6-1988

An Investigation of a Soil Gas Sampling Technique and Its Applicability for Detecting Gaseous PCE and TCA Over an Unconfined Granular Aquifer

Timothy J. Mayotte

Recommended Citation

Mayotte, Timothy J., "An Investigation of a Soil Gas Sampling Technique and Its Applicability for Detecting Gaseous PCE and TCA Over an Unconfined Granular Aquifer" (1988). *Master's Theses*. 1201.
https://scholarworks.wmich.edu/masters_theses/1201

AN INVESTIGATION OF A SOIL GAS SAMPLING TECHNIQUE AND ITS APPLICABILITY FOR DETECTING GASEOUS PCE AND TCA OVER AN UNCONFINED GRANULAR AQUIFER

by

Timothy J. Mayotte

A Thesis
Submitted to the
Faculty of The Graduate College
in partial fulfillment of the
requirements for the
Degree of Master of Science
Department of Geology

Western Michigan University
Kalamazoo, Michigan
June 1988

AN INVESTIGATION OF A SOIL GAS SAMPLING TECHNIQUE AND ITS APPLICABILITY FOR DETECTING GASEOUS PCE AND TCA OVER AN UNCONFINED GRANULAR AQUIFER

Timothy J. Mayotte, M.S.

Western Michigan University, 1988

A soil gas sampling and analytical technique was investigated to evaluate its ability and versatility for detecting chlorinated hydrocarbons in unconfined aquifers. The technique was used successfully to delineate plumes of perchloroethene (PCE), and 1,1,1-trichloroethane (TCA) contamination present in the vadose zone, and at the water table of an unconfined sand and gravel aquifer. Soil gas samples were obtained by concentrating PCE and TCA vapors diffusing from these sources onto a sorbent material. The samples were analyzed by gas chromatography. The data from the analysis of these samples were used to provide an initial estimate of the source areas, and the areal extent of the groundwater plumes beneath the study area. These estimates were confirmed with water quality data. High degrees of correlation were proven to exist between the soil gas and water quality data obtained during this study.

ACKNOWLEDGEMENTS

I would like to thank all of those people who lended technical and clerical assistance and were instrumental in completing this study. I would especially like to thank my parents, Bernard and Jean Mayotte. Over the years they have sacrificed much of their personal interests and have given invaluable support while I have worked to complete my educational goals.

Finally, I want to thank my wife Kathleen for all the support and encouragement she has given me while I have worked on this study. Kath has also, willingly, sacrificed many of her own interests and has been my constant source of strength over these past few years. It is to her that I dedicate this study.

Timothy J. Mayotte

INFORMATION TO USERS

This reproduction was made from a copy of a document sent to us for microfilming. While the most advanced technology has been used to photograph and reproduce this document, the quality of the reproduction is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help clarify markings or notations which may appear on this reproduction.

1. The sign or "target" for pages apparently lacking from the document photographed is "Missing Page(s)". If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure complete continuity.
2. When an image on the film is obliterated with a round black mark, it is an indication of either blurred copy because of movement during exposure, duplicate copy, or copyrighted materials that should not have been filmed. For blurred pages, a good image of the page can be found in the adjacent frame. If copyrighted materials were deleted, a target note will appear listing the pages in the adjacent frame.
3. When a map, drawing or chart, etc., is part of the material being photographed, a definite method of "sectioning" the material has been followed. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.
4. For illustrations that cannot be satisfactorily reproduced by xerographic means, photographic prints can be purchased at additional cost and inserted into your xerographic copy. These prints are available upon request from the Dissertations Customer Services Department.
5. Some pages in any document may have indistinct print. In all cases the best available copy has been filmed.

University
Microfilms
International

300 N. Zeeb Road
Ann Arbor, MI 48106

Reproduced with permission of the copyright owner. Further reproduction prohibited without permission.

Order Number 1334189

An investigation of a soil gas sampling technique and its applicability for detecting gaseous PCE and TCA over an unconfined granular aquifer

Mayotte, Timothy Joseph, M.S.

Western Michigan University, 1988

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

TABLE OF CONTENTS

CHAPTER

Table of Contents--Continued

CHAPTER

APPENDICES

Table of Contents--Continued

CHAPTER

LIST OF TABLES

LIST OF FIGURES

List of Figures--Continued

List of Figures--Continued

CHAPTER I

INTRODUCTION

The detection and delineation of plumes of chlorinated hydrocarbons in the groundwater of unconfined aquifers is, often, an expensive, time consuming endeavor. In the past, the discovery, and definition of the areal extent of these plumes has been accomplished through the installation and sampling of borings and monitoring wells. Although samples acquired by these means are the best way to quantitatively measure contaminants in the groundwater, such sample acquisition and analysis is expensive and may require weeks to accomplish. In cases where little is known of the groundwater flow conditions or contaminant distributions, many borings or wells may be required to adequately define the extent of plumes. The detection and delineation of chlorinated hydrocarbon (CH) plumes by monitoring the vadose zone air (soil gas) over these plumes is an inexpensive and rapid alternative.

Previous Studies

Soil gas composition data have been acquired and used extensively over the past few years to help locate sources and delineate groundwater plumes of chlorinated hydrocarbons. These data have often been used to aid in the design of monitoring well networks over these plumes.

Lappala and Thompson (1983) discussed the theory behind, and applications related to, the detection of groundwater contamination by shallow soil gas sampling in the vadose zone of unconfined granular aquifers. Marrin and Thompson (1984) presented case histories where soil gas data were used successfully to map plumes of trichlorethene and 1,1,1-trichloroethane in granular water table aquifers. Marrin (1985) showed how soil gas data were also useful for determining the sources for, and delineation of, groundwaters contaminated with methane, benzene, toluene and total hydrocarbons. Marrin (1986) investigated how soil gas data could be interpreted to distinguish between dichloroethene, perchloroethene, and 1,1,1-trichloroethane contamination in the vadose zone as opposed to in the groundwater. Mills (1986) described the use of a static soil vapor collector to identify trichloroethene and perchloroethene contamination in the groundwater.

A summary of various soil gas sampling and analytical techniques, that have been used successfully to detect petroleum and chlorinated hydrocarbon vapors emanating from plumes of these contaminants in unconfined sand and gravel aquifers, was compiled by Eklund

May, 1985. In this report the uses of soil cores, surface and downhole flux chambers, accumulator devices and ground probe testing as soil gas sampling methods were discussed. A brief review of the various techniques available for the analysis of soil gas samples was provided as well.

The Problem

A soil gas sampling technique, which utilizes a ground probe, and concentrates soil gas constituents onto a sorbent medium, has been used extensively by the NUS Corporation to aid in identifying sources of chlorinated hydrocarbon contamination in water table aquifers. The data from previous soil gas surveys performed with the NUS technique have been used successfully for this purpose. However, the versatility of the technique for not only detecting source "hot spots" but also for delineating plumes of contamination has been in question. At no site has there been a sufficient amount of soil gas and corresponding water quality data available to evaluate the ability of the technique for accomplishing plume delineation. Therefore, a study was needed that would have a data base sufficient to evaluate the use of soil gas data obtained by the NUS method for defining plumes, as well as sources, of chlorinated hydrocarbons in unconfined granular aquifers.

Objectives

The objectives of this study are to evaluate the ability and versatility of this soil gas sampling and analysis technique for detecting vapors diffusing from chlorinated hydrocarbon contamination in the vadose zone and in the groundwater of an unconfined granular aquifer.

The manner in which soil vapors are sampled using this technique entails drawing a specified volume of soil vapor through a stainless steel sampling probe installed at depths of up to 5 feet below the ground surface, into a small stainless steel tube packed with sorbent material. One liter of soil gas is drawn through the tube and the chlorinated hydrocarbon vapors are adsorbed onto Tenax (60/80 mesh) packed in the tube. The steel tube is then inserted directly into a liquid sample concentrating device and the sample is analyzed by purge and trap gas chromatography.

To achieve these objectives, the technique has been utilized over a plume of known groundwater contamination. Water quality data, most of which were obtained at the same locations and same approximate times as the soil gas samples, were used for verification of, and correlation with, the soil gas data. Sampling was done during both the summer and winter.

The study area, located in west-central Michigan, is underlain by an unconfined sand and gravel aquifer with a depth to water table of approximately 8 to 10 feet below ground level. The aquifer is contaminated with the chlorinated hydrocarbons PCE and TCA. The contamination is known to have originated at a former truck servicing facility for a hazardous waste hauling company.

A Remedial Investigation (RI) of this facility has been carried out, for the Michigan Department of Natural Resources (MDNR), by NUS. During the investigation, soil gas, temporary well, soil and monitoring well sampling data were acquired. Many of these data have been used to serve as, or supplement the data base for this study.

The soil gas data obtained for this study were used successfully to define the PCE and TCA sources and to delineate the contaminant plumes present at the water table. High correlations were found to exist between the soil gas and corresponding water quality data.

CHAPTER II

CONTAMINANT TRANSPORT THEORY: LITERATURE REVIEW

The presence of chlorinated hydrocarbons (CH) in the vadose zone, or at the water table of unconfined granular aquifers may be verified by detecting the vapors of these compounds in the soil gas above, and around the contaminated zones.

In order for CH's in the groundwater to be detected in the vadose zone, these compounds must move upward from the water table, through the capillary fringe and then to the point at which a soil gas sample is taken (Lappala and Thompson, 1984).

Many factors control the migration and fate of CH's in the vadose zone and in the groundwater of unconfined granular aquifers. These factors determine how a plume of CH will be distributed at the water table and, consequently, how the CH vapors will be dispersed above the plume. This will, of course, determine the extent to which a groundwater contaminant plume may be delineated using soil gas sampling data.

The situation that has been described is when gases volatilize from dissolved CH's (solute) at the water table. However, gases can also emanate from nondissolved CH liquid (raw product) retained in the vadose zone above the water table. In this section, the mechanisms that control the movement of CH plumes in unconfined granular aquifers, and the migration of CH gases above these plumes will be discussed. In doing this, the theoretical migration behavior of a spill or leak of CH's occurring above this type of aquifer will be described. Thus, consideration will also be given to the migration of CH liquids, solutes and vapors in the vadose zone.

The prediction or evaluation of the migration process of a given CH fluid in granular deposits is based upon several physical and chemical characteristics of that substance. These characteristics include the viscosity, surface tension, density, solubility, volatility and the vapor density of the substance (Schwille, 1984). In the following sections of this Chapter a description of the role each characteristic plays in the migration process will be presented.

Infiltration Into An Unconfined Aquifer

When a spill or point-source leak of a CH liquid takes place over a granular aquifer the liquid will migrate downward in the vadose zone under the influence of gravity. The velocity at which the migration occurs is dependent upon the fluid viscosity of the substance.

The more viscous the fluid, the slower it will migrate. The depths to which the compound will migrate will depend on the volume of the CH fluid that has been spilled or is leaking, and the retention capacity of the porous medium. If the volume of the substance is large enough such that the residual saturation of the liquid has been exceeded, and the porous media is homogeneous, then flow will continue to the water table (Schwille, 1984). Soil containing lenses or zones of deposits having lower permeabilities and higher water retention capacities than the surrounding materials may restrict the depth of penetration of this flow. A lateral component of flow may result as the migrating CH fluid encounters these local heterogeneities in the porous media. Consequently, a broadening of the fluid body may result (Schwille, 1984).

Theoretically, the fluid body may even become perched above semi-impermeable deposits in the vadose zone.

If the volume of CH fluid that has been spilled or leaked is small, such that the retention capacity of the soil material has not been exceeded above the water table, then the fluid will be retained under residual saturation. This can occur as the fluid is held in the soil matrix under capillary retention, capillary entrapment (Bear, 1979; de Marsily, 1986), or by adsorption of the CH liquid to the soil particles (Schwarzenbach and Giger, 1985). The degree to which capillarity will occur will be governed by the surface tension of the fluid and by the porosity of the material (Schwille, 1984). Substances having high surface tensions are more easily retained in a porous medium than substances with low surface tensions.

For spills of CH fluid that have penetrated the full extent of the vadose zone and have infiltrated the groundwater, the density of the substances comprising the fluid will dictate the position in the aquifer to which each substance will migrate (Zachara, 1986). The density of the substance relative to the density of water will control whether the substance will sink through the aquifer or float on top of the water table. Most chlorinated hydrocarbons are denser than water and will sink through the aquifer as a result. Both PCE and TCA have densities greater than water; thus, we will consider such behavior only.

The migration of the CH fluid, because it is immiscible with water, is slowed slightly as it reaches the water table. This occurs because water must be displaced from its path of migration (Schwille, 1984). The continued flow of the CH fluid through the saturated thickness of the aquifer is determined by the same factors that control migration in the vadose zone. If the retention capacity of the saturated zone is exceeded the CH fluid will sink to the base of the aquifer. The CH fluid will then spread out over this semi-impermeable zone much like pancake batter over a fry pan (Schwille, 1984; Cherry, 1987). Much CH fluid is retained throughout the saturated zone behind the migrating fluid front. As in the vadose zone, the fluid is in a state of residual saturation. The CH fluid is held in the pores of the aquifer material under the effects of capillarity. Some of the CH fluid may also be adsorbed into the matrix of the aquifer by the phenomena of solid-liquid partitioning as discussed by Schwarzenbach and Giger (1985). For a large spill, the amount of CH fluid under residual saturation on the lee side of the fluid front may be quite significant. For a transient leak of CH fluid, the flux of material into the vadose zone and the underlying aquifer could also result in a significant distribution of CH fluid in residual saturation along the path of the fluid's migration.

These CH fluid bodies in residual saturation are pervious to the flow of water, both in the vadose zone and the saturated zone. When infiltrating water or groundwater flows through the immiscible CH fluid it will dissolve some of that fluid (Zachara, 1986).

The solubility of the components of the fluid will determine the concentration of the solution zone formed on the downgradient side of the CH fluid bodies (Schwille, 1984). A plume of dissolved constituents is formed throughout the entire thickness of the saturated zone as a result of this phenomena (Cherry, 1987; de Marsily, 1986; Schwille, 1984). Dissolved constituents may also be transported vertically through the vadose zone by this process. Schwille describes the plume of dissolved CH constituents as a hydrous solution having a density only slightly higher than water. As a result, there is no significant tendency for the plume to sink within the aquifer.

Transport in the Saturated Zone

The transport of the dissolved CH (solute) plume will be governed primarily by the processes of advection, hydrodynamic dispersion and chemical reaction (Mackay, Freyberg and Roberts, 1986). Sorption processes, although important to the rate of migration of the CH solute plume, do not directly control the shape or spreading of the plume during transport. Consequently, the effects of sorption on the migrating solute plume will not be discussed further.

Advection represents the movement of a solute with the bulk fluid as given by the seepage velocity in the pore space (Bedient, Borden and Leib, 1985). The rate of transport of the solute is equal to the average linear the groundwater as determined by

$$\bar{v} = v/n$$

where v is the seepage velocity, or darcy velocity, and n is the porosity of the aquifer material (Freeze and Cherry, 1979).

Advection is usually the dominant solute transport mechanism in the saturated zone. In relatively coarse grained aquifers that are not affected by significant recharge or groundwater extraction, such transport is predominantly horizontal (Lappala and Thompson, 1983).

Hydrodynamic dispersion (D_H) is a combination of the processes of mechanical dispersion (D_l) and molecular diffusion (D^*) and can be expressed by

$$D_H = D_l + D^*$$

Mechanical dispersion is a mixing phenomenon due mainly to heterogeneities in the aquifer medium that cause variations in flow velocities and flow paths (Bear, 1979). As a result, CH solutes flowing in granular aquifers can be spread out in directions parallel, and transverse to the direction of mean groundwater flow.

