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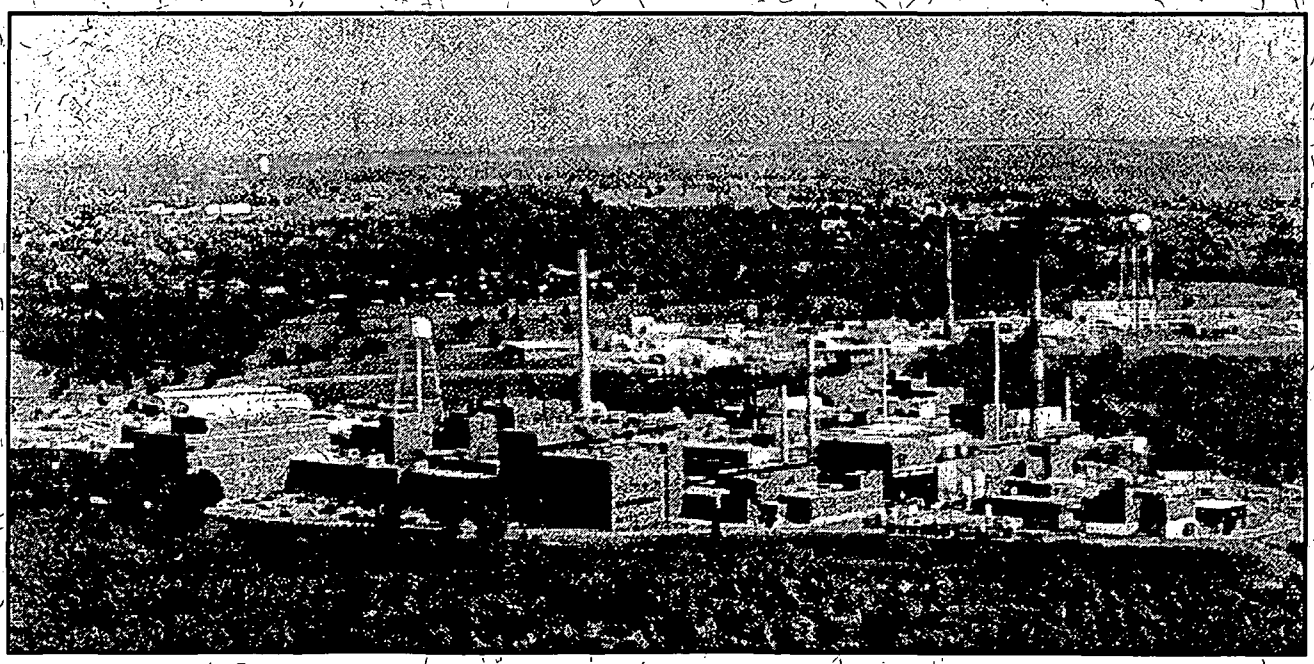
Environmental
Restoration
Program

Miamisburg Closure Project
Potential Release Site Package

PRS 417

Public Review Draft
March 2003



Environmental Restoration Program

MIAMISBURG CLOSURE PROJECT
POTENTIAL RELEASE SITE PACKAGE
Notice of Public Review Period

The following Potential Release Site (PRS) package is available for public review in the CERCLA Public Reading Room, 305 E. Central Ave., Miamisburg, Ohio. Public comment on this document will be accepted 02 April 2003 through 02 May 2003.

PRS 417: Soil Contamination, High Soil Gas near Well 0312

Questions can be referred to Paul Lucas at (937) 865-4578

PRS 417 Package Tracking Sheet

REVISION	DESCRIPTION	DATE
Working Draft (to DOE)	Binned FA on 6 August 1998.	
Draft (to Core Team)		
Draft Proposed Final	Addendum 1 submitted to CT. No USEPA comments. OEPA comments included adding Table 1 with Maximum VOC results. PRS binned NFA on 19 March 2003. Added Addendum 1 to original package and submitted as public review draft.	**January 2003**
Public Review Draft	Public review period: 02 April to 02 May 2003.	**March 2003**
Final		

ADDENDUM 1

SUPPORTING NFA RECOMMENDATION

Environmental
Restoration
Program

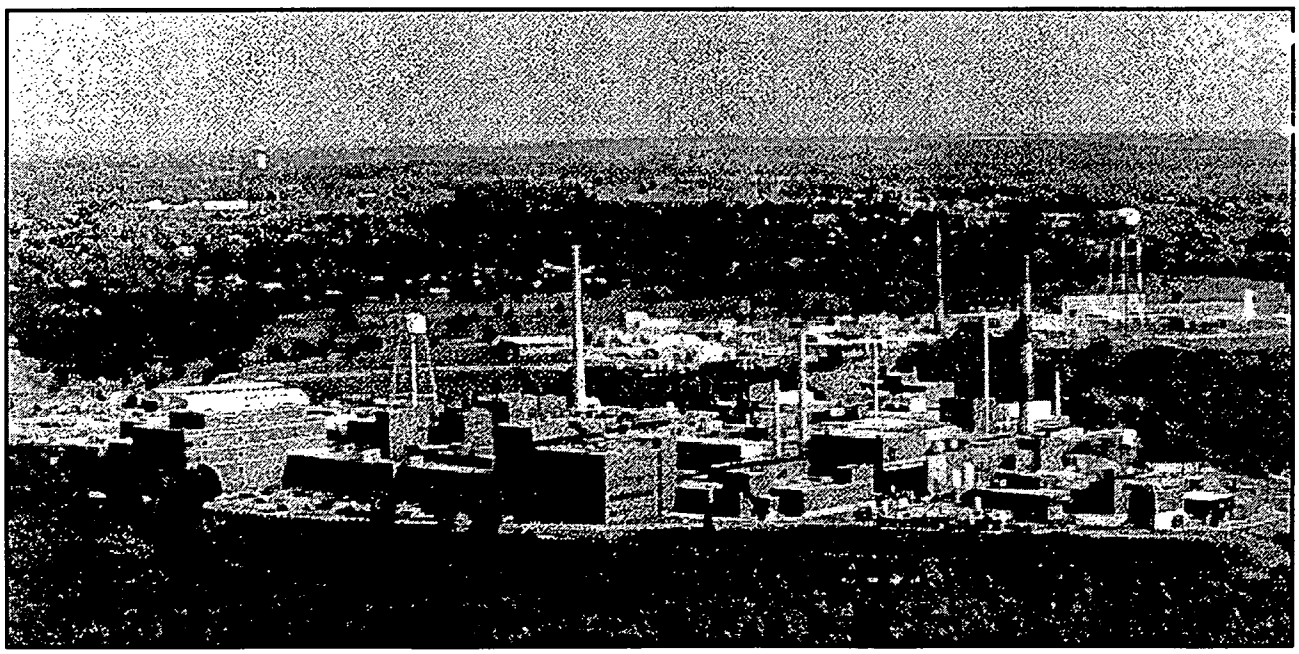
Miamisburg Closure Project

Potential Release Site Package

PRS 417

Addendum 1

Public Review Draft
March 2003



PRS HISTORY:

Potential Release Site (PRS) 417 is located on the western boundary of the site as shown on Figure 1 and was binned Further Assessment (FA) by the Core Team on 6 August 1998. PRS 417 was identified based on the leaching potential of historic soil sample results of TCE (trichloroethylene) at depths to 15-20 feet below ground surface.

FURTHER ASSESSMENT ACTIVITY:

PRS 417 sampling was grouped with PRSs 41 and 64 due to their proximity to each other. This addendum applies to PRS 417 only. The potential contaminant of concern (COC) was TCE via VOC (volatile organic compound) analysis. TCE has been detected in four groundwater monitoring wells downgradient from PRS 417 (Figure 2). TCE detections have been trending downward as shown on Figures (3-6) and results for all four wells are currently below the maximum contamination level (MCL) for TCE.

Further Assessment sampling was completed in November 2002 per the Sampling and Analysis Plan (**SAP**)[1] approved by the Core Team.

All 55 soil samples, six duplicate samples, and one groundwater sample were analyzed for VOCs. The FA sample locations are presented in Figure 7. The FA **Data Report**[2] presents a full account of soil and groundwater sampling activities and sample results.

Further Assessment results confirmed that TCE, and all other VOCs analyzed, are significantly below the more stringent of the 10^{-6} Risk-Based Guideline Values (RBGVs) or Hazard Index of one values.

Detection limits for all analytes were significantly below the more restrictive of the 10^{-6} RBGVs or Hazard Index of one values. The only detections were for TCE, 1,2-dichloroethene, and methylene chloride. TCE and 1,2-dichloroethene detections (Table 1) were found to not have the potential to leach to groundwater at unacceptable levels. Methylene chloride detections were not assessed for leachability because the analyte was found in all of the lab blanks analyzed.

Table 1: VOC Detections (ug/kg)

Analyte	Maximum Result	Soil Screening Level	Screening Level*
TCE	180	180	5,090
1,2-dichloroethene	130	730	2,130,000

* more restrictive of 10^{-6} RBGV or Hazard Index of one value

FIGURES:

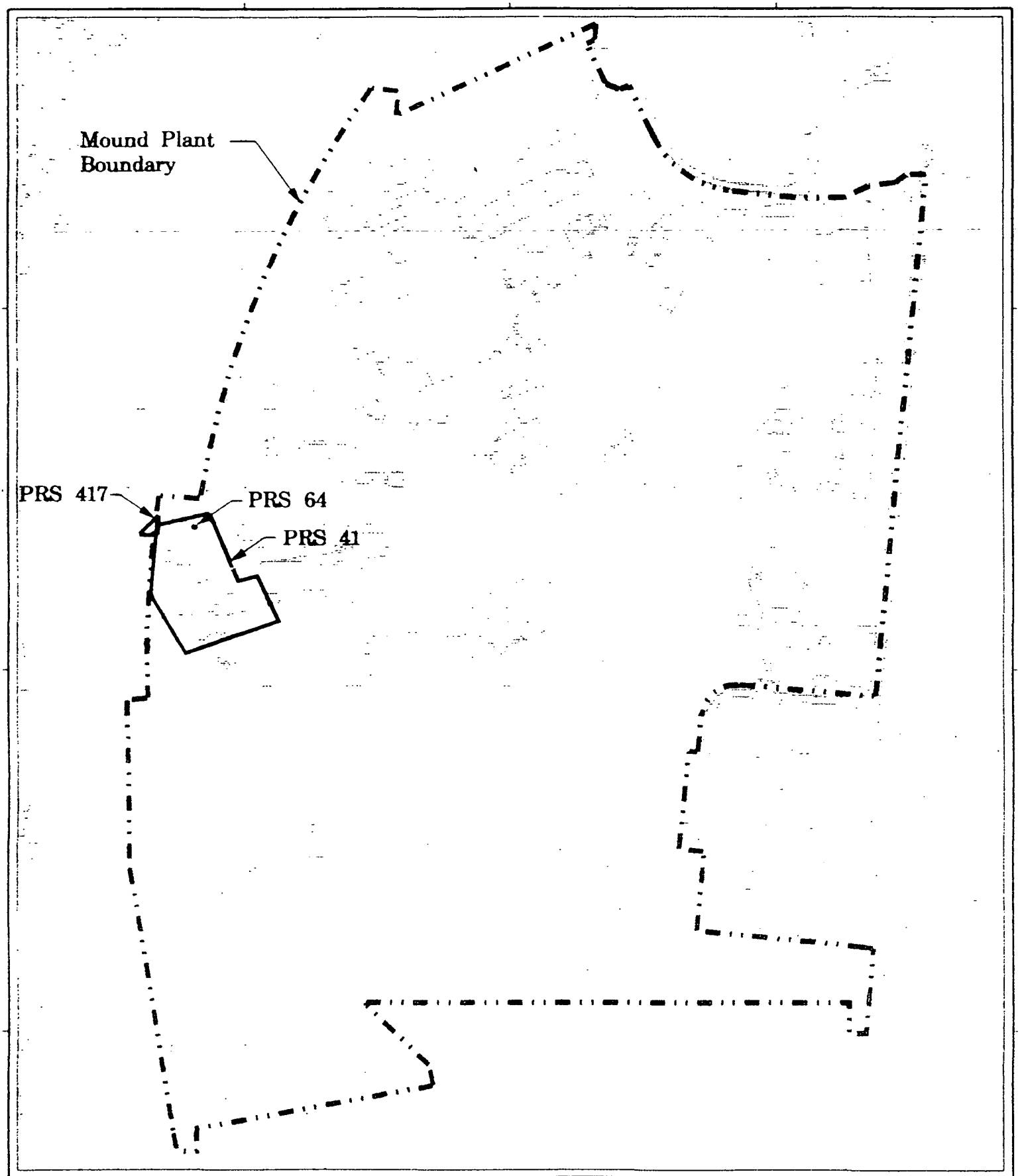
Figure 1: Location of PRS 41/64/417
Figure 2: Location of Wells
Figures 3-6: TCE Trend Results
Figure 7: PRS 417 Sample Locations

REFERENCES:

1) PRS 41/64/417 Sampling and Analysis Plan, Final, November 2002
2) PRS 41/64/417 Data Report, Rev. 0, December 2002

PREPARED BY:

Gary Miller, CH2MHill, ER Technical Staff
Karen M. Arthur, CH2MHill, ER QA



Legend

Structures
Paved roadway
Unpaved roadway
Mound Plant boundary
Railroad

0 100 200 400 600 800 1000
Scale in Feet

MOUND
Environmental Restoration Geographic Information System

Figure 1:
Location of PRS 41/64/417

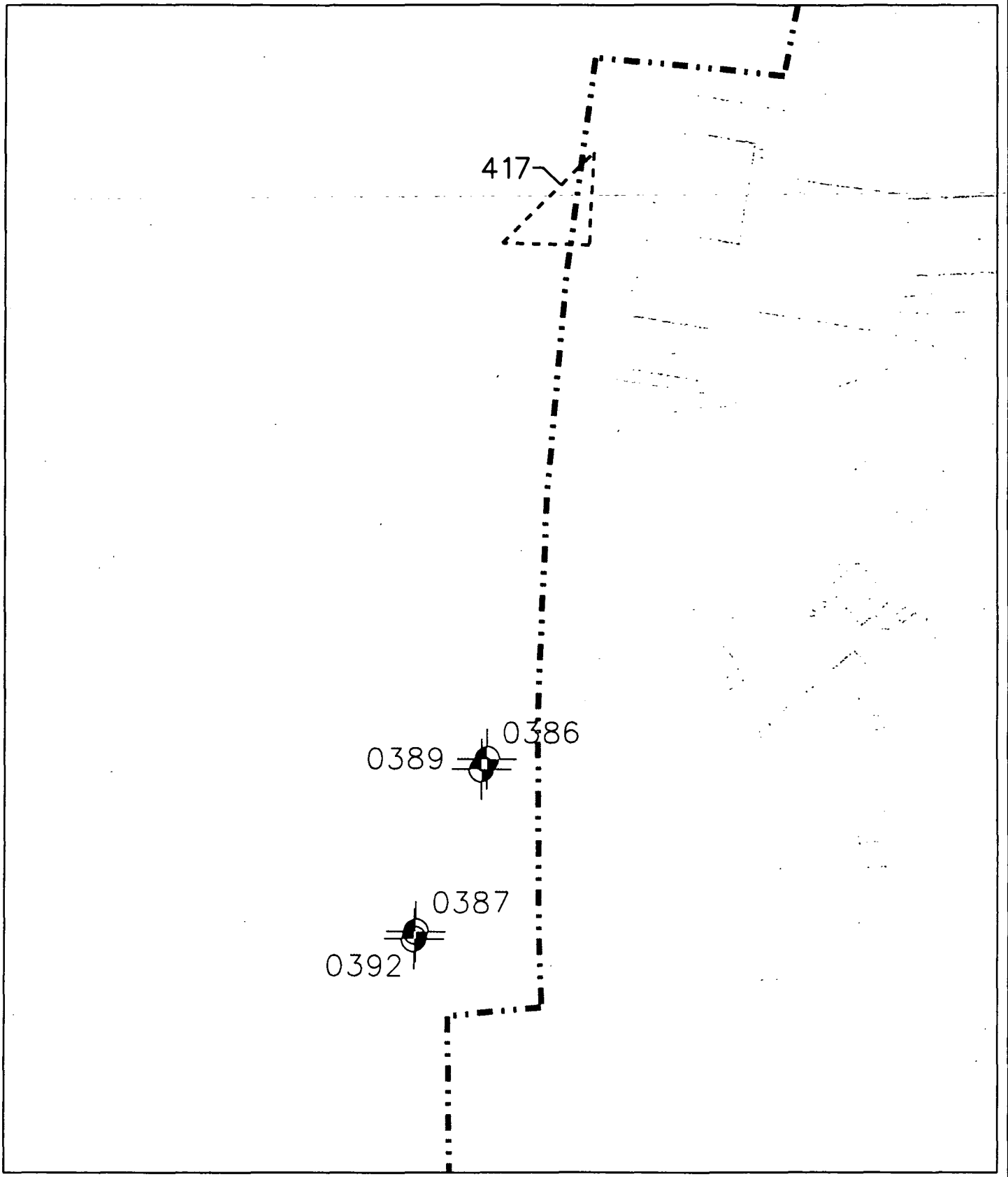
UNCLASSIFIED

gen_site_plan.dgn

STE | ER-GIS | MSTATION

06/24/92 | SSP

3 of 10



0 20 40 60 80 100
Scale In Feet

MOUND
Environmental Restoration Geographic Information System

SHEET	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
ISSUE																					

SHEET	1	2	3	4	5	6
ISSUE						

PART CLASSIFICATION

Figure 2: Wells Down Gradient of PRS 417

DRAWING CLASSIFICATION: UNCLASSIFIED

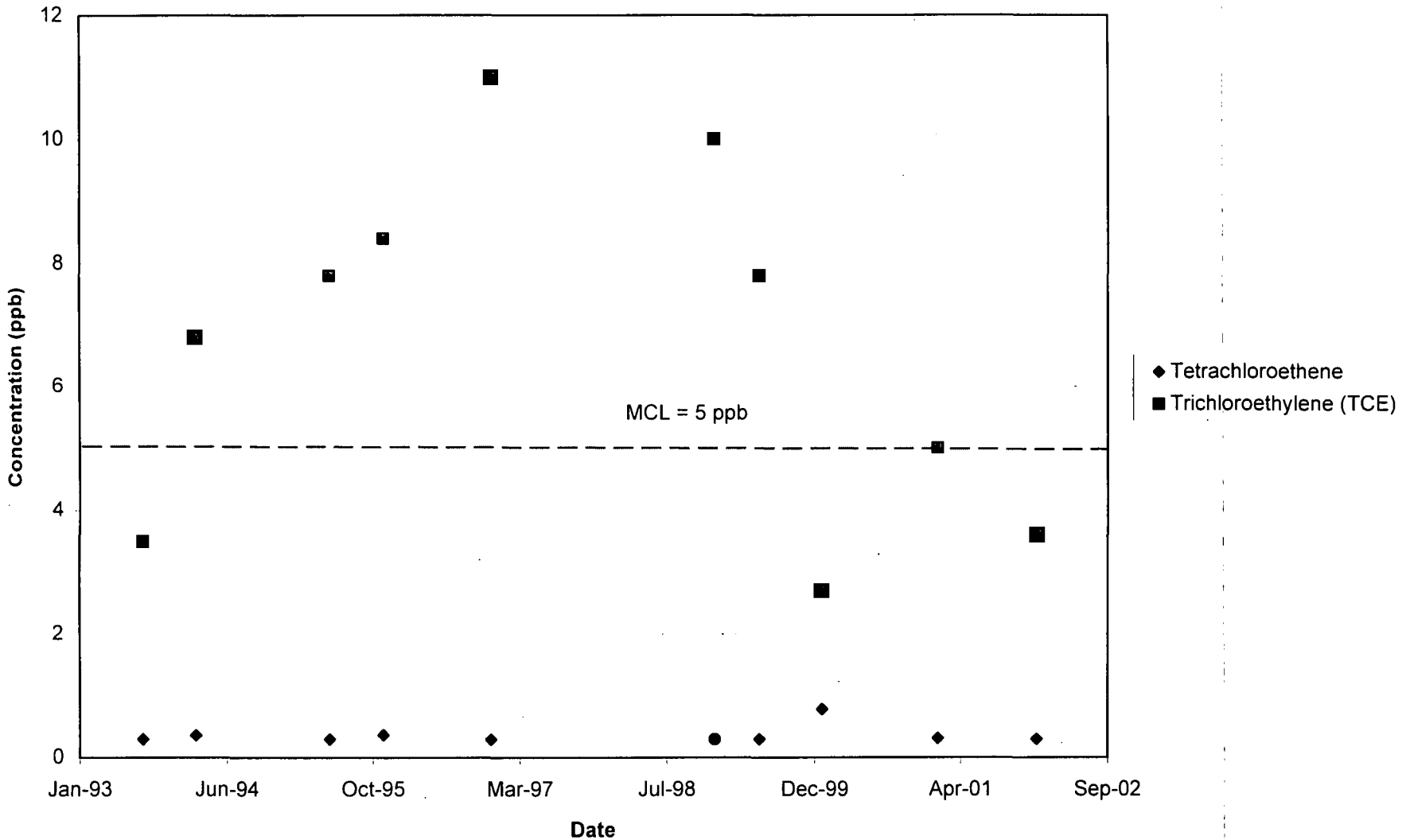
SIZE | DRAWING NUMBER | JOB NUMBER

DBD TYPE SYE | PROJ ER-GIS | CAGEC | SCALE | SHEET 1 OF 1

STATUS MD-REL-02/27/03 | ORIGIN MSTATION / J

ISS	DATE	REVISION	BY	CHKR	ENG	UPDCC	APVD	ISS
	02/27/03		SSF					

Figure 3: TCE and PCE in Monitoring Well 0386



5 of 16

Figure 4: TCE and PCE in Monitoring Well 0387

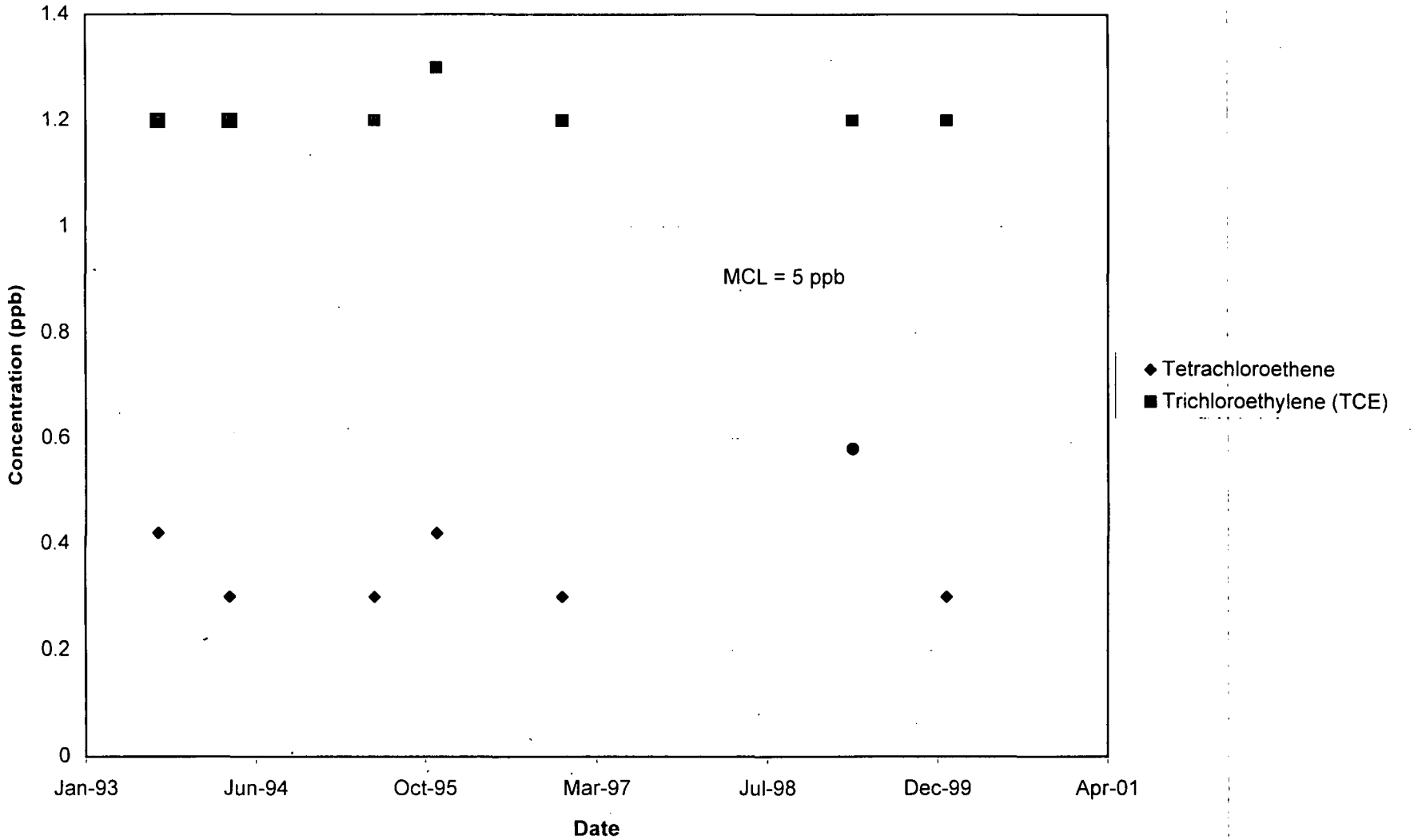


Figure 5: TCE and PCE in Monitoring Well 0389

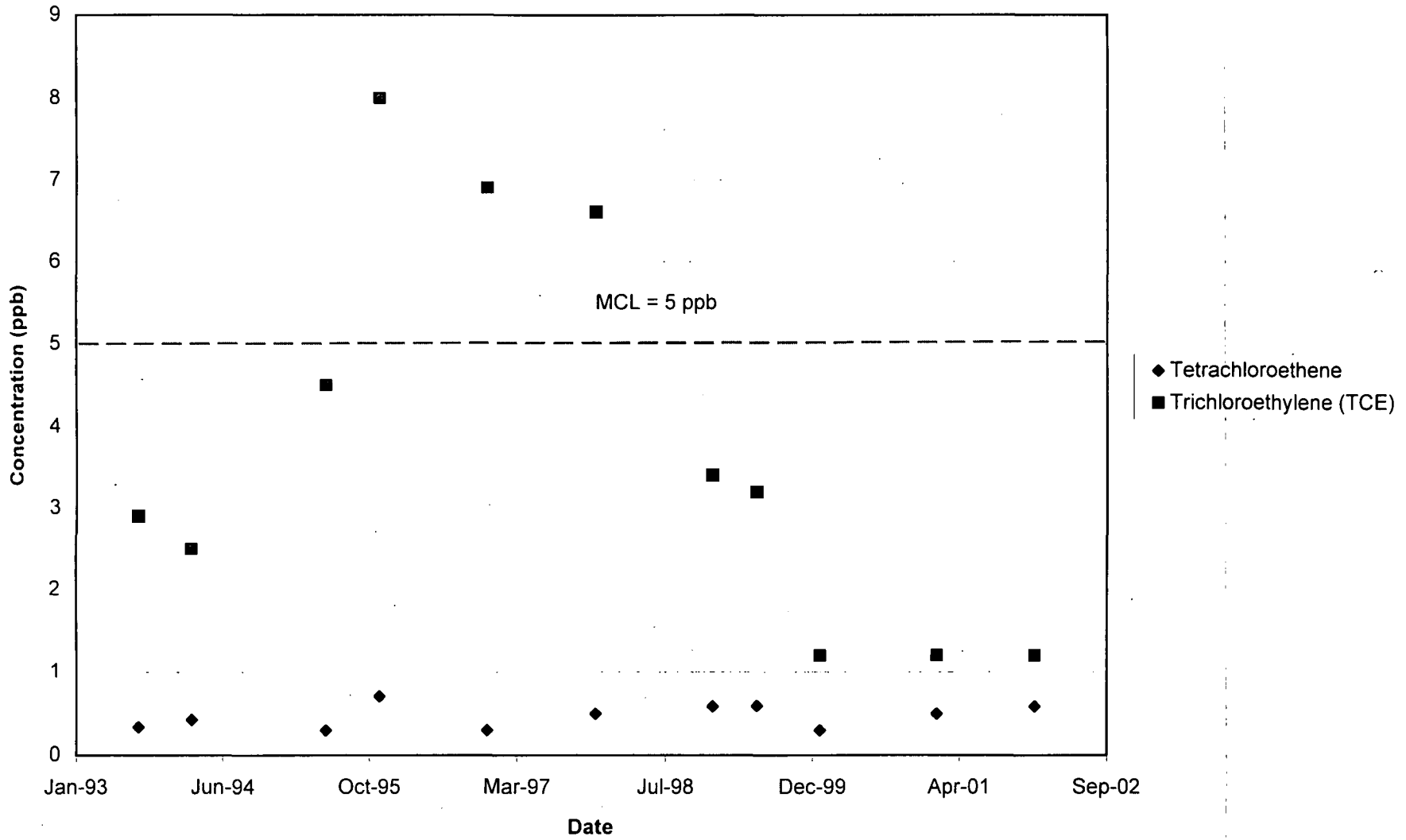
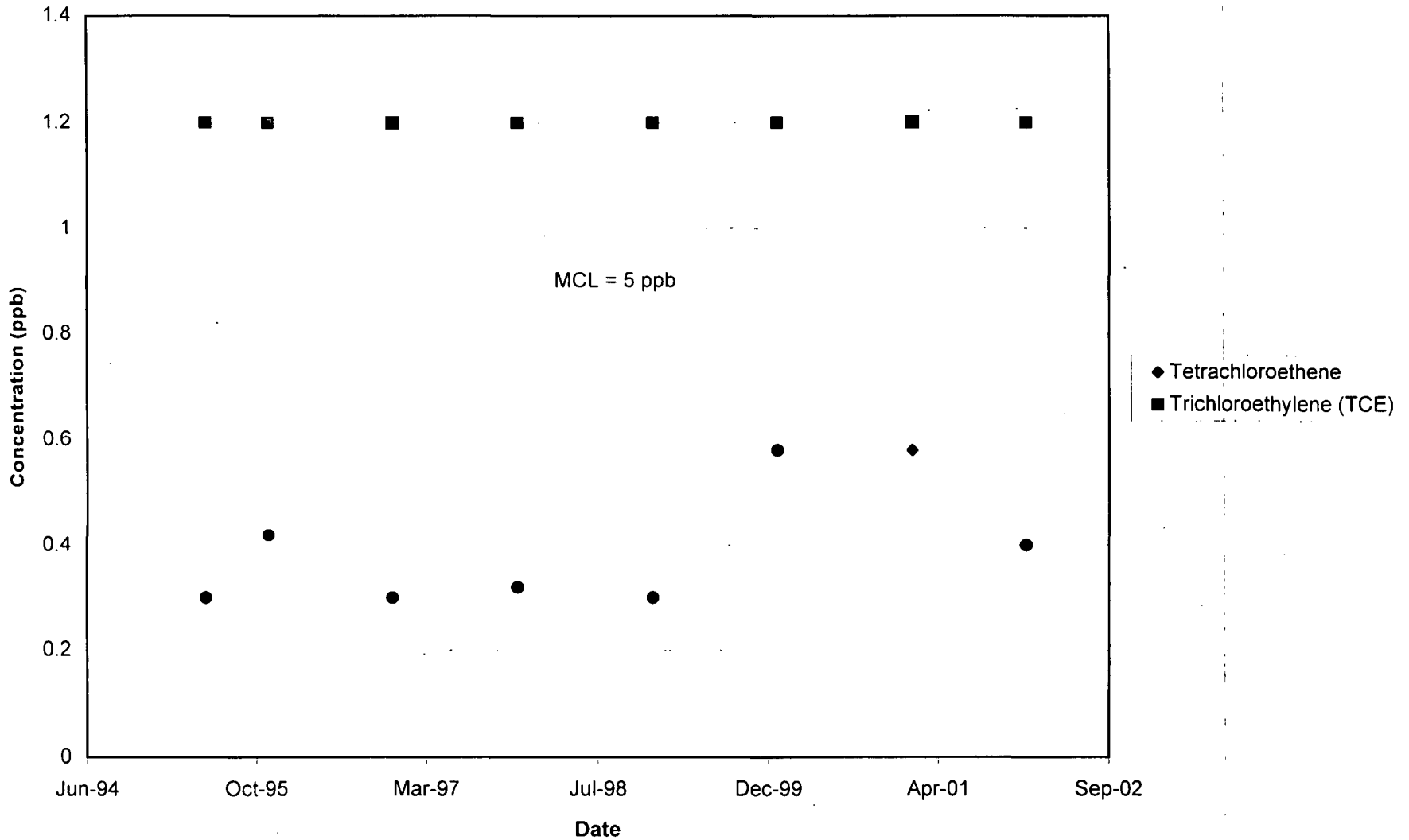
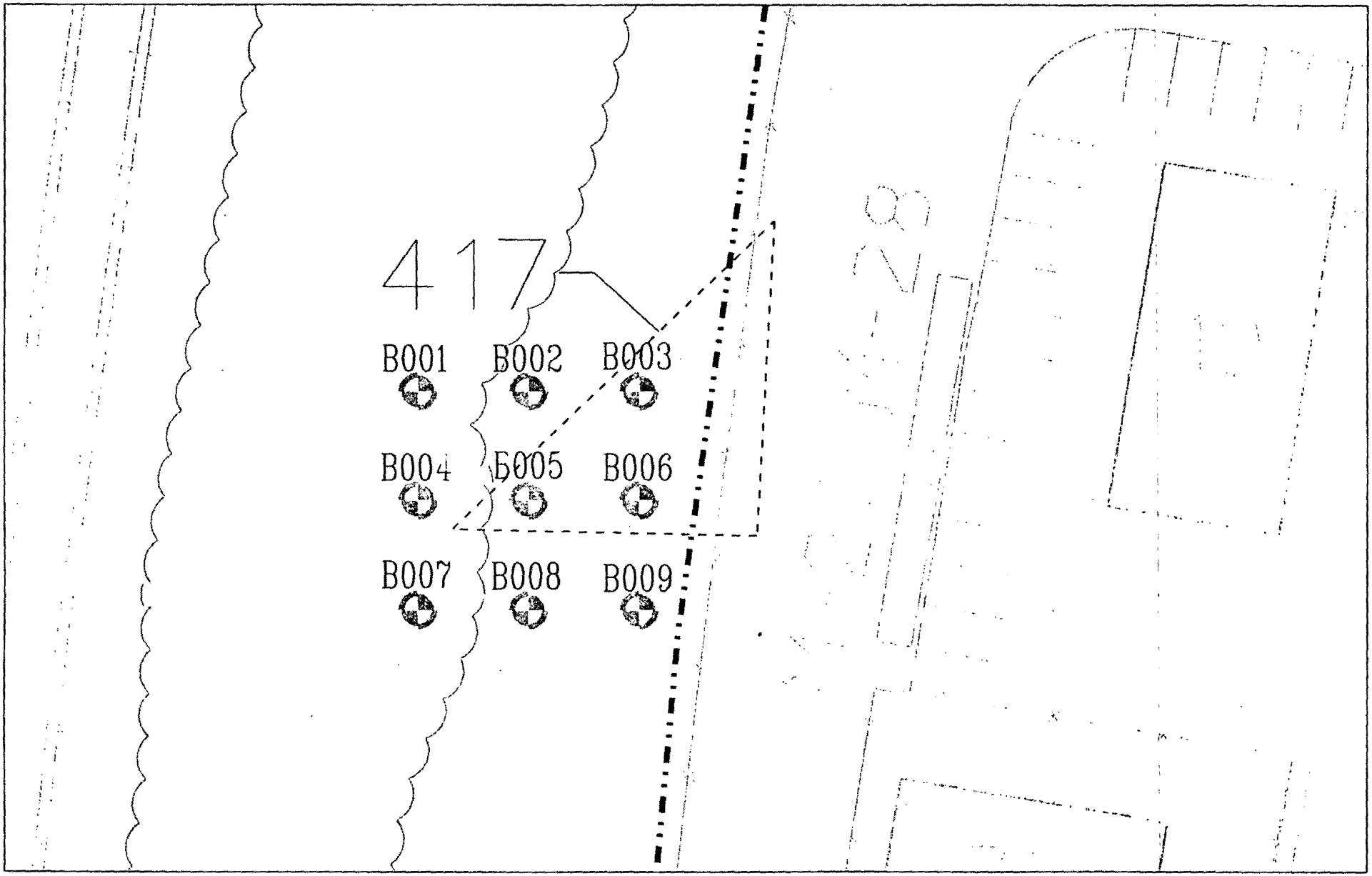


Figure 6: TCE and PCE in Monitoring Well 0392





PRS 417 (VOC) @ 9x6 intervals

20 10 0 20 40FT
GRAPHIC SCALE

ISS	DATE	REVISION	BY	CHKR	ENG	LPREC	APVD	M
	01/15/03		SSF					

MOUND
Environmental Restoration Geographic Information System

SHEET 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
ISSUE
SHEET 1 2 3 4 5 6
ISSUE *
PART CLASSIFICATION

Figure 7 PRS 417 Sample Locations

DRAWING CLASSIFICATION UNCLASSIFIED
SIZE
DRAWING NUMBER fig2_prs417.dgn
JOB NUMBER *
DWG TYPE STE
PRNG ER-GIS
CAGEC
SCALE *
SHEET 1 OF *
STATUS MD-REL-01/15/03
ORIGIN MSTATION / J

MIAMISBURG CLOSURE PROJECT
PRS 417

RECOMMENDATION:

Potential Release Site (PRS) 417 is located on the western boundary of the site (Figure 1) and was binned Further Assessment by the Core Team on 6 August 1998. PRS 417 was identified based on the leaching potential of historic soil sample results of TCE (trichloroethylene) at depths to 15-20 feet below ground surface. Although not apparently connected to PRS 417, ongoing monitoring for TCE at four downgradient wells will continue, to confirm that levels of TCE remain below the MCL.

Further Assessment was performed and confirmed that the levels of TCE, and all other VOCs (volatile organic compounds) analyzed, are below the more stringent of the 10^{-6} Risk-Based Guideline Values (RBGV) or Hazard Index of one values.

Further, the only results above detection limits were for TCE, 1,2-dichloroethene, and methylene chloride. TCE and 1,2-dichloroethene detections were found to not have the potential to leach to groundwater at unacceptable levels. Methylene chloride detections were not assessed for leachability because the analyte was found in all of the lab blanks analyzed.

Therefore, the Core Team recommends **No Further Assessment** for PRS 417.

A PRS Package with an NFA recommendation signed by the Core Team will be placed in the Public Reading Room for a 30-day review period. Upon closure of the public review comments, if any, the PRS Package will be issued as a final document and made available in the Public Reading Room.

CONCURRENCE:

DOE/MCP: _____ 3/19/03
Robert S. Rothman, Remedial Project Manager (date)

USEPA: _____ 3/26/03
David P. Seely, Remedial Project Manager (date)

OEPA: _____ 3/19/03
Brian K. Nickel, Project Manager (date)

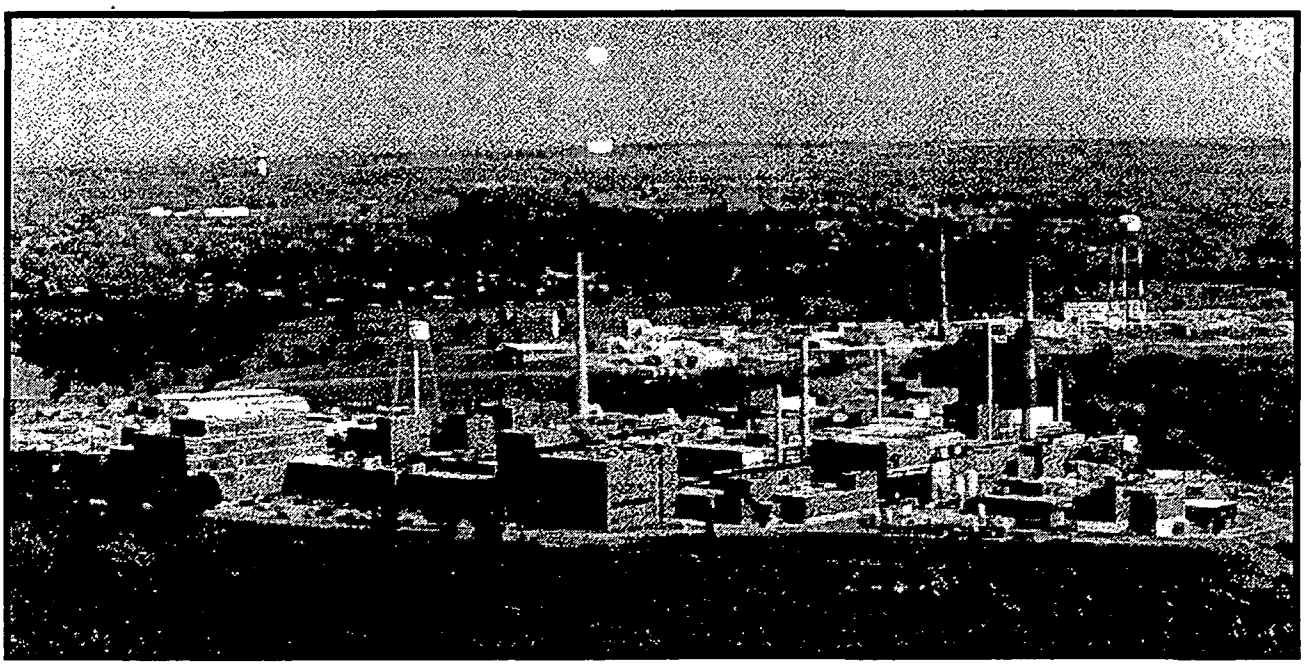
ORIGINAL DOCUMENT

SUPPORTING FA RECOMMENDATION

Environmental
Restoration
Program

Miamisburg Closure Project
Potential Release Site Package

PRS 417

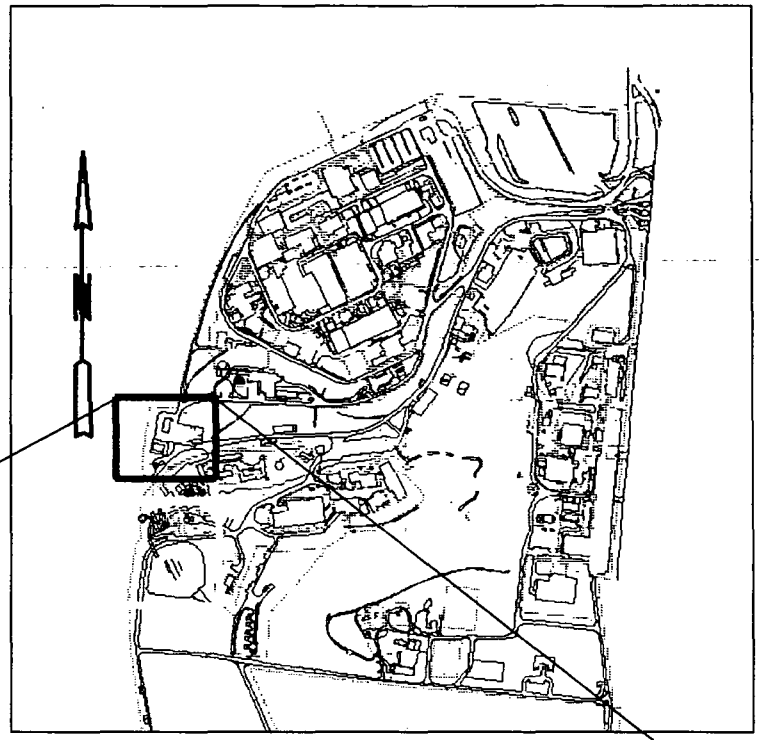


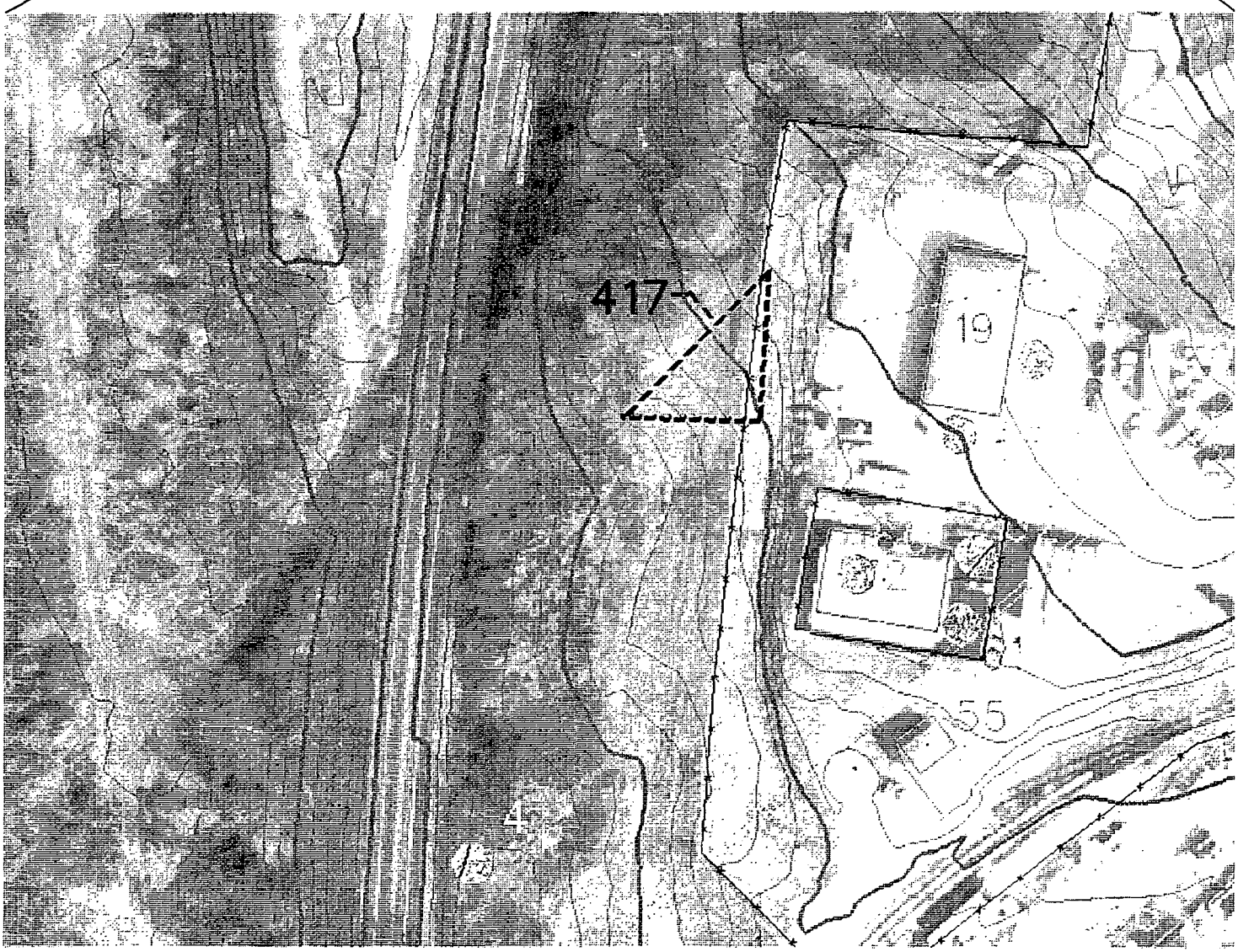
Mound Plant

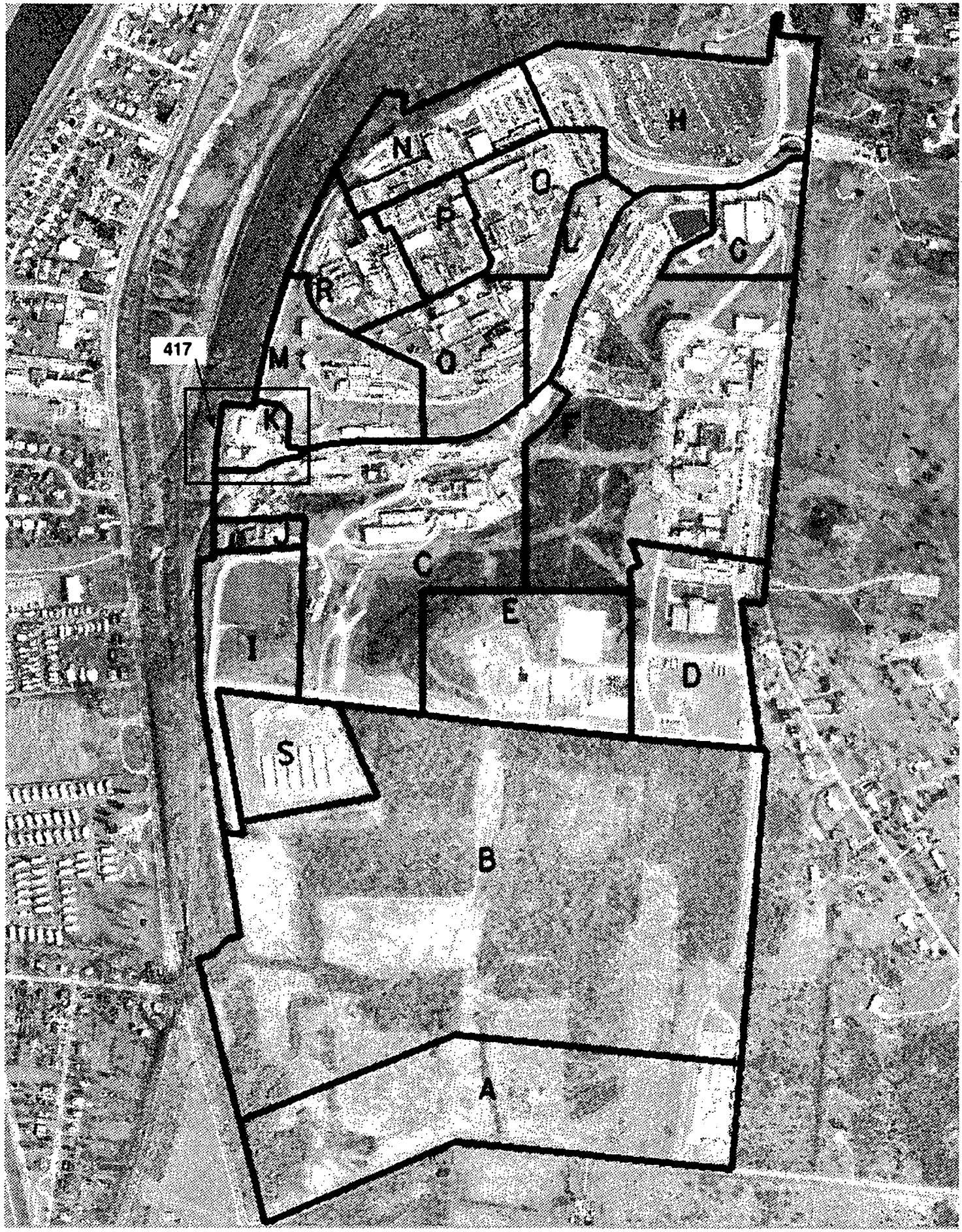
PRS 417

Soil Contamination – High Soil Gas Near Well 0312

On the map below:
- Building number and location shown in tan
- PRS number and location shown in black
- Fencing shown in red
- Elevation contours shown in brown



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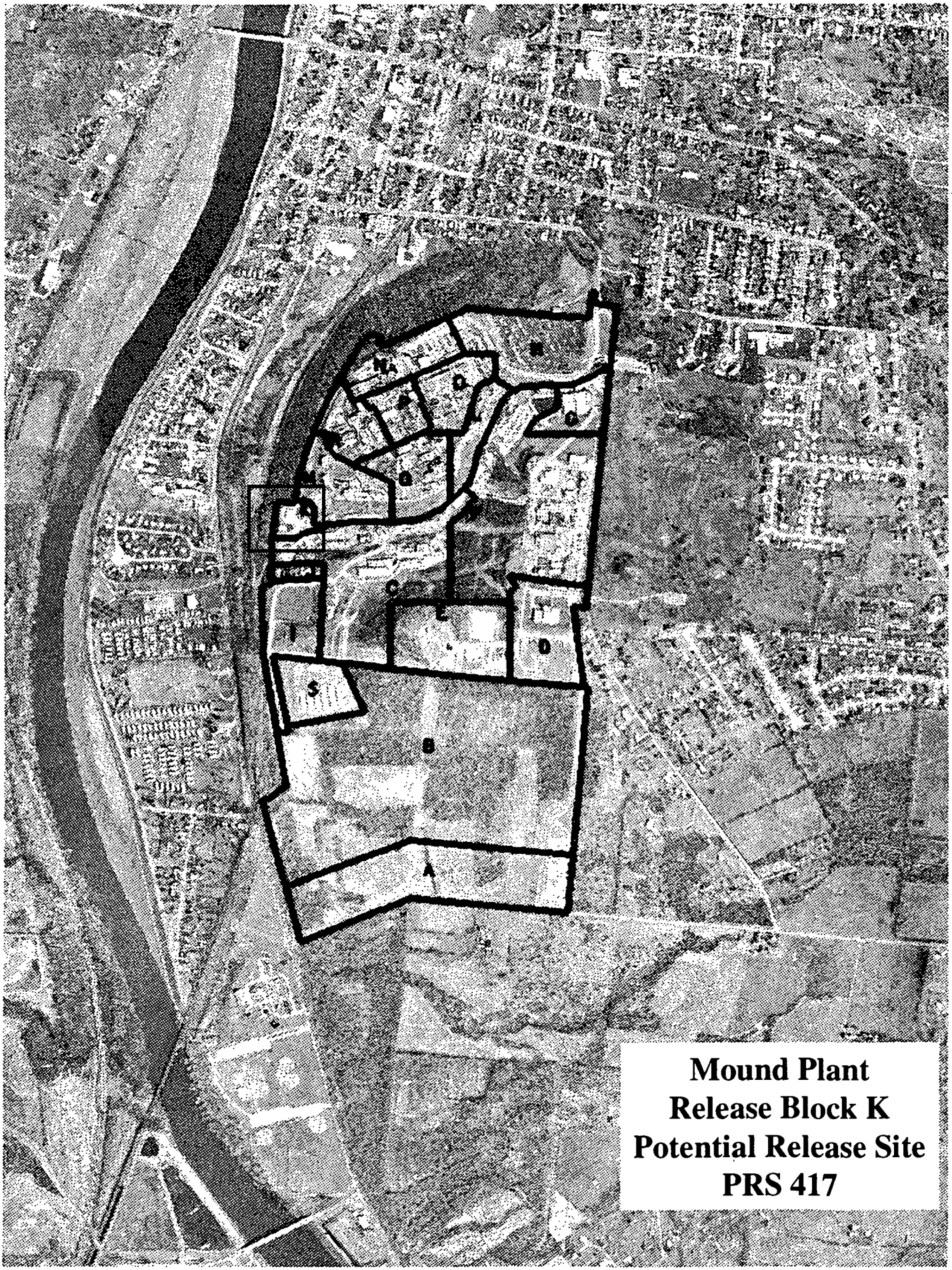
Mound Plant
Release Block K
Potential Release Site
PRS 417

PRS 417

PRS HISTORY:

PRS 417 is identified as a localized region of Volatile Organic Compound (VOC) contaminated soils located just west of Building 19. This PRS was identified as a result of a Limited Field Investigation study conducted in the summer of 1997[1].

CONTAMINATION:

Several Soil Gas Surveys have been conducted at the Mound Plant for the purpose of site characterization.

In 1997, a very large scale reconnaissance survey utilizing a geoprobe identified very localized elevated concentrations of TCE in the soil gas just southwest of Building 19. Field results indicated TCE concentrations in excess of 300 parts per billion (ppb) volume/volume (v/v), and laboratory analysis indicated TCE concentrations in excess of 880 ug/kg in these soils. See Reference 1, especially Appendices A and B.

Mound Plant soil screening guidance equations[2] indicate that the TCE contaminated soils associated with PRS 417 may serve as a source of leachate to the Buried Valley Aquifer (BVA) at dissolved concentrations in excess of 5 ppb (MCL). Ohio EPA studies suggest that given the laboratory verified bulk soil TCE concentration of 880 ug/kg, it is theoretically possible to achieve TCE concentrations of about 80 ppb at the edge of the BVA. See Reference 1, Appendices C and D.

REFERENCES:

1) Limited Field Investigation (LFI) Volatile Organic Compounds In Monitoring Wells, Mound Plant, Miamisburg, Ohio, November 1998.
2) Potential Release Site Packages Reading and Understanding, Volume II (Preliminary), Appendix D4, August 7, 1996.

PREPARED BY:

Mark Gilliat, Member of Babcock & Wilcox of Ohio Technical Staff
Joseph Geneczko, Member of Babcock &Wilcox of Ohio Technical Staff

MOUND PLANT
PRS 417
Soil Contamination - High Soil Gas Near Well 0312

RECOMMENDATION:

CONCURRENCE:

DOE/MEMP: _____
Arthur W. Kleinrath, Remedial Project Manager (date)

USEPA: _____
Timothy J. Fischer, Remedial Project Manager (date)

OEPA: _____
Brian K. Nickel, Project Manager (date)

SUMMARY OF COMMENTS AND RESPONSES:

Comment period from _____ to _____

☐ No comments were received during the comment period.

☐ Comment responses can be found on page _____ of this package.

Reference Material

LIMITED FIELD INVESTIGATION

VOLATILE ORGANIC COMPOUNDS IN MONITORING WELLS

FINAL

Mound Plant
Miamisburg, OH

November 1993

Department of Energy
Ohio Field Office

Prepared by the Soils Project of
BABCOCK & WILCOX OF OHIO

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ACRONYMS

BVA	Buried Valley Aquifer
CFR	Code of Federal Regulations
DOE	Department of Energy
DPT	Direct Push Technology
gpm	gallons per minute
LFI	Limited Field Investigation
MCL	Maximum Contaminant Level
MSL	Mean Sea Level
NPL	National Priorities List
PCE	Tetrachloroethene
ppb	parts per billion
PRS	Potential Release Site
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
TCA	1,1,1-Trichloroethane
TCE	Trichloroethane
VOC	Volatile Organic Compound
v/v	volume per volume

1.0 INTRODUCTION

The Mound Plant was placed on the National Priorities List (NPL) in 1989 because of volatile organic compounds (VOCs) contaminating the groundwater in the Buried Valley Aquifer (BVA). Since then, remedial investigations/feasibility studies (RI/FS) and remedial actions have focused on groundwater at Operable Unit 1. A Record of Decision (ROD) was signed for Operable Unit 1, and remediation is in progress.

Over 100 groundwater monitoring wells were installed as part of the RI/FS. The monitoring network included wells installed near Operable Unit 1. The network also includes wells installed on and around the Mound Plant with the objective of characterizing the site hydrogeology. These wells have been sampled and VOCs have been detected at some of the wells located away from Operable Unit 1. The Department of Energy (DOE) completed a Limited Field Investigation (LFI) to investigate the nature and extent of elevated levels of volatile organic compounds (VOCs) in four groundwater monitoring wells.

1.1 Objectives

The LFI was conceived with three objectives:

a. Identify VOC concentration trends or patterns in soil gas in the study area.

b. Identify VOC concentration trends or patterns in groundwater within the study area.

c. Determine if previously known or unknown potential release sites (PRS) were contributing to trends or patterns.

1.2 Area of Investigation

Several Mound groundwater monitoring wells outside of the OU 1 area have shown consistently elevated levels of trichloroethane (TCE). The wells include monitoring wells 0312, 0315, 0386 and 0389. Figure 1 shows the location of these Mound monitoring wells. Monitoring well 0312 is a "hybrid" well in that it is screened across the soil-bedrock interface. The remaining wells are completed in the Buried Valley Aquifer (BVA).

Sampling and analysis results for well 0312 have been consistently above the 40 CFR 141 Maximum Contaminant Level (MCL) of 5 parts per billion (ppb) for trichloroethane, with levels in the 20-50 ppb range. The results for the other wells have included TCE concentrations at or slightly above the MCL. The TCE concentrations with time are shown for each well in Figures 2 through 5.

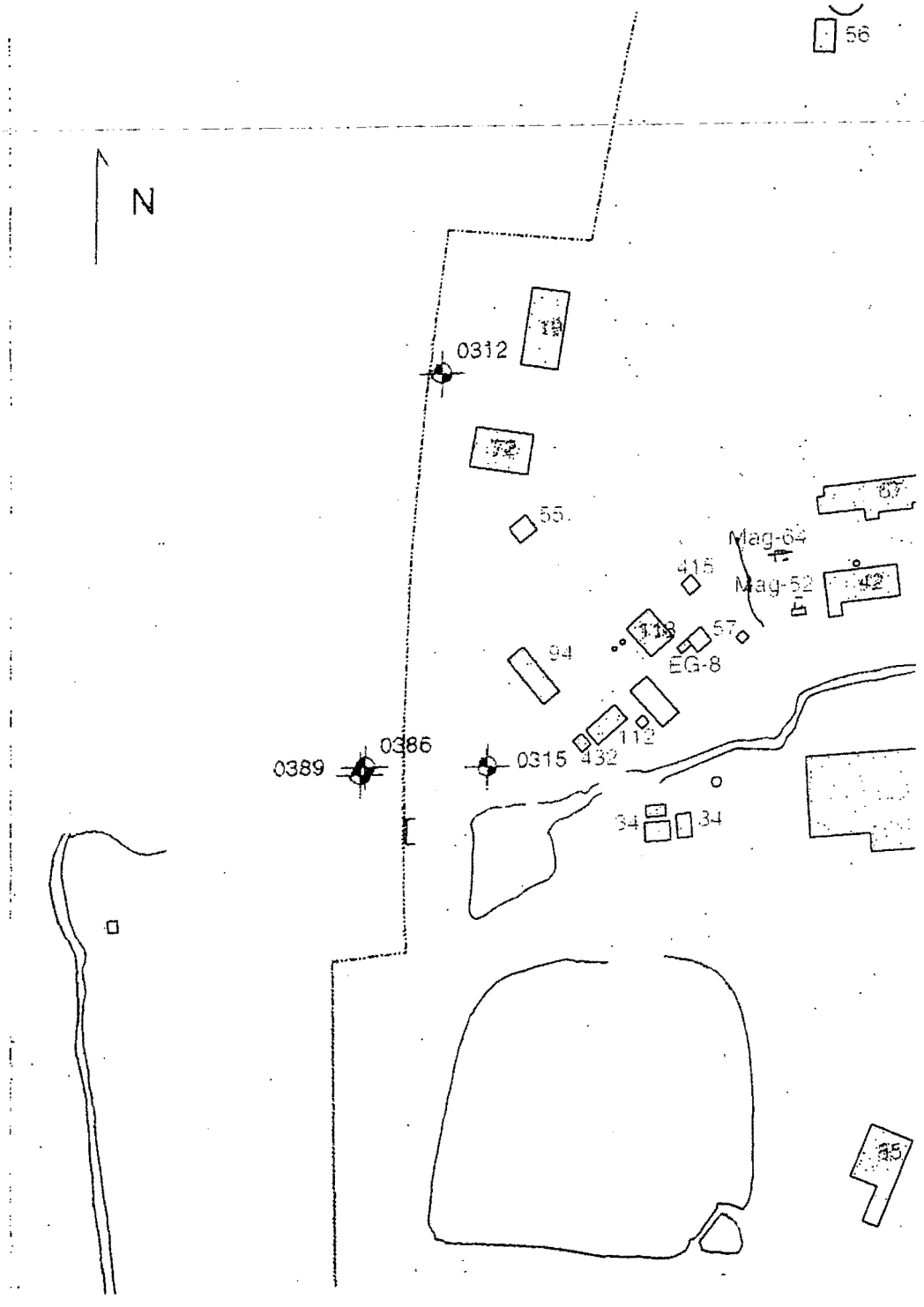

Figure 1 - Monitoring Well Location

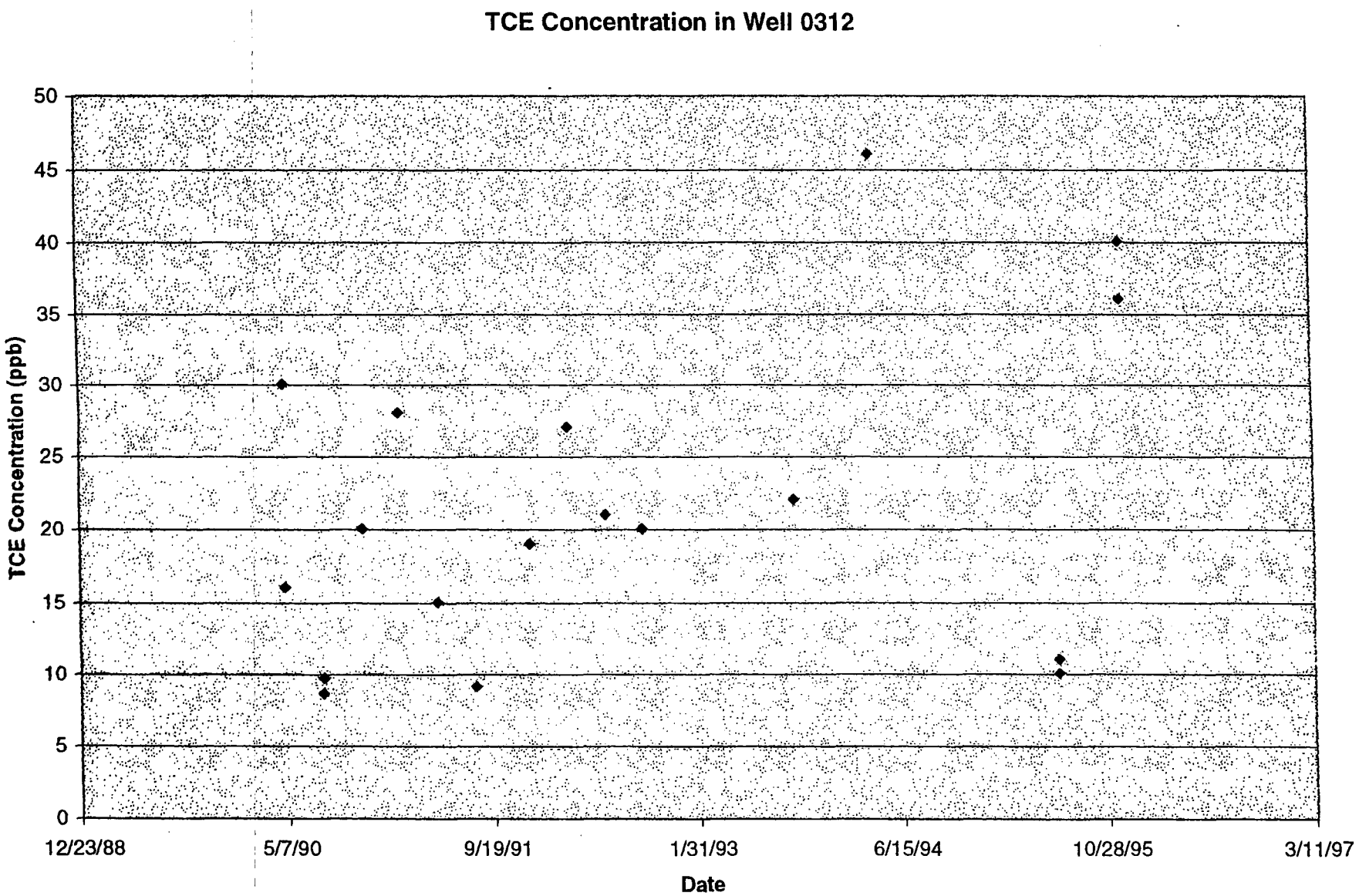
TCE Concentration in Well 0312
TCE Concentration (ppb)
50
45
40
35
30
25
20
15
10
5
0
12/23/88
5/7/90
9/19/91
1/31/93
6/15/94
10/28/95
3/11/97
Date

Figure 2

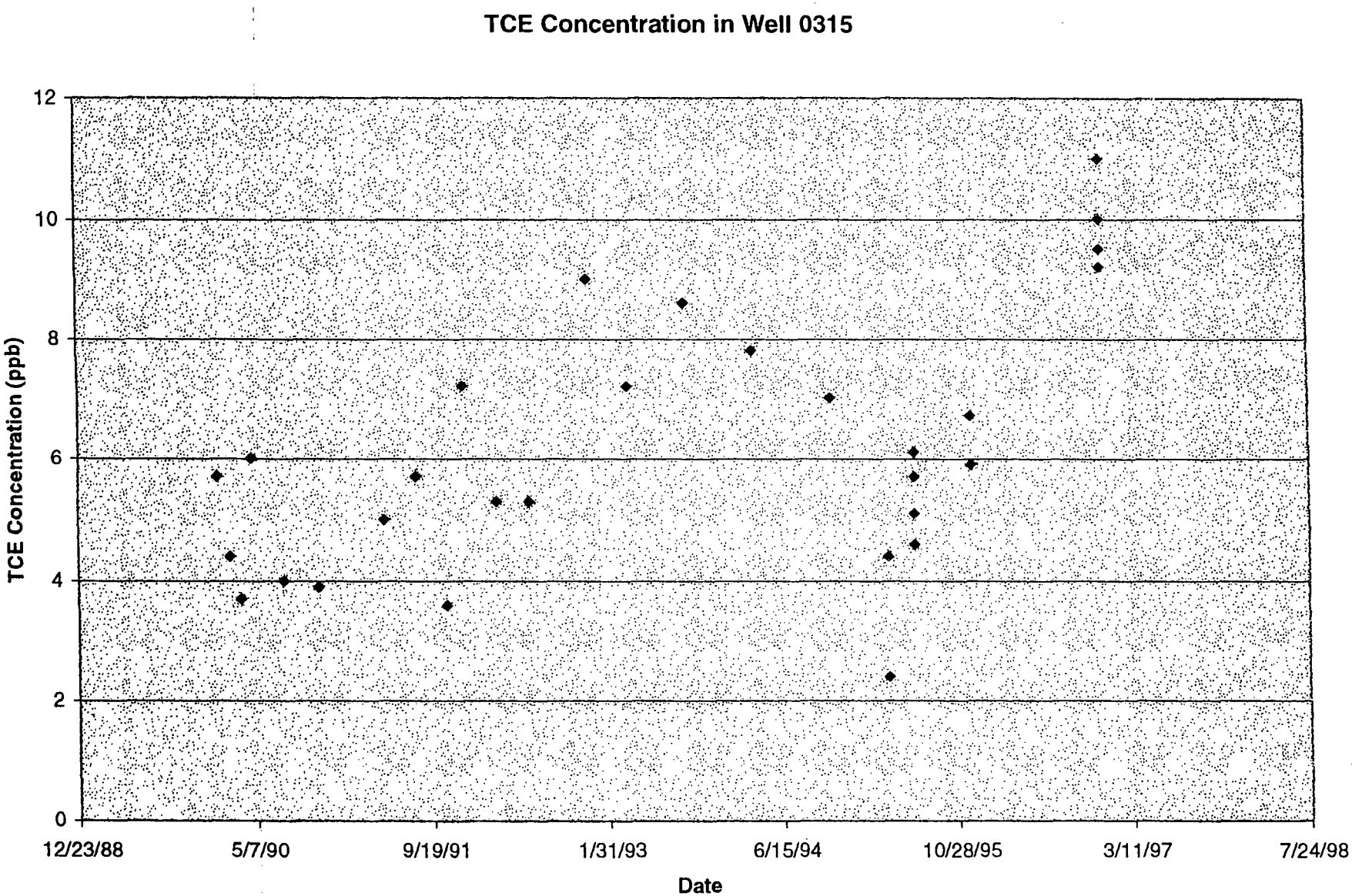
TCE Concentration in Well 0315
TCE Concentration (ppb)
12
10
8
6
4
2
0
12/23/88
5/7/90
9/19/91
1/31/93
6/15/94
10/28/95
3/11/97
7/24/98
Date

Figure 3

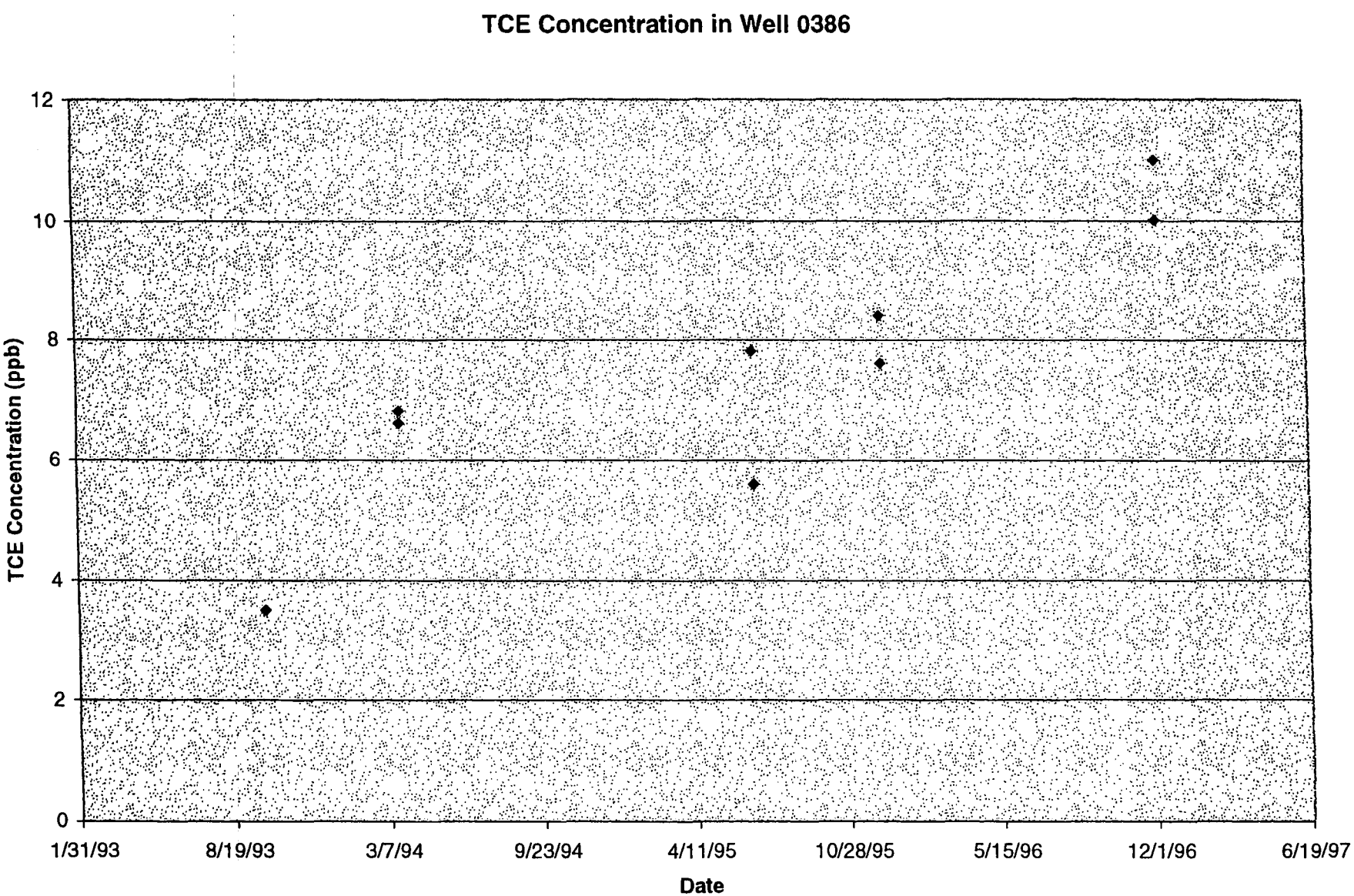
TCE Concentration in Well 0386
TCE Concentration (ppb)
12
10
8
6
4
2
0
1/31/93
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
Date

Figure 4

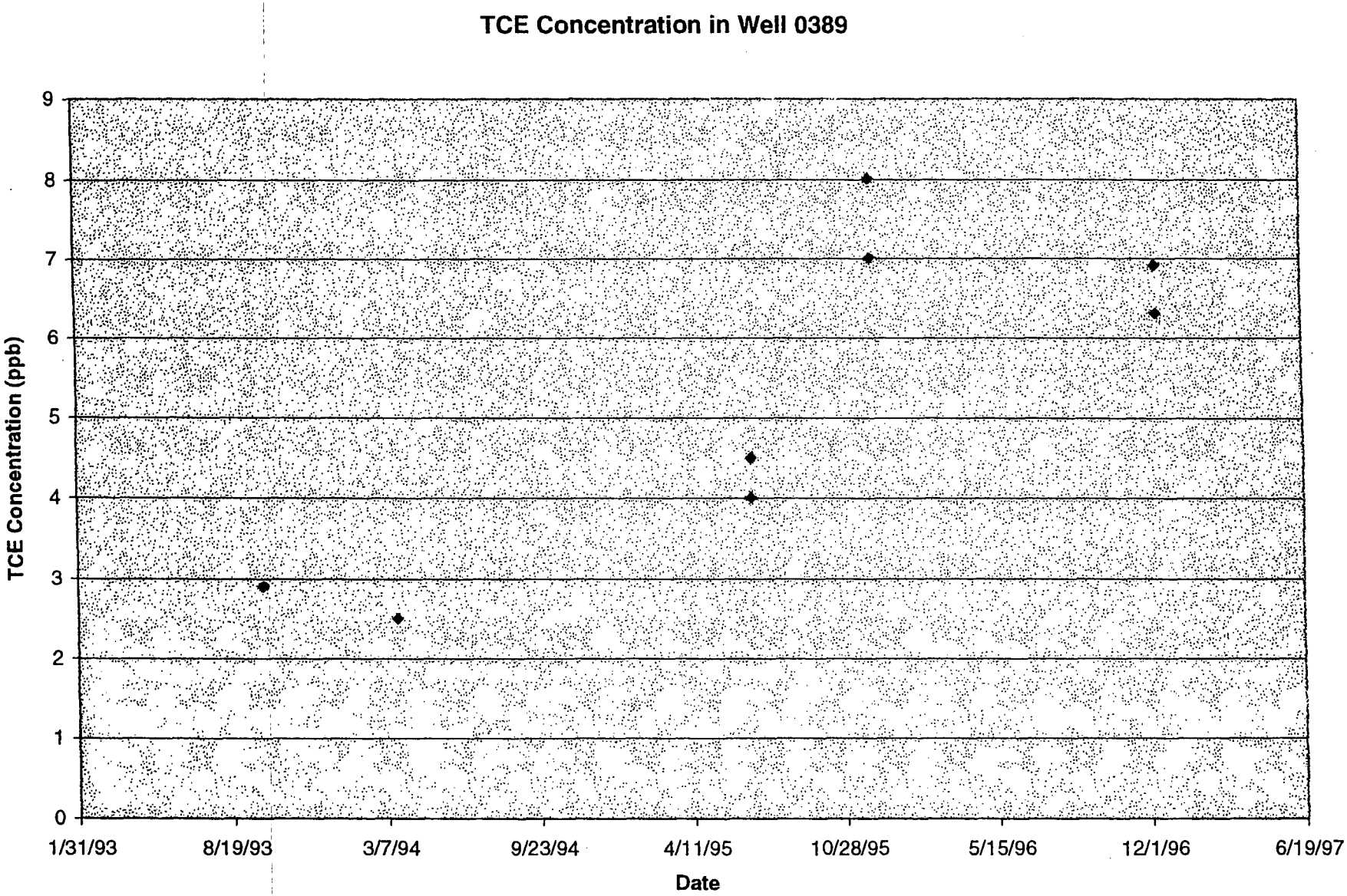
TCE Concentration in Well 0389
TCE Concentration (ppb)
0
1
2
3
4
5
6
7
8
9
1/31/93
8/19/93
3/7/94
9/23/94
4/11/95
10/28/95
5/15/96
12/1/96
6/19/97
Date

Figure 5

1.3 Previous Investigations

Soil gas surveys conducted at the Mound Facility in 1987 indicated elevated levels of VOCs in the soils adjacent to Building 19 (DOE, 1989). As a result, in 1989, monitoring well 0312 was installed to the west of Building 19. Additional soil gas surveys were conducted at the Mound Facility in 1992 and 1994. The 1992 survey was designed as a reconnaissance survey with the objective of providing data to enhance the planning of future site characterization (DOE, 1992). Two surveys were conducted in 1994. The first survey was site specific in that samples were collected from areas surrounding or near several buildings: Paint Shop, M, WD, DS, G and GW (DOE, 1994a). The second survey utilized the "Petrex" soil sampling methodology. Petrex samples are small canisters with an activated charcoal absorption element. The canisters are installed 18" below the surface with the charcoal element exposed to the soil gas for a specified time period (DOE, 1995). The 1992 and the first 1994 survey involved collection of shallow (generally less than 5 feet) soil gas samples, while the second 1994 survey sampled soil gas throughout the vertical soil profile. The results of all surveys indicated the occurrence of many low concentration detections located across much of the site with a limited number of locations showing relatively elevated (greater than 1,000 ppb v/v)VOC soil gas concentrations. Of particular interest to the current investigation are the 1992 soil gas survey results showing slightly elevated (66 ppb v/v) TCE concentrations adjacent to Building 19.

1.4 Investigation Plan

Technical experts devised an investigation plan consisting of :

a. Review of historical information including aerial photographs and the history of waste management at the Mound Plant.

b. Review of existing groundwater hydraulic (flow) data for the monitoring wells of interest.

c. Complete sampling and analysis using direct push technology (DPT) and real time sampling analysis.

This LFI Report describes the results of those investigations.

2.0 RESULTS

2.1 Historical Review

A historical review of waste management activities at the Mound Plant did not reveal any documented treatment of storage or disposal activities with the exception of activities at OU 1 involving VOCs near the area of investigation (DOE, 1993). Historical aerial photographs were used to identify suspect areas within the area of investigation. The photographs spanned the time period from 1949 through 1985. Additionally, the Operable Unit 9, Site Scoping Report Volume 6, Photo History Report was reviewed. These suspect areas are:

Area 1 Identified on a 1949 aerial photograph (unpublished, scale 1" = 200') as a drainage ditch from the top of the main hill. This ditch could have captured and carried contaminants from the main hill, if any were present. There is no documented history of discharge of contaminants into the ditch.

Area 2 This area was identified on the 1959 photograph (scale 1" = 800') as fill material and later on the 1965 photograph it appeared that drums were staged at this location.

Area 3 The 1965 photograph (unpublished, no scale) indicated the presence of drums being stored at this location.

Area 4 The 1968 aerial photograph (scale 1" = 1000') showed drums staged along the north side of Building 67.

Area 5 A vehicle turn around area was identified on the 1959 photograph (scale 1" = 800'). There is no documentation of waste treatment, storage or disposal at the turnaround.

Area 6 The 1973 photograph (scale 1" = 1000') showed potential cargo boxes along the railroad spur. There is no documentation of VOCs in the cargo boxes.

Area 7 The 1973 photograph (scale 1" = 1000') revealed the presence of possible drum storage in this area to the northwest of the present day large retention basin.

Area 8 Operable Unit 5, Area 3 Petrex soil gas study detected elevated halogenated hydrocarbons.

The historical review did not find written documentation to confirm or refute treatment, storage or disposal of VOCs at the locations indicated by the photographic record. The suspect areas are shown in Figure 6.

A review of the current Potential Release Site (PRS) map indicates several PRSs lie within the area encompassing the suspect areas. None of the PRSs coincides directly with an identified suspect area. These PRSs do not involve contamination associated with halogenated organic compounds.

2.2 Field Sampling and Analysis

A 50 foot by 50 foot sampling grid was designed that allowed efficient coverage of the large sample area at a frequency that would allow trends in soil and groundwater contamination to become apparent. Figure 6 shows the grid layout superimposed over the study area.

Sampling involved utilizing a van-mounted hydraulically driven Geoprobe™ Model M sampling probe. It uses DPT to force a sampling probe into the ground. The van was also equipped with a gas chromatograph allowing for immediate VOC analysis of soil gas and groundwater samples. At each sampling location, in-situ soil gas samples were collected at five foot intervals until groundwater was encountered. Once groundwater was encountered, groundwater samples were collected every five feet until bedrock was encountered. Results of the onsite analysis of soil gas and groundwater VOC concentrations were plotted on the sampling grid to identify contamination trends and help identify areas requiring more detailed sampling.

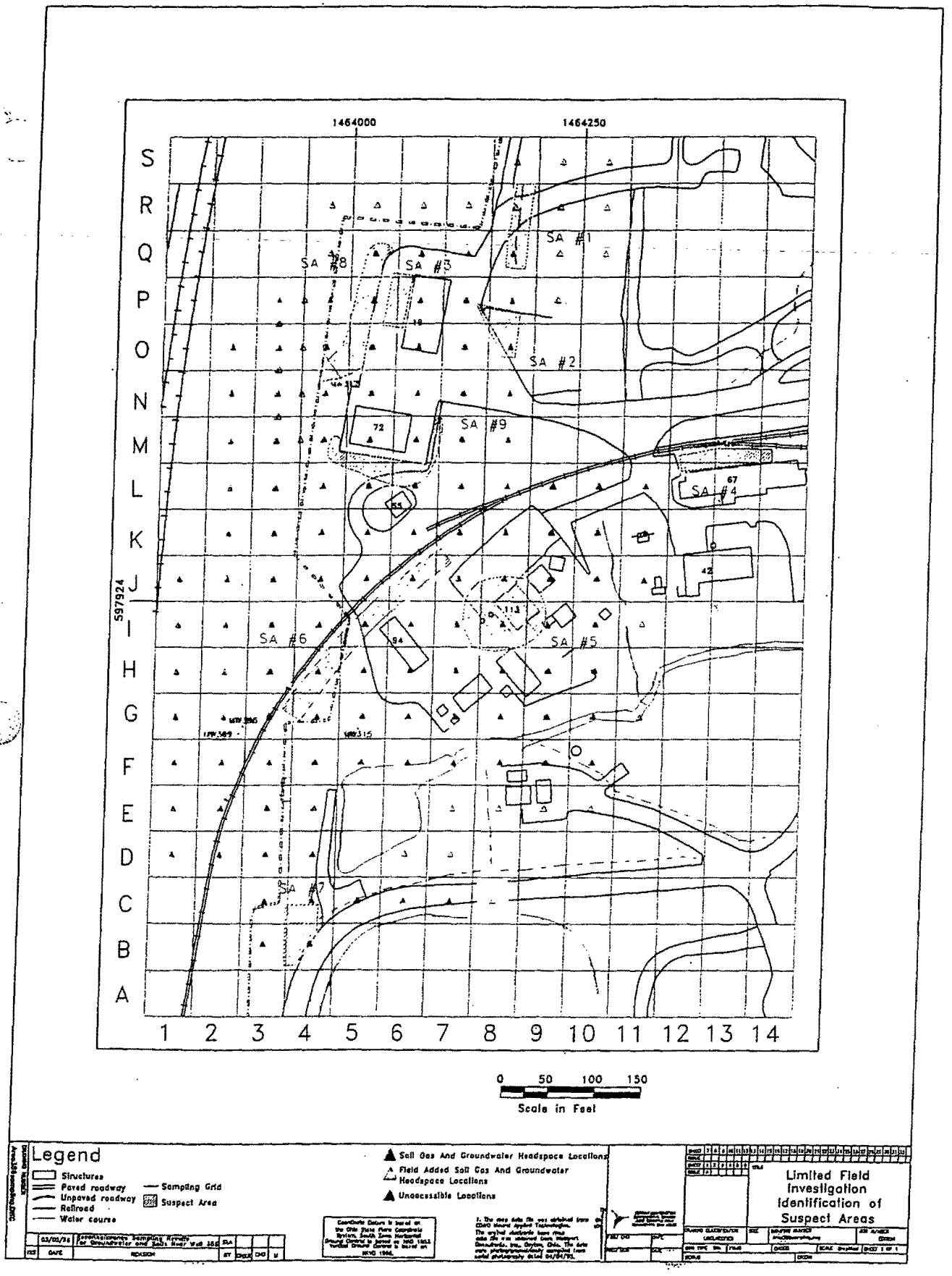

Figure 6 - "Suspect Areas" & Grid Layout

2.2.1 Field Results

The results of the field sampling are shown in Appendix A. Figure 7 shows the spatial distribution of the highest VOC concentration soil gas sample and groundwater sample detected at each sampling location Figures 8 and 9 show the distribution of TCE soil gas and 1,1,1-Trichloroethane (TCA) soil gas detections greater than 5 ppb respectively. Bulk soil confirmation samples were collected and analyzed to verify the field results. The bulk soil results for TCE are shown in Appendix B.

Examination of the data indicate that there is no discernable trend in soil gas or groundwater VOC concentrations. A large proportion of the sampling locations showed either non detectable quantities of VOCs in both soil gas and groundwater or extremely low levels. The field results indicate that the only trend or pattern observed are in the form of the isolated VOC hotspot found near monitoring well 0312. As a result, the remainder of this report will focus on the region around well 0312.

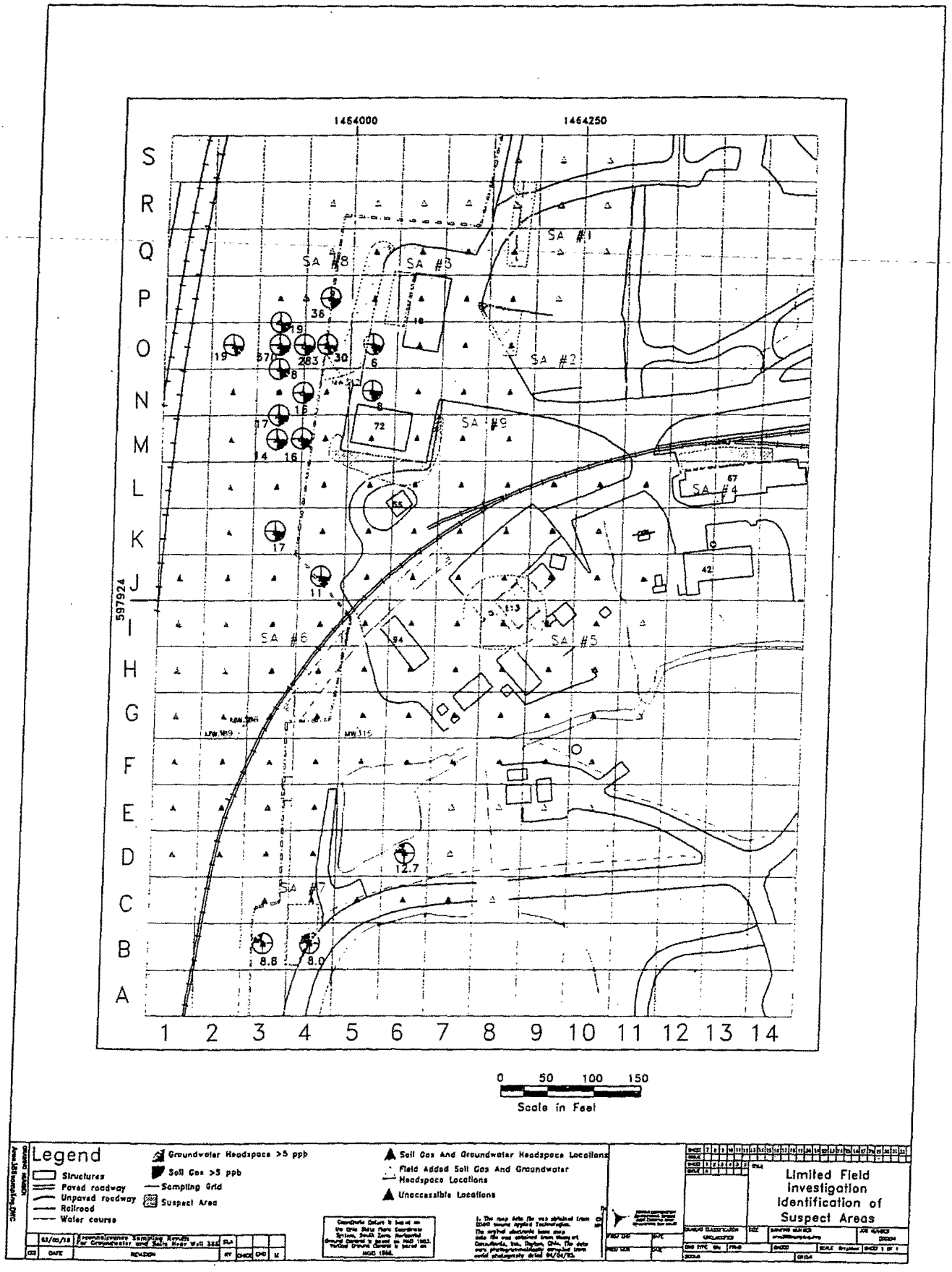

Figure 7 - Highest VOC Concentrations

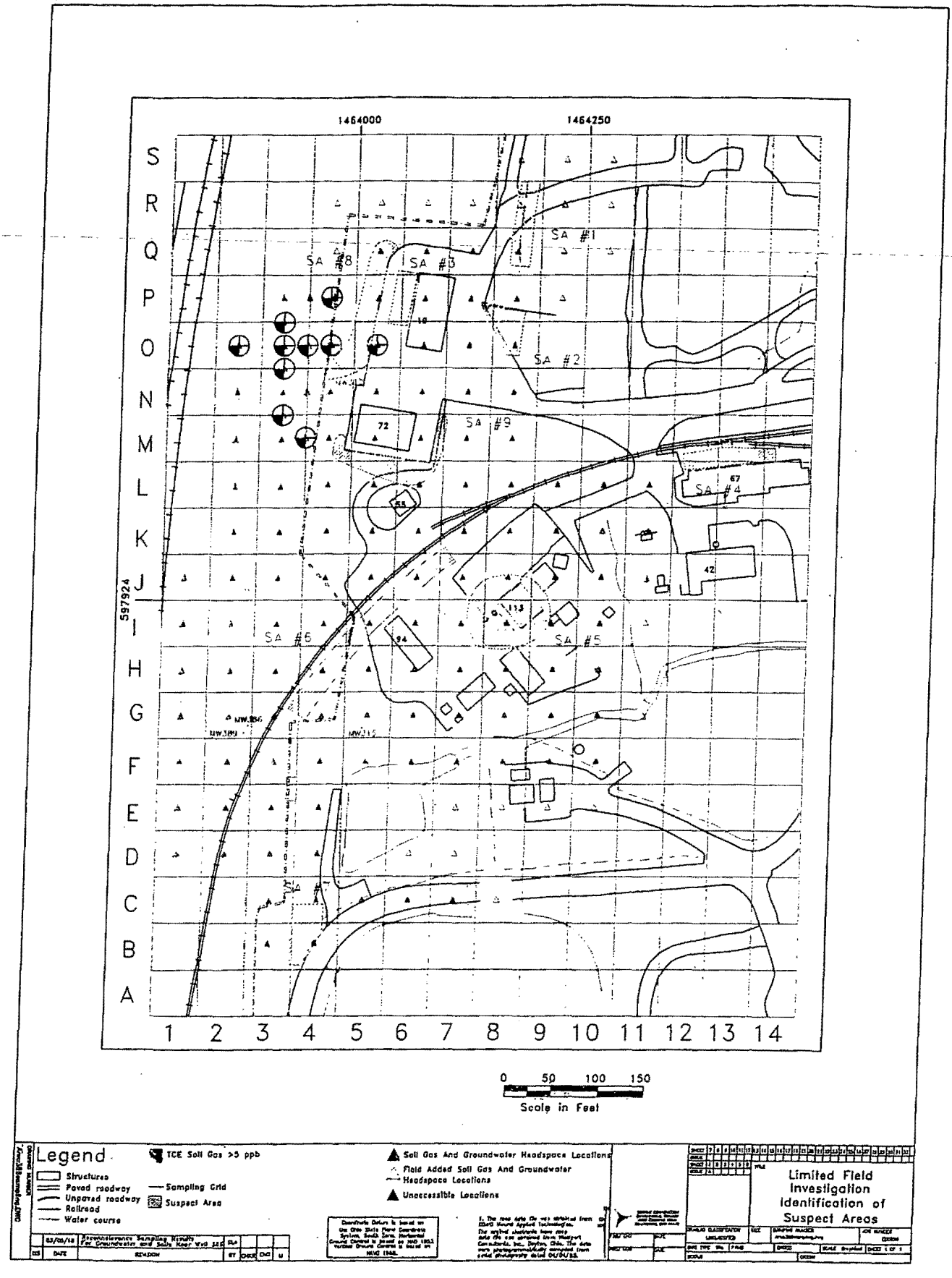

Figure 8 - TCE Soil Gas > 5 ppb

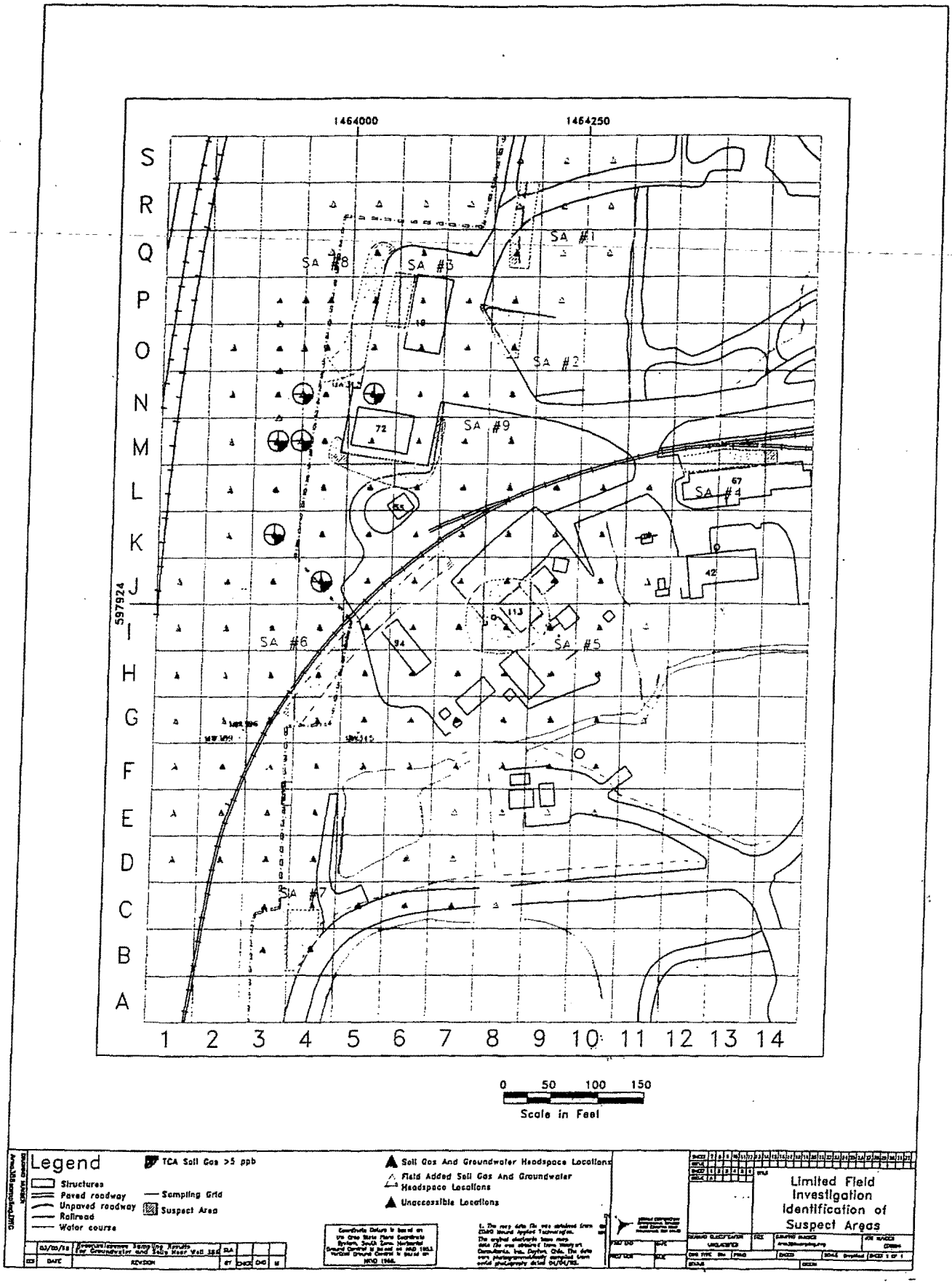

Figure 9 - TCA Soil Gas > 5 ppb

3.0 DISCUSSION OF AREA NEAR MONITORING WELL 0312

3.1 Geology

Well 0312 is located just beyond the plant boundary to the west of Building 19. Well 0312 was installed in late 1989. The well is a four inch diameter stainless steel well screened across the vadose zone-bedrock interface. Figure 10 shows the geologic log associated with well 0312. The lithologic sequence consists of sandy clays in the upper 15 feet grading to an approximately 8 foot thick section of clayey sandy gravel overlying greenish-grey shale bedrock. The bedrock surface slopes fairly steeply in the vicinity of the well with elevation rising rapidly to the northeast and dropping quickly to the southwest (see Figure 11). The well is screened considerably above the BVA water table elevation and therefore is not in direct hydraulic connection with BVA groundwater.

3.2 Groundwater Data

An analysis of historical groundwater levels in monitoring well 0312 reveals that the well consistently holds water at an elevation of approximately 700 feet (Figure 12). This data seems to contradict water level monitoring data from other Mound wells, which indicates seasonal fluctuations of groundwater. The water level data indicates that well 0312 may simply act as a "sump" pit, intercepting and collecting water moving down slope along the soil-bedrock interface with subsequent transfer out of the well into the fractured bedrock. Although not verified by field results, the inflow to the well most likely represents a small flux of water associated with unsaturated flow along the soil-bedrock interface. The rate of inflow into the well appears to meet the rate of outflow as evidenced by the relatively constant water elevation of 700 ft. If the well was actually in contact with a saturated portion of the bedrock it would be anticipated that the water levels would vary considerably more than is seen in the data. The variation would reflect the periodic response of the water table to precipitation recharge events.

The following field data lends indirect evidence in support of the above hypothesis:

a. Falling head tests previously conducted to determine hydraulic characteristics of the bedrock flow system indicate that wells screened in the upper portion of the fracture carapace are able to sustain water inflow rates less than 1 gallon per minute (gpm) (DOE, 1994b). The likelihood of a low inflow rate, controlled by the hydraulic conductivity of the rock, is consistent with the concept that well 0312 may act as a sump, intercepting water across the soil/bedrock interface and subsequently transferring water out through the fracture zone (i.e. inflow rate approximately equal to the outflow rate).

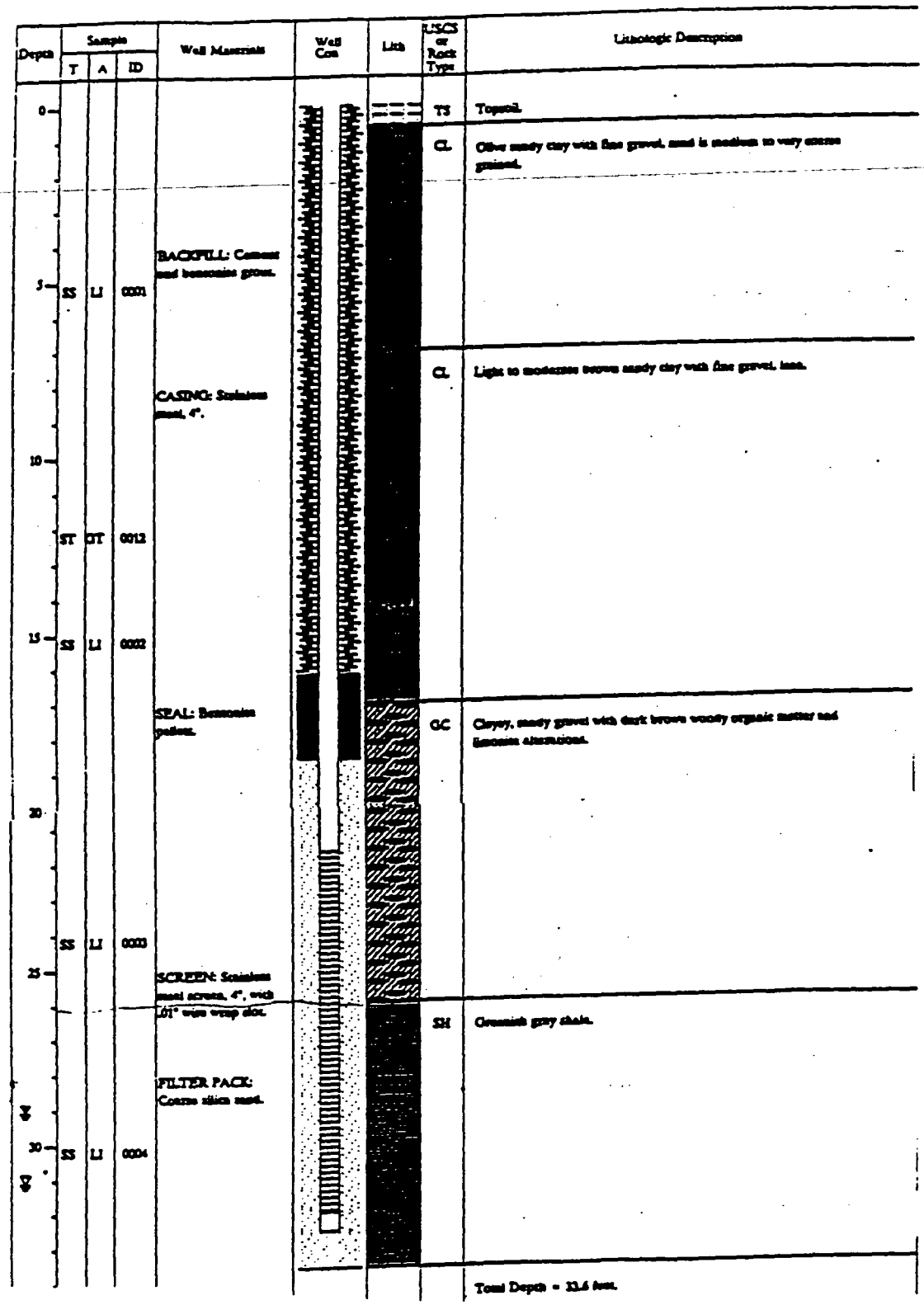

Figure 10 - Geologic Log of Well 0312

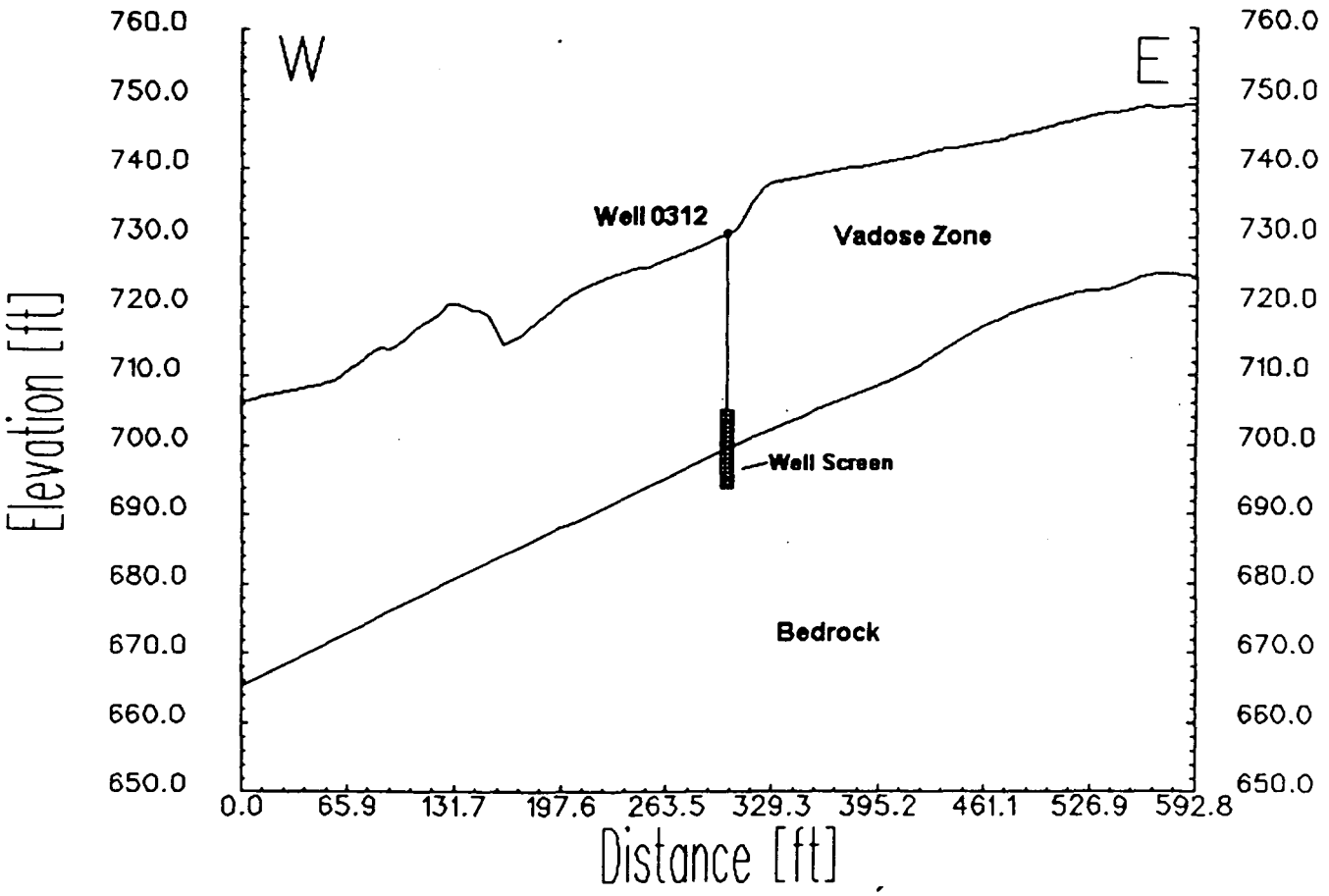

Figure 11 - Cross Section

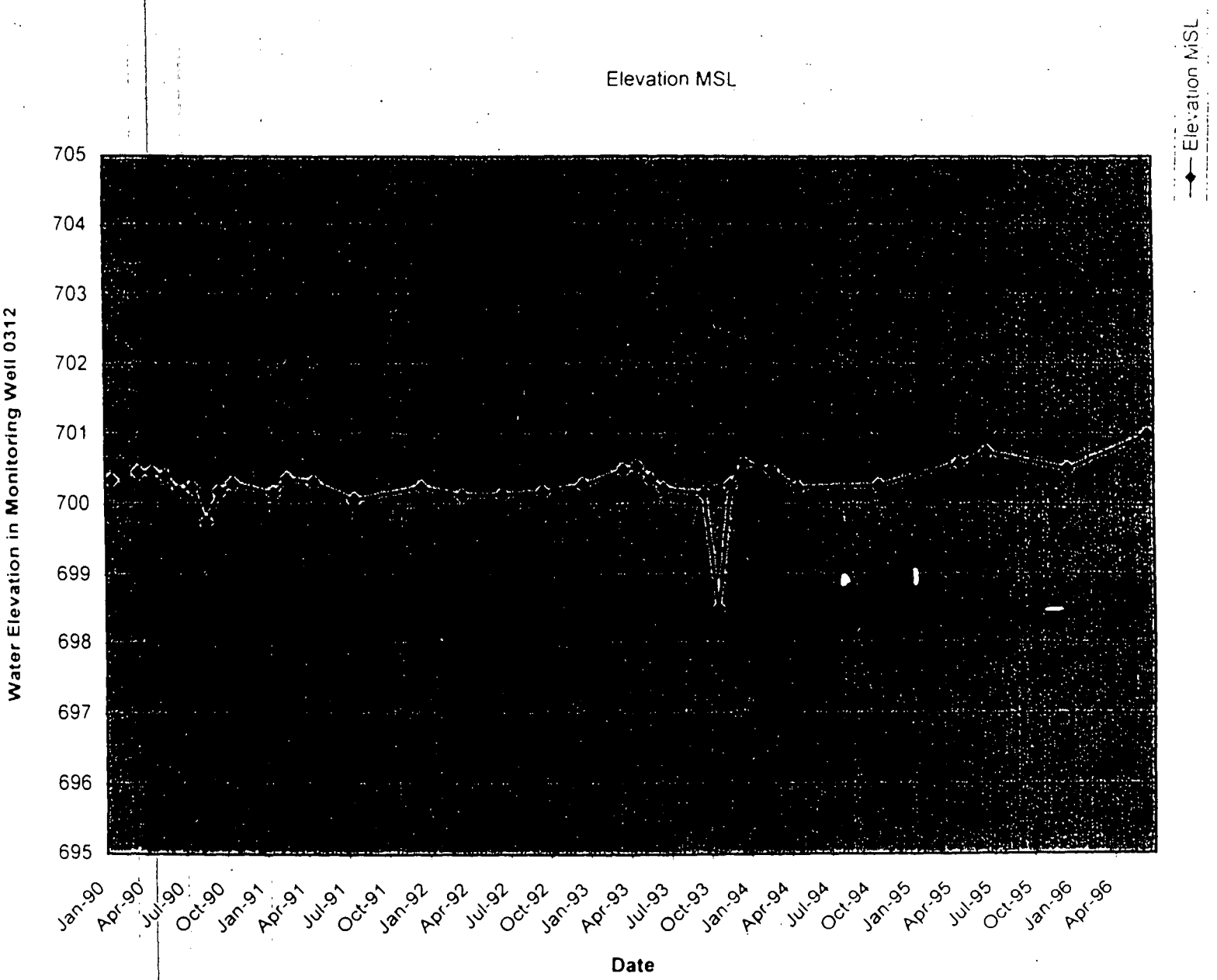

Figure 12 - Water in Well 0312

b. During the geoprobe field study, a 2 inch continuous soil core sample was collected near 0312. It was noted that the soil at the bedrock interface was quite moist relative to the sediments in the upper portion of the sequence. This information supports the concept that the soil/bedrock interface collects and transfers water down slope.

c. Seep 601 data indicates a continual source of water uphill from well 0312. Figure 13 shows seep discharge in gallons per minute throughout the year. The seep flows year round even during extended periods of little or no precipitation. The continual water source has been speculated to represent leakage from pressurized underground water utility lines.

Appendix E contains a hypothetical determination of potential water flux into well 0312 utilizing estimated hydraulic parameters for the soil. The calculation shows it is reasonable to conclude the well may be receiving continual inflow from the overlying unsaturated interface.

Vertical infiltration of water through the vadose from precipitation and precipitation runoff is also a likely source of recharge to well 0312. A study was conducted to determine the spatial relationship of the fluid potential in the vicinity of well 0312. Fluid potential is an important measure of the energy status of soil water, and spatial differences in potential indicate direction of soil-water movement (Stephens, 1996). Three tensiometers were installed at depths of 24, 36 and 60 inches below the surface. The tensiometers measure soil suction in centibars (this gives a direct measure of the fluid potential in the soils adjacent to the tensiometer). Data from the tensiometers were collected during August and September of 1997. The data is presented in Figure 14. The data indicates a general decrease in soil water potential with depth between the tensiometers installed between 24 and 36 inches. This would indicate a downward flow gradient. In the case of the deeper tensiometer, the data appears to show the opposite trend. This is most likely due to transient variances in the soil water content throughout the soil rather than an indication of a long-term upward gradient.

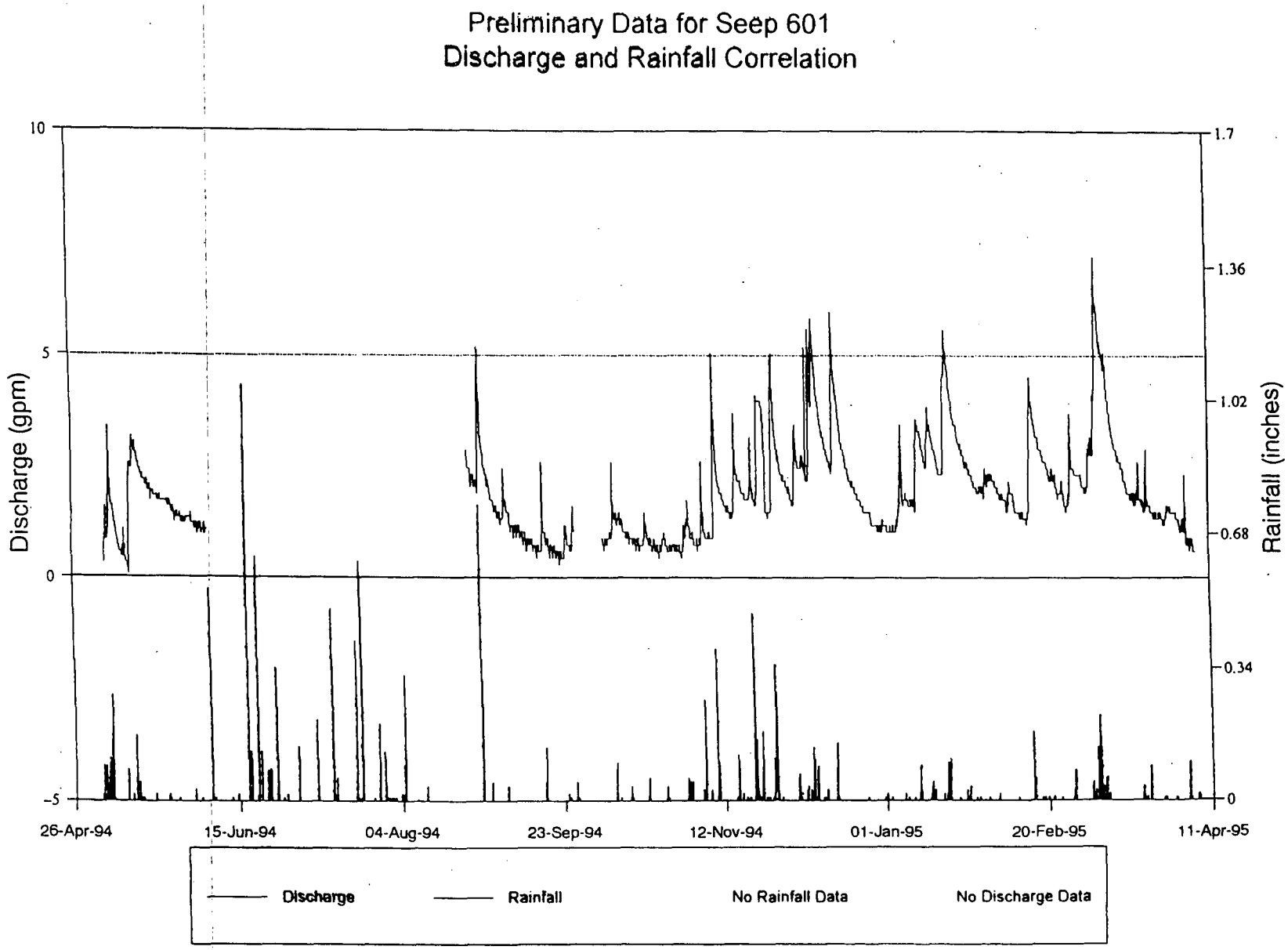
Preliminary Data for Seep 601
Discharge and Rainfall Correlation
Discharge (gpm)
Rainfall (inches)
10
5
0
-5
1.7
1.36
1.02
0.68
0.34
0
26-Apr-94
15-Jun-94
04-Aug-94
23-Sep-94
12-Nov-94
01-Jan-95
20-Feb-95
11-Apr-95
Discharge
Rainfall
No Rainfall Data
No Discharge Data

Figure 13

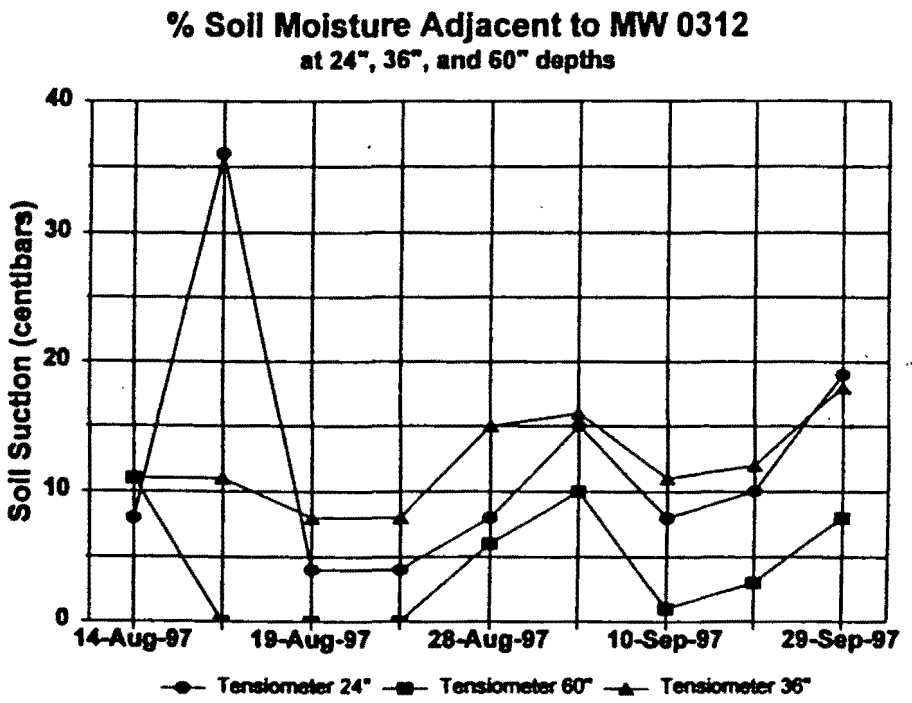

Figure 14 - Tensiometer Data

4.0 CONCLUSIONS

4.1 Discussion of Geoprobe Field Investigation

Results of the field soil gas and groundwater headspace analyses reveal no discernable trends in VOC contamination. There were isolated detections of 1,1,1-trichloroethane (TCA) in the soil gas and tetrachloroethene (PCE) in the groundwater headspace analyses. The LFI indicates that there is not a widespread VOC contaminant source in the soil or groundwater within the study area.

The VOC levels seen in monitoring wells 0315, 0386 and 0389 do not appear to be related to widespread soil or groundwater contamination. The data does indicate a region of elevated TCE soil gas levels in the vicinity of monitoring well 0312. Field gas chromatograph data indicates TCE soil gas levels in excess of 300 ppb in soils immediately west of monitoring well 0312. Sample grid-point O3 indicates elevated TCE soil gas levels at all depths sampled (Appendix A). The elevated levels suggest that there was likely a spill or other release of TCE onto the soil somewhere in the vicinity of monitoring 0312.

The highest soil gas levels encountered during the LFI were in the lower 300 ppb range. This represents less than a few hundredths of a percent of the TCE saturated vapor concentration. The field data therefore suggest that the TCE soil gas levels are not indicative of highly contaminated soil but rather appears to represent low level residual TCE contamination in the soil.

4.2 Discussion of Possible Mechanisms for Transport of Contaminant to Well 0312

Two mechanisms for transfer of water into well 0312 were discussed in Section 3. Those two physical mechanisms are: 1) interception of water moving in the vadose zone along the soil-bedrock interface and 2) intercepting water moving vertically through the vadose zone into the upper well screen of well 0312. The first mechanism involves transport of water to the well from a water source up slope from well 0312. That water source has been suggested to represent the same source that supplies continual flow to seep 601 (i.e. buried leaky pressurized water utility lines). The second mechanism involves downward percolation of water resulting from precipitation events. The contaminant source for each mechanism appears to represent two unrelated sources. In Case 1 (interception of water moving along the interface), examination of the LFI field data does not indicate soil contamination up slope from well 0312. However, the water chemistry data collected from seep 601 reveals that seep water does have low concentrations of VOCs including TCE. This most likely represents a situation where the source is located outside the area covered by this LFI. In Case 2 (downward percolation of water through the vadose zone)

the field data clearly shows a potential TCE source zone in the vicinity of well 0312. The source zone could be associated with the previously identified suspect Area #3 (a 1965 aerial photograph showing potential drum storage behind Building 19). Data from the tensiometer study supports the water percolation mechanism showing that a downward hydraulic gradient is present in the upper vadose zone. As water infiltrates down through the vadose zone it comes into contact with the TCE contaminated soils. TCE could then partition into the liquid phase and subsequently be transferred down to the well screen and into the wellbore.

5.0 SUMMARY

5.1 Additional Field Work to Further Refine Source Areas

The LFI demonstrated that there is not a widespread source of VOC contamination in the soils and groundwater within the study area. There are several isolated hot-spots. These isolated hot spots are not reflected in widespread elevated VOCs in groundwater and are not therefore providing a significant source of VOCs to the Buried Valley Aquifer. Mound continues to maintain an extensive groundwater monitoring network capable of detecting the movement of VOC contaminants from the study area into the BVA. As a result, it is sufficient to continue to periodically monitor the wells for VOCs in the study area and down gradient of the study area.

5.2 Elevated Soil TCE Concentrations in the Vicinity of Well 0312

The LFI showed localized TCE soil contamination near well 0312. This region is at an elevation significantly above the BVA (i.e. BVA water elevation is approximately 680 ft MSL and the base of the screen at well 0312 is at an elevation of approximately 700 ft MSL). The Mound soil screening guidance equations were applied to the soils overlying the bedrock aquifer system in the vicinity of well 0312 to evaluate the potential for these soils to serve as a source of TCE to the BVA. The model results indicate that the soils may serve as a source of leachate to the BVA with dissolved TCE concentration in excess of 5 ppb, (see Appendix C). Additional work conducted by the Ohio Environmental Protection Agency suggests that given bulk soil TCE concentration in excess of 800 ug/kg (highest soil confirmation sample) it is theoretically possible to achieve TCE concentrations of about 80 ppb at the edge of the BVA, (see Appendix D).

6.0 REFERENCES

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Stephens, D.B. "Vadose Zone Hydrology". CRC, Lewis Publishers, 1996.

APPENDIX A

Field Data

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
B3	08-Jul-97	SG	TCE	10	ND	5	
B3	08-Jul-97	SG	TCE	15	ND	5	
B3	08-Jul-97	SG	TCE	25	ND	5	
B3	08-Jul-97	GW	TCE	38.9	0.7	5	J
B3	08-Jul-97	GW	TCA	38.9	0.3	5	J
B3	08-Jul-97	GW	PCE	38.9	8.8	5	
B4	14-May-97	SG	TCE	5	ND	5	
B4	14-May-97	SG	TCE	10	ND	5	
B4	14-May-97	SG	TCE	15	ND	5	
B4	14-May-97	GW	TCE	34	0.9	5	J
B4	14-May-97	GW	PCE	34	6.7	5	
B4	14-May-97	GW	TCE	39.2	1.5	5	J
B4	14-May-97	GW	PCE	39.2	8	5	
C3	08-Jul-97	SG	TCA	5	0.4	5	J
C3	08-Jul-97	SG	TCE	5	ND	5	
C3	08-Jul-97	SG	TCE	10	ND	5	
C3	08-Jul-97	SG	PCE	10	0.4	5	J
C3	08-Jul-97	SG	TCA	10	0.1	5	J
C3	08-Jul-97	SG	TCE	15	ND	5	
C3	08-Jul-97	SG	PCE	15	0.1	5	J
C3	08-Jul-97	SG	TCA	15	0.4	5	J
C3	08-Jul-97	SG	TCE	20	ND	5	
C3	08-Jul-97	SG	PCE	20	0.7	5	J
C3	08-Jul-97	SG	TCA	20	0.6	5	J
C3	08-Jul-97	SG	TCE	25	ND	5	
C3	08-Jul-97	SG	PCE	25	0.7	5	J
C3	08-Jul-97	SG	TCA	25	0.5	5	J
C3	08-Jul-97	SG	TCE	28	ND	5	
C3	08-Jul-97	SG	PCE	28	0.2	5	J
C3	08-Jul-97	SG	TCA	28	0.5	5	J
C3	08-Jul-97	GW	No Water Detected				
C4	13-May-97	SG	TCE	5	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
D3	09-Jul-97	SG	TCE	25	ND	5	
D3	09-Jul-97	SG	TCA	25	0.4	5	J
D3	09-Jul-97	SG	PCE	25	0.3	5	J
D3	09-Jul-97	GW	TCE	32.4	ND	5	
D3 - Dup. Sample	09-Jul-97	SG	TCE	20	ND	5	
D3 - Dup. Sample	09-Jul-97	SG	TCA	20	0.1	5	J
D3 - Dup. Sample	09-Jul-97	SG	PCE	20	0.1	5	J
D4	13-May-97	SG	TCE	5	ND	5	
D4	13-May-97	SG	TCE	10	ND	5	
D4	13-May-97	SG	TCE	15	ND	5	
D4	13-May-97	GW	TCE	21.2	ND	5	
D6	16-May-97	SG	TCE	5	ND	5	
D6	16-May-97	SG	TCE	10	ND	5	
D6	16-May-97	SG	TCE	15	ND	5	
D6	16-May-97	SG	TCE	20	ND	5	
D6	16-May-97	GW	TCE	38	ND	5	
D6	16-May-97	GW	TCA	38	4.6	5	J
D6	16-May-97	GW	PCE	38	2.5	5	J
D6	16-May-97	GW	TCE	43.2	ND	5	
D6	16-May-97	GW	TCA	43.2	2.7	5	J
D6	16-May-97	GW	PCE	43.2	12.7	5	
D6 - Dup. Sample	16-May-97	GW	TCE	43.2	ND	5	
D6 - Dup. Sample	16-May-97	GW	TCA	43.2	2.5	5	J
D6 - Dup. Sample	16-May-97	GW	PCE	43.2	12.8	5	
D7	19-May-97	SG	TCE	10	ND	5	
D7	19-May-97	GW	No Water Detected				
E1		SG	Obstructed by Trees and Grade			5	J
E1		GW	Obstructed by Trees and Grade			5	J
E10	22-May-97	SG	TCE	24	ND	5	
E10	22-May-97	GW	No Water Detected				
E2	18-Jun-97	SG	TCE	5	ND	5	
E2	18-Jun-97	SG	TCE	10	ND	5	
E2	18-Jun-97	SG	TCE	15	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
F2	18-Jun-97	SG	TCE	20	ND	5	
F2	18-Jun-97	GW	TCE	45	0.3	5	J
F2	18-Jun-97	GW	TCA	45	1	5	J
F2	18-Jun-97	GW	TCE	50	0.4	5	J
F2	18-Jun-97	GW	TCA	50	1	5	J
F2	18-Jun-97	GW	TCE	55	0.5	5	J
F2	18-Jun-97	GW	TCA	55	1	5	J
F2	18-Jun-97	GW	TCE	59.2	2.1	5	J
F2	18-Jun-97	GW	TCA	59.2	1	5	J
F2	18-Jun-97	GW	PCE	59.2	1	5	J
F2 - Conf. Sample Lo	18-Jun-97	GW	TCE	49	0.4	5	J
F2 - Conf. Sample Lo	18-Jun-97	GW	TCE	53.8	0.1	5	J
F3		SG	Obstructed by Grade				
F3		GW	Obstructed by Grade				
F4	19-May-97	SG	TCE	10	ND	5	
F4	19-May-97	SG	TCE	15	ND	5	
F4	19-May-97	SG	TCE	20	ND	5	
F4	19-May-97	GW	No Water Detected				
F5		SG	Obstructed by Trees and Grade				
F5		GW	Obstructed by Trees and Grade				
F6		SG	Obstructed by Trees and Grade				
F6		GW	Obstructed by Trees and Grade				
F7		SG	Obstructed by Trees and Grade				
F7		GW	Obstructed by Trees and Grade				
F8		SG	Obstructed by Ditch and Grade				
F8		GW	Obstructed by Ditch and Grade				
F9	21-May-97	SG	TCE	10	ND	5	
F9	21-May-97	SG	TCE	25	ND	5	
F9	21-May-97	GW	No Water Detected				
G1		SG	Obstructed by Trees and Grade				
G1		GW	Obstructed by Trees and Grade				
G10	04-Jun-97	SG	TCE	5	ND	5	
G10	04-Jun-97	SG	TCE	10	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
G6	28-May-97	GW	TCE	38.9	ND	5	
G6 - Conf. Sample Lc	28-May-97	GW	TCE	43.8	ND	5	
G7	30-Jun-97	SG	TCE	10	ND	5	
G7	30-Jun-97	SG	TCE	30	ND	5	
G7	30-Jun-97	SG	TCE	35	ND	5	
G7	30-Jun-97	GW	TCE	15	ND	5	
G7	30-Jun-97	GW	TCA	15	0.3	5	J
G8	24-Jun-97	SG	TCE	5	ND	5	
G8	24-Jun-97	SG	TCE	10	ND	5	
G8	24-Jun-97	SG	TCE	15	ND	5	
G8	24-Jun-97	SG	TCE	35	ND	5	
G8	24-Jun-97	GW	No Water Detected				
G9	24-Jun-97	SG	TCE	5	ND	5	
G9	24-Jun-97	SG	TCE	10	ND	5	
G9	24-Jun-97	SG	TCE	15	ND	5	
G9	24-Jun-97	SG	TCE	20	ND	5	
G9	24-Jun-97	SG	TCE	25	ND	5	
G9	24-Jun-97	SG	TCE	30	ND	5	
G9	24-Jun-97	GW	No Water Detected				
H1		SG	Obstructed by Trees and Grade				
H1		GW	Obstructed by Trees and Grade				
H10	26-Jun-97	SG	TCE	5	ND	5	
H10	26-Jun-97	SG	TCE	10	ND	5	
H10	26-Jun-97	SG	TCE	15	ND	5	
H10	26-Jun-97	SG	TCE	20	ND	5	
H10	26-Jun-97	GW	No Water Detected				
H2		SG	Obstructed by Trees and Grade				
H2		GW	Obstructed by Trees and Grade				
H3	02-Jul-97	SG	TCE	5	ND	5	
H3	02-Jul-97	SG	TCE	10	ND	5	
H3	02-Jul-97	SG	TCE	15	ND	5	
H3	02-Jul-97	SG	TCE	20	ND	5	
H3	02-Jul-97	SG	TCE	25	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
I10	30-Jun-97	SG	TCE	20	ND	5	
I10	30-Jun-97	SG	TCE	25	ND	5	
I10	30-Jun-97	SG	TCE	30	ND	5	
I10	30-Jun-97	SG	TCE	35	ND	5	
I10	30-Jun-97	SG	TCE	40	ND	5	
I10	30-Jun-97	SG	TCE	54	ND	5	
I10	30-Jun-97	GW	TCE	10	ND	5	
I11	14-Jul-97	SG	TCE	5	ND	5	
I11	14-Jul-97	SG	TCE	15	ND	5	
I11	14-Jul-97	SG	TCE	20	ND	5	
I11	14-Jul-97	SG	TCE	25	ND	5	
I11	14-Jul-97	SG	TCE	30	ND	5	
I11	14-Jul-97	SG	TCE	35	ND	5	
I11	14-Jul-97	GW	No Water Detected				
I2		SG	Obstructed by Trees and Grade				
I2		GW	Obstructed by Trees and Grade				
I3	10-Jul-97	SG	TCE	5	ND	5	
I3	10-Jul-97	SG	TCE	10	ND	5	
I3	10-Jul-97	SG	TCE	15	ND	5	
I3	10-Jul-97	SG	TCE	20	ND	5	
I3	10-Jul-97	SG	TCE	25	ND	5	
I3	10-Jul-97	GW	No Water Detected				
I4	02-Jul-97	SG	TCE	5	ND	5	
I4	02-Jul-97	SG	TCE	10	ND	5	
I4	02-Jul-97	GW	No Water Detected				
I5	01-Jul-97	SG	TCE	5	ND	5	
I5	01-Jul-97	SG	TCE	10	ND	5	
I5	01-Jul-97	SG	TCE	20	ND	5	
I5	01-Jul-97	SG	TCE	35	ND	5	
I5	01-Jul-97	GW	No Water Detected				
I6	01-Jul-97	SG	TCE	5	ND	5	
I6	01-Jul-97	SG	TCE	10	ND	5	
I6	01-Jul-97	SG	TCE	15	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
J3	09-Jul-97	SG	TCE	20	ND	5	
J3	09-Jul-97	GW	No Water Detected				
J4	02-Jul-97	SG	TCE	5	ND	5	
J4	02-Jul-97	SG	TCE	10	ND	5	
J4	02-Jul-97	SG	TCA	10	7	5	
J4	02-Jul-97	SG	TCE	15	ND	5	
J4	02-Jul-97	SG	TCA	15	10.63	5	
J4	02-Jul-97	SG	TCE	20	ND	5	
J4	02-Jul-97	SG	TCA	20	7.7	5	
J4	02-Jul-97	SG	TCE	25	ND	5	
J4	02-Jul-97	SG	TCA	25	9.02	5	
J4	02-Jul-97	SG	TCE	28.6	ND	5	
J4	02-Jul-97	SG	TCA	28.6	6.23	5	
J4	02-Jul-97	GW	No Water Detected				
J4 - Dup. Sample	02-Jul-97	SG	TCE	25	ND	5	
J4 - Dup. Sample	02-Jul-97	SG	TCA	25	9.44	5	
J5	23-Jun-97	SG	TCE	35	ND	5	
J5	23-Jun-97	SG	TCE	38	ND	5	
J5	23-Jun-97	GW	No Water Detected				
J5 - Conf. Sample Loc	23-Jun-97	SG	TCE	5	ND	5	
J5 - Conf. Sample Loc	23-Jun-97	SG	TCE	15	ND	5	
J5 - Conf. Sample Loc	23-Jun-97	SG	TCE	25	ND	5	
J6	23-Jun-97	SG	TCE	5	ND	5	
J6	23-Jun-97	SG	TCE	35	ND	5	
J6	23-Jun-97	SG	TCE	45	ND	5	
J6	23-Jun-97	GW	TCE	23.2	ND	5	
J7	19-Jun-97	SG	TCE	5	ND	5	
J7	19-Jun-97	GW	No Water Detected				
J8	19-Jun-97	SG	TCE	5	ND	5	
J8	19-Jun-97	SG	TCE	10	ND	5	
J8	19-Jun-97	SG	TCE	15	ND	5	
J8	19-Jun-97	SG	TCE	20	ND	5	
J8	19-Jun-97	SG	TCE	25	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
K6	16-Jun-97	GW	No Water Detected				
K7	23-Jun-97	SG	TCE	5	ND	5	
K7	23-Jun-97	SG	TCE	10	ND	5	
K7	23-Jun-97	SG	TCE	25	ND	5	
K7	23-Jun-97	SG	TCE	28.4	ND	5	
K7	23-Jun-97	GW	No Water Detected				
K8	20-Jun-97	SG	TCE	15	ND	5	
K8	20-Jun-97	SG	TCE	20	ND	5	
K8	20-Jun-97	SG	TCE	25	ND	5	
K8	20-Jun-97	GW	No Water Detected				
K9	19-Jun-97	SG	TCE	5	ND	5	
K9	19-Jun-97	SG	TCE	15	ND	5	
K9	19-Jun-97	GW	No Water Detected				
L10	23-Jun-97	SG	TCE	5	ND	5	
L10	23-Jun-97	SG	TCE	10	ND	5	
L10	23-Jun-97	GW	No Water Detected				
L10 - Conf. Sample Lo	23-Jun-97	SG	TCE	20	ND	5	
L10 - Conf. Sample Lo	23-Jun-97	SG	TCE	30	ND	5	
L11	19-Jun-97	SG	TCE	5	ND	5	
L11	19-Jun-97	SG	TCE	10	ND	5	
L11	19-Jun-97	SG	TCE	15	ND	5	
L11	19-Jun-97	SG	TCE	20	ND	5	
L11	19-Jun-97	SG	TCE	25	ND	5	
L11	19-Jun-97	GW	No Water Detected				
L2		SG	Obstructed by Trees and Grade			5	J
L2		GW	Obstructed by Trees and Grade			5	J
L3	09-Jul-97	SG	No Soil Gas Detected				
L3	09-Jul-97	GW	No Water Detected				
L4	24-Jun-97	SG	TCE	5	ND	5	
L4	24-Jun-97	SG	TCE	10	ND	5	
L4	24-Jun-97	SG	TCE	22	ND	5	
L4	24-Jun-97	GW	No Water Detected				
L5	13-Jun-97	SG	TCE	5	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
M2		SG	Obstructed by Trees and Grade				
M2		GW	Obstructed by Trees and Grade				
M3	08-Jul-97	SG	TCE	5	ND	5	
M3	08-Jul-97	SG	TCE	10	0.47	5	J
M3	08-Jul-97	SG	TCE	15	1.31	5	J
M3	08-Jul-97	SG	TCA	15	12.86	5	
M3	08-Jul-97	SG	TCE	20	1.23	5	J
M3	08-Jul-97	SG	TCA	20	13.76	5	
M3	08-Jul-97	SG	TCE	23	1.02	5	J
M3	08-Jul-97	SG	TCA	23	12.91	5	
M3	08-Jul-97	GW	No Water Detected				
M3 - Conf. Sample Lo	08-Jul-97	SG	TCE	5	ND	5	
M3 - Conf. Sample Lo	08-Jul-97	SG	TCE	10	ND	5	
M3 - Conf. Sample Lo	08-Jul-97	SG	TCE	15	ND	5	
M3 - Conf. Sample Lo	08-Jul-97	SG	TCE	20	ND	5	
M3 - Conf. Sample Lo	08-Jul-97	SG	TCA	20	11.3	5	
M4	24-Jun-97	SG	TCE	5	ND	5	
M4	24-Jun-97	SG	TCE	15	ND	5	
M4	24-Jun-97	SG	TCE	20	ND	5	
M4	24-Jun-97	SG	TCE	22	ND	5	
M4	24-Jun-97	GW	No Water Detected				
M5	17-Jun-97	SG	TCE	5	ND	5	
M5	17-Jun-97	SG	TCE	10	ND	5	
M5	17-Jun-97	SG	TCE	25	ND	5	
M5	17-Jun-97	SG	TCE	30	ND	5	
M5	17-Jun-97	SG	TCE	35	ND	5	
M5	17-Jun-97	GW	No Water Detected				
M6	10-Jun-97	SG	TCE	5	ND	5	
M6	10-Jun-97	SG	TCE	10	ND	5	
M6	10-Jun-97	SG	TCE	15	ND	5	
M6	10-Jun-97	GW	No Water Detected				
M7	12-Jun-97	SG	TCE	5	ND	5	
M7	12-Jun-97	SG	TCE	10	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
N2	04-Aug-97	SG	TCE	5	ND	5	
N2	04-Aug-97	SG	TCE	10	ND	5	
N2	04-Aug-97	SG	TCE	15	ND	5	
N2	04-Aug-97	SG	TCE	20	ND	5	
N2	04-Aug-97	SG	TCE	25	ND	5	
N2	04-Aug-97	SG	TCE	30	ND	5	
N2	04-Aug-97	SG	TCE	30.8	ND	5	
N2	04-Aug-97	GW	No Water Detected				
N3	08-Jul-97	SG	TCE	5	0.56	5	J
N3	08-Jul-97	SG	TCE	10	0.78	5	J
N3	08-Jul-97	SG	TCE	15	1.02	5	J
N3	08-Jul-97	SG	TCE	20	1.09	5	J
N3	08-Jul-97	SG	TCE	25	1.83	5	J
N3	08-Jul-97	SG	TCE	30	0.19	5	J
N3	08-Jul-97	GW	No Water Detected				
N4	07-Jul-97	SG	TCE	5	ND	5	
N4	07-Jul-97	SG	TCE	25	ND	5	
N4	07-Jul-97	SG	TCE	28.7	ND	5	
N4	07-Jul-97	GW	No Water Detected				
N5	01-Jul-97	SG	TCE	7	ND	5	
N5	01-Jul-97	SG	TCA	7	2.39	5	J
N5	01-Jul-97	SG	TCE	12	ND	5	
N5	01-Jul-97	SG	TCA	12	2.86	5	J
N5	01-Jul-97	SG	TCA	17	4.69	5	J
N5	01-Jul-97	SG	TCE	17	ND	5	
N5	01-Jul-97	SG	TCE	22	ND	5	
N5	01-Jul-97	SG	TCA	22	5.02	5	
N5	01-Jul-97	SG	TCE	27	ND	5	
N5	01-Jul-97	SG	TCA	27	5.1	5	
N5	01-Jul-97	SG	TCE	32	ND	5	
N5	01-Jul-97	SG	TCA	32	7.89	5	
N5	01-Jul-97	SG	TCE	37	ND	5	
N5	01-Jul-97	SG	TCA	37	7.81	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
O2	31-Jul-97	SG	TCE	15	10.8	5	
O2	31-Jul-97	SG	TCA	15	0.3	5	J
O2	31-Jul-97	SG	TCE	20	9.8	5	
O2	31-Jul-97	SG	TCA	20	0.7	5	J
O2	31-Jul-97	SG	TCE	25	18.8	5	
O2	31-Jul-97	SG	TCA	25	0.6	5	J
O2	31-Jul-97	SG	TCE	28.7	ND	5	
O2	31-Jul-97	GW	No Water Detected				
O3	07-Jul-97	SG	TCE	5	283.77	5	
O3	07-Jul-97	SG	TCE	10	329.92	5	
O3	07-Jul-97	SG	TCE	15	328.83	5	
O3	07-Jul-97	SG	TCE	20	367.72	5	
O3	07-Jul-97	SG	TCE	25	308.24	5	
O3	07-Jul-97	GW	No Water Detected				
O3 - Conf. Sample Lc	07-Jul-97	SG	TCE	5	18.98	5	
O3 - Conf. Sample Lc	07-Jul-97	SG	TCE	10	1.79	5	J
O3 - Conf. Sample Lc	07-Jul-97	SG	TCE	20	96.61	5	
O3 - Conf. Sample Lc	07-Jul-97	SG	TCE	25	158.88	5	
O4	03-Jul-97	SG	TCE	5	29.6	5	
O4	03-Jul-97	SG	TCA	5	2.6	5	J
O4	03-Jul-97	SG	TCE	10	13.02	5	
O4	03-Jul-97	SG	TCA	10	2.4	5	J
O4	03-Jul-97	SG	TCE	15	19.9	5	
O4	03-Jul-97	SG	TCA	15	2	5	J
O4	03-Jul-97	SG	TCE	20	24.5	5	
O4	03-Jul-97	SG	TCA	20	4.39	5	J
O4	03-Jul-97	SG	TCE	29	8.98	5	
O4	03-Jul-97	SG	TCA	29	1.4	5	J
O4	03-Jul-97	GW	No Water Detected				
O5	09-Jun-97	SG	TCE	5	6.4	5	
O5	09-Jun-97	SG	TCE	10	ND	5	
O5	09-Jun-97	GW	No Water Detected				
O5 - Dup. Sample	09-Jun-97	SG	TCE	5	7.6	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
P3		GW	Obstructed by Trees and Grade				
P4	07-Jul-97	SG	TCE	5	22.96	5	
P4	07-Jul-97	SG	TCE	10	26.1	5	
P4	07-Jul-97	SG	TCE	15	36	5	
P4	07-Jul-97	SG	TCE	20	32.84	5	
P4	07-Jul-97	SG	TCE	25	31.19	5	
P4	07-Jul-97	SG	TCE	30	23.12	5	
P4	07-Jul-97	GW	No Water Detected				
P5	04-Jun-97	SG	TCE	5	ND	5	
P5	04-Jun-97	SG	TCE	10	ND	5	
P5	04-Jun-97	SG	TCE	15	ND	5	
P5	04-Jun-97	SG	TCE	20	ND	5	
P5	04-Jun-97	SG	PCE	20	1	5	J
P5	04-Jun-97	GW	No Water Detected				
P6	05-Jun-97	SG	TCE	5	ND	5	
P6	05-Jun-97	SG	TCE	10	ND	5	
P6	05-Jun-97	SG	TCE	15	ND	5	
P6	05-Jun-97	SG	TCE	20	ND	5	
P6	05-Jun-97	SG	TCE	25	ND	5	
P6	05-Jun-97	GW	TCE	20	ND	5	
P6	05-Jun-97	GW	TCE	25	ND	5	
P6	05-Jun-97	GW	TCE	30.6	ND	5	
P7	10-Jul-97	SG	No Soil Gas Detected				
P7	10-Jul-97	GW	TCE	10	ND	5	
P7	10-Jul-97	GW	TCE	15	ND	5	
P7	10-Jul-97	GW	TCA	15	0.02	5	J
P7	10-Jul-97	GW	TCE	22.9	ND	5	
P7	10-Jul-97	GW	TCA	22.9	0.03	5	J
P8	12-Jun-97	SG	TCE	5	ND	5	
P8	12-Jun-97	GW	TCE	5	1.4	5	J
P8	12-Jun-97	GW	TCE	10.4	1.3	5	J
P9	30-Jul-97	SG	No Soil Gas Detected				
P9	30-Jul-97	GW	TCE	13.3	ND	5	

Grid Location	Sample Date	Sample Type	Parameter	Feet Below Ground Surface	Concentration (ppb)	Det. Limit (ppb)	Qualifier
R10	29-Jul-97	GW	TCE	21.9	ND	5	
R4	24-Jul-97	SG	TCE	5	ND	5	
R4	24-Jul-97	SG	TCE	15	ND	5	
R4	24-Jul-97	SG	TCE	25	ND	5	
R4	24-Jul-97	SG	TCE	30	0.9	5	J
R4	24-Jul-97	SG	TCE	30.9	ND	5	
R4	24-Jul-97	SG	TCA	30.9	0.8	5	J
R4	24-Jul-97	GW	No Water Detected				
R5	24-Jul-97	SG	TCE	5	ND	5	
R5	24-Jul-97	SG	TCE	10	ND	5	
R5	24-Jul-97	SG	TCE	25	ND	5	
R5	24-Jul-97	GW	TCE	30	ND	5	
R5	24-Jul-97	GW	TCE	30	ND	5	
R6	25-Jul-97	SG	TCE	16.3	ND	5	
R6	25-Jul-97	GW	No Water Detected				
R7	25-Jul-97	SG	TCE	5	ND	5	
R7	25-Jul-97	GW	TCE	12.6	ND	5	
R8	28-Jul-97	SG	TCE	10	ND	5	
R8	28-Jul-97	GW	TCE	16.4	ND	5	
R9	28-Jul-97	SG	TCE	5	ND	5	
R9	28-Jul-97	SG	TCE	10	ND	5	
R9	28-Jul-97	SG	TCE	15	ND	5	
R9	28-Jul-97	GW	No Water Detected				
S10	10-Aug-97	SG	TCE	5	ND	5	
S10	10-Aug-97	SG	TCE	10	ND	5	
S10	10-Aug-97	GW	No Water Detected				
S8	30-Jul-97	SG	TCE	5	ND	5	
S8	30-Jul-97	SG	TCE	10	ND	5	
S8	30-Jul-97	GW	TCE	13.2	ND	5	
S9	11-Aug-97	SG	TCE	5	ND	5	
S9	11-Aug-97	SG	TCE	10	ND	5	
S9	11-Aug-97	SG	TCE	14.5	ND	5	
S9	11-Aug-97	GW	No Water Detected				

APPENDIX B

Bulk Soil Confirmation Results

		TCE Bulk Soil Confirmation Results		
Grid Location	Sample date	Sample Type	Feet Below Ground Surface	Concentration (ug/kg)
I5	8/12/97	soil	20	ND
I8	8/12/97	soil	18	ND
J6	8/13/97	soil	15	ND
K4	8/12/97	soil	15	ND
L10	8/12/97	soil	10	ND
L8	8/12/97	soil	15	ND
M3	8/6/97	soil	15	1.4
N2	8/5/97	soil	10	ND
O2	8/5/97	soil	15	56
O2	8/5/97	soil	25	8.4
O3	8/6/97	soil	15	880
O3	8/6/97	soil	25	89
O4	8/6/97	soil	15	4.5
P2	8/5/97	soil	10	1.5
P4	8/6/97	soil	15	ND
Q4	8/6/97	soil	20	2.3

APPENDIX C

Soil Screening Calculations

APPLICATION OF STANDARDIZED MOUND SOIL SCREENING GUIDANCE EQUATIONS FOR DETERMINING A POTENTIAL CONTAMINANT SOURCE AREA TO THE BURRIED VALLEY AQUIFER

INTRODUCTION

In the summer of 1997, Mound initiated a "Limited Field Investigation" to investigate the nature and extent of elevated volatile organic compounds (VOCs) in several groundwater monitoring wells. Results indicate that within the study area there is not a widespread soils VOC contamination problem. The data do however indicate an isolated area (in the immediate vicinity of monitoring well 0312) of soil contaminated with trichloroethene. Soil gas samples were collected at concentrations of approximately 300 ug/l. Bulk soil samples were also taken from the area as confirmation samples. These samples were sent to RECRA labs and analyzed for total soil concentration in accordance with Method SW-846 8021. Results show localized bulk soil contamination concentrations up to approximately 900 ug/kg, (refer to the Limited Field Investigation – VOCs in Monitoring Wells report, 4/98, for maps showing the distribution of soil gas and soil confirmation sample results).

The State of Ohio Environmental Protection Agency requested that DOE utilize the "soil screening guidance equations" to evaluate the potential for these TCE contaminated soils to serve as a significant source term of TCE to the Buried Valley Aquifer (BVA) groundwater system. Details of the Standardized Equations based upon EPA Soil Screening Guidance are found in Attachment D4, Volume II of *Potential Release Site packages, Reading and Understanding,* PRELIMINARY, August , 1996.

RESULTS

The soil screening guidance equations were applied to the soils overlying the bedrock aquifer system in the immediate vicinity of monitoring well 0312. There are essentially 4 input parameters in the model that define the physical setting. Those parameters are: 1) source length parallel to groundwater flow, 2) aquifer thickness, 3) hydraulic conductivity, and 4) hydraulic gradient at the source.

For model runs, the parameters were allowed to vary as shown below:

Source length parallel to groundwater flow was allowed to vary between 15 and 50 meters, with 50 representing the most conservative case.

Aquifer thickness was allowed to vary between 5 and 15 meters, with 5 representing the most conservative case.

Hydraulic conductivity was varied between 50 and 100 meters/year, with 50 being the most conservative value.

Hydraulic gradient was varied between 0.08 and 0.14 (essentially the slope of the bedrock surface) with 0.08 representing the most conservative gradient.

All other parameters, with the exception of horizontal distance to the receptor, were either chemical specific or were previously defined as site specific values. Horizontal distance to the receptor was taken as the distance between well 0312 and the boundary of the BVA (defined as the 685 foot elevation contour).

The results of the modeling indicate that even when utilizing the least conservative set of input parameters, the model cannot preclude the possibility that the contaminated soils are a source area for TCE groundwater concentrations in excess of 5 ppb at the BVA boundary. Model results indicate that the least conservative set of input parameters yield a TCE soil screening level of 690 ug/kg. This number is below the maximum value of 880 ug/kg for the soil confirmation sample.

In summary, the soil screening model indicates that the soils in the vicinity of monitoring well 0312, contaminated with TCE at 880 ug/kg (highest laboratory confirmed concentration of a single sample), could serve as a source of groundwater contamination, with dissolved TCE concentration in excess of 5 ppb, to the BVA groundwater system.

Estimate of Hypothetical Soil Water Concentration Resulting from a Total TCE Soil Concentration of 880 µg/kg

$$C_w = \frac{C_t \rho_b}{K_d \rho_b + n_w + H_c n_a}$$

From Feenstra et al. (1991)

C(t) = total soil concentration (mg/kg)
P(b) = dry bulk density of soil
N(w) = water filled porosity (volume fraction)
N(a) = air filled porosity (volume fraction)
K(d) = partition coefficient for TCE
H(c) = Dimensionless form of Henry's Law Constant for TCE
C(w) = calculated porewater concentration (mg/L)

For Mound Soils adjacent to Monitoring Well 0312:

C(t) = 880 ug/kg TCE
P(b) = 1.6 kg/L
N(w) = 0.15
N(a) = 0.28
H(c) = 0.435 (TCE)
K(d) = 2.24 L/kg (TCE)

C(w) = {(880 ug/kg)(1.6 kg/L) / [(2.24 L/kg)(1.6 kg/L) + 0.15 + (0.435)(0.28)] }

C(w) = 142 ppb

Reference: Feenstra, S., D.M. Mackay and J.A. Cherry, 1991. A Method for Assessing the Presence of Residual NAPL Based on Organic Chemical Concentrations in Soil Samples. Ground Water Monitoring Review, Vol. 11, No. 2, pp. 128 - 136

APPENDIX D

Potential Groundwater Concentration Calculations

IOC

TO: Brian Nickel, OFFO/SWDO

FROM: Matthew Justice through Rich Bendula CPG, DDAGW/SWDO

SUBJECT: One Dimensional Solute Transport Model to Evaluate the submitted Limited Field Investigation: VOCs in Monitoring Wells, (draft) April, 1998

PROJECT: 08-03-98-01-4-600

DATE: August 28, 1998

INTRODUCTION

During an August 6th conference between OEPA, USEPA, US DOE Mound, and Babcock and Wilcox, the results of the soil screening model simulation were discussed. The simulation run by B&W was used to back calculate from the BVA, an acceptable soil concentration for the presumed source area. An acceptable soil concentration was defined as one which would not cause ground water at a reception point to exceed MCLs. A representative bulk soil concentration for TCE at the location of node O3 (Limited Field Investigation), was found to exceed the calculated soil screening limit. In order to estimate a ground water concentration at the BVA, the OEPA/DDAGW used a one dimensional analytical fate and transport model created by Domenico and Robbins, 1985. Various scenarios of the model were run. The results support the findings of the soil screening model. The model results indicate that steady state TCE concentrations of at least 83 ppb will be encountered at the BVA down gradient of the source area.

CONCEPTUAL MODEL

The source area lies on a intensely fractured, bedrock high on the western slope of the Main Hill. Approximately 25 feet of unsaturated soil overlay a shale, limestone fractured carapace. The Limited Field Investigation, which conducted a closely spaced soil gas survey in the unsaturated soil, defined a small 50 foot wide area, centered around core O3, with elevated TCE soil gas. The survey indicated elevated TCE, down to bedrock at 25 feet. Babcock and Wilcox used the highest bulk soil concentration from core O3, 888 ppb, to compute a theoretical leachate concentration of 143 ppb. The conceptual model assumes that this leachate will infiltrate down into the saturated bedrock. Once in the bedrock, the ground water flows down gradient to the BVA. Observations of bedrock exposures at Mound indicate that the bedrock behaves similar to a porous media.

DOMENICO & ROBBINS MODEL

Ohio EPA used the theoretical leachate value as the initial ground water concentration to predict a final concentration at the BVA reception point fifty meters down gradient. The Domenico &

Robbins Model can be referred to as a plug flow model with both longitudinal and transverse dispersion

$$C = (C_0/2) * erfc((x - vt) / 2(disp_x vt)^{1/2}) * erf(Y / (4(disp_y x)^{1/2})) * erf(Z / (2(disp_z x)^{1/2}))$$

where

C	final concentration (ppb)
C_0	initial concentration (ppb)
t	time (days)
x	distance to the receptor (meters)
v	average linear velocity of the contaminant (meters/day)
$disp$	dispersivity (meters)
Y	width of the source area (meters)
Z	source area depth (meters)
$erfc$	complementary error function
erf	error function

Once the arguments for the error functions and complementary error function are found, the solution values may be found on page 637 of Domenico and Schwarz.

Reference: Domenico, P. A et al, Physical and Chemical Hydrogeology, 1990

Just as the soil screening model, this model treats the bedrock is a porous, homogenous, continuum with a continuous planar source area feeding leachate to the water table. It predicts concentration values for various times along a one-dimensional flow path with a constant velocity.

Because the model incorporates longitudinal and transverse spreading of the contaminant, the dimensions of the source have to be estimated. The results of the soil gas survey were used to estimate the dimensions of the source area. Because the model assumes a nonreacting species, the only attenuation processes incorporated in the model are multi-dimensional dispersion.

Required Input Parameters

Because the overlying soil is unsaturated, the model input parametrs selected were used to simulate flow through the bedrock aquifer. OEPA used the most conservative values for aquifer input parameters. Other than dispersivity, and source area dimensions, the values are the same as those selected by B&W for the soil screening model.

Hydraulic Conductivity ranges from 50 to 100 m/yr, OEPA used the conservative value of 50 m/yr or **0.14 m/day**.

Hydraulic Gradient was taken from the average slope of the bedrock surface between the source area and reception point as **0.08**.

Saturated Porosity used was that from the soil screening model **0.15.**

Average Linear Velocity was calculated to be **0.07 m/day**.

Longitudinal Dispersivity, $disp_x$, values ranging from **0.1 to 2 meters** were used (Domenico & Schwarz, p 374)

Transverse Dispersivities, $disp_y$ & $disp_z$ were taken to be one order of magnitude less than the longitudinal dispersivity (Domenico & Schwarz, p 374)

Source Size depth dimension twenty-five feet or **8.2 m**.

Source Size width fifty feet or **16 m**.

Optional Input Parameters

In order to examine the effect of retardation on transport, a retardation factor was calculated using input parameters from the soil screening model. The retardation factor was divided into the average linear velocity determine a retarded contaminant velocity for TCE.

Dry Bulk Density value was that used in the soil screening model of **1.5 Kg/L**.

Koc **165.69**

Fraction of Organic Carbon foc **0.02**

Distribution Coefficient **3.31 L/Kg**

Retardation Factor **34.1**

Contaminant Velocity **0.002 m/day**

RESULTS

Four simulations of the Domenico and Robbins Model were run to examine the effects of multi-dimensional dispersion, and retardation.

According to Domenico and Schwarz, the range of field values for longitudinal dispersivity is 0.1 to 2.0 meters. Two model simulations were run to encompass this range. Figure One shows that if a longitudinal dispersivity of 2.0 meters is used, with transverse dispersivities of 0.2 meters, the

MCL of five ppb for TCE will be reached in 241 days. After the initial dispersion zone passes through, the steady state portion of the plume, with a concentration of 83 ppb will reach the reception point in 250 days.

Figure Two illustrates the effect of using the low end of the acceptable longitudinal dispersivity range, 0.1 meters. Longitudinal dispersion is not an attenuating factor because the source is modeled as continuous. Therefore attenuation is dependent upon the transverse dispersivities. In this case the transverse dispersivities are too low to induce attenuation. Therefore, the steady state portion of the plume is not attenuated, but remains at the initial concentration of 143 ppb. This is not representative of actual conditions.

Figures Three and Four examine the effect of retardation on the cases illustrated by Figure One and Two respectively. As shown, retardation has no effect on the concentration of TCE. Instead the effect is to reduce the travel time significantly. However, simulating retardation for the case of water migrating through weathered rock is probably not applicable. Retardation is proportional to the amount of available organic carbon. Although the rock does contain organic carbon, this carbon is most likely bound within the rock matrix. In addition, the rock has a low surface area, compared to an unconsolidated porous media. Without a significant surface area for sorption to take place, the effect of retardation would be greatly reduced.

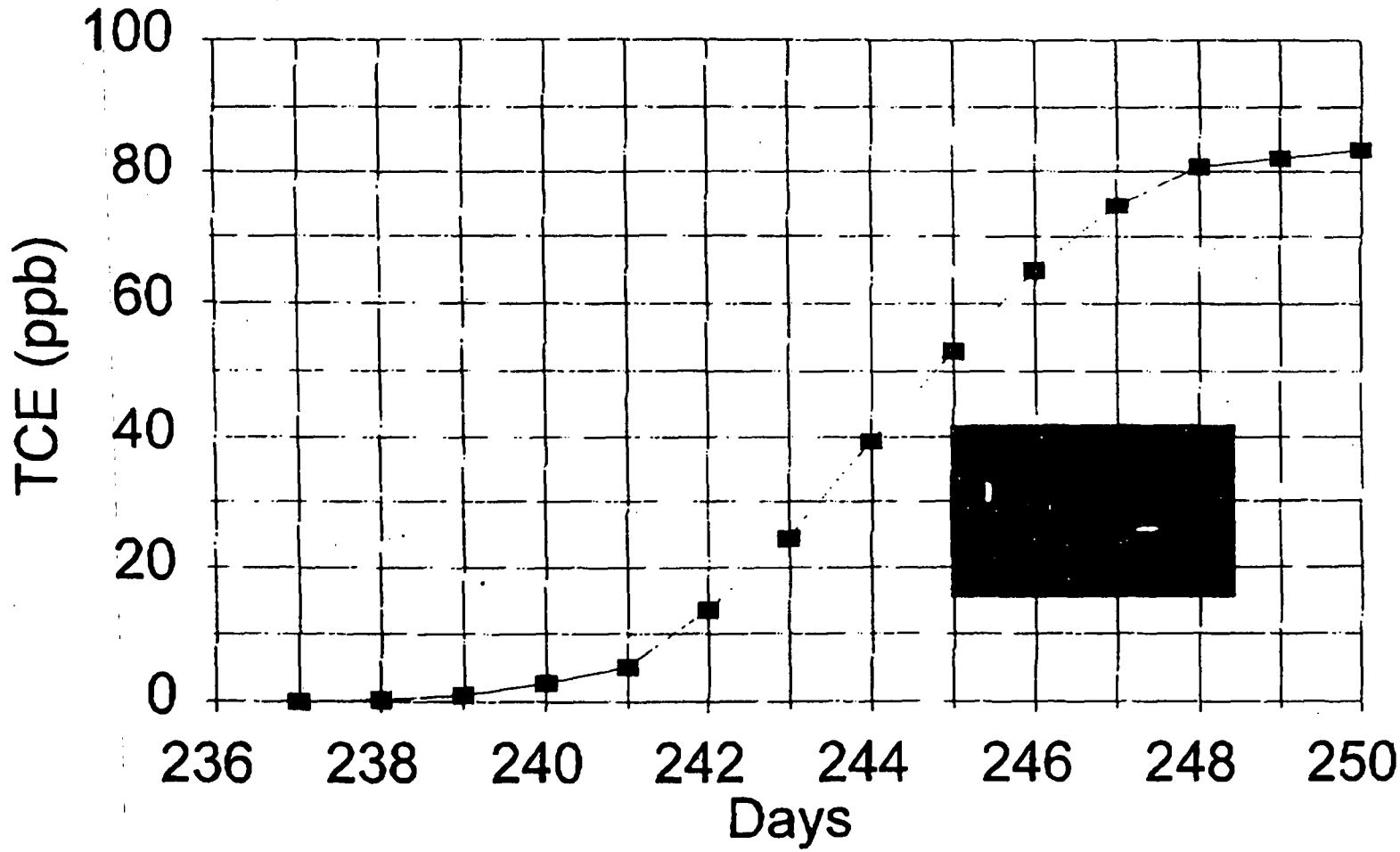
CONCLUSIONS

The best approximation of TCE concentrations reaching the BVA reception point can be estimated from the results shown in Figures One and Two. These simulations exclude retardation but encompass the acceptable range of dispersivity. Therefore the results indicate that steady state concentrations of 85 ppb or greater will reach the reception point between 250 to 680 days.

cc:
Jeff Patzke CO/DDAGW
Lisa Anderson SWDO/OFFO
Kathy Lee Fox SWDO/OFFO

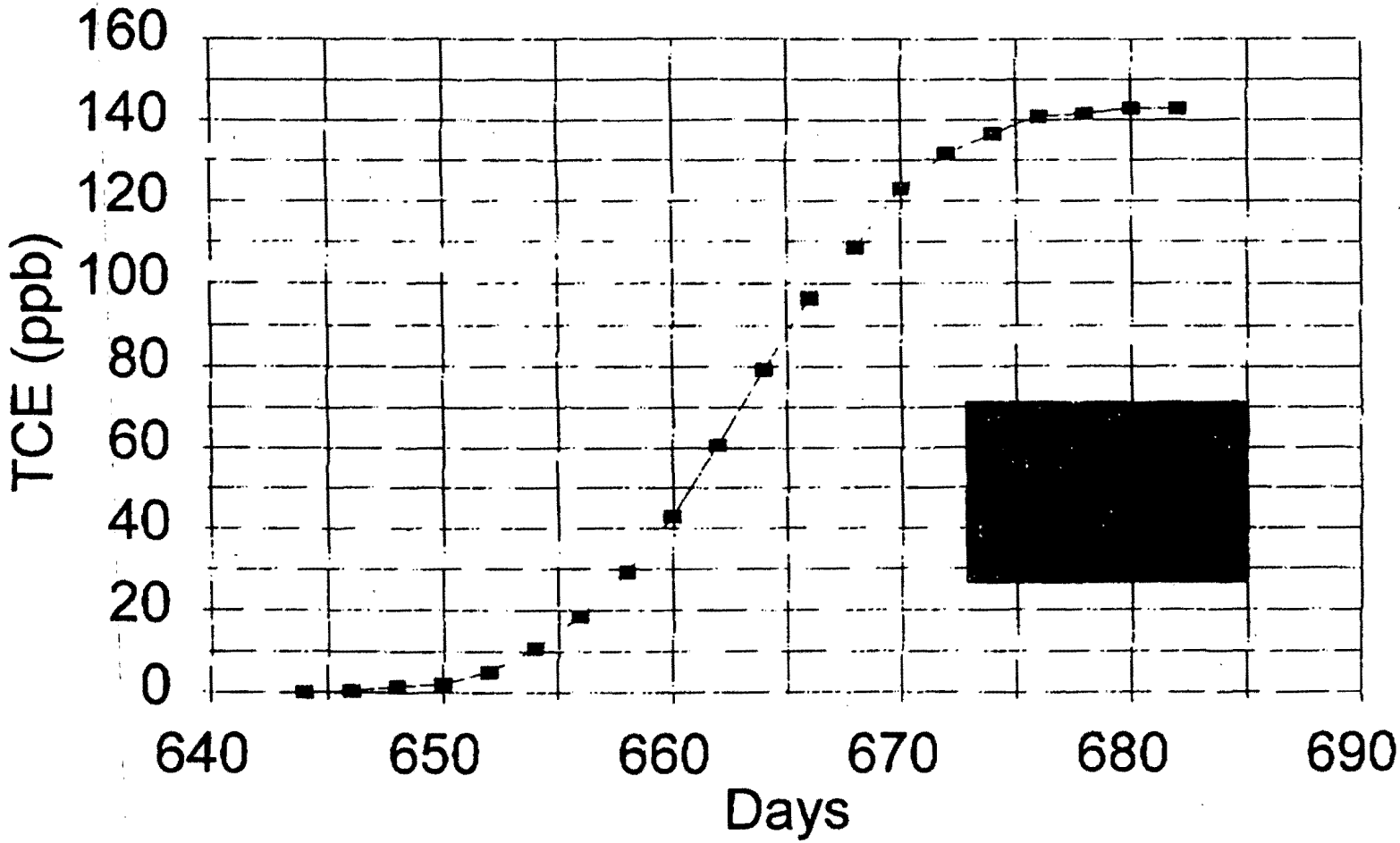
High Dispersion, No Retardation

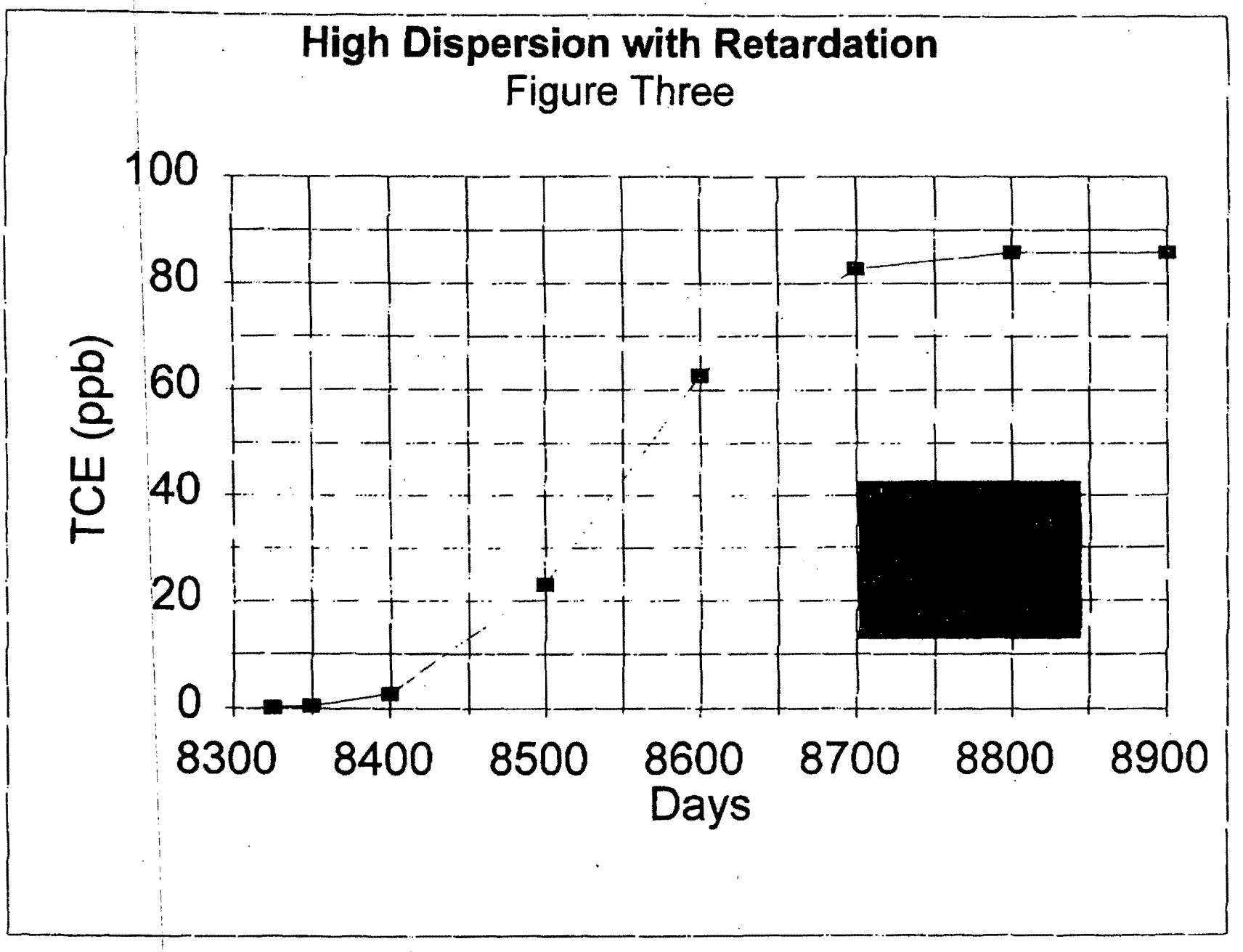
Figure One

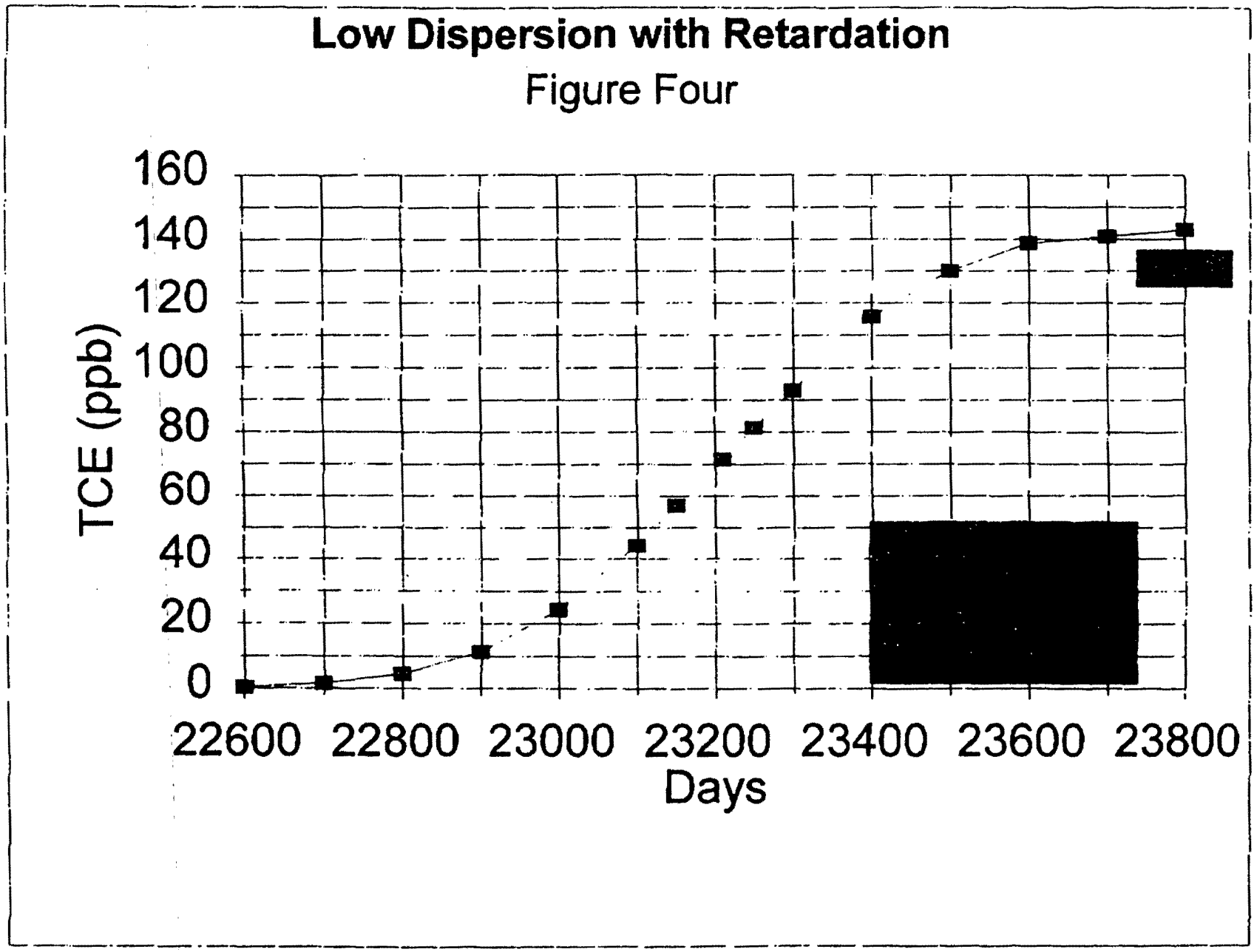


Low Dispersion, No Retardation

Figure Two




High Dispersion with Retardation
Figure Three
TCE (ppb)
100
80
60
40
20
0
8300
8400
8500
8600
8700
8800
8900
Days


Low Dispersion with Retardation
Figure Four
TCE (ppb)
160
140
120
100
80
60
40
20
0
22600
22800
23000
23200
23400
23600
23800
Days

APPENDIX E

Estimated Flux of Groundwater into Well 0312

ESTIMATED FLUX OF GROUNDWATER INTO WELL 0312

Assumptions:

- Unsaturated Hydraulic Conductivity = 2×10^{-6} cm/sec[a]
- Hydraulic Gradient = 0.60[b]
- Flow intercepts one half of the circumference of the wellscreen on the upgradient side. Cross-sectional area perpendicular to flow therefore equals:

$$(\pi r) * \textit{thickness of flow zone}$$

- Bottom 3 inches of soil contribute a bulk of the flow to the well along the interface[c]

Well 0312 consistantly holds water at an elevation of 700 ft msl. The bottom of the well lies at elevation approximately 698 ft msl. Therefore the wellbore holds approximately 2 ft of water. This equates to a volume of approximately 1 gallon.

Sampling events at well 0312 indicate that when the wellbore is purged prior to sampling it takes over 24 hours to recharge with a volume sufficient for sampling. The recharge rate in gpm assuming the well is bailed dry and takes 24 hours too fully recovery is 0.0007 gpm.

Estimated flux to well 0312 from seepage along soil/bedrock interface using the assumptions listed above:

$Q = KiA$ where:

Q = groundwater flux into the well
K = unsaturated hydraulic conductivity
I = hydraulic gradient
A = cross-sectional area perpendicular to flow

$Q = (2 \times 10^{-6}\ \text{cm/sec})(0.6)(121\text{cm}^2)$

$Q = 2 \times 10^{-5}$ gpm

[a] Estimated based on 50% of the saturated hydraulic conductivity of a silty sand
[b] Estimated based on the slope of the bedrock surface in the region of 0312. Hydraulic gradient consists of both pressure head gradient and elevation head gradient. Under unsaturated conditions it is assumed that the pressure head does not vary and therefore the only component of gradient that must be considered is that due to elevation difference along the interface.

MOUND

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VOLUME II

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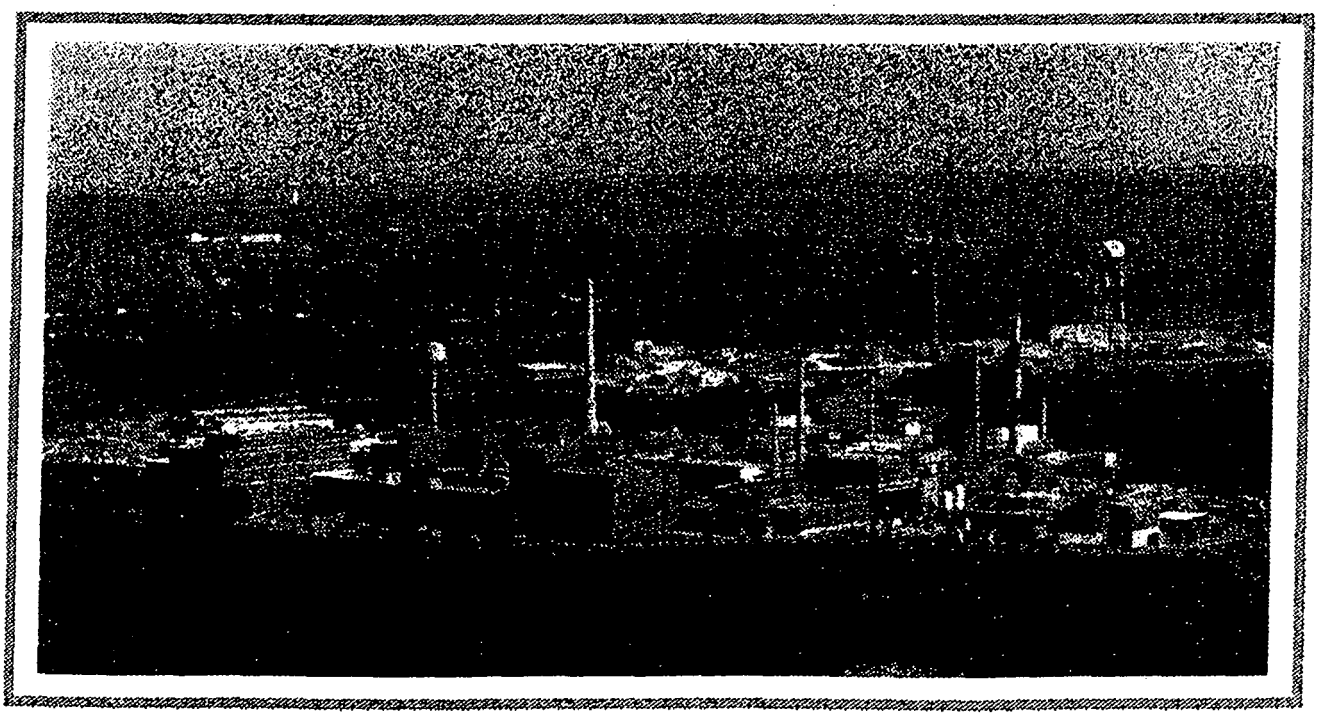

August 7, 1996

POTENTIAL RELEASE SITE PACKAGES

READING AND UNDERSTANDING

VOLUME II

(PRELIMINARY)

AUGUST 8, 1996

STANDARDIZED EQUATIONS BASED UPON USEPA SOIL SCREENING GUIDANCE FOR THE SOIL TO GROUND WATER MIGRATION PATHWAY

A CONSERVATIVE FATE AND TRANSPORT MODEL WHICH IS DEPENDENT UPON SOURCE TERM SIZE, AQUIFER THICKNESS, GRADIENT, AND DISTANCE TO POTENTIAL RECEPTOR TO DETERMINE DILUTION WITHIN GROUNDWATER. NO CHEMICAL ADSORPTION WITHIN THE AQUIFER IS CONSIDERED.

PURPOSE OF SOIL SCREENING LEVELS (SSL) FOR MOUND

The primary purpose of SSLs is to define a level in soil below which no further study or action would be required. Soil screening level calculations are a necessary part of evaluating potential release sites (PRS) to determine whether residual soil contamination poses a threat to ground water. This method is a screening method which will identify any PRS that exceeds a soil screening level concentration. Due to the conservative assumptions, any PRS that does not exceed the SSLs can be considered a non-problem with regard for potential leaching of contaminants into ground water. This method is designed to be a conservative method and is not a full contaminant fate and transport analysis. The assumptions involved are conservative, but site specific. If soil concentrations exceed the calculated levels, additional more detailed site-specific contaminant fate and transport models will be used to determine whether remedial action is needed.

The Mound plant is assumed to continue in an industrial/office park type of land use. Bedrock ground water within the Mound Plant property boundaries will be evaluated to residential standards and MCLs where it migrates across the property boundary towards credible potential receptors or where it may flow into the Buried Valley Aquifer (BVA). It is assumed that there will be no production of bedrock ground water within the site boundaries due to relatively low well specific capacities that would not support industrial activities.

DEVELOPMENT OF SOIL SCREENING LEVELS (SSL) FOR MOUND

The soil screening equations for the migration to the ground water pathway are developed to identify chemical concentrations in soil that have the potential to contaminate ground water. Migration of contaminants from soil to ground water can be thought of as a two-stage process: (1) the release of contaminants in soil leachate and (2) the transport of the contaminant through the underlying soil and aquifer to a receptor well. The equations consider both of these fate and transport mechanisms in developing SSLs that are protective of human health through the migration to ground water pathway. To be used for early PRS evaluation, the methodology needs to be easily applied.

Soil Screening Level (SSL): a chemical concentration in soil below which there is no concern under CERCLA for ingestion, inhalation, and migration to ground water exposure pathways, provided certain conditions are met.

Simple Site-Specific Method: standardized equations to calculate SSLs with easily obtained site-specific data.

Direct ingestion and inhalation of soil volatiles and fugitive dusts:
The Soil Screening framework differs from a site-specific estimate of risk in that the exposure equations and models are run in reverse to back-calculate to an "acceptable level" of contaminant in soil. Toxicity criteria are used to define the acceptable level: a level corresponding to a 10^{-6} risk for carcinogens and a hazard quotient (HQ) of 1 for non-carcinogens. The concept of back-calculating to an acceptable level in soil was presented in RAGS Part B (US EPA, 1991). This is the method utilized to obtain the current Mound Plant PRGs (DOE, 1994).

Migration to ground water:
For the migration to the ground water pathway, SSLs are back-calculated from acceptable ground water concentrations which are maximum contaminant levels (MCLs), or health-based limits (HBLs) calculated at the target risk levels. There are two parts to the ground water migration pathway:

1. Leaching from the soil into the ground water immediately below the source term.

2. Contaminant fate and transport to the potential receptor. Depending upon site-specific conditions the receptor may be considered to be at the source term or at some distance down gradient. The results of the model will be a dilution factor which will be used to modify the back-calculated soil concentrations.

ASSUMPTIONS FOR SOIL TO WATER LEACHING

1. There is no allowance for chemical degradation or volatilization. The source does not decrease in concentration over time. This assumption is conservative, especially for the small sites at Mound.

2. Adsorption is linear with concentration. This is valid for low concentrations (e.g. in the low ppb range) of most chemicals and for halogenated hydrocarbons, polynuclear aromatic hydrocarbons, benzene and chlorinated benzenes at higher concentrations.

3. The soil and pore water concentrations are at equilibrium with respect to adsorption. This assumption is conservative. The concentration in the pore water will be less than predicted by the calculations if equilibrium conditions are not met.

4. Adsorption is reversible and instantaneous. This is conservative as desorption is usually a slower process than adsorption and some chemicals may never completely desorb.

5. Soil contamination extends from the surface to the water table. In reality the source often does not extend to the water table. This is a conservative assumption

6. The potential receptor well is within the plume.

ASSUMPTIONS FOR GROUND WATER MIGRATION AND DILUTION

1. No chemical dispersion is accounted for. This is conservative in that chemical concentrations will be over estimated by these equations.

2. No adsorption within the aquifer in accounted for. This is conservative as the chemical concentrations will be over estimated.

3. Mixing is due only to horizontal trasnport and dilution by infiltrating rain water. Flow is assumed to by laminar and follows Darcy's Law. If Darcy assumptions are incorrect and flow becomes turbulent, the mixing is more complete than would be predicted by the equations.

4. The aquifer is assumed to act as an equivalent porous media. On the scale of transport at Mound, the fractured bedrock will not have preferential fracture transport pathways.

The equations incorporate a standard linear equilibrium soil/water partition equation to estimate contaminant release in soil leachate (equations 1 & 2) and a simple water-balance equation that calculates a dilution factor to account for dilution of soil leachate in an aquifer (equations 2 & 3). The dilution factor represents the reduction in soil leachate contaminant concentrations by mixing in the aquifer, expressed as the ratio of leachate concentration to the concentration in ground water at the receptor point (receptor well or point of compliance).

Simple PRS or Release Block SSLs are back calculated from acceptable ground water concentrations (i.e. non-zero MCLs). First the acceptable ground water concentration is multiplied by the dilution/attenuation factor (DAF) to obtain a target leachate concentration. For example, if the DAF is 10 and the acceptable ground water concentration is 0.05 mg/L, the target soil leachate concentration would be 0.5 mg/L. The partition equation (equation 1) is then used to calculate the total soil concentration or soil screening level (SSL) corresponding to this soil leachate concentration.

1.0 SOIL LEACHING

Utilizing the calculated guideline values for ground water (acceptable water concentration) from HAZWRAP, a corresponding soil concentration or soil screening level (SSL) can be calculated from:

$$SSL = C_w\{K_d + (\theta_w + (\theta_a H'))/\rho_b\} \qquad \textbf{(Equation 1)}$$

$$K_d = K_{oc} * f_{oc} \qquad \textbf{(Equation 2)}$$

where

Parameter	Definition	Units
C_w	target soil leachate. Acceptable water concentration • DAF	mg/L
K_d	soil-water partition coefficient (K_{oc} • f_{oc} for organic chemicals)	L/kg
θw	saturated porosity	
θa	air filled porosity	
H	Henry's Law constant • 41 (0 for metals and radionuclides)	
ρ_b	dry soil bulk density	kg/L
K_{oc}	soil organic carbon/water partition coefficient	L/kg
f_{oc}	fraction organic carbon in soil	

2.0 DILUTION/ATTENUATION

As contaminants in soil leachate move through the soil and ground water, they are subjected to physical, chemical, and biological processes that tend to reduce the eventual contaminant concentration at the receptor point. The processes include adsorption onto soil and aquifer media, chemical transformation, biological degradation, and dilution due to mixing of the leachate with ambient ground water. The reduction in concentration can be expressed by the DAF, which is defined as the ratio of contaminant concentration in soil leachate to the concentration in ground water at the receptor point. The DAF is used to back-calculate the target soil leachate concentration from an acceptable ground water concentration.

This simple site-specific model addresses only one of these dilution-attenuation processes: contaminant dilution in ground water. A simple equation, broken into two parts for ease of use, derived from geohydrologic water-balance relationships is used. This simplifying use of only ground water dilution is used for several reasons.

First, the assumption that the source will last infinitely, results in all subsurface adsorption sites being eventually filled and no longer available to attenuate contaminants. Second, soil contamination is assumed to extend to the water table, eliminating attenuation processes in the unsaturated zone. Finally, chemical specific biological and chemical degradation rates are not known for many chemicals and where they are known there is a wide range in values.

MIXING ZONE DEPTH (d)

One aspect of the model is the determination of the depth that a contaminant leachate will mix in the aquifer. This is called the mixing zone depth and it is dependent upon the rainfall infiltration rate, the length of the source term parallel to the ground water flow direction, the horizontal distance to a potential ground water receptor, and the hydraulic gradient. The mixing zone depth equals the thickness of the saturated portion of the aquifer if mixing is completely effective. This can occur if the aquifer is relatively thin and the distance to the potential receptor is relatively great.

$$d = (0.0112(L+x_r)^2)^{0.5} + d_a\{1 - \exp[(-in(L+x_r))/Kid_a]\} \qquad \text{(Equation 3)}$$

where

Parameter	Definition	Units
L	source length parallel to ground water flow	m
d_a	aquifer thickness	m
K	hydraulic conductivity	m/y
i	hydraulic gradient at the source	m/m
x_r	horizontal distance to receptor	m
in	infiltration rate	m/y

Equation 2 assumes that the mixing depth cannot exceed the thickness of the aquifer. The equation is composed of two terms. The first term relates vertical mixing due to horizontal ground water flow, the second term relates the downward infiltration component due to rainfall recharge.

For Mound we assume that ground water contaminants from potential release sites that overlie the bedrock will be governed by this equation. This mixing zone depth equation is appropriate for use at PRSs that directly overlie the BVA, however the distance to the receptor must be assumed to be 0 m.

Once the mixing zone depth has been calculated, the actual dilution-attenuation factor (DAF) is calculated from the following equation:

$$\mathbf{DAF = 1 + Kid/inL} \qquad \textbf{(Equation 4)}$$

where the parameters are the same as in equation 2 and d = the mixing zone depth (equation 3).

Equation 3 incorporates the result of the calculated mixing zone depth with the volume of water that is traversing beneath the contaminant site. This is the effective dilution that occurs in the aquifer. This dilution could be as low as a factor of 1 if it is assumed that a receptor well is located within the leachate at the source term.

The calculated DAF shall be multiplied by the acceptable soil leachate concentration (back calculated from MCLs or risk derived concentrations) to obtain the target soil leachate concentration (C_w). The target soil leachate concentration is utilized in equation 1 to obtain the site specific SSL.

Additional dilution takes place when the migrating contaminant joins the BVA. It is reasonable to assume that any well that a resident installs for drinking water in the BVA is unlikely to located exactly at the edge of the BVA. This additional mixing that will take place is not accounted for in this SSL model. The assumption that the potential receptor is at the exact edge of the BVA, where the aquifer is too thin for a productive well is conservative.

SITE SPECIFIC DATA VALUES

These equations require site specific data for:

Parameter	Definition	SM/PP Hill top soil	Main Hill top soil	Units
L	source length parallel to ground water flow	45	45	m
d_a	aquifer thickness (DOE 1994)	10	15	m
K	hydraulic conductivity (DOE 1994)	52	52	m/y
i	hydraulic gradient at the source	site specific	site specific	m/m
x_r	horizontal distance to receptor	site specific	site specific	m
in	infiltration rate (Schairbaum & Frost 1988)	0.15	0.15	m/y
K_d	soil-water partition coefficient (K_{oc} * f_{oc} for organic chemicals)	chemical specific	chemical specific	L/kg
θ_w	saturated porosity	0.15	0.15	
θ_a	air filled porosity	0.28	0.28	
H	Henry's Law constant * 41 (0 for metals and radionuclides)	chemical specific	chemical specific	
ρ_b	dry soil bulk density	1.5	1.5	kg/L
K_{oc}	soil organic carbon/water partition coefficient	chemical specific	chemical specific	L/kg
f_{oc}	fraction organic carbon in soil (DOE Mound Plant Database)	0.02	0.02	

SOIL POROSITY AND DENSITY DETERMINATION

Although the soils at Mound rarely extends completely to the aquifer, a conservative assumption is that the soils do extend to the aquifer, providing a larger potential source that can desorb contaminants into the ground water.

The determination of the average soil pH is 7.45 from the Mound Plant site specific soil database.

The Mount Plant surface soils are typical of loam type soils. The f_{oc} from the Mound Plant soil database is 2.0%. There are no site specific values obtained for the soil bulk density or porosity. The default values that USEPA (USEPA, 1994) provides will be used in these equations.

HYDRAULIC GRADIENT DETERMINATION

The hydraulic gradient for a given PRS will be determined from nearby wells, or will be determined to be the same as the slope of the topography (or bedrock in fill areas) at the PRS location.

DISTANCE TO A POTENTIAL RECEPTOR

The distance to a potential receptor will be determined to be along the ground water flow direction until ground water encounters the edge of the BVA. The Mound Facility Boundary may be determined to define the distance to a potential receptor if it is deemed possible that a down gradient potential receptor well may be installed at or near the site boundary.

SOURCE LENGTH PARALLEL TO THE GROUND WATER FLOW DIRECTION

The size of the potential source can be quite variable. For PRS evaluation purposes, a length of 45 meters will be used which corresponds to a 1/2 acre potential source area. Soil chemical concentrations for this half acre area will be averaged. For some PRS's, the size is known to be substantially less, and the corresponding smaller value will be used in the equations.

CHEMICAL SPECIFIC PARAMETERS (H and K_{oc})

The values of H and K_{oc} are from the Technical Background Document for Soil Screening Guidance (USEPA, 1994). Although this draft document states that this document should not be cited or quoted, personal communication with Robert Truesdale of RTI indicates that these values may be used in the equations.

CHEMICAL NAME	H	Koc		Kd	MCL	10-6 Guideline Value		
		L/kg		L/kg	mg/L	mg/L		
Acenapthene	7.54E-03	5846	0.2	1169.2	—			
Acetone	1.18E-03	0.46	0.2	0.092	—	3.6		
Aldrin	4.22E-03	94623	0.2	18924.6	—			
Anthracene	4.55E-03	18162	0.2	3632.4	0.007			
Arochlor 1016	—	147410	0.2	29482	—			
Arochlor 1254	—	892520	0.2	178504	—	0.00073		
Arochlor 1260	—	4425557	0.2	885111.4	—	0.00001[1]		
Benzene	2.24E-01	66	0.2	13.2	0.005			
Benzo(a)anthracene	1.48E-04	272847	0.2	54569.4	0.007			
Benzo(b)flouranthene	2.53E-04	882588	0.2	176517.6	0.007			
Benzoic Acid	1.37E-05	—	0.2		—	140		
Benzo(a)pyrene	3.43E-05	749569	0.2	149913.8	0.0002			
Bis(2-chlorethyl)ether	8.77E-04	76	0.2	15.2	—			
Bis(2-ethylhexyl)phthalate	3.43E-04	94361	0.2	18872.2	—			
Bromodichloromethane	1.30E-01	54	0.2	10.8	0.08			
Bromoform	2.52E-02	97	0.2	19.4	0.08			
Butanol	3.50E-04	5	0.2	1	—			
Butyl benzyl phthalate	7.83E-05	15975	0.2	3195	—	7.3		
Carbazole	8.12E-05	2441	0.2	488.2	—			
Carbon disulfide	5.21E-01	52	0.2	10.4	—	0.033		
Carbon tetrachloride	1.18E+00	187	0.2	37.4	0.005			
Chlordane	2.73E-03	61155	0.2	12231	0.002			
p-Chloroaniline	4.80E-05	41	0.2	8.2	—			
Chlorobenzene	1.79E-01	213	0.2	42.6	—			
Chlorodibromomethane	1.02E-01	72	0.2	14.4	0.08			
Chloroform	1.65E-01	47	0.2	9.4	0.08			
2-Chlorophenol	6.81E-04	—	0.2		—			
Chyrsene	4.96E-05	312425	0.2	62485	—	0.0046		
DDD	2.03E-04	84937	0.2	16987.4				
DDE	5.08E-03	108469	0.2	21693.8		0.00017		
DDT	2.20E-03	77577	0.2	15515.4		0.001		
Dibenzo(a,h)anthracene	4.59E-07	1914389	0.2	382877.8	—			
Di-n-butyl phthalate	5.86E-05	16851	0.2	3370.2	—	3		
1,2-Dichlorobenzene (o)	8.61E-02	693	0.2	138.6	0.6			
1,2-Dichlorobenzene (p)	1.15E-01	653	0.2	130.6	0.075			
3,3-Dichlorobenzidene	8.53E-07	2441	0.2	488.2	—			
1,1-Dichloroethane	2.36E-01	35	0.2	7	—	1.1		
1,2-Dichloroethane	5.25E-02	20	0.2	4	0.005			
1,1-Dichloroethylene	1.04E+01	64	0.2	12.8	0.007			
cis-1,2 Dichloroethylene	1.85E-01	29	0.2	5.8	0.07			
trans-1,2-Dichloroethylene	2.29E-01	50	0.2	10	0.1			
1,2-Dichloropropane	1.15E-01	59	0.2	11.8	0.005			
1,3-Dichloropropene	1.21E-01	33	0.2	6.6	—			
2,4-Dichlorophenol	9.76E-06	—	0.2		—			
Dieldrin	1.09E-04	18388	0.2	3677.6	—	0.0018		
Diethyl phthalate	2.24E-05	152	0.2	30.4	—			
2,4-Dimethylphenol	1.33E-04	—	0.2					
Dimethyl phthalate	2.37E-05	32	0.2	6.4				

CHEMICAL NAME	H	Koc		Kd	MCL	10-6 Guideline Value		
2,4-Dinotrotoluene	6.03E-06	51	0.2	10.2	—			
2,6-Dinotrotoluene	5.33E-06	42	0.2	8.4	—			
Di-n-octyl phthalate	3.14E-05	9.8E+08	0.2	1.96E+08		0.73		
Endosulfan	9.47E-04	738	0.2	147.6				
Endrin	4.88E-05	9335	0.2	1867	0.002			
Ethylbenzene	3.18E-01	388	0.2	77.6	0.7			
Fluoranthene	3.83E-04	72025	0.2	14405		0.87		
Fluorene	2.99E-03	9226	0.2	1845.2	—			
Heptachlor	2.41E-02	11651	0.2	2330.2	0.0004			
Heptachlor epoxide	3.40E-04	7236	0.2	1447.2	0.0002			
Hexachlorobenzene	2.19E-02	27996	0.2	5599.2	0.001			
Hexachloro-1,3-butadiene	9.80E-01	6992	0.2	1398.4	—			
alpha-HCH (alpha-BHC)	2.78E-04	1310	0.2	262				
beta-HCH (beta-BHC)	1.42E-05	1392	0.2	278.4		0.000047		
gamma-HCH (lindane)	1.39E-04	1085	0.2	217	0.0002			
Hexachlorocyclopentadien	7.05E-01	9589	0.2	1917.8	0.05			
Hexachloroethane	1.48E-01	1829	0.2	365.8	—			
Indeno(1,2,3-c,d)pyrene	1.99E-07	4364700	0.2	872940	—	0.000026		
Isophorone	2.54E-04	30	0.2	6	—	7.2		
Mercury	4.67E-01	—	0.2		0.002			
Methoxychlor	2.60E-04	77936	0.2	15587.2	0.04			
Methyl bromide	5.82E-01	11	0.2	2.2				
Methyl chloride	1.85E+00	7	0.2	1.4				
Methylene chloride	9.72E-02	13	0.2	2.6				
2-Methylphenol	6.72E-05	—	0.2					
Napthalene	1.98E-02	1549	0.2	309.8	—			
Nitrobenzene	8.45E-04	—	0.2					
N-Nitrosodiphenylamine	2.86E-02	327	0.2	65.4				
N-Nitrosodi-n-propylamine	1.70E-03	17	0.2	3.4				
Pentachlorobenzene	—	13274	0.2	2654.8				
Pentachlorophenol	5.82E-04	—	0.2		0.001			
Phenol	2.44E-05	—	0.2		—	22		
Pyrene	3.39E-04	59865	0.2	11973	—	0.68		
Styrene	1.37E-01	573	0.2	114.6	0.1			
1;1,2,2-Tetrachloroethane	1.53E-02	104	0.2	20.8	—			
Tetrachloroethylene	7.09E-01	139	0.2	27.8	0.005			
Toluene	2.52E-01	171	0.2	34.2	1			
Toxaphene	1.38E-04	501	0.2	100.2	0.003			
1,2,4-Trichlorobenzene	1.07E-01	1840	0.2	368	0.07			
1,1,1-Trichloroethane	7.63E-01	110	0.2	22	0.2			
1,1,2-Trichloroethane	4.10E-02	61	0.2	12.2	0.005			
Trichloroethylene	4.35E-01	112	0.2	22.4	0.005			
2,4,5-Trichlorophenol	1.80E-04	—	0.2					
2,4,6-Trichlorophenol	1.66E-04	—	0.2		—			
Vinyl acetate	2.26E-02	5	0.2	1				
Vinyl chloride	3.45E+00	11	0.2	2.2	0.002			
Xylenes (total)	2.48E-01	381	0.2	76.2	10			

CHEMICAL NAME	H	Koc		Kd	MCL	10-6 Guideline Value		
Antimony			0.2		0.006			
Arsenic			0.2		0.05			
Barium			0.2		2			
Beryllium			0.2		0.004			
Bromate			0.2		0.01			
Cadmium			0.2		0.005			
Chloramine			0.2		4			
Chlorine			0.2		4			
Chlorine Dioxide			0.2		0.8			
Chromium (total)			0.2		0.1			
Cyanide			0.2		0.2			
Fluoride			0.2		4			
Mercury			0.2		0.002			
Nickel			0.2		0.1			
Nitrate			0.2		10			
Nitrite			0.2		1			
Selenium			0.2		0.05			
Sulfate			0.2		500			
Thallium			0.2		0.002			
			0.2					
Radium 226			0.2		20			
Radon			0.2		300			
Tritium			0.2		20			
			0.2		20,000			
Actinium 227			0.2			0.076		
Americium 241			0.2			0.15		
Bismuth 207			0.2			9.4		
Cesium 137			0.2			1.5		
Cobalt 60			0.2			2.5		
Plutonium 238			0.2			0.16		
Plutonium 239			0.2			0.15		
Plutonium 240			0.2			0.15		
Strontium 90			0.2			0.85		
Thorium 228			0.2			0.21		
Thorium 230			0.2			1.3		
Thorium 232			0.2			1.5		

EXAMPLE SSL CALCULATION FOR THE B-BUILDING SOLVENT SHED

B-Building Solvent Shed SSL Calculations

B-Building Solvent Shed

Definition	Parameter	Main Hilltop soil
source length parallel to ground water flow	L	10
aquifer thickness (DOE 1994)	da	15
hydraulic conductivity (DOE 1994)	K	52
hydraulic gradient at the source	i	0.008
horizontal distance to receptor	xr	150
infiltration rate (Schairbaum & Frost 1988)	in	0.15
soil-water partition coefficient (Koc * foc for organic chemicals)	Kd	chemical specific
saturated porosity	Ow	0.15
air filled porosity	Oa	0.28
Henry's Law constant * 41 (0 for metals and radionuclides)	H	chemical specific
dry soil bulk density	B	1.6
soil organic carbon/water partition coefficient	Koc	chemical specific
fraction organic carbon in soil (DOE Mound Plant Data Base)	foc	0.02

CALCULATED SOIL SCREENING LEVELS (acceptable concentrations to remain in soils)	
CHEMCIAL	SSL
	mg/kg
Trichoroethene	0.0621748
Toluene	18.358506
1,1,1-TCA	2.5049478
cis,1-2DCE	0.2550524
Freon 113*	—

* TLV in air is 1000ppm

CALCULATED 95% UCL FROM VERIFICATION SAMPLES	95% UCL
CHEMICAL	mg/kg
Trichoroethene	0.045
Toluene	0.014
1,1,1-TCA	0.011
cis,1-2DCE	0.03
Freon 113*	0.008
* TLV in air is 1000ppm	

CONCLUSION
Since acceptable soil screening level concentrations exceed the 95% UCL from the verification sampling, there is no need for additional remediation.

Mixing Zone Depth Calculation

MIXING ZONE DEPTH (d)

$d = (0.0112(L+xr)^2)^{0.5} + da(1 - \exp((\ln(L+xr))/Kida))$ (Equation 3)

DILUTION FACTOR (df) (Equation 4)

$df = 1 + Kid/inL$

CALCULATED PARAMETERS

d	15	mixing zone thickness (m)
df=	5.16	dilution factor

SOIL SCREENING LEVEL CALCULATION

$SSL = Cw(Kd + (Ow + (OaH))/B)$ (Equation 1)

$Kd = Koc * foc$ (Equation 2)

INPUT PARAMETER DEFINITION

MCL	mg/L	
Cw	mg/L	target soil leachate. Acceptable water concentration * df
Kd	L/kg	soil-water partition coefficient
Ow		saturated porosity
Oa		air filled porosity
H		Henry's Law constant * 41 to make dimensionless
B	kg/L	dry soil bulk density
Koc	L/kg	soil organic carbon/water partition coefficient
foc	g/g	fraction organic carbon in soil

CALCULATED SOIL SCREENING LEVELS

CHEMICAL	MCL/Guide Value	Cw	H	Koc	Kd	SSL
	mg/L	mg/L		L/kg	L/kg	mg/kg
Trichloroethene	0.005	0.0258	0.435	112	2.24	0.062175
Toluene	1	5.16	0.252	171	3.42	18.35851
1,1,1-TCA	0.2	1.032	0.763	110	2.2	2.504948
cis,1-2DCE	0.07	0.3612	0.185	29	0.58	0.255052
Freon 113*	1.9	9.804	—	—	—	—

* TLV in air is 1000ppm

Gradient Calculation between wells 113 and 114

Date	Well 114	Well 113	Hirizontal	Gradient
	Water elevation	gw elev.	Distance	
5/5/93	821.6	824.3	575	0.004696
5/19/93	821.62	824.11	575	0.00433
6/2/93	821.59	823.47	575	0.00327
9/2/93	821.54	821.09	575	-0.00078
10/6/93	821.62	821.54	575	-0.00014
11/2/93	821.63	823.67	575	0.003548
12/14/93	821.64	823.75	575	0.00367
2/15/94	821.62	851.59	575	0.052122
4/28/94	821.6	824.24	575	0.004591
			Average =	0.008367

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