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FINAL REMEDIAL INVESTIGATION REPORT FOR THE WAINWRIGHT PROPERTY OPERABLE UNIT VALLEY PARK, MISSOURI

April 20, 1994

PREPARED FOR

MISSOURI DEPARTMENT OF NATURAL RESOURCES
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1 0 INTRODUCTION

This Draft Remedial Investigation Report was developed pursuant to Section VII C 3 of the Wainwright Property Operable Unit-Administrative Order on Consent for Remedial Investigation/Feasibility Study (RI/FS) dated May 22, 1991, and Task 3, Section D of the Statement of Work for Remedial Investigations and Feasibility Studies, Wainwright Operable Unit, Valley Park, Missouri, utilizing the Environmental Protection Agency (EPA) format as outlined in "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" The development of this report was aided by utilizing the references listed at the end of this report

1.1 Purpose of Report

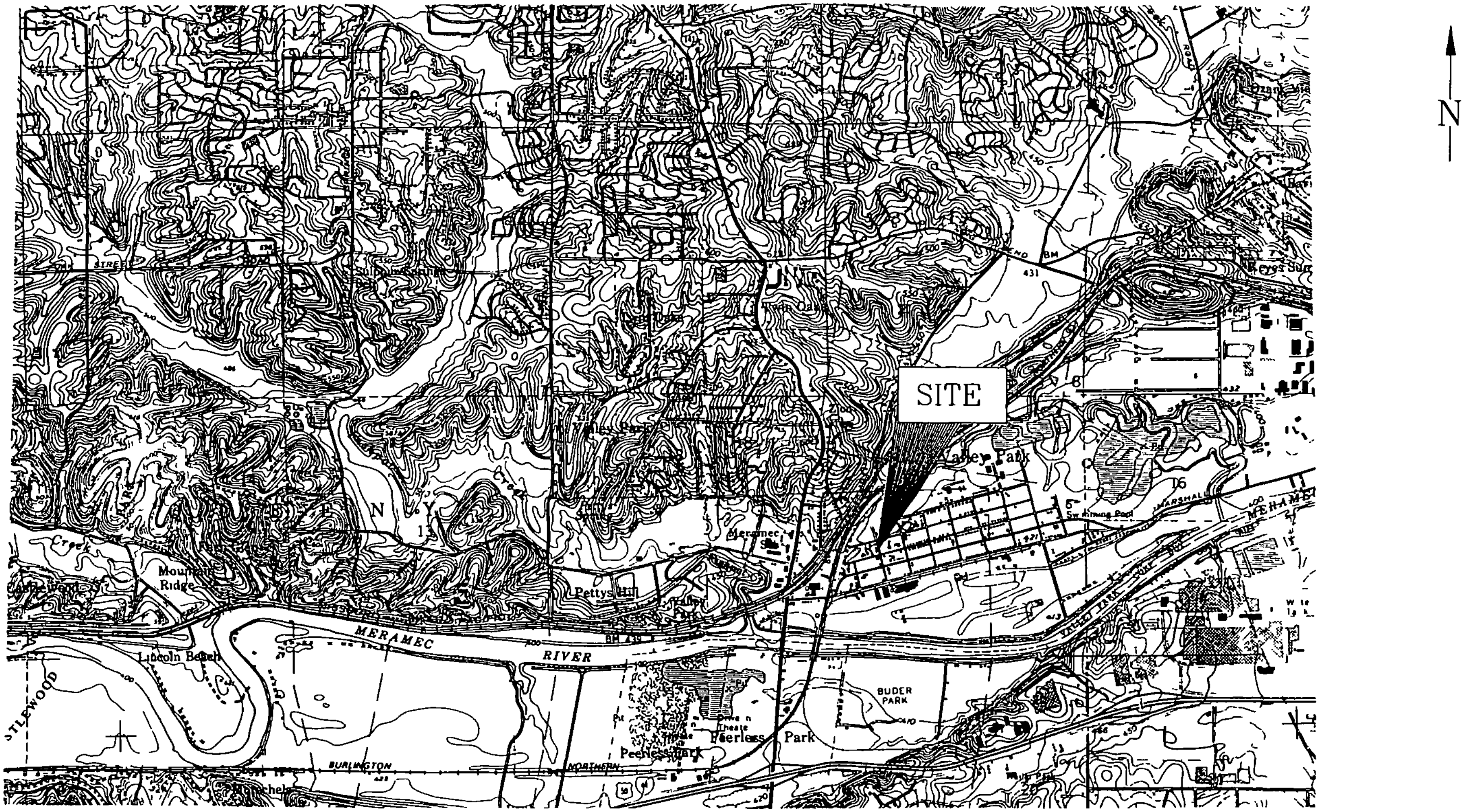
The purpose of this report is to provide a concise summary of site characterization activities which have occurred at the Wainwright Operable Unit in Valley Park, Missouri The report reviews the investigative activities which have taken place, summarizes the data which have been collected, describes the site, and provides an overview of present site conditions This report will provide a basis for the development of a risk assessment, evaluation and screening of remedial alternatives, and refinement and identification of applicable or relevant and appropriate standards, limitations, criteria and requirements (ARARs)

1 2 Site Background

1 2 1 Site Description

The Wainwright Operable Unit, part of the Valley Park TCE site, is located at 224 Benton Avenue in Valley Park, Missouri The legal description of the site is as follows, the NE ¼, NW ¼, SW ¼, Section 17, T 44 N, R 5 E Figure 1 depicts the geographic location of the site in relation to the Valley Park region The site consists of city lots 1203, 0800, 0653 and 0644 (see Figure 2 for property boundaries) The site is bordered by residential property to the east, Vest Avenue to the north, industrial property to the west, and Benton Avenue to the south The industrial property to the west is used by Valcour Printing and the St Louis Boat and Canoe Company

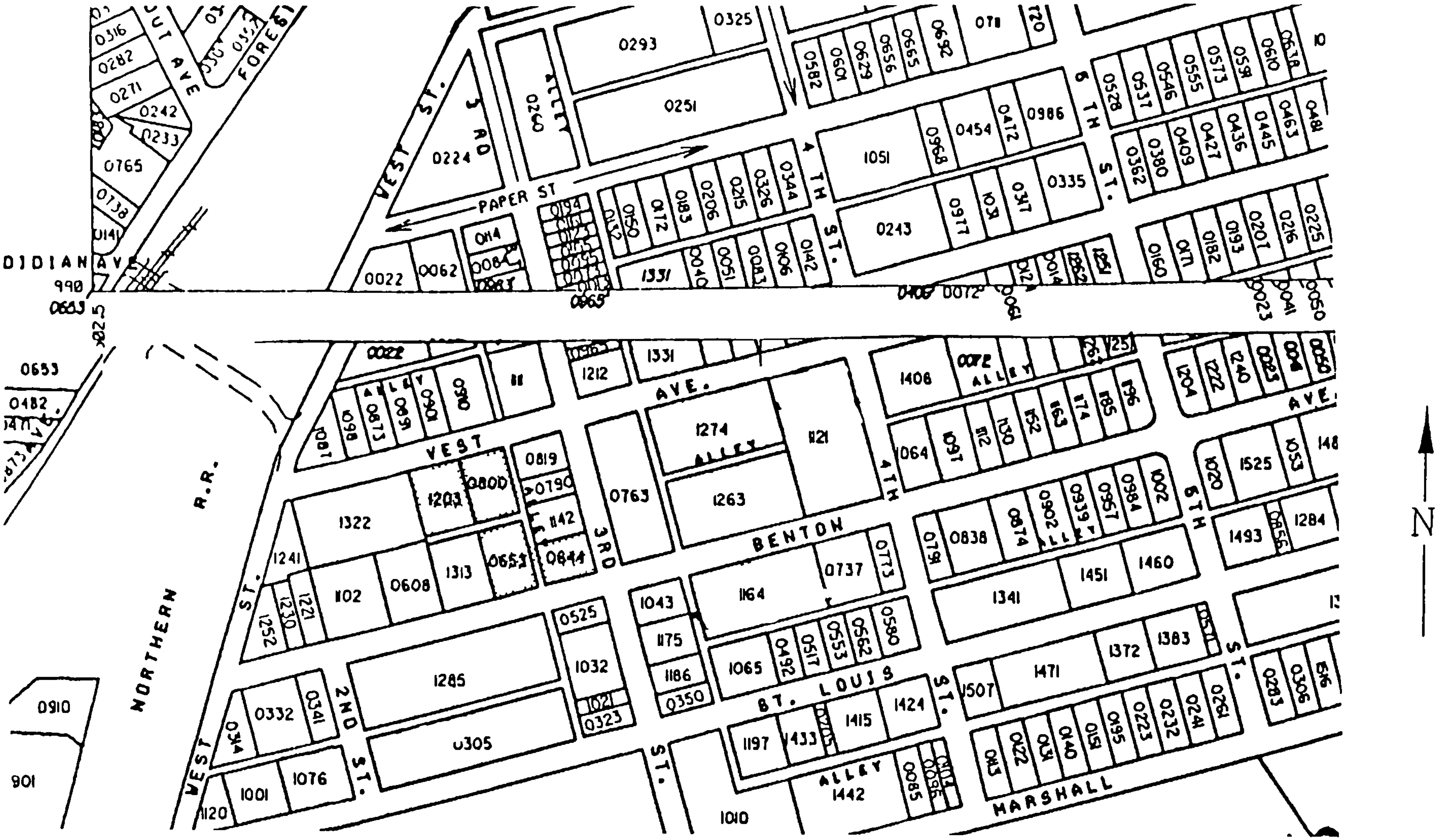
Currently, the property contains one building which is constructed of wood and metal The building houses offices and manufacturing facilities The L E Mueller Company is the current tenant of the facility The rear portion of the site contains gravel driveways and a parking/storage lot The remaining portion of the site is relatively flat and grass covered Sewer and water lines traverse the property from west to east, turning 90° at the east end of the property and extending south to Benton Avenue



Source Kirkwood and Manchester Quadrangles
Missouri
7 5 Minute Series (Topographic)

VALLEY PARK VICINITY
VALLEY PARK MISSOURI

FIGURE 1	SCHREIBER & GRANA YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS
SCALE 1 =2000	
WAIN 07	



WAINWRIGHT INDUSTRIES PROPERTY BOUNDARIES LOTS 1203, 0800, 0653 AND 0644

FIGURE 2

SCALE
1" = 160'

WAIN 07

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& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS

The property is currently owned by Wainwright Industries, Inc and was previously occupied by Wainwright Industries, Inc from 1947 to 1980 Wainwright then leased the facility to Imperial Ornamental Metal Company, Inc (IOM) from 1980 until 1987 Following IOM, Wainwright leased the property to L E Mueller, Inc (Mueller), the current tenant All of the tenants from 1947 through the present have been involved in metal fabrication

1 2 2 Site History

Valley Park is a small municipality (1980 population 3,232) located on the north bank of the Meramec River in south central St Louis County, Missouri The area is primarily industrial and residential but periodic flooding of the Meramec River limits its use as an industrial area Valley Park's history has naturally been linked to the Meramec River The area was an Indian settlement including three areas which manufactured stone war clubs, tomahawks and arrowheads In 1760, the area was settled by a small group of pioneers In 1855, the Missouri Pacific Railroad built a station just north of the current downtown area A settlement called Meramec began to grow around the station In 1900, the community was renamed Valley Park From 1902 to 1907, the population of Valley Park grew from 300 to over 2,000 due mainly to the construction of the St Louis Plate Glass Company factory By 1909, other industries had located in Valley Park In 1915, the river rose 35 feet above flood stage, leaving 2,000 people homeless and causing substantial damage to the glass company which declared bankruptcy and relocated Other industries also relocated and Valley Park was reduced to a resort town of 500 inhabitants During Prohibition, Valley Park became a popular resort area After Prohibition, the resort industry decreased markedly From the 1930s to the present, the area has experienced slow growth with industry leading the way

Wainwright Industries has owned the property at 224 Benton Avenue since 1947 Wainwright manufactured metal stampings and operated as a contract tool and die shop at the property Part of the manufacturing process included a solvent degreasing system that used trichloroethylene from 1963 to 1970 and tetrachloroethylene from 1970 to 1979 These chemicals were stored in a 1,000 gallon above ground storage tank In 1980, the property was leased to IOM, which operated at the location until 1987 IOM produced ornamental and structural metal fabrications for various industries Plant processes included cutting, milling, grinding, drilling, welding and painting Since April 1988, the property has been leased to Mueller, a repair/remodeling shop for emergency fire vehicles

1 2 3 Previous Investigations

Sample analyses by the Missouri Department of Natural Resources in July 1982 and April 1983, detected volatile organic compounds (VOCs), including trichloroethylene (TCE), tetrachloroethylene (PCE) and 1,1,1-trichloroethane (TCA) in three Valley Park municipal wells Figure 3 presents the locations of the three Valley Park municipal wells, along with two Kirkwood municipal wells (and all groundwater monitoring wells, discussed later in this report)

The level of VOCs increased dramatically during late 1983 and early 1984 Valley Park Well 3 In July, 1987, Valley Park Well #3 found to contain 236 parts per billion (ppb) of TCA and 337 ppb of TCE Subsequent monitoring by MDNR showed other wells in the area similarly contaminated A summary of the Valley Park Municipal Wells Contamination Data is provided by Table 1

In June, 1983, a partial NPDES compliance monitoring inspection was performed by the EPA, Region VII at the Spencer-Kellogg facility (owned by Reichhold Chemical, Inc [Reichhold]) in downtown Valley Park (see Figure 1) Reichhold, a division of NL Chemical, manufacturers resins and polyesters Prior to 1979, this plant was owned by Ashland Chemical Company, Columbus, Ohio Ashland Chemical produced resins, polyesters, paints, varnishes and lacquers The EPA analytical results in June, 1983 indicted the presence of chlorinated hydrocarbons Since the source of the water was from an on-site well and the well was only used for non-contact cooling, the investigation concluded that the well water was contaminated

In 1985, the EPA performed a partial evaluation of the problem under the Hazard Ranking System Since the actual source area was undetermined, only the groundwater route was ranked The reviewer concluded that there was an observed release of contaminants to the aquifer On the November, 1989 National Priorities List, the Valley Park TCE Site was ranked 597

In 1986, the EPA and PRC Engineering, Chicago, Illinois, performed a potentially responsible party (PRP) search As stated in the PRP Search, Wainwright Industries was identified as the most likely PRP based on circumstantial evidence The PRC also cited another industry in Valley Park as a possible PRP and stated that <u>unknown sources</u> may have led to the contamination of the Valley Park wells

TAB[illegible] 1
CONTAMINATION DATA FOR VALLEY PARK MUNICIPAL WELLS (7-12-82 - 7-23-87)
Source PRC Engineering, 1986
ESE Limited RI, 1988

Date	Well #1			Well #2			Well #3		
	Trichloro-ethylene (ug/l)	Tetrachloro-ethylene (ug/l)	1,1,1-Trichloro-ethane (ug/l)	Trichloro-ethylene (ug/l)	Tetrachloro-ethylene (ug/l)	1,1,1-Trichloro-ethane (ug/l)	Trichloro-ethylene (ug/l)	Tetrachloro-ethylene (ug/l)	1,1,1-Trichloro-ethane (ug/l)
July 12, 1982	--	--	--	--	--	--	95	1 5	33
April 6, 1983*	--	--	--	67	3 3	38	56	3 0	34
	--	--	--	63	3 5	37	69	3 5	38
April 14, 1983*	75	10 0	49	--	--	--	--	--	--
	76	12 0	48	--	--	--	--	--	--
September 19, 1983*	310	222	58	420	21 0	280	20	3 6	12
	280	130	60	370	18 0	26	370	16 0	190
October 12, 1983	290	120	130	190	16 0	120	280	78	180
November 9, 1983	310	94	180	180	16 0	120	--	--	--
December 14, 1983	220	58	140	110	6 7	11 0	--	--	--
February 3, 1984	330	200	140	--	--	--	200	12 0	120
June 26, 1984	--	--	--	--	--	--	180	11 0	120
October 24, 1984	63	18	62	--	--	--	93	9 2	120
January 29, 1985	62	78	25	--	--	--	140	9 1	75
June 18, 1985*	25	42	7 7	--	--	--	98	9 6	57
	30	44	10 0	--	--	--	90	9 9	56
July 10, 1985*	--	--	--	--	--	--	79	8 4	47
	--	--	--	--	--	--	83	8 1	44
September 16, 1985	41	63	16	--	--	--	113	11 2	67
October 28, 1985	46	33	19	--	--	--	56	5 2	32
March 17, 1986	26	21	9 1	--	--	--	79	6 9	46
July 23, 1987	21 1	140	4 25	--	--	--	337	225	236

*Morning and afternoon samples, respectively
-- denotes non-detect concentrations

On or about August 13, 1986, MDNR, with assistance from the City of Valley Park, collected and analyzed three shallow soil samples taken near the sewer line manhole from the alley between Benton and Vest Street to the rear of the Wainwright property The analytical results revealed the presence of chlorinated hydrocarbons, similar to those found impacting the City of Valley Park municipal water supply wells A shallow soil sample collected from a shallow (0 inches to 2 inches below grade) immediately outside of the sewer line excavation produced 51 ppb benzene, and 2100 ppb TCE A samples collected from within the excavation (0 inches to 15 inches below grade) produced 100 ppb PCE, while a second sample collected from within the excavation (15 inches to 24 inches below grade) produced 430 ppb benzene, 35 ppb chlorobenzene, 570 ppb trans 1,2 dichlorobenzene, 190 ppb ethylbenzene, 43 ppb TCA, and 28,500 ppb TCE

In March, 1987, MDNR conducted a Hazardous Waste Compliance Inspection at Wainwright Industries in St Peters, Missouri, and at IOM Company in Valley Park, the former tenant at the Wainwright Industries property These inspections revealed that IOM was not a generator of chlorinated hydrocarbon wastes, and that Wainwright Industries then used PCE at their St Peters facility and earlier used PCE and TCE at the Valley Park Facility

Between May and September, 1987, Hunter Engineering/ESE (ESE) performed a Limited Remedial Investigation (LRI) for MDNR This investigation was primarily a groundwater study with the emphasis placed on the Valley Park investigation area Twenty-six monitoring wells were installed at 17 locations The ESE wells in the Valley Park investigation area and their cross sections are shown in Figures 3, 4, 5, 6 and 7 One round of sampling and analysis was performed, including existing industrial wells, municipal wells and the Meramec river The analytical results are shown in Table 2

Summarizing the ESE LRI (for inclusion in this RI) indicated the following regarding the area of investigation

- Groundwater table elevations (on August 27, 1987) ranged from a high of 391 21 feet above mean sea level (MSL) in MW-1C , to 385 83 feet MSL in MW-15C (Table 3)

- PCE, TCE and TCA concentrations in the groundwater were found at various locations

- Sources of TCE and PCE contamination appeared to be in the vicinity of the alley located in the block immediately north of Well 17 and a source of TCA contamination appears to be located between Marshall Road and Valley Park Well 3

- The highest TCA concentration was found in Valley Park Well 3

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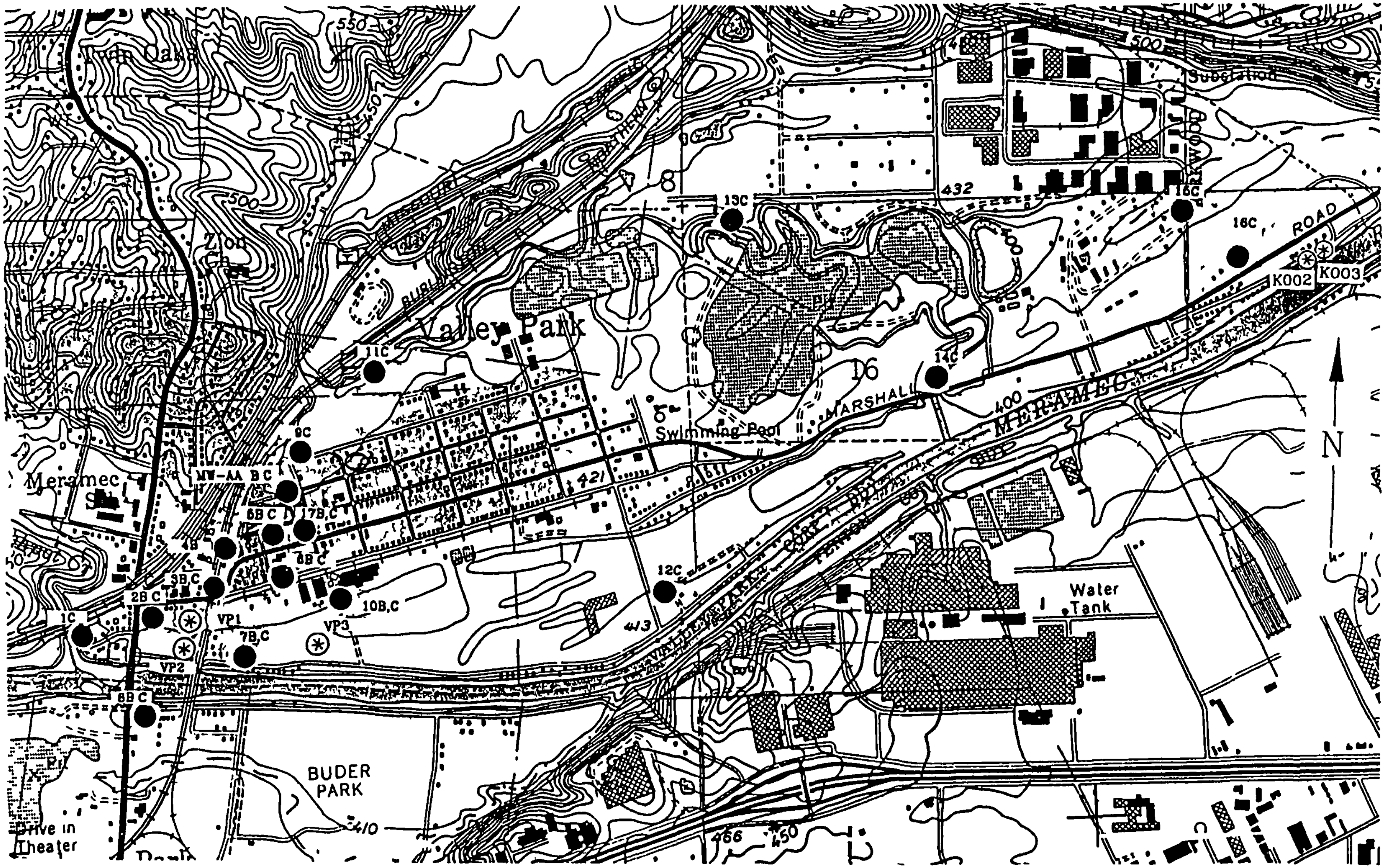

LEGEND

CROSS SECTION (9-VP3) KIRKWOOD (K) PUMPING WELL
VALLEY PARK (VP) PUMPING WELL ⊛

CROSS SECTION (1-17) GROUNDWATER MONITORING WELL ●

CROSS SECTION (9-8)

VALLEY PARK MUNICIPAL
WELLS & GROUNDWATER
MONITORING WELLS
VALLEY PARK-KIRKWOOD
VICINITY
VALLEY PARK, MISSOURI

FIGURE 3

SCALE
1" = 1620'

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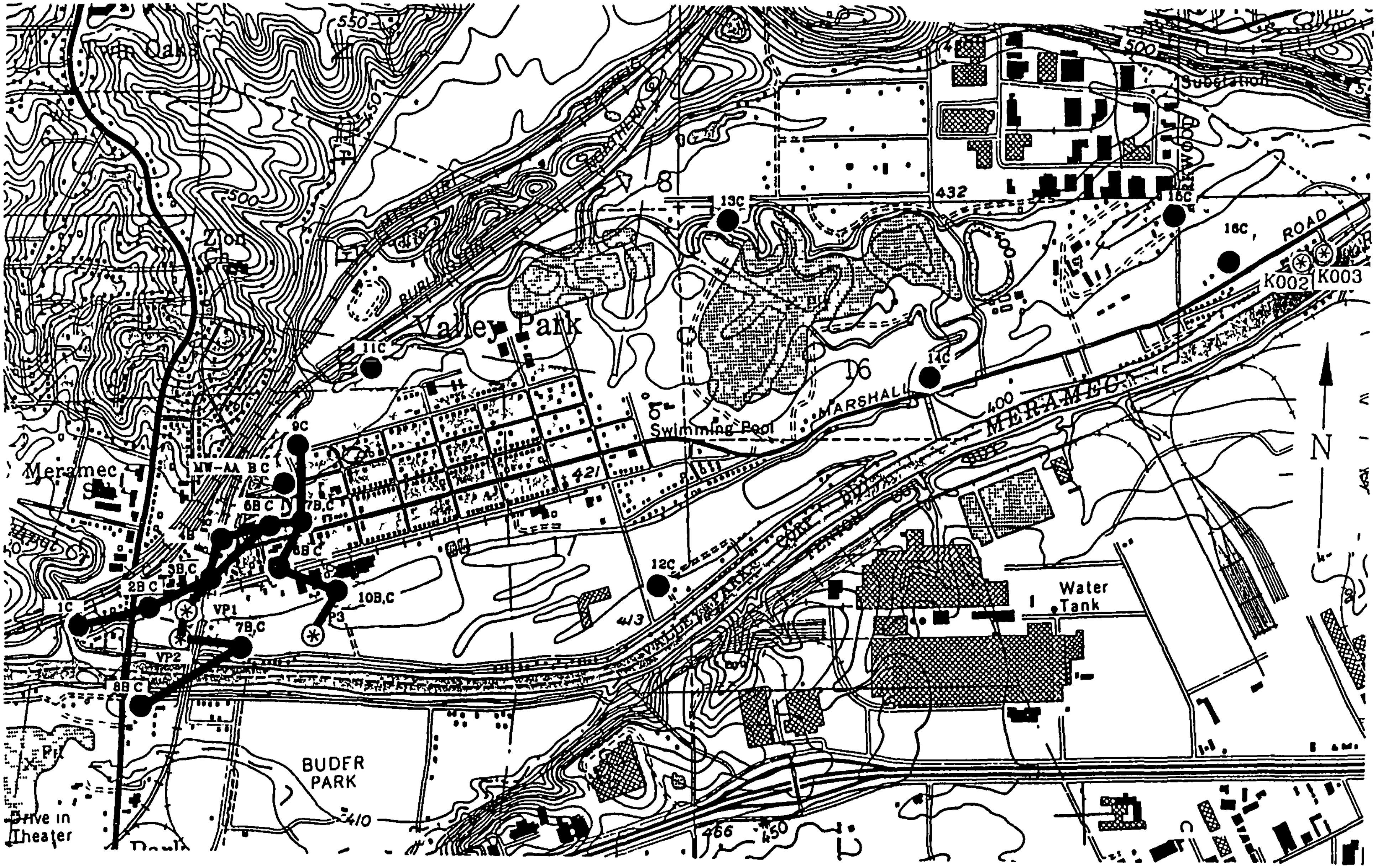


LEGEND

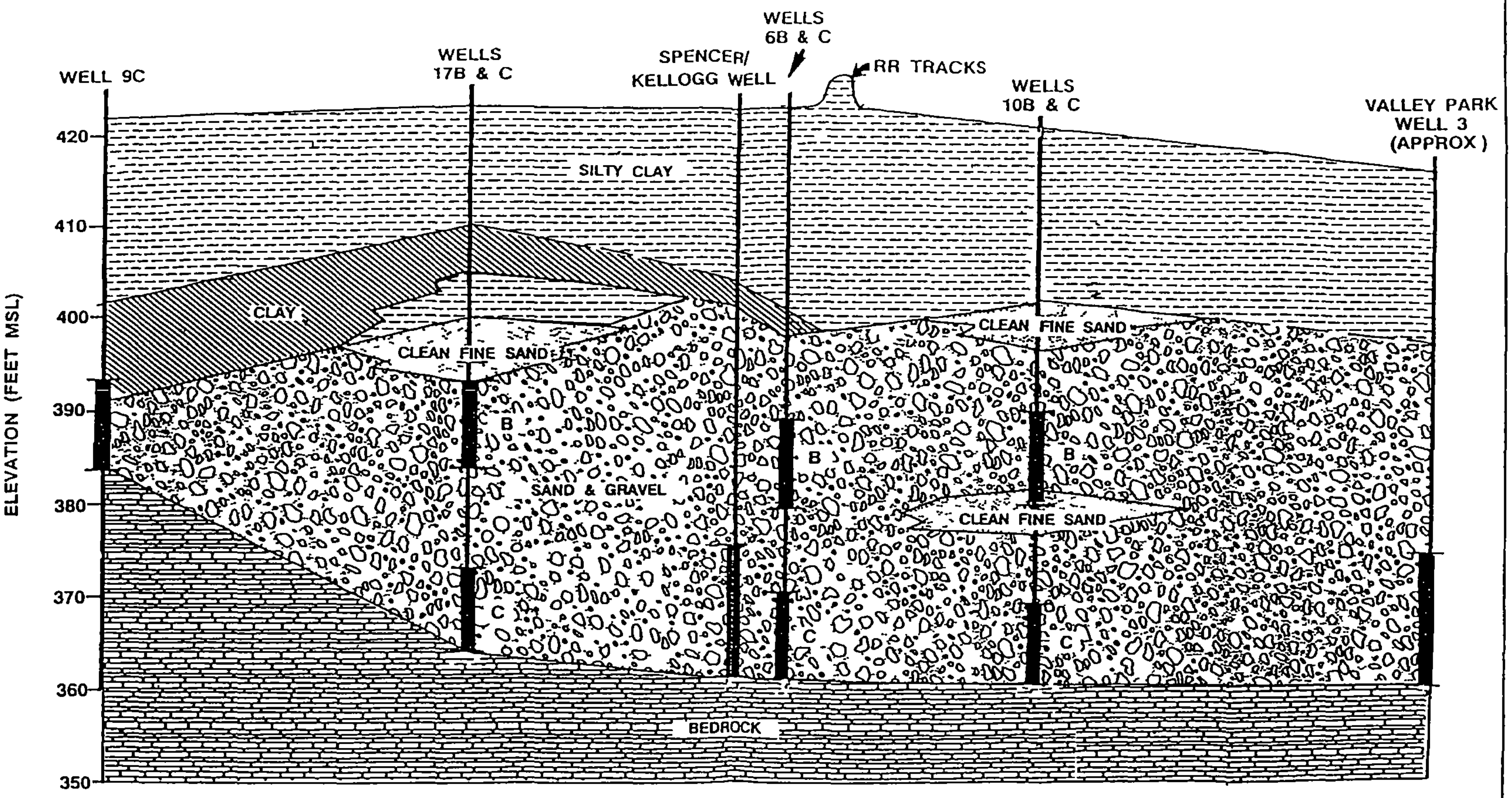
CROSS SECTION (9–VP3)

CROSS SECTION (1–17)

CROSS SECTION (9–8)

KIRKWOOD (K) PUMPING WELL VALLEY PARK (VP) PUMPING WELL	⊛
GROUNDWATER MONITORING WELL	●

MUNICIPAL AND MONITORING WELL LOCATIONS, AND CROSS SECTIONS VALLEY PARK, MISSOURI	FIGURE 4 SCALE 1" = 1620' WAIN 07	SCHREIBER GRANA & YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS



SOURCE: ESE, INC. 1988

GEOLOGIC
CROSS SECTION 9-VP3
VALLEY PARK MISSOURI

FIGURE 5

9/16/93

WAIN 07

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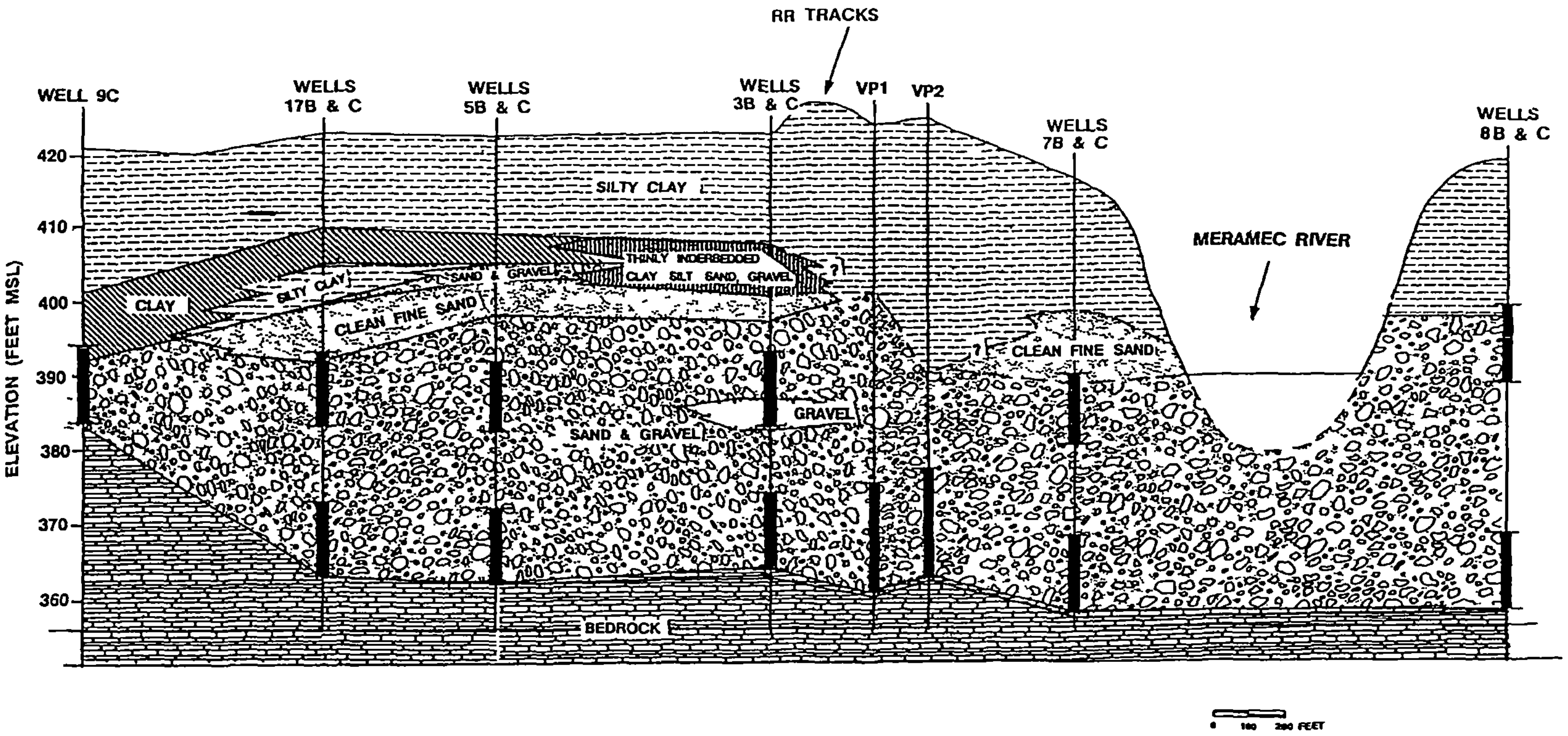
& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



SOURCE: ESE, INC., 1988

GEOLOGIC
CROSS SECTION 9-8
VALLEY PARK MISSOURI

FIGURE 6

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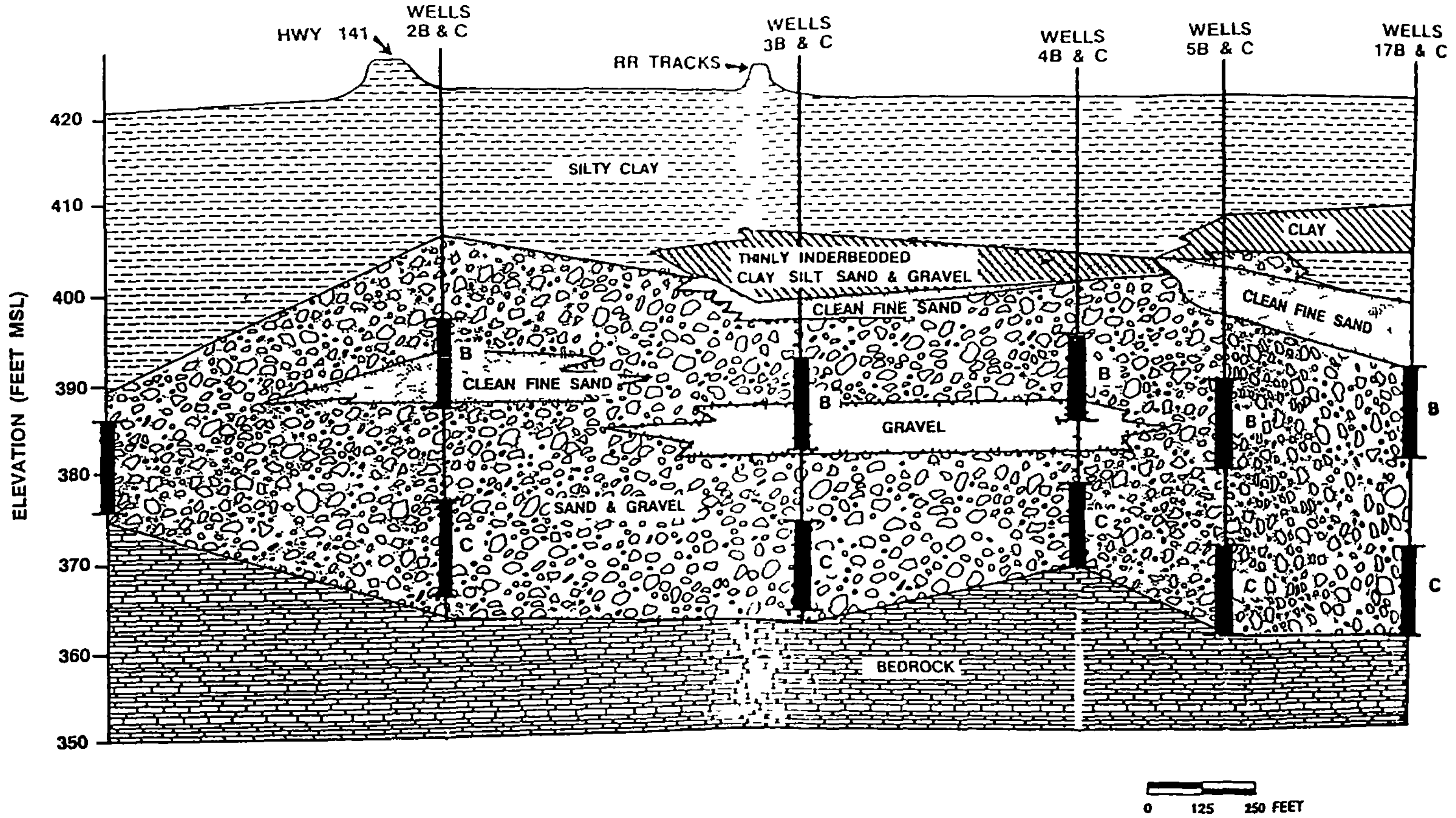
INCORPORATED
ENVIRONMENTAL ENGINEERS



SOURCE ESE, INC., 1988

GEOLOGIC
CROSS SECTION 1-17
VALLEY PARK MISSOURI

FIGURE 7

9/16/93

WAIN 07

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& YONLEY
INCORPORATED

TA[illegible] 2
ANALYTICAL RESULTS OF VALLEY PARK SAMPLING
(JULY 1987 - ESE)

PARAMETER UNITS FLD GRP	#	SAMPLE ID	DATE	TIME	CHLORIDE MG/L	DICHLORO ETHYLENE UG/L	1 2 DICHLO ROETHYLENE UG/L	CHLOROFOR M UG/L	1 1 1 TCA UG/L	TETRA CHLORIDE UG/L	TRICHLORO ETHYLENE UG/L	TETRACHLORO ETHYLENE UG/L
VALPA2	31	MW01C0	07/24/87	08 45	92 4	2 17	<2 50	1 38	<2 00	1 96	<2 00	<2 50
VALPA2	41	MW02B0	07/28/87	09 00	138	<1 75	2 66	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	38	MW02C0	07/28/87	09 40	148	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	37	MW03B0	07/28/87	10 45	67 5	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	39	MW03C0	07/28/87	10 25	51 6	<1 75	<2 50	<1 00	<2 00	<1 25	15 9	5 48
VALPA2	44	MW04C0	07/28/87	11 40	59 6	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	43	MW05B0	07/28/87	13 45	119	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	22 4
VALPA2	45	MW05C0	07/28/87	13 15	40 7	<1 75	<2 50	<1 00	<2 00	<1 25	7 91	<2 50
VALPA2	1	MW06B0	07/29/87	10 20	114	<1 75	2 74	<1 00	4 46	<1 25	28 0	66 4
VALPA2	7	MW06C0	07/29/87	09 50	59 6	2 47	4 62	<1 00	8 81	<1 25	50 5	63 8
VALPA2	18	MW07B0	07/27/87	15 35	36 2	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	14	MW07C0	07/27/87	15 00	95 3	4 24	8 46	3 25	21 0	<1 25	45 8	<2 50
VALPA2	15	MW07C0	07/27/87	15 00	09 4	3 02	12 0	<1 00	31 0	<1 25	69 7	8 6
VALPA2	25	MW08B0	07/27/87	08 45	58 6	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	26	MW08C0	07/27/87	09 30	43 7	<1 75	5 52	<1 00	<2 00	<1 25	2 64	<2 50
VALPA2	42	MW09C0	07/28/87	14 40	33 8	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	17	MW10B0	07/27/87	14 15	83 4	<1 75	4 70	<1 00	<2 00	<1 25	38 8	38 2
VALPA2	13	MW10C0	07/27/87	13 45	98 3	3 02	5 70	2 55	5 37	2 28	102	248
VALPA2	16	MW11C0	07/27/87	11 50	566	<1 75	3 32	<1 00	<2 00	<1 25	16 8	95 0
VALPA2	34	MW12C0	07/27/87	10 55	9 53	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	28	MW13C0	07/24/87	10 50	145	<1 75	<2 50	<1 00	<2 00	<1 25	3 60	4 82
VALPA2	29	MW13C0	07/24/87	10 55	140	<1 75	<2 50	<1 00	<2 00	<1 25	3 94	6 45
VALPA2	30	MW04C0	07/24/87	15 25	50 6	<1 75	<2 50	1 03	<2 00	1 58	<2 00	<2 50
VALPA2	33	MW15C0	07/24/87	15 00	77 5	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	36	MW16C0	07/24/87	11 50	47 2	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	12	MW17B0	07/29/87	11 30	80 4	<1 75	113	<1 00	<2 00	<1 25	535	2907
VALPA2	11	MW17B0	07/29/87	11 30	78 5	<1 75	110	<1 00	<2 00	<1 25	646	3207
VALPA2	10	MW17C0	07/29/87	11 15	72 5	<1 75	47 4	<1 00	<2 00	<1 25	311	815
VALPA2	20	VP0100	07/23/87	11 20	59 6	<1 75	5 19	<1 00	4 25	<1 25	21 1	14 0
VALPA2	21	VP0300	07/23/87	11 35	49 4	13 1	15 4	<1 00	236	<1 25	337	22 5
VALPA2	27	KW0100	07/23/87	15 30	39 7	2 25	<2 50	<1 00	5 21	<1 25	5 72	<2 50
VALPA2	22	KW0200	07/23/87	15 55	45 2	2 46	<2 50	<1 00	6 76	1 40	<2 00	<2 50
VALPA2	19	CM0100	07/23/87	14 45	34 3	<1 75	5 93	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	23	RC0100	07/23/87	13 40	83 7	2 01	<150	<1 00	5 47	1 43	518	1977
VALPA2	24	AC0100	07/23/87	14 30	111	2 65	<2 50	1 70	4 45	2 78	25 5	33 9
VALPA2	32	BB0100	07/27/87	09 15	<2 00	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	35	MR0100	07/27/87	10 00	8 44	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA2	40	HP0100	07/29/87	08 30	<2 00	<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA1	10	SC0100	06/25/87	14 43		<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA1	3	DW0100	06/25/87	15 30		<1 75	<2 50	7 40	<2 00	<1 25	<2 00	<2 50
VALPA1	2	AD0100	06/25/87	15 00		<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50
VALPA1	4	AD0200	07/09/87	07 40		<1 75	<2 50	<1 00	<2 00	<1 25	<2 00	<2 50

Notes
MW = Monitoring Wells
VP = Valley Park Wells
DW = Drilling Water
KW = Kirkwood Wells
CM = Cromer Wells
AD = Auger Decon
RC = Reichhold Chemical
AC = Absorbent Cotton
BB = Bailer Blank
MR = Meramec River
HP = Hand Pump Blank
SC = Steam Cleaner

TA 3
GROUNDWATER LEVELS

Well Number	A 8-27-87 Water Level (feet msl)	B 8-31-87 Water Level (feet msl)	Change from 8-27-87 (B-A) (feet)	C 9-20-87 Water Level (feet msl)	Change from 8-31-87 (B-C) (feet)
1c	391 21	391 21	--	--	--
2b	--	388 99	--	388 40	0 59
2c	388 38	388 91	0 53	388 39	0 52
3b	388 16	388 39	0 23	387 90	0 49
3c	388 14	388 41	0 27	387 91	0 50
4b	389 41	389 65	0 24	388 75	0 90
4c	389 35	389 25	-0 10	388 70	0 55
5b	388 24	388 32	0 08	387 68	0 64
5c	388 30	388 29	-0 01*	387 65	0 64
6b	388 22	388 24	0 02	387 66	0 58
6c	388 18	388 23	0 05	387 66	0 57
7b	388 31	388 72	0 41	388 38	0 34
7c	388 22	388 80	0 58	388 47	0 33
8b	390 25	390 44	0 19	--	--
8c	390 22	390 47	0 25	--	--
9c	389 79	389 71	-0 08	389 61	0 10
10b	388 38	388 19	-0 19	387 87	0 32
10c	387 91	388 16	0 25	387 85	0 31
11c	389 50	389 02	-0 48	--	--
12c	388 56	388 55	-0 01*	--	--
13c	388 84	--	--	--	--
14c	387 89	--	--	--	--
15c	385 83	--	--	--	--
16c	381 89	--	--	--	--
17b	388 20	388 24	0 04	387 67	0 57
17c	388 28	388 22	-0 06	387 65	0 57

*Negligible, best accuracy of measurement method is 0 01 feet
(Source ESE, 1988)
-- Denotes no measurement recorded

- Highest TCE and PCE concentrations were in Wells 17B and 17C, the Reichhold well and MW 10C southeast of the Reichhold plant

In April and October 1988, Lafser & Schreiber, Inc performed shallow soil sampling for Wainwright Industries behind the facility Samples were collected at 1, 4 and 8 foot depths Samples of like depths were composited within three regions north to south and east to west as shown in Figures 8 and 9 The results are shown in Table 4