On a microscopic scale, mechanical dispersion is caused by frictional drag along pore walls much like the laminar flow of water through a conduit. Flow through a pore is much quicker down the axis of the pore as friction causes flow along the pore walls to be slowed (Bear, 1979; de Marsily, 1986). Also, flow is spread out, or dispersed as streamlines fluctuate in space with respect to the mean direction of flow due to the shape of the interconnected pore space (Bear, 1979). Variations in pore size can create differential flow velocities as water flowing in smaller pores is impeded by encountering a greater surface area of solid as compared to larger pores (de Marsily, 1986).

On a macroscopic scale, a stratification or other features of large scale heterogeneities such as lenses or interlayered deposits, broken or fractured zones, etc. also introduce a heterogeneity into the flow field, which, through the same mechanisms described above, causes the solute body to mix and spread out in all directions of space (de Marsily, 1986). Groundwater flow streamlines will tend to follow paths of least resistance and, thus, will migrate around zones of low permeability and follow more permeable zones of the aquifer in the path of flow (Freeze and Cherry, 1979).

The result of the micro and macro scale dispersion processes is the spreading of a CH solute plume increasing with distance from the source (Anderson, 1984). This spreading will occur in the direction of mean groundwater flow (longitudinally), and perpendicular to this flow direction (transversely). Longitudinal mechanical dispersion (D_l) and transverse mechanical dispersion (D_t) are given by:

$$D_l = \alpha_L \bar{v},$$

$$D_t = \alpha_T \bar{v},$$

respectively. Here α_L and α_T are characteristic properties of the aquifer materials known as the dynamic dispersivities (Freeze and Cherry, 1979). These dispersivities are a measure of the mechanical dispersion property of the aquifer material in the longitudinal direction (α_L) and the transverse direction (α_T) and are defined as a characteristic length describing the ability of the aquifer material to disperse solutes (Walton, 1984). The more heterogeneous and anisotropic the aquifer material the greater the values of the dispersivities. Typically, transverse dispersivity values are smaller than longitudinal dispersivity values by a factor of 5-20 (Freeze and Cherry, 1979). Longitudinal dispersivity values for relatively homogeneous sandy materials range from 0.1 meters to 21 meters (Walton, 1984).

Molecular diffusion is the phenomenon linked to molecular agitation whereby solute particles are transferred from zones of high concentration to zones of low concentration under their own kinetic energy (Bear, 1979; de Marsily, 1986). This process can occur in moving or non-moving fluids and is given by Fick's first law

$$Q_d = -n_e D^* dc/dx$$

Where Q_d is the diffusive flux of the solute in the porous media, n_e is the effective porosity of the aquifer material, D^* is the effective diffusion coefficient of the diffusing fluid and -dc/dx is the concentration gradient of the fluid front (Sudicky, Gillham and Frind, 1985). The effective diffusion coefficient is related to the molecular diffusion coefficient, D_d, of the solute in a free solution by

$$D^* = D_d \tau$$

where τ is the tortuousity of the medium (Bear, 1972). The tortuosity is the ratio of the length of the actual flow path the solute will follow through the aquifer to the length of the aquifer. The molecular diffusion coefficient is dependent on the solute concentration and temperature.

The process of molecular diffusion in groundwater systems is slow. The significance of the diffusion process on solute migration is low relative to mechanical dispersion in coarse granular aquifers with relatively quick groundwater velocities. However, in fine grained materials like silts and clays with low groundwater velocities, molecular diffusion may be the dominant solute transport mechanism (Gillham and Cherry, 1982). Yet, even in these situations, the rate of transport is low.

Transport in the Capillary Fringe

The transport of a CH solute plume in the capillary fringe or tension saturated zone may occur by the processes of transverse hydrodynamic dispersion (Lappala and Thompson, 1983). However, the fluctuations of the elevation of the water table probably have a greater ability for distributing solute above, and throughout the capillary fringe than those mechanisms (Lappala and Thompson, 1983). As the water table rises it may transport solute, which was present at or close to the water table, into, or above the capillary fringe. As the water table recedes it leaves behind contaminated water retained in the vadose zone and throughout the capillary fringe. This retention is enhanced by hysteresis and the relationship between pressure head and water content as described by Hillel (1982).

Vapor Transport in the Vadose Zone

Up to now the processes which are responsible for distributing CH fluid bodies and solutes throughout the vadose and saturated zones have been described. As a result, it is understood how CH fluid bodies and solute plumes can be distributed such that the fluid body or plume is in direct contact with the air phase of the vadose zone. It is therefore known where the interface exists upon which the volatilization, or gas-liquid partitioning, of the CH constituents may occur (Lapalla and Thompson, 1983). Hence, this interface is the source for CH gases in the vadose zone and its dimensions will most likely determine where these gases can be detected.

The partitioning of CH fluid bodies and solutes between the liquid phase and the gas phase is the process of volatilization. The volatilization phenomenon is based upon Henry's law, which states that for ideal gases and solutions the vapor phase concentration of a chemical (C_G) above a solution is proportional to its concentration in the solution, C_L (Mabey et al., 1982). This can be written as

$$C_G = K_H C_L$$

wherein K_H , the proportionality constant, is known as Henry's constant. This constant is a measure of a chemical's tendency to partition between the gas and liquid phases at equilibrium (Jury, Spencer and Farmer, 1983). In other words, the larger the value of K_H for a given compound, the greater the tendency for that compound to volatilize from the liquid phase into the gas phase. Consequently, more of the compound's vapor is liberated into, and transported upward through the vadose zone. The Henry's constant for a chemical can be determined by

$$K_H = C_G^* / C_L^*$$

where C_G^* is the saturated vapor density, or vapor pressure, and C_l^* is the solubility of the chemical. This relationship holds true only if C_g^* and C_l^* data are for the pure material at the same temperature and the same phase (solid or liquid) (Mabey et al., 1982).

The vapor density of many CH's may be higher than that of air. These vapors will tend to accumulate along the top of the capillary fringe over the plume (Schwille, 1984).

The migration of CH vapors through the vadose zone of granular aquifers can occur by two different mechanisms: convection and gaseous diffusion (Baver, Gardner and Gardner, 1940). Convection, or mass flow, is the process whereby masses of air, or gases are driven by the force of a gradient of total gas pressure resulting in movement of the masses from zones of high pressure to zones of low pressure. Gaseous diffusion, on the other hand, is controlled by a gradient of partial pressure (or concentration) of the gaseous constituents which cause the gas molecules of an evenly distributed constituent to migrate from zones of high concentrations to zones of low concentrations even while the gas as a whole may remain isobaric and stationary (Hillel, 1982). It is believed that gaseous diffusion is the dominant process of vapor migration in the vadose zone (Evans, 1965).

Convective vapor flow is controlled by a number of different factors. These factors include: temperature variations within the vadose zone, and between the vadose zone and the atmosphere, barometric pressure changes in the atmosphere, wind action over the ground surface, water infiltration through the vadose zone, water table fluctuations and the compaction or consolidation of the soil by heavy machinery (Baver et al., 1940; Hillel, 1982).

Temperature variations within the vadose zone, and between the vadose zone and the atmosphere may cause soil vapors to migrate. Vapor movement tends to take place from warm to cold parts of the soil. Since during the daytime the soil surface is warmer, and during the night colder than deeper layers, vapor movement tends to be downward during the day and upward during the night (Hillel, 1980). However, it has been shown that temperature differences within the vadose zone, and between the vadose zone and the atmosphere contribute approximately less than 1/800 and 1/240 of normal soil aeration, respectively (Rommel, 1922).

Barometric pressure increases in the atmosphere may, correspondingly, cause a decrease in the soil gas volume. Conversely, a decrease in barometric pressure should produce an expansion of the volume of soil gas. As a result, barometric pressure increases may cause atmospheric air to infiltrate the soil pores, and a decrease in barometric pressure may result in soil vapors being liberated into the atmosphere (Baver et al., 1940). This process has also been determined to be of minor consequence in soil aeration. Laboratory experiments have shown that the penetration of atmospheric air within a permeable soil column 10 feet deep would only amount to about 0.12 to 0.22 inches, depending on the magnitude of barometric pressure change (Buckingham, 1904).

Wind gusts over the surace of a soil mass can cause suction effects at shallow depths in the soil profile. As a result, a pressure gradient may be increased near the surface of the soil (Baver et al., 1940). The effect of wind action on soils is limited to the first meter or two below the land surface (Weeks, Earp and Thompson, 1982). Rommell estimated that wind action is responsible for no more than 1/1000 of normal aeration.

Water infiltrating a soil mass after rainfalls or snowmelts may cause soil vapors to be displaced from the pores in the soil (Baver et al., 1940). The infiltrating water may also entrap or envelope soil gases for short periods of time. Water retained in the soil after infiltration can cause differential impedences to the mass flow of soil vapors. It is estimated that gas displacement due to the infiltration of water in a soil accounts for approximately 1/12 to 1/16 of normal aeration (Rommell, 1922).

and, as a result, the expulsion of soil vapors from these pores (Hillel, 1982). As with water retention, over-consolidated soils may act as a barrier to soil vapor movement due to the porosity decrease.

As with the diffusion of CH solutes in the groundwater, gaseous diffusion is a molecular transfer of the solute through the porous media. In gaseous diffusion, this molecular transfer is, however, of gases through the vadose zone as opposed to the saturated zone. The diffusive transfer of the CH solute molecules is driven by a concentration gradient that exists between the solute gas front and the ambient soil vapor. This process can be described by Fick's first law:

$$q_d = -D_s dc/dx,$$

where q_d is the diffusive flux of gases across a unit area per unit time, D_s is the diffusion coefficient of the solute vapor in the porous media and $-dc/dx$ is the concentration gradient outward from the solute front (Hillel, 1982).

Due to the tortuous path that a diffusing gas must follow, the coefficient of diffusion for a given solute vapor in a porous media must be smaller than that in ambient air (Penman, 1940).

Gaseous diffusion in soils is directly proportional to the area available through which the gas flux can occur (Marshall, 1959). This area is, or course, to the area available through which the gas flux can occur (Marshall, 1959). This area is, or course, dependent upon the effective porosity within the soil. The more reduced the porosity of a soil volume is, the slower diffusion will occur through it. This is due in part to the reduction in area through which the gas may migrate, and to the increase in the tortuous path that the diffusing gas molecules must follow in the soil (Troeh et al., 1982).

The diminution of pore size in a porous media increases its water retention capacity; water is more readily retained in soils of low permeability (silty clays, silty sands, clayey sands, etc.) by capillary processes. Correspondingly, this water retention will entail a reduction in the cross-sectional area available for gaseous diffusion through the porous solid (Schearer, 1966). The water filled pores act as solid interfaces in this situation. Even water adhered to soil grains can decrease pore diameters and, consequently, the total pore area available for gas flux (Karimi, Farmer and Cliath, 1987).

Based upon the above explanations, it must be necessary to describe the solute diffusion coefficient in the porous media as a function of the total porosity (P_t), the air filled porosity (P_a) of the medium, and the solute vapor diffusion coefficient in air (D_0).

Millington and Quirk (1961) expressed this relationship as:

$$D_s = D_o\,(P_a^{10/3}/P_t^2).$$

Gas phase diffusion coefficients for solutes are 10^4 to 10^5 times as large as liquid phase diffusion coefficients (Weeks et al., 1982).

The air diffusion coefficient, D_o , for most chlorinated hydrocarbons can be estimated by

$$D_o = 10^{-3}\sqrt{M_r}\,(T^{1.75})/[P(V_a^{1/3}+V_c^{1/3})^2]$$

where T is the temperature, P is the ambient pressure, V_a is the molar volume of air, V_c is the molar volume of contaminant in gaseous phase and where

$$M_r = (MW_A + MW_C)/(MW_A \cdot MW_C).$$

Here, MW_A is the molecular weight of air and MW_C is the molecular weight of the contaminant (Marrin and Thompson, 1984).

One can see how the heterogeneities in a soil body can cause the flux of contaminant vapors through the vadose zone to be non-uniform. The migration of gases can be impeded, channeled or spread out as the vapors encounter zones of material with contrasting bulk densities, air filled porosities, and water contents throughout the vadose zone.

The mechanisms by which the geometry of the CH vapor distribution throughout the vadose zone of an unconfined granular aquifer is controlled in the situation of a spill or leak of a CH fluid has now been sufficiently explained. Figure 1 schematically describes these processes.

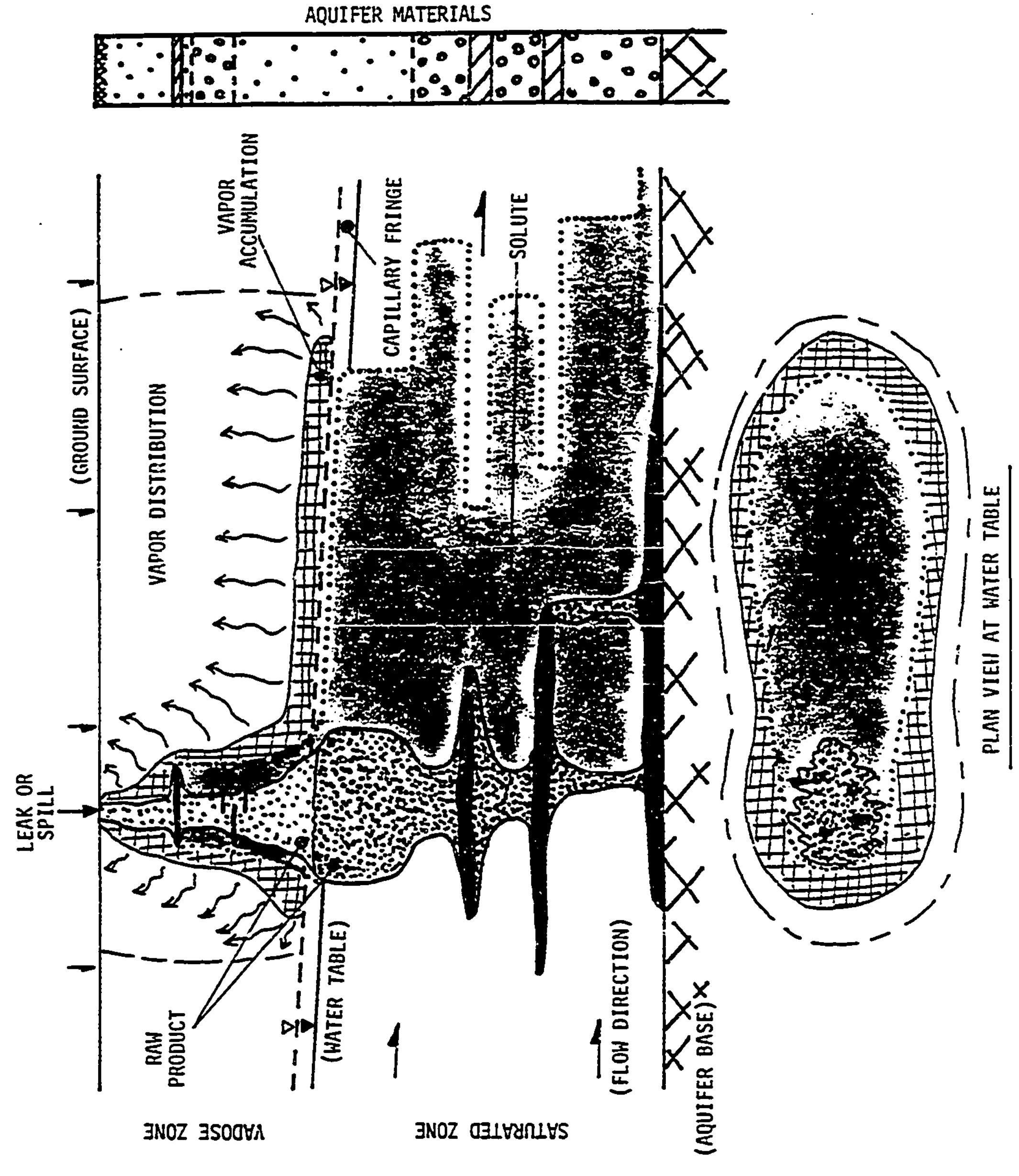


Figure 1. Contaminant Transport Processes.
Source: Schwille, 1988.

The distribution of CH vapors over a plume should, theoretically, envelope the extent of the plume in plan view. The vapors from the plume will be diffused above and, to a lesser extent, lateral to it. The concentrations of the vapors above the plume should reflect the distribution of the dissolved CH concentrations in the plume.

Theory holds that if a concentration gradient exists throughout the vadose zone where the concentration of a contaminant vapor is zero at the ground surface, and is given by its vapor pressure at the source (i.e., solute retained in caillary fringe, fluid retained in vadose zone), then the withdrawal and subsequent chemical analysis, of the soil vapors at a specific depth in the vadose zone should reveal a concentration of that contaminant vapor representative of the gradient at that depth. If the withdrawl entails pumping of the soil gas at a specific depth and concentrating it over time, then this should reflect a space/time averaged concentration for that depth. However, if the sampling procedure is consistant over an areal extent over a solute plume, then correlations between the gas concentration and the source concentration should be valid. The ratio between the concentration of a CH vapor in the soil gas and the dissolved constituents in the groundwater (water table) at the same location should be relatively consistent.

CHAPTER III

DESCRIPTION OF STUDY AREA

The plume of groundwater contamination which serves as the focal point for this study lies beneath the Georgetown Industrial Park located just west of the City of Jenison in Georgetown Township, Ottawa County, Michigan (Figure 2).

The source of this contamination was the site of the Rozema Industrial Waste Inc. truck servicing facility (Rozema's Garage). The Rozema Garage site is now home to a small domestic transport company located at 6680 Wilshere Drive (Figure 2).

History

The Rozema Industrial Waste Inc. was a hauler of wastes produced primarily in the metal works and plating industries. Rozema trucks hauled large amounts of metal plating sludge and, to a lesser extent, industrial solvents and degreasing products. The Rozema Garage site was used primarily as a truck parking and servicing facility.

During a winter thaw in February, 1976, a tanker trailer containing treated metal hydroxide waste tipped

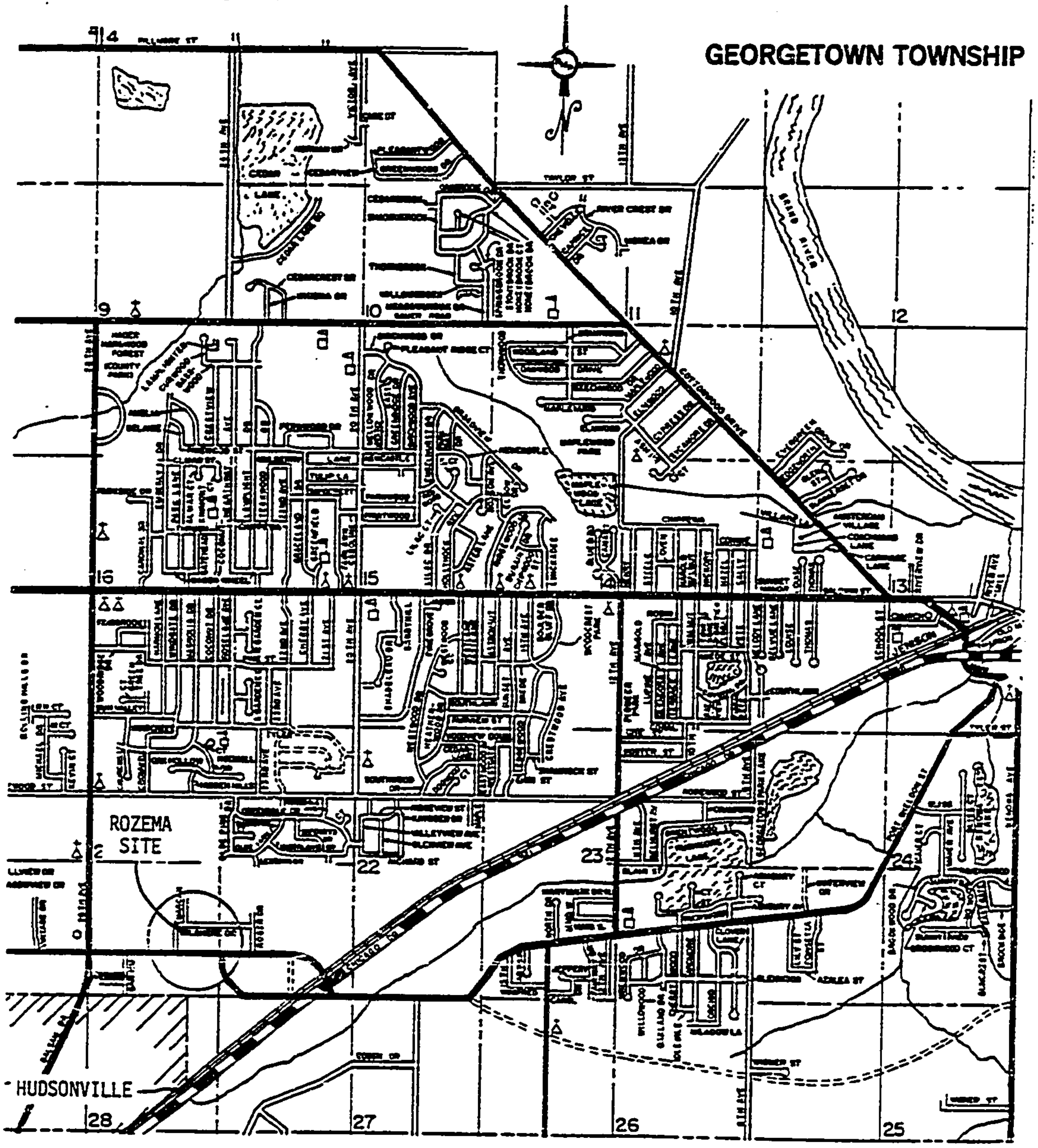


Figure 2. Location of Study Area.

over on the site spilling a portion of its contents. MDNR officials ordered Gerald Rozema, owner of the facility, to clean up the spill and dispose of the tanker and affected soils at a nearby landfill. Mr. Rozema informed the MDNR that he would comply with the order; however, these disposal activities were not supervised by State officials.

Approximately one year after the spill occurred, it was discovered that the spilled wastes had infiltrated the groundwater beneath the site. Water samples obtained from domestic wells near the site indicated that elevated concentrations of chromium, zinc, copper and nickel were present in the groundwater.

At this time, Mr. Rozema was ordered by the MDNR to install a small groundwater purging system and three monitoring wells around the site. This system, which was used to mitigate the migration of contaminants in the groundwater beneath the site, was in operation, intermittently, from late 1977 to late 1979. The monitoring wells were used to monitor the effectiveness of the purging system.

In October of 1979 an open dumpster containing liquid wastes, presumed to be metal hydroxide wastes, was discovered on the site. Tainted soil was visible around the dumpster. The dumpster and soil were removed from the site.

In December of 1979, the Michigan Department of Public Health (MDPH) requested that the monitoring wells on site, and a domestic well next to the site be sampled and that the samples be analyzed for volatile organic compounds. The analysis of these samples revealed that concentrations of 1,1,1- trichloroethane (TCA), tetrachloroethene (PCE) and trichloroethene were present in the groundwater.

Early in 1980 it was revealed that the tanker which had tipped over in 1976 had not been moved from the site, but was buried on the site instead. It was also discovered that the buried tanker was used to store industrial wastes. The wastes included solvents and degreasing products. It is believed that the contents of the buried tanker leaked into the surrounding soils and into the groundwater beneath the site. The tanker has since been removed from the site.

During the period of time the site was owned by Rozema Industrial Waste, there had been numerous unofficial reports of semi-tankers being drained onto the ground at the site.

Since 1984, the Rozema Garage Site has been on the list of sites requiring Remedial Investigations under the Michigan Environmental Response Act, Act Number 307 of the Public Acts of 1982.

In March of 1986, the NUS Corporation was contacted by the MDNR to develop a Work Plan for the Rozema Garage site. Since that time, NUS has initiated a Remedial Investigation (RI) of the site. All of the work performed during this RI has been carried out by the NUS Michigan Regional Office where the author is currently employed.

To date, the field activities that have been performed by NUS for the Rozema RI include soil gas, temporary well, and soil sampling and monitoring well installation and sampling. Many of the data acquired during these field activities have been used for this study as well.

Geography and Demography

The Rozema Garage Site is located between the cities of Jenison and Hudsonville in the eastern portion of Ottawa County, Michigan (Figure 2). The area of this study includes, but is not limited to, the Rozema Garage Site. As shown in Figure 3, the study area extends southeast from the Rozema property.

The study area is located in the lower Grand River basin. The lower part of the Grand River basin in this area is generally flat to gently rolling. Elevations across the study area range from 650 feet to 620 feet

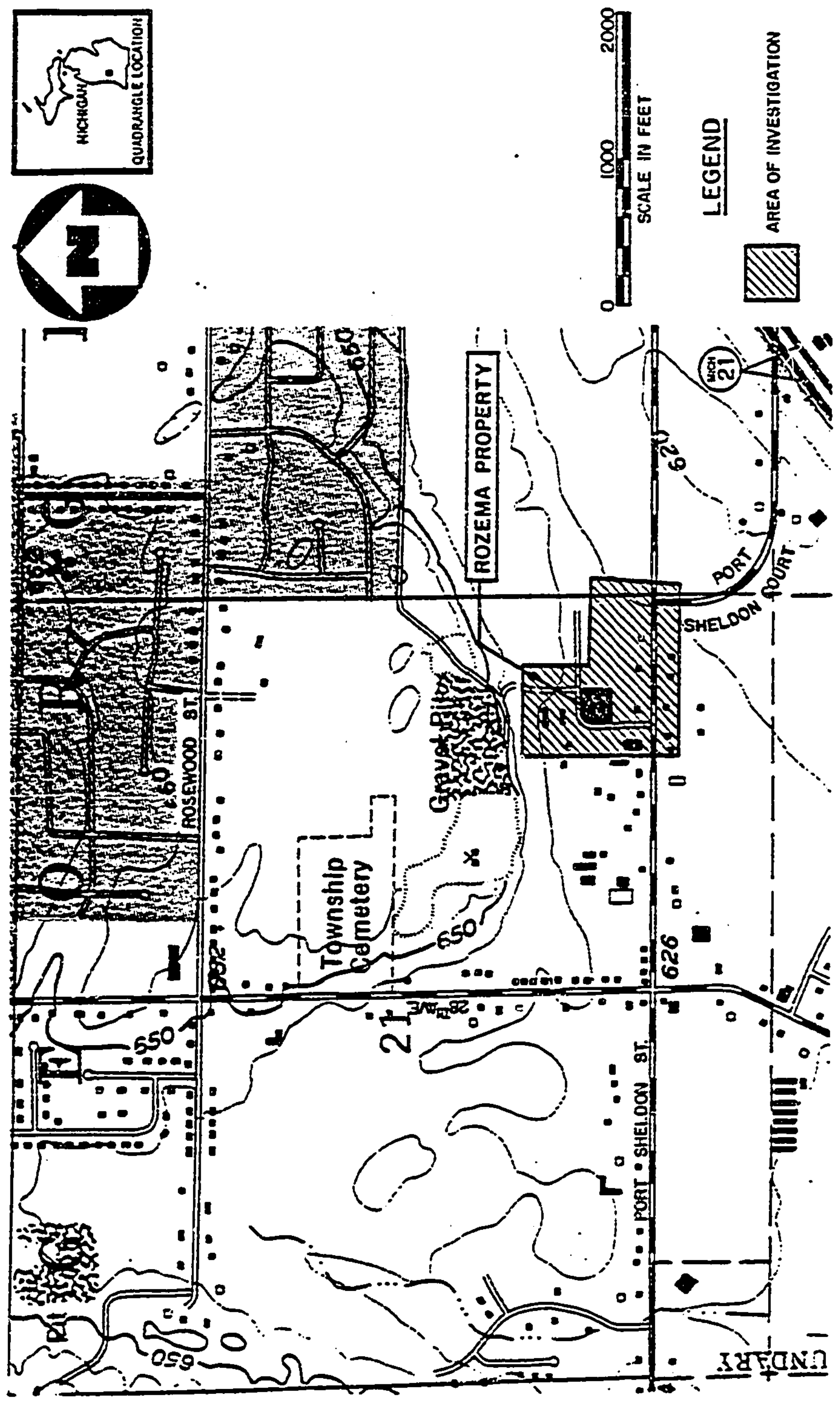


Figure 3. Study Area and Boundries.

above mean sea level (USGS Datum). The topography slopes gently towards the southeast over the area (Figure 3).

The immediate area of this study is occupied primarily by light industrial facilities and domestic residences. However, the area is generally rural with farmland dominating the landscape of the region. The study area is bordered to the north by a large gravel pit and to the south by a small farming operation.

Industries in the study area include a diesel repair shop located south of the Rozema Garage site, a truck trailer painting operation and a construction company located to the west and north of the site, respectively. The east side of the Rozema property is occupied by an open field. Other industries in the immediate vicinity include a small transport company and a transfer station for a disposal company.

A schematic of the Rozema site is provided in Figure 4. In the center of the property is a prefabricated building. The building is used as office space and for truck servicing work by the transport company that now owns the property. Truck traffic on the property is generally concentrated around the perimeter of the building (Figure 4). Parking of trucks, trailers and light vehicles is confined to the area along the fence surrounding the site. At the

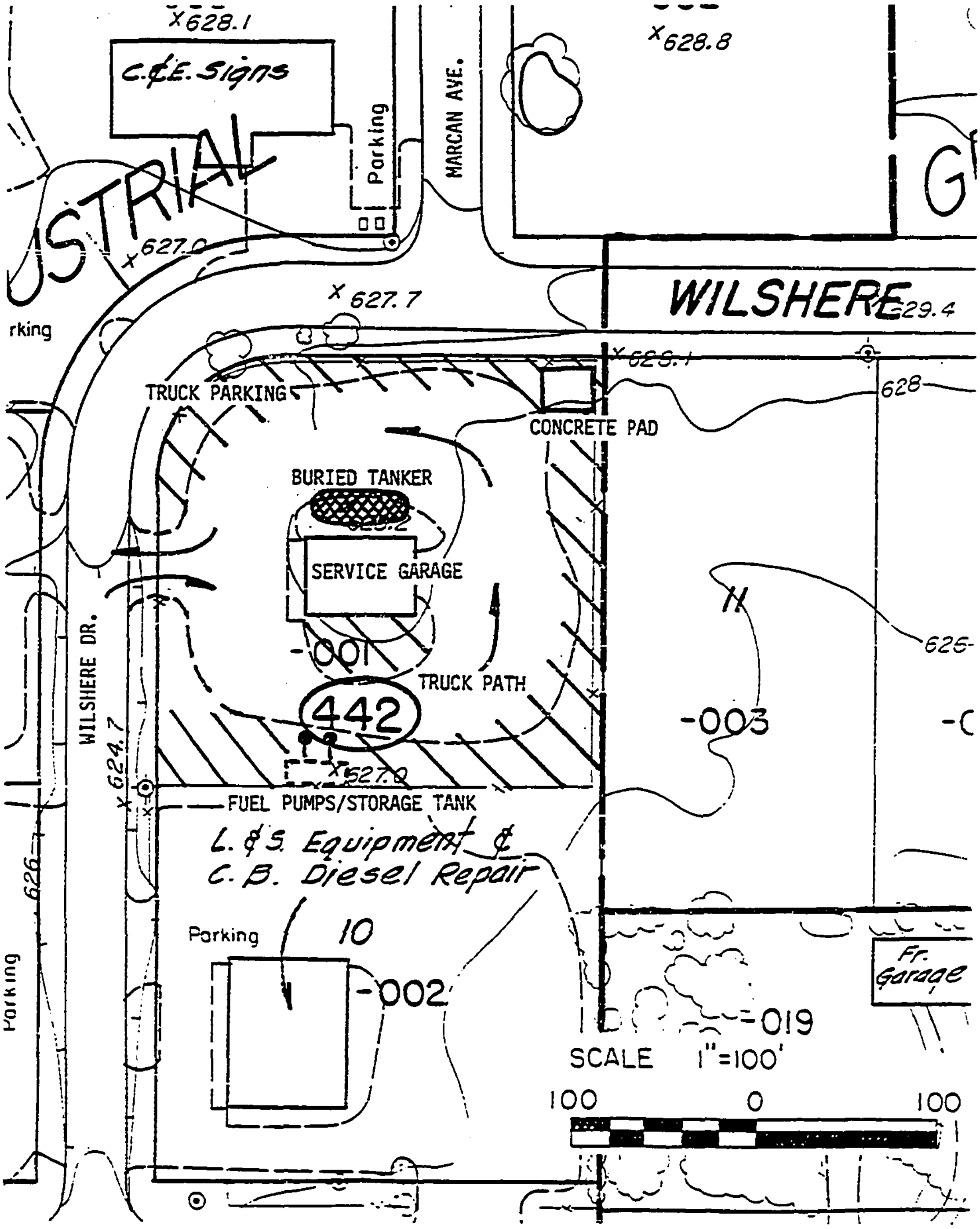


Figure 4. Rozema Garage Site Schematic.

northeast corner of the property is a concrete pad used specifically for parking tractor trailers. Along the southern edge of the property are two diesel fuel pumps. The underground fuel storage tank is located between the pumps and the southern fence line. The location where the tanker had been buried on site is also shown in Figure 4; it is identified by the cross-hatched zone on the north edge of the building.

Climatology

Ottawa County experiences rapid short-term weather changes due to the constant succession of cyclonic (lows) and anticyclonic (highs) fronts associated with the prevailing westerly winds.

The climate of Ottawa County is primarily continental, and is marked by the occurrence of distinct seasons. The county is bordered on the west by Lake Michigan. The lake has a modifying effect on the climate throughout the county. In general, areas with continental climates experience warm summers and cold winters. However, the lag of Lake Michigan surface temperatures behind land temperatures results in cooler summers and milder winters than the central regions of the state.

In the summer season the average daily maximum temperature is 76.7 Deg. F. The winter average daily minimum temperature is 22.32 Deg. F. The average temperature during the periods of soil gas sampling for this study, which were conducted in January, and June and July, 1987, were 21.0 Deg. F and 79.6 Deg. F, respectively.

More than half the annual precipitation, an average of 57 percent, falls during the six month period of April through September. September is the wettest month of the year with an average total precipitation of 3.29 inches. February is the month of the lightest precipitation with an average total of 1.78 inches. No precipitation occurred during the period of soil gas sampling performed in the summer of 1987.

The average seasonal snowfall for Ottawa County is 66 inches. Average seasonal totals are probably higher in the western portion of the county due to the effect of Lake Michigan. Snowfall was common during the soil gas sampling carried out in January, 1987, with accumulations of several inches during some days.

The average total evaporation recorded (Class A pan) between the first of April and the end of October is 36.51 inches. This is more than twice the average total rainfall for the same six month period. The deficit is made up from water stored in the soils, most of which accumulates from the rains of winter and early spring.

Information on climatology was obtained in part from the U.S. Department of Agriculture.

Soils

The soils in the vicinity of the study area are predominantly loamy sands and sandy loams as classified by the U.S. Department of Agriculture Soil Conservation Service (Figure 5). The following soil types are found in the area around the Rozema Garage site: Bayer loamy sand, Gelford sandy loam, Wasepi sandy loam and Adrian muck. The Bayer loamy sand is a well-drained soil that occurs on outwash plains and sandy moraines. The Gelford sandy loam is a poorly drained soil commonly occurring in depressions on outwash plains, lake plains and glacial drainage ways. The Wasepi sandy loam is a somewhat poorly drained soil typically found on outwash plains and low terraces. The Adrian muck occupies bottom lands and shallow depressions on sandy plains of the uplands. This soil is characterized by layering of organic and sandy material. The organic material often contains wood fragments.

A typical soil profile in the study area is loamy sands and gravels to a depth of 42 inches over a sand substratum. In low lying areas the upper 12 to 42 inches of soil consists of sandy organic materials.

Domestic well logs from the area, and information from boring logs obtained during the field investigation

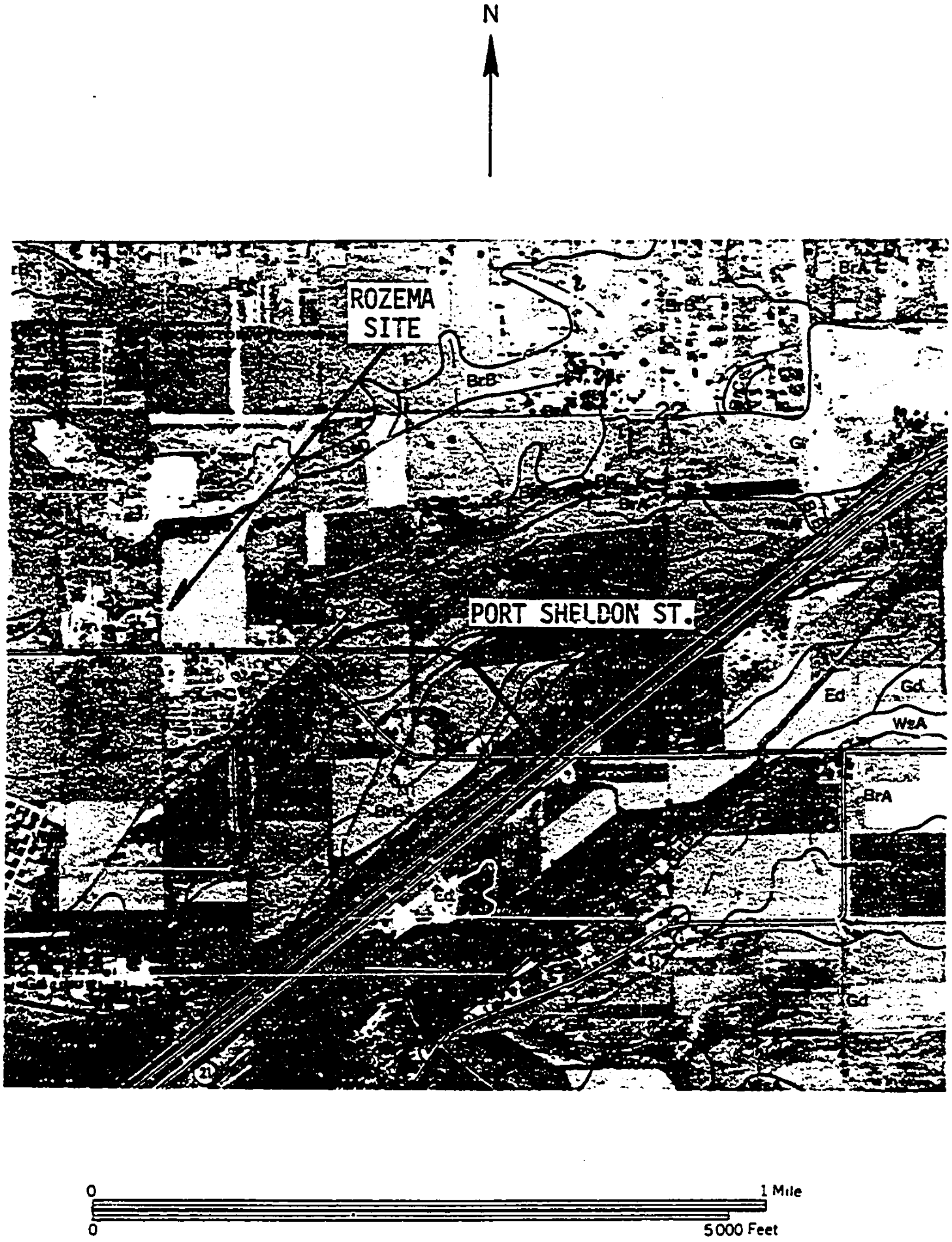


Figure 5. Soil Types Across the Study Area.

of this study indicate that approximately 15 to 29 feet of fine to medium sand overlies sandy clays and silts.

Surface Waters

There are no natural bodies of water or streams present in the immediate vicinity of the study area. There is a man-made pond formed in a gravel pit, and a small drainage network, both of which are located east of the study area (Figure 6). The pond is known to be dewatered periodically during the year. However, it is unknown to what extent the pond or drainageway effect the groundwater flow in the area, if at all.

Geology

Ottawa County is located over the western flank of the Michigan structural basin. Specifically, the county overlies the bevelled and truncated edges of the Coldwater Shale, the Marshall Sandstone and the Michigan Formation. The Michigan Formation subcrops beneath the study area. Shales and gypsum are the predominant lithologies of the Michigan Formation in this area.

Overlying the Michigan Formation is a mass of glacial drift deposited during the Wisconsin period of the Pleistocene glaciation. The surficial deposits in the study area and vicinity are mapped as glacial outwash and post-glacial alluvium. These deposits have

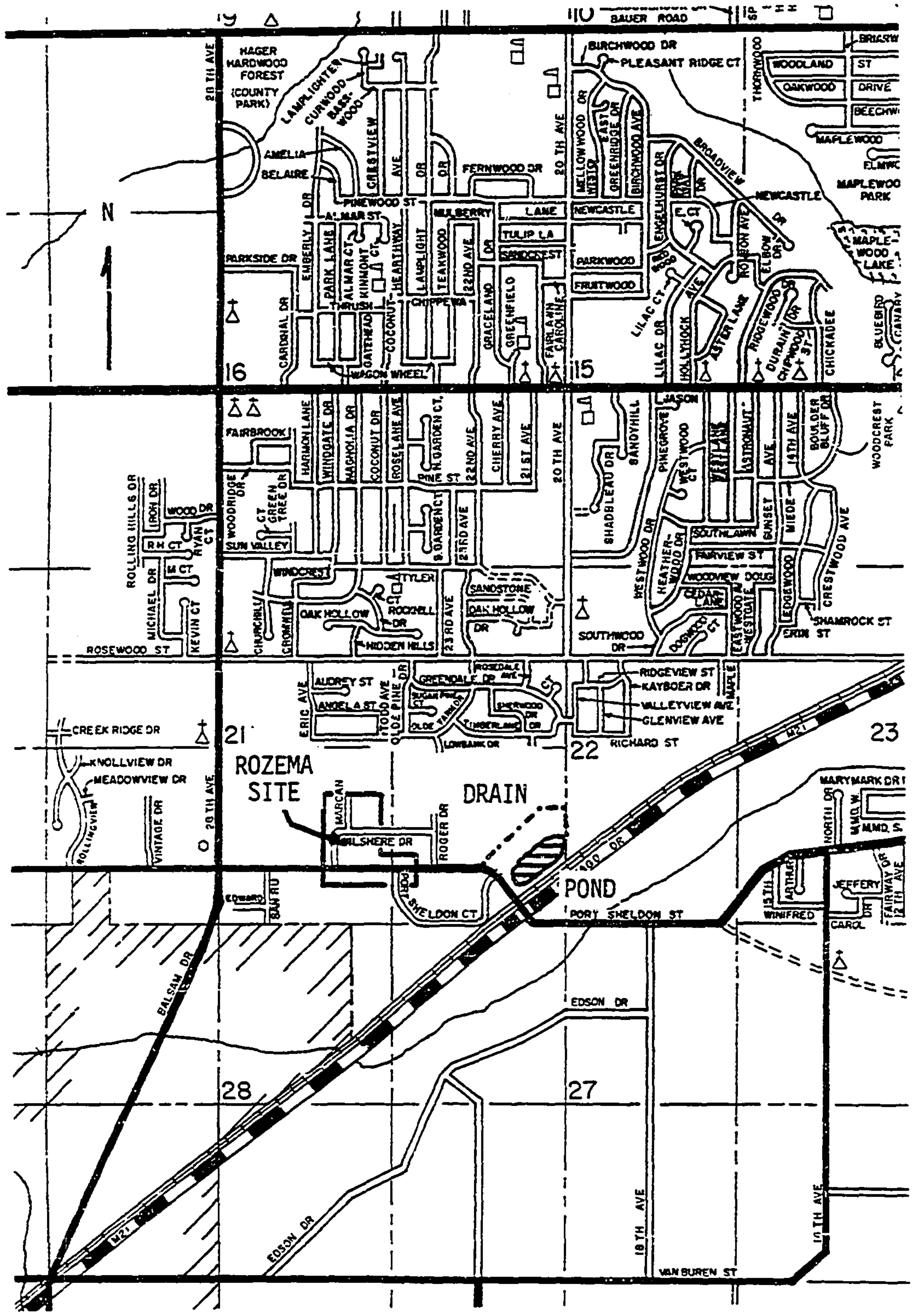


Figure 6. Surface Waters.

been described as pale brown to pale reddish brown, fine to coarse sand alternating with layers of fine gravel to cobbles (NUS, 1988). The gravel and cobbles consist of a mixed lithology of igneous, sedimentary and metamorphic rock fragments. In the immediate area of study these deposits occur as fluvial terraces along present and abandoned drainageways.

Well log information in the study area indicates that the glacial drift ranges from as little as 20 feet thick to as much as 100 feet thick over the Michigan Formation.

The geologic materials encountered and sampled during the temporary well sampling phase of this study include sand and gravel deposits overlying what is believed to be a horizontally extensive sandy clay to sandy silt unit. Figure 7 identifies the locations of cross sections of the surficial geolcgy of the study area. Figures 8 through 10 depict the geologic cross sections developed from boring log information acquired during the temporary well point drilling and monitoring well installation work conducted by NUS and the author.

The coarse grained deposits under the study area consist mainly of brown and gray-brown, uniform fine and medium sand. Within the uniform sands,lenses or zones of fine to coarse sand with fine gravel were sampled and described. Locally, silt is present in the uniform sand

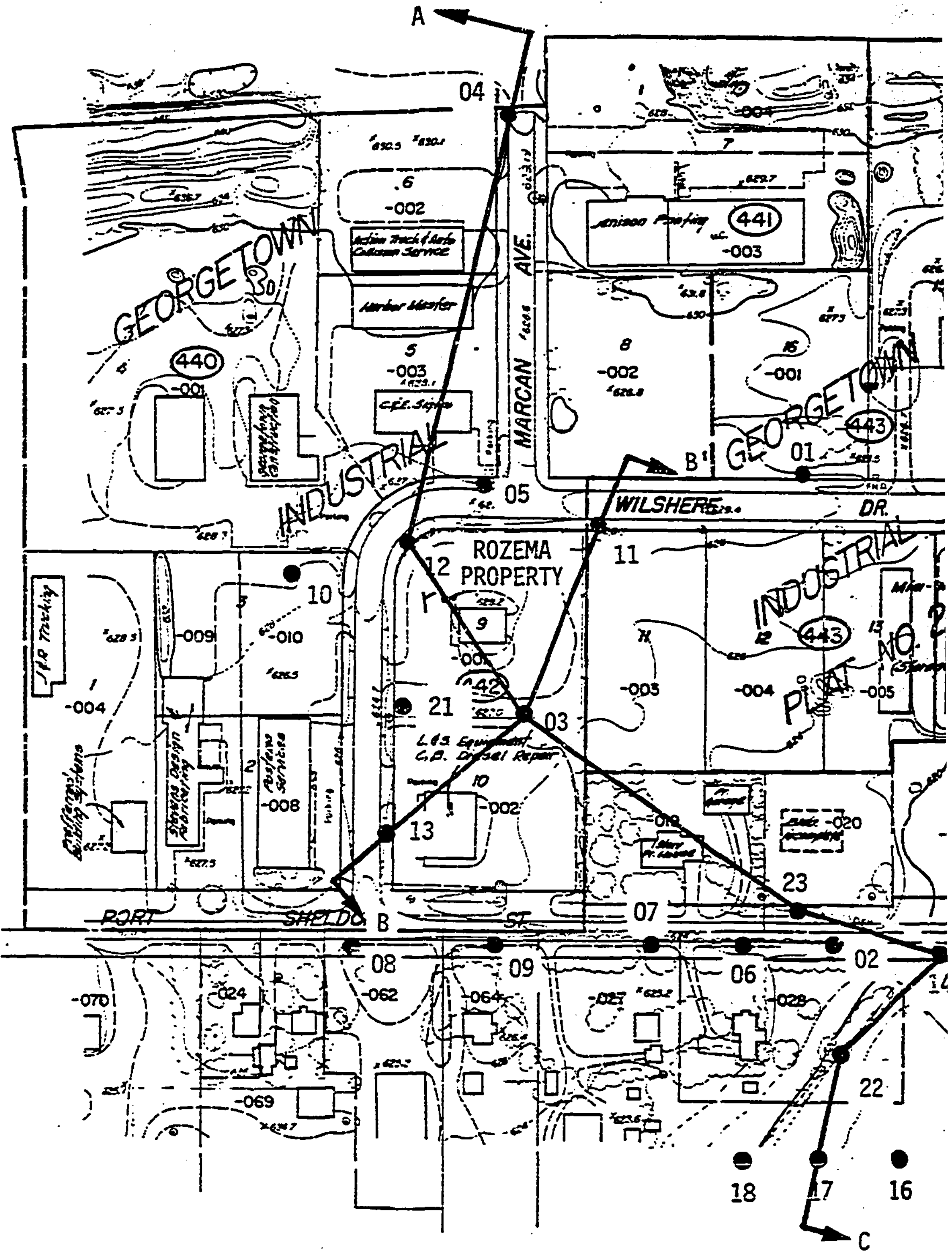
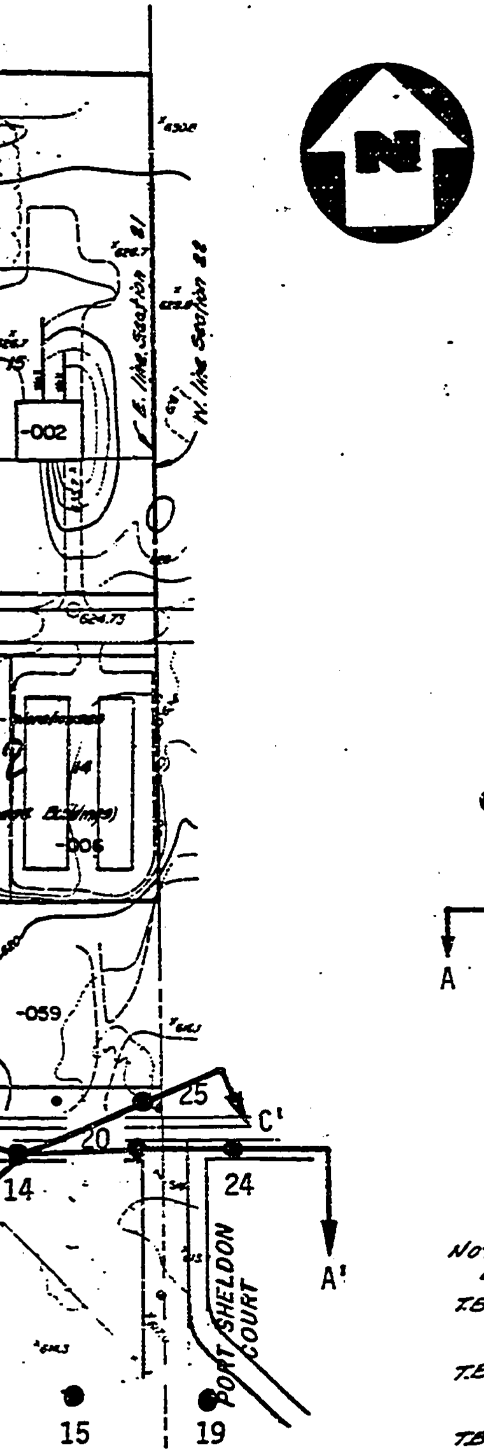


Figure 7. Locations of Geologic Cross Section.



● Boring Locations for Temporary Wells (03)
and Monitoring Wells (RZ-MW-03)

Cross-Section Locations
A A'

0 200 400
SCALE IN FEET

NOTE:
Elevations are based on N.G.V.D. (1929).
T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 600'± E. of 28th Ave.
1.25' above ground Elev. 628.82.
T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 1000'± E. of 28th Ave.
0.6' above ground Elev. 627.30.
T.B.M.#3 - N. rim of Michigan Consolidated Gas Co.
manhole N.E. corner Port Sheldon St. &
Wilshere Drive Elev. 625.70.

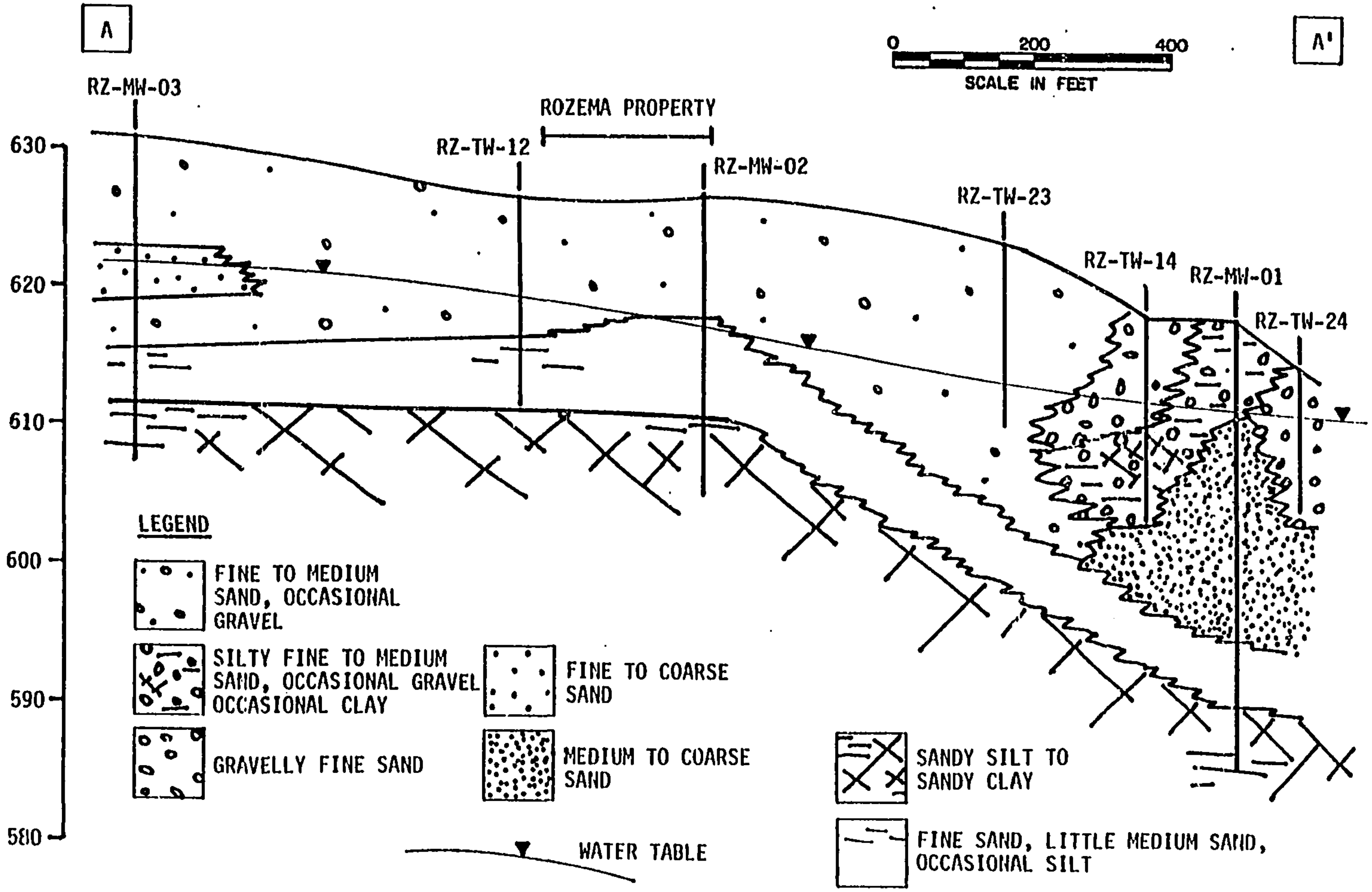


Figure 8. Geologic Cross Section A-A'.

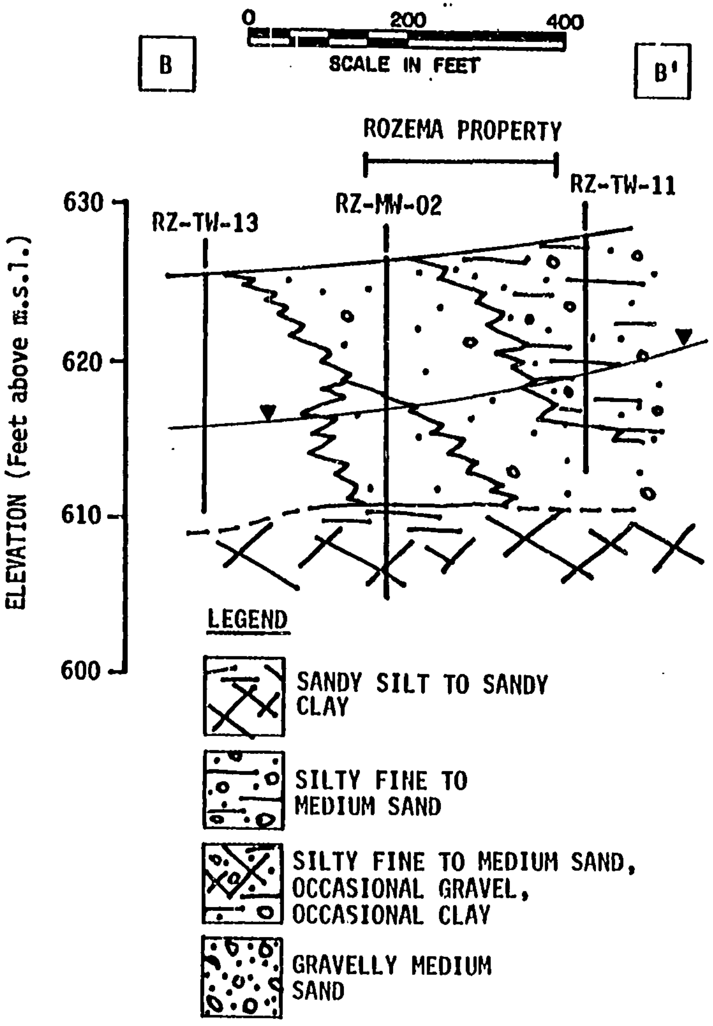


Figure 9. Geologic Cross Section B-B'.

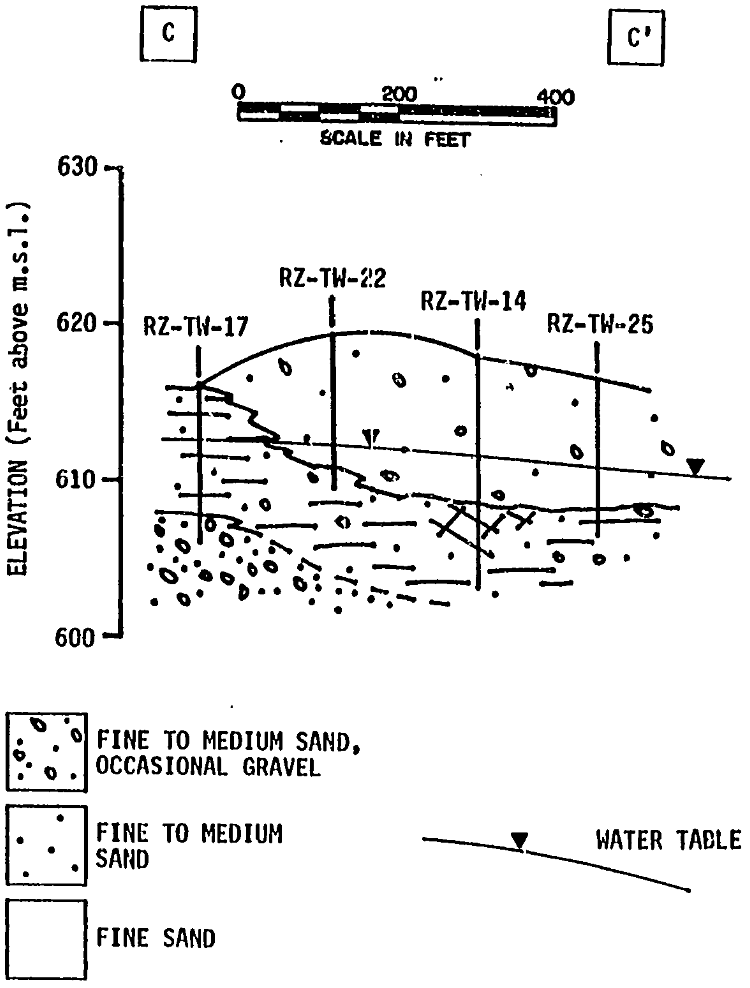


Figure 10. Geologic Cross Section C-C'.

deposits as well.

A sandy clay to sandy silt unit was encountered beneath the coarse grained deposits in each deep boring drilled during the monitoring well installation phase of the NUS RI. The thickness of this fine grained unit is unknown. However, it is assumed it is over five feet in thickness based on drilling and sampling information acquired from these borings.

Boring logs for monitoring wells RZ-MW-01 through RZ-MW-03 and temporary wells RZ-TW-11 through RZ-TW-25 installed by NUS are provided in Appendix A.

Hydrogeology

One aquifer was encountered during the subsurface investigation of the Rozema Garage site RI. This aquifer is unconfined. The aquifer materials are the sands, and sand and gravel deposits overlying the sandy clay to sandy silt unit. The saturated thickness of this aquifer ranges from approximately 6.0 feet at RZ-MW-03 to 21.0 feet at RZ-MW-01.

Groundwater flow directions across the site are depicted in Figure 11. This map was developed using static water level (SWL) data obtained from the temporary wells installed by NUS during the summer of 1987. It is supplemented with SWL data acquired during the temporary well point sampling done in the winter of 1987.

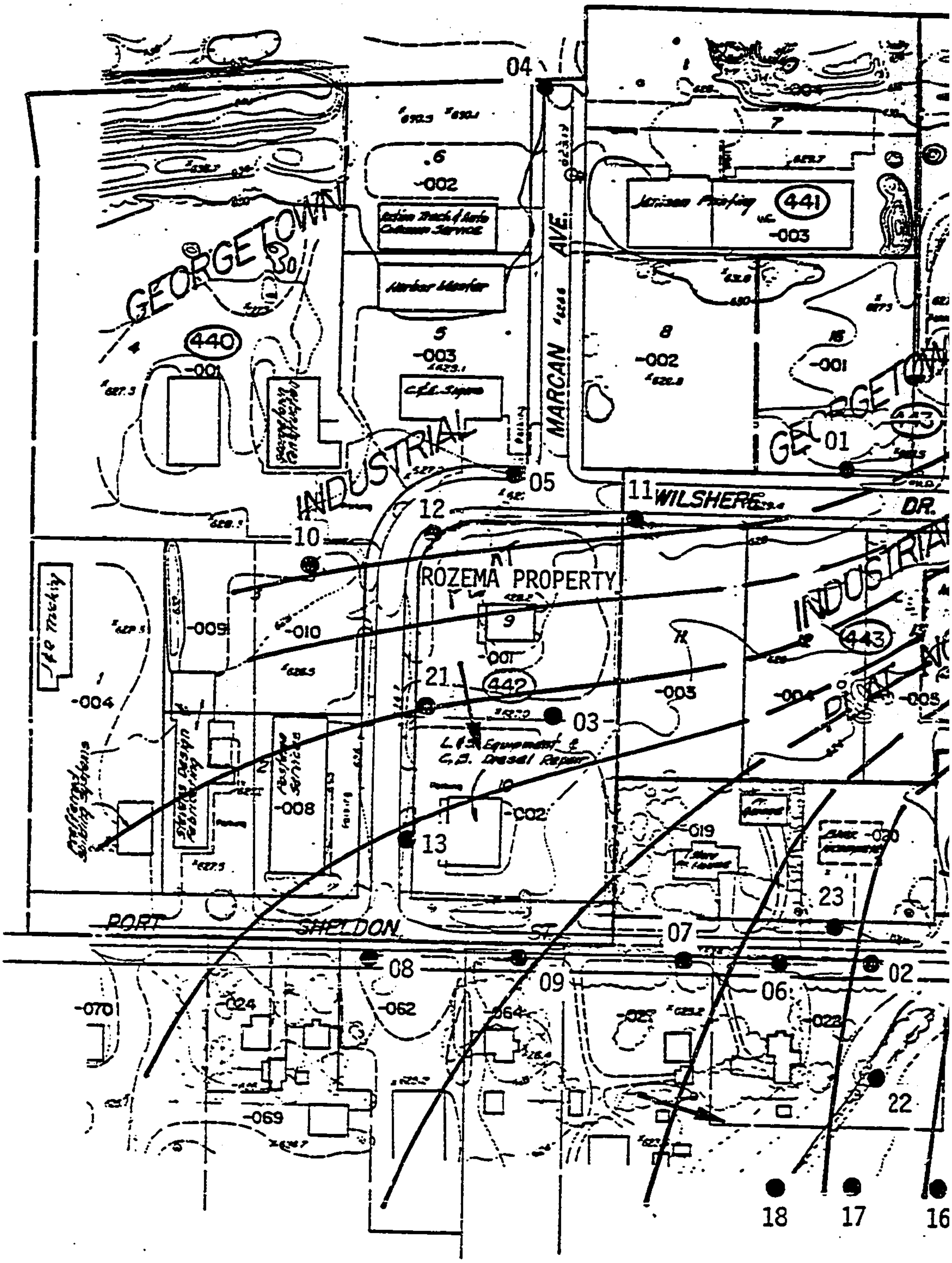
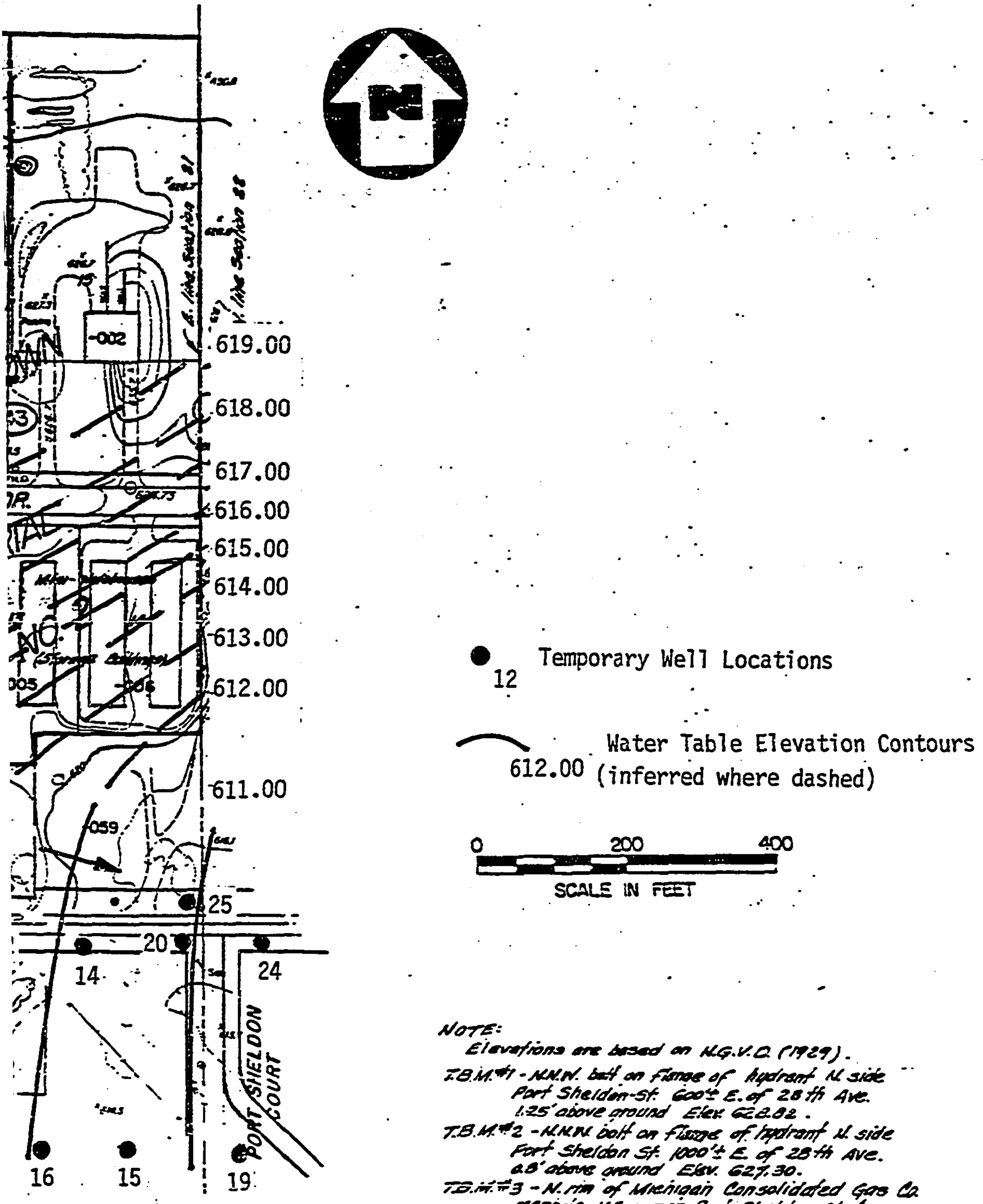


Figure 11. Groundwater Contours.



NOTE:

Elevations are based on N.G.V.D. (1929).

T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 600'± E. of 28th Ave. 1.25' above ground Elev. 622.82.

T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 1000'± E. of 28th Ave. 0.8' above ground Elev. 627.30.

T.B.M.#3 - N. rim of Michigan Consolidated Gas Co. manhole N.E. corner Port Sheldon St. & Wilshere Drive Elev. 625.70.

The groundwater flow direction across the study area is believed to be controlled by the existence of the underlying sandy clay to sandy silt unit, and by the regional flow direction in the area. It is postulated that flow under the Rozema Garage site is a localized flow component originating beneath the hilly upland region north of the site. There, recharging groundwaters migrate south along the slope of the sandy clay to sandy silt unit. Groundwater flowing under and south of the Rozema site is then redirected towards the east-southeast. This is a result of this local flow component being incorporated into the regional flow regime. The regional flow is presumed to be directed east towards the Grand River.

In-situ aquifer parameter testing was performed during the NUS RI. The data obtained from these tests were used to calculate hydraulic conductivity and transmissivity values of the materials in which NUS monitoring wells were constructed. The average hydraulic conductivity was calculated to be approximately $3.35X10^{-2}$ cm/s. The transmissivity values range from about 6.13 cm^2/s to 21.44 cm^2/s. Using the average hydraulic conductivity, an average groundwater flow gradient of $8.10X10^{-3}$ foot/foot and an estimated effective porosity of 0.20, the groundwater flow velocities in the study area were determined. Flow is calculated to be migrating at an approximate rate of 1.36x10 cm/s (117.5 cm/day).

Target Compounds

The organic contaminants of interest in this study include the chlorinated hydrocarbon compounds perchloroethene and 1,1,1-trichloroethane. Perchloroethene (PCE), or tetrachloroethene, is a colorless liquid used in the dry cleaning and metal works industries as a solvent for fats, greases, waxes, rubber, gums and caffeine from coffee. 1,1,1-trichloroethane (TCA), (methylchloroform) is also used as a solvent in the metal works industry for chlorinated rubber and various organic materials such as fats, oils and resins (Verschueren, 1983).

The physical and chemical properties of each compound are presented in Table 1. Included in this table, for comparison, are some of the physical and chemical properties of water and moist air.

Table 1

Physical and Chemical Properties of PCE, TCA, Water and Moist Air

	Physical and Chemical Properties								
Parameter	Molecular Weight (g/mol)	Specific Gravity (20°c/4°c)	Water Solubility (Mg/l @ 20°c)	Vapor Pressure (mm Hg @ 20°c)	Molar Volume (cm^3/mol @ 20°c)	Vapor Density (@ 20°c)	Surface Tension (dynes/cm @ 20°c)	Viscosity (centipoise @ 20°c)	Henrys' Constant (atm m^3/mol)
Tetrachloroethene	165.83	1.626	150(@25°c)	14 24(@30°c) 45(@40°c)	102.19	5.83	31.74	----	0.0153
1,1,1-Trichloroethane	133.41	1.350	4,400	100 155(@30°c)	99.63	4.63	----	1.2	0.0300
Water	----	1.0	----	17.535 55.32(@40°c)	----	0.00075 (g/cm^3)	72.75 (in contact w/air)	1.002	----
Moist Air	28.97	----	----	17.55	20.10	1.0	----	----	----

Sources: Verschueren, 1983; Marrin and Thompson, 1983; Mabey et al, 1983; Hinds, 1982; Chemical Rubber Company, 1974.

CHAPTER IV

DATA ACQUISITION

This study was developed primarily from data acquired during the Rozema Garage Site RI conducted by NUS. Data obtained from one phase of soil gas sampling and two phases of temporary well sampling, both conducted by NUS, were utilized in this study. The author conducted an additional round of soil gas sampling in order to complete the basis of this study.

In this section, the techniques used and procedures followed for the acquisition of soil gas and water quality samples will be presented. The methodologies used to analyze these samples will also be explained.

Soil Gas Sampling

Soil gas sampling was performed by NUS personnel at the Rozema Garage Site and vicinity during January 15 through January 30, 1987. During this time, 41 soil gas samples were obtained. The author collected 51 additional samples on June 14, 23, 24, 28 and July 7, 9, and 22, 1987. Soil gas samples were taken at twenty-four locations during this time.

Figure 12 identifies the soil gas sampling locations

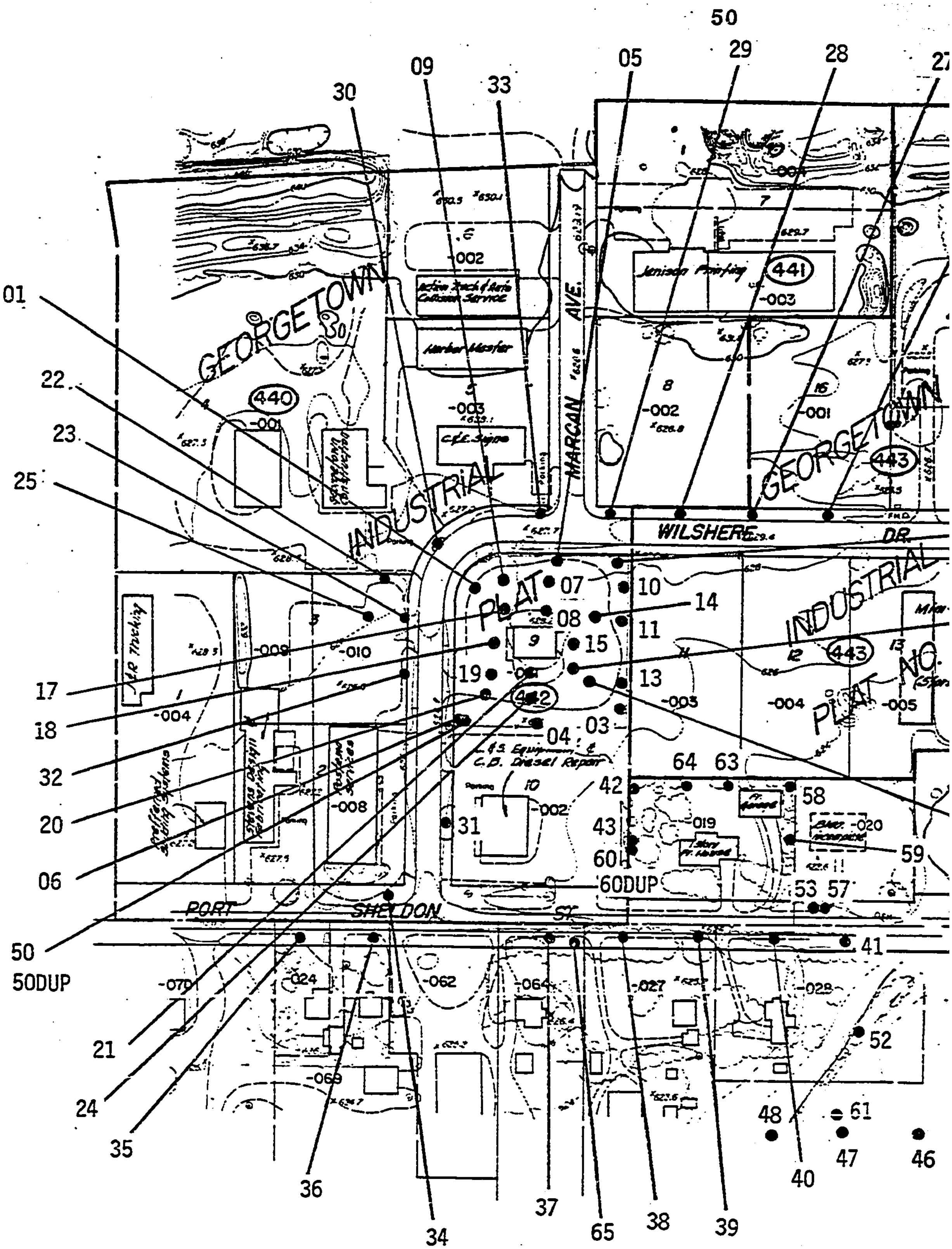
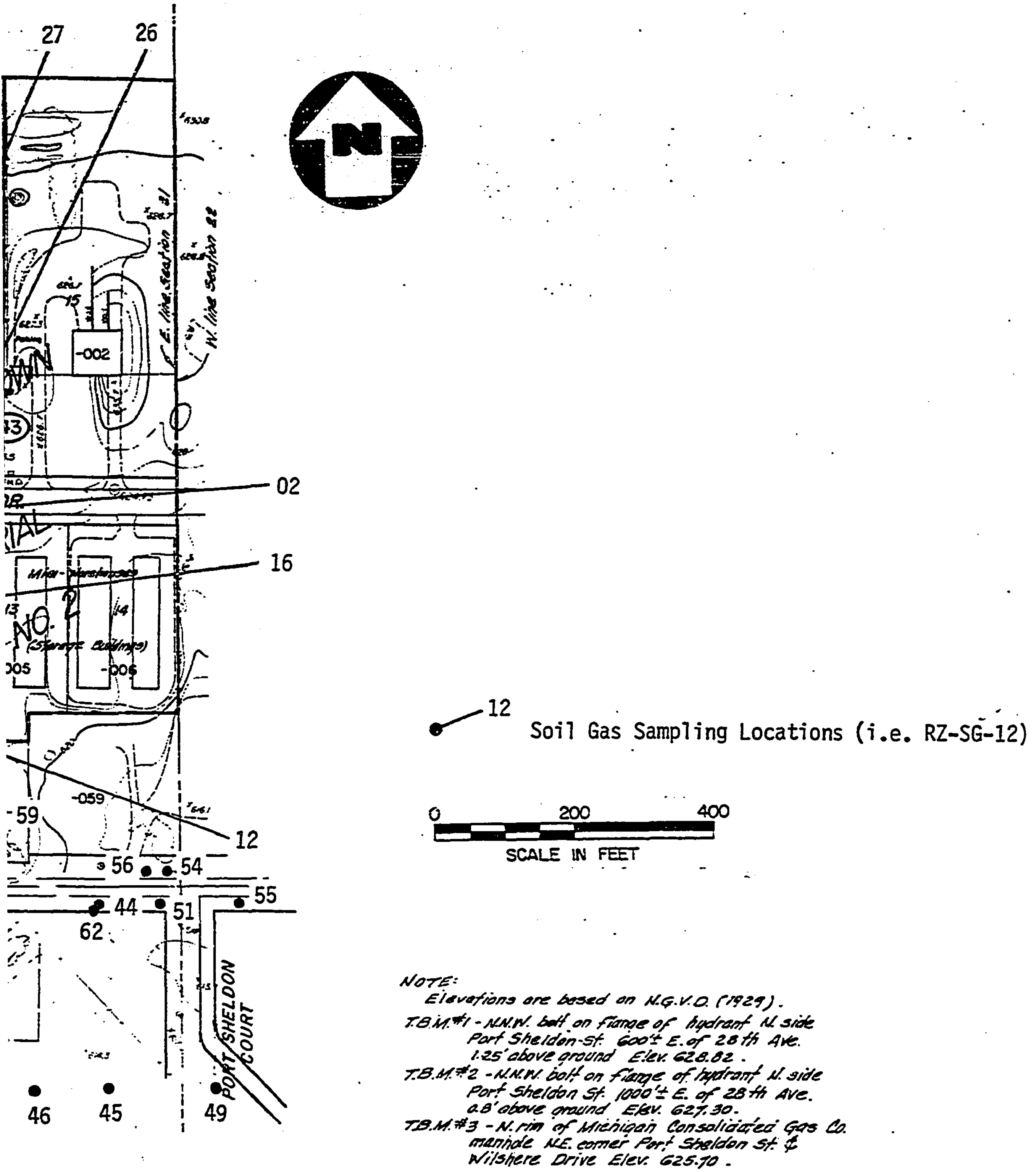


Figure 12. Soil Gas Sampling Locations.



12 Soil Gas Sampling Locations (i.e. RZ-SG-12)

NOTE:
Elevations are based on N.G.V.O. (1929).
T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 600'± E. of 28th Ave. 1.25' above ground Elev. 628.82.
T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 1000'± E. of 28th Ave. 0.8' above ground Elev. 627.30.
T.B.M.#3 - N. rim of Michigan Consolidated Gas Co. manhole N.E. corner Port Sheldon St. & Wilshere Drive Elev. 625.70.

for this study. Twenty four of these locations were coincident with locations where temporary wells were sampled during the same period of time.

The total number of soil gas samples acquired for this study was 92. This number includes ambient air blank samples, transport and laboratory blanks, field duplicates and resamples. The ambient air blanks were acquired for the purposes of determining detection limits for the target compounds and for troubleshooting purposes, which will be described later in the Chapter. The transport (trip), and laboratory blanks were obtained to identify if extraneous contamination was in contact with the samples either while in transport to, or in the laboratory. Field duplicates and resamples were obtained to verify that data replication was consistent during the study.

The initial soil gas sampling round was conducted in an effort to determine the source areas of the PCE and TCA contamination on the Rozema property and to estimate the direction of migration of these contaminants in the groundwater. The subsequent soil gas sampling was performed in conjunction with temporary well sampling in order to determine correlations between the two data sets.

The following is an explanation of the soil gas sampling procedure used during this study. Each soil gas sample was obtained in the manner described below. Any digressions or deviations from this procedure were noted on log sheets filled out for each sample. These logs are provided in Appendix B.

The equipment used for the acquisition of the soil gas samples is listed, with specifications in Table 2.

Prior to use in sampling, the air sampling pumps, used to draw the soil gas through the sample medium, must be calibrated. In addition, the Tenax trap tubes (the sampling medium) must be assembled and conditioned before beginning a sampling effort. The calibration, and assembly and conditioning processes are presented in Appendices C and D, respectively.

Prior to acquiring any soil gas sample from a specific location the sampling apparatus was thoroughly decontaminated. This process is always the first step in the soil gas sampling procedure.

The stainless steel probes and probe points were decontaminated with a soap solution. Nutrogena dissolved in water was applied liberally over the probe exterior with a spray bottle (Figure 13). The probe was then wiped down with paper toweling, then rinsed thoroughly with deionized water and wiped dry. The probe points were cleaned by forcing the soap solution through all openings on the point with the spray bottle (Figure 14). The soap was also applied over the entire surface

Table 2

Soil Gas Sampling Equipment

Item Number	Description
1.	1/2 in. (I.D.), 11/16 in.(o.d.)x5.5 ft. stainless steel probe with 20 lb. slide hammer
2.	11/16 in.(o.d.) stainless steel probe point
3.	2 mm. (I.D.) polyethylene tubing
4.	2 mm. (I.D.) teflon tubing
5.	12 in. x 1/8 in. Tekmar LSC-2 Tenax (60/80 mesh) filled trap tubes
6.	1/8 in. (I.D.) plastic caps
7.	SKC Model 222 air sampling pumps
8.	1 liter plastic freezer bags
9.	1/2 liter plastic freezer bags
10.	1/4 in. (I.D.) P.V.C. electrical wire threaders
11.	20 ml. and 40 ml. glass vials
12.	1 liter glass pipet bubblometer
13.	1 liter plastic spray bottles
14.	Nutrogena soap (bar)
15.	Stopwatch
16.	Paper toweling
17.	Trash bags
18.	Scissors
19.	Air pump calibration log
20.	Indellible ink pen
21.	Chain-of-custody forms
22.	Soil gas sample log sheets
23.	Electrical tape
24.	Channel lock pliers
25.	Surgical gloves
26.	Cooler

Figure 13. Decontamination of Soil Gas Probe.

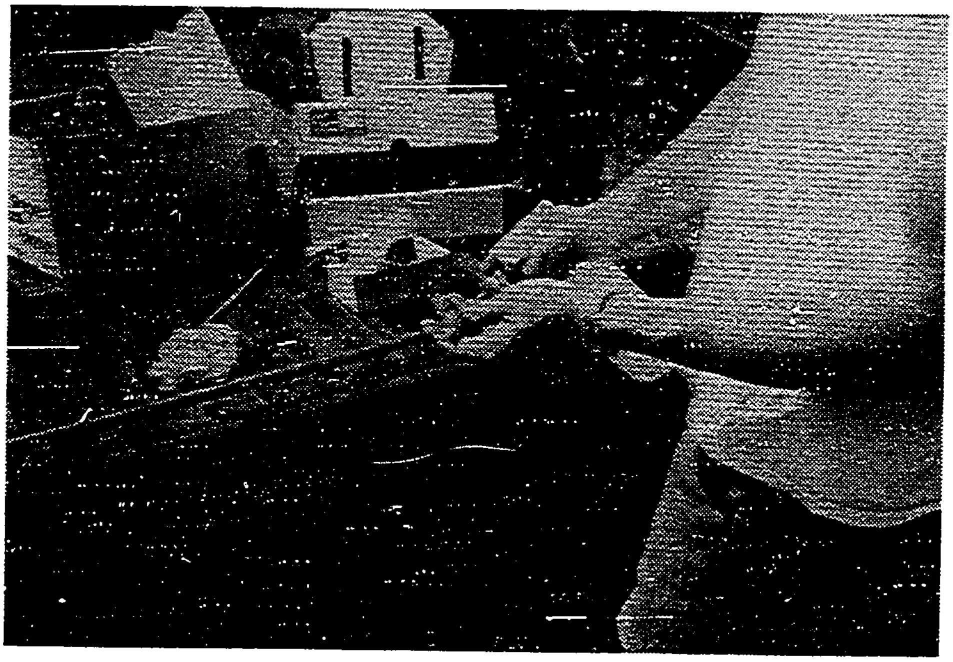


Figure 14. Decontamination of Probe Points.

of the point. The points were then rinsed with deionized water and then dried with paper toweling. Small (1-2 inches) pieces of Teflon tubing (Figure 15), which were used as joints, or connectors, in the sampling procedure, were also decontaminated with soap and water before obtaining each sample.

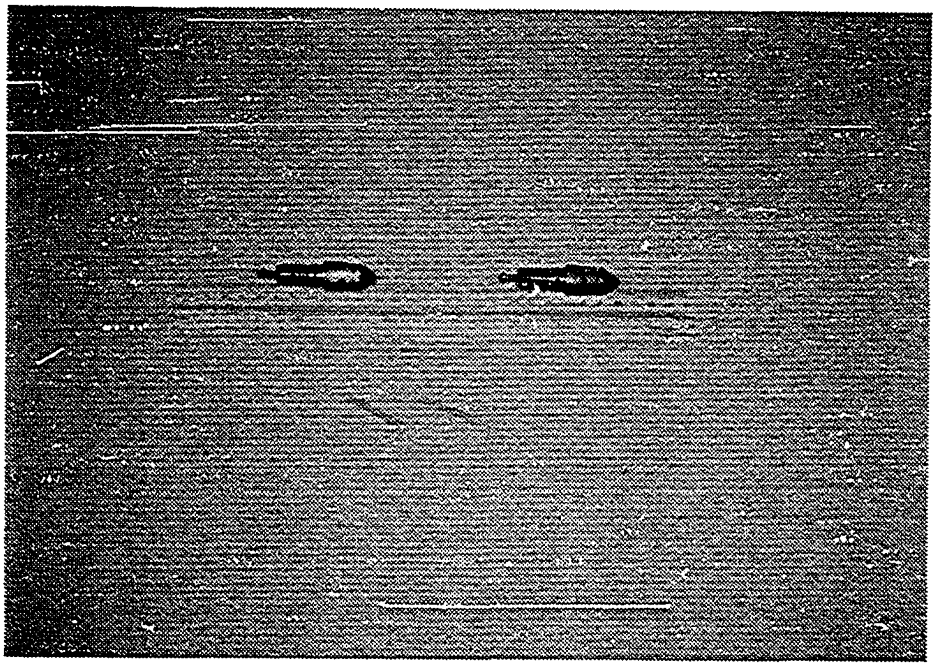


Figure 15. Teflon Joints and Soil Gas Probe Points.

Nutrogena was chosen for decontamination soap because it is free of organic based fumigants and is phosphorous free (Scheib, 1987).

After the probes and points were decontaminated, polyethylene (PE) tubing was inserted into each probe with the aid of plastic threaders (Figure 16). Once the

PE tubing had been extended through a probe, approximately four to six inches of the tubing was cut off at the bottom end of the probe. This was done to insure that no grit or dust, which may have been picked up during the threading process, could clog or soil this end of the tubing. The PE tubing was cut at the top end of the probe so that two to three feet of tube extended out of this end.

Figure 16. Threading PE Tubing into Soil Gas Probe.

One of the small Teflon joints was attached to the PE tube, which was extending out the bottom end of the probe. The Teflon joint was pushed over the PE until about half of its length covered the PE. The probe point was then attached to the Teflon joint. The joint was pushed over the flanged extension of the point until a tight connection was made (Figure 17). Only about a tenth of an inch was separating the point and the end of the PE tubing.

Figure 17. Soil Gas Probe Point and PE Tubing Connection.

The tubing threaders were then removed from each probe.

Next, the point was screwed into the bottom end of the probe. This was accomplished by rotating the probe as the point was held in place firmly by hand, or by a clean wrench (Figure 18). All the while, the point and

PE tubing assemblage were kept stationary so that no twisting or kinking occurred at the joint.

Figure 18. Connecting Soil Gas Probe and Probe Point.

Rubber surgeons gloves were usually worn while assembling the sampling probes. This was done in order to minimize the possibility of contamination carry-over from the hands. When gloves were not available, the probe point was handled with the wrench or with clean paper toweling.

Having the point secured tightly onto the probe, the apparatus was ready for sample acquisition.

Before heading off to a sampling point, additional

Teflon joints were placed in glass jars. Doing this minimized the possibility of contaminating or soiling the joints while moving to, and setting up at each sampling location.

At each location the probe was pushed into the ground until refusal, if possible. Then, the slide hammer on the probe was used to drive the probe down to the desired sampling depth. This process was generally done without much difficulty. This was especially true in moist granular soils that contained little or no gravel. Even when gravel was encountered, often it was just a matter of pulling the probe out of the ground and moving over a foot or two to try again. However, in cohesive soils or dry granular soils, the hammering process could be very difficult.

Frozen, or over-consolidated ground also make driving the probes very difficult. To facilitate sampling in such conditions, as was done at the Rozema site, a hand operated, hydraulically powered earth auger was used to bore a pilot hole at the sample location. (Figure 19). Pilot holes were drilled to as much as three feet into the ground. Probes were then inserted into these holes and driven to the desired sampling depth.

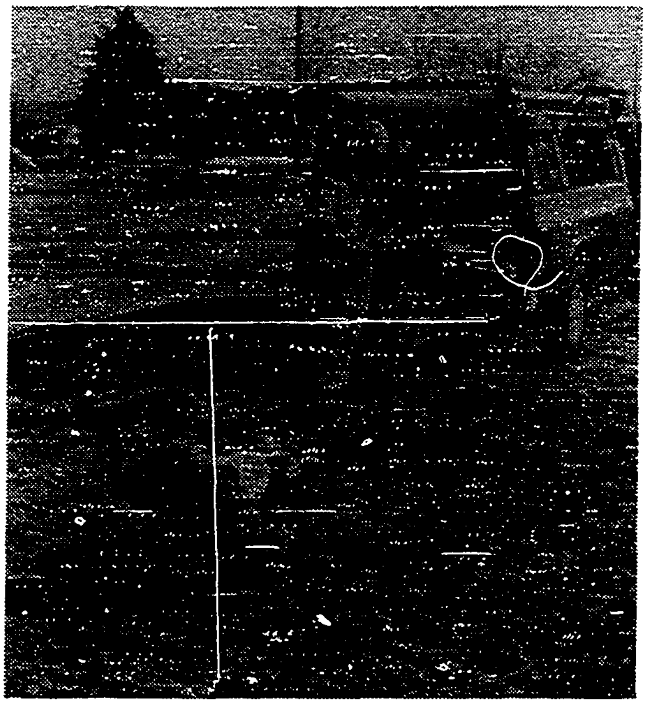


Figure 19. Drilling Pilot Hole.

Driving the probe into the ground with the 20-pound slide hammer is a somewhat delicate process. Care was taken to assure that the PE tubing assembly within the probe did not twist or vibrate loose during the hammering process. Once the probe was driven to the desired sampling depth, a slight tug was made on the PE tubing extending from the top of this probe. If the tube did not pull loose, then sampling would continue. However, if the tubing came loose, then the probe was withdrawn from the ground and reassembled.

After assuring that the tubing assemblage had not twisted or come loose, the probe was tapped up (withdrawn) two to four inches with the slide hammer. Doing this opens the point head and increases the surface area over which soil gas can be drawn. In addition, the pulling back of the probe creates a void in the soil beneath the point. As a result, a head space was established below the sampling point.

Next, an SKC Model 222 air sampling pump was attached to the PE tubing that was extending out of the top of the probe. The pump was then engaged and allowed to run for about 30 seconds. This purging process was done to remove the ambient air within the PE tubing and to insure that only in-situ soil gases were drawn through the Tenax filled trap tube once it was attached.

After the PE tubing had been purged, approximately three to six inches of it was trimmed off the end. This was done to remove any contamination that may have collected on the tubing end during handling. A Teflon joint was then pushed on the trimmed PE tubing.

Next, a Tenax filled trap tube (Figure 20), was attached to the PE tubing assembly . The flanged end of the trap tube was pushed through the plastic holding bag. The plastic cap covering the end of the trap tube was then removed. The Teflon joint on the PE tubing was then pushed snugly over the trap tube flange so that the ends of the trap tube and PE tubing were almost touching.

The other end of the trap tube was then pushed through the bag. The plastic cap was removed from the end of the tube which was then pushed tightly into the SKC air pump. Care was taken to handle only the plastic bag or Teflon joint throughout this process in order to avoid contaminating the assembly.

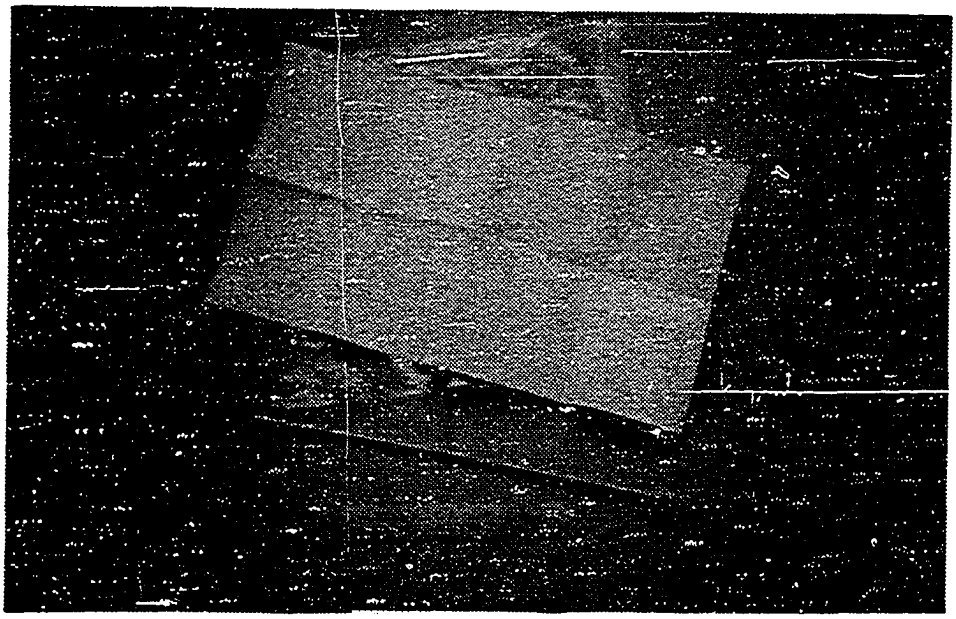


Figure 20. Tenax Filled Trap Tube.

Once the air pump had been connected to the trap tube, it was secured to either the probe shaft or onto the ground. This was done in such a manner so that the PE tubing and Teflon joint did not kink. Most often, the air pump was taped to the probe shaft (Figure 21). Occasionally, the plastic bag housing the trap tube had to be taped to the probe as well. This was necessary because wind would often catch the bag and dislodge the trap tube from the air pump.

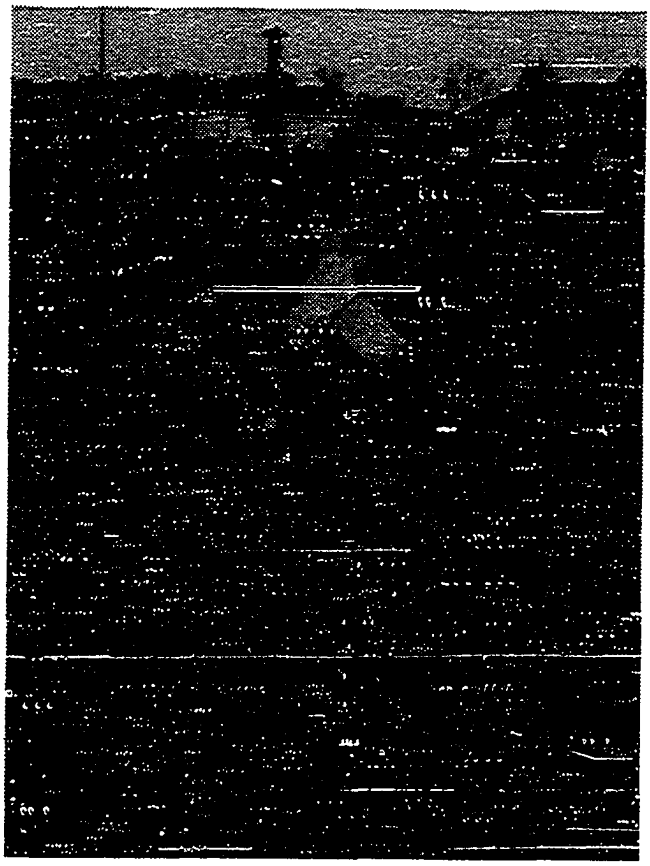


Figure 21. Soil Gas Probe and SKC Pump In Place.

At this point in the sampling procedure, a sample log sheet was filled out for the respective sample. The site name, sample number, date, time, sampling depth and location were noted on these logs. In addition, note was taken of the weather conditions at the time of sampling.

This included temperature, wind, relative humidity and cloud cover. Other points of interest that were written on the logs included the sample medium used and the method and the equipment used to analyze the sample. Notes were also made on these logs of any unusual sampling occurrences, or procedural digressions while obtaining a specific sample. An example of a completed log is given in Figure 22.

It was decided that drawing one liter of soil vapor through a trap tube would be sufficient to concentrate contaminants, if present, on the Tenax material without achieving breakthrough of the contaminants through the tube (Scheib, 1987). Over-purging could cause some contaminants to be drawn completely through the tube.

In the comments section of each sample log, the number identifying the air pump used for obtaining the sample was written down. Before starting the sampling purge, a record was made on the sample log of the counts visible on the pump display panel (Figure 23). The number of counts required to purge one liter of soil gas with a pump, as determined by the pump calibration process, was written on the face of each pump (Figure 24). This number was added to the pump count on the sample log sheet. The sum of these two numbers was the pump count which indicated when one liter of soil gas had been purged. Once this count was achieved the pump

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-014

DATE SAMPLED: 1/21/87

TIME SAMPLED:

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 47 FT WEST OF EAST FENCE LINE. 7 FT NORTH OF SAMPLE OIL LINE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP 5890 A

COMMENTS:

CLOUDY, COLD (~20°)

Pump #4 ST – 538917
11240 –
END – 550157

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

Figure 22. Soil Gas Sample Log Sheet.

was shut off and sampling was complete.

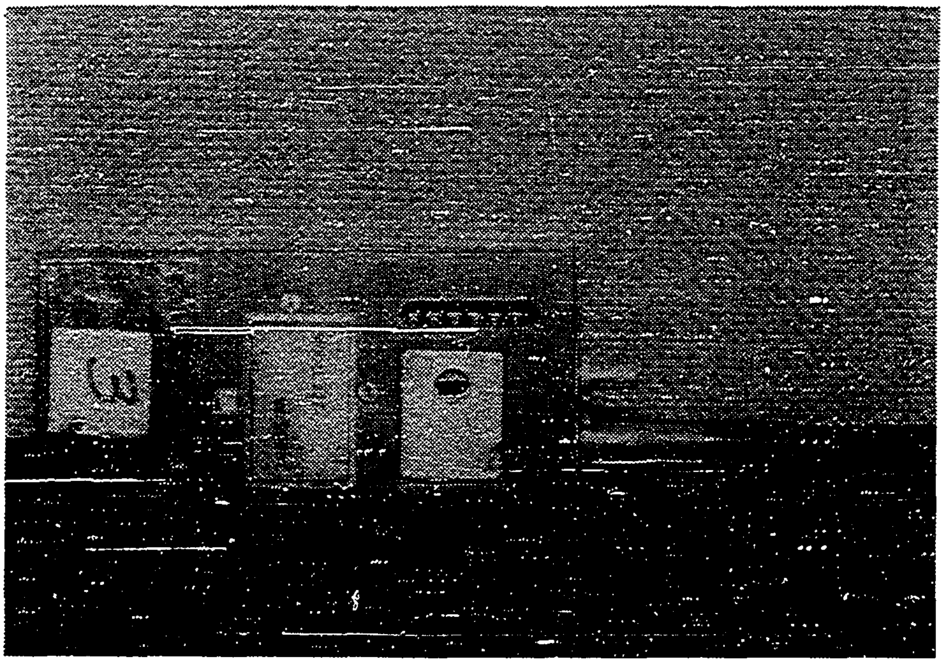


Figure 23. SKC Air Sampling Pump.

Once the probe was in place and the pump was connected the sample number was then written, in ink, on the outside of the trap tube bag.

Sampling began with a simple flick of the switch on the air sampling pump.

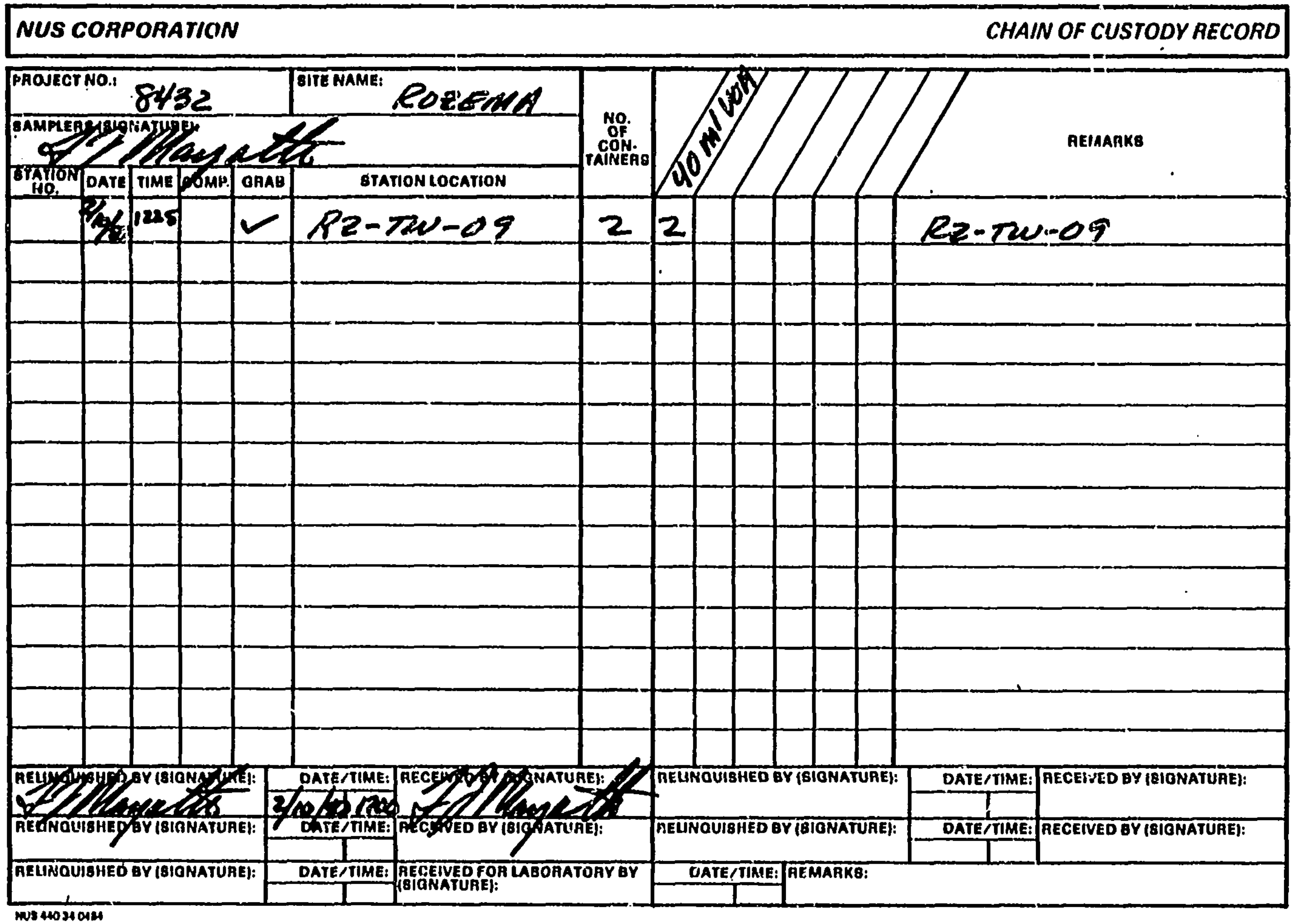
The plastic caps from the trap tube were held in glass vials during the purging process to minimize any carry-over of contaminants.

After purging one liter of soil gas, the trap tube was disconnected from the air pump and PE tubing and was recapped. The trap tube was then pushed back into the plastic holding bag and the sample was placed into a cooler. Ice was placed into the cooler with the samples when each sampling round was completed.

After each sampling round was completed, the samples were transported to the field analytical laboratory for analysis. At the laboratory, the samples were transferred directly from the cooler to a refrigerator and were stored at 4.0 Deg. C to await analysis.

In January, 1987 the soil gas samples were handed over directly to the analytical personnel. Chain-of-custody for these samples was insured by the sampling personnel who maintained possesion of the samples at all times. However, the samples obtained in the summer of 1987 were delivered to, and stored in the laboratory.

For these samples, a record of the chain-of-custody was kept for the samples acquired during each sampling round. NUS Chain-of-Custody forms (Figure 24) were used to record the sample number, date, time, and location of each sample collected during a sampling effort. This form was signed by the personnel who were responsible for obtaining the samples and in whose custody the samples were held. The personnel responsible for the analysis of the samples signed the Chain-of-Custody as soon as the samples were handed over to them. By doing this, the evidentiary value of the samples was maintained.



NUS CORPORATION **CHAIN OF CUSTODY RECORD**

PROJECT NO.: 8432
SITE NAME: ROZEMA
SAMPLERS (SIGNATURE):

STATION NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CON-TAINERS	40 ml VOA						REMARKS
	2/10/88	1225		✓	R2-TW-09	2	2						R2-TW-09

RELINQUISHED BY (SIGNATURE):	DATE/TIME: 2/10/88 1700	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):
RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED FOR LABORATORY BY (SIGNATURE):	DATE/TIME:	REMARKS:	

NUS 440 34 0484

Figure 24. NUS Chain of Custody Form.

The analysis of the soil gas samples was performed in an NUS mobile laboratory equipped with full gas chromatography capabilities.

Soil Gas Sample Analysis

The method by which the soil gas samples were analyzed is based on EPA Method 624. Soil gas samples were desorbed and sequentially analyzed by temperature-programmed, purge and trap gas chromatography (GC). A Tekmar LSC-2 Liquid Sample Concentrator (purge and trap device) and a Hewlett Packard 5890A gas chromatograph were used for the analysis of these samples. Detection was accomplished by a flame ionization detector (FID) and the FID responses were quantified using a Shimadzu C-R3A integrator.

The analysis of a set of soil gas samples began by preparing and analyzing a soil gas standard. The soil gