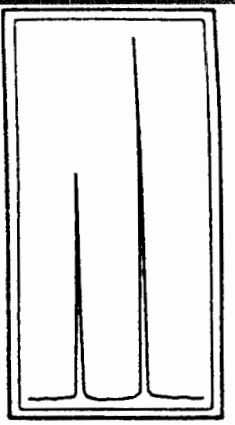

TRACER RESEARCH CORPORATION
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SOIL GAS INVESTIGATION

AT

PUBLIC SERVICE COMPANY OF NEW MEXICO'S PERSON GENERATING STATION

ALBUQUERQUE, NEW MEXICO

JUNE 1985

Prepared for:

Public Service Company of New Mexico
Alvarado Square
Albuquerque, New Mexico 87109

Submitted by:

Tracer Research Corporation

TABLE OF CONTENTS

SUMMARY

- Shallow soil gas samples (5 feet below the ground surface) were collected at 90 sampling points at Public Service Company of New Mexico's (PNM) Person Generating Station in Albuquerque, New Mexico.

- TCA and PCE plumes in soil gas are oriented in a predominantly east-northeast direction across the PNM property and have their highest concentrations in the area of the buried waste tank.

- Soil gas concentrations of TCA and PCE have exponential decay patterns in directions away from the buried waste tank.

- Based on soil gas/groundwater correlations from a limited sample set, TCA and PCE soil gas concentrations of about 0.01 µg/l hypothetically correspond to the low ppb concentration range of these compounds in groundwater.

INTRODUCTION

Soil gas contaminant investigation refers to a method developed by Tracer Research Corporation (TRC) for investigating underground contamination from volatile chemicals such as industrial solvents, cleaning fluids and petroleum products by looking for their vapors in the shallow soil gas. The method involves pumping a small amount of soil gas out of the ground through a hollow probe driven a few feet into the ground and analyzing the gas for the presence of volatile contaminants. The presence of contaminants in the soil gas usually means that there is contamination from the observed compound either in the soil near the probe or in the groundwater below the probe. Ideally, soil gas is a remote sensing technique for assessing groundwater contamination. The soil gas analysis is performed in the field so that samples do not have to be packed or shipped. Even more importantly, the analytical results are available immediately and can be used to help direct the investigation. The investigation usually proceeds by analyzing soil gas in transects across the contaminated area until the boundaries are well defined.

A shallow soil gas investigation was performed by Tracer Research Corporation (TRC) in the vicinity of Public Service Company of New Mexico's (PNM) Person Generating Station. The investigation was conducted from June 4 to June 8, 1985. The primary objective of the investigation was to delineate halocarbon plume boundaries in soil gas on and near the facility.

PNM has installed monitoring wells at several locations on and around Person Generating Station. Analyses of groundwater from these wells indicated the presence of 1,1-dichloroethylene (DCE), 1,1,1-trichloroethane (TCA) and tetrachloroethylene (PCE). On the basis

of these groundwater investigations, TRC analyzed soil gas samples for the presence of DCE, TCA, TCE (trichloroethylene) and PCE. Water levels in monitoring wells around the PNM facility vary from about 90 to 150 feet below the ground surface and the hydraulic gradient is predominantly to the east. The vadose zone consists of a dry sand which is optimum for diffusive movement of volatile contaminants through the vadose zone.

SAMPLING PROCEDURE

Soil gas samples were collected by driving a hollow steel probe 5 feet into the ground and evacuating 5 to 10 liters of gas with a vacuum pump. During the soil gas investigation, samples were collected by inserting a syringe needle through the silicone evacuation line and down into the steel probe. Ten milliliters of gas were collected for immediate analysis in the TRC analytical field van. Soil gas was subsampled (duplicate injections) in volumes ranging from 1 ul to 2 cc, depending on the halocarbon concentration at any particular location. The TRC analytical field van is equipped with two Tracor 540 gas chromatographs and two Spectra-Physics SP4260 computing integrators. Analyses were performed on an OV-101 packed column. Detection limits for the halocarbon solvents were 0.002 to 0.0003 ug/l in soil gas using the electron capture detector. Detection limits are a function the injection volume as well as detector sensitivity for individual compounds.

TRC's normal quality assurance procedures were followed in order to prevent any cross-contamination of soil gas samples. Prior to sampling, syringes were purged with nitrogen (i.e. carrier gas) and checked for contamination by injection into the gas chromatograph. System blanks were run periodically to confirm that there was no contamination in the probes, adaptors, or 10 cc syringes. Soil gas probes were used only once during the course of a working day and then cleaned with a high pressure soap and hot water wash before use on the subsequent day. Analytical instruments were continuously checked for calibration by the use of chemical standards prepared in water from commercially available pure chemicals. Soil gas pumping was monitored by a vacuum gauge to ensure that an adequate gas flow from the vadose zone was maintained. A negative pressure (vacuum) greater than 15 in. of H_g usually indicates that a reliable gas sample cannot be obtained because of a clogged probe or because the soil has a very low air porosity.

FIELD INVESTIGATION

Soil gas was collected from a total of 90 sampling points on or near the site. Transects were established both parallel and perpendicular to the regional hydraulic gradient in order to delineate the boundaries of the plume. Additional sampling points were added on the basis of real-time results obtained in the field. Soil gas was sampled at a consistent depth of 5 feet below the ground surface. Although the water table varies from about 90 to 150 feet below the ground surface at this site, halocarbon concentrations in soil gas are directly comparable because samples are drawn from the uppermost portion of the concentration gradient. There are only very gradual changes in VOC concentrations with depth in this upper portion of the vadose zone. The results of similar investigations conducted by TRC (e.g. deep aquifers overlain by dry sandy soils) suggest that normal variations in ground elevation do not have a significant effect on VOC concentrations in shallow soil gas.

The air porosity at all 90 sampling points was high enough to permit soil gas to be extracted, however, more than one probe was driven at several locations because of boulders which were encountered above the 5 foot depth. Soil gas was sampled adjacent to several monitoring wells around the facility to obtain a correlation between halocarbon concentrations in soil gas and groundwater on a µg/l basis. Soil gas/groundwater correlations are often useful in locating surface or vadose zone sources and in estimating groundwater concentrations (order-of-magnitude basis) where there are no monitoring wells.

RESULTS & DISCUSSION

The identification number, sampling date, and soil gas concentration of halocarbon solvents are given for each sampling point in Appendix A.

The location of sampling points and corresponding concentrations of DCE, TCA and PCE in soil gas are shown in Figure 1. All concentrations are in the units of µg/l. The detection limits are indicated in each analysis where any of the contaminants were either not detected or detected below a concentration which could be reliably integrated by the analytical instruments.

TCA DISTRIBUTION

Concentration contours of TCA in soil gas are shown in Figure 2. The highest soil gas concentrations encountered on the PNM site (200 and 400 µg/l) were located near the buried waste tank at the north end of the power plant building. The concentric contour lines around the tank area suggest that it is the primary source of TCA in soil gas on and around the property. The TCA plume is oriented in an east-northeast direction with a lobe of the soil gas plume located south of the tank. Sampling point SG72, located within the southern lobe, had an anomalously high TCA concentration (30 µg/l) compared to the predominant distributional pattern.

TCA is present in soil gas hydraulically upgradient (west) of the buried waste tank which is characteristic of a site where the depth to water exceeds 100 feet. Radial spreading of TCA in the vadose zone (immiscible, dissolved or vapor phases) will result in soil gas contamination around the tank, regardless of its presence or absence in groundwater. Previous studies conducted by TRC in similar soils suggest that lateral diffusion of VOC's from a point source in the vadose zone extends a radial distance equal to about 3 times the depth to water. Assuming a groundwater depth of about 100 feet in the tank area, the lateral diffusion would be expected to extend radially about 300 feet from the point source.

PCE DISTRIBUTION

The distribution and concentration contours of PCE (Figure 3) in soil gas are quite similar to those of TCA. As observed for TCA, the PCE soil gas plume is concentric around the buried waste tank and oriented predominantly east-northeast. The highest PCE concentration (200 µg/l at SG75) was encountered near the buried waste tank at the north end of the power plant building. Sampling point SG72, located within the southern lobe of the plume, had an anomalously high PCE concentration (5 µg/l) compared to the predominant distributional pattern. The upgradient contours of PCE are similar to those of TCA, further suggesting that the two solvents have a common source.

The general shape of the PCE and TCA plumes are very similar. The 0.1 µg/l contour for PCE and the 0.01 µg/l contour for TCA are almost identical. The flattened shape of the plume near the northeastern boundary may be influenced by the presence of a dry wash which runs in a southwest direction. Infiltration along the wash can affect plume migration in both groundwater and soil gas.

DCE DISTRIBUTION

The dichloroethylene isomer tentatively identified by TRC in soil gas was cis-1,2-DCE whereas, 1,1-DCE was identified in water samples from monitoring wells. Although the 1,1-DCE isomer may have been present in the soil gas, the analysis of soil gas was optimized for the measurement of TCA and PCE and thus a small 1,1-DCE peak would have been masked by the air peak. Only a large 1,1-DCE peak would have been detected. The indentification of the cis-1,2 isomer was based on a single column analysis and thus is subject to uncertainty.

The distribution pattern of DCE (Figure 4) is highly influenced by DCE values measured at three sampling locations east of the power plant building (SG69, SG70, and SG71). Similar to the TCA and PCE plumes, the DCE plume is oriented predominantly in a northeasterly direction with a lobe in a southerly direction.

SOIL GAS/GROUNDWATER CORRELATIONS

Correlation coefficients were calculated for TCA and PCE concentrations in soil gas (µg/l) and groundwater (µg/l) based on the results of TRC sampling near 7 existing monitoring wells (Figures 5 and 6). There is no correlation for DCE because only the 1,1-isomer was measured in groundwater and only the cis-1,2 isomer was analyzed in soil gas.

The PCE and TCA regression lines indicated that the 0.01 µg/l contour in soil gas hypothetically correspond to the 1 µg/l (ppb) contour in groundwater. The correlation coefficients for PCE ($r = 0.92$) and TCA ($r = 0.91$) were quite high, which is characteristic of deep aquifers overlain by relatively dry and sandy soils. However, the regression equations were calculated assuming that detection limits (i.e., 0.1 µg/l) were the actual values of TCA and PCE in monitoring wells #4, 5 and 7, and using soil gas values for SG75 and SG90 located near the known vadose zone source. Due to these assumptions and the limited sample size available for the performing the regression, a high degree of uncertainty is inherent in the correlation calculations. The slope of the regression lines

for TCA and PCE are nearly identical, suggesting that the areal extent of the soil gas plumes are comparable. In other words, the 0.01 µg/l contours for PCE and TCA in soil gas represent approximately the same boundary values in groundwater.

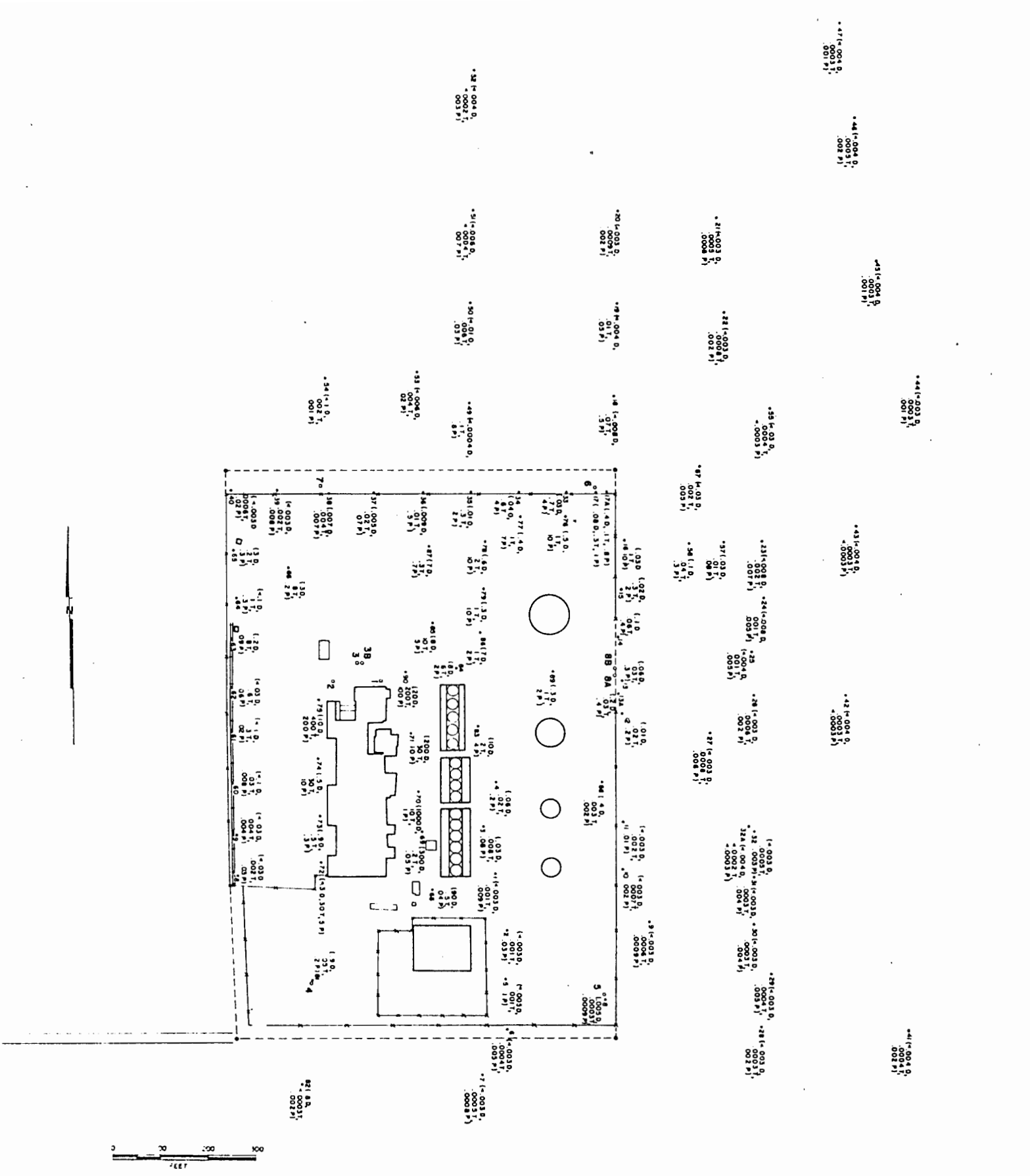


Figure 1. Location of Soil Gas Sampling Points at PNM's Person Generating Station, June 4 - 8, 1985

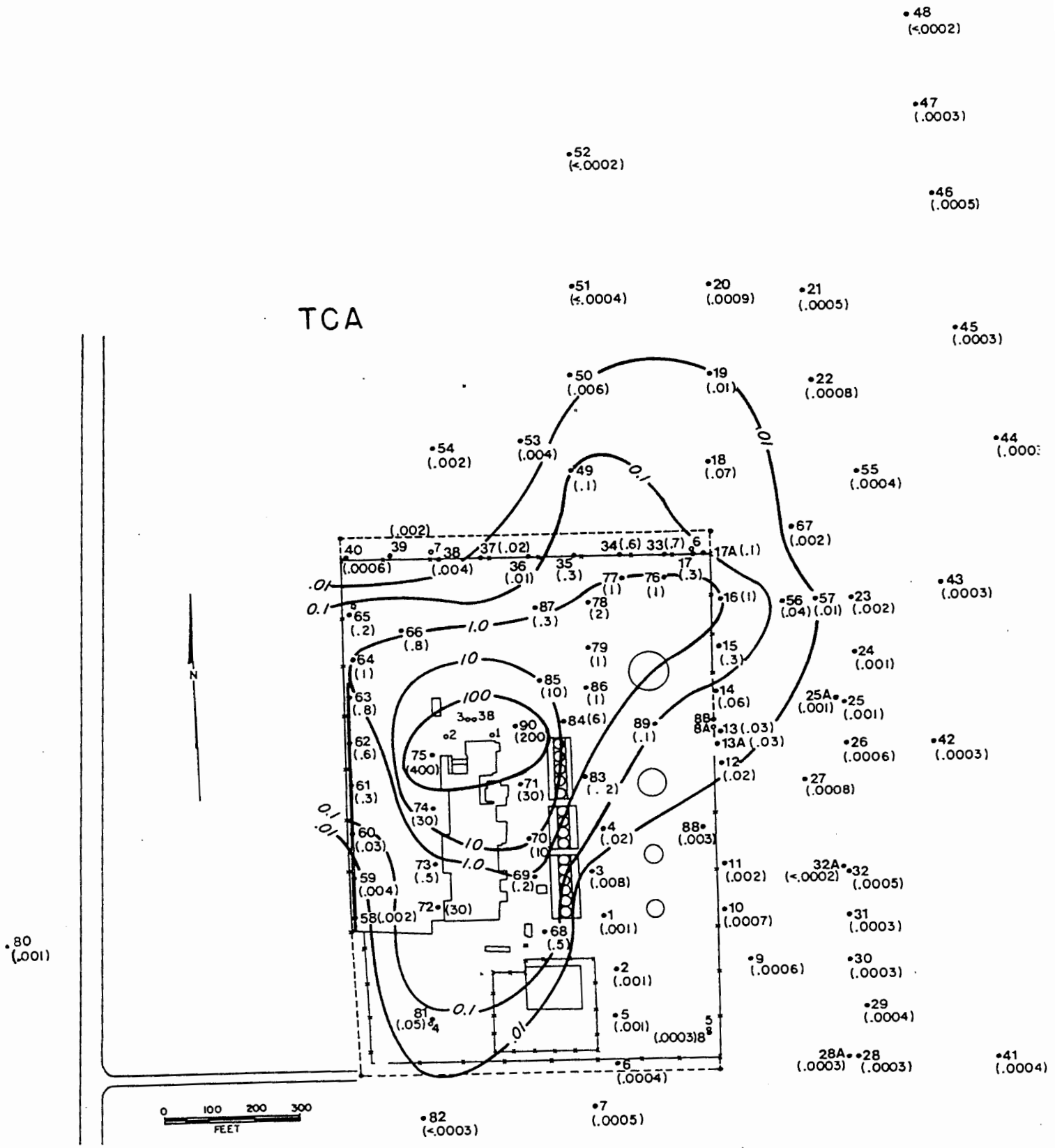


Figure 2. TCA Concentration Contours in Soil Gas at PNM's Person Generating Station June 4-8, 1985

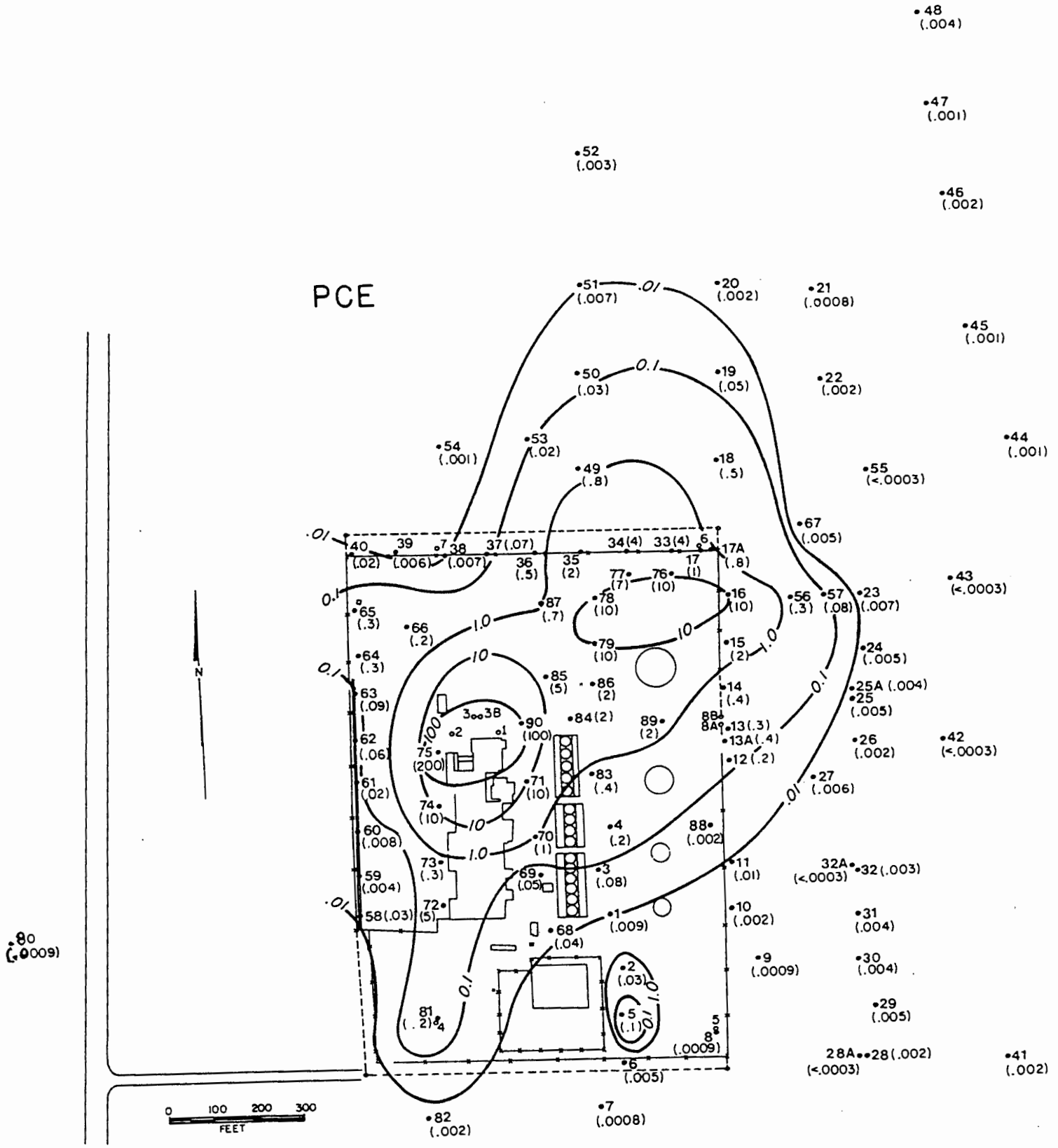


Figure 3. PCE Concentration Contours in Soil Gas at PNM's Person Generating Station, June 4-8, 1985

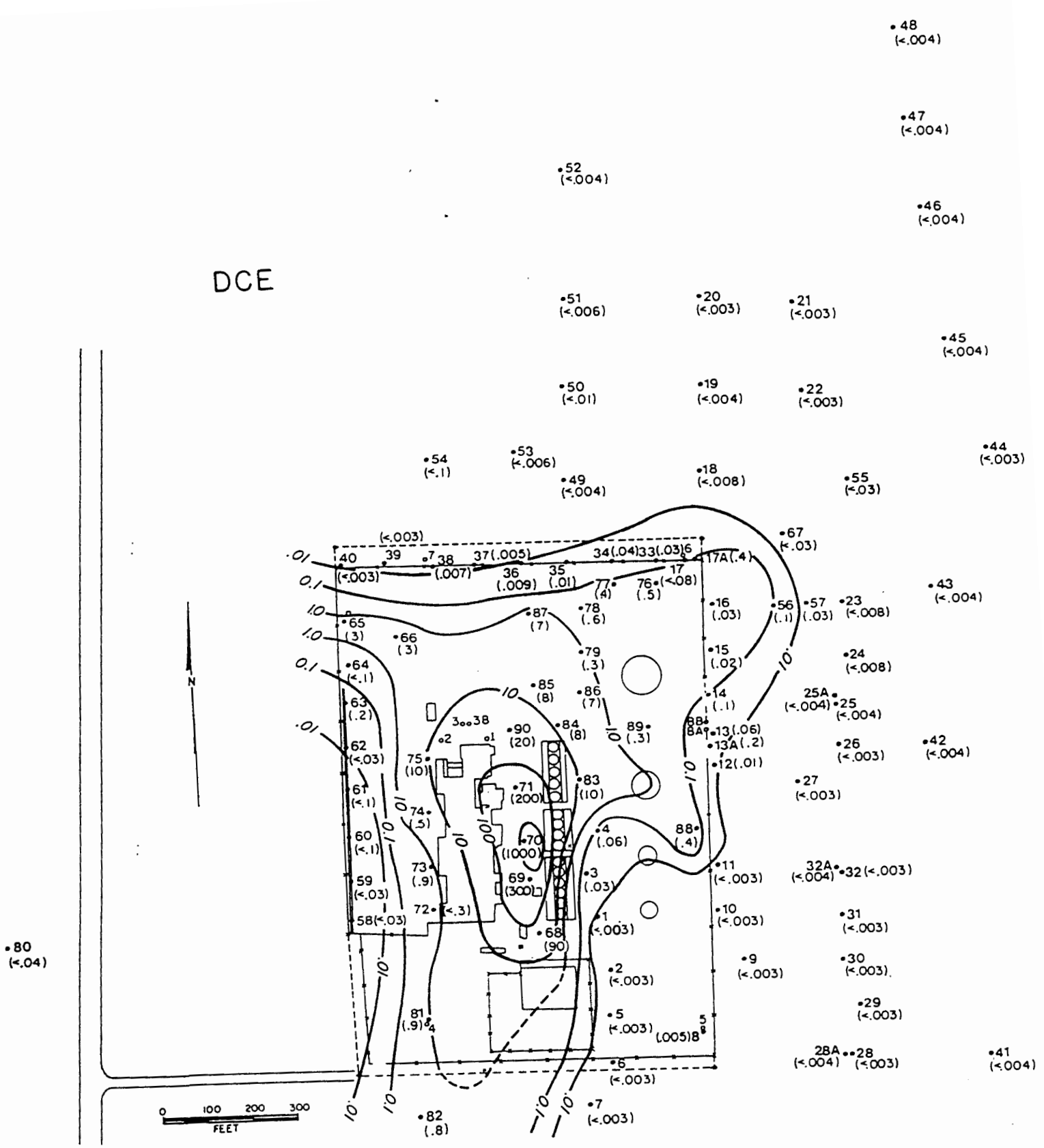


Figure 4. DCE Concentration Contours in Soil Gas at PNM's Person Generating Station, June 4 - 8, 1985

Figure 5. Groundwater vs. soil gas concentrations (ug/l) of 1,1,1-trichloroethane at 7 monitoring wells around the PNM site. The correlation coefficient (r) is 0.92. Monitoring wells #4, 5 and 7 had TCA levels below the 0.1 ppb detection limit.

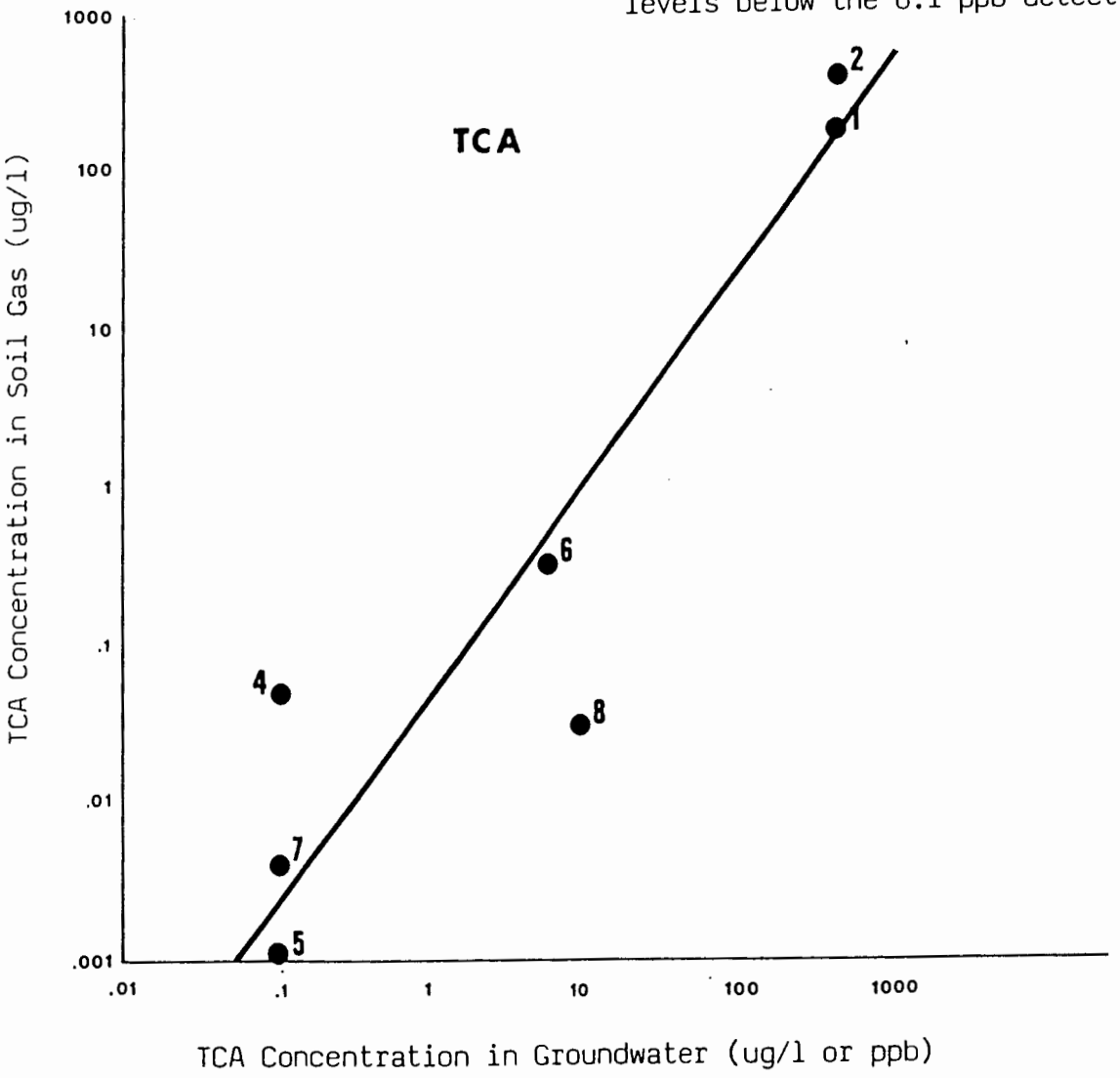
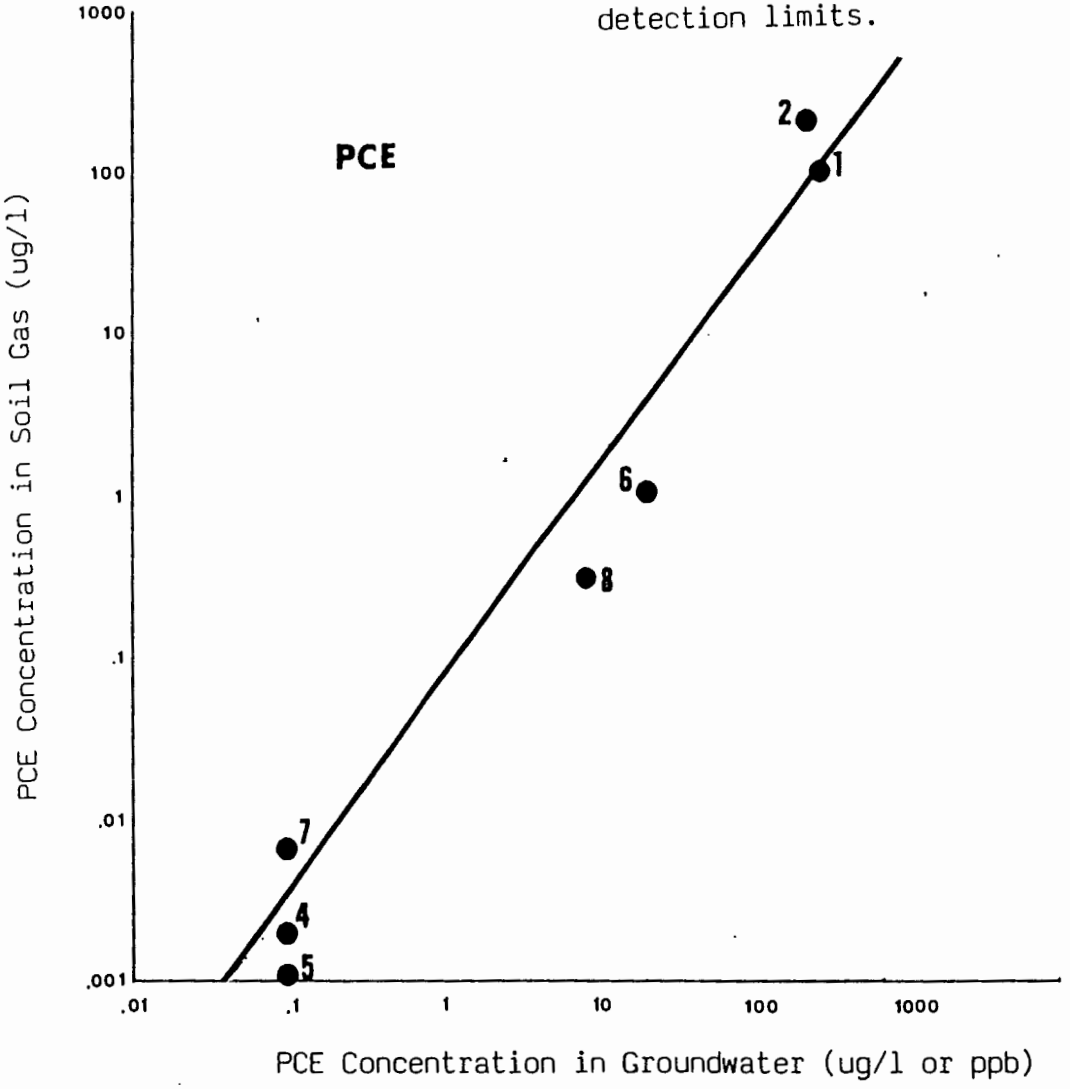


Figure 6. Groundwater vs. soil gas concentrations (ug/l) of perchloroethylene at 7 monitoring wells around the PNM site. The correlation coefficient (r) is 0.91. Monitor wells #4, 5 and 7 had PCE levels below the 0.1 ppb detection limits.



APPENDIX A:

Table of Analytical Results

Job Public Service Co. of New Mexico (Person Station)

TRACER RESEARCH CORPORATION

Date 6/4-6/8/85 Page 1 of 6

DATA SUMMARY

			DCE			TCA			TCE			PCE		
standard conc.				µg/l			µg/l			µg/l			µg/l	
response from			1	area		1	area		1	area		1	area	
5ul injection			2	area		2	area		2	area		2	area	
			3	area		3	area		3	area		3	area	
RFs for this sheet				g/area			g/area			g/area			g/area	
sample	date	amt inj	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean
SG1-3'	6/4			<.003			.001			.001			.009	
SG2-5'	6/4			<.003			.001			.001			.03	
SG3-5'	6/4			.03			.008			.001			.08	
SG4-5'	6/4			.06			.02			<0.001			0.2	
SG5-5'	6/4			<.003			.001			0.0009			0.1	
SG6-4'	6/4			<.003			0.0004			0.0008			0.005	
SG7-5'	6/4			<.003			0.0005			<0.0004			0.0008	
SG8-5'	6/4			.005			0.0003			0.0007			0.0009	
SG9-5'	6/4			<.003			0.0006			0.0007			0.0009	
SG10-5'	6/4			<.003			0.0007			<0.0004			0.002	
SG11-5'	6/4			<.003			0.002			0.0004			0.01	
SG12-5'	6/4			.01			0.02			0.0005			0.2	
SG13-5'	6/4			.06			0.03			0.0005			0.3	
SG14-5'	6/4			0.1			0.06			0.003			0.4	
SG15-5'	6/4			.02			0.3			0.008			2	
SG16-5'	6/4			.03			1			0.03			10	
SG17-5'	6/4			<.08			0.3			0.01			1	
SG18-5'	6/5			<0.008			0.07			<0.0008			0.5	

Notations: RF response factor
I interference with adjacent peaks

Analysed by D. Marrin

Job Public Service Co. of New Mexico (Person Station)

TRACER RESEARCH CORPORATION

Date 6/4-6/8/85 Page 2 of 6

DATA SUMMARY

			DCE			TCA			TCE			PCE		
standard conc.				µg/l			µg/l			µg/l			µg/l	
response from			1	area		1	area		1	area		1	area	
5ul injection			2	area		2	area		2	area		2	area	
			3	area		3	area		3	area		3	area	
RFs for this sheet				g/area			g/area			g/area			g/area	
sample	date	amt inj	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean
SG19-5'	6/5			<0.004			0.01			<0.0004			0.05	
SG20-5'	6/5			<0.003			0.0009			<0.0003			0.002	
SG21-5'	6/5			<0.003			0.0005			<0.0003			0.0008	
SG22-5'	6/5			<0.003			0.0008			<0.0003			0.002	
SG23-5'	6/5			<0.008			0.002			<0.0008			0.007	
SG24-5'	6/5			<0.008			0.001			0.002			0.005	
SG25-5'	6/5			<0.004			0.001			0.002			0.005	
SG26-5'	6/5			<0.003			0.0006			0.0005			0.002	
SG27-5'	6/5			<0.003			0.0008			0.003			0.006	
SG28-5'	6/5			<0.003			0.0003			0.0007			0.002	
SG29-5'	6/5			<0.003			0.0004			0.0008			0.005	
SG30-5'	6/5			<0.003			0.0003			0.001			0.004	
SG31-5'	6/5			<0.003			0.0003			0.0009			0.004	
SG32-5'	6/5			<0.003			0.0005			0.0005			0.003	
SG33-5'	6/5			0.03			0.7			0.01			4	
SG34-5'	6/5			0.04			0.6			0.03			4	
SG35-5'	6/5			0.01			0.3			0.01			2	
SG36-5'	6/5			.009			0.01			0.001			0.5	

Notations: RF response factor
I interference with adjacent peaks
NA not analysed

Analysed by D. Evans

Job Public Service Co. of New Mexico (Person Station)

TRACER RESEARCH CORPORATION

Date 6/4-6/8/85 Page 3 of 6

DATA SUMMARY

			DCE			TCA			TCE			PCE		
standard conc.				µg/l			µg/l			µg/l			µg/l	
response from			1	area		1	area		1	area		1	area	
5ul injection			2	area		2	area		2	area		2	area	
			3	area		3	area		3	area		3	area	
RFs for this sheet				g/area			g/area			g/area			g/area	
sample	date	amt inj	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean
SG37-5'	6/5			0.005			0.02			0.003			0.07	
SG38-5'	6/5			0.007			0.004			0.002			0.007	
SG39-5'	6/5			<0.003			0.002			0.0007			0.006	
SG40-5'	6/5			<0.003			0.0006			0.001			0.02	
SG41-5'	6/6			<0.004			0.0004			0.0004			0.002	
SG42-5'	6/6			<0.004			0.0003			<0.0003			<0.0003	
SG43-5'	6/6			<0.004			0.0003			<0.0003			<0.0003	
SG44-5'	6/6			<0.003			0.0003			<0.0002			0.001	
SG45-5'	6/6			<0.004			0.0003			<0.0003			0.001	
SG46-5'	6/6			<0.004			0.0005			<0.0003			0.002	
SG47-5'	6/6			<0.004			0.0003			<0.0003			0.001	
SG48-5'	6/6			<0.004			<0.0002			0.001			0.004	
SG49-5'	6/6			<0.004			0.1			0.0005			0.8	
SG50-5'	6/6			< 0.01			0.006			0.003			0.03	
SG51-5'	6/6			<0.006			<0.0004			0.002			0.007	
SG52-5'	6/6			<0.004			<0.0002			0.001			0.003	
SG53-5'	6/6			<0.006			0.004			<0.0005			0.02	
SG54-5'	6/7			<0.1			0.002			0.001			0.001	

Notations: RF response factor
I interference with adjacent peaks
NA not analysed

Analysed by D. Evans

Job Public Service Co. of New Mexico (Person Station)

TRACER RESEARCH CORPORATION

Date 6/4-6/8/85 Page 4 of 6

DATA SUMMARY

			DCE			TCA			TCE			PCE		
standard conc.				µg/l			µg/l			µg/l			µg/l	
response from			1	area		1	area		1	area		1	area	
5ul injection			2	area		2	area		2	area		2	area	
			3	area		3	area		3	area		3	area	
RFs for this sheet				g/area			g/area			g/area			g/area	
sample	date	amt inj	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean
SG55-5'	6/7			<0.03			0.0004			<0.0006			<0.0003	
SG56-5'	6/7			.1			0.04			<0.002			0.3	
SG57-5'	6/7			0.03			0.01			<0.001			0.08	
SG58-5'	6/7			<0.03			0.002			<0.001			0.03	
SG59-5'	6/7			<0.03			0.004			<0.0006			0.004	
SG60-5'	6/7			<0.1			0.03			<0.0006			0.008	
SG61-5'	6/7			<0.1			0.3			<0.0006			0.02	
SG62-5'	6/7			<0.03			0.6			<0.002			0.06	
SG63-5'	6/7			0.2			0.8			<0.002			0.09	
SG64-5'	6/7			<0.1			1			<0.002			0.3	
SG65-5'	6/7			3			0.2			0.003			0.3	
SG66-5'	6/7			3			0.8			<0.002			0.2	
SG67-5'	6/7			<0.03			0.002			0.002			0.005	
SG68-5'	6/7			90			0.5			0.1			0.04	
SG69-5'	6/7			300			0.2			0.2			0.05	
SG70-5'	6/7			1000			10			4			1	
SG71-5'	6/7			200			30			<0.004			10	
SG72-5'	6/7			<0.3			30			<0.004			5	

Notations:
RF response factor
I interference with adjacent peaks
NA not analysed
E estimated peak area

Analysed by D. Evans

Checked by G. Thompson

Job Public Service Co. of New Mexico (Person Station)

TRACER RESEARCH CORPORATION

Date 6/4-6/8/85 Page 5 of 6

DATA SUMMARY

	DCE			TCA			TCE			PCE		
standard conc.			µg/l			µg/l			µg/l			µg/
response from	1		area	1		area	1		area	1		area
5ul injection	2		area	2		area	2		area	2		area
	3		area	3		area	3		area	3		area
RFs for this sheet			g/area			g/area			g/area			g/area

sample	date	amt inj	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean
SG73-5'	6/7			0.9			0.5			0.005			0.3	
SG74-5'	6/7			0.5			30			<0.004			10	
SG75-5'	6/7			.10			400			<0.09			200	
SG76-5'	6/7			0.5			1			0.03			10	
SG77-5'	6/7			0.4			1			0.03			7	
SG78-5'	6/7			0.6			2			0.04			10	
SG79-5'	6/7			0.3			1			0.04			10	
SG80-5'	6/8			<0.04			0.001			0.0008			0.0009	
SG81-2'	6/8			0.9			0.05			0.01			0.2	
SG82-5'	6/8			0.8			<0.0003			0.01			0.002	
SG83-5'	6/8			10			0.2			0.05			0.4	
SG84-5'	6/8			8			6			0.09			2	
SG85-5'	6/8			8			10			0.8			5	
SG86-5'	6/8			7			1			0.07			2	
SG87-5'	6/8			7			0.3			0.07			0.7	
SG88-3.5'	6/8			0.4			0.003			0.004			0.002	
SG89-5'	6/8			0.3			0.1			0.005			2	
SG90-5'	6/8			20			200			<0.04			100	

Notations: RF response factor
I interference with adjacent peaks
NA not analysed

Analysed by D. Evans

Job Public Service Co. of New Mexico (Person Station)

TRACER RESEARCH CORPORATION

Date 6/4-6/8/85 Page 6 of 6

DATA SUMMARY

			DCE			TCA			TCE			PCE		
standard conc.				µg/l			µg/l			µg/l			µg/l	
response from			1	area		1	area		1	area		1	area	
5ul injection			2	area		2	area		2	area		2	area	
			3	area		3	area		3	area		3	area	
RFs for this sheet				g/area			g/area			g/area			g/area	
sample	date	amt inj	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean	area	µg/l	mean
SG13A-5'	6/8			0.2			0.03			<0.002			0.4	
SG17A-5'	6/8			0.4			0.1			0.006			0.8	
SG25A-5'	6/6			<0.004			0.001			<0.0003			0.004	
SG28A-5'	6/6			<0.004			0.0003			<0.0003			<0.0003	
SG32A-5'	6/6			<0.004			<0.0002			<0.0003			<0.0003	

Notations:
RF response factor
I interference with adjacent peaks
NA not analysed

Analysed by D. Evans