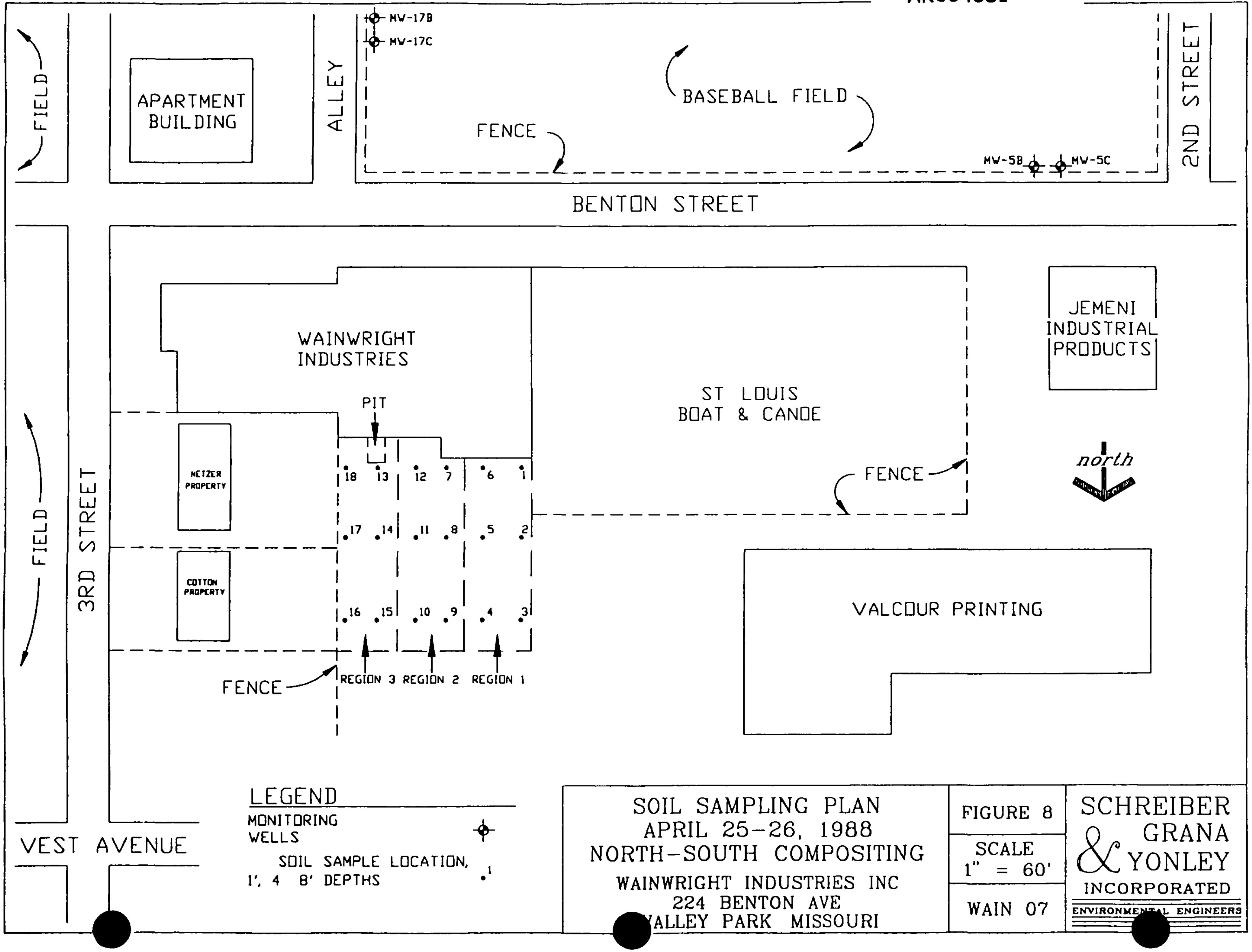
On July 13 and September 27-29, 1989, Lafser & Schreiber, Inc collected subsurface samples at 19 locations on the Wainwright Industries Valley Park property, 15 inside (and north) the building and three along Benton Street The 15 sample locations were advanced with a hand auger to a depth of 10 feet below grade, at which point a sample was collected, field screened and submitted for laboratory analysis The three sample locations from along Benton Street were advanced with a truck-mounted drill rig to a depth of 35 feet below grade Continuous soil logging/sampling was accomplished on the four drill-rig locations A sample was retained for laboratory analysis every five feet A portable infrared spectrometer (Miran 1B) was used to analyze the head spaces of all soil samples PCE All soil borings were drilled at the approximate locations depicted in Figure 10

Analytical sampling was performed at each boring location which produced Miran 1B detections (as well as Borings 3 and 15E) The field observations indicated levels of PCE contamination underneath the "NW Annex" above 20 ppm (see Table 5) The concentrations significantly decreased to 36 ppb directly south of point #2 and #A and to 11 ppb southeast of point #2 and #A In July, 1989, the Missouri Department of Health (MDOH) did a cleanup assessment and determined that a cleanup level of 100 ppm PCE and 70 TCE in the soil should leave the area safe for unrestricted use provided the levels of chemicals are reduced below those listed in Table 6 These cleanup levels are based solely on ingestion of soil, and do not consider risks derived from dermal contact of soil or groundwater, inhalation of volatilized contaminants, or the leaching of contaminants from soil to groundwater

On February 23, 1989, ESE submitted to MDNR a proposal to conduct an RI/FS at the Valley Park TCE site

On March 3, 1989, Lafser & Schreiber, Inc submitted a proposal for remedial action at the Wainwright property

On June 22, 1989, Lafser & Schreiber, Inc submitted a proposal to conduct an RI/FS at Unit 1 (Downtown Valley Park TCE site)



LEGEND

MONITORING WELLS ⌖

SOIL SAMPLE LOCATION, 1', 4 8' DEPTHS •1

SOIL SAMPLING PLAN
APRIL 25-26, 1988
NORTH-SOUTH COMPOSITING

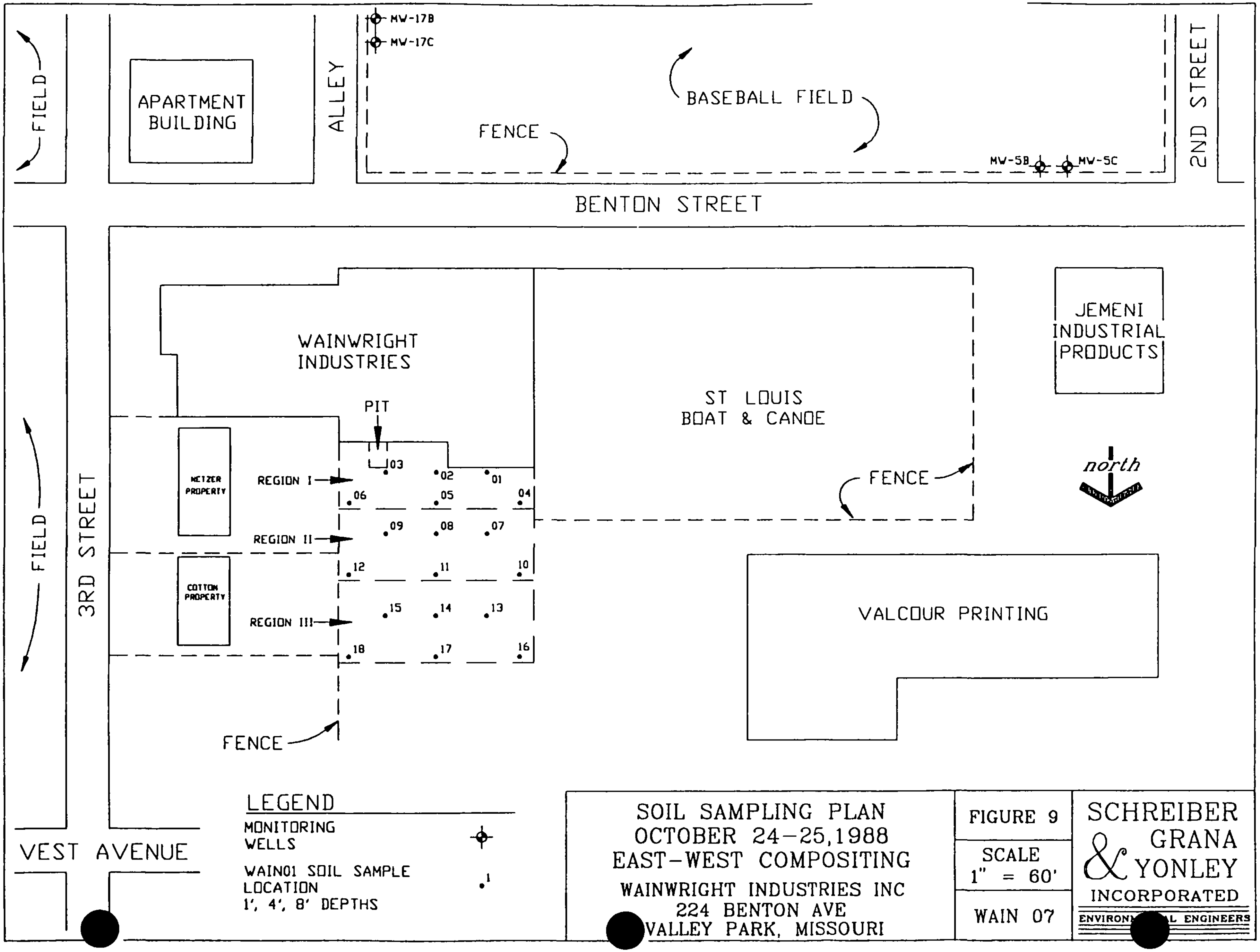
WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK MISSOURI

FIGURE 8

SCALE
1" = 60'

WAIN 07

SCHREIBER
GRANA
& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



SOIL SAMPLING PLAN
OCTOBER 24–25, 1988
EAST–WEST COMPOSITING

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 9

SCALE
1" = 60'

WAIN 07

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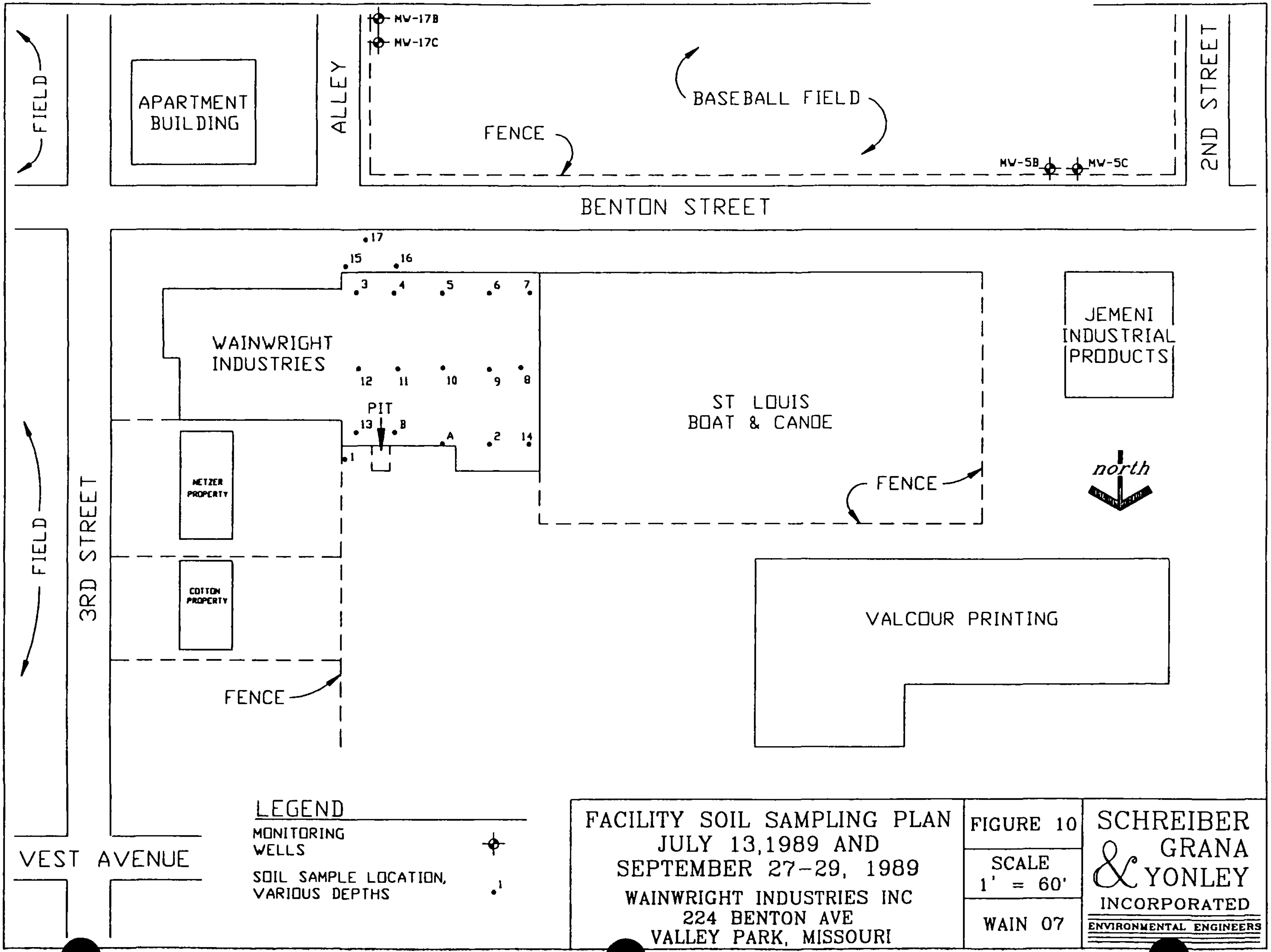
& GRANA
YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



FACILITY SOIL SAMPLING PLAN
JULY 13,1989 AND
SEPTEMBER 27-29, 1989
WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 10

SCALE
1' = 60'

WAIN 07

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INCORPORATED
ENVIRONMENTAL ENGINEERS

TABLE 4
SOIL SAMPLE ANALYSIS RESULTS (224 BENTON AVENUE) BEHIND FACILITY

Previous Subsurface Investigation (4-88) North/South Compositing

Region	Depth (Ft)	PCE (ppb)	TCE (ppb)	Remarks
Region 1	1	34,000	ND	
Region 1	4	80	11	
Region 1	8	88	ND	
Region 2	1	1,800,000	16,000	"WAIN07" - Heavy odors
Region 2	4	9,800	ND	
Region 2	8	88	ND	
Region 3	1	12,000	ND	
Region 3	4	ND	ND	
Region 3	8	ND	ND	

Site Sampling Results With MDNR (10-88) East/West Compositing

Region	Depth (Ft)	PCE (ppb)	TCE (ppb)	Remarks
Region I	1	2,200,000	540,000	"WAIN02" - Heavy odors
Region I	4	140 000	4,000	
Region I	8	140	4	
Region II	1	26,000	3,000	
Region II	4	27	6	
Region II	8	19	8	
Region III	1	140	38	
Region III	4	250	28	
Region III	8	38	4	

Notes ND denotes non-detect concentrations
ppb denotes parts per billion

TABLE 5
SOIL SAMPLE ANALYSIS RESULTS (224 BENTON AVENUE) UNDERNEATH FACILITY (JULY/SEPTEMBER 1989)

SAMPLE	(ppm)	ANALYTICAL RESULTS (ppb)	
LOCATION-DEPTH	MIRAN 1B	TETRACHLOROETHYLENE	TRICHLOROETHYLENE
#1-10 ft	85-90	61	ND
#2-10 ft	>250	27,000	ND
#3-10 ft	ND	430	ND
#4-10 ft	ND	NT	NT
#5-10 ft	ND	NT	NT
#6-10 ft	ND	NT	NT
#7-10 ft	ND	NT	NT
#8-10 ft	ND	NT	NT
#9-10 ft	20-30	36	ND
#10-10 ft	ND	NT	NT
#11-10 ft	100 ppm, sewage odor	29	ND
#12	Hit sewer line @ approx 3 ft - no samples taken --		
#13-10 ft	100	1,680	520
#14	Digging Obstruction @ 8 in - no samples taken -----		
#15A-5 ft	ND	NT	NT
#15B-10 ft	ND	NT	NT
#15C-15 ft	ND	NT	NT
#15D-20 ft	ND	NT	NT
#15E-25-30 ft	ND	11	13
#16A-5 ft	ND	NT	NT
#16B-10 ft	ND	NT	NT
#16C-15 ft	ND	NT	NT
#16D-20 ft	ND	NT	NT
#16E-25-30 ft	ND	NT	NT
#17A-5 ft	ND	NT	NT
#17B-10 ft	ND	NT	NT
#17C-15 ft	ND	NT	NT
#17D-20 ft	ND	NT	NT
#17E-25-30 ft	ND	NT	NT
#A-10 ft	>250 ppm	368,000	6,340
#B-15 ft	80-100 ppm	457	13

Notes The Miran 1B was calibrated for PCE, All Miran readings are derived from soil headspace samples
ND denotes non-detect concentrations
NT denotes not tested

TABLE 6
1989 MISSOURI DEPARTMENT OF HEALTH SITE ASSESSMENT (224 BENTON AVENUE)

CHEMICAL	HIGHEST LEVEL FOUND AT SITE IN THE SOIL* (PPM)		DOH RECOMMENDED SAFE LEVEL (PPM)		HEALTH EFFECTS POSSIBLE ABOVE RECOMMENDED LEVEL
	MDNR	SGY	WATER	SOIL	
Acetone	12	----	----	----	Insufficient data
Bromodichloromethane	18	----	1	200	Attacks liver and kidney, incoordination and sleepiness, possible carcinogen
2-Butanone (methyl ethyl ketone)	7	----	860A	5000	Eye, nose irritant, headaches, dizziness, vomiting, attaches CNS
Chlorobenzene	19	----	----	----	Insufficient data
Ethylbenzene	033	----	7E	10000	Renal and hepatic disorders chronic respiratory and dermal damage
Tetrachloroethylene	42	2200	005	100	CNS depressant, hepatoxic, positive animal carcinogen, renal injury
1,1,1-Trichloroethane	33	----	200	9000	CNS depressant, dizziness, drowsiness, unconsciousness
1,1,2-Trichloroethane	17	----	----	3000	Eye and nose irritant, potential carcinogen
Trichloroethylene	26	540	005	70	CNS depressant, probable human carcinogen
Toluene	5	----	2	30000	CNS depressant, liver and kidney damage
Xylene, total	11	----	10	6126	CNS depressant, liver and kidney damage

Notes * No water samples were taken, Richard H Gnaedinger, June 7, 1989
-- denotes parameter not analyzed
A = Health Advisory 9-83,
E = Environmental Protection Agency Maximum Contaminant Level
MDNR = Missouri Department of Natural Resources
SGY = Schreiber, Grana & Yonley, Inc
DOH = Department of Health
CNS = Central Nervous System

On August 13, 1990, MDNR and EPA approved Lafser & Schreiber, Inc 's Revised Removal Work Plan for Wainwright Industries' Valley Park site This work plan outlined a removal action which would take an estimated 250 cubic yards of VOC-contaminated soil from the area of the site in which previous sampling results and field monitoring indicated contamination greater than 20 ppm of PCE and TCE This removal action was performed under an Administrative Order on Consent (AOC) between the EPA and Wainwright Industries, signed August 7, 1990

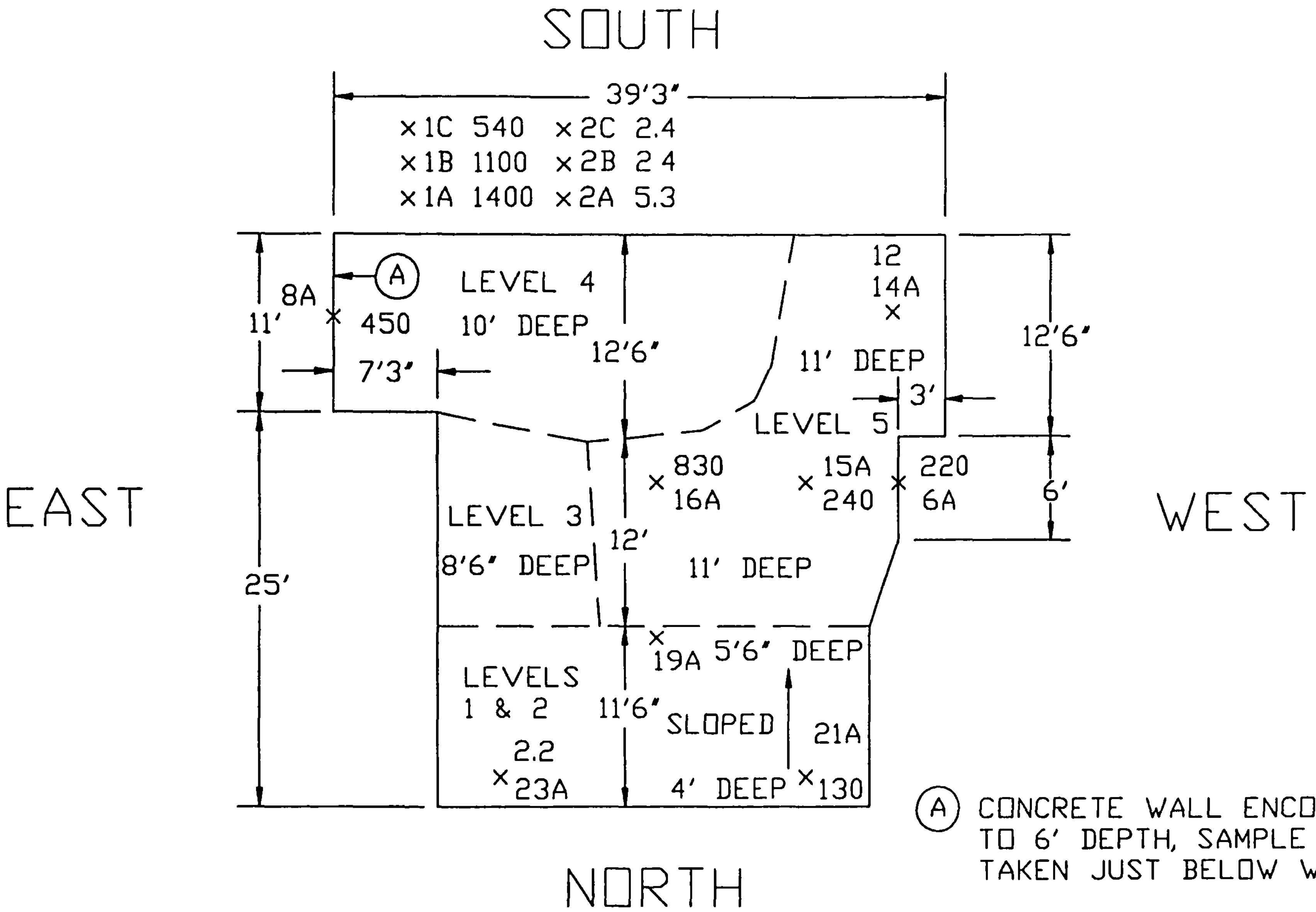
As a result of implementing the Revised Removal Work Plan, approximately 330 cubic yards of TCE and PCE contaminated soil were excavated and disposed of at the United States Pollution Control Inc Grassy Mountain hazardous waste landfill facility located in Lakepoint, Utah in September and October, 1990 This removal resulted in an excavation of various depth levels Dimensions of these levels are presented in Figure 11 and Figure 12

Verification sampling was performed to determine the effectiveness of the removal action Results of this discrete sampling indicated that certain grids in the excavated area still exceeded the established soil removal cleanup level of 20 ppm for TCE and PCE (see Figures 11 and 12, and Table 7)

In addition to these verification samples collected by Lafser & Schreiber, Inc , representatives of the USEPA and the MDNR collected and split additional samples which included analysis of metals Results of these sampling events can be found in Report from the Environmental Protection Agency to Lafser & Schreiber, Inc dated March 1, 1991 on the analytical results from the split samples obtained from the removal action plan and Soil Contamination Investigation, Wainwright Industries, Valley Park, Missouri, September 10, 11, 1990, Missouri Department of Natural Resources, February 8, 1991, with Appendices, respectively Results presented from these events are consistent with those previously described

In light of this information, it was determined that the removal be suspended until the site is thoroughly characterized for the extent and magnitude of contamination Wainwright agreed to conduct an RI/FS of the WOU in order to suspend the removal action

The excavated area was subsequently backfilled with pea gravel and asphalted to eliminate the possibility of personal contact with the remaining contaminated soil and to reduce the potential for precipitation to aid in the migration of contamination The removal activities are detailed in the Final Report on the Removal Action for the Property Located Behind 224 Benton Avenue, Valley Park, Missouri dated August 30, 1991



Ⓐ CONCRETE WALL ENCOUNTERED
TO 6' DEPTH, SAMPLE
TAKEN JUST BELOW WALL

2ND ROUND VERIFICATION SAMPLE RESULTS
TETRACHLOROETHYLENE IN PPM
REMOVAL ACTION OCTOBER 2, 1990

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 11

SCALE
N T S

WAIN 07

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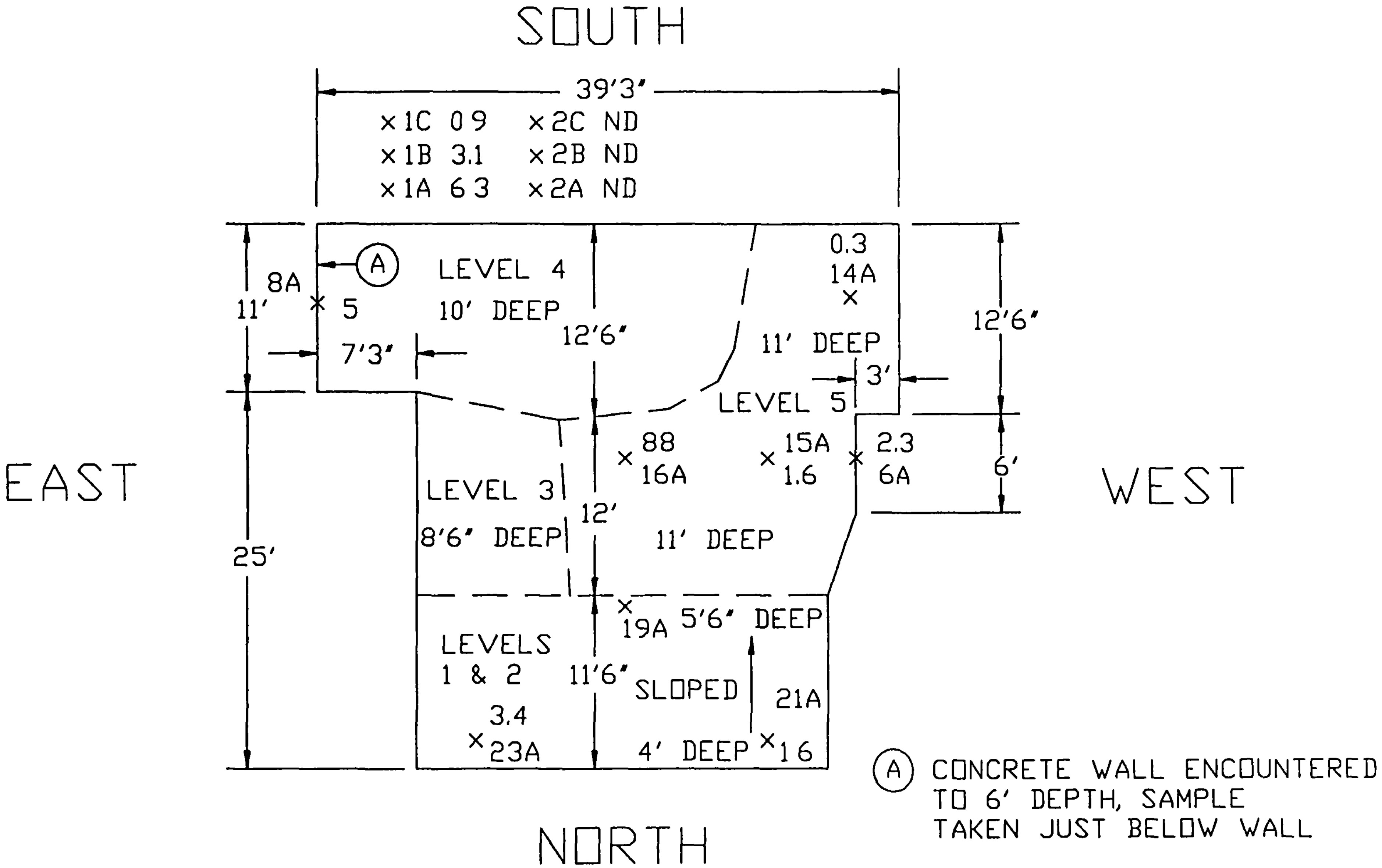

Ⓐ CONCRETE WALL ENCOUNTERED TO 6' DEPTH, SAMPLE TAKEN JUST BELOW WALL

2ND ROUND VERIFICATION SAMPLE RESULTS
TRICHLOROETHYLENE IN PPM
REMOVAL ACTION OCTOBER 2, 1990

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 12

SCALE
N T S

WAIN 07

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& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS

TABLE 7
2ND ROUND
FINAL VERIFICATION SAMPLE LOG

					RESULTS (ppm)	
SAMPLE ID NO.	**DEPTH**	**MATRIX**	**LOCATION**	**ANALYSIS**	**TCE**	**PCE**
WANG 1A	4	soil	Grid 1	*VOA	6 3	1400
WANG 1B**	4	soil	Grid 1	*VOA	3 1	1100
WANG 1C**	4	soil	Grid 1	*VOA	9	540
WANG 2A	4	soil	Grid 2	*VOA	ND	5 3
WANG 2B**	4	soil	Grid 2	*VOA	ND	2 4
WANG 2C**	4	soil	Grid 2	*VOA	ND	2 4
WANG 6A	6	soil	Grid 6	*VOA	2 3	220
WANG 8A	6	soil	Grid 8	*VOA	5	450
WANG 14A	11	soil	Grid 14	*VOA	3	12
WANG 15A	11	soil	Grid 15	*VOA	1 6	240
WANG 16A	11	soil	Grid 16	*VOA	88	830
WANG 21A	4	soil	Grid 21	*VOA	1 6	130
WANG 23A	4	soil	Grid 23	*VOA	3 4	2 2
WANG 40A	--	distilled water	--	*VOA	ND	ND
WANG 50A	11	soil	Grid 16	*VOA	40	230
WANG 60A	--	soil	Grid 19	*VOA	Matrix Spike	

Notes

ND = Non Detected
*VOA - Volatile Organics SW-846 8240
**Denotes horizontal boring underneath the building with sample collected at 4 feet (B sample) and 6 feet (C sample) into the south wall
WANG 50A is a duplicate of WANG 16A
-- Denotes not applicable

2.0 STUDY AREA INVESTIGATIONS

The purpose of this investigation was to fully characterize, vertically and horizontally in all directions, the extent of all contamination of the on-site and off-site soils, determine if groundwater is contaminated, determine whether there is a connection, if any, between the soil and the groundwater contamination, and continue to investigate potential on-site sources of contamination

The above referenced investigative activities were detailed in documents previously submitted to the MDNR and EPA These documents are RI/FS Workplan for Wainwright Property Unit, Valley Park, Missouri, revised, date February, 1992, Sampling & Analysis Plan (SAP) for a Remedial Investigation/Feasibility Workplan at the Wainwright Property Operable Unit, Valley Park, Missouri, revised, date February, 1992, Site Health and Safety Plan for Remediation Investigation/Feasibility Study Workplan at the Wainwright Property Operable Unit Valley Park, Missouri, revised, date January, 1992, and Amended Sampling & Feasibility Workplan at the Wainwright Property Operable Unit, Valley Park, Missouri, dated August 10, 1992

The following sections provide a brief outline of investigative activities which took place during this phase of work at the Wainwright Property Operable Unit, Valley Park, Missouri

2 1 Investigations

2 1 1 Contaminant Source Investigation

Schreiber, Grana & Yonley, Inc investigated the potential on-site sources of chlorinated hydrocarbon contamination The source of the chlorinated hydrocarbon contamination is very likely from the loss or disposal of industrial solvents commonly used as degreasers and/or cleaners The major solvents found in the groundwater and/or soil are PCE, TCE, and 1,1,1 TCA Wainwright Industries manufactured metal stampings and operated as a contract tool and die shop at the property Part of the manufacturing process included a solvent degreasing system that used PCE from 1963 to 1970 and TCE from 1970 to 1979 These chemicals were stored in a 1,000 gallon aboveground storage tank

The aforementioned compounds are all dense nonaqueous liquids (DNAPLs) These liquids are denser (heavier) than water, i e , each have a molecular weight greater than water TCE has a molecular weight of 131 grams per moles, while PCE is 166 grams per moles, each greater than 1 0 grams per moles for water For this reason, the compounds have the ability to sink when introduced into the subsurface and move/migrate vertically in the vadose and saturated zones under the influence of gravity If the DNAPLs are of sufficient mass to overcome the capillary force of water, they will continue to migrate vertically until an aquiclude (often bedrock) is encountered At this point, they have the ability to accumulate on the surface, displacing the water and forming a distinct liquid-phase layer

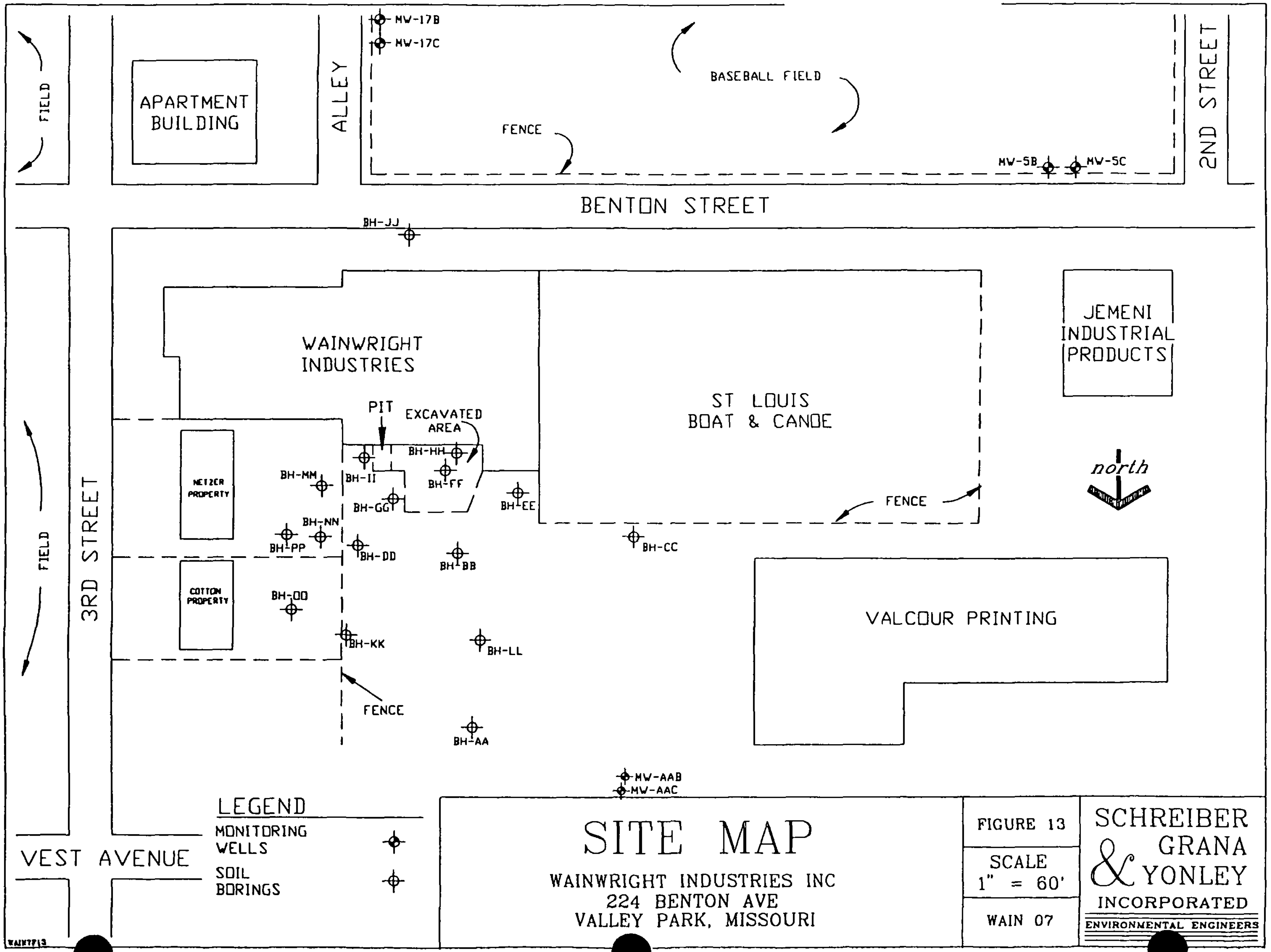
The approved RI/FS Revised Work Plan (Lafser & Schreiber, 1992a) discussed in Section 2 0 did not include the installation of groundwater monitoring wells to the top of the bedrock surface For this reason, the presence of DNAPLs beneath the Wainwright property is not known

2 1.2 Soil and Vadose Zone Investigation

The purposes of the soil and vadose zone investigation were to fully characterize, vertically and horizontally in all directions the extent of all contamination of the on-site and off-site soils, if applicable, to identify the connection, if any, between the soil contamination and any groundwater contamination at the site, and to determine if other off-site sources are contributing to the contamination at the site The approved Sampling and Analysis Plan (SAP), dated February, 1992, proposed the installation of one (1) groundwater monitoring well cluster, consisting of two (2) groundwater monitoring wells (MW-AAB and MW-AAC), and drilling eleven (11) soil borings (BH-AA through BH-KK) Figure 13 shows the locations of the groundwater monitoring well cluster MW-AAB and C, soil boring locations (including the additional five (5) soil boring locations [BH-LL through BH-PP] approved during the amended SAP dated August 10, 1992), and the two (2) ESE well clusters MW-5B and C, and MW-17B and C

On April 13 and 14, 1992, representatives of Schreiber, Grana & Yonley, Inc , Missouri Department of Natural Resources, and Brotcke Engineering (drilling contractor) were present at the Wainwright Operable Unit site to install two (2) groundwater monitoring wells

The borings, in which the groundwater monitoring wells would be constructed, were advanced into the ground using 3 3/4" hollow stem augers The soils were sampled using a patented five (5) foot continuous sampling device The hollow stem augers were decontaminated between holes and the continuous sampling devices were decontaminated between samples to prevent cross contamination between holes and samples The soil samples were then screened in the field for the presence of tetrachloroethylene utilizing a Miran 1B infrared spectrometer (see boring logs for Miran 1B readings, Appendix A) Soil samples were collected from predetermined intervals in accordance with the SAP (see Table 8 for sample intervals) Immediately after field screening, each soil sample was placed in a glass sample jar with a teflon lined lid, labeled, refrigerated and sent to Professional Service Industries, Inc , 480 West 15th Street, Lawrence, Kansas 66049 All sampling utensils were decontaminated between samples using a water and Alconox solution followed by a distilled water rinse, to prevent cross contamination The soil samples were analyzed in accordance with the SAP (see Table 8) Samples were accompanied to the laboratory by a properly completed chain-of-custody form Copies of the laboratory results and chain-of-custody forms are included in Appendix B



SITE MAP

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 13

SCALE
1" = 60'

WAIN 07

SCHREIBER
GRANA
& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS

TABLE 8
FSP SOIL SAMPLE LOG

SAMPLE ID	MATRIX	DEPTH	ANALYSIS
BH AA 1	SOIL	5	VOA 8240
BH AA 2	SOIL	15	VOA 8240
BH AA 3	SOIL	25	VOA 8240
BH AA 4	SOIL	35'	VOA 8240
BH BB 1	SOIL	6" 12"	VOA 8240
BH BB 2	SOIL	5'	VOA 8240
BH BB 3	SOIL	10	VOA 8240
BH BB 4	SOIL	15	VOA 8240
BH BB 5	SOIL	25	VOA 8240
BH BB 6	SOIL	35	VOA 8240*
BH CC 1	SOIL	5'	TCL
BH CC 2	SOIL	15	TCL
BH CC 3	SOIL	25'	TCL
BH CC 4	SOIL	35	TCL*
BH DD 1	SOIL	6"-12"	TCL
BH DD 2	SOIL	5	TCL
BH DD 3	SOIL	10	TCL
BH DD 4	SOIL	15	TCL
BH DD 5	SOIL	25	TCL
BH DD 6	SOIL	35	TCL*
BH EE 1	SOIL	6 12"	VOA 8240
BH EE 2	SOIL	5	VOA 8240
BH EE 3	SOIL	10	VOA 8240
BH EE 4	SOIL	15	VOA 8240
BH EE 5	SOIL	25	VOA 8240
BH EE 6	SOIL	35	VOA 8240*
BH FF 1	SOIL	15	TCL
BH FF 2	SOIL	25	TCL
BH FF 3	SOIL	35	TCL
BH GG 1	SOIL	6"-12"	VOA 8240*
BH GG 2	SOIL	5	VOA 8240
BH GG 3	SOIL	10	VOA 8240
BH GG 4	SOIL	15	VOA 8240
BH GG 5	SOIL	25	VOA 8240
BH GG 6	SOIL	35	VOA 8240*
BH HH 1	SOIL	15	VOA 8240
BH HH 2	SOIL	25	VOA 8240
BH HH 3	SOIL	35	VOA 8240*
BH II 1	SOIL	6' 12	VOA 8240
BH II 2	SOIL	5	VOA 8240
BH II 3	SOIL	10	VOA 8240
BH II 4	SOIL	15	VOA 8240
BH II 5	SOIL	25'	VOA 8240
BH II 6	SOIL	35	VOA 8240*
BH JJ 1	SOIL	5'	VOA 8240
BH JJ 2	SOIL	15	VOA 8240
BH JJ 3	SOIL	25'	VOA 8240
BH JJ 4	SOIL	35	VOA 8240*
BH KK 1	SOIL	5	VOA 8240
BH KK 2	SOIL	15'	VOA 8240
BH KK 3	SOIL	25	VOA 8240
BH KK 4	SOIL	35	VOA 8240
MW AA 1	SOIL	5	VOA 8240
MW AA 2	SOIL	15	VOA 8240
MW AA 3	SOIL	25	VOA 8240
MW AA 4	SOIL	35'	VOA 8240

Notes * Sample not collected
TCL - Target Compound List (VOA 8240, BNA 8270, Metals 6010)

On June 22 through June 24, 1992, representatives of Schreiber, Grana & Yonley, Inc , Missouri Department of Natural Resources, and Brotcke Engineering (drilling contractor) were present at the Wainwright Operable Unit to drill eleven (11) soil borings The borings were advanced into the ground using 3 3/4" hollow stem augers The soils were sampled using a patented five (5) foot continuous sampling device The hollow stem augers were decontaminated between holes and the continuous sampling devices were decontaminated between samples to prevent cross contamination between holes and samples The soil samples were then screened in the field for the presence of tetrachloroethylene utilizing a Miran 1B infrared spectrometer and the total concentration of ionizable gases and vapors utilizing a MicroTip photoionization detector (see boring logs for Miran 1B/MicroTip readings, Appendix A) Soil samples were collected from predetermined intervals in accordance with the SAP (Table 8) in borings BH-AA through BH-KK

The SAP was modified in the field due to the fact that the 35 foot soil sample was located in the aquifer and would not be representative of unsaturated soil Additionally, low sample recovery and subsequent difficulty of analysis, the lack of a confining layer across the site, and Miran 1B detections (in some borings) into the alluvial materials precluded the necessity of the 35 foot sampling Therefore, the last sample collected in each subsequent boring was at the 25 foot interval Immediately after field screening, each soil sample was placed in a glass sample jar with a teflon lined lid, labeled, refrigerated and sent to Professional Service Industries, Inc , 480 West 15th Street, Lawrence, Kansas 66049 All sampling utensils were decontaminated between samplings, using water and Alconox mixture followed by a distilled water rinse, to prevent cross contamination Samples were accompanied to the laboratory by a properly completed chain-of-custody form Copies of the laboratory results and chain-of-custody forms are included in Appendix B

After receiving analytical results from the soil samples previously collected, it was determined that the soil contamination had not been fully defined, primarily along the east property line In response to these analytical results, an Amended Sampling & Analysis Plan (ASAP) was submitted on August 10, 1992, and approved on August 18, 1992 The ASAP proposed the drilling of five (5) additional borings (see Figure 13 for boring locations BH-LL, BH-MM, BH-NN, BH-OO, and BH-PP) Prior to the start of field activities, access agreements were obtained to facilitate off-site drilling and sampling activities (see Appendix C)

On August 20 and 21, 1992, representatives of Schreiber, Grana & Yonley, Inc , Missouri Department of Natural Resources, and Riedel Environmental Services (drilling contractor) were present at the Wainwright Operable Unit to drill five (5) soil borings The borings were advanced into the ground using 2" solid flight augers The soils were sampled using a drive tube sampling device The solid flight augers were decontaminated between holes and the sampling device was decontaminated between samples to prevent cross contamination between holes and samples The soil samples were then screened in the field for the total concentrations of ionizable gases and vapors utilizing a MicroTip photoionization detector (see boring logs for MicroTip readings Appendix A) Soil samples were collected from predetermined intervals in accordance with the ASAP (Table 9) Immediately after field screening, each soil sample was placed in glass sample jar with a teflon lined lid, labeled, refrigerated and sent to Professional Service Industries, Inc , 480 West 15th Street, Lawrence, Kansas 66049 All sampling utensils were decontaminated between samplings, using water and Alconox mixture followed by a distilled water rinse, to prevent cross contamination The soil samples were analyzed in accordance with the ASAP (Table 9) Samples were accompanied to the laboratory by a properly completed chain-of-custody form Copies of the laboratory results and chain-of-custody forms are included in Appendix B

All drill rigs, augers and continuous samplers used in the investigation were decontaminated prior to use on the site and prior to removal from the site This procedure eliminated the possibility of contamination being introduced from an off-site source and assured that any possible contamination encountered from the investigation did not leave the site

All decontamination fluids were collected and contained on-site in 55 gallon steel drums Based on the results of the water analysis, this decontamination fluid was then passed through a carbon treatment system and then discharged to the Metropolitan Sewer District (MSD) sewerage system

All soil cuttings accumulated while drilling were placed into a 5 gallon container specifically designated for that boring Disposal of each container will depend on the analytical results from the samples taken from each respective borehole Disposal of this material will be in accordance with all Federal, State and local regulations and will not occur until approved by MDNR

All boreholes were then backfilled using bentonite hole plug hydrated with St Louis County water All personal protective equipment (PPE) was bagged and disposed of in a sanitary landfill

2 1 3 Groundwater Investigation

The purpose of the groundwater investigation was to determine if groundwater under the Wainwright Operable Unit is contaminated, to characterize groundwater flow patterns under the site, and to determine if potential connections exist between the soil contamination and the groundwater The initial SAP, dated February 1992, proposed the installation of one (1) groundwater monitoring well cluster, consisting of two (2) groundwater monitoring wells (MW-AA-B and MW-AA-C), the sampling of existing wells MW 17-B, MW 17-C, MW 5-B and MW 5-C, and the sampling of the new wells MW AA-B and MW AA-C

TABLE 9
FSP SOIL SAMPLE LOG

SAMPLE ID	MATRIX	DEPTH	ANALYSIS
BH LL 1	SOIL	6"-12"	VOA 8240
BH LL 2	SOIL	5'	VOA 8240
BH LL 3	SOIL	10'	VOA 8240
BH LL 4	SOIL	15'	VOA 8240
BH LL 5	SOIL	25'	VOA 8240
BH MM 1	SOIL	6"-12"	VOA 8240, BNA 8270
BH MM 2	SOIL	5'	VOA 8240, BNA 8270
BH MM 3	SOIL	10'	VOA 8240, BNA 8270
BH MM 4	SOIL	15'	VOA 8240, BNA 8270
BH MM 5	SOIL	25'	VOA 8240, BNA 8270
BH NN 1	SOIL	6"-12"	VOA 8240, BNA 8270
BH NN 2	SOIL	5'	VOA 8240, BNA 8270
BH NN 3	SOIL	10'	VOA 8240, BNA 8270
BH NN 4	SOIL	15'	VOA 8240, BNA 8270
BH NN 5	SOIL	25'	VOA 8240, BNA 8270
BH OO 1	SOIL	6"-12"	VOA 8240, BNA 8270
BH OO 2	SOIL	5'	VOA 8240, BNA 8270
BH OO 3	SOIL	10'	VOA 8240, BNA 8270
BH OO 4	SOIL	15'	VOA 8240, BNA 8270
BH OO 5	SOIL	25'	VOA 8240, BNA 8270
BH PP 1	SOIL	6"-12"	VOA 8240, BNA 8270
BH PP 2	SOIL	5'	VOA 8240, BNA 8270
BH PP 3	SOIL	10'	VOA 8240, BNA 8270
BH PP 4	SOIL	15'	VOA 8240, BNA 8270
BH PP 5	SOIL	25'	VOA 8240, BNA 8270

Following the completion of the borings MW AA-B and MW AA-C, groundwater monitoring wells were completed in the open boreholes on April 13 and 14, 1992 The two (2) monitoring wells were constructed of 2-inch diameter, Schedule 40 NSF certified PVC casing and screen Pipe sections were connected by standard threaded joints, with "0-ring" seals No glues, solvents or adhesive tapes were used The screens were 10 feet in length with factory-cut 0 010-inch slots The bottom of each screen was capped with a PVC plug which provided a 6-inch long sump below the screen (see Appendix D for well completion diagrams)

Since the contaminants of concern have specific gravities greater than water, they will tend to migrate downward in the saturated zone Therefore, a deep well labeled as MW AA-C, was installed resting on bedrock (or as close as possible) and a shallow well, labeled as MW AA-B, was installed near the top of the aquifer A minimum spacing of 5 feet was allowed between the bottom of the shallow well screen and the top of the deep well screen

Once the augers had advanced to the desired depth, the well screen and casing were lowered through the augers The augers were slowly withdrawn and a clean silica sand pack (WB-40 sand) was placed up to at least 2 feet above the top of the screen An approximately 3-foot long seal of bentonite pellets was then placed on top of the sand pack

A bentonite cement grout was tremied into the borehole to seal the annulus space from the bentonite seal up to the surface To ensure the integrity of the seal, the grout was tremied in lifts of about 5 feet each St Louis County water was used to mix the grout

Each well was constructed with approximately 2 feet of stick-up and a vented PVC cap Each well has a locking steel outer protective casing set in concrete

Development of monitoring wells MW AA-B and MW AA-C, consisted of pumping a total of three (3) well volumes of water from each well The three (3) well volumes removed assured the removal of any volumes of water introduced to the well during well installation and any sediment in the well from construction The wells were then allowed to recharge for a week Wells were developed using a 2 inch Redi-flow down hole pump This pump was thoroughly decontaminated before use and in between wells

Water level measurements were made on all sampling locations using an electric measuring tape Prior to the purging of a well or sample collection, it was extremely important to measure and record the water level in each well to be sampled Water level measurements were needed to estimate the amount of water to be purged from the well prior to sample collection

In addition, this information was used to interpret monitoring results Low water levels may reflect the influence of a nearby production well High water levels compared to other period may indicate recharge events Non-pumping water levels of all wells will provide additional historical data on the present hydraulic conditions at the area of investigation Analysis of the information, along with the 1987 data, may reveal changes in flow paths and serve as a check on the effectiveness of each well to monitor changing hydrologic conditions Water level measurements from the well clusters were used to calculate vertical gradients within the alluvial aquifer Water level measurements are essential to develop an understanding of associated chemical concentrations at each monitored site

Two rounds of groundwater sampling and analysis were collected, the first round was collected on April 23, 1992, and the second round was collected on May 22, 1992, from the existing monitoring wells MW 17-B, MW 17-C, MW 5-B, MW 5-C and new monitoring wells MW AA-B and MW AA-C and analyzed for the parameters presented in Table 10 Minor differences in the laboratory analyses between the two rounds indicated analytical reporting differences For example, the first analytical report showed presence of xylenes (total) and 1,2 dichloroethene (total), while the second round reported presence of xylenes (m-,p-), xylene (o-), and cis 1,2 dichloroethene

The samples were collected from each well after they had been properly purged Purging of groundwater monitoring wells MW AA-B, MW AA-C, MW 5-B, MW 5-C, MW 17-B, and MW 17-C, consisted of pumping a minimum of three (3) well volumes of water from each well The wells were purged using a 2 inch Redi-flow downhole pump This pump was thoroughly decontaminated before use and in between wells Samples were collected from the bottom of the monitoring well Samples were collected using disposable bailers

Following collection, each sample was placed in a glass sample jar with a teflon lined lid, labeled, refrigerated, and sent to Professional Service Industries, In , 480 West 15th Street, Lawrence, Kansas 66049 for analysis Samples were accompanied to the laboratory by properly completed chain-of-custody forms (see Appendix B)

All water accumulated while developing and sampling the monitoring wells was contained in 55 gallon steel drums and stored on the Wainwright Industries site Based on the results of the water analysis, this water was then passed through a carbon treatment system and discharged to the MSD sewer

TABLE 10
FSP GROUNDWATER SAMPLE LOG

SAMPLE ID	MATRIX	ANALYSIS
MW AA B-1	WATER	TCL *
MW AA C-1	WATER	TCL *
MW 17 B-1	WATER	TCL *
MW 17 C-1	WATER	TCL *
MW 17 C-1A	WATER	TCL *
MW 5 B-1	WATER	TCL *
MW 5 C-1	WATER	TCL *
MW AA B-2	WATER	TCL *
MW AA C-2	WATER	TCL *
MW 17 B-2	WATER	TCL *
MW 17 C-2	WATER	TCL *
MW 17 C-2A	WATER	TCL *
MW 5 B-2	WATER	TCL *
MW 5 C-2	WATER	TCL *

TCL - TARGET COMPOUND LIST
*pH, CONDUCTIVITY AND TEMPERATURE

Disposable bailers and personal protective equipment used while sampling were bagged and disposed of in a sanitary landfill

Well casing elevations were surveyed on May 22, 1992 by Schreiber, Grana & Yonley, Inc personnel The survey was conducted to provide vertical control for the monitoring well casings Elevations for the top of the PVC casing were obtained via a level, a tripod and a measuring rod The elevations were surveyed relative to the ESE datum established at MW-17-B and to an accuracy of 0 01 feet The survey data allows the calculation of relative fluid level elevations in the wells The bench mark utilized for the survey was the City of Valley Park basketball pole located at the City Hall parking lot

The top of casing data elevations used during the calculation of the fluid elevation at the WOU are as follows

Well ID	Top of Casing Elevation
• MW-AA-B	425 32
• MW-AA-C	425 73
• MW-5-B	425 56
• MW-5-C	425 80
• MW-17-B	424 70
• MW-17-C	424 42

3 0 PHYSICAL SITE CHARACTERISTICS

3 1 Site Characterizations

It is important to define the physical characteristics of a site, so as to provide some insight into the movement and possibly the source of contamination The following sections will better define the physical characteristics of the Wainwright Operable Unit and the area surrounding it

3 1 1 Meteorology

The Valley Park area has a climate of the interior continental type in which large temperature ranges in the daily, monthly and seasonal values occur The air masses that generally influence the climate move predominantly from the southwest, which frequently bring moisture-laden air from the Gulf of Mexico It is this same southwesterly flow of air which at other times brings the hot, dry air from the desert southwest which can result in drought conditions The average annual temperature is about 56 F and temperatures as low as -33 F and as high as 115 F have been recorded in the basin During the summer months, the Meramec Basin is subject to heavy rainfall over a wide area for several days duration The average annual precipitation for the basin is about 39 inches The annual range of the mean is from 35 44 to 43 50 inches The growing season is from mid-April to mid-October About 23 inches of rain (59%) normally falls in this period Precipitation is fairly well distributed throughout the year with the highest average occurring during the months of April, May and June, and the lowest during the months of December, January and February Frequent fall storms cause the rainfall averages for August, September and October to be relatively high General storms with heavy rainfall extending over several days have produced the more notable storms over the basin Major storms have occurred in the following years

1913
1915
1916
1919
1927
1933
1935
1939
1942
1945
1947
1950
1957
1961
1979
1982
1983

The top eight floods in the basin, according to the Corps of Engineers [COE] (1985), have occurred as follows

		Rainfall (inches)
1	August 18-20, 1915	8 22
2	December 26-29, 1942	4 93
3	June 5-11, 1945	6 12
4	January 1-6, 1950	4 10
5	June 26-July 2, 1957	5 06
6	April 8-12, 1979	3 96
7	December 2-5, 1982	7 20
8	April 27-May 1, 1983	5 24

Additionally, during the spring and summer of 1993, the Mississippi River experienced severe flooding which subsequently backflooded the lower Meramec River reaching the Valley Park area

3 1 2 Surface Water Hydrology

The major surface water drainage features in the Valley Park area are the Meramec River, Fishpot Creek and Grand Glaize Creek The Meramec River borders the Valley Park TCE site on the south, and is located downgradient from the Wainwright Property Operable Unit This river and its tributaries drain 3980 square miles of east-central Missouri It rises in the Ozark Plateau and flows northwesterly Fishpot Creek is perennial and receives little drainage from the area of investigation Grand Glaize Creek enters the Meramec River Valley just west of Valley Park Grand Glaize Creek is a drainage route for a large portion of west St Louis County

There are various water-filled pits, ponds and lagoons in the Valley Park Area, including the City of Valley Park's sewage lagoons which are now used as overflow or detention basins for MSD's Grand Glaize Wastewater Treatment Plant (see Figure 1, north end of Ninth Street)

One spring and an artesian well are located in the Valley Park area Petty's Spring is located about one mile west of downtown Valley Park and near the Fishpot Creek dump site (see Figure 1) An artesian well also exists in Lake Hill Park on the north side of Valley Park

3 1 3 Geology

The geologic setting of Valley Park lies at the boundary of two physiographic sub-provinces To the northeast are the Dissected Till Plains The northern two-thirds of St Louis County is included in this province To the southwest lies the Salem Plateau of the Ozarks The Dissected Till Plains are gently undulating from 500-

700 feet mean sea level (MSL) Valley Park elevations vary from 400-500 feet MSL The elevation of the Wainwright property varies between 420-421 feet MSL

This particular area was glaciated twice during the Pleistocene period, but glacial till deposits are thin and dissected and none were detected at the site The general stratigraphic column for the area is shown by Figure 14 The stratigraphic sequence consists primarily of limestone and dolomite These were deposited for the most part in shallow epicontinental seas Rocks range in age from Precambrian to Holocene The water-bearing character of the Holocene alluvium can yield more than 2000 gpm The present overall rock structure in the area shows a regional dip to the northeast Tension, compressional and uplifting forces have altered some units so as to superimpose their structures upon the regional trend Based on limited data, ESE attempted to show a generalized 3-dimensional view of the top of the bedrock in the Valley Park-Kirkwood vicinity (see Figure 15) The depth to bedrock in 17 borings done in 1987 by ESE varied from 37 65 feet to greater than 75 feet, or from 378 21 feet to 348 41 feet MSL

The geology underlying the Valley Park area of investigation is similar to typical regional river basins The alluvium is fine-grained at the top and coarse-grained at the base Basically, three horizons exist The uppermost horizon consists mainly of silty clay and clay The middle horizon consists mainly of sand and gravel The bottom horizon is bedrock

The upper silty clays range in thickness from about 5 feet to 40 feet, with the average thickness being about 21 feet for all of the 17 wells in the 1987 test area For the wells near the area of investigation, the thicknesses are shown in Table 11

The location of the 1987 monitoring wells and cross-section index are shown in Figure 4

Geologic cross-sections were developed by ESE in 1987 and are presented in Figures 5, 6 and 7 Detailed information regarding the Valley Park municipal wells was not available for this investigation

The bedrock surface elevation in the area of investigation as shown in Table 11 varies from 358 9' to 384 01' MSL Bedrock occurs high in Well 9 and Well 1 Well 9 is north of downtown Valley Park and Well 1 is west of downtown Valley Park Apparently, the top of the ridges extend into the bedrock basin in those locations A minor bedrock trough may be located between these bedrock highs and slopes to the south through the western portion of downtown Valley Park

The Corps of Engineers reported that the bedrock underlying Valley Park is part of the Burlington-Keokuk formation, a massive limestone formation with chert layers

Aquifers most favorable as water sources are shaded

System	Series	Group	Formation	Aquifer group	Thickness (feet)	Dominant lithology	Water bearing character
Quaternary	Holocene		Alluvium[1]		0-150	Sand gravel silt and clay	Some wells yield more than 2,000 gpm
	Pleistocene		Loess		0-110	Silt	Essentially not water yielding
			Glacial till		0 55	Pebbly clay and silt	
Pennsylvanian	Missourian	Pleasanton	Undifferentiated	1	0-75	Shales siltstones "dirty" sandstones coal beds and thin limestone beds	Generally yields very small quantities of water to wells Yields range from 0-10 gpm
		Marmaton	Undifferentiated		0-90		
	Desmoinesian	Cherokee	Undifferentiated		0-200		
	Atokan		Undifferentiated				
Mississippian	Meramecian		Ste Genevieve Formation		0-160	Argillaceous to arenaceous limestone	Yields small to moderate quantities of water to wells Yields range from 5 to 50 gpm Higher yields are reported for this interval locally
			St Louis Limestone		0-180		
			Salem Formation		0-180		
			Warsaw Formation		0 110		
	Osagean		Burlington-Keokuk Limestone		0-240	Cherty limestone	
			Fern Glen Formation		0-105	Red limestone and shale	
	Kinderhookian	Chouteau	Undifferentiated		0 122	Limestone dolomitic limestone shale and siltstone	
Devonian	Upper	Sulphur Springs	Bushberg Sandstone		0-60	Limestone and sandstone.	
			Glen Park Limestone				
			Grassy Creek Shale		0-50	Fissile carbonaceous shale.	
Silurian			Undifferentiated		0-200	Cherty limestone	
Ordovician	Cincinnatian		Maquoketa Shale		0 163	Silty calcareous or dolomitic shale	Probably constitutes a confining influence on water movement.
			Cape Limestone		0-5	Argillaceous limestone	
	Champlainian		Kimmswick Formation	2	0 145	Massive limestone	Yields small to moderate quantities of water to wells Yields range from 3 to 50 gpm Decorah Formation probably acts as a confining bed locally
			Decorah Formation		0 50	Shale with interbedded limestone	
			Plattin Formation		0 240	Finely crystalline limestone	
			Rock Levee Formation		0 93	Dolomite and limestone some shale	
			Joachim Dolomite		0-135	Primarily argillaceous dolomite.	
			St Peter Sandstone	3	0 160	Silty sandstone cherty limestone grading upward into quartzose sandstone	Yields moderate quantities of water to wells Yields range from 10 140 gpm
			Everton Formation		0-130		
	Canadian		Powell Dolomite	4	0 150	Sandy and cherty dolomites and sandstone	Yields small to large quantities of water to wells Yields range from 10 to 300 gpm Upper part of aquifer group yields only small amounts of water to wells
			Cotter Dolomite		0 320		
			Jefferson City Dolomite		0 225		
			Roubidoux Formation		0-177		
			Gasconade Dolomite Gunter Sandstone Member		0 280		
Cambrian	Upper		Eminence Dolomite	5	0 172	Cherty dolomites siltstones sandstone and shale	Yields moderate to large quantities of water to wells Yields range from 10 to 400 gpm
			Potosi Dolomite		0 325		
		Elvins	Derby-Doerun Dolomite		0 165		
			Davis Formation		0 150		
			Bonneterre Formation		245 385		
			Lamotte Sandstone		235+		
Precambrian						Igneous and metamorphic rocks	Does not yield water to wells in this area

[1] Basal part may be of Pleistocene age

NOTE Stratigraphic nomenclature may not necessarily be that of the U S Geological Survey

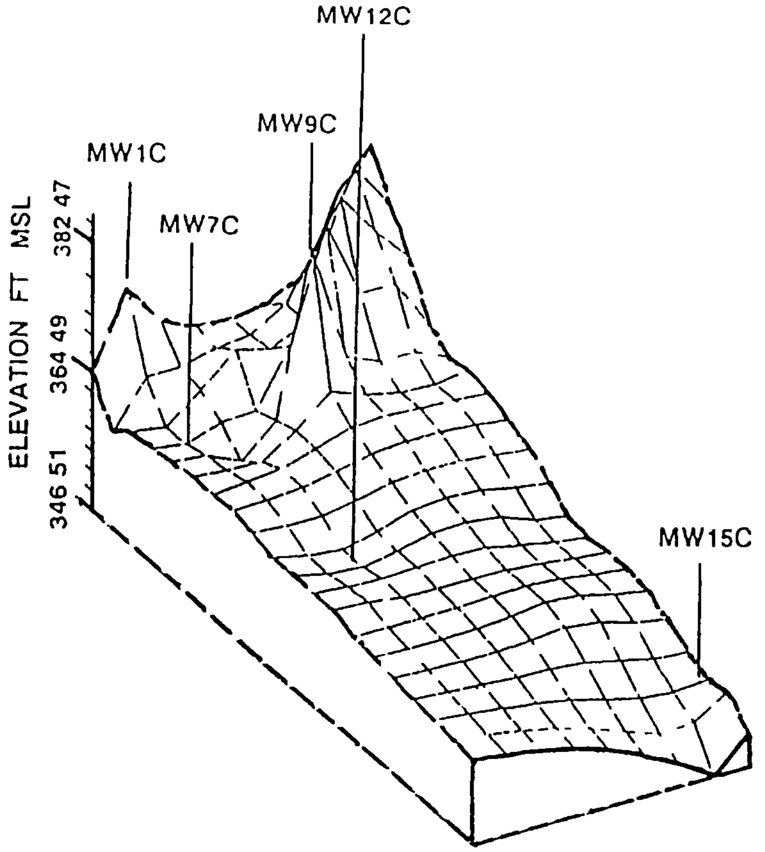
GENERALIZED STRATIGRAPHIC COLUMN FOR ST LOUIS, ST CHARLES AND JEFFERSON COUNTIES, MISSOURI

FIGURE 14

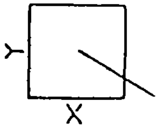
9/15/93

WAIN 07

SCHREIBER
GRANA
& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



VERTICAL EXAGERATION 15X



SOURCE: ESE, INC., 1988

GENERALIZED 3-DIMENSIONAL VIEW OF THE TOP OF THE BEDROCK VALLEY PARK-KIRKWOOD VICINITY	FIGURE 15 9/16/93 WAIN 07	SCHREIBER GRANA & YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS

TABLE 11
VALLEY PARK AREA OF INVESTIGATION
MONITORING WELLS HORIZON THICKNESS

Well No	Clay Plus Silty Clay	Gravel	Sand	Bedrock (MSL)
1	30'	15'	--	375 51'
2	17'	36'	5' (30-35')	364 87'
3	15'-22'	39'	5' (35-40')	364 65'
4	18'-21'	27'	5' (35-40')	369 91'
5	15'-20'	34 5'	5' (20-25')	362 91'
6	26'	37'	--	360 4'
7	16'	31 7'	9' (16-25')	360 48'
8	18 5'	40 5'	--	358 9'
9	20'-29'	8 65'	--	384 01'
10	20'	38'	10' (20-25') (40-45')	359 36'
17	22 5'	29'	8' (22-30')	363 57'
Range	15'-30'	8 65'-40 5'	0-10'	358 9' to 384 01'
Avg Thickness	20 8'	30 5'	4 27'	365 8' (Average elevation of bedrock)

Source ESE, 1988
Note -- denotes that the soil horizon was not encountered

3 1 4 Soils

The soils underlying Valley Park are similar to typical regional river basins The alluvium is fine-grained at the top and coarse-grained at the base Basically three different horizons exist The uppermost horizon consists mainly of silty clay and clay The middle horizon consists mainly of sand and gravel The basal horizon is bedrock

From the two drilling programs conducted by ESE and Schreiber, Grana & Yonley, Inc , it was determined that the upper silty clays range in thickness from about 5 to 40 feet The average thickness is about 21 feet This horizon consists mainly of relatively impermeable, cohesive, light to dark brown and grey silty clays Many samples exhibited some degree of mottling, low to medium plasticity, and occasional iron staining At many borings, root scars or worm traces (up to 0 25-inch diameter) were evident down to a depth of about 15 to 20 feet Nearly all such features were silt and/or clay healed

In most borings, basically two units were evident at or near the base of the upper horizon One unit is a light grey, highly plastic, massive clay about 1 to 8 feet thick The other unit consisted of about 3 5 to 10 5 foot thick lenses of thinly interbedded, brown to bright orange clays, silts, sands, and gravels The individual beds range up to 5 inches thick These two units are only partially continuous across the City of Valley Park

A Shelby tube sample of the silty clay was taken at each of the following wells 2B, 3B, 4B, 5B, 6B, 10B, and 17B The samples were taken from a depth interval of 5 0 to 7 0 feet Hydraulic conductivity (permeability) tests were later performed on the samples From 7 0 to 8 5 feet, split spoon samples were taken and tested for total organic carbon The results are shown on Table 12 The results suggest that the upper horizon exhibits very impermeable characteristics However, as none of these wells are located on the property, it cannot be determined with certainty that the silty clay layer is present beneath the property These data were gathered during the Limited Remedial Investigation

The middle horizon consists of relatively high permeability, orangish-brown and brown to tannish, gravelly sands and gravels Gravelly sands are most common In general, the grains range in size from fine sand to medium gravel, sub-rounded to sub-angular, and consist of orangish-brown weathered chert (along with finer clear and white quartz sand grains) Some silts exist in the sands and gravels Occasionally large gravel and cobbles were encountered The middle horizon ranges in thickness from about 8 to 46 feet, with an average thickness of 34 feet Although very thin discontinuous stringers exist throughout the unit, larger gravel and clean fine sand lenses were evident in the middle and upper portions The lenses range from 5 to 7 feet thick As can be seen from the cross sections, Figures 4, 5 and 6, most lenses are not very continuous (except for an upper sand lens)

TABLE 12
RESULTS OF SHELBY TUBE SAMPLES, VALLEY PARK

Well Number	Hydraulic Conductivity (cm/sec)	Porosity (%)	Total Organic Carbon (%)
2B	5 23x10^{8}	--	0 48
3B	9 93x10^{7}	--	0 31
4B	5 96x10^{8}	43 3	0 86
5B	1 08x10^{7}	40 8	0 32
6B	6 15x10^{8}	41 2	0 32
10B	3 85x10^{7}	--	0 22
17B	7 47x10^{7}	--	0 32
Average	3 44x10^{7}	41 8	0 40

Source ESE, 1988
Note -- denotes not tested

3 1 5 Hydrogeology

When the monitoring wells were checked for this study, the water levels in the sand and gravel aquifer existed under unconfined conditions During the drilling program, no perched groundwater was encountered in the upper silty clays

The overall groundwater flow trends easterly, along with the river and river basin This is consistent with the findings of the Kirkwood groundwater study (Brotcke et al , 1982) and the Missouri Geological Survey (MSGS) report (Miller et al , 1974) As evident from the groundwater contour maps drawn by ESE, Figures 16, 17 and 18, the water table was found to be relatively flat Considering the contour intervals versus horizontal scale, the hydraulic gradients are fairly low

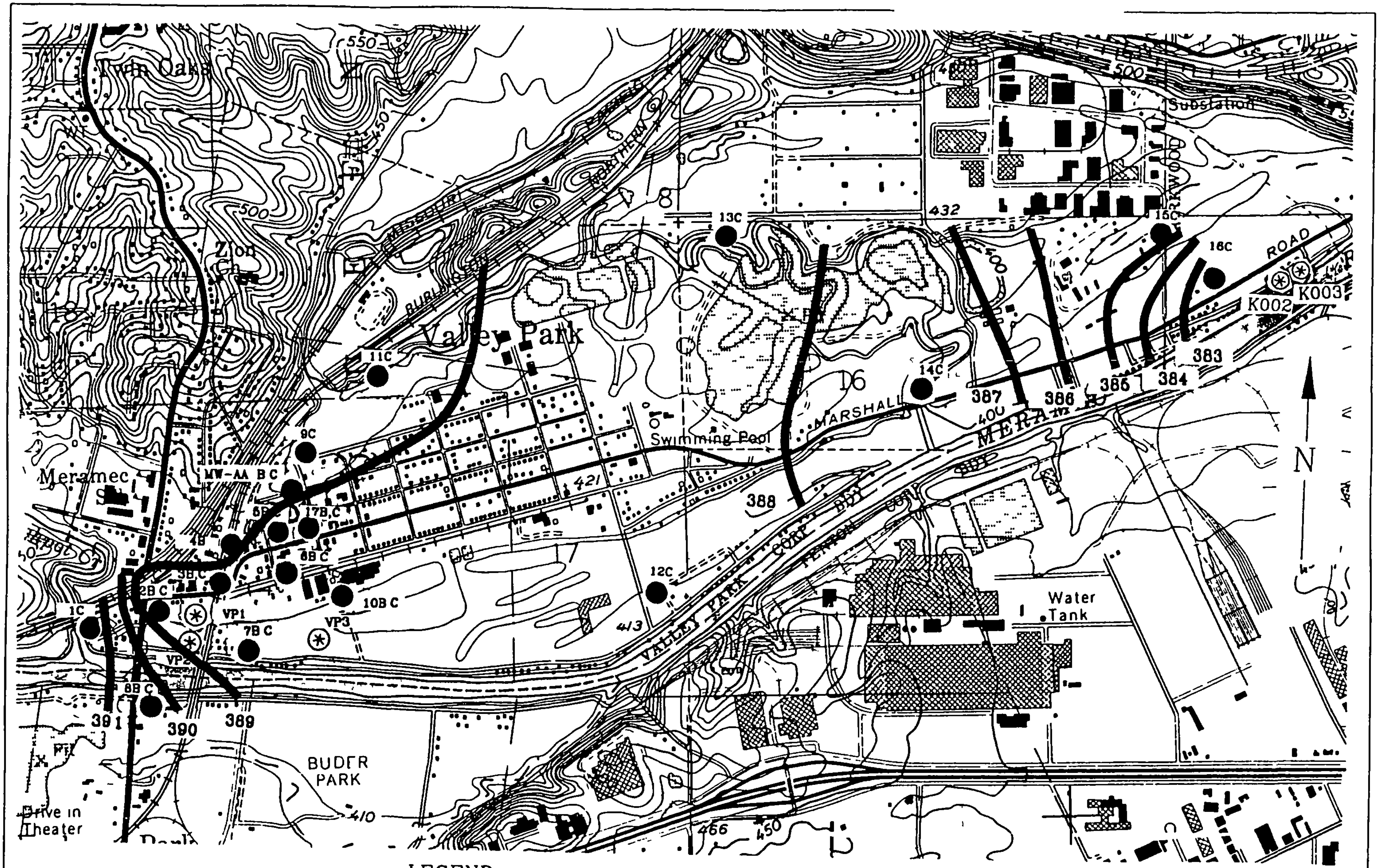
According to the ESE LRI (1987), Valley Park include two (2) Absorbent Cotton wells and one Reichhold Chemical, Inc well Both industries reported that well pumping is usually reduced over weekends, from midnight Fridays to midnight Sundays (ESE, 1987)

Information from Absorbent Cotton indicates a usual pumping rate of roughly 350,000 gallons per day (gpd) on weekdays, and about 200,000 gpd on weekends (pumping is not continual) (ESE, 1987) Reichhold Chemical, Inc estimates an average pumping rate of 72,000 gpd at its well (ESE, 1987) On weekends the rate is about a third or a quarter of the weekday rate (ESE, 1987) Withdrawals from the Kirkwood wells average 4,500,000 gpd (Miller et al , 1974)

The hydraulic conductivity for the Valley Park sand and gravel aquifer may be inferred from pumping tests performed for Kirkwood, just northeast of MW-16C The average value determined for that location is 6,700 gpd per square foot Pump tests have been conducted on the other supply wells in Valley Park (Miller et al , 1974) The specific capacity (ratio of discharge to drawdown) of the wells in the Valley Park area falls in the 60 to 100 gallons per minute per foot (gpm/ft) drawdown range During development, the monitoring wells produced water at rates consistent with those described above

To determine if vertical gradients exist in the aquifer, nested monitoring wells were utilized An analysis of the groundwater level measurements conducted by ESE as a part of the LRI at each well cluster indicated little or no vertical gradients within the sand and gravel aquifer

Using a line from Well 11C to 16C, a horizonal gradient for roughly the length of Valley park can be determined The resulting value is about 0 0007 ft/ft Gradients appear steepest in the vicinity of well pairs 1C/2C and 15C/16C This may be due to the fact that the two well pairs are located near Valley Park and Kirkwood municipal wells respectively (both in operation during the fluid level measurements) The most gentle gradient appears to exist in the area around Well 12C Using the above, horizontal gradients range from 0 0002 ft/ft to 0 0054 ft/ft



LEGEND

KIRKWOOD (K) PUMPING WELL
VALLEY PARK (VP) PUMPING WELL ⊛
GROUNDWATER MONITORING WELL ●
GROUNDWATER ELEVATION 389 ▬
(ft msl)

GROUNDWATER TABLE
ELEVATIONS 8/27/87
VALLEY PARK, MISSOURI

SOURCE ESE, INC., 1988

FIGURE 16

SCALE
1" = 1620'

WAIN 07

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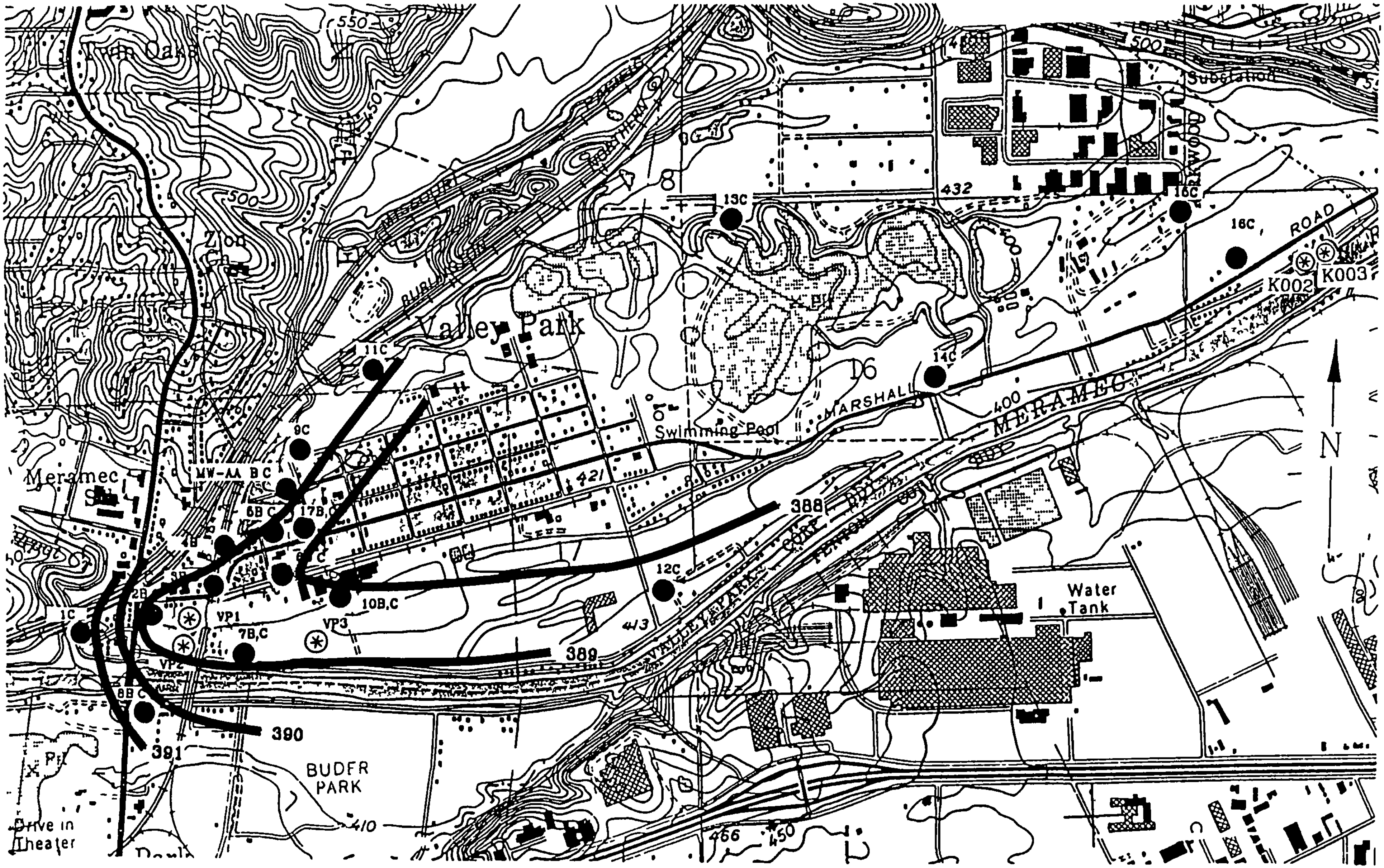


LEGEND

KIRKWOOD (K) PUMPING WELL VALLEY PARK (VP) PUMPING WELL	⊛
GROUNDWATER MONITORING WELL	●
GROUNDWATER ELEVATION (FT MSL)	389 ▬

GROUNDWATER TABLE ELEVATIONS 8/31/87 VALLEY PARK, MISSOURI

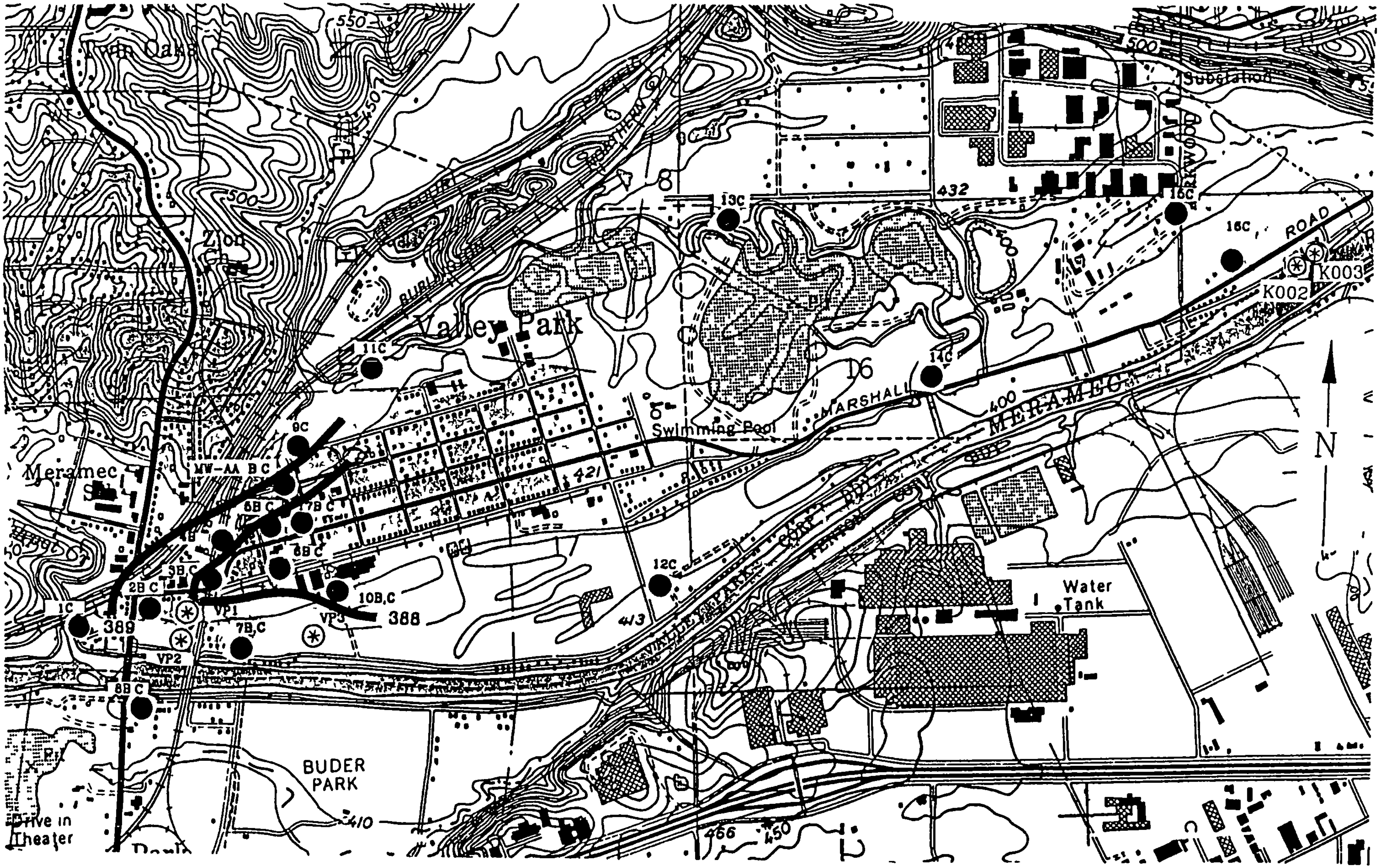
SOURCE: ESE, INC., 1988

FIGURE 17

SCALE
1" = 1620'

WAIN 07

SCHREIBER
& GRANA
YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



LEGEND

KIRKWOOD (K) PUMPING WELL
VALLEY PARK (VP) PUMPING WELL ⊛

GROUNDWATER MONITORING WELL ●

GROUNDWATER ELEVATION (FT MSL) 389 ▬

GROUNDWATER TABLE ELEVATIONS 9/20/87 VALLEY PARK, MISSOURI

SOURCE: ESE, INC., 1988

FIGURE 18

SCALE
1" = 1620'

WAIN 07

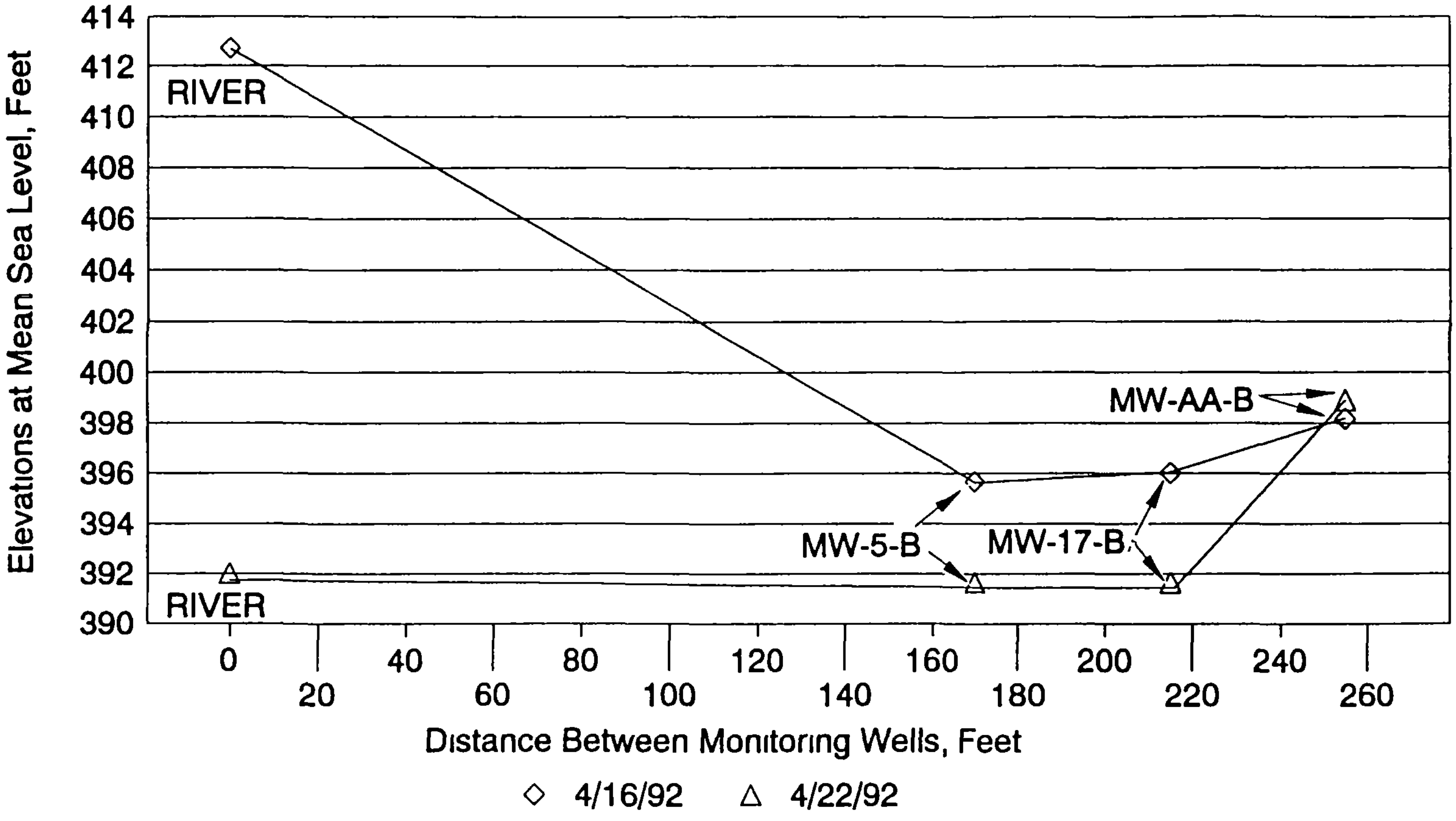
SCHREIBER
GRANA
& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS

Using the above gradients, a hydraulic conductivity of 6,700 gpd per square foot, and a porosity of 0 30 (typical for sand/gravel), groundwater flow velocities can be estimated Using a gradient of 0 0007 for Valley Park, the average linear velocity is 763 feet per year Using the other gradients, the average linear velocities range from about 220 to 5,900 feet per year

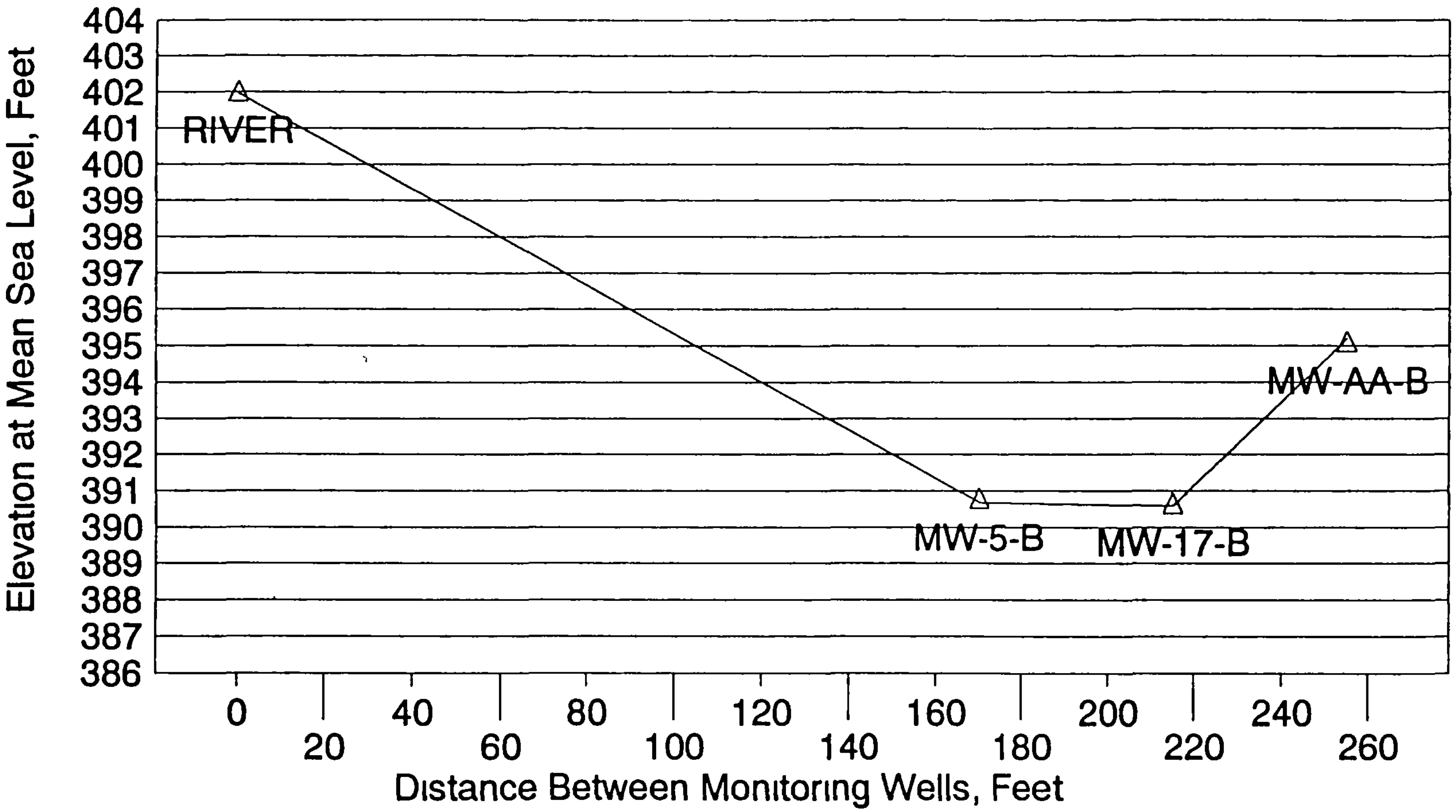
Concerning aquifer recharge and discharge, in 1970 the potentiometric surface was shown to vary directly with the elevation of the Meramec River (Miller, 1974) Water levels from this study generally support Miller's finding For the days that groundwater levels were measured, the National Weather Service and/or the City of Valley Park reports indicated that the Meramec River elevation at the Highway 141 bridge was highest on July 6 and 22, 1993, and January 7, 1993 (416 45 and 412 07 and 413 92 feet msl, respectively), and lowest on June 22, 1992 and August 20, 1992 (390 92 and 390 82 feet msl, respectively) Results of groundwater level measurements made on those days reflect the river elevation changes Generally, the groundwater elevations were higher on January 7, 1993 and May 22, 1992, and lower on June 22, 1992 and August 20, 1992 Although the groundwater level changed with the river elevation, the amount of change was somewhat inconsistent (Table 13) The inconsistencies may be attributable to aquifer-induced delay effects As the river rises in elevation (sometimes rapidly), the aquifer elevation also rises, although at a lesser rate However, as evident during July 6 and 22, 1993, the river and groundwater elevation data indicate the effects of both delay and equilibrium The difference in river elevations between July 22, 1993 and August 20, 1992 was -25 65 feet, while the average difference in groundwater elevations was -24 24 feet The recharge relationship between the aquifer and the groundwater can be determined from the groundwater elevation graphs presented in Figures 19 through 25 At the various times that the water levels were measured, it appears that the river was both recharging the aquifer and accepting discharge from the aquifer This is evident since the elevation of the surface water was both higher and lower than the potentiometric surface of the groundwater, at locations equally perpendicular to the direction of groundwater flow It is important to note, however, that due to limited data points across the river this determination is based upon contour lines within a restricted area

In view of the above, it can be generally expected that during times of high surcharge, the river probably acts as a recharge to the aquifer During time of low flow, the aquifer probably discharges to the river

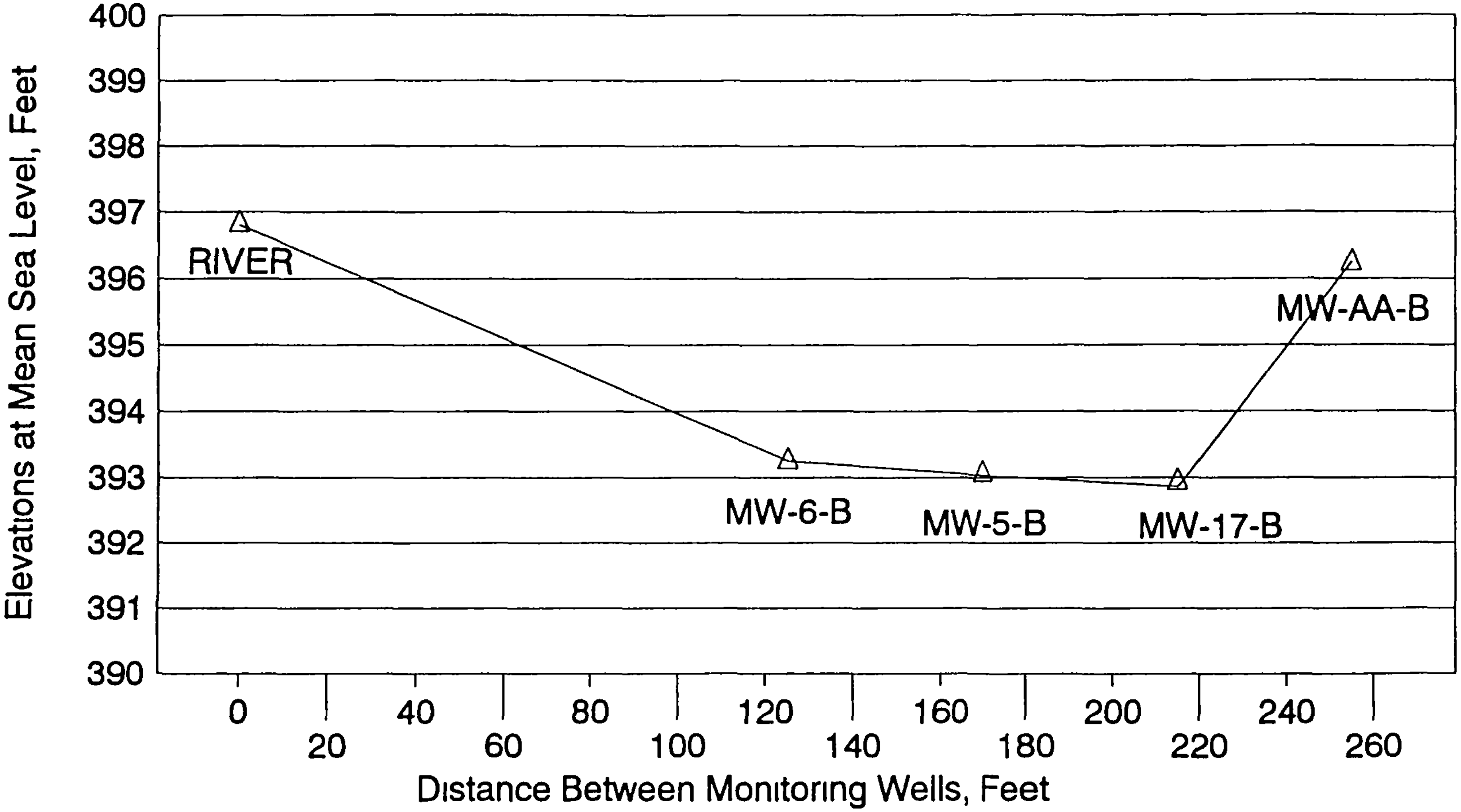
Although the vertical permeability of the upper silty clay appears low, the aquifer receives recharge from percolation of precipitation Additionally, the alluvial basins entering with Fishpot Creek and Grand Glaize Creek contribute as recharge sources



GROUNDWATER LEVEL ELEVATIONS RECORDED 4/16/92 & 4/22/92 VALLEY PARK, MISSOURI	FIGURE 19 DATE 4-14-94 WAIN07	SCHREIBER & GRANA YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS



GROUNDWATER LEVEL ELEVATIONS RECORDED 11/24/92 VALLEY PARK, MISSOURI	FIGURE 20 DATE 4-14-94 WAIN07	SCHREIBER GRANA & YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS



GROUNDWATER LEVEL ELEVATIONS
RECORDED 11/30/92

VALLEY PARK, MISSOURI

FIGURE 21

DATE
4-14-94

WAIN07

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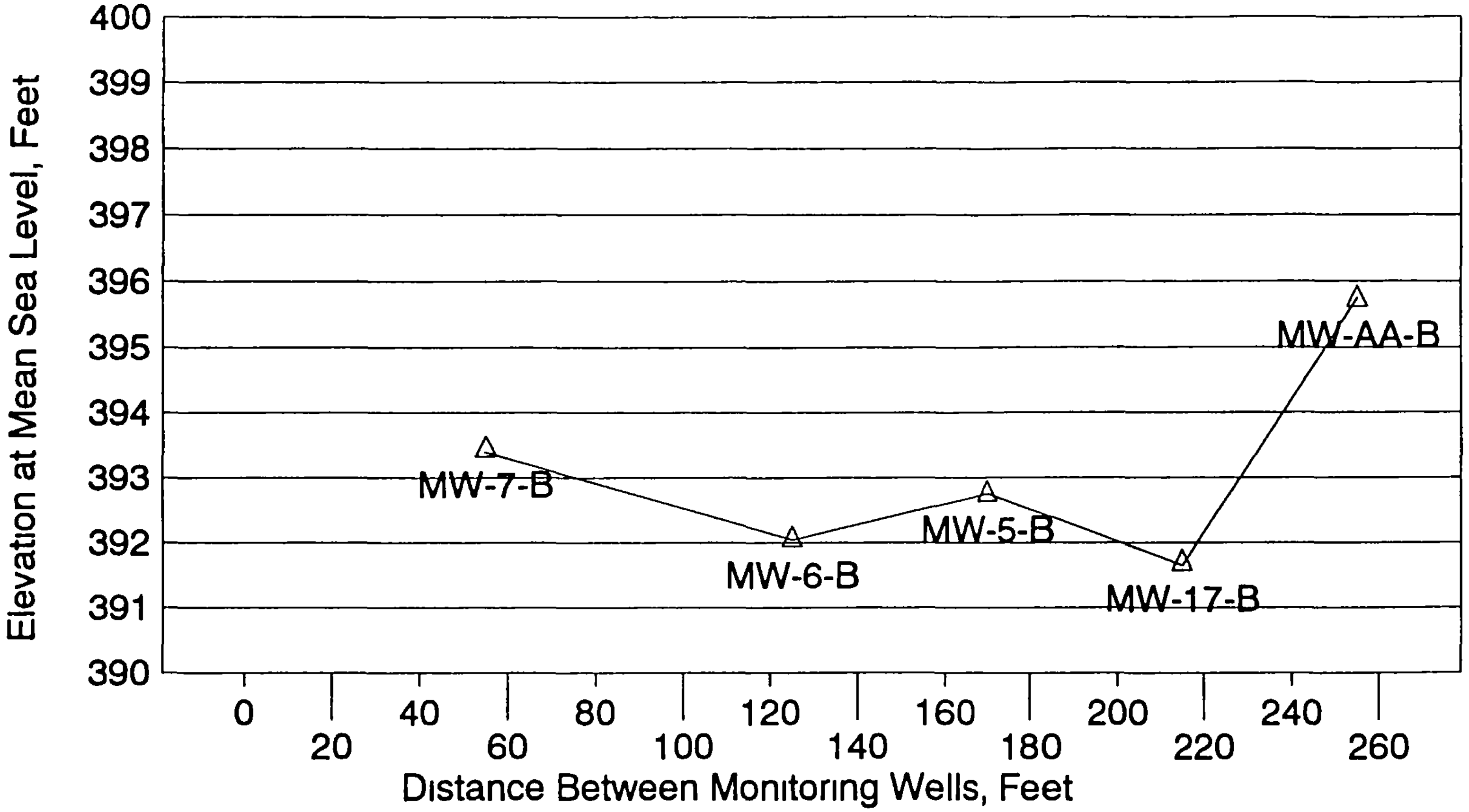
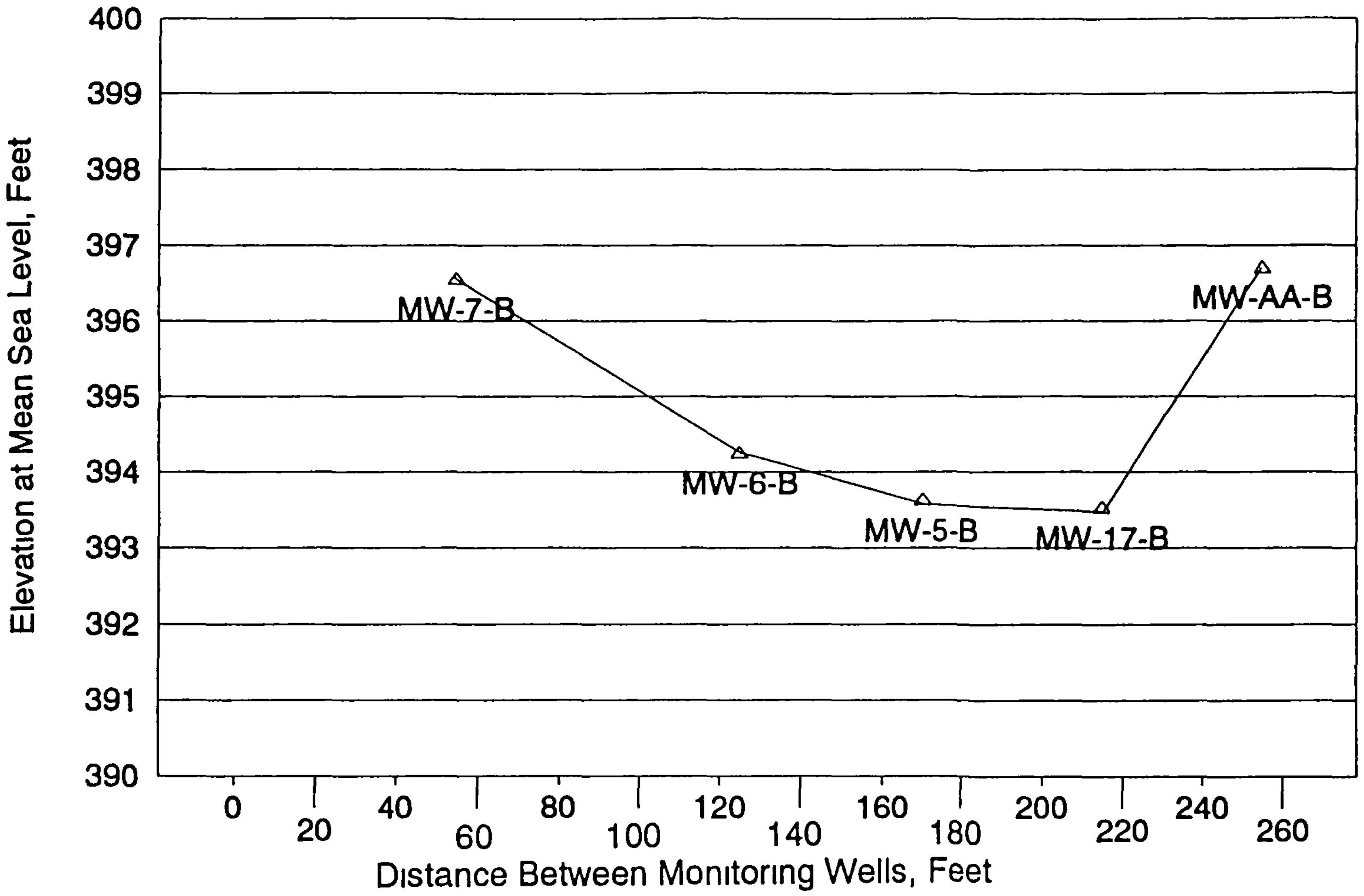
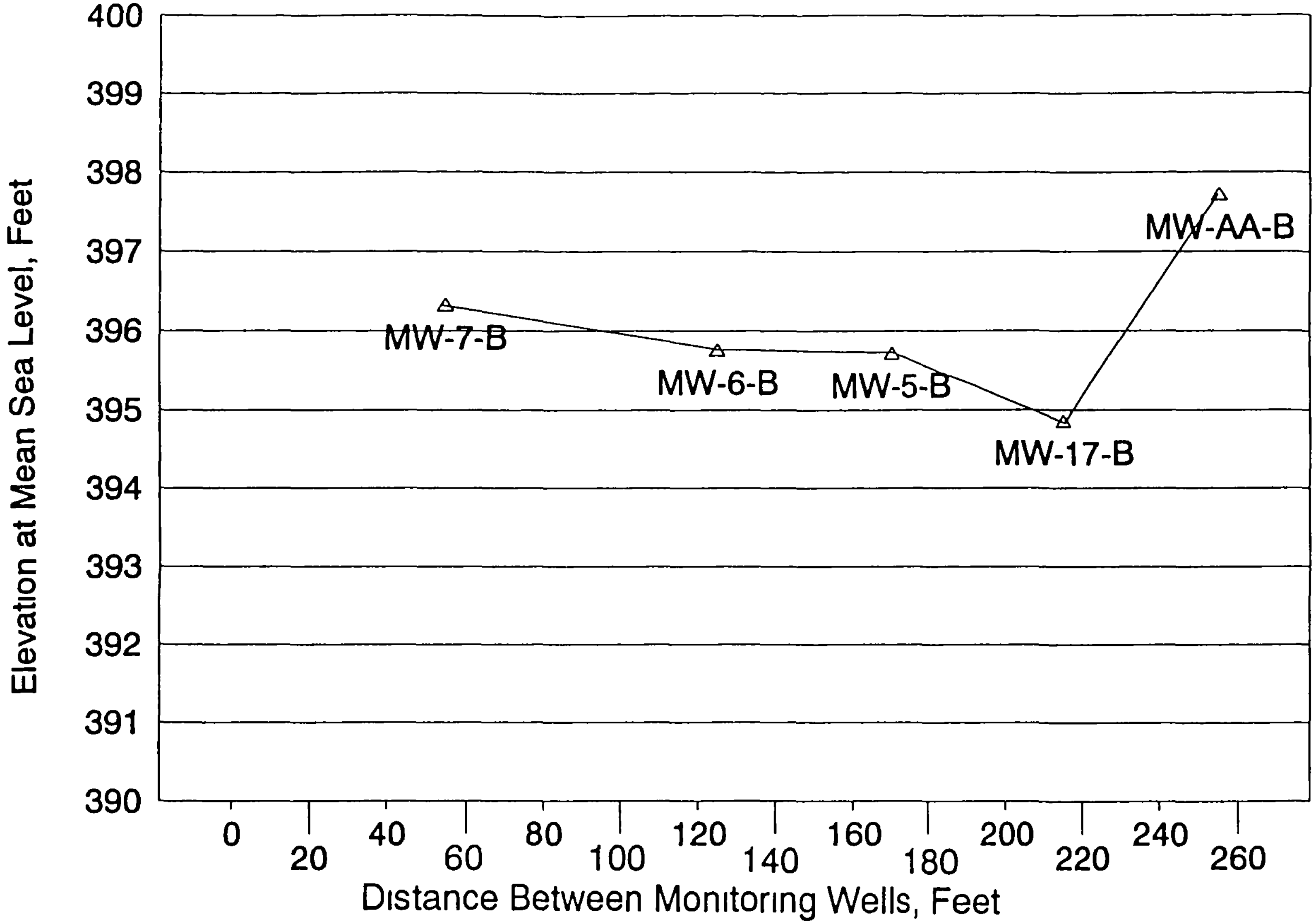
& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



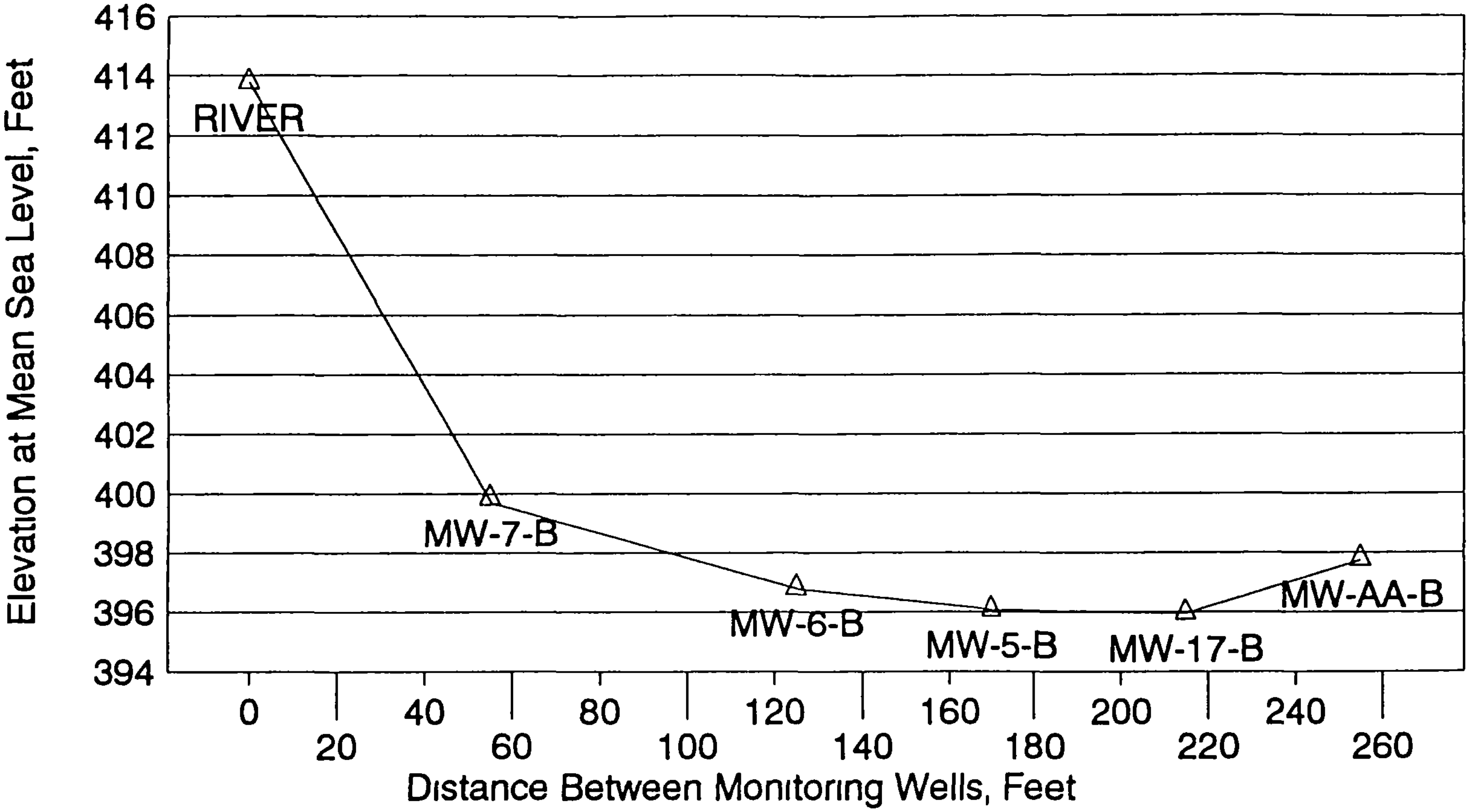
GROUNDWATER LEVEL ELEVATIONS RECORDED 12/16/92 VALLEY PARK, MISSOURI	FIGURE 22 DATE 4-14-94 WAIN07	SCHREIBER & GRANA YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS



GROUNDWATER LEVEL ELEVATIONS RECORDED 12/18/92	FIGURE 23	SCHREIBER GRANA & YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS
	DATE 4-14-94	
VALLEY PARK, MISSOURI	WAIN07	



GROUNDWATER LEVEL ELEVATIONS RECORDED 12/23/92 VALLEY PARK, MISSOURI	FIGURE 24 DATE 4-14-94 WAIN07	SCHREIBER & GRANA & YONLEY INCORPORATED ENVIRONMENTAL ENGINEERS



GROUNDWATER LEVEL ELEVATIONS
RECORDED 1/7/93
VALLEY PARK, MISSOURI

FIGURE 25
DATE
4-14-94
WAIN07

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& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS

TABLE 13
GROUNDWATER LEVEL DATA

	MW AA B			MW 5 B			MW 17 B			MW 6 B			MW 7 B		
DATE	WATER LEVEL	WATER ELEV	RIVER ELEV	WATER LEVEL	WATER ELEV	RIVER ELEV	WATER LEVEL	WATER ELEV	RIVER ELEV	WATER LEVEL	WATER ELEV	RIVER ELEV	WATER LEVEL	WATER ELEV	RIVER ELEV
4/16/92	26 4	398 92	392 02	33 9	391 66	392 02	33 05	391 65	392 02		-	392 02	--	-	392 02
4/22/92	27 16	398 16	412 72	29 9	395 66	412 72	28 66	396 01	412 72	-	--	412 72	--	--	412 72
5/22/92	29 36	395 96	392 22	32 02	393 54	392 22	32 18	392 52	392 22	-	-	392 22	--		392 22
6/15/92	29 8	395 52	391 62	33 85	391 71	391 62	33 02	391 68	391 62		--	391 62	--	-	391 62
6/22/92	30 12	395 2	390 92	34 4	391 16	390 92	33 56	391 14	390 92	-	--	390 92	--	-	390 92
7/31/92	30 7	394 62	393 22	35 1	390 46	393 22	34 28	390 42	393 22	-		393 22	--	-	393 22
8/20/92	31 26	394 06	390 82	36 02	389 54	390 82	35 18	389 52	390 82	-	--	390 83	-	-	390 82
11/13/92	31 72	393 6	395 32	36 8	388 76	395 32	35 96	388 74	395 32	--	--	395 32	--	-	395 32
11/23/92	30 46	394 86	399 32	35 22	390 34	399 32	34 48	390 22	399 32		--	399 32	--	-	399 32
11/24/92	30 2	395 12	402 02	34 76	390 8	402 02	34 04	390 66	402 02	--	--	402 02	--		402 02
11/25/92	29 98	395 34	402 92	34 38	391 18	402 92	33 64	391 06	402 92	--		402 92	-	--	402 92
11/27/92	29 5	395 82	399 32	33 18	392 38	399 32	32 42	392 28	399 32	-	--	399 32	--		399 32
11/30/92	29 04	396 28	396 87	32 46	393 1	396 87	31 72	392 98	396 87	31 3	393 3	396 87	--	--	396 87
12/3/92	29 04	396 28		32 62	392 94	-	31 82	392 88		31 68	392 92	-	24 72	393 65	--
12/16/92	29 54	395 78	-	32 76	392 8		32 96	391 74		32 5	392 1	--	24 88	393 49	-
12/18/92	28 6	396 72	--	31 92	393 64	-	31 16	393 54	-	30 34	394 26	--	21 8	396 57	-
12/23/92	27 6	397 72	--	29 84	395 72		29 84	394 86	--	38 84	395 76	-	22 04	396 33	-
1/7/93	27 4	397 92	413 92	29 36	396 2	413 92	28 6	396 1	413 92	27 66	396 94	413 92	18 38	399 99	413 92
4/20/93	20 11	405 21	407 12	21 22	404 34	407 12	20 43	404 27	407 12	20 22	404 38	407 12	12 94	405 43	407 12
6/2/93	24 2	401 12	394 32	26 1	399 46	394 32	25 28	399 42	394 32	25 48	399 12	394 32	19 46	398 91	394 32
7/8/93	19 68	405 64	412 07	20 36	405 2	412 07	19 58	405 12	412 07	19 08	405 52	412 07	10 78	407 59	412 07
7/22/93	9 82	415 5	416 47	10 4	415 16	416 47	9 52	415 18	416 47	9 34	415 26	416 47	**	--	416 47
8/27/93	19 80	405 52	402 22	21 22	404 34	402 22	20 37	404 33	402 22		-	402 22	-	--	402 22

Notes ( ) denotes no data collected
** denotes inaccessible

As previously stated, no perched groundwater was detected in the silty clay horizon Vertical permeability tests were performed on 3 Shelby tube samples of the silty clay The results indicate an average vertical permeability of $3\ 44 \times 10^{7}$ cm per second (cm/sec) Because of bedding planes, macropores, and occasional stringers, the horizontal permeability (hydraulic conductivity) would be expected to be higher

3 1 6 Land Use and Demography

Land use in Valley Park is represented by a mixture of residential, commercial/industrial, and recreational property Since a majority of the City's developments are located within the floodplain, relatively high flood damages are incurred

The primary study area is bordered generally on the north and west by the Burlington-Northern railroad tracks, on the south by the Meramec River, and on the east by the City of Kirkwood

The main land use in Valley Park is residential In 1980, the census report indicated a population of 3,232 According to the Corps of Engineers, out of the 679 total structures located in the flood plain primary study area, 510 structures are residential

The second most prominent land use is commercial/industrial Of the 679 total structures in the study area, 169 are classified as non-residential (COE, 1985)

Recreational land use is also evident Most prominent are the softball fields just north of the Meramec River Others include the speed-way, swimming pool and tennis club, municipal parks, and the river itself for water sports (e g , fishing and boating)

The predominant factors influencing use of natural resources in Valley Park are the geology and hydrology The river-deposited sediments in the basin have been a significant source of construction materials and groundwater Typical of the Meramec River Valley, Valley Park has been a significant source of sand and gravel (COE, 1985) One such source, now abandoned, is locally known as Simpson's Pit, it is now water filled The sediment-filled river basin also serves as a fairly high production aquifer The groundwater is used by Kirkwood for municipal water
Although not a prime land use now, the sediments of the floodplain provide fertile topsoil for agriculture Lush residential gardens and truck farm patches, along with small hay fields, make use of this resource

Finally, the river itself provides an aquatic resource Despite periodic episodes of river pollution and advisories from the State of Missouri, fishing has remained popular

4 0 NATURE AND EXTENT OF CONTAMINATION

4 1 Nature of Contaminants

The major contaminants of concern in the Valley Park area are chlorinated ethenes and ethanes The source of this contamination is very likely from the loss or disposal of industrial solvents commonly used as degreasers and/or cleaners The major solvents found in the groundwater and/or soil are PCE, TCE, and 1,1,1-TCA Due to their widespread use and subsequent appearance in the environment, these solvents have been the subject of numerous studies on human health, degradation, and movement in soils and groundwater

The aforementioned compounds are all DNAPLs These liquids are denser (heavier) than water, i e , each have a molecular weight greater than water (greater than 1 0) For this reason, the compounds have the ability to sink when introduced into the subsurface and move/migrate vertically in the vadose and saturated zones under the influence of gravity

An additional concern involves all other compounds and metals detected at the site, described below in detail

4 2 Sources

Wainwright Industries manufactured metal stampings and operated as a contract tool and die shop at the property Part of the manufacturing process included a solvent degreasing system that used TCE from 1963 to 1970 and PCE from 1970 to 1979 These chemicals were stored in a 1,000 gallon aboveground storage tank (formerly located directly north of the main building, over the excavated area) The compounds were used to clean automotive parts A by-product of this process resulted in the compound solution becoming mixed with various sludge, oil, and/or grease Subsequently, the actual solution (and associated physical/chemical properties) generated at the end of each de-greasing cycle was unknown Material Safety Data Sheets (MSDS) for the TCE and PCE solvents used at the WOU are included as Appendix E

4 3 Soil and Vadose Zone

The soil and vadose zone investigation involved the drilling of seventeen (17) soil borings and the collection of 70 soil samples from depths ranging from six (6) inches to 35 feet All of the soil samples were analyzed for VOCs according to EPA Method 8240, while a selected portion were analyzed for BNAs (semi-volatiles) according to EPA Method 8270 and 23 metals in accordance with EPA Method 6010 The analytical laboratory results are included in Appendix B

The results of the metal analyses are presented in Table 14 Tidball (1984) United States Geological Survey Professional Paper 954-H,1 , Geochemical Survey of Missouri, was referenced to determine the appropriate (Valley Park regional) background concentration range per metal Each metal concentration per sample was compared to the values published as background This comparison revealed that most of the metal detections were within the appropriate background range However, Calcium and Lead each were above the respective background concentrations in soil boring BH-DD2 These concentrations were 122,700 ppm and 179 ppm each, respectively The upper range of calcium background (90% of all Missouri samples) were less than 8300 ppm, while the lead background (96% of all Missouri samples) were less than 40 ppm

Other metals above background concentrations (as reported in Tidball, 1984) among the soil samples were Copper (BH-DD1, 28 3 ppm, and BH-DD2, 99 6 ppm, both greater than the upper background concentration of 25 ppm), Magnesium (BH-DD2, 21,750 ppm, greater than the upper background concentration of 5600 ppm), and Zinc (BH-DD1, 247 4 ppm, and BH-DD2, 214 1 ppm, both grater than the (approximate) upper background concentration of 100 ppm Additionally, Selenium was detected above the (approximate) upper background concentration of 1 0 ppm in all of the detected samples The analytical result detections ranged from 5 7 ppm to 17 9 ppm This may be indicative of a localized, elevated background condition in the Valley Park region

The elevated metal detections at BH-DD may be the result of the fact that the area is adjacent to the sewer line The integrity of the sewer system between the WOU and its various discharge/intake points in unknown Past Meramec River flooding events may have affected this region via fluid backwashing through the system Additionally, the backfill materials associated with the sewer line (utility conduits) often consist of more permeable materials, sand/gravel, than the natural soils, clay/silt An additional consideration involves the fact that the area is slightly depressed (a topographic low), and could have aided in fluid/material accumulation

The semi-volatile analysis, conducted on a total of seven soil borings (BH-CC, DD, FF, MM, NN, OO, and PP) , totalling 33 samples revealed a variety of detections Table 15 presents the complete listing of semi-volatile detections (along with volatile detections) The majority of the compounds were detected below the quantitation limit The most commonly detected compounds included Pyrene, bis (2-ethylhexyl) Phthalate, Phenanthrene, Flouranthrene, Benzo (a) Anthracene, and Chrysene detected in a total of 9, 15, 6, 7, 5, and 5 samples (out of the 33 samples) each, respectively Soil sample BH-NN-1 (0 5 feet to 1 0 feet) produced the most semi-volatile detections, 11 total In addition to the above listing of compounds, 2-Methylnaphthalene, Anthracene, Benzo (b) Flouranthrene, Benzo (k) Flouranthrene, and Diethylphthalate were each detected either above or estimated below the detection limits

The semi-volatile results within the residential backyards may also be associated with the sewer/utility conduit and topographic low rationality (discussed above in the metals narrative) Additionally, the west fence line of the backyards may have been extended to include a portion of the former alley way upon its closure As this may have been the

TABLE 14

ANALYTICAL SUMMARY - SOIL

METAL	BH-CC-1 5'	BH-CC-2 15'	BH-CC-3 25'	BH-DD-1 0 5 - 1'	BH-DD-2 5'	BH-DD-3 10'	BH-DD-3A 10'	BH-DD-4 15'	BH-DD-5 25'	BH-FF-1 11'	BH-FF-2 15'	BH-FF-3 25'
Aluminum	8691	10,440	1281	6791	4508	16,970	15,080	12,560	7567	11,910	6250	5767
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Barium	160 6	230 7	27	161 5	135 6	64 9	155 5	134 8	160	143 6	94 3	82
Beryllium	0 6	0 8	0 5	0 7	0 6	1 2	1 2	1 2	0 9	1 5	0 7	0 5
Cadmium	ND	0 9	0 8	1 4	2 6	0 9	0 7	1 2	1	0 9	0 6	0 5
Calcium	1366	5337	395	10,390	122,700	3509	3406	4616	3105	3297	6133	2123
Chromium	13 1	16 6	8 7	13 5	31 6	18 4	17 3	16 5	13 3	15 1	10 1	9 9
Cobalt	5 6	8 6	4 6	9 3	5 8	9 6	6 6	13	11 7	9 3	3 3	7 3
Copper	11 6	16	4 2	28 3	99 6	14 5	13 4	18 2	13 7	13	9 4	8 6
Iron	12 430	15,720	13,440	12,150	31,860	19 790	19,840	20,900	16,120	20,850	10,070	7799
Lead	16	28	12	114	179	27	18	22	19	31	7	16
Magnesium	1414	2994	187 9	1984	21,750	3103	2887	3446	2220	2703	2111	1818
Manganese	275 5	1076	221	590 8	661 2	733 2	444 7	1147	427	642 1	176 7	124 3
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Nickel	9 8	17 7	7 3	12 9	23 7	18 4	16 9	24 5	13 1	17 8	13 3	8 1
Potassium	690	865	115	932	667	965	848	1146	908	678	564	617
Selenium	17 9	16 5	14 6	16 3	9 4	17 4	ND	8 3	9 6	5 7	ND	ND
Silver	0 4	ND	0 4	ND	ND	0 7	0 5	0 5	ND	0 6	ND	ND
Sodium	36	147	41	42	101	145	146	224	147	83	77	64
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium	26 2	24 2	20 9	22 9	20	33 9	33 9	36 8	38 7	40 1	17 3	13 4
Zinc	51 4	93 1	66 7	247 4	214 1	86	79 7	98 4	84 8	80 5	53	55 9

Notes Units are mg/kg or ppm
ND = Not Detected

TABLE9 W07

TABLE 15

ANALYTICAL SUMMARY - SOIL
0 5' to 1'

ANALYTE	BH-BB-1	BH-DD-1	BH-EE-1	BH-GG-1	BH-II-1	BH-LL-1	BH-MM-1
Anthracene	NA	ND	NA	NA	NA	NA	0 068 J
Benzo(a)anthracene	NA	ND	NA	NA	NA	NA	0 28 J
Benzo(a)pyrene	NA	ND	NA	NA	NA	NA	0 072 J
Benzo(b)fluoranthene	NA	ND	NA	NA	NA	NA	0 32 J
Benzo(k)fluoranthene	NA	ND	NA	NA	NA	NA	0 18 J
Bis(2-Ethylhexyl) Phthalate	NA	0 78	NA	NA	NA	NA	ND
Chrysene	NA	ND	NA	NA	NA	NA	0 3 J
Cis-1,2-Dichloroethene	2 6 J	1 4 J	ND	ND	ND	0 002 J	ND
Ethyl benzene	ND	ND	ND	ND	36	ND	ND
Fluoranthene	NA	ND	NA	NA	NA	NA	0 76
Isopropyl benzene	ND	ND	ND	ND	10	ND	ND
p-Isopropyl toluene	ND	ND	ND	ND	22	ND	ND
Methylene chloride	2 4 BJ	1 7 BJ	2 5 BJ	4 7 BJ	4 8 J	0 004 BJ	0 023 J
Naphthalene	ND	ND	ND	ND	61	ND	ND
Phenanthrene	NA	ND	NA	NA	NA	NA	0 5
Pyrene	NA	0 16 J	NA	NA	NA	NA	0 73
Tetrachloroethene	6800	2400	16	1800	12	0 41	0 39
Toluene	2 2 J	ND	ND	ND	28	0 003 J	0 008 J
Trichloroethene	420	51	ND	110	ND	0 093	0 041
1,2,4-Trimethylbenzene	1 3 J	ND	ND	ND	410	ND	ND
1,3 5-Trimethylbenzene	1 8 J	ND	ND	ND	ND	ND	ND
Xylenes (m-, o-)	2 0 J	ND	ND	ND	360	ND	ND
Xylene (p)	ND	ND	ND	ND	220		ND

Notes Units are mg/kg or ppm
NA = No Analysis Conducted
ND = Not Detected at Quantitation Limit
J = Detected Below Quantitation Limit, Estimated
B = Detected in Method Blank

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
0 5' to 1'

ANALYTE	BH-NN-1	BH-OO-1	BH-PP-1
Anthracene	0 042 J	ND	ND
Benzo(a)anthracene	0 22	0 11 J	0 11 J
Benzo(a)pyrene	0 21	ND	ND
Benzo(b)fluoranthene	0 25	ND	ND
Benzo(k)fluoranthene	0 098 J	ND	ND
Bis(2-Ethylhexyl) Phthalate	0 036 J	ND	0 039 J
Chrysene	0 23	0 13 J	0 14 J
Cis-1,2-Dichloroethene	ND	ND	ND
Ethyl benzene	ND	ND	ND
Fluoranthene	0 5	0 21	0 27
Isopropyl benzene	ND	ND	ND
p-Isopropyl toluene	ND	ND	ND
Methylene chloride	0 023 J	0 025	0 023 J
Naphthalene	ND	0 0125	0 0125
Phenanthrene	0 25	0 15 J	0 17 J
Pyrene	0 39	0 26	0 27
Tetrachloroethene	0 066	0 059	0 012 J
Toluene	ND	ND	ND
Trichloroethene	0 019 J	0 14	ND
1,2,4-Trimethylbenzene	ND	ND	ND
1,3,5-Trimethylbenzene	ND	ND	ND
Xylenes (m-, o-)	ND	ND	ND
Xylene (p)	ND	ND	ND

Notes Units are mg/kg or ppm
ND = Not Detected at Quantitation Limit
J = Detected Below Quantitation Limit, Estimated

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
5'

ANALYTE	MW-AA-1	BH-AA-1	BH-BB-2	BH-CC-1	BH-DD-2	BH-EE-2	BH-GG-2	BH-II-2
Acetone	ND	ND	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	NA	NA	NA	ND	ND	NA	NA	NA
Bis(2-Ethylhexyl) Phthalate	NA	NA	NA	ND	2 2	NA	NA	NA
2-Butanone	ND	ND	ND	ND	ND	99 J	ND	ND
Carbon Disulfide	004 J	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	56 J	ND	ND	ND	ND	ND
Chrysene	NA	NA	NA	ND	ND	NA	NA	NA
Diethylphthalate	NA	NA	NA	ND	ND	NA	NA	NA
Cis-1,2-Dichloroethene	ND	ND	3	ND	ND	ND	ND	ND
Fluoranthene	NA	NA	NA	ND	ND	NA	NA	ND
Methylene chloride	ND	ND	3 BJ	0 007	1 4 BJ	54 BJ	5 6 BJ	ND
Phenanthrene	NA	NA	NA	ND	ND	NA	NA	NA
Pyrene	NA	NA	NA	ND	14 J	NA	NA	NA
Tetrachloroethene	004 J	73 E	1300 E	0 039	2300 E	2 3	20	0 01
Methyl Tertiary Butyl Ether (MTBE)	NA	002 J	ND	ND	ND	ND	ND	0 013
Toluene	ND	ND	0 75	ND	ND	ND	ND	ND
1,2,3-Trichlorobenzene	NA	ND	ND	ND	ND	12 J	ND	ND
1,2,4-Trichlorobenzene	NA	ND	ND	ND	ND	13 J	ND	ND
1 1 1-Trichloroethane	ND	ND	0 26	ND	ND	ND	ND	ND
Trichloroethene	ND	0 021	280 E	0 012	69	ND	9	ND

Notes Units are mg/kg or ppm
NA = Not Analyzed for
ND = Not Detected at Quantitation Limit
J = Detected Below Quantitation Limit, Estimated
E = Concentration Exceeds Calibration Curve
B = Detected in Method Blank

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
5'

ANALYTE	BH-JJ-1	BH-KK-1	BH-LL-2	BH-LL-2A	BH-MM-2	BH-NN-2	BH-OO-2	BH-PP-2
Acetone	ND	ND	0 016	ND	ND	ND	ND	ND
Benzo(a)anthracene	NA	NA	NA	NA	ND	ND	ND	039 J
Bis(2-Ethylhexyl) Phthalate	NA	NA	NA	NA	ND	ND	ND	041 J
2-Butanone	ND	ND	ND	ND	ND	ND	ND	ND
Carbon Disulfide	ND	0 028	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
Chrysene	NA	NA	NA	NA	ND	ND	ND	039 J
Diethylphthalate	NA	NA	NA	NA	ND	ND	072 J	ND
Cis-1,2-Dichloroethene	ND	ND	0 01	003 J	ND	ND	ND	ND
Fluoranthene	ND	ND	ND	NA	052 J	ND	ND	091 J
Methylene chloride	ND	0 007	ND	ND	015 J	0 024	024 J	025 J
Phenanthrene	NA	NA	NA	NA	ND	ND	ND	1 J
Pyrene	NA	NA	NA	NA	034 J	ND	ND	093 J
Tetrachloroethene	ND	0 054	0 22	65 E	011 J	013 J	007 J	009 J
Tertiary Butyl Methyl Ether (MTBE)	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ND	ND	ND	0 006	ND	ND	ND	ND
1,2,3-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
1 2,4-Trichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	002 J	ND	ND	ND	ND
Trichloroethene	ND	006 J	0 097	0 034	ND	009 J	009 J	ND

Notes Units are mg/kg or ppm
NA = Not Analyzed for
ND = Not Detected at Quantitation Limit
J = Detected Below Quantitation Limit, Estimated
E = Concentration Exceeds Calibration Curve

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
10'

ANALYTE	BH-BB-3	BH-DD-3	BH-DD-3A	BH-EE-3	BH-FF-1	BH-GG-3
Bis(2-Ehtylhexyl) Phthalate	NA	11 J	13 J	NA	ND	NA
Chloroform	ND	ND	ND	ND	ND	ND
Cis-1,2-Dichloroethene	0 12	ND	ND	ND	ND	ND
Methylene chloride	012 BJ	ND	15 BJ	43 BJ	41 J	1 9 BJ
Tetrachloroethene	15 E	780 E	2000 E	8 9	1 6	24
Toluene	009 J	ND	ND	ND	ND	ND
Trichloroethene	1 9 E	25	56	ND	41 J	8 5
Trichlorofluoromethane	ND	ND	ND	ND	17 J	NA
1,2,4-Trimethylbenzene	ND	ND	ND	ND	ND	NA
1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	NA
Xylenes (m-, p-)	ND	ND	ND	ND	ND	NA
Xylene (o)	ND	ND	ND	ND	ND	NA

Notes Units are mg/kg or ppm
NA = Not analyzed for
ND = Not detected
J = Detected below RQL, Estimated
E = Concentration Exceeds Calibration Curve
B = Detected in Method Blank

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
10'

ANALYTE	BH-II-3	BH-LL-3	BH-MM-3	BH-NN-3	BH-OO-3	BH-PP-3
Bis(2-Ehtylhexyl) Phthalate	NA	NA	ND	ND	ND	ND
Chloroform	ND	ND	ND	0 007 J	ND	ND
Cis-1,2-Dichloroethene	36 E	012 J	009 J	012 J	ND	ND
Methylene chloride	005 J	013 J	014 J	012 J	017 J	ND
Tetrachloroethene	1 7 E	0 34	0 66	1 8	015 J	0 13
Toluene	ND	ND	ND	ND	ND	ND
Trichloroethene	0 15	0 13	0 24	6 1	0 053	0 13
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	002 J	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	004 J	ND	ND	ND	ND	ND
Xylenes (m-, p-)	002 J	ND	ND	ND	ND	ND
Xylene (o)	002 J	ND	ND	ND	ND	ND

Notes Units are mg/kg or ppm
NA = Not analyzed for
ND = Not detected
J = Detected below RQL, Estimated
E = Concentration Exceeds Calibration Curve

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
15'

ANALYTE	MW-AA-2	BH-AA-2	BH-BB-4	BH-CC-2	BH-DD-4	BH-EE-4	BH-FF-2	BH-GG-4	BH-HH-1
Acetone	ND	ND	ND	ND	ND	ND	ND	ND	ND
Bis(2-Ethylhexyl) Phthalate	NA	NA	NA	ND	072 J	NA	13 J	NA	NA
2-butanone	ND	ND	ND	ND	ND	8 J	ND	ND	ND
Chlorobenzene	ND	ND	0 009	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	004 J	ND	ND	ND	ND	ND	ND
cis-1,2-Dichloroethene	ND	002 J	0 18	ND	ND	ND	ND	ND	16 J
Trans-1,2-Dichloroethene	ND	ND	002 J	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	ND	ND	006 J	10 BJ	79 B	2 0 BJ	2 1 BJ	6 BJ
Naphthalene	NA	ND	001 J	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	ND	ND	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	0 17	0 18	12 E	0 16	680 E	1 2	22	60	5 7
Toluene	ND	ND	0018	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	003 J	ND	ND	ND	ND	ND	ND
Trichloroethene	0 006	0 013	6 3 E	0 064	16	ND	3 5 J	9 5	6 J
Trichlorofluoromethane	NA	ND	ND	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	NA	ND	002 J	ND	ND	ND	ND	ND	ND
Xylene (m-, p-)	ND	ND	005 J	ND	ND	ND	ND	ND	ND
Xylene (o)	ND	ND	002 J	ND	ND	ND	ND	ND	ND

Notes Units are mg/kg or ppm
NA = No Analysis Conducted
ND = Not Detected
J = Detected below RQL, Estimated
E = Concentration Exceeds Calibration Curve
B = Detected in Method Blank

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
15'

ANALYTE	BH-HH-2	BH-II-4	BH-JJ-2	BH-KK-2	BH-LL-4	BH-MM-4	BH-NN-4	BH-OO-4	BH-PP-4
Acetone	ND	ND	21	ND	ND	ND	ND	ND	ND
Bis(2-Ethylhexyl) Phthalate	NA	NA	NA	NA	NA	ND	1 1	ND	ND
2-butanone	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chloroform	ND	ND	ND	ND	ND	ND	ND	005 J	ND
cis-1,2-Dichloroethene	ND	38 E	ND	ND	0 027	022 J	ND	018 J	006 J
Trans-1,2-Dichloroethene	ND	002 J	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	ND	004 J	3 3 BJ	ND	ND	011 J	018 J	018 J	006 J
Naphthalene	ND	001 J	ND	ND	ND	ND	ND	ND	ND
4-Methyl-2-Pentanone	ND	ND	006 J	ND	ND	ND	ND	ND	ND
Tetrachloroethene	150	6 7 E	ND	0 014	0 45	1 6	0 89	0 66	0 92
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1,1-Trichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
Trichloroethene	3 9 J	53 E	ND	0 01	0 12	0 51	0 95	3 5	1 2
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND
1 2,4-Trimethylbenzene	ND	002 J	ND	ND	ND	ND	ND	ND	ND
Xylene (m-, p-)	ND	002 J	ND	ND	ND	ND	ND	ND	ND
Xylene (o)	ND	002 J	ND	ND	ND	ND	ND	ND	ND

Notes Units are mg/kg or ppm
NA = No Analysis Conducted
ND = Not Detected
J = Detected below RQL, Estimated
E = Concentration Exceeds Calibration Curve

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
20' TO 23 5'

ANALYTE	MW-AA-3	MW-AA-3A	BH-LL-5	BH-MM-5	BH-NN-5	BH-OO-5	BH-PP-5
Acetone	0 011	ND	ND	ND	ND	ND	ND
Bis(2-Ethylhexyl) Phthalate	ND	NA	NA	NA	054 J	04 J	ND
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND
Cis-1,2-Dichloroethene	001 J	002 J	0 031	0 045	ND	ND	ND
Methylene chloride	ND	002 BJ	ND	02 J	019 J	0 055	ND
Tetrachloroethene	0 71	76 E	0 29	2 5	1 3	0 034	1 3
Trichloroethene	0 016	0 017	0 42	0 95	1 1	0 049	1 2

ANALYTICAL SUMMARY - SOIL
25'

ANALYTE	BH-AA-3	BH-BB-5	BH-CC-3	BH-DD-5	BH-EE-5	BH-EE-5A
Bis(2-Ethylhexyl) Phthalate	NA	NA	ND	13 J	NA	ND
2-Butanone	ND	93 J	ND	ND	ND	79 J
n-Butylbenzene	ND	ND	ND	ND	ND	ND
Cis-1,2-Dichloroethene	ND	15 J	ND	ND	ND	ND
Fluoranthene	NA	NA	ND	ND	NA	ND
Methylene chloride	ND	18 BJ	005 J	5 6 BJ	1 3 B	49 BJ
2-Methylnaphthalene	NA	NA	ND	ND	NA	ND
Phenanthrene	NA	NA	ND	ND	NA	ND
Pyrene	NA	NA	ND	ND	NA	ND
Tetrachloroethene	002 J	3 1	0 011	700 E	1	ND
Trichloroethene	ND	1 6	002 J	14	ND	ND
Trichlorofluoromethane	ND	14 J	ND	ND	14 J	ND
1,2,4-Trimethylbenzene	ND	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	ND	ND	ND	ND	ND	ND

Notes Units are mg/kg or ppm
NA = No Analysis Conducted
ND = Not Detected
J = Detected below RQL, Estimated
E = Concentration Exceeds Calibration Curve
B = Detected in Method Blank

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
25'

ANALYTE	BH-FF-3	BH-GG-5	BH-HH-3	BH-II-5	BH-JJ-3	BH-KK-3
Bis(2-Ethylhexyl) Phthalate	1 J	NA	NA	NA	NA	NA
2-Butanone	ND	ND	ND	ND	ND	ND
n-Butylbenzene	1 9 J	ND	ND	002 J	ND	ND
Cis-1,2-Dichloroethene	ND	ND	ND	0 008	ND	001 J
Fluoranthene	039 J	NA	NA	NA	NA	NA
Methylene chloride	4 6 BJ	1 8 BJ	ND	005 J	007 J	ND
2-Methylnaphthalene	1 J	NA	NA	NA	NA	NA
Phenanthrene	098 J	NA	NA	NA	NA	NA
Pyrene	077 J	NA	NA	NA	NA	NA
Tetrachloroethene	360 E	32	ND	4 2 E	ND	0 054
Trichloroethene	110	ND	ND	0 034	ND	0 036
Trichlorofluoromethane	ND	ND	ND	ND	ND	ND
1,2,4-Trimethylbenzene	1 5 J	ND	ND	ND	ND	ND
1,3,5-Trimethylbenzene	1 6 J	ND	ND	ND	ND	ND

Units are mg/kg or ppm
NA = Analysis Not Conducted
ND = Not Detected
J = Detected below RQL, Estimated
E = Concentration Exceeds Calibration Curve
B = Detected in Method Blank

TABLE 15 (CONT'D)

ANALYTICAL SUMMARY - SOIL
35'

