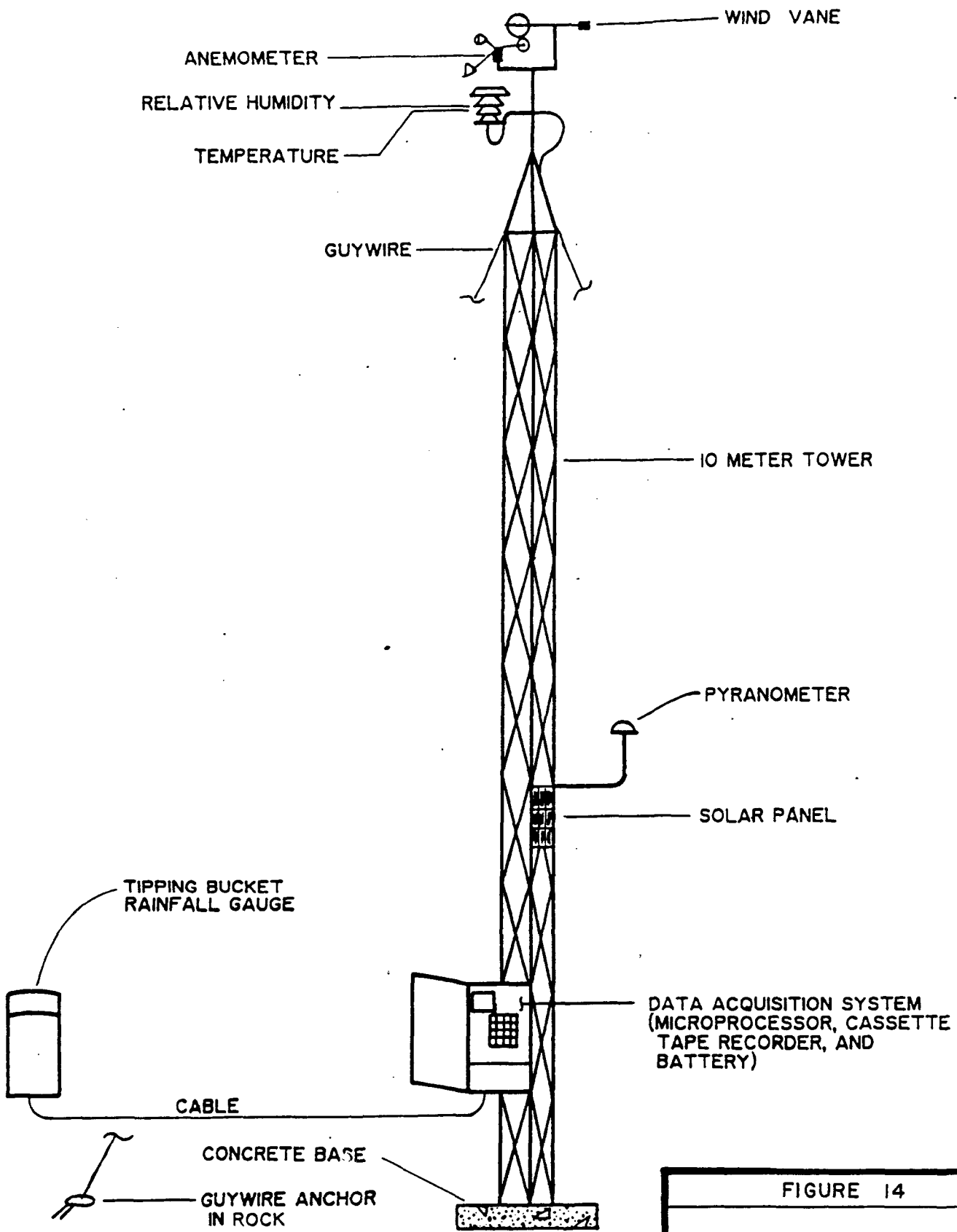


FIGURE 14

METEOROLOGICAL MONITORING STATION

E.H. SCHILLING LANDFILL

TABLE 8
METEOROLOGICAL EQUIPMENT

TELEDYNE GEOTECH METEOROLOGICAL COMPONENTS

Sensor Equipment

Anemometer (Wind Speed Sensor - SS-201)
Wind Vane (Wind Direction Sensor - SD-201)
Capacitance Element (Relative Humidity Sensor - WS-201-R)
Platinum Resistance Probe (Temperature Sensor - WS-201-T)
Pyranometer black and white (Solar Radiation Sensor - R-100)
Precipitation gauge, tipping bucket type (Rainfall Sensor - PG-400)

Data Acquisition System

Basic Micro-Met Data Acquisition System with added processors for relative humidity, solar radiation MM-100; HSR-100)
Microprocessor and cassette tape storage (CR-100)
Adapters, cables, and connectors as needed
Solar Panel and battery

ROHM METEOROLOGICAL TOWER COMPONENTS

Three 3.3-meter triangular sections combined for 10-meter tower (UNR-25)
Concrete base and metal stand
Three guywires and guywire supports

components in more detail. In addition, a wind sock was visible to on-site workers above and below the dam indicating local wind directions for personnel protection purposes.

The microprocessor continuously records data, and calculates hourly averages which are stored on cassette tape. In addition, the microprocessor determines the maximum daily temperature and peak wind speed values, calculates the variance of the wind direction, and computes daily averages of the following parameters: wind speed, wind direction, wind direction variance, temperature, relative humidity and radiation. The microprocessor also computes daily totals of precipitation. The computed daily averages, maximum/minimum parameters and totals are recorded on cassette tape at the end of each day, and new computations are begun for the next day.

Data collection tapes are replaced every three to five weeks. The data tapes are returned to Law Environmental (Louisville office) and are uploaded to a personal computer through a cassette tape reader that reformats the data. The reformatted data are stored on floppy disks for future printout and use in computer modeling.

Due to volume, data in hard copy form are not included in this report. The data are being stored on floppy disks and can be distributed in that form, if required. An example of the hourly meteorological data is given in Table 9. Wind speed is measured in meters per second, wind direction is measured in degrees (0-360), temperature is measured in degrees Celsius, relative humidity is measured in percentage, precipitation in inches and radiation is measured in langleys per minute. The daily averages are the average of the hourly records, with the exception of precipitation, which is the daily total precipitation.

TABLE 9
EXAMPLE PRINTOUT OF HOURLY METEOROLOGICAL DATA

89/03/20 0000 ID=0001 UC=8899 0009

TIME	WS	WSPK	WD	WDS	TEMP	R.H.	PREC	RAD	BP	OPT1	OPT2	OPT3	
0000	0100D	0.6	3.0	35	29.0	2.6	63	0.00	0.000	0	0	0	12.76
0100	0200D	0.6	1.4	29	23.5	2.4	66	0.00	0.000	0	0	0	12.76
0200	0300D	0.9	3.5	32	18.5	2.3	65	0.00	0.000	0	0	0	12.75
0300	0400D	0.4	3.8	54	34.0	2.3	66	0.00	0.000	0	0	0	12.74
0400	0500D	0.3	1.7	60	48.0	2.3	68	0.00	0.000	0	0	0	12.74
0500	0600D	1.1	2.7	7	21.5	2.5	67	0.00	0.000	0	0	0	12.74
0600	0700D	0.3	1.5	23	46.0	2.4	70	0.00	0.000	0	0	0	12.74
0700	0800D	0.6	3.1	95	49.5	2.2	79	0.01	0.003	0	0	0	12.73
0800	0900D	0.4	2.5	63	37.0	1.5	98	0.01	0.001	0	0	0	12.73
0900	1000D	0.3	2.0	37	29.0	1.8	100	0.07	0.017	0	0	0	12.72
1000	1100D	0.7	3.4	83	36.5	2.9	100	0.07	0.044	0	0	0	12.72
1100	1200D	1.0	4.3	104	45.5	3.8	100	0.05	0.084	0	0	0	12.72
1200	1300D	1.6	4.2	129	23.5	4.9	100	0.02	0.094	0	0	0	12.72
1300	1400D	1.9	5.6	130	18.5	5.6	100	0.00	0.072	0	0	0	12.72
1400	1500D	1.5	4.7	150	32.5	7.1	100	0.10	0.018	0	0	0	12.72
1500	1600D	1.4	3.9	246	67.0	7.8	100	0.11	0.011	0	0	0	12.74
1600	1700D	2.6	6.8	150	16.5	8.7	100	0.04	0.015	0	0	0	12.75
1700	1800D	2.7	7.8	167	26.5	10.5	100	0.08	0.001	0	0	0	12.75
1800	1900D	2.6	5.9	167	24.0	11.1	100	0.11	0.000	0	0	0	12.75
1900	2000D	2.3	6.6	169	27.0	11.5	100	0.02	0.000	0	0	0	12.75
2000	2100D	0.9	2.7	197	31.0	11.5	100	0.07	0.000	0	0	0	12.75
2100	2200D	1.6	4.7	339	40.5	10.5	100	0.13	0.000	0	0	0	12.75
2200	2300D	1.5	4.6	340	24.0	8.8	100	0.08	0.000	0	0	0	12.75
2300	0000D	2.1	6.5	336	23.5	8.1	100	0.05	0.000	0	0	0	12.74
DAILY	AVG	1.3	7.8	78	70.5	5.6	89	1.02	0.016	0	0	0	12.74

89/03/20 2359 ID=0001 UC=8899 0009 ;MAX T= 11.7;MIN T= 1.2

ABBREV.	PARAMETER	UNITS
WS	Wind Speed	m/s
WSPK	Peak Wind Speed	m/s
WD	Wind Direction	Degrees (0-360)
WDS	Standard Deviation of Wind Speed (sigma)	---
TEMP	Temperature	Degrees Celcius
R.H.	Relative Humidity	Percent
PREC	Precipitation	Inches
RAD	Solar Radiation	Langleys/minute
BP	Barometer Pressure	- data not collected
OPT1	Option 1	- not used
OPT2	Option 2	- not used
OPT3	Option 3	- system voltage
Max T	Maximum Temperature	Degrees Celcius
Min T	Minimum Temperature	Degrees Celcius

Barometric pressure was not collected at the Schilling Landfill site. The Huntington, West Virginia airport collects hourly barometric pressure. Airport personnel indicate that the Schilling Landfill site would have barometric pressures that are only 1 millibar less than their data due to elevation differences. The reported 30-year annual average barometric pressure for Huntington was 987.5 millibars, and the monthly average range is only 984.9-989.2 millibars or a deviation of only 0.2% from the average. The small variance indicates that the airport data is adequate for the site, especially since the latest approved air dispersion modeling does not require barometric pressure data.

The meteorology of the landfill is influenced by the topography at the site. The valleys and ridges reduce wind speeds and channel the wind flow across the site in a west-east direction. Eddy currents resulting from the wind movement across the ridges surrounding the site cause micro-scale changes in the wind direction, as occasionally indicated by observed movements of the wind sock, survey stake ribbons, and wind vane at the site.

2.6 Air Quality Investigation

2.6.1 Introduction

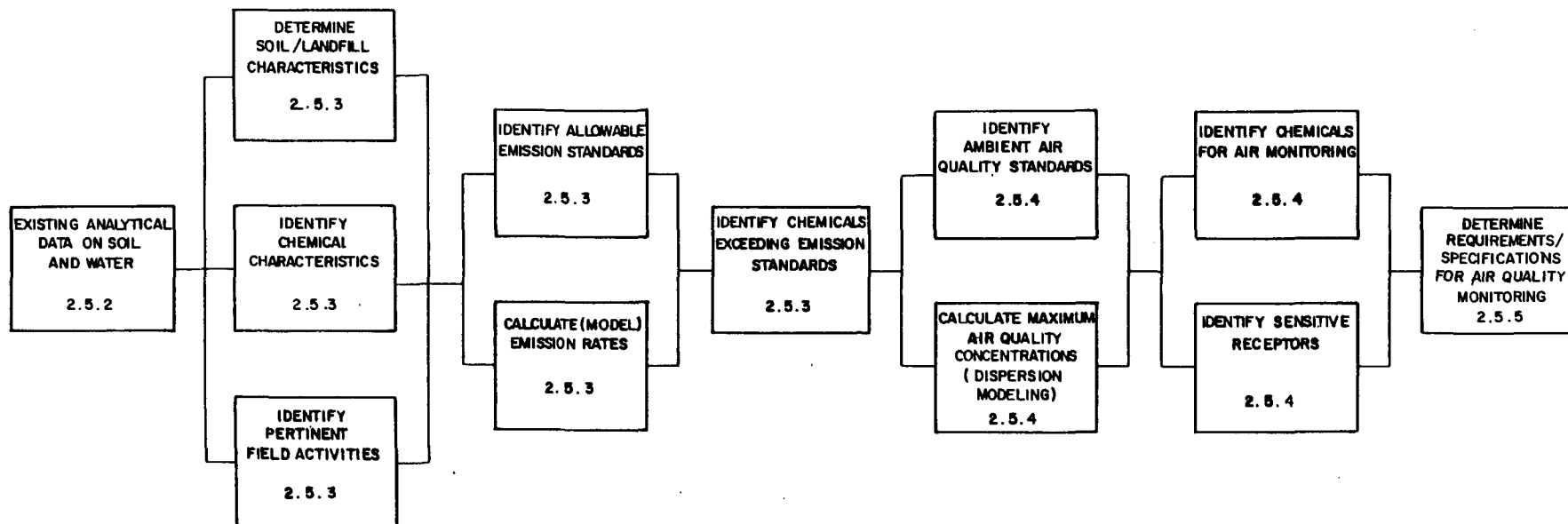
The purpose of the air quality investigation was to provide the technical basis for protection of the workers on the site and to assess the ambient air quality impacts on the area surrounding the site. The activities conducted during the Phase I Remedial Investigation of the landfill site included grading, road construction, and sampling activities. Exposures to gases and contaminated dusts are considered the primary hazards to site personnel. The maximum air quality impact from the landfill site will occur during stable atmospheric

conditions (E and F stability) directly downwind of the source. Air monitoring and air dispersion modeling were used to estimate maximum air quality concentrations of potential air constituents for the existing conditions of the undisturbed (capped) landfill, and the maximum air quality concentrations that may occur during remedial actions.

The air quality investigation for the landfill included the following tasks: review of existing analytical data, emission rate analysis, air dispersion modeling, and air monitoring. A flow diagram of the air quality investigation activities is shown in Figure 15. These tasks follow those described in the Sampling Plan for the Phase I Remedial Investigation at the landfill dated October, 1987.

2.6.2 Review of Existing Analytical Data

A review of analytical data for soils, leachate, and surface waters collected between October 30, 1979, and February 10, 1983, was conducted to identify chemical compounds that have a potential for air emissions at the landfill. A preliminary list of potential air constituents was selected for the initial air sampling periods of February 15, 1988, and May 24, 1988. The preliminary list of air constituents is shown in Table 10. The initial air sampling at the site was used to characterize emissions from the landfill and to provide a basis for analysis of potential air constituents. Screening technologies were used to monitor emissions from landfill waste in the undisturbed state and from landfill waste in the disturbed state (i.e., testing of gases directly above drilling operations and leachate collection). These historical data, combined with monitoring data, additional landfill waste data, and a knowledge of site activities resulted in development of the air monitoring/air dispersion modeling approach taken for this assessment.



NOTE : NUMBERS REFER TO TEXT SECTIONS IN APPROVED SAMPLING PLAN , DATED OCTOBER 1987

FIGURE 15

AIR INVESTIGATION WORK
TASK FLOW CHART

E. H. SCHILLING LANDFILL

TABLE 10
Preliminary List of Potential Air Contaminants

Preliminary Air Contaminant	Sampling Method		
	High-Volume Sample	VOCCS Canister	Detector Tube
Arsenic	X		
Barium	X		
Cadmium	X		
Calcium	X		
Chromium	X		
Cobalt	X		
Iron	X		
Lead	X		
Magnesium	X		
Manganese	X		
Mercury	X		
Nickel	X		
Sodium	X		
Zinc	X		
Acetone		X	X
Benzene		X	X
Hydrogen Cyanide			X
Ethylbenzene		X	X
Mercury vapor			X
Carbonyl Nickel			X
Phenol			X
Styrene		X	X
Toluene		X	X

2.6.3 Emission Rate Analysis

The emission rate analysis for the landfill included air monitoring and air dispersion modeling to assess the impact from potential air emissions. Because no specific emission rate factors existed at the time of this analysis, the emission rate analysis was developed based upon site-specific factors such as concentrations of constituents in landfill wastes, air monitoring data, and air dispersion modeling. Figure 16 is a schematic of the air pathways analysis used for this assessment.

2.6.3.1 Landfill Waste Characteristics

Waste samples were collected at the landfill as part of the remedial investigation in April, 1988. Laboratory analysis of these samples was completed in June, 1988, for inclusion in the existing historical and monitoring data bases for estimating potential emissions. The maximum concentrations of each constituent detected in the landfill waste samples (LW-01 through LW-09) were chosen as the basis for calculating emission rates from the capped and uncapped landfill.

2.6.3.2 Emission Rate Estimates

Emission rates were estimated through a modeling process where the estimated emission rates for the area source were refined to correlate with actual monitoring data. Estimated emission rates along with meteorological data collected during air monitoring were modeled to calculate a predicted downwind concentration. This concentration was then compared to the measured downwind concentration and after comparison, was adjusted appropriately.

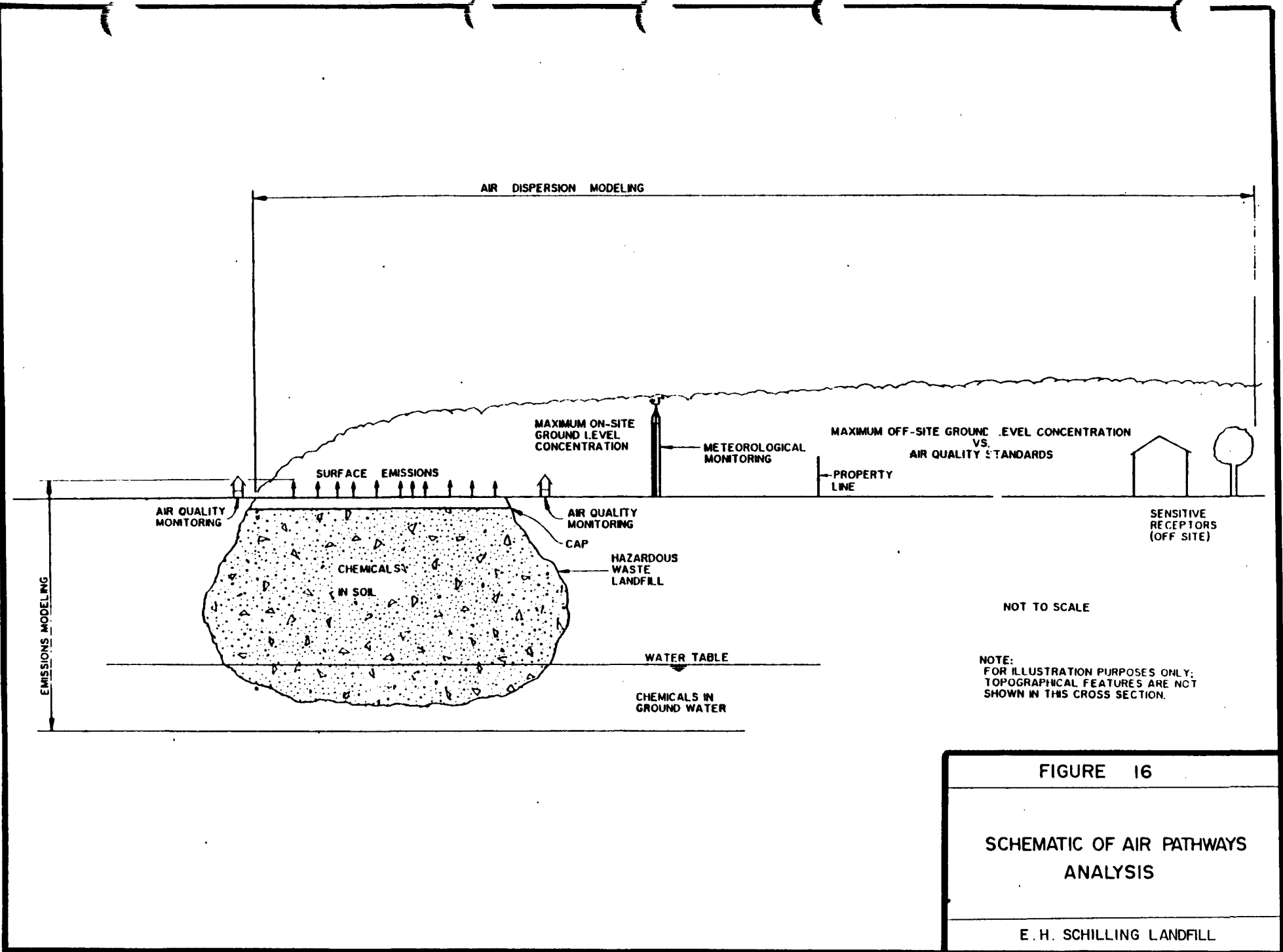


FIGURE 16

SCHEMATIC OF AIR PATHWAYS ANALYSIS

E. H. SCHILLING LANDFILL

This process was performed for the total VOCs and metals and for individual VOCs and metals.

The maximum emission rate was estimated by using the total mass of each constituent found in the landfill waste samples and converted to micrograms per square meter per second ($\mu\text{g}/\text{m}^2\text{-sec}$). The constituents were assumed to exist uniformly and to be emitted over an 8-hour period. An 8-hour period was chosen to allow comparison of estimates with Threshold Limit Values published by the American Council of Governmental Industrial Hygienists (ACGIH) and other air quality standards that are based on time-weighted averages of 8 hours.

Maximum VOC emission rates were also estimated using the Chem Dat 6 model. The Chem Dat 6 model was developed by EPA to estimate emissions from landfills, land piles, and lagoons. The model uses landfill area, cap thickness, porosities found in the cap, temperature, pressure, depth of waste, water content, time, and the weight fraction of volatile organics as input data. Extensive data is required to utilize the Chem Dat 6 model and to correlate model results with field test data. The model results for the capped and uncapped landfill were found to exceed concentrations derived from air monitoring data and were adjusted accordingly.

Maximum emission rates for metals were based upon the assumption that the metals were absorbed on total suspended particulates (TSPs) at ambient temperatures. The maximum concentration of each metal constituent of landfill waste was proportioned to the TSP emissions to obtain maximum emission rate estimates.

The estimated maximum emission rates for VOCs and metals were modeled using the Industrial Source Complex-Short Term (ISCST) air dispersion model and meteorological data obtained during air monitoring events. The ISCST model was selected as appropriate for the landfill site based upon EPA's Guideline on Air Quality Models. The meteorological data was chosen during stable atmospheric conditions to provide the maximum air quality impact.

The initial modeling of total VOC emission rates predicted ambient concentrations that exceeded reasonable maximum concentrations measured during actual air sampling events. The modeled ambient concentrations for total VOC were adjusted to agree with air sampling data and proportioned to landfill waste concentrations. The adjusted ambient concentrations for total VOCs were utilized to back-calculate emission rates using the modeling techniques.

The metal concentrations predicted by the model exceeded the measured downwind concentration for TSP. The modeled metal concentrations were adjusted to TSP concentrations and proportioned to landfill waste concentrations. The emission rates for metals were back-calculated using the adjusted metal concentrations and the air dispersion model as shown in Appendix B5.

After the total VOC and metal concentrations were refined, emission rates were refined further for specific constituents. Air monitoring data for specific VOCs and metal concentrations were used to provide an estimate of emission rates using the same modeling

technique. The refined emission rates for VOCs and metals were multiplied by a safety factor of 3. This safety factor was derived from the uncertainty of model predictions as discussed in air modeling literature.

2.6.4 Air Dispersion Modeling

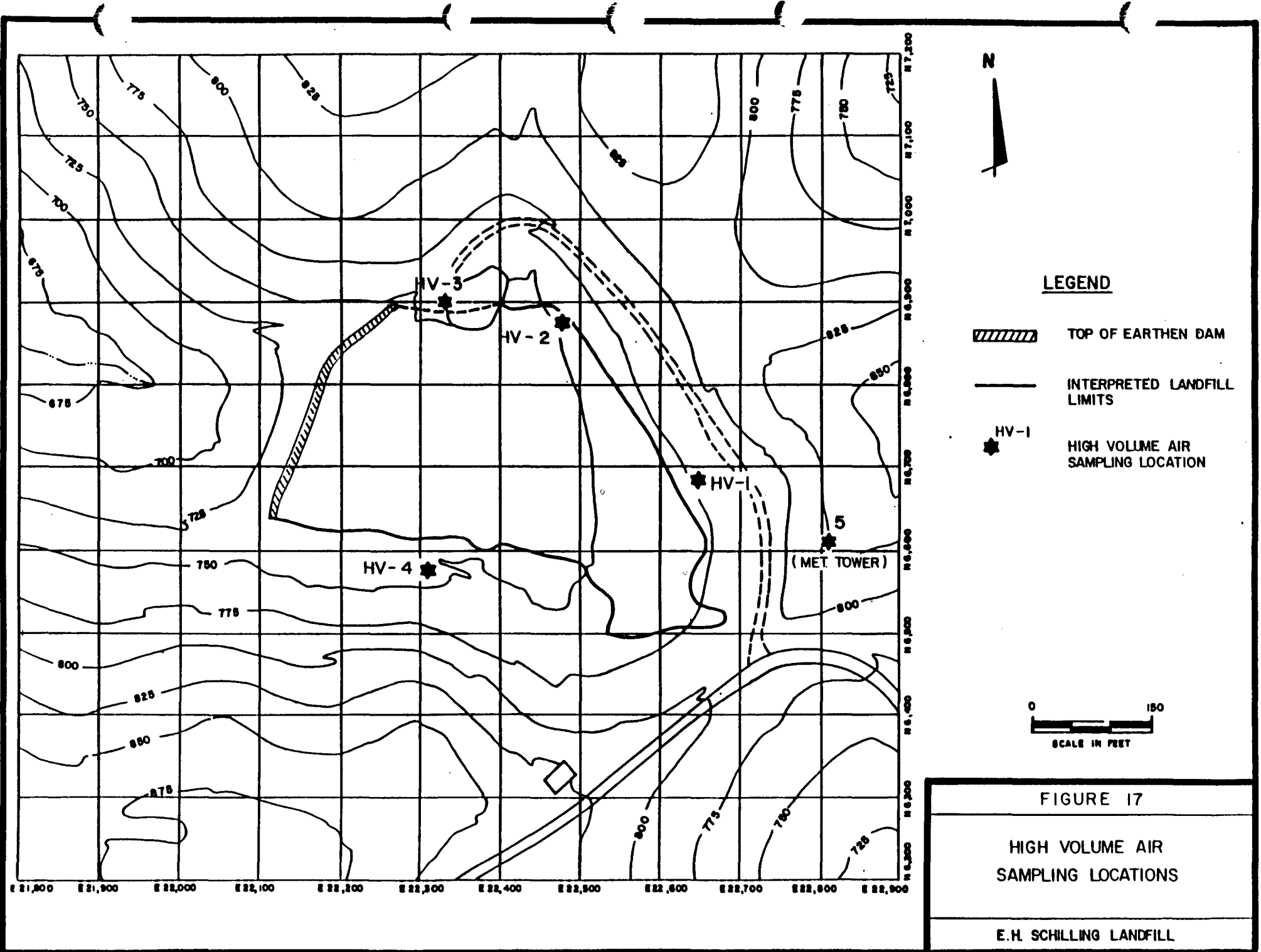
The air dispersion model used was the ISCST model. ISCST is a refined model that can be applied to area sources and can be used to simulate the effects of fugitive emissions from landfills. The model input data includes landfill area, coordinates, elevations and meteorological data. The meteorological data used in this analysis consisted of 1979 surface and upper-air data from Huntington, West Virginia located 17 miles (27 km) southeast of the Schilling Landfill. This year of data was used in accordance with OEPA recommendations.

The receptor grid for the ISCST modeling analysis consisted of 563 discrete receptors spaced 100 feet (30.48 meters) apart out to a distance of 0.91 km from the edge of the landfill area. The grid selected excludes the actual landfill area. The coordinates and topographic elevations at each receptor point were input to the model. OEPA was contacted to obtain the ambient air quality standards for the constituents addressed in this analysis. OEPA defines the current ambient air quality standards by policy rather than regulation. The ambient air quality standard for VOC is defined as the TLV of each contaminant divided by 42. There are some constituents that do not have any listed TLV values. Therefore, for these constituents no comparison is made to the ambient air quality standards.

2.6.5 Air Monitoring

The initial air monitoring events were conducted on February 15, 1988 and May 24, 1988 for TSP and non-methane organic compounds (NMOC). One high-volume sampler and one volatile organic compound canister sampler (VOCCS) were used for these sampling periods. Additional samples of selected organic compounds were taken using direct readout instruments (detector tubes). Sampling locations were selected downwind of site activities and close to potential sources of air emission to determine worker exposure. The sampling location is shown as HV-1 in Figure 17. The high-volume samples were analyzed for TSP and metals. The VOCCS samples were analyzed for non-methane organic compounds greater than 1 part per million by volume. Samples were analyzed as outlined in Section 4.4 and 7.2.3 of the Quality Assurance Project Plan dated April, 1988. The results of the initial air sampling are discussed in Section 4.2 of this report.

The ambient air sampling events occurred on August 4, 1988, October 12, 1988, and January 26, 1989. These sampling events consisted of five high-volume samplers, one VOCC sampler, and detector tube samples. The placement of the samplers is shown on Figure 17. By prior agreement in the Sampling Plan, the list of constituents was modified by Law Environmental. The list of air contaminants was modified after the initial sampling to include additional VOC and metals. US EPA issued Compendium Method TO-14 for determination of volatile organic compounds in ambient air using VOCCS canisters in May, 1988. The issuance of this analytical procedure and the resulting changes to the target detection limits of the laboratory prompted this amendment to the list of compounds shown in Table 23 of the approved Quality Assurance Project Plan. The analysis of the high-volume samples included TSP and twenty-one metals. The detector tube samples were



LEGEND




-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  HV-1
HIGH VOLUME AIR SAMPLING LOCATION



FIGURE 17

HIGH VOLUME AIR SAMPLING LOCATIONS

E.H. SCHILLING LANDFILL

utilized to check for six compounds. Samples were taken as direct readings during sampling and drilling activities at the site. Table 11 shows the revised list of air constituents for the ambient air sampling events.

2.7 Hydrogeologic Investigation

2.7.1 Literature Search

A thorough literature search was undertaken to gather information on the regional hydrogeology. Sources of information contacted included: (1) the US Geological Survey; (2) the Ohio Department of Natural Resources; (3) the Lawrence County Soil Conservation Survey; and (4) other local, state and federal authorities.

The geology of southern Ohio has been studied intermittently. The geology of Lawrence County was described as part of a study by Stout (1916) on the geology of southern Ohio. Stout emphasized the coal deposits north and east of the Schilling site. Maxey (1940) studied the stratigraphy and economic deposits of an area north and east of Ironton. The nearest edge of his study area is about 3 1/2 miles east of the Schilling site. The surface and ground-water resources of the towns and communities surrounding the area were described by Stout and others (1943). In a more recent study, Razem and Sedam (1985) investigated the ground-water quality and geochemistry of aquifers associated with coal in the Allegheny and Monongahela Formations in Southeastern Ohio.

2.7.2 Field Geologic Mapping Reconnaissance

A geologic field reconnaissance was conducted by Law Environmental March 28-31, 1988 over the area surrounding the Schilling Landfill site. This study involved observation of the

TABLE 11
Revised List of Potential Air Contaminants

Preliminary Air Contaminant	Sampling Method		
	High-Volume Sample	VOCCS Canister	Detector Tube
Aluminum	X		
Antimony	X		
Arsenic	X		
Barium	X		
Beryllium	X		
Cadmium	X		
Calcium	X		
Chromium	X		
Cobalt	X		
Copper	X		
Cyanide (HCN)			X
Iron	X		
Lead	X		
Magnesium	X		
Manganese	X		
Mercury	X		
Nickel	X		
Potassium	X		
Selenium	X		
Silver	X		
Sodium	X		
Zinc	X		
Acetone		X	X
Benzene		X	X
Bromodichloromethane		X	
Bromoform		X	
Bromomethane		X	
2-Butanone		X	
Carbon Tetrachloride		X	
Chlorobenzene		X	
Chloroethane		X	
Chloroform		X	
Chloromethane		X	
o-Dichlorobenzene		X	
m-Dichlorobenzene		X	
p-Dichlorobenzene		X	
Dibromochloromethane		X	
1,1-Dichloroethane		X	
1,2-Dichloroethane		X	
1,1-Dichloroethene		X	

TABLE 11 (continued)
 Revised List of Potential Air Contaminants

Preliminary Air Contaminant	Sampling Method		
	High-Volume Sample	VOCCS Canister	Detector Tube
trans-1,2-Dichloroethene		X	
1,2-Dichloropropane		X	
cis-1,3-Dichloropropene		X	
trans-1,3-Dichloropropene		X	
Ethylbenzene		X	
Heptane		X	
Isopropyl Benzene		X	
Methylene Chloride		X	
Phenol			X
Styrene		X	X
Tetrachloroethene		X	
1,1,2,2-Tetrachloroethane		X	
Toluene		X	X
1,1,1-Trichloroethane		X	
1,1,2-Trichlorethane		X	
Trichloroethene		X	
Trichlorofluoromethane		X	
Vinyl Chloride		X	
Xylene (o-, m-, p-)		X	

rock outcrops around the site, measurement of several stratigraphic sections, and logging of drill cores from the site.

Stratigraphic sections were measured wherever significant outcrops were present. Sections were measured using a Brunton compass and Jacob's staff. The Brunton compass was used as a hand level attached to the top of the Jacob's staff, a rod of known length with graduated markings. Each section was measured from the base of the slope to the top. By sighting a level from the staff to a point on the ground surface, a known height was measured. The staff was then moved to the point sighted and another segment of height measured. Because the rocks are essentially flat-lying, a unit increase in height corresponded to the same thickness of rock. The rocks were described where they were exposed. The thickness of sequence covered by soil, vegetation or loose rock was also measured. The elevations of the top and bottom of each section were determined using an altimeter and topographic maps of the site.

Eight significant stratigraphic sections were measured in the study area. The location of each measured section is shown on Figure 18.

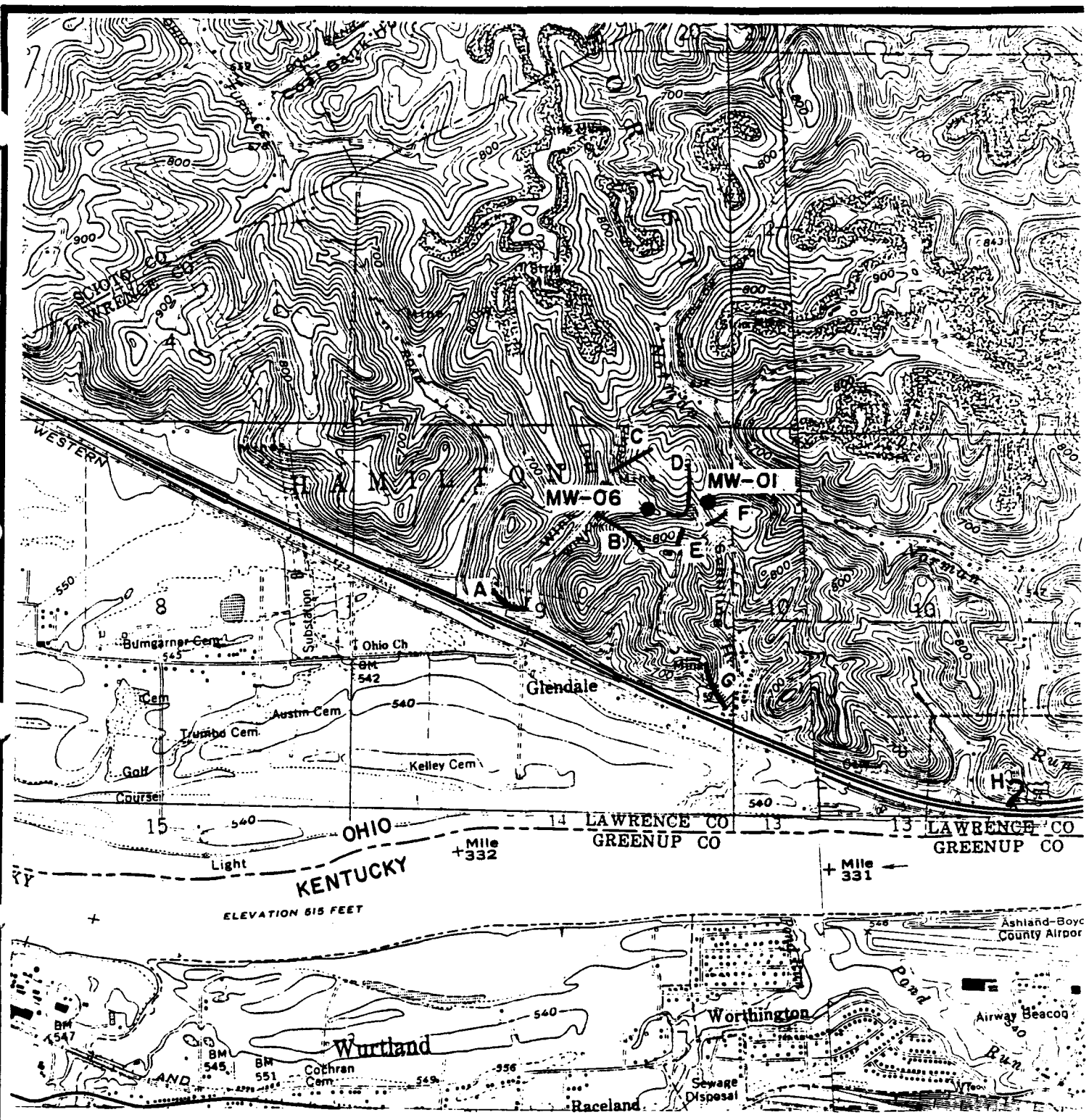
2.7.3 Rock Coring and Packer Testing

Rock coring was performed on the deep borings at well cluster MW-01 and MW-06 to provide detailed information on subsurface lithologies and rock quality/competency. A double-tube core barrel fitted with a diamond studded NX-size bit was used. The coring effort was performed in general conformance with ASTM specification D-2113-83. Potable water obtained from the City of Ironton Municipal Water Department was used in the

coring procedure. Only the minimum amount of water, consistent with good drilling practice was utilized. After completion of the drill run, which was generally ten feet, the core barrel was recovered and the rock samples were removed and placed in boxes. The rock samples were examined and described with respect to lithology and hydrogeologic characteristics. The core recovery and rock quality designation (RQD) were measured for each run. Field drilling logs were utilized to record all work, observations and interpretations. Details on drilling method, coring procedures and sample logging are included in Appendix B2.

The locations for the rock corings are shown on Figure 18. One coring, identified as MW-01B, was located at the top of the ridge northeast of the landfill. After packer testing and logging, the borehole was finished as the deep monitoring well in a two-well cluster. A second coring was performed at MW-06 core located downslope of the landfill at the base of the earthen dam.

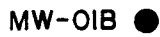
Packer tests (pressure tests) were used in the cored rock holes to determine the in-situ mass permeability of the bedrock layers. The test procedure involves sealing off a section of borehole with inflatable bladders. The tested section is then subjected to pressurized potable water inflow. The flow pressure and volume are functions of bedrock permeability. Water used during testing procedures was obtained from the City of Ironton Municipal Water Department. A representative water sample was subjected to analysis for CLP TCL to identify chemical constituents that might have an impact on the ground-water chemistry for future sampling from the well (results of chemical analyses are presented in Appendix B1).



LEGEND



STRATIGRAPHIC SECTION



CORE BORING



SOURCE: U.S. G.S. TOPOGRAPHIC QUADRANGLE MAPS OF GREENUP, KY AND IRONTON, OHIO

FIGURE 18

LOCATIONS OF STRATIGRAPHIC SECTIONS AND ROCK CORES

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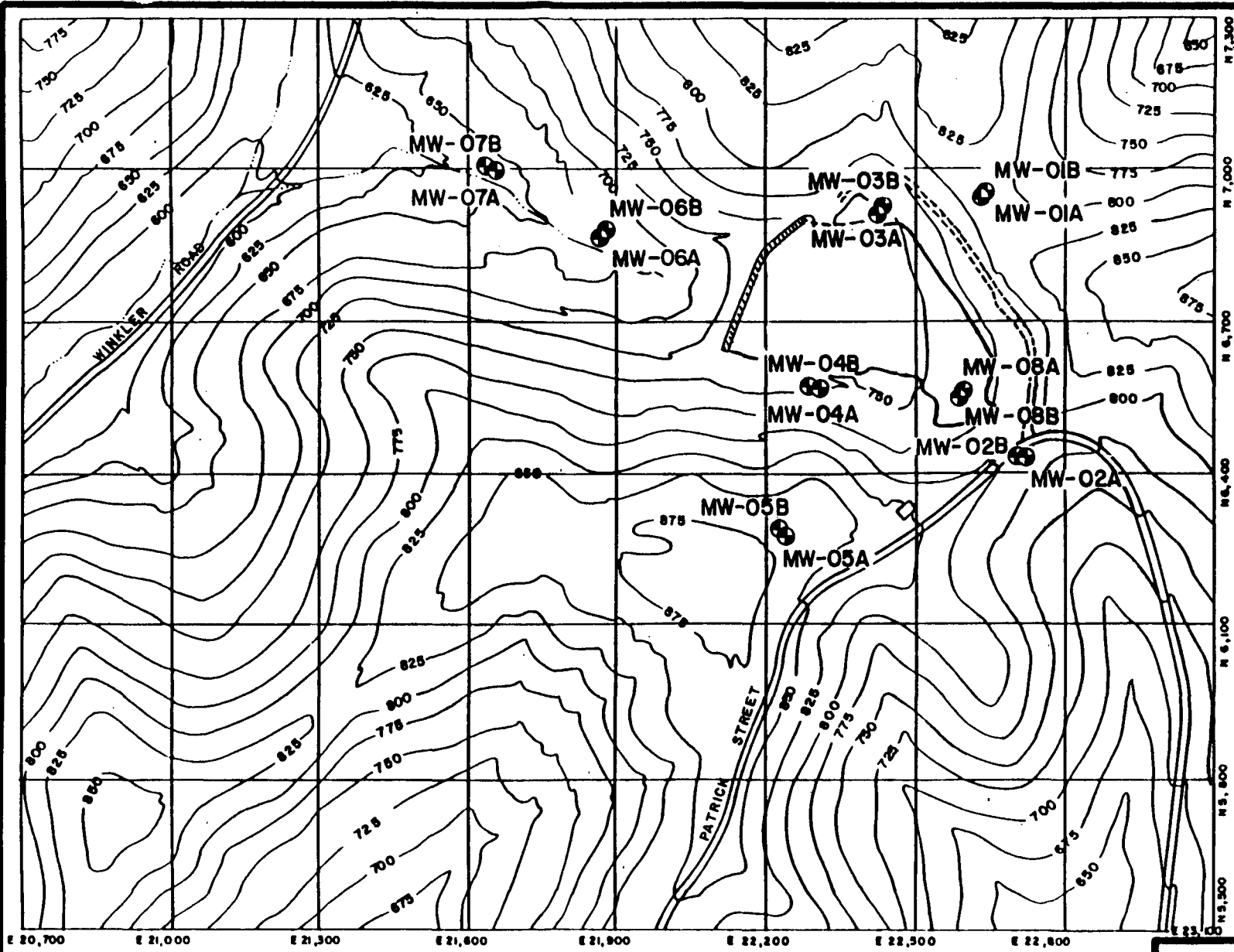
2.7.4 Monitoring Well Drilling and Installation

Sixteen monitoring wells were installed in accordance with the approved Sampling Plan to selectively isolate separate water-bearing units for physical and quality parameters assessment. Each monitoring location consists of a two-well cluster that selectively isolates the uppermost and the next lowest water-bearing zones. Separate borings were drilled for each well of the cluster. Wells installed within the unconsolidated materials are of Type II design. Type III and Type IV wells were installed in rock to monitor the upper bedrock and lower bedrock water-bearing zones, respectively. Wells were constructed to prevent vertical migration of water into the well from the surface or, in the case of the deeper well of the cluster, from the overlying water-bearing zone. All wells are constructed of 2-inch diameter stainless steel. Mild steel casings were used on the Type III (6-inch casing) and Type IV (10-inch and 6-inch casings) wells to seal off upper zones. Well construction details are provided in Table 12. Downhole geophysical logging was performed on the deep well borings of each cluster prior to well installation. Drill cuttings and geophysical logs were utilized to delineate the subsurface stratigraphy and thereby determine the monitoring well design factors.

Three clusters are located along the periphery of the landfill (MW-03, MW-04 and MW-08), two downslope of the landfill (MW-06 and MW-07) and three on ridges surrounding the landfill (MW-01, MW-02 and MW-08) as shown on Figure 19.

TABLE 12
SUMMARY OF WELL CONSTRUCTION DATA

BORING/ WELL NO.	WELL LOCATION COORDINATES NORTHING \ EASTING		TOP OF WELL RISER ELEV. (feet,msl)	WELL PAD ELEV. (feet,msl)	TOTAL DEPTH OF BORING (feet)	TOTAL LENGTH OF WELL (feet)	DEPTH TO BTM OF 10" CASING (feet)	DEPTH TO BTM OF 8" CASING (feet)	DEPTH TO TOP OF SEAL (feet)	DEPTH TO TOP OF SANDPACK (feet)	SCREENED INTERVAL (feet)
MW-01A	6948.75	22627.00	812.31	810.10	124	122.71	N/A	30	103.5	106.3	109.6 - 119.9
MW-01B	6958.05	22642.29	813.34	810.78	163	157.71	30	124	145.1	146.8	149.8 - 154.8
MW-02A	6430.43	22722.36	796.33	793.37	84	85.83	18	60	67.4	69.5	72.0 - 82.3
MW-02B	6432.91	22700.46	799.31	795.34	127	125.90	18	84.5	107.8	110.4	111.7 - 122.0
MW-03A	6915.09	22423.44	749.19	746.19	21	20.57	N/A	11	10.3	11.0	12.2 - 17.2
MW-03B	6924.04	22427.24	749.84	746.93	80	80.96	14	30	62.5	68.5	67.6 - 77.9
MW-04A	6566.73	22307.06	752.27	749.62	27	30.70	N/A	8	17.4	19.8	21.8 - 26.8
MW-04B	6571.45	22283.27	752.11	749.11	75	75.98	8	29.5	56.2	60.0	62.3 - 72.6
MW-05A	6275.73	22235.10	872.13	869.71	140	141.09	N/A	17.5	120.5	124.0	127.8 - 138.1
MW-05B	6292.19	22224.35	873.13	870.28	210	210.90	17	151.5	191.1	193.7	197.2 - 207.5
MW-06A	6874.07	21865.29	673.38	670.71	18	20.51	N/A	N/A	6.2	10.2	12.2 - 17.2
MW-06B	6880.08	21872.84	674.18	671.23	75	75.99	N/A	20	57.2	60.9	62.3 - 72.6
MW-07A	7005.41	21649.38	636.78	634.00	13	15.51	N/A	N/A	2.5	3.8	7.2 - 12.2
MW-07B	7008.28	21641.66	637.30	633.48	47.5	50.87	N/A	18	27.7	32.0	36.5 - 46.8
MW-08A	6561.68	22594.25	761.42	758.73	28	30.85	N/A	11	13.0	15.0	17.2 - 27.5
MW-08B	6550.09	22585.89	761.83	758.43	79	80.62	11	29	64.0	68.0	67.2 - 77.5



LEGEND




-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  MW-01A MONITORING WELL LOCATION



FIGURE 19

MONITORING WELL LOCATIONS

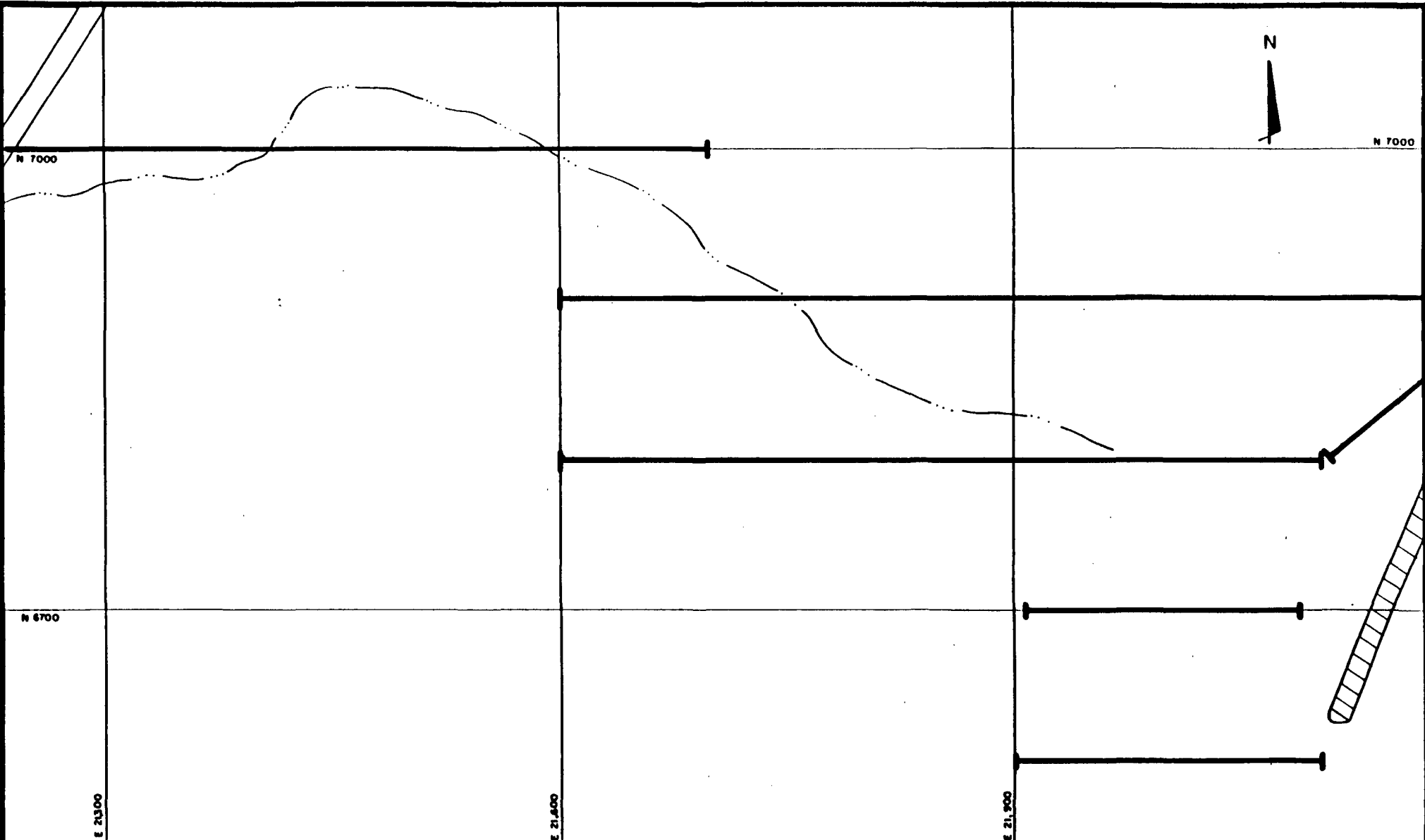
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2.7.5 Geophysical Survey


Geophysics was employed for two purposes: (1) to map possible shallow soil and ground-water contamination in the valley northwest of the dam (surface geophysical survey); and (2) to provide lithologic, stratigraphic and structural information from borings (downhole geophysical survey).

Electromagnetic (EM), electrical resistivity (ER) and seismic refraction (SR) surveys were conducted in the valley below the dam to map the depth to rock and potential ground-water contamination. Figure 20 shows the location of continuous EM-31 survey lines used to indicate the apparent conductivity of materials (within the upper 20 feet) and define electrically conductive material in the soil and ground water. Shallow resistivity soundings (Figure 21) assisted the interpretation of the EM survey. Shallow seismic refraction (Figure 21) gave the depth to rock and allowed interpretation of the degree to which the rock is weathered. The EM survey was extended downgradient to trace the extent of the likely contaminant plume.

Borehole geophysical logging was used in the deep well borings advanced at the site. The logging program utilized gamma ray, single point resistance and spontaneous potential logging functions to indicate the lithology of the rocks in the subsurface. Contacts between sandstones and shales were easily identified through logs. Stratigraphy between borings was extrapolated as much as possible.



LEGEND

 EM-31 SURVEY LINE

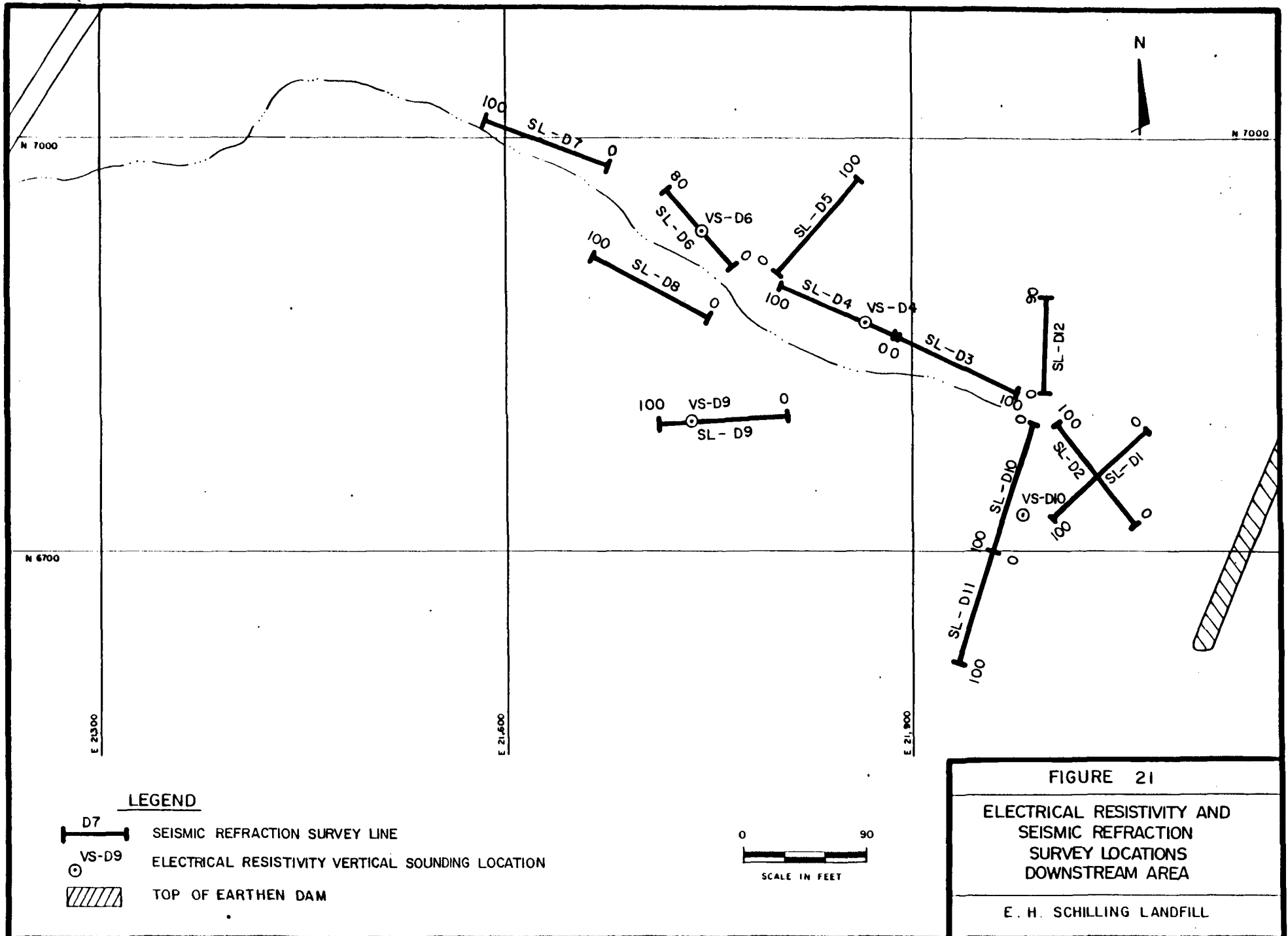
 OF EARTHEN DAM



FIGURE 20

**EM-31 SURVEY LINE LOCATIONS
DOWNSTREAM AREA**

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2.7.6 Ground-Water Sampling

The locations of eight monitoring well clusters were shown previously on Figure 19. The upgradient well location is shown as cluster MW-01 on the top of the ridge northeast of the landfill. This cluster (1) provides background chemical composition of the ground water and (2) aids in establishing flow direction(s). Well clusters MW-03 through MW-08 (1) provide data on water quality to establish the lateral and vertical extent of ground-water contamination, if present, and (2) furnish water-level data necessary to determine ground-water flow direction(s). Monitoring wells are labeled "A" or "B" to correspond with shallow and deep wells, respectively.

Static water levels have been measured in all monitoring wells on a monthly basis for one year. These data have been analyzed to determine ground-water flow directions. In addition, the response of the aquifer(s) to climatic changes is being observed.

Following well completion and development, static water levels were measured on June 6, 1988 and all wells were purged and sampled on June 7-8, 1988. Wells MW-01A, MW-02A and MW-04A contained insufficient water for sampling. Samples from the other wells were submitted to the laboratory for CLP TCL analyses. Monitoring wells were sampled a second time during December 13-14, 1988 in fulfillment of requirements set forth in the Sampling Plan. Wells MW-01A and MW-02A again were not sampled at either sampling event due to insufficient water. At the December sampling event, sufficient water was available in MW-04A for VOC analyses, but insufficient water existed at the June sampling.

2.8 Landfill Diversion Ditch Investigation

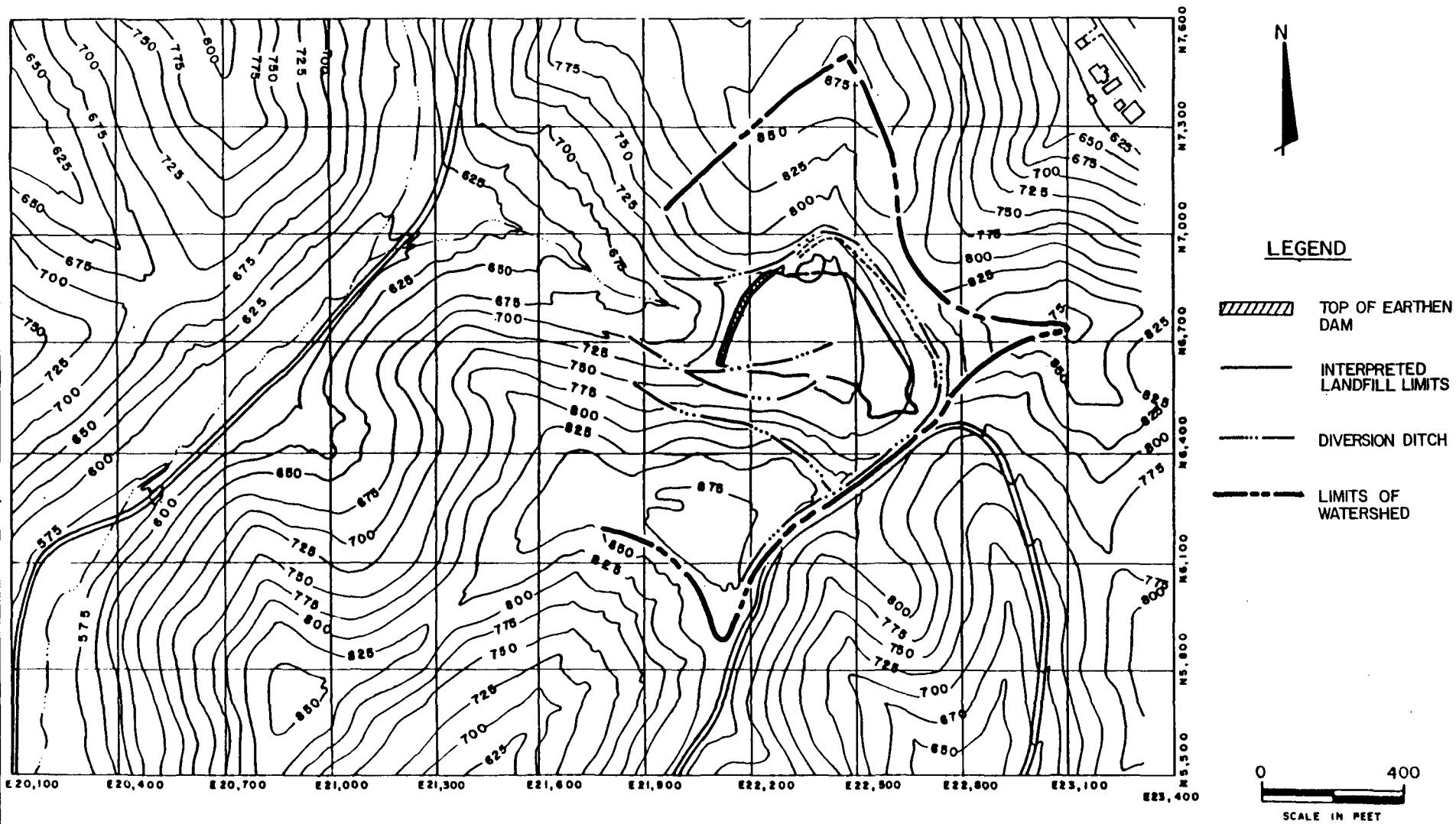
Several ditches exist at the site to collect rainfall runoff from the side slopes of the valley and divert this water around the landfill and below the earthen dam to the Winkler Run tributary (Figure 22). Law Environmental personnel performed visual inspection of the diversion ditches at various times during the RI to document ditch geometries, soil type and degree of erosion.

An evaluation of the ditch design was made by calculating the required ditch cross-sectional area for peak (flash-flood) discharge amounts and comparing this to the observed geometry at key locations along each diversion ditch. A detailed description of the analytical procedures and results are given in Section 3.6.2.

2.9 Earthen Dam Investigation

The earthen dam is approximately forty-five feet in height. Minor failures of the dam have been verbally described by Mr. Pat Schilling. A more significant failure was documented by the Corps of Engineers (see Section 3.6.3.1) prompting an investigation of the dam stability during this remedial investigation.

The original investigation program as outlined in Section 2.9.3 of the Sampling Plan consisted of four tasks: (1) soil test borings; (2) downhole geophysical logging; (3) piezometer installation; and (4) laboratory soil testing. This scope of work was slightly modified during the field investigation as actual field conditions were encountered and evaluated. The materials encountered in the dam were extremely heterogeneous in consistency and composition. Polystyrene and other wastes, high water levels and soft soil







- LEGEND**
-  TOP OF EARTHEN DAM
 -  INTERPRETED LANDFILL LIMITS
 -  DIVERSION DITCH
 -  LIMITS OF WATERSHED

FIGURE 22

**DIVERSION DITCHES
LOCATIONS**

E. H. SCHILLING LANDFILL

with gravel caused borehole collapse and obstructions to the sampling equipment. Borehole collapse prevented any downhole geophysical logging for bulk density testing. Alternative in-situ soil testing methods were selected by Law Environmental and approved by US EPA by letter dated June 1, 1988.

2.9.1 Site Reconnaissance

Prior to other field activities, the downstream surface of the dam was visually inspected on foot to determine significant site features. The dam is covered by weeds and a few small trees. Numerous boulders are scattered over the dam face. Several seeps were noted, primarily at the dam midpoint near the right abutment, at the lower third point near the left abutment and along the dam toe. The seepage is relatively clear and does not contain soil fines indicating erosion from within the dam. Probing with a metal rod around the seeps did not reveal any significant soft areas except at the soil surface. Total seepage from the dam appeared to be less than 5 gpm. This seepage estimate is based upon visual observations made during the RI field investigation and other site visits made during the course of the project. The seepage may vary from this estimated flow during other times. Review of all available data shows no need for more detailed studies or measurements of the dam seepage.

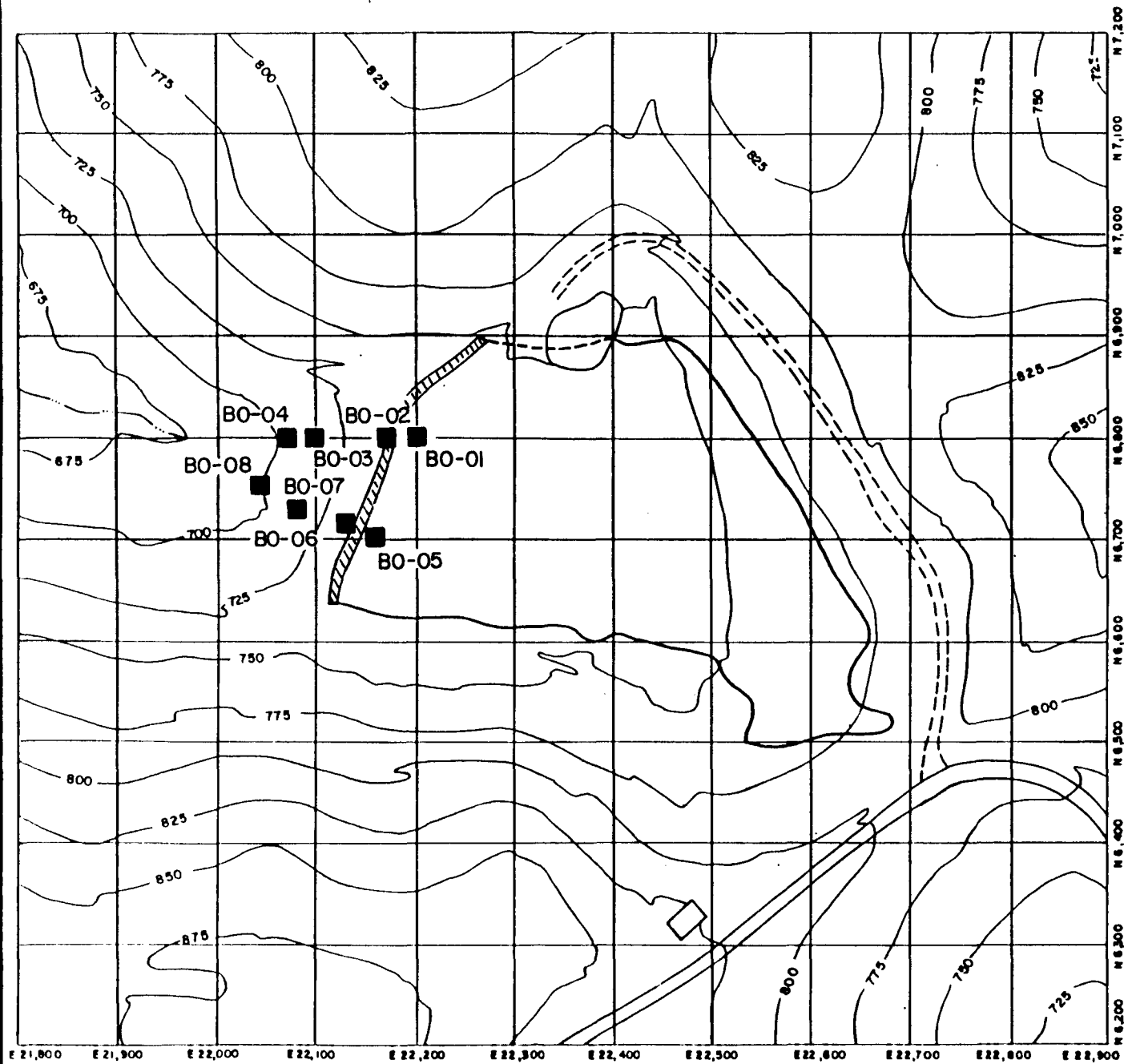
The landfill area behind the dam was also visually inspected on foot. It was noted that diversion ditches have been excavated around the perimeter of the landfill to intercept surface water runoff from the surrounding area. The ditches divert the collected water around the dam. The only water that could collect behind the dam is rainfall directly on the landfill or ground water. However, the left end of the dam at the abutment has been

breached by a ditch to prevent the impoundment of surface water behind the dam. The ditch is more than 20 feet wide and is excavated several feet below the landfill surface.

2.9.2 Soil Test Borings

Soil test borings were performed per the approved Sampling Plan in order to evaluate the structural integrity of the earthen dam. All borings were drilled until refusal (top of rock) was encountered. The test borings were drilled along two separate profile lines. Each profile line was laid out in the field based on surface soil conditions and seepage locations (Figure 23). Along each profile line, one boring was drilled at the crest of the dam; one boring was drilled approximately twenty to thirty feet from the crest towards the landfill; and two borings were drilled on the downstream slope.

Each of the eight borings was performed following the same procedure. Borings were advanced using continuous flight 3 1/4-inch I.D. hollow stem augers. Boring and sampling operations were conducted in general accordance with ASTM Specification D1586-84 as appropriate for the site. Sampling was generally conducted at two foot intervals. At the sampling depth, the drilling tools were removed and soil samples obtained with a standard 1 3/8-inch I.D., cylindrical, split-spoon sampler. The sampler was lowered to the bottom of the borehole, seated six inches to penetrate any loose cuttings and then driven an additional foot with blows of a 140-pound hammer falling thirty inches. The number of hammer blows required to drive the sampler the final foot was recorded and designated as the "standard penetration resistance." The standard penetration resistance was evaluated as an index to the engineering properties of the soil.



LEGEND




-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  BO-01 SOIL TEST BORING / PIEZOMETER LOCATION



FIGURE 23

SOIL TEST BORING / PIEZOMETER LOCATIONS

E.H. SCHILLING LANDFILL

A representative portion of each sample recovered with the split spoon sampler was collected and placed in a glass jar. The jar was labeled and stored in the event that physical testing of the soil might be required at a later date.

In borings BO-01 and BO-05, waste materials were recovered in the sampler. Portions of the waste material were collected, preserved and stored for chemical analysis, as required in Section 2.1.3.4 of the Sampling Plan. Borings BO-02, BO-06 and BO-07 also encountered varying amounts of waste, but not of sufficient volume for chemical analysis.

In addition to split spoon samples, relatively undisturbed (UD) samples were collected at selected depths within some of the boreholes as shown in Table 13. A UD sample is obtained by pushing a 3 inch diameter, thin-walled steel tube into the material to be sampled. Section 2.9.3.1 of the Sampling Plan proposed that split spoon (SS) and UD Samples were to be collected alternately in each boring. Boring BO-06 was the first boring performed in which several UD attempts were made. An attempt was made to obtain approximately twenty-four inches of undisturbed soil sample at each sampling depth. However, gravel and waste materials generally prevented retrieval of full 24-inch samples. Two additional borings were drilled adjacent to BO-02 (BO-02a) and BO-06 (BO-06a) in an attempt to obtain better UD sampling results. Limited success was achieved in these and other borings. Table 13 summarizes all of the UD sampling locations, sample intervals and sample amounts recovered. Due to the lack of success in UD sampling efforts it was determined that it was preferable to obtain samples with SS methods where sample retrieval (for classification purposes) was more easily obtained.

TABLE 13
UNDISTURBED SAMPLE LOCATIONS

Boring No.	Sample Interval (ft.)	Amount Recovered (ft.)
B0-02a	0.0 - 2.0	1.1
	5.0 - 7.0	2.0
	10.0 - 12.0	0.0
	12.0 - 12.8	0.0
	15.0 - 16.9	1.9
	16.5 - 16.6*	0.0
	20.0 - 20.2	0.2
	21.0 - 23.0*	2.0
	25.0 - 25.0	NA
	27.5 - 29.5	0.0
	29.5 - 29.5	NA
	29.5 - 30.8	0.0
	32.0 - 34.0	0.1
	35.0 - 35.8	0.0
	40.0 - 42.0	0.0
42.0 - 42.6	0.0	
B0-03	9.0 - 9.5	0.0
B0-04	4.5 - 6.5	0.0
B0-05	18.0 - 19.0	0.0
B0-06a	0.0 - 0.5	0.5
	1.5 - 1.5	NA
	5.0 - 7.0	2.0
	7.0 - 8.1	0.8
	10.0 - 12.0	2.0
	15.0 - 16.7	1.7
	19.5 - 21.3*	1.4
	20.0 - 21.9	1.9
	25.0 - 27.0	0.0
	27.0 - 29.0	2.0
	29.5 - 31.0*	1.0
	30.0 - 30.0	NA
	32.0 - 32.0	NA
	35.0 - 37.0	0.4
	37.0 - 37.0	NA
40.0 - 40.8	0.7	
40.0 - 42.0*	1.8	
45.0 - 45.0	NA	
47.0 - 47.0	NA	
B0-08	10.5 - 11.9	0.0

Note: NA - Denotes that it was not possible to push UD tube due to obstruction
* - UD taken from boring as originally drilled - others in adjacent hole

Soil Test Boring Records showing the various subsurface conditions encountered at each boring location are included in Appendix B2. Also shown is a graphical presentation of each standard penetration resistance and UD sample locations.

2.9.3 Piezometer Installation

Piezometers were installed within each of the boreholes to measure static water levels in the dam subsurface. The piezometers were installed immediately after completion of soil test borings BO-03, 04, 07, and 08. Initially, borings BO-01, 02, 05, and 06 were left open after completion of the soil test borings in order to perform additional tests in the boreholes. However, the boreholes collapsed, preventing any additional testing. The hollow stem augers were again advanced in the collapsed boreholes to permit the installation of their respective piezometers.

Piezometers consisted of one-inch I.D., flush coupled, threaded PVC. Piezometer screen lengths of both ten feet and five feet were used, depending on location. The longer screens were used in areas where the water levels may have greater variation. The screens were constructed with 0.010-inch machined slots. After piezometers were placed to their installation depth, a sandpack consisting of medium to fine sand was placed in the annulus around the screen section. Above the sandpack, the remainder of the borehole was filled with a neat Type I Portland cement/grout mixture. Details showing the construction characteristics of each piezometer are shown on the Test Boring Records included in Appendix B2.

Embankment pore pressures are not expected to build up in the earthen dam since the generally sandy nature of the dam materials is not conducive to this phenomenon. Therefore, pore pressures were not evaluated. Water levels were measured on a monthly basis to coincide with monitoring well water level measurements.

2.9.4 In-Situ Soil Testing

The approved October 1987 Sampling Plan required borehole geophysical logging to obtain in-situ properties of the natural and waste materials used to construct the dam. During the drilling of the eight borings across the top and face of the dam, numerous subsurface obstructions were encountered, including large pieces of solid plastic waste. The water table encountered within each borehole was found to be quite shallow relative to land surface.

During removal of the hollow-stem augers from the borings after drilling and sampling, the soil in the borings caved in due to the high ground-water surface and weak material. This left unconsolidated soil around the hole which was not representative of the in-situ conditions and unacceptable for geophysical logging. To collect the required data, logging inside of a hollow-stem auger within a fluid-supported boring was considered. However, logging was not attempted inside the hollow stem auger because discontinuities of steel and soil around the auger could result in inaccurate data. Logging was not performed in holes held open with drilling fluid because the use of drilling fluid might influence water level measurements.

To collect data comparable to that which would have been obtained during geophysical logging of the borings, an attempt was made to obtain undisturbed samples of the earth dam materials for laboratory testing. However, few samples were obtained from the waste layer due to difficulties in pushing the sampling tubes through the nonhomogeneous waste.

Field vane shear tests were performed in accordance with ASTM D-2573 to determine the in-situ strength of the waste. The tests were performed in boring BO-5a (adjacent to boring BO-5) and in boring BO-2a (adjacent to boring BO-2). The tests were performed in the waste material layer in zones which, based on low standard penetration resistance values, were suspected to be soft and weak.

2.9.5 Laboratory Soil Testing

Laboratory analyses were performed on samples from the earthen dam to characterize the materials for the dam analysis. Tests were performed on samples from the waste material, fill material, and residual soil; no tests were performed on the underlying rock. The analyses included moisture content, Atterberg limits, grain size, dry unit weight, and triaxial shear strength tests. The test methods used to perform the analyses are described in Appendix A4.

2.9.6 Slope Stability Computer Analysis

Computer modeling was utilized, based upon the collected or calculated field and laboratory data in order to evaluate landfill dam stability. A complete discussion of this effort is described in Section 3.6.3 of this report.

2.10 Surface Water and Sediments Investigation

The purposes of the surface water and sediments investigation were to (1) determine extent and concentrations of surface water and sediments contamination and (2) delineate drainage basin divides and to measure streamflow volumes.

No study area flow data had been collected by either US EPA or OEPA during previous on-site studies. Previous environmental quality data obtained by US EPA and OEPA indicated potential contamination of surface waters in the area from the Schilling Landfill. However, the extent of contamination was unknown. The streams in the study area include Winkler Run and the tributary to Winkler Run as shown in Figure 2. Also, an intermittent stream flows in the valley south of the landfill past Schillingville.

2.10.1 Literature Search

A literature search was performed in order to obtain data on regional surface water characteristics. Various local, state and federal authorities were contacted.

The available published information on the surface water features in the site vicinity was obtained. Several studies have been conducted on the surface-water quality in coal regions in Southeastern Ohio, including Westover and Eberle (1987) and Pfaff et al., (1981). This information was used in part to evaluate sample results from the Winkler Run tributary, which flows through an area once mined for coal.

2.10.2 Surface-Water and Sediment Sampling and Analysis

Six locations (labeled SW-01 through SW-06, and SD-01 through SD-06, respectively) were selected for surface water and sediment sample collection, as shown in Figure 12. Both water and sediment samples were collected at each referenced location. Sample station SW-01 was located in Schilling Hollow. Samples SW-02 and SW-03 were collected downgradient from the landfill in Winkler Run tributary, at approximate distances of 400 and 70 feet, respectively, from the base of the dam. The location of SW-02 (400 feet from the dam) was approximated to coincide with the point where all of the separate drainage features from the landfill and dam area meet to form the Winkler Run tributary. Sample SW-04 was collected along Winkler Run approximately 100 feet upstream from the point of intersection of the Winkler Run tributary and Winkler Run. Samples SW-5 and SW-6 were collected to further delineate the extent of potential contamination downstream of the junction point, respectively. The distance of travel for surface water from the landfill to station SW-06 is approximately 1100 feet. All sampling locations were identified with Agency approval in the field.

Surface water sample collection times coincided with leachate sampling. This was performed on a seasonal basis (May 1988 and December 1988). Sediment samples were obtained only during the initial sampling phase. All surface water and sediment samples collected were analyzed for the CLP TCL substances.

2.10.3 Streamflow Gauging

Streamflow gauging was performed on the three main streams in the study area; (1) Winkler Run, (2) the Winkler Run tributary and (3) the stream course within Schilling

Hollow. Gauging was performed in general conformance with the methods described by Carter and Davidian (1968).

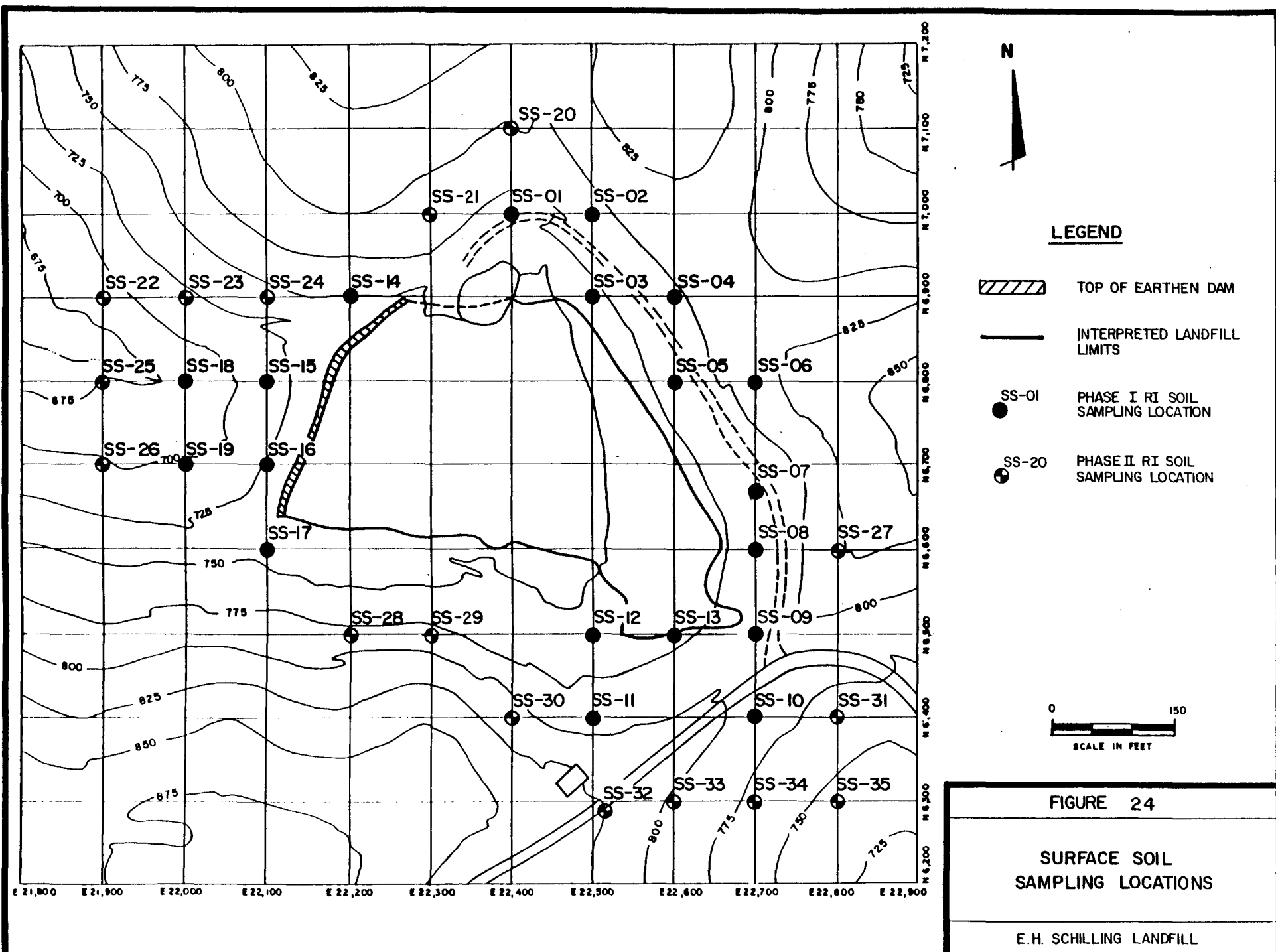
Streamflow volumes change with seasonal weather conditions. Therefore, stream gauging was conducted on a seasonal basis (May and December, 1988). Stream gauging work was done in coincidence with ground-water measurement episodes to allow for data correlation.

2.11 Soil Investigation

The objective of the soil investigation is to determine the extent of soil contamination in the area surrounding the landfill property. The investigation program was designed to collect and analyze near-surface (0 to 3 feet) soils to assess the impact of landfill operations outside of the landfill itself.

Nineteen locations (SS-01 through SS-19) at various site grid intersection points were selected for sampling during the Phase I RI (Figure 24). Included in the sampling were areas below the earthen dam and from the high wall area downslope of the paved road. Samples were collected from clean stainless steel hand augers. Sampling and analysis procedures were specified in the approved QAPP. Analyses were performed for the complete CLP TCL constituents.

Additional soil sampling and analysis was required in the Phase II RI to further delineate the extent of contamination. In accordance with the Phase II Work Plan and QAPP, 16 new locations were sampled on March 7, 1989 by Law Environmental personnel (Figure 24). Samples were analyzed by CompuChem Laboratories for CLP TCL constituents.



LEGEND





-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  SS-01 PHASE I RI SOIL SAMPLING LOCATION
-  SS-20 PHASE II RI SOIL SAMPLING LOCATION



FIGURE 24

SURFACE SOIL SAMPLING LOCATIONS

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2.12 Landfill Cap Integrity Investigation

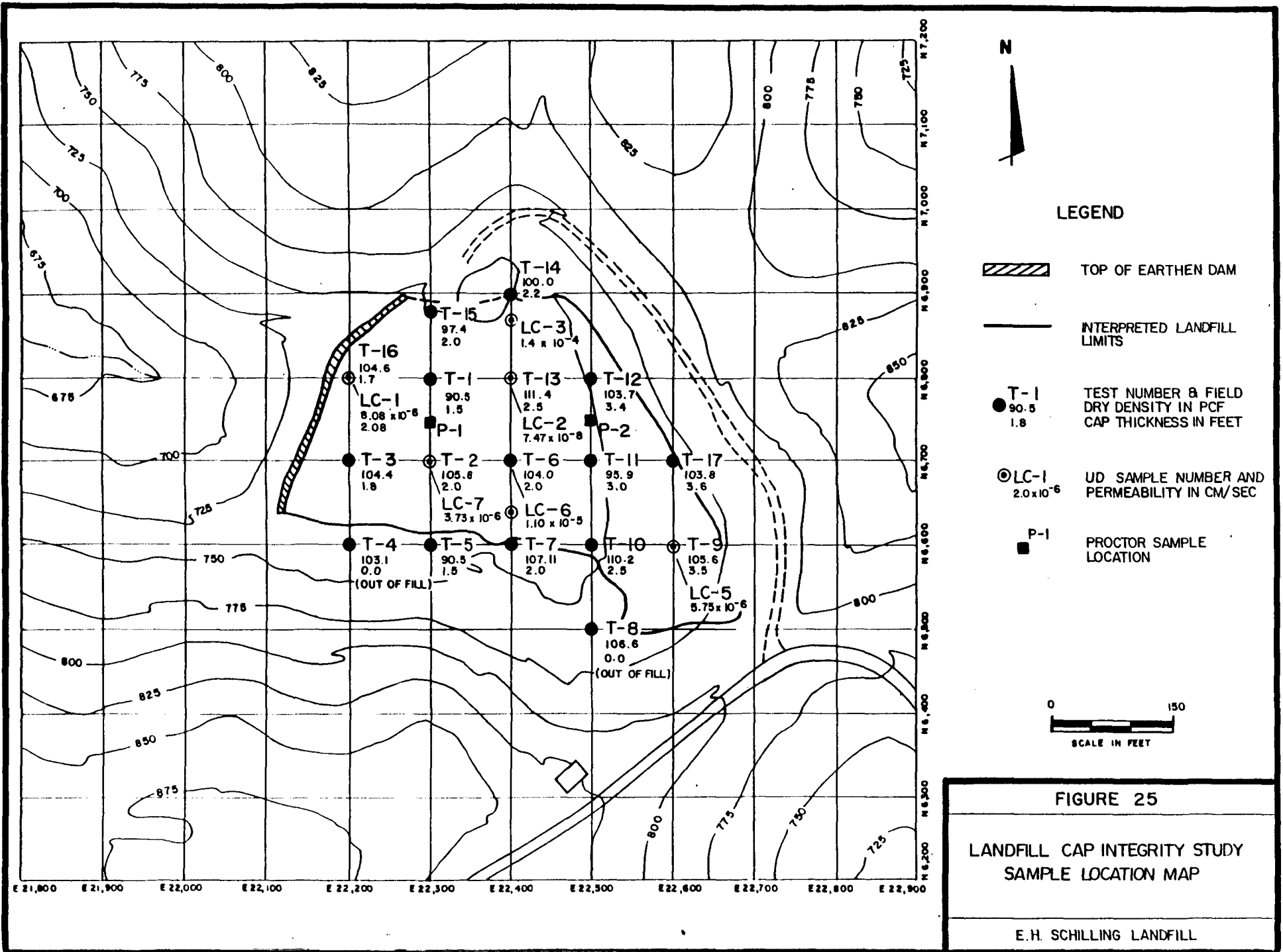
The landfill cap was subjected to a detailed investigation during the Phase I RI to determine its physical characteristics and condition and its compliance with RCRA design compliance (40 CFR 264.310) and/or OEPA requirements set forth in Ohio Revised Code Section 3745-27-10. These objectives were accomplished by analysis and interpretation of (1) hand auger soil cuttings, (2) undisturbed soil samples, and (3) drive tube in-place density samples. During the Phase II RI, six shallow piezometers were installed to investigate an area of leachate on the eastern end of the landfill.

2.12.1 Hand Auger Sampling

At each site grid intersection point within the limits of the landfill, a manual hand auger sampling effort was conducted for the purpose of determining cap thickness and soil classification. A total of 17 locations were sampled as shown on Figure 25 (T-1 to T-17).

2.12.2 Undisturbed Soil Sampling and Analysis

Upon completion of the hand auger exploration, 7 undisturbed landfill cap soil samples were obtained by a drill rig pressing 3-by 30-inch shelly tubes. Locations are shown on Figure 25 and designated LC-1 to LC-7. The UD tubes were subjected to laboratory testing for determination of various physical parameters; including porosity, permeability, natural moisture content, unit weight, erosion potential and freeze/thaw potential.



2.12.3 In-Place Density Testing and Analysis

Law Environmental performed a series of in-place density tests of the landfill cap. A total of 17 tests were accomplished under the Drive-Cylinder Method ASTM D 2937 (at locations shown on Figure 25). The in-place density of the soil was compared to the maximum dry density obtained from two Standard Proctor compaction tests, ASTM method D 698. Proctor testing locations are also shown on Figure 25. Site activities were conducted on May 23-24, 1989.

2.12.4 Piezometer Installation

Installation of six additional piezometers was accomplished in the Phase II RI. Two profiles of three piezometers each were used to investigate a zone of leachate seepage in the upper portion of the landfill near the E 22500 site grid line. A hand auger fitted with a 3 1/4 inch bucket facilitated placement of 1 1/4-inch flush coupled, threaded PVC pipe and screen (0.010-inch machine slots) to shallow depths into the landfill. Boring depths ranged from 4.5 to 7.7 feet. Upon boring termination, a PVC pipe and screen was lowered to the bottom of the hole and coarse sand added around the screen. Above the sandpack, a seal of bentonite was packed in place and the remaining annulus around the pipe was filled with grout. Test Boring Records shown in Appendix B2 illustrate the construction details.

2.13 Residential Well Investigation

Various aspects of the residential well investigation were accomplished during the Phase I and II remedial investigations. During the Phase I RI, residential wells in the study area vicinity were located through a literature search. Various state and federal agencies, including the ODNR Division of Water and OEPA, were contacted to gather available

information of previous well sampling analyses, well logs, construction details and well locations.

On April 19, 1988 the OEPA sampled a well and a developed spring owned by [REDACTED] [REDACTED] in Rock Hollow. Analyses were performed for volatiles (well only), acid extractables and base neutral extractables. The results are included in Appendix B7. There were no volatiles, acid extractable or base neutral extractable detected in the samples analyzed.

Various data from the RI including results of site monitoring well analyses were evaluated to determine the potential for off-site contamination of residential wells from the landfill contaminants. Monitoring wells had been strategically placed in areas between the landfill and nearby residential centers so that this evaluation could be made. Based on the monitoring well and OEPA sampling results, it was determined that no off-site migration of contaminated ground water has occurred and that sampling of residential wells was not necessary.

During the Phase II RI, a house-to-house survey of residential wells was performed along a portion of Rock Hollow Road (Rt. 4) and in Schillingville (Schilling Hollow). Aerial photographs were used to initially identify residences in these areas. A total of 10 residences were selected (with EPA approval) in Rock Hollow, beginning at the intersection of Winkler Run Road and Rock Hollow Road and extending southward 0.5 miles towards US Rt. 52 (see Figure 26). The house-to-house survey was conducted by representatives of Law Environmental and OEPA. Information was gathered on well construction, quality

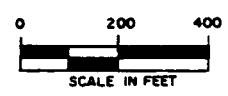
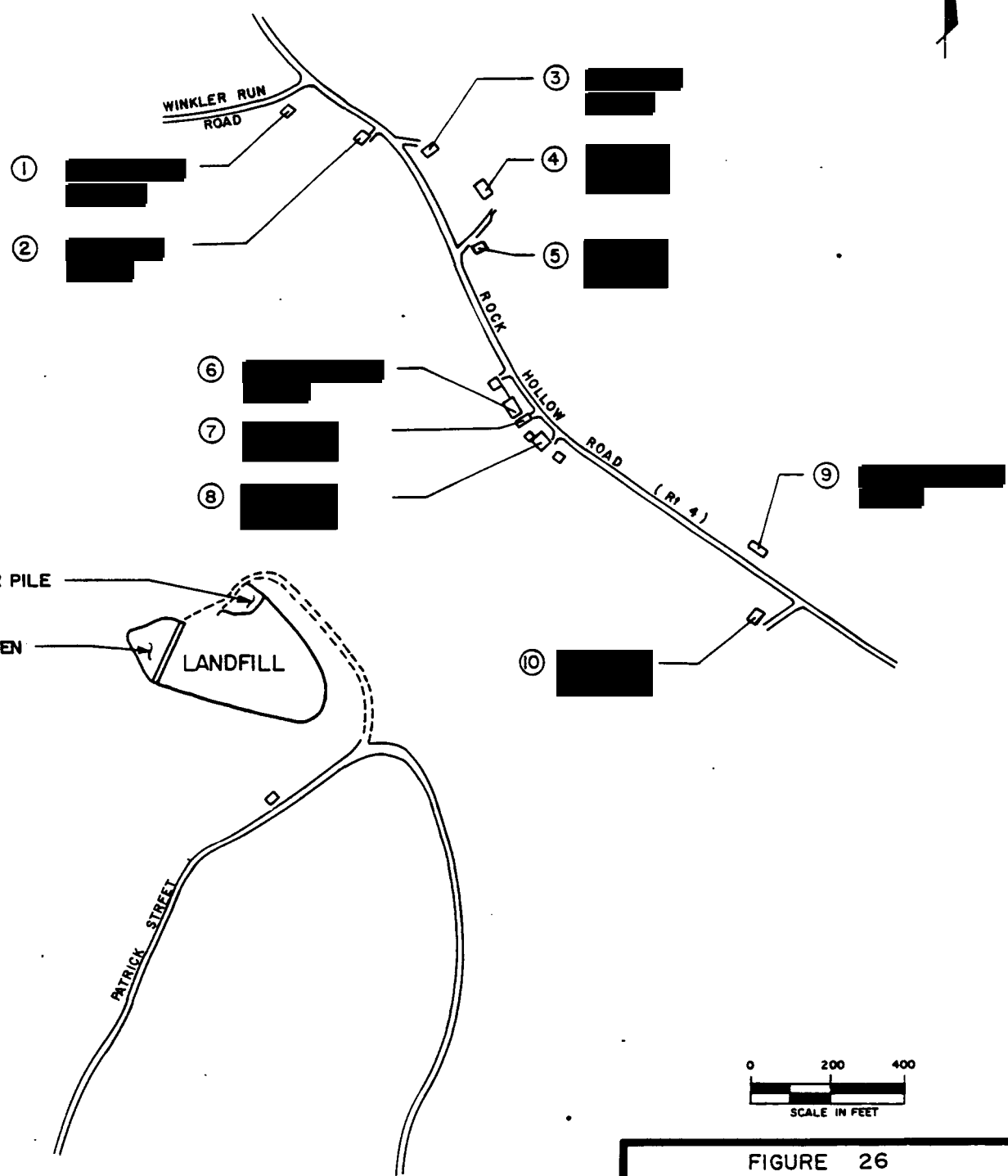


FIGURE 26
RESIDENTIAL WELL LOCATION
MAP
ROCK HOLLOW
E.H. SCHILLING LANDFILL

and use of water. Completed inventory forms are included in Appendix B7. Mr. E.H. Schilling was contacted for information on wells in Schillingville.

Of the 10 residences in Rock Hollow, six have dug wells, three have drilled wells, and one has a developed spring. The dug wells are generally less than 15 feet deep and have a tendency to go dry during the summer months. Many of the dug wells are not sealed at the ground surface, allowing rainfall runoff to potentially enter the well directly. Many residences reported problems with high iron and hydrogen sulfide content. Hecla Water is currently installing a main water line into the area. Work was observed in progress in April 1989.

Three drilled wells are located in Schillingville (Figure 27). The wells are eight inches in diameter and from 50 to 100 feet deep. These wells once supplied water to the residences in Schillingville but have not been in use for many years as the area is now supplied by Hecla Water.

N

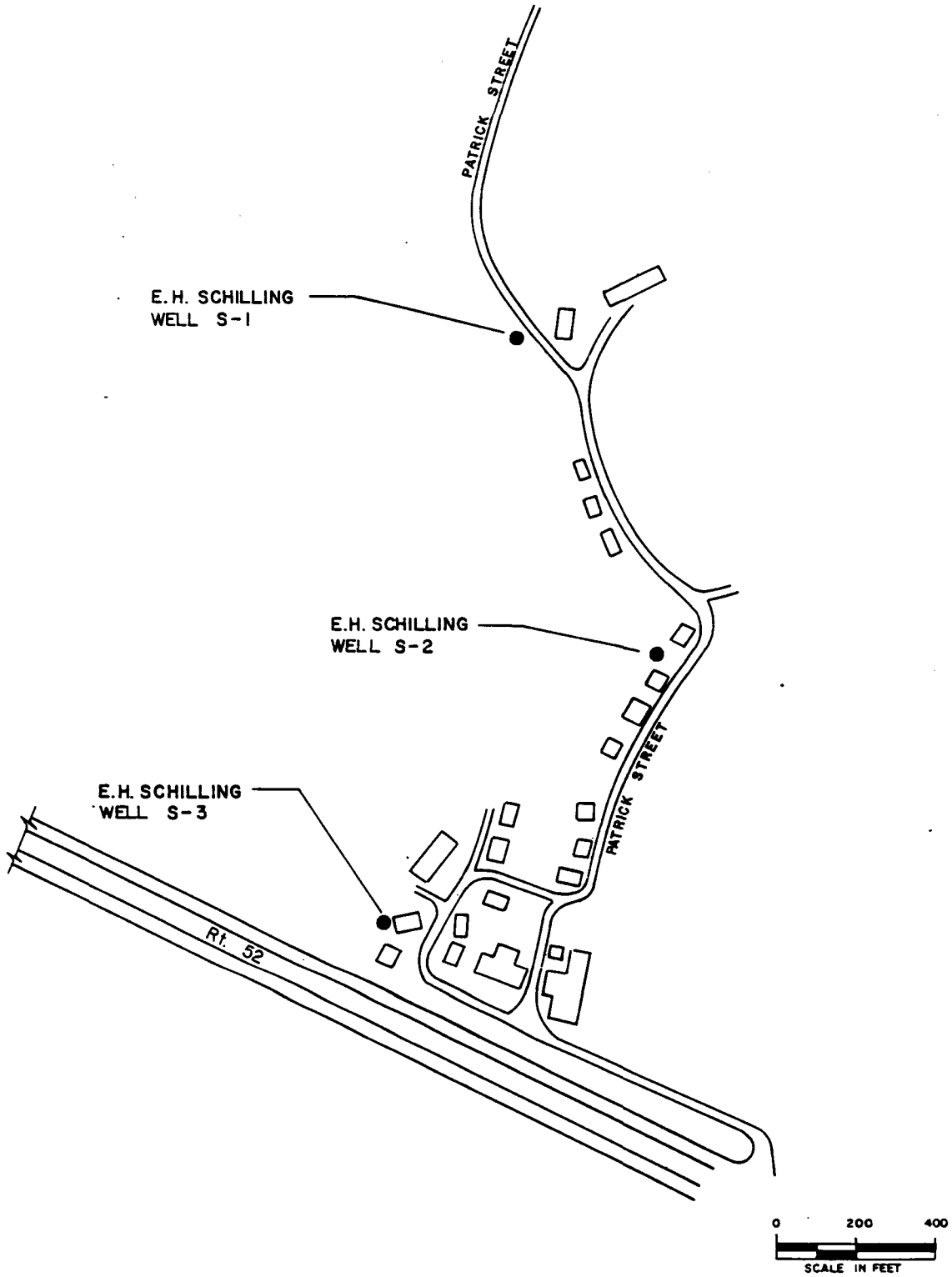


FIGURE 27

RESIDENTIAL WELL LOCATION
MAP

SCHILLING HOLLOW

E.H. SCHILLING LANDFILL

3.0 PHYSICAL CHARACTERISTICS OF STUDY AREA

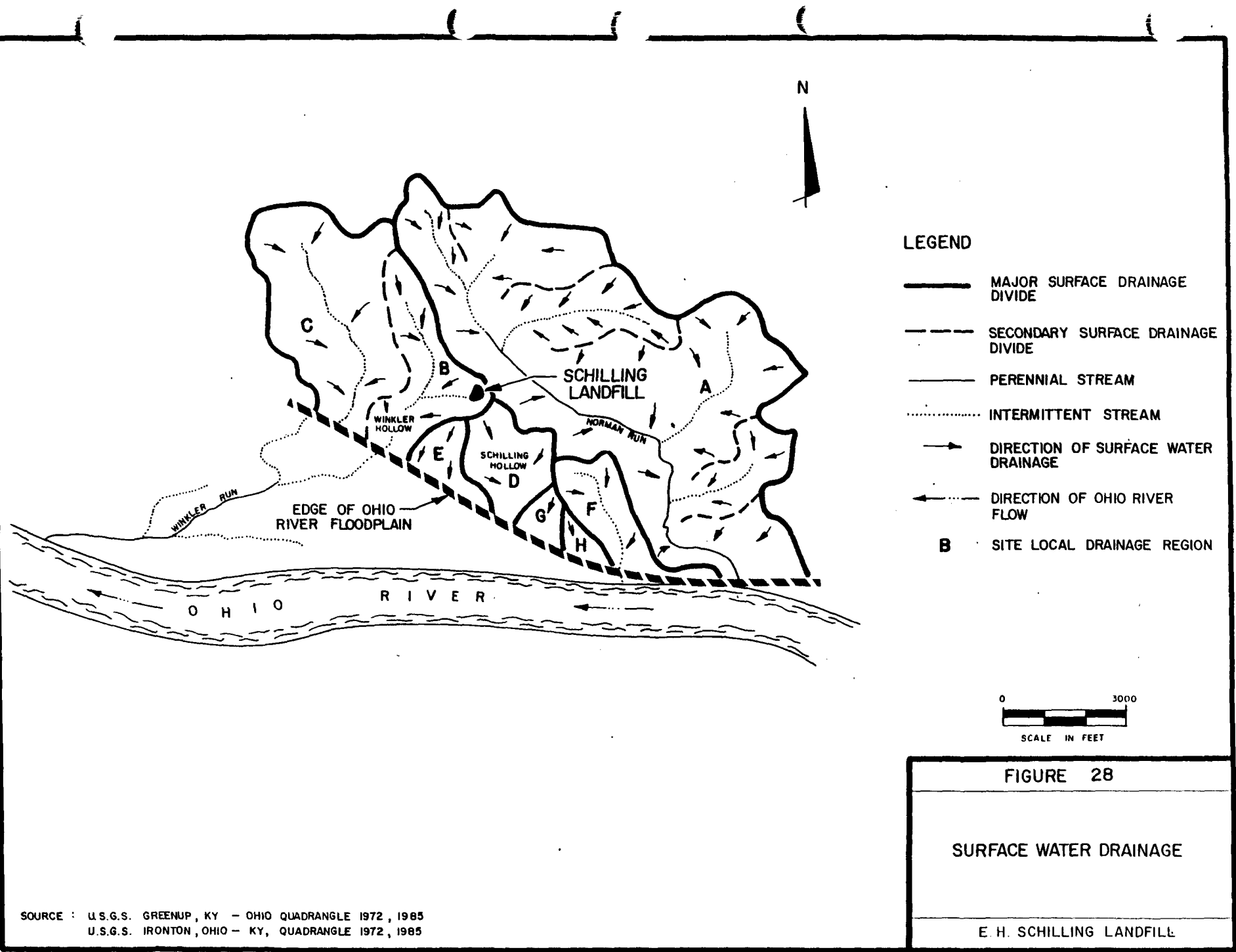
3.1 Topography and Drainage

The areal topography in the site vicinity is a deeply dissected plateau with steep side slopes and narrow ridges. The landfill is situated at the head of a ravine behind a man-made earthen dam. The site resembles a natural amphitheater with side slopes ranging from 20 to 50 percent. The slope along the axis of the intermittent drainage way in the valley bottom downslope (west) of the landfill is approximately 20 percent.

The topography changes abruptly at about US Route 52 where the dissected plateau gives way to the Ohio River floodplain. The slope from the plateau to the Ohio River is approximately two percent. The Ohio River is about 0.8 miles south of the landfill.

On a regional scale, the landfill lies within the Little Scioto River and Pine Creek drainage basins. Within the site vicinity, eight small-scale drainage basins exist as shown on Figure 28 (areas A through H). Norman Run drains a large hollow (Rock Hollow) east of the Schilling Landfill. The landfill itself is located within the Winkler Hollow drainage area which includes the eastern branch of Winkler Run. Schilling Hollow lies immediately southeast of the landfill. Below is a compilation of the respective drainage basin areas:

<u>Location</u>	<u>Drainage Area</u> <u>(sq. mi.)</u>
Area A : Norman Run and associated tributaries	1.83
Area B : Winkler Hollow and landfill	0.26



LEGEND

- MAJOR SURFACE DRAINAGE DIVIDE
- - - - SECONDARY SURFACE DRAINAGE DIVIDE
- PERENNIAL STREAM
- INTERMITTENT STREAM
- DIRECTION OF SURFACE WATER DRAINAGE
- - - - DIRECTION OF OHIO RIVER FLOW
- SITE LOCAL DRAINAGE REGION



FIGURE 28

SURFACE WATER DRAINAGE

E. H. SCHILLING LANDFILL

SOURCE : U.S.G.S. GREENUP, KY - OHIO QUADRANGLE 1972, 1985
 U.S.G.S. Ironton, OHIO - KY, QUADRANGLE 1972, 1985

Area C :	Western Branch of Winkler Run	0.54
Area D :	Schilling Hollow	0.16
Area E :	Valley between Schilling Hollow and Winkler Hollow	0.085
Area F :	Valley between Schilling Hollow and Norman Run	0.16
Area G :	Valley east of Schilling Hollow	0.043
Area H :	Valley between area 'E' and 'F'	0.038

The Ohio River is the main surface water feature in the area. All streams and tributaries in the region drain into the Ohio River. The Winkler Hollow drainage area is drained by the eastern branch of Winkler Run. The eastern and western branches of Winkler Run are intermittent streams. South of US Route 52 the two branches meet to form a continuous flowing stream to the Ohio River. A small intermittent stream flows from the valley downslope of the landfill earthen dam toward the headwater area of the eastern branch of Winkler Run and is herein called the "Winkler Run tributary".

3.2 Demography and Land Use

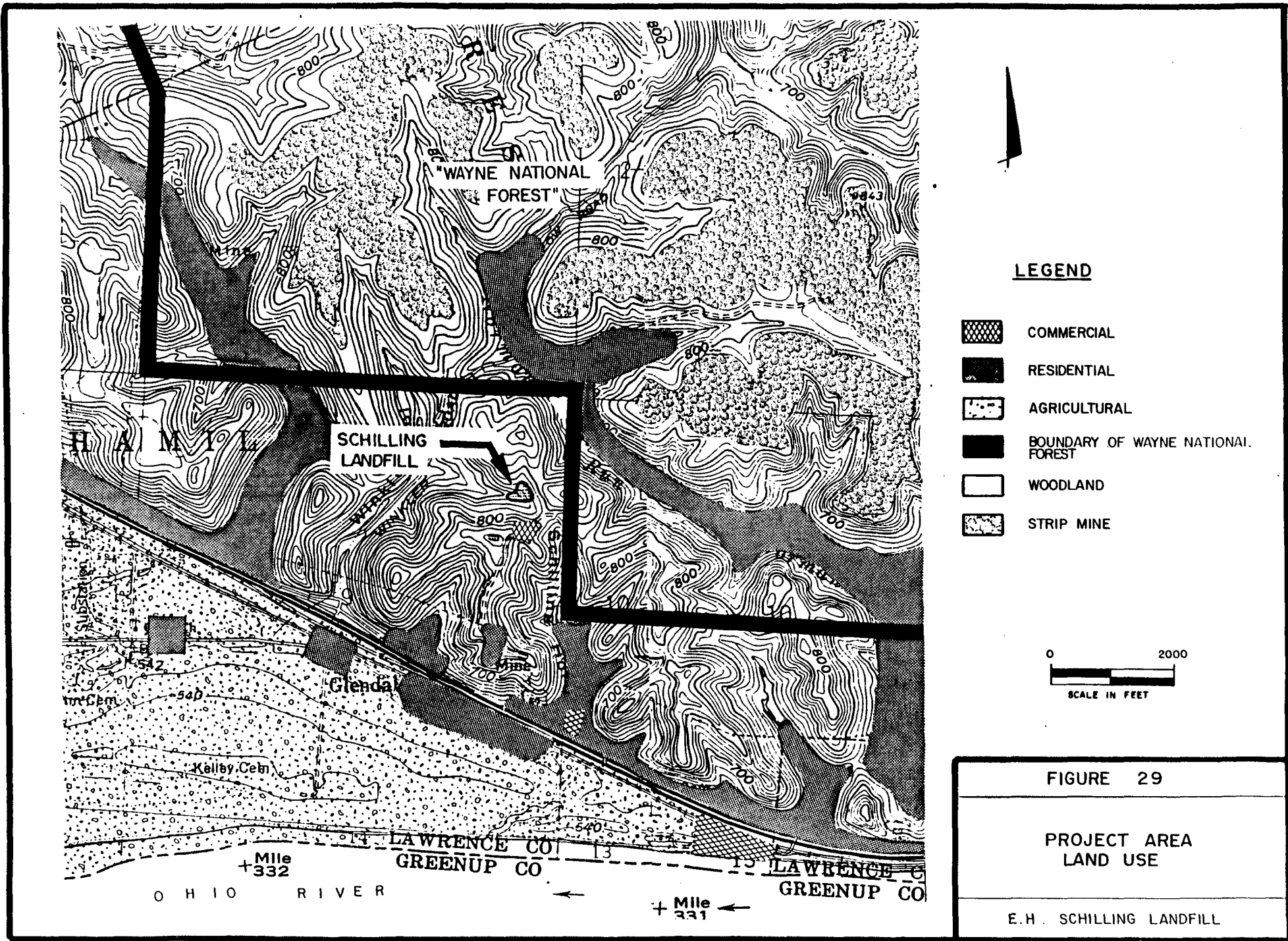
The site vicinity is characterized by broad expanses of undeveloped or presently old strip-mined lands appearing as rolling hills, narrow ridges, steep valleys, confined lowlands and generally well-dissected terrain. Both active and inactive strip mines conspicuously mark the landscape. Almost all industrial, commercial and residential development in the site vicinity has occurred in the Ohio River Valley. In addition, all major transportation modes have utilized the Ohio River's narrow level floodplain.

Most of the land north and east of the study area consists of undeveloped parcels, individual residences, small commercial businesses, and former strip mined tracts lying within the boundaries of the Wayne National Forest. Land lying to the west of the project area is undeveloped forest. Lands south of the project area (i.e., south of US Route 52) are predominantly agricultural. Some residential development also exists.

The subject site is situated in an upland setting common to the North American mixed deciduous forest. It is surrounded on all four sides by stands of young to mature deciduous trees. Isolated groups of young conifers are apparent along the landfill's north, south and eastern margins.

Study area land use is illustrated on Figure 29. Land uses include commercial, agricultural, residential, woodland and strip mine. A brief description of each category follows:

- o **Agricultural.** The area generally south of US Route 52 has been utilized for farming. Presently, it is utilized for miscellaneous commercial crop production. The area is fertile bottomland, historically re-nourished by flooding of the Ohio River (now controlled by a system of locks and dams).
- o **Commercial.** Smaller businesses are located in individual structures north and south of US Route 52.
- o **Residential.** Individual one and two-story frame residences are located north and east of the site along Rock Hollow Road, south of the site adjacent to



LEGEND







-  COMMERCIAL
-  RESIDENTIAL
-  AGRICULTURAL
-  BOUNDARY OF WAYNE NATIONAL FOREST
-  WOODLAND
-  STRIP MINE



FIGURE 29

PROJECT AREA
LAND USE

E.H. SCHILLING LANDFILL

US Route 52 and at several locations on the strip of land between the highway and the Ohio River.

- o **Woodland.** Much of the upland area immediately surrounding the site consists of undeveloped deciduous forest. Most of this woodland lies within the boundaries of the Wayne National Forest.

- o **Strip Mine.** Significant tracts within the Wayne National Forest have been strip mined. Some areas are currently being mined by small operators. Most areas lie inactive. A few of the former strip mine areas have been reclaimed.

Nearby study area communities include Hanging Rock, Glendale and Schillingville. The area's population is generally caucasians. Median age and family income values are not known. Employment is reportedly industrial-related, as a major percentage of residents commute to nearby heavy industrial and chemical manufacturing plants. A single business, E. H. Schilling and Sons, General Contractors, Inc., employs some local residents for general labor, heavy earth-moving and crane operators in its contracting projects.

3.3 Meteorology

Meteorological data acquisition served a twofold purpose for the project: (1) historical records of regional meteorology were used in air modeling; and (2) on-site monitoring was performed for use in air modeling and in estimating the site water balance.

3.3.1 Regional Meteorology

The Tri-State Airport in Huntington, West Virginia is the nearest meteorological station to the site, approximately 17 miles to the southeast. The station is located on a man-made plateau constructed by excavating the tops of several hills and filling intervening valleys near the confluence of the Ohio and Big Sandy Rivers.

Table 14 is a 30-year (1951-1980) summary of meteorological data collected at the Huntington, West Virginia Station. The average wind speed was 6.5 miles per hour. The lower monthly averages occurred in July (5.0 miles per hour) August (4.9 miles per hour), and September (5.0 miles per hour). The greatest monthly average wind speed occurred in March (8.1 miles per hour). The prevailing wind directions are not given in Table 14. However, resultant wind directions were given in the annual reports for 1984 through 1987. The resultant wind directions for 1984, 1985, 1986, and 1987 are respectively 243°, 242°, 248°, and 241° as measured clockwise from North.

The average annual temperature for 1951-1980 was 55.2°F. January was the coldest month at an average temperature of 32.8°F, and July was the hottest month with an average temperature of 75.4°F. The average annual relative humidity was 70 percent (average of four daily measurements), and the average annual precipitation was 40.72 inches.

3.3.2 Site Meteorology

The meteorology of the E. H. Schilling Landfill site is influenced by the areal topography. The valleys and ridges tend to reduce wind speeds and channel the wind flow across the site in an east-west direction. Eddy currents resulting from the wind movement across the

Table 14

Summary of Meteorological Data (1951-1980)
Huntington, West Virginia Station

Month	Temperature °F							Normal Degree days Base 65 °F		Precipitation in inches										
	Normal			Extremes						Water equivalent					Snow, ice pellets					
	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Heating	Cooling	Normal	Maximum monthly	Year	Minimum monthly	Year	Maximum in 24 hrs.	Year	Maximum monthly	Year	Maximum in 24 hrs.	Year
(a)				23		23											22		22	
J	41.1	24.5	32.8	74	1967	-15	1963	998	0	3.24	6.37	1978	0.64	1981	2.63	1978	30.3	1978	11.6	1978
F	45.0	26.6	35.8	79	1977	-4	1970	818	0	2.83	5.66	1962	0.53	1968	2.43	1968	18.1	1979	6.5	1979
M	55.2	35.0	45.1	85	1973	-2	1980	617	0	4.08	7.58	1963	1.12	1966	3.43	1967	11.0	1971	7.9	1971
A	67.2	44.4	55.8	90	1963	21	1982	293	17	3.48	6.56	1966	0.78	1976	2.26	1978	0.8	1978	0.6	1978
M	75.7	52.8	64.3	92	1963	27	1966	125	103	3.94	9.26	1974	0.93	1965	2.60	1974	1	1963	7	1963
J	82.6	60.7	71.7	95	1980	40	1977	17	218	3.56	7.63	1979	0.41	1966	3.42	1979	0.0		0.0	
J	85.6	65.1	75.4	100	1983	46	1968	0	322	4.47	8.57	1962	1.37	1978	4.27	1962	0.0		0.0	
A	84.4	64.0	74.2	100	1983	43	1965	0	285	3.73	6.86	1979	0.68	1962	2.90	1964	0.0		0.0	
S	78.7	57.2	68.0	97	1983	31	1983	62	152	3.07	5.64	1966	0.63	1983	2.74	1964	0.0		0.0	
O	67.6	44.9	56.3	86	1962	16	1962	293	24	2.40	5.71	1983	T	1963	2.10	1977	0.4	1974	3.4	1974
N	55.2	35.9	45.6	82	1979	8	1968	582	0	2.82	5.17	1973	0.73	1976	2.28	1973	4.6	1969	4.4	1969
D	45.2	28.5	36.9	80	1982	-9	1983	871	0	3.12	8.69	1978	0.31	1965	3.36	1978	13.2	1967	6.7	1967
YR	65.3	45.0	55.2	100	AUG 1983	-15	JAN 1963	4676	1121	40.72	9.26	MAY 1974	T	OCT 1963	4.27	JUL 1962	30.3	JAN 1978	11.6	JAN 1978

NOTE: NORMAL COOLING DEGREE DATA PUBLISHED IN THE 1982 ANNUAL WERE FOR THE 1951-1980 PERIOD.

Month	Relative humidity pct.				Mean speed m.p.h.	Wind			Pct. of possible sunshine	Mean sky cover, tenths, sunrise to sunset	Mean number of days										Average station pressure mb.		
	Hour	Hour	Hour	Hour		Speed m.p.h.	Direction	Year			Sunrise to sunset			Precipitation .01 inch or more	Snow, ice pellets 1.0 inch or more	Thunderstorms	Heavy fog, visibility 1/4 mile or less	Temperatures °F				Elev. feet m.s.l.	
											Clear	Partly cloudy	Cloudy					Max.	Min.	90° and above			37° and below
(a)	21	22	22	22	21	21	21		22	22	22	22	22	22	21	21	22	22	22	22	22	11	
J	73	77	66	64	7.6	38	27	1971	7.6	5	6	20	14	3	0	3	0	10	24	2	988.6		
F	71	76	62	59	7.6	41	26	1967	7.6	4	6	18	13	2	1	3	0	6	21	0	988.5		
M	67	75	55	53	8.1	37	25	1971	7.5	4	8	19	14	1	3	2	0	1	14	0	985.7		
A	66	75	49	49	7.7	44	18	1968	7.1	5	8	17	13	0	0	1	0	0	4	0	985.9		
M	78	84	53	56	6.1	47	29	1967	6.8	6	9	16	12	0	0	1	0	0	0	0	984.9		
J	86	88	58	62	5.5	35	24	1973	6.7	5	11	14	11	0	7	7	0	0	0	0	986.2		
J	88	90	61	66	5.0	32	31	1976	6.8	4	12	15	12	0	9	10	7	0	0	0	987.1		
A	89	92	60	68	4.9	35	24	1965	6.8	4	13	14	10	0	7	11	5	0	0	0	988.2		
S	89	92	61	69	5.0	28	30	1963	6.6	6	10	14	9	0	2	10	2	0	0	0	988.2		
O	81	86	55	60	5.7	29	27	1969	6.0	9	8	14	9	0	1	6	0	0	4	0	989.2		
N	74	80	60	62	6.9	35	23	1966	7.4	5	6	19	11	0	1	0	0	0	11	0	988.9		
D	74	78	66	66	7.4	35	30	1983	7.7	5	5	21	13	1	0	3	0	5	20	0	986.9		
YR	78	83	59	61	6.5	47	29	MAY 1967	7.0	62	102	201	140	8	43	65	18	23	99	2	987.5		

(a) Length of record, years, through the current year unless otherwise noted, based on January data.
 (b) 70° and above at Alaskan stations.
 + Less than one half.
 T Trace.
 BLANK entries denote missing or unreported data.

NORMALS - Based on record for the 1951-1980 period.
 MEANS - Length of record in (a) is for complete data years.
 EXTREMES - Length of record in (a) may be for other than complete or consecutive data years. Date is the most recent in cases of multiple occurrence.
 WIND DIRECTION - Numerals indicate tens of degrees clockwise from true north. 00 indicates calm.
 FASTEST MILE WIND - Speed is fastest observed 1-minute value when direction is in tens of degrees.

NORMALS, MEANS, AND EXTREMES TABLE NOTE(S):

Means and extremes above are from existing and comparable exposures. Annual extremes have been exceeded at other sites in the locality as follows:

Temperature
 Highest: 108 in Jul. 1930. Precipitation
 Maximum monthly : 9.90 in Jul. 1961.
 Snowfall
 Maximum in 24 hours: 12.0 in Feb. 1960.

ridges surrounding the landfill cause micro-scale changes in the wind direction, as occasionally indicated by observed movements of the wind sock, survey stake ribbons, and the wind vane at the site.

As discussed previously, meteorological data was collected on a hourly basis at the on-site meteorological station. Twelve months of on-site meteorological data were obtained to characterize the local meteorology as required by the Sampling Plan. Tables 15 and 16 are summaries of the meteorological data collected for the period of February 18, 1988 to February 28, 1989.

As shown in Table 15, the average wind speed was 3.4 miles per hour. The monthly average wind speed ranged from a low of 1.6 miles per hour in September 1988 to a high of 5.8 miles per hour in February 1988. The resultant wind direction for the period was 244° (clockwise from North), and ranged from 177° in September to 330° in May. The average temperature for the year was 46.0°F, with a low monthly average of 33.4°F in February 1989 and a high monthly average of 77.7°F in August 1988. The average annual relative humidity of 65% ranged from monthly averages of 59% to 86%. Daily data collected for the twelve month period is presented on Table 16.

3.3.3 Comparison of Regional and Site Meteorological Data

Table 17 compares historical data collected at the Huntington, West Virginia station with the data collected at the Schilling landfill site. This table includes data for February 1988 through February 1989 monitored at the Schilling landfill site and compares these data with the Huntington station averages for 1951-1980.

TABLE 15

Monthly Summary of Meteorological Data

Period	Days Monitored		Average Speed (miles/hour)	Resultant Wind Direction (Degrees clockwise from North)	Average Temperature (Degrees F)	Average Relative Humidity (%)
	Onsite	Huntington				
February 1988	9	3	5.8	236	36.3	59
March 1988	20	11	5.4	258	43.9	63
April 1988	29	1	4.5	273	55.4	59
May 1988	23	9	1.8	330	64.6	70
June 1988	30	0	2.0	272	73.6	63
July 1988	----	31		----		
August 1988	28	3	1.8	232	77.7	80
September 1988	22	8	1.6	162	66.6	86
October 1988	31	0	2.7	265	50.5	73
November 1988	30	0	4.7	190	47.7	77
December 1988	19	11	4.7	207	39.0	66
January 1989	31	0	5.1	197	41.2	75
February 1989	28	0	3.6	306	33.4	77
Average to Date			===== 3.6	===== 244	===== 52.5	===== 70.7

TABLE 16

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average (degrees Celcius)			
=====									
FEBRUARY 1988									
18	0.5	3.3	38	5.5	6.5	7.7	54	0.00	0.000
19	1.8	14.9	127	11.4	4.6	7.2	87	0.25	0.210
20	4.3	13.8	262	8.2	-2.8	3.7	68	0.00	0.088
21	2.1	13.3	264	-0.3	-10.2	-4.9	43	0.00	0.271
22	4.5	16.9	162	17.7	-3.9	8.2	36	0.00	0.261
23	2.8	16.0	268	15.2	-1.7	4.2	81	0.25	0.038
24	2.8	12.7	261	1.6	-5.2	-2.2	61	0.00	0.174
25	2.6	12.3	267	2.7	-6.3	-3.0	53	0.00	0.203
26	2.2	9.6	197	10.3	-7.9	0.8	45	0.00	0.287
27 *	4.6	12.5	330	8.9	-0.6	4.4	52	0.00	----
28 *	2.5	6.7	260	9.4	-2.2	3.9	52	0.00	----
29 *	3.1	8.0	330	11.1	-2.2	4.4	49	0.00	----
Average	2.6	12.5	205	8.0	-3.0	2.4	59		0.170
Total								0.50	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average (degrees Celcius)			
=====									
MARCH 1988									
1 *	1.7	7.2	210	12.2	-5.0	3.9	55	0.00	----
2 *	2.1	7.2	180	14.4	-2.8	6.1	52	0.00	----
3 *	2.6	6.3	80	11.7	5.0	8.3	92	0.20	----
4 *	3.4	8.0	10	10.6	0.0	5.6	98	1.55	----
5 *	3.0	6.7	50	9.4	-3.3	3.3	69	0.00	----
6 *	2.9	7.6	270	12.8	-2.2	5.6	66	0.00	----
7 *	2.9	5.8	160	14.4	2.2	8.3	64	0.00	----
8 *	2.8	8.0	200	22.8	-0.6	11.1	54	0.00	----
9	1.3	6.0	310	11.7	4.4	8.1	100	0.07	0.012
10	1.9	7.7	3	11.0	1.5	5.4	66	0.01	0.283
11	1.3	6.4	110	17.8	-1.1	8.8	47	0.00	0.318
12	2.9	16.1	171	17.3	6.3	11.3	65	0.28	0.068
13	4.0	13.3	270	10.0	-3.9	2.6	73	0.00	0.041
14	3.5	12.9	272	2.4	-5.9	-3.6	73	0.00	0.153
15	3.4	13.4	274	-1.4	-4.0	-3.7	76	0.00	0.160
16	2.9	9.2	268	2.0	-5.2	-1.3	73	0.00	0.142
17	1.9	8.6	291	8.3	-1.8	2.7	57	0.00	0.270
18	1.0	5.7	283	3.7	0.0	1.6	90	0.23	0.023
19	3.2	12.5	263	10.2	-1.9	2.9	65	0.00	0.237
20	3.1	16.2	331	9.4	0.2	4.9	50	0.00	0.274
21	1.3	5.0	17	9.6	-1.7	2.3	49	0.00	0.332
22	0.9	6.0	68	19.6	-3.5	8.2	36	0.00	0.364
23	3.0	13.0	173	28.3	10.4	18.6	36	0.00	0.339
24	3.0	13.2	170	24.9	15.4	19.5	45	0.00	0.228
25	3.3	15.3	169	20.2	11.1	16.0	74	0.32	0.064
26	2.8	14.9	215	18.7	6.5	11.5	78	0.04	0.196
27	3.4	12.0	287	11.1	0.9	5.3	56	0.00	0.372
28	0.8	6.0	102	22.3	0.3	11.0	46	0.00	0.379
29 *	3.7	10.3	210	28.3	12.2	20.6	24	0.00	----
30 *	3.1	13.9	220	20.6	9.4	15.0	59	0.02	----
31 *	2.5	5.8	40	18.3	7.8	13.3	72	0.24	----
Average	2.4	10.7	202	12.9	1.4	6.6	63		0.213
Total								0.95	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average (degrees Celcius)			
=====									
APRIL 1988									
1	0.8	3.4	147	20.5	13.9	17.2	92	0.00	0.142
2	1.5	5.9	133	27.4	12.7	18.9	82	0.06	0.144
3	3.4	12.0	160	25.6	14.9	19.5	77	0.27	0.089
4	2.1	11.7	279	22.0	11.5	16.8	70	0.33	0.320
5	1.8	10.0	170	33.2	11.3	21.2	53	0.00	0.379
6	3.5	19.5	184	26.4	4.2	14.8	69	0.38	0.079
7	2.4	11.3	338	10.0	3.5	5.8	100	0.30	0.019
8	2.4	10.0	349	16.3	5.1	9.7	72	0.00	0.412
9	1.4	7.7	351	18.0	0.7	9.0	58	0.00	0.423
10	1.2	6.2	36	26.4	3.8	13.4	45	0.00	0.404
11	1.8	6.9	9	23.4	6.5	14.9	30	0.00	0.326
12	1.5	7.3	24	19.0	9.7	13.6	42	0.00	0.294
13	1.0	6.6	98	26.4	4.5	13.2	56	0.00	0.406
14	2.5	13.7	211	23.0	9.3	15.3	46	0.00	0.190
15	2.6	14.7	307	14.9	4.3	9.3	45	0.00	0.381
16	1.6	8.9	302	14.6	1.9	7.7	48	0.00	0.402
17	2.4	11.1	200	25.3	4.2	13.8	42	0.00	0.432
18	1.8	8.8	220	18.7	3.6	9.8	89	0.66	0.034
19	1.5	10.5	320	12.4	1.1	6.0	63	0.00	0.373
20	1.8	10.1	195	17.6	-0.9	9.6	48	0.00	0.380
21	1.8	14.0	304	19.2	6.6	12.8	53	0.26	0.413
22	0.8	5.7	26	19.3	5.5	11.3	82	0.27	0.325
23	2.6	19.1	210	28.9	10.7	19.4	60	0.01	0.268
24 *	3.8	10.3	320	15.6	4.4	10.0	60	0.00	----
25	0.9	6.4	147	19.3	7.3	13.4	47	0.00	0.482
26	1.0	6.8	321	32.0	4.3	14.7	45	0.00	0.447
27	3.7	16.7	246	17.1	8.4	12.8	47	0.00	0.362
28	3.5	14.8	264	11.2	3.1	6.5	81	0.04	0.037
29	3.3	14.5	287	18.2	4.0	11.3	41	0.00	0.457
30	1.3	7.7	339	25.1	8.1	14.8	42	0.00	0.426
Average	2.0	10.4	213	21.1	6.3	13.0	59		0.305
Total								2.58	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Wind Speed (m/s)	Peak Wind		Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
		Speed (m/s)	Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average			
=====									
MAY 1988									
1	0.9	7.3	351	27.3	6.8	15.9	44	0.00	0.438
2	0.9	8.5	1	29.0	7.6	16.3	39	0.00	0.459
3	0.6	6.5	344	24.0	6.2	15.6	49	0.00	0.411
4	0.5	5.5	4	13.8	8.5	11.2	89	0.65	0.048
5	2.2	7.9	286	12.7	8.5	10.4	98	0.37	0.057
6	1.4	7.6	338	22.9	10.5	15.5	78	0.02	0.276
7 *	2.0	6.7	40	25.6	7.2	16.7	56	0.00	----
8 *	3.4	8.9	190	28.9	6.7	17.8	54	0.00	----
9 *	4.2	13.0	220	26.1	15.0	20.6	68	0.06	----
10 *	4.3	11.6	260	24.4	13.9	19.4	62	0.01	----
11 *	3.1	7.2	330	21.7	10.0	16.1	65	0.00	----
12 *	2.8	6.7	200	26.1	4.4	15.6	55	0.00	----
13 *	3.7	10.3	250	28.9	10.6	20.0	54	0.01	----
14 *	2.5	10.3	160	28.9	14.4	21.7	74	0.30	----
15 *	2.8	12.5	200	29.4	13.3	21.7	77	0.27	----
16	2.4	11.6	300	31.6	19.2	25.2	37	0.00	0.321
17	1.0	6.5	336	28.4	12.6	18.8	63	0.00	0.378
18	0.8	5.5	324	17.5	11.4	14.3	94	0.00	0.066
19	0.5	3.6	306	14.8	11.3	13.8	100	0.01	0.032
20	0.6	4.6	235	23.3	12.8	17.2	88	0.01	0.220
21	0.5	5.5	120	29.0	13.7	19.2	87	0.03	0.317
22	0.4	4.1	89	42.7	14.1	22.7	73	0.00	0.388
23	1.1	13.6	78	34.1	17.2	22.0	81	0.29	0.386
24	0.4	5.1	98	22.2	11.6	17.5	98	0.10	0.179
25	0.8	8.2	351	22.8	9.1	15.7	51	0.01	0.527
26	0.7	4.4	213	34.1	4.7	15.0	61	0.00	0.478
27	0.6	4.4	176	37.0	8.6	19.2	62	0.00	0.468
28	0.8	5.6	266	43.0	11.1	21.3	60	0.00	0.484
29	0.5	4.9	179	43.8	12.3	22.5	60	0.00	0.479
30	0.4	5.9	182	50.0	12.5	24.1	62	0.00	0.468
31	0.5	4.7	264	50.0	15.6	25.0	68	0.00	0.405
Average	0.8	6.4	220	29.7	11.2	18.1	70		0.331
Total									1.49

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average (degrees Celcius)			
=====									
JUNE 1988									
1	1.4	7.5	255	35.5	17.4	25.6	65	0.00	0.434
2	0.9	5.9	339	43.5	12.6	22.3	70	0.00	0.348
3	0.7	5.1	1	22.4	8.9	15.3	71	0.01	0.379
4	0.4	4.6	6	25.1	6.8	15.5	65	0.00	0.431
5	1.5	7.1	225	29.2	8.1	18.6	62	0.00	0.489
6	1.7	6.8	253	35.1	24.7	28.9	48	0.00	0.219
7	1.7	9.5	252	35.3	18.6	26.4	51	0.00	0.460
8	1.0	8.5	223	38.7	17.5	26.2	56	0.00	0.433
9	0.9	12.0	3	26.0	8.0	15.3	70	0.18	0.344
10	0.5	5.5	355	23.3	6.5	13.8	60	0.00	0.373
11	0.7	6.3	272	37.6	6.5	17.6	62	0.00	0.484
12	0.8	6.1	182	37.3	11.5	21.5	58	0.00	0.451
13	0.4	3.9	142	49.8	13.2	24.2	61	0.00	0.454
14	0.5	5.2	213	50.0	15.5	25.7	65	0.00	0.436
15	0.8	7.1	218	45.1	17.3	26.4	67	0.00	0.430
16	0.6	10.8	177	34.5	18.4	23.4	84	0.20	0.286
17	0.2	3.0	2	43.4	17.5	21.4	83	0.02	0.272
18	0.4	4.4	11	45.5	13.6	23.2	58	0.00	0.483
19	0.7	6.1	200	36.3	14.8	24.3	64	0.00	0.433
20	1.4	9.1	208	37.9	19.9	27.6	69	0.00	0.418
21	1.2	6.3	219	40.4	21.9	28.5	68	0.00	0.350
22	1.8	8.8	214	40.1	18.8	29.6	59	0.00	0.431
23	0.9	4.7	294	46.0	21.5	28.3	62	0.00	0.327
24	0.3	3.1	6	50.0	15.3	25.3	51	0.00	0.463
25	1.3	8.0	217	41.5	17.9	28.6	61	0.00	0.426
26	1.3	9.0	302	35.9	17.5	27.0	57	0.00	0.424
27	0.5	4.3	17	41.4	12.2	21.2	53	0.00	0.476
28	0.9	8.4	237	34.9	11.8	22.4	54	0.00	0.449
29	0.2	2.8	355	28.9	16.7	19.1	80	0.06	0.073
30	0.5	6.0	4	37.0	14.3	20.9	63	0.00	0.501
Average	0.9	6.5	180	37.6	14.8	23.1	63		0.399
Total								0.47	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Average (degrees Celcius)			
=====									
JULY 1988									
1 *	2.6	9.4	50	26.1	10.0	18.3	44	0.00	----
2 *	2.2	7.2	70	28.9	8.3	18.9	49	0.00	----
3 *	2.2	9.4	60	32.8	11.1	22.2	44	0.00	----
4 *	2.2	6.3	120	34.4	13.3	23.9	48	0.00	----
5 *	3.0	7.6	140	34.4	17.8	26.1	49	0.00	----
6 *	2.6	7.2	160	35.6	16.7	26.1	47	0.00	----
7 *	2.0	6.3	40	37.2	16.1	26.7	47	0.00	----
8 *	2.4	6.3	60	38.9	18.9	28.9	44	0.00	----
9 *	2.0	6.3	80	37.8	19.4	28.9	49	0.01	----
10 *	3.2	8.9	200	34.4	21.7	28.3	51	0.01	----
11 *	3.0	10.3	250	29.4	20.0	25.0	77	0.09	----
12 *	2.5	6.7	270	26.1	36.1	22.8	85	0.01	----
13 *	3.1	8.0	210	28.3	36.1	23.9	79	0.01	----
14 *	3.5	7.2	260	33.9	22.8	28.3	69	0.00	----
15 *	2.8	9.4	310	38.3	24.4	31.7	48	0.00	----
16 *	3.7	13.0	220	38.9	22.2	30.6	56	0.00	----
17 *	4.1	9.8	260	37.8	22.8	30.6	59	0.00	----
18 *	3.6	22.4	210	36.1	21.7	28.9	75	1.53	----
19 *	2.8	12.5	250	29.4	22.2	26.1	89	1.22	----
20 *	3.1	18.3	210	32.2	21.7	27.2	91	2.95	----
21 *	3.1	----	270	23.9	20.0	22.2	84	0.09	----
22 *	2.6	6.7	160	30.6	17.8	24.4	76	0.00	----
23 *	2.4	9.4	240	29.4	18.9	24.4	77	0.41	----
24 *	2.7	6.7	250	30.6	17.8	24.4	71	0.00	----
25 *	2.3	5.4	140	30.6	18.3	24.4	67	0.00	----
26 *	2.5	5.8	50	30.0	18.9	24.4	81	0.58	----
27 *	2.0	4.5	40	31.1	17.2	24.4	75	0.00	----
28 *	1.8	5.4	50	32.8	17.2	25.0	67	0.00	----
29 *	2.0	5.4	90	34.4	17.8	26.1	68	0.00	----
30 *	3.3	8.9	170	31.7	20.6	26.1	72	0.01	----
31 *	2.8	6.7	240	30.6	21.7	26.1	77	0.00	----

Average and total not reported as no onsite data was collected in July.

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average (degrees Celcius)			
=====									
AUGUST 1988									
1 *	2.0	5.8	280	34.4	19.4	27.2	73	0.00	----
2 *	2.2	4.5	100	36.1	19.4	27.8	70	0.00	----
3 *	2.1	4.5	190	28.9	22.2	25.6	87	0.01	----
4	0.7	5.2	143	40.0	26.3	27.9	81	0.00	0.388
5	1.2	9.3	160	36.2	19.5	27.1	86	0.00	0.328
6	0.9	4.3	210	31.7	19.6	23.9	99	0.30	0.143
7	0.8	5.7	264	50.0	21.0	27.3	72	0.00	0.438
8	0.5	4.8	186	41.9	18.6	26.6	72	0.00	0.412
9	0.7	6.0	260	42.9	18.7	27.0	71	0.00	0.379
10	0.6	5.2	213	41.2	19.9	28.0	71	0.00	0.398
11	0.8	5.4	203	39.4	21.0	28.5	75	0.00	0.371
12	0.8	5.5	232	42.5	22.8	28.2	84	0.00	0.332
13	0.6	4.7	175	45.5	22.2	28.6	84	0.00	0.285
14	1.1	7.8	216	39.2	22.5	29.7	74	0.00	0.372
15	0.8	8.7	182	36.9	22.4	27.5	86	0.37	0.314
16	0.5	5.3	307	50.0	21.8	29.1	72	0.00	0.409
17	1.2	6.8	242	42.4	20.5	29.9	70	0.00	0.387
18	1.3	8.0	249	47.1	23.3	30.9	67	0.00	0.376
19	0.7	7.7	267	31.9	20.8	24.7	96	0.73	0.132
20	0.4	4.3	327	35.7	20.5	23.8	96	1.76	0.194
21	0.2	3.4	4	37.2	16.8	23.1	77	0.00	0.374
22	0.3	3.9	353	48.5	13.8	22.2	77	0.00	0.378
23	1.3	14.6	178	27.3	18.4	22.0	97	0.62	0.086
24	2.1	9.8	243	31.6	17.7	23.7	78	0.00	0.355
25	1.8	8.6	223	32.4	16.3	22.8	69	0.00	0.396
26	0.6	3.9	313	41.4	16.7	23.2	73	0.00	0.365
27	0.8	7.8	164	36.5	16.4	24.7	69	0.00	0.334
28	1.0	7.8	130	30.7	20.9	24.3	84	0.00	0.168
29	0.5	8.0	337	22.0	16.1	18.8	100	0.35	0.049
30	0.3	3.7	348	37.8	10.8	18.1	79	0.00	0.359
31	0.4	3.7	9	41.2	11.1	19.5	75	0.00	0.375
Average	0.8	6.4	219	38.6	19.2	25.4	80		0.318
Total								4.13	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average			
=====									
SEPTEMBER 1988									
1	0.4	4.5	43	47.8	13.5	21.8	73	0.00	0.35
2	0.7	3.3	153	33.2	17.0	23.2	75	0.00	0.301
3	0.9	6.9	141	30.1	18.9	21.8	93	1.17	0.139
4	1.8	8.1	253	27.7	17.1	20.8	91	0.39	0.178
5	1.2	6.8	282	20.3	13.0	15.9	98	0.08	0.083
6	0.5	5.7	357	27.5	9.9	14.5	78	0.00	0.318
7	0.4	4.7	9	28.5	6.4	15.0	73	0.00	0.385
8	0.4	3.9	128	34.6	10.1	18.0	74	0.00	0.364
9 *	2.0	4.5	140	25.6	8.9	17.2	82	0.00	----
10 *	1.7	4.0	120	26.7	12.8	20.0	83	0.00	----
11 *	2.4	6.7	110	28.3	13.9	21.1	84	0.00	----
12 *	2.7	7.2	210	28.9	17.8	23.3	87	0.07	----
13 *	4.1	7.6	260	29.4	20.6	25.0	81	0.03	----
14 *	2.5	5.4	40	26.1	14.4	20.6	69	0.00	----
15 *	3.4	7.6	90	25.6	10.0	17.8	71	0.00	----
16 *	2.6	5.8	180	25.6	12.8	19.4	82	0.06	----
17	0.2	1.7	143	77.7	18.5	19.8	100	0.05	0.010
18	0.4	4.9	156	41.2	16.1	21.0	93	0.00	0.259
19	0.6	6.7	124	27.6	18.1	22.0	96	0.00	0.124
20	2.4	13.4	231	27.8	16.8	22.5	77	0.13	0.336
21	1.0	5.8	274	35.1	12.7	18.6	83	0.00	0.330
22	0.8	5.8	192	31.1	11.0	19.2	78	0.00	0.326
23	1.4	8.8	229	30.0	19.5	22.9	89	0.01	0.164
24	0.2	3.1	13	19.7	12.5	16.3	100	0.34	0.029
25	0.3	5.3	347	38.0	12.0	16.4	84	0.14	0.284
26	0.2	2.1	154	17.5	11.5	13.8	100	0.00	0.073
27	0.5	3.9	180	36.0	10.0	16.6	89	0.00	0.279
28	0.3	4.1	150	44.0	13.8	20.0	83	0.00	0.300
29	0.4	4.9	125	41.6	13.0	19.9	85	0.00	0.264
30	0.5	3.1	124	37.6	16.4	21.7	88	0.00	0.219
Average	0.7	5.3	173	34.3	14.0	19.2	86		0.233
Total								2.31	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Wind Speed (m/s)	Peak Wind Speed (m/s)	Wind Direction (degrees)	Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (Lang/min)
				Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average			
=====									
OCTOBER 1988									
1	0.7	4.7	144	42.1	17.7	22.0	86	0.00	0.201
2	1.3	6.2	221	27.5	17.0	20.1	90	0.01	0.140
3	0.6	3.8	354	21.3	12.2	15.3	85	0.00	0.148
4	1.0	6.8	321	19.8	5.4	12.2	70	0.00	0.255
5	0.9	7.1	278	14.9	3.2	7.8	79	0.00	0.207
6	0.3	4.5	339	19.0	-0.4	8.0	71	0.00	0.275
7	0.5	6.9	344	18.7	2.1	9.1	64	0.00	0.245
8	0.6	5.3	284	18.1	1.9	9.5	67	0.00	0.268
9	0.8	6.0	183	21.4	4.7	11.1	68	0.00	0.211
10	2.6	16.1	219	19.7	6.7	12.3	77	0.00	0.187
11	1.9	9.7	299	18.1	5.4	12.4	65	0.00	0.220
12	0.9	8.1	314	10.2	2.3	5.1	74	0.01	0.134
13	0.5	6.0	334	13.8	-3.0	5.0	71	0.00	0.252
14	1.0	6.8	161	21.6	-1.3	9.0	62	0.00	0.249
15	1.0	6.0	154	24.9	8.7	15.0	49	0.00	0.204
16	1.0	10.5	143	24.0	8.5	13.8	79	0.07	0.174
17	1.2	10.8	145	28.1	11.8	17.3	87	0.02	0.133
18	2.1	12.4	286	22.6	9.8	16.1	87	0.51	0.083
19	1.6	9.7	295	17.2	5.8	10.0	75	0.00	0.183
20	0.4	5.4	316	24.0	0.9	8.2	77	0.11	0.202
21	1.2	7.3	212	10.2	6.3	8.0	100	1.05	0.018
22	1.8	10.3	279	10.9	4.3	8.0	89	0.09	0.069
23	1.3	11.2	159	13.7	0.6	6.8	96	0.28	0.054
24	3.1	14.1	244	11.1	4.1	8.1	68	0.00	0.172
25	2.0	10.4	231	16.1	3.4	8.2	62	0.00	0.162
26	1.8	11.6	259	11.2	0.6	5.8	58	0.00	0.225
27	0.8	5.8	129	18.5	-2.4	7.7	62	0.00	0.206
28	2.7	13.0	255	16.3	4.5	10.7	64	0.05	0.201
29	0.6	5.6	272	14.2	-2.0	4.9	63	0.00	0.158
30	0.8	4.0	3	12.2	1.2	5.5	55	0.00	0.188
31	0.7	3.5	6	17.3	-3.2	6.2	66	0.00	0.203
Average	1.2	8.1	232	18.7	4.4	10.3	73		0.182
Total								2.20	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average			
NOVEMBER 1988									
1	2.2	14.2	243	17.2	6.4	10.0	79	0.00	0.188
2	1.6	6.9	291	12.5	2.6	6.3	76	0.00	0.164
3	1.0	3.0	124	20.8	-0.2	9.8	84	0.09	0.108
4	3.1	12.4	148	25.7	12.1	18.7	62	0.00	0.174
5	2.6	15.5	221	18.3	6.6	12.0	95	0.97	0.040
6	3.1	15.1	198	6.7	-0.6	3.4	96	0.07	0.020
7	2.0	10.3	216	15.2	2.6	8.1	71	0.00	0.179
8	2.3	10.8	281	18.6	5.8	11.0	70	0.08	0.191
9	0.7	5.1	101	20.0	0.5	9.7	72	0.00	0.173
10	3.7	15.9	254	18.8	7.3	13.6	76	0.20	0.123
11	1.0	7.0	323	9.4	0.9	5.1	80	0.00	0.108
12	1.7	10.5	114	16.1	-0.2	7.2	70	0.00	0.101
13	3.1	13.6	208	15.0	6.4	11.0	76	0.18	0.189
14	0.9	4.0	157	422.4	2.9	11.1	70	0.00	0.184
15	1.1	5.9	129	18.8	3.9	12.4	74	0.00	0.101
16	4.1	14.7	174	22.9	4.2	16.2	76	0.11	0.033
17	2.5	10.0	251	9.1	0.8	4.7	63	0.00	0.185
18	0.6	4.7	96	12.8	-1.8	5.6	63	0.00	0.158
19	1.0	6.4	102	10.2	4.1	7.3	95	1.46	0.011
20	4.4	20.7	214	27.6	6.1	12.8	90	2.18	0.129
21	1.4	7.2	334	6.7	1.8	4.7	83	0.01	0.061
22	1.1	4.1	0	9.2	-0.9	3.7	78	0.00	0.170
23	0.8	3.7	355	12.4	-2.8	4.0	82	0.00	0.169
24	0.4	2.5	119	14.9	-3.2	5.3	70	0.00	0.169
25	1.5	7.8	141	22.1	1.2	9.8	70	0.00	0.154
26	2.5	15.0	127	20.8	6.7	13.7	67	0.00	0.078
27	3.5	15.6	215	19.5	4.0	13.0	88	0.03	0.078
28	3.5	14.0	247	5.6	-0.8	1.5	88	0.00	0.045
29	1.8	7.5	159	8.9	-2.9	2.9	72	0.00	0.166
30	3.3	14.9	224	9.6	1.7	5.8	61	0.00	0.147
Average	2.1	10.0	192	28.9	2.5	8.7	77		0.127
Total								5.38	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average (degrees Celcius)			
=====									
DECEMBER 1988									
1	1.7	8.3	248	5.7	-2.9	1.3	72	0.00	0.118
2	1.8	7.5	222	7.5	-6.4	-1.0	75	0.00	0.157
3	2.7	8.2	196	18.5	-1.0	6.9	57	0.00	0.160
4	1.8	8.3	326	7.0	-2.1	-0.1	58	0.00	0.163
5	2.1	9.5	200	13.4	-3.6	3.1	47	0.00	0.132
6	2.2	9.1	174	15.0	1.7	8.0	28	0.00	0.166
7	2.0	6.6	228	14.6	4.7	9.3	57	0.04	0.080
8	1.1	3.3	341	----	----	3.0	85	0.00	0.092
9	1.9	11.0	297	3.2	-4.7	-0.7	60	0.00	0.155
10	1.5	5.0	199	3.0	-5.4	1.0	59	0.00	0.115
11 *	2.3	7.6	30	-2.8	-10.0	-6.1	55	0.01	----
12 *	1.8	4.0	100	-0.6	-12.8	-6.7	59	0.00	----
13 *	2.9	10.3	240	2.2	-4.4	-1.1	81	0.10	----
14 *	5.0	16.1	230	17.2	-0.6	8.3	54	0.00	----
15 *	3.3	9.8	330	12.8	-2.8	5.0	60	0.00	----
16 *	1.9	5.4	30	-1.7	-6.7	-3.9	62	0.01	----
17 *	3.1	11.2	28	-2.2	-6.7	-4.4	76	0.11	----
18 *	2.3	7.6	23	0.0	-10.6	-5.0	65	0.01	----
19 *	3.5	8.0	21	15.0	-0.6	7.2	43	0.00	----
20 *	4.6	14.3	22	18.3	8.3	13.3	36	0.01	----
21 *	2.5	7.2	28	16.1	2.2	9.4	85	1.18	----
22	0.7	5.1	103	6.7	2.3	3.6	100	0.00	0.031
23	2.2	15.9	185	16.8	6.5	12.2	57	0.30	0.128
24	3.4	17.2	214	21.5	5.1	11.4	65	1.29	0.051
25	3.0	10.5	284	9.4	0.0	4.1	65	0.00	0.152
26	5.0	5.2	29	4.3	-5.1	0.1	74	0.00	0.115
27	3.5	15.4	152	22.4	1.2	10.9	52	0.00	0.132
28	3.3	21.1	267	17.6	-6.5	3.5	79	0.34	0.032
29	0.7	4.5	346	-0.3	-5.8	-2.5	78	0.00	0.164
30	0.7	3.8	157	5.1	-3.5	0.8	77	0.00	0.062
31	0.8	3.7	159	9.0	-0.9	3.9	79	0.00	0.132
Average	2.1	9.0	216	10.0	-1.3	3.9	66		0.117
Total								1.97	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

* Data for these days are from the NOAA station at the Huntington, W.V. airport and are not included in onsite monthly averages/totals.

---- Data not available from the NOAA station.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average			
=====									
JANUARY 1989									
1	1.5	7.3	276	4.8	0.0	3.1	98	0.16	0.004
2	2.1	9.9	233	4.2	1.3	2.8	100	0.00	0.004
3	3.0	18.3	204	6.6	-0.6	2.1	94	0.01	0.006
4	2.0	14.0	325	1.0	-5.2	-2.1	72	0.00	0.091
5	1.6	8.1	140	11.6	-6.5	0.9	80	0.26	0.134
6	1.5	9.6	171	9.6	4.0	7.4	100	0.25	0.009
7	2.0	10.8	129	18.7	4.2	11.8	91	0.01	0.097
8	3.7	16.9	243	17.0	1.3	7.1	67	0.42	0.046
9	2.2	9.6	272	5.0	-1.3	-0.1	52	0.00	0.050
10	1.3	7.3	150	9.4	-3.1	2.2	79	0.00	0.119
11	0.9	5.0	117	9.3	0.6	5.6	95	0.48	0.066
12	2.4	10.4	189	16.3	3.6	10.6	98	0.56	0.010
13	1.8	8.1	333	4.2	-3.2	0.5	66	0.00	0.167
14	0.8	6.4	90	7.4	-4.0	-0.1	92	0.84	0.015
15	2.2	10.9	269	7.9	1.5	3.6	98	0.01	0.020
16	2.0	9.3	252	7.3	0.2	3.2	67	0.00	0.170
17	2.2	10.4	193	11.2	-2.0	4.7	56	0.00	0.169
18	2.4	10.6	193	15.6	2.4	7.4	57	0.00	0.125
19	1.7	7.2	206	13.0	1.3	6.9	64	0.00	0.175
20	3.2	12.2	287	8.6	-2.6	2.8	68	0.01	0.065
21	0.9	6.5	44	4.5	-7.1	-2.1	54	0.00	0.183
22	8.0	4.1	146	12.8	-5.1	2.9	51	0.00	0.183
23	7.0	3.4	150	18.4	-2.2	6.5	54	0.00	0.183
24	1.0	5.3	166	15.0	0.2	8.5	58	1.00	0.116
25	1.2	6.6	160	19.6	8.5	14.2	65	0.00	0.105
26	3.2	17.0	216	17.7	4.2	11.6	83	0.09	0.016
27	2.4	8.9	253	33.0	9.4	-0.3	70	0.00	0.187
28	1.1	5.1	165	14.9	-2.1	7.1	52	0.00	0.167
29	1.2	6.4	172	16.7	6.2	10.8	62	0.00	0.034
30	2.5	12.1	242	16.5	3.6	7.7	95	0.11	0.031
31	2.5	10.5	171	18.1	2.7	10.0	74	0.00	0.195
Average	2.3	9.3	199	12.1	0.3	5.1	75		0.095
Total								4.21	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

TABLE 16 (continued)

Meteorological Data Summary

Date	Peak			Temperature			Relative Humidity (%)	Rainfall (inches)	Radiation (lang/min)
	Wind Speed (m/s)	Wind Speed (m/s)	Wind Direction (degrees)	Max (degrees Celcius)	Min (degrees Celcius)	Hourly Average			
=====									
FEBRUARY 1989									
1	2.4	9.7	192	23.7	11.2	15.5	66	0.00	0.191
2	1.3	9.2	270	17.5	8.3	13.2	93	0.28	0.028
3	1.0	5.7	357	8.4	-4.2	0.3	100	0.96	0.006
4	0.0	0.0	360	-3.7	-5.8	-4.7	85	0.00	0.039
5	0.0	0.0	360	-1.0	-5.2	-3.3	87	0.00	0.064
6	0.5	4.7	300	-0.7	-7.6	-4.0	79	0.03	0.191
7	1.5	5.9	274	0.7	-9.4	-5.1	72	0.02	0.205
8	3.3	14.4	250	5.5	-9.3	-4.2	66	0.00	0.154
9	2.5	9.2	249	-4.1	-14.5	-9.7	55	0.00	0.225
10	2.5	9.1	228	1.9	-8.2	-3.5	54	0.01	0.216
11	2.7	12.1	231	9.6	-4.0	2.7	54	0.00	0.219
12	1.7	7.8	292	6.4	-3.9	0.8	64	0.00	0.224
13	1.6	8.0	119	7.5	-1.9	3.4	91	1.31	0.011
14	1.1	5.9	29	9.1	4.4	6.2	100	0.91	0.008
15	0.9	7.9	347	8.3	4.2	5.7	100	2.32	0.012
16	1.5	5.8	2	7.3	-2.1	2.7	81	0.22	0.155
17	1.2	4.6	16	1.4	-3.8	-1.2	69	0.01	0.084
18	0.8	3.6	10	7.0	-3.7	0.4	64	0.00	0.233
19	0.6	4.3	352	7.9	-4.1	1.9	70	0.00	0.141
20	1.0	5.7	126	10.0	0.8	5.3	96	0.55	0.053
21	2.6	10.5	231	12.5	3.3	9.4	100	1.01	0.037
22	1.8	6.9	308	3.6	-2.2	0.1	95	0.01	0.051
23	2.6	10.0	356	-1.6	-10.9	-5.2	77	0.00	0.117
24	1.9	8.1	328	1.0	-12.6	-7.5	63	0.00	0.276
25	1.9	9.3	187	8.5	-8.7	-0.8	58	0.00	0.266
26	3.0	13.5	252	6.0	-0.6	2.3	90	0.05	0.038
27	1.2	8.8	304	4.6	-2.5	0.0	72	0.00	0.171
28	1.8	8.8	300	8.1	-6.1	1.6	67	0.00	0.265
Average	1.6	7.5	237	5.9	-3.5	0.8	77		0.131
Total								7.69	

Note: Max and Min Temperatures are instantaneous values and may last only seconds, whereas Average Temperature represents the daily average.

TABLE 17

Comparison of Meteorological Data Collected at the
Huntington, West Virginia and Schilling Landfill Sites

Period	Average Speed (miles/hour)		Resultant Wind Direction (Degrees clockwise from North)		Average Temperature (Degrees F)		Average Relative Humidity (%)	
	Huntington	Schilling	Huntington	Schilling	Huntington	Schilling	Huntington	Schilling
February 1988	7.6	5.8	212	236	35.8	36.3	67	59
March 1988	8.1	5.4	213	258	45.1	43.9	63	63
April 1988	7.7	4.5	273	273	55.8	55.4	60	59
May 1988	6.1	1.8	132	330	64.3	64.6	68	70
June 1988	5.5	2.0	139	272	71.7	73.6	74	63
July 1988	6.0	----	177	----	79.3		67	
August 1988	4.9	1.8	187	232	74.2	77.7	77	80
September 1988	5.0	1.6	187	162	68.0	66.6	78	86
October 1988	5.7	2.7	184	265	56.3	50.5	71	73
November 1988	6.9	4.7	188	190	45.6	47.7	69	77
December 1988	7.4	4.7	246	207	36.9	39.0	71	66
January 1989	7.6	5.1	262	197	32.8	41.2	70	75
February 1989	7.6	3.6	212	306	35.8	33.4	67	77
Average to Date	6.5	3.4	234	244	55.5	54.0	70	72

As expected, the average temperature and relative humidity for the two stations deviate very little. The average temperature at the Huntington, West Virginia station was 47.9°F as compared to 46.0°F at the Schilling landfill site. The average relative humidity at the Huntington, West Virginia site was 56% as compared to 65% at the Schilling landfill site.

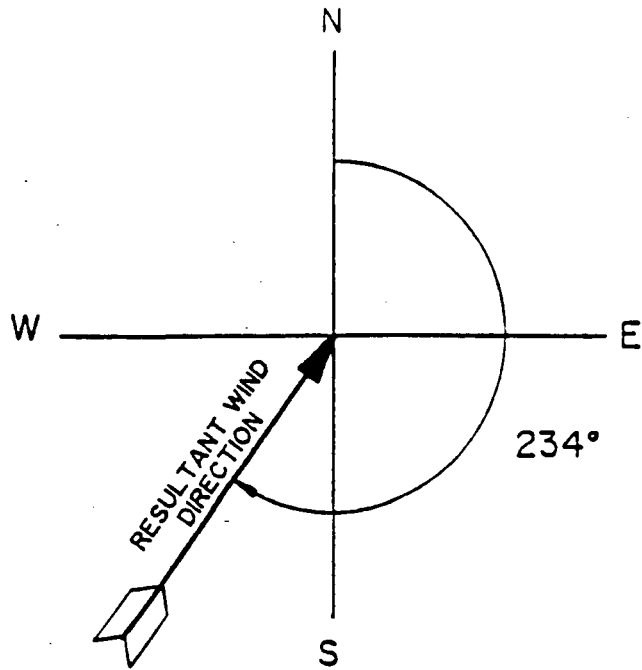
However, the average wind speeds and resultant wind direction at the two sites varied significantly. The Schilling landfill site station averages lower wind speeds at 3.4 miles per hour as compared to 6.2 miles per hour for the Huntington, West Virginia station. The resultant wind direction at the Schilling landfill site was 244° clockwise from north. The Huntington, West Virginia station calculates a resultant wind direction of 234°. Figure 30 illustrates the resultant wind directions at the two meteorological stations.

The resultant wind direction at the site is 26° south of west, as opposed to 36° south of west for the Huntington station. This is apparently due to valley-channeling of the winds at the site. The measurements of wind direction show that the meteorological station, and key monitoring stations are appropriately located downwind of the landfill.

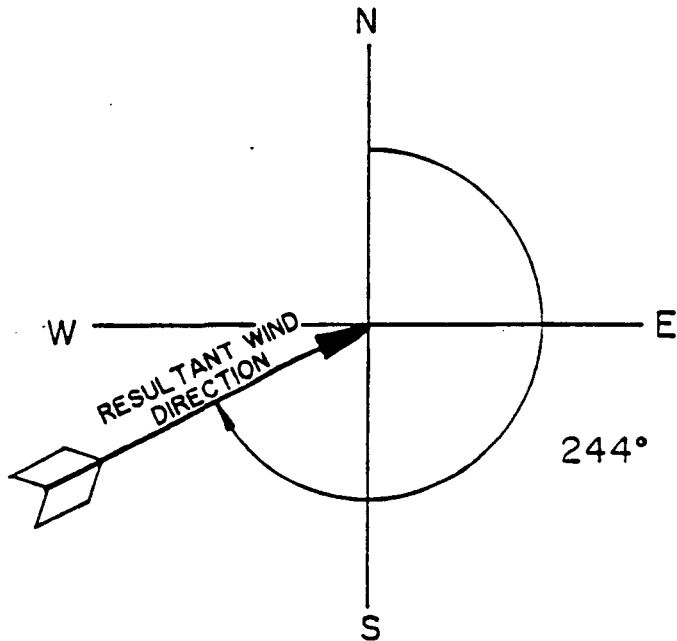
3.4 Hydrogeology

3.4.1 Physiographic Setting

The State of Ohio contains portions of two major physiographic provinces as shown in Figure 31. The western and northern two-thirds of the state belong to the Central Lowlands Physiographic Province. This area contains broad flat plains and low, gently rolling hills. The southeastern one-third of the state belongs to the Appalachian Plateaus



RESULTANT WIND DIRECTION
 TRI-STATE AIRPORT METEOROLOGICAL DATA (1987)
 HUNTINGTON, WEST VIRGINIA



RESULTANT WIND DIRECTION
 SCHILLING LANDFILL SITE METEOROLOGICAL DATA (Feb 88 - Feb 89)
 SCHILLINGVILLE, OHIO

FIGURE 30
COMPARISON OF RESULTANT WIND DIRECTION AT THE HUNTINGTON, WEST VIRGINIA METEOROLOGICAL STATION AND SCHILLING LANDFILL SITE
E. H. SCHILLING LANDFILL

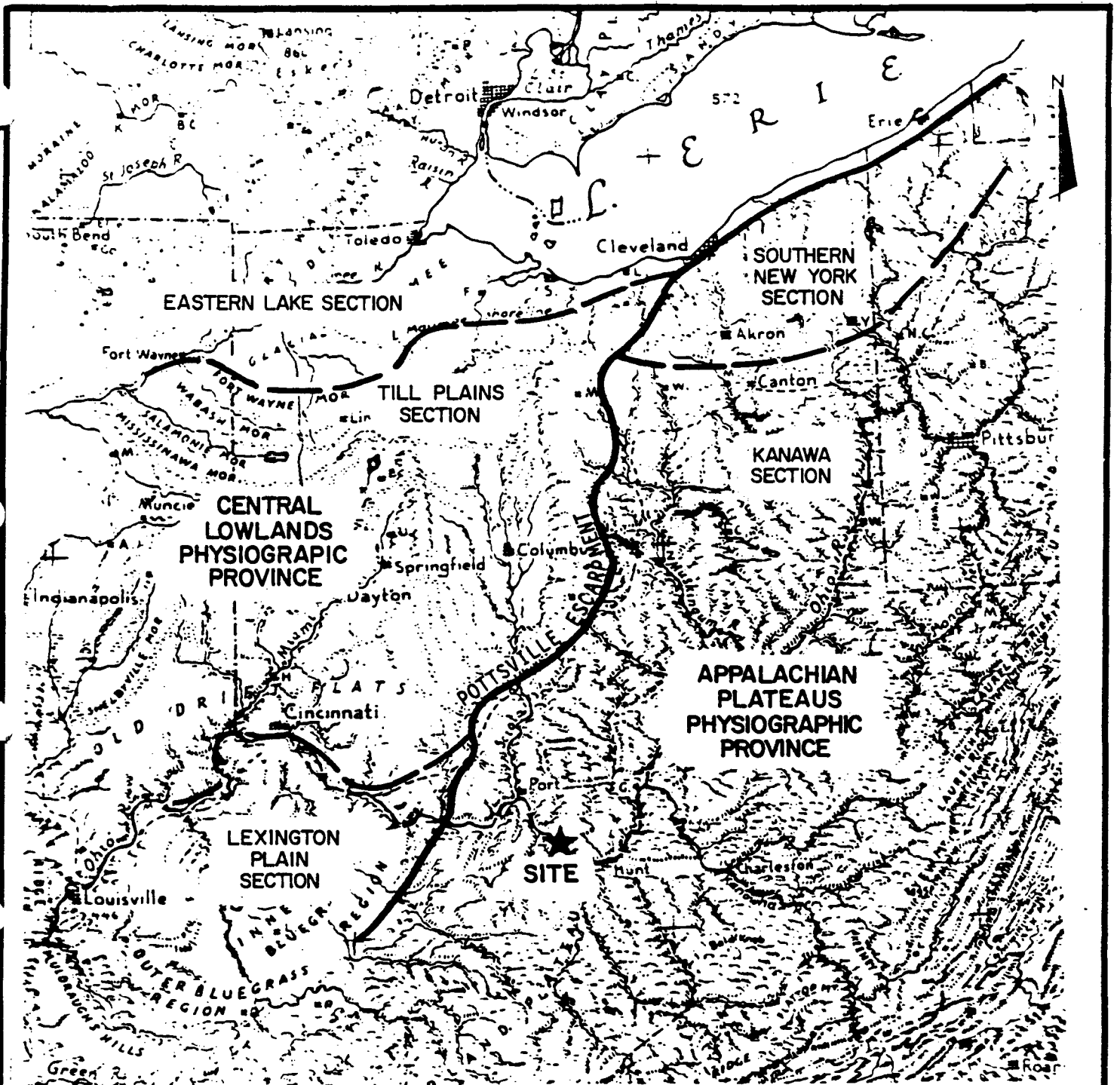


FIGURE 31

PHYSIOGRAPHIC MAP OF OHIO

E. H. SCHILLING LANDFILL

Physiographic Province. This province consists of steep hills with relatively concordant summits and narrow valleys. The boundary between the two provinces in southern Ohio is the Pottsville Escarpment, a distinct west-facing ridge marking the limit of the plateau hills (Ettensohn, 1979).

3.4.2 Regional Hydrogeology

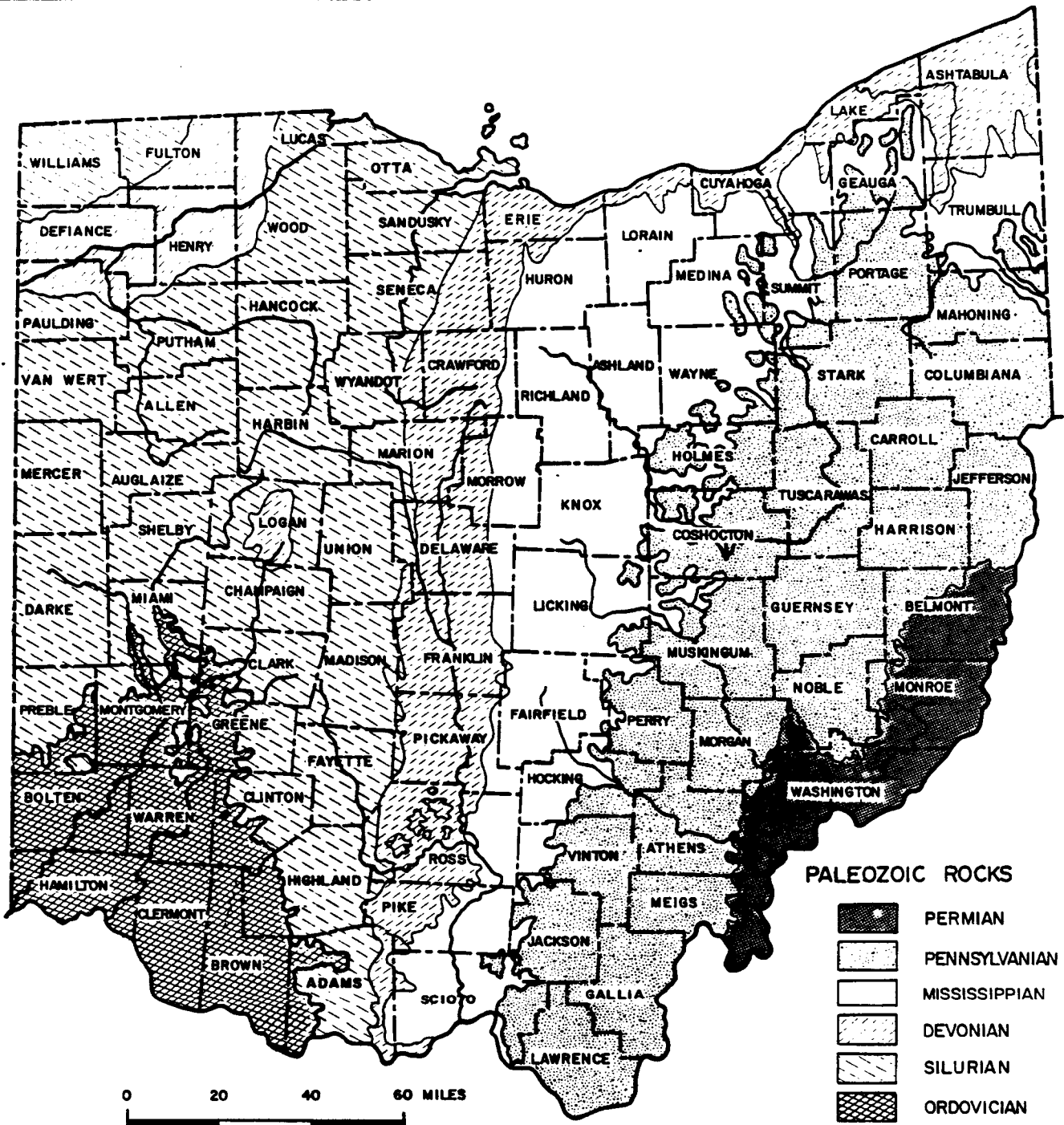
Two distinct hydrogeologic systems occur in the Lawrence County Region; the Ohio River floodplain and the Appalachian Plateaus uplands. The ability of each system to transmit water and the water quality in each system is quite varied due to lithologies.


Within the Ohio River floodplain system, permeable unconsolidated deposits of sand and gravel are typical. Potential ground-water yields may exceed 500 gpm. Well depths range from 40 to 90 feet and average about 75 feet (Schmidt, 1985).

Sedimentary rocks of Pennsylvanian age comprise the Appalachian Plateau uplands. Sandstones and shales are the predominant rock types within this system, with minor amounts of limestone, clay, coal and ore present (Stout et al., 1943). The sandstones are the principal water-bearing units; these generally yield less than 3 gpm (Schmidt, 1985). Brackish water may be encountered in wells exceeding 100 feet in depth.

3.4.2.1 Stratigraphy

Nearly flat-lying sedimentary rocks of Paleozoic age (Figure 32) underlie the state. In the Central Lowlands Physiographic Province, the rocks are primarily limestones, dolomites and shales of Ordovician to early Mississippian age. These rocks were deposited in shallow to



- PALEOZOIC ROCKS**
-  PERMIAN
 -  PENNSYLVANIAN
 -  MISSISSIPPIAN
 -  DEVONIAN
 -  SILURIAN
 -  ORDOVICIAN

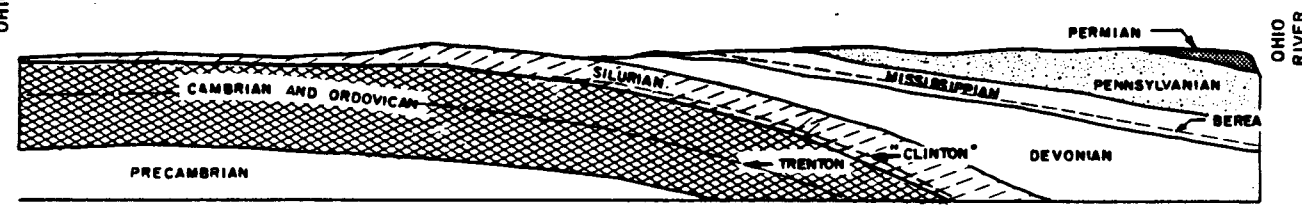
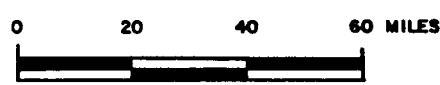


FIGURE 32

GEOLOGIC MAP OF OHIO

E. H. SCHILLING LANDFILL

deep marine environments in the inland seas that covered much of central North America during the Paleozoic era. The rocks dip very gently eastward and are younger toward the Appalachian Plateaus.

The rocks of the Appalachian Plateaus are primarily Mississippian and Pennsylvanian age sandstones and shales with minor limestones. These rocks were deposited in deltas and shallow shoreline environments adjacent to the inland seas of that time. The rocks dip gently and thicken eastward. Coal deposits are interbedded within these rocks and have been mined extensively from this province in Ohio and the adjacent eastern states.

During the Pennsylvanian period (about 330 to 290 million years before present), the Appalachian Mountains experienced their most rapid uplift and greatest elevation. The continental interior was sporadically covered by a shallow inland sea. This produced a broad basin of deposition which continuously subsided during this period. When subsidence exceeded the rate of deposition, the seas of the continental interior transgressed eastward toward the Appalachian front. A regression of the seas westward occurred when the rate of deposition exceeded subsidence. These fluctuations produced a repeated alternation of marine and terrestrial sequences. Coal was formed in vast salt marshes and swamps. The term "cyclothem" is used to describe the orderly progression of lithologies deposited under the transitional marine to terrestrial environment (Krumbein and Sloss, 1963).

A typical cyclothem consists of the following stratigraphic sequence (from top to bottom):

marine - shale

marine - limestone

terrestrial - coal

terrestrial - underclay

terrestrial - shale

terrestrial - sandstone

Unconformities exist at the base of each sandstone unit marking the change from a marine to a terrestrial depositional environment and thus the beginning of a new cyclothem. There were as many as one hundred or so sequences for the Pennsylvanian period.

The thickness of units within each cyclothem is highly variable. The basal sandstone may range in thickness from a few inches to two hundred feet. These are laterally extensive sheets deposited as stream channel sands. Dark gray to black, organic-rich shales are deposited in floodplain regions between stream channels. Therefore, the sandstones often wedge out laterally into shales. Stratigraphically above the sandstone is a terrestrial shale ranging from about ten to thirty feet in thickness. This shale originated from stream channel muds deposited in a lower energy environment seaward of the zone of sand deposition. The underclay, where present, is a very thin unit formed from exposure of the underlying shale to the surface atmosphere, allowing for the development of a soil profile. As the continental interior continued to subside, the elevation of the land surface decreased and sea-side swamps developed. Coals formed in these swamps vary from a few inches to ten feet thick. With continued subsidence, the swamps dropped below sea level. Marine limestones up to ten feet thick were deposited as the seas transgressed inland. Finally, a renewed influx of terrigenous debris produced the marine shales above the limestone. These shales range in thickness from about ten to twenty feet thick. As the shallow sea

filled with terrigenous debris, the region shifted to a terrestrial depositional environment and the cycle repeated.

The cyclothem sequence in the southern Ohio region is predominantly terrestrial in origin. Brant and DeLong (1960) describe the sequence as a coal-to-coal interval, beginning with a basal coal seam followed upwards in the stratigraphic section by sandstone, shale, under clay and another coal seam at the top of the interval. Thin layers of shale and limestone may be present above the basal coal seam and beneath the under clay. Further to the east into Pennsylvania, the sequence is composed entirely of the terrestrial sandstones and shales.

Four major formations containing Pennsylvanian cyclothem are recognized in Ohio. These are the Pottsville, Allegheny, Conemaugh and Monongahela formations. Only the Pottsville and Allegheny crop out in the vicinity of the site.

Pottsville Formation

The Pottsville Formation crops out throughout much of eastern Ohio. The unit is a major resistant ridge forming unit. It forms many hills and slopes and the Pottsville escarpment in central Ohio. The Pottsville Formation is up to 256 feet thick (Frye, 1979).

The base of the Pottsville is located at the unconformable boundary between the Mississippian and Pennsylvanian series. The basal member of the formation in northern Ohio is the distinctive Sharon Conglomerate (Ford, 1987). This unit is a medium to coarse-grained quartz sandstone with thin pebbly layers. The Sharon is about twenty to thirty feet

thick in northern Ohio, but is absent in much of southern Ohio. In these areas the base of the Pottsville is placed near the base of the Sharon No. 1 coal.

The Pottsville Formation in Ohio consists primarily of thin to medium-bedded shales, siliceous clays and sandstones. Individual layers are 1 to 24 feet thick. Minor amounts of limestone (Lower and Upper Mercer limestones) and iron ore-bearing sands occur within the unit. Several thin and discontinuous coal units occur throughout the formation. Thicknesses of the coals range from a few inches to three feet.

The top of the unit is placed at the base of the Brookville coal where it is exposed, and near the top of the Homewood Sandstone where the Brookville is absent. However, since it is often difficult to identify either unit, the contact between the Pottsville and Allegheny formations is often arbitrarily located (Ettensohn, 1979).

Allegheny Formation

The Allegheny Formation overlies the Pottsville throughout eastern Ohio. It forms the resistant tops of hills across much of the Appalachian Plateaus. The formation is usually 160 to 200 feet thick (Maxey, 1940) and is up to 213 feet thick (Ettensohn, 1979).

The base of the Allegheny is placed at the Brookville Coal where it is present. The formation consists primarily of quartz sandstones with shale and clay. Individual layers are 1 to 33 feet thick. It also contains coal, limestone and minor zones of iron ore. The Allegheny is one of the major coal-bearing formations in the Appalachians. Coal layers are up to 4 feet thick and are more laterally continuous than those in the Pottsville. The

Vanport Limestone is a distinct six foot-thick marker unit about 60 feet above the base of the formation. The top of the Allegheny Formation is placed at the top of the Upper Freeport No. 7 coal.

3.4.2.2 Structure

The rocks of eastern Ohio are nearly flat lying. Structure contour maps of the region near the site show an eastward dip of about 20 to 40 feet per mile (Maxey, 1940).

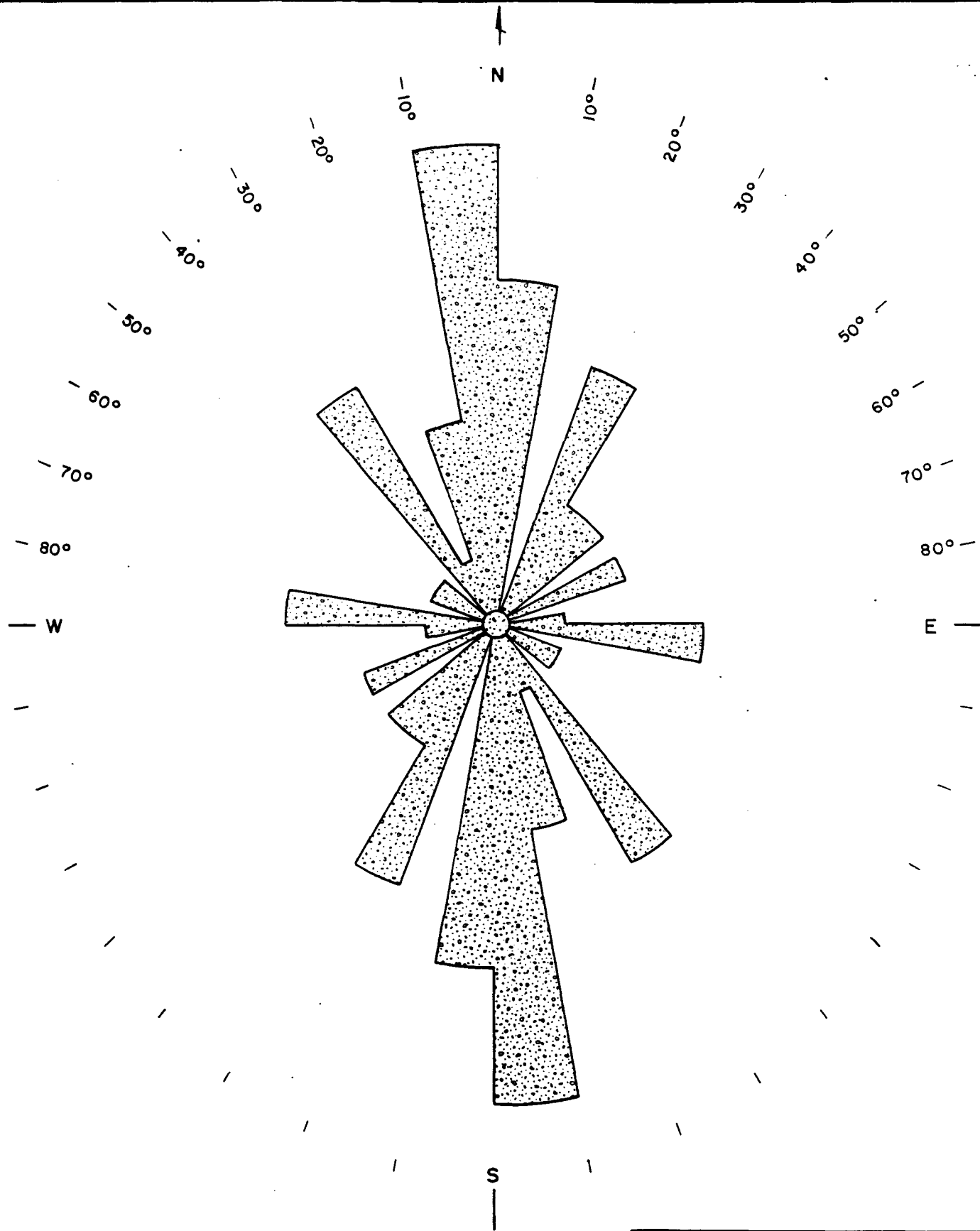
Based upon the site reconnaissance, bedding in the area of the site appears to be horizontal, except in local outcrops where it appears to dip gently where beds are pinching out or along cross-beds. Distinct fracture patterns were not common in the rocks observed. The shales and coal are relatively incompetent and tend to break irregularly into small fragments. The sandstones are competent and contain some bedding-plane fractures, but display few distinct high-angle joints. Table 18 summarizes bedrock joint orientation data. A rose diagram of joint orientations measured on exposed stratigraphic sections near the site (Figure 33) shows a weakly dominant set of north-striking joints. Other joint orientations occur randomly across the study area.

3.4.2.3 Mining Activity

Small, economic deposits of coal and iron ore occur in the vicinity of the study area. Where exposed, they have been mined in small pits and trenches along the sides of the hills. Waste rock was dumped directly down slope from the mines. The most extensive mining in the study area occurred along the Winkler Run tributary downstream from the

TABLE 18
MEASURED JOINT ORIENTATIONS

STRATIGRAPHIC SECTION A	N2°E72°SE
- U.S. 52 at Winkler Run Road	N8°W87°SW
	N0°E69°E
	N8°W79°NE
	N13°W77°NE
	N5°W83°NE
	N20°W70°NE
 STRATIGRAPHIC SECTION C	 N35°W70°NE
- Winkler Run North of Landfill	N90°E85°S
 STRATIGRAPHIC SECTION D	 N45°E72°SE
- North side of Landfill	N60°W90°
 Isolated outcrop at approximate site coordinates N7050 E23100	 N8°W82°SW
 STRATIGRAPHIC SECTION H	 N30°E83°NW
- U.S. 52 at Norman Run	N30°W90°
	N25°E35°SE
	N65°E85°SE
	N85°W82°NE
	N35°W87°SW



NUMBER OF MEASURED JOINTS = 18
 SCALE : 1" = 1 MEASURED JOINT

FIGURE 33
ROSE DIAGRAM OF MEASURED JOINT ORIENTATIONS
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base of the landfill. These activities have disrupted the natural shape of the topography, leaving pits, benches and mounds of mine spoil on the hillsides.

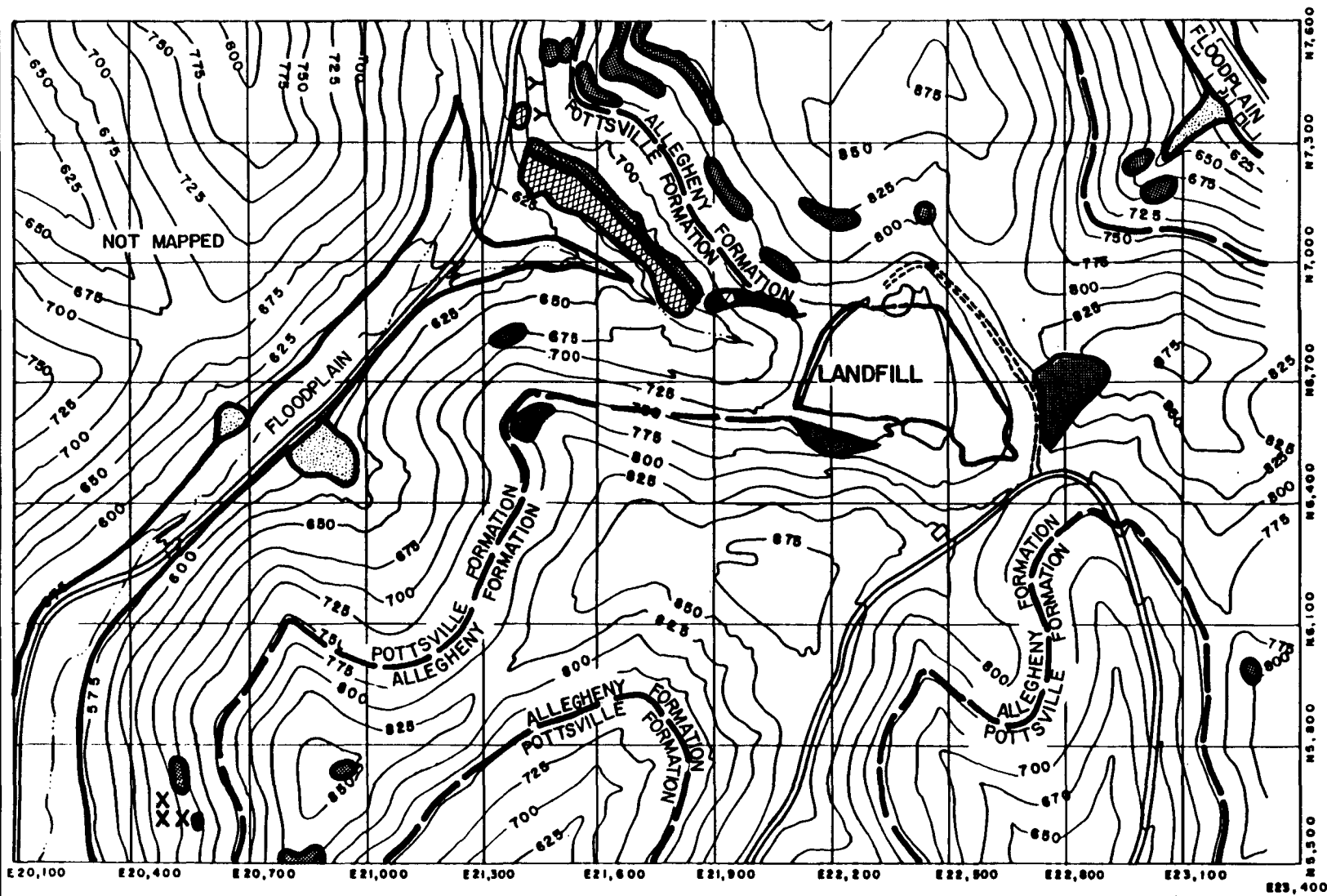
3.4.3 Site Hydrogeology

3.4.3.1 Site Stratigraphy



Eight significant stratigraphic sections were measured in the study area during the geologic mapping effort. The site reconnaissance confirmed the presence of Pennsylvanian bedrock formations in the study area. The Pottsville Formation occurs on the lower slopes of the hills, while the Allegheny Formation occurs on the upper slopes and tops of the hills. The estimated interface of the major formations is shown on Figure 34. Recent surficial soil and rock deposits were noted along the valley floors. Detailed descriptions of each section are presented in Appendix B3.

The subsurface stratigraphy in the study area generally consists of a soil profile grading into a partially weathered rock zone to bedrock below. The soil is formed from in-situ weathering of the parent rock material. Colluvium is found along the valley bottoms.



The depth to bedrock encountered in borings within the study area varied from about 1 foot (MW-04) to 20 feet (MW-01 and MW-06), with typical values ranging from 5 to 10 feet. Bedrock at the site is composed of alternating sandstone and shale with thin discontinuous coal seams. The sandstone and shale layers vary from less than 1 foot in thickness to greater than 30 feet, but typically range from 20 to 25 feet. Appendix B3 of this report provides Test Borings Records with detailed descriptions of lithologies encountered in each of the site well borings.



QUATERNARY UNITS

-  FLOODPLAIN
-  ALLUVIAL FAN

PENNSYLVANIAN POTTSVILLE & ALLEGHENY FORMATIONS

-  SANDSTONE
-  SHALE

SYMBOLS







-  CONTACT OR EDGE OF OUTCROP
-  APPROX. CONTACT
-  ADIT
-  OPEN-PIT MINE
-  MINE WASTE PILE
-  PROSPECT

FIGURE 34

GEOLOGIC MAP OF STUDY AREA

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Pottsville Formation

The upper part of the Pottsville Formation is well exposed in cliffs along the floodplain of the Ohio River. A few small outcrops occur on the slopes around the site. These are primarily small exposures of more resistant sandstone on the steeper slopes. Gentler slopes are often developed where the bedrock is shale. Thus, an apparent bench and slope topography has developed around the site. This has been accentuated where coal layers have been mined along the benches.

The rocks in this area are primarily sandstone and shale with minor coal. The sandstones are light brown to yellowish brown on exposed outcrops and light gray in the unweathered core. Layers vary from fine sand to medium and coarse sand. The composition is predominantly quartz with low to moderate amounts of feldspar. Micaceous sandstone layers occur within the unit, with mica concentrations and frequency increasing higher in the unit. The sands are often limonite stained. Irregular thin zones of hematite-replaced sandstone occur throughout the unit. In a few places the alteration has been extensive enough to form a minable quantity of iron ore. Layers are thinly to thickly bedded, and cross-beds are often present.

The shales are usually light to medium gray and weather to brown. In outcrops they are very thinly bedded to fissile, while in core they may appear as fissile shales or massive mudstones. Some layers are fine sandy shale or shaley sandstone.

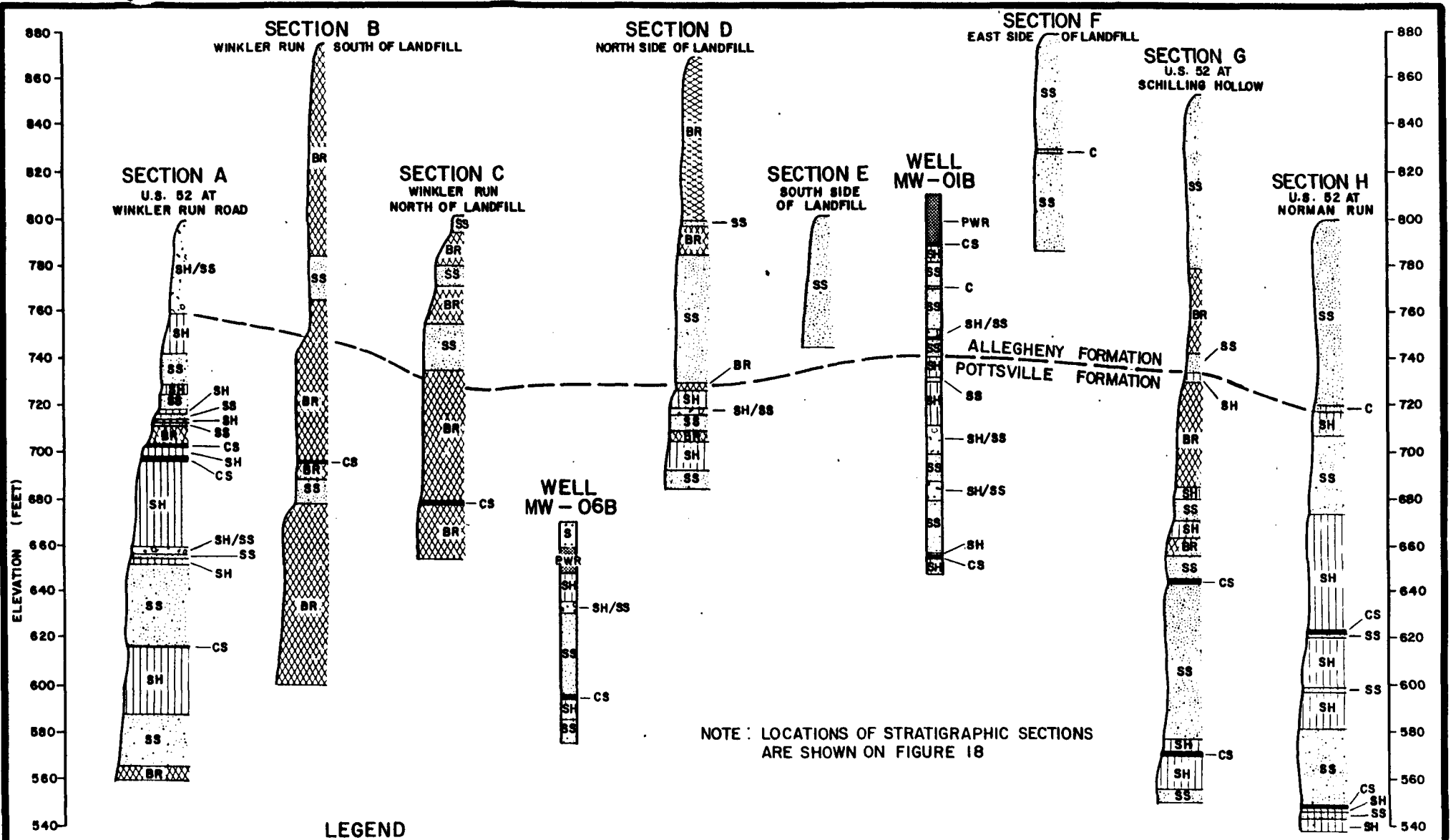
Coal layers occur irregularly throughout the study area. They are a few inches up to about one foot thick. They consist of black bituminous coal and shaley coal.

The repetition of the sequence of sandstone, shale and coal throughout the Pottsville Formation is typical of the terrestrial portion of a cyclothem. The marine portion of the sequence was not identified in the study area. Individual layers within the Pottsville are laterally discontinuous, pinching out or interfingering with other layers. This is most obvious in the different elevations at which coal has been mined across the site. This vertical and lateral variability and repetition of lithologies is typical of the rapid cyclic changes in sea level that caused the deposition of the cyclothem during the Pennsylvanian. Thus, the lateral extent of individual layers cannot be predicted, and they cannot be reliably correlated across the site. Figure 35 illustrates the correlation of measured stratigraphic sections and well core logs in the study area.

Allegheny Formation

The Allegheny Formation occurs throughout the area above an elevation of about 720 to 760 feet. The rocks are exposed in outcrops along the Ohio River floodplain and near the tops of the ridges. Slopes are moderate to steep, and small ledges and vertical cliffs of sandstone occur occasionally on the slopes. Honeycomb weathering of the sandstone has occurred on some natural outcrops near the top of the ridges.

The rocks of the Allegheny Formation are lithologically similar to those of the Pottsville, but are predominantly sandstone with minor conglomerate, shale and coal. Sandstones are fine to coarse-grained, thinly to thickly bedded, frequently cross-bedded, and



NOTE: LOCATIONS OF STRATIGRAPHIC SECTIONS ARE SHOWN ON FIGURE 18

FIGURE 35

CORRELATION OF STRATIGRAPHIC SECTIONS

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occasionally micaceous. They contain a few layers up to one foot thick of dark reddish-brown conglomerate with up to one-inch diameter quartz pebbles and a hematite-replaced matrix. Shales are gray to brown, fissile, and are often fine sandy, slightly carbonaceous shales. Coal layers are up to one foot thick and are bituminous or shaley coal. The Vanport Limestone was not observed in this area.

The contact between the Pottsville and Allegheny formation is reportedly difficult to identify and is often arbitrarily placed (Frey, 1979). A lithologic contact has been placed at the top of the highest significant shale layer in each measured section or core sample (Figure 35). This contact approximately corresponds in elevation with the Pottsville-Allegheny contact of Maxey (1940).

Surficial Deposits

Quaternary (recent age) surficial deposits occur along the valley floors of Winkler Run and Norman Run. Two types of deposits are identifiable based on their geomorphologies: alluvial fans and floodplain alluvium. The alluvial fans are recognized by gently-sloping, cone-shaped deposits along the sides of the valleys where steeply-flowing gullies empty onto the floodplains. The deposits consist of poorly-sorted, unconsolidated pebbles and cobbles in a fine to coarse-grained sand matrix. Pebbles and cobbles are primarily eroded fragments of sandstone with minor shale. The toes of the alluvial fans are gradational into the floodplain alluvium. The floodplain deposits fill the valley floors to a thickness of several feet with poorly to moderately sorted and stratified, unconsolidated sand and gravel.

3.4.3.2 Subsurface Water-Bearing Zones

Air rotary drilling techniques used for well installation were useful in delineating water-bearing zones in the subsurface. These zones were generally distinguished by the drill cuttings becoming moist; only in a few instances did water actually come up the borehole during drilling. In most cases the water-bearing zones were encountered in sandstone units near the top of an underlying shale. For the deeper well boring of each cluster ('B' well), the upper zone was sealed off with steel casing prior to drilling further to a lower zone. Once the upper zone was sealed, cuttings (usually shale) were generally very dry until the lower zone was reached. Well logs shown in Appendix B3 indicate the depths at which water was encountered during drilling.

3.4.3.3 Rock Competency

Core drilling procedures were utilized to determine the character and competency of the bedrock at the site. Coring was performed with an NX-size barrel in general accordance with ASTM Method D2113-83. Core runs were generally ten feet. Upon completion of each run, the inner barrel was brought to the surface and the core removed and placed in wooden boxes. Samples were examined and logged with respect to lithology and competency characteristics by a field geologist.

Rock competency was determined from recovery and rock quality designation (RQD). Recovery is the ratio of the sample length obtained to the length of the core run as a percentage. RQD is the percentage of the length of core with segments four or more inches in length compared to the total run length. Coring was performed at MW-01B and MW-06 core.

In MW-01B, coring began at a depth of 23.7 feet and terminated at 163.3 feet. Core recovery was excellent, ranging from 87% to 100% with 16 of the 18 total core runs having greater than 95% recovery (Table 19A). RQD values ranged from 69% to 100%.

Deere (1964) proposed a ranking system for rock competency based on RQD:

- 90% to 100% - Excellent
- 75% to 90% - Good
- 50% to 75% - Fair
- 25% to 50% - Poor

Of the 18 runs performed on MW-01B, 13 runs indicated 'excellent' rock competency, 4 were 'good' and 1 'fair'. Table 19B provides the data for MW-06 core, which exhibits quality characteristics similar to MW-01B.

Breakage in the rock tended to occur along natural bedding planes, especially within the shale units. No vertical or high angle jointing was evident in the core. Based on the high recovery and RQD of the core, it is evident that bedrock is very competent and tight with little secondary permeability development (i.e. fractures, joints).

3.4.3.4 Rock Permeability

Packer testing was performed within the two coreholes as a means of obtaining a semi-quantitative estimate of the permeability of the various rock types encountered in the

TABLE 19A
CORING DATA: MW-01B

RUN NO.	DEPTH INTERVAL (feet)	ELEVATION (ft. N.G.V.D.)	RUN LENGTH (feet)	CORE REC. (feet)	% CORE REC.	RQD (feet)	% RQD
1	23.76 - 32.89	787.04 - 777.91	9.13	7.95	87%	7.50	94%
2	33.89 - 42.9	777.91 - 767.90	10.01	9.67	97%	7.40	77%
3	42.9 - 52.9	767.90 - 757.90	10.0	9.28	93%	7.60	82%
4	52.9 - 62.9	757.90 - 747.90	10.0	10.00	100%	8.30	83%
5	62.9 - 72.9	747.90 - 737.90	10.0	10.00	100%	10.00	100%
6	72.9 - 82.9	737.90 - 727.90	10.0	9.96	99.6%	9.21	92%
7	82.9 - 88.5	727.90 - 722.30	5.6	5.60	100%	4.95	88%
8	88.5 - 93.5	722.30 - 717.30	5.0	4.85	97%	4.85	100%
9	93.5 - 98.8	717.30 - 712.00	5.3	5.30	100%	5.30	100%
10	98.8 - 103.7	712.00 - 707.10	4.9	4.90	100%	4.50	92%
11	103.7 - 113.7	707.10 - 697.10	10.0	10.00	100%	10.00	100%
12	113.7 - 118.8	697.10 - 692.00	5.1	5.10	100%	5.00	98%
13	118.8 - 123.65	692.00 - 687.15	4.85	4.85	100%	4.85	100%
14	123.65 - 124.9	687.15 - 685.90	1.25	1.25	100%	1.25	100%
15	124.9 - 132.55	685.90 - 678.25	7.65	7.65	100%	7.20	94%
16	132.55 - 142.72	678.25 - 668.08	10.17	10.17	100%	9.15	90%
17	142.72 - 152.76	668.08 - 658.04	10.04	10.04	100%	9.84	98%
18	152.76 - 163	658.04 - 647.80	10.0	10.0	100%	4.90	47% (1)
			10.0	7.10	—	4.90	69% (2)

(1),(2): The run length was approximately 10 feet. However, the lower 3 feet of the recovered core received substantial mechanical breakage during removal from the core barrel. The RQD% reported in (2) is based upon a core recovery of 7.10 above the area of mechanical breakage.

TABLE 19B
CORING DATA: MW-06 core

RUN NO.	INTERVAL (feet)	ELEVATION (ft., M.G.V.D.)	RUN LENGTH (feet)	CORE REC. (feet)	% CORE REC.	RQD (feet)	% RQD
1	20.0 - 22.3	651.20 - 648.90	2.3	2.30	100%	1.80	78%
2	22.3 - 32.3	648.90 - 638.90	10.0	8.00	80%	7.80	97.5%
3	32.3 - 42.2	638.90 - 629.00	9.9	9.93	100%	8.73	88%
4	42.2 - 52.3	629.00 - 618.90	10.1	10.10	100%	10.10	100%
5	52.3 - 62.4	618.90 - 608.80	10.1	10.10	100%	10.10	100%
6	62.4 - 72.3	608.80 - 598.90	9.9	9.90	100%	9.90	100%
7	72.3 - 82.2	598.90 - 589.00	9.9	9.93	100%	9.03	91%
8	82.2 - 84.5	589.00 - 586.70	2.3	(1)	(1)	(1)	(1)
9	84.5 - 94.5	586.70 - 576.70	10.0	10.00	100%	10.00	100%

(1) Very little rock core was recovered from run #8 due to clogging in the core barrel and subsequent mechanical breakage of the rock.

subsurface. A double packer was used to test discrete 10-foot sections in the corehole. Specific test procedures are outlined in Appendix A3.

Table 20 summarizes the packer test results. Permeabilities of the rock varied from 1×10^{-4} cm/sec to 'no take'. In general, the shale units exhibited about one order of magnitude lower permeability than the sandstone. Shale permeability approximations range from 1.5×10^{-4} cm/sec (test section was partially within a weathered shale zone) to 'no take', with an average of about 1×10^{-6} cm/sec. Sandstone permeabilities were from 1.2×10^{-4} cm/sec to 'no take' and averaged about 1×10^{-5} cm/sec. Appendix B3 contains field data and calculations pertaining to the packer testing.

3.4.3.5 Ground-Water Levels

Water levels were measured in all site monitoring wells (and piezometers) on June 6, 1988 after development work was completed and prior to sampling. Ground-water levels were measured again on June 21, 1988 approximately two weeks following the sampling work. This measurement episode marks the beginning of the monthly monitoring (for a one-year period) required by the scope of work in the Phase I RI Sampling Plan. In accordance with the monitoring schedule, water levels were measured approximately monthly thereafter up to May, 1988. Table 21 summarizes the monthly water-level measurements.

As seen on Table 21, large differences in ground-water elevations exist between the shallow and deep wells of each cluster pair. The magnitude of this difference ranges from approximately 20 feet in well cluster MW-07 to 65 feet in well cluster MW-03. These data

TABLE 20

SUMMARY OF PACKER TEST RESULTS

BORING NO.	INTERVAL (feet)	PERMEABILITY APPROXIMATION (cm/sec)	TEST PRESSURE (psi)	(Predominant) LITHOLOGY TESTED
MW-01B	50.5 - 60.5	1.2×10^{-4}	53.7	SANDSTONE
	60.5 - 70.5	1.8×10^{-5}	53.7	SANDSTONE
	70.5 - 80.5	6.8×10^{-6}	53.7	SHALE
	80.5 - 90.5	6.6×10^{-6}	63.7	SHALE
	89.5 - 99.5	NO TAKE	53.7	SHALE
	100.5 - 110.5	1.4×10^{-4}	53.7	SHALE
	110.5 - 120.5	8.7×10^{-5}	62.0	SANDSTONE
	110.5 - 120.5	1.8×10^{-5}	53.7	
	121.0 - 131.0	1.4×10^{-5}	87.6	SHALE AND SANDSTONE
	131.0 - 141.0	6.2×10^{-6}	85.9	SANDSTONE
	141.0 - 151.0	2.7×10^{-5}	83.2	SANDSTONE
151.0 - 161.0	NO TAKE	92.9	SHALE AND SANDSTONE	
MW-06B	23.1 - 33.1	1.5×10^{-4}	45.8	SHALE/PWR
	29.1 - 39.1	7.1×10^{-5}	58.5	SHALE AND SANDSTONE
	39.1 - 49.1	NO TAKE	73.5	SANDSTONE
	49.1 - 59.1	NO TAKE	68.5	SANDSTONE
	59.1 - 69.1	1.1×10^{-4}	68.5	SANDSTONE
	69.1 - 79.1	9.8×10^{-6}	58.5	SHALE AND SANDSTONE

Table 21
Summary of Ground-Water Elevations
1988-89 Data

Sampling Date	MW-1A	MW-1B	MW-2A	MW-2B	MW-3A	MW-3B	MW-4A	MW-4B	MW-5A	MW-5B	MW-6A	MW-6B
** Depth to Ground-Water (feet)												
06/06/88	DRY	136.05	84.34	105.81	6.45	72.81	27.41	44.58	116.76	176.01	7.36	66.56
06/21/88	DRY	135.98	84.71	105.34	6.48	72.68	26.76	44.24	116.92	176.01	7.73	47.09
07/20/88	DRY	136.10	DRY	105.45	7.43	72.79	25.56	44.52	117.32	176.12	6.88	47.38
08/20/88	DRY	135.96	85.00*	105.33	7.53	72.56	22.10	44.53	117.37	175.99	5.69	47.27
09/19/88	DRY	136.28	85.00*	105.67	8.00	72.79	18.88	44.83	117.80	176.31	7.44	47.31
10/18/88	DRY	136.37	DRY	105.77	8.46	72.78	16.51	45.03	118.01	176.41	6.91	47.44
11/17/88	DRY	136.78	DRY	106.07	8.45	73.21	14.94	45.40	118.38	176.78	6.99	47.30
12/12/88	DRY	136.90	DRY	106.30	7.67	73.30	13.75	45.22	118.50	176.94	7.17	47.08
01/12/89	DRY	136.57	DRY	105.94	4.12	72.99	21.61	45.08	118.52	176.62	5.15	46.98
02/23/89	DRY	136.44	DRY	105.83	2.69	73.08	17.66	43.88	117.96	176.61	5.21	45.91
03/11/89	DRY	136.19	DRY	105.71	2.65	72.87	16.32	44.01	117.52	176.44	5.79	45.95
04/20/89	DRY	136.01	DRY	105.54	2.51	72.80	13.43	43.55	116.72	176.34	6.03	45.84
05/16/89	DRY	135.72	DRY	105.19	2.09	72.63	11.87	43.16	115.99	176.03	5.02	44.99
** Ground-Water Elevation (feet NGVD)												
06/06/88	DRY	677.29	711.99	693.50	742.74	677.03	724.86	707.53	755.37	697.12	666.02	607.62
06/21/88	DRY	677.36	711.62	693.97	742.71	677.16	725.51	707.87	755.21	697.12	665.65	627.09
07/20/88	DRY	677.24	DRY	693.86	741.76	677.05	726.71	707.59	754.81	697.01	666.50	626.80
08/20/88	DRY	677.38	711.33*	693.98	741.66	677.28	730.17	707.58	754.76	697.14	667.69	626.91
09/19/88	DRY	677.06	711.33*	693.64	741.19	677.05	733.39	707.28	754.33	696.82	665.94	626.87
10/18/88	DRY	676.97	DRY	693.54	740.73	677.06	735.76	707.08	754.12	696.72	666.47	626.74
11/17/88	DRY	676.56	DRY	693.24	740.74	676.63	737.33	706.71	753.75	696.35	666.39	626.88
12/12/88	DRY	676.44	DRY	693.01	741.52	676.54	738.52	706.89	753.63	696.19	666.21	627.10
01/12/89	DRY	676.77	DRY	693.37	745.07	676.85	730.66	707.03	753.61	696.51	668.23	627.20
02/23/89	DRY	676.90	DRY	693.48	746.50	676.76	734.61	708.23	754.17	696.52	668.17	628.27
03/11/89	DRY	677.15	DRY	693.60	746.54	676.97	735.95	708.10	754.61	696.69	667.59	628.23
04/20/89	DRY	677.33	DRY	693.77	746.68	677.04	738.84	708.56	755.41	696.79	667.35	628.34
05/16/89	DRY	677.62	DRY	694.12	747.10	677.21	740.40	708.95	756.14	697.10	668.36	629.19

* Note: Appropriate measurement based on length of wetted plumb bob.

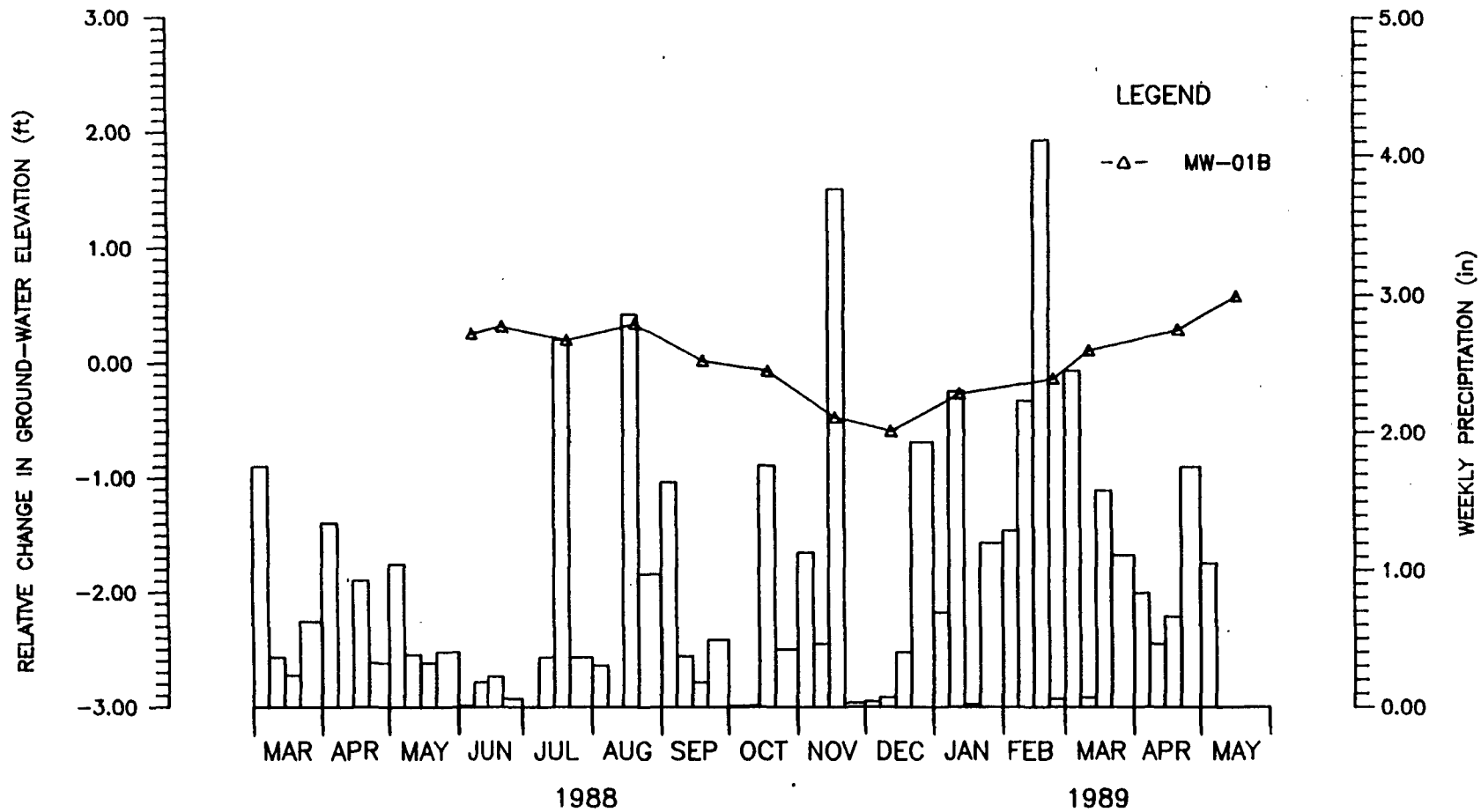
Table 21 (cont.)
 Summary of Ground-Water Elevations
 1988-89 Data

Sampling Date	MW-7A	MW-7B	MW-8A	MW-8B	BO-01	BO-02	BO-03	BO-04	BO-05	BO-06	BO-07	BO-08
** Depth to Ground-Water (feet)												
06/06/88	7.15	29.56	11.82	65.08	9.62	10.53	2.62	3.01	8.08	8.57	13.03	10.19
06/21/88	7.70	29.50	12.08	62.58	9.66	10.64	1.81	3.25	8.13	8.75	13.21	10.44
07/20/88	7.42	30.41	12.60	62.87	10.29	11.29	1.69	3.43	8.78	9.57	13.90	10.98
08/20/88	6.12	29.49	12.53	62.60	10.50	11.46	1.62	3.19	8.94	10.16	13.70	10.66
09/19/88	7.48	29.01	12.42	62.92	10.69	11.66	2.52	2.59	9.09	10.95	13.60	10.57
10/18/88	7.63	29.46	12.80	63.02	11.15	12.18	4.19	2.74	9.60	11.65	14.51	11.35
11/17/88	7.02	28.31	12.87	63.37	11.57	12.47	5.42	2.92	9.93	12.36	14.16	10.85
12/12/88	6.87	27.25	12.50	63.58	--	--	--	--	--	--	--	--
01/12/89	5.60	26.84	11.63	63.29	10.29	11.21	4.75	2.74	8.98	10.85	13.03	9.92
02/23/89	5.48	25.72	10.27	63.29	8.85	9.80	3.87	1.50	7.21	8.10	13.44	6.50
03/11/89	5.56	25.65	9.74	63.16	8.08	9.02	3.03	1.44	6.45	7.85	13.23	10.05
04/20/89	5.59	25.71	9.57	62.98	7.22	8.14	1.17	1.19	5.61	7.10	12.48	9.42
05/16/89	5.54	25.39	9.55	61.71	6.54	7.64	1.17	1.18	5.17	5.89	11.67	8.89
** Ground-Water Elevation (feet NGVD)												
06/06/88	629.63	607.74	749.60	696.75	733.84	734.16	719.08	701.24	734.28	735.43	700.08	693.56
06/21/88	629.08	607.80	749.34	699.25	733.80	734.05	719.89	701.00	734.23	735.25	699.90	693.31
07/20/88	629.36	606.89	748.82	698.96	733.17	733.40	720.01	700.82	733.58	734.43	699.21	692.77
08/20/88	630.66	607.81	748.89	699.23	732.96	733.23	720.08	701.06	733.42	733.84	699.41	693.09
09/19/88	629.30	608.29	749.00	698.91	732.77	733.03	719.18	701.66	733.27	733.05	699.51	693.18
10/18/88	629.15	607.84	748.62	698.81	732.31	732.51	717.51	701.51	732.76	732.35	698.60	692.40
11/17/88	629.76	608.99	748.55	698.46	731.89	732.22	716.28	701.33	732.43	731.64	698.95	692.90
12/12/88	629.91	610.05	748.92	698.25	--	--	--	--	--	--	--	--
01/12/89	631.18	610.46	749.79	698.54	733.17	733.48	716.95	701.51	733.38	733.15	700.08	693.83
02/23/89	631.30	611.58	751.15	698.54	734.61	734.89	717.83	702.75	735.15	735.90	699.67	697.25
03/11/89	631.22	611.65	751.68	698.67	735.38	735.67	718.67	702.81	735.91	736.15	699.88	693.70
04/20/89	631.19	611.59	751.85	698.85	736.24	736.55	720.53	703.06	736.75	736.90	700.63	694.33
05/16/89	631.24	611.91	751.87	700.12	736.92	737.05	720.53	703.07	737.19	738.11	701.44	694.86

support findings cited in Section 3.4.3.2 of this report that separate, vertically stratified water-bearing zones exist at the site.

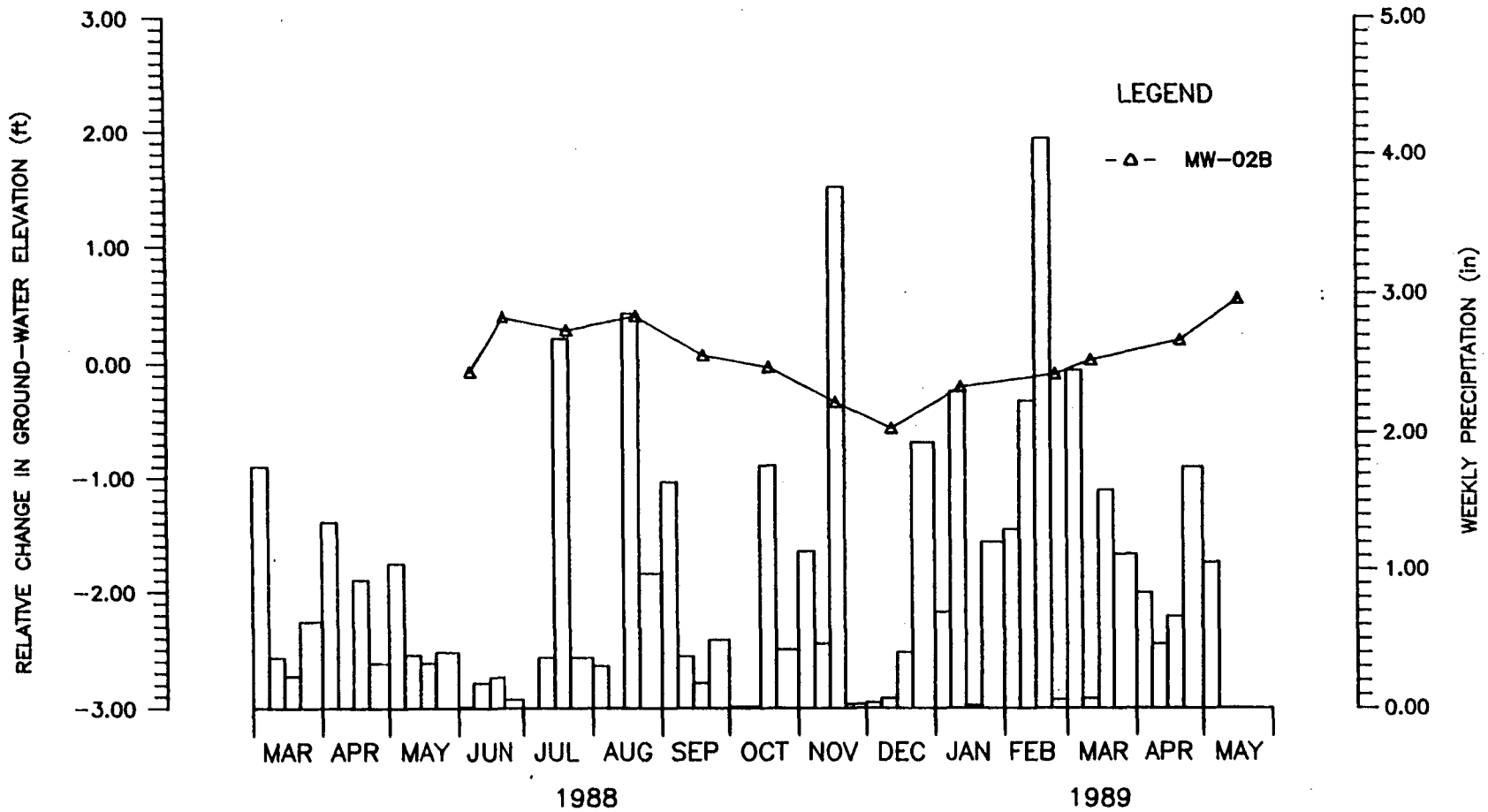
Hydrographs depicting relative temporal changes in ground-water elevations for each well cluster pair have been prepared (Figures 36A to 36H). Relative changes were computed by subtracting the monthly elevation measurements from the median for each well, so that both wells of a cluster could be displayed on the same hydrograph. Weekly on-site precipitation totals are superimposed on the graphs (heights of bars) to allow correlation of water-level trends with seasonal rainfall. Several key points are evident:

- o The shallow well of each cluster generally exhibits a greater fluctuation in water levels than the deep well. In the shallow wells, the annual fluctuation ranged from 1.80 feet in well MW-05A to 5.95 feet in well MW-03A. In the deep wells, the annual fluctuation ranged from 0.94 feet in well MW-01B to 4.76 feet in well MW-07B.
- o Most wells experienced a steady decline in water levels during the summer and fall months in response to lesser rainfall amounts. A steady rise in ground-water levels corresponds to greater precipitation volume in the winter and spring.
- o Wells MW-06A and MW-07A show a rather erratic temporal pattern of water-level fluctuations. Anomalous peaks occur for July 20, August 20, and October 18, 1988 (well MW-06A only) and January 12, 1989 superimposed



NOTE : WELL MW-01A HAS BEEN DRY SINCE JUNE 1988

FIGURE 36 A
 HYDROGRAPH OF GROUND-WATER
 ELEVATION AND PRECIPITATION
 WELL CLUSTER MW-01
 E.H. SCHILLING LANDFILL



NOTE : WELL MW-02A HAS BEEN DRY SINCE JULY 1988

FIGURE 36 B
 HYDROGRAPH OF GROUND-WATER
 ELEVATION AND PRECIPITATION
 WELL CLUSTER MW-02
 E.H. SCHILLING LANDFILL

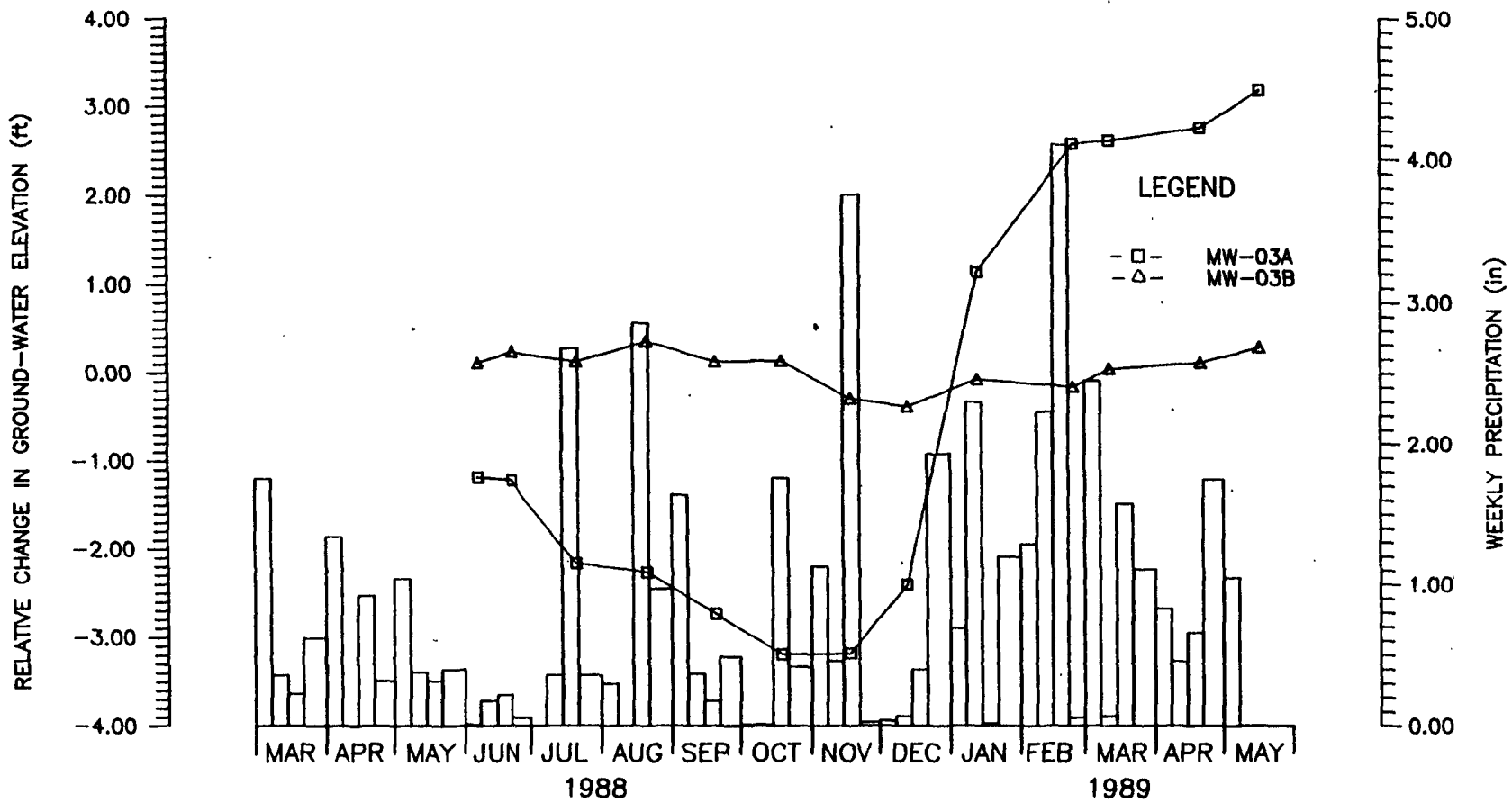
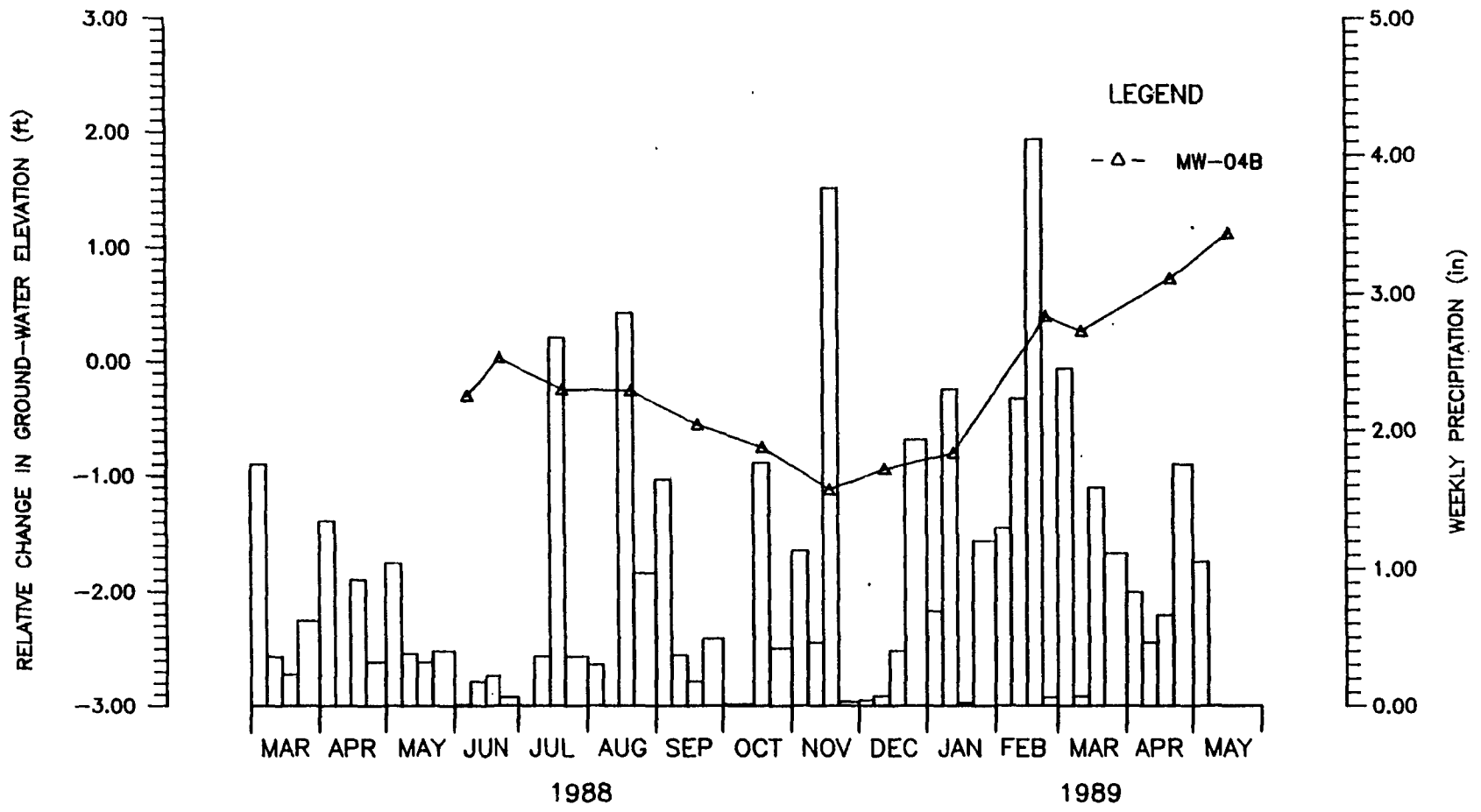


FIGURE 36 C

HYDROGRAPH OF GROUND-WATER
ELEVATION AND PRECIPITATION
WELL CLUSTER MW-03

E. H. SCHILLING LANDFILL



NOTE : WELL MW-04A RECHARGED VERY SLOWLY AFTER SAMPLE PURGING EVENTS AND THEREFORE STATIC CONDITIONS WERE NOT MET FOR DEPICTION ON THE HYDROGRAPH

FIGURE 36 D
 HYDROGRAPH OF GROUND-WATER ELEVATION AND PRECIPITATION
 WELL CLUSTER MW-04
 E. H. SCHILLING LANDFILL

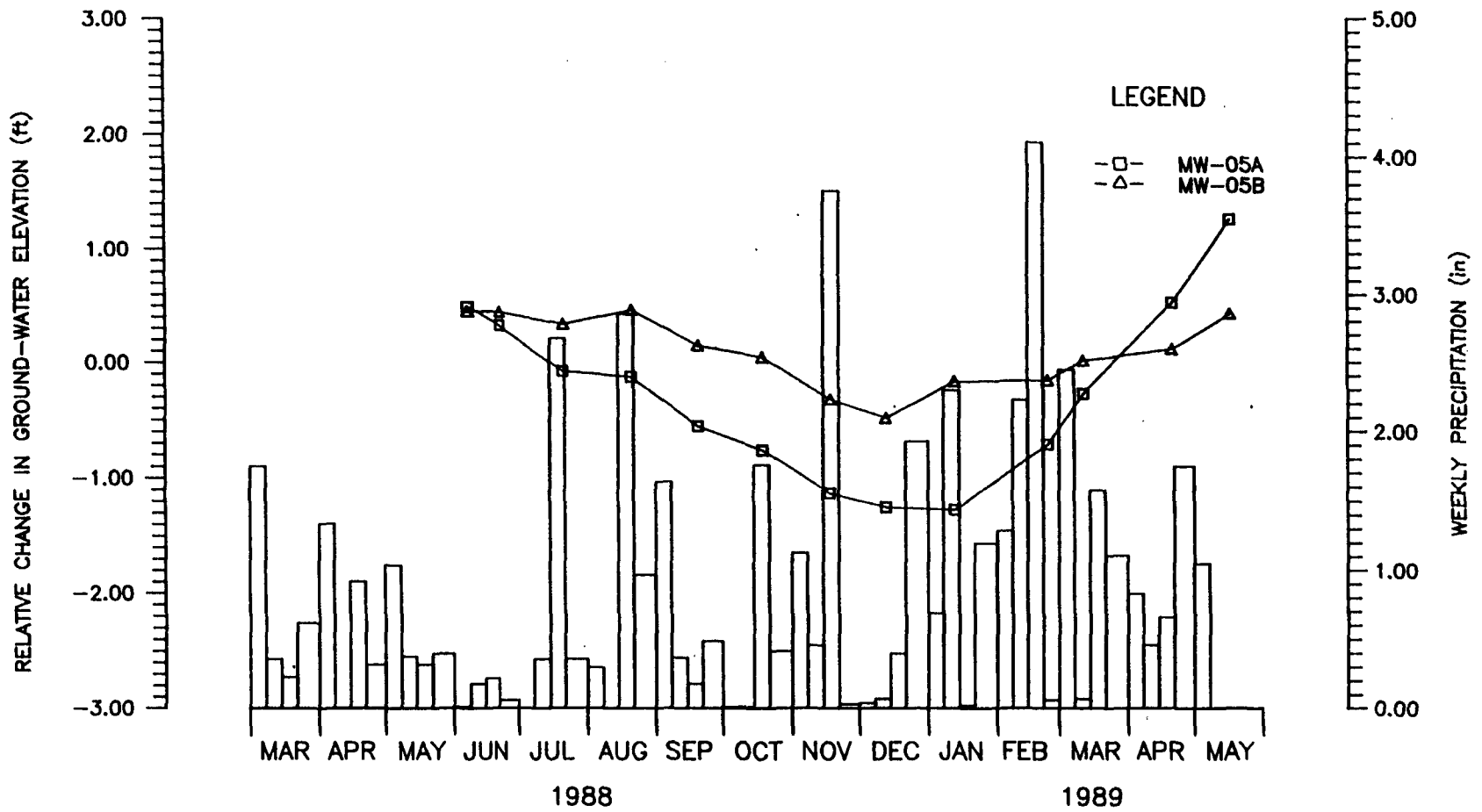


FIGURE 36 E

HYDROGRAPH OF GROUND-WATER
ELEVATION AND PRECIPITATION
WELL CLUSTER MW-05

E. H. SCHILLING LANDFILL

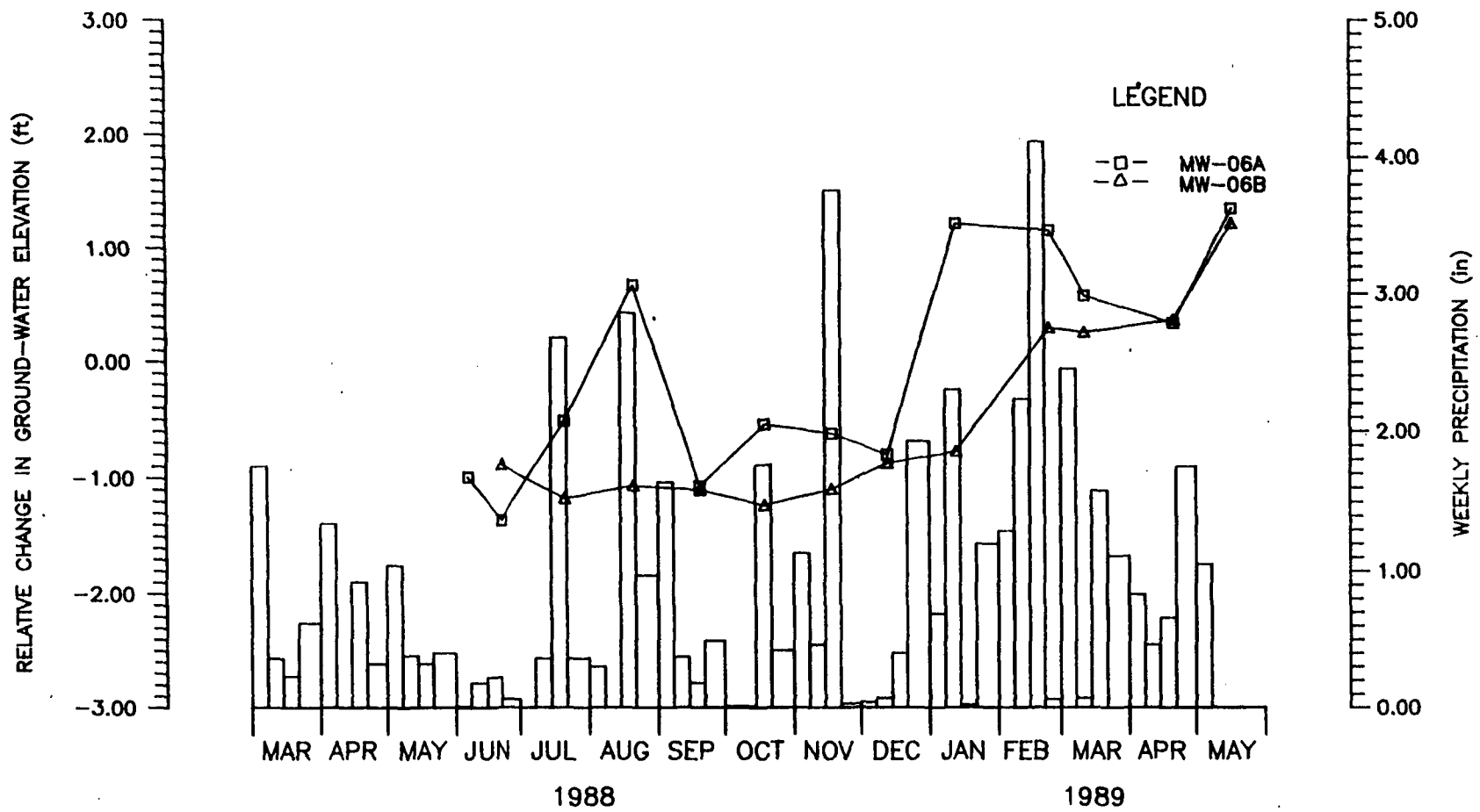


FIGURE 36 F

HYDROGRAPH OF GROUND-WATER
ELEVATION AND PRECIPITATION
WELL CLUSTER MW-06

E. H. SCHILLING LANDFILL

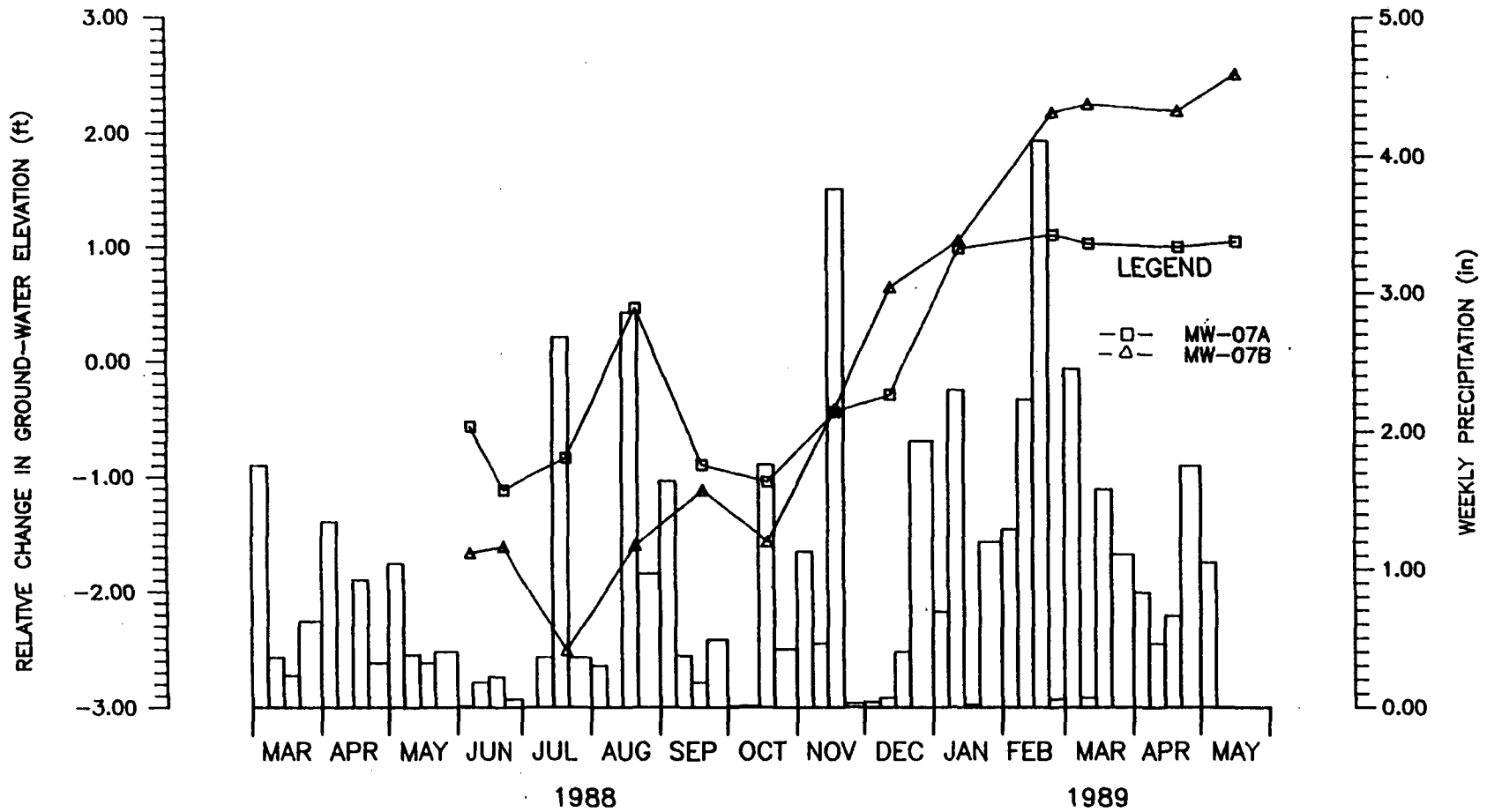


FIGURE 36 G
 HYDROGRAPH OF GROUND-WATER
 ELEVATION AND PRECIPITATION
 WELL CLUSTER MW-07
 E. H. SCHILLING LANDFILL

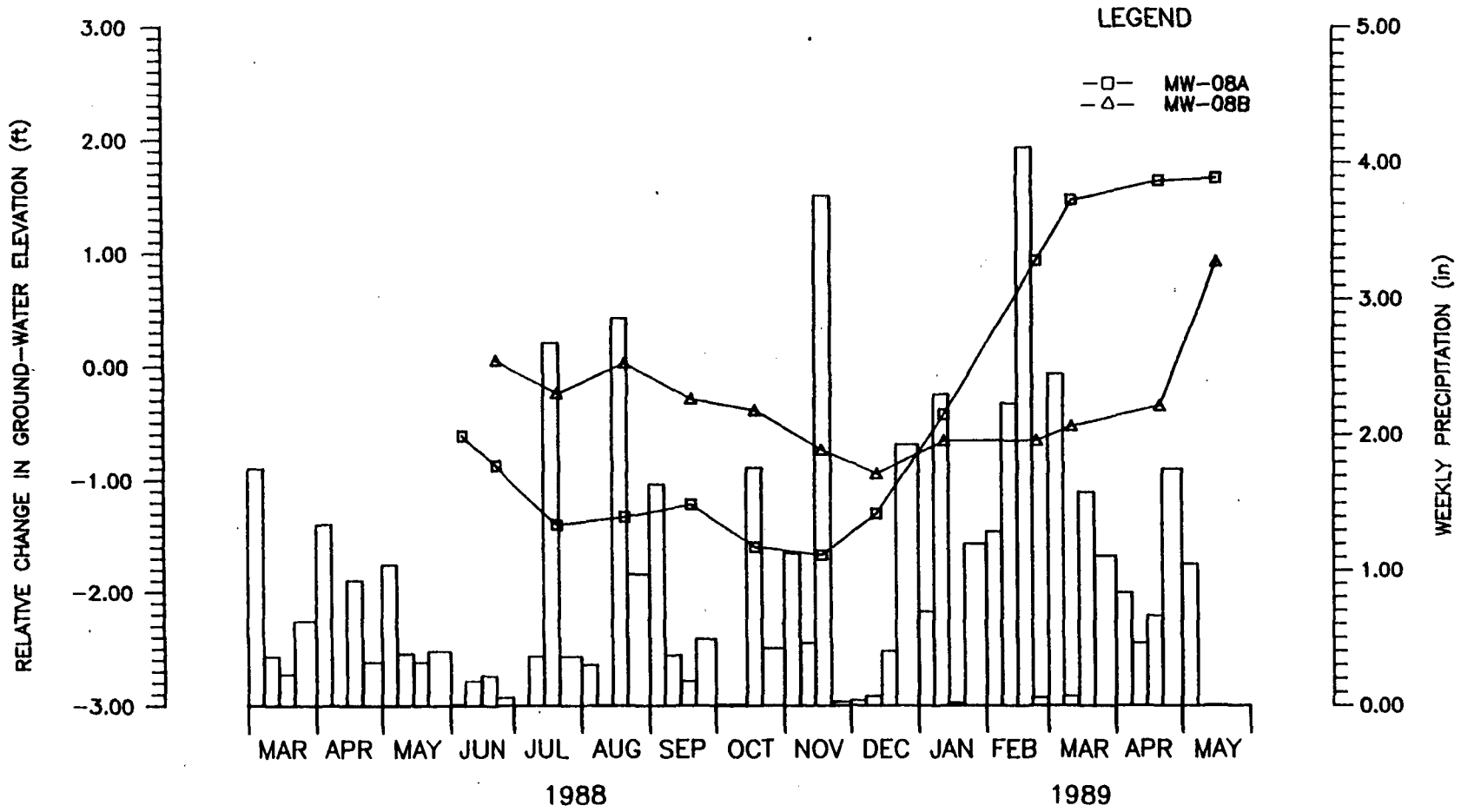


FIGURE 36 H
 HYDROGRAPH OF GROUND-WATER
 ELEVATION AND PRECIPITATION
 WELL CLUSTER MW-08
 E. H. SCHILLING LANDFILL

over the general trend. These peaks may be explained by the heavy rainfall on these dates:

July 20	2.95 in.
August 20	1.76 in.
October 18	0.51 in.
January 12	0.56 in.

These wells are screened in the shallow colluvium that has accumulated in the valley below the dam, and therefore are more likely to fluctuate with immediate climatic changes.

Well MW-01A has been dry ever since water-level measurements began on June 6, 1988, although water was encountered during drilling of the well in April. Likewise, well MW-02A became dry in July 1988 and has remained dry since.

All measurements were made using a chalked steel tape. Reading were taken to the nearest 0.01 foot. The top of well casing was used as a surveyed reference datum.

3.4.3.6 Ground-Water Flow Direction and Gradient

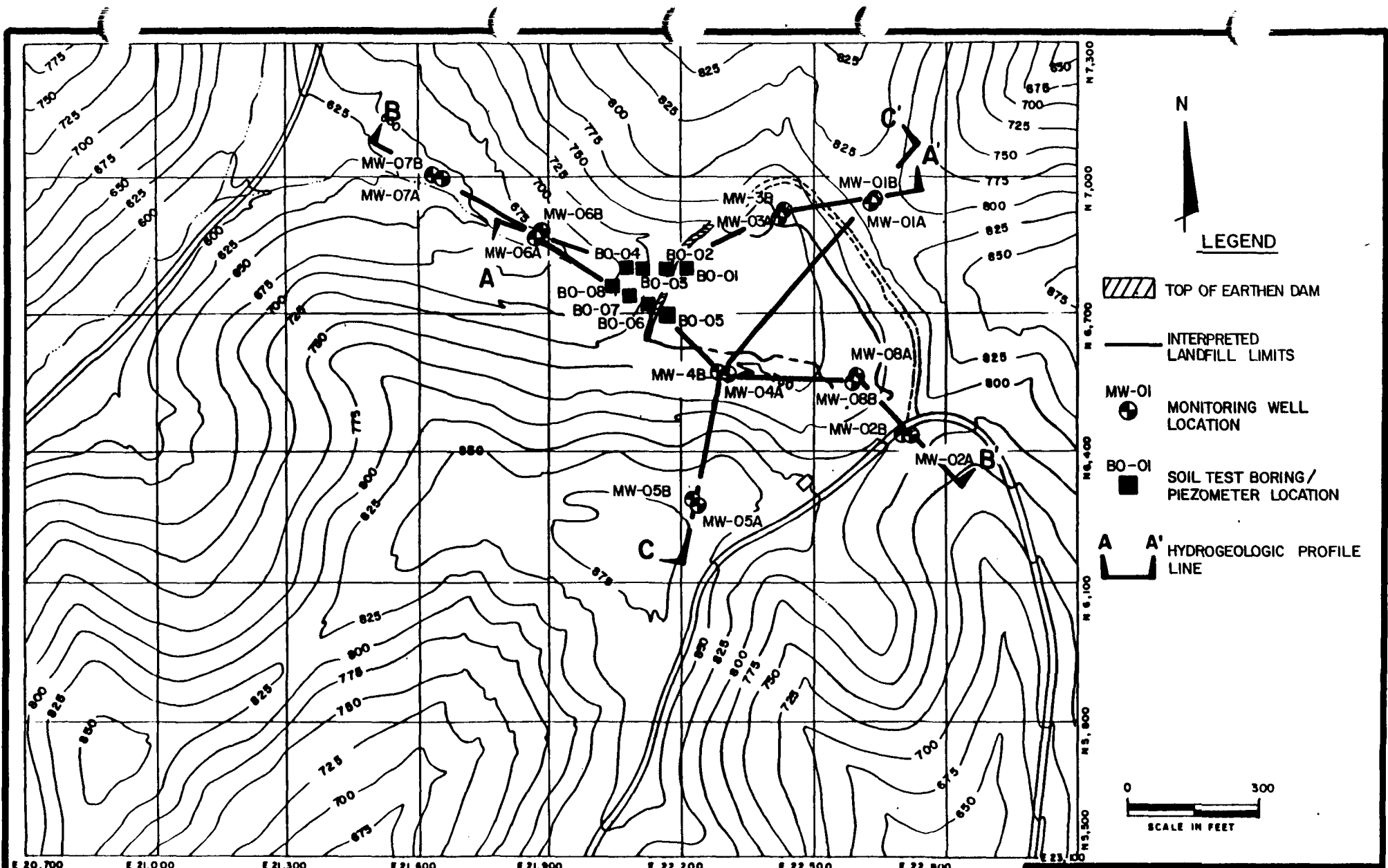
Hydrogeologic profiles are a useful means of graphically illustrating various aspects of ground-water flow as related to the geology, topography and other factors affecting the flow characteristics. Three profiles were prepared from the site monitoring well and soil test boring logs, two paralleling the major axis of the landfill valley and one transverse to it.

Figure 37 is a plan view of the three profiles, with vertical profiles shown on Figures 38 to 40.

Profile A-A' (Figure 38) includes wells MW-01, MW-03 and MW-06 and earthen dam borings BO-01 to BO-04. Parallel to this section along the southern portion of the site is profile B-B', which includes wells MW-02, MW-04, MW-06, MW-07, MW-08 and borings BO-05 to BO-08 (Figure 39). Profile C-C' includes wells MW-01, MW-04 and MW-05 (Figure 40).

These profiles show a frequent alternation in sandstone and shale layers in each boring. Correlations of layers are not drawn on the profiles and, due to lateral discontinuities of the layers, are believed not to exist. Water was typically encountered during drilling near the base of a sandstone overlying a shale layer, which is where the screen sections of the wells were installed. Due to lateral discontinuities in the stratigraphy, the screens are not at the same elevation from well to well. Another key point illustrated by the profiles is the large differences in ground-water elevations from the shallow to the deep well of each cluster pair.

Due to the complexities discussed above, it is not technically feasible to construct potentiometric surface maps of the ground-water elevation data. It is apparent that components of vertical and lateral ground-water flow exist. However, it is impossible to quantify the respective components of flow or gradient due to the variability in rock permeabilities measured in the two cored borings (MW-01B and MW-06 core) and the lack of permeability data for all other borings. The shales, however, act as confining units



LEGEND






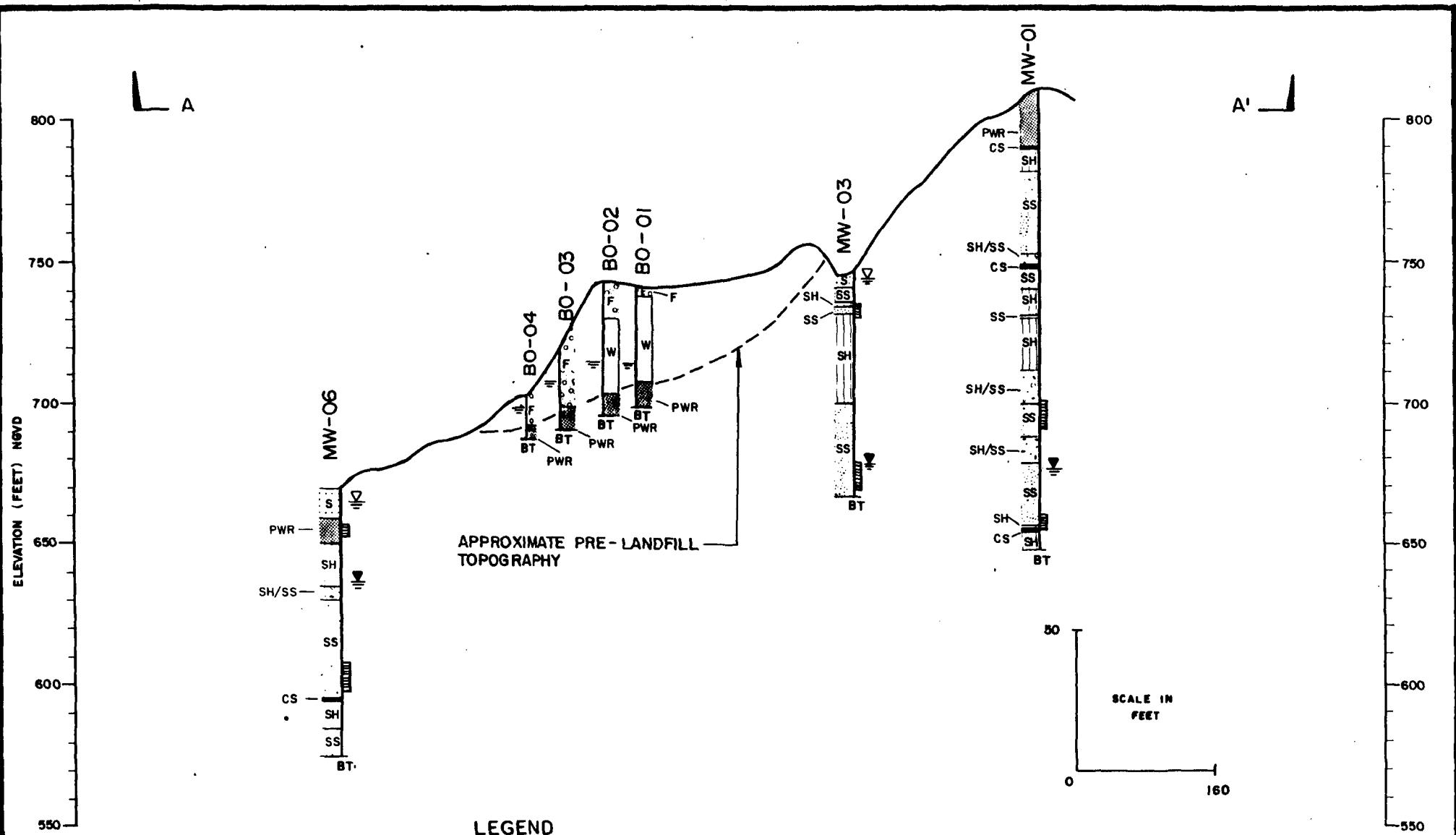
-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  MW-01 MONITORING WELL LOCATION
-  BO-01 SOIL TEST BORING / PIEZOMETER LOCATION
-  A A' HYDROGEOLOGIC PROFILE LINE



FIGURE 37

**HYDROGEOLOGIC
PROFILE LOCATION MAP**

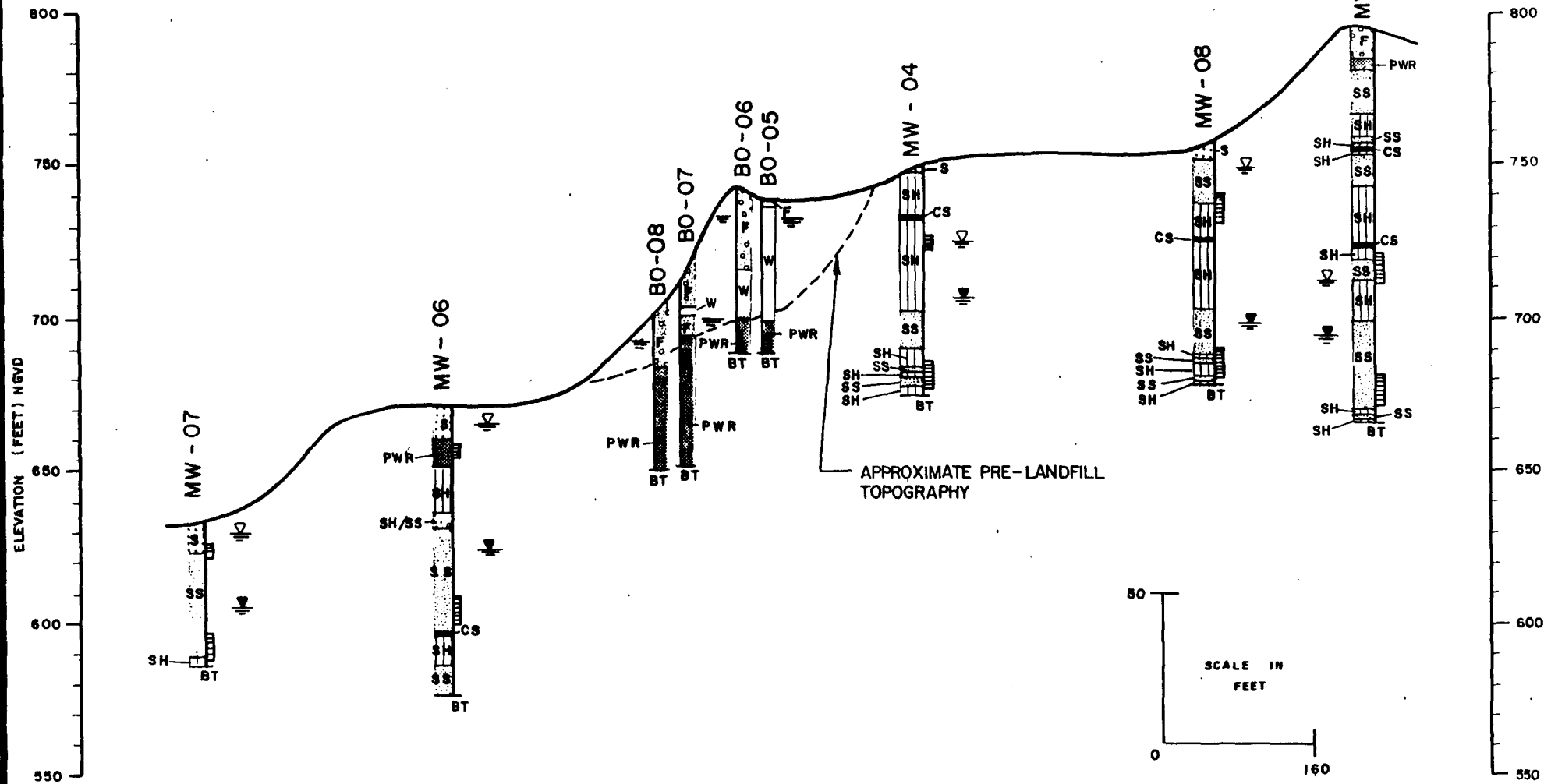
E.H. SCHILLING LANDFILL



LEGEND

- | | | | | | |
|--|--------------------------|--|-------------------|--|---|
| | FILL | | SANDSTONE | | PIEZOMETER WATER LEVEL (6/21/88) |
| | SOIL | | COAL SEAM | | 'A' (SHALLOW) MONITORING WELL WATER LEVEL (6/21/88) |
| | SHALE | | SHALE & SANDSTONE | | 'B' (DEEP) MONITORING WELL WATER LEVEL (6/21/88) |
| | PARTIALLY WEATHERED ROCK | | WASTE | | BORING TERMINATED |
| | | | SCREEN | | |

FIGURE 38
 HYDROGEOLOGIC PROFILE
 A - A'
 E. H. SCHILLING LANDFILL



LEGEND

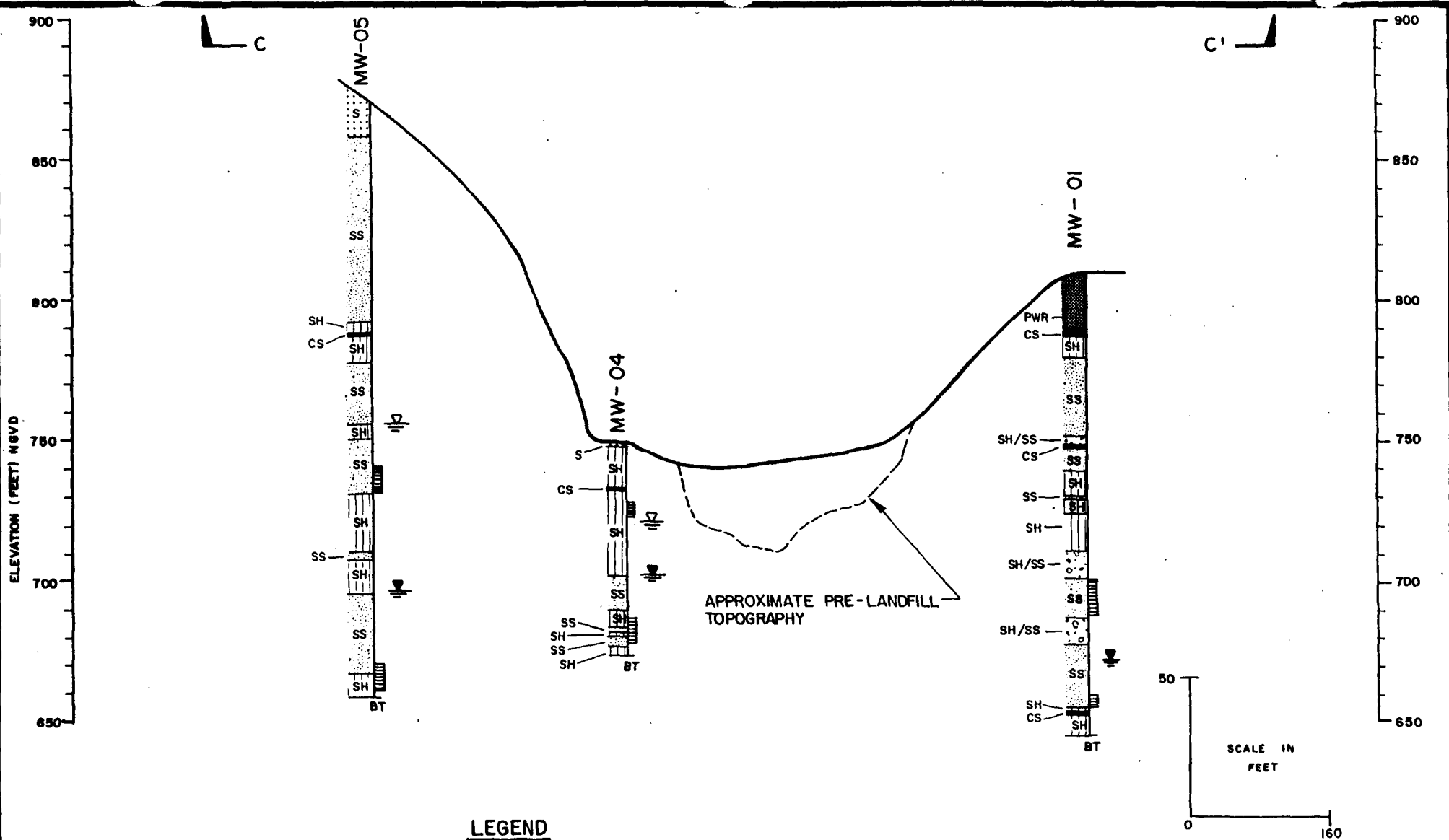
- | | | | | | |
|--|--------------------------|--|-------------------|--|---|
| | FILL | | SANDSTONE | | PIEZOMETER WATER LEVEL (6/21/88) |
| | SOIL | | COAL SEAM | | 'A' (SHALLOW) MONITORING WELL WATER LEVEL (6/21/88) |
| | SHALE | | SHALE & SANDSTONE | | 'B' (DEEP) MONITORING WELL WATER LEVEL (6/21/88) |
| | PARTIALLY WEATHERED ROCK | | WASTE | | BORING TERMINATED |
| | | | SCREEN | | |

FIGURE 39

HYDROGEOLOGIC PROFILE

B - B'

E. H. SCHILLING LANDFILL



LEGEND

- | | | | | | |
|--|--------------------------|--|-------------------|------|---|
| | FILL | | SANDSTONE | | PIEZOMETER WATER LEVEL (6/21/88) |
| | SOIL | | COAL SEAM | | 'A' (SHALLOW) MONITORING WELL WATER LEVEL (6/21/88) |
| | SHALE | | SHALE & SANDSTONE | | 'B' (DEEP) MONITORING WELL WATER LEVEL (6/21/88) |
| | PARTIALLY WEATHERED ROCK | | SCREEN | | BORING TERMINATED |
| | | | | B.T. | |

FIGURE 40
 HYDROGEOLOGIC PROFILE
 C - C'
 E. H. SCHILLING LANDFILL

that limit vertical flow; the predominant component of flow presumably is lateral and tends to follow the surface topography.

3.4.3.7 Surface Seepage Zones

Based on numerous observations following a period of heavy rainfall, many seepage areas (seeps) were seen at rock outcrops along US Route 52 and in the site vicinity. Generally the observed seeps occur at or near the contact of a sandstone overlying a shale. Observations of the large roadcuts indicate that the seeps emanate from discrete points or small linear zones along the contact, demonstrating that the sandstone is more permeable than the shale. These seeps tend to be temporary features that become dry relatively soon after a rainfall event.

A reconnaissance of the site vicinity was conducted on May 22, 1988, to locate seeps following a dry weather period. Only one seep was located at approximate site coordinates N 6820 E 21520, upslope of the Winkler Run tributary at an approximate 670 NGVD elevation. Although rock was not exposed at this location, the site geologic map (Figure 34) indicates that a sandstone occurs above elevation 675 feet with a distinct slope break (probable shale unit) below. Flow from the seeps was too low for measurement.

3.4.4 Conceptual Model

The site resides in a complex hydrogeologic setting. Steep sloping topography coupled with the heterogeneous nature of the bedrock makes characterization of the system difficult. Literature search efforts have revealed three separate studies of other sites within the

Appalachian Plateaus region which support the Schilling data and provide supplemental information necessary to develop a conceptual hydrogeologic model.

Stress - Relief Fracturing

Wyrick and Borchers (1981) studied the hydrologic effects of stress-relief fracturing in an Appalachian Plateaus valley setting. They concluded that the valley floors are underlain by horizontal fractures with vertical slump fractures along the valley walls, and the two types of fractures become interconnected at the base of the valley wall. The fractures tend to be concentrated in the upper 60 feet of rock. These valleys tend to exhibit a high degree of secondary permeability and thus act as a conduit for ground-water flow. Primary permeability is negligible, and wells that do not penetrate fractures will produce little water.

Supporting data to the Wyrick and Borchers study are available from the Schilling field investigation. Data from the sections at MW-01 and MW-06, as described in Section 3.4.3.3 of this report, showed the bedrock to be very competent with no evidence of fracture development. It is not surprising that these and most other wells at the Schilling site purged dry during sampling and were slow to recover. Well MW-07B, located at the base of the valley wall below the earthen dam, encountered major water-producing zones at approximate depths of 22 and 45 feet during drilling. It is likely that stress-relief fractures were intercepted by this well boring.

Vertically Stratified Aquifers

Razem and Sedam (1985) developed a generalized ground-water flow system for the Allegheny and Monongahela Formations in southeastern Ohio. They reported that vertical

flow of ground water is restricted by shale strata, producing vertically stratified perched aquifers in the intervalley ridges. Figure 41 is a conceptual diagram depicting the hydrogeology of this environment. Regional (i.e. laterally continuous) aquifers exist at depths associated with base elevations of the major valley floors. Ground water in the ridge areas moves laterally and discharges as seeps or springs along the valley wall.

The concept of vertically stratified aquifers is supported by findings previously cited in Sections 3.4.3.5 (Ground-Water Levels) and 3.4.3.7 (Surface Seepage Zones) of this report. Hydrogeologic profiles previously shown in Figures 38 to 40 are especially useful in illustrating the large differences in ground-water elevations between the shallow and deep wells of each cluster pair. Booth (1988) reported this phenomenon for a similar site in western Pennsylvania.

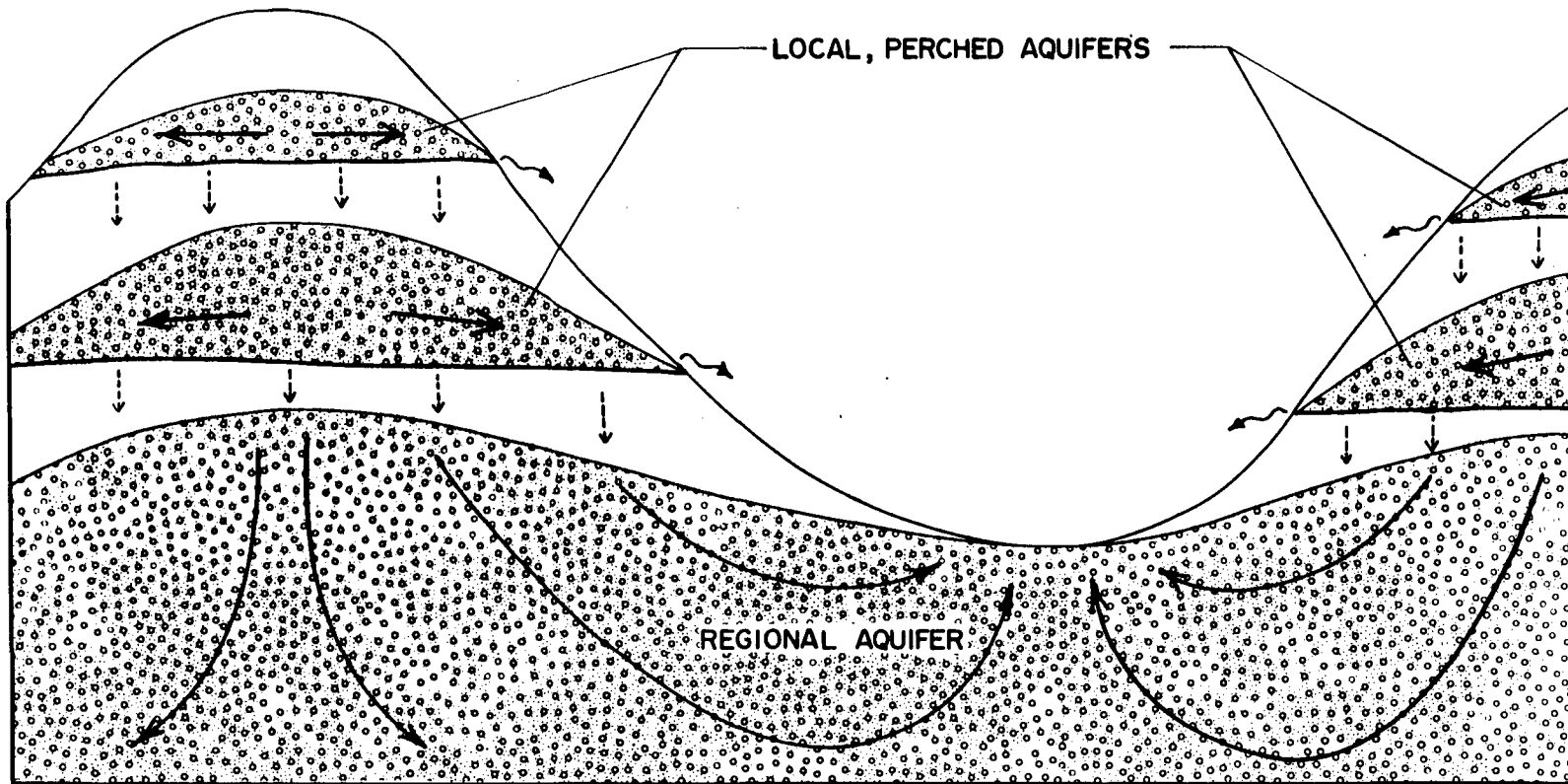
3.4.5 Hydrologic Budget

3.4.5.1 Theory and Basic Equations





A hydrologic budget is a means of quantifying the various influxes and withdrawals of water within a given watershed. In a steady-state system for which there are no net external inflows or outflows of ground water, the water-balance equation for an annual period takes the form:

$$P = Q + E + \Delta S_s + \Delta S_g$$

where P is the precipitation, Q the runoff, E the evapotranspiration, ΔS_s the change in storage of the surface-water reservoir, and ΔS_g the change in storage of the ground-water



LEGEND

-  SATURATED ZONE
-  VERTICAL LEAKAGE
-  SPRING LOCATIONS
-  DIRECTION OF GROUND-WATER FLOW

SOURCE : RAZEM , ALLAN C. AND A.C. SEDAM. 1985

FIGURE 41

**CONCEPTUAL DIAGRAM OF TYPICAL
GROUND-WATER FLOW SYSTEM
IN SOUTHEASTERN OHIO**

E. H. SCHILLING LANDFILL

reservoir (both saturated and unsaturated) during the annual period (Freeze and Cherry, 1979). When averaged over several years of record, components of surface-water and ground-water storage equal such that:

$$P = Q + E$$

where P is the average annual precipitation, Q is the average annual runoff, and E is the average annual evapotranspiration. Runoff and evapotranspiration are reported in inches over the drainage basin area so that units are consistent with precipitation.

In a typical watershed, the majority of the watershed comprises a recharge area and the discharge area is restricted to a very small area adjacent to a drainage feature (stream). Two separate hydrologic-budget equations may be written for the recharge and discharge areas, respectively. In the recharge area:

$$P = Q_s + R + E_r$$

where Q_s is the surface-water component of average annual runoff, R is the average annual ground-water recharge, and E_r the average annual evapotranspiration from recharge area (Freeze and Cherry, 1979). In the discharge area precipitation (P) becomes insignificant and therefore:

$$Q = Q_s + D - E_D$$

where D is the average annual discharge (and equal to R), and E_D the average annual evapotranspiration from the discharge area. By setting

$$Q_G = D - E_D$$

the hydrologic-budget equation for the discharge area becomes:

$$Q = Q_s + Q_G$$

where Q_G is the ground-water component of average annual runoff (of the baseflow component).

3.4.5.2 Site Application

Meteorological data were collected from the landfill for use as input into the site water balance. Two of the three main parameters of the water balance equation, precipitation (P) and evapotranspiration (E), were attainable from the meteorological data. Precipitation was measured directly. The Penman Equation (Penman, 1948) was used to calculate potential evapotranspiration from on-site data of four meteorological parameters: (1) solar radiation; (2) air temperature; (3) dewpoint temperature (computed from air temperature and relative humidity); and (4) wind velocity. This approach is considered by many to be more accurate than other methods which rely upon less meteorological input.

The Penman Equation is expressed as:

$$E = 0.7 \left[\frac{\Delta}{\Delta + \gamma} Q_n + \frac{\gamma}{\Delta + \gamma} E_a \right]$$

where

Δ = the slope of the saturation vapor pressure versus temperature T_a

γ = a constant defined by the Bowen ratio equation

Q_n = the net radiation exchange

E_a = evaporation.

Typically, the solution utilizes a nomograph to solve for E, as shown in Figure 5-1 of Linsley et al. (1982). Each of the elements of the Penman Equation is also expressed by a mathematical formula permitting a computer solution (see Section 5-18, Linsley et al., 1982).

Evapotranspiration was computed using monthly average meteorological data for March 1988 to February 1989. Table 22 lists input data and the computed results for each month. The total calculated potential evapotranspiration for the year was 33.50 inches. This compares closely with an estimated 33 inches by the National Weather Service for the area (see Figure 10 in EPA SW-867).

Table 22 also provides a summary of monthly precipitation for comparison with evapotranspiration. From March 1988 to August 1988 potential evapotranspiration exceeded precipitation, with June and July having the largest magnitude of difference. Precipitation exceeded evapotranspiration from September 1988 to February 1989, with January and February having the largest difference. Thornthwaite and Mather (1955)

TABLE 22

SUMMARY OF MONTHLY EVAPOTRANSPIRATION

DATE	TEMP. °C	REL. HUM. (%)	RADIATION (lang/min)	WIND VEL. (m/s)	EVAPOTRANS. (in)		PRECIP. (in)
March	7.5	63	0.213	2.6	2.43	>	2.29
April	12.9	62	0.305	2.1	3.55	>	2.68
May	18.3	68	0.235	1.5	3.07	>	1.82
June	23.1	63	0.399	0.9	5.51	>	0.47
July	26.3	67	0.350*	2.7	6.12	>	3.40
August	25.5	79	0.318	0.9	4.36	>	4.13
September	19.5	85	0.233	1.2	2.42	<	2.68
October	10.3	73	0.182	1.2	1.67	<	3.08
November	8.7	77	0.127	2.1	1.23	<	4.85
December	3.1	65	0.117	2.4	1.37	<	2.44
January	5.1	75	0.095	2.3	1.01	<	4.21
February	0.8	77	0.131	1.6	0.76	<	7.69

* Actual site data were not measured due to equipment failure.

Estimated value is taken as the approximate average of June and August solar radiation.

studied the relationship between precipitation and evapotranspiration as related to ground-water recharge and concluded that significant recharge typically occurs in the late winter months. Figure 42 illustrates this concept. Earlier, during the discussion of site ground-water levels (Section 3.4.3.5) this report provided evidence of recharge during winter and early spring at the Schilling site and the decline during the summer and fall months.

To reiterate, the basic water balance equation is expressed as:

$$P = Q + E$$

rearranging the terms yields:

$$Q = P - E$$

These equations may be solved for the runoff (Q) given values for precipitation (P) and evapotranspiration (E), such that:

$$Q = 39.74 - 33.50$$

$$Q = 6.24 \text{ inches}$$

This Q represents the average annual runoff of both surface and ground water. To quantify the two components would require either the use of a flow net or a continuous streamflow hydrograph, both of which are beyond the scope of this project and require additional data not acquired during the RI.

A semi-quantitative estimate of the two components may be made by comparing the computed runoff with actual streamflow data and ground-water elevation measurements

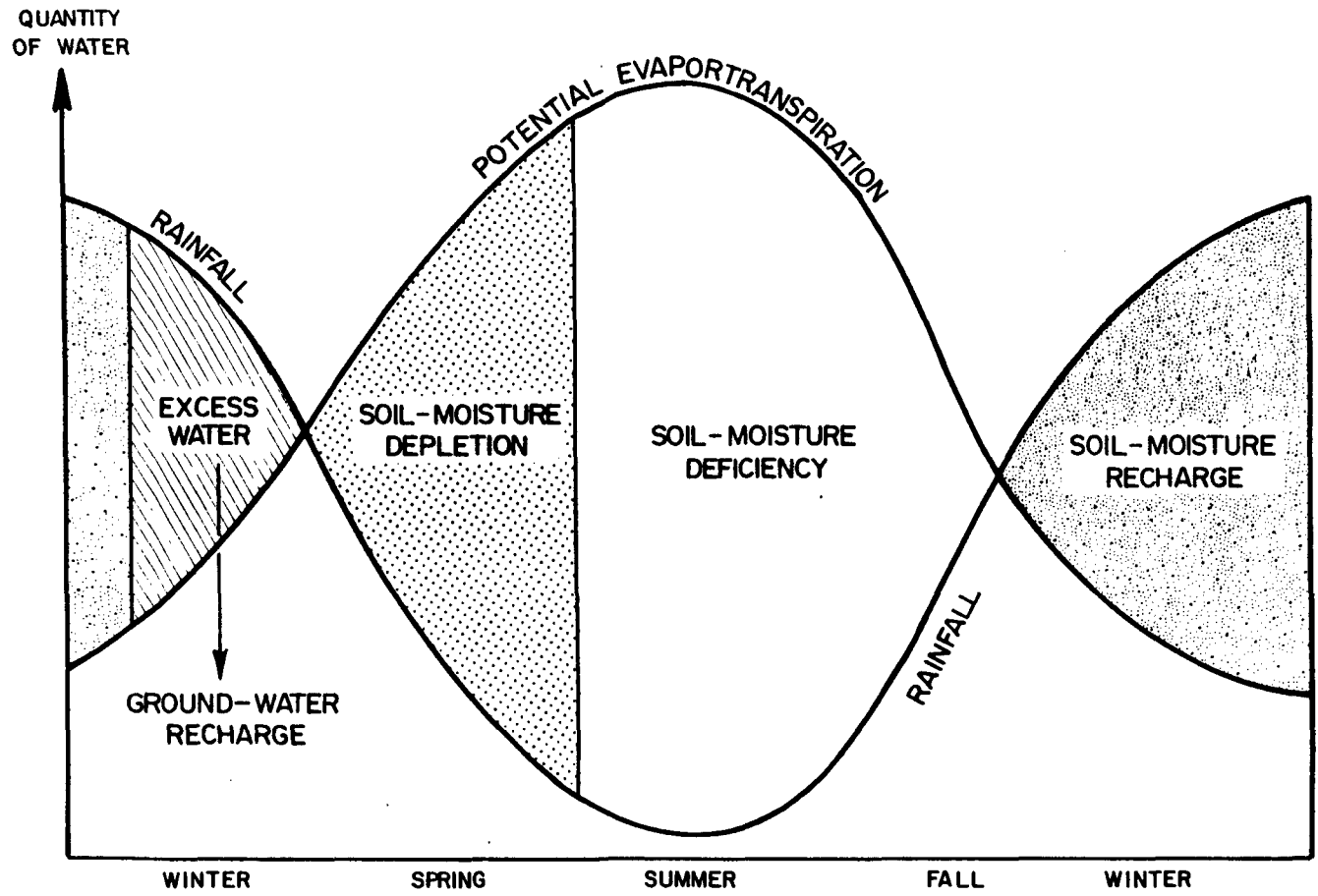


FIGURE 42

RELATIONSHIP BETWEEN
EVAPOTRANSPIRATION,
RAINFALL & SOIL MOISTURE

E. H. SCHILLING LANDFILL

SOURCE : MODIFIED FROM THORNTHWAITE AND MATHER

at one of the gauging stations. Station SW-02 located about midway between wells MW-06 and MW-07 is the best choice. The first step involves converting the Q in inches to a volumetric discharge so that units are equivalent to gauging data. This was done by measuring the land area draining to SW-02 and multiplying this by the Q. Based on a planimeter survey of the site topographic map, approximately 417,604 square feet of land area drains to SW-02 and when multiplied by the runoff of 6.25 inches, the volumetric runoff computes to 0.007 cubic feet per second (cfs).

This runoff compares favorably with streamflow results of 0.006 cfs and 0.008 cfs measured at SW-02 during May 2 and December 13, 1988, respectively. Both of these gauging dates were preceded by a period of dry weather and therefore may represent baseflow conditions (i.e. discharge is from ground water). Table 23 provides a summary of precipitation preceding the gauging events.

The nearest USGS gauging station to the Schilling site is at Symmes Creek in Getaway, Ohio, approximately eight miles southeast of the site. The mean discharge measured over the period of 1939 to 1947 was 337 cfs (Cross and Hedges, 1959). The creek has a drainage area of 333 square miles, which computes to a runoff of 13.74 inches. Although the gauging station at the Schilling site and the gauging station at Symmes Creek may not be directly comparable, uncertainties exist between the estimated site runoff (6.24 inches) and the best available gauging data (13.74 inches) at Symmes Creek.

TABLE 23

SUMMARY OF PRECIPITATION PRECEDING STREAMFLOW GAUGING

Gauging date - 5/02/88

Date	Precipitation	Days preceding gauging
4/7	0.30	25
4/8-17	0.00	
4/18	0.66	14
4/19-20	0.00	
4/21	0.26	11
4/22	0.27	10
4/23	0.01	9
4/24-27	0.00	
4/28	0.04	4
4/29-5/3	0.00	

Gauging date - 12/13/88

Date	Precipitation	Days preceding gauging
11/20	2.18	23
11/21	0.01	22
11/22-26	0.00	
11/27	0.03	16
11/28-12/6	0.00	
12/7	0.04	6
12/8-13	0.00	

3.4.6 Geophysical Survey of Winkler Run Tributary Area

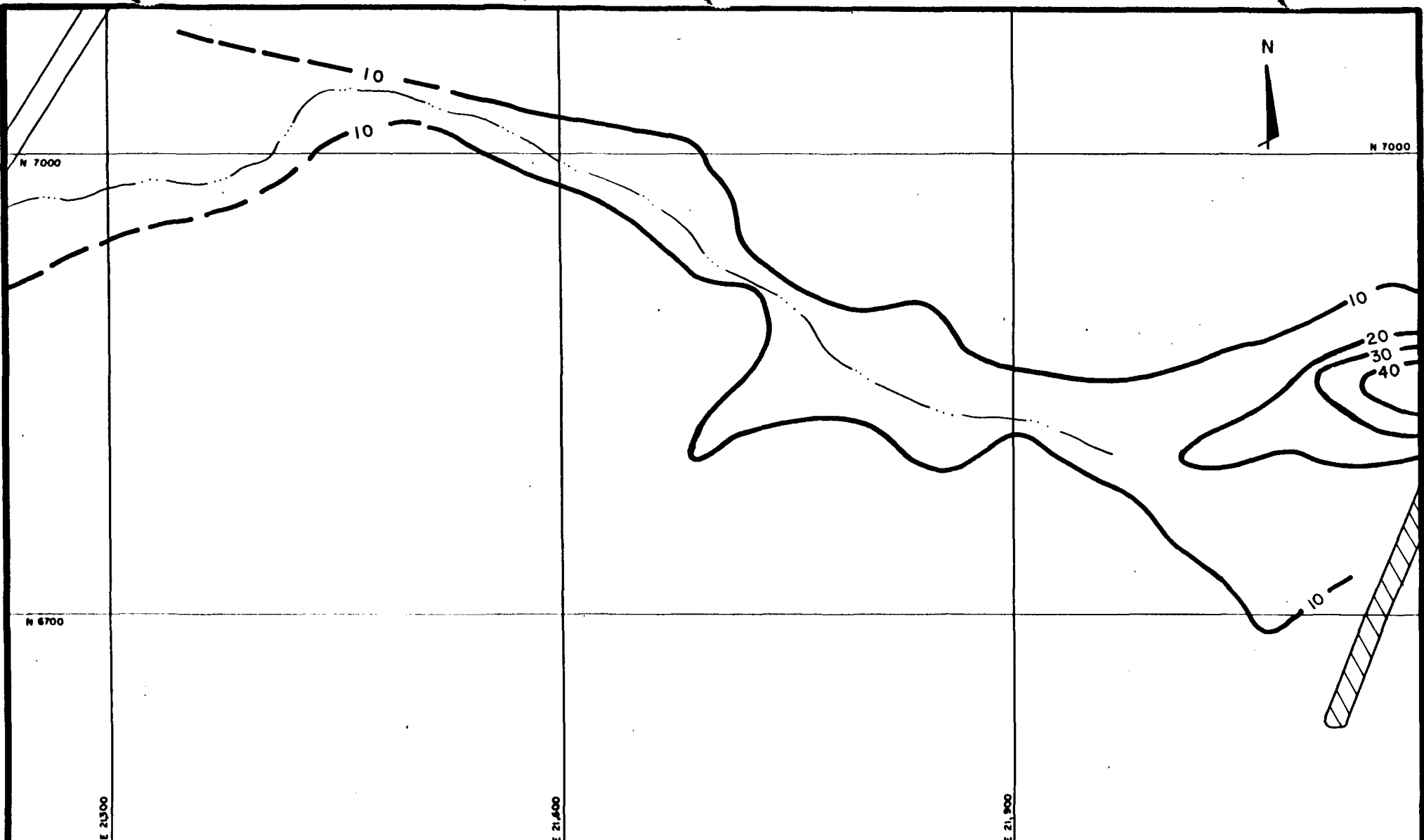
3.4.6.1 Electromagnetic (EM-31) Conductivity Survey

An EM survey downstream of the dam measured the apparent conductivity of the shallow materials to determine the possibility of electrically conductive leachate in the soil and ground water. The EM-31 survey consisted of continuous apparent conductivity measurements along approximately 2300 linear feet of survey lines.

The results of the EM-31 survey are presented on an apparent conductivity contour map in Figure 43. Apparent conductivity values ranged from 4.5 to 49 millimhos/meter. The highest (more than 30 millimhos/meter) apparent conductivity values coincided with a leachate seep on the side of the dam. Apparent conductivities decreased downstream of the dam to background values near 10 millimhos/meter.

3.4.6.2 Electrical Resistivity Soundings (ER)

Four ER vertical soundings were conducted. These soundings were located on or close to seismic profile lines. The nominal depths of penetration for these ER soundings were 32 to 50 feet. Resistivities ranged from 130 to 4000 ohm-feet (Figure 44). The lowest resistivity was interpreted in sounding VS-D4 in a topographic low area by the Winkler Run tributary at a depth of 2 feet. This value of 130 ohm-feet (which corresponds to an apparent conductivity of approximately 25 millimhos/meter) is indicative of one of the following conditions: (1) electrolytes present in the ground water; (2) greater clay content in the soil; or (3) more porous alluvial/colluvial material.



LEGEND


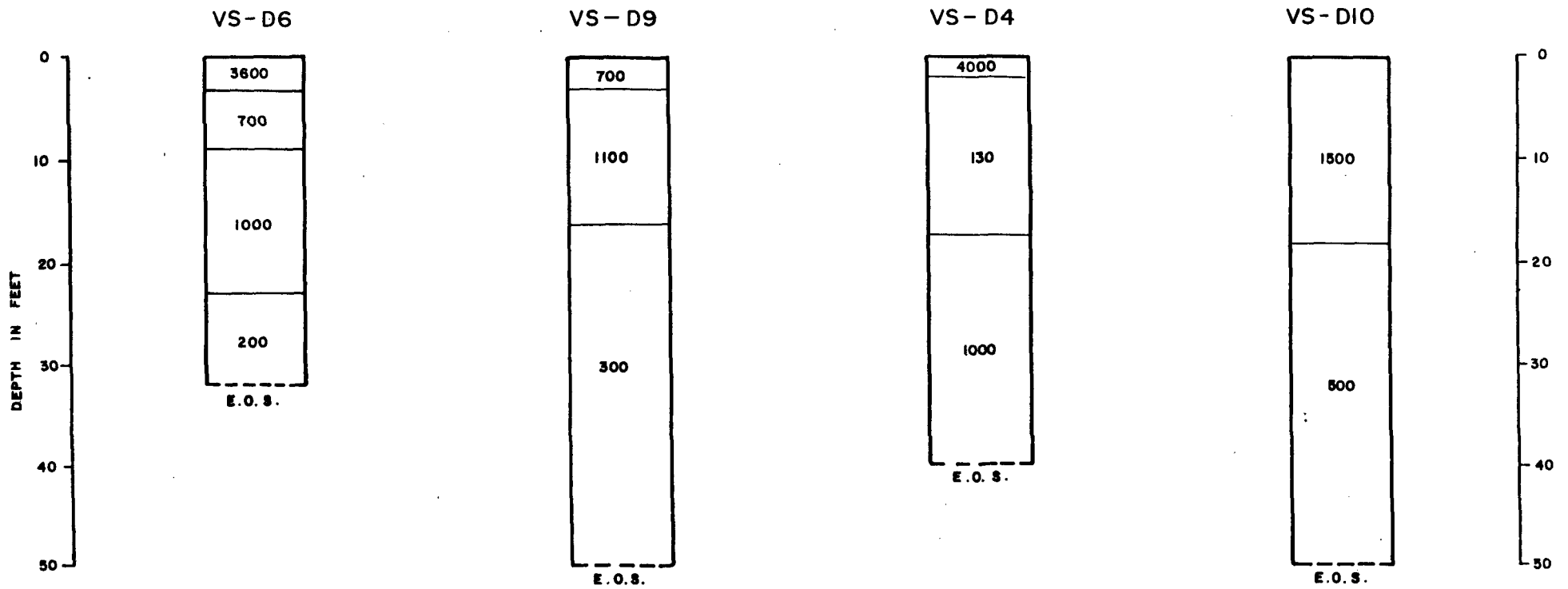
- 20 — APPARENT CONDUCTIVITY CONTOUR, DASHED WHERE INFERRED, CONTOUR INTERVAL 10 MILLIMHOS/METER
-  TOP OF EARTHEN DAM



FIGURE 43

EM - 31 APPARENT CONDUCTIVITY
CONTOUR MAP

E. H. SCHILLING LANDFILL



LEGEND

3600 ELECTRICAL RESISTIVITY IN OHM FEET

E.O.S END OF SURVEY

NOTE: PSEUDO LOGS ARE DEPICTIONS OF SUBSURFACE GEOELECTRIC LAYERING
BASE ON "FORWARD" MODELING.

FIGURE 44

ELECTRICAL RESISTIVITY
VERTICAL SOUNDINGS
PSEUDO LOGS
DOWNSTREAM AREA

E. H. SCHILLING LANDFILL

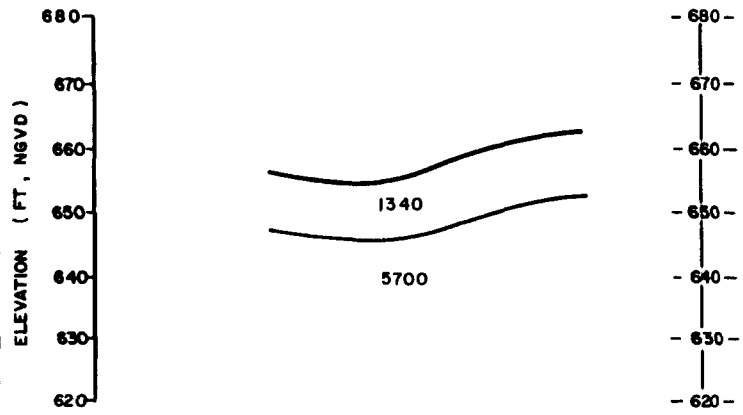
Soundings VS-D9 and VS-D10 were located at higher elevations on the southern wall of the valley. They are similar in indicating an upper resistive layer (700 to 1500 ohm-feet or 6 millimhos/meter or less) underlain by a more conductive layer of 300 to 500 ohm-feet (or about 7 to 11 millimhos/meter) at depths of 16 to 18 feet. The lower, less resistive, layer may correspond to a lithology change (i.e. shale vs. sandstone) or to the water table.

3.4.6.3 Seismic Refraction

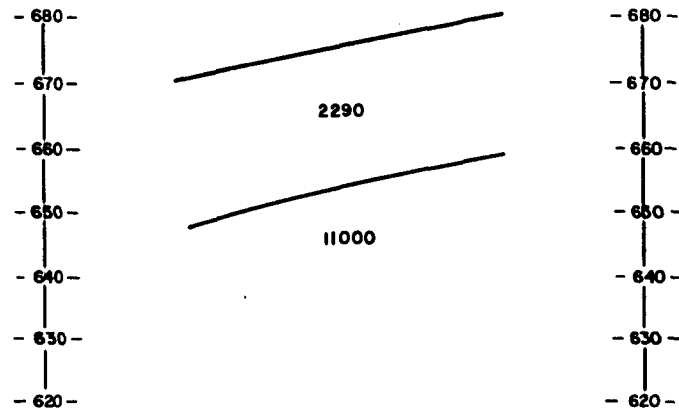
The purpose of the shallow seismic refraction survey was to indicate the depth to rock and help in the interpretation of the degree of weathering of rock in the valley northwest of the dam. Twelve seismic profiles, 80 to 100 feet long, were conducted close to the stream bed and on the sides of the valley. They were conducted using a Geometrics 125 single channel seismograph with the equivalent of a forward and reverse shot at the ends of each spread. The seismic profiles were located using the established site grid coordinate system, tape measure and Brunton compass.

The interpreted results of the seismic survey are shown in Figures 45 through 47 as cross sections of seismic velocities and depths of change of seismic properties of materials. The range of calculated seismic velocities was 1210 to 3000 feet per second (fps) for the upper (lowest velocity) layer and 5700 to 11000 fps for the lower (highest velocity) layer. Seismic velocities in the range of 1000 to 3000 fps are representative of soil and dense soil cover. Material with seismic velocities in the range of 3000 to 6000 fps is interpreted as weathered rock.

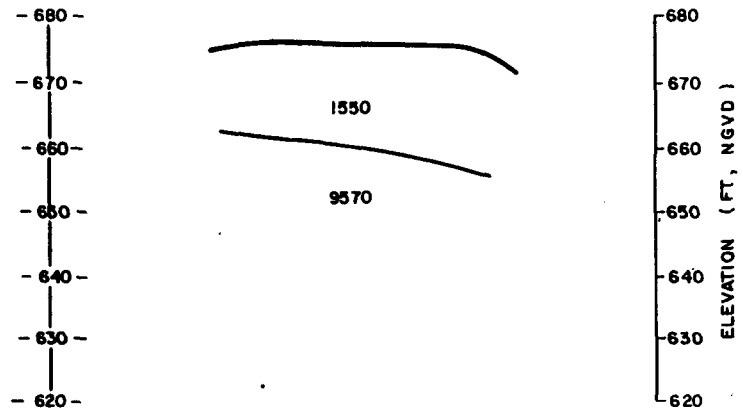
SL - D8



SL - D5



SL - D9



LEGEND

2290 SEISMIC VELOCITY IN FEET PER SECOND

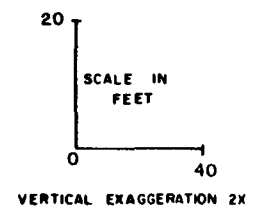


FIGURE 45

SEISMIC REFRACTION PROFILES
SL-D5, SL-D8 AND SL-D9
DOWNSTREAM AREA

E. H. SCHILLING LANDFILL

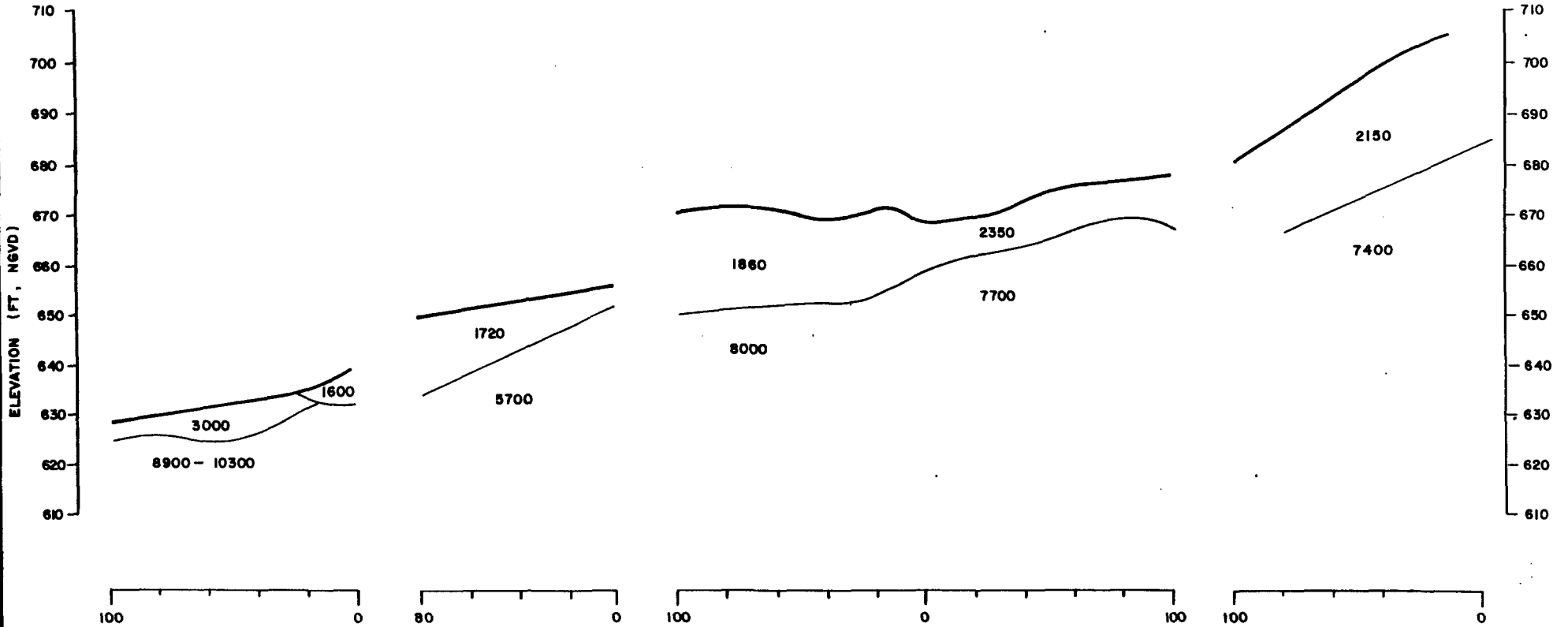
SL-D7

SL-D6

SL-D4

SL-D3

SL-D2



LEGEND

1600 SEISMIC VELOCITY IN FEET PER SECOND

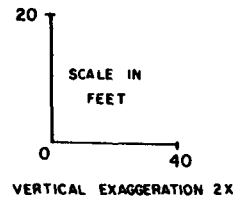


FIGURE 46

SEISMIC REFRACTION PROFILES
 SL-D7, SL-D6, SL-D4, SL-D3 & SL-D2
 DOWNSTREAM AREA

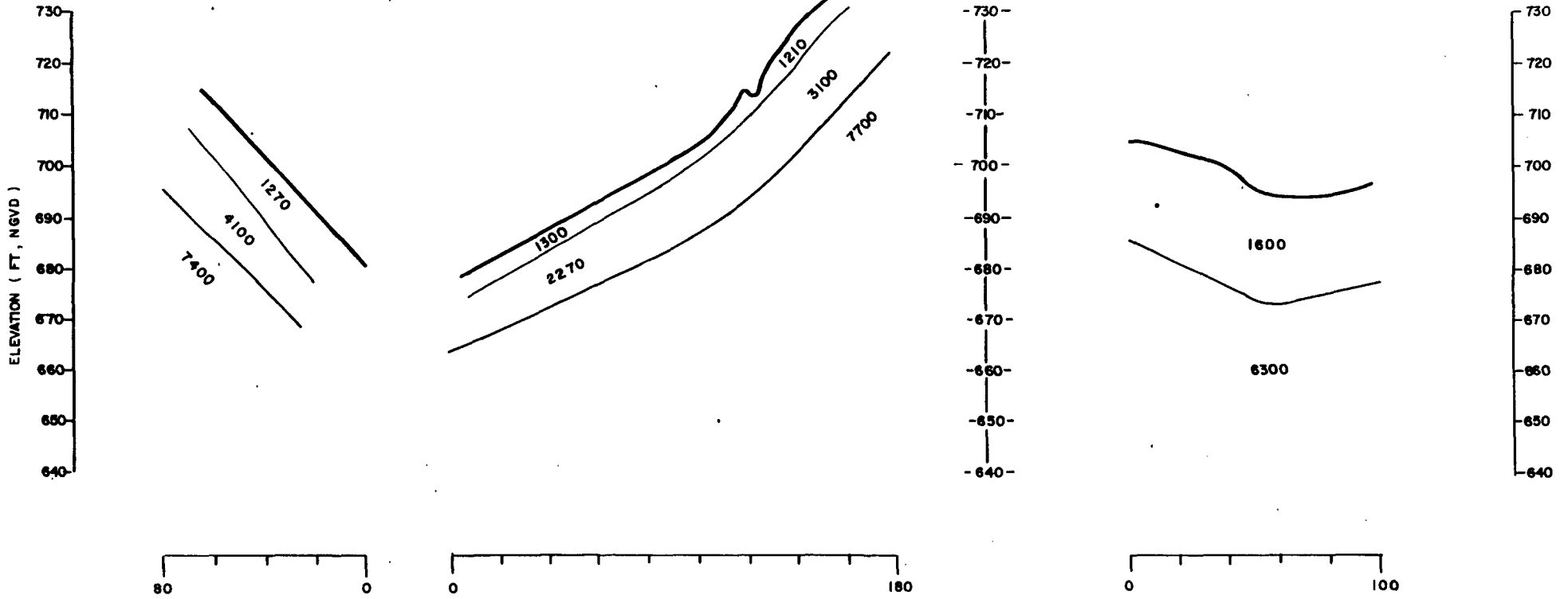
E.H. SCHILLING LANDFILL

SL-DI2

SL-DIO

SL-DII

SL-DI



LEGEND

1270 SEISMIC VELOCITY IN FEET PER SECOND

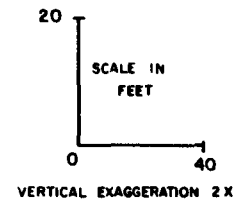


FIGURE 47

SEISMIC REFRACTION PROFILES
SL-DI2, SL-DIO & SL-DII
DOWNSTREAM AREA

E. H. SCHILLING LANDFILL

Generally, material with seismic velocities ranging from 6000 to 10000 fps is interpreted to be fractured rock. Typical seismic velocities for the shale and sandstones in the area are estimated to range from 6000 to 10000 fps for shale and from 8000 to 14000 fps for sandstone. Fractured rock has a lower seismic velocity than unweathered rock. Table A-1 in Appendix A presents more information on the description of subsurface materials and seismic velocities.

Most profiles were interpreted to have 2 layers, soil above weathered and/or fractured rock. Seismic profiles SL-D10 through SL-D12 encountered three velocity layers: soil or alluvium with seismic velocities of 1210 to 1300 fps, underlain by dense soil to weathered rock, with seismic velocities from 7400 to 8000 fps.

Results - Combination of Methods

The electromagnetic survey outlined an area of apparent leachate seepage from the dam with apparent conductivities as high as 49 millimhos/meter, as previously shown in Figure 43. Downstream, apparent conductivities in the stream bed decreased to background levels on the order of 10 millimhos/meter.

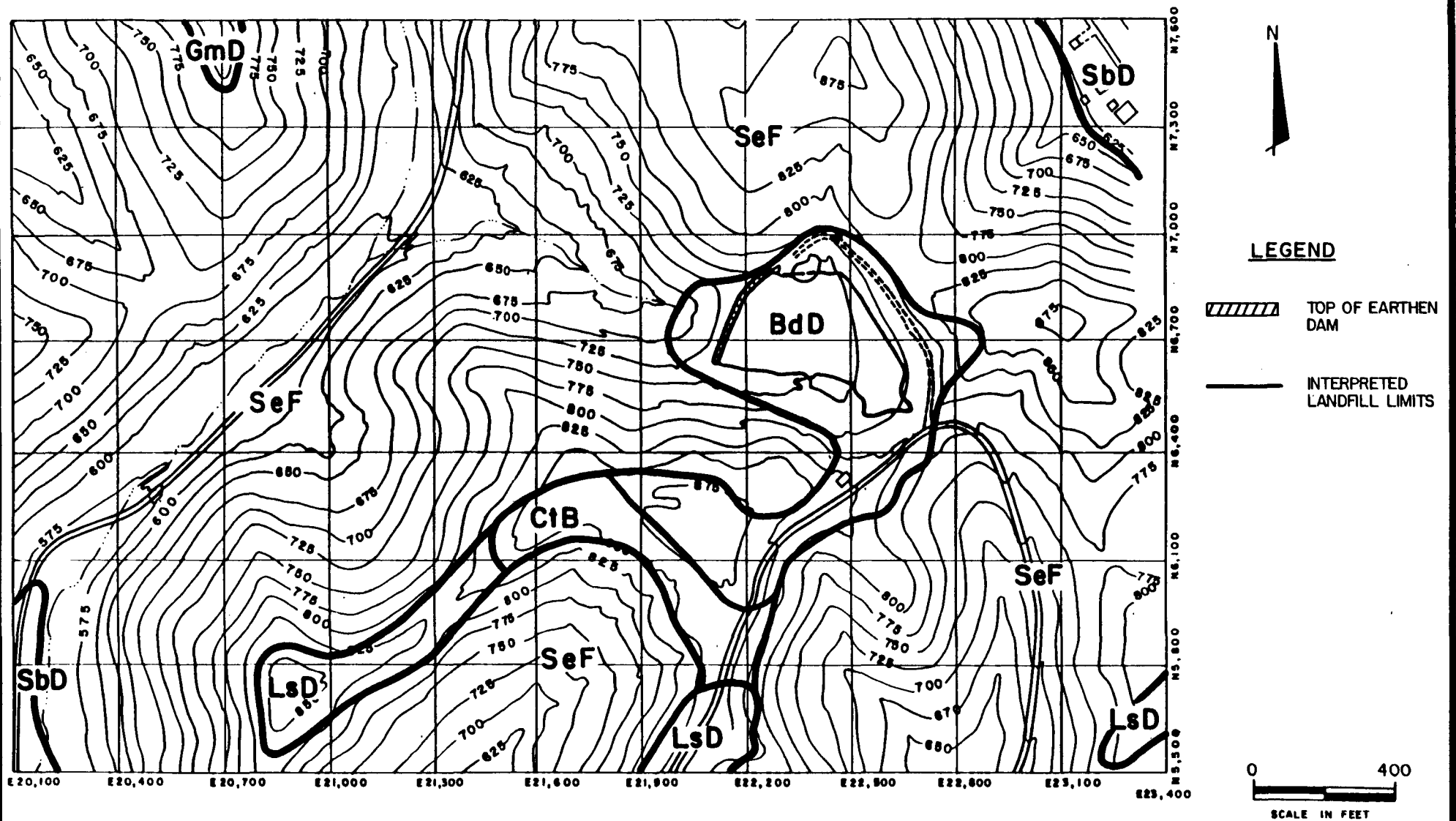
The top of rock, weathered and/or fractured, was interpreted in both seismic refraction and electrical resistivity surveys. Where the two surveys were performed at the same location, the interpreted depth to top of rock was similar. A comparison of the seismic and electrical resistivity data reveals that rock at the locations of VS-D4 and VS-D6, for example, is more resistive than at VS-D9 and VS-D10, probably due to a change in lithology, since sandstones are more resistive than shales.

Data gathered by the three geophysical techniques (EM, ER and SR) in the valley downstream of the dam correlate well with each other in identifying the top of rock and areas of high apparent conductivities (low resistivities). The apparent conductivities did not indicate the presence of metal. Apparent conductivities indicated contaminated water seeping from the dam. However, apparent conductivities approached background levels downstream of the dam.



3.5 Soils

According to preliminary information furnished by the US Department of Agriculture, Soil Conservation Service (1988), Ironton, Ohio, six distinct surface soil units have been mapped in the study area. The distribution of these units within the study area is illustrated on Figure 48. A brief description of each unit follows:

- o Bethesda Channery Silty Clay (BdD) - This soil unit may have originally developed as a narrow band of residuum occupying narrow benches, saddles and slightly to moderately steep enclosed valley walls. The unit is described as a gravelly (rocky) silty clay or sandy clayey gravel. It is significant to this study because it has been cut and reworked from areas immediately adjacent to the site for use in landfill construction. The soil is deep, well drained and possesses moderately slow permeabilities. It is underlain by bedrock. The unit is subject to slope and erosion potential use constraints.



LEGEND

-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS

SOIL CLASSIFICATION

BdD	BETHESDA CHANNERY SILTY CLAY	LsD	LATHAM - STEINSBURG COMPLEX
CiB	COOLVILLE - TILSIT SILT LOAM	SbD	SHELOCTA SILT LOAM
GmD	GILPIN - LATHAM SILT LOAM	SeF	STEINSBURG - SHELOCTA ASSOCIATION

FIGURE 48

STUDY AREA SURFACE SOILS

E. H. SCHILLING LANDFILL

SOURCE: MODIFIED FROM INFORMATION FURNISHED BY USDA, SOIL CONSERVATION SERVICE (1988) BASED ON AERIAL IMAGERY DATED MARCH 12, 1986

- o Coolville - Tilsit Silt Loam (CtB) - This soil unit may have originally developed as a narrow band of residuum occupying broad ridgelines and adjacent gradual slopes. The unit is described as a sandy silty clay, sandy silt or clayey silt. It is significant to this study because it occurs at high study area elevations above and adjacent to the E.H. Schilling Landfill. The soil is deep, is moderately well drained, and possesses slow to very slow permeabilities. It is underlain by soft siltstone bedrock. The unit's usefulness is restricted due to erosion susceptibility, seasonally perched water tables and wetness (a reference to generally high natural moisture contents).

- o Gilpin - Latham Silt Loam (GmD) - This soil unit developed as residuum on ridgetops, benches and adjacent slight to moderate slopes. It is described as a sandy silt, silty clay or sandy clayey silt. The unit is shallow to moderately deep and is moderately well drained. It possesses moderate to slow permeabilities. Partially weathered sandstone or siltstone bedrock underlies the unit at depths on the order of two feet below grade. The unit's usefulness is restricted due to a severe erosion hazard, seasonal wetness and shallow depths to bedrock.

- o Latham - Steinsburg Complex (LsD) - This soil unit consists of two associated soil types generally mapped together due to physical similarities and limited extent. It has developed as narrow bands of residuum on ridgelines and adjacent slopes, at elevations generally above 800 feet, NGVD. It is described as sandy silty clay, silty clay or silty sand. The unit is generally

shallow to moderately deep and is moderately well drained to well drained. It possesses moderately rapid to slow permeabilities. Siltstone or sandstone bedrock underlies the unit at depths ranging from two to four feet below grade. The unit is subject to severe erosion potential, seasonal wetness and shallow depths to bedrock.

- o Shelocta Silt Loam (SbB) - This unit may have developed as a tabular accumulation of colluvium in narrow valleys such as Rock Hollow and Winkler Hollow, along gradually inclined valley sides and on coalescing colluvial fans. Typically, it consists of gravelly sandy silt and sandy silt. The unit is generally deep, well drained and possesses moderate permeability. Locally, this mapping unit may be subject to several potential use constraints, including erosion potential, flooding potential and shallow depths to bedrock.

- o Steinsburg - Shelocta Association (SeF) - This soil unit consists of two associated soils generally mapped together due to common source materials, physical similarities and the similar types of vegetation they support. The unit's typical slopes are steep, typically ranging from forty to sixty percent. Its distribution extends over broad expanses of the study area. It is described as gravelly sandy silt and silty sand. The unit is shallow to moderately deep and is generally well drained. It possesses moderately rapid to moderate permeabilities. Locally, weathered siltstone, shale or sandstone underlie this unit at depths ranging from surface to five or more feet below grade. The usefulness of the Steinsburg - Shelocta Association may be limited due to

outcrops or shallow depths to bedrock, steep slopes and a severe erosion hazard potential. The unit's optimum uses include hardwood forests and wildlife habitat.

Table 24 summarizes the engineering use data for each unit mapped in the study area. USDA texture, Unified Soil Classification System, estimated permeability and likely use constraints are described for each of the six units.

3.6 Site Features

The Schilling Landfill is situated at the head of a narrow valley behind a man-made earthen dam. The site resembles a natural amphitheater with side slopes ranging from 20 to 50 percent. The landfill itself occupies approximately 3 acres of land. The landfill surface was reportedly capped in 1980 with soil borrowed from a side slope immediately east of the site. Several ditches were excavated in and around the landfill to divert runoff and minimize the potential of leachate production.

3.6.1 Landfill Characteristics

The geophysical investigation described in Section 2.2.1 was intended to characterize the landfill by delineating the extent and thickness of waste materials and identify zones of buried metallic debris. Magnetic (MG) and electromagnetic conductivity (EM) surveys were utilized to characterize landfill materials, while seismic refraction (SR) and electrical resistivity (ER) techniques along with EM identified the limits and thickness of waste.

TABLE 24
STUDY AREA SOIL UNITS

MAP SYMBOL	UNIT DESCRIPTION	USDA TEXTURE (Major Fraction)	TYPICAL THICKNESS (Inches)	UNIFIED CLASSIFICATION SYSTEM (Major Fraction)	PERMEABILITY (Estimated)	CONSTRUCTION OR DEVELOPMENT USE CONSTRAINTS
BdD	Bethesda channery silty clay loam, 8 to 25% slopes	Gravelly silty clay, sandy clayey gravel	80	GM - GC, GP	Moderately slow	Slopes, erosion potential
C+B	Coolville - Tilsit silt loam, 3 to 8% slopes	Sandy silty clay, sandy silt or clayey silt	50 - 114	SP, SM - SC, CL	Slow to very slow	Subject to erosion, perched water tables and seasonal wetness
GmD	Gilpin - Latham silt loam, 15 to 25% slopes	Sandy silt, sandy clayey silt or silty clay	27 - 28	SP - SM, ML, CL	Moderate to slow	Subject to erosion; seasonal wetness; shallow bedrock
LsD	Latham - Steinsburg Complex 15 to 25% slopes	Sandy silty clay silty clay or silty sand	24 - 40	SP, SM, ML, CL	Moderately rapid to slow	Severe erosion hazard; seasonal wetness; shallow bedrock
SbB	Schelocta silt loam, 2 to 6% slopes	Gravelly sandy silt; sandy silt	48 - 80	GM, SP - SM	Moderate	Erosion potential; flooding potential; possible shallow bedrock
SeF	Steinsburg - Schelocta Association, slopes to > 60%	Gravelly sandy silt; silty sand	0 - 55	GM, SP, SM	Moderately rapid to moderate	Slopes; severe erosion hazard; out crops or shallow depth to bedrock

SOURCE: Modified from USDA, Soil Conservation Service preliminary survey data, 1988.

Figure 49 presents a computer-generated magnetic field contour map with a contour interval of 100 gammas. The distribution of the magnetic field contours indicates concentrations of ferromagnetic material in at least four main areas, and to a lesser extent, throughout the site.

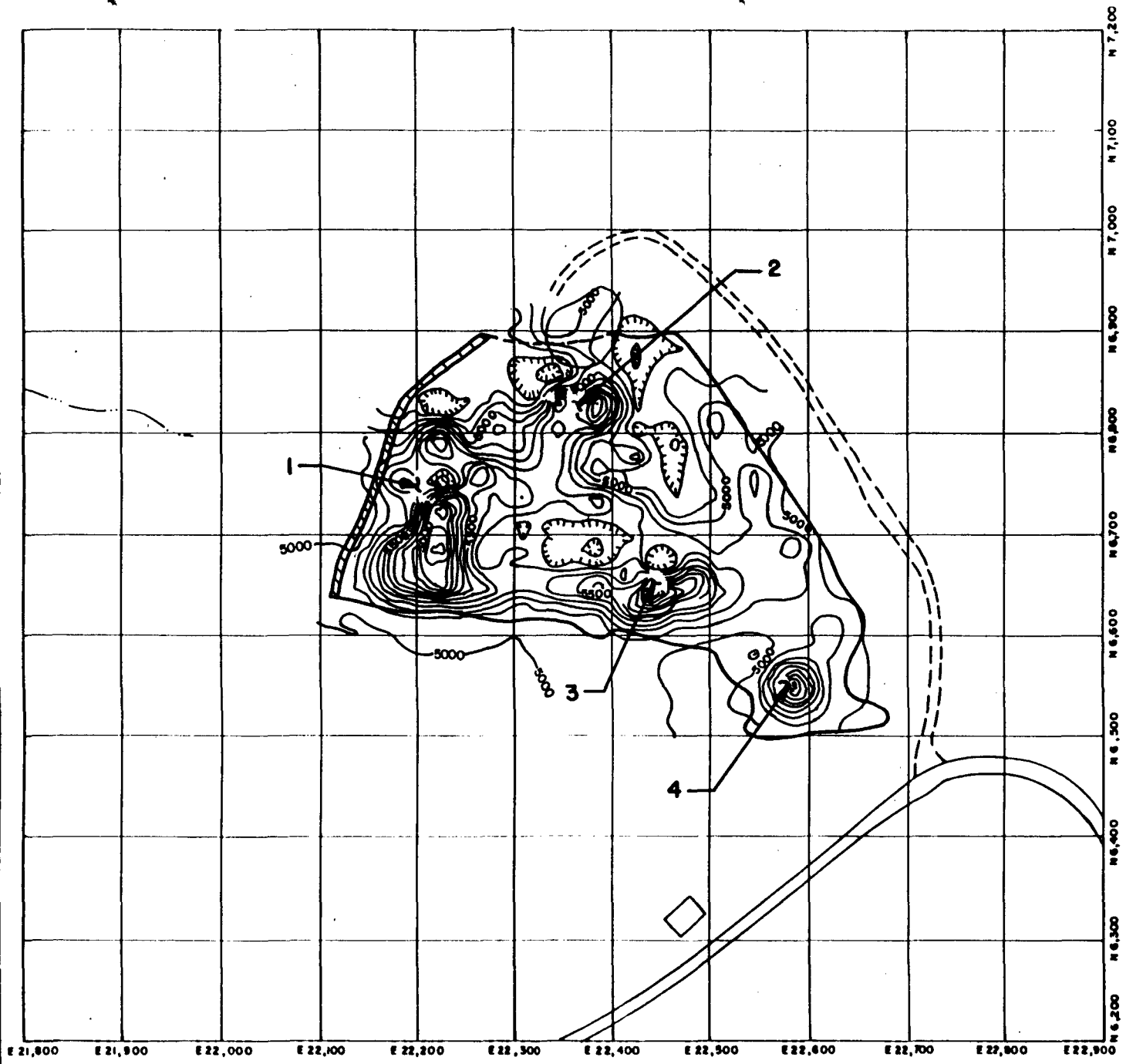
Zone 1, an area in the vicinity of the earthen dam, contains the largest anomaly, both in magnetic field value and in areal size. The measured magnetic field values in this area were greater than 56000 gammas. Two peaks are located in the zone, indicating multiple metallic objects. Magnetic field values taken south of the landfill were about 55000 gammas.

Zone 2, an area near and beneath a mound in the northern part of the landfill south of the fly ash pile, had a peak measured value at 55705 gammas. Results in this area indicate the presence of multiple metallic objects.





Zone 3 is an elongated feature south of Zone 2. The highest measured magnetic field value was 55929 gammas. This area appears to be connected with Zone 1 by a trench-like feature between the two zones.

Zone 4 is an isolated feature in the southeast corner of the landfill. The highest measured value was 55895 gammas.

These four zones are interpreted to have the highest concentration of metallic objects. It is not possible by the geophysical methods utilized, however, to determine the exact nature



LEGEND

-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
- 1 - 4** AREAS OF MAGNETIC HIGHS
-  MAGNETIC CONTOUR LINE
-  DEPRESSION CONTOUR

CONTOUR INTERVAL : 100 GAMMAS , ADD 50,000 TO CONTOUR VALUES FOR ACTUAL GAMMA VALUES



FIGURE 49

MAGNETIC CONTOUR MAP

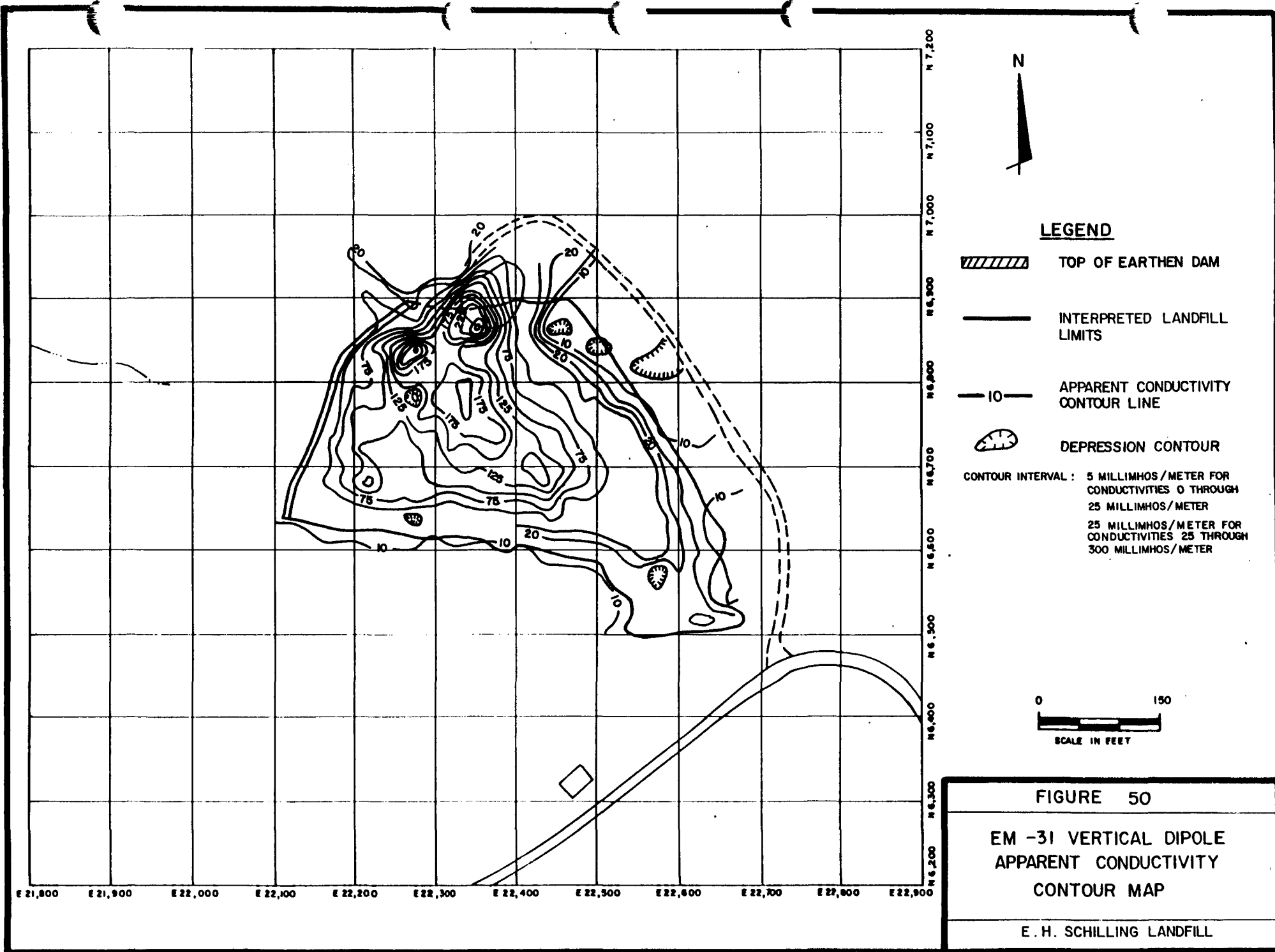
E. H. SCHILLING LANDFILL

of the objects, i.e. drums as opposed to other metallic items such as rebar or car parts. However, historical records and photographs indicate that metal drums exist within the landfill.

The rest of the landfill area has a relatively uniform distribution of the magnetic field with values not exceeding 55300 gammas. A relatively large area of low magnetic values was encountered in the northeast part of the landfill. The measured values were as low as 54625 gammas. This probably indicates an area in the landfill with relatively little metal.

An EM-31 survey recording both the out-of-phase (apparent conductivity) and the in-phase components of the electromagnetic field was used to determine the horizontal extent of the landfill and aid in identification of buried metal. Figure 50 is a computer-generated contour map of the EM-31 apparent conductivity data. The apparent conductivity values were digitized from the field records, and the map generated is based on over 1700 digitized points. The data indicate the following:

- o Background values outside of the landfill are typically about 10 millimhos/meter.
- o The central part of the landfill has apparent conductivity values greater than 150 millimhos/meter.
- o The highest apparent conductivity values (greater than 250 millimhos/meter) are associated with an area near magnetic Zone 2.



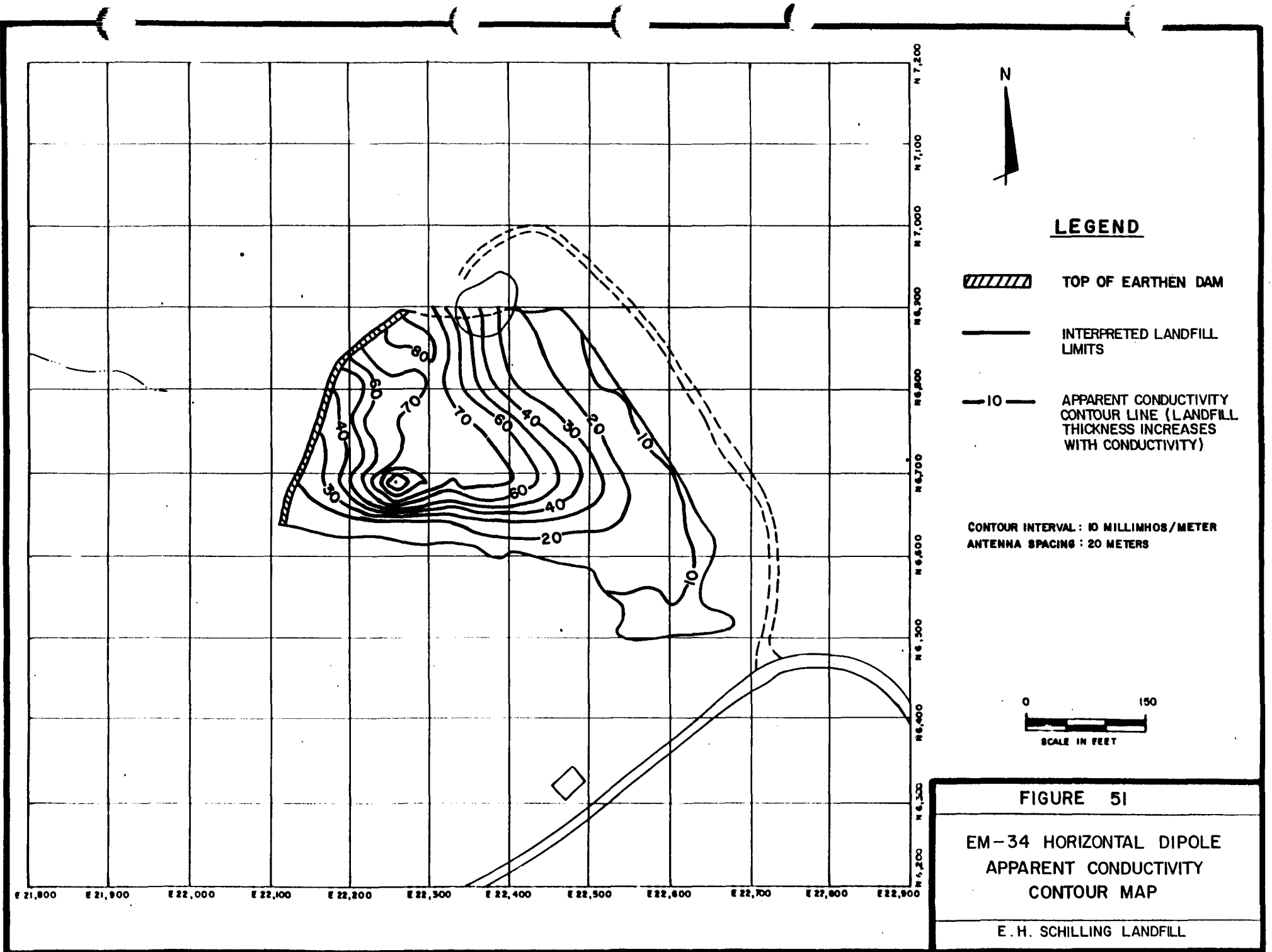
- o An area with apparent conductivity values higher than the surrounding area is also associated with magnetic Zone 1.

- o The EM-31 data indicates scattered metal at shallow depths in magnetic Zone 4.

- o The EM data was variable in the landfill area, indicating the possibility of scattered metal throughout.

Figure 50 shows the interpreted limits of the landfill based on the EM-31 data.

An EM-34 survey was performed to delineate areas of electrical conductivity anomalies. Measurements were made both in horizontal and vertical dipole modes. Apparent conductivity background values for the horizontal dipole survey are approximately 5-10 millimhos/meter. Within the landfill the apparent conductivity values reach a maximum of over 100 millimhos/meter. The distribution of values from the horizontal dipole survey is interpreted to outline the area of thicker fill (Figure 51). The interpreted thickest part of the landfill is outlined by the axis of highest apparent conductivity values. This axis is the interpreted axis of the pre-existing valley. The apparent conductivity values measured with the EM-34 are lower than those measured with the EM-31, due to the deeper penetration into the less conductive natural terrain beneath the landfill.





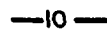

Background apparent conductivity values for the EM-34 survey in the vertical dipole mode are 6-10 millimhos/meter. Within the landfill area the distribution of apparent conductivity values, ranging from negative values to 53 millimhos/meter, indicate the concentration of conductive material, probably metals. The vertical dipole mode was more affected by metallic objects than the horizontal mode. Negative values and very high values typically indicate metallic interference and not necessarily real apparent conductivity values. They do, however, outline areas of concentrated metallic objects.

Figure 52 is a computer generated contour map of the EM-34 vertical dipole apparent conductivity values. The topographically lower section of the landfill appears to contain most of the concentrations of highly conductive material. Dependent on the relative position of the profile lines versus the position of the apparent conductive materials, the conductivity values may show a high or a low. Apparent conductivity highs and lows are associated with magnetic Zones 1, 2, 3 and the trench-like connection between Zones 1 and 3. The relatively small EM-34 response in the Zone 4 area suggests the shallow and isolated nature of the metal in this area.

All ER soundings were conducted within the interpreted extent of the landfill to depths ranging between 40 and 64 feet below ground. Underneath a thin cover (2.0 - 2.5 feet) of material with resistivities of 200 - 1100 ohm-feet, probably varying with the amount of clayey minerals and water content, all ER soundings indicate the presence of less resistive material (12 - 120 ohm-feet), interpreted as landfill material. Underlying this conductive material is a layer characterized by higher resistivities. They range from 1000 ohm-feet in VS-5 to 2000 ohm-feet in VS-1. The top of this geoelectric layer is interpreted to indicate



LEGEND

-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  10 APPARENT CONDUCTIVITY CONTOUR LINE
-  DEPRESSION CONTOUR

CONTOUR INTERVAL : 10 MILLIMHOS/METER
 ANTENNA SPACING : 20 METER



FIGURE 52

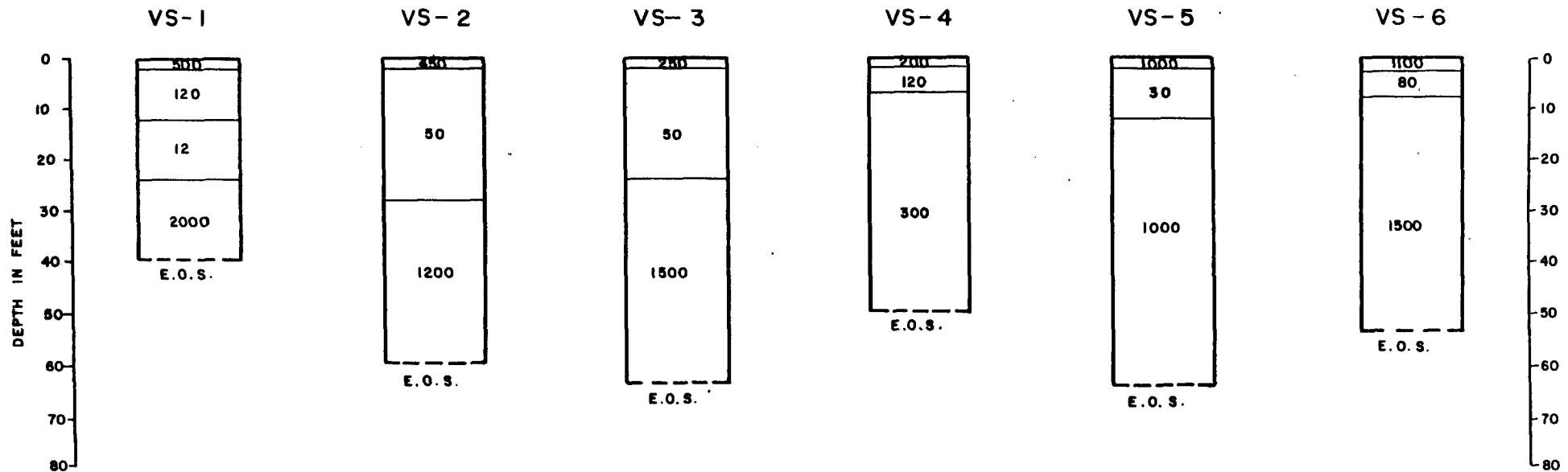
**EM-34 VERTICAL DIPOLE
 APPARENT CONDUCTIVITY
 CONTOUR MAP**

E. H. SCHILLING LANDFILL

the bottom of the landfill. ER sounding VS-4 is an exception in that it does not indicate the presence of a more resistive layer. The more conductive (less resistive) material as indicated by soundings VS-1, 2, 3 and 5 is located in areas that correspond to a deeper landfill bottom. The interpretation of the six ER soundings is shown in Figure 53.

Seismic refraction methods were employed to investigate the landfill depth. Seismic data were collected on profile lines, each 120 feet long. The interpreted seismic velocity layers and depths are presented as cross-sections in Figures 54 through 56. Materials with seismic velocities on the order of 1000-2000 feet per second are interpreted as landfill material or soil. Materials with seismic velocities of approximately 2600-3000 feet per second and higher are considered to be either decomposed rock (soil) with high standard penetration test (SPT) resistances of up to 100 blows/foot or partially weathered rock with SPT resistances higher than 100 blows/foot. These velocities are interpreted to indicate the bottom of the landfill and also a transition layer to the weathered rock layer immediately underneath. Layers with velocities of 6000 feet per second are interpreted as weathered rock. The interpreted thickness of the landfill based on the seismic refraction data is presented in Figure 57.

At some seismic refraction line intersections the interpreted seismic velocities in the weathered to fractured rock zone from one spread may not correspond to the seismic velocity from another spread. This may be due to anisotropy in the weathered and fractured rock zones and seismic averaging, or poor data quality. However, that does not affect the interpreted thickness of the landfill material.



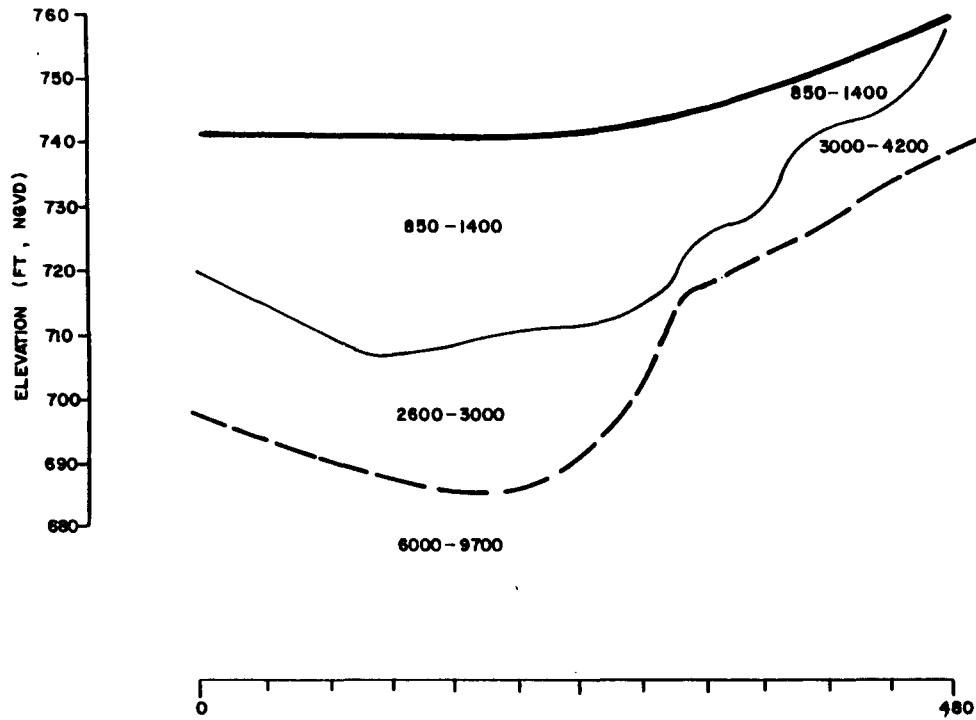
LEGEND

500 ELECTRICAL RESISTIVITY IN OHM FEET

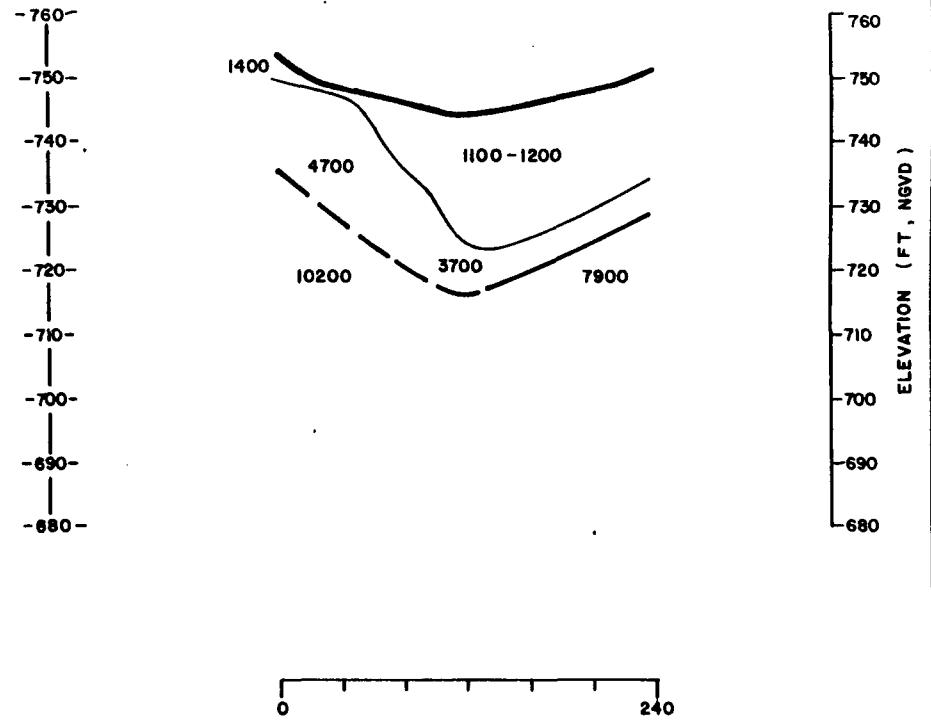
E.O.S. END OF SURVEY

FIGURE 53
 ELECTRICAL RESISTIVITY
 VERTICAL SOUNDINGS
 PSEUDO LOGS
 DOWNSTREAM AREA
 E.H. SCHILLING LANDFILL

SL - 1



SL - 2



LEGEND

850 - 1400 SEISMIC VELOCITIES IN FEET PER SECOND

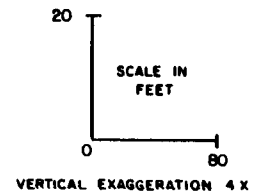


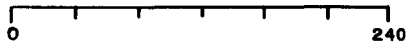
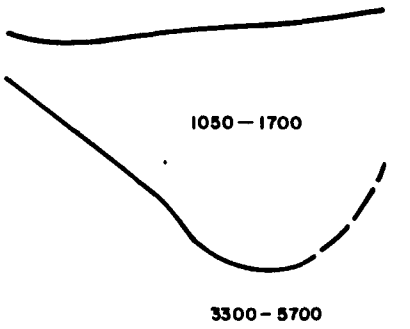
FIGURE 54

SEISMIC REFRACTION PROFILES
SL-1 AND SL-2

E. H. SCHILLING LANDFILL

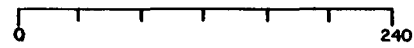
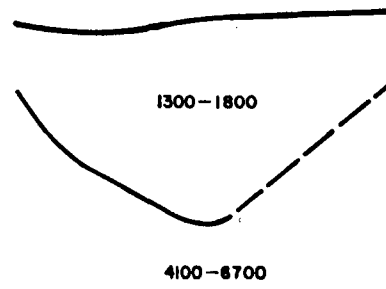
SL - 4

ELEVATION (FT , NGVD)
750
740
730
720
710
700
690



SL - 3

-750-
-740-
-730-
-720-
-710-
-700-
-690-



ELEVATION (FT , NGVD)
750
740
730
720
710
700
690

LEGEND

1050-1700 SEISMIC VELOCITIES IN FEET PER SECOND

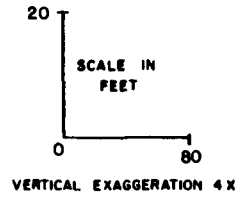
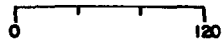
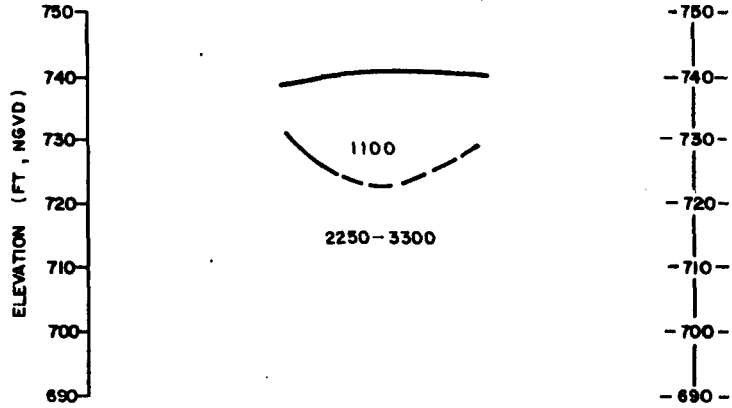


FIGURE 55

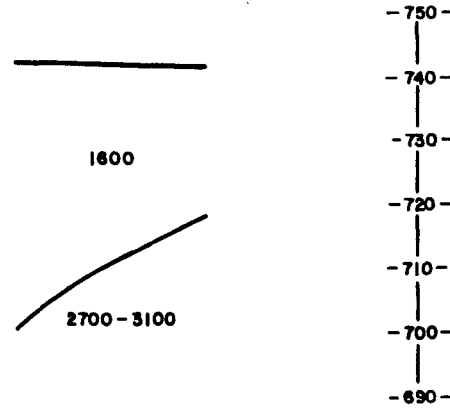
SEISMIC REFRACTION PROFILES
SL - 3 AND SL - 4

E. H. SCHILLING LANDFILL

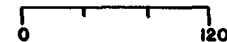
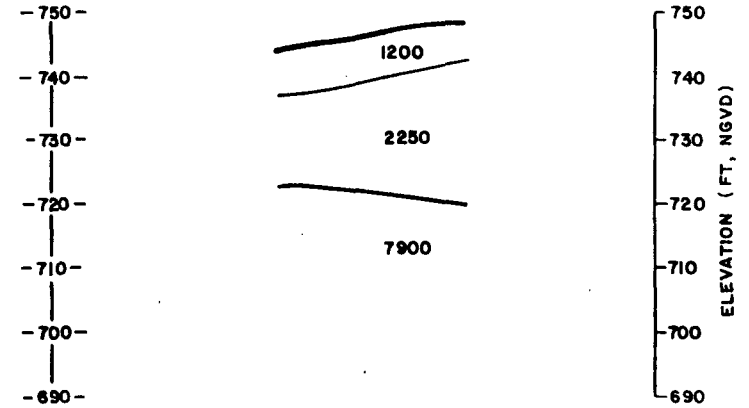
SL - 5



SL - 6



SL - 7



LEGEND

1100 SEISMIC VELOCITIES IN FEET PER SECOND

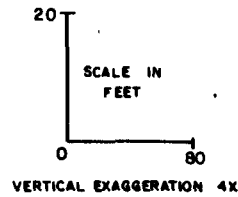
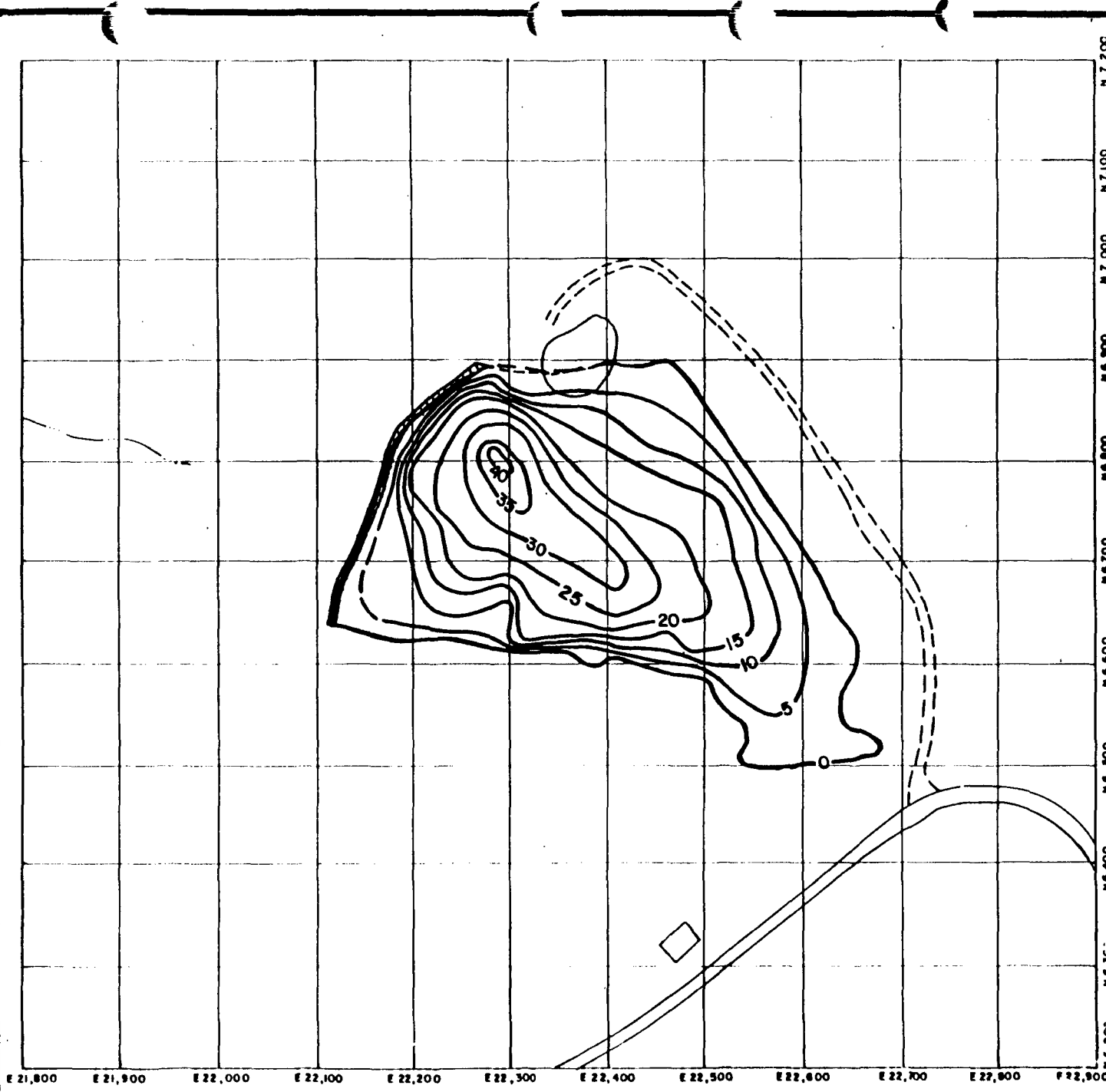





FIGURE 56

SEISMIC REFRACTION PROFILES
SL-5, SL-6 AND SL-7

E. H. SCHILLING LANDFILL



LEGEND

-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  - 10 - CONTOUR LINE OF INTERPRETED LANDFILL THICKNESS INCLUDING CLAY CAP

NOTE : CONTOUR INTERVAL IS 5 FEET.



FIGURE 57

INTERPRETED THICKNESS
OF LANDFILL MATERIAL

E.H. SCHILLING LANDFILL

Discussion of Results

The horizontal extent of the landfill is best depicted by the EM-31 survey. The high conductivity of the ash pile on the north side of the landfill obscured the landfill edge in that area.

The vertical extent of the landfill is interpreted from the seismic, ER, and EM-34 surveys. The EM-34 horizontal dipole contour map (Figure 51) is interpreted to show the pre-existing valley axis (and therefore the deepest parts of the landfill). The seismic profiles (Figures 54 through 56) and ER soundings (Figure 53) show interpreted landfill thickness at those locations. The interpreted landfill thickness based on the above is shown in Figure 57.

Within the landfill, four main areas of magnetic material were delineated (Zones 1 - 4 in Figure 49). These areas were confirmed by either the EM-31 or EM-34 surveys or both.

Zone 1, the area of the greatest magnetic anomaly, and also associated with conductive anomalies, is near N 6740; E 22240. This suggests that Zone 1 is the area of largest concentration of metals in the landfill.

Zone 2, near N 6850; E 22350, was also identified by magnetic and conductive anomalies. This area has the highest EM-31 apparent conductivity values. The magnetic anomaly at Zone 1 was larger in aerial extent and field strength than that of Zone 2 suggesting a higher concentration of metallic objects in Zone 1. Apparent conductivity is influenced by metallic objects, as well as conductive pore fluids, making the magnetometer a better indicator of

metallic mass than the EM-31. Zone 2 corresponds to a topographic rise in the landfill surface. Zone 3, adjacent to N 6650, E 22450 and possibly extending westward to Zone 1 in a trench-like fashion Zone 3 has a magnetic anomaly along with a more subdued apparent conductivity anomaly.

Zone 4 is near grid coordinates N 6560, E 22580. Zone 4 is interpreted as a shallow, isolated anomaly based upon the magnetic, EM-31 and seismic surveys.

The landfill area to the east and northeast exhibited the least changing magnetic field values and lowest apparent conductivity values in the landfill. This probably indicates minimal metal debris.

The EM-31 in-phase response showed variations throughout the landfill, indicating at least the possibility of various amounts of metal or conductive pore fluids throughout the landfill area.

The combination of methods correlates well at individual locations. The seismic and ER values indicated similar landfill depths. The ER and EM surveys both indicated similar conductivity values for the landfill material. MG and EM surveys indicated the presence of metallic objects in the same areas.

3.6.2 Diversion Ditches

The watershed drainage area limits upgradient of the earthen dam encompasses approximately 15 acres of land. The steep topography promotes rapid rainfall runoff. To

minimize the flow of runoff onto the landfill surface, three diversion ditches had been constructed at or near the base of the valley side slopes and one within the landfill itself. The collected water is diverted below the earthen dam to the Winkler Run tributary. Figure 22 (from Section 2.8) illustrates the features described above.

The ditches around the landfill are essentially triangular in shape with widely varying widths and depths. Typically, the ditches are two to four feet wide and two to eighteen inches deep. Ditch slopes range from about ten to thirty percent. At several locations, especially around the north side of the site, the ditches are much deeper. This is due to erosion of the exposed surface soils.

A ditch had been constructed from the central portion of the landfill area to the southern end of the dam (See Figure 22). The ditch is currently only a few inches deep with relatively flat side slopes. The slope of the ditch is about six percent. The ditch facilitates the movement of water across the landfill surface.

The soils exposed in the ditch bottoms are typically a silty or clayey sand. At some locations, the materials are very clayey and are more appropriately described as a sandy clay. The soils are generally very firm to dense in consistency. Weathered bedrock is exposed in some of the ditches.

An evaluation was made of the capacity of the diversion ditches using methods that compute the depth of the trench required to carry the design flow. The surface run-off volumes were determined using the procedures presented in "Urban Hydrology for Small

Watersheds," Technical Release No. 55, USDA Soil Conservation Service, 1975. The calculation is based on the Rational Equation for run-off, but incorporates factors for soil type, ground-cover type, time of concentration, and peak run-off, based on observed responses of surfaces to actual storms. It is noted that the approved October 1987 Sampling Plan stated that the Rational Equation in conjunction with Manning's Equation, as outlined in EPA document SW-867, was to be used to calculate run-off. However, the method cited above typically predicts a higher maximum flow (more conservative). The design storm for calculating run-off was chosen as the 25-year, 24-hour maximum rainfall event of approximately 4.5 inches for the area [EPA SW-867, Figure 9, 1975 (after USDA)].

The required ditch size was determined using Manning's equation for open-channel flow; the maximum size was determined in terms of depth of flow in triangular-shaped ditches. The calculated required ditch size was compared to the widely varying actual ditch sizes observed at several locations. Surface scour was evaluated using the scour equation relating maximum depth of flow to the particle size of the exposed material in the unlined ditch. Surface scour is erosion which occurs in the steeper portions of the unlined ditch with subsequent downstream siltation occurring in flatter sections. Calculations and a comparison of ditch sizes are included in Appendix B2.

The analyses show that the diversion ditches in the vicinity of the landfill are of sufficient dimensions to carry the flows of water generated by the design rainstorm. This is due in part to the number of ditches in the area, which make the land surface area each ditch is required to drain relatively small. It was observed that flow within the diversion ditches after rainfall events during the RI field work did not fill the ditches to capacity.

Our analysis confirms field observations that the ditches are susceptible to surface scour due to the lack of any lining, rip rap, or vegetation in the steeply sloping ditches.

3.6.3 Earthen Dam

The earthen dam was subjected to a thorough geotechnical investigation to determine the structural integrity and overall stability against sudden failure. The approximate dimensions of the dam are as follows:

height -	45 feet
length -	350 feet
width of crest -	16 feet

3.6.3.1 Background

On September 16, 1985 representatives of the US Army Corps of Engineers, Jacobs Engineering Group, Inc., and Weston, Inc., met at the Schilling Landfill to inspect the earthen dam, a portion of which had recently experienced failure. Text from their report dated September 24, 1985, is provided below:

In September 1985, Messrs. James A. Coffman, Jr., and Charles D. Barry, Huntington District, Corps of Engineers (ORHED-G), met in the District Office with Mr. Ed Burk of Jacobs Engineering Group, Inc., and Mr. David Hartman of Roy F. Weston, Inc., (representing the US EPA), to reconnoiter an embankment and effluent at a waste disposal site. The aforementioned traveled to the site (approximately 5 miles west of Ironton, Ohio, along US highway 52) and met with Mr. Earl H. Schilling of General Contracting, Inc., owner and operator of the waste disposal site. Upon inspection, the disposal area was determined to be fill which had been placed to within approximately 5 feet of the retaining embankment crest; however, neither impounded water nor waste was observed. Ground-water data and subsurface information was not available during the visit.

The embankment contained a surficial and circular failure within the downstream face which, at the crest, extended to a maximum depth of about five feet. This

failure appeared to be within upper and oversteepened portions of the embankment. The embankment did not evidence conditions which would have resulted from a high hydrostatic load. Construction methods and embankment materials are not known; however, the crest and downstream slope are mantled with weathered sandstone. Mr. Schilling stated that Dow Chemical, Inc., and US Steel, Inc., had disposed of solid and liquid wastes at this site and that the embankment was constructed to retain these wastes. Mr. Schilling recalled that the embankment, which had been constructed in one phase, was modified with 12 feet of additional height and a downstream berm.

After a plan review it was determined that the constructed embankment varied from geometries shown by the (original design) drawing. An approximate embankment section is shown as Enclosure 2 [(Figure 58)]. Though the embankment contains a surficial upperslope failure, breaching with resulting loss of life or property damage is not imminent.

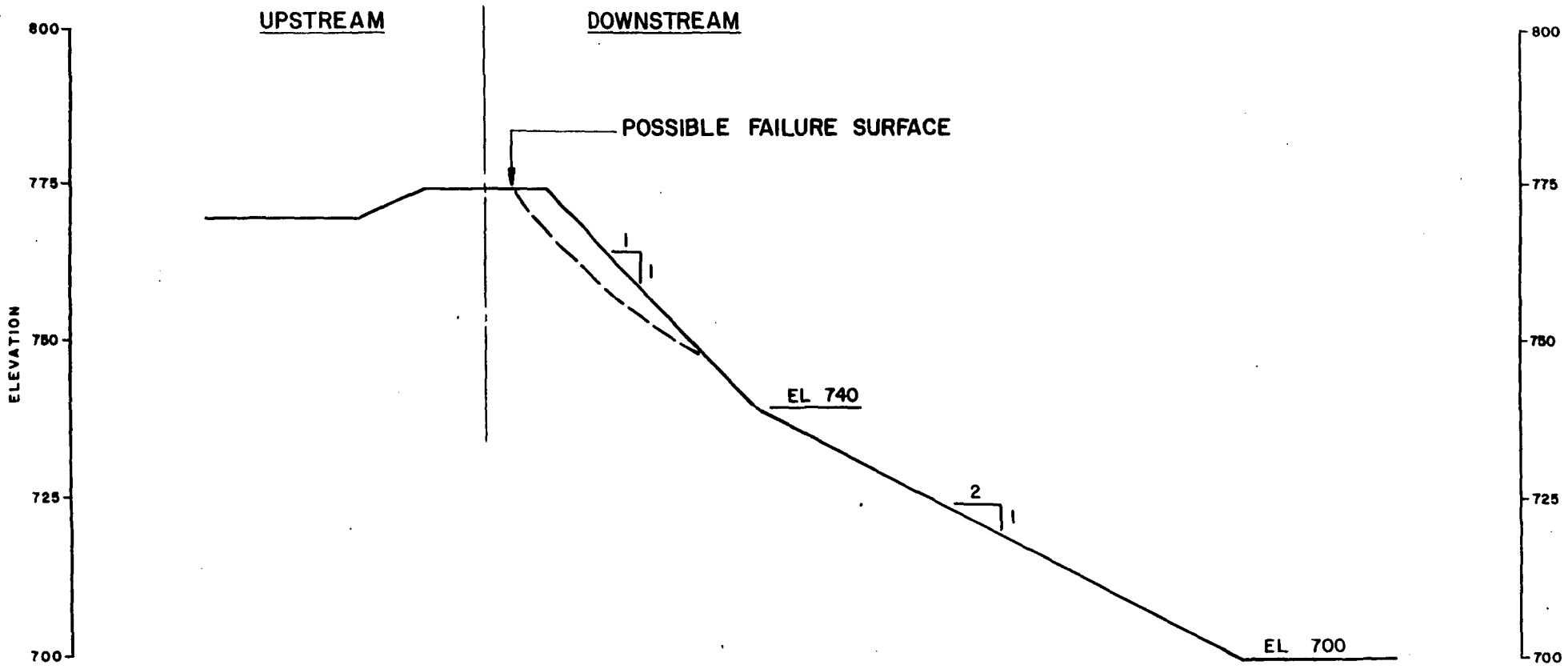
No residences are immediately downstream of the disposal site. The embankment is approximately 1000 feet upstream from the nearest road (Winkler Road). There are excavated spillways at both abutments to intercept surface runoff. Seepages were observed within mid- and lower abutment slopes. Clear seepages were encountered on the embankment at mid-height. Seepages, on 16 September 1985, at the toe of abutment totaled less than 5 gpm. The representatives for US EPA obtained jar samples of seepage from the embankment face and downstream toe.

Subsequent to the 1985 inspection, minor modifications were made to the dam. No written documentation of the modifications has been found. It should be noted that elevations shown on Figure 58 were later shown to be in error.

3.6.3.2 Slope Stability Analysis

A thorough characterization and stability analysis of the dam was performed during RI activities in the spring of 1988 to fill data gaps remaining from the 1985 investigation.

Eight soil test borings were drilled along two separate profile lines through the earthen dam at locations shown on Figure 59. Test boring, field, and laboratory data were used to perform a slope stability analysis of the dam as it currently exists.



NOTE : SLOPES , ELEVATIONS AND HORIZONTAL DISTANCES ARE APPROXIMATE

COMMENT: ELEVATIONS WERE LATER SHOWN TO BE IN ERROR

SOURCE : ENCLOSURE 2, SEPTEMBER 24, 1985 REPORT BY JACOBS ENGINEERING GROUP, INC.

FIGURE 58

APPROXIMATE EARTHEN DAM
EMBANKMENT SECTION
JACOBS ENGINEERING GROUP, INC.

E. H. SCHILLING LANDFILL

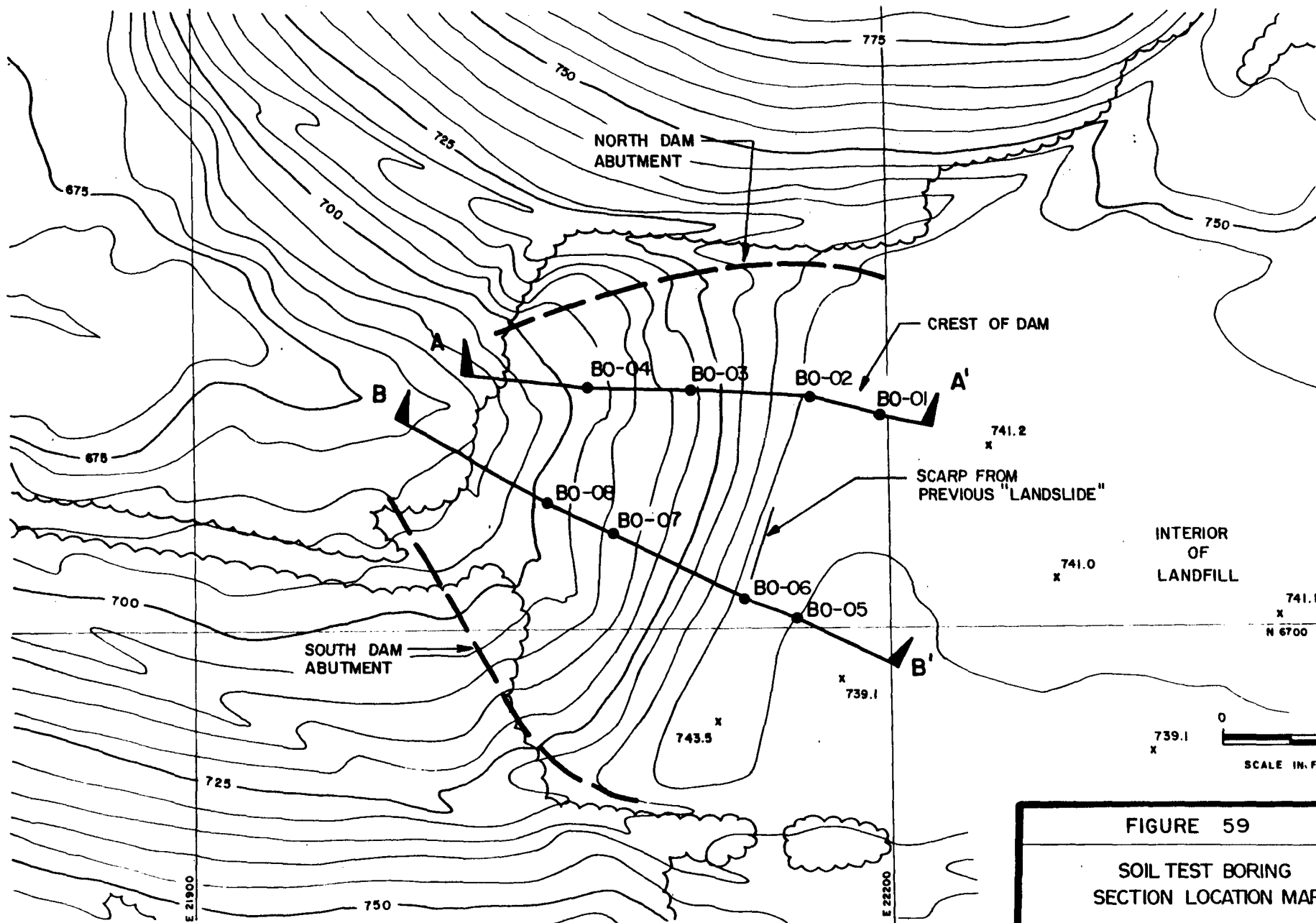


FIGURE 59
SOIL TEST BORING
SECTION LOCATION MAP
 E. H. SCHILLING LANDFILL

The materials encountered in the test borings included waste fill, soil fill, residual soil and rock. A brief description of each material follows:

- a) Waste fill - includes a variety of material including wood, cinders, plastic beads, styrene boards, and brick fragments mixed with sand, silt and clay.
- b) Soil fill - typically a silty sand excavated from the hillsides and used for construction of the dam.
- c) Residual soil - soil that has weathered in place from the underlying rock.
- d) Rock - shale or sandstone

Waste overlain by soil fill was encountered below the ground surface in borings BO-01, BO-02, BO-05, BO-06 and BO-07, with overlying soil fill depths ranging from 3 to 18 feet.

Waste was encountered in these borings in thicknesses ranging from 13 to 31 feet. Six to 30 feet of residual soil extending to the top of rock was encountered beneath the waste fill.

In borings BO-03, BO-04 and BO-05, no waste was encountered overlying 7 to 30 feet of residual soil and rock. Figure 60 shows a cross-section (A-A') through borings BO-01, BO-02, BO-03 and BO-04 and Figure 61 shows a cross-section (B-B') through borings BO-05, BO-06, BO-07 and BO-08. Soil or waste fill, residual soil, and rock layers are identified, and the phreatic water surface as of June 15, 1988 is shown.

The ground-water levels vary between the two sections. The levels in A-A' are approximately six feet higher than along B-B'. Also, the water intersects the face of the dam at Section A-A'.

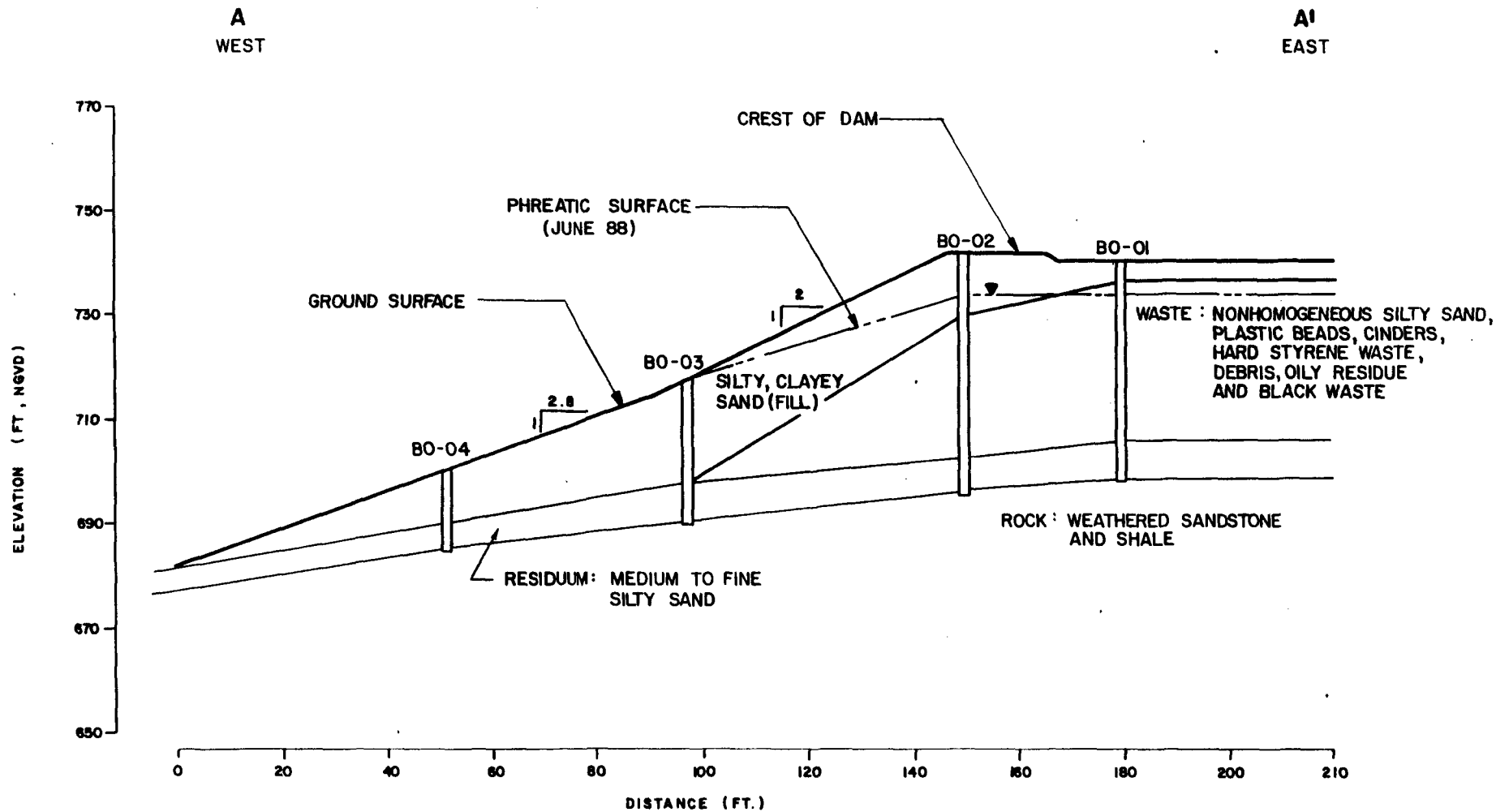


FIGURE 60

DAM SECTION A-A'

E. H. SCHILLING LANDFILL

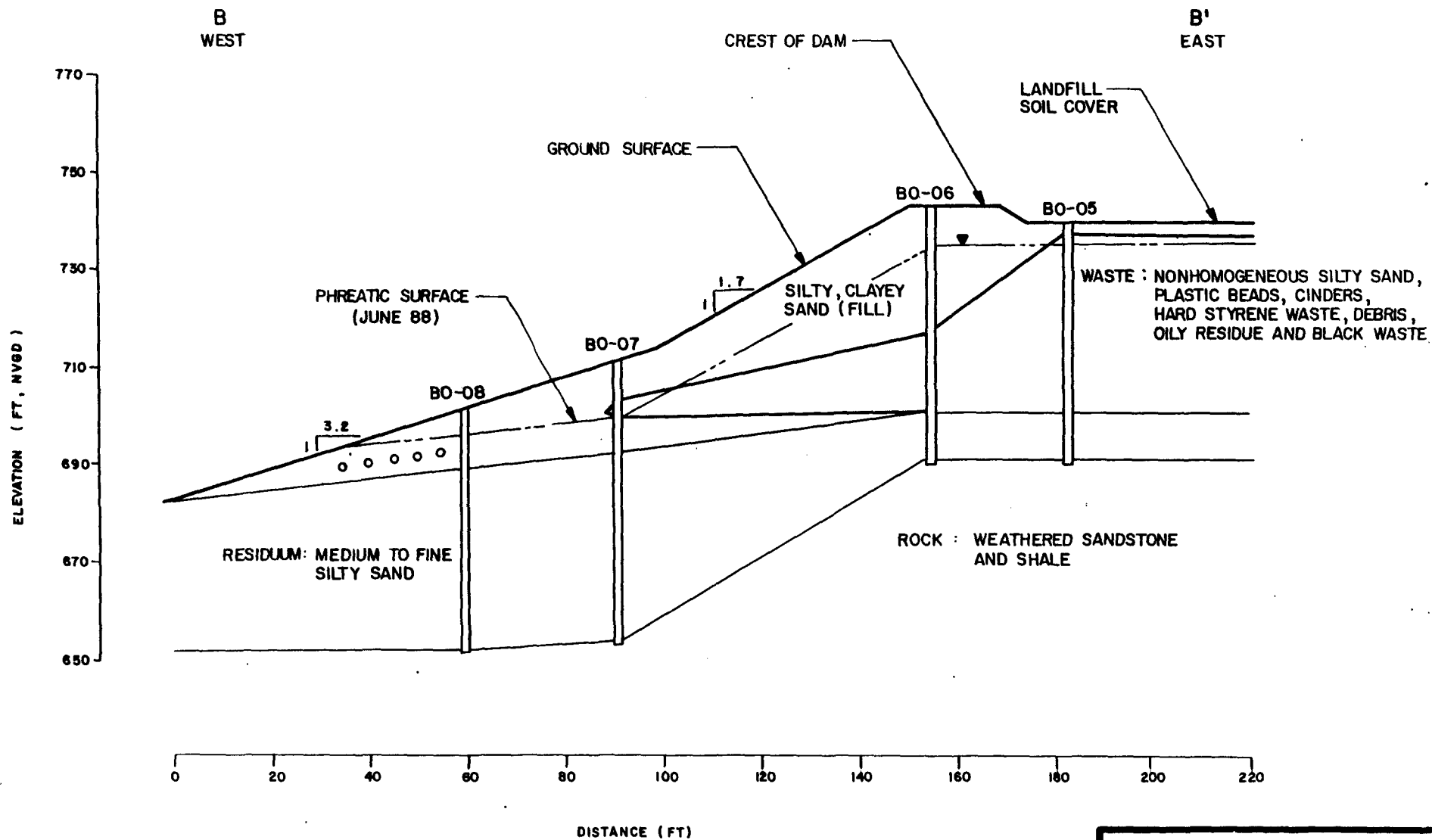


FIGURE 61

DAM SECTION B-B'

E. H. SCHILLING LANDFILL

o o o o THIS PORTION OF PHREATIC SURFACE ASSUMED FOR MODELING

In conversations with Messrs. Earl and Pat Schilling, it was stated that the dam was constructed in two phases. The first phase included constructing the lower portion of the dam extending to elevations of approximately 710 feet. The second or more recent phase included the upper portion of the dam. The materials encountered in the borings indicate a significant portion of the second phase construction was performed over the then-existing waste fill material. Also, the undulating surface features in the center of the face of the dam, along with the presence of waste in boring BO-07, suggests that there may have been several small dike extensions between the times of construction of the two major construction events. The waste material is interpreted to extend below the upper portion of the dam as shown on Figures 60 and 61.

Strength parameters for the materials were determined by triaxial shear strength tests performed on the soil fill, waste fill and residual soil layers, as summarized on Table 25. The laboratory testing program was concentrated on samples from boring BO-06, since they were representative of the consistency of the materials in all the other borings and were weaker based on 'N' values. The soil fill is a silty, low plasticity sand with a Unified Soil Classification System (USCS) designation of SP-SM. Triaxial shear strength test results indicate a total friction angle and cohesion of 30 degrees and 400 pounds per square foot (psf), respectively. The waste material is a very low density clean to clayey low plasticity sand with a USGS designation of SC or SP. Triaxial shear strength test results on a waste sample indicate a total friction angle and cohesion of 27 degrees and 250 psf, respectively. The residual soil is a low plasticity, silty sand with a USCS designation of SM and total friction angle and cohesion of 37 degrees and 0 psf, respectively. The rock material was

TABLE 25

SUMMARY OF LABORATORY TESTS RESULTS

Sample Description	Location	Sample Type	Moisture Content (%)	Atterberg Limits			Grain-Size Test Results			USCS	Dry Unit Weight (lb/ft ³)	Shear Strength Test Results			
				LL (%)	PL (%)	PI (%)	Percent Gravel	Percent Sand	Percent Fines			Total Cohesion	Total Friction Angle (deg)	Effective Cohesion (psf)	Effective Friction Angle (deg)
Waste	BO-06 29-30 ft.	UD	18	28	18	10	13	52	35	SC	104.5	---	---	---	---
Fill	BO-06 9-10.5 ft.	SS	14	25	19	6	14	52	34	SM/SC	---	---	---	---	---
Waste	BO-06 31-32.5 ft.	SS	33	---	---	NP	14	56	30	SM	---	---	---	---	---
Residuum	BO-06 43.5 ft.	SS	12	23	17	6	10	46	44	SM/SC	---	---	---	---	---
Residuum	BO-06 40-42 ft.	UD	42	---	---	---	---	---	---	---	80	0	37	0	45
Waste	BO-06 27-29 ft.	UD	65	---	---	---	---	---	---	---	60	250	27	0	44
Fill	BO-06 10-12 ft.	UD	16	---	---	---	---	---	---	---	115	400	27	400	30

Notes: (1) USCS = UNIFIED SOIL CLASSIFICATION SYSTEM
 (2) L.L. = LIQUID LIMIT
 --- TEST WERE NOT PERFORMED.

(3) P.L. = PLASTIC LIMIT
 (4) P.I. = PLASTICITY INDEX

(5) SS = SPLIT SPOON
 (6) UD = UNDISTURBED

not tested for strength. Appendix B2 provides the grain size distribution curves and triaxial test curves.

In addition to triaxial shear testing, field vane shear testing was performed in Boring BO-05a at the 9-foot depth and boring BO-02a at 16 and 18 feet to determine the in-situ strength of the waste material encountered at these depths. Table 26 presents the results of the testing.

Computer Program Selection and Input

Several computer programs were considered for analysis of the dam, including "STABA", "STABL", "GEOSLP", "LANDSLI", and "FEADAM". Each of these programs is discussed in the Phase I Remedial Investigation Sampling Plan for the facility. The program "STABL" was chosen for the analyses because of its ability to analyze for both circular-arc and block sliding failures. The other programs either were not flexible in this respect (STABA, GEOSLP, and LANDSLI) or required other types of data. Program STABL is judged to be an excellent analytical tool for determining stability of the dam.

STABL is a limiting-equilibrium slope stability analysis program which uses Bishop's simplified method for circular-arc stability analyses and uses the simplified Janbu method for block sliding stability analysis. The circular arc analysis of slope stability calculates the factor of safety for a selected circular failure surface. The factor of safety is expressed as the ratio of resisting rotation (failure) about the circle center to the moments inducing failure. The program generates individual factors of safety, after which the critical failure surface is chosen by the user.

TABLE 26

VANE SHEAR TEST RESULTS

Test Dates: May 18-19, 1988

Test No. 1: B-05a, 9 ft. depth		Test No. 2: B-02a, 16 ft. depth		Test No. 3: B-02a, 18 ft. depth	
FORCE [pounds]	SOIL STRENGTH [pounds/sq. ft.]	FORCE [pounds]	SOIL STRENGTH [pounds/sq. ft.]	FORCE [pounds]	SOIL STRENGTH [pounds/sq. ft.]
225	1971	280	2453	280	2453

Note: Vane shear tests assume the soil is saturated, cohesive, and non-frictional. Since the soil tested at the site is frictional, the above strengths are not representative of the actual in-situ soil strength.

Input required for the STABL program includes surface and subsurface geometry, material properties, the phreatic surface location and material strength parameters (see Appendix B2 for input). For the analysis, the ground surface topography was determined from the site topographic map and the subsurface geometry was interpreted from the results of soil test borings in the dam. The soil and waste material strength parameters were obtained from the results of both in-situ strength tests and laboratory strength tests on samples obtained from the dam. These parameters were utilized in various computer runs to evaluate stability. Lower strength parameters were also utilized for the residuum in the slope stability analyses; however, no significant differences in the factors of safety were obtained. No testing was performed on the rock at the site since the material has considerable strength and a critical failure surface would not involve shearing of the rock. In order to model this strong material layer, a strength parameter of 10,000 psf for cohesion and 50 degrees for friction was assigned. These values were chosen as conservative estimated strength values for the sandstone and shale.

Additional input into the STABL model included the slope of the earthen dam face. The slope at Sections A-A' and B-B' were determined from the site topographic map as well as the surveyed elevations at the boring locations. Actual slopes determined in this manner along A-A' were approximately 2(H):1(V) along the upper portion and 2.8:1 along the lower portion. Along section B-B', the upper and lower slopes were approximately 1.7:1 and 3.2:1, respectively.

Selection of Critical Cross-Section

A "critical" cross section, which presumably has the greatest probability of failure, is typically selected for a dam analysis. For this dam, two cross-sections were selected for analysis during the development of the Sampling Plan. The test borings performed along these sections confirm that two sections should be analyzed due to the variable materials present and their varied thickness.

Results of Computer Analyses

The circular-arc and block sliding analysis were performed on both cross-sections at several different depths above rock. The phreatic surface initially used for analyses was that measured in June, 1988. This was the highest measured along each section prior to the date that the computer analyses were performed. Slightly higher levels have been measured in the spring of 1989 following heavy rain. However, it is considered that the June 1988 data are adequate values for practical maximums. These data apply because the diversion ditches and dam configuration prevent impoundment and buildup of ground water in the landfill behind the dam. Figures 62 and 63 show the location of the failure surfaces with the lowest factors of safety for each analyses. The critical surfaces are located within the waste material, the weakest material within the dam.

The lowest factors of safety were 1.3 at Section A-A' and 1.5 at Section B-B' based on the June ground water data. Although the June data are probably near the highest level that can occur along each section, the effect of raising the ground-water surface by approximately 6 feet in Section B-B' and having it seep on the dam face was evaluated. This simulates the condition along Section A-A' and represents a worse case with a

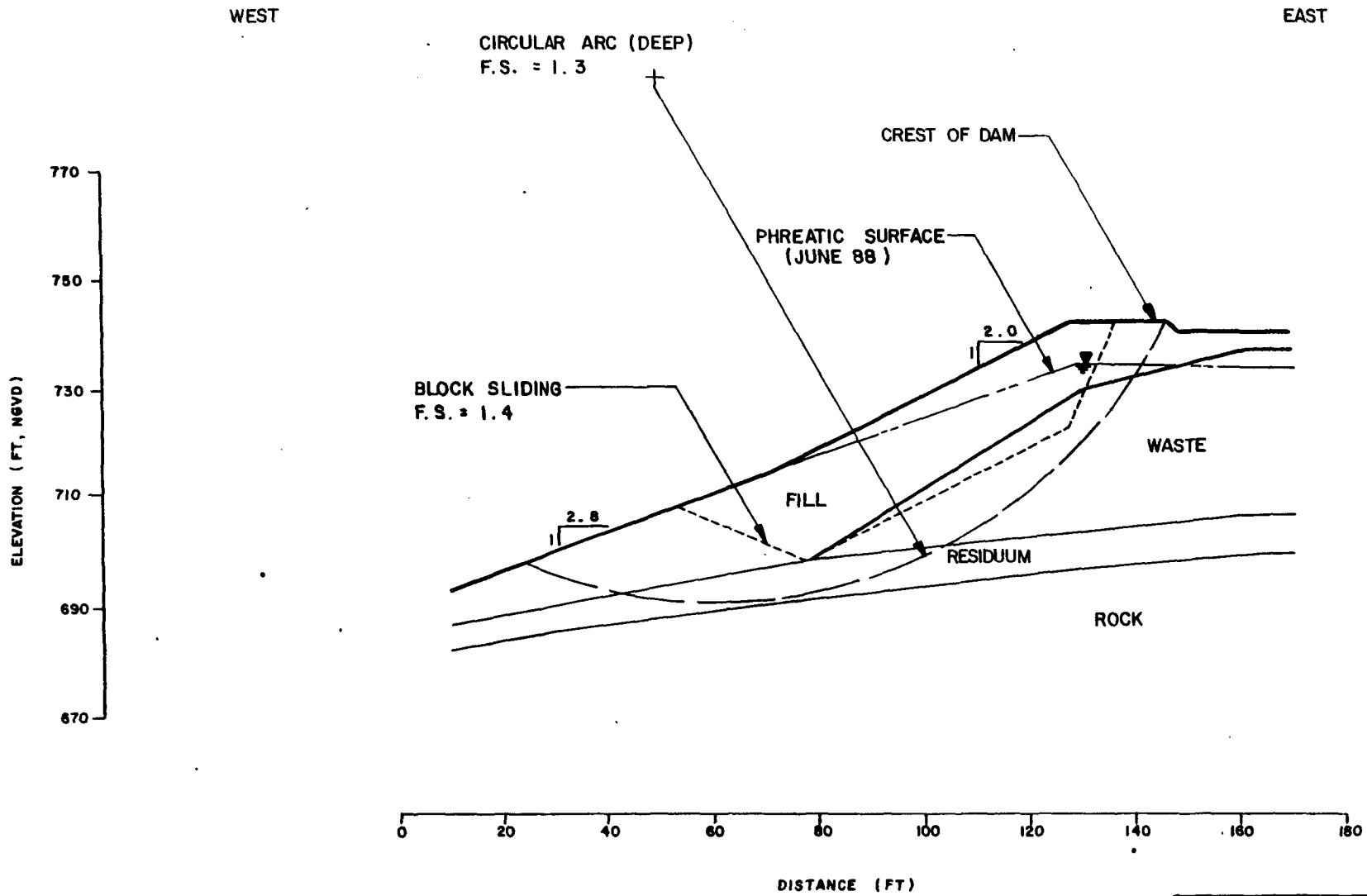


FIGURE 62

RESULTS OF STABILITY ANALYSES
SECTION A-A'

E. H. SCHILLING LANDFILL

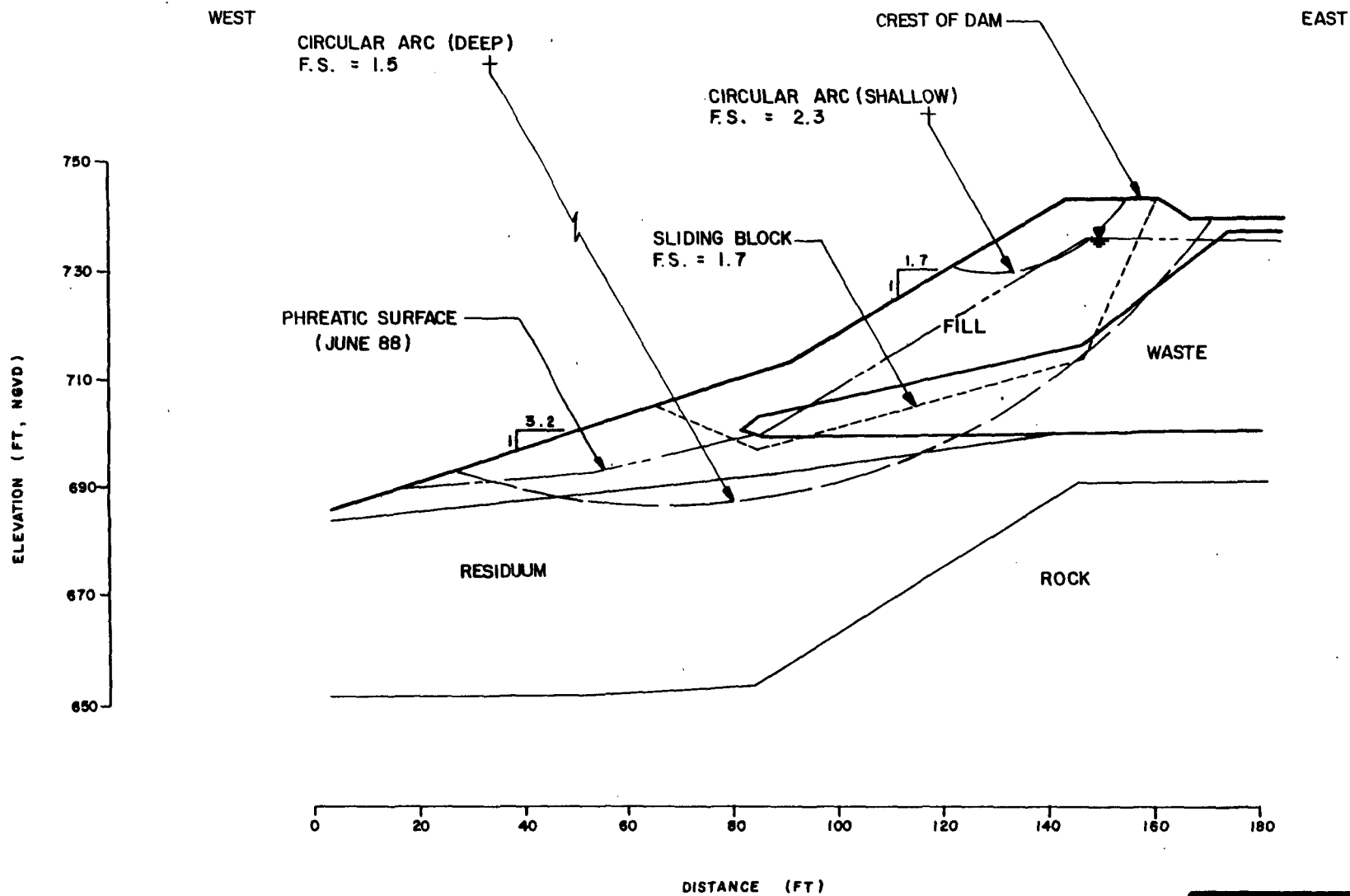


FIGURE 63

RESULTS OF STABILITY ANALYSES
SECTION B-B'

E. H. SCHILLING LANDFILL

computed factor of safety at Section B-B' of 1.3. A factor of safety equal to 1.0 would indicate that the dam is at a point of impending failure. A factor of safety of 1.5 is generally considered as a minimum allowable design factor of safety for a structure of this kind. Because a factor of safety of 1.3 was calculated using somewhat conservative strength parameters, and allowing for varying material in the dam section, the dam is considered structurally stable. However, the factor of safety is not adequate to meet standard design practice.

A computation was also performed to evaluate the possibility of a shallow failure or landslide at the crest of the dike similar to that which occurred several years ago. Only the fill is involved in the shallow failure surface as shown on Figure 63. The calculated factor of safety for this condition is 2.3. This high factor of safety is due to the modifications made to the dam after the previous failure.

3.6.3.3 Conclusions

The analyses performed show that the dam is structurally stable. However, the calculated factors of safety against sliding of the embankment are marginal compared against standard practice.

The presence of seepage as high as the mid-point of the dam face is of concern. The seepage on the face of the dam has apparently remained constant for a number of years (based on historical site records) and there does not appear to be erosion of soil fines from the dam interior. The seepage does not appear to be presently affecting the structural stability of the dam. However, seepage conditions could change with time, affecting

stability. Modifications are required to increase the factor of safety of the dam against instability to at least 1.5 per current design practices.

Time was factored into the conclusions by relating past observations to the analyses of present conditions. Observations had shown seepages to be consistently clear, with no fines. Seepage has apparently remained constant. The analyses of observations and test data showed the dam to be stable with "current conditions."

Changed conditions can affect stability of any dam. Regular inspection of all the dam would show any changed conditions. Such inspections would include visual survey of the dam surface for changes that could be interpreted to affect the stability of the dam.

3.6.4 Landfill Cap

The landfill cap integrity study was performed in accordance with Sampling Plan Section 2.8 with the exception of Agency approved changes as stated previously in Section 1.6. The stated purpose of this study was to determine compliance with 40 CFR 264.310 (RCRA Landfill Closure and Post-Closure Care) and ORC 3745-27-10 (Ohio Sanitary Landfill Rules and Regulations). The methodology used included the collection and evaluation of information describing the cap's composition, construction and condition.

3.6.4.1 Investigation Program

The investigation program consisted of two phases: a field data collection effort and a series of soil mechanics laboratory testing. The field work included the following:

- o Landfill cap surface inspection to determine its condition.
- o Hand augering through the cap at seventeen grid intersection locations to determine cap thickness.
- o Collection of seven undisturbed samples of cap soils for laboratory testing.
- o Performance of two Standard Proctor Tests (ASTM D 698) to determine maximum dry density of cap soils.
- o Performance of seventeen in-place density tests (ASTM D 2937) to determine actual cap density.
- o Visual classification (ASTM D 2488)

The soil mechanics laboratory testing of landfill cap materials included:

- o Grain size analysis (ASTM D 421, 422)
- o Atterberg Limits (ASTM D 423, 424)
- o Classification by Unified System (ASTM D 2487)
- o Unit weight and Natural Moisture Content (ASTM D 2216)
- o Permeability (US Army Corps of Engineers EM 1110-21906)
- o Erosion potential (based on guidance in US EPA 625/6-85/006)
- o Freeze - thaw potential (based on NAVFAC DM 7.1-39, 1982)

3.6.4.2 Data Evaluation

The data collected were evaluated, using guidance presented in the following publications:

- o Evaluating Cover Systems for Solid and Hazardous Waste, US EPA, Publication No. SW-867, 1982
- o Soil Properties, Classification and Hydraulic Conductivity Testing, US EPA Publication No. SW-925, 1984.
- o Remedial Action at Waste Disposal Sites, US EPA Publication No. 625/6-85/006, 1985
- o US Navy Facilities Engineering Command Design Manual 7.1, 1982

The evaluation process began with the landfill cap surface inspection. The cap's physical appearance, vegetation cover, slope, run-on/run-off control, etc., were noted. The maximum landfill cap slope, steepest slope gradient, and type of soil present at land surface were recorded. Cap thickness and soil type information were noted. The cap's in-place density and percent compaction relative to the Standard Proctor Test were determined in the field. This information was evaluated by direct comparison to required specifications. The data obtained from the soil mechanics laboratory testing of the seven undisturbed samples were compared to specifications for evaluation.

The landfill cap's erosion potential was evaluated based on guidance presented in US EPA publication 625/6-85/006, which uses soils engineering and agricultural procedures for evaluating the "potential" or "likelihood" for erosion to occur, given a particular set of circumstances.

The freeze/thaw potential of the landfill cap material was assessed using the guidance presented in NAVFAC DM 7.1-39, 1982.

3.6.4.3 Results

The results of study area inspection, field (in-situ) testing, laboratory physical testing and the comparison to relevant RCRA and ORC specifications are summarized on Table 27 and are described below.

TABLE 27

LANDFILL CAP INTEGRITY STUDY
COMPARISON OF SITE CONDITIONS AND REGULATORY REQUIREMENTS

PARAMETER	SITE CONDITIONS	RCRA 264.310	ORC 3745-27-10	COMPLIANCE
COVERAGE	COMPLETE	COMPLETE	COMPLETE	YES
THICKNESS	1.5 TO 3.5 FEET	NOT SPECIFIED	2.0 FEET	NO-DUE TO VARIABLE THICKNESS
UNIFORM TEXTURE	VARIES	NOT SPECIFIED	REQUIRED	NO
COMPACTION	77 TO 94% STD. PROCTOR	NOT SPECIFIED	95% STD. PROCTOR* 90% MOD. PROCTOR*	NO
PERMEABILITY	10^{-4} TO 10^{-8} CM/SEC	\leq NATURAL SUBSOILS	$\leq 10^{-7}$ CM/SEC*	NO-DUE TO VARIABLE PERMEABILITY
GRADIENT	4.4%	NOT SPECIFIED	1 - 25%	YES
RUN ON PROTECTION	PROVIDED	REQUIRED	REQUIRED	YES
RUN OFF CONTROL	PROVIDED	REQUIRED	REQUIRED	YES
VEGETATION COVER	PROVIDED	NOT SPECIFIED	REQUIRED	YES
ROUTINE MAINTENANCE	PROVIDED	REQUIRED	REQUIRED	YES

* NOT SPECIFIED IN REGULATIONS BUT ENFORCED AS A MATTER OF POLICY.

The inspection of the landfill cap indicated that its surface consists of a light brown fine to coarse sandy clayey silt. Locally, gravel, cobbles and larger rock fragments occur at ground surface. Sporadic erosional incisions to depths of one foot are apparent in the southeast quadrant of the landfill area, between the N 6500 and N 6700 lines and between E 22400 to E 22600.

The longest exposed slope is approximately 450 feet, measured east-west along N 6700. Maximum relief along the slope alignment is on the order of twenty feet, yielding a slope gradient of 4.4%. The materials visible at ground (landfill cap) surface include gravelly fine to coarse sandy clayey silt, sandy silty clay and clayey, silty fine to coarse sand. Large shale and sandstone cobbles were observed during a landfill inspection. Sandstone boulders are exposed in fill soils along the landfill edge and on the earthen dam's face. Cap soils fell into several classifications based on the Unified Soil Classification System (Table 28): these are CL, ML, SP, SM/GM and GP.

Run-on protection is provided by diversion ditches. Run-off control is provided by drainage ditches located north and south of the earthen dam. A sparse vegetation cover is present and routine cap maintenance has been provided on an "as needed" basis by E. H. Schilling.

The extent of the landfill cap's coverage and cap thickness were investigated in the field by analysis of soil samples obtained using a hand auger. Hand auger borings were advanced through cap material at all 17 site coordinate system grid intersections falling within the landfill's limits. Thickness and soil identification information was obtained. Cap thickness information was previously illustrated on Figure 25.

TABLE 28
UNIFIED SOIL CLASSIFICATION CHART

Major Division		Group Symbol	Laboratory Classification Criteria		Soil Description
			Finer than 200 Sieve (%)	Supplementary Requirements	
Coarse-grained (over 50% by weight coarser than No. 200 sieve)	Gravelly soils (over half of coarse fraction larger than No. 4)	GW	0-5*	D_{60}/D_{10} greater than 4 $D_{30}^2/(D_{60} \times D_{10})$ between 1 & 3 Not meeting above gradation for GW PI less than 4 or below A-line PI over 7 and above A-line	Well-graded gravels, sandy gravels Gap-graded or uniform gravels, sandy gravels Silty gravels, silty sandy gravels Clayey gravels, clayey sandy gravels
		GM	0-5*		
		GC	12 or more*		
		GC	12 or more*		
	Sandy soils (over half of coarse fraction finer than No. 4)	SW	0-5*	D_{60}/D_{10} greater than 4, $D_{30}^2/(D_{60} \times D_{10})$ between 1 & 3 Not meeting above gradation requirements PI less than 4 or below A-line PI over 7 and above A-line	Well-graded, gravelly sands Gap-graded or uniform sands, gravelly sands Silty sands, silty gravelly sands Clayey sands, clayey gravelly sands
		SP	0-5*		
Fine-grained (over 50% by weight finer than No. 200 sieve)	Low compressibility (liquid limit less than 50)	ML	Plasticity chart		Silts, very fine sands, silty or clayey fine sands, micaceous silts Low plasticity clays, sandy or silty clays Organic silts and clays of low plasticity
		CL	Plasticity chart		
		OL	Plasticity chart, organic odor or color		
	High compressibility (liquid limit more than 50)	MH	Plasticity chart		Micaceous silts, diatomaceous silts, volcanic ash Highly plastic clays and sandy clays Organic silts and clays of high plasticity
		CH	Plasticity chart		
		OH	Plasticity chart, organic odor or color		
Soils with fibrous organic matter		Pt	Fibrous organic matter; will char, burn, or glow		Peat, sandy peats, and clayey peat

* For soils having 5 to 12% passing the No. 200 sieve, use a dual symbol such as GW-GC.

Source: Sowers, 1979.

The maximum dry density of existing materials was determined by collecting two representative bag samples of soil in the field and performing Standard Proctor Compaction Tests (ASTM D 698). For comparison, 17 drive cylinder soil density tests (ASTM D 2937) were performed to determine the cap's in-place density. Comparison of the in-place density to the maximum dry density of the materials show that the existing compaction of the cap materials varies from 77 to 94 percent. A summary of field density test measurements is given in Table 29.

Seven undisturbed samples of cap soils were collected for laboratory testing. Grain size distribution (ASTM D 421, 422) and Atterberg Limits (ASTM D 423, 424) tests were performed to confirm material identifications. The results of the tests are as follows. Natural moisture contents ranged from 11.7 to 25.8 percent (Table 30). The samples were slightly plastic. The maximum dry density ranged from 77.0 to 120.8 pounds per cubic foot. Coefficients of permeability ranged from about 2×10^{-4} centimeters per second to 7×10^{-8} centimeters per second. Calculated porosities range from 36 to 40 percent. Appendix B2 contains all field data and calculations pertaining to the landfill cap investigation.

RCRA Section 264.310 provides that landfill covers must function with minimal maintenance and provide long-term minimization of liquids (i.e., rain) through the cap. Cap cracking or heaving due to the action of frost expansion could potentially cause seasonal breaches in the cap's integrity. Therefore, this possibility was examined.

TABLE-29

SUMMARY OF CAP INTEGRITY STUDY FIELD DENSITY TESTS

E.H. SCHILLING LANDFILL

SAMPLING POINT NO.	LOCATION	MOISTURE, %	DRY DENSITY, pcf	COMPACTION, %*	PROCTOR TEST NO. **
T-1	N 6800 E 22300	42.9	90.5	77	1
T-2	N 6700 E 22300	25.0	105.8	90	1
T-3	N 6700 E 22200	25.0	104.4	86	1
T-4	N 6625 E 22200	11.1	103.1	87	1
T-5	N 6635 E 22300	33.3	90.5	77	1
T-6	N 6700 E 22400	17.6	104.0	88	1
T-7	N 6645 E 22400	17.6	107.1	91	1
T-8	N 6500 E 22480	17.6	106.6	90	1
T-9	N 6600 E 22600	17.6	105.6	89	2
T-10	N 6630 E 22500	17.6	110.2	93	2
T-11	N 6700 E 22500	17.6	95.9	81	2
T-12	N 6800 E 22520	11.1	103.7	87	2
T-13	N 6800 E 22400	5.3	111.4	94	1
T-14	N 6875 E 22400	17.6	100.0	85	1
T-15	N 6860 E 22300	17.6	97.4	83	1
T-16	N 6800 E 22200	17.6	104.6	89	1
T-17	N 6700 E 22600	25.0	103.2	87	1

NOTES: DENSITY TESTS PERFORMED IN GENERAL CONFORMANCE WITH ASTM D 2937.
 PROCTOR TESTS PERFORMED IN GENERAL CONFORMANCE WITH ASTM D 698.

* REFERS TO PERCENT MAXIMUM COMPACTION, DETERMINED BY THE STANDARD PROCTOR TEST, ASTM D-698

** PROCTOR NO. 1 118.0 PCF AT 11.2% MOISTURE CONTENT
 PROCTOR NO. 2 119.0 PCF AT 11.0% MOISTURE CONTENT

TABLE 30

CAP INTEGRITY STUDY
SUMMARY OF LABORATORY TEST RESULTS

SAMPLE ID (FT.)	MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	DRY UNIT WEIGHT (PCF)	PERMEABILITY (CM/SEC @ 20° C)	
LC-1	0-2	11.7	28	18	10	120.8	2.08×10^{-6}
LC-2	0-2	12.7	18	13	5	115.5	7.47×10^{-8}
LC-3	0-2	10.8	29	19	10	110.7	1.43×10^{-4}
LC-4	0-2	15.4	27	17	10	*---	*---
LC-5	0-2	13.9	23	18	5	113.8	5.75×10^{-6}
LC-6	0-2	25.8	23	19	4	77.0	1.10×10^{-5}
LC-7	0-2	18.8	25	18	7	107.3	3.73×10^{-6}

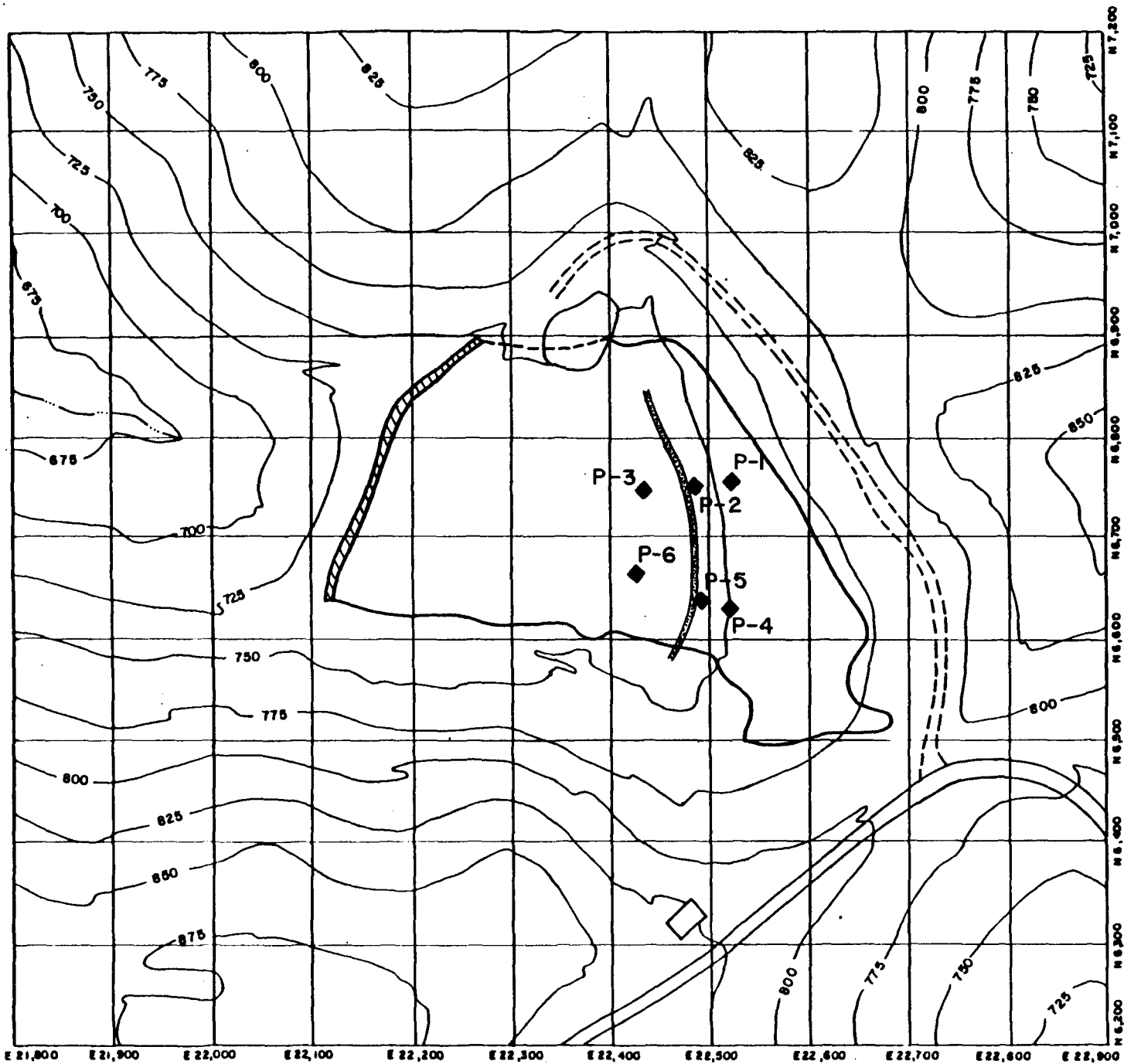
* NOT ENOUGH MATERIAL TO TEST

The test procedures were as follows: representative portions of cap material were obtained from six of the undisturbed tube samples used for permeability and material classification. Each sample was measured and weighed in the laboratory, and then subjected to two freeze/thaw cycles. Samples were frozen to -16° Celsius and thawed to 20° Celsius (room temperature). Test results showed a two to three percent volume increase in soil upon freezing (see Appendix B2 for lab testing results). According to NAVFAC Design Manual DM 7.1-39, the expected heave in non-frost susceptible soils may result in a four percent volume increase upon freezing. Therefore, it may be concluded from the test results that the cap in place overlying the site is not susceptible to frost action and associated breaching.

The freeze/thaw testing, although not formally required by the Sampling Plan, was voluntarily performed to obtain data describing the effects on the cap of extreme temperature variations possible in this part of the country. The freeze/thaw testing and calculation of possible effects used NAVFAC DM 7.1-39 (1982) methodology, the Cincinnati Building Code (1980) and Introductory Soil Mechanics and Foundations, Third Edition, by George F. Sowers, McMillan Publishers, 1970. The maximum anticipated freezing effects indicate that the likely depth of maximum frost penetration in the study area may be on the order of thirty inches.

3.6.4.4 Additional Studies

Six shallow piezometers were installed during the Phase II RI to investigate an area of leachate along the eastern end of the landfill. The leachate emanates along a linear zone at the approximate 744 ft. contour line shown on Figure 64. Leachate was observed flowing nearly year-round during the RI.



LEGEND





-  TOP OF EARTHEN DAM
-  INTERPRETED LANDFILL LIMITS
-  P-3
PIEZOMETER LOCATION
-  LEACHATE SEEP ZONE (APPROXIMATE)



FIGURE 64

**LANDFILL CAP INTEGRITY STUDY
PIEZOMETER LOCATIONS**

E. H. SCHILLING LANDFILL

The eastern end of the landfill is at a higher elevation than the central portion. Added waste material was added to the eastern end after original closing of the landfill when OEPA ordered E.H. Schilling to remove portions of the highwall area due to improper disposal activities in that area (per discussion with Mr. Pat Schilling). This "second lift" is conspicuously higher and has a steeper gradient. The leachate seeps are present where the slope flattens onto the original landfill surface. In the Phase I RI it was postulated that rainfall infiltrating through the upper lift materials became trapped by the original landfill cap (buried beneath the upper lift) and moved downslope to discharge as leachate, but no data were obtained to substantiate this postulate.

Two profiles of three piezometers (P-1 to P-6) were installed to measure ground-water elevations beneath the cap. Along each profile, two were installed in the upper lift area to a depth near the original landfill cap and one outside of this upper lift to monitor water levels in the main landfill area. Table 31 contains ground-water elevations measured on March 11, April 20 and May 16, 1989. Piezometers P-2 and P-5, both located near the base of the upper lift area immediately upslope of the leachate zone, exhibit ground-water under artesian conditions (i.e. water level is above the ground surface in the piezometer).

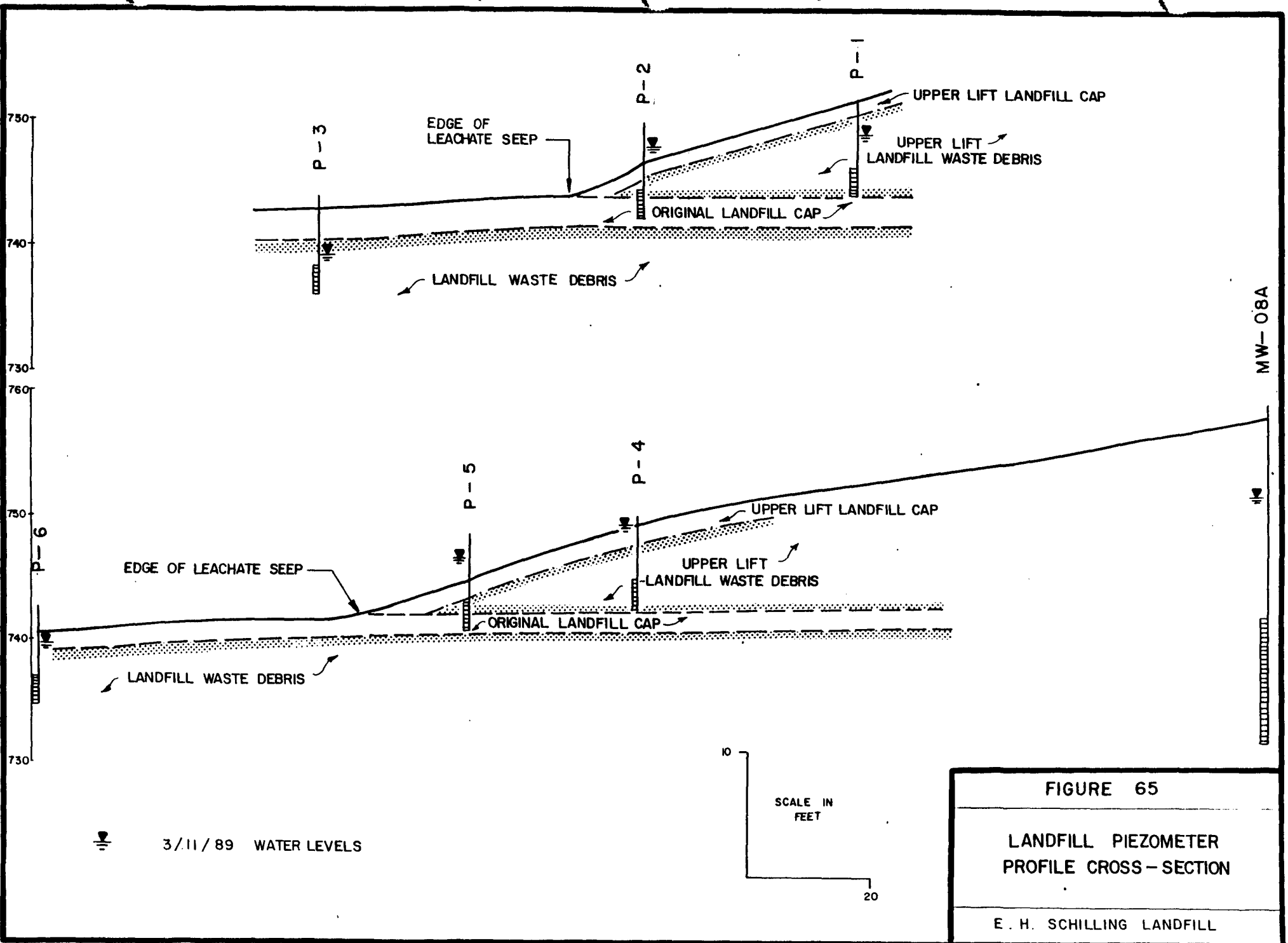
Figure 65 shows the two profiles in cross-section. This figure shows that the original cap below the upper lift prevents vertical migration and causes water to build up artesian pressure, resulting in leachate discharging on the downslope edge. The upper lift cap tends to hold back this water, permitting a slow release that is sustained during periods of little or no rainfall.

TABLE 31

SUMMARY OF LANDFILL PIEZOMETRIC
GROUND-WATER ELEVATIONS

INSTALLATION DATE	APPROX. GROUND SURFACE ELEV. (ft., N.G.V.D.)	GROUND-WATER ELEVATION (ft., N.G.V.D.)			
		03/11/89	04/20/89	05/16/89	
P-1	03/08/89	752.4	749.1	749.9	748.3
P-2	03/08/89	747.0	748.2*	747.2*	747.8*
P-3	03/09/89	742.6	739.2	739.5	739.7
P-4	03/09/89	749.4	749.2	748.2	748.6
P-5	03/09/89	745.4	746.7*	746.5*	746.7*
P-6	03/08/89	740.4	739.5	739.6	740.0

Note: * Artesian well ground-water elevations



3.7 Surface-Water Hydrology

The Ohio River is the dominant surface water feature in the area. All other streams and tributaries in the region drain into the Ohio River. A small intermittent stream flows from the valley downslope of the landfill earthen dam (Winkler Run tributary) toward the headwater area of the eastern branch of Winkler Run. Winkler Run is also an intermittent stream at this point, but flows continuously further downstream where the two (western and eastern) branches meet (Figure 2).

In accordance with the scope of work outlined in the Phase I RI Sampling Plan, streamflow was performed at six preestablished stations in the site vicinity. Station SW-01 is located in a small drainage feature southeast of the landfill within Schilling Hollow. Stations SW-02 and SW-03 are located along the Winkler Run tributary and stations SW-04 through SW-06 are located along the eastern branch of Winkler Run (Figure 12). Measurements were made on May 2, 1988 and December 13, 1988, with a Pygmy current meter. Table 32 is a tabulation of the results of the streamflow data. These gauging points were dry (no observed flow) at times during the summer and early fall months following a period of little to no rainfall. Note that the flow measured at SW-05 is greater than that recorded further downstream along Winkler Run at SW-06. It is possible that the stream loses water to the subsurface (influent stream) in this area. Appendix B6 contains calculations for the stream data.

TABLE 32

SUMMARY OF STREAMFLOW MEASUREMENTS
WINKLER RUN AND WINKLER RUN TRIBUTARY

STREAM GAUGING STATION	LOCATION COORDINATES		STREAM BOTTOM ELEVATION (ft., N.G.V.D.)	STREAM FLOW (cfs)	
	NORTHING	EASTING		05/02/88	12/13/88
SW-01	5736.99	22916.53	645.03	0.004	---
SW-02	6908.00	21758.01	648.70	0.006	0.008
SW-03	7051.56	21445.64	616.47	0.090	0.006
SW-04	6982.62	21131.18	593.94	0.096	0.003
SW-05	6896.44	21076.51	591.09	0.39	0.02
SW-06	6776.93	20951.79	585.37	0.18	0.007

NOTES: --- Negligible flow

Streamflow data were used to compare against calculated results of the site water balance approximation, discussed previously in Section 3.4.5.2. There is a good agreement between the actual measured flow with the calculated/approximated flow.

4.0 NATURE AND EXTENT OF CONTAMINATION

This section of the RI discusses the contaminants present in the landfill and the extent of the area impacted. The chemical data obtained are summarized relative to concentration and sampling location.

4.1. Waste Inventory

The E. H. Schilling Landfill received a variety of waste materials during its operation. Waste deposited in the landfill by Aristech Chemical Corporation and Dow Chemical are listed in Table 33 and Appendix B8. Additional wastes of unknown composition and volume were deposited by Ashland Oil Company; Associated Metals and Metallurgical Corporation; Matlack, Inc.; and Roy McGovney Construction, Inc.

4.2 Nature of Contamination

Eight media types were identified and chemically evaluated at the site:

- o Landfill waste
- o Soil borings
- o Leachate
- o Air
- o Surface water
- o Stream sediments
- o Surface soils
- o Ground water

Representative samples were obtained from each media type to determine the nature and extent of contamination at the site. All samples were analyzed for the target compound list

TABLE 33. SUMMARY OF WASTES DISPOSED IN
THE E. H. SCHILLING LANDFILL

Acetophenone	Fire drill (burning site)
Alcohol-aldehyde waste	cleanup
Alcohol waste, miscellaneous	Fuel oil tank bottoms
Ammonia	Lime waste
AMS waste	2-Methylstyrene
Aniline	Oil
Ash	Oil refuse
Ash settling pit	Oil sludge
Broken pallets, trash	Phenol-acetone waste
tert-Butylbenzene	Phenolic sludges
Calcium carbonate	Phenolic waste, miscellaneous
Calcium sulfate	Plant ditch dredgings
Calgon filters	Polystyrene chemicals
Chemical storage waste	Polystyrene waste, miscellaneous
Clarifier bottoms (river mud)	Process cell settlings
Coal	Reactor area waste
Concrete scrap	River debris
Cumene	River dock cleanup
Dimethylbenzyl alcohol	Septic waste
Ditch skimmer cleanout	Silo waste
Dowtherm waste	Sodium phenate
Drums	Styrene waste
Dump area cleanup	Styrofoam
Ethofoam	Thorane
Filter media	Waste clay
Fire fighting foam	Waste foam

TCL). Analyses were performed by CompuChem according to the Quality Assurance Project Plan.

4.2.1 Source Characterization

4.2.1.1 Landfill Waste Characterization

A total of thirteen landfill waste (LW) samples were obtained from eleven sampling points (Figure 9). Nine of the waste samples (LW-01 through LW-09) were obtained from just below the landfill cap. Four other waste samples (BO-01-1, BO-01-2, BO-05-1, and BO-05-2) were obtained from soil test borings drilled for the Earthen Dam Investigation (Section 2.9).

Laboratory analyses of the LW samples for the TCL chemicals identified eight volatile organic constituents, thirteen semi-volatile organic constituents, three pesticides, and twenty metals at concentrations equal to or greater than the Contract Required Quantitation Limit (CRQL). Laboratory analyses of the four BO samples for TCL chemicals identified twelve volatile organic constituents, twelve semi-volatile organic constituents, one pesticide, fourteen metals, and cyanide at concentrations greater than or equal to the CRQL.

Combining these two datasets resulted in a total of thirteen volatile organic constituents, thirteen semi-volatile organic constituents, twenty metals, four pesticides, and cyanide being identified at concentrations greater than or equal to the CRQL in the waste samples (Table 34). A complete listing of all LW and BO sample analyses results is included in Appendix B9.

TABLE 34. Constituents Identified in Landfill Waste Samples at Concentrations Greater than or Equal to Contract Required Quantitation Limit (CRQL)

CONSTITUENT	SAMPLING LOCATION	CRQL* (mg/kg)
<u>Volatile Organics</u>		
1,2-Dichloroethane	B01-02	0.005
2-Butanone	LW-02; B01-02	0.010
4-Methyl-2-pentanone	LW-02; B01-02	0.010
Acetone	LW-02, 05, 06, 09; B01-02	0.010
Benzene	B01-02	0.005
Chlorobenzene	B01-02	0.005
Chloroethane	B01-02	0.010
Dichloromethane	LW-02, 05, 09; B01-02	0.005
Ethylbenzene	LW-02, 03, 06, 07, 08, 09; All B0 Locations	0.005
Styrene	LW-06, 07, 09; B01-02, B05-02	0.005
Tetrachloroethene	LW-02	0.005
Toluene	B01-02	0.005
Xylenes (NOS)	LW-02; B01-02	0.005
<u>Semi-volatile Organics</u>		
Anthracene	LW-01	0.33
Benzo(a)anthracene	LW-01; All B0 Locations	0.33
Benzo(a)pyrene	LW-01; All B0 Locations	0.33
Benzo(b,k)fluoranthene	LW-01; All B0 Locations	0.33
Benzo(g,h,i)perylene	LW-01; B01-01, B01-02, B05-01	0.33
Chrysene	LW-01; All B0 Locations	0.33
Dibenzo(a,h)anthracene	B05-01	0.33
Fluoranthene	LW-01; B01-02, B05-01, B05-02	0.33
Indeno(1,2,3-cd)pyrene	LW-01; B05-01	0.33
Phenanthrene	LW-01; All B0 Locations	0.33
Phenol	LW-01, 02, 03, 08; B01-01	0.33
Pyrene	LW-01; All B0 Locations	0.33
bis(2-Ethylhexyl)phthalate	LW-01; B05-02	0.33

*Quantitation limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

TABLE 34.(CONTINUED) Constituents Identified in Landfill Waste Samples at Concentrations Greater than or Equal to Contract Required Quantitation Limit (CRQL)

CONSTITUENT	SAMPLING LOCATION	CRQL* (mg/kg)
<u>Pesticides</u>		
Aldrin	LW-07	0.008
Heptachlor	LW-09	0.005
4,4-DDD	LW-02, 03, 07, 08, 09	0.016
4,4-DDE	LW-02, 03, 07, 08, 09	0.016
<u>Inorganics**</u>		
Aluminum	All LW and B0 Locations	3.2
Antimony	LW-06	5.4
Arsenic	All LW and B0 Locations	0.6
Barium	All LW Locations; B01-01	0.4
Beryllium	LW-01, 02, 03, 04, 06, 07, 08, 09; B01-01	0.2
Calcium	LW-01, 02, 03, 06, 07, 08, 09; B01-01, B01-02, B05-02	2.0
Chromium	All LW and B0 Locations	0.6
Cobalt	All LW Locations; B01-01, B05-01, B05-02	1.2
Copper	All LW and B0 Locations	0.6
Iron	All LW and B0 Locations	0.8
Lead	All LW and B0 Locations	0.2
Magnesium	LW-03, 06, 07; B05-02	0.2
Manganese	All LW and B0 Locations	0.4
Mercury	LW-02, 07	0.1
Nickel	LW-01, 02, 03, 06, 07, 08, 09; B01-01, B05-01	2.2
Selenium	LW-07	0.6
Silver	LW-06	0.8
Sodium	LW-06, 07	6.8
Vanadium	LW-02, 03, 04, 06, 07, 09	0.6
Zinc	All LW and B0 Locations	0.4
Cyanide	B01-02, B05-01	0.5

*Quantitation limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

**Detection limits for an extract of 1 gram of solid in 200 ml of extractant based upon current Instrument Detection Levels (IDL's).

4.1.3 Leachate Sampling Results

Leachate samples (LS) were obtained at seven sampling points (LS-01 through LS-07 Figure 10). Analyses of leachate samples for TCL chemicals identified fifteen volatile organic constituents, four semi-volatile organic constituents, one pesticide, twenty metals, and cyanide at concentrations greater than or equal to the CRQL (Table 35). A complete listing of all leachate sample (LS) analyses results is included in Appendix B9.

4.2.1 Air

Site-specific air-quality data were obtained through sampling for analysis for total suspended particulates (TSP), heavy metals, and volatile organic compounds. Results show that twenty metals were identified in the three sets of TSP air samples collected from the five sampling points (Figure 17 and Table 36). No organic chemicals were detected in the volatile organic compound canister samples obtained at the air sampling stations. A complete listing of all air sample analyses results is included in Appendix B9.

An analysis was performed to estimate the maximum air quality concentrations for existing conditions of the capped landfill and to estimate maximum air quality concentrations that may occur during remedial actions. Emission rate estimates were developed as described in Section 2.6.3.2, Emission Rate Analysis. Based upon the analysis of the capped landfill, nickel slightly exceeds calculated allowable emission rates and is the only constituent evaluated that exceeds a calculated allowable emission rate. Table 37 lists the emission rate estimates for the capped landfill compared to the calculated allowable emission rates based upon ambient air-quality standards.

TABLE 35. Constituents Identified in Leachate Samples at Concentrations Greater than or Equal to Contract Required Quantitation Limit (CRQL)

CONSTITUENT	SAMPLING LOCATION	CRQL (ug/l)
<u>Volatile Organics</u>		
1,1-Dichloroethane	LS-01, 04, 06	5
1,2-Dichloroethane	LS-01, 02, 03, 04, 06, 07	5
1,2-Dichloroethenes (total)	LS-04	5
2-Butanone	LS-01, 04	10
4-Methyl-2-pentanone	LS-03, 04, 05	10
Acetone	All LS Locations	10
Benzene	LS-01	5
Carbon disulfide	LS-01	5
Chloroethane	LS-02, 03, 07	10
Methylene Chloride	LS-01, 04, 07	5
Ethylbenzene	LS-01, 02, 03, 05, 06, 07	5
Tetrachloroethene	LS-04, 05, 06	5
Toluene	LS-02, 03, 07	5
Trichloromethane	LS-01	10
Xylenes (NOS)	LS-05	5
<u>Semi-volatile Organics</u>		
2-Methylphenol	LS-03	10
4-Methylphenol	LS-02, 03, 07	10
Benzoic Acid	LS-02, 03, 07	50
Phenol	LS-01, 02, 03, 04, 05, 06, 07	10
<u>Pesticides</u>		
Heptachlor	LS-03	0.05
<u>Inorganics</u>		
Aluminum	All LS Locations	200
Antimony	LS-04	60
Arsenic	LS-02, 03, 04, 07	10
Barium	LS-01, 02, 03, 04, 06, 07	200
Beryllium	LS-03, 04, 05, 06	5
Calcium	All LS Locations	5000

TABLE 35.(CONTINUED) Constituents Identified in Leachate Sample at Concentrations Greater than or Equal to Contract Required Quantitation Limit (CRQL)

CONSTITUENT	SAMPLING LOCATION	CRQL (ug/L)
<u>Inorganics (continued)</u>		
Chromium	LS-02, 03, 04, 07	10
Cobalt	LS-04 05, 06	50
Copper	LS-01, 02, 03, 04, 05, 06	25
Iron	All LS Locations	100
Lead	All LS Locations	5
Magnesium	All LS Locations	5000
Manganese	All LS Locations	15
Mercury	LS-04	0.2
Nickel	LS-01, 03, 04	40
Potassium	All LS Locations	5000
Silver	LS-06	10
Sodium	All LS Locations	5000
Vanadium	LS-02, 03, 04	50
Zinc	All LS Locations	20
Cyanide	LS-06, 07	10

Table 36.
Schilling Landfill
Summary Statistics for
Air

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Silver, (ug/l)	15	5	0.00067	0.00067	0.00049	73.19251	BDL	0.001
Aluminum, (ug/l)	10	0	0.4421	0.4335	0.1305	29.51885	0.266	0.701
Arsenic, (ug/l)	15	15					BDL	BDL
Barium, (ug/l)	10	0	0.0264	0.024	0.00707	26.79625	0.019	0.039
Beryllium, (ug/l)	15	0	0.00173	0.00173	0.00046	26.40794	0.001	0.002
Calcium, (ug/l)	10	0	0.9885	0.877	0.56073	56.72505	0.476	2.213
Cadmium, (ug/l)	15	2	0.00193	0.00193	0.00198	102.45832	BDL	0.008
Chromium, (ug/l)	15	0	0.00293	0.00293	0.00308	105.0489	0.001	0.012
Copper, (ug/l)	15	0	0.02813	0.02813	0.02002	71.16448	0.006	0.07
Iron, (ug/l)	10	0	0.1361	0.1375	0.03432	25.21454	0.094	0.198
Mercury, (ug/l)	15	11	0.00033	0.00033	0.00062	185.16402	BDL	0.002
Potassium, (ug/l)	10	0	0.9052	0.8445	0.24235	26.77304	0.628	1.439
Manganese, (ug/l)	10	0	0.0049	0.0045	0.00099	20.29447	0.004	0.006
Sodium, (ug/l)	10	0	25.8325	25.451	14.06612	54.45127	11.896	55.337
Nickel, (ug/l)	15	0	0.0552	0.0552	0.20025	362.77999	0.001	0.779
Lead, (ug/l)	15	0	0.00553	0.00553	0.00295	53.291	0.002	0.012
Antimony, (ug/l)	15	0	0.067	0.067	0.02358	35.19351	0.037	0.123
Selenium, (ug/l)	15	8	0.00047	0.00047	0.00052	110.65667	BDL	0.001
Thallium, (ug/l)	15	0	0.067	0.067	0.02358	35.19351	0.037	0.123
Vanadium, (ug/l)	10	0	0.1229	0.12	0.06727	54.73934	0.056	0.246
Zinc, (ug/l)	15	0	0.02653	0.02653	0.00675	25.43687	0.019	0.041

BDL = Below Detection Limit

TABLE 37

Calculated Emission Rates for Metals for the
Capped Landfill and Calculated Allowable Emission Rates

PARAMETER	Calculated		Calculated Allowable Emission Rate** Based upon Ambient Air Quality Standard (ug/s-m2)
	(lb/hr)	Emission Rate* (ug/s-m2)	
Aluminum	0.026	0.272	2.280
Antimony	0.001	0.014	0.569
Arsenic	0.000	0.001	0.228
Barium	0.003	0.029	0.569
Beryllium	0.000	0.000	0.002
Cadmium	ND	ND	0.057
Calcium	0.033	0.344	2.280
Chromium	0.000	0.002	0.057
Cobalt	0.000	0.001	0.114
Copper	0.002	0.024	1.140
Iron	0.005	0.055	1.140
Lead	0.001	0.007	0.171
Magnesium	0.002	0.020	11.400
Manganese	0.000	0.001	5.690
Mercury	0.000	0.000	0.011
Nickel	0.014	0.143	0.114
Potassium	0.052	0.540	NA
Selenium	0.000	0.000	0.228
Silver	0.000	0.000	0.011
Sodium	0.203	2.110	NA
Thallium	0.003	0.033	0.114
Vanadium	0.003	0.029	0.057
Zinc	0.002	0.026	11.400

NA - Allowable Emission Rate Standard Not Available

ND - Not Detected in Soils Analysis.

* Calculated Emission Rate for each parameter is based upon the soils and landfill characteristics data for each parameter. The total quantities of pollutants estimated to be released were adjusted by a mass balance with total quantities measured by actual air sampling and analysis. (ug/s-m2) - micrograms per second - square meter describes the weight of air contaminant emitted each second from one square meter of landfill surface.

** Calculated allowable emission rates for each parameter was based upon Ambient Air Quality Standards equal to the TLV (Threshold Limit Value) divided by 42. The given Air Quality Standards were back-calculated using the air dispersion model to obtain these calculated allowable emission rates.

TABLE 37 (Continued)

Calculated Preliminary Emission Rates for the
Capped Landfill and Calculated Allowable Emission Rates

PARAMETER	Calculated*		Calculated Allowable
	Emission Rate (lb/hr)	(ug/s-m2)	Emission Rate** Based Upon Ambient Air Quality Standard (ug/s-m2)
Acetone	0.098	1.020	2,030
Benzene	ND	ND	34
Bromodichloromethane	ND	ND	NA
Bromoform	ND	ND	6
Bromomethane	ND	ND	1,010
2-Butanone	0.000	0.005	671
Carbon Tetrachloride	ND	ND	34
Chlorobenzene	0.000	0.001	398
Chloroethane	ND	ND	2960
Chloroform	ND	ND	57
Chloromethane	ND	ND	119
o-Dichlorobenzene	ND	ND	341
m-Dichlorobenzene	ND	ND	NA
p-Dichlorobenzene	ND	ND	511
Dibromochloromethane	ND	ND	NA
1,1- Dichloroethane	ND	ND	922
1,2- Dichloroethane	ND	ND	455
1,1- Dichloroethene	ND	ND	23
trans-1,2-Dichloroethene	ND	ND	899
1,2-Dichloropropane	ND	ND	398
cis-1,3-Dichloropropene	ND	ND	6
trans-1,3-Dichloropropene	ND	ND	6
Ethylbenzene	0.475	4.927	495
Heptane	ND	ND	1820
Hexane	ND	ND	205
Isopropyl Benzene	ND	ND	NA
Methylene Chloride	0.358	3.710	199
Styrene	0.083	0.863	245
Tetrachloroethene	0.065	0.672	381
1,1,2,2,- Tetrachloroethane	ND	ND	8
Toluene	2.835	29.400	427
1,1,1- Trichloroethane	ND	ND	2,162
1,1,2- Trichloroethane	ND	ND	51
Trichloroethene	ND	ND	307
Trichlorofluoromethane	ND	ND	6360
Vinyl Chloride	ND	ND	11
Xylene (o-,m-,p-)	2.180	22.600	495

NA - Allowable Emission Rate Standard Not Available.

ND - Not Detected in Soils Analysis.

Air dispersion modeling for the capped landfill was performed using the calculated emission rates given in Table 37. The air dispersion model selected for this project is the ISCST (Industrial Source Complex-Short Term), as described in Section 2.6.4. Table 38 contains the air dispersion modeling results that indicate nickel may exceed ambient air-quality standards for the capped landfill.

Table 39 estimates resultant air quality from the uncapped landfill that might occur during those remedial alternatives requiring excavation. These estimates are based upon the assumption that as much as 1,000 cubic yards per eight-hour period would be removed during excavation and on-site treatment or disposal actions. Beryllium, cobalt, iron, and ethylbenzene are shown to exceed ambient air-quality standards for an uncapped landfill condition.

4.2.2 Ground Water

Ground-water samples were obtained from the eight monitoring well clusters (MW-01 through MW-08, (Figure 66)) at the site. Analyses of these samples for TCL chemicals identified four volatile organic constituents, one semi-volatile organic constituent, and fifteen dissolved metals at concentrations greater than or equal to the CRQL. Table 40 presents for the maximum organic chemical concentrations detected at each sampling location. Total concentrations of volatile and semi-volatile chemicals are presented by sampling point in Figure 66.

Ground-water samples obtained during the March 1989 sampling event were analyzed for both total and dissolved metal constituents. The analytical results of these samples show

TABLE 38

Air Dispersion Modeling Results for the
Capped Landfill

AIR CONSTITUENT	Air Dispersion Modeling Results* (ug/m3)	Ambient Air Quality Standard** (ug/m3)
Aluminum	5.700	47.600
Antimony	0.300	11.900
Arsenic	0.000	4.760
Barium	0.600	11.900
Beryllium	0.009	0.050
Cadmium	ND	1.190
Calcium	7.200	47.600
Chromium	0.033	1.190
Cobalt	0.030	2.380
Copper	0.510	23.800
Iron	1.140	23.800
Lead	0.150	3.570
Magnesium	0.420	238.000
Manganese	0.030	119.000
Mercury	0.000	0.240
Nickel	3.000	2.380
Potassium	11.310	NA
Selenium	0.003	4.760
Silver	0.009	0.240
Sodium	44.100	NA
Thallium	0.600	2.380
Vanadium	0.600	1.190
Zinc	0.540	238.000

* Air dispersion modeling results are based upon emission rates from Table 7.1-1 and use of the ISCST detailed air dispersion model.

** Ambient Air Quality Standards are equivalent to the TLV (Threshold Limit Value) divided by 42.

NA - Air Quality Standard Not Available (TLV not available).

ND - Dispersion Modeling was not applicable because constituent was not reported at a concentration as great as the CRQL.

TABLE 38 (Continued)

Air Dispersion Modeling Results
for the Capped Landfill

AIR CONSTITUENT	Air Dispersion Modeling Results (ug/m ³)	Ambient Air Quality Standard** (ug/m ³)
Acetone	21	42,400
Benzene	ND	714
Bromodichloromethane	ND	NA
Bromoform	ND	119
Bromomethane	ND	21,200
2-Butanone	ND	14,000
Carbon Tetrachloride	ND	714
Chlorobenzene	ND	8,330
Chloroethane	ND	61,900
Chloroform	ND	1,190
Chloromethane	ND	2,500
o-Dichlorobenzene	ND	7,140
m-Dichlorobenzene	ND	NA
p-Dichlorobenzene	ND	10,700
Dibromochloromethane	ND	NA
1,1- Dichloroethane	ND	19,300
1,2- Dichloroethane	ND	9,520
1,1- Dichloroethene	ND	476
trans-1,2-Dichloroethene	ND	18,800
1,2-Dichloropropane	ND	8,330
cis-1,3-Dichloropropene	ND	119
trans -1,3- Dichloropropene	ND	119
Ethylbenzene	103	10,400
Heptane	ND	38,100
Hexane	ND	4,290
Isopropyl Benzene	ND	NA
Methylene Chloride	78	4,170
Styrene	18	5,120
Tetrachloroethene	14	7,980
1,1,2,2- Tetrachloroethane	ND	167
Toluene	587	8,930
1,1,1- Trichloroethane	ND	45,200
1,1,2- Trichloroethane	ND	1,070
Trichloroethene	ND	6,430
Trichlorofluoromethane	ND	133,000
Vinyl Chloride	ND	238
Xylene (o-,m-,p-)	471	10,400

ND - Dispersion modeling was not applicable because constituent was not reported at a concentration as great as the CRQL.

NA - Air Quality Standard Not Available (TLV not available).

TABLE 39

Air Dispersion Modeling Results for
the Uncapped Landfill

Air Constituent	Air Dispersion Modeling Results* (ug/m3)	Ambient Air Quality Standard** (ug/m3)
Aluminum	23.780	47.600
Antimony	0.090	11.900
Arsenic	0.090	4.760
Barium	0.350	11.900
Beryllium	0.130	0.050
Cadmium	ND	1.190
Calcium	38.710	47.600
Chromium	0.170	1.190
Cobalt	5.230	2.380
Copper	0.610	23.800
Iron	113.430	23.800
Lead	0.280	3.570
Magnesium	20.410	238.000
Manganese	35.000	119.000
Mercury	0.000	0.240
Nickel	0.350	2.380
Potassium	1.680	NA
Selenium	0.000	4.760
Silver	0.010	0.240
Sodium	22.860	NA
Thallium	0.000	2.380
Vanadium	0.040	1.190
Zinc	1.720	238.000

* Air dispersion modeling results are based upon emission rates from Table 7.1-1 and use of the ISCST detailed air dispersion model.

** Ambient Air Quality Standards are equivalent to the TLV (Threshold Limit Value) divided by 42.

NA - Air Quality Standard Not Available (TLV not available).

ND - Cadmium was not detected in the soils analysis.

TABLE 39 (Continued)

Air Dispersion Modeling Results for
the Uncapped Landfill

AIR CONSTITUENT	Air Dispersion Modeling Results* (ug/m ³)	Ambient Air Quality Standard** (ug/m ³)
Acetone	132	42,400
Benzene	ND	714
Bromodichloromethane	ND	NA
Bromoform	ND	119
Bromomethane	ND	21,200
2-Butanone	1	14,000
Carbon Tetrachloride	ND	714
Chlorobenzene	0	8,330
Chloroethane	ND	61,900
Chloroform	ND	1,190
Chloromethane	ND	2,500
o-Dichlorobenzene	ND	7,140
m-Dichlorobenzene	ND	NA
p-Dichlorobenzene	ND	10,700
Dibromochloromethane	ND	NA
1,1- Dichloroethane	ND	19,300
1,2- Dichloroethane	ND	9,520
1,1- Dichloroethene	ND	476
trans-1,2-Dichloroethene	ND	18,800
1,2-Dichloropropane	ND	8,330
cis-1,3-Dichloropropene	ND	119
trans -1,3- Dichloropropene	ND	119
Ethylbenzene	22,947	10,400
Heptane	ND	38,700
Hexane	ND	4,290
Isopropyl Benzene	ND	NA
Methylene Chloride	285	4,170
Styrene	765	5,120
Tetrachloroethene	216	7,980
1,1,2,2- Tetrachloroethane	ND	167
Toluene	0	8,930
1,1,1- Trichloroethane	ND	45,200
1,1,2- Trichlorethane	ND	1,070
Trichloroethene	ND	6,430
Trichlorofluoromethane	ND	133,000
Vinyl Chloride	ND	238
Xylene (o-,m-,p-)	1	10,400

ND - Dispersion modeling was not applicable because constituent was not reported at a concentration as great as the CRQL.

NA - Air Quality Standard Not Available (TLV not available).

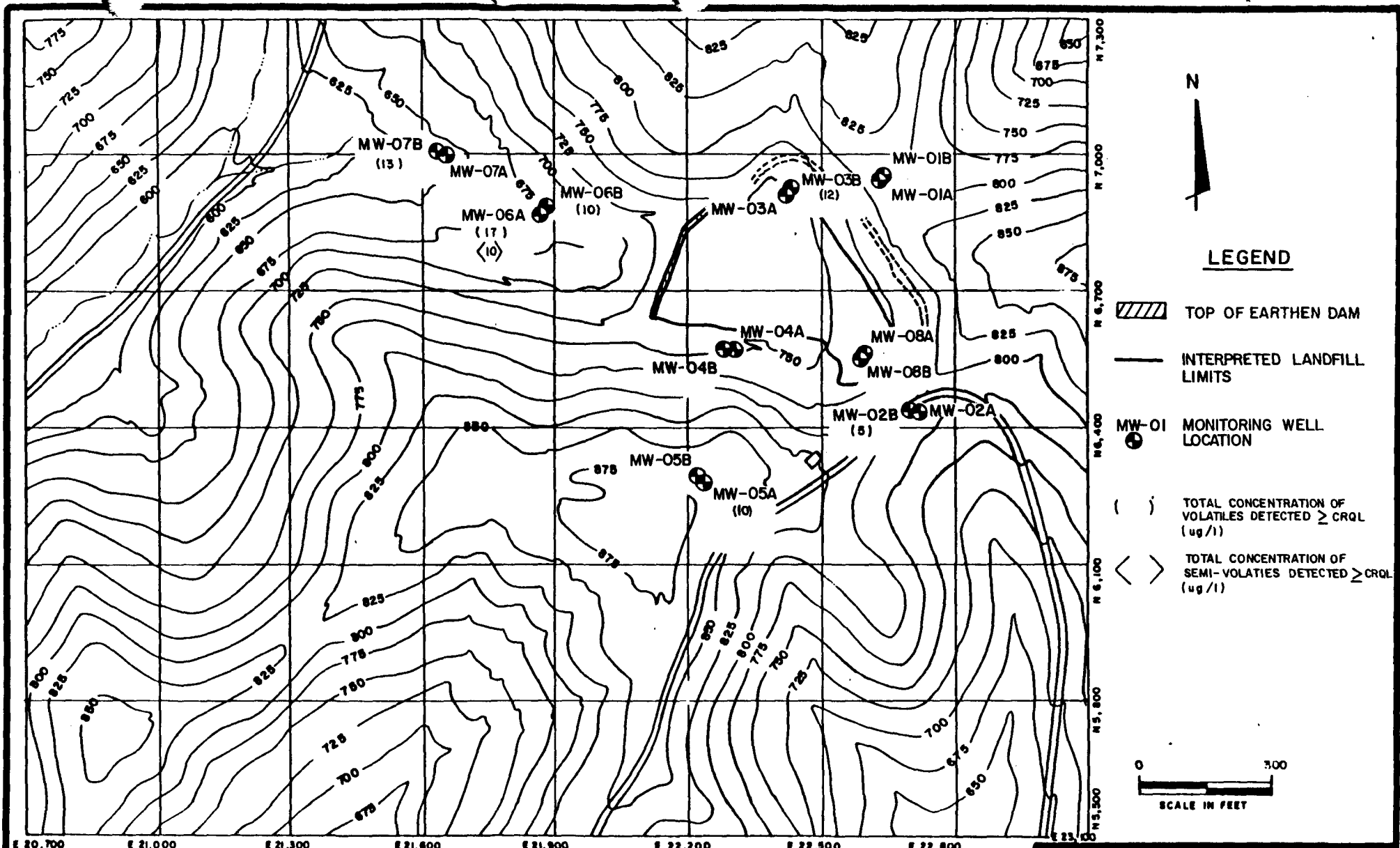


FIGURE 66
 TOTALS OF THE MAXIMUM ORGANIC
 CHEMICAL CONCENTRATIONS REPORTED
 IN GROUND WATER SAMPLES
 (6/88, 12/88, AND 3/89)
 E.H. SCHILLING LANDFILL

TABLE 40. Maximum Concentrations of Constituents Reported in Monitoring Wells
 at Concentrations Greater than or Equal to Contract Required Quantitation Limit (CRQL)

CONSTITUENT	CONCENTRATION (ug/l)	SAMPLING LOCATION	CRQL (ug/l)
<u>Volatile Organics</u>			
Acetone	12	MW-03B	10
Benzene	5	MW-02B	5
Carbon Disulfide	13	MW-07B	5
Chloroethane	17	MW-06A	10
<u>Semi-volatile Organics</u>			
1,4-Dichlorobenzene	10	MW-06A	10
<u>Dissolved Metals</u>			
Aluminum	9480	MW-07A	200
Arsenic	5.2	MW-01A	10
Barium	428	MW-07A	200
Beryllium	3.8	MW-07A	5
Calcium	58,300	MW-01B	5000
Cobalt	81.5	MW-07A	50
Copper	5.3	MW-01B	25
Iron	13,100	MW-03A	100
Magnesium	24,700	MW-07A	5000
Manganese	2,610	MW-07A	15
Nickel	108	MW-07A	40
Potassium	8,380	MW-01B	5000
Sodium	16,400	MW-01B	5000
Vanadium	5.5	MW-03A	50
Zinc	378	MW-07A	20

that the dissolved metal concentrations were significantly lower than the total metal concentrations for most of the metals detected (Table 41). These data show that total metal concentrations were artificially high due to the presence of clay/silt particles in the wells. A listing of all ground-water analytical data is included in Appendix B9.

4.2.3 Surface Water and Sediment

Surface-water (SW) and stream-sediment samples (SD) were obtained at six sampling locations (SW-01 through SW-06, and SD-01 through SD-06, Figure 12). Analyses of surface water samples for TCL chemicals showed that eleven metals were present at concentrations greater than or equal to the CRQL (Table 42).

Analyses of stream sediment samples for TCL chemicals identified two volatile organic constituents, seven semi-volatile organic constituents, and fourteen metals at concentrations greater than or equal to the CRQL (Table 43). A listing of the surface-water and sediment data is included in Appendix B9.

Stream sediment sample station SD-01 was originally selected to represent a background condition. However, analytical analysis of the sediment sample indicated that the sampling location was influenced by an unidentified off-site source. All seven semi-volatile organic constituents identified in sediment samples; benzo(a)anthracene, benzo(b,k)fluoranthene, benzo(a)pyrene, chrysene, pyrene, fluoranthene, and phenanthrene were only detected in the sample from Station SD-01. Surface water drainage from the landfill does not impact the area around SD-01. Therefore, it is concluded that the semi-volatile contamination present at SD-01 is due to sources other than the landfill itself.

TABLE 41. Concentrations of Total and Dissolved Metal Results
for Selected Ground Water (MW) Sampling Locations

Location	Parameter	Total (ug/l)	Dissolved (ug/l)
MW-01B	Aluminum	207	ND
MW-03A	Aluminum	26000	ND
MW-03A	Aluminum	21500	ND
MW-07A	Aluminum	46300	9480
MW-07A	Arsenic	3.1	3
MW-01B	Barium	377	379
MW-03A	Barium	136	23.1
MW-03A	Barium	122	23.1
MW-07A	Barium	428	10.3
MW-03A	Beryllium	5.7	ND
MW-03A	Beryllium	4.8	ND
MW-07A	Beryllium	7.2	3.8
MW-01B	Calcium	60500	58300
MW-03A	Calcium	10500	6200
MW-03A	Calcium	10300	6110
MW-07A	Calcium	26400	26800
MW-01B	Chromium	130	ND
MW-03A	Chromium	67	ND
MW-03A	Chromium	58.8	ND
MW-07A	Chromium	131	ND
MW-01B	Cobalt	8.5	ND
MW-03A	Cobalt	31.3	10.2
MW-03A	Cobalt	29.5	ND
MW-07A	Cobalt	103	81.5
MW-01B	Copper	10.3	5.3
MW-03A	Copper	51.5	3.3
MW-03A	Copper	50.7	ND
MW-07A	Copper	68	ND
MW-01B	Iron	3210	576
MW-03A	Iron	131000	13100
MW-03A	Iron	121000	11400
MW-07A	Iron	232000	8030
MW-01B	Lead	1.3	ND
MW-03A	Lead	15.9	ND
MW-03A	Lead	20.2	ND
MW-07A	Lead	55.4	ND

ND: Not Detected in Concentrations Greater Than CRQL

TABLE 41. Concentrations of Total and Dissolved Metal Results
(Continued) for Selected Ground Water (MW) Sampling Locations

Location	Parameter	Total (ug/l)	Dissolved (ug/l)
MW-01B	Magnesium	10400	10100
MW-03A	Magnesium	14300	5640
MW-03A	Magnesium	13600	5550
MW-07A	Magnesium	29400	24700
MW-01B	Manganese	203	222
MW-03A	Manganese	1420	659
MW-03A	Manganese	1380	654
MW-07A	Manganese	3050	2610
MW-07A	Mercury	0.34	ND
MW-01B	Nickel	98.4	ND
MW-03A	Nickel	99.9	ND
MW-03A	Nickel	88.3	ND
MW-07A	Nickel	163	108
MW-01B	Potassium	10400	8380
MW-03A	Potassium	9390	5340
MW-03A	Potassium	7620	ND
MW-07A	Potassium	17500	5890
MW-01B	Sodium	18000	16400
MW-03A	Sodium	9240	7580
MW-03A	Sodium	7240	5860
MW-07A	Sodium	12400	10400
MW-01B	Vanadium	7.4	ND
MW-03A	Vanadium	32.9	5.5
MW-03A	Vanadium	32.9	ND
MW-07A	Vanadium	101	5.3
MW-01B	Zinc	376	240
MW-03A	Zinc	388	48.2
MW-03A	Zinc	347	36
MW-07A	Zinc	912	378

ND: Not Detected in Concentrations Greater Than CRQL

TABLE 42. Maximum Concentrations of Constituents Reported in Surface Water
at Concentrations Greater than or Equal to Contract Required Quantitation Limit

CONSTITUENT	CONCENTRATION (ug/l)	SAMPLING LOCATION	CRQL (ug/l)
<u>Total Metals</u>			
Aluminum	20,400	SW-03	200
Beryllium	9.5	SW-03	5
Calcium	53,300	SW-03	5000
Cobalt	67	SW-03	50
Iron	27,800	SW-03	100
Lead	329	SW-05	5
Magnesium	43,700	SW-02	5000
Manganese	4,350	SW-03	15
Nickel	94	SW-03	40
Sodium	112,000	SW-02	5000
Zinc	270	SW-03	20

TABLE 43. Maximum Concentrations of Constituents Reported in Sediment at Concentrations Greater than or Equal to the Contract Required Quantitation Limit

CONSTITUENT	CONCENTRATION (mg/kg)	SAMPLING LOCATION	CRQL* (ug/kg)
<u>Volatile Organics</u>			
Acetone	0.024	SD-04	0.010
Dichloromethane	0.084	SD-05	0.005
<u>Semi-volatile Organics</u>			
Benzo(a)anthracene	0.62	SD-01	0.33
Benzo(b,k)fluoranthene	0.72	SD-01	0.33
Benzo(a)pyrene	0.60	SD-01	0.33
Chrysene	0.70	SD-01	0.33
Fluoranthene	1.2	SD-01	0.33
Phenanthrene	0.54	SD-01	0.33
Pyrene	0.94	SD-01	0.33
<u>Inorganics**</u>			
Aluminum	5,460	SD-01	3.2
Arsenic	7.0	SD-01	0.6
Barium	68	SD-01	0.4
Beryllium	2.9	SD-01	0.02
Chromium	12	SD-03	0.6
Cobalt	17	SD-01	1.2
Copper	20	SD-03	0.6
Iron	33,600	SD-03	0.8
Lead	14	SD-01	0.2
Manganese	895	SD-02	0.4
Mercury	1.4	SD-03	0.1
Nickel	17	SD-04	2.2
Vanadium	17	SD-03	0.6
Zinc	69	SD-01	0.4

*Quantitation limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

**Detection limits for an extract of 1 gram of solid in 200 ml of extractant based upon current Instrument Detection Levels (IDL's).

4.2.4 Soil

Surface soil samples (SS) were obtained from thirty-five sampling locations (Figure 67) surrounding the landfill. Analysis of these samples for TCL chemicals identified three volatile organic compounds, thirteen semi-volatile organic compounds, seventeen metals, and cyanide at concentrations greater than or equal to the CRQL (Table 44). Figure 67 shows the totals of the maximum volatile and semi-volatile organic chemical concentrations detected at each sampling location. A complete listing of all surface soil samples analyses results is included in Appendix B9.

Five semi-volatile organic constituents; anthracene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene, were detected only in sample SS-32, which is apparently contaminated due to sources other than the landfill itself. The presence of these PAHs is considered to be the result of an alternate source because analyses of SS-28, SS-29, and SS-30, which are located between the landfill and SS-32 do not contain PAHs. Therefore, SS-32 data are not considered to be representative of Schilling Landfill.

4.3 Extent of Contamination

Based upon data presented Sections 4.2, the extent of contamination at the site appears to be limited to the area immediately surrounding the landfill. A comparison of data from the landfill waste samples (i.e. leachate and soil samples - both LS and BO) to the other site samples indicates that the contamination has not migrated far beyond the interpreted limits of the landfill as the relative concentrations of chemicals detected in these samples

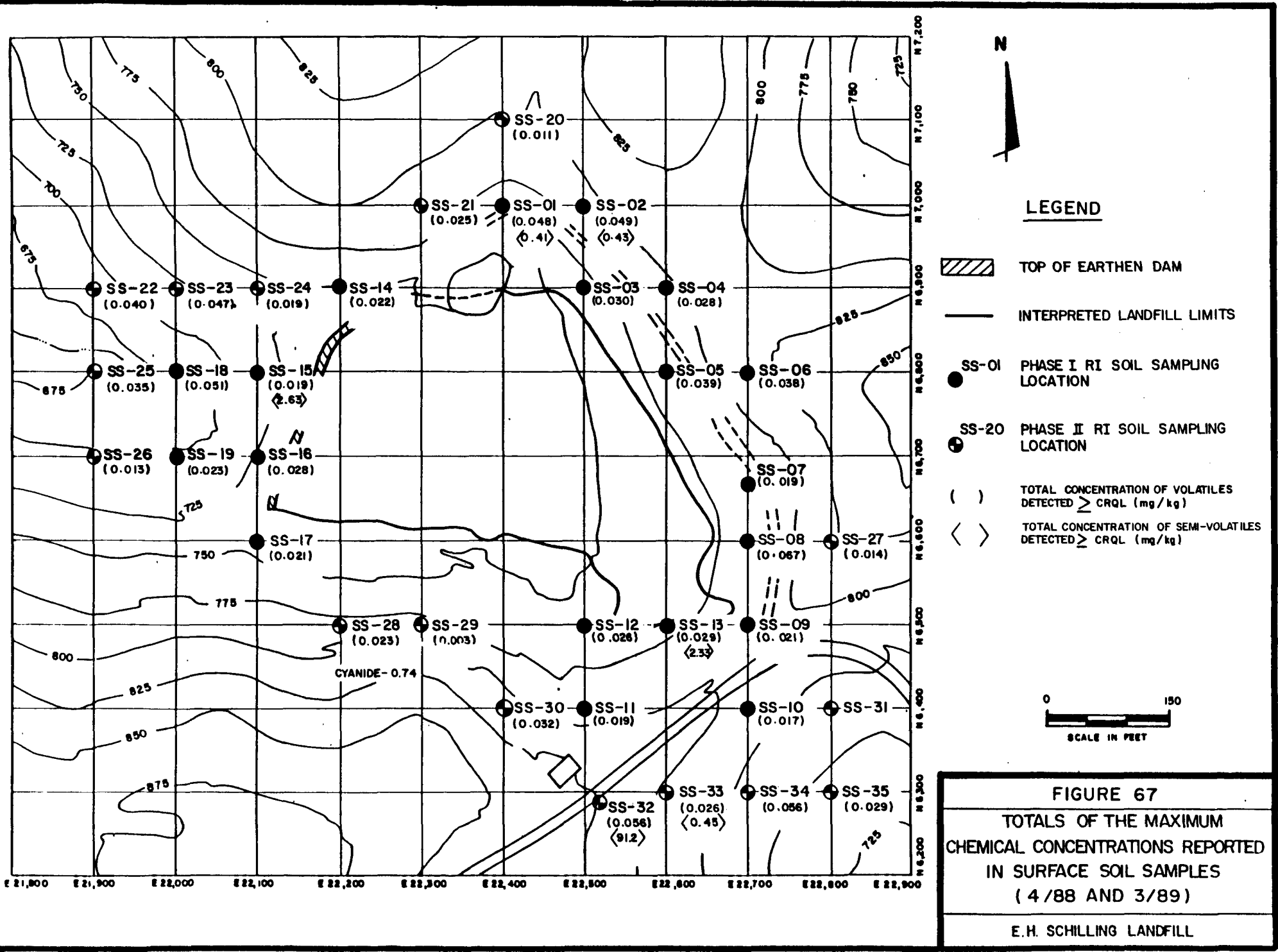


TABLE 44. Maximum Concentrations of Constituents Reported in Surface Soil at Concentrations Greater than or Equal to Contract Required Quantitation Limit (CRQL)

CONSTITUENTS	CONCENTRATION (mg/kg)	SAMPLING LOCATION	CRQL* (mg/kg)
<u>Volatile Organics</u>			
Acetone	0.041	SS-08	0.01
Dichloromethane	0.051	SS-18	0.005
Trichloromethane	0.003	SS-04	0.005
<u>Semi-volatile Organics</u>			
Anthracene	2.1	SS-32	0.33
Benzo(a)anthracene	11	SS-32	0.33
Benzo(b)fluoranthene	9.5	SS-32	0.33
Benzo(k)fluoranthene	7.8	SS-32	0.33
Benzo(g,h,i)perylene	3.9	SS-32	0.33
Benzo(a)pyrene	11	SS-32	0.33
bis(2-Ethylhexyl)phthalate	0.45	SS-33	0.33
Chrysene	11	SS-32	0.33
Dibenzo(a,h)anthracene	1.2	SS-32	0.33
Fluoranthene	16	SS-32	0.33
Indeno(1,2,3-cd)pyrene	4.8	SS-32	0.33
Phenanthrene	7.7	SS-32	0.33
Pyrene	13	SS-32	0.33
<u>Inorganics**</u>			
Aluminum	11,700	SS-08	3.2
Arsenic	22.1	SS-32	0.6
Barium	132	SS-32	0.4
Beryllium	67	SS-08	0.02
Calcium	29,800	SS-32	2000
Chromium	19.7	SS-20	0.6
Cobalt	27.3	SS-20	1.2
Copper	175	SS-08	0.6
Iron	35,900	SS-04	0.8
Lead	27.3	SS-20	0.2
Magnesium	1,210	SS-31	0.4
Manganese	4,160	SS-32	0.4
Mercury	1.7	SS-21	0.1
Nickel	17.1	SS-32	2.2
Selenium	0.41	SS-22	0.6
Vanadium	22	SS-08	0.6
Zinc	75.6	SS-32	0.4
Cyanide	0.74	SS-28	0.5

*Quantitation limits listed for soil/sediment are based on wet weight. The Quantitation Limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

**Detection limits for an extract of 1 gram of solid in 200 ml of extractant based upon current Instrument Detection Levels (IDL's).

are generally at least an order of magnitude greater than the chemicals identified in the other media types at the site.

4.3.1 Ground Water

Based upon the available data, the extent of ground-water contamination at the site is limited to monitoring wells immediately surrounding the landfill and monitoring wells downhill of the dam (Appendix B9).

4.3.2 Surface Water

Surface waters appear to be relatively unaffected by landfill activities. Dissolved metals were the only site-specific chemicals identified in the surface water samples (Appendix B9).

4.3.3 Stream Sediments

The analytical results for the stream sediments samples indicate that the extent to which the sediments have been affected by landfilling activities is limited to the mid to upper reaches of Winkler Run (Appendix B9).

4.3.4 Surface Soils

The extent of contamination of surficial soils primarily consists of those areas which are exposed to landfill leachate. Contamination of surficial soils outside of the immediate landfill area is primarily limited to metals.

4.3.5 Benthos

4.3.5.1 Discussion

Benthic macroinvertebrates are animals that inhabit, during at least part of their life cycle, the substratum of lakes, streams, estuaries and marine waters. They can be either sessile (attached) or mobile during all or part of their life. Macroinvertebrate organisms are large enough to be seen by the unaided eye and retained by a U.S. Standard No. 30 sieve (38 meshes per inch) (EPA 1973). The major taxonomic groups included in freshwater systems are insects, annelids, mollusks, flatworms, roundworms, and crustaceans.

The macroinvertebrate community in an aquatic ecosystem is sensitive to stress and thus its community structure (density, diversity, and species composition) can serve as a useful tool for detecting environmental changes. Stress for the purpose of this discussion is defined as a drain of potential energy. When a biological community is stressed, some of the potential energy available to do work (food gathering, reproduction, etc.) is lost. Because of the limited mobility and relatively long life span of macroinvertebrates, their community structure is a function of the environmental conditions during the recent past, including reactions to infrequently discharged wastes that would be difficult to detect by periodic chemical sampling.

Three conditions, organic loading, substrate alteration and toxic chemical pollution have been documented to result in changes in macroinvertebrate community structure (APHA 1971). Organic pollution can result in a corresponding reduction in species diversity and an increase in the density of the remaining, tolerant, organisms. Substrate alteration, for example, siltation, and inorganic chemical pollution may also reduce species diversity.

Macroinvertebrate community structure may also be altered by other natural or anthropogenic, physical, chemical or biological factors.

4.3.5.2 Station Locations

Six benthic macroinvertebrate sample locations, labeled BE-01 through BE-06, were selected and approved by the US EPA for sampling. Location BE-01 is south of the landfill in Schilling Hollow. Locations BE-02 and BE-03 are located west and downstream of the landfill dam on the tributary to Winkler Run. BE-04, BE-05, and BE-06 are located on Winkler Run. The benthic sampling stations were located, whenever possible, in close proximity to the surface water (labeled SW-01 through SW-06) and sediment (labeled SD-01 through SD-06) sampling stations in an effort to compliment the previous sampling programs and establish as much comparable data as possible. With one exception, benthic sampling took place within three to ten feet of the designed surface water and sediment sample stations. Due to the absence of water at BE-01 during the June 7 to 8, 1988 sampling, the station was relocated. Station BE-01 was relocated within the same drainage system, downstream, approximately 22 feet to the south. The relocated BE-01 sampling station was marked with plastic flagging at the sampling point and labeled. Flagging was secured to a tree adjacent to the paved road located to the west of the new BE-01 station to facilitate site location.

4.3.5.3 Field Data

General stream physical characteristics, velocity, depth, width, and substrate type were documented for sample station comparison purposes (Table 45).

Table 45. Stream physical characteristics within the immediate vicinity of the sample station; June 7 and 8, 1988, E.H. Schilling Landfill.

Sample Station	Stream Width ^a Bank (m)	Wetted	Ratio	Depth (cm)	Velocity (cm/sec)	Substrate Characteristics ^c
BE-01	1.15	0.30	0.26	1.5- 2	Trace ^b	Clay and sand with isolated areas of exposed rubble
BE-02	0.95	0.70	0.74	1.5- 5	1.4	Clay and sand with isolated areas of exposed rubble
BE-03	0.85	0.35	0.41	1 - 6	2.5	Clay and sand with isolated areas of exposed rubble
BE-04	1.20	0.80	0.67	2 - 5	Trace	Predominantly sand with some clay, very little rubble
BE-05	1.20	0.60	0.50	1.5-6.5	6.2	Clay and sand with isolated areas of exposed rubble
BE-06	1.60	0.40	0.25	1 -13.5	6.2	Clay and sand with isolated areas of exposed rubble

^aBank perimeter is defined as the width of the natural stream; wet perimeter is that portion of the bank perimeter which was either inundated or saturated.

^bTrace indicates that stream flow was observed but velocity was below detection limit.

^cSubstrate characteristics or size, e.g. sand, clay rubble, follow those discussed in EPA 1973.

Total stream depth in the vicinity of the sampling stations ranged from 1 to 13.5 centimeters. BE-06 had the greatest water depth. Stream flow was observed at all stations. Minimal flows were observed at stations BE-01 and BE-4, while BE-05 and BE-06 had the greatest flows. No surface water was observed upstream of BE-01, BE-02, and BE-04.

The wetted width to bank width ratio was determined to compare stream widths. This ratio gives an indication of the amount of stream bed being used for the transport of water at the time field work was performed. Stations BE-01 and BE-06 had the smallest ratios; BE-02, the first station below the dam, had the largest ratio. Similar substrate conditions were observed at all stations except BE-04, appeared to have less gravel and rubble and a greater amount of sand-size material than other sampling stations. Some of the stations (BE-01, BE-02 and BE-04) were little more than seeps. Such streams are very difficult to sample quantitatively.

Several terrestrial and aquatic organisms were observed while conducting the sampling. In Schilling Hollow, an eastern box turtle (Terrapene carolina carolina) was observed not far from station BE-01. Upstream from station BE-02 a northern black racer (Coluber constrictor constrictor) was observed. Between stations BE-03 and BE-05, at the downstream end of the culvert which crosses beneath Winkler Run Road, an unidentified water snake (Natrix sp.) and several frogs were observed. The frogs appeared to be the northern leopard frog (Rana pipiens pipiens).

4.3.5.4 Physical - Chemical Measurements

Water-quality parameters, pH, conductivity, and temperature, were measured at each station prior to collection of the benthic samples. Water-quality data was collected to determine the existing conditions, and provide baseline information.

Table 46 lists the results of the water-quality determinations by station. A water-quality sample was not collected at station BE-01 due to insufficient water. Surface water temperature at the remaining stations (BE-02 to BE-06) ranged from 59.4 to 66.4 °F; pH ranged from 3.3 to 7.3; and conductivity ranged from 227 to 890 umhos/cm.

A four pH unit variation was noted between stations BE-02 and BE-03. This wide pH variation was verified by collecting replicate samples. These two stations are both in the Winkler Run tributary, approximately 300 feet apart and downstream from the landfill. Leachate from mine spoils in the area could be a factor contributing to this variation in pH. As discussed above, no water was observed upstream relative to BE-02.

4.3.5.5 Benthic Samples

Two types of benthic sampling were conducted, quantitative and qualitative. The quantitative sampling used an Ekman grab sampler to sample a known surface area, as specified in the approved Sampling Plan. The Ekman grab sampler is capable of sampling only soft sediments. The qualitative sampling was employed in the gravel and rubble littered areas of the stream bed where the Ekman grab sampler was ineffective. A relatively low number of individuals were collected using the qualitative methods. Therefore, only the quantitative grab samples have been used for data interpretation. It

Table 46. Water quality analysis. Samples collected June 7 and 8, 1988; Schilling Landfill.

Sample Station Number	Temperature (°F)	pH (units)	Conductivity (umhos/cm)
BE-01	Insufficient water for analysis		
BE-02	61.7	7.3	890
BE-03	59.4	3.3	793
BE-04	66.4	5.1	227
BE-05	64.4	4.3	370
BE-06	65.3	4.3	288

is assumed that the specified and approved quantitative method (Ekman grab) used for sampling provided representative and quantitatively comparable samples. No problems were encountered in sorting samples at the stream sites.

The results of the benthic macroinvertebrate sampling are presented in Table 47 to 49. Table 47 and 48 list the results of the qualitative sampling and terrestrial component of the quantitative samples, respectively. Table 49 lists the results for the quantitative benthic macroinvertebrate sampling. As specified by the approved study plan, diversity and equitability were calculated for each station (Table 50). Because of the paucity of animals at some of the stations, data from the three replicate samples were composited for analyses and for making comparisons between stations.

The two indices calculated were diversity and equitability. Diversity is affected by numbers of species (species richness) and by the distribution of individuals among the species (species composition). Equitability extracts the "species composition" component from the overall index. Essentially, equitability provides a measure of community imbalance resulting from dominance by one or several taxa. Such dominance is often typical of the biota in a stressed environment.

Diversity and equitability are erratic and unreliable with small sample sizes. EPA (1973) suggests that diversity or equitability not be calculated at sample sizes of less than 100 individuals. Stations BE-03, BE-04, BE-05, and Be-06, after compositing, all had less than 100 individuals. Overall, the intermittent stream systems being sampled in this study are

Table 47. List of organisms and number of individuals collected using qualitative search procedure; Schilling Landfill, 7-8 June 1988.

Organism	Sample Stations					
	BE-01	BE-02	BE-03	BE-04	BE-05	BE-06
Phylum Arthropode						
Class Insecta						
Order Megaloptera						
Family Corydalidae						
<u>Nigronia Fasciatus</u>						
(hellgrammite)						
					1	
Class Chilapoda						
Order Lithobiomorpha						
Family Lithobiidae						
(centipede)						
			1			
Phylum Chordata						
Class Amphibia						
Order Urodela						
Family Plethodontidae						
<u>Desmognathus Fuscus</u>						
<u>Fuscus</u>						
(dusky salamander)						
					1	1

Table 48. Distribution of terrestrial organisms and number of individuals collected with an Ekman grab: Schilling Landfill, 7-8 June 1988.

TERRESTRIAL ORGANISMS	Sample Station Replicates																	
	BE-			BE-			BE-			BE-			BE-			BE-		
	01a	01b	01c	02a	02b	02c	03a	03b	03c	04a	04b	04c	05a	05b	05c	06a	06b	06c
Number of Individuals																		
Phylum Arthropoda																		
Class Crustacea																		
Order Isopoda																		
(Sowbug)																		
Class Chilopoda																		
Order Lithobiomorpha																		
Family Lithobiidae																		
Class Arachnida																		
Order Araneida																		
Family Lycosidae																		
(Wolf spider)																		
Class Insecta																		
Order Collembola																		
Family Sminthuridae																		
(Springtail)																		
Order Homoptera																		
Family Cicadellidae																		
(Leaf hopper)																		
Family Aphidae																		
(Aphid)																		
Order Coleoptera																		
Family Staphylinidae																		
(Rove beetle)																		
Family Curculionidae																		
(Snout beetle)																		
Order Lepidoptera																		
Family Noctuidae																		
(Noctuid moth)																		
Order Hymenoptera																		
Family Formicidae																		
(Ant)																		

Table 49. List of aquatic benthic macroinvertebrates and number of individuals collected with an Ekman grab; Schilling Landfill, 7-8 June 1998.

AQUATIC BENTHIC MACROINVERTEBRATES	Sample Station Replicates																	
	BE-01a			BE-02a			BE-03a			BE-04a			BE-05a			BE-06a		
	01b	01c		02b	02c		03b	03c		04b	04c		05b	05c		06b	06c	
Number of Individuals																		
Phylum Annelida																		
Class Clitellata																		
Order Haplotaxida																		
Family Tubificidae																		
<u>Limnodrilus</u> sp. 60 17 5 31 31 19 12 12 12 1																		
<u>Pelosclex</u> sp. 23 213 5																		
(Worm)																		
Class Hirudinea																		
Order Rhynchobdellida																		
Family Glossiphoniidae																		
nr. <u>Placobdella</u> sp. 1																		
(Leech)																		
Phylum Arthropoda																		
Class Insecta																		
Order Odonata																		
Family Cordulegastridae																		
<u>Cordulegaster fasciata</u> 7 10																		
(Dragonfly)																		
Family Aeshnidae																		
<u>Anax junius</u> 2																		
(Dragonfly)																		
Family Libellulidae																		
<u>Symptetrum</u> sp. 1																		
(Dragonfly)																		
Order Plecoptera																		
Family Leuctridae																		
<u>Leuctra</u> sp. 11																		
(Stonefly)																		
Family Nemouridae																		
<u>Amphinemoura delosa</u> 1																		
(Stonefly)																		
Order Megaloptera																		
Family Corydalidae																		
<u>Nigronia fasciatus</u> 1 1																		
(Hellgrammite)																		
Family Sialidae																		
<u>Sialis ioppa</u> 1 1																		
(Alderfly)																		

Table 49. List of aquatic benthic macroinvertebrates and number of individuals collected with an Ekman grab; Schilling Landfill, 7-9 June 1988. (cont.)

AQUATIC BENTHIC MACROINVERTEBRATES	Sample Station Replicates																	
	BE- 01a 01b 01c			BE- 02a 02b 02c			BE- 03a 03b 03c			BE- 04a 04b 04c			BE- 05a 05b 05c			BE- 06a 06b 06c		
	Number of Individuals																	
Order Trichoptera																		
Family Rhyacophilidae																		
<u>Rhyacophila</u> nr.	1																	
<u>carpenteri</u>																		
(Caddisfly)																		
Family Limnephilidae																		
<u>Pycnopsyche</u> sp.																		
Family Molannidae																		
<u>Molanna blenda</u>										2 1								
(Caddisfly)																		
Order Coleoptera																		
Family Hydrophilidae																		
<u>Helochaes</u> sp.																1		
(Water beetle)																		
Family Dytiscidae																		
<u>Liodessus</u> sp.				1														
(Diving Beetle)																		
Order Diptera																		
Family Tipulidae																		
<u>Limnophila</u> sp.	9 5 1			1						1								
(Crane fly)																		
<u>Tipula</u> sp.				1									3			1		
(Crane fly)																		
<u>Tipula</u> nr.	1																	
<u>abdominalis</u>																		
(Crane fly)																		
Family Ceratopogonidae																		
<u>Palpomyia</u> sp.	1									1								
(Biting midge)																		
<u>Bezzia</u> sp.	4 2			1 2			1 1			1 1 2						1 2		
(Biting midge)																		
Family Chironomidae																		
<u>Ablabesmyia</u> sp.				2 3														
(Chironomid midge)																		
<u>Chironomus</u> sp.				1														
(Chironomid midge)																		
<u>Stenochironomus</u> sp.	1																	
nr <u>Smittia</u> sp.	2			2 7 6			2 8 9			1			1 7			2 6 52		
(Chironomid midge)																		
<u>Tanytarsus</u> sp.	1			1														
(Chironomid midge)																		

Table 49. List of aquatic benthic macroinvertebrates and number of individuals collected with an Ekman grab; Schilling Landfill, 7-8 June 1988. (cont.)

AQUATIC BENTHIC MACROINVERTEBRATES	Sample Station Replicates																		
	BE-			BE-			BE-			BE-									
	01a	01b	01c	02a	02b	02c	03a	03b	03c	04a	04b	04c	05a	05b	05c	06a	06b	06c	
Number of Individuals																			
Family Tabanidae																			
<u>Tabanus</u> sp.																			
(Horse fly)																			
Family Muscidae																			
<u>Limnophora</u> sp.																			
(Anthomyiid fly)																			
<u>Bittacomorpha</u>																			
<u>clavipes</u>	1	4	7																
(Phantom crane fly)																			
Family Psychodidae																			
<u>Psychoda</u> sp.																			
(Moth fly)	1	3	1	3															

Table 50. Summary of data evaluation indices for benthic macroinvertebrate sampling; Schilling Landfill, 7-8 June 1988.

Indices	STATION NUMBERS					
	BE-01	BE-02	BE-03	BE-04	BE-05	BE-06
Number of Taxa	17	12	4	8	4	6
Number of Individuals	167	315	46	56	12	81
Mean Diversity	2.49	1.54	1.49	1.36	1.42	1.25
Equitability	0.48	0.31	0.88	0.40	0.83	0.48

naturally stressed and that partially accounts for the low standing crop and low species richness shown by the samples collected.

Of the two stations BE-01 and BE-02) where sample size was adequate, the indices suggest that station BE-02 was subject to stress compared to station BE-01.

Species richness (number of species) is probably the best parameter available for evaluating stress in the Schilling data set. Strictly on the basis of species richness, stations BE-03, BE-05, and BE-06 (4, 4 and 6 taxa, respectively) are severely stressed while stations BE-01, BE-02, and BE-04 (17, 12 and 8 taxa, respectively) probably support communities fairly typical of a headwater stream system.

4.3.5.6 Conclusions

The benthic macroinvertebrate investigation of the intermittent streams adjacent to the Schilling Landfill indicated the presence of a benthic community at all six sampling stations. The benthic community, based on diversity and equitability indices, appears to be stressed. The stream systems sampled are naturally stressed due to their intermittent flow patterns which partially accounts for the minimal number of organisms and species richness.

As discussed above, the low equitability at station BE-02 (a result of dominance by the oligochaete - Pelosclex sp.) indicates stress. Therefore, the data indicate that those stations assumed to be outside the impact of the landfill (stations BE-01 and BE-04), are the least stressed of the stations sampled.

The severely stressed stations (BE-03, BE-05, and BE-06) had very low surface-water pH, ranging from 3.3 to 4.3. The low pH could possibly result from mining activities in the area. The very acidic conditions indicated by these low pH values would provide sufficient stress to severely inhibit the benthic fauna.

Quantitatively, the taxonomic composition of the communities at the six stations is fairly typical of headwater streams and provides no unique insights. Of the 27 taxa collected, 15 are predators; seven are collector-gatherers; four are shredders; and the feeding activity of one is unknown. Numerically, the standing crop (in all samples) was 570 collector-gatherers; 18 shredders; and 93 predators.

In first order intermittent streams, as sampled here, the major function of the macroinvertebrate fauna is processing of coarse terrestrial detritus. Therefore, collector-gatherers and shredders with a concomitant melange of predators is typical of a relatively unperturbed system.

4.4 Chemical and Physical Properties of Contaminants Present in the Source

The available physical and chemical characteristics of 63 constituents detected in the landfill waste are presented in Table 51. The volatile organic compounds and some of the semi-volatile organic compounds are moderately to highly soluble in water (0.02% to 30%). These constituents generally have low tendencies to adsorb to the soil as indicated by soil organic-matter partition coefficients of less than 500. The remaining semi-volatile organic compounds (light and heavy polynuclear aromatic hydrocarbons and pesticides) are much

Table 51.
Physical Chemistry Data

Constituent	CAS Number	Formula Weight (gm/mole)	Reference	Melting Point (deg C)	Reference	Boiling Point (deg C)	Reference	Vapor Density (air = 1)	Reference
1,1-Dichloroethane	75-34-3	98.96	3	-97.4	3	57.3	3	3.42	3
1,2-Dichloroethane	78-87-5	99.	3	-35.4	3	83.5	3		
1,2-trans-Dichloroethene	156-60-5	96.95	3	-50	3	48.	3	3.34	3
2-Butanone	78-93-3	72.1	3	86.4	3	79.6	3	2.41	3
2-Methylnaphthalene	91-57-6	142.2	3	34.	3	241/242	3		
2-Methylphenol (o-Cresol)	95-48-7	108.13	3	31.	3	191.	3	3.7	3
4-Methyl-2-pentanone	108-10-1	100.2	3	-85/-80	3	116/119	3	3.45	3
4-Methylphenol (p-Cresol)	106-44-5	108.13	3	34.8	3	202.	3	3.72	3
Acenaphthene	83-32-8	154.21	3	90/95	3	279.	3		
Acetone	67-64-1	58.08	3	-95.	3	56.2	3	2.00	3
Aldrin	309-00-2	365	5	104-105.5	3				
Aluminum, Elemental	7429-90-5	26.982	1	660.37	1	2467.	1		
Anthracene	120-12-7	178.23	3	216.2/216.4	3	340	3	6.15	3
Arsenic, Elemental	7440-38-2	74.921	1	817.	1	613.(sub)	1		
Barium, Elemental	7440-39-3	137.34	1	725.	1	1640	1		
Benzene	71-43-2	78.11	3	55.	3	80.1	3	2.77	3
Benzo(a)anthracene	56-32-8	228.	1	162.	1	435.(sub)	1		
Benzo(a)pyrene	50-32-8	252.3	3	179.	3	311 @ 10mmHg	3		
Benzo(b)fluoranthene	205-99-2	252.32	15	167.	15				
Benzo(g,h,i)perylene	191-24-2	276	3						
Benzo(k)fluoranthene	207-08-9	252.	5	217	1	480	1		
Benzoic Acid	65-85-0	122.1	3	121.7	3	249	3	4.21	3
Beryllium, Elemental	7440-41-7	9.01	1			2970	1		
bis(2-Chloroethyl) Ether	111-44-4	143.02	3	-50	3	178	3	4.93	3
bis(2-Ethylhexyl) phthalate	117-81-7	396.	3	206/208	3	191.	3		
Cadmium, Elemental	7440-43-9	112.41	1	320.9	1	765.	1		
Calcium, Elemental	7440-70-2	40.08	1	839.	1	1484.	1		
Chlorobenzene	108-90-7	113.	3	-45	3	132.	3	3.88	3
Chloroethane		64.5	3	-138.3	3	12.4	3	2.23	3
Chloromethane	74-87-3	51.	3	-97.7	3	-24.	3	1.8	3
Chromium, Elemental	7440-47-3	51.996	1	1837/1877	1	2672.	1		
Chrysene	218-01-9	228.2	3	254.	3	448.	3		
Cobalt, Elemental	7440-48-4	58.933	1	1495.	1	2870.	1		
Copper, Elemental	7440-50-8	63.54	1	1083.	1	2567.	1		
DDD	72-54-8	320.1	3	112	3			11	3
DDE	72-55-9	318	3			260	1		
Dibenzo(a,h) anthracene	53-70-3	278.35	3	266/267	3	524.	3		
Dibenzofuran	132-64-9	168.21	1	86/87	1	287.	1		
Fluoranthene	53-70-3	202.	3	107.	3	250	3		
Heptachlor	76-44-8	374	5	95-96	3				
Indeno(1,2,3-cd) pyrene	193-39-5	276.34	3	160/163	3	536.	3		
Iron, Elemental	7439-89-6	55.85	1	1535.	1	2750	1		
Lead, Elemental	7439-92-1	207.19	1	327.502	1	1740	1		
Magnesium, Elemental	7439-94-4	24.31	1	648.8	1	1090	1		
Manganese, Elemental	7439-96-5	54.94	1	1244.	1	1962.	1		
Mercury, Elemental	7439-97-6	200.59	1	-38.84	1	356.58	1		
Methyl butyl ketone	591-78-6	100.16	1	-57.	1	128.	1	3.45	3
Naphthalene	91-20-3	128.19	1	80.1	1	217.9	3	4.42	3
Nickel, Elemental	7440-02-0	58.71	1	1455.	1	2730	1		
Phenanthrene	85-01-8	178.24	1	101.	1	340	1		
Phenol	108-95-2	94.11	1	41.	3	182.	1	3.24	3
Potassium cyanide	151-50-8	65.12	21	634.5	21	decomposes	21		
Potassium, Elemental	7440-09-7	39.09	1	63.25	1	760	1		
Pyrene	129-00-0	202.24	21	156.	21	404.	21		
Selenium, Elemental	7782-49-2	78.96	1	60/170/217	1	684.8/684.9	1		
Silver, Elemental	7440-22-4	107.868	1	961.93	1	2212.	1		
Sodium, Elemental	7440-23-5	22.98	1	97.81	1	882.9	1		
Styrene	100-42-5	104.14	3	-30.6	3	145.2	3		
Thallium, Elemental	7440-28-0	204.37	1	303.5	1	1457+/-10	2		
Tin, Elemental	7440-31-5	118.69	1	231.9	1	2260/2270	1		
Toluene	108-88-3	92.1	3	-95.1	3	110.8	3	3.14	3
Vanadium, Elemental	7440-62-2	50.942	1	1917.	21	3380.	1		
Xylenes/NOS	1330-20-7	106	5						

Table 51 continued.
Physical Chemistry Data

Constituent	Specific Gravity		Reference	Vapor Pressure		Vapor Pressure		Reference
	@ deg C			@ 20 C (mm Hg)		@ deg C (mm Hg)		
1,1-Dichloroethane	1.174	20/4	3	180	3	70/234/270	0/25/30	3
1,2-Dichloroethane	1.25	20/4	3	61.	3	40/105	10/30	3
1,2-trans-Dichloroethene	1.26	20/4	3	324	5	200	14.	3
2-Butanone	0.805	20/4	3	77.5	3			
2-Methylnaphthalene	0.994	20/4	3					
2-Methylphenol (o-Cresol)	1.041	20/4	3			0.24/5	25/64	3
4-Methyl-2-pentanone	0.8017	20/4	3	6	3			
4-Methylphenol (p-Cresol)	1.0347	20/4	3	0.04	3	0.11/1	25/53	3
Acenaphthene	1.069	20/4	3	2.8E-03	9	1.55E-03	20/30	5
Acetone	0.791	20/4	3			89/270	5/30	3
Aldrin				2, 3E-05	3			
Aluminum, Elemental	2.702	20/4	1					
Anthracene	1.25	20/4	3			760	342.	1
Arsenic, Elemental	5.727	14.	1					
Barium, Elemental	3.51	20/4	1					
Benzene	0.8786	20/4	3	76.	3	60/118	15/30	3
Benzo(a)anthracene						2.2E-08	20/30	5
Benzo(a)pyrene				7.32E-07	6	5.6E-09	20/30	5
Benzo(b)fluoranthene						5.00E-07	20/30	5
Benzo(g,h,i)perylene								
Benzo(k)fluoranthene						5.1E-07	20/30	5
Benzoic Acid	1.27	20/4	3					
Beryllium, Elemental	1.85	20/4	1					
bis(2-Chloroethyl) Ether	1.22	20/4	3	0.71	3			
bis(2-Ethylhexyl) phthalate	1.593	20/4	3					
Cadmium, Elemental	8.642	20/4	1					
Calcium, Elemental	1.55	20/4	1			10.	983.	17
Chlorobenzene	1.1066	20/4	3	8.8	3	11.8	25.	3
Chloroethane	0.92	0/4	3	457	3			
Chloromethane	0.991	-25.	3	3800	3	5090	30	3
Chromium, Elemental	7.20	28.	1					
Chrysene	1.274	20/4	3	1E-11/1E-08	6	6.3E-09	20/30	5
Cobalt, Elemental	8.92	20/4	1			0.001	1894.	1
Copper, Elemental	8.96	20/4	1					
DDD				1.89E-06	5			
DDE				6.50E-06	5			
Dibenzo(a,h) anthracene				1.0E-10	6			
Dibenzofuran	1.0886	99.	17					
Fluoranthene				1E-06/1E-04	6	5.00E-06	20/30	5
Heptachlor	1.57	20/4	3	3.00E-04	3			
Indeno(1,2,3-cd) pyrene				1E-10	6			
Iron, Elemental	7.87	20/4	1					
Lead, Elemental	11.34	16.	1					
Magnesium, Elemental	1.738	20/4	1					
Manganese, Elemental	7.21/7.44	20/4	1					
Mercury, Elemental	13.546	20/4	1	1.3E-03	9			
Methyl butyl ketone	0.8113	20/4	17	2.0	3	3.8	25.	17
Naphthalene	1.152	100/4	3	0.23	9			
Nickel, Elemental	8.90	20/4	1					
Phenanthrene	1.025	20/4	3	2.1E-04	9			
Phenol	1.07	20/4	3	0.2	3			
Potassium cyanide	1.52	16.	21					
Potassium, Elemental	0.862	20/4	1					
Pyrene				2.5E-06	5			
Selenium, Elemental	4.26/4.81	20/4	1					
Silver, Elemental	10.5	20	1					
Sodium, Elemental	0.971	20/4	1					
Styrene				5.	3	9.5	30	3
Thallium, Elemental	11.85	20/4	1					
Tin, Elemental	5.75/7.28		1					
Toluene	0.867	20/4	3	28.1	5	10/40	6.4/31.8	3
Vanadium, Elemental	6.11	18.7	1			0.001	2525.	1
Xylenes/NOS				10	5			

Table 51 continued.
Physical Chemistry Data

Constituent	Diffusion Coefficient ((cm ²)/sec)	Reference	Henry's Law Constant ((atm*m ³)/mole)	Reference	Aqueous Solubility @ deg C (mg per liter)		Reference
1,1-Dichloroethane	9.19E-02	4	4.31E-03	5	5500	20	3
1,2-Dichloroethane					8690	20	3
1,2-trans-Dichloroethene					600	20	3
2-Butanone			2.61E-05	7	335000	10	3
2-Methylnaphthalene							
2-Methylphenol (o-Cresol)			1.10E-06	5	31000/56000	40/100	3
4-Methyl-2-pentanone					19000	20	3
4-Methylphenol (p-Cresol)	5.05E-06	10	1.10E-06	5	24000/53000	40/100	3
Acenaphthene			9.20E-05	11	3.9	20.	9
Acetone	0.1049	4	2.06E-05	5	miscible		
Aldrin					0.01	25	3
Aluminum, Elemental							
Anthracene			1.02E-03	5	0.073	NA	13
Arsenic, Elemental							
Barium, Elemental							
Benzene	0.0932	4	5.5E-3	9	1780/820	20/NA	3
Benzo(a)anthracene			1.16E-06	5	0.014/0.044	24/25	14
Benzo(a)pyrene			1.55E-06	5	0.038	25.	14
Benzo(b)fluoranthene			1.19E-05	5	0.001	25.	16
Benzo(g,h,i)perylene					2.6E-04	25	3
Benzo(k)fluoranthene			3.94E-05	5	0.00055	25.	16
Benzoic Acid					2900	20.	3
Beryllium, Elemental							
bis(2-Chloroethyl) Ether							
bis(2-Ethylhexyl) phthalate					5400	14.	3
Cadmium, Elemental							
Calcium, Elemental							
Chlorobenzene	0.0747	4	3.45E-03	10	488.		13
Chloroethane					3300	0.	3
Chloromethane			4.40E-02	5	9100		3
Chromium, Elemental							
Chrysene			1.05E-06	5	0.0015/0.006	15/25	3
Cobalt, Elemental							
Copper, Elemental							
DDD					0.160	24	3
DDE					0.04	20.	3
Dibenzo(a,h) anthracene			7.33E-08	5	0.0005	27.	16
Dibenzofuran							
Fluoranthene			6.46E-06	5	0.265	25.	3
Heptachlor							
Indeno(1,2,3-cd) pyrene			6.68E-08	5	0.0005	25.	16
Iron, Elemental							
Lead, Elemental							
Magnesium, Elemental							
Manganese, Elemental							
Mercury, Elemental			1.1E-02	9	0.030	NA	9
Methyl butyl ketone					1640		17
Naphthalene			1.15E-03	9	31.7	20	13
Nickel, Elemental							
Phenanthrene			1.59E-04	11	1.277/0.816	30/21	3
Phenol	0.085	19	4.54E-07	11	82000	15.	18
Potassium cyanide					5E06		21
Potassium, Elemental							
Pyrene			5.04E-06	5	0.16	26.	3
Selenium, Elemental							
Silver, Elemental							
Sodium, Elemental							
Styrene			3.3E-03	9	280/300	15/20	3
Tin, Elemental							
Toluene			6.37E-03	5	470/515	16/20	3
Vanadium, Elemental							
Xylenes/NOS					1.98E+02		5

Table 51 continued.
Physical Chemistry Data

Constituent	Octanol-Water Partition Coefficient	Reference
1,1-Dichloroethane	61.7	5
1,2-Dichloroethane	32.	6
1,2-trans-Dichloroethene	30	6
2-Butanone	1.8	8
2-Methylnaphthalene	13000	9
2-Methylphenol (o-Cresol)		
4-Methyl-2-pentanone		
4-Methylphenol (p-Cresol)	83/87	3
Acenaphthene		
Acetone	0.58	3
Aldrin		
Aluminum, Elemental		
Anthracene	28200	9
Arsenic, Elemental		
Barium, Elemental		
Benzene	130	3
Benzo(a)anthracene	407000	6
Benzo(a)pyrene	1.1E06	6
Benzo(b)fluoranthene		
Benzo(g,h,i)perylene		
Benzo(k)fluoranthene	1.15E06	3
Benzoic Acid		
Beryllium, Elemental		
bis(2-Chloroethyl) Ether		
bis(2-Ethylhexyl) phthalate	0.10/0.41	3
Cadmium, Elemental		
Calcium, Elemental		
Chlorobenzene	676.	18
Chloroethane		
Chloromethane	8.9	5
Chromium, Elemental		
Chrysene	407000	3
Cobalt, Elemental		
Copper, Elemental		
DDD		
DDE		
Dibenzo(a,h) anthracene	933000	6
Dibenzofuran		
Fluoranthene	79000	19
Heptachlor		
Indeno(1,2,3-cd) pyrene	4.57E07	20
Iron, Elemental		
Lead, Elemental		
Magnesium, Elemental		
Manganese, Elemental		
Mercury, Elemental		
Methyl butyl ketone		
Naphthalene	1000/2800	3
Nickel, Elemental		
Phenanthrene	37000	13
Phenol	29.	3
Potassium cyanide		
Potassium, Elemental		
Pyrene	76000	9
Selenium, Elemental		
Silver, Elemental		
Sodium, Elemental		
Styrene		
Tin, Elemental		
Toluene	128.	8
Vanadium, Elemental		
Xylenes/NOS		

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less soluble in water (Table 51) and have a greater tendency to adsorb to the soils. Therefore, the rate of migration from the landfill through the surface water or ground water would be less for the heavy polynuclear aromatic hydrocarbons than for the highly soluble constituents.

Physical and chemical characteristics of the TCL constituents detected in the waste characterization samples have been obtained from the literature and are presented in Table 51. These characteristics are useful to describe, in part, the environmental mobility and fate of each constituent.

The characteristics in Table 51 may be used to segregate the detected TCL constituents into different Structure Activity Relationship (SAR) groups. These SAR groups are used as a basis for selecting indicator constituents for purposes of risk assessment and future monitoring or remediation assessment.

4.5 Statistical Analysis of Data

The Schilling Landfill analytical data was subjected to a statistical analysis to help assess significance of contamination at the site. The statistical analysis used two main techniques:

- o Q-mode cluster analysis
- o R-mode principal components analysis.

A BMDP (1988) Statistical Software computer package was used in the analysis.

Due to the large number of constituents detected (74), and due to limitations imposed by the computer software, the project analytical data base was subdivided to limit the number

of chemical constituents to be subjected to the analysis. Organic constituent data (volatiles and semi-volatiles) and metals were first separated. Constituents which were detected a minimum of ten occurrences for either organics or metals were retained for statistical analysis. The selection of ten as the cut-off value was made to limit the number of variables/constituents for both metals and organics to between 15 and 20 for statistical analysis. Eight media groupings were selected:

- (1) Metals - Soil Media Types (BO, LW, SD, SS)
- (2) Organics - Soil Media Types (BO, LW, SD, SS)
- (3) Metals - Water Media Types (MW, SW, LS)
- (4) Organics - Water Media Types (MW, SW, LS)
- (5) Metals - Surface Soils Only (SS)
- (6) Organics - Surface Soils Only (SS)
- (7) Metals - Ground Water and Surface Water (MW and SW)
- (8) Organics - Ground Water and Surface Water (MW and SW)

Surface soils (SS), were the only individual media type which warranted a separate statistical analysis. The other individual media types were represented by low numbers of individual samples, and therefore, media groupings were made based upon similar matrix compositions (i.e. water and soil media types).

The data base consisted of all Phase I and Phase II RI sampling results. In the various computer output files, case numbers and sample labels appear with the data. Due to multiple sampling events (and duplicate laboratory analyses of some samples), there are often two or three sets of data reported for a given sample location. For example, case

number 1, sample label MW-01B might have been used to designate the June 1988 sampling results for wells MW-01B. Case number 2, sample label MW-01B might represent the December 1988 results for the same well. At times, there are sufficient variations in the data between sampling event of a given sample such that a statistical separation of the sample occurs. Where this occurs, the number of occurrences (cases) appears in parentheses after the sample label in the following discussion to denote that the discussion does not apply to all cases for that particular sample. This type of statistical separation might occur, for example, when a constituent is below detection limit for one sampling episode, and above the limit for some other sampling for a given sample.

THEORY

Q-Mode Cluster Analysis

Cluster analysis is a useful statistical tool for identifying the latent structure within the data set. Q-mode cluster analysis is specifically designed to reveal groupings of samples (i.e. wells) in a data set with n samples and m variables (i.e. chemical constituents) such that the degree of association is high among members of the same group. The degree of similarity is measured by the Euclidean distance, d_{ij} , which is computed by (Davis, 1973):

$$d_{ij} = \left[\frac{\sum_{k=1}^m (X_{ik} - X_{jk})^2}{m} \right]^{1/2}$$

where =

X_{ik} = the k^{th} variable measured on sample i , and
 X_{jk} = the k^{th} variable measured on sample j .

Thus, m variables are measured for each sample and d_{ij} is the distance between two samples i and j . Small distances indicate close similarity. Prior to computing the distance, the $n \times m$ raw data matrix is standardized to ensure equal weighing for all variables.

An $n \times m$ symmetrical matrix is formed by computation of similarities between all possible pairs of samples. The next step is to arrange the samples in a hierarchical structure in order to join samples with the highest mutual similarity. Clusters of samples associated with others are joined until all samples have been placed into a complete classification scheme.

A BMDP2M (Cluster Analysis of Cases) Statistical Software program was employed for this study. Similarities were computed by the centroid method. The program produces a dendrogram (tree diagram) which illustrates the similarities of grouping of samples.

R-Mode Principal Components Analysis

R-mode principal components analysis (often referred to as factor analysis) is a method which seeks to determine the minimum number of causal influences necessary to account for the bulk of the variation between variables in the data set. The dimensionality of the data set is expressed by means of a coordinate axis system with the length of the axes being proportional to the axial variation in the data points. There are as many dimensions (and thus axes) as there are variables (m). Principal components analysis creates a new coordinate system where the origin is located at the centroid of the data set. The first axis is positioned in m -dimensional space so as to account for as much of the total variation as possible. The second axis is positioned in space at right angles to the first axis so as to

account for as much of the remaining variation in data as possible. The third axis is positioned at right angles to the first and second axes and explains the maximum possible remaining variation, and so forth until all axes are defined. Each axis in the new coordinate system is called a principal component (or factor).

The length of each axis is proportional to the amount of total variation (eigenvalue) they describe. Each of the new axes may be geometrically represented by vectors termed eigenvectors. The relationship between the original variables and the "new variables" (or principal components) are given by the loadings, which are the Pearson product-moment correlation coefficients which describe the strength of the relationship between a component and an original variable. There is for each sample in the original data set a value for each of the "m" variables. Factor "score" is the term for the new value for each sample measured in terms of the new variables or components. Factor scores correspond to the projection of the original data points onto each component axis.

It is useful, in many instances, to move the positions of the component axes by rotating them so that they will achieve what is termed a "simple structure", meaning that the component axes are located in positions such that, for each factor only a relatively few variables will have high loadings and the remainder will have loadings on only a few factors (Klovan, 1975). The main goal of axis rotation is to improve the interpretability of the principal components or factors.

A BMDP4M (Factor Analysis) Statistical Software program was used in the analysis of the Schilling Landfill environmental data, the same data that were used in the cluster

analysis. The number of significant principal components is determined from the unrotated factor loading pattern. There are two non-statistical rules of decision for evaluating the significance of each component (see Klovan, 1975):

Rule 1 - Only those principal components with eigenvalues (variance explained by each component) greater than 1 are significant.

Rule 2 - Retain only those components that provide communalities for all or nearly all variables in excess of some specified value (usually 0.8).

Communality is defined as the sum of squares of factor loadings for a given variable.

RESULTS

Metals - Soil Media Types (BO, LW, SD, SS samples)

Using the screening criteria discussed earlier, nineteen metals were selected for analysis. These included Aluminum (Al), Arsenic (As), Barium (Ba), Beryllium (Be), Calcium (Ca), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Mercury (Hg), Magnesium (Mg), Manganese (Mn), Sodium (Na), Nickel (Ni), Lead (Pb), Antimony (Sb), Selenium (Se), Vanadium (V) and Zinc (Zn). Input data and results are included in Appendix B10 under the output file name "SOIM2M. OUT".

No distinct sample groupings of this data set were delineating by the cluster analysis procedure, as shown on page three of the program output (Appendix B10). The Euclidean distance (called Amalgamation distance in the program output) is posted along the left margin and sample labels along the top of the dendrogram. The SS and SD samples tend to group at lower distances than BO and LW samples, due to the lower metals

concentrations. Two surface soil samples, SS-08 and SS-32, are grouped with the landfill waste samples as outliers to the main cluster body.

Factor score plots (ordination plots) produced by the principal components analysis program are also useful in identifying sample groupings. A factor score plot of the soils-metals data set is shown on Figure 68. A tight grouping of the SD and SS samples is indicated, with the LW samples scattered outside of the grouping. Surface soil samples SS-08 and SS-32 also plot outside of the main group, similar to the cluster analysis results described above.

The principal components analysis output is shown as output file "SOIM4M.OUT" in Appendix B10. Page nine of the output indicates that four principal components are significant factors in explaining the variation in the data set. The first four components account for only 81.81% of the total variation. Therefore, there appears to be no dominant factor(s) involved in explaining the data variation. Applying Rule 2 described earlier, six variables (Ba, Be, Ca, Co, Fe, Se) are not accounted for by the four principal compounds based on their communalities (page ten of program output).

Organics - Soil Media Types (BO, LW, SD, SS samples)

Fifteen organic constituents were selected for statistical analysis. These included five volatile organics and ten semi-volatiles as listed below:

EXPLANATION OF SYMBOLS

- * BO SOIL TEST BORING
- ◇ LW LANDFILL WASTE
- △ SD SEDIMENT
- SS SURFACE SOIL

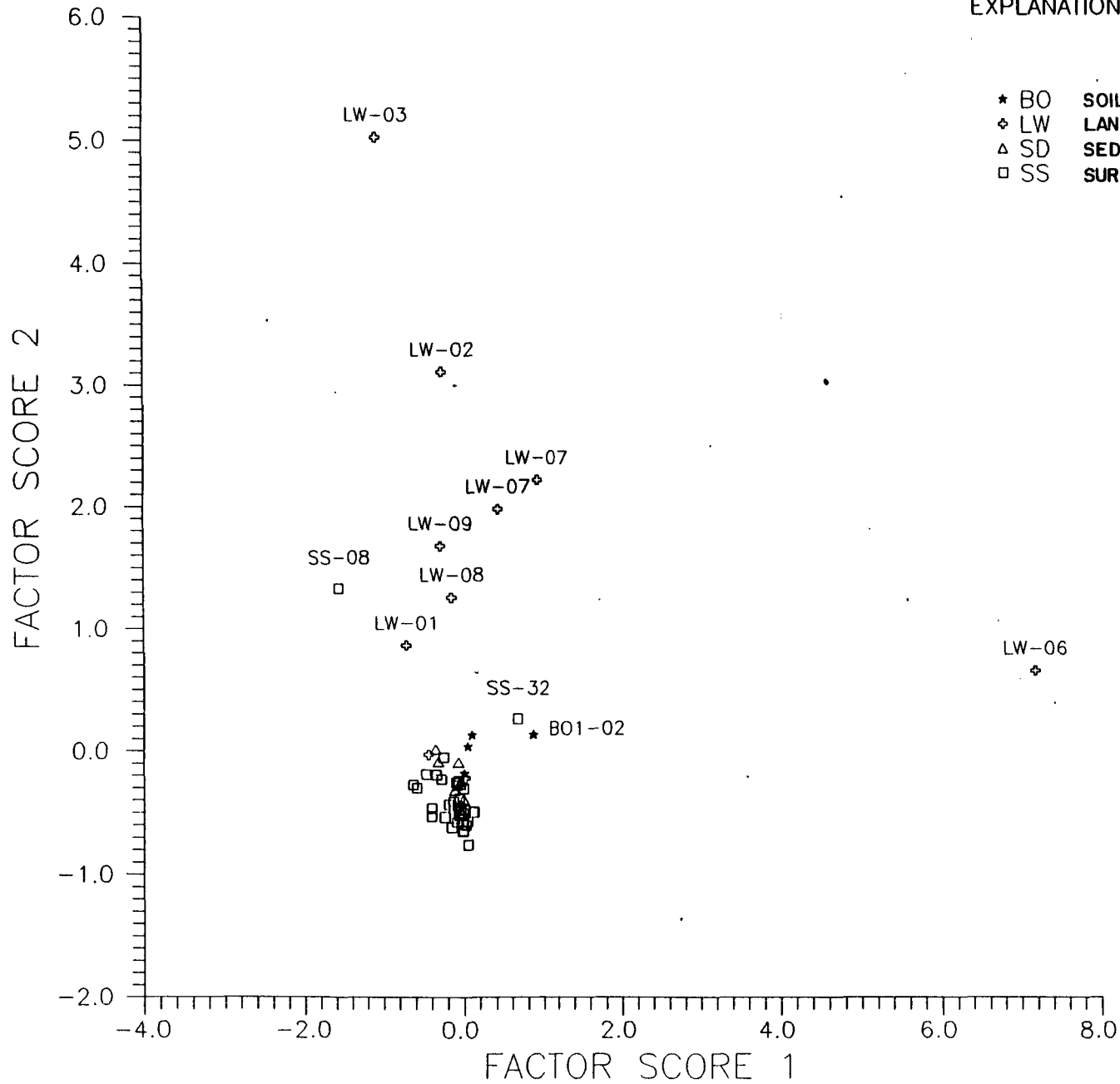


FIGURE 68

FACTOR SCORE PLOT
METALS FOR BO, LW, SD AND
SS SAMPLE MEDIA

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Volatiles

1,2-Dichloroethane
Acetone
Chloroethane
Ethylbenzene
Dichloromethane

Semi-volatiles

Benzo (a) Anthracene
Benzo (a) Pyrene
Benzo (b) Fluoranthene
Benzo (k) Fluoranthene
Chrysene
Fluoranthene
Phenanthrene
Phenol
Pyrene
bis (2-Ethylhexyl) Phthalate

The cluster analysis and principal components analysis program output files are labeled SOIO2M.OUT and SOIO4M.OUT, respectively, in Appendix B10.

Four sample groupings have been established based on the cluster analysis. Cluster 1 represents the tightest grouping (least variance in the data) indicative of non-contaminated samples. The Euclidean distance range is from 0.001 to 0.071, and includes all SD samples, all SS samples excluding SS-32, and LW-05.

Cluster 2 represents a Euclidean distance range of 0.297 to 0.687. Three samples falling in this range include LW-02, LW-04 and SS-32. These samples are considered as slightly to moderately contaminated with respect to organic constituents.

Cluster 3 is comprised of landfill wastes samples LW-01, LW-03, LW-06, LW-07, and LW-09. In addition, two of the four soil test boring samples, BO1-01 and BO5-02, are included. The Euclidean distance ranges from 1.027 to 4.120 in this grouping.

The final grouping, cluster 4, represents the most highly contaminated samples. These samples, at the far end of the dendrogram, include LW-08, BO5-01 and BO1-02.

The initial principal components analysis was performed using all of the fifteen organic constituents listed earlier. The program computes the squared multiple correlations of each variable with all other variables. If a singular correlation matrix is computed (i.e. correlation = 1.0), it is suggested that the analysis be performed with these variables eliminated. Singular correlations were computed for 1,2-Dichloroethane, Benzo (a) Anthracene, Benzo (b) Fluoranthene, Chloroethane and Chrysene. Therefore, these five constituents were eliminated for the final analysis (the cluster analysis previously discussed was also performed with the reduced variable input).

Two principal components were identified from the BMDP4M analysis of the soils type media organics data. The first principal component accounts for 66.10% of the total variation in the data, and contains high variable loadings from the semi-volatile constituents. The volatile constituents load heavily upon the second principal component, accounting for 27.01% of the remaining variation. All other components account for only 6.89% of the variation.

Figure 69 is an ordination plot of factor scores 1 and 2. Similar to the cluster analysis, the plot is useful in delineating grouping of variables with similar data variation. The plot shows a very tight grouping of SD and SS samples, with a scatter of the LW and BO samples away from the main group. The tight cluster represents non-contaminated samples, and the divergence from this group represents an increasing level of contamination.

EXPLANATION OF SYMBOLS

- * BO SOIL TEST BORING
- ◇ LW LANDFILL WASTE
- △ SD SEDIMENT
- SS SURFACE SOIL

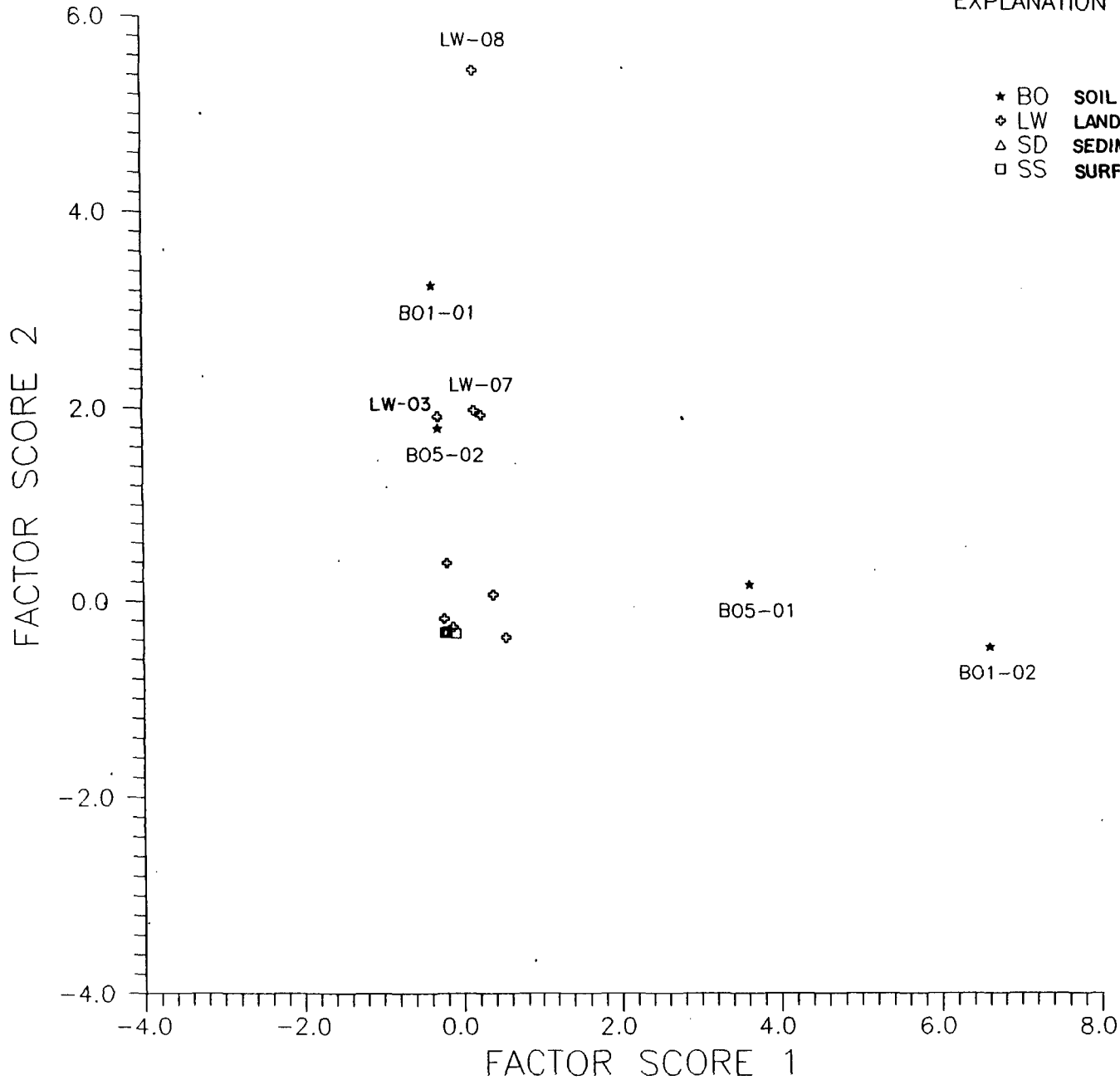


FIGURE 69
FACTOR SCORE PLOT
ORGANICS FOR BO, LW, SD AND
SS SAMPLE MEDIA
E. H. SCHILLING LANDFILL

Metals - Water Media Types (MW, SW, LS samples)

Seventeen metals were used for analysis of the water media type samples. These included Aluminum, Barium, Beryllium, Calcium, Cobalt, Chromium, Copper, Iron, Potassium, Magnesium, Manganese, Sodium, Nickel, Lead, Selenium, Vanadium and Zinc.

No distinct clustering was evident with the BMDP2M analysis, similar to the analysis of metals in the soils media. The SW and MW samples tend to group loosely at the lower Euclidean distances with LS samples at higher distances. Pages three and four of the program output (see output file "WATM2M.OUT" in Appendix B10) show MW-05A, MW-05B, SW-05, LS-04 and LS-06 at the far end of the dendrogram, indicative of higher and greater number of metal constituent concentrations.

Output of the principal components analysis for the metals/water data is shown as output file "WATM4M.OUT" in Appendix B10. Page nine of the output shows that three principal components (PC's) exhibit eigenvalues exceeding 1.0, and are therefore considered significant. PC1 accounts for 60.41% of the total variation, PC2 accounts for 14.41% and PC3 only 8.20%, with a remaining 16.98% not accounted for by the first three components. These relatively low percentages indicate that these are not dominant components, similar to results obtained for the metals/soils data set described earlier.

Page ten of the program output shows the loadings of each variable upon the respective three PC's. Below is a summary of significant variable loadings:

<u>PC1</u>	<u>PC2</u>	<u>PC3</u>
Al	Ca	Ba
Be	Mg	Cr
Cu		Ni
Fe		
V		
Zn		

Four metals, K, Mn, Na and Pb do not exhibit significant loadings upon the first three components. Upon rotation of the component axes, the following significant loadings are recognized (Page 13 of output).

<u>PC1</u>	<u>PC2</u>	<u>PC3</u>
Co	Al	Cr
Be	Fe	Ni
Cu	Ca	Mn
Zn	Mg	
V	Na	
	Ba	
	K	

There is a marked difference between the two variable loading patterns. This further supports the assumption that no dominant factor(s) are involved in the data variation. An ordination plot of factor score 1 and 2 is shown on Figure 70. A relatively tight cluster is formed by the MW and SW samples, with the LS samples scattered loosely away from the main cluster. Sample SW-05 (1 case) and MW-06A (2 cases) are positioned outside of the cluster, indicating higher metals concentrations. LS-04 is an outlier with respect to other LS samples.

Organics - Water Media Types (MW, SW, LS samples)

Fifteen organic constituents (five volatiles and ten semi-volatiles) were submitted for statistical analysis for the organics/water data set. These were the same as listed earlier

EXPLANATION OF SYMBOLS

- * LS LEACHATE
- o MW MONITORING WELL
- ◇ SW SURFACE WATER

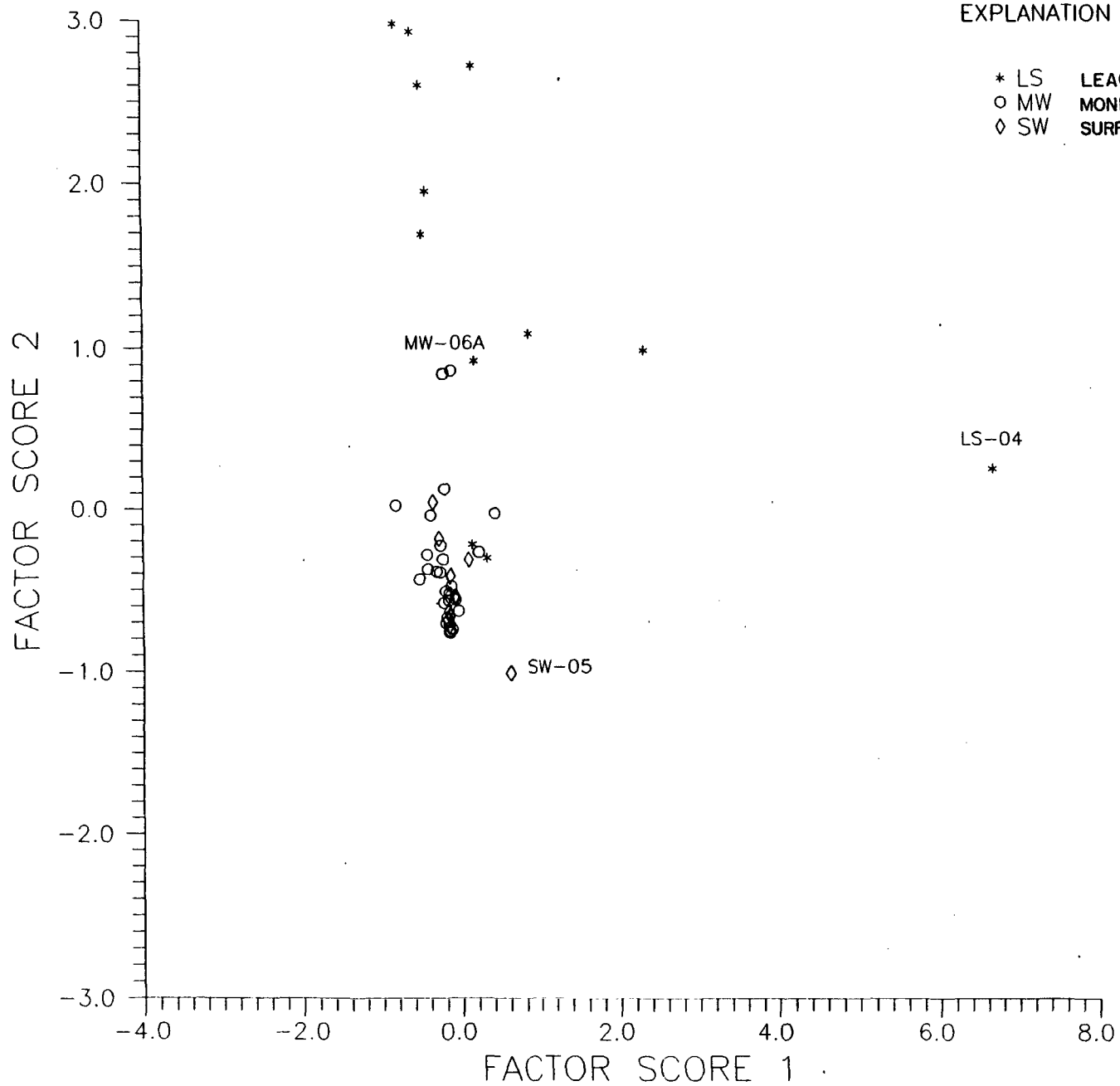


FIGURE 70

FACTOR SCORE PLOT
METALS FOR LS, MW AND
SW SAMPLE MEDIA

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for the soils media analysis. Preliminary BMDP4M runs indicated that four of the constituents should be eliminated from the statistical analysis, based on computation of singular correlations. The constituents eliminated were Benzo (a) Anthracene, Benzo (a) Pyrene, Benzo (b) Fluoranthene and Fluoranthene.

Five fairly distinct groupings were produced by the cluster analysis. Cluster 1 represents a tight grouping of samples within a Euclidean distance range of 0.000 to 0.006. Within this cluster are all MW samples excluding MW-03A, MW-04B and MW-06A, and SW-01 to SW-06 (various cases). Cluster 1 represents the non-contaminated samples with respect to organic constituents.

Cluster 2 may also be considered as representative of non-contaminated conditions, based upon the low Euclidean distance range of 0.021 to 0.093. Samples included within this group include MW-03A, MW-04B, MW-06A (1 case), SW-01, SW-02 and SW-05.

The third grouping, cluster 3, includes MW-06A (1 case), SW-06 (1 case), LS-01 , LS-04 (1 case) and LS-06. These samples join the previous groupings within a Euclidean distance interval of 0.211 to 0.339. This cluster represents slightly contaminated samples.

Samples LS-02, LS-07 and MW-08A (1 case) cluster in a Euclidean distance range of 0.668 to 1.976. The MW-08A sample appears to be a statistical anomaly as it contains substantially lower constituent concentrations than LS-02 and LS-07.

Cluster 5 represents the most contaminated sample grouping, and consists of LS-03, LS-04 and LS-05. These samples fall within a Euclidean distance range of 3.967 to 14.628.

Sample groupings from the principal components analysis program are shown on Figure 71. A tight grouping of MS and SW samples is indicated. LS samples appear scattered away from the main group. Samples LS-03, LS-04 and LS-05 are the most distinct outliers. Similar to the cluster analysis output described above, these results suggest that only the LS samples are contaminated.

Three principal components exhibit eigenvalues exceeding 1.0, as shown on page nine of output file "WATO4M.OUT" in Appendix B10. PC1 accounts for 58.49% of the total variation, PC2 accounts for 23.32% and PC3 11.28%, with a remaining 6.91% for all other components. There are no significant loadings upon PC1 for the unrotated factor loadings pattern (page ten of output). The PAH constituents tend to load upon PC2 and volatiles upon PC3. Upon rotation of component axes (page thirteen of output), there is a general shift upward such that PC1 exhibits heavy loadings from the PAH's and PC2 from the volatile organics.

Metals - Surface Soils (SS samples)

A statistical analysis was performed on the surface soil data to define the nature and extent of contamination of the surface soil media, independent of the other media types.

Output file "SSMET2M.OUT" in Appendix B10 contains the BMDP cluster analysis statistical output for the surface soil data. Similar to previous cluster analysis results for

EXPLANATION OF SYMBOLS

- * LS LEACHATE
- o MW MONITORING WELL
- ◇ SW SURFACE WATER

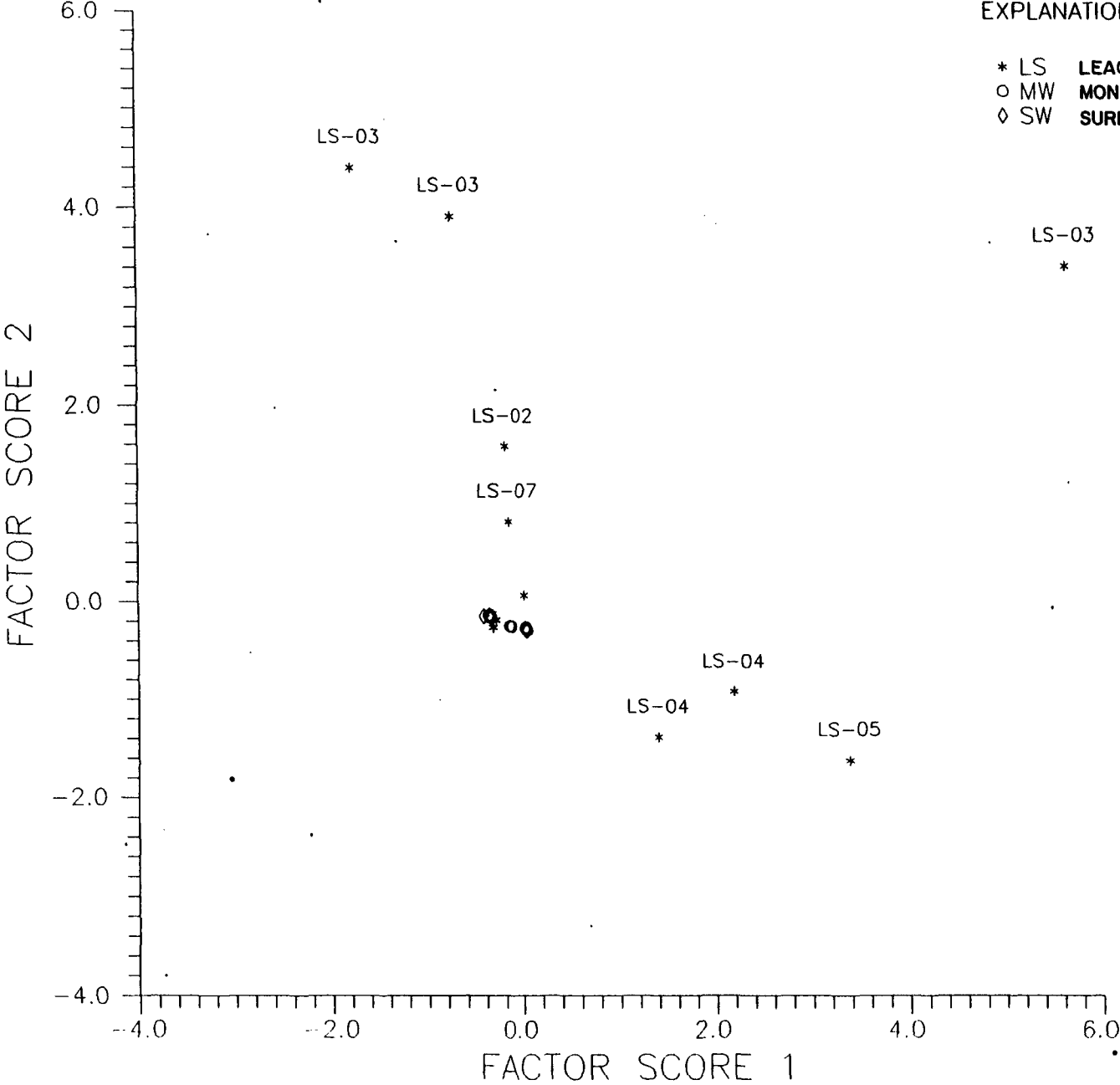


FIGURE 71
FACTOR SCORE PLOT
ORGANICS FOR LS, MW
AND SW SAMPLE MEDIA
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metals data, there is a general lack of distinct sample groupings for the SS data. Rather, there appears a gradual increase in Euclidean distances as samples join the main cluster. A potential separation of the cluster occurs between adjacent Euclidean distances of 5.747 and 8.332 on the dendrogram (see page three of output). Three samples occur beyond 8.332: SS-20, SS-08 and SS-32. These three samples are interpreted as the "worse case" with respect to metals concentrations.

Principal components analysis of these data suggest that possible random processes control the metals concentrations in the soil. Page nine of output file "SSMET4M.OUT" (Appendix B10) shows that a large number of components (five) exhibit eigenvalues exceeding 1.0, while the proportion of variance explained by each is low.

Similar to the cluster analysis dendrogram, the factor ordination plot shown on Figure 72 shows a large, loosely clustered grouping of data. Sample SS-20 is shown as an outlier on the plot indicative of higher metals concentrations.

Organics - Surface Soils (SS Samples)

The same fifteen organic constituents discussed previously were used in the analysis of the SS samples. Due to computation of singular correlation matrices, the following constituents were eliminated for final statistical analysis: 1,2-Dichloroethane, Benzo (a) Pyrene, and Benzo (b) Fluoranthene.

The cluster analysis of the organics/surface soils data shows a distinct grouping of samples within a Euclidean distance interval of 0.131 to 2.945, which includes all but two of the SS

EXPLANATION OF SYMBOLS

□ SS SURFACE SOIL

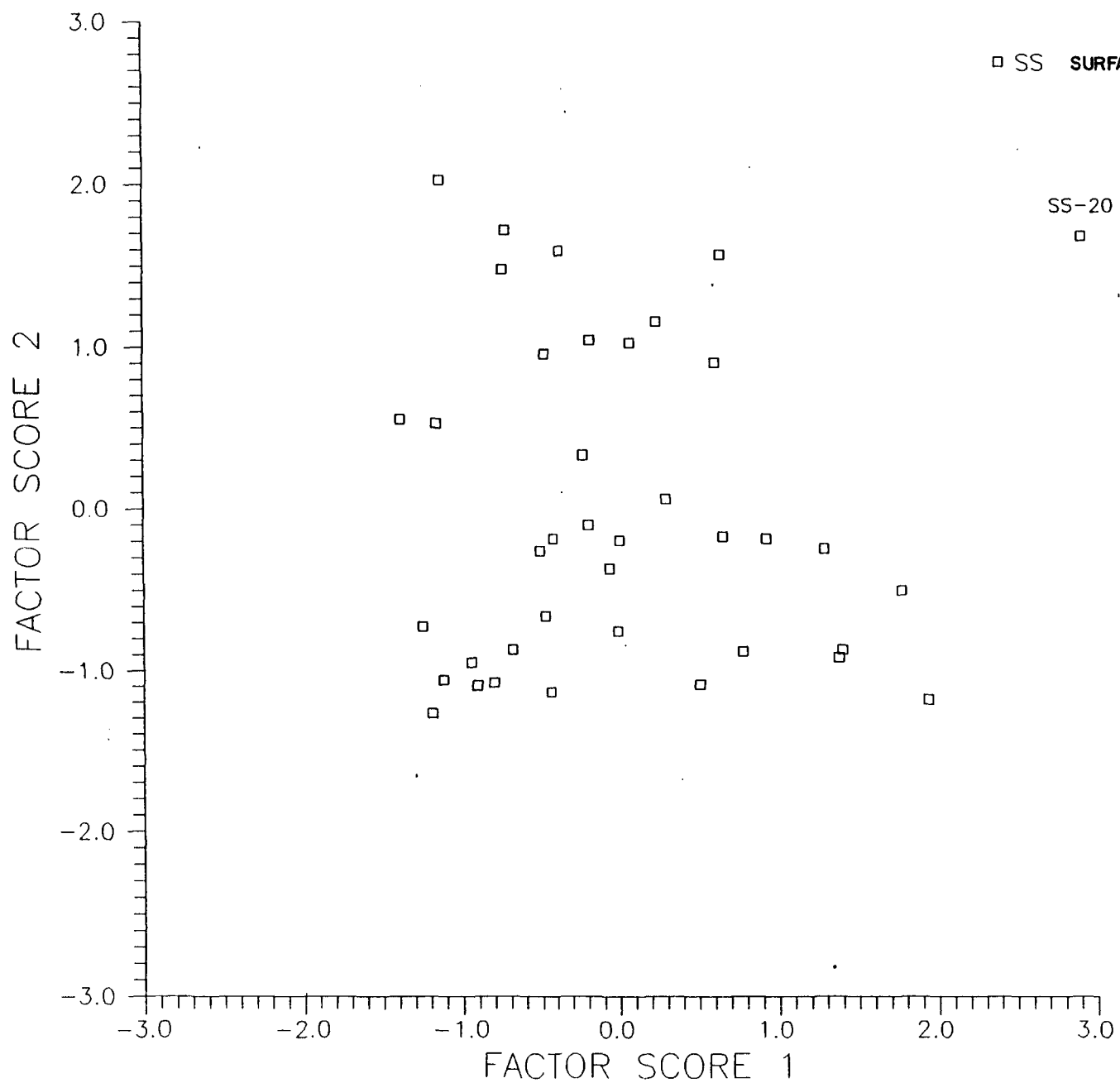


FIGURE 72

FACTOR SCORE PLOT
METALS FOR
SS SAMPLE MEDIA

E. H. SCHILLING LANDFILL

samples. Sample SS-18 and SS-32 occur at distances of 11.401 and 15.826, respectively, as outliers to the main cluster. These two samples are considered to be contaminated. Output file "SSORG2M.OUT" shows the cluster analysis output (Appendix B10).

Two significant principal components, with explained variances of 56.64% (PC1) and 28.42% (PC2), respectively, are indicated on page eight of output file "SSORG4M.OUT" in Appendix B10. The PAH constituents tend to load upon PC1 and the volatiles upon PC2 in respect to the unrotated factor loadings pattern. Similar results are obtained with the rotated factor loadings.

Figure 73 is the ordination plot of factor scores 1 and 2. A tight, linear grouping of the SS samples is shown. The elongation is along the factor 2 axis, indicating greater variation in the variable loadings upon PC2. Two distinct outliers occur relative to the main grouping, SS-18 and SS-32, similar to those shown by the cluster analysis dendrogram described earlier. Thus, the ordination plot further supports the cluster analysis results.

Metals - MW and SW Samples

Due to the potential masking of low levels of contamination by more concentrated leachate media, it was decided to perform a separate statistical analysis with only the monitoring well and surface water samples. Sixteen metals were selected for the analysis. These include: Aluminum, Barium, Beryllium, Calcium, Cobalt, Chromium, Copper, Iron, Potassium, Magnesium, Manganese, Sodium, Nickel, Lead, Vanadium and Zinc.

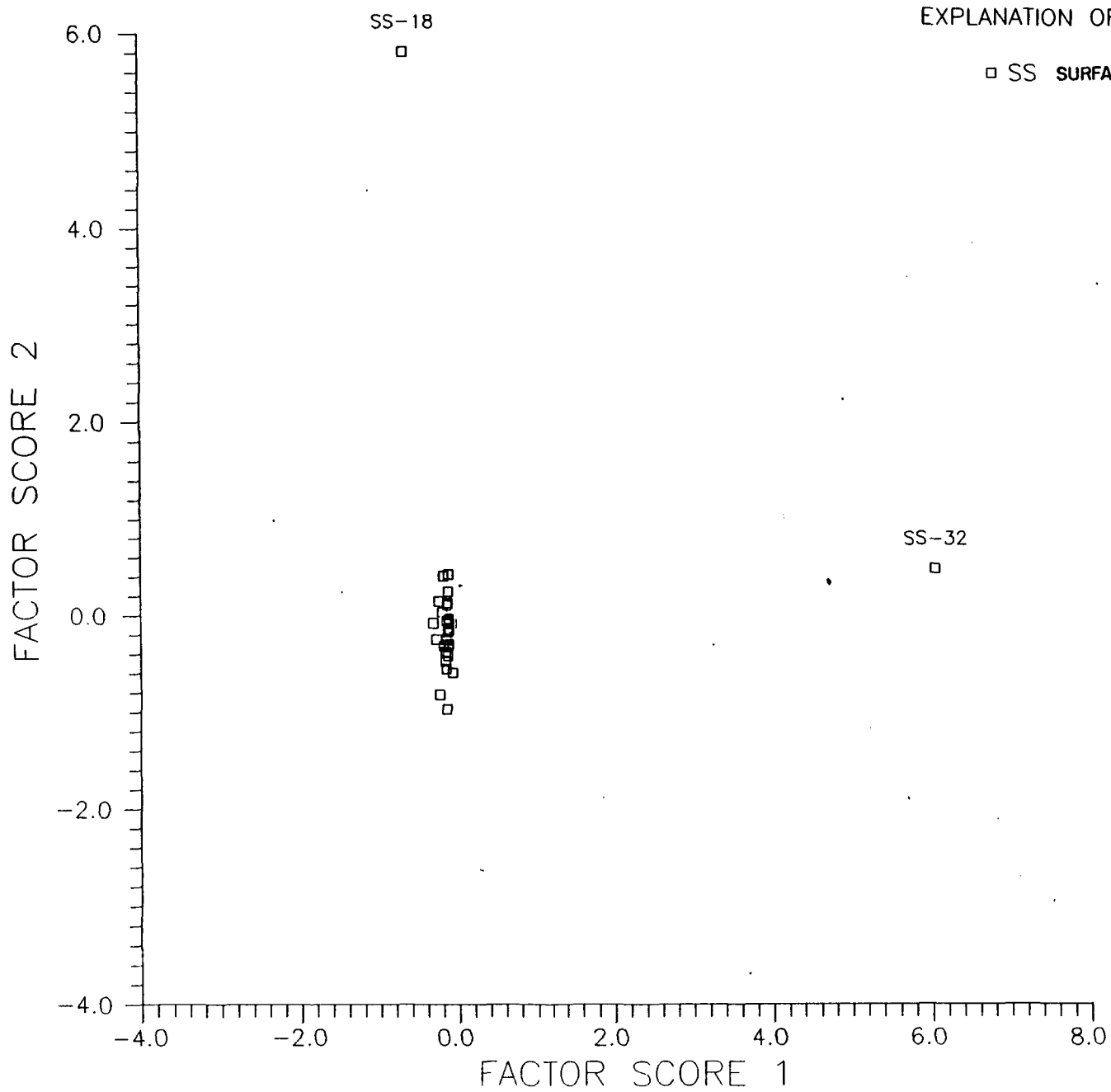


FIGURE 73

FACTOR SCORE PLOT
ORGANICS FOR
SS SAMPLE MEDIA

E. H. SCHILLING LANDFILL

Output file "MWSWME2M.OUT", in Appendix B10, is a listing of results from the cluster analysis program. No distinct breaks in the dendogram are evident, but rather there is a general increase in Euclidean distance as samples cluster together. Some samples that occur at larger distances include (in order of decreasing distance): MW-07A, MW-02B, SW-05, SW-03, MW-05A and MW-05B.

Results of the principal components analysis were similar to previously discussed analyses of metals in the other media types (see output file "MWSWME4M.OUT" in Appendix B10). The proportion of variance explained by the significant PC's (those with eigenvalues > 1.0) was very low, indicating that no dominant factors are involved in the metals concentrations. No ordination plot of factor scores is presented due to the low proportional variances explained by the components.

Organics - MW and SW Samples

Of the fifteen organic constituents selected for the statistical analysis of the various media types previously discussed, seven were eliminated due to computation of singular correlations in preliminary principal components analysis runs. The following constituents were retained for the final analyses: 1,2-Dichloroethane, Acetone, Benzo (k) Fluoranthene, Chloroethane, Phenol, Pyrene, bis(2-Ethylhexyl)Phthalate and Dichloromethane.

Cluster analysis output is included in Appendix B10 as "MWSWOR2M.OUT". Page three of the output file shows the dendogram, which illustrates the sample clustering. The majority of the MW and SW samples occur at very low Euclidean distances (at or below 0.000), indicating a close similarity in constituent concentrations. These indicate probable

background conditions. Several samples join the dendrogram at slightly larger distances. Three outliers to the main cluster are recognized, and include samples SW-05 (1 case), MW-06A (all cases) and MW-08A (1 case). MW-06A is the only one of these samples that contained organic constituents at concentrations above the CRQL. The other outliers represent statistical anomalies and may be due to differences in detection limits used as data input.

Two principal components are considered significant, based on eigenvalues exceeding 1.0. PC1 accounts for 40.90% of the total variance in the data, and PC2 an additional 29.33% (see output file "MWSWOR4M.OUT" in Appendix B10). The remaining variance not accounted for by the first two PC's is 29.77%. These results suggest that, although only two components are significant, others still account for a large proportion of the variance. Thus, there appears to be no dominant factor(s) involved in the data variation, which is expected due to the overall lack of organics detected above the CRQL in these samples.

Variable loadings are shown on page nine of the output for the unrotated factor loadings pattern. Phenol is the only constituent to load heavily upon PC1, and Benzo (k) Fluoranthene and Pyrene load heavily upon PC2. Upon rotation, there is a complete shift of the loadings. It is clear that the analysis is unstable for this data set. Therefore, no ordination plot of factor scores is presented.

SUMMARY

The cluster analysis technique was useful in identifying sample groupings, such that the data could be evaluated in terms of the extent of contamination. The tightest cluster are

formed by non-contaminated samples, and the Euclidean distance is used to quantify the divergence of the outliers to the main cluster body. Contaminated samples show as outliers to the main cluster.

Principal components analysis in the form of ordination plots of factor scores, is very similar to cluster analysis in identifying groupings of samples with similar variation in the data. This technique is also useful in evaluating the nature of the data, by identifying causal factors in the data variation. With the organics, the PAH constituents were shown to group/load upon component 1 and the volatiles upon component 2. Component 1 represents the dominant factor. It is apparent that, considering the wide variety of wastes disposed within the landfill, the PAH's are the main contaminants at the site in terms of concentration levels and abundance. No distinct patterns were found with regards to the metals.

5.0 CONTAMINANT TRANSPORT AND FATE

5.1 Potential Routes of Migration

Contaminant migration pathways in air, ground water, surface water, and soil have been examined. The US EPA (1986) defined an exposure pathway as consisting of the following necessary elements:

- o A source and mechanism of chemical release to the environment
- o An environmental transport medium
- o A potential receptor exposure point
- o A receptor exposure route

Four potential exposure pathways exist at the landfill; air, ground water, surface water, and soil.

The air pathway is susceptible to contamination via volatilization of constituents and the generation of fugitive dust. The ground-water pathway is most susceptible to direct contamination via the leaching of landfill wastes. The surface-water pathway is susceptible to contamination via both the overflow of water due to episodic precipitation events and due to ground-water seepage. The porosity of the present cap on the landfill could result in continued contamination of the surface soil by the leachate seeps.

5.2 Contaminant Fate

The environmental fate of a chemical is dependent on the transport medium and the site-specific conditions of the medium. Volatile compounds and some semi-volatile compounds may volatilize from surface water and surface soil. Photolytic degradation may also occur. Volatile and some of the semi-volatile compounds will leach through the soil to the ground

water. The environmental fate of these compounds in the soil and ground water is dependent on site-specific conditions such as availability of oxygen and the presence of acclimated micro-organisms. The light and heavy PAHs and the pesticides will tend to adsorb to the soil. Degradation of these compounds is dependent on site-specific conditions, specifically the presence of acclimated micro-organisms.

5.3 Contaminant Transport

The soil organic-carbon partition coefficients (Kocs) for the constituents detected at the E. H. Schilling Landfill site are listed on Table 51. With respect to the constituents detected at the site, the volatile organic compounds and some of the semi-volatile compounds (phenols, ketones, and phthalates) exhibit moderate to high solubility in water (0.02% to 30%). The constituents with high solubility (greater than 1%) generally do not adsorb to the soils as indicated by Kocs less than 20. The constituents with moderate solubility (0.02% to 1%) would generally adsorb to the soil more and, therefore, be less mobile through the ground water pathway. The remaining semi-volatile compounds (light and heavy PAHs and pesticides) are much less soluble (less than 0.005%) and exhibit high Kocs (greater than 1000). These constituents would generally adsorb to the soil and not be mobile through the ground water pathway. Migration of these constituents is not expected to be significant. The mobility of the metals is dependent on physical/ chemical conditions of the soil and ground water, particularly the pH.

6.0 RISK ASSESSMENT

A risk assessment was conducted at the E. H. Schilling Landfill in Hamilton Township, Lawrence County, Ohio by Law Environmental. This risk assessment included a review of the available site characterization and analytical data to evaluate potential risks to human health and the environment in the absence of remedial action at the site. This risk assessment serves as the baseline against which proposed remedial alternatives will be evaluated.

Law Environmental conducted the risk assessment in general accordance with procedures described in the following documents:

- o "Superfund Public Health Evaluation Manual," US EPA, October, 1986
- o "Superfund Exposure Assessment Manual," US EPA, April, 1988
- o "US EPA Endangerment Assessment Handbook," ICAIR, 1985

This risk assessment consists of the following four components: Data Review, Selection of Indicator Chemicals, Exposure Assessment, and Risk Characterization.

6.1 Data Review

A total of 74 chemicals were identified in the samples collected from the site (Table 52). Review of QA/QC blanks indicates that several of the organic chemicals (acetone, bis(2-ethylhexyl)phthalate, and methylene chloride), are probable laboratory contaminants. The chemicals identified in the laboratory blanks include: acetone, methylene chloride,

TABLE 52. Chemicals Detected at E. H. Schilling Landfill

1,1-Dichloroethane	p,p-DDD
1,2-Dichloroethane	p,p-DDE
1,2-Dichloroethenes (total)	Ethylbenzene
1,4-Dichlorobenzene	Iron
2-Butanone	Fluoranthene
2-Hexanone	Fluorene
2-Methylnaphthalene	Heptachlor
2-Methylphenol (o-Cresol)	Mercury
4-Methyl-2-pentanone	Indeno(1,2,3-cd) pyrene
4-Methylphenol (p-Cresol)	Potassium
Acenaphthene	Magnesium
Acetone	Manganese
Silver	Sodium
Aluminum	Nickel
Aldrin	Naphthalene
Anthracene	Lead
Arsenic	Phenanthrene
Benzo(g,h,i)perylene	Phenol
Barium	Pyrene
Beryllium	Antimony
Benzene	Selenium
Benzo(a)anthracene	Styrene
Benzo(a)pyrene	Thallium
Benzo(b)fluoranthene	Toluene
Benzo(k)fluoranthene	Vanadium
Benzoic Acid	Xylenes/NOS
Chlorobenzene	Zinc
Chloroethane	bis(2-Chloroethyl) Ether
Chloromethane	bis(2-Ethylhexyl) phthalate
Cyanide	Dibenzo(a,h) anthracene
Calcium	Dibenzofuran
Carbon disulfide	Dichloromethane
Cadmium	Di-n-butyl phthalate
Chrysene	Pentachlorophenol
Cobalt	Tetrachloroethene
Chromium	Trichloroethene
Copper	Trichloromethane

bis(2-ethylhexyl)phthalate in all media; arsenic, beryllium, cobalt, copper, and vanadium in ground water, ethylbenzene in sediment; and copper, vanadium, cobalt, and beryllium in the surficial soil samples (Table 53). The presence of these constituents in the blanks causes the overall quality, and thus the applicability of these data, to be suspect.

Presence of a constituent in a sample at a concentration equal to or up to five times greater than the reported blank concentration can be used as justification to eliminate data as being non representative. These data were retained and used in this assessment, thus further enhancing the conservative nature of this report.

6.2 Selection of Indicator Chemicals

6.2.1 Purpose

Indicator chemicals are a selected subset of site-specific chemicals which represent the "highest risk" potential to human health and the environment (Appendix B11). The selection of indicator chemicals was conducted in accordance with procedures outlined in the "Superfund Public Health Evaluation Manual," US EPA, October, 1986.

6.2.2 Selection Process and Identification of Chemicals Present at the Site

Indicator chemicals were selected in three steps. First, the chemicals detected at the site were identified and the maximum concentration of each chemical by media type was determined (Appendix B11). For the purpose of this risk assessment, eight media types were represented:

- o Surface soils from within and outside of the interpreted limits of the landfill, SS (0-6" in depth)

Table 53 Continued
Schilling Landfill
Samples in which it was determined
that the analyte was also found in
the associated blank

Parameter Sample Date	LW-05	LW-09	Monitoring Well Field Blank 8	MW-01B	MW-02B	MW-03A	MW-06A	MW-07A	Detection Limit
Acetone (mg/kg) 05/20/88 Base Sample	--	0.079 B	--	--	--	--	--	--	0.033
Acetone (ug/l) 06/08/88 Base Sample	--	--	--	--	--	--	6 BJ	--	10
Aluminum, Total (ug/l) 03/07/89 Base Sample	--	--	78.4 BP	--	--	--	--	--	Not Listed
Arsenic, Dissolved (ug/l) 03/07/89 Base Sample	--	--	--	5.2 BWF	--	--	--	3.0 BWF	2.4
Arsenic, Total (ug/l) 03/07/89 Base Sample	--	--	--	3.6 BNF	--	--	--	3.1 BWN	2.4
Barium, Dissolved (ug/l) 03/07/89 Base Sample	--	--	2.0 BP	--	--	23.1 BP	--	10.3 BP	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	23.1 BP	--	--	Not Listed
Barium, Total (ug/l) 03/07/89 Base Sample	--	--	3.4 BP	--	--	122 BP	--	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	136 BP	--	--	Not Listed
Beryllium, Dissolved (ug/l) 03/07/89 Base Sample	--	--	--	--	--	--	--	3.8 BP	1.2
Beryllium, Total (ug/l) 03/07/89 Base Sample	--	--	--	--	--	4.8 BP	--	--	1.2
Calcium, Dissolved (ug/l) 03/07/89 Base Sample	--	--	128 BP	--	--	--	--	--	Not Listed
Calcium, Total (ug/l) 03/07/89 Base Sample	--	--	288 BP	--	--	--	--	--	Not Listed
Cobalt, Dissolved (ug/l) 03/07/89 Base Sample	--	--	7.7 BP	--	--	10.2 BP	--	--	5.1
Cobalt, Total (ug/l) 03/07/89 Base Sample	--	--	6.7 BP	8.5 BP	--	31.3 BP	--	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	29.5 BP	--	--	Not Listed
Copper, Dissolved (ug/l) 03/07/89 Base Sample	--	--	--	5.3 BP	--	--	--	--	1.6
03/07/89 Blind Duplicate	--	--	--	--	--	3.3 BP	--	--	1.6

Table 53 Continued
 Schilling Landfill
 Samples in which it was determined
 that the analyte was also found in
 the associated blank

Parameter Sample Date	LW-05	LW-09	Monitoring Well Field Blank 8	MW-01B	MW-02B	MW-03A	MW-06A	MW-07A	Detection Limit
Copper, Total (ug/l) 03/07/89 Base Sample	--	--	--	10.3 BP	--	--	--	--	1.6
Dichloromethane (mg/kg) 05/20/88 Base Sample	0.030 B	--	--	--	--	--	--	--	0.008
05/20/88 Base Sample	--	0.076 B	--	--	--	--	--	--	0.016
Dichloromethane (ug/l) 06/08/88 Base Sample	--	--	--	--	--	--	1 BJ	--	5
12/13/88 Base Sample	--	--	--	--	2 BJ	--	--	2 BJ	5
12/13/88 Blind Duplicate	--	--	--	--	--	--	2 BJ	--	5
Iron, Dissolved (ug/l) 03/07/89 Base Sample	--	--	11.6 BP	--	--	--	--	--	Not Listed
Lead, Total (ug/l) 03/07/89 Base Sample	--	--	1.3 BWN	1.3 BWN	--	--	--	--	Not Listed
Magnesium, Dissolved (ug/l) 03/07/89 Base Sample	--	--	307 BEP	--	--	--	--	--	Not Listed
Magnesium, Total (ug/l) 03/07/89 Base Sample	--	--	345 BP	--	--	--	--	--	Not Listed
Manganese, Total (ug/l) 03/07/89 Base Sample	--	--	6.3 BP	--	--	--	--	--	Not Listed
Sodium, Dissolved (ug/l) 03/07/89 Base Sample	--	--	4300 BP	--	--	--	--	--	Not Listed
Sodium, Total (ug/l) 03/07/89 Base Sample	--	--	3350 BP	--	--	--	--	--	Not Listed
Vanadium, Dissolved (ug/l) 03/07/89 Base Sample	--	--	6.9 BP	--	--	5.5 BP	--	5.3 BP	4.4
Vanadium, Total (ug/l) 03/07/89 Base Sample	--	--	6.1 BP	7.4 BP	--	32.9 BP	--	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	32.9 BP	--	--	Not Listed
Zinc, Dissolved (ug/l) 03/07/89 Base Sample	--	--	18.1 BP	--	--	--	--	--	Not Listed
bis(2-Ethylhexyl) phthalate (ug/l) 06/07/88 Base Sample	--	--	--	4 BJ	--	--	--	4 BJ	20

Table 53 Continued
 Schilling Landfill
 Samples in which it was determined
 that the analyte was also found in
 the associated blank

Parameter Sample Date	Sediment Field Blank	Surface Soil Field Blank 1	Surface Soil Field Blank 2	SS-01	SS-02	SS-03	Surface Soil Field Blank 3	SS-04	Detection Limit
Acetone (mg/kg)									
04/25/88 Base Sample	0.023 B	0.039 B	0.011 B	--	--	--	--	--	0.01
04/25/88 Base Sample	--	--	--	0.029 B	0.020 B	0.020 B	--	0.011 B	0.012
Barium, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	1.5 BP	--	Not Listed
Calcium, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	34.1 BP	--	Not Listed
Copper, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	2.2 BP	--	Not Listed
Dichloromethane (mg/kg)									
04/25/88 Base Sample	0.035 B	0.014 B	0.009 B	--	--	--	--	--	0.005
04/25/88 Base Sample	--	--	--	0.019 B	0.029 B	0.010 B	--	0.014 B	0.006
03/07/89 Base Sample	--	--	--	--	--	--	0.022 B	--	0.006
Lead, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	0.44 BW	--	Not Listed
Trichloromethane (mg/kg)									
04/25/88 Base Sample	--	--	--	--	--	--	--	0.003 B	0.006
bis(2-Ethylhexyl) phthalate (mg/kg)									
04/25/88 Base Sample	--	--	--	0.41 B	0.43 B	--	--	--	0.39

Table 53 Continued
 Schilling Landfill
 Samples in which it was determined
 that the analyte was also found in
 the associated blank

Parameter Sample Date	SS-05	SS-06	SS-07	SS-08	SS-09	SS-10	SS-11	SS-12	Detection Limit
Acetone (mg/kg)									
04/25/88 Base Sample	--	0.025 B	--	--	--	--	--	--	0.011
04/25/88 Base Sample	0.021 B	--	--	--	--	--	--	--	0.012
04/25/88 Blind Duplicate	0.016 B	--	--	--	--	--	--	--	0.012
04/25/88 Base Sample	--	--	--	0.041 B	--	--	--	--	0.013
04/26/88 Base Sample	--	--	0.009 B	--	--	--	--	0.010 B	0.011
04/26/88 Base Sample	--	--	--	--	0.011 B	0.005 B	0.006 B	--	0.012
04/26/88 Blind Duplicate	--	--	--	--	--	--	0.005 B	--	0.012
Dichloromethane (mg/kg)									
04/25/88 Base Sample	0.013 B	0.013 B	--	0.026 B	--	--	--	--	0.006
04/25/88 Blind Duplicate	0.018 B	--	--	--	--	--	--	--	0.006
04/26/88 Base Sample	--	--	0.010 B	--	0.010 B	0.012 B	0.013 B	0.016 B	0.006
04/26/88 Blind Duplicate	--	--	--	--	--	--	0.010 B	--	0.006

Table 53 Continued
 Schilling Landfill
 Samples in which it was determined
 that the analyte was also found in
 the associated blank

Parameter Sample Date	SS-13	SS-14	SS-15	SS-16	SS-17	SS-18	SS-19	SS-20	Detection Limit
Acetone (mg/kg)									
04/26/88 Base Sample	--	--	0.008 B	0.007 B	--	--	--	--	0.011
04/26/88 Base Sample	0.011 B	0.006 B	--	--	--	--	0.006 B	--	0.012
04/27/88 Base Sample	--	--	--	--	0.008 B	--	--	--	0.011
Barium, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	--	47.1 BP	Not Listed
Beryllium, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	--	0.88 BP	Not Listed
Calcium, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	--	301 BP	Not Listed
Dichloromethane (mg/kg)									
04/26/88 Base Sample	0.018 B	0.016 B	0.011 B	0.021 B	--	--	0.017 B	--	0.006
04/26/88 Base Sample	--	--	--	--	--	0.051 B	--	--	0.015
04/27/88 Base Sample	--	--	--	--	0.013 B	--	--	--	0.006
03/07/89 Base Sample	--	--	--	--	--	--	--	0.011 B	0.007
Magnesium, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	--	740 BP	Not Listed

Table 53 - continued
 Schilling Landfill
 Samples in which it was determined
 that the analyte was also found in
 the associated blank

Parameter Sample Date	SS-21	SS-22	SS-23	SS-24	SS-25	SS-26	SS-27	SS-28	Detection Limit
Acetone (mg/kg)									
03/07/89 Base Sample	0.008 B	0.013 B	--	--	--	--	--	--	0.012
03/07/89 Base Sample	--	--	0.029 B	--	--	--	--	--	0.013
03/07/89 Blind Duplicate	--	--	--	--	0.012 B	--	--	--	0.013
Arsenic, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	2.0 BF	--	2.4 BF	--	2.5 BF	Not Listed
Barium, Total (mg/kg)									
03/07/89 Base Sample	15.8 BP	43.8 BP	30.1 BP	17.1 BP	--	47.6 BP	17.1 BP	--	Not Listed
Beryllium, Total (mg/kg)									
03/07/89 Base Sample	--	0.74 BP	--	--	0.87 BP	--	1.1 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	0.88 BP	--	--	--	Not Listed
Calcium, Total (mg/kg)									
03/07/89 Base Sample	58.7 BP	153 BP	166 BP	63.1 BP	290 BP	655 BP	40.1 BP	239 BP	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	311 BP	--	--	--	Not Listed
Cobalt, Total (mg/kg)									
03/07/89 Base Sample	--	4.3 BP	3.1 BP	2.2 BP	9.3 BP	11.3 BP	5.6 BP	10.6 BP	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	9.6 BP	--	--	--	Not Listed
Copper, Total (mg/kg)									
03/07/89 Base Sample	2.4 BP	--	3.9 BP	1.4 BP	3 BP	6 BP	2.4 BP	4.8 BP	Not Listed
Dichloromethane (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	0.014 B	--	0.005
03/07/89 Base Sample	0.017 B	0.027 B	0.018 B	0.019 B	0.023 B	0.013 B	--	0.023 B	0.006
03/07/89 Blind Duplicate	--	--	--	--	0.019 B	--	--	--	0.006
Magnesium, Total (mg/kg)									
03/07/89 Base Sample	147 BP	779 BP	528 BP	263 BP	798 BP	638 BP	597 BP	949 BP	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	867 BP	--	--	--	Not Listed
Nickel, Total (mg/kg)									
03/07/89 Base Sample	--	--	9.3 BP	--	8.6 BP	--	--	--	Not Listed
Selenium, Total (mg/kg)									
03/07/89 Base Sample	--	0.41 BW	--	--	--	--	--	--	Not Listed
Vanadium, Total (mg/kg)									
03/07/89 Base Sample	10 BP	--	9.6 BP	6.9 BP	--	8.2 BP	6.4 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	11.9 BP	--	--	--	Not Listed

Table 53 Continued
 Schilling Landfill
 Samples in which it was determined
 that the analyte was also found in
 the associated blank

Parameter Sample Date	SS-21	SS-22	SS-23	SS-24	SS-25	SS-26	SS-27	SS-28	Detection Limit
Zinc, Total (mg/kg)									
03/07/89 Base Sample	--	--	--	--	--	--	45.5 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	46.8 BP	--	--	--	Not Listed

Table 53 Continued
Schilling Landfill
Samples in which it was determined
that the analyte was also found in
the associated blank

Parameter Sample Date	SS-29	SS-30	SS-31	SS-32	SS-33	SS-34	SS-35	Surface Water Field Blank 3	Detection Limit
Acetone (mg/kg)									
03/07/89 Base Sample	0.003 B	0.012 B	0.010 B	0.025 B	0.008 B	--	0.011 B	--	0.012
03/07/89 Blind Duplicate	--	--	--	--	--	--	0.005 B	--	0.012
03/07/89 Base Sample	--	--	--	--	--	0.029 B	--	--	0.013
Arsenic, Total (mg/kg)									
03/07/89 Base Sample	--	--	1.8 BWF	--	--	--	--	--	Not Listed
Barium, Total (mg/kg)									
03/07/89 Base Sample	31.7 BP	39.7 BP	--	--	--	--	--	--	Not Listed
Beryllium, Total (mg/kg)									
03/07/89 Base Sample	0.46 BP	1 BP	--	--	0.38 BP	0.89 BP	0.84 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	--	0.68 BP	--	Not Listed
Calcium, Total (mg/kg)									
03/07/89 Base Sample	344 BP	481 BP	440 BP	--	452 BP	675 BP	403 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	--	324 BP	--	Not Listed
Cobalt, Total (mg/kg)									
03/07/89 Base Sample	2.8 BP	6.8 BP	10.1 BP	9.9 BP	7.2 BP	6.8 BP	11.1 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	--	9.6 BP	--	Not Listed
Copper, Total (mg/kg)									
03/07/89 Base Sample	4.4 BP	--	2.3 BP	--	5.2 BP	6 BP	5.7 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	--	5 BP	--	Not Listed
Dichloromethane (mg/kg)									
03/07/89 Base Sample	--	--	--	0.031 B	0.018 B	0.027 B	0.018 B	--	0.006
Dichloromethane (ug/L)									
04/28/88 Base Sample	--	--	--	--	--	--	--	7.0 B	5
Magnesium, Total (mg/kg)									
03/07/89 Base Sample	729 BP	503 BP	419 BP	--	536 BP	511 BP	510 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	--	341 BP	--	Not Listed
Vanadium, Total (mg/kg)									
03/07/89 Base Sample	8 BP	--	8 BP	--	9 BP	11.2 BP	10.8 BP	--	Not Listed
03/07/89 Blind Duplicate	--	--	--	--	--	--	8.6 BP	--	Not Listed
bis(2-Ethylhexyl) phthalate (mg/kg)									
03/07/89 Base Sample	--	--	0.100 B	--	0.45 B	--	--	--	0.4

- o Sediment, SD (0-6" in depth)
- o Landfill waste, LW (hand auger below cap)
- o Soil borings, BO (drilled borings; 10.5 to 30.0 ft)
- o Leachate sample, LS (liquid collected from seeps)
- o Surface water, SW (stream samples)
- o Ground water, MW (monitoring wells; A-shallow-13 to 140 ft
B-deep-47.5 to 210 ft)
- o Air

Second, the maximum concentration values were multiplied by media-specific toxicity constants to yield indicator scores (Appendix B11).

The media-specific toxicity constants used in developing indicator scores for this assessment were:

- o Soil for SS, SD, LW and BO samples
- o Surface water for LS and SW samples
- o Ground water for MW samples
- o Air for air samples

Third, indicator chemicals were selected based on:

- o Indicator scores for potentially carcinogenic (PC) and non-carcinogenic (NC) chemicals (Appendix B11)
- o Physical/chemical characteristics (Appendix B11)
- o Frequency of occurrence by media type (Tables 54 through 61)

Table 54.
Schilling Landfill
Summary Statistics for
Surface Soils

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Background SS-27
Acenaphthene, (mg/kg)	38	37	0.00126		0.00779	616.4414		0.048	
Acetone, (mg/kg)	38	7	0.01092	0.0085	0.00974	89.21935		0.041	
Aluminum, Total, (mg/kg)	38	0	5711.57895	5370	2382.18674	41.70802	2210	11700	3890
Anthracene, (mg/kg)	38	37	0.00368		0.02271	616.4414		0.14	
Arsenic, Total, (mg/kg)	38	1	4.00263	3.6	2.14369	53.55697		11	
Benzo(g,h,i)perylene, (mg/kg)	38	35	0.01103		0.04376	396.89193		0.24	
Barium, Total, (mg/kg)	38	0	45.27105	38.35	26.86855	59.35039	9.8	104	17.1
Beryllium, Total, (mg/kg)	38	3	2.99342	0.855	10.78087	360.15222		67	1.1
Benzo(a)anthracene, (mg/kg)	38	32	0.04326		0.12791	295.64975		0.67	
Benzo(a)pyrene, (mg/kg)	38	33	0.03213		0.10287	320.14644		0.54	
Benzo(b)fluoranthene, (mg/kg)	38	33	0.02597		0.08114	312.37778		0.37	
Benzo(k)fluoranthene, (mg/kg)	38	33	0.02703		0.08263	305.75565		0.37	
Benzoic Acid, (mg/kg)	38	34	0.01021		0.03209	314.32019		0.13	
Calcium, Total, (mg/kg)	38	0	307.23421	257	252.75796	82.26882	19	1110	40.1
Chrysene, (mg/kg)	38	32	0.05632		0.16958	301.13204		0.92	
Cobalt, Total, (mg/kg)	38	1	6.95263	6.6	4.95252	71.23227		27.3	5.6
Chromium, Total, (mg/kg)	38	0	7.31053	6.7	3.16969	43.35784	3.3	19.7	4.7
Copper, Total, (mg/kg)	38	0	12.78684	7.55	27.44459	214.63149	1.4	175	2.4
Iron, Total, (mg/kg)	38	0	12464.47368	10450	7258.60298	58.23433	4710	35900	13300
Fluoranthene, (mg/kg)	38	32	0.04382		0.16742	382.09672		0.98	
Fluorene, (mg/kg)	38	37	0.002		0.01233	616.4414		0.076	
Mercury, (mg/kg)	17	15	0.15176	0.15176	0.45228	298.01085		1.7	
Mercury, Total, (mg/kg)	21	19	0.0099	0.0099	0.03134	316.41264		0.11	
Indeno(1,2,3-cd) pyrene, (mg/kg)	38	35	0.00697		0.02499	358.33531		0.11	
Potassium, Total, (mg/kg)	38	34	71.76316		213.35523	297.30469		779	
Magnesium, Total, (mg/kg)	38	0	568.47368	523	310.044	54.53973	95	1270	597
Manganese, Total, (mg/kg)	38	0	330.94211	160	342.26894	103.4226	4.1	1210	332
Sodium, Total, (mg/kg)	38	37	7.76316		47.85532	616.4414		295	
Nickel, Total, (mg/kg)	38	16	6.09211	6.9	5.73733	94.17649		16.3	
Lead, Total, (mg/kg)	38	0	11.23421	11	4.16025	37.03201	3.3	27.3	3.3
Phenanthrene, (mg/kg)	38	32	0.02953		0.11042	373.97734		0.66	
Phenol, (mg/kg)	38	35	0.01158		0.05729	494.8138		0.35	
Pyrene, (mg/kg)	38	30	0.05105		0.14221	278.54815		0.69	
Selenium, Total, (mg/kg)	38	32	0.08895		0.21134	237.59887		0.71	
Vanadium, Total, (mg/kg)	38	0	10.66316	9.75	4.35402	40.83241	4.7	22	6.4
Zinc, Total, (mg/kg)	38	0	33.82368	33	14.13151	41.77994	8.5	71.9	45.5
bis(2-Ethylhexyl) phthalate, (mg/kg)	38	26	0.05655		0.11931	210.97341		0.45	
Dibenzo(a,h) anthracene, (mg/kg)	38	37	0.00263		0.01622	616.4414		0.1	
Dichloromethane, (mg/kg)	38	3	0.0165	0.0165	0.00892	54.07477		0.051	0.014
Di-n-butyl phthalate, (mg/kg)	38	36	0.00324		0.01471	454.47392		0.082	
Tetrachloroethene, (mg/kg)	38	37	0.00005		0.00032	616.4414		0.002	
Trichloromethane, (mg/kg)	38	33	0.00029		0.0008	277.15489		0.003	

Table 55.
Schilling Landfill
Summary Statistics for
Sediments

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Background SD-04
2-Methylnaphthalene, (mg/kg)	7	5	0.01571	0.01571	0.02694	171.41367		0.059	
Acetone, (mg/kg)	7	0	0.01386	0.01386	0.00888	64.06424	0.004	0.024	0.024
Aluminum, Total, (mg/kg)	7	0	3627.14286	3627.14286	756.91731	20.86814	2520	4570	3960
Arsenic, Total, (mg/kg)	7	0	3.41429	3.41429	0.80089	23.4571	2.5	4.9	2.8
Barium, Total, (mg/kg)	7	0	27.67143	27.67143	14.08388	50.89684	9.7	45	39
Beryllium, Total, (mg/kg)	7	1	0.78857	0.78857	0.44375	56.27268		1.2	
Benzoic Acid, (mg/kg)	7	6	0.011	0.011	0.0291	264.57513		0.077	
Calcium, Total, (mg/kg)	7	0	322	322	151.12578	46.93347	142	544	544
Cobalt, Total, (mg/kg)	7	0	6.82857	6.82857	2.30269	33.7214	3.6	9.9	9.9
Chromium, Total, (mg/kg)	7	0	7.91429	7.91429	2.63592	33.3059	3.8	12	6.5
Copper, Total, (mg/kg)	7	0	13.61429	13.61429	4.49534	33.0193	7.5	20	13
Ethylbenzene, (mg/kg)	7	5	0.00071	0.00071	0.00125	175.49929		0.003	
Iron, Total, (mg/kg)	7	0	22300	22300	8551.41314	38.34714	12200	33600	16200
Mercury, Total, (mg/kg)	7	6	0.2	0.2	0.52915	264.57513		1.4	
Magnesium, Total, (mg/kg)	7	0	687.85714	687.85714	218.61109	31.78147	394	1040	563
Manganese, Total, (mg/kg)	7	0	320.28571	320.28571	268.97628	83.9801	86	895	312
Nickel, Total, (mg/kg)	7	1	9.92857	9.92857	5.57217	56.12255		17	17
Lead, Total, (mg/kg)	7	0	9.64286	9.64286	1.95777	20.30278	5.8	12	10
Phenanthrene, (mg/kg)	7	5	0.04286	0.04286	0.07342	171.31301		0.16	
Pyrene, (mg/kg)	7	6	0.00729	0.00729	0.01928	264.57513		0.051	
Selenium, Total, (mg/kg)	7	6	0.1	0.1	0.26458	264.57513		0.7	
Vanadium, Total, (mg/kg)	7	0	10.08571	10.08571	4.0085	39.74436	5.9	17	8.6
Zinc, Total, (mg/kg)	7	0	41.28571	41.28571	11.88436	28.78566	23	56	56
bis(2-Ethylhexyl) phthalate, (mg/kg)	7	5	0.02543	0.02543	0.04509	177.31343		0.11	
Dichloromethane, (mg/kg)	7	0	0.03257	0.03257	0.02306	70.81081	0.018	0.084	0.019
Trichloromethane, (mg/kg)	7	6	0.00014	0.00014	0.00038	264.57513		0.001	

Table 56.
Schilling Landfill
Summary Statistics for
Landfill Wastes

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
2-Butanone, (mg/kg)	12	10	0.00208		0.00487	233.77378		0.013
2-Methylnaphthalene, (mg/kg)	10	7	0.188		0.33266	176.94645		0.95
4-Methyl-2-pentanone, (mg/kg)	12	11	0.00058		0.00202	346.41016		0.007
Acenaphthene, (mg/kg)	10	8	0.05		0.12193	243.85788		0.38
Acetone, (mg/kg)	12	8	0.18283		0.5426	296.77152		1.9
Silver, Total, (mg/kg)	10	8	0.91		2.48482	273.05721		7.9
Aluminum, Total, (mg/kg)	10	0	5977	5050	2837.70271	47.47704	3710	13400
Aldrin, (mg/kg)	10	9	0.0031		0.0098	316.22777		0.031
Anthracene, (mg/kg)	10	9	0.07		0.22136	316.22777		0.7
Arsenic, Total, (mg/kg)	10	0	26.11	29	15.31916	58.67161	4.4	50
Benzo(g,h,i)perylene, (mg/kg)	10	9	0.058		0.18341	316.22777		0.58
Barium, Total, (mg/kg)	10	0	123.3	125	52.96131	42.95321	54	201
Beryllium, Total, (mg/kg)	10	0	18.86	5.95	23.98996	127.20022	1.5	71
Benzo(a)anthracene, (mg/kg)	10	8	0.405		0.99288	245.15492		3.1
Benzo(a)pyrene, (mg/kg)	10	8	0.312		0.74453	238.63226		2.3
Benzo(b)fluoranthene, (mg/kg)	10	8	0.64		1.54575	241.52295		4.8
Benzo(k)fluoranthene, (mg/kg)	10	8	0.64		1.54575	241.52295		4.8
Benzoic Acid, (mg/kg)	10	7	1.427		4.41806	309.60505		14
Chlorobenzene, (mg/kg)	12	11	0.00008		0.00029	346.41016		0.001
Calcium, Total, (mg/kg)	10	0	5949	5370	6107.53351	102.66488	1140	21800
Carbon disulfide, (mg/kg)	12	11	0.00025		0.00087	346.41016		0.003
Chrysene, (mg/kg)	10	8	0.38		0.88544	233.00993		2.7
Cobalt, Total, (mg/kg)	10	0	858.3	449	1085.09212	126.42341	18	2950
Chromium, Total, (mg/kg)	10	0	38.12	28	29.62614	77.71811	6.2	95
Copper, Total, (mg/kg)	10	0	106.84	55	116.55209	109.09031	9.4	341
p,p-DDD, (mg/kg)	10	5	0.0861	0.011	0.15562	180.74607		0.45
Ethylbenzene, (mg/kg)	12	3	56.84833	0.76	105.56715	185.69964		330
Iron, Total, (mg/kg)	10	0	26580	23700	15306.04819	57.58483	11700	63800
Fluoranthene, (mg/kg)	10	7	0.731		1.85444	253.6852		5.9
Fluorene, (mg/kg)	10	9	0.037		0.117	316.22777		0.37
Heptachlor, (mg/kg)	10	9	0.003		0.00949	316.22777		0.03
Mercury, Total, (mg/kg)	10	7	0.061		0.10311	169.03716		0.26
Indeno(1,2,3-cd) pyrene, (mg/kg)	10	9	0.064		0.20239	316.22777		0.64
Potassium, Total, (mg/kg)	10	3	611.3	735	451.31094	73.82806		1270
Magnesium, Total, (mg/kg)	10	0	2086.9	929.5	3347.35638	160.3985	515	11500
Manganese, Total, (mg/kg)	10	0	2824.9	277.5	6113.38058	216.41051	109	19700
Sodium, Total, (mg/kg)	10	6	1723		4018.38013	233.21997		13000
Nickel, Total, (mg/kg)	10	0	45.3	34	55.27517	122.02024	8	198
Naphthalene, (mg/kg)	10	8	0.107		0.27006	252.39605		0.85
Lead, Total, (mg/kg)	10	0	39	29.5	43.57369	111.72742	11	159
Phenanthrene, (mg/kg)	10	7	0.96		1.5479	161.23977		3.3
Phenol, (mg/kg)	10	4	5.341	1.105	10.55978	197.71173		34
Pyrene, (mg/kg)	10	7	0.656		1.50607	229.58394		4.7
Antimony, Total, (mg/kg)	10	9	4.8		15.17893	316.22777		48

Table 56 continued.
Schilling Landfill
Summary Statistics for
Landfill Wastes

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Selenium, Total, (mg/kg)	10	3	0.682	0.76	0.58141	85.25104		1.8
Styrene, (mg/kg)	12	8	1.811		3.55853	196.49522		11
Thallium, Total, (mg/kg)	10	4	0.458	0.565	0.41593	90.81383		0.98
Toluene, (mg/kg)	12	11	0.00008		0.00029	346.41016		0.001
Vanadium, Total, (mg/kg)	10	0	17.4	16	5.81569	33.42349	11	27
Xylenes/NOS, (mg/kg)	12	11	0.00175		0.00606	346.41016		0.021
Zinc, Total, (mg/kg)	10	0	160.1	169	105.78642	66.07522	32	407
bis(2-Ethylhexyl) phthalate, (mg/kg)	10	1	3.1917	0.705	4.66881	146.27985		14
Dibenzo(a,h) anthracene, (mg/kg)	10	9	0.034		0.10752	316.22777		0.34
Dibenzofuran, (mg/kg)	10	8	0.045		0.10124	224.98285		0.3
Dichloromethane, (mg/kg)	12	5	0.48658	0.0215	1.16431	239.28347		4.1
Tetrachloroethene, (mg/kg)	12	9	0.3075		0.89238	290.20591		3.1

Table 57.
Schilling Landfill
Summary Statistics for
Borings

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
1,2-Dichloroethane, (mg/kg)	5	4	0.04	0.04	0.08944	223.6068		0.2
2-Butanone, (mg/kg)	5	4	0.034	0.034	0.07603	223.6068		0.17
2-Hexanone, (mg/kg)	5	4	0.0022	0.0022	0.00492	223.6068		0.011
2-Methylnaphthalene, (mg/kg)	5	2	3.12	3.12	4.78874	153.48515		11
4-Methyl-2-pentanone, (mg/kg)	5	4	0.0054	0.0054	0.01207	223.6068		0.027
Acenaphthene, (mg/kg)	5	4	2.2	2.2	4.91935	223.6068		11
Acetone, (mg/kg)	5	4	0.084	0.084	0.18783	223.6068		0.42
Aluminum, Total, (mg/kg)	4	0	4132.5	4120	338.85838	8.19984	3800	4490
Anthracene, (mg/kg)	5	0	21.829	21.829	34.30191	157.13918	0.059	82
Arsenic, Total, (mg/kg)	4	0	13.775	10.05	9.62302	69.85858	7	28
Benzo(g,h,i)perylene, (mg/kg)	5	0	78.19	78.19	71.2953	91.18212	0.42	140
Barium, Total, (mg/kg)	4	0	44.75	39	20.3695	45.51844	27	74
Beryllium, Total, (mg/kg)	4	0	0.84	0.625	0.50971	60.67926	0.51	1.6
Benzene, (mg/kg)	5	4	0.0038	0.0038	0.0085	223.6068		0.019
Benzo(a)anthracene, (mg/kg)	5	0	342.72	342.72	316.55235	92.36472	1.6	640
Benzo(a)pyrene, (mg/kg)	5	0	284.52	284.52	259.73318	91.2882	1.1	510
Benzo(b)fluoranthene, (mg/kg)	5	0	156.442	156.442	149.19117	95.36516	0.91	330
Benzo(k)fluoranthene, (mg/kg)	5	0	156.442	156.442	149.19117	95.36516	0.91	330
Benzoic Acid, (mg/kg)	5	4	0.074	0.074	0.16547	223.6068		0.37
Chlorobenzene, (mg/kg)	5	4	0.0054	0.0054	0.01207	223.6068		0.027
Chloroethane, (mg/kg)	5	4	0.0062	0.0062	0.01386	223.6068		0.031
Cyanide, Total, (mg/kg)	4	2	0.8	0.65	0.95568	119.46059		1.9
Calcium, Total, (mg/kg)	4	0	2735.75	2855	1458.19257	53.30138	883	4350
Carbon disulfide, (mg/kg)	5	4	0.0006	0.0006	0.00134	223.6068		0.003
Chrysene, (mg/kg)	5	0	538.92	538.92	494.25118	91.71142	2	1000
Cobalt, Total, (mg/kg)	4	0	43	26	43.59664	101.38753	13	107
Chromium, Total, (mg/kg)	4	0	8.1	8.05	1.51217	18.6688	6.7	9.6
Copper, Total, (mg/kg)	4	0	16.5	15.5	5.56776	33.74403	11	24
p,p-DDE, (mg/kg)	4	3	0.006		0.012	200		0.024
Ethylbenzene, (mg/kg)	5	0	394.28	394.28	678.40017	172.06051	7.4	1600
Iron, Total, (mg/kg)	4	0	13707.5	14200	4321.21414	31.52445	8030	18400
Fluoranthene, (mg/kg)	5	0	99.442	99.442	127.01699	127.72973	0.39	310
Fluorene, (mg/kg)	5	4	2.4	2.4	5.36656	223.6068		12
Indeno(1,2,3-cd) pyrene, (mg/kg)	5	0	28.462	28.462	26.56888	93.34859	0.15	57
Magnesium, Total, (mg/kg)	4	0	948	1021.5	461.60373	48.69238	339	1410
Manganese, Total, (mg/kg)	4	0	194.5	155	89.58236	46.05777	140	328
Sodium, Total, (mg/kg)	4	3	124.75		249.5	200		499
Nickel, Total, (mg/kg)	4	0	13.775	12.95	6.25693	45.42236	8.2	21
Naphthalene, (mg/kg)	5	4	0.0142	0.0142	0.03175	223.6068		0.071
Lead, Total, (mg/kg)	4	0	19.5	19.5	8.73689	44.80459	11	28
Phenanthrene, (mg/kg)	5	0	176.256	176.256	205.34724	116.50511	0.52	500
Phenol, (mg/kg)	5	4	0.44	0.44	0.98387	223.6068		2.2
Pyrene, (mg/kg)	5	0	344.68	344.68	353.40638	102.53173	1.6	820
Styrene, (mg/kg)	5	1	38.24	38.24	48.06233	125.68602		110

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Table 57 continued.
Schilling Landfill
Summary Statistics for
Borings

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Toluene, (mg/kg)	5	3	0.372	0.372	0.64955	174.61121		1.5
Vanadium, Total, (mg/kg)	4	0	7.55	7.7	2.8396	37.61061	4.8	10
Xylenes/NOS, (mg/kg)	5	4	0.0122	0.0122	0.02728	223.6068		0.061
Zinc, Total, (mg/kg)	4	0	70.25	56.5	38.79326	55.22172	41	127
bis(2-Ethylhexyl) phthalate, (mg/kg)	5	3	0.196	0.196	0.27428	139.93922		0.57
Dibenzo(a,h) anthracene, (mg/kg)	5	0	35.094	35.094	32.27684	91.97253	0.16	65
Dichloromethane, (mg/kg)	5	1	3.6772	3.6772	4.52682	123.10508		10
Tetrachloroethene, (mg/kg)	5	4	0.072	0.072	0.161	223.6068		0.36

Table 58.
Schilling Landfill
Summary Statistics for
Leachates

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
1,1-Dichloroethane, (ug/l)	17	9	3.64706	3.64706	4.67629	128.22073		14
1,2-Dichloroethane, (ug/l)	17	6	22.82353	22.82353	40.28684	176.5145		160
1,2-Dichloroethene, (ug/l)	17	14	1.41176	1.41176	3.50105	247.99106		11
2-Butanone, (ug/l)	17	15	2.47059	2.47059	6.97422	282.28974		21
2-Hexanone, (ug/l)	17	16	0.23529	0.23529	0.97014	412.31056		4
2-Methylphenol (o-Cresol), (ug/l)	15	12	2.06667	2.06667	4.68229	226.56226		15
4-Methyl-2-pentanone, (ug/l)	17	9	10.76471	10.76471	13.85428	128.701		36
4-Methylphenol (p-Cresol), (ug/l)	15	7	402.2	402.2	565.57407	140.62011		1600
Acetone, (ug/l)	17	1	373.94118	373.94118	549.01383	146.81823		1600
Silver, Total, (ug/l)	12	11	0.91667		3.17543	346.41016		11
Aluminum, Total, (ug/l)	12	0	38102.5	18850	52542.40627	137.89753	3530	188000
Arsenic, Total, (ug/l)	12	0	47.88333	9.55	102.96756	215.03841	3.8	368
Barium, Total, (ug/l)	12	0	502.83333	348.5	439.79868	87.46411	81	1450
Beryllium, Total, (ug/l)	12	1	63.25	23.5	102.39599	161.8909		332
Benzene, (ug/l)	17	7	2.82353	2.82353	2.98403	105.68426		8
Benzoic Acid, (ug/l)	15	8	498	498	742.91126	149.17897		2400
Chloroethane, (ug/l)	17	12	55.29412	55.29412	92.6767	167.6068		250
Chloromethane, (ug/l)	17	16	0.94118	0.94118	3.88057	412.31056		16
Cyanide, Total, (ug/l)	12	10	9.75		30.4754	312.5682		106
Calcium, Total, (ug/l)	12	0	286833.33333	208000	156192.0923	54.45395	166000	646000
Carbon disulfide, (ug/l)	17	15	0.47059	0.47059	1.50489	319.78997		6
Cobalt, Total, (ug/l)	12	0	1282.66667	122.5	2444.37894	190.57008	12	8140
Chromium, Total, (ug/l)	12	3	35.76667	19.5	51.87053	145.02477		175
Copper, Total, (ug/l)	12	0	148.41667	44	236.96392	159.66126	14	741
Ethylbenzene, (ug/l)	17	2	1428.05882	1428.05882	2786.54579	195.12822		8000
Iron, Total, (ug/l)	12	0	195583.33333	109000	264910.02875	135.44612	40300	1016000
Heptachlor, (ug/l)	12	11	0.0225		0.07794	346.41016		0.27
Mercury, Total, (ug/l)	12	6	0.27333	0.12	0.4139	151.42769		1.3
Potassium, Total, (ug/l)	12	0	20579.16667	22600	9457.95525	45.95888	5830	36900
Magnesium, Total, (ug/l)	12	0	94841.66667	103500	34399.06073	36.26999	33100	140000
Manganese, Total, (ug/l)	12	0	3276.66667	3340	1819.43215	55.52692	1220	7880
Sodium, Total, (ug/l)	12	0	198433.33333	177850	157942.44253	79.59471	25200	393000
Nickel, Total, (ug/l)	12	5	72.58333	34.5	120.42762	165.91635		420
Lead, Total, (ug/l)	12	0	69.73333	28	110.38222	158.29191	8.8	403
Phenanthrene, (ug/l)	15	13	0.46667	0.46667	1.24595	266.98839		4
Phenol, (ug/l)	15	0	212.66667	212.66667	136.14418	64.01764	100	520
Antimony, Total, (ug/l)	12	8	15.08333		24.1264	159.95405		70
Toluene, (ug/l)	17	9	142.64706	142.64706	292.5863	205.11205		860
Vanadium, Total, (ug/l)	12	0	85.725	45	119.02474	138.84484	9.7	429
Xylenes/NOS, (ug/l)	17	14	2.35294	2.35294	6.3732	270.8609		22
Zinc, Total, (ug/l)	12	0	468.58333	156.5	738.70408	157.64626	106	2670
bis(2-Chloroethyl) Ether, (ug/l)	15	14	0.4	0.4	1.54919	387.29833		6
Dichloromethane, (ug/l)	17	7	28.94118	28.94118	63.01733	217.74281		260
Pentachlorophenol, (ug/l)	15	12	1.73333	1.73333	5.16121	297.76215		20

Table 58 continued.
Schilling Landfill
Summary Statistics for
Leachates

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Tetrachloroethene, (ug/l)	17	10	9	9	14.91643	165.73815		53
Trichloroethene, (ug/l)	17	13	0.47059	0.47059	0.87447	185.82586		2
Trichloromethane, (ug/l)	17	14	1.29412	1.29412	2.88887	223.23111		8

Table 59.
Schilling Landfill
Summary Statistics for
Surface Waters

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Background SW-04
Acetone, (ug/l)	15	14	0.2	0.2	0.7746	387.29833		3	
Aluminum, Total, (ug/l)	15	0	3251.33333	3251.33333	5088.46603	156.50398	19	20400	596
Barium, Total, (ug/l)	15	0	37.73333	37.73333	10.87899	28.83124	27	57	43
Beryllium, Total, (ug/l)	15	3	2.97333	2.97333	2.33711	78.60244		9.5	
Calcium, Total, (ug/l)	15	0	31120	31120	11077.53196	35.59618	14000	53300	23200
Cobalt, Total, (ug/l)	15	3	16.53333	16.53333	17.72064	107.18127		67	5.8
Copper, Total, (ug/l)	15	14	1.2	1.2	4.64758	387.29833		18	
Iron, Total, (ug/l)	15	0	4308.13333	4308.13333	7243.12224	168.1267	23	27800	154
Mercury, Total, (ug/l)	15	13	0.028	0.028	0.07399	264.24434		0.22	
Potassium, Total, (ug/l)	15	11	896.66667	896.66667	1577.24292	175.9007		4270	
Magnesium, Total, (ug/l)	15	0	23230.66667	23230.66667	10062.26861	43.31459	9260	43700	14000
Manganese, Total, (ug/l)	15	0	1228.66667	1228.66667	1126.69331	91.70049	40	4350	271
Sodium, Total, (ug/l)	15	0	29449.33333	29449.33333	27992.71346	.95.05381	4790	112000	5850
Nickel, Total, (ug/l)	15	9	20.06667	20.06667	29.01346	144.58536		94	
Lead, Total, (ug/l)	15	8	22.77333	22.77333	84.72283	372.02648		329	
Vanadium, Total, (ug/l)	15	10	1.72667	1.72667	2.58912	149.94883		6.6	
Zinc, Total, (ug/l)	15	0	99	99	66.93494	67.61105	17	270	56
bis(2-Ethylhexyl) phthalate, (ug/l)	22	21	0.13636		0.6396	469.04158		3	
Dichloromethane, (ug/l)	15	7	1	1	1.13389	113.38934		3	2

Table 60.
Schilling Landfill
Summary Statistics for
Monitoring Wells

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Background MW-01B
1,2-Dichloroethane, (ug/l)	31	28	0.25806	0.25806	0.81518	315.8817		3	
1,4-Dichlorobenzene, (ug/l)	42	39	0.64286		2.35632	366.53936		10	
Acetone, (ug/l)	31	25	1.54839	1.54839	3.45291	223.00037		12	
Aluminum, Dissolved, (ug/l)	4	3	2370		4740	200		9480	
Aluminum, Total, (ug/l)	34	0	5191.44118	454.5	11249.52355	216.69365	56	46300	1300
Arsenic, Dissolved, (ug/l)	4	2	2.05	1.5	2.5318	123.50233		5.2	5.4
Arsenic, Total, (ug/l)	34	16	2.29412	2.15	2.57116	112.07629		9.1	6.4
Barium, Dissolved, (ug/l)	4	0	108.875	23.1	180.18439	165.49657	10.3	379	379
Barium, Total, (ug/l)	34	0	126.97059	103	99.17554	78.10906	26	428	377
Beryllium, Dissolved, (ug/l)	4	3	0.95		1.9	200		3.8	
Beryllium, Total, (ug/l)	34	25	1.62941		3.45758	212.19811		15	
Benzene, (ug/l)	31	26	0.32258	0.32258	0.97936	303.60061		5	1
Chlorobenzene, (ug/l)	31	30	0.03226	0.03226	0.17961	556.77644		1	
Chloroethane, (ug/l)	31	28	1.32258	1.32258	4.17442	315.6271		17	
Cyanide, Total, (ug/l)	30	29	0.46667		2.55604	547.72256		14	
Calcium, Dissolved, (ug/l)	4	0	24352.5	16500	24635.51011	101.16214	6110	58300	58300
Calcium, Total, (ug/l)	34	0	34764.41176	36600	21170.40318	60.89677	6250	72100	60500
Carbon disulfide, (ug/l)	31	28	0.54839	0.54839	2.36416	431.11133		13	
Cadmium, Total, (ug/l)	34	32	0.70588		2.90798	411.96335		14	
Cobalt, Dissolved, (ug/l)	4	2	22.925	5.1	39.34492	171.6245		81.5	
Cobalt, Total, (ug/l)	34	3	20.13235	8.3	30.60784	152.0331		127	12
Chromium, Total, (ug/l)	34	3	98.23824	48.5	143.14584	145.71296		695	286
Copper, Dissolved, (ug/l)	4	2	2.15	1.65	2.61343	121.55474		5.3	5.3
Copper, Total, (ug/l)	34	20	12.35882		19.69382	159.35032		68	26
Iron, Dissolved, (ug/l)	4	0	8276.5	9715	5549.20015	67.04767	576	13100	576
Iron, Total, (ug/l)	34	0	30519.82353	13350	52269.48032	171.26403	446	232000	10900
Mercury, Total, (ug/l)	34	32	0.01941		0.07885	406.21339		0.34	
Potassium, Dissolved, (ug/l)	4	1	4902.5	5615	3525.81314	71.91868		8380	8380
Potassium, Total, (ug/l)	34	13	5952.94118	4005	7835.9674	131.63186		36600	19000
Magnesium, Dissolved, (ug/l)	4	0	11497.5	7870	9054.31895	78.75033	5550	24700	10100
Magnesium, Total, (ug/l)	34	0	17790	8475	24494.79759	137.68858	2390	92200	10400
Manganese, Dissolved, (ug/l)	4	0	1036.25	656.5	1068.97533	103.15805	222	2610	222
Manganese, Total, (ug/l)	34	0	1771.79412	709.5	2170.05167	122.47764	69	7530	535
Sodium, Dissolved, (ug/l)	4	0	10060	8990	4622.46687	45.94897	5860	16400	16400
Sodium, Total, (ug/l)	34	0	24692.64706	10420	39375.50964	159.46249	4390	162000	20600
Nickel, Dissolved, (ug/l)	4	3	27		54	200		108	
Nickel, Total, (ug/l)	34	9	88.81176	73	95.12869	107.11272		372	164
Naphthalene, (ug/l)	42	39	0.2619		0.96423	368.15923		4	
Lead, Total, (ug/l)	34	6	6.52353	3.2	10.35977	158.80625		55.4	5.4
Phenol, (ug/l)	42	39	0.40476		1.54698	382.19509		8	
Pyrene, (ug/l)	42	41	0.07143		0.46291	648.07407		3	
Antimony, Total, (ug/l)	34	33	0.73529		4.28746	583.09519		25	
Total Suspended Solids, (mg/l)	4	0	2281.5	950	3308.05618	144.99479	26	7200	26
Toluene, (ug/l)	31	30	0.03226	0.03226	0.17961	556.77644		1	

Table 60 continued.
Schilling Landfill
Summary Statistics for
Monitoring Wells

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum	Background MW-018
Vanadium, Dissolved, (ug/l)	4	2	2.7	2.65	3.11876	115.50965		5.5	
Vanadium, Total, (ug/l)	34	8	11.60294	4.55	20.06209	172.90524		101	7.4
Zinc, Dissolved, (ug/l)	4	0	175.55	144.1	164.14631	93.50402	36	378	240
Zinc, Total, (ug/l)	34	0	198.29412	103.5	225.23893	113.58831	27	1000	376
bis(2-Ethylhexyl) phthalate, (ug/l)	42	34	0.69048		1.522	220.42799		5	
Dichloromethane, (ug/l)	31	22	0.6129	0.6129	1.08558	177.12175		4	
Di-n-butyl phthalate, (ug/l)	42	41	0.09524		0.61721	648.07407		4	
Tetrachloroethene, (ug/l)	31	30	0.03226	0.03226	0.17961	556.77644		1	1

Table 61.
Schilling Landfill
Summary Statistics for
Air

Parameter	Number of Observations	Number of NDs	Mean	Median	Standard Deviation	Coefficient of Variation	Minimum	Maximum
Silver, (ug/l)	15	5	0.00067	0.00067	0.00049	73.19251		0.001
Aluminum, (ug/l)	10	0	0.4421	0.4335	0.1305	29.51885	0.266	0.701
Arsenic, (ug/l)	15	15						
Barium, (ug/l)	10	0	0.0264	0.024	0.00707	26.79625	0.019	0.039
Beryllium, (ug/l)	15	0	0.00173	0.00173	0.00046	26.40794	0.001	0.002
Calcium, (ug/l)	10	0	0.9885	0.877	0.56073	56.72505	0.476	2.213
Cadmium, (ug/l)	15	2	0.00193	0.00193	0.00198	102.45832		0.008
Chromium, (ug/l)	15	0	0.00293	0.00293	0.00308	105.0489	0.001	0.012
Copper, (ug/l)	15	0	0.02813	0.02813	0.02002	71.16448	0.006	0.07
Iron, (ug/l)	10	0	0.1361	0.1375	0.03432	25.21454	0.094	0.198
Mercury, (ug/l)	15	11	0.00033	0.00033	0.00062	185.16402		0.002
Potassium, (ug/l)	10	0	0.9052	0.8445	0.24235	26.77304	0.628	1.439
Manganese, (ug/l)	10	0	0.0049	0.0045	0.00099	20.29447	0.004	0.006
Sodium, (ug/l)	10	0	25.8325	25.451	14.06612	54.45127	11.896	55.337
Nickel, (ug/l)	15	0	0.0552	0.0552	0.20025	362.77999	0.001	0.779
Lead, (ug/l)	15	0	0.00553	0.00553	0.00295	53.291	0.002	0.012
Antimony, (ug/l)	15	0	0.067	0.067	0.02358	35.19351	0.037	0.123
Selenium, (ug/l)	15	8	0.00047	0.00047	0.00052	110.65667		0.001
Thallium, (ug/l)	15	0	0.067	0.067	0.02358	35.19351	0.037	0.123
Vanadium, (ug/l)	10	0	0.1229	0.12	0.06727	54.73934	0.056	0.246
Zinc, (ug/l)	15	0	0.02653	0.02653	0.00675	25.43687	0.019	0.041

- o Maximum concentrations by media type (Appendix B11)
- o Historical waste inventory (Table 33 and Appendix B8)
- o Review of laboratory blank data (Table 53)
- o Data qualifiers such as natural background conditions
- o Professional judgement
- o Structural activity relationship groups

The basis for selecting each of the indicator chemicals is discussed as follows:

1,2 Dichloroethane was selected as a indicator chemical because:

- o Based upon analysis of landfill waste and landfill boring samples, 1,2 Dichloroethane appears to be in the chemical waste in the landfill
- o Toxicity - 1,2 Dichloroethane is a carcinogenic chemical
- o Frequency of occurrence - 1,2 Dichloroethane was identified in leachate at relatively high concentrations and in the ground water
- o 1,2 Dichloroethane is a relatively mobile constituent based upon the physical chemical data available

Benzene was selected as a indicator chemical because:

- o Toxicity - Benzene is a carcinogenic chemical
- o Occurrence - Benzene was identified in the leachate and ground-water samples
- o Benzene is environmentally mobile based upon available physical chemical data

Benzo(a)pyrene was selected as a indicator chemical because:

- o Toxicity - Benzo(a)pyrene is a carcinogenic chemical
- o Benzo(a)pyrene was identified in the landfill waste samples, therefore it appears to be representative of landfill waste
- o Benzo(a)pyrene is representative of the heavy PAH's identified in the various media at the site

Ethylbenzene was selected as a indicator chemical because:

- o Ethylbenzene was identified in the landfill waste samples including the landfill waste, borings, and the leachate
- o Ethylbenzene is a landfill waste constituent
- o Ethylbenzene is a non-carcinogenic compound
- o Ethylbenzene is a member of the volatile organic subgroup

Heptachlor was selected as a indicator chemical because:

- o Toxicity - Heptachlor is a carcinogenic chemical
- o Heptachlor is a pesticide and therefore, was selected to represent the pesticide/herbicide chemicals identified at the site

Phenol was selected as a indicator chemical because:

- o Phenol has been identified in the landfill waste, borings, and leachate samples
- o Phenol appears to be a waste constituent within the landfill

- o Phenol was chosen as the representative chemical for all the phenolics at the site, due to the fact that Phenol is known to be deposited in the landfill

Styrene (monomer) was identified as a indicator chemical because:

- o Even though Styrene (monomer) has not been identified in any of the eight media identified at the site, styrene (monomer) is known to have been deposited in the landfill

Arsenic was selected as a indicator chemical because:

- o Toxicity - arsenic is a carcinogenic compound
- o Frequency - arsenic was detected in all media at the site

Manganese was identified as a indicator chemical because:

- o Frequency - Manganese has been detected in all media at the site

Nickel was selected as a indicator chemical because:

- o Frequency - Nickel was identified in all media at the site

6.3 Exposure Assessment

6.3.1 Introduction

The purpose of an exposure assessment is to identify the potential environmental pathways and to estimate the concentrations of indicator chemicals at the exposure point based on available data. This exposure assessment consisted of the following three steps:

- o Identification of potential exposure pathways (Section 4.2)

- o Estimation of exposure point concentrations (Section 4.3)
- o Identification of Applicable or Relevant and Appropriate Requirements (ARARs) (Section 4.4)

6.3.2 Identification of Potential Exposure Pathways

6.3.2.1 Introduction

Exposure pathways were identified through analyses of four factors:

- o The source and mechanism of chemical release to the environment (Section 6.3.2.2)
- o The environmental transport medium for the released chemical (Section 6.3.2.3)
- o The point of potential receptor contact with the contaminated medium (referred to as the "exposure point")(Section 6.3.2.4)
- o The receptor exposure route (e.g., ingestion of drinking water) (Section 6.3.2.5).

6.3.2.2 Chemical Source and Release Mechanisms

The Schilling Landfill represents the release source. Due to limited historical information, the exact contents of the landfill cannot be totally defined. Releases to the environment were evaluated by sampling various media and locations in and surrounding the landfill. The chemicals identified in the samples taken are presented, by media type, in Tables 54 through 61.

6.3.2.3 Analysis Of Potential Environmental Transport Media

Eight transport media were analyzed as part of the exposure assessment step of the risk assessment. Evaluation of transport media defines potential routes by which site-specific

constituents may potentially impact human and environmental receptors. The eight potential transport media present at the site are:

- o Surface soil (SS)
- o Sediment (SD)
- o Landfill waste (LW)
- o Soil borings (BO)
- o Leachate (LS)
- o Surface water (SW)
- o Ground water (MW)
- o Air

Surface Soils

A total of 38 surface-soil samples taken at depths of 0 to 6 inches were collected from 35 locations at the site (Figure 24). Forty-two chemicals were identified in the surficial soil samples (Table 54). The surface soils represent a potential transport medium because direct contact with contaminated soils by human and environmental receptors may result in dermal, inhalation, or oral exposure. While surface-soil samples were not obtained from the cap or the face of the dam, the presence of leachate seeps on the cap and along the face and toe of the dam would suggest that the surficial soils from these areas should also be considered as a potential transport medium.

Surface-soil samples SS-06 and SS-27 are considered to represent background conditions. The analytical results for SS-32 indicate the presence of heavy PAHs in the surficial soils (Appendix B9). The presence of these PAHs is considered to result from an alternate

source because analyses of SS-28, SS-29, and SS-30, which are located between the landfill and SS-32 do not contain PAHs (Figure 24 and Appendix B9). Therefore, SS-32 data are not considered representative of Schilling Landfill and will not be included in this risk assessment.

Sediment

A total of five stream-sediment samples taken at depths of 0 to 6 inches were collected from locations at the site (Figure 12). Twenty-six chemicals have been identified in the stream sediment samples at the site (Table 55). The stream sediment represents a potential transport medium because some of the organic contaminants identified at the site tend to partition onto sediments rather than dissolve in the water column. Direct contact with these sediments by humans and animals may result in dermal or oral exposure.

Sediment sample SD-04 is the background sample, because it was taken from Winkler Run at a point upstream from the confluence of the unnamed tributary, which drains the area around the site, and Winkler Run.

The analytical results from sediment sample SD-01 indicate the presence of high concentrations of PAH's (Appendix B9). This sample was originally obtained to serve as "background". Review of data from station SD-01 and the lack of PAH constituents in surface soil samples SS-28, SS-29, and SS-30 indicate the presence of an off-site source (Figure 24 and Appendix B9). Therefore, SD-01 data are not considered as being representative of Schilling Landfill and will not be included in this risk assessment.

Landfill Waste

A total of 12 landfill waste samples (LW) taken from beneath the landfill cap were collected from nine locations at the site (Figure 9). Fifty-six chemicals have been identified in the landfill waste samples (Table 56). The landfill wastes represent a potential transport medium because direct contact with these wastes by burrowing animals may result in dermal or oral exposure; e.g. through burrowing and preening activities, ingestion of contaminants may occur. These wastes do not represent a potential transport medium to humans because they are beneath the landfill cap.

Soil Borings

A total of four soil boring samples taken at depths of 10.5 to 30 feet below the surface were collected from two locations (BO-1 and BO-5) at the site (Figure 9). Fifty-two chemicals were identified in the soil test boring samples (Table 57). These soil boring sample locations do not represent a potential transport medium because they were located at depths beyond the normal burrowing depths of small mammals, and thus, at depths not accessible to human or environmental receptors.

Leachate

A total of 17 leachate samples were collected from seven locations at the site (Figure 10). Forty-seven chemicals have been identified in the leachate samples (Table 58). The leachate represents a transport medium because direct contact with the leachate by humans and environmental receptors may result in dermal, inhalation, or oral exposure.

Surface Water

A total of six surface-water samples were collected from the six locations at the site (Figure 12). Nineteen chemicals were identified in the surface water (Table 59). The surface water represents a potential transport medium because direct contact with the surface water by humans and environmental receptors may result in dermal or oral exposure.

Ground Water

A total of 42 ground-water samples were collected from the eight monitoring well clusters at the site (Figure 19). Fifty-two chemicals were identified in the ground water (Table 60). Direct contact with the ground water by humans and environmental receptors may result in dermal or oral exposure. Ground-water sampling location MW-01 served as background for this medium type (Appendix B9).

Air

Air was sampled on three occasions from each of the five air-sampling stations (Figure 17). Twenty chemicals were identified in the air samples (Table 61). The air represents a transport medium because direct inhalation of contaminated air by humans and environmental receptors may result in exposure. On-site meteorological data are presented in Appendix B12.

6.3.2.4 Analysis Of Potential Receptors And Significant Exposure Points

The receptor analysis determines human and biotic populations that may be exposed to site-specific hazardous chemical constituents at the E. H. Schilling Landfill, and identifies

significant exposure points according to procedures outlined in the Superfund Public Health Evaluation Manual. The potential receptors within a four-mile radius of the site were examined in accordance with these procedures.

Human Receptors

Total Population

The potential human receptors within a four-mile radius of the site (approximately fifty square miles) have been determined based on population data from United States Department of Commerce, Census Bureau census for the Ohio cities of Ironton and Hanging Rock; the Kentucky cities of Flatwoods, Raceland, Greenup, Wurtland, and Worthington; and the Ohio counties of Lawrence and Scioto, and the Kentucky county of Greenup (USDC, 1980). The estimated total population within the four-mile radius is 23,000 persons, 18,692 of which reside in towns (Table 62) and 4,308 of which reside in rural areas.

Demographic Variables

Potentially sensitive subgroups of the population are children (0-14 years of age), women of child-bearing age (15-34 years of age), and the elderly (65 years of age or over). Based upon the demographics of the cities and towns in the area, the study area population is estimated to contain 5,200 children (23%); 3,700 women of child-bearing age (16%); and 2,700 elderly persons (12%).

The area within the four-mile radius is primarily undeveloped land (an estimated 46% of the total fifty square miles), and the land immediately surrounding the site is rural

TABLE 62. POPULATIONS AND DEMOGRAPHICS OF TOWNS WITHIN FOUR MILES OF SITE

CITY	TOTAL POPULATION	% WITHIN 4 MI RADIUS	NET POPULATION	% CHILDREN	NET : (TOTAL)	% CBW	NET : (TOTAL)	% 65 & OLDER	NET : (TOTAL)
GREENUP	1,386	70	970	22.0	: 213	16.3	: 158	12.3	: 119
WURLAND	1,294	100	1,294	21.9	: 283	14.5	: 188	17.5	: 226
WORTHINGTON	1,948	100	1,948	25.4	: 495	18.4	: 359	6.6	: 129
RACELAND	1,970	100	1,970	23.2	: 457	17.2	: 339	9.6	: 189
FLATWOODS	8,354	60	5,012	25.7	: 1,288	17.8	: 893	6.5	: 325
IRONTON	14,290	50	7,145	20.7	: 1,479	15.0	: 1,073	16.8	: 1,198
HANGING ROCK	353	100	353	24.1	: 85	16.4	: 58	10.2	: 36
TOTALS			18,692	23%	: 4,300	16%	: 3,068	12%	: 2,222

1. FROM DEPARTMENT OF COMMERCE, CENSUS BUREAU

2. ESTIMATE FROM USGS ROAD MAPS

3. NET POPULATION = (TOTAL POPULATION) X (% WITHIN 4 MI)

4. NET (TOTAL) = (%) X (NET POPULATION)

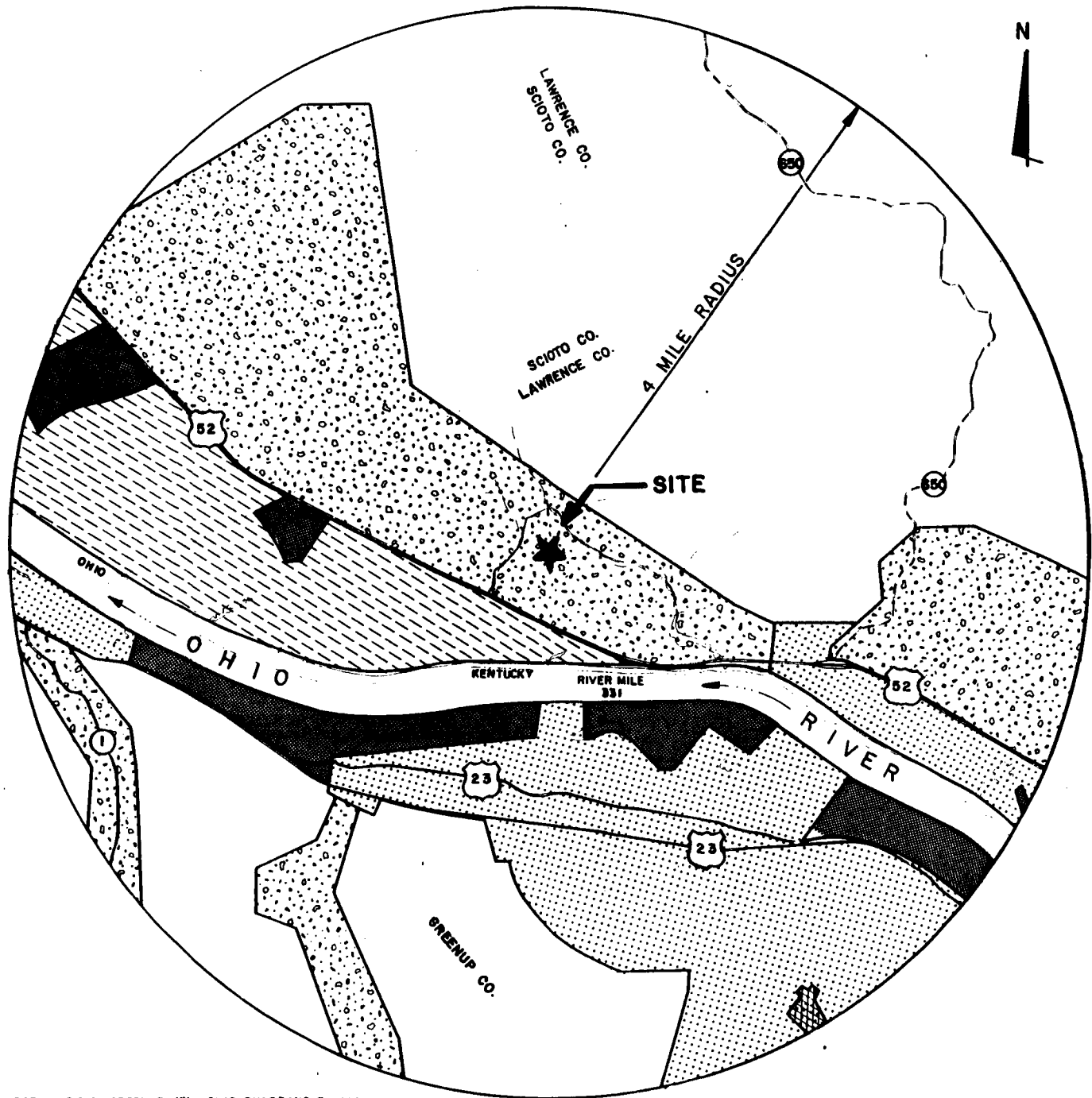
CBW: WOMEN OF CHILD-BEARING AGE

(individual town zoning maps for Ironton, Ohio; and Flatwoods, Kentucky, and USGS topographical map series: Pedro, Greenup, Ironton, and Wheelersburg quads) (Figure 74). A site survey by Law Environmental, and confirmed by USGS topographical maps, showed the nearest population to the site to be the approximately 50 homes on Rock Hollow Road (USGS topographical maps, Greenup and Ironton quads). Rock Hollow Road is oriented in a northwest/southeast direction, and the houses are between 0.25 miles and 1.5 miles from the site (USGS topographical maps, Greenup quad) (Figure 26). Data are insufficient to determine the actual number of people residing in this area, but an upper bound estimate is two hundred persons (an average four persons per household).

Environmental Receptors

The ODNR Wildlife and Natural Areas & Preserves Divisions provided information concerning potential threatened, rare, or endangered species in Lawrence and Scioto counties. Review of these ODNR data revealed that the two counties contain 13 potentially threatened, rare, or endangered animal species (Table 63), and 86 potentially threatened, rare or endangered plant species (Table 64).

The Kentucky Department of Natural Resources (KDNR), Wildlife Division, provided information concerning the presence of threatened, rare, or endangered species for Greenup County. Review of the KDNR information revealed eleven potentially threatened, rare, or endangered species. Of these, three are mammals and eight are fish (Table 63). In addition, one plant species (Sida hermaphrodite, Virginia mallow) was cited as being endangered within the area of interest (personal communication, Kentucky State Nature Preserves Commission).



LEGEND







-  INDUSTRIAL
-  COMMERCIAL
-  RURAL
-  RESIDENTIAL
-  AGRICULTURAL
-  UNDEVELOPED



FIGURE 74

LAND USE WITHIN
FOUR MILES OF SITE

E.H. SCHILLING LANDFILL

SOURCE: U.S.G.S. GREENUP, KY -OHIO QUADRANGLE 1972,1985
U.S.G.S. IRONTON, OHIO -KY QUADRANGLE 1972,1985

TABLE 63. THREATENED FAUNA

Ohio Wildlife Districts Surrounding E. H. Schilling Landfill Site

SPECIES (Scientific Name, Common Name)

MAMMALS

Myotis sodalis, Indiana Myotis (Bat)
Lutro canadensis, River otter
Belus rufus, Bobcat

BIRDS

Acciptor striatus, Sharp-shinned Hawk
Rallus elegans, King Rail
Bartramia longicauda, Upland Sandpiper

AMPHIBIANS

Plethondon wehrlei, Wehrle's Salamander
Hemidactylum scutatum, Four-toed Salamander
Sneides aeneus, Green Salamander

MUSSELS

Lampsilis abrupta, Pink Mucket Pearly Mussel
Lasnigona compressa, Creek Heel Splitter
Epioblasma triquetra, Freshwater Mussel
Cyprogenia stegaria, Fanshell

Greenup County, Kentucky

SPECIES (Scientific Name, Common Name)

MAMMALS

Microsorex hoyi, Pygmy Shrew
Myotis sodalis, Indiana Myotis (Bat)
Ursus americanus, Black bear

TABLE 63. (CONTINUED) THREATENED FAUNA

Greenup County, Kentucky (continued)

SPECIES (Scientific Name, Common Name)

FISH

Ichthyomyzon fossor, Northern Brook Lamprey

Acipenser fulvescens, Lake Sturgeon

Clinostomus funduloides, Rosyside Dace

Cycleptus elongatus, Blue Sucker

Ictiobus niger, Black buffalo

Percopsis omiscomaycus, Trout-perch

Ammocrypta asprella, Crystal Darter

Ammocrypta pellucida, Eastern Sand Darter

Sources: Ohio Department of Natural Resources (Wildlife Division)
Ohio Division, US Fish and Wildlife Service
Commonwealth of Kentucky, Department of Fish & Wildlife
Resources

TABLE 64. THREATENED FLORA

from the Ohio Department of Natural Resources, 1988-89 Status List

LAWRENCE COUNTY

<u>SPECIES (Scientific, Common Name)</u>	<u>STATUS</u>
<u>Botrychium biternatum</u> , Sparce-lobe Grape-fern	Threatened
<u>Vittaria lineata</u> , Appalachian Gametophyte	Potentially Threatened
<u>Cystopteris tennesseensis</u> , Tennessee Bladder Fern	Potentially Threatened
<u>Potamogeton pulcher</u> , Spotted Pondweed	Threatened
<u>Potamogeton tennesseensis</u> , Tennessee Pondweed	Endangered
<u>Carex glaucoidea</u> , Blue-green Sedge	Potentially Threatened
<u>Carex nigromarginata</u> , Black-marginal Sedge	Potentially Threatened
<u>Carex rugosperma</u> , Low Sand Sedge	Potentially Threatened
<u>Scleria triglomerata</u> , Tall Nut-rush	Potentially Threatened
<u>Stenanthium gramineum</u> , Feather-bells	Threatened
<u>Iris verna</u> , Dwarf Iris	Endangered
<u>Corallorhiza wisteriana</u> , Spring Coral-root	Threatened
<u>Cypripedium calceolus</u> , var. pb., Large Yellow Lady's-Slipper	Potentially Threatened
<u>Malaxis unifolia</u> , Green Adder's-mouth	Potentially Threatened
<u>Quercus falcata</u> , Spanish Oak	Threatened
<u>Quercus marilandica</u> , Blackjack Oak	Threatened
<u>Phoradendron serotinum</u> , American Mistletoe	Potentially Threatened
<u>Heuchera parviflora</u> , Small-flowered Alumroot	Potentially Threatened
<u>Heuchera villosa</u> , Hairy Alumroot	Threatened
<u>Prunus nigra</u> , Canada Plum	Endangered
<u>Clitoria mariana</u> , Butterfly-pea	Potentially Threatened
<u>Phaseolus polystachios</u> , Wild Kidney Bean	Potentially Threatened
<u>Euonymus americana</u> , American Strawberry-bush	Potentially Threatened
<u>Sida hermaphrodita</u> , Virginia Mallow	Potentially Threatened
<u>Viola tripartita</u> var. gl., Wedge-leaf Violet	Endangered
<u>Opuntia humifusa</u> , Prickly Pear	Potentially Threatened
<u>Eryngium yuccifolium</u> , Rattlesnake-master	Potentially Threatened
<u>Rhododendron maximum</u> , Great Rhododendron	Threatened
<u>Rhododendron nudiflorum</u> var. ro., Northern Rose Azalea	Potentially Threatened
<u>Asclepias amplexicaulus</u> , Bluntleaf Milkweed	Potentially Threatened
<u>Asclepias variegata</u> , White Milkweed	Potentially Threatened
<u>Scutellaria saxatilis</u> , Rock Skullcap	Threatened
<u>Scutellaria serrata</u> , Showy Skullcap	Potentially Threatened
<u>Synandra huspidula</u> , Synandra	Potentially Threatened
<u>Gratiola viscidula</u> , Short's Hedge-hyssop	Potentially Threatened
<u>Penstemon canescens</u> , Gray Beard-tongue	Threatened
<u>Bignonia capreolata</u> , Cross-vine	Potentially Threatened
<u>Ruellia caroliniensis</u> , Carolina Ruellia	Potentially Threatened
<u>Spermacoce glabra</u> , Smooth Buttonweed	Potentially Threatened

TABLE 64. (CONTINUED) THREATENED FLORA

LAWRENCE COUNTY (continued)

<u>SPECIES (Scientific, Common Name)</u>	<u>STATUS</u>
<u>Aster infirmus</u> , Weak Aster	Potentially Threatened
<u>Cacalia Muhlenbergii</u> , Great Indian-plantain	Potentially Threatened
<u>Eupatorium incarnatum</u> , Pink Thoroughwort	Potentially Threatened
<u>Silphium laciniatum</u> , Compass-plant	Endangered
<u>Solidago odora</u> , Sweet Goldenrod	Threatened
<u>Verbesina occidentalis</u> , Yellow Crownbeard	Threatened

SCIOTO COUNTY

<u>SPECIES (Scientific, Common Name)</u>	<u>STATUS</u>
<u>Lycopodium porophilum</u> , Rock Clubmoss	Potentially Threatened
<u>Botrychium biternatum</u> , Sparse-lobe Grape-fern	Threatened
<u>Lygodium palmatum</u> , Climbing Fern	Potentially Threatened
<u>Vittaria lineata</u> , Appalachian Gametophyte	Potentially Threatened
<u>Lorinseria areolata</u> , Netted chain-fern	Threatened
<u>Paspalum fluitans</u> , Riverbank Paspalum	Endangered
<u>Carex abscondita</u> , Southern Leafy Wood Sedge	Endangered
<u>Carex glaucoidea</u> , Blue-green Sedge	Potentially Threatened
<u>Carex purpurifera</u> , Purple Wood Sedge	Endangered
<u>Muzula bulbosa</u> , Southern Woodrush	Endangered
<u>Disporum maculatum</u> , Nodding Mandarin	Threatened
<u>Erythronium rostratum</u> , Goldenstar	Endangered
<u>Stenanthium gramineum</u> , Feather-bells	Threatened
<u>Iris verna</u> , Dwarf Iris	Endangered
<u>Carollorhiza maculata</u> , Spotted Coral-root	Potentially Threatened
<u>Cypripedium calceolus var. pb.</u> , Large Yellow Lady's-Slipper	Potentially Threatened
<u>Malaxis unifolia</u> , Green Adder's mouth	Potentially Threatened
<u>Platanthera ciliaris</u> , Yellow Fringed Orchid	Threatened
<u>Spiranthes ovalis</u> , Lesser Ladies'-tresses	Threatened
<u>Quercus marilandica</u> , Blackjack Oak	Threatened
<u>Ranunculus pusillus</u> , Low Spearwort	Endangered
<u>Magnolia tripetala</u> , Umbrella Magnolia	Threatened
<u>Heuchera parviflora</u> , Small-flowered Alumroot	Potentially Threatened
<u>Heuchera villosa</u> , Hairy Alumroot	Threatened
<u>Phaseolus polystachios</u> , Wild Kidney Bean	Potentially Threatened
<u>Euonymus americana</u> , American Strawberry-bush	Potentially Threatened
<u>Sida hermaphrodita</u> , Virginia Mallow	Potentially Threatened
<u>Viola lanceolata</u> , Lance-leaved Violet	Threatened
<u>Viola tripartita var. gl.</u> , Wedge-leaf Violet	Endangered

TABLE 64. (CONTINUED) THREATENED FLORA

SCIOTO COUNTY (continued)

<u>SPECIES (Scientific, Common Name)</u>	<u>STATUS</u>
<u>Rhododendron maximum</u> , Great Rhododendron	Threatened
<u>Rhododendron nudiflorum var. ro.</u> , Northern Rose Azalea	Potentially Threatened
<u>Hottania inflata</u> , Featherfoil	Endangered
<u>Gentiana villosa</u> , Sampson's Snakeroot	Endangered
<u>Phlox glaberrima</u> , Smooth Phlox	Potentially Threatened
<u>Polemonium reptans var. vi.</u> , Braun's Jacob's-ladder	Potentially Threatened
<u>Collinsonia verticillata</u> , Early Stoneroot	Endangered
<u>Gratiola viscidula</u> , Short's Hedge-hyssop	Potentially Threatened
<u>Eupatorium aromaticum</u> , Small White Snakeroot	Threatened
<u>Solidago odora</u> , Sweet Goldenrod	Threatened
<u>Verbisina helianthoides</u> , Hairy Wing-stem	Potentially Threatened
<u>Verbisina occidentalis</u> , Yellow Crownbeard	Threatened

SOURCE: Ohio Department of Natural Resources
(Division of Natural Areas & Preserves)

A potential risk to environmental receptors exists at the site. Track, scat, and other signs indicate that deer, rabbit, raccoon and other smaller mammals frequent the site area. No rare or endangered species or habitat were noted during a limited walkover of the area.

6.3.2.5 Exposure Routes

An exposure route is that mechanism by which a chemical within an environmental transport medium at an exposure point can enter the receptor. An example of an exposure route would be ingestion of water from a contaminated well. Exposure route potential quantified as high, moderate, or low is presented by media type in Table 65. In order to assign a high, moderate, or low exposure route potential, the relative accessibility of the chemicals identified in each media type and concentrations at which the chemicals were detected were considered. A discussion, by exposure route, is presented below.

Inhalation

Inhalation has been identified as a potential exposure route to human and environmental receptors. Exposure may occur by inhalation of particulate matter or vapors from contaminated surface soil, or inhalation of vapors from leachate through the air pathway. The potential for exposure to both human and ecological receptors via the inhalation route is characterized as low for surface soils, moderate for leachate, and high for air pathways.

Dermal Contact

Dermal contact has been identified as a potential exposure route to human and environmental receptors due to contact with contaminated surface soils, stream sediment,

Table 65. Exposure Route Potential by Media Type

MEDIA TYPE	HUMAN			ENVIRONMENTAL			COMMENTS
	Inhalation	Dermal	Ingestion	Inhalation	Dermal	Ingestion	
Surface Soil (SS)	L *	H	L	L	H	M	Unsecured site
Sediment (SD)	N/A	L	L	N/A	M	L	Very limited human exposure
Landfill Waste (LW)	N/A	N/A	N/A	N/A	M	L	Burrowing animals
Soil Borings (BO)	N/A	N/A	N/A	N/A	N/A	N/A	Not a route
Leachate Sample (LS)	M	H	M	M	H	M	Unsecured site
Surface Water (SW)	N/A	M	M	N/A	H	H	Very limited human exposure
Ground Water (MW)	N/A	L	L	N/A	L	L	Very limited human and environmental exposure
Air	H	N/A	N/A	H	N/A	N/A	Unsecured site

*H - High potential
M - Moderate potential
L - Low potential
N/A - Not applicable

leachate, surface water, and ground water. Dermal contact has been identified as a potential exposure route to environmental receptors in contact with landfill wastes as a result of burrowing activities. The potential for exposure to both human and environmental receptors via the dermal exposure route is characterized as high for surface soils, leachate, and surface water; and low for ground water. Dermal exposure potential to stream sediments is considered low for humans and moderate for ecological receptors; the potential for dermal contact to landfill wastes by ecological receptors, specifically burrowing animals, is characterized as high.

Ingestion

Solids

The exposure potential via ingestion of solids includes ingestion of surface soils, stream sediments and landfill waste by human and environmental receptors. The potential for ingestion of landfill wastes by human populations is precluded due to the presence of a soil cap on the landfill. The exposure potential via ingestion of surface soils and stream sediments by human populations is characterized as low.

For ecological receptors the exposure potential has been characterized as low for landfill wastes and stream sediments, and moderate for surface soils.

Liquids

The exposure potential via ingestion of liquids includes the ingestion of surface water, ground water, and leachate.

To evaluate the human exposure potential via ingestion of ground water, the ground-water source nearest the landfill was sampled. Two water samples were collected from a developed spring by OEPA on April 18, 1988. One sample was obtained directly from the spring, the other was obtained from the bathroom sink of the residence using the spring as a water supply. The residence, which is owned by [REDACTED] and leased by [REDACTED], is located along Rock Hollow Road (Figure 26). This residence is located in the closest proximity to the landfill of the homes along Rock Hollow Road. These water samples were analyzed for acid extractable and base-neutral extractable organic compounds. The bathroom sink sample was also analyzed for volatile organic compounds. These analyses indicated no detectable concentrations of organic compounds in the samples.

Ingestion of potentially contaminated ground water could offer an exposure route. Analyses of the ground-water samples by OEPA and review of water sample analytical results for MW-01 (the well cluster situated between the landfill and the homes on Rock Hollow Road) indicate that no ground-water communication apparently exists between the landfill, and the wells along Rock Hollow Road. The homes in Rock Hollow are located in a different drainage divide than the landfill.

The exposure potential for human and environmental receptors to surface water by ingestion has been characterized as moderate and high, respectively. The human and environmental receptor exposure potential is considered moderate for leachate. The exposure potential for human and environmental receptors is considered low for ingestion of ground water.

6.3.2.6 Exposure Pathways

A complete exposure pathway consists of four components:

- o A source and mechanism of chemical release to the environment
- o An environmental transport medium (surface water, ground water, soil, air)
- o A point of potential receptor contact with the contaminated medium
- o A receptor exposure route (i.e. ingestion, inhalation, dermal contact)

If any of these four components is not present, the pathway is incomplete.

The source of chemical releases for each potential exposure pathway is the landfill. Evidence of a release mechanism for a chemical was detection of site-specific chemicals in samples obtained from one of the eight previously identified transport media. The exposure potentials to human and environmental receptors for the eight media types were individually evaluated. Table 65 summarizes the results of the exposure evaluation. Based upon this review of the exposure route potential, a human/environmental pathway analysis was conducted for each media type. Table 66 summarizes the pathways evaluation for both human and environmental receptors.

Surface Soils

The primary route of exposure for surface soils is via dermal contact with the contaminated soils. The potential for dermal exposure to human populations and/or animals in contact with or animals burrowing into the contaminated surface soils is considered high. Inhalation and ingestion have also been identified as potential exposure routes.

Table 66. Complete Exposure Pathway Analysis by Media and Receptor Type

INDICATOR CHEMICAL	RECEPTOR	MEDIA TYPE							
		Surface Soil	Sediment	Landfill Waste	Soil Boring	Leachate Sample	Surface Water	Ground Water	Air
1,2-Dichloroethane	Human	ND	ND	I	I	C	ND	C	ND
	Env.	ND	ND	ND	I	C	ND	C	ND
Benzene	Human	ND	ND	I	I	C	ND	C	ND
	Env.	ND	ND	ND	I	C	ND	C	ND
Benzo(a)pyrene	Human	C	C	I	I	ND	ND	ND	ND
	Env.	C	C	C	I	ND	ND	ND	ND
Ethylbenzene	Human	ND	C	I	I	C	ND	ND	C
	Env.	ND	C	C	I	C	ND	ND	C
Heptachlor	Human	ND	ND	I	I	C	ND	ND	ND
	Env.	ND	ND	C	I	C	ND	ND	ND
Phenol	Human	C	ND	I	I	C	ND	C	ND
	Env.	C	ND	C	I	C	ND	C	ND
Styrene (Monomer)	Human	ND	ND	I	I	ND	ND	ND	ND
	Env.	ND	ND	C	I	ND	ND	ND	ND
Arsenic	Human	C	C	I	I	C	ND	C	C
	Env.	C	C	C	I	C	ND	C	C
Manganese	Human	C	C	I	I	C	C	C	C
	Env.	C	C	C	I	C	C	C	C
Nickel	Human	C	C	I	I	C	C	C	C
	Env.	C	C	C	I	C	C	C	C

ND - Incomplete; chemical not detected

C - Complete

I - Incomplete; no exposure route exists because the site is covered by a cap, and soil borings were obtained from depths of 10.5 feet below the ground surface.

Env. - Environmental receptor

NOTE: Surficial soil sample SS-32 and Sediment Sample SD-01 are not evaluated as these data points are impacted by sources other than Shilling Landfill.

Stream Sediment

Exposure to stream sediment is by dermal contact and ingestion. The potential for human exposure via dermal contact and ingestion is characterized as low. For environmental receptors the potential for exposure is characterized as low for ingestion and moderate for dermal contact.

Landfill Waste

Exposure to landfill waste is limited to dermal contact and ingestion by burrowing animals on the site. The potential for exposure is characterized as low for exposure via ingestion and moderate for dermal exposure.

Soil Borings

As stated in Section 4.2.3.5, the samples from soil test borings were obtained to depths of 10.5 to 30 feet below the landfill surface. Soils at these depths are inaccessible to human and environmental receptors.

Leachate

The potential for exposure to human and environmental receptors is considered to be moderate to high for all exposure routes evaluated. Human access to the unsecured site should be limited due to the remoteness of the landfill and the surrounding area. Based on observation of track, scat, and other sign; deer as well as other potential ecological receptors frequent the site. Potential for exposure, particularly to burrowing animals, does exist.

Human and environmental receptors would potentially avoid the leachate due to organoleptic aversion response. This scenario would only apply when organic and/or inorganic contaminants are present at concentrations which are sufficiently high to be sensed by the receptor. The organoleptic aversion response would not apply to organic and/or inorganic contaminants which are present at concentrations below a receptor's response level.

Surface Water

The potential for exposure to human and environmental receptors is considered to be moderate and high, respectively. Winkler Run, a low-flow stream, is not used as a drinking water source by humans. Winkler Run is a probable drinking water source for deer and other animals based on field observations. Winkler Run may pond upon reaching the Ohio River floodplain, and persons may access Winkler Run at these points for wading and/or swimming. These floodplain access points to Winkler Run are the nearest significant exposure points for human receptors to the surface-water pathway.

Deer track were observed in the vicinity of the site. Deer and other animals could access the stream, drink the surface water, and later be eaten by local humans thereby entering the food chain. Although the potential exists, such bioconcentration of chemicals is unlikely due to several causes. Deer, for example, typically range over 200 to 1000 acres, making it unlikely that a given animal will drink from the same water source repetitively. Deer meat is very lean (it has little fat), decreasing the potential for bioconcentration of fat-soluble contaminants in the meat.

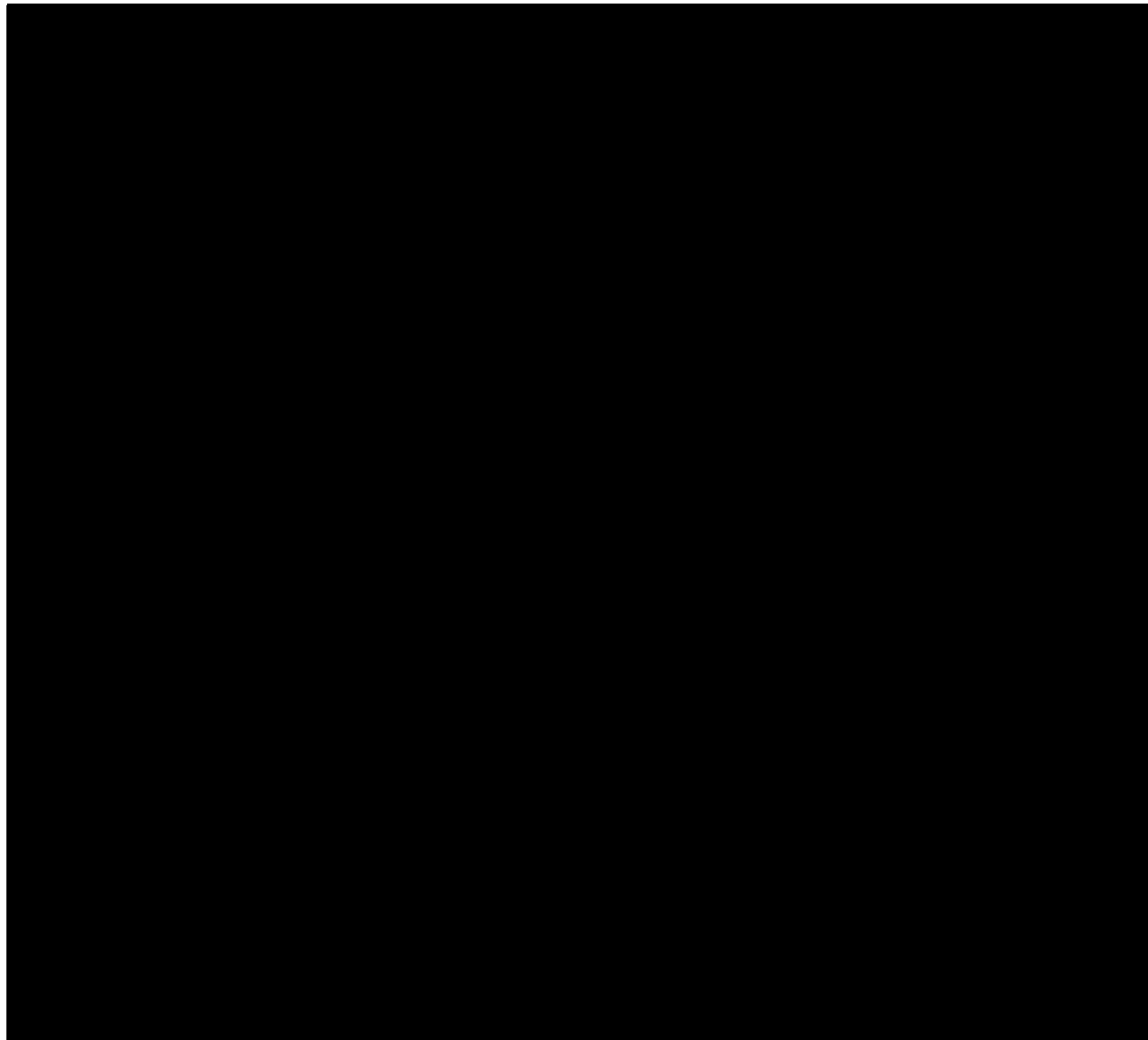
Ground Water

The potential for exposure to ground water by human and environmental receptors is considered low. The potential point of exposure for humans would be the residential wells located on Rock Hollow Road (Figure 26).

In Kentucky, the cities of Raceland and Flatwoods purchase their water from the Ashland Water Department, which obtains water from the Ohio River approximately seven miles upstream of the site. Greenup, Kentucky, pumps its water supply from the Little Sandy River, which empties into the Ohio River approximately four miles downstream of the site. The towns of Wurtland and Worthington each have their own municipal wells (personal communications, Greenup County Water Division).

In Ohio, the city of Ironton pumps water from the Ohio River approximately four miles upstream from the site. The Ironton Water Department also provides water service to the city of Hanging Rock (personal communication, Ironton Water Filtration Department).

An estimated 47 private wells are within a three-mile radius of the site (Figure 75 and Table 67). Present data are insufficient to determine current supply or consumption levels for users of these wells. The direction and velocity of ground-water movement is not well documented. A Law Environmental site survey determined the nearest population using private wells to be located along Rock Hollow Road east of the site. The estimated distance to the nearest private water well from the edge of the landfill is 800 feet (Figure 26). The well survey reviewed ten wells: three between 50 and 100 feet deep, six from 10 to 15 feet deep, and one developed spring (Figure 26 and Table 68). Exact records of these



LEGEND

● PRIVATE WELL LOCATION



FIGURE 75

RECORDED PRIVATE WELLS
WITHIN THREE MILES OF
SITE

E. H. SCHILLING LANDFILL

SOURCE : STATE OF OHIO, DEPARTMENT OF NATURAL RESOURCES, DIVISION OF WATER
STATE OF KENTUCKY, DEPARTMENT OF NATURAL RESOURCES, DIVISION OF WATER, 1989

TABLE 67. RECORDED PRIVATE WELLS WITHIN THREE MILES OF
E. H. SCHILLING LANDFILL SITE

Well #	Owner's Name	Date Completed	Total Depth (Feet)	Yield(GPM)
1		12/31/61	63	a
2		05/--/67	90	4
3		08/12/64	100	3
4		09/07/62	60	3
5		03/23/63	50	2
6		08/29/64	50	a
7		08/05/64	60	a
8		04/26/65	50	a
9		07/26/65	50	a
10		02/21/76	65	25
11		10/14/63	50	a
12		10/04/61	45	a
13		07/18/63	60	a
14		09/19/78	41	10
15		07/20/63	50	a
16		06/01/77	55	2.5
17		07/04/57	35	5
18		06/14/82	193	10
19		09/03/82	62	20
20		05/08/78	34	20
21		05/08/66	77	10
22		05/19/78	68	20
23		06/14/71	42	100
24		08/04/58	80	200
25		02/31/61	75	225
26a		10/24/55	84	350
26b		10/22/55	79	a
26c		10/20/55	93	a
26d		03/04/66	76	151
27		05/20/62	48	a
28		05/26/62	47	a
29a		05/06/63	47	a
29b		09/12/66	47	a
30		12/23/68	80	a
31		05/16/64	49	a

a: Data Not Available
GPM: Gallons Per Minute

TABLE 67. (CONTINUED) RECORDED PRIVATE WELLS WITHIN THREE MILES
OF E. H. SCHILLING LANDFILL SITE

Well #	Owner's Name	Date Completed	Total Depth (Feet)	Yield(GPM)
32a	[REDACTED]	06/06/64	66	5
32b		10/18/65	140	1
32c		11/18/68	60	a
32d		09/18/65	104	3
32e		11/--/64	60	a
32f		07/18/58	110	a
33a		12/21/60	110	a
33b		12/29/60	65	40
33c		10/09/61	70	30
34		08/05/78	51	20
35a		12/15/67	75	217
35b		10/--/66	75	a

a: Data Not Available
GPM: Gallons Per Minute

TABLE 68. NEAR-SITE RESIDENTIAL WELL SURVEY

Owner	Date Well Completed	Depth (feet)
[REDACTED]	a	10 - 12
[REDACTED]	a	Developed Spring
[REDACTED]	Pre-1971.	15 - 20
[REDACTED]	Pre-1982	a
[REDACTED]	a	10 - 12
[REDACTED]	1974	50
[REDACTED]	1983	10 - 15
[REDACTED]	1964	10 - 15
[REDACTED]	1980	50 -100
[REDACTED]	1939	30 o

a: Data Not Available

wells were unavailable. The information provided is based on discussions with the resident owners. Homes on Patrick Street use a private water company (HECLA) as the source of water. HECLA obtains its water from three wells which are located approximately 35 miles east of the site.

6.3.3 Exposure Point Concentrations

The exposure point concentrations were assumed to be equal to the maximum detected concentrations on a media-specific basis. This assumption represents the "worst case scenario" and is, therefore, conservatively protective of human health.

6.3.4 Identification of Applicable or Relevant and Appropriate Requirements (ARARs)

Four sources of information were incorporated in the development of Applicable or Relevant and Appropriate Requirements (ARARs) for the site-specific indicator chemicals:

- o The drinking water maximum contaminant levels (MCL's) and proposed maximum contaminant levels (pMCLs) of the Safe Drinking Water Act
- o The federal ambient water quality criteria (WQC) of the Clean Water Act
- o Superfund Public Health Evaluation Manual
- o Integrated Risk Information System

These sources of information comply with the regulatory guideline that chemical clean-up levels meet ARARs. Where ARARs were not available, health-based criteria were developed. The ARARs for the ten indicator chemicals are presented in Table 69. Clean-up levels are calculated for the indicator chemicals in soils and ground water using Risk-Specific Doses (RSD) and Reference Doses (RfD). In the development of these levels, the

TABLE 69. ARARS FOR INDICATOR CHEMICALS

Indicator Chemicals	Ground Water (mg/l)	Reference
1,2-Dichloroethane ¹	0.005	MCL
Benzene ¹	0.005	MCL
*Benzo(a)pyrene ¹	3.1 X 10 ⁻³	AWQC
Ethylbenzene ²	0.70	pMCL
*Heptachlor ^{1,2}	1.1 X 10 ⁻³	AWQC
Phenol ²	1.4	IRIS
Styrene ²	0.005	pMCL
Arsenic ^{1,2}	0.05	MCL
Manganese ²	0.05	SMCL
Nickel ²	0.70	**

*Risk = 10⁻⁶

¹ Carcinogen

² Non-Carcinogen

** RCRA Facility Investigation Guidance Document, July 1987

health protection goals are maintained by the use of appropriate concentration criteria. Clean-up levels for soil and ground water derived from RSD and RfD equations (as illustrated below) can be used as ARARs. These numbers are health-based.

$$\text{RSD} = (\text{R}/\text{CPF}) \times (\text{W}/\text{I})$$

where

RSD = Risk Specific Dose in mg/kg, is defined as environmental concentrations that under specific intake assumptions, correspond to excess lifetime cancer risks of 10^{-6} for Class A and B carcinogens, or 10^{-5} for Class C carcinogens.

R = The specific risk level (10^{-6} or 10^{-5})

CPF = Carcinogenic Potency Factor in (mg/kg/day)⁻¹

W = Weight of individual, in kg

I = Intake amount

or

$$C_i = (\text{RfD}) \times (\text{W}/\text{I})$$

where

C_i = Concentration for constituent

RfD = Reference Dose, in mg/kg/day, is defined as an estimate of a daily exposure to the human population that is not likely to result in adverse health effects during a lifetime

W = Weight of individual

I = Intake amount

6.4 Risk Characterization

The potential risks to human health were determined for dermal exposure, oral ingestion and inhalation on a media-specific basis for each of the indicator chemicals. If an indicator chemical was not identified in a specific media type, an intake was not calculated.

Estimated daily intakes (EDI) were calculated for adults and children at both long-term (20 days) and short-term (1 day) exposure durations assuming trespassing at the site. Site-specific intake values included; frequency of exposure, duration of exposure, body weight, ingestion and inhalation rates.

The EDI for dermal exposure to and ingestion of soil and sediments were calculated based upon an equation in the Endangerment Assessment for the Westinghouse Plant Site (U.S. EPA, 1989).

The equation used is as follows:

$$EDI = f \times v \times I_s \times \frac{C_s}{W} \times 10^{-6} \text{ kg/mg} \quad (1)$$

f = Fraction of lifetime exposed

v = Visits to site (day/yr/365 days/yr)

I_s = Soil absorption or consumption (mg/day)

C_s = Soil concentration (mg/kg)

W = Body weight (kg)

Soil absorption for dermal exposure was calculated from:

$$I_s (\text{mg/day}) = S \times DA \times P \quad (2)$$

Where S = Surface area exposed (cm²)
 DA = Dust adherence (mg/cm² day)
 P = Percent absorbed

Dermal exposure to and ingestion of ground water, surface water, and leachate were based upon equations from the Superfund Exposure Assessment Manual (U.S. EPA, 1988). EDIs via dermal exposure to ground water, surface water, and leachate were calculated as follows:

$$EDI = Te \times S \times PC \times F \times \frac{C_w \times \text{one liter}}{1000\text{cm}^3} \times \frac{1}{D} \quad (3)$$

Where Te = Duration of exposure (hours/event)
 S = Skin surface area exposed (cm²)
 PC = Dermal permeability constant (cm/hr)
 F = Frequency of exposure events per lifetime
 C_w = Contaminant concentration in water (mg/l)
 W = Body weight (kg)
 D = Days per lifetime

The EDI via ingestion of ground water, surface water, and leachate were calculated as follows:

$$EDI = Te \times I_w \times F \times \frac{C_w \times 1}{W} \times \frac{1}{D} \quad (4)$$

Where I_w = Water intake

The EDI determined for inhalation exposure via airborne contaminants and fugitive dust were calculated using an equation based upon the Superfund Exposure Assessment Manual (U.S. EPA, 1988):

$$EDI = Te \times F \times I_a \times \frac{C_a \times 1}{W} \times \frac{1}{D} \quad (5)$$

Where C_a = Contaminant concentration in air (mg/m^3)

I_a = Air intake (m^3/day)

The contaminant concentration in air as fugitive dust was calculated as follows:

$$C_a (\text{mg}/\text{m}^3) = C_f \times C_s \times 1(10^{-6}) \frac{\text{kg}}{\text{mg}} \quad (6)$$

Where C_f = Concentration of fugitive dust (mg/m^3)

The following assumptions were incorporated in characterizing the potential risk to human health:

- o The calculation of estimated daily intakes assumed that the receptors (adults and children) would frequent the site 1 to 20 days per year out of 365 days per year. The fraction of lifetime exposed was 1/70 of a lifetime.
- o The ground-water medium pathway calculations assumed that the receptor would drink and/or bathe in the water daily.
- o It was assumed that the average weight and life expectancy of an adult was 70 kg and 70 years, respectively.
- o The average weight of a child was assumed to be 20 to 40 kg, while it was assumed that a receptor would be considered a child for five years (i.e. child's "lifetime" was five years).
- o Information presented in Table 70.

Table 70. ASSUMPTIONS USED IN THE CALCULATIONS

	Adult	Child
Lifetime (years)	70	5
Days per lifetime (days/lifetime)	2.56(10 ⁴)	1825
Body Weight (kg)	70	20-40
Skin Area (cm ²)		
Total	18,150	9,400
Hands & Feet	1,700	1,000-1,500
Dust Adherence (mg/cm ² day)	1.0	1.0
Percent Absorbed (2/0)	0.1-1	0.1-1
Soil Intake (kg/day)	1.7(10 ⁻⁴)-1.7(10 ⁻⁵)	0.0002-0.0008
Water Intake (1/day)	2	1
TIME OF EXPOSURE		
Ground Water (dermal exposure only)	0.25 hr/bath	0.25 hr/bath
Surface Water/Leachate	2.6 hr/visit	2.6 hr/visit
Soil/Sediment	1 yr/70 yr	1 yr/70 yr
FREQUENCY		
Ground Water	daily	daily
Surface Water/Leachate	1-20 days/yr	1/20 days/yr
Soil/Sediment	1-20 days/yr	1-20 days/yr
Air Intake (m ³ /day)	20	5
Fugitive Dust from soil (mg/m ³)	35	35

Table 70. (Contd.)

DERMAL PERMEABILITY CONSTANT (cm/hr)

1,2-dichloroethane	0.41
Arsenic	$1(10^{-5})$
Benzene	0.41
Benze(a)pyrene	0.001
Ethylbenzene	0.001
Heptachlor	0.001
Manganese	$1(10^{-5})$
Nickel	$1(10^{-5})$
Phenol	0.882
Styrene	0.001

Source: U.S. EPA, April 1988
U.S. EPA, 1989
Hawley, unpublished article

Tables 71 through 82 summarize the calculated intakes and risks to children and adults due to exposure to each media type. Two of the indicator chemicals (arsenic and Heptachlor) have both carcinogenic and non-carcinogenic effects, and were evaluated as both (Table 70). The daily intakes for non-carcinogens were summed over each route of exposure and compared to the reference dose. The daily intakes for carcinogens were multiplied by the carcinogenic potency factor and summed over each exposure route (Tables 83 through 88). Except for ingestion of nickel in ground water by adults, the most conservative risk was to children.

6.4.1 Non-carcinogenic Risk

6.4.1.1 Ingestion Exposure Route

Health based allowable daily intakes; i.e. reference doses, were obtained from the literature for the non-carcinogenic indicator chemicals (Table 70). These allowable intakes were compared to estimated daily intakes at the exposure point (Tables 71 through 77). The estimated daily intakes were then compared to the health-based allowable daily intakes (Tables 78 through 82).

The estimated daily intakes for a child via ingestion were summed over all media types and compared to the allowable intakes. The results from these calculations for the non-carcinogens indicate that manganese is the only indicator chemical which poses even a unacceptable risk to human health (Table 84). However, manganese concentrations in surface soil samples from the site ranged from 4.1 to 1210 mg/kg at an average concentration of 560 mg/kg while the average concentration of manganese in surface soils of the United States is 560 mg/kg with a range of <1 to 7,000 mg/kg (McElroy et. al,

- 1) calculated using the following equation:

$$\text{DEX} = f \times v(\text{days/yr}/365 \text{ days/yr}) \times \text{DA}(\text{mg}/\text{cm}^2/\text{day}) \times S(\text{cm}^2) \times P(\%) / 100 \times \text{Cs}(\text{mg}/\text{kg}) / W(\text{kg}) \times 1\text{E}-06(\text{kg}/\text{mg})$$

where DEX = dermal exposure (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 DA = dust adherence = 1.0 mg/cm²/day
 S = surface area of exposed skin = 1000 - 1500²cm
 P = percent absorbed = 0.1 - 1 %
 Cs = soil concentration
 W = body weight = 20 - 40 kg

- 2) calculated using the following equation:

$$\text{Exp} = f \times v(\text{days/yr}/365 \text{ days/yr}) \times \text{Is}(\text{kg}/\text{day}) \times \text{Cs}(\text{mg}/\text{kg}) / W(\text{kg})$$

where Exp = exposure via ingestion (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 Is = soil intake = 0.0002 - 0.0008 kg/day
 Cs = soil concentration
 W = body weight = 20 - 40 kg

- 3) calculated using following equation:

$$\text{IEX} = f \times v(\text{days/yr}/365 \text{ days/yr}) \times \text{Cf}(\text{ug}/\text{m}^3) \times \text{Ia}(\text{m}^3/\text{day}) \times \text{Cs}(\text{mg}/\text{kg}) / W(\text{kg}) \times 1\text{E}-09(\text{kg}/\text{ug})$$

where IEX = exposure via inhalation (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 Cf = concentration of fugitive dust from resuspended soil = 35 ug/m³
 Ia = air intake = 5 m³/day
 Cs = soil concentration

Source: Equations 1 and 2 modified from Endangerment Assessment for the Westinghouse Plant Site, Bloomington, Indiana

Equation 3 modified from Superfund Exposure Assessment and Endangerment Assessment for the Westinghouse Plant Site, Bloomington, Indiana

Table 71A. Estimated Daily Intakes for Surficial Soils
 Exposure to Children
 E.W. Schilling Landfill

Constituent	Maximum Concentration (mg/kg)	Estimated Daily Intake: Dermal Exposure (1)		Estimated Daily Intake: Ingestion (2)		Estimated Daily Intake: Inhalation of Fugitive Dust (3)	
		Low	High	Low	High	Low	High
1,2-Dichloroethane	ND	NA	NA	NA	NA	NA	NA
Arsenic	11	1.08E-11	6.60E-09	2.15E-09	3.44E-07	1.88E-12	7.54E-11
Benzene	ND	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.54	5.28E-13	3.24E-10	1.06E-10	1.69E-08	9.23E-14	3.70E-12
Ethylbenzene	ND	NA	NA	NA	NA	NA	NA
Heptachlor	ND	NA	NA	NA	NA	NA	NA
Manganese	1210	1.18E-09	7.26E-07	2.37E-07	3.79E-05	2.07E-10	8.29E-09
Nickel	16.3	1.59E-11	9.78E-09	3.19E-09	5.10E-07	2.79E-12	1.12E-10
Phenol	0.35	3.42E-13	2.10E-10	6.85E-11	1.10E-08	5.98E-14	2.40E-12
Styrene	ND	NA	NA	NA	NA	NA	NA

ND = Not Detected
 NA = Not applicable

Table 71B. Estimated Daily Intakes for Surficial Soils:
 Exposure to Adults
 E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/kg)	Estimated Daily Intakes: Dermal Exposure (1)		Estimated Daily Intakes: Ingestion (2)		Estimated Daily Intakes: Inhalation of Fugitive Dust (3)	
		Low	High	Low	High	Low	High
1,2-Dichloroethane	ND	NA	NA	NA	NA	NA	NA
Arsenic	11	1.05E-11	2.09E-09	1.05E-10	2.09E-08	4.30E-12	8.61E-11
Benzene	ND	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	0.54	5.13E-13	1.03E-10	5.13E-12	1.03E-09	2.11E-13	4.23E-12
Ethylbenzene	ND	NA	NA	NA	NA	NA	NA
Heptachlor	ND	NA	NA	NA	NA	NA	NA
Manganese	1210	1.15E-09	2.30E-07	1.15E-08	2.30E-06	4.73E-10	9.47E-09
Nickel	16.3	1.55E-11	3.10E-09	1.55E-10	3.10E-08	6.37E-12	1.28E-10
Phenol	0.35	3.32E-13	6.65E-11	3.32E-12	6.65E-10	1.37E-13	2.74E-12
Styrene	ND	NA	NA	NA	NA	NA	NA

ND = Not detected
 NA = Not applicable

- 1) calculated using the following equation:

$$DEX = f \times v(\text{days/yr}/365 \text{ days/yr}) \times DA(\text{mg}/\text{cm}^2/\text{day}) \times S(\text{cm}^2) \times P(\%) / 100 \times C_s(\text{mg}/\text{kg}) / W(\text{kg}) \times 1\text{E}-06(\text{kg}/\text{mg})$$

where DEX = dermal exposure (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 DA = dust adherence = 1.0 mg/cm²/day
 S = surface area of exposed skin = 1700 cm²
 P = percent absorbed = 0.1 - 1 %
 C_s = soil concentration
 W = body weight = 70 kg

- 2) calculated using the following equation:

$$\text{Exp} = f \times v(\text{days/yr}/365 \text{ days/yr}) \times I_s(\text{kg}/\text{day}) \times C_s(\text{mg}/\text{kg}) / W(\text{kg})$$

where Exp = exposure via ingestion (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 I_s = soil intake = 1.7E-05 - 1.7E-04 kg/day
 C_s = soil concentration
 W = body weight = 70 kg

- 3) calculated using following equation:

$$IEX = f \times v(\text{days/yr}/365 \text{ days/yr}) \times C_f(\text{ug}/\text{m}^3) \times I_a(\text{m}^3/\text{day}) \times C_s(\text{mg}/\text{kg}) / W(\text{kg}) \times 1\text{E}-09(\text{kg}/\text{ug})$$

where IEX = exposure via inhalation (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 C_f = concentration of fugitive dust from resuspended soil = 35 ug/m³
 I_a = air intake = 20 m³/day
 C_s = soil concentration

Source: Equations 1 and 2 modified from Endangerment Assessment for the Westinghouse Plant Site, Bloomington, Indiana

Equation 3 modified from Superfund Exposure Assessment and Endangerment Assessment For the Westinghouse Plant Site, Bloomington, Indiana

Table 72A. Estimated Daily Intakes for Sediments
Exposure to Children
E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/kg)	Estimated Daily Intakes: Dermal Exposure		Estimated Daily Intakes: Ingestion	
		Low	High	Low	High
1,2-Dichloroethane	ND	NA	NA	NA	NA
Arsenic	4.9	4.79E-12	2.88E-09	4.23E-20	6.77E-18
Benzene	ND	NA	NA	NA	NA
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	0.003	2.94E-15	1.76E-12	3.24E-30	5.18E-28
Heptachlor	ND	NA	NA	NA	NA
Manganese	895	8.76E-10	5.25E-07	1.41E-15	2.26E-13
Nickel	17	1.66E-11	9.98E-09	1.82E-17	2.91E-15
Phenol	ND	NA	NA	NA	NA
Styrene	ND	NA	NA	NA	NA

ND = Not detected

1) calculated using the following equation:

$$DEX = f \times v(\text{days/yr}/365 \text{ days/yr}) \times DA(\text{mg}/\text{cm}^2/\text{day}) \times S(\text{cm}^2) \times P(\%) / 100 \times Cs(\text{mg}/\text{kg}) / W(\text{kg}) \times 1E-06(\text{kg}/\text{mg})$$

where DEX = dermal exposure (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 DA = dust adherence = 1.0 mg/cm²/day
 S = surface area of exposed skin = 1000 - 1500²cm
 P = percent absorbed = 0.1 - 1 %
 Cs = soil concentration
 W = body weight = 20 - 40 kg

2) calculated using the following equation:

$$Exp = f \times v(\text{days/yr}/365 \text{ days/yr}) \times Is(\text{kg}/\text{day}) \times Cs(\text{mg}/\text{kg}) / W(\text{kg})$$

where Exp = exposure via ingestion (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 Is = soil intake = 0.0002 - 0.0008 kg/day
 Cs = soil concentration
 W = body weight = 20 - 40 kg

Constituent	Maximum Concentration (mg/kg)	Estimated Daily Intakes: Dermal Exposure		Estimated Daily Intakes: Ingestion	
		Low	High	Low	High
		1,2-Dichloroethane	ND	NA	NA
Arsenic	4.9	4.66E-12	9.31E-10	4.66E-11	9.31E-09
Benzene	ND	NA	NA	NA	NA
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	0.003	2.85E-15	5.70E-13	2.85E-14	5.70E-12
Heptachlor	ND	NA	NA	NA	NA
Manganese	895	8.50E-10	1.70E-07	8.50E-09	1.70E-06
Nickel	17	1.62E-11	3.23E-09	1.61E-10	3.23E-08
Phenol	ND	NA	NA	NA	NA
Styrene	ND	NA	NA	NA	NA

ND = Not Detected
 NA = Not applicable

1) calculated using the following equation:

$$DEX = f \times v(\text{days/yr}/365 \text{ days/yr}) \times DA(\text{mg}/\text{cm}^2/\text{day}) \times S(\text{cm}^2) \times P(\%) / 100 \times Cs(\text{mg}/\text{kg}) / W(\text{kg}) \times 1\text{E}-06(\text{kg}/\text{mg})$$

where DEX = dermal exposure (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 DA = dust adherence = 1.0 mg/cm²/day
 S = surface area of exposed skin = 1700 cm²
 P = percent absorbed = 0.1 - 1 %
 Cs = soil concentration
 W = body weight = 70 kg

2) calculated using the following equation:

$$Exp = f \times v(\text{days/yr}/365 \text{ days/yr}) \times Is(\text{kg}/\text{day}) \times Cs(\text{mg}/\text{kg}) / W(\text{kg})$$

where Exp = exposure via ingestion (mg/kg/day)
 f = fraction of lifetime exposed = 1/70
 v = visits = 1 - 20 days/year per 365 days/year
 Is = soil intake = 1.7E-05 - 1.7E-04 kg/day
 Cs = soil concentration
 W = body weight = 70 kg

Constituent	Maximum Concentration (mg/L)	Estimated Daily Intakes: Dermal Exposure (1)		Estimated Daily Intakes: Ingestion (2)	
		Low	High	Low	High
1,2-Dichloroethane	0.014	1.02E-06	6.08E-05	1.04E-07	4.16E-06
Arsenic	0.368	6.55E-10	3.90E-08	2.73E-06	1.09E-04
Benzene	0.008	5.84E-07	3.48E-05	5.94E-08	2.38E-06
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	8	1.42E-06	8.48E-05	5.94E-05	2.38E-03
Heptachlor	0.00027	4.81E-11	2.86E-09	2.00E-09	8.02E-08
Manganese	7.88	1.40E-08	8.35E-07	5.85E-05	2.34E-03
Nickel	0.42	7.48E-10	4.45E-08	3.12E-06	1.25E-04
Phenol	0.52	7.61E-06	4.53E-04	3.86E-06	1.54E-04
Styrene	ND	NA	NA	NA	NA

ND = Not detected
 NA = Not applicable

1) calculated using following equation:

$$DEX = t_e(\text{hr/day}) \times F(\text{days/lifetime}) \times S(\text{cm}^2) \times PC(\text{cm/hr}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/1825 \text{ days}) \times (1 \text{ L}/1000 \text{ cm}^3)$$

where DEX = dermal exposure (mg/kg/day)
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 5 - 100 days/lifetime
 S = exposed skin surface area = 1000 - 1500 cm^2
 PC = dermal permeability constant
 C_w = water concentration
 W = body weight = 20 - 40 kg

2) calculated using following equation:

$$Exp = t_e(\text{hrs/day}) \times F(\text{days/lifetime}) \times I_w(\text{L/day}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/1825 \text{ days}) \times (1 \text{ day}/24 \text{ hours})$$

where Exp = exposure via ingestion
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 5 - 100 days/lifetime
 I_w = water intake = 1 L/day
 C_w = water concentration
 W = body weight = 20 - 40 kg

Table 73B. Estimated Daily Intakes for Leachate
Exposure to Adults
E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/kg)	Estimated Daily Intakes: Dermal Exposure (1)		Estimated Daily Intakes: Ingestion (2)	
		Low	High		
1,2-Dichloroethane	0.014	9.93E-07	1.99E-05	1.18E-07	2.37E-06
Arsenic	0.368	6.37E-10	1.27E-08	3.11E-06	6.22E-05
Benzene	0.008	5.67E-07	1.13E-05	6.77E-08	1.35E-06
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	8	1.38E-06	2.77E-05	6.77E-05	1.35E-03
Heptachlor	0.00027	4.67E-11	9.34E-10	2.28E-09	4.56E-08
Manganese	7.88	1.36E-08	2.73E-07	6.67E-05	1.33E-03
Nickel	0.42	7.27E-10	1.45E-08	3.55E-06	7.10E-05
Phenol	0.52	7.39E-06	1.48E-04	4.40E-06	8.79E-05
Styrene	ND	NA	NA	NA	NA

ND = Not detected
NA = Not applicable

1) calculated using following equation:

$$DEX = t_e(\text{hr/day}) \times F(\text{days/lifetime}) \times S(\text{cm}^2) \times PC(\text{cm/hr}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/2.56 \times 10^4 \text{ days}) \times (1 \text{ L}/1000 \text{ cm}^3)$$

where DEX = dermal exposure (mg/kg/day)
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 70 - 1400 days/lifetime
 S = exposed skin surface area = 1700 cm²
 PC = dermal permeability constant
 C_w = water concentration
 W = body weight = 70 kg

2) calculated using following equation:

$$Exp = t_e(\text{hrs/day}) \times F(\text{days/lifetime}) \times I_w(\text{L/day}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/2.56 \times 10^4 \text{ days}) \times (1 \text{ day}/24 \text{ hours})$$

where Exp = exposure via ingestion
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 70 - 1400 days/lifetime
 I_w = water intake = 2 L/day
 C_w = water concentration
 W = body weight = 70 kg

Table 74A. Estimated Daily Intakes for Surface Water
 Exposure to Children
 E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/L)	Estimated Daily Intakes: Dermal Exposure (1)		Estimated Daily Intakes: Ingestion (2)	
		Low	High	Low	High
1,2-Dichloroethane	ND	NA	NA	NA	NA
Arsenic	ND	NA	NA	NA	NA
Benzene	ND	NA	NA	NA	NA
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	ND	NA	NA	NA	NA
Heptachlor	ND	NA	NA	NA	NA
Manganese	4.35	7.74E-09	4.61E-07	3.23E-05	1.29E-03
Nickel	0.094	1.67E-10	9.96E-09	6.97E-07	2.79E-05
Phenol	ND	NA	NA	NA	NA
Styrene	ND	NA	NA	NA	NA

ND = Not detected
 NA = Not applicable

1) calculated using following equation:

$$DEX = t_e(\text{hr/day}) \times F(\text{days/lifetime}) \times S(\text{cm}^2) \times PC(\text{cm/hr}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/1825 \text{ days}) \times (1 \text{ L}/1000 \text{ cm}^3)$$

where DEX = dermal exposure (mg/kg/day)
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 5 - 100 days/lifetime
 S = exposed skin surface area = 1000 - 1500 cm²
 PC = dermal permeability constant
 C_w = water concentration
 W = body weight = 20 - 40 kg

2) calculated using following equation:

$$Exp = t_e(\text{hrs/day}) \times F(\text{days/lifetime}) \times I_w(\text{L/day}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/1825 \text{ days}) \times (1 \text{ day}/24 \text{ hours})$$

where Exp = exposure via ingestion
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 5 - 100 days/lifetime
 I_w = water intake = 1 L/day
 C_w = water concentration
 W = body weight = 20 - 40 kg

Constituent	Maximum Concentration (mg/kg)	Estimated Daily Intakes: Dermal Exposure (1)		Estimated Daily Intakes: Ingestion (2)	
		Low	High		
1,2-Dichloroethane	ND	NA	NA	NA	NA
Arsenic	ND	NA	NA	NA	NA
Benzene	ND	NA	NA	NA	NA
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	ND	NA	NA	NA	NA
Heptachlor	ND	NA	NA	NA	NA
Manganese	4.35	7.53E-09	1.51E-07	3.68E-05	7.35E-04
Nickel	0.094	1.63E-10	3.25E-09	7.95E-07	1.59E-05
Phenol	ND	NA	NA	NA	NA
Styrene	ND	NA	NA	NA	NA

ND = Not detected
 NA = Not applicable

1) calculated using following equation:

$$DEX = t_e(\text{hr/day}) \times F(\text{days/lifetime}) \times S(\text{cm}^2) \times PC(\text{cm/hr}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/2.56E+04 \text{ days}) \times (1 \text{ L}/1000 \text{ cm}^3)$$

where DEX = dermal exposure (mg/kg/day)
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 70 - 1400 days/lifetime
 S = exposed skin surface area = 1700 cm²
 PC = dermal permeability constant
 C_w = water concentration
 W = body weight = 70 kg

2) calculated using following equation:

$$Exp = t_e(\text{hrs/day}) \times F(\text{days/lifetime}) \times I_w(\text{L/day}) \times C_w(\text{mg/L})/W(\text{kg}) \times (\text{lifetime}/2.56E+04 \text{ days}) \times (1 \text{ day}/24 \text{ hours})$$

where Exp = exposure via ingestion
 t_e = duration of exposure = 2.6 hrs/day
 F = frequency of exposure = 70 - 1400 days/lifetime
 I_w = water intake = 2 L/day
 C_w = water concentration
 W = body weight = 70 kg

Table 75A. Estimated Daily Intakes for Ground Water
 Exposure to Children
 E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/L)	Estimated Daily Intakes: Dermal Exposure (1)		Estimated Daily Intakes: Ingestion (2)	
		Low	High	Low	High
		1,2-Dichloroethane	0.003	7.23E-05	1.45E-04
Arsenic	0.0091	5.35E-09	1.07E-08	2.28E-04	4.55E-04
Benzene	0.005	1.21E-04	2.42E-04	1.25E-04	2.50E-04
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	ND	NA	NA	NA	NA
Heptachlor	ND	NA	NA	NA	NA
Manganese	7.53	4.43E-06	8.89E-06	1.88E-01	3.77E-01
Nickel	0.372	2.19E-07	4.39E-07	9.30E-03	1.86E-02
Phenol	0.008	3.87E-05	7.76E-05	2.00E-04	4.00E-04
Styrene	ND	NA	NA	NA	NA

ND = Not detected
 NA = Not applicable

1) calculated using following equation:

$$DEX = te(\text{hrs/event}) \times S(\text{cm}^2) \times PC(\text{cm/hr}) \times F(\text{events/lifetime}) \times Cw(\text{mg/L})/W(\text{kg}) \times \text{lifetime}/1825 \text{ days} \times 1 \text{ L}/1000 \text{ cm}^3$$

where DEX = dermal exposure (mg/kg/day)
 te = duration of exposure (hrs/event)
 S = exposed skin surface area = 1000 - 1500 cm²
 PC = dermal permeability constant
 F = frequency of events per lifetime = 1825 baths/lifetime
 Cw = water concentration
 W = body weight = 20 - 40 kg

2) calculated using following equation:

$$Exp = Iw(\text{L/day}) \times F(\text{days/lifetime}) \times Cw(\text{mg/L})/W(\text{kg}) \times \text{lifetime}/1825 \text{ days}$$

where Exp = exposure via ingestion (mg/kg/day)
 Iw = water intake = 1 L/day
 F = frequency of events per lifetime = 1825 days/lifetime
 Cw = water concentration
 W = body weight = 20 - 40 kg

Table 75B. Estimated Daily Intakes for Ground Water
 Exposure to Adults
 E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/L)	Estimated Daily Intakes: Dermal Exposure (1)		Estimated Daily Intakes: Ingestion (2)	
		Low	High	Low	High
1,2-Dichloroethane	0.003	NA	7.98E-05	NA	1.95E-04
Arsenic	0.0091	NA	5.91E-09	NA	5.91E-04
Benzene	0.005	NA	1.33E-04	NA	3.25E-04
Benzo(a)pyrene	ND	NA	NA	NA	NA
Ethylbenzene	ND	NA	NA	NA	NA
Heptachlor	ND	NA	NA	NA	NA
Manganese	7.53	NA	4.89E-06	NA	4.89E-01
Nickel	0.372	NA	2.41E-07	NA	2.41E-02
Phenol	0.008	NA	4.27E-05	NA	5.19E-04
Styrene	ND	NA	NA	NA	NA

ND = Not detected
 NA = Not applicable

1) calculated using following equation:

$$DEX = te(\text{hrs/event}) \times S(\text{cm}^2) \times PC(\text{cm/hr}) \times F(\text{events/lifetime}) \times Cw(\text{mg/L})/W(\text{kg}) \times \text{lifetime}/2.56E+04 \text{ days} \times 1 \text{ L}/1000 \text{ cm}^3$$

where DEX = dermal exposure (mg/kg/day)
 te = duration of exposure (hrs/event)
 S = exposed skin surface area = 1700 cm²
 PC = dermal permeability constant
 F = frequency of events per lifetime = 2.56+04 baths/lifetime
 Cw = water concentration
 W = body weight = 70 kg

2) calculated using following equation:

$$Exp = Iw(\text{L/day}) \times F(\text{days/lifetime}) \times Cw(\text{mg/L})/W(\text{kg}) \times \text{lifetime}/2.56E+04 \text{ days}$$

where Exp = exposure via ingestion (mg/kg/day)
 Iw = water intake = 2 L/day
 F = frequency of events per lifetime = 2.56E+04 days/lifetime
 Cw = water concentration
 W = body weight = 70 kg

Table 76A. Estimated Daily Intakes for Air
Exposure to Children
E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/m ³)	Estimated Daily Intakes: Inhalation (1)	
		Low	High
1,2-Dichloroethane	ND	NA	NA
Arsenic	ND	NA	NA
Benzene	ND	NA	NA
Benzo(a)pyrene	ND	NA	NA
Ethylbenzene	ND	NA	NA
Heptachlor	ND	NA	NA
Manganese	1.00E-05	4.89E-11	1.96E-09
Nickel	2.00E-05	9.78E-11	3.92E-09
Phenol	ND	NA	NA
Styrene	ND	NA	NA

ND = Not detected
NA = Not applicable

1) calculated using the following equation:

$$IEI = f \times v(\text{days/year}/365 \text{ days/year}) \times Ia(\text{m}^3/\text{day}) \times Ca(\text{mg}/\text{m}^3) / W(\text{kg})$$

where f = fraction of lifetime exposed = 1/70
v = number of visits = 1 - 20 days/yr per 365 days/yr
Ia = air intake = 5 m³/day
Ca = air concentration (mg/m³)
W = body weight = 20 - 40 kg

Source : Modified from Endangerment Assessment for the Westinghouse Site,
Bloomington, Indiana

Table 768. Estimated Daily Intakes for Air
Exposure to Adults
E.H. Schilling Landfill

Constituent	Maximum Concentration (mg/m ³)	Estimated Daily Intakes: Inhalation (1)	
		Low	High
1,2-Dichloroethane	ND	NA	NA
Arsenic	ND	NA	NA
Benzene	ND	NA	NA
Benzo(a)pyrene	ND	NA	NA
Ethylbenzene	ND	NA	NA
Heptachlor	ND	NA	NA
Manganese	1.00E-05	1.12E-10	2.24E-09
Nickel	2.00E-05	2.24E-10	4.48E-09
Phenol	ND	NA	NA
Styrene	ND	NA	NA

ND = Not detected
NA = Not applicable

1) calculated using the following equation:

$$IEX = f \times v(\text{days/year}/365 \text{ days/year}) \times Ia(\text{m}^3/\text{day}) \times \frac{Ca(\text{mg}/\text{m}^3)}{W(\text{kg})}$$

where f = fraction of lifetime exposed = 1/70
v = number of visits = 1 - 20 days/yr per 365 days/yr
Ia = air intake = 20 m³/day
Ca = air concentration (mg/m³)
W = body weight = 70 kg

Source : Modified from Endangerment Assessment for the Westinghouse Site,
Bloomington, Indiana

Table 77A. Estimated Carcinogenic Risks and Hazard Indices for Surficial Soils
 Exposure to Children
 E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-Carcinogenic Risk)		Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-Carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	1.70E-10	1.02E-07	5.27E-07	3.16E-04	3.40E-08	5.44E-06	1.05E-04	1.69E-02
Benzene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	6.08E-12	3.65E-09	NA	NA	1.22E-09	1.94E-07	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Hexachlorocyclopentadiene	NA	NA	5.80E-05	3.48E-02	NA	NA	1.16E-02	1.86E+00
Nickel	NA	NA	5.58E-08	3.35E-05	NA	NA	1.12E-05	1.79E-03
Phenol	NA	NA	5.99E-10	3.60E-07	NA	NA	1.20E-07	1.92E-05
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RfD = reference doses for chemical

Table 77B. Estimated Carcinogenic Risks and Hazard Indices for Surficial Soils
 Exposure to Adults
 E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-Carcinogenic Risk)		Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-Carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	1.65E-10	3.30E-08	7.37E-09	1.46E-06	1.65E-09	3.30E-07	7.70E-08	1.46E-05
Benzene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	5.90E-12	1.18E-09	NA	NA	5.90E-11	1.18E-08	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	8.11E-07	1.61E-04	NA	NA	8.47E-06	1.61E-03
Nickel	NA	NA	7.80E-10	1.55E-07	NA	NA	8.15E-09	1.55E-06
Phenol	NA	NA	8.38E-12	1.66E-09	NA	NA	8.75E-11	1.66E-08
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RfD = reference doses for chemical

Table 78A. Estimated Carcinogenic Risks and Hazard Indices for Sediments
 Exposure to Children
 E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated		Hazard Indices (2)		Calculated		Hazard Indices (2)	
	Carcinogenic Risk (1)		(Non-carcinogenic Risk)		Carcinogenic Risk (1)		(Non-carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7.58E-11	4.54E-08	3.36E-08	2.01E-06	1.52E-08	2.42E-06	6.71E-07	1.07E-04
Benzene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	2.94E-13	1.76E-11	NA	NA	5.87E-12	9.39E-10
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	6.13E-06	3.68E-04	NA	NA	1.23E-04	1.96E-02
Nickel	NA	NA	5.82E-05	3.49E-03	NA	NA	1.66E-07	2.66E-05
Phenol	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RFD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RFD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 78B. Estimated Carcinogenic Risks and Hazard Indices for Sediments
 Exposure to Adults
 E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-carcinogenic Risk)		Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7.35E-11	1.47E-08	3.28E-09	6.52E-07	7.35E-10	1.47E-07	2.40E-06	4.56E-04
Benzene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	2.87E-14	5.70E-12	NA	NA	2.10E-11	3.99E-09
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	6.00E-07	1.19E-04	NA	NA	4.39E-04	8.33E-02
Nickel	NA	NA	8.14E-10	1.61E-07	NA	NA	5.95E-07	1.13E-04
Phenol	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equations:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 79A. Estimated Carcinogenic Risk and Hazard Indices for Leachate
 Exposure to Children
 E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-carcinogenic Risk)		Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	9.32E-08	3.73E-06	NA	NA	9.47E-09	3.79E-07	NA	NA
Arsenic	1.03E-08	4.14E-07	4.59E-07	1.83E-05	4.31E-05	1.73E-03	1.91E-03	7.65E-02
Benzene	1.69E-08	6.77E-07	NA	NA	1.72E-09	6.89E-08	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	1.42E-05	5.70E-04	NA	NA	5.94E-04	2.38E-02
Heptachlor	2.16E-10	8.65E-09	9.61E-08	3.84E-06	9.02E-09	3.61E-07	4.01E-06	1.60E-04
Manganese	NA	NA	9.82E-06	3.93E-04	NA	NA	4.09E-02	1.64E-00
Nickel	NA	NA	3.74E-08	1.50E-06	NA	NA	1.56E-04	6.24E-03
Phenol	NA	NA	1.90E-04	7.61E-03	NA	NA	9.65E-05	3.86E-03
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 79B. Estimated Carcinogenic Risks and Hazard Indices for Leachate
Exposure to Adults
E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated		Hazard Indices (2)		Calculated		Hazard Indices (2)	
	Carcinogenic Risk (1)		(Non-carcinogenic Risk)		Carcinogenic Risk (1)		(Non-carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	9.06E-08	1.81E-06	NA	NA	1.08E-08	2.16E-07	NA	NA
Arsenic	1.01E-08	2.01E-07	4.46E-07	8.91E-06	4.92E-05	9.83E-04	2.18E-03	4.35E-02
Benzene	1.65E-08	3.29E-07	NA	NA	1.96E-09	3.92E-08	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	1.38E-05	2.77E-04	NA	NA	6.77E-04	1.35E-02
Heptachlor	2.10E-10	4.20E-09	9.34E-08	1.87E-06	1.03E-08	2.05E-07	4.57E-06	9.13E-05
Manganese	NA	NA	9.54E-06	1.91E-04	NA	NA	4.67E-02	9.32E-01
Nickel	NA	NA	3.63E-08	7.27E-07	NA	NA	1.78E-04	3.55E-03
Phenol	NA	NA	1.85E-04	3.70E-03	NA	NA	1.10E-04	2.20E-03
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

- 1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
CPF = carcinogen potency factor for chemical
EDI = estimated daily intake for chemical

- 2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
EDI = estimated daily intake for chemical
RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 80A. Hazard Indices for Surface Water
 Exposure to Children
 E.H. Schilling Landfill

Constituent	Dermal Exposure Hazard Indices (1) (Non-Carcinogenic Risk)		Ingestion Hazard Indices (1) (Non-Carcinogenic Risk)	
	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA
Benzene	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA
Manganese	5.42E-06	2.17E-04	2.26E-02	9.04E-01
Nickel	8.37E-09	3.35E-07	3.49E-05	1.40E-03
Phenol	NA	NA	NA	NA
Styrene	NA	NA	NA	NA

NA = Not applicable

1) Hazard Index calculated using following equation:

$$HI = EDI(\text{mg/kg/day})/RfD(\text{mg/kg/day})$$

where HI = hazard index for chemical

EDI = estimated daily intake for chemical

RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 808. Hazard Indices for Surface Water
 Exposure to Adults
 E.H. Schilling Landfill

Constituent	Dermal Exposure Hazard Indices (1) (Non-Carcinogenic Risk)		Ingestion Hazard Indices (1) (Non-Carcinogenic Risk)	
	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA
Benzene	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA
Manganese	5.27E-06	1.05E-04	2.58E-02	5.15E-01
Nickel	8.13E-09	1.63E-07	3.98E-05	7.94E-04
Phenol	NA	NA	NA	NA
Styrene	NA	NA	NA	NA

NA = Not applicable

1) Hazard Index calculated using following equation:

$$HI = EDI(\text{mg/kg/day})/RfD(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 81A. Estimated Carcinogenic Risk and Hazard Indices for Ground Water
 Exposure to Children
 E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated		Hazard Indices (2)		Calculated		Hazard Indices (2)	
	Carcinogenic Risk (1)		(Non-Carcinogenic Risk)		Carcinogenic Risk (1)		(Non-Carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	6.60E-06	1.32E-05	NA	NA	6.84E-06	1.37E-05	NA	NA
Arsenic	8.45E-08	1.70E-07	3.75E-06	7.52E-06	3.59E-03	7.19E-03	1.59E-01	3.19E-01
Benzene	3.50E-06	7.02E-06	NA	NA	3.63E-06	7.25E-06	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	3.10E-03	6.22E-03	NA	NA	1.32E+02	2.64E+02
Nickel	NA	NA	1.09E-05	2.19E-05	NA	NA	4.65E-01	9.30E-01
Phenol	NA	NA	9.67E-04	1.94E-03	NA	NA	5.00E-03	1.00E-02
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{Rfd}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 Rfd = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 81B. Estimated Carcinogenic Risks and Hazard Indices for Ground Water
 Exposure to Adults
 E.H. Schilling Landfill

Constituent	Dermal Exposure				Ingestion			
	Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-Carcinogenic Risk)		Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-Carcinogenic Risk)	
	Low	High	Low	High	Low	High	Low	High
1,2-Dichloroethane	NA	7.28E-06	NA	NA	NA	1.78E-05	NA	NA
Arsenic	NA	9.33E-08	NA	4.13E-06	NA	9.33E-03	NA	4.13E-01
Benzene	NA	3.86E-06	NA	NA	NA	9.41E-06	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	NA	NA	NA	3.42E-03	NA	NA	NA	3.42E+02
Nickel	NA	NA	NA	1.21E-05	NA	NA	NA	1.21E+00
Phenol	NA	NA	NA	1.07E-03	NA	NA	NA	1.30E-02
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 82A. Estimated Carcinogenic Risks and Hazard Indices for Air
Exposure to Children
E.H. Schilling Landfill

Constituent	Calculated Carcinogenic Risk		Hazard Indices (Non-Carcinogenic Risk)	
	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA
Benzene	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA
Manganese	NA	NA	3.42E-08	1.37E-06
Nickel	NA	NA	4.89E-09	1.96E-07
Phenol	NA	NA	NA	NA
Styrene	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equations:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
 CPF = carcinogen potency factor for chemical
 EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
 EDI = estimated daily intake for chemical
 RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 82B. Estimated Carcinogenic Risk and Hazard Indices for Air
Exposure to Adults
E.H. Schilling Landfill

Constituent	Calculated Carcinogenic Risk (1)		Hazard Indices (2) (Non-Carcinogenic Risk)	
	Low	High	Low	High
1,2-Dichloroethane	NA	NA	NA	NA
Arsenic	NA	NA	NA	NA
Benzene	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA
Ethylbenzene	NA	NA	NA	NA
Heptachlor	NA	NA	NA	NA
Manganese	NA	NA	7.84E-08	1.57E-06
Nickel	NA	NA	1.12E-08	2.24E-07
Phenol	NA	NA	NA	NA
Styrene	NA	NA	NA	NA

NA = Not applicable

1) Carcinogenic Risk calculated using following equation:

$$\text{Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{EDI}(\text{mg/kg/day})$$

where Risk = calculated carcinogenic risk
CPF = carcinogen potency factor for chemical
EDI = estimated daily intake for chemical

2) Hazard Index calculated using following equation:

$$\text{HI} = \text{EDI}(\text{mg/kg/day})/\text{RfD}(\text{mg/kg/day})$$

where HI = hazard index for chemical
EDI = estimated daily intake for chemical
RfD = reference doses for chemical

Source: Superfund Public Health Evaluation Manual

Table 83. Total Chronic Daily Intakes
E.H. Schilling Landfill

Constituent	Total Daily Intake (1) Ingestion		Total Daily Intake (1) Dermal Contact		Total Daily Intake (1) Inhalation	
	Children	Adult	Children	Adult	Children	Adult
1,2-Dichloroethane	1.54E-04	1.97E-04	2.06E-04	9.97E-05	NA	NA
Arsenic	5.64E-04	6.53E-04	5.92E-08	2.16E-08	7.54E-11	8.61E-11
Benzene	2.52E-04	3.26E-04	2.77E-04	1.44E-04	NA	NA
Benzo(a)pyrene	1.69E-08	1.03E-09	3.24E-10	1.03E-10	3.70E-12	4.23E-12
Ethylbenzene	2.38E-03	1.35E-03	8.48E-05	2.77E-05	NA	NA
Heptachlor	8.02E-08	4.56E-08	2.86E-09	9.34E-10	NA	NA
Manganese	3.81E-01	4.91E-01	1.14E-05	5.71E-06	1.03E-08	1.17E-08
Nickel	1.88E-02	2.42E-02	5.13E-07	2.65E-07	4.03E-09	4.61E-09
Phenol	5.54E-04	6.07E-04	5.31E-04	1.91E-04	2.40E-12	2.74E-12
Styrene	NA	NA	NA	NA	NA	NA

NA = Not applicable

1) Total Daily Intake (TDI) for each exposure route is calculated using following equation:

$$TDI_i = \sum_j EDI_{ij}$$

where TDI_i = total daily intake ith exposure route
 EDI_{ij} = estimated daily intake for ith exposure route
and jth medium (e.g., soil, sediments, etc.)

**Table 84. Hazard Indices and Calculated Carcinogenic Risks
Based on Total Daily Intakes for Ingestion
E.H. Schilling**

Constituent	Total Daily Intake (1) Ingestion		Reference Dose (RfD) (mg/kg/day)	Carcinogen Potency Factor (CPF) (mg/kg/day) ⁻¹ Ingestion	Hazard Indices (2)		Calculated Carcinogenic Risks (3)	
	Children	Adult			Children	Adult	Children	Adult
1,2-Dichloroethane	1.54E-04	1.97E-04	NA	9.12E-02	NA	NA	1.41E-05	1.80E-05
Arsenic	5.64E-04	6.53E-04	1.43E-03	1.58E+01	3.95E-01	4.57E-01	8.92E-03	1.03E-02
Benzene	2.52E-04	3.26E-04	NA	2.90E-02	NA	NA	7.32E-06	9.46E-06
Benzo(a)pyrene	1.69E-08	1.03E-09	NA	1.15E+01	NA	NA	1.94E-07	1.18E-08
Ethylbenzene	2.38E-03	1.35E-03	1.00E-01	NA	2.38E-02	1.35E-02	NA	NA
Heptachlor	8.02E-08	4.56E-08	5.00E-04	4.50E+00	1.60E-04	9.12E-05	3.61E-07	2.05E-07
Manganese	3.81E-01	4.91E-01	1.43E-03	NA	2.66E+02	3.44E+02	NA	NA
Nickel	1.88E-02	2.42E-02	2.00E-02	NA	9.38E-01	1.21E+00	NA	NA
Phenol	5.54E-04	6.07E-04	4.00E-02	NA	1.39E-02	1.52E-02	NA	NA
Styrene	NA	NA	1.43E-01	NA	NA	NA	NA	NA

NA Not applicable.

(1) Total Daily Intake (TDI) for each exposure route is calculated using following equation:

$$TDI_i = \sum_j EDI_{ij}$$

where TDI_i = total daily intake ith exposure route
 EDI_{ij} = estimated daily intake for ith exposure route and jth medium (e.g., soil, sediments, etc.)

(2) Hazard Index = Total Daily Intake/Reference Dose

(3) Calculated Carcinogenic Risk = Total Daily Intake x Carcinogen Potency Factor

Table 85. Hazard Indices and Carcinogenic Risks
Based on Total Daily Intakes for Dermal Contact
E.H. Schilling

Constituent	Total Daily Intake (1) Dermal Contact		Reference Dose (RfD) (mg/kg/day)	Carcinogen Potency Factor (CPF) (mg/kg/day)-1 Ingestion	Hazard Indices (2)		Calculated Carcinogenic Risks (3)	
	Children	Adult			Children	Adult	Children	Adult
1,2-Dichloroethane	2.06E-04	9.97E-05	NA	9.12E-02	NA	NA	1.88E-05	9.09E-06
Arsenic	5.92E-08	2.16E-08	1.43E-03	1.58E+01	4.14E-05	1.51E-05	9.35E-07	3.41E-07
Benzene	2.77E-04	1.44E-04	NA	2.90E-02	NA	NA	8.03E-06	4.18E-06
Benzo(a)pyrene	3.24E-10	1.03E-10	NA	1.15E+01	NA	NA	3.73E-09	1.18E-09
Ethylbenzene	8.48E-05	2.77E-05	1.00E-01	NA	8.48E-04	2.77E-04	NA	NA
Heptachlor	2.86E-09	9.34E-10	5.00E-04	4.50E+00	5.72E-06	1.87E-06	1.29E-08	4.20E-09
Manganese	1.14E-05	5.71E-06	1.43E-03	NA	8.01E-03	4.00E-03	NA	NA
Nickel	5.13E-07	2.65E-07	2.00E-02	NA	2.57E-05	1.33E-05	NA	NA
Phenol	5.31E-04	1.91E-04	4.00E-02	NA	1.33E-02	4.77E-03	NA	NA
Styrene	NA	NA	1.43E-01	NA	NA	NA	NA	NA

NA Not applicable

(1) Total Daily Intake (TDI) for each exposure route is calculated using following equation:

$$TDI_i = \sum_j EDI_{ij}$$

where TDI_i = total daily intake i th exposure route
 EDI_{ij} = estimated daily intake for i th exposure route
and j th medium (e.g., soil, sediments, etc.)

(2) Hazard Index = Total Daily Intake/Reference Dose

(3) Calculated Carcinogenic Risk = Total Daily Intake x Carcinogen Potency factor

Table 86. Hazard Indices and Calculated Carcinogenic Risks
Based on Total Daily Intakes for Inhalation
E.H. Schilling Landfill

Constituent	Total Daily Intake (1) Inhalation		Reference Dose (RfD) (mg/kg/day)	Carcinogen Potency Factor (CPF) (mg/kg/day) ⁻¹ Inhalation	Hazard Indices (2)		Calculated Carcinogenic Risks (3)	
	Children	Adult			Children	Adult	Children	Adult
1,2-Dichloroethane	NA	NA	NA	9.12E-02	NA	NA	NA	NA
Arsenic	7.54E-11	8.61E-11	1.43E-03	5.00E+01	5.28E-08	6.03E-08	3.77E-09	4.31E-09
Benzene	NA	NA	NA	2.90E-02	NA	NA	NA	NA
Benzo(a)pyrene	3.70E-12	4.23E-12	NA	1.15E+01	NA	NA	4.25E-11	4.86E-11
Ethylbenzene	NA	NA	1.00E-01	NA	NA	NA	NA	NA
Heptachlor	NA	NA	5.00E-04	NA	NA	NA	NA	NA
Manganese	1.03E-08	1.17E-08	1.43E-03	NA	7.18E-06	8.22E-06	NA	NA
Nickel	4.03E-09	4.61E-09	2.00E-02	NA	2.02E-07	2.30E-07	NA	NA
Phenol	2.40E-12	2.74E-12	4.00E-02	NA	6.00E-11	6.85E-11	NA	NA
Styrene	NA	NA	1.43E-01	NA	NA	NA	NA	NA

NA Not applicable

(1) Total Daily Intake (TDI) for each exposure route
is calculated using following equation:

$$TDI_i = \sum_j EDI_{ij}$$

where TDI_i = total daily intake ith exposure route
 EDI_{ij} = estimated daily intake for ith exposure route
and jth medium (e.g., soil, sediments, etc.)

(2) Hazard Index = Total Daily Intake/Reference Dose

(3) Calculated Carcinogenic Risk = Total Daily Intake x Carcinogen Potency factor

Table 87. Cumulative Carcinogenic Risks
 Based on Calculated Carcinogenic Risks
 for Ingestion, Dermal Exposure, and Inhalation
 E.H. Schilling

Constituent	Calculated Carcinogenic Risks							
	Ingestion		Dermal Contact		Inhalation		Cumulative (1)	
	Children	Adults	Children	Adults	Children	Adults	Children	Adults
1,2-Dichloroethane	1.41E-05	1.80E-05	1.88E-05	9.09E-06	NA	NA	3.29E-05	1.80E-05
Arsenic	8.92E-03	1.03E-02	9.35E-07	3.41E-07	3.77E-09	4.31E-09	8.92E-03	1.03E-02
Benzene	7.32E-06	9.46E-06	8.03E-06	4.18E-06	NA	NA	1.54E-05	9.46E-06
Benzo(a)pyrene	1.94E-07	1.18E-08	3.73E-09	1.18E-09	4.25E-11	4.86E-11	1.98E-07	1.18E-08
Ethylbenzene	NA	NA	NA	NA	NA	NA	NA	NA
Heptachlor	3.61E-07	2.05E-07	1.29E-08	4.20E-09	NA	NA	3.74E-07	2.05E-07
Manganese	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	NA	NA	NA	NA	NA	NA	NA	NA
Styrene	NA	NA	NA	NA	NA	NA	NA	NA

NA Not Applicable

(1) Cumulative Carcinogenic Risks is the sum of the calculated carcinogenic risks for ingestion, dermal exposure, and inhalation.

Table 88. Cumulative Hazard Indices
 Based on Calculated Hazard Indices
 for Ingestion, Dermal Contact, and Inhalation
 E.H. Schilling

Constituent	Hazard Indices (1) Ingestion		Hazard Indices (1) Dermal Contact		Hazard Indices (1) Inhalation		Total Hazard Indices (2)	
	Children	Adult	Children	Adult	Children	Adult	Child	Adult
1,2-Dichloroethane	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	3.95E-01	4.57E-01	4.14E-05	1.51E-05	5.28E-08	6.03E-08	3.95E-01	4.57E-01
Benzene	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Ethylbenzene	2.38E-02	1.35E-02	8.48E-04	2.77E-04	NA	NA	2.46E-02	1.38E-02
Heptachlor	1.60E-04	9.12E-05	5.72E-06	1.87E-06	NA	NA	1.66E-04	9.31E-05
Manganese	2.66E+02	3.44E+02	8.01E-03	4.00E-03	7.18E-06	8.22E-06	2.66E+02	3.44E+02
Nickel	9.38E-01	1.21E+00	2.57E-05	1.33E-05	2.02E-07	2.30E-07	9.38E-01	1.21E+00
Phenol	1.39E-02	1.52E-02	1.33E-02	4.77E-03	6.00E-11	6.85E-11	2.72E-02	2.00E-02
Styrene	NA	NA	NA	NA	NA	NA	NA	NA
Cumulative HI (3):	2.67E+02	3.46E+02	2.22E-02	9.08E-03	7.43E-06	8.51E-06	2.67E+02	3.46E+02

NA Not applicable

(1) Hazard Index = Total Daily Intake/Reference Dose

(2) Total Hazard Index calculated by summing across the exposure routes. This assumes that each exposure route is present at each exposure point.

(3) Cumulative Hazard index is calculated by summing the hazard index of each chemical. This is a conservative approach as it assumes the same toxicological mode of action for each of the non-carcinogenic chemicals.

1976). Therefore, although manganese was detected in sample SS-31 at a concentration of 1210 mg/kg, approximately twice the site average, this value is still well within normal natural ranges.

6.4.1.2 Dermal Exposure Route

The dermal exposure route analysis for non-carcinogenic indicator chemicals results indicate there would be no unacceptable risks as a result of exposure (Tables 71 through 82).

6.4.1.3 Inhalation Exposure Route

The inhalation exposure route analysis for non-carcinogenic indicator chemicals results indicate there would be no unacceptable risks as a result of exposure (Tables 71 through 82).

6.4.2 Carcinogenic Risk

6.4.2.1 Ingestion Exposure Route

A total incremental risk for a child via ingestion for the carcinogenic indicator chemicals over all media. The results indicate that three of the indicator chemicals (arsenic, $(8.92E^{-03})$ benzene, $(7.32E^{-06})$ and 1,2-dichloroethane $(1.4E^{-05})$) potentially pose an unacceptable risk. Although calculated incremental risks indicate that both benzene and 1,2-dichloroethane exceed the 1×10^{-6} risk level in ground water; the maximum detected concentrations of these constituents in the ground water do not exceed the respective ground water ARARs; i.e. the MCLs from the Safe Drinking Water Act.

Because the potential for ingestion of contaminated ground water is low, and because the current maximum concentrations in ground water are at or below the ARARs, exposure to benzene and/or 1,2-dichloroethane does not appear to pose an unacceptable risk to human health.

The incremental risk associated with exposure to the carcinogenic indicator chemicals was calculated by multiplying the carcinogenic potency factor (obtained from IRIS) by the estimated daily intakes (calculated from exposure point concentrations) at the exposure points. Arsenic exceeds the 1×10^{-6} risk level in four of the site-specific media (ground water, $(7.19(10^{-3}))$ leachate, $(1.73(10^{-3}))$ surface soils $(5.44(10^{-6}))$ and sediment $(2.42(10^{-6}))$). Arsenic concentrations in surface soil samples from the site ranged from not detected to 11 mg/kg at mean concentration of 4.0 mg/kg. The surface soil background samples SS-07 and SS-27 contained arsenic concentrations of 4.5 mg/kg and not detected, respectively. Sediment arsenic concentrations at the site ranged from 2.5 to 4.9 mg/kg with a mean concentration of 3.4 mg/kg. The sediment background sample, SD-04, contained arsenic at a concentration of 2.8 mg/kg. A comparison of site-specific arsenic concentrations with published values by media is shown in Table 89. The calculated risk for arsenic at this site is comparable to risks computed for naturally occurring concentrations throughout the United States.

6.4.2.2 Dermal Exposure Route

A total incremental risk for a child via dermal exposure was calculated for the carcinogenic indicator chemicals over all media. The results indicate that two of the indicator chemicals

Table 89. Site-Specific Arsenic Concentrations
 Compared with Published Data by Media Type

Media	Site-specific Detected Concentrations	Published Concentrations
Ground water	Avg. 4.3 Range (2.1 to 9.1)ug/l	Avg. 17.9 Range (0.01 to 800) ug/l
Surface soils	Avg. 4.1 Range (1.8 to 11)mg/kg	7.4 mg/kg Uncontaminated Soils Nationwide
Sediment	Avg. 3.4 Range (2.5 to 4.9)mg/kg	Avg. 2.6 Range (0.6 to 6.2) mg/kg
Air	0.007 ug/m	Range (0.0 to 0.16)ug/m

Source: US FWS, 1988. Contaminant Hazard Reviews, Rpt. 12, Arsenic Hazards to Fish, Wildlife and Invertebrates: A Synoptic Review

(benzene, $8.03E^{-06}$) and 1,2-dichloroethane ($1.88E^{-05}$)) potentially pose an unacceptable risk.

Exposure to benzene and/or 1,2-dichloroethane does not appear to pose an unacceptable risk to human health because the potential for dermal exposure of contaminated ground water is low, and the current maximum concentrations in ground water are at or below the ARARs. The maximum concentration for 1,2-dichloroethane (0.014 mg/l) did exceed the ARARs in the leachate.

6.4.2.3 Inhalation Exposure Route

The inhalation exposure route for carcinogenic indicator chemicals results indicate there would be no unacceptable risk as a result of exposure (Tables 71 through 82).

6.5 Assumptions and Site-Specific Uncertainty Factors

The assumptions made in appraising the risk result in a conservative estimate. This estimate may overstate the practical risk; it is really a "worst-case" scenario. Results of the baseline evaluation cannot be interpreted as statements of absolute risk since the number of assumptions made and uncertainties present do not allow quantitative analysis of complete risk. The results highlight potential sources of risk which can be used to guide remediation.

The following uncertainties and assumptions apply to this risk assessment:

- o The risk assessment was performed without consideration of remediation activities. The results of this risk assessment, therefore, apply to the site in its current state and do not take into account any physical site changes.
- o Overall data adequacy specifically the analytical data for the site samples, is assumed to be correct and of sufficient detail.
- o Laboratory QA/QC problems with contaminated blanks caused the associated sample analytical data to be suspect.
- o The indicator chemicals evaluated as part of this risk assessment were the most toxic, mobile, and environmentally persistent of the chemicals detected at the site and are assumed to be representative of the chemical risk at the site.
- o Samples SW-01, SD-01, and SS-32 were determined to be not representative of the site due to contamination by other sources.
- o Maximum chemical concentrations in the eight media samples were used to estimate the exposure concentrations resulting in a conservative estimate which overestimates the risk.
- o The risk assessment considered all chemicals detected at or above the contract required qualification limits (CRQL). Tentatively identified compounds and chemicals detected at concentrations below the CRQL were not addressed.

- o Summing the exposure over each route probably overestimates the risk since it is highly unlikely that any one person would be exposed to all media types over an extended period of time.

6.6 Conclusions

This risk assessment was conducted in general accordance with procedures described in the following documents: "Superfund Public Health Evaluation Manual," US EPA, October, 1986; "Superfund Exposure Assessment Manual," US EPA, April 1988; and "US EPA Endangerment Assessment Handbook," ICAIR, 1985.

This risk assessment evaluated the available site-specific physical and analytical data in characterizing potential risks to human health and the environment in the absence of any remedial action at the site. The risk assessment may also serve as the baseline against which proposed remediation alternatives may be evaluated.

Twenty-nine complete human receptor and thirty-seven complete environmental receptor exposure pathways exist based on the ten indicator chemicals.

The purpose of this risk assessment was to evaluate the risk to human health and the environment given the current site conditions. The risk characterization has been based on a worst case assumption that the same child will be exposed to all media types over an extended period of time (i.e. five years) or adult for 70 years. This assumption, which is

very conservative, was incorporated because no site-specific feature; e.g. fence line, exists to define the point of exposure.

The risk characterization exposure via inhalation was evaluated by summing over all media (i.e. most conservative approach). The results indicated that inhalation did not currently present an unacceptable risk to human health.

Exposure via ingestion and dermal contact were also summed over all media (i.e. most conservative approach). The results indicated that exposure via ingestion and dermal contact potentially posed an unacceptable risk. The non-carcinogenic indicator chemical present with an unacceptable hazard index (266) was manganese. The carcinogenic indicator chemicals present at unacceptable risk levels were benzene ($7.32E^{-06}$, ingestion; $8.03E^{-06}$, dermal), 1,2-dichloroethane ($1.41E^{-05}$, ingestion; $1.88E^{-05}$, dermal), and arsenic ($8.92E^{-05}$, ingestion). However, if ground water was considered separate from the other seven media types, the risk to human health due to exposure via ingestion or dermal contact is very low. Evaluating the ground-water pathway separately is entirely appropriate as the exposure assessment conservatively indicates that a low potential for exposure exists via the ground-water pathway. This was supported by analytical data from the ground-water source nearest the landfill which showed the absence of site-specific chemicals. In addition, the maximum concentrations for benzene (0.005 mg/l) and 1,2-dichloroethane (0.003 mg/l) detected in the ground water do not exceed the ground-water ARARs, (0.005 mg/l) and (0.005 mg/l) respectively.

The site-specific and national average natural background concentrations of arsenic and manganese, the two inorganic indicator chemicals which exceed ground-water ARARs, are well within the expected ranges for those metals in all media types at the site.

Given the results of the risk characterization, and considering the conservative assumptions that were used throughout the risk calculation process, the site in its current condition does not present a high risk of exposure to human and environmental receptors. Detailed risk calculations were not developed for the environmental receptors because it was assumed that the risks determined for human exposure would be protective for both receptor types.

Unchecked erosion of the diversion ditches and landfill cap, as well as any increased seepage through the earthen dam will increase the future potential for risk from exposure to ground water, surface water, leachate, sediment, and surface soil. Alternate site use such as residential and agriculture (with associated installation of ground-water supply wells on the landfill), or the excavation and removal of materials from the site would increase the risk of exposure to human receptors.

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