ANALYTE	BH-AA-4	BH-KK-4
Acetone	ND	0 026
Cis-1,2-Dichloroethene	ND	002 J
Methylene chloride	ND	ND
Tetrachloroethene	0 015	0 025
Trichloroethene	005 J	0 012

Notes
Units are mg/kg or ppm
ND = Not Detected
J = Detected below RQL, Estimated

case, a portion of the current backyards may have (at one time) been public right-of-way and, thus accessible to the general public

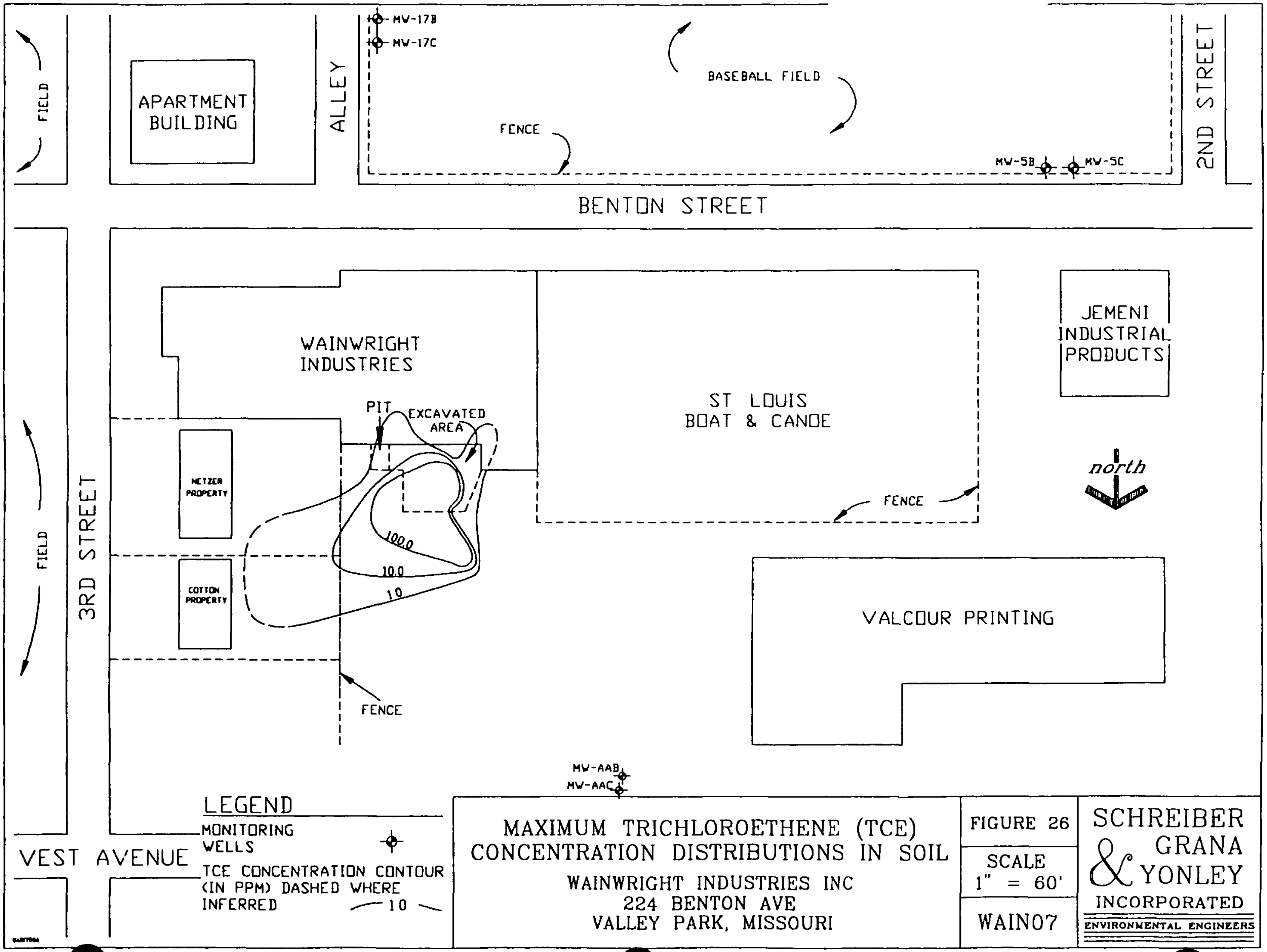
A summary of the detected volatile organic constituents (along with semi-volatiles) is presented in Table 15 In general, TCE and PCE comprised the majority of the detections across the site TCE and PCE concentration distribution diagrams are presented in Figures 26 and 27, respectively These figures were generated using all individual sample locations and subsequent analytical data gathered to date The contours were generated using the maximum TCE and PCE concentrations per sample location, regardless of depth The two figures present similar concentration distributions, both being greatest immediately north of the Wainwright building within and beneath the soil excavation area The PCE distribution is greater, being located further to both the east and west, while also extending beneath the Wainwright building to the south Maximum concentrations remaining in-situ exceed 6000 ppm The distribution of TCE across the site is less extensive than PCE, however, it does also extend to the east to the residential region adjacent to 3rd Street Maximum concentrations exceed 400 ppm, beneath the soil excavation

The volatile organic constituent analytical results at the WOU may also be associated with the sewer/utility conduit and topographic low rationality (discussed above in the metals narrative) Additionally, the 1000 gallon above ground storage tank (formerly used to store the TCE/PCE, located over the excavated area) may have been a potential chlorinated solvent source

Geologic cross-sections and a plan view depicting the section traverses are presented in Figures 28, 29, 30 and 31 These three cross-sections depict both the underlying soil type as well as the Miran field readings, and TCE and PCE analytical concentrations As was depicted in Figures 26 and 27, the maximum concentrations are present beneath the soil excavation area, immediately north of the Wainwright building Detections were noted within both the upper clay and the lower sand and gravel zones Maximum Miran field readings were encountered in BH-FF in both the clay (5400 ppm, 15-20 feet below grade), and the sand/gravel zone (5000 to 7000 ppm, 20-25 feet below grade) Other soil borings exhibiting high Miran readings were BH-DD and BH-GG

Analytical concentrations were greatest BH-DD, BH-GG, BH-BB, and BH-FF Borings BH-GG, and BH-BB each generally produced the greater concentrations nearer the surface (0 feet to 15 feet below grade), while BH-DD and BH-FF both exhibited more uniform concentrations throughout the borehole run (each to depths of 25 feet below grade)

The above concentration distribution pattern is indicative of past TCE/PCE sources emanating from the areas of BH-FF, BH-DD, BH-BB, and BH-GG As the Miran concentrations are greatest in BH-FF and BH-DD, these locations were most likely the nearest to a potential source(s) Additionally, as the analytical concentrations in BH-BB and BH-GG decrease with depth, this implies that the vertical TCE and PCE migration within the clay zone (at these boreholes) was inhibited by retardation effects as well as being a function of a limited effective porosity typical of clay



LEGEND
MONITORING WELLS ⌖
TCE CONCENTRATION CONTOUR (IN PPM) DASHED WHERE INFERRED — 10 —

MAXIMUM TRICHLOROETHENE (TCE) CONCENTRATION DISTRIBUTIONS IN SOIL
WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 26
SCALE 1" = 60'
WAIN07

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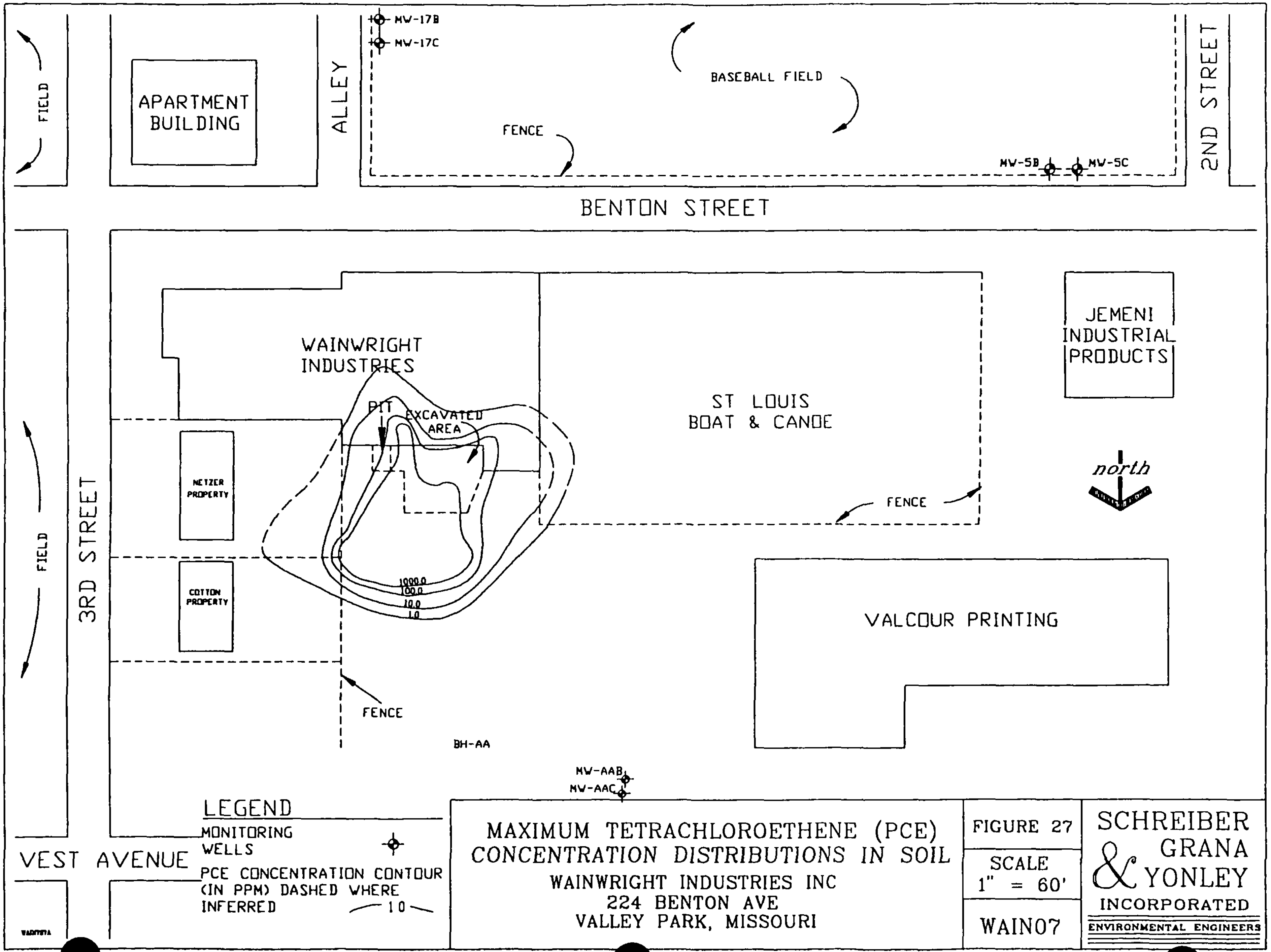

LEGEND

MONITORING WELLS ⌖

PCE CONCENTRATION CONTOUR (IN PPM) DASHED WHERE INFERRED — 10 —

MAXIMUM TETRACHLOROETHENE (PCE) CONCENTRATION DISTRIBUTIONS IN SOIL

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 27

SCALE
1" = 60'

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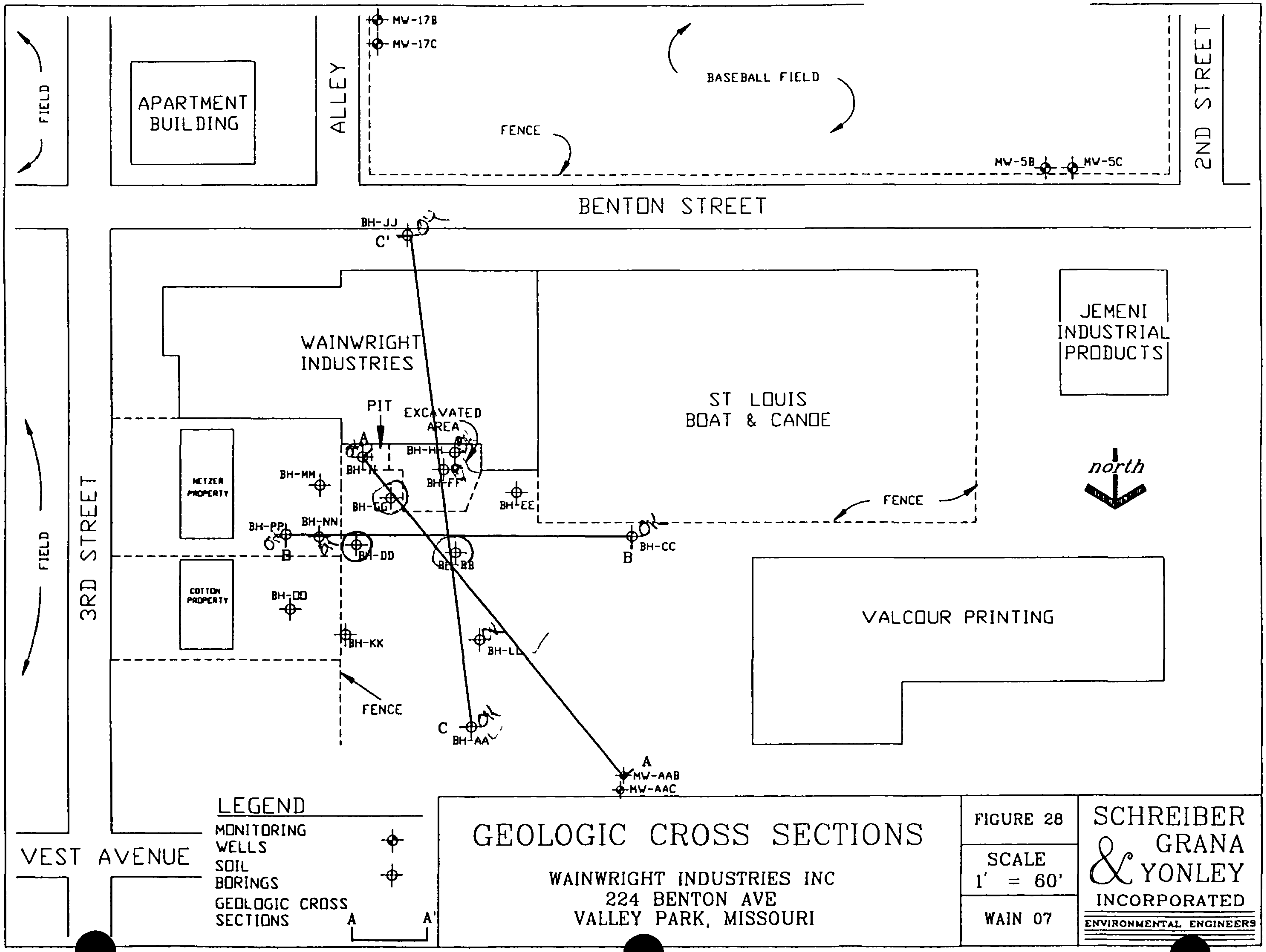

GEOLOGIC CROSS SECTIONS

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 28

SCALE
1' = 60'

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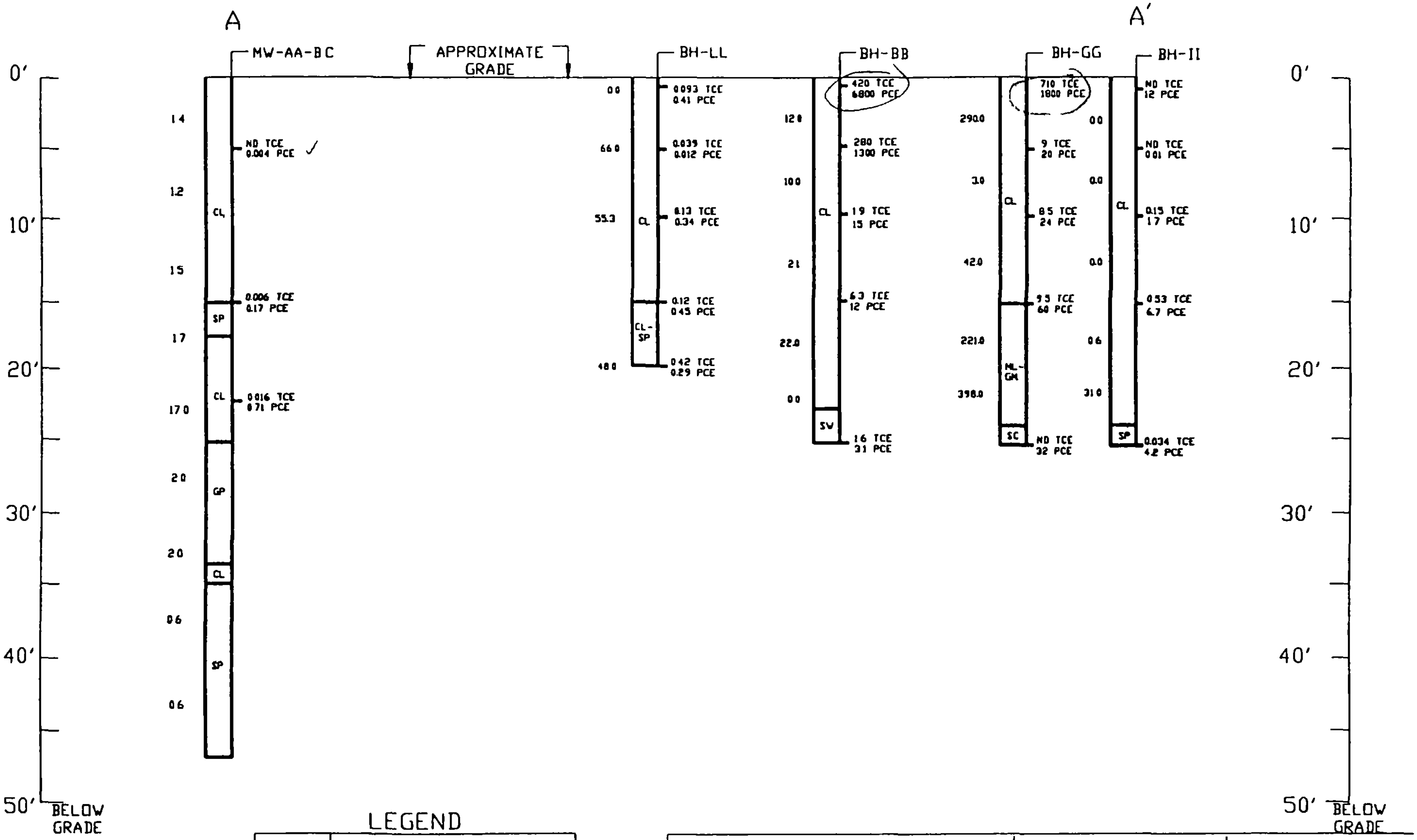
VAIN7A



LEGEND

0.0	MIRAN 1-B IN PARTS PER MILLION (ppm)
420 TCE,	TRICHLOROETHENE IN ppm
6800 PCE	TETRACHLOROETHENE IN ppm
CL	UNIFIED SOIL CLASSIFICATION

- ALL ANALYTICAL RESULTS ARE FROM SOIL SAMPLES

GEOLOGIC CROSS SECTION
A–A'

WAINWRIGHT INDUSTRIES
224 BENTON AVENUE
VALLEY PARK MISSOURI

FIGURE 29

VERTICAL SCALE
1" = 10'
HORIZONTAL SCALE
1" = 30'

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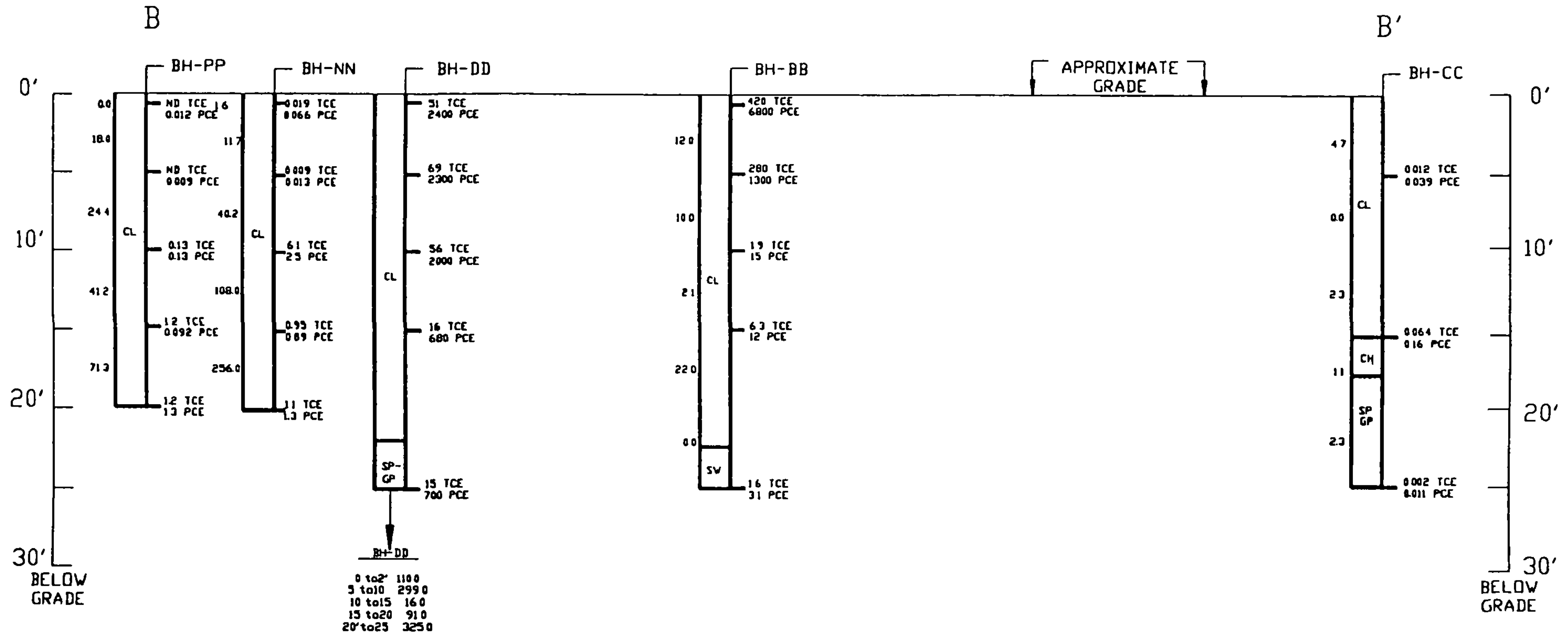
WAIN7B



LEGEND

0.0	MIRAN 1-B IN PARTS PER MILLION (ppm)
420 TCE	TRICHLOROETHENE IN ppm
6800 PCE	TETRACHLOROETHENE IN ppm
CL	UNIFIED SOIL CLASSIFICATION

- ALL ANALYTICAL RESULTS ARE FROM SOIL SAMPLES

GEOLOGIC CROSS SECTION
B-B'

WAINWRIGHT INDUSTRIES
224 BENTON AVENUE
VALLEY PARK, MISSOURI

FIGURE 30

VERTICAL SCALE
1' = 10'
HORIZONTAL SCALE
1' = 20'

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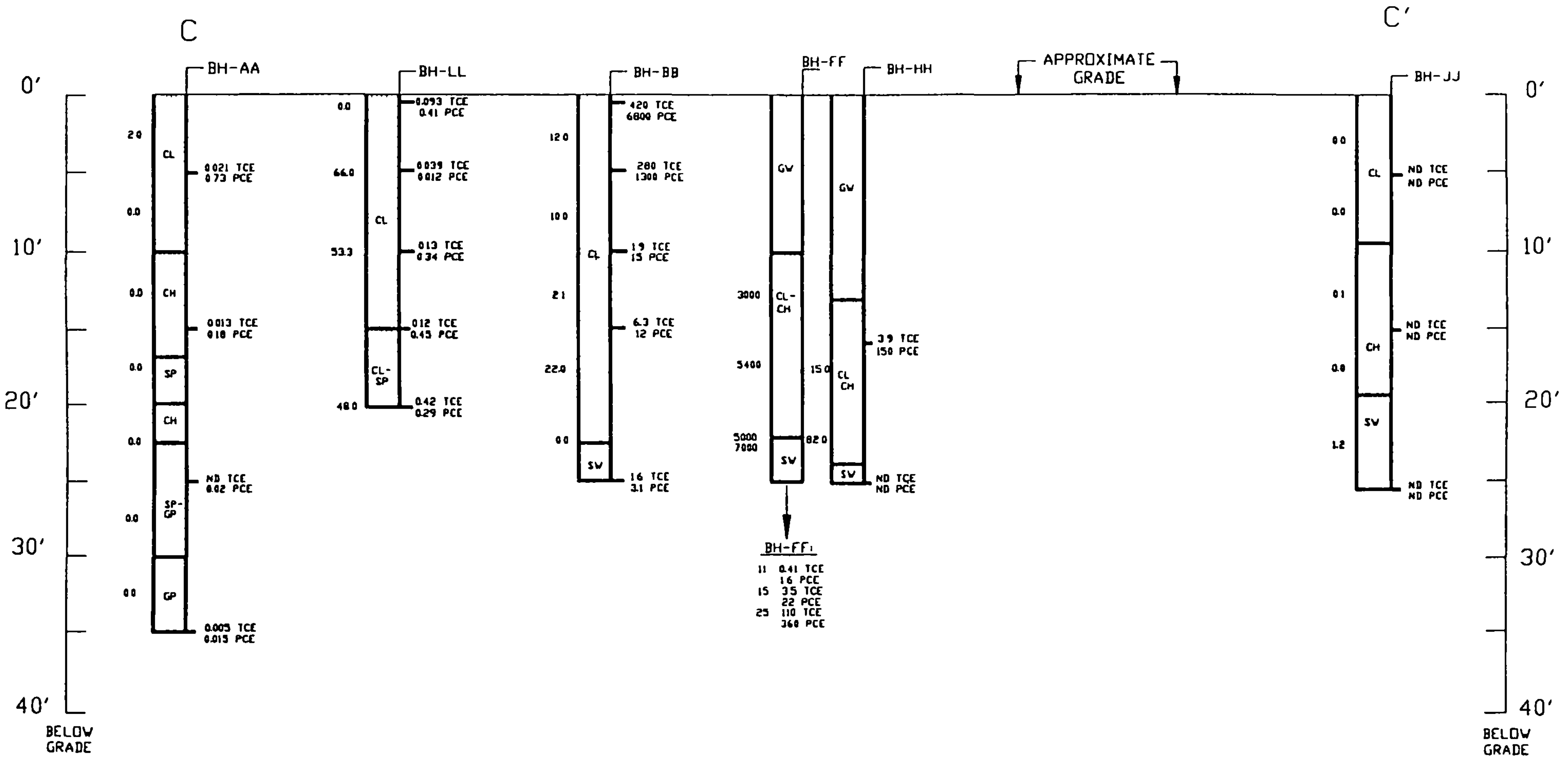
VAIN7C



LEGEND

0.0	MIRAN 1-B IN PARTS PER MILLION (ppm)
420 TCE	TRICHLOROETHENE IN ppm
6800 PCE	TETRACHLOROETHENE IN ppm
CL	UNIFIED SOIL CLASSIFICATION

ALL ANALYTICAL RESULTS ARE FROM SOIL SAMPLES

GEOLOGIC CROSS SECTION C–C′

WAINWRIGHT INDUSTRIES
224 BENTON AVENUE
VALLEY PARK, MISSOURI

FIGURE 31

VERTICAL SCALE
1′ = 10′
HORIZONTAL SCALE
1″ = 30′

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4 4 Groundwater

The groundwater investigation involved the installation of one (1) upgradient well cluster (MW-AA), two (2) rounds of water samples from well clusters MW-5, MW-17 and MW-AA, and continued gathering of groundwater elevation data The wells, six total, are installed in clusters of two per location, one shallow and one deep

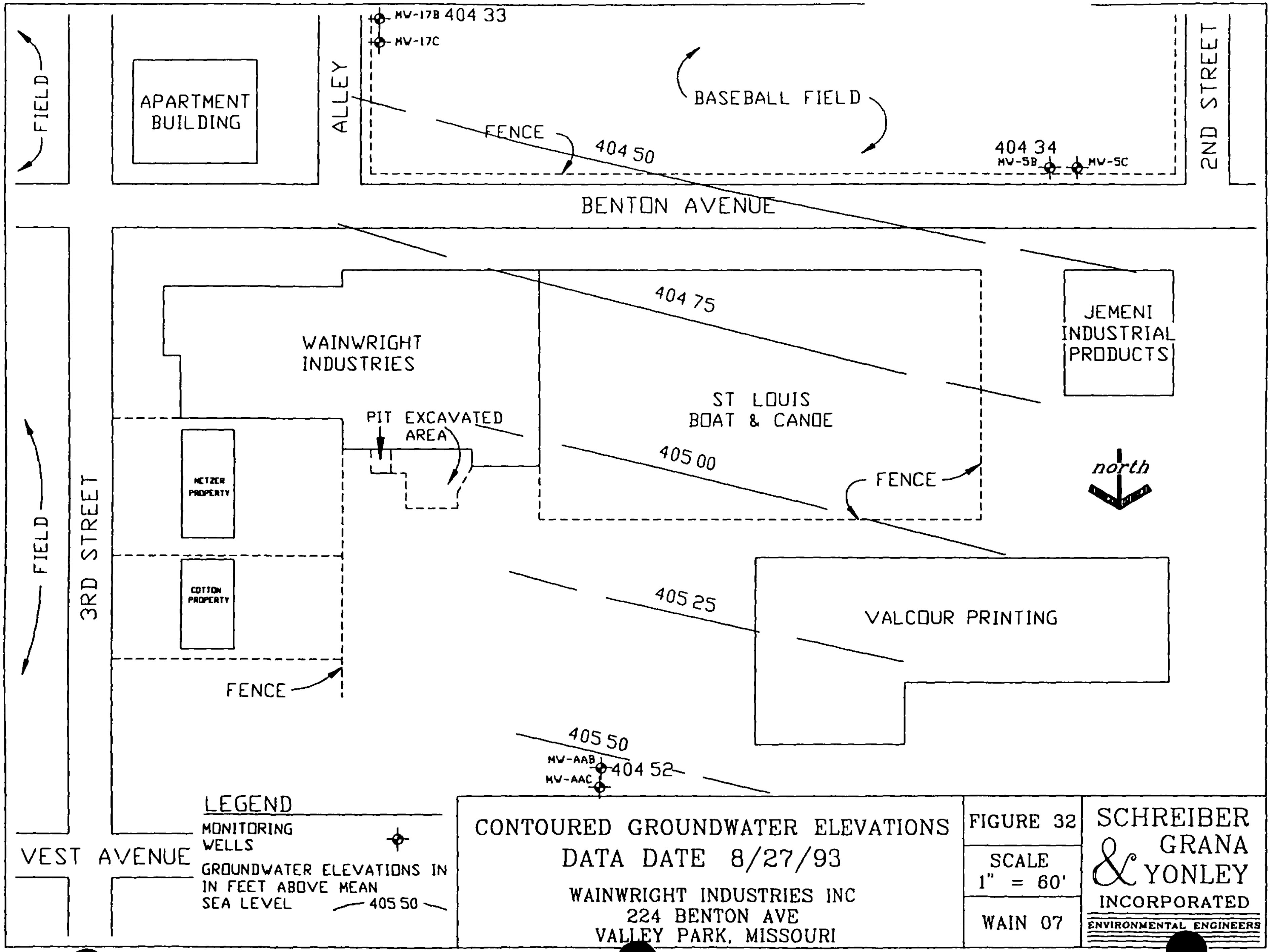
Groundwater elevations were gathered over a 15 month period The data is presented in Table 13 The most recent groundwater elevation data, gathered August 27, 1993 is presented in Figure 32 This map presents the configuration of the groundwater surface relative to feet above MSL On this date, groundwater was encountered between 19 8 feet below grade (MW-AAB) and 21 22 feet below grade (MW-5B) The flow direction was to the south under an average horizontal hydraulic gradient of 0 003 feet per foot

Table 16 presents the data and calculations used to determine the vertical gradients of the three well nests (MW-AA, MW-5, and MW-17) monitored during August 27, 1993 On this date, the vertical gradients were -0 023 feet per foot (ft/ft) for the MW-AA well nest, -0 014 ft/ft for MW-5, and 0 014 ft/ft for MW-17 According to the data, well nests MW-AA and MW-5 are located within aquifer discharge areas, i e , upward gradients, while MW-17 is recharging the aquifer All three gradients are indicative of non-perched groundwater conditions, this data may not be indicative of the actual groundwater conditions beneath the site

The groundwater samples were analyzed for pH, conductivity, cyanide, VOCs in accordance with EPA Method 8240, BNAs in accordance with EPA Method 8270, 23 metals in accordance with EPA Method 6010, PCBs, pesticides and herbicides in accordance with EPA Method 8080, and total extractable hydrocarbons in accordance with EPA Method 8015 A summary of the detected analytes in the groundwater is presented in Tables 17, 18, 19 and 20 Laboratory results are included in Appendix B

The results of the groundwater sampling indicated that a variety of volatile compounds are present in the groundwater beneath the Wainwright facility As was the case with the soil sampling program, both TCE and PCE are detected Monitor well cluster MW-17 produced TCE concentrations ranging from non-detect to 420 ppb and PCE concentrations from 140 ppb to 1500 ppb Monitor well cluster MW-5 produced TCE concentrations ranging from non-detect to 11 ppb and PCE concentrations ranging from non-detect to 22 ppb Monitor well cluster MW-AA produced no detections of TCE Detections of PCE were 92 and 35 ppb (encountered in the B well) The A well produced no PCE detections

The presence of PCE in the hydraulically upgradient monitor well (MW-AA-B) could be attributed to any one (or more) of the following factors gradient reversal due to Meramec River flooding, mobile vapors, an irregular bedrock surface dipping from the WOU to the MW-AA well cluster, and potential off-site (or unknown) sources Data to prove or disprove any of these factors is beyond the scope of this Operable Unit RI/FS



LEGEND

MONITORING WELLS ⌖

GROUNDWATER ELEVATIONS IN IN FEET ABOVE MEAN SEA LEVEL — 405 50 —

CONTOURED GROUNDWATER ELEVATIONS
DATA DATE 8/27/93
WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 32

SCALE 1" = 60'

WAIN 07

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TABLE 16

VERTICAL GRADIENTS
August 28, 1993

Monitoring Well	Depth to Water	dh	Total Depth	dl	Vertical Gradient (Ft/Ft)
MW-AAB MW-AAC	19 80 20 12	-0 32	33 25 46 89	13 64	-0 023
MW-5B MW-5C	21 22 21 48	-0 26	41 35 59 90	18 55	-0 014
MW-17B WW-17C	20 37 20 10	0 27	39 60 59 25	19 65	0 014

Notes dh denotes difference in depth to water
dl denotes difference in total depth
vertical gradient derived by dh/dl
(-) denotes upward gradient
All measurements in feet

TABLE 17

ANALYTICAL SUMMARY - GROUNDWATER

April 23, 1992

ANALYTE	MW-AA-B1	MW-AA-C1	MW-5-B1	MW-5-C1	MW-17-B1	MW-17-C1	MW-17-C1A	MCL
Acetone	2 J	925	ND	ND	6 J	9 J	ND	
Bis(2-Ethylhexyl) phthalate	ND	24	ND	ND	ND	ND	ND	
Butyl benzyl phthalate	ND	3 J	ND	ND	ND	ND	ND	
Carbon disulfide	120	ND	39	38	19	37	7	
1,2-Dichloroethene (total)	ND	ND	ND	ND	5 J	9	7	70
cis-1,2-Dichloroethene	NA	NA	NA	NA	NA	NA	NA	70
Methylene Chloride	ND	70	ND	ND	ND	2 J	2 J	
Phenol	3 J	20	11	ND	ND	ND	ND	
Tetrachloroethene	92	ND	22	4 J	620	140	140	5
Trichloroethene	1 J	ND	6	11	170	78	71	5
Trichlorofluoromethane	NA	NA	NA	NA	NA	NA	NA	
Toluene	ND	ND	ND	ND	ND	ND	ND	2,000
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	10,000

Notes Units are ug/L or ppb
MCL = Maximum Contaminant Level
NA = No Analysis Conducted
ND = Not Detected at the Quantitation Level
J = Detected Below Quantitation Level
Methylene Chloride and Acetone detected in the method blank
MW17C1A is a duplicate of MW17C1

TABLE 18

ANALYTICAL SUMMARY - GROUNDWATER
April 23, 1992

METALS	MW-AA-B1	MW-AA-C1	MW-5-B1	MW-5-C1	MW-17-B1	MW-17-C1	MW-17-C1A	MCL	SMCL
Aluminum*	5340*	4680*	3100*	11,660*	3150	28,160*	3,049*		50
Antimony	ND	ND	ND	ND	ND	ND	ND		
Arsenic	4	7	ND	ND	ND	4	ND	50	
Barium	266	265	248	628	228	1609	240	1000	
Beryllium	3	ND	2	ND	ND	2	ND		
Cadmium	ND	9	ND	ND	ND	6	ND	10	
Calcium	154,600	118,800	69,300	73 390	93,370	142,500	110,500		
Chromium	13	27	12	20	10	52	7	50	
Cobalt	6	ND	ND	11	ND	26	ND		
Copper	11	47	19	22	9	67	11		1000
Iron	18,510	16 840	5230	12,860	7030	44,770	3640		300
Lead	27	47	20	21	18	53	11	15	
Magnesium	26,860	27,600	14,950	36,050	27,450	36,420	31,410		
Manganese	716	627	1574	5360	854	10,570	1011		50
Mercury	ND	ND	ND	ND	0 4	4 4	1 5	2	
Nickel	ND	33	15	35	17	81	ND		
Potassium	3200	2750	2720	3200	2450	4592	2130		
Selenium	2	ND	3	ND	ND	ND	ND	10	
Silver	ND	ND	ND	ND	ND	ND	ND		
Sodium	59 000	101,600	49,000	34 750	52 250	32,140	31,940		
Thallium	ND	ND	ND	ND	ND	ND	ND		
Vanadium	25	18	7	30	15	84	7		
Zinc	92	402	245	167	115	411	103		5000

Notes Units are ug/L or ppb
ND = Not Detected at the Quantitation Limit
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
*Problem with element - Estimated
MW17C1A is a duplicate of MW17C1

TABLE 19

ANALYTICAL SUMMARY - GROUNDWATER

May 22, 1992

ANALYTE	MW-AA-B2	MW-AA-C2	MW-5-B2	MW-5-C2	MW-17-B2	MW-17-C2	MW-17-C2A	MCL
Acetone	ND	3 J	ND	ND	ND	6 J	ND	
Bis(2-Ethylhexyl) phthalate	ND	ND	2 J	ND	2 J	2 J	2 J	
Butyl benzyl phthalate	ND	ND	ND	ND	ND	ND	ND	
Carbon disulfide	29	14	11	250	110	46	43	
1,2-Dichloroethene (total)	NA	NA	NA	NA	NA	NA	NA	70
cis-1,2-Dichloroethene	ND	ND	ND	ND	ND	10	11	70
Methylene chloride	ND	ND	ND	ND	ND	ND	ND	
Phenol	ND	ND	ND	ND	ND	ND	ND	
Tetrachloroethene	35	ND	19	ND	1500	150	160	5
Trichloroethene	ND	3J	2 J	ND	420	100	110	5
Trichlorofluoromethane	2J	ND	ND	ND	ND	ND	ND	
Toluene	ND	ND	1 J	ND	ND	2 J	9	2,000
Xylene (m-, n-)	ND	ND	ND	ND	ND	1 J	1 J	10,000
Xylene (o-)	ND	ND	ND	ND	ND	ND	ND	

Notes Units are ug/L or ppb
MCL = Maximum Contaminant Level
NA = No Analysis Conducted
ND = Not Detected at the Quantitation Level
J = Detected Below Quantitation Level
MW17C2A is a duplicate of MW17C2
Acetone was Detected in the Method Blank

TABLE 20

ANALYTICAL SUMMARY - GROUNDWATER
May 22, 1992

METALS	MW-AA-B2	MW-AA-C2	MW-5-B2	MW-5-C2	MW-17-B2	MW-17-C2	MW-17-C2A	MCL	SMCL
Aluminum	13,560	33,180	56,660	17,600	5390	1497	2050		50
Antimony	ND	ND	ND	ND	ND	ND	ND		
Arsenic	4	5	6	4	ND	ND	ND	50	
Barium	348	914	2447	1255	332	176	205	1000	
Beryllium	2	6	3	ND	ND	ND	ND		
Cadmium	ND	12	9	6	ND	7	ND	10	
Calcium	155,300	414,600	126,500	81,380	91 070	87,740	103,100		
Chromium	33	94	109	37	16	8	6	50	
Cobalt	15	50	51	19	11	ND	ND		
Copper	20	126	74	48	13	14	11		1000
Iron	34,490	91,970	75,540	24,230	8530	1740	1840		300
Lead	56	170	160	44	23	16	11	15	
Magnesium	27,080	95,060	26,610	39,340	26,960	26,990	30,070		
Manganese	796	2591	13,150	9077	1176	520	756		50
Mercury	ND	0 3	0 3	ND	0 7	1 3	2 3	2	
Nickel	26	107	115	62	15	ND	ND		
Potassium	2900	4900	6500	4000	2600	2900	2700		
Selenium	3	2	4	ND	ND	ND	ND	10	
Silver	ND	ND	ND	ND	ND	ND	ND		
Sodium	53,960	29,590	63,310	34,720	44,630	32,890	31,260		
Thallium	ND	ND	ND	ND	ND	ND	ND		
Vanadium	58	176	123	53	21	7	8		
Zinc	241	881	604	342	108	244	167		5000
Chloride	111,000	43,000	139,000	55,000	121,000	56,000	58,000		250,000

Notes Units are ug/L or ppb
ND = Not Detected at the Quantitation Limit
MCL = Maximum Contaminant Level
SMCL = Secondary Maximum Contaminant Level
MW17C2A is a duplicate of MW17C2

Figures 33 through 36 present the spatial distribution of the TCE and PCE soluble-phase plumes across the site Maximum Contaminant Levels (MCLs) for TCE and PCE were exceeded according to the analytical results The tables list the MCLs and/or Secondary MCLs (SMCLs) where appropriate MCLs represent an enforceable, maximum permissible level of contaminant in a water system which is delivered to any user of a public water system SMCLs represents a non-enforceable concentration of a drinking water contaminant that is protective of adverse human health effects and allows an adequate margin of safety

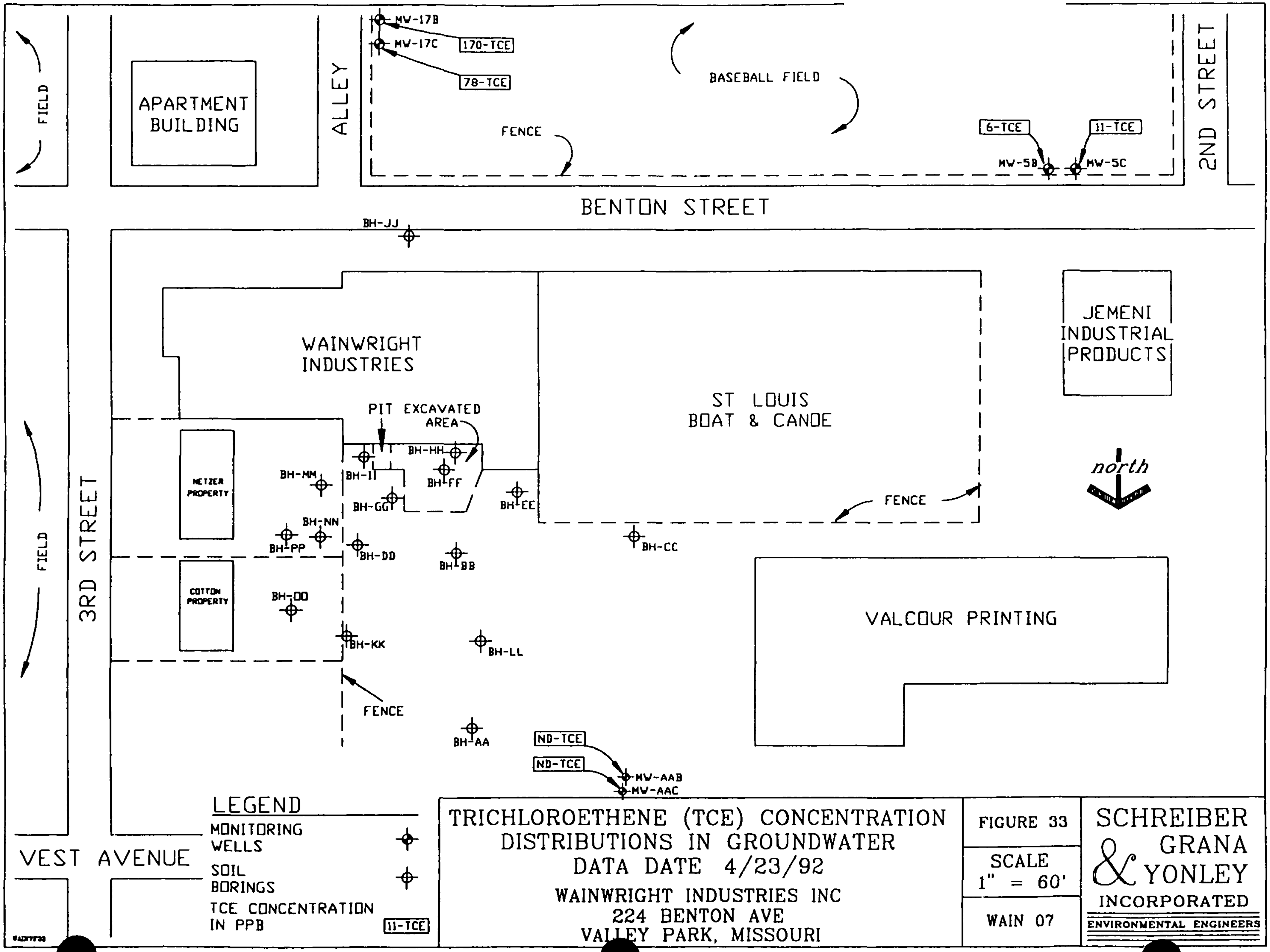
Other detected VOCs/SVOCs include Acetone, Bis (2-Ethylhexyl) Phthalate, Butyl benzyl Phthaltate, Carbon Disulfide, 1,2 Dichloroethene, cis-1,2 Dichloroethene, Methylene Chloride, Phenol, Trichloroflouromethane, Toluene, and m-, p- Xylene MCLs and/or SMCLs (if applicable) were not exceeded among these compounds

The carbon disulfide results are varied across the three well nests This cannot be attributed to laboratory error as the detections were fairly consistent between the two sampling events The spatial distribution of this compound across the study area does not identify a source, or sources The soil analytical results produced carbon disulfide at BH-AA (0 004 ppm), and BH-KK (0 028 ppm), each at a depth of 5 feet below grade In order to identify a potential source(s), as well as to explain the variability in the analytical results, an exhaustive investigative/sampling program would need to be initiated, this is beyond the scope of the WOU RI

The metals analysis disclosed a number of detections A complete listing is included in Tables 18 and 20 Comparison of the analytical results to the MCLs and SMCLs revealed a number of exceedances Among the MCL exceedances are Barium (MW-5B2, MW-5C2, MW-17C1), Cadmium (MW-AAC2), Chromium (MW-AAC2, MW-5-B2, and MW-17C1), Lead (all samples except MW-17-C1A and MW-17-C2A), and Mercury (MW-17C1, and MW-17C2A) Secondary MCL exceedances were observed in each sample for Aluminum, Iron, and Manganese

A direct relationship between the chlorinated solvent concentrations in both the groundwater (soluble-phase) and soil (adsorbed and vapor-phase) chlorinated solvent concentrations becomes apparent when viewing the spatial distribution of the soluble-phase plumes and the geologic cross sections (and associated adsorbed-phase concentrations) It is evident that due to the highly variable depth to the groundwater surface, direct contact occurs with the chlorinated solvents This phase transformation is a result of the fate and transport of the individual compounds of concern, occurring primarily via retardation, transformation, advection, and hydrodynamic dispersion The various fate and transport processes for TCE and PCE are discussed further in section 5 0

As presented in Table 13, the depth to groundwater (in July, 1993) was approximately 9 to 10 feet below grade During late August 1993, the depth to groundwater lowered approximately 10 feet below grade across the site (between 19 8 feet and 21 2 feet below grade) This fluctuation, most likely due to the Mississippi River flooding and subsequent effect on the Meramec River, increases the potential for phase transformation



TRICHLOROETHENE (TCE) CONCENTRATION
DISTRIBUTIONS IN GROUNDWATER
DATA DATE 4/23/92

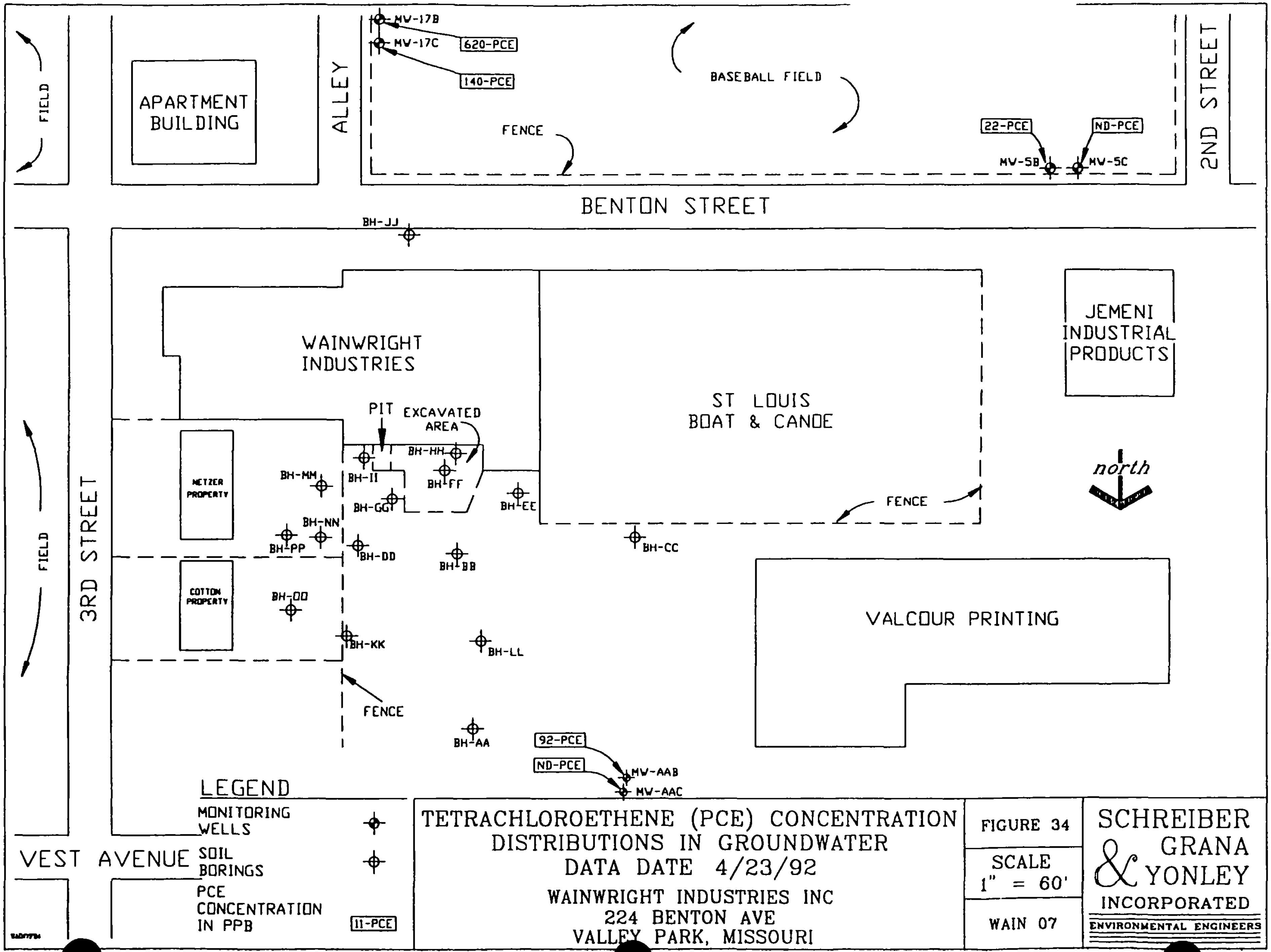
WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 33

SCALE
1" = 60'

WAIN 07

SCHREIBER
& GRANA
YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



LEGEND

MONITORING WELLS	⌖
SOIL BORINGS	⌖
PCE CONCENTRATION IN PPB	11-PCE

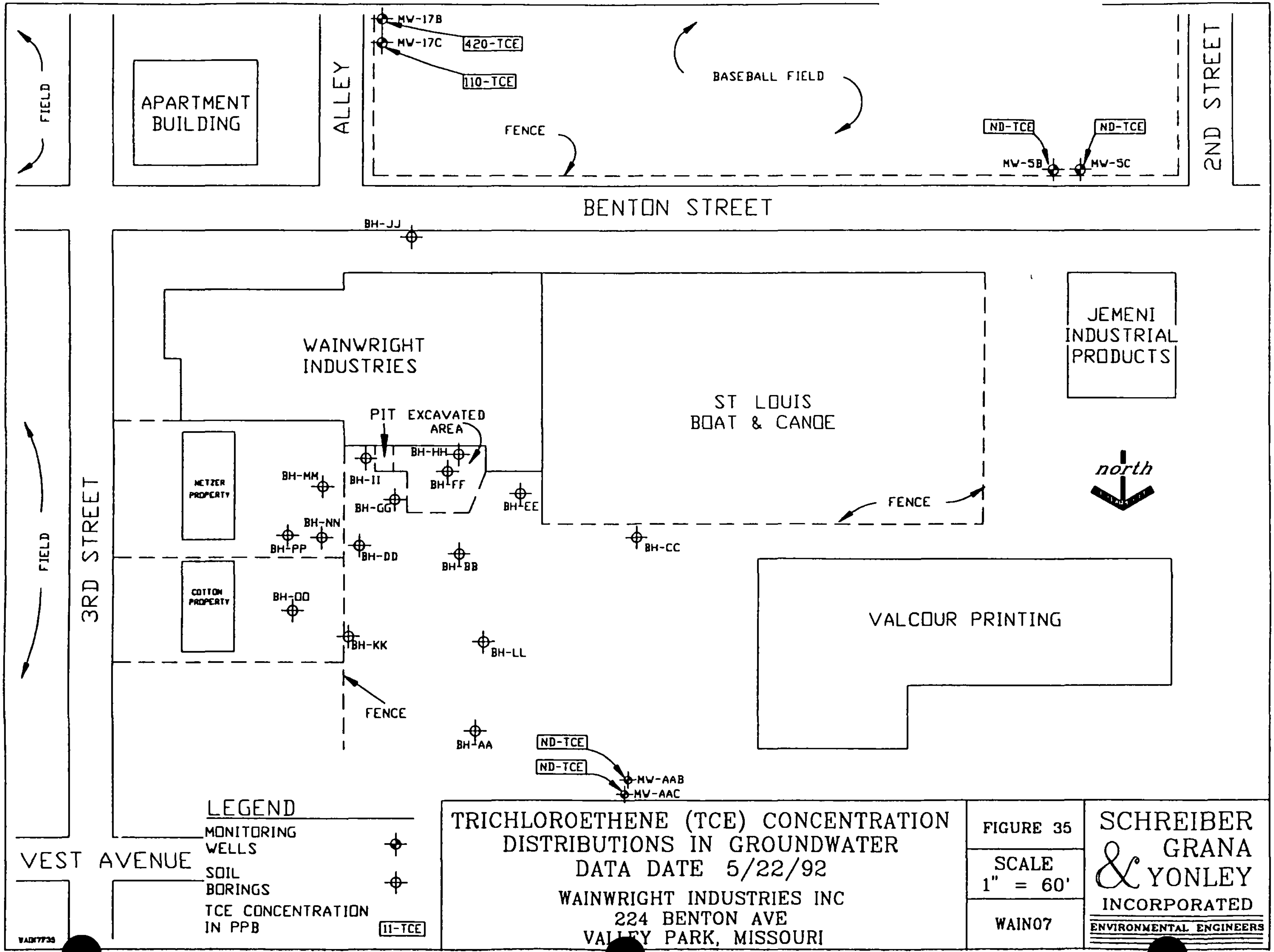
TETRACHLOROETHENE (PCE) CONCENTRATION DISTRIBUTIONS IN GROUNDWATER
DATA DATE 4/23/92
WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 34

SCALE
1" = 60'

WAIN 07

SCHREIBER GRANA & YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



TRICHLOROETHENE (TCE) CONCENTRATION
DISTRIBUTIONS IN GROUNDWATER
DATA DATE 5/22/92

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 35

SCALE
1" = 60'

WAIN07

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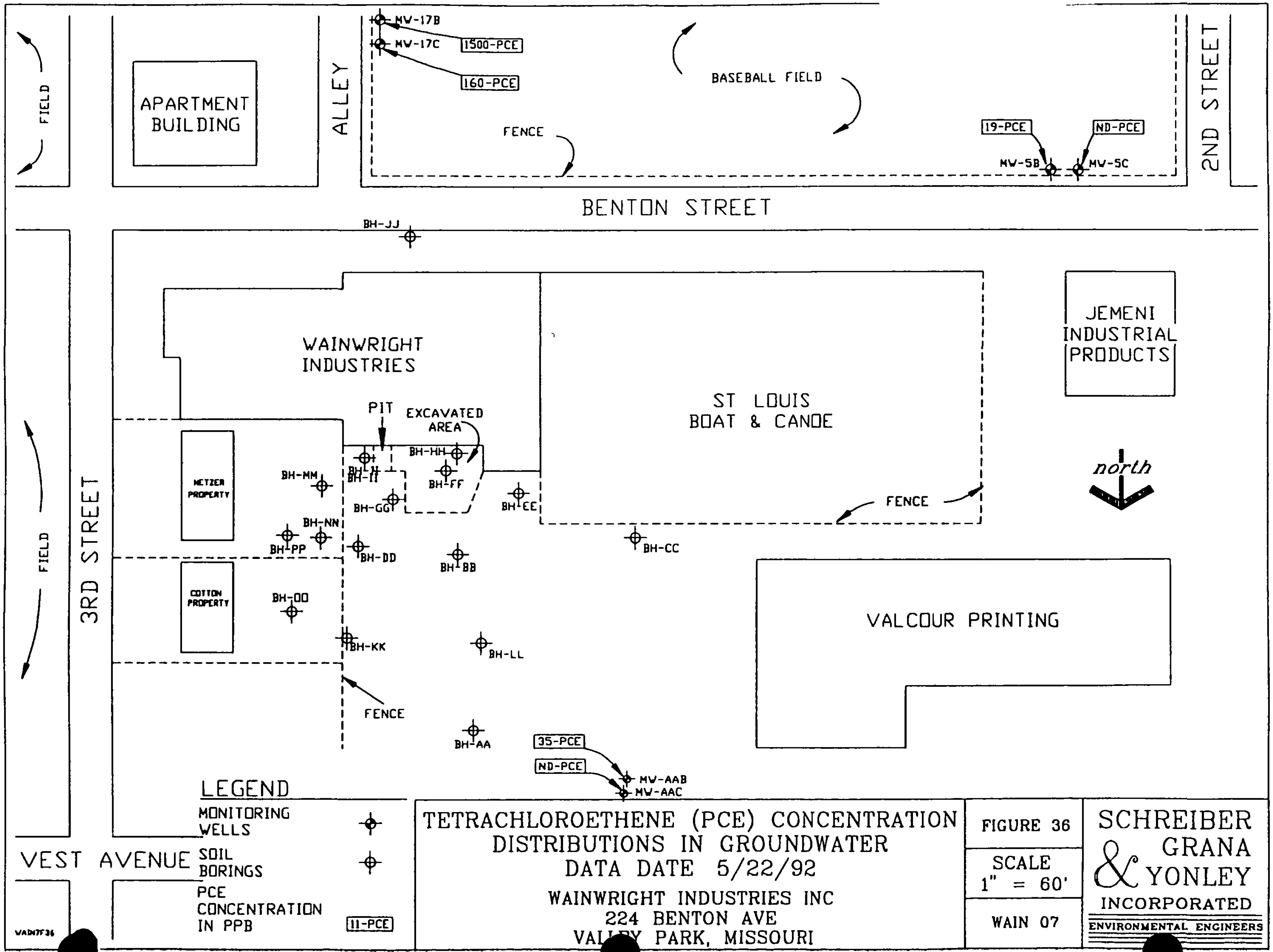
& YONLEY
INCORPORATED
ENVIRONMENTAL ENGINEERS



LEGEND

MONITORING WELLS	⌖
SOIL BORINGS	⌖
PCE CONCENTRATION IN PPB	11-PCE

TETRACHLOROETHENE (PCE) CONCENTRATION
DISTRIBUTIONS IN GROUNDWATER
DATA DATE 5/22/92

WAINWRIGHT INDUSTRIES INC
224 BENTON AVE
VALLEY PARK, MISSOURI

FIGURE 36

SCALE
1" = 60'

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5 0 CONTAMINANT FATE AND TRANSPORT

5 1 Phase Occurrences/Potential Routes of Migration

The TCE/PCE contamination investigation process at the WOU can be conceptualized as a three-fold process as follows, not necessarily in the following order

- a Source(s) is identified
- various Media are impacted
- Receptors are potentially impacted

In order to further investigate the impacted media at the WOU, an understanding of the fate and transport of TCE and PCE is necessary These compounds are reactive, i e , dynamic in nature, when introduced/released into the subsurface The total volume and duration of a suspected release, as well as the area impacted by a release are important factors to consider when evaluating the fate and transport of TCE and PCE

Both TCE and PCE are DNAPLs This means that both are denser (heavier) than water, each have a molecular weight greater than water (equal to 1 0 grams per mole) For this reason, the compounds have the ability to sink when introduced into the subsurface and move/migrate vertically in the vadose zone under the influence of gravity This transport phenomena is independent of groundwater flow

In addition to the DNAPL (liquid-phase), a dissolved phase can also develop as the compounds are soluble in water Three-phase flow can occur above the groundwater surface (vadose zone), air (vapor-phase), water (soluble-phase) and DNAPL (liquid-phase), while two phase flow can occur below the groundwater surface, DNAPL (liquid-phase) and water (soluble-phase) DNAPL can also partition to the air as a vapor phase An adsorbed-phase can also develop, this incorporates the partitioning of DNAPL (and to a lesser extent, soluble and vapor phases) to (within) the soil matrix

Once introduced into the subsurface, TCE/PCE has the potential to partition into any one (or more) of four phases, adsorbed, solution, vapor, and liquid phases This can be expressed via the following equation

$$C_T = (p_b)(C_A) + (\phi)(C_L) + (a)(C_G) + (C_{NAPL})$$

where,

C_T = total quantity of chemical per soil volume (micrograms per cubic centimeter [ug/cm^3])
p_b = soil bulk density (grams per cubic centimeter [g/cm^3])
C_A = adsorbed chemical in soil (micrograms per gram [ug/g])
ϕ = volumetric water content
C_L = soluble chemical in groundwater (micrograms per cubic meter [ug/cm^3]
a = volumetric air content
C_G = vapor density (micrograms per cubic centimeter [ug/cm^3])
C_{NAPL} = liquid-phase chemical in soil and groundwater (ug/cm^3)

The flow (persistence and migration) of liquid-phase (DNAPL) TCE/PCE is dependant upon the density, viscosity, and interfacial tension of the fluid DNAPL can also migrate from the subsurface to the atmosphere in the vapor-phase Soluble-phase persistence and migration is dependant upon various transport phenomena such as, groundwater flow, retardation, transformation, advection, dispersion, and diffusion Vapor-phase transport is highly dependant on the vapor pressure/density and volatility of the specific compound

The following sections presents a discussion regarding the fate and transport of TCE and PCE (in the liquid, vapor, and soluble-phases) in relation to the various affected media at the site As the RI did not investigate for the presence of DNAPLs, this section (5 0) focuses primarily on soluble-phase TCE and PCE (Sections 5 4 and 5 5) However, discussions involving DNAPL (liquid-phase) and vapor-phase transport mechanisms are provided (Sections 5 2 and 5 3)

5 2 Liquid-Phase (DNAPL) Transport

As discussed above, TCE and PCE are DNAPLs, they are denser (heavier) than water, and have the ability to sink when introduced into the subsurface and move/migrate vertically under the influence of gravity If the DNAPLs are of sufficient mass to overcome the capillary pressures of water and air in the vadose zone, vertical migration occurs until reaching the saturated (aquifer) zone At this point, the DNAPL will continue to migrate vertically (independent of groundwater flow) if the DNAPL remains of sufficient mass to overcome the capillary forces holding the water in the pore space DNAPL transport in the saturated zone typically occurs as vertical stringers When the stringers have a sufficient height, water displacement occurs and vertical migration occurs until an aquiclude (often bedrock) is encountered If the groundwater flow has sufficient force to overcome the DNAPL capillary pressure, it can displace vertical DNAPL stringers in the horizontal direction (in the direction of groundwater flow) Once DNAPL accumulates on an aquiclude, it has the ability to accumulate on the surface, displacing the water and forming a distinct liquid-phase layer The DNAPL can also migrate along the surface, typically in the direction of aquiclude dip, regardless of the prevailing groundwater flow direction

The WOU RI did not include the installation of groundwater monitoring wells to the top of the bedrock surface For this reason, the presence of DNAPLs beneath the Wainwright property (MW-AA) is not known In addition to physical monitoring/measuring (at MW-5C and MW-17C, both installed on the bedrock surface), the presence of DNAPL can be qualitatively monitored by evaluating the groundwater sampling data (discussed in Section 4 4) If the appropriate compound solubility is attained, 1100 ppm TCE and 200 ppm PCE, DNAPL may be present The maximum concentrations encountered via the groundwater sampling (MW-AA, MW-5, and MW-17 well nests) were 420 ppb TCE and 1500 ppb PCE While these wells are not installed on the top of the bedrock (aquiclude) surface, where the TCE/PCE concentrations would be expected to be the greatest, the analytical results (concentrations) indicate that DNAPL may not be present at such surface

If sufficient DNAPL mass is not present, it can partition to vapor, adsorbed, and/or soluble-phases

As discussed in Section 4 2, the actual degreasing solutions used during the site manufacturing operations are presented in the MSDS forms (Appendix E) A by-product of the processes resulted in the compound solutions becoming mixed with various sludge, oil, and/or grease Subsequently, the actual solution (and associated physical/chemical properties) generated at the end of each de-greasing cycle was unknown Pre-process, compound specific data can be found on the MSDS forms

As discussed above in Section 5 1, the flow (persistence and migration) of liquid-phase (DNAPL) TCE/PCE is dependant upon the density (specific gravity), viscosity, and interfacial tension of the fluid The molecular weight for TCE is listed at 131 4 grams per moles, while PCE is listed at 165 83 grams per moles, each greater than 1 0 grams per moles for water The actual fluid viscosities are unknown Interfacial tension involves the contact between a fluid (TCE, PCE, and water) and a solid (soil particle) This contact creates an interfacial energy, which is created by the difference in the degree of attraction for the molecules of the substance at the liquid surface to each other compared with their degree of attraction for molecules of the other substance Two liquids, i e , the DNAPLs and water will compete for attraction to a surface One fluid dominates and coats (wets) the surface As an aquifer is water wet (already saturated), DNAPL (oil) will not coat the various soil particles However, the vadose zone may be may be either water-wet or oil-wet, depending on the degree of saturation

5 3 Vapor-Phase Transport

Vapor-phase transport is highly dependant on the vapor pressure/density and volatility of the specific compound Compound specific parameters (formerly used at the WOU) are listed on the MSDS forms (Appendix E) Vapor densities for TCE and PCE are 4 53 and 5 83/5 76 respectively, both heavier than air (listed on the MSDS forms as 1 0) The vapor pressures (as listed on the MSDS forms) are 58 0 millimeters mercury and 15 8/13 0 millimeters mercury for TCE and PCE respectively These values are indicative of moderate volatility, i e , moderate mobility within the vadose zone DNAPL can also migrate through the vadsoe zone and into the atmosphere, thus further highlighting the fact of the compounds mobility in the vapor-phase

Vapor-phase transport within the saturated (aquifer) zone is a complex and unstable phenomena, being difficult to predict and/or model The flow field is a function of many parameters, however, soil structure (permeability, and air entry pressure) appears to be the most significant parameter

5 4 Soluble-Phase Transport

As discussed above in Section 5 2, a liquid-phase (DNAPL) may also be present at the WOU However in the absence of a sufficient contaminant mass (in the subsurface), DNAPL typically dissolves (solubilizes) into groundwater, volatilizes into the vapor-phase, and/or adheres to the vadose zone/aquifer matrix (adsorbed-phase) This section focuses on the fate and transport of soluble-phase TCE and PCE

5 4 1 Contaminant Persistence

The transport of soluble-phase TCE and PCE within the subsurface is a function of 1) the hydrodynamic properties of the soil matrix and the subsequent advective, diffusional flow system, and 2) physical/chemical interactions between the compounds and the soil Highly sorptive compounds will not migrate significantly from its source Conversely, the solubility of the compound can aid in the migration process when such comes in contact with the groundwater surface A discussion of each of the compounds individual physical properties is necessary to understand the potential fate of each in the subsurface

The persistence, or fate, of soluble-phase TCE and PCE within the soil matrix and aquifer is a function of two factors, 1) retardation, and 2) transformation

5 4 1 1 Retardation

The soluble front of TCE and PCE (as the compounds pass through the soil) is termed the rate of retardation (R) Retardation involves various phenomena which control the movement of solutes through a porous media and can be expressed as follows

$$R = 1 + (P_b/\phi)\,(K_d)$$

where ,

P_b/ϕ = ratio of the dry soil bulk density (estimated at 1 7 g/cm^3) over the saturated soil pore volume (estimated at 0 30, dimensionless)

K_d = soil-water distribution coefficient (milliliters per gram [ml/g]), itself a product of the following

K_d = $(K_{oc})\,(f_{oc})$

where,

K_{oc} = the organic carbon water partition coefficient

f_{oc} = the fraction of the soil Total Organic Carbon (TOC), termed the f_{oc}

The greater the f_{oc}, the greater the affinity for compounds to adsorb to the soil matrix Values of f_{oc} typically range from 0 5 to 0 005 Site specific data reported in Table 12 of this report indicates an average value for TOC of 40% (0 004 f_{oc}) Compound-specific K_{oc} values are available in literature, 126 ml/g TCE and 364 ml/g PCE

The dominant process controlling retardation involves the process of sorption, which refers to the partitioning of the compound between the liquid and the solid phases in porous media The term includes the following, adsorption, ion-exchange, colloid filtration, reversible precipitation, and irreversible mineralization Of these, adsorption is the dominant process, this represents the transfer from the liquid-phase to the surface of the individual soil particle The reverse process (solid-phase to liquid-phase) is termed desorption

Adsorption is the bonding of a compound to either a soil mineral particle or organic matter particle The effect of such temporarily immobilizes the compound from transport into either the soluble or vapor phase It is a linear, equilibrium process which is rapid and reversible The influence of adsorption in retarding the migration of TCE and PCE is directly proportional to the TOC of the soil matrix (along with grain-size to a lesser extent) This in turn influences the ability of a compound to partition to the soil (K_d)

Using the above equation and substituting values into the variables, R values can be derived Using an estimated P_b/ϕ ratio value of 5 7 g/cm^3, f_{oc} value of 0 004, and K_d values of 0 504 ml/g TCE and 1 46 ml/g PCE, the following values are derived

R = 3 87 (3 9) for TCE
R = 9 32 (9 3) for PCE

These values are average and quantify the approximate difference between the rate of contaminant migration to that of groundwater, i e , the groundwater is moving at a velocity which is 3 9 times faster than that of the TCE This is due to the degree of retardation experienced by the compound in relation to the soil matrix (TCE in this example) If steady-state conditions are achieved, compound attenuation does not occur through adsorption, and the R value becomes near 1 0

Migration of TCE and PCE with regard to that of the uncontaminated groundwater aquifer can be determined through use of the following equation

v_c = v/R

where,

v_c = TCE and PCE migration velocity, in feet per year (ft/yr)
v = uncontaminated groundwater velocity, 763 ft/yr (section 3 1 5, page 51)
R = retardation factor, 3 9 for TCE and 9 3 for PCE

Using this equation, v_c values of approximately 197 ft/yr for TCE and 82 ft/yr for PCE were derived, both less than the reported groundwater flow rate of 763 ft/yr

Solubility is yet another variable which influences the degree of retardation in the subsurface Solubility values for TCE and PCE in water are 1100 ppm and 200 ppm, respectively These values along with the respective K_{oc} values reflect a medium mobility classification in the subsurface

5 4 1 2 Transformation

Transformation (decay) represents a generalized process under which compounds such as TCE and PCE experience additional change when introduced into the subsurface This term includes a variety of chemical reactions including hydrolysis, volatilization, oxidation, reduction, precipitation, and biodegradation (such as anaerobic reductive dechlorination), all first order characteristics As mass is neither created or destroyed, these transformations result in the formation of daughter by-products

Hydrolysis represents an addition or alteration of a water molecule in association with a contaminant Oxidation and reduction represents a give and take of electrons affecting microorganisms Precipitation is when immobile solids develop due to certain ion combinations

Volatilization occurs near the surface, resulting in an exchange of vapors with the atmosphere The process is limited by the chemical vapor concentration which is maintained at the soil surface and by the rate at which the vapor is carried from the soil to the atmosphere

Biodegradation represents the natural breakdown of compounds under both aerobic and/or anaerobic conditions It is highly sensitive being dependent on 1) the indigenous microbial population, 2) the available oxygen and nutrients, 3) temperature of the aquifer, and 4) the molecular structure of the compounds The following flow diagram illustrates the typical biodegradation process experienced by TCE and PCE

BIODEGRADATION PATHWAYS

Example 1

PCE → TCE → DCE → VC

Example 2

$$\begin{tikzcd}
\text{TCE} \arrow[r] \arrow[d] & \text{DCA} \arrow[r] & \text{CA} \\
\text{DCE} \arrow[r] & \text{VC} &
\end{tikzcd}$$

Abbreviations

PCE	tetrachloroethene
TCE	trichloroethene
DCE	1,2-dichloroethene
VC	vinyl chloride
DCA	1,1-dichloroethane
CA	chloroethane

As presented above, both TCE and PCE produce Vinyl Chloride as an end product under prevailing conditions, which itself is a carcinogen However, DuPont recently reported success in implementing and achieving PCE anaerobic biodegradation in the field to non-detectable levels using indigenous bacteria

Chemical transformations are generally simulated as first-order reactions, i e , the rate of change of mass is proportional to the concentration of substance reacting This can be described through the following equation

$$dC/dt = (-k)(C)$$

where,

dC/dt = the rate of concentration change with respect to time

k = the first order decay-coefficient, negative sign indicates a decreasing concentration

C = the contaminant concentration

5 4.2 Contaminant Migration

As stated earlier, both TCE and PCE are reactive (i e , dynamic in nature) in the subsurface The migration of these compounds is a complex and dynamic process involving not only the previously discussed fate criteria (retardation and transformation), but various transport mechanisms as well The migration, or transport of TCE and PCE within the soil matrix and related aquifer is a function of three factors, 1) advection, 2) molecular diffusion, and, 3) mechanical/hydrodynamic dispersion Once in contact with the aquifer, it is a direct function of the hydraulic gradients and hydraulic conductivity of the aquifer

The transport of a contaminant within a saturated medium can be expressed as follows

Mass In - Mass Out - Mass Decay = Mass Accumulation
↓ ↓
→ advection ←
→ diffusion ←
→ dispersion ←

5 4 2 1 Advection

Qualitatively, advection is the most important mode of transport of a soluble compound It is dependant on the hydraulic gradient, hydraulic conductivity and aquifer flow velocity It is characterized as anisotropic Advection can be defined as the bulk movement of water caused by differences in density, temperature, or pressure When a groundwater body containing soluble-phase compounds is in motion, the transportation of such occurs For simplicity in the following discussions and equation presentations, this section (5 3) and Section 5 4, will emphasize on compound migration in one direction (x-direction) However, in any anisotropic media, transport also can occur in both the y and z directions in nature

The rate of advection in response to the rate of groundwater flow can be expressed as follows

$$M_{ax} = (C)(Q_x)$$

where,

M_{ax} = mass of contaminant transported by advection in the x-direction (kilograms per day [kg/day])

C = concentration of the compound in the fluid (TCE 170 mg/l, or 0 17kg/m^3)(PCE 1500 mg/l, or 1 5 kg/m^3)

Q_x = volumetric flow rate of the fluid in the x-direction (39 6 cubic meters per day [m^3/day]), defined as follows

$$Q_x = (K)(I)(A)$$

where,

K = hydraulic conductivity, 6,700 gpd/ft^2, or 25 37 meters per day [m/day])
I = hydraulic gradient, 0 003 ft/ft
A = cross-sectional area of groundwater flow perpendicular to the TCE/PCE (on-site) plumes, ≈ 40 foot thick aquifer (to bedrock) by 140 foot (maximum adsorbed-phase plume width on-site, 5,600 square feet, or 520 2 square meters, [m^2])

Substituting the above values produces a M_{ax} value of 6 7 kg/day of TCE and 59 4 kg/day PCE transported by advection

5 4 2 2 Molecular Diffusion

Molecular diffusion represents the random fluctuation of molecules in solution in response to a groundwater gradient It is a slow and isotropic process Ionic and molecular species move from areas of higher concentration (more molecules) to area of lower concentration (less molecules), occurring primarily through the liquid-phase It can be explained via Ficks first law as follows

$$F_x = (dC/dx)\,(A)\,(\phi)\,(s)\,(-D_o)$$

where,

F_x = mass flux of the contaminant transported by diffusion in the x-direction (kg/day)
dC/dx = the concentration gradient in the x-direction (kg/m^3-m)
A = cross-sectional area of groundwater flow (520 2 m^2)
ϕ = porosity of the medium (0 30, saturated diffusion only, dimensionless)
s = water saturation (1 0, dimensionless)
$-D_o$ = diffusion coefficient (5 x 10^{-6} cm^2/s, or 4 32 x 10^{5} m^2/d), defined as follows,

$$-D_o = (\tau)\,(D_o)$$

where,

τ = tortuosity of the media (typically between 0 3 to 0 7, average of 0 5)
D_o = molecular diffusion for solute in free water (typically near 10^{5} cm^2/s)

Values for dC/dx can be derived for both TCE and PCE using approximate concentration changes detected within the Valley Park region Using monitor well MW-17 (hydraulic high) to MW-6 (hydraulic low) as the detection points, a distance of 65 feet was obtained Using the analytical data presented in this report, approximate concentrations changes between the wells was noted With this data, dC/dx values of 3 14 x 10^{2} kg/m^{3}/19 8 meters for TCE and 5 95 x 10^{-4} kg/m^{3}/19 8 meters for PCE were derived

Applying the above data into Ficks first law, values of 2 0 x 10^{7} kg/day for TCE and 1 1 x 10^{5} kg/day for PCE are derived The low values illustrate the fact that diffusion is an insignificant transport mechanism when compared to contaminant transport by other means, namely advection and dispersion However, in low permeability media, diffusion is more dominant as advection and dispersion are minimized

Although molecular diffusion is an isotropic process, the amount of contaminant mass transported can vary in the x, y, and z-directions due to differences in the concentration gradients

5 4 2 3 Mechanical Dispersion

Mechanical dispersion pertains to the spreading and transport of contaminants in complex pathways It is the initial dispersion experienced in the z-direction (downward, within the vadose zone) resulting from the bulk movement of a contaminant (fluid) from a single point The complex velocity variations, meanderings, and bifurcations cause the contaminant to spread in the both longitudinal and transverse directions Three processes control the movement of the contaminant, intrapore velocity variations (frictional resistance at the boundary of the pore space), interpore velocity variations (pore space size variations causing velocity variations), and, tortuosity of the media (complexity of the media causing the fluid stream to split and deflect in the flow direction)

These three processes suggest that mechanical dispersion is a scale dependent, anisotropic phenomenon, varying in magnitude in all three flow directions Bulk fluid flow is required for this process to occur If there is no fluid in motion, there are no velocity variations and thus, no mechanical dispersion It can be expressed mathematically as follows

$$M'_{dx} = (dC/dx)\,(A)\,(\phi)\,(s)\,(-D'_{x})$$

where,

M'_{dx} = mass of the contaminant transported due to mechanical dispersion in the x-direction (kg/day)

dC/dx = the concentration gradient in the x-direction (3 14 x 10^{2} kg/m^{3}/19 8 meters [TCE], and 5 95 x 10^{-4} kg/m^{3}/19 8 meters [PCE])

A = cross-sectional area of groundwater flow (520 2 m^{2})

ϕ = porosity of the medium (0 30, dimensionless)

s = water saturation (1 0, dimensionless)

$-D'_{x}$ = dispersion coefficient (6 86 m^{2}/d), defined as follows,

$-D'_{x}$ = $(\alpha)\,(V)$

where,
α = dispersivity value (1 0 meters, estimated and assumed from literature reported values, varies greatly in nature suggesting that it is a calibration/site-specific parameter)
V = the groundwater velocity (6 86 m/day)

Applying the above data into the mechanical dispersion, values of $3\ 21 \times 10^{2}$ kg/day for TCE and 1 7 kg/day for PCE are derived Both values are greater than those of diffusion, further emphasizing the fact that mechanical dispersion is a principal transport parameter at the WOU

5 4 2 4 Hydrodynamic Dispersion

As the effects of mechanical dispersion and molecular diffusion cannot be separated in flowing groundwater, the two processes are combined into one within this regime This is termed the hydrodynamic dispersion It is a function of scale, i e , the greater the area of measurement, the value can become larger The effects of hydrodynamic dispersion causes a contaminant to decrease in concentration with distance from the source The effects of spreading will be greater within the downgradient portion of the aquifer, in the direction of flow, rather than perpendicular to flow It can be expressed mathematically as follows

$$M_{dx} = \{(-D'_x)\ (Dc/dx)\ (A)\ (\phi)\ (s)\}\ \{(-D_o)\ (dC/dx)\ (A)\ (\phi)\ (s)\}$$

Multiplying the terms of $-D'_x$ and $-D_o$ produces the term $-D_x$ (hydrodynamic dispersion) and reduces the equation to

$$M_{dx} = (-D_x)\ (dC/dx)\ (A)\ (\phi)\ (s)$$

where,
M_{dx} = mass of the contaminant transported due to hydrodynamic dispersion in the x-direction (kg/day)
$-D_x$ = hydrodynamic dispersion coefficient ($2\ 83 \times 10^{-4}$ m^2/d)
dC/dx = the concentration gradient in the x-direction ($3\ 14 \times 10^{2}$ kg/m^3/19 8 meters [TCE], and $5\ 95 \times 10^{-4}$ kg/m^3/19 8 meters [PCE])
A = cross-sectional area of groundwater flow (520 2 m^2)
ϕ = porosity of the medium (0 30, dimensionless)
s = water saturation (1 0, dimensionless)

Solving the equation with the above data, values for hydrodynamic dispersion of $1\ 3 \times 10^{6}$ kg/day for TCE and $7\ 0 \times 10^{5}$ kg/day for PCE are derived As with any modeling effort, the results of such are a direct function of the input data and the subsequent assumptions of the data set Any adjustments in the database will consequently affect the results of the model

5 5 Summary of Soluble-Phase Fate and Transport Mechanisms

The fate and transport of soluble-phase TCE and PCE in the subsurface of the WOU can be expressed mathematically using the data from the above sections The terms/values of hydrodynamic dispersion, advection, retardation, and first-order decay are all combined into one governing equation Additional assumptions of the equation are that of a linear, adsorption isotherm, a homogeneous medium/aquifer, with one-dimensional, unsteady-state flow (x-direction) The general transport equation can now be expressed as follows

$$\underset{\substack{\downarrow\\ \text{hydrodynamic}\\ \text{dispersion}}}{D\,(d^2C/dx)} \;-\; \underset{\substack{\downarrow\\ \text{advection}}}{V\,(dC/dx)} \;=\; \underset{\substack{\downarrow\\ \text{retardation}\\ \text{(storage)}}}{R\,(dC/dt)} \;+\; \underset{\substack{\downarrow\\ \text{decay}}}{kC}$$

An analytical solution to the above equation requires either 1) a literature search, or 2) a numerical solution using either a finite-element method or a finite difference method Various computer models are also available which solve transport equations such as that presented above Schreiber, Grana & Yonley, Inc did not attempt to further analyze the TCE/PCE fate and transport of the soluble-phase plume at the WOU with any analytical/computer models beyond that which is presented in the above sections As this work phase involves only the WOU, complete delineation of the soluble-phase plume across the entire Valley Park area was not conducted, nor is it appropriate as a part of this document However, field investigation activities to date have delineated the extent of the adsorbed-phase TCE/PCE at the site, and immediately off-site Full soluble-phase plume delineation and/or groundwater modeling will be implemented (if deemed necessary) during the Valley Park RI/FS

6 0 BASELINE RISK ASSESSMENT

A Revised Final Baseline Risk Assessment (RA) for the WOU was prepared by the MDOH, being finalized in December, 1993 (MDOH, 1993b) This is included in Appendix F This section of the RI (Section 6 0) was derived in its entirety from the MDOH report and represents a summary of the MDOH RA The RA examines the risks resulting from exposure to contaminated groundwater, soil, and air at the WOU The exposure pathways examined include ingestion of and dermal contact with contaminated groundwater and soil, and inhalation of air contaminated with compounds volatilizing from the groundwater and soil

6 1 Chemicals of Potential Concern

The MDOH evaluated all detected compounds, chemicals, and metals identified at the site during the soil and groundwater sampling work phases All VOCs and SVOCs detected in the groundwater and the soil were retained for the exposure assessment The metals detected in the groundwater and the soil were evaluated on an individual basis Average metal concentrations (in the groundwater) from monitor well clusters MW-5 and MW-17 were compared to detected concentrations at monitor well cluster MW-AA Those metals found to be below concentrations at MW-AA (hydraulically upgradient, i e , background) were not included in the exposure assessment Metals detected in the soil present below published background concentrations (according to Tidball, 1984) were also excluded from the exposure assessment A listing of all metals included in the exposure assessment are presented in Table 21

6 2 Human Health Evaluation

6 2 1 Exposure Assessment

The Exposure Assessment is accomplished through the identification of exposure pathways, development of Reasonable Maximum Exposure (RME) scenarios, and the calculation of contaminant intake values

Pathways are defined as contact of a receptor with a contaminant In order for the exposure to occur, a source of contamination must be present, a receptor must exist, a person or other living organism, and a mechanism or pathway must exist thereby allowing interaction with the receptor Several potential exposure pathways may exist, such as ingestion of and dermal contact with contaminated soil and groundwater, and inhalation of air contaminated with compounds volatilizing from the groundwater and soil

TABLE 21

METALS RETAINED IN EXPOSURE ASSESSMENT

METAL	MEDIA
Aluminum	groundwater
Barium	groundwater
Cadmium	groundwater
Calcium	soil
Chromium	groundwater
Cobalt	groundwater
Copper	groundwater, soil
Iron	groundwater
Lead	groundwater, soil
Magnesium	soil
Manganese	groundwater
Mercury	groundwater
Nickel	groundwater
Potassium	groundwater
Selenium	groundwater, soil
Vanadium	groundwater
Zinc	groundwater, soil
Chloride	groundwater

A total of six RMEs were developed by the MDOH for the WOU They are as follows

1) RME #1 - A 70 kg adult worker incidentally ingesting and directly contacting soil, and inhaling volatilized compounds from the soil, wearing a t-shirt, jeans, socks, and shoes exposed to the site 250 days per year over a period of 25 years

2) RME #2 - A 43 kg adolescent, 10-16 years of age, incidentally ingesting and directly contacting soil, and inhaling volatilized compounds from the soil, wearing a t-shirt, jeans, socks, and shoes visiting the site two times per week for 39 weeks per year over a six year period

3) RME #3 - A 70 kg adult off-site resident incidentally ingesting and directly contacting soil, and inhaling volatilized compounds from the soil, wearing a t-shirt, jeans, socks, and shoes exposed to the site 365 days per year over a period of 30 years

4) RME #4 - A 15 kg child (0-6 years of age) off-site resident incidentally ingesting and directly contacting soil, and inhaling volatilized compounds from the soil, wearing a t-shirt, jeans, socks, and shoes exposed to the site 365 days per year over a period of 7 years

5) RME #5 - A 70 kg adult living on the WOU site incidentally ingesting and directly contacting soil, inhaling volatilized compounds from the soil, ingesting and directly contacting contaminated groundwater, and inhaling volatilized compounds from the groundwater, wearing a t-shirt, jeans, socks, and shoes exposed to the site 365 days per year over a period of 30 years

6) RME #6 - A 15 kg child (0 to 6 years of age) living on the WOU site incidentally ingesting and directly contacting soil, inhaling volatilized compounds from the soil, ingesting and directly contacting contaminated groundwater, and inhaling volatilized compounds from the groundwater, wearing a t-shirt, jeans, socks, and shoes exposed to the site 365 days per year over a period of 7 years

Contaminant intake values were derived using pathway-specific equations found in the EPA documents 540/1-89/002 and OER 9285 7-01B involving risk assessment, further described in the MDOH RA

6 2 2 Toxicity Assessment

The toxicity assessment is separated into two types of effects, non-carcinogenic and carcinogenic Non-carcinogenic effects from oral exposure were quantified by utilizing oral reference dose (RfD) values, as presented in the EPA Integrated Risk Information System and/or EPA OSWER Directive 9284 6-03 Dermal exposure effects were quantified by adjusting the RfD value in response to compound-specific oral absorption efficiency values

As there are no published/available toxicity values for lead, the Lead Biokinetic Uptake Model was utilized This model assesses the adverse health effects of lead exposure, combining intake variables from several potential lead exposure pathways and predicts blood lead levels for children in a residential setting

Carcinogenic effects were derived using an EPA classification system and slope factors This system is based on the known carcinogenic characteristics of the compound on humans and/or laboratory animals Based on this information, the compound is assigned a provisional weight-of-evidence classification, ranging from A (human carcinogen) to F (evidence of non-carcinogenicity in humans) The slope factors (plausible upperbound estimates of probability of a response per unit intake of a chemical expressed over a lifetime) were then used to assess the carcinogenic effects for specific contaminants The slope factors were also adjusted to assess the carcinogenic effects of dermal contact

6 2 3 Risk Characterization

Non-carcinogenic hazard quotients were calculated for each contaminant by dividing the contaminant intake value by the RfD value The non-cancer hazard quotients within each hazard pathway were then summed to produce a pathway hazard index These values, in turn were then summed to produce a Total Hazard Index for each RME According to the EPA human health risks may exist when the Total Hazard Index exceeds a value of 1 0

Lifetime carcinogenic risks were calculated for each contaminant by multiplying the contaminant intake values by the slope factor values Within each pathway, the chemical-specific risks were summed to produce the total pathway cancer risk, which are, in turn, summed to produce a Total Excess Lifetime Cancer Risk EPA generally considers a Total Lifetime Excess Cancer Risk for an RME of 1 x 10^{-6} to 1 x 10^{-4} to be unacceptable, while remedial action is considered necessary when this value exceeds 1 x 10^{-4}

Noncarcinogenic and carcinogenic risks were evaluated for all RMEs Summaries of noncarcinogenic and carcinogenic risks are presented in Tables 22 and 23 Pathway hazard indices for RME 5 (ingestion of groundwater, dermal contact with groundwater, inhalation of vapors from groundwater), and RME 6 (ingestion of groundwater) exceeded 1 0 Consequently, noncarcinogenic health risks may be present for individuals working or trespassing at the WOU Noncarcinogenic health risks may be present for (future) individuals living on, and adjacent to the WOU However, assumptions made in estimating contaminant intakes for these pathways were conservative and may overestimate the risk

With the exception of a pathway cancer risk of 1 9 in 10,000,000 (1 9 x 10^{7}) for inhalation of volatilized compounds from soil for RME 2, pathway cancer risks for all RMEs for all pathways exceeded 1 in 1,000,000 (1 x 10^{6}) Pathway cancer risks exceeded 1 in 10,000 (1 x 10^{-4}) for ingestion of groundwater (RMEs 5 and 6), ingestion of soil (RMEs 4 and 6), dermal contact with soil (RMEs 3 and 5), and inhalation of volatilized compounds from groundwater while showering (RME 5) Total lifetime cancer risks for all RMEs (except RME 2) exceeded 1 in 10,000 (1 x 10^{-4}), while RME 2 exceeded a risk of 1 in 1,000,000 (1 x10^{6}) Thus, carcinogenic health risks may be present for adults and children working, living and trespassing on the site

The Lead Biokinetic Uptake Model was used to predict blood lead levels for all RMEs at the WOU site Because all predicted levels were well below 10 micrograms per liter (ug/L), a health hazard is not expected to exist from ingestion of impacted groundwater and soil from the site

Preliminary remediation goals (PRGs) based on carcinogenic risks are usually more conservative (more protective of human health) than those based non-carcinogenic risks Because carcinogenic risks may be present for all RMEs evaluated, the PRGs calculated for the WOU are based on the carcinogenic risks

The following list presents the media, potential exposure pathway, and the chemicals of concern per RME at the WOU

RME-1, Dermal contact with soil PCE, Benzo (a) Pyrene
    Soil ingestion PCE
    Inhalation of vapors from soil TCE, PCE

RME-2, Dermal contact with soil PCE
    Soil ingestion PCE

RME-3, Dermal contact with soil Benzo (a) Pyrene, PCE
    Soil ingestion TCE, PCE, Benzo (a) Pyrene
    Inhalation of vapors from soil PCE

TABLE 22

Summary of Noncarcinogenic Risks
Wainwright Operable Unit
Valley Park, MO

Pathway Hazard Indices							
	Groundwater		Soil		Air		
RME	Ingestion	Dermal Contact	Ingestion	Dermal Contact	Inhalation (while showering)	Inhalation (soil offgassing)	Total Hazard Index
RME 1	NC	NC	0 15	0 049	NC	0 0014	0 64
RME 2	NC	NC	0 029	0 09	NC	0 00071	0 12
RME 3	NC	NC	0 42	0 073	NC	0 002	1 2
RME 4	NC	NC	0 76	0 79	NC	0 0095	1 6
RME 5	51	4 0	0 42	0 73	1 1	0 002	57
RME 6	11	0 64	0 76	0 79	0 59	0 0095	15

NC = Not Calculated

TABLE 23
Summary of Carcinogenic Risks
Wainwright Operable Unit
Valley Park, MO

Pathway Cancer Risks							
	Groundwater		Soil		Air		
RME	Ingestion	Dermal Contact	Ingestion	Dermal Contact	Inhalation (while showering)	Inhalation (soil offgassing)	Total Cancer Risk
RME 1	NC	NC	2 5 x 10^{5}	6 2 x 10^{5}	NC	3 1 x 10^{5}	1 2 x 10^{-4}
RME 2	NC	NC	6 1 x 10^{6}	6 9 x 10^{6}	NC	1 9 x 10^{7}	1 3 x 10^{5}
RME 3	NC	NC	8 7 x 10^{5}	1 1 x 10^{-4}	NC	2 7 x 10^{-6}	2 0 x 10^{-4}
RME 4	NC	NC	1 9 x 10^{-4}	7 0 x 10^{5}	NC	3 0 x 10^{-6}	2 6 x 10^{-4}
RME 5	5 3 x 10^{-4}	5 7 x 10^{5}	8 7 x 10^{5}	1 1 x 10^{-4}	7 7 x 10^{-4}	2 7 x 10^{6}	1 6 x 10^{3}
RME 6	2 9 x 10^{-4}	2 5 x 10^{5}	1 9 x 10^{-4}	7 0 x 10^{5}	3 7 x 10^{5}	3 0 x 10^{6}	6 2 x 10^{-4}

NC = Not Calculated

RME-4, Dermal contact with soil PCE, Benzo (a) Pyrene,
Bis (2-Ethylhexyl) phthalate
Soil ingestion PCE, TCE, Benzo (a) Pyrene
Inhalation of vapors from soil PCE

RME-5, Dermal contact with groundwater PCE, TCE, Manganese (MN)
Groundwater ingestion TCE, PCE, Methylene Chloride (MeCL),
Inhalation of vapors from groundwater Carbon Disulfide, MeCL, TCE, PCE
Dermal contact with soil PCE, Benzo (a) Pyrene,
Bis (2-Ethylhexyl) phthalate
Soil ingestion TCE, PCE, Benzo (a) Pyrene
Inhalation of vapors from soil PCE

RME-6, Dermal contact with groundwater PCE
Groundwater ingestion PCE, TCE, MN, Barium
Inhalation of vapors from groundwater TCE, PCE
Dermal contact with soil PCE, Benzo (a) Pyrene,
Bis (2-Ethylhexyl) phthalate
Soil ingestion PCE, TCE, Benzo (a) Pyrene
Inhalation of vapors from soil PCE

In summary, TCE and PCE represent the two compounds which pose the greatest potential environmental impact to the WOU and the surrounding area These compounds could potentially impact a receptor (identified as a RME) via any of the above stated exposure pathways Benzo (a) Pyrene could represent a risk via dermal contact with soil, while Manganese could represent a risk through groundwater ingestion and dermal contact Other compounds of potential concern which could present a risk include Methylene Chloride, Bis (2-Ethylhexyl) Phthalate, and Carbon Disulfide, each through various pathways

7 0 SUMMARY AND CONCLUSIONS

7 1 Summary

7 1 1 Nature and Extent of Contamination

The contaminants of concern in the Valley Park area are chlorinated ethenes and ethanes, the source of which is very likely from the loss or disposal of industrial solvents commonly used as degreasers and/or cleaners The major solvents found in the groundwater and/or soil are PCE, TCE, and 1,1,1-TCA

Wainwright Industries manufactured metal stampings and operated as a contract tool and die shop at the property Part of the manufacturing process included a solvent degreasing system that used TCE from 1963 to 1970 and PCE from 1970 to 1979 These chemicals were stored in a 1,000 gallon aboveground storage tank

The aforementioned compounds are all DNAPLs These liquids are denser (heavier) than water, i e , each have a specific gravity greater than water (greater than 1 0) For this reason, the compounds have the ability to sink when introduced into the subsurface and move/migrate vertically in the vadose zone under the influence of gravity If the DNAPLs are of sufficient mass to overcome the capillary force of water, they will continue to migrate vertically until a confining layer (often bedrock) is encountered At this point, they have the ability to accumulate on the surface, displacing the water and forming a distinct liquid-phase layer

The soil and vadose zone investigation involved the drilling of seventeen (17) soil borings and the collection of 70 soil samples from depths ranging from six (6) inches to 35 feet All of the soil samples were analyzed for VOCs according to EPA Method 8240, while a selected portion were analyzed for BNAs (semi-volatiles) according to EPA Method 8270 and 23 metals in accordance with EPA Method 6010

The results of the metal soil analysis indicated that the majority of the metal detections across the site were within the expected range of published background concentrations for the Valley Park region of Missouri However, Calcium, Lead, Copper, Magnesium, Selenium, and Zinc each were above the respective background concentrations within some or all of the soil samples

The semi-volatile soil analysis revealed a variety of detections The most commonly detected compounds included Pyrene, bis (2-ethylhexyl) Phthalate, Phenanthrene, Flouranthrene, Benzo (a) Anthracene, and Chrysene, with a lesser number of sample detections for 2-Methylnaphthalene, Anthracene, Benzo (b) Flouranthrene, Benzo (k) Flouranthrene, and Diethylphthalate (each detected either above or estimated below the detection limits) Soil Borings BH-FF, BH-GG, BH-DD, and BH-BB produced the greatest concentrations of TCE and PCE

The volatile organic constituents detected in the soil produced a variety of detections, consisting predominantly of TCE and PCE, with a lesser number of sample detections for other compounds Field soil screening readings and analytical concentrations were greatest at BH-DD, BH-GG, BH-BB, and BH-FF Borings BH-GG, and BH-BB each generally produced the greater concentrations nearer the surface (0 feet to 15 feet below grade), while BH-DD and BH-FF both exhibited more uniform concentrations throughout the borehole run (each to depths of 25 feet below grade)

The groundwater investigation involved the installation of one (1) upgradient well cluster (MW-AA), two (2) rounds of water samples from well clusters MW-5, MW-17 and MW-AA, and continued gathering of groundwater elevation data The wells, six total, are installed in clusters of two per location, one shallow and one deep

The RI did not include the installation of groundwater monitoring wells to the top of the bedrock surface For this reason, the presence of DNAPLs beneath the WOU is not known

Groundwater elevations were gathered over a 15 month period (April, 1992 through August 1993) On July, 22, 1993, the depth to groundwater was elevated above the levels previously noted, the depths ranged from 9 34 feet below grade (MW-6B) to 10 4 feet below grade (MW-5B) On the most recent groundwater elevation gauging event (August 27, 1993), groundwater was encountered between 19 8 feet below grade (MW-AAB) and 21 22 feet below grade (MW-5B), flowing to the south under an average horizontal hydraulic gradient of 0 003 feet per foot

Vertical gradients data gathered from the three well nests (MW-AA, MW-5, and MW-17) on August 27, 1993 indicate gradients of -0 023 feet per foot (ft/ft) for the MW-AA well nest, -0 014 ft/ft (MW-5), and 0 014 ft/ft (MW-17) According to the August 27, 1993 data, well nests MW-AA and MW-5 were located within aquifer discharge areas, i e , upward gradients, while MW-17 was recharging the aquifer All three gradients are indicative of non-perched groundwater conditions, this data may not be indicative of the actual groundwater conditions beneath the site

The groundwater samples were analyzed for pH, conductivity, cyanide, VOCs in accordance with EPA Method 8240, BNAs in accordance with EPA Method 8270, 23 metals in accordance with EPA Method 6010, PCBs, pesticides and herbicides in accordance with EPA Method 8080, and total extractable hydrocarbons in accordance with EPA Method 8015

The results of the groundwater sampling indicated that a variety of volatile compounds present in the groundwater beneath the Wainwright facility TCE and PCE comprised the most common and notable detections Maximum TCE and PCE concentrations detected in monitor well cluster MW-17 were 170 ppb and

1500 ppb, respectively Monitor well cluster MW-AA produced no detections of TCE, while PCE was detected at a maximum concentration of 92 ppb Monitor well cluster MW-5 produced maximum TCE and PCE concentrations of 11 ppb and 22 ppb respectively

Other detected VOCs/SVOCs include Acetone, Bis (2-Ethylhexyl) Phthalate, Butyl benzyl Phthaltate, Carbon Disulfide, 1,2 Dichloroethene, cis-1,2 Dichloroethene, Methylene Chloride, Phenol, Trichloroflouromethane, Toluene, and m-, p- Xylene MCLs and/or SMCLs (if applicable) were not exceeded among these compounds

A variety of metal detections were noted during the groundwater sampling Metals detected (among the three well clusters) exceeding MCLs include Barium, Cadmium, Chromium, Lead, and Mercury Secondary MCL exceedances of Aluminum, Iron, and Manganese were also noted

7 1 2 Contaminant Fate And Transport

The two compounds of interest at the WOU are TCE and PCE Both of these compounds are reactive (dynamic) when introduced/released into the subsurface

Both TCE and PCE are DNAPLs, i e , they are denser (heavier) than water and have the ability to sink when introduced into the subsurface If the DNAPLs are of sufficient mass to overcome the capillary pressures of water and air in the vadose zone, vertical migration occurs until reaching the saturated (aquifer) zone At this point, the DNAPL will continue to migrate vertically (independent of groundwater flow) if the DNAPL remains of sufficient mass to overcome the capillary forces holding the water in the pore space DNAPL transport in the saturated zone typically occurs as vertical stringers When the stringers have a sufficient height, water displacement occurs and vertical migration occurs until an aquiclude (often bedrock) is encountered If the groundwater flow has sufficient force to overcome the DNAPL capillary pressure, it can displace vertical DNAPL stringers in the horizontal direction (in the direction of groundwater flow)

Once DNAPL accumulates on an aquiclude, it has the ability to accumulate on the surface, displacing the water and forming a distinct liquid-phase layer The DNAPL can also migrate along the surface, typically in the direction of aquiclude dip, regardless of the prevailing groundwater flow direction

The flow (persistence and migration) of liquid-phase (DNAPL) TCE/PCE is dependant upon the density, viscosity, and interfacial tension of the fluid DNAPL can also migrate from the subsurface to the atmosphere in the vapor-phase

If sufficient DNAPL mass is not present, it can partition to vapor, adsorbed, and/or soluble-phases

Three-phase flow can occur above the groundwater surface (vadose zone), air (vapor-phase), water (soluble-phase) and DNAPL (liquid-phase), while two phase flow can occur below the groundwater surface, DNAPL (liquid-phase) and water (soluble-phase) DNAPL can also partition to the air as a vapor phase An adsorbed-phase can also develop, this incorporates the partitioning of DNAPL (and to a lesser extent, soluble and vapor phases) to (within) the soil matrix

Vapor-phase transport is highly dependant on the vapor pressure/density and volatility of the specific compound Vapor densities for TCE and PCE are 4 53 and 5 83/5 76 respectively, both heavier than air The vapor pressures are 58 0 millimeters mercury and 15 8/13 0 millimeters mercury for TCE and PCE respectively These values are indicative of moderate volatility, i e , moderate mobility within the vadose zone DNAPL can also migrate through the vadsoe zone and into the atmosphere, thus further highlighting the fact of the compounds mobility in the vapor-phase

Vapor-phase transport within the saturated (aquifer) zone is a complex and unstable phenomena, being difficult to predict and/or model The flow field is a function of many parameters, however, soil structure (permeability, and air entry pressure) appears to be the most significant parameter

The transport of soluble-phase TCE and PCE within the subsurface is a function of 1) the hydrodynamic properties of the soil matrix and the subsequent advective, diffusional flow system, and 2) physical/chemical interactions between the compounds and the soil

The persistence, or fate, of soluble-phase TCE and PCE within the soil matrix and aquifer is a function of two factors, 1) retardation, and 2) transformation

The soluble front of TCE and PCE as such passes through the soil is termed the rate of retardation (R) Retardation involves various phenomena which control the movement of solutes through a porous media The dominant process controlling retardation involves the process of sorption, which refers to the partitioning of the compound between the liquid and the solid phases in porous media and represents the transfer from the liquid-phase to the surface of the individual soil particle

Calculated values of retardation are 3 9 (TCE) and 9 3 (PCE), i e , groundwater is moving at a velocity which is 3 9 and 9 3 times faster than that of TCE and PCE, respectively The subsequent migration rates of TCE and PCE (with respect to the flow of the uncontaminated groundwater aquifer) are approximately 197 ft/yr and 82 ft/yr, respectively, both less than the reported groundwater flow rate of 763 ft/yr

Transformation (decay) represents a generalized process under which compounds such as TCE and PCE experience additional change when introduced into the subsurface This term includes a variety of chemical reactions including hydrolysis, volatilization, oxidation, reduction, precipitation, and biodegradation (such as anaerobic reductive dechlorination), all first order characteristics As mass is neither created or destroyed, these transformations result in the formation of daughter by-products Biodegradation represents the most probable transformation mechanism at the site

The migration, or transport of soluble-phase TCE and PCE within the soil matrix and aquifer is a function of three factors 1) advection, 2) molecular diffusion, and 3) mechanical/hydrodynamic dispersion

Qualitatively, advection is the most important mode of transport of a soluble compound It is dependant on the hydraulic gradient, hydraulic conductivity and aquifer flow velocity and is characterized as anisotropic Advection can be defined as the bulk movement of water caused by differences in density, temperature, or pressure When a groundwater body containing soluble-phase compounds is in motion, the transportation of such occurs The mass of TCE and PCE transported by advection at the WOU is calculated as being 6 7 kg/day and 59 4 kg/day, respectively

Molecular diffusion represents the random fluctuation of molecules in solution in response to a groundwater gradient It is a slow and isotropic process Ionic and molecular species move from areas of higher concentration (more molecules) to area of lower concentration (less molecules), occurring primarily through the liquid-phase The mass of TCE and PCE transported by molecular diffusion at the WOU is calculated as being 2 0 x 10^{7} kg/day and 1 1 x 10^{5} kg/day, respectively The low values illustrate the fact that diffusion is insignificant when compared to advection and dispersion (discussed below)

Mechanical dispersion pertains to the spreading and transport of contaminants in complex pathways It is the initial dispersion experienced in the z-direction (downward, within the vadose zone) resulting from the bulk movement of a contaminant (fluid) from a single point The complex velocity variations, meanderings, and bifurcations causes the contaminant to spread in the both longitudinal and transverse directions Three processes control the movement of the contaminant, intrapore velocity variations (frictional resistance at the boundary of the pore space), interpore velocity variations (pore space size variations causing velocity variations), and, tortuosity of the media (complexity of the media causing the fluid stream to split and deflect in the flow direction) The mass of TCE and PCE transported by mechanical dispersion at the WOU is calculated as being 3 21 x 10^{2} kg/day and 1 7 kg/day, respectively As these values are greater than those derived for diffusion, this emphasizes the fact that mechanical dispersion is a principal transport parameter at the WOU

As the effects of mechanical dispersion and molecular diffusion cannot be separated in flowing groundwater, the two processes are combined into one term, hydrodynamic dispersion It is a function of scale, i e , the greater the area of measurement, the value can become larger The effects of hydrodynamic dispersion causes a contaminant to decrease in concentration with distance from the source The effects of spreading will be greater within the downgradient portion of the aquifer, in the direction of flow, rather than perpendicular to flow The mass of TCE and PCE transported by means of hydrodynamic dispersion at the WOU is calculated as being 1 3 x 10^6 kg/day and 7 0 x 10^5 kg/day, respectively

7 1 3 Baseline Risk Assessment

A RA for the WOU was prepared by the MDOH The RA examines the risks resulting from exposure to contaminated groundwater, soil, and air at the WOU The exposure pathways examined include ingestion of and dermal contact with contaminated groundwater and soil, and inhalation of air contaminated with compounds volatilizing from the groundwater and soil

The MDOH evaluated all detected compounds, chemicals, and metals identified at the site during the soil and groundwater sampling work phases All VOCs and SVOCs detected in the groundwater and the soil were retained for the exposure assessment The metals detected in the groundwater and the soil were evaluated on an individual basis, retained if present above background concentrations

The Exposure Assessment is accomplished through the identification of exposure pathways, development of RME scenarios, and the calculation of contaminant intake values Pathways represent contact of a receptor with a contaminant Several potential exposure pathways were investigated (in various combinations) per RME, ingestion of and dermal contact with contaminated soil and groundwater, and inhalation of air contaminated with compounds volatilizing from the groundwater and soil

A total of six RMEs were developed by the MDOH for the WOU They include the following

- RME 1 - A 70 kg adult on-site worker, exposed to the site 250 days per year over a period of 25 years
- RME 2 - A 43 kg adolescent, 10-16 years of age, visiting the site two times per week for 39 weeks per year over a six year period
- RME 3 - A 70 kg adult off-site resident exposed to the site 365 days per year over a period of 30 years
- RME 4 - A 15 kg child (0-6 years of age) off-site resident exposed to the site 365 days per year over a period of 7 years
- RME 5 - A 70 kg adult living on the WOU site exposed to the site 365 days per year over a period of 30 years
- RME 6 - A 15 kg child (0 to 6 years of age) living on the WOU site exposed to the site 365 days per year over a period of 7 years

The toxicity assessment includes both non-carcinogenic and carcinogenic effects

According to the EPA,human health risks may exist when the Total Hazard Index exceeds a value of 1 0 (for non-carcinogenic risks) Calculated lifetime carcinogenic risks, termed the Total Excess Lifetime Cancer Risk, in excess of 1 x 10^{6} to 1 x 10^{-4} (per RME) is unacceptable according to the EPA Furthermore, remedial action is considered necessary when this value exceeds 1 x 10^{-4}

Noncarcinogenic and carcinogenic risks were evaluated for all RMEs
Pathway hazard indices for RME 5 (ingestion of groundwater, dermal contact with groundwater, inhalation of vapors form groundwater), and RME 6 (ingestion of groundwater) exceeded 1 0 Consequently, noncarcinogenic health risks may be present for individuals working or trespassing at the WOU Noncarcinogenic health risks may be present for (future) individuals living on, and adjacent to the WOU

With the exception of a pathway cancer risk of 1 9 in 10,000,000 (1 9 x 10^{7}) for inhalation of volatilized compounds from soil for RME 2, pathway cancer risks for all RMEs for all pathways exceeded 1 in 1,000,000 (1 x 10^{6}) Pathway cancer risks exceeded 1 in 10,000 (1 x 10^{-4}) for ingestion of groundwater (RMEs 5 and 6), ingestion of soil (RMEs 4 and 6), dermal contact with soil (RMEs 3 and 5), and inhalation of volatilized compounds from groundwater while showering (RME 5) Total lifetime cancer risks for all RMEs (except RME 2) exceeded 1 in 10,000 (1 x 10^{-4}), while RME 2 exceeded a risk of 1 in 1,000,000 (1 x10^{6}) Thus, carcinogenic health risks may be present for adults and children working, living and trespassing on the site

The Lead Biokinetic Uptake Model was used to predict blood lead levels for all RMEs at the WOU site Because all predicted levels were well below 10 micrograms per liter (ug/L), a health hazard is not expected to exist from ingestion of impacted groundwater and soil from the site

In summary, TCE and PCE represent the two compounds which pose the greatest potential environmental impact to the WOU and the surrounding area These compounds could potentially impact a receptor (identified as a RME) via any of the above stated exposure pathways Other compounds of potential concern which could present a risk include Methylene Chloride, Benzo (a) Pyrene, Bis (2-Ethylhexyl) Phthalate, Carbon Disulfide, Manganese, and Barium each through various pathways

7 2 Conclusions

7 2 1 Data Limitations and Recommendations for Future Work

Schreiber, Grana & Yonley, Inc has conducted this investigation according to industry standard quality assurance/quality control procedures All data, findings, and conclusions of this report are valid as of the date of the investigation

Schreiber, Grana & Yonley, Inc has no control over, and disclaims, any responsibility from any errors and omissions arising from all analytical testing results conducted at independent testing laboratories Therefore, any data interpretations and/or conclusions arising from such data are wholly dependent upon the quality of such

One data issue in need of further quantification/clarification involves the analytical results of the groundwater metals sampling This data, generated on April 23, 1992 and May 23, 1992 produced manganese and barium at concentrations deemed by the MDOH to present an unacceptable non-carcinogenic risk The concentrations detected may not be indicative of actual solubilized metals, but rather suspended solids The method of well purging/sampling (Redi-Flow submersible pump) may have increased the turbidity of the groundwater and thus, increased the suspended solids content Additionally, sample filtering in the field was not accomplished

Schreiber, Grana & Yonley recommends re-sampling well nests MW-AA, MW-5, and MW-17 for Total Metals (EPA Method 6010) The sampling is recommended to be accomplished via pumping/bailing at a slow rate in combination with field sample filtering in an effort to lower the suspended solids content This potentially may reduce the soluble metals concentrations If lower metals concentrations are achieved, then the manganese and barium non-carcinogenic risks at the WOU may lower the Total Hazard Index to less than 1 0 Subsequently, groundwater treatment for the removal of metals would not need to be conducted at the WOU

7 2 2 Recommended Remedial Action Objectives

Based on information collected during the remedial investigation, and data presented in the RA, Wainwright Industries has developed recommended remedial action objectives for contaminants in the soil and groundwater that are protective of human health and the environment Tables 24 and 25 present the remedial action objectives developed for the affected media and pathways which would affect human health and the environment The media involved are soil and groundwater Possible pathways which would affect human health and the environment include inhalation, ingestion, and dermal contact Remedial action objectives were developed for exposure compounds which had either a hazard quotient of greater than one (1) or cancer risk of greater than 1 x 10^{6}

TABLE 24

REMEDIAL ACTION OBJECTIVES
WAINWRIGHT OPERABLE UNIT
VALLEY PARK, MISSOURI

ENVIRONMENTAL MEDIA	**Remedial Action Objectives**
GROUNDWATER	Prevent the dermal contact of water containing tetrachloroethene, trichloroethene, and manganese with a total excess cancer risk greater than 10^{6} and/or a hazard quotient greater than one
	Prevent the ingestion of water containing tetrachloroethene, trichloroethene, methylene chloride, manganese, and barium in excess of MCLs, a total excess cancer risk greater than 10^{6}, and/or a hazard quotient of greater than one
	Prevent the inhalation of tetrachloroethene, trichloroethene, methylene chloride, and carbon disulfide volatilizing from water with a total excess cancer risk greater than 10^{6} and/or a hazard quotient greater than one
SOIL	Prevent the inhalation of tetrachloroethene and trichloroethene volatilizing from soil posing excess cancer risk levels greater than 10^{-6} and/or a hazard quotient grater than one
	Prevent the dermal contact with soil containing tetrachloroethene, benzo(a)pyrene, and bis(2-ethylhexyl)phthalate having a cancer risk greater than 10^{6} and/or a hazard quotient greater than one
	Prevent the ingestion of soil containing tetrachloroethene, trichloroethene, and benzo(a)pyrene having a cancer risk greater than 10^{6} and/or a hazard quotient of greater than one

TABLE 25

REMEDIAL ACTION OBJECTIVES
WAINWRIGHT OPERABLE UNIT
VALLEY PARK, MISSOURI

MEDIA OF CONCERN	POTENTIAL CHEMICALS OF CONCERN	POTENTIAL EXPOSURE PATHWAYS	REMEDIAL ACTION OBJECTIVES	SUMMARY OF CHEMICALS OF CONCERN
Groundwater	acetone bis(2 ethylhexyl)phthalate butyl benzyl phthalate carbon disulfide cis 1,2 dichloroethene methylene chloride phenol tetrachloroethene trichloroethene trichlorofluoromethane toluene xylene (m p) aluminum barium cadmium chromium cobalt copper iron lead manganese mercury nickel potassium selenium vanadium zinc chloride	Ingestion Dermal Contact Inhalation	Reduce the ingestion of tetrachloroethene, trichloroethene, methylene chloride, manganese, and barium to an acceptable level of risk Reduce the dermal contact of tetrachloroethene, trichloroethene, and manganese to an acceptable level of risk Reduce the inhalation of tetrachloroethene, trichloroethene, methylene chloride and carbon disulfide to an acceptable level of risk	tetrachloroethene trichloroethene methylene chloride carbon disulfide manganese barium

TABLE 25 (cont'd)

REMEDIAL ACTION OBJECTIVES
WAINWRIGHT OPERABLE UNIT
VALLEY PARK, MISSOURI

MEDIA OF CONCERN	POTENTIAL CHEMICALS OF CONCERN	POTENTIAL EXPOSURE PATHWAYS	REMEDIAL ACTION OBJECTIVES	SUMMARY OF CHEMICALS OF CONCERN
Soil	anthracene benzo(a)anthracene benzo(a)pyrene benzo(b)fluoranthene benzo(k)fluoranthene bis(2 ethylhexyl) phthalate crysene cis 1,2 dichloroethene ethyl benzene fluoranthene isopropyl benzene p isopropyl toluene methylene chloride naphthalene phenanthrene pyrene tetrachloroethene toluene trichloroethene 1,2,4 trimethylbenzene 1,3,5 trimethylbenzene xylene (m p) xylene (o) calcium copper lead magnesium selenium zinc	Dermal Contact Ingestion Inhalation	Reduce the dermal contact of tetrachloroethene, benzo(a)pyrene and bis(2 ethylhexyl) phthalate to an acceptable level of risk Reduce the ingestion of tetrachloroethene trichloroethene and benzo(a)pyrene to an acceptable level of risk Reduce the inhalation of tetrachloroethene and trichloroethene to an acceptable level of risk	benzo(a)pyrene tetrachloroethene trichloroethene bis(2 ethylhexyl) phthalate

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APPENDIX A

BORING LOGS

LAFSER & SCHREIBER, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO MW-AA-B

Project: Wainwright Industries, Inc	Job No Wain 07	Sheet 1 of 2	
Client: Wainwright Industries, Inc	Drilling Agency: Brotcke Engineering		
Size and Type of Bit: 7 7/8" Hollow Stem O D	Location (Coordinates or Station): Wainwright Property		
Direction and Inclination of Hole. Vertical	Soil Boring Footage. 33 35 ft	Coring Footage. 0	Total Depth. 33.25 ft
Elevation.	Mfr. Designation of Drill CME-750	Number Of Soil Samples Penetration 7 Tubes 7	
Depth to water 24 ft.	No Of Cores Boxes:	Date Started. 4/14/92 Date Completed. 4/14/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
		Brown moist clay w/gray mottling, grading to dark brown clay w/gray mottling and blocky structure	1 MW-AA-1 @ 5 ft.	90		No odor 1 4 ppm
5		Light brown silty clay w/iron staining, grading to brown plastic clay w/gray mottling and red brown mottling	2	100		No odor 1.2 ppm
10		Brown clay w/blocky structure and gray mottling Chert fragment present at 13'	3 MW-AA-2 @ 15 ft	100		No odor 1 5 ppm
15		1 foot of heavily mottled brown clay, 4 inch sand lens, white, good sorting grading to brown clay sand Stiff brown clay w/heavy gray mottling	4	100		No odor 1 7 ppm
20		6 inches of heavy gray mottled brown clay, 3 inch sand lens white, rounded, good sorting grading to brown plastic clay lower 6 inches course chert river gravel	5 MW-AA-3 @ 24 ft	80		No odor 2.0 ppm Duplicate sample taken @ 24 ft
25						

*Miran Ambient Air Analyzer Reading

LAFSER & SCHREIBER, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO MW-AA-B

Project Wainwright Industries, Inc		Job No Wain 07	Sheet 2 of 2
Client Wainwright Industries, Inc		Drilling Agency Brotcke Engineering	
Size and Type of Bit 7 7/8" Hollow Stem O.D.		Location (Coordinates or Station) Wainwright Property	
Direction and Inclination of Hole. Vertical		Soil Boring Footage. 33.25 ft	Coring Footage. 0 Total Depth: 33.25 ft.
Elevation.	Mfr Designation of Drill CME-750	Number Of Soil Samples Penetration 7 Tubes 7	
Depth to water 24 ft.	No Of Cores Boxes	Date Started. 4/14/92 Date Completed. 4/14/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
		Chert river gravel, poorly sorted Brown clay, white sand and chert gravel	6	15		No odor 2 0 ppm
30		Chert gravel grading to dark gray stiff sandy clay	7	70		No odor 2 0 ppm
33.25						

*Miran Ambient Air Analyzer Reading

LAFSER & SCHREIBER, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO MW-AA-C

Project: Wainwright Industries, Inc	Job No Wain 07	Sheet 1 of 2	
Client: Wainwright Industries, Inc	Drilling Agency: Brotcke Engineering		
Size and Type of Bit: 7 7/8" Hollow Stem O D	Location (Coordinates or Station) Wainwright Property		
Direction and Inclination of Hole. Vertical	Soil Boring Footage. 46 89 ft.	Coring Footage. 0	Total Depth. 46 89 ft.
Elevation. / Mfr Designation of Drill CME-750	Number Of Soil Samples Penetration 10 Tubes 10		
Depth to water 22 5 ft. / No Of Cores Boxes:	Date Started. 4/13/92 Date Completed. 4/13/92	Inspector(s): Terry Miner	

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
		Dark brown, plastic clay grading to a soft moist clay Light brown clay w/dark brown mottling, roots present.	1	85		No odor No detection
5		Brown silty clay w/gray mottling, becoming very plastic in lower 2 foot	2	100		No odor No detection
10		Same as above	3	100		No odor 0 5 ppm
15		Brown sandy silty w/ medium grain sand lens, iron staining present. Lower 2 foot grading back to brown plastic clay w/gray mottling	4	100		No odor No detection
20		Brown heavily mottled moist clay, gray mottling Lower 4 inches course poorly sorted chert river gravel	5	65		No odor 17 ppm
25						

*Miran Ambient Air Analyzer Reading

LAFSER & SCHREIBER, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO MW-AA-C

Project Wainwright Industries, Inc		Job No Wain 07	Sheet 2 of 2
Client Wainwright Industries, Inc		Drilling Agency Brotcke Engineering	
Size and Type of Bit 7 7/8" Hollow Stem O D.		Location (Coordinates or Station) Wainwright Property	
Direction and Inclination of Hole. Vertical		Soil Boring Footage. 46 89 ft.	Coring Footage: 0 — Total Depth. 46 89 ft.
Elevation.	Mfr Designation of Drill CME-750	Number Of Soil Samples Penetration 10 Tubes 10	
Depth to water 22 5 ft.	No Of Cores Boxes	Date Started. 4/13/92 Date Completed. 4/13/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks
30		Poorly sorted chert gravel, some silty sand present	6	Barral plugged poor recovery 5		No odor 0 7 ppm
35		Same as above Gray plastic clay layer in lower 1 5 feet	7	40		No odor 0 6 ppm
40		Fine grain white poorly sorted, angular sand Grading to poorly sorted chert gravel	8	15		No odor 0 6 ppm
45		Very fine grain, well sorted, white sand, grading to poorly sorted chert gravel Stiff gray clay in lower 1 foot	9	35		No odor 0 6 ppm
46.89		Fine white sand w/angular chert and broken limestone fragment	10	100		No odor
		TD 46 89 ft.				

*Miran Ambient Air Analyzer Reading

SCHREIBER, GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO. BH-AA

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 2
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D.		Location (Coordinates or Station) Wainwright Property	
Direction and Inclination of Hole Vertical		Soil Sampling Footage. 35'	Coring Footage. 0' / Total Depth. 35'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 4 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started: 6/22/92 Date Completed. 6/22/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
6" 5		Brown top soil w/chert gravel. Dry stiff slightly plastic light brown clay w/heavy gray mottling and iron stainage.	1 BH-AA-1 at 5 ft.	90%		No odor 2 ppm
10		Same as above to 7 ft., one foot of heavy iron stain layer Crumbly light brown silty clay, dry	2	90%		No odor No detection
15		Same as above w/more iron staining, becoming plastic.	3 BH-AA-2 at 15 ft.	100%		No odor No detection
20		Stiff plastic gray clay, w/brown mottling and river gravel 17 ft. sand w/gravel layer, iron staining	4	100%		No odor No detection

*MicroTip Photoionization Detector Reading
+Miran Readings

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-AA

Project: Wainwright Industries, Inc.	Job No WAIN 07	Sheet 2 of 2
Client: Wainwright Industries, Inc.	Drilling Agency Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D	Location (Coordinates or Station). Wainwright Property	
Direction and Inclination of Hole. Vertical	Soil Sampling Footage 35'	Coring Footage 0'
		Total Depth. 35'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 4 Penetration Tubes
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 6/22/92 Date Completed 6/22/92
		Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
25		Stiff plastic gray clay w/abundant sand and gravel, iron at 23 ft. clean white sand grading and chert gravel	5 BH-AA-3 at 25 ft.	75%		No odor No detection
30		Interbedded sands white clean sand, chert and gravels	6	30%		No odor No detection
35		Course poorly sorted chert gravel w/some interbedded silty clays	7 BH-AA-4 at 35 ft.	40%		No odor No detection

*MicroTip Photoionization Detector Reading
+Miran Readings

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-BB

Project: Wainwright Industries, Inc.	Job No WAIN 07	Sheet 1 of 1	
Client: Wainwright Industries, Inc.	Drilling Agency Brotcke Engineering		
Size and Type of Bit: 7' 7/8 O.D	Location (Coordinates or Station) Wainwright Property		
Direction and Inclination of Hole Vertical	Soil Sampling Footage. 25'	Coring Footage. 0'	Total Depth. 25'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 5 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 6/24/92 Date Completed. 6/24/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
6" 12"		Top soil brown w/chert gravel	1 BH-BB-1 at 6 in. to 12 in.	100%		slight odor 11 ppm
5		Crumbly brown clay w/gray mottling.	Sampled from top of run 2 BH-BB-2 at 5 ft.	65%		slight odor 12 ppm
10		Crumbly brown clay w/gray mottling Becoming stiff and plastic at bottom.	2 BH-BB-3 at 10 ft.	100%		slight odor 10 ppm
15		Stiff plastic brown clay w/gray mottling 13 ft. crumbly 6" brown clay	3 BH-BB-4 at 15 ft.	100%		No odor 2.1 ppm
20		Stiff plastic gray clay w/brown mottling Iron stain 3 inch sand lens grading same as above.	4	90%		odor 22 ppm in sand
25		Sandy gray clay grading to gravely sand at 23 ft.	5 BH-BB-5 at 25 ft.	80%		No odor No detection

*MicroTip Photoionization Detector Reading
+Miran Readings

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-CC

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 1
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D		Location (Coordinates or Station) Wainwright Property	
Direction and Inclination of Hole. Vertical		Soil Sampling Footage 25'	Coring Footage. 0' / Total Depth. 25'
Elevation. N/A	Mfr. Designation of Drill CME 550	Number Of Soil Samples 3 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes. N/A	Date Started. 6/24/92 Date Completed. 6/24/92	Inspector(s) Ed Shepard

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
12" 5		Top soil w/gravel Brown silty clay w/gray mottling, moist, crumbly	1 BH-CC-1 at 5ft.	100%		No odor 4 7 ppm
10		Gray silty clay w/brown mottling Crumbly grading to stiff and plastic.	2	60%		Shelby tube 5 ft.-7 ft. No odor No detection
15		Brownish gray silty clay w/dark gray mottling Becomes crumbly at 14 ft.	3 BH-CC-2 at 15 ft.	100%		No odor 2.3 ppm
20		Stiff gray plastic clay w/brown mottling, clean white sand grading to chert gravel Reddish sand and chert gravel at 18.5 ft.	4	60%		Tube 15 ft.-17 ft. No odor 1 1 ppm
25		Sand and chert gravel w/reddish clay, poorly sorted	5 BH-CC-3 at 25 ft.	60%		No odor 2.3 ppm

*MicroTip Photoionization Detector Reading
+Miran Readings

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO. BH-DD

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 1	
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering		
Size and Type of Bit: 7' 7/8 O.D.		Location (Coordinates or Station): Wainwright Property		
Direction and Inclination of Hole: Vertical		Soil Sampling Footage. 25'	Coring Footage. 0'	Total Depth. 25'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 5 Penetration Tubes		
Depth to water N/A	No Of Cores Boxes: N/A	Date Started. 6/23/92 Date Completed 6/23/92		Inspector(s). Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
6"-12" 5		Very moist dark brown clay w/chert gravel.	1 BH-DD-1 at 6 in. to 12 in. BH-DD-2 at 5 ft. taken from top of run 2	15%		Odor 110 ppm
10		Stiff plastic brown clay	2 BH-DD-3 at 10 ft.	100%		Odor 299 ppm
15		Stiff plastic brown clay w/iron stains and gray mottling	3 BH-DD-4 at 15 ft.	100%		Slight odor 16 ppm
20		Same as above w/heavy gray mottling, some sand grains and chert gravel in bottom.	4	80%		Odor 91 ppm
25		Clay and chert gravel mixture. Clean white rounded sand grading to chert gravel at 22 ft.	5 BH-DD-5 at 25 ft. Duplicate taken	90%		325 ppm

*MicroTip Photoionization Detector Reading
+Miran Readings

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-EE

Project: Wainwright Industries, Inc.	Job No WAIN 07	Sheet 1 of 1
Client: Wainwright Industries, Inc.	Drilling Agency Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D	Location (Coordinates or Station) Wainwright Property	

Direction and Inclination of Hole. Vertical		Soil Sampling Footage. 25'	Coring Footage 0'	Total Depth. 25'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 5 Penetration Tubes		
Depth to water N/A	No Of Cores Boxes: N/A	Date Started. 6/24/92 Date Completed 6/24/92		Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
6"-12" 5		Crumbly dark brown clay grading to crumbly light brown clay	1 BH-EE-1 at 6 in. to 12 in. BH-EE-2 at 5 ft. Sample taken at top of run 2	85%		No odor 1 ppm
10		Stiff plastic brown clay w/gray mottling, iron staining	2 BH-EE-3 at 10 ft.	100%		Slight odor 100 ppm 7.5 ft. = 2100 ppm.
15		Same as above Clean white sand lens at 13 ft.	3 BH-EE-4 at 15 ft.	100%		Odor 20 ppm 270 ppm at 13 ft.
20		Brown clay w/heavy gray mottling and iron staining Clean white sand lens at 18 ft.	4	90%		Odor 497 ppm
25		Same as above w/more sand lenses Clean white sand at 24 ft.	5 BH-EE-5 at 25 ft. Duplicate taken	65%		Odor 1100 ppm at 24 ft.

*MicroTip Photoionization Detector Reading
+Miran Readings

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-FF

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 1
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D		Location (Coordinates or Station). Wainwright Property	
Direction and Inclination of Hole. Vertical		Soil Sampling Footage 25'	Coring Footage 0' Total Depth 25'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 2 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes. N/A	Date Started. 6/24/92 Date Completed. 6/24/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
5		Pea Gravel				
10		Pea Gravel				
11 15		Base of pit at 11 ft. Brown clay w/gray mottling iron stained stiff plastic sand layer at 14 ft.	1 BH-FF-1 at 11 ft. BH-FF-2 at 15 ft.	100%		Odor 3000 ppm at 14 ft.
20		Brown clay w/heavy gray mottling Dry sand 4" from bottom. Stiff plastic gray clay w/brown mottling	2	100%		Strong odor 5400 ppm
25		Same as above down to 23 ft. Clean white sand w/chert gravel	3 BH-FF-3 at 25 ft.	90%		Strong gasoline odor 5000 ppm - 7000 ppm

*MicroTip Photoionization Detector Reading
+Miran Reading

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-GG

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 1
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D		Location (Coordinates or Station) Wainwright Property	
Direction and Inclination of Hole. Vertical		Soil Sampling Footage. 25'	Coring Footage. 0'	Total Depth. 25'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 5 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 6/23/92 Date Completed 6/23/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
6" 12"		Gravel and fill	1 BH-GG-1 at 6 in. to 12 in.	100%		Strong odor 290 ppm
5		No recovery Sample taken from top of next run	2 BH-GG-2 at 5 ft.	0%		
10		Dry crumbly brown clay w/gray mottling Clay becoming stiff and plastic	3 BH-GG-3 at 10 ft.	100%		No odor 3 ppm
15		Same as above except for very crumbly clay at 14 ft.	4 BH-GG-4 at 15 ft.	100%		Odor 42 ppm
20		Brown clay w/gray mottling. Grading to sandy silt and chert gravel	5	100%		Strong odor 221 ppm
25		Same as above Grading to Iron stained sand and chert gravel Clean white sand at 24 ft.	6 BH-GG-5 at 25 ft.	75%		Strong odor 398 ppm

*MicroTip Photoionization Detector Reading
+Miran Reading

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-HH

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 1
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D		Location (Coordinates or Station) Wainwright Property	
Direction and Inclination of Hole. Vertical		Soil Sampling Footage 25'	Coring Footage 0' Total Depth 25'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 2 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 6/23/92 Date Completed 6/23/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
5		Pea gravel				
10		Pea gravel				
15		Pea gravel to 14 ft. Stiff plastic brown clay w/gray mottling	1 BH-HH-1 at 14 ft. BH-HH-2 at 15 ft.	30%		No odor
20		Same as above except for becoming sandier	2	100%		Slight odor 15 ppm
25		Stiff plastic gray clay down to 24 ft. Chert gravel layer then clean white sand	3 BH-HH-3 at 25 ft.	85%		Slight odor 82 ppm

*MicroTip Photoionization Detector Reading
+Miran Reading

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-II

Project: Wainwright Industries, Inc.
Job No WAIN 07
Sheet 1 of 1

Client: Wainwright Industries, Inc.
Drilling Agency Brotcke Engineering

Size and Type of Bit: 7' 7/8 O.D
Location (Coordinates or Station) Wainwright Property

Direction and Inclination of Hole. Vertical
Soil Sampling Footage 25'
Coring Footage. 0'
Total Depth. 25'

Elevation. N/A
Mfr Designation of Drill CME 550
Number Of Soil Samples 5 Penetration Tubes

Depth to water N/A
No Of Cores Boxes N/A
Date Started. 6/23/92
Date Completed 6/23/92
Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
6" 12"		Top soil dark brown.	1 BH-II-1 at 6 in. to 12 in.	100%		No detection paint odor
5		Crumbly light brown clay w/gray mottling	2 BH-II-2 at 5 ft.	80%		No odor No detection
10		Brown clay w/gray mottling Becoming stiff and plastic in lower 2 ft.	3 BH-II-3 at 10 ft.	100%		No odor No detection
15		Same as above	4 BH-II-4 at 15 ft.	100%		No odor No detection
20		Same as above w/some sand	5	100%		No odor 0 6 ppm
25		Brown plastic clay w/very heavy gray mottling Sand at 24 ft. w/chert and gravel	6 BH-II-5 at 25 ft.	100%		Odor 31 ppm

*MicroTip Photoionization Detector Reading
+Miran Reading

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-JJ

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 1	
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering		
Size and Type of Bit: 7' 7/8 O.D		Location (Coordinates or Station) Wainwright Property		
Direction and Inclination of Hole. Vertical		Soil Sampling Footage. 25'	Coring Footage 0'	Total Depth 25'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 3 Penetration Tubes		
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 6/24/92 Date Completed 6/24/92		Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
5" 5		Asphalt Light brown crumbly clay w/iron staining.	1 BH-JJ-1 at 5 ft.	85%		No odor No detection
10		Same as above except more crumbly	2	100%		No odor No detection
15		Stiff plastic brown clay w/gray mottling grading to gray clay w/brown mottling	3 BH-JJ-2 at 15 ft.	100%		No odor 0 1 ppm Crumbly layer at 14 ft.
20		Same as above Clean sand w/gravel at 19 ft.	4	100%		No odor No detection
25		Clean white sand	5 BH-JJ-3 at 25 ft.	40%		No odor 1.2 ppm

*MicroTip Photoionization Detector Reading
+Miran Reading

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO. BH-KK

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 1 of 2
Client: Wainwright Industries, Inc.		Drilling Agency· Brotcke Engineering	
Size and Type of Bit: 7' 7/8 O.D		Location (Coordinates or Station) Wainwright Property	
Direction and Inclination of Hole. Vertical		Soil Sampling Footage. 35'	Coring Footage. 0'	Total Depth. 35'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 4 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 6/22/92 Date Completed 6/22/92	Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks +
0* 5		Gray clay w/dark brown mottling	1 BH-KK-1 at 5 ft.	95%		No odor No detection
10		Brown stiff slightly plastic clay w/gray mottling and black iron stains	2	100%		No odor No detection
15		Gray very stiff plastic clay w/black and red iron staining	3 BH-KK-2 at 15 ft.	100%		No odor No detection
20		Same as above w/very heavy iron staining	4	100%		No odor No detection
25		Gray clay w/chert gravel and interbedded sand layer Lower 1 ft. clean white sand	5 BH-KK-3 at 25 ft.	50%		No odor No detection

*MicroTip Photoionization Detector Reading
+Miran Reading

SCHREIBER GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO. BH-KK

Project: Wainwright Industries, Inc.		Job No WAIN 07	Sheet 2 of 2	
Client: Wainwright Industries, Inc.		Drilling Agency Brotcke Engineering		
Size and Type of Bit: 7' 7/8 O.D		Location (Coordinates or Station) Wainwright Property		
Direction and Inclination of Hole Vertical		Soil Sampling Footage. 35'	Coring Footage. 0'	Total Depth. 35'
Elevation. N/A	Mfr Designation of Drill CME 550	Number Of Soil Samples 4 Penetration Tubes		
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 6/22/92 Date Completed. 6/22/92		Inspector(s) Terry Miner

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC / % RQD	Box Number	Remarks +
30		Gravel w/interbedded clay layers Clean white sand w/gravel poorly sorted.	6	30%		No odor No detection
35		Fine white sand and small chert gravel grading to black chert gravel	7 BH-KK-4 at 35 ft.	15%		No odor No detection

*MicroTip Photoionization Detector Reading
+Miran Reading

SCHREIBER, GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-LL

Project. Wainwright Industries, Inc	Job No WAIN 07	Sheet 1 of 1	
Client. Wainwright Industries, Inc.	Drilling Agency Riedel Environmental Services		
Size and Type of Bit. 2" Carbide	Location (Coordinates or Station) BH-LL		
Direction and Inclination of Hole. Vertical	Soil Sampling Footage 20'	Coring Footage 0	Total Depth. 20'
Elevation. N/A	Mfr Designation of Drill Dig-R-Mobile	Number Of Soil Samples 5 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 08/21/92 Date Completed. 08/21/92	Inspector(s) Doug Abeln Joe Darmody

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
5		Topsoil 0"-12" Dry brown, silty crumbly clay	1 BH-LL1 @ 6"-12" BH-LL2 @ 5 ft.			Headspace PID = 0 0 ppm Headspace PID = 66 0 ppm Sample PID = 0 0 ppm
10		Slightly moist, grayish brown silty clay	2 BH-LL3 @ 10 ft			Headspace PID = 53 3 ppm Sample PID = 0 0 ppm
15		Slightly moist, brown, silty clay	3 BH-LL4 @ 15 ft			
20		Brownish gray, silty, sandy clay - mixed with small gravel	4 BH-LL5 @ 20 ft.			Headspace PID = 48 0 ppm Sample PID = 0 0 ppm

*MicroTip Photoionization Detector Reading

SCHREIBER, GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
LOUIS, MISSOURI 63108

BORING NO BH-MM

Project. Wainwright Industries, Inc	Job No WAIN 07	Sheet 1 of 1	
Client: Wainwright Industries, Inc	Drilling Agency Riedel Environmental Services		
Size and Type of Bit: 2" Carbide	Location (Coordinates or Station) BH-MM		
Direction and Inclination of Hole Vertical	Soil Sampling Footage 20'	Coring Footage 0	Total Depth 20'
Elevation N/A	Mfr Designation of Drill Dig-R-Mobile	Number Of Soil Samples 5 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started. 08/20/92 Date Completed 08/20/92	Inspector(s) Doug Abeln Joe Darmody

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
5		Topsoil 0"-12" Firm, dry, brown, crumbly clay	1 BH-MM1 @ 6"-12" BH-MM2 @ 5 ft			Headspace PID = 1 6 ppm Sample PID = 0 0 ppm Headspace PID = 5 0 ppm Sample PID = 0 5 ppm
10		Very stiff brown clay – little moisture, (no odor)	2 BH-MM3 @ 10 ft			Headspace PID = 9 1 ppm Sample PID = 0 0 ppm
15		Brown, tight, moist clay – gray mottling	3 BH-MM4 @ 15 ft			Headspace PID = 20 1 ppm Sample PID = 2 7 ppm
20		Brownish gray silty clay	4 BH-MM5 @ 20 ft.			Headspace PID = 20 2 ppm Sample PID = 0 8 ppm

*MicroTip Photoionization Detector Reading

SCHREIBER, GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-NN

Project. Wainwright Industries, Inc	Job No WAIN 07	Sheet 1 of 1	
Client. Wainwright Industries, Inc	Drilling Agency Riedel Environmental Services		
Size and Type of Bit. 2" Carbide	Location (Coordinates or Station) BH-NN		
Direction and Inclination of Hole. Vertical	Soil Sampling Footage 20'	Coring Footage 0	Total Depth 20'
Elevation. N/A	Mfr Designation of Drill Dig-R-Mobile	Number Of Soil Samples 5 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started 08/20/92 Date Completed 08/20/92	Inspector(s) Doug Abeln Joe Darmody

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
		Topsoil 0"-12" Dry brown, crumbly silty clay -- some dark brown mottling	1 BH-NN1 @ 6"-12"			Headspace PID = 1 6 ppm Sample PID = 0 0 ppm
5			BH-NN2 @ 5 ft			Headspace PID = 11 7 ppm Sample PID = 4 0 ppm
10		Dry brown, firm, silty clay -- with black and gray mottling	2 BH-NN3 @ 10 ft			Headspace PID = 23 3 ppm Sample PID = 40 2 ppm
15		Slightly moist, grayish brown, silty clay, (possible slight odor)	3 BH-NN4 @ 15 ft			Headspace PID = 108 ppm Sample PID 27 4 ppm
20		Fairly moist, gray, silty clay -- some blackish red mottling (no odor)	4 BH-NN5 @ 20 ft			Headspace PID = 77 0 ppm Sample PID 256 ppm

*MicroTip Photoionization Detector Reading

SCHREIBER, GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-OO

roject. Wainwright Industries, Inc	Job No WAIN 07	Sheet 1 of 1
Client Wainwright Industries, Inc	Drilling Agency Riedel Environmental Services	
Size and Type of Bit. 2" Carbide	Location (Coordinates or Station) BH-OO	

Direction and Inclination of Hole Vertical		Soil Sampling Footage 23 5'	Coring Footage 0	Total Depth 23 5'
Elevation N/A	Mfr Designation of Drill Dig-R-Mobile	Number Of Soil Samples 5 Penetration Tubes		
Depth to water N/A	No Of Cores Boxes N/A	Date Started 08/20/92 Date Completed 08/20/92		Inspector(s) Doug Abeln Joe Darmody

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
5		Loose brown topsoil 0"-12" Loose, gray, silty clay -- changing to a firmer brown silty clay, moist	1 BH-OO1 @ 6"-12" BH-OO2 @ 5 ft			Headspace PID = 1 3 ppm Headspace PID = 5 0 ppm Sample PID = 0 0 ppm
10		Similar brown clay -- very firm, fairly dry -- some mottling	2 BH-OO3 @ 10 ft			Headspace PID = 18 2 ppm Sample PID 0 2 ppm
15		Moist, grayish, brown mottled clay -- stiff and some moisture	3 BH-OO4 @ 15 ft			Headspace PID = 17 4 ppm Sample PID = 6 6 ppm
20		Grayish, brown clay	4			
23 5		Brown clay mixed with sand and gravel-- loose	5 BH-OO5 @ 23 5 ft			Sample PID = 0 5 ppm

*MicroTip Photoionization Detector Reading

SCHREIBER, GRANA & YONLEY, INC.
22 NORTH EUCLID AVENUE
ST. LOUIS, MISSOURI 63108

BORING NO BH-PP

Project. Wainwright Industries, Inc		Job No WAIN 07	Sheet 1 of 1
Client. Wainwright Industries, Inc		Drilling Agency Riedel Environmental Services	
Size and Type of Bit 2" Carbide		Location (Coordinates or Station) BH-PP	
Direction and Inclination of Hole Vertical		Soil Sampling Footage 20'	Coring Footage 0
Elevation N/A	Mfr Designation of Drill Dig-R-Mobile	Number Of Soil Samples 5 Penetration Tubes	
Depth to water N/A	No Of Cores Boxes N/A	Date Started 08/21/92 Date Completed 08/21/92	Inspector(s) Doug Abeln/Joe Darmody

Total Depth 20'

Depth in Feet	Graphic Log	Classification of Materials (Description)	Sample Or Run Number	% REC % RQD	Box Number	Remarks *
5		Topsoil 0"-12" Dry brown, crumbly, silty, clay with white mottling	1 BH-PP1 @ 6"-12" BH-PP2 @ 5 ft			Headspace PID = 0 0 ppm Sample PID = 0 0 ppm Headspace PID = 18 0 ppm Sample PID = 6 8 ppm
10		Somewhat moist brown clay – fairly stiff	2 BH-PP3 @ 10 ft			Headspace PID = 21 5 ppm Sample PID = 24 4 ppm
15		Fairly moist brown silty clay – changing to a moist, pliable gray silty clay	3 BH-PP4 @ 15 ft			Headspace PID = 41 2 ppm Sample PID = 28 6 ppm
20		Brownish silty, stiff clay changing to a grayish pliable silty clay – changing to a somewhat coarse sand/silty clay mixture	4 BH-PP5 @ 20 ft			Headspace PID = 71 3 ppm Sample PID = 10 9 ppm

*MicroTip Photoionization Detector Reading

APPENDIX B

LABORATORY RESULTS AND CHAIN-OF-CUSTODY FORMS

The analytical results for the groundwater samples and the soil samples collected during this investigation have been previously submitted to MDNR in the monthly progress reports

APPENDIX C

ACCESS AGREEMENTS

LAW OFFICES
FRANK L PELLEGRINI
A PROFESSIONAL CORPORATION
SUITE 400
CHOUTEAU CENTER
133 SOUTH ELEVENTH STREET
ST LOUIS MISSOURI 63102
TELEPHONE (314) 241-7445
FAX (314) 241-7449

FRANK L. PELLEGRINI
JULIE A. EMMERICH

KIM ROGER LUTHER P C
OF COUNSEL

August 18, 1992

Anne and Bennett Netzer
314 Third Street
Valley Park, Missouri 63088

Re: Access Agreement

Dear Mr. & Mrs. Netzer:

Enclosed for your record is a fully executed copy of the Access Agreement. As I stated during our meeting, please do not hesitate to contact me for any reason if you have any questions regarding the terms of the Access Agreement or any work to be conducted on the property. We will do our best to conduct all work as smoothly as possible.

Sincerely yours,

Julie A. Emmerich

JAE/gf
Enc.

ACCESS AGREEMENT

This Agreement is made as of the 18th day of Agst, 1992 between Wainwright Industries, Inc., its successors and assigns (Wainwright), a Missouri corporation, and Anne and Bennett Netzer, property owners, their successors and assigns.

Whereas, Wainwright represents that pursuant to the provisions of the Missouri Hazardous Waste Management Law, §260.350, RSMo et seq., the Missouri Department of Natural Resources (MDNR) and Wainwright entered into an Administrative Order on Consent (AOC) on May 22, 1991 to conduct a Remedial Investigation/Feasibility Study for purposes of determining the nature and extent of releases of hazardous substances on a certain site described in the AOC;

Whereas, the work to be conducted under the AOC is specified in detail in the Remedial Investigation/Feasibility Study Work Plan ("RI/FS Work Plan"), which includes a sampling and analysis plan and might require modification to meet the requirements of the AOC, and;

Whereas, in order to implement its RI/FS Work Plan, Wainwright seeks access to the property owned by Anne and Bennett Netzer, located at 314 Third Street, Valley Park, Missouri, for itself and its authorized representatives, for MDNR, its authorized contractors and oversight officials, and for the U.S. Environmental Protection Agency (USEPA) and its contractors and desires to grant such access subject to the terms and conditions set forth below.

Therefore, for the purposes set forth above, and in consideration of mutual promises herein contained, Anne and Bennett Netzer and Wainwright agree as follows:

1. Anne and Bennett Netzer hereby grant Wainwright, its authorized representatives, MDNR, its contractors and oversight officials, and USEPA and its contractors, a license to enter upon and use the Operational Area of the 314 Third Street, Valley Park, Missouri property as described in paragraph 6, below, subject to the terms and conditions set forth herein.

2. The persons identified in paragraph 1, above, may enter upon the Operational Area of the 314 Third Street, Valley Park, Missouri property solely for fulfillment of investigative activities necessitated by the AOC referenced herein, as set forth in greater detail in the RI/FS Work Plan. The parties agree that such activities do not include remediation of the Operational Area.

3. This Agreement shall continue in effect for such period of time as the performance of the work described herein or the MDNR may require, but not more than twenty-four (24) months from the date of this Agreement unless extended by mutual agreement of parties hereto.

4. Under the license granted herein, the persons identified in paragraph 1, above, may bring such equipment and vehicles onto the 314 Third Street, Valley Park, Missouri property as are reasonably necessary for the performance of the activities described in paragraph 2, above. Wainwright and its

representatives shall use due care in all activities conducted on the 314 Third Street, Valley Park, Missouri property.

5. It is acknowledged by the parties that Wainwright is not a representative of MDNR for any purposes, and that MDNR is not a representative of Wainwright for any purposes.

6. For purposes of the work described herein, the parties agree that the term, "Operational Area" means that portion of the 314 Third Street, Valley Park, Missouri property necessary for Wainwright to enter or traverse for purposes of evaluating the presence of any constituents of interest.

7. Wainwright shall comply with and obtain at its own expense all the registrations, licenses or permits required by all federal, state and local laws, regulatory authorities or commissions in connection with the work by Wainwright required under this Agreement, which are not exempted by federal or state statute.

8. This Agreement shall be governed by and construed in accordance with the laws of the State of Missouri.

9. Except as specifically referenced herein, this Agreement contains the entire agreement between the parties and supersedes and replaces all prior agreements and understandings with respect to the subject matter hereof. No representatives or warranties are made or have been relied upon by either party other than those expressly set forth herein.

10. No agent, employee or other representative of either party is empowered to alter or amend any of the terms of this Agreement, unless such alteration and/or amendment is in writing

and has been signed by an authorized representative of both parties. This provision cannot be orally waived.

11. This Agreement is not an admission of liability or fault by either party for any activities or conditions in the Operational Area or the area covered under the terms of the AOC. This Agreement shall not in any way indicate any assumption of responsibility by Anne and Bennett Netzer or Wainwright of any actions by personnel for the other party pursuant to this Agreement. Nothing in this Agreement shall be construed as an agreement to remediate said conditions.

12. Wainwright and its authorized representatives shall use due care in conducting all activities on the property of Anne and Bennett Netzer which relate to the Operable Unit RI/FS, and will take the necessary action to restore, if necessary, the property to the condition as it existed prior to the activities pursuant to this Agreement.

13. Anything to the contrary notwithstanding, the terms and conditions of this Agreement, and the rights and obligations created as a result thereof, shall be binding upon and/or inure to the benefit of the parties hereto, their officers, directors, agents, employees, their respective successors, assigns, designees and contractors.

IN WITNESS WHEREOF, the parties have executed this Agreement on the date first written above.

ATTEST

(PROPERTY OWNER)

By: Anne B. Netzer
Anne Netzer

Bennett Netzer
Bennett Netzer

314 3rd St
Address

WAINWRIGHT INDUSTRIES, INC.

By:

for Frank C. Pellegrini PC.

LAW OFFICES
FRANK L. PELLEGRINI
A PROFESSIONAL CORPORATION
SUITE 400
CHOUTEAU CENTER
133 SOUTH ELEVENTH STREET
ST. LOUIS MISSOURI 63102
TELEPHONE (314) 241-7445
FAX (314) 241-7449

FRANK L. PELLEGRINI
JULIE A. EMMERICH

KIM ROGER LUTHER P C
OF COUNSEL

August 18, 1992

Jack and Mary Cotton
328 Jefferson Street
Valley Park, Missouri 63088

Re: Access Agreement

Dear Mr. & Mrs. Cotton:

Enclosed for your record is a fully executed copy of the Access Agreement. As I stated during our meeting, please do not hesitate to contact me for any reason if you have any questions regarding the terms of the Access Agreement or any work to be conducted on the property. We will do our best to conduct all work as smoothly as possible.

Sincerely yours,

Julie A. Emmerich

JAE/gf
Enc.

ACCESS AGREEMENT

This Agreement is made as of the 18th day of August, 1992 between Wainwright Industries, Inc., its successors and assigns (Wainwright), a Missouri corporation, and Jack and Mary Cotton, property owners, their successors and assigns.

Whereas, Wainwright represents that pursuant to the provisions of the Missouri Hazardous Waste Management Law, §260.350, RSMo et seq., the Missouri Department of Natural Resources (MDNR) and Wainwright entered into an Administrative Order on Consent (AOC) on May 22, 1991 to conduct a Remedial Investigation/Feasibility Study for purposes of determining the nature and extent of releases of hazardous substances on a certain site described in the AOC;

Whereas, the work to be conducted under the AOC is specified in detail in the Remedial Investigation/Feasibility Study Work Plan ("RI/FS Work Plan"), which includes a sampling and analysis plan and might require modification to meet the requirements of the AOC, and;

Whereas, in order to implement its RI/FS Work Plan, Wainwright seeks access to the property owned by Jack and Mary Cotton, located at 318 Third Street, Valley Park, Missouri, for itself and its authorized representatives, for MDNR, its authorized contractors and oversight officials, and for the U.S. Environmental Protection Agency (USEPA) and its contractors and desires to grant such access subject to the terms and conditions set forth below.

Therefore, for the purposes set forth above, and in consideration of mutual promises herein contained, Jack and Mary Cotton and Wainwright agree as follows:

1. Jack and Mary Cotton hereby grant Wainwright, its authorized representatives, MDNR, its contractors and oversight officials, and USEPA and its contractors, a license to enter upon and use the Operational Area of the 318 Third Street, Valley Park, Missouri property as described in paragraph 6, below, subject to the terms and conditions set forth herein.

2. The persons identified in paragraph 1, above, may enter upon the Operational Area of the 318 Third Street, Valley Park, Missouri property solely for fulfillment of investigative activities necessitated by the AOC referenced herein, as set forth in greater detail in the RI/FS Work Plan. The parties agree that such activities do not include remediation of the Operational Area during the time of the investigation.

3. This Agreement shall continue in effect for a period of sixty (60) days from its execution by the parties. After the sixty day period has expired, the Agreement shall be automatically extended for consecutive thirty (30) day periods until either party notifies the other in writing that that party is terminating the Agreement.

4. Under the license granted herein, the persons identified in paragraph 1, above, may bring such equipment and vehicles onto the 318 Third Street, Valley Park, Missouri property as are reasonably necessary for the performance of the activities

described in paragraph 2, above. Wainwright and its representatives shall use due care in all activities conducted on the 318 Third Street, Valley Park, Missouri property.

5. It is acknowledged by the parties that Wainwright is not a representative of MDNR for any purposes, and that MDNR is not a representative of Wainwright for any purposes.

6. For purposes of the work described herein, the parties agree that the term, "Operational Area" means that portion of the 318 Third Street, Valley Park, Missouri property necessary for Wainwright to enter or traverse for purposes of evaluating the presence of any constituents of interest.

7. Wainwright shall comply with and obtain at its own expense all the registrations, licenses or permits required by all federal, state and local laws, regulatory authorities or commissions in connection with the work by Wainwright required under this Agreement, which are not exempted by federal or state statute.

8. This Agreement shall be governed by and construed in accordance with the laws of the State of Missouri.

9. Except as specifically referenced herein, this Agreement contains the entire agreement between the parties and supersedes and replaces all prior agreements and understandings with respect to the subject matter hereof. No representatives or warranties are made or have been relied upon by either party other than those expressly set forth herein.

10. No agent, employee or other representative of either party is empowered to alter or amend any of the terms of this

Agreement, unless such alteration and/or amendment is in writing and has been signed by an authorized representative of both parties. This provision cannot be orally waived.

11. This Agreement is not an admission of liability or fault by either party for any activities or conditions in the Operational Area or the area covered under the terms of the AOC. This Agreement shall not in any way indicate any assumption of responsibility by Jack and Mary Cotton or Wainwright of any actions by personnel for the other party pursuant to this Agreement. Nothing in this Agreement shall be construed as an agreement to remediate said conditions.

12. Wainwright and its authorized representatives shall use due care in conducting all activities on the property of Jack and Mary Cotton which relate to the Operable Unit RI/FS, and will take the necessary action to restore, as soon as is feasible, the property to the condition as it existed prior to the activities pursuant to this Agreement.

13. Anything to the contrary notwithstanding, the terms and conditions of this Agreement, and the rights and obligations created as a result thereof, shall be binding upon and/or inure to the benefit of the parties hereto, their officers, directors, agents, employees, their respective successors, assigns, designees and contractors.

IN WITNESS WHEREOF, the parties have executed this Agreement on the date first written above.

ATTEST

(PROPERTY OWNER)

By: Mary Cotton
Mary Cotton

Jack C Cotton
Jack Cotton

328 JEFFERSON AVE
Address

WAINWRIGHT INDUSTRIES, INC.

By:

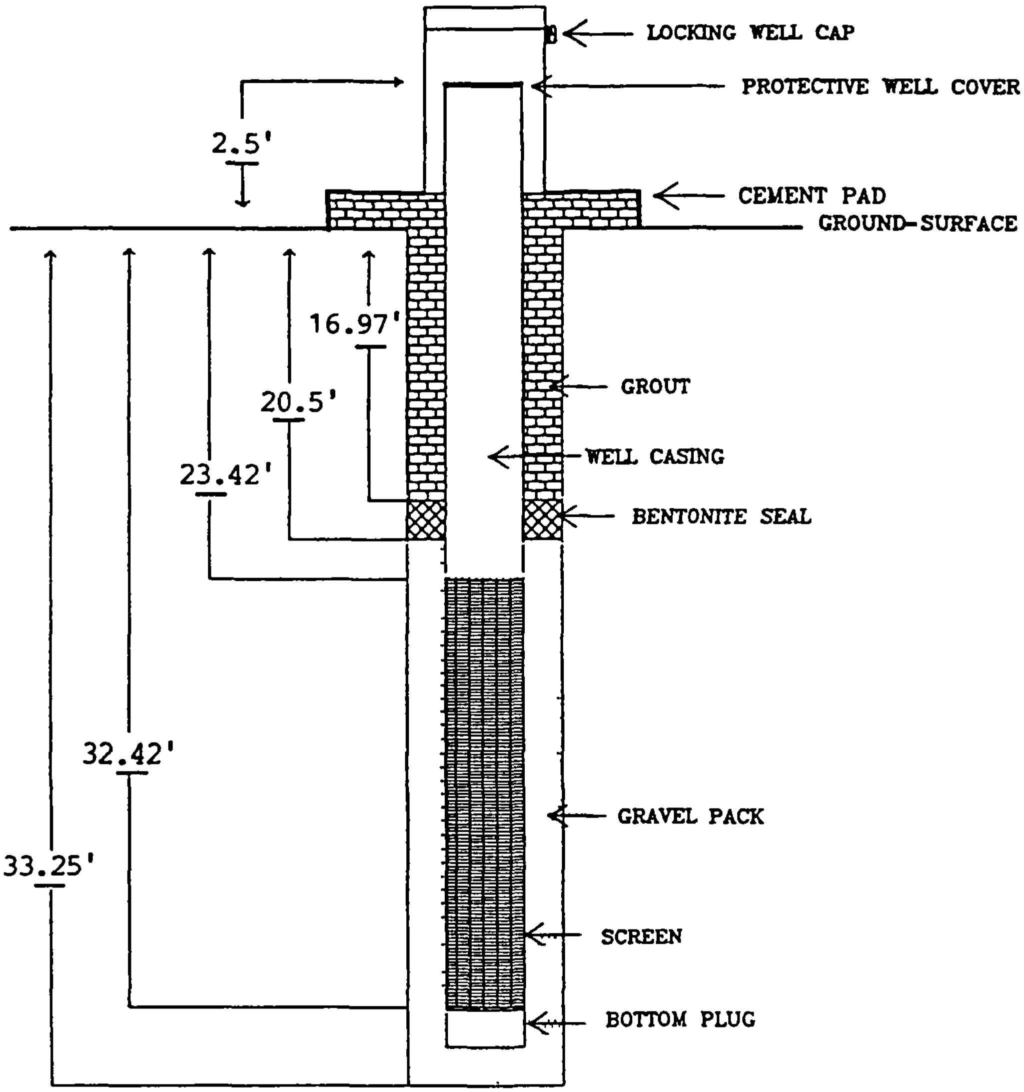
for Frank L. Pellegrini P.C.

APPENDIX D

WELL COMPLETION DIAGRAMS

SCHREIBER GRANA & YONLEY, INC
WELL COMPLETION FORM

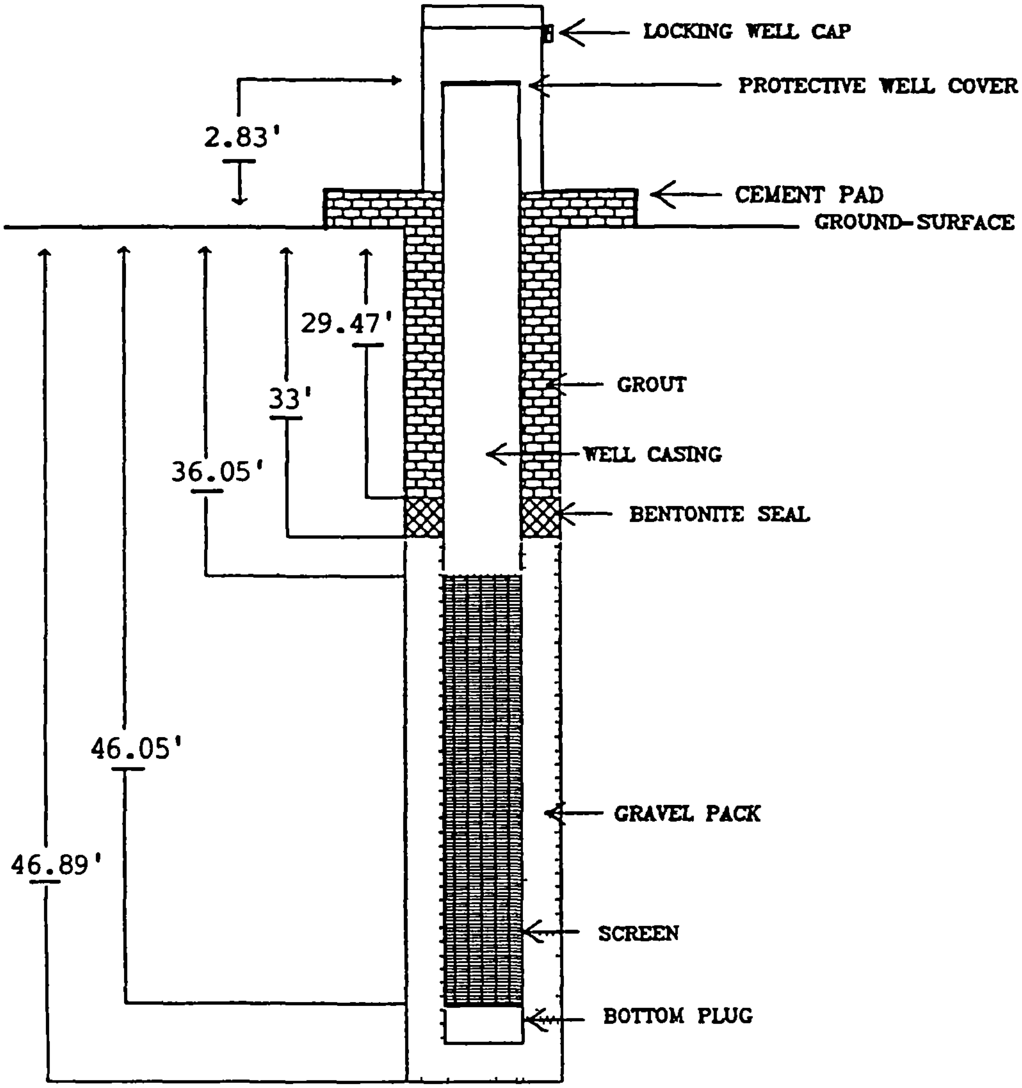
PROJECT Wainwright Industries, Inc.		**CONTRACTORS** Brotcke Engineering	
ADDRESS 224 Benton Ave., Valley Park, MO		**PROJECT MANAGER** Doug Abeln	
SG&Y PROJECT # WAIN07		**DATE INSTALLED** 4/14/92	
BORING # MW-AA-B		**ELEVATION - SURFACE**	**CASING**
CASING LENGTH 24.92'	**DIAMETER** 2"	**SCREEN LENGTH** 9'	**DIAMETER** 2"
CASING MATERIAL PVC		**SCREEN MATERIAL** PVC	
JOINT TYPE Threaded		**SCREEN TYPE** Slotted	**SIZE** .01
FILTER PACK TYPE Sand	**SIZE** WB-40	**BENTONITE SEAL THICKNESS** 3.53' 9-gal. of slurry	
WATER LEVEL BEFORE	**AFTER DEVELOPMENT**	**DEVELOPMENT METHOD** 2" Redi-flow pump	



LOCATION Wainwright Industries, Inc.

SCHREIBER GRANA & YONLEY, INC
WELL COMPLETION FORM

PROJECT Wainwright Industries, Inc.	CONTRACTORS Brotcke Engineering
ADDRESS 224 Benton Ave., Valley Park, MO	PROJECT MANAGER Doug Abeln
SG&Y PROJECT # WAIN07	DATE INSTALLED 4/13/92
BORING # MW-AA-C	ELEVATION – SURFACE CASING
CASING LENGTH 38.88' DIAMETER 2"	SCREEN LENGTH 9' DIAMETER 2"
CASING MATERIAL PVC	SCREEN MATERIAL PVC
JOINT TYPE Threaded	SCREEN TYPE Slotted SIZE .01
FILTER PACK TYPE Sand SIZE WB-40	BENTONITE SEAL THICKNESS 3.53' 9-gal. of slurry
WATER LEVEL BEFORE AFTER DEVELOPMENT	DEVELOPMENT METHOD 2" Redi-flow pump



LOCATION Wainwright Industries, Inc.

APPENDIX E

MATERIAL SAFETY DATA SHEETS

No. 313

PERCHLOROETHYLENE

Revision C

Date November 1978

MATERIAL SAFETY DATA SHEET

GENIUM PUBLISHING CORPORATION
P O BOX 1436, SCHENECTADY, NY 12301 USA
(518) 385-2577

GENIUM PUBLISHING CORP

SECTION I. MATERIAL IDENTIFICATION

MATERIAL NAME PERCHLOROETHYLENE

OTHER DESIGNATIONS. Perchlorethylene, Tetrachloroethylene, Ethylene Tetrachloride, $Cl_2C=CCl_2$, GE Material D5B84, CAS# 000 127 184

MANUFACTURER & TRADENAME BLACO-PER (Baron-Blakeslee), PERCHLOR (PPG), PERK (Stauffer), PERCLENE (Diamond Shamrock)

SECTION II. INGREDIENTS AND HAZARDS

SECTION II. INGREDIENTS AND HAZARDS	%	HAZARD DATA
Perchloroethylene plus stabilizer* ----------------------	ca 100	8-hr TWA 100 ppm** with 200 ppm Ceiling and 300 ppm 5 minute peak in any 3 hrs Rat, inhalation LCLo 4000 ppm/4 hrs
*Stablized material usually contains a small amount of amine and/or phenolic stabilizer. Stabilizers and levels used vary with the grade and the supplier **Current OSHA levels ACGIH TLV (1978) is 100 ppm (skin) In 1976 NIOSH proposed a 10-hr TWA of 50 ppm with a 100 ppm ceiling (15 minute sample) NIOSH (1978) has warned of possible carcogenicity based on animal tests		

SECTION III. PHYSICAL DATA

Boiling point, 1 atm, deg F (C) ----	250 (121)	Specific gravity 20/4°C ---	1 623
Vapor pressure at 22 C, mm Hg ------	15 8	Volatiles, % ------------	ca 100
Vapor density (Air=1) -------------	5 83	Evaporation rate (CCl_4=1) -	0 27
Water solubility -----------------	Negligible	Molecular weight ---------	165 83

Appearance & Odor Colorless liquid with pleasant etheral odor whose recognition threshold (100% of test panel, unfatigued) is 4 68 ppm in air

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp	Flammability Limits In Air	LOWER	UPPER
Not Combustible	None	N/A	N/A	N/A

Extinguishing Media. Use that which is suitable for the surrounding fire Although not combustible, perchloroethylene can be hazardous in a fire situation because of vapor generation and from thermo-oxidative degradation at high temperature to phosgene (highly toxic) and hydrogen chloride (corrosive)

Firefighters should use self-contained breathing apparatus when this material is involved in a fire situation.

SECTION V. REACTIVITY DATA

Perchloroethylene is considered a stable compound under normal storage and handling conditions However, vapor exposure to high temperature or electric arcs may cause decomposition to hydrogen chloride and phosgene (highly toxic)

Avoid mixing with caustic soda or potash. Do not allow hydrochloric acid build-up to occur in degreasing tanks (stabilizer exhausted)

Prolonged exposure to sunlight (UV) can degrade unstabilized material.

No. 313

SECTION VI. HEALTH HAZARD INFORMATION

TLV 100 ppm (skin) (See Sect II)

Perchloroethylene may cause dermatitis through prolonged or repeated skin contact with liquid and irritation, lachrymation, and burning sensation of the eyes by liquid or vapor contact Loss of coordination, narcosis, tremors, abdominal cramps, irritation of the respiratory tract, and nausea may result from inhalation of excessive airborne concentrations (600 ppm for 10 minutes may effect the central nervous system) Very high exposures produce unconsciousness and even death

FIRST AID

Eye contact Wash eyes with copious amounts of running water to relieve irritation

Skin contact Remove contaminated clothes. Wash exposed skin with soap and water

Inhalation Remove patient to fresh air, restore breathing if necessary Promptly contact physician Advise doctor not to administer adrenalin.

Ingestion If taken internally, induce vomiting Contact physician promptly; Advise doctor not to administer adrenalin

SECTION VII. SPILL, LEAK, AND DISPOSAL PROCEDURES

Supply maximum ventilation Confine spill to small area, do not allow run off into sewer Those involved in clean-up need protection from liquid contact and vapor inhalation Pick up spill on absorbent solid.

DISPOSAL Place in covered container for disposal Chlorinated solvents in large amounts should be burned in an approved incinerator with appropriate fume scrubbing Also, consult licensed waste disposal company in your locality and consider recovery of perchloroethylene solvent by distillation Scrap solvent and distillation residues must be handled as toxic waste Follow Federal, State and local regulations for waste disposal

SECTION VIII. SPECIAL PROTECTION INFORMATION

Airborne levels should be kept below TLV levels by use of general ventilation and local exhaust ventilation. Provide floor level ventilation to remove these vapors.

For emergency and non-routine exposure above the TLV approved full facepiece respirators should be used - cartridge and canister types up to 500 ppm, and air-supplied or self-contained types above 500 ppm

Neoprene, Viton, PVA or PVC coated gloves should be used to prevent skin exposure Where splashing is possible, aprons and protective clothing may be indicated Appropriate eye and face protection should be used Where eye contamination is possible, an eye wash fountain should be readily available.

SECTION IX. SPECIAL PRECAUTIONS AND COMMENTS

Store in a cool, dry, well-ventilated place in closed containers away from fire hazards High temperature (700°C) or intense UV light can decompose perchloroethylene to toxic and corrosive materials Smoking, open flame, welding, etc. should not be permitted in area of use or storage.

It is recommended that workers with blood pressure, heart, liver, kidney or pulmonary problems, with nervous system disorders, with excessive obesity, or with alcohol consumption problems should not work in proximity to this or other chlorinated solvents

One study has indicated possible teratogenic effects NIOSH has recommended that this material be handled as if it were a human carcinogen. (Current Intelligence Bulletin No 20, 1978)

DATA SOURCE(S) CODE: 1-9, 12, 21

APPROVALS: MIS, CRD	
Industrial Hygiene and Safety	
Corporate Medical Staff	

GENIUM PUBLISHING

MATERIAL SAFETY DATA SHEET

(APPROVED BY THE U S. DEPARTMENT OF LABOR AS - 'essentially similar' to form OSHA 20)

Information on this form is furnished solely for the purpose of compliance with the Occupational Safety and Health Act of 1970 and shall not be used for any other purpose. Use or dissemination of all or any part of this information for any other purpose may result in a violation of law or constitute grounds for legal action

Section 1 NAME & PRODUCT

MANUFACTURER'S NAME	CITY STATE ZIP CODE	EMERGENCY PHONE NO 24 HO
DOW CHEMICAL U.S A	MIDLAND MICHIGAN 48640	517 - 636 - 4400

DATE THIS FORM WRITTEN: January 3, 1974

PREPARED BY (Signature): C. E. Kassinel

TRADE NAME: DOWPER® Solvent

SYNONYMS:

Section 2 INGREDIENTS

	%	TL
Perchloroethylene (minimum) (Not a specification value)	99	10

Section 3 PHYSICAL DATA

BOILING POINT (°F)	250 (121.1°C)	SOLUBILITY IN WATER 25°C	0 015 gm/100 g
VAPOR PRESSURE (mmHg at 20°c)	13	SPECIFIC GRAVITY (H₂O = 1)	1 619 @ 25/25°C
VAPOR DENSITY (air = 1)	5 76	% VOLATILE BY VOLUME	100 (Essentially

APPEARANCE: Colorless Liquid

Section 4 FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (AND METHOD USED): None °F T O C . T C C C O C

FLAMMABLE LIMITS (STP IN AIR): LFL None UFL None

EXTINGUISHING MEDIA: ☐ WATER FOG ☐ FOAM ☐ ALCOHOL FOAM ☐ CO_2 ☐ DRY CHEMICAL ☐ OTHER Non-flammable

SPECIAL FIRE FIGHTING PROTECTION EQUIPMENT AND HAZARDS: Self-contained respiratory equipment.

Section 5 REACTIVITY DATA

STABILITY (NORMAL CONDITIONS): X STABLE ☐ UNSTABLE

CONDITIONS TO AVOID: Open flames, welding arcs or other high temperature sourc which induce thermal decomposition

INCOMPATIBILITY — MATERIALS TO AVOID: ☐ WATER ☐ ACID ☐ BASE ☐ CORROSIVE ☐ OXIDIZING MATERIAL

OTHER ☐

HAZARDOUS DECOMPOSITION PRODUCTS: Open flames and welding arcs can cause thermal degrac tion with the evolution of hydrogen chloride and very small amounts of phosgene and chlorin

HAZARDOUS POLYMERIZATION: ☐ MAY OCCUR X WILL NOT OCCUR

CONDITIONS TO AVOID:

Section 6 SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Use respiratory protection described i Section 8. Small leaks: Get ventilation to area first Throw rags on spi Place rags in tumbler to reclaim solvent Large spills: Evacuate area. G ventilation to area. Contain liquid, transfer to closed metal containers Keep out of water suppl

DISPOSAL METHOD: Send solvent to reclaimer. In some cases it can be transported to an area where it can be placed on the ground and allowed to evaporate safely Refer to Chemical Safety Data Sheet SD-24, Manufacturing Chemists Association, 1825 Connecticut Avenue, Washington, D C. 20009.

DOWPER® Solvent

MATERIAL SAFETY DATA SHEET (CONT)

DOW CHEMICAL U S A
MIDLAND MICHIGAN 486-0

Section 7 HEALTH HAZARD DATA

ot likely to be a hazard. LD_{50} for mice greater than 8000 mg/kg. Estimating rom these data, the lethal dose for a 150 pound person is estimated to be in the range of half a pint

EYE CONTACT

Pain and irritation, but no corneal injury should occur.

SKIN CONTACT

Short contact - no irritation. Prolonged or frequently repeated contact - irritation. If confined to skin - pain and irritation, even a burn.

SKIN ABSORPTION

Very low. . Not considered to be a hazard

INHALATION

TLV 100 (1972) Odor threshold - 50 ppm. Unacclimated; 200 ppm acclimated

EFFECTS OF OVEREXPOSURE May lead to dizziness, drunkenness, unconsciousness, even death. Possible organic injury

AID PROCEDURES		
EYE FLUSH WITH FLOWING WATER AT LEAST ___ MINUTES	EYES AND SKIN: Flush with plenty of water and get medical attention if irritation or injury occurs. INHALATION. If illness occurs, remove patient to fresh air, keep warm and quiet and get medical attention. If breathing stops, start artificial respiration INGESTION Do not induce vomiting. Call a physician immediately * CAUTION With some solvents, drinking alcohol before, during or after exposure may cause undesirable effects.	NEVER GIVE FLUIDS OR INDUCE VOMITING IF PATIENT IS UNCONSCIOUS OR HAVING CONVULSIONS

Section 8 SPECIAL PROTECTION INFORMATION

VENTILATION

Limit concentration in air to TLV - Mechanical ventilation is normally needed

RESPIRATORY PROTECTION (specify type) Up to 100 ppm - none. Respiratory protection required in the absence of environmental control For levels up to 2% for ½ hour or less a suitable full face mask with organic canister should be used. Above 2 % and for emergencies, use a self-contained breathing apparatus.

PROTECTIVE CLOTHING

No special protective clothing needed For repeated skin contact, solvent resistant gloves shall be worn.

EYE PROTECTION ☐ NOT NORMALLY NECESSARY ☒ SAFETY GLASSES WITHOUT SIDE SHIELDS ☐ SAFETY GLASSES WITH SIDE SHIELDS ☐ CHEMICAL WORKERS GOGGLES

☐ GAS TIGHT GOGGLES OR EQUIVALENT ☒ OTHER Eye wash stations and safety showers should be readily available

Section 9 SPECIAL PRECAUTIONS OR OTHER COMMENTS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING

Handle with reasonable care and caution. Avoid breathing vapors

NOTE TO PHYSICIAN: Overexposure to many of the chlorinated solvents, especially if accompanied by anoxia, may temporarily increase cardiac irritability. Main ain adequate oxygenation until recovery. Avoid sympatomimetic amines, such as_epinephrine, which may precipitate arrhythmias

Material Safety Data Sheet

From Genium's Reference Collection
Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8855

GENIUM PUBLISHING CORP

No 312
TRICHLOROETHYLENE
(Revision E)

Issued July 1979
Revised August 1987

SECTION 1. MATERIAL IDENTIFICATION

23

MATERIAL NAME TRICHLOROETHYLENE

DESCRIPTION (Origin/Uses) Prepared from *sym*-tetrachloroethane by way of eliminating HCl by boiling with lime Used to manufacture organic chemicals, pharmaceuticals, in degreasing and dry cleaning, and as a solvent for fats, waxes, rubbers, oils, paints, varnishes, ethers, and cellulose esters

OTHER DESIGNATIONS Ethylene Trichloride, TCE, Trichloroethene, 1,1,2-Trichloroethylene, C_2HCl_3 NIOSH *RTECS* #KX4550000, CAS #0079-01-6

MANUFACTURER/SUPPLIER Available from several suppliers, including Dow Chemical USA, 2020 Dow Center, Midland, MI 48640, Telephone (517) 636-1000, (800) 258-CHEM

COMMENTS Trichloroethylene is a toxic solvent and a suspected occupational carcinogen.

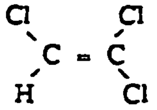
1
2 0

HMIS
H 2
F 1
R 1
PPE*
* See sect. 8

R 1
I 3
S 1
K 0

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	HAZARD DATA
Trichloroethylene, CAS #0079-01-6, NIOSH *RTECS* #KX4550000	100	ACGIH Values 1987-88 TLV-TWA* 50 ppm, 270 mg/m^3 TLV-STEL** 200 ppm, 1080 mg/m^3 OSHA PEL 1986*** 8-Hr TWA 100 ppm Ceiling 200 ppm NIOSH REL 1986 10-Hr TWA 25 ppm TOXICITY DATA Human, Oral, LD_{Lo} 7 g/kg Human Inhalation, TC_{Lo} 6900 mg/m^3 (10 Min) Human, Inhalation, TC_{Lo} 160 ppm/83 Min Human, Inhalation, TD_{Lo} 812 mg/kg



- * The TLV-TWA is set to control subjective complaints such as headache, fatigue, and irritability
- ** The TLV-STEL is set to prevent incoordination and other beginning anesthetic effects from TCE These levels should provide a wide margin of safety in preventing liver injury
- *** The OSHA PEL is 300 ppm for 5 minutes in any 2 hours

SECTION 3 PHYSICAL DATA

Boiling Point	188 6 F (87 C)	Evaporation Rate	Not Listed
Vapor Pressure ..	58 Torr at 68 F (20°C)	Specific Gravity	1 4649 at 68 F (20 C)
Water Solubility	Insoluble	Melting Point	-120 64 F (-84 8°C)
Vapor Density (Air = 1)	4 53	Molecular Weight	131 40 Grams/Mole

Appearance and odor Colorless nonflammable mobile liquid, sweetish odor like chloroform.

COMMENTS TCE is highly soluble in lipids A high vapor pressure at room temperature provides the potential for TCE vapors to contaminate use areas

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
Not Listed	770 F (410°C)	% by Volume	8%	10.5%

EXTINGUISHING MEDIA TCE has no flash point in a conventional closed tester at room temperature, but it is moderately flammable at higher temperatures Use dry chemical, carbon dioxide, alcohol foam, or other extinguishing agents suitable for the surrounding fire

OSHA Flammability Class (29 CFR 1910 106) Not Regulated

UNUSUAL FIRE/EXPLOSION HAZARDS During fire conditions TCE emits highly toxic and irritating fumes, including hydrochloric acid and phosgene. SPECIAL FIRE-FIGHTING PROCEDURES Wear a self-contained breathing apparatus with a full facepiece operated in a pressure-demand or another positive-pressure mode At TCE vapor levels of 300-1000 ppm, fire fighters who lack the proper respiratory equipment may experience incoordination and impaired judgment.

DOT Flammability Class (49 CFR 173 115) Not Regulated

SECTION 5 REACTIVITY DATA

Trichloroethylene is stable Hazardous polymerization can occur under certain circumstances (see Conditions to Avoid and Comments, below)

CHEMICAL INCOMPATIBILITIES include magnesium or aluminum powder, NaOH KOH, or other strong alkaline materials Reactions with alkaline materials may lead to the formation of dangerous explosive mixtures of chloroacetylenes

CONDITIONS TO AVOID When TCE is heated (as in the case with vapor degreasers) or exposed to sunlight, it requires extra stabilization against oxidation, degradation, and polymerization It is slowly decomposed by light when moist.

PRODUCTS OF HAZARDOUS DECOMPOSITION include hydrochloric acid and phosgene under certain conditions at elevated temperatures

COMMENTS TCE is stable under normal handling and storage conditions, and hazardous polymerization is not expected to occur However, failure of the stabilizer at elevated temperatures or other extreme conditions may allow polymerization to take place

No 312 8/87 TRICHLOROETHYLENE

SECTION 6. HEALTH HAZARD INFORMATION

Trichloroethylene is listed as a carcinogen by the NTP, IARC and OSHA. NIOSH recommends that trichloroethylene be treated as an occupational carcinogen IARC carcinogenic results are animal suspect, animal positive, and human indefinite. SUMMARY OF RISKS Moderate exposures to TCE cause symptoms similar to those of alcohol inebriation. Higher concentrations cause narcotic effects Ventricular fibrillation has been cited as the cause of death following heavy exposures TCE-induced hepato cellular carcinomas have been detected in mice during tests conducted by the National Cancer Institute (*Chem & Eng News* 54 [April 5, 1976] 4) Organ systems affected by overexposure to TCE are the central nervous system (euphoria, analgesia, anesthesia), degeneration of the liver and kidneys, the lungs (tachypnea), heart (arrhythmia) and skin (irritation, vesication, and paralysis of fingers when immersed in liquid TCE) Contact with the liquid defats the skin, causing topical dermatitis Certain people appear to experience synergistic effects from TCE exposure concomitant with exposure to caffeine, alcohol, and other drugs. When combined with alcohol intake, toxic effects are increased and may cause a red, blotchy facial and upper body rash commonly called 'degreaser's flush." Other reported symptoms of TCE exposure include abnormal fatigue, headache, irritability, gastric disturbances, and intolerance to alcohol Toxic effects from testing of TCE on humans include hallucination, distorted perception, somnolence (general depressed activity), and jaundice. TARGET ORGANS Respiratory system, central nervous system, heart, liver, kidneys, and skin PRIMARY ENTRY Ingestion, inhalation, skin contact ACUTE EFFECTS Headache, vertigo, visual disturbance, tremors, nausea, vomiting, dermatitis, dizziness, drowsiness, and irritation to the eyes, nose and throat CHRONIC EFFECTS None Reported MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE Diseases of the liver, kidneys, lungs, and central nervous system FIRST AID EYE CONTACT Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Get medical help.* SKIN CONTACT Wash thoroughly with soap and water Remove and launder contaminated clothing before wearing it again, clean material from shoes and equipment. Get medical help.* INHALATION Remove victim to fresh air restore and/or support his breathing as needed. Do not give adrenalin to the victim. Get medical help.* INGESTION Call a poison control center Never give anything by mouth to someone who is unconscious or convulsing A professional decision regarding whether or not to induce vomiting is required. Do not give adrenalin to the victim. Get medical help.*

*GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC COMMUNITY Get prompt medical assistance for further treatment, observation, and support after first aid.

COMMENTS Workers responses to TCE vary significantly because of many factors, including age, health status, nutrition, and intake of alcohol, caffeine and medicines. Do not use these substances before, during, or after exposure to TCE. If a worker displays any of the symptoms of exposure to TCE, thoroughly investigate all the possible contributing factors to determine, if possible, how much the work environment levels of TCE are responsible

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK Inform safety personnel of any trichloroethylene spill or leak and evacuate the area for large spills Cleanup personnel must use respiratory and liquid contact protection Adequate ventilation must be provided Confine the spilled TCE to as small an area as possible Do not allow it to run off to sewers or open waterways Pick up spilled TCE with a vacuum cleaner or an absorbent such as vermiculite

DISPOSAL Consider reclamation, recycling, or destruction rather than disposal in a landfill

Trichloroethylene is designated as a hazardous substance by the EPA (40 CFR 116 4)

Trichloroethylene is reported in the 1983 EPA TSCA Inventory

EPA Hazardous Waste Number (40 CFR 261 33) U228

EPA Reportable Quantity (40 CFR 117 3) 1000 lbs (454 kgs)

Aquatic Toxicity Rating TLm 96 Not Listed

SECTION 8 SPECIAL PROTECTION INFORMATION

GOGGLES Always wear protective eyeglasses or chemical safety goggles Follow the eye and face protection guidelines of 29 CFR 1910 133 GLOVES Wear impervious gloves RESPIRATOR Use a NIOSH-approved respirator per the *NIOSH Guide to Chemical Hazards* (Genium ref 88) for the maximum-use concentrations and/or the exposure limits cited in section 2 Follow the respirator guidelines in 29 CFR 1910 134 Any detectable concentration of TCE requires an SCBA, full facepiece, and pressure-demand/positive-pressure modes WARNING Air-purifying respirators will not protect workers from oxygen-deficient atmospheres OTHER EQUIPMENT Wear rubber boots, aprons, and other suitable body protection appropriate to the existing work environment. VENTILATION Install and operate general and local exhaust ventilation systems of sufficient power to maintain airborne concentrations of TCE below the OSHA PEL standards cited in section 2 SAFETY STATIONS Make eyewash stations washing facilities, and safety showers available in areas of use and handling Contact lenses pose a special hazard soft lenses may absorb irritants, and all lenses concentrate them OTHER SPECIAL MODIFICATIONS IN THE WORKPLACE Because of the unresolved controversy about the carcinogenic status of TCE, all existing personal protective equipment and engineering technology should be used to prevent any possibility of worker contact with this material

COMMENTS Practice good personal hygiene Keep material off of your clothes and equipment. Avoid transfer of material from hands to mouth while eating, drinking, or smoking Adhere to the sanitation requirements of 29 CFR 1910 141 and 29 CFR 1910 142

SECTION 9 SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION Prevent TCE from coming into contact with strong caustics such as NaOH, KOH, chemically active metal like Ba, Li, Na, Mg, Ti, and powdered aluminum or magnesium in acidic solutions. SPECIAL HANDLING/STORAGE Store this material in a cool, dry, well-ventilated area. Avoid elevated temperatures because products of toxic and corrosive decomposition from TCE may form. Monitor the level of any stabilizer component that may be added to the TCE. (Consult the technical data from the supplier to determine the specifics of any added stabilizer) If applicable, follow the supplier's recommendation concerning proper rotation of stock, shelf-life requirements and levels of stabilizers ENGINEERING CONTROLS IN THE WORKPLACE Avoid collecting aluminum fines (very small particles) or chips in a TCE vapor degreaser Monitor TCE stabilizer levels regularly Only trained personnel should operate vapor degreasers

TRANSPORTATION DATA (per 49 CFR 172 101-2)

DOT Hazard Class ORM-A	DOT ID No UN1710	IMO Class 6 1
IMO Label St. Andrew's Cross (X)*	DOT Shipping Name. Trichloroethylene	DOT Label None

* Harmful - Stow away from foodstuffs (IMO Label, Materials of Class 6 1 Packaging Group III)

References 1-9, 12, 14 21 73 87-94 PI

Approvals JO Accurocco

Indust Hygiene/Safety 11-19-87

Medical Review

APPENDIX F

MISSOURI DEPARTMENT OF HEALTH RISK ASSESSMENT

The Risk Assessment has been previously received by the MDNR and the US EPA Region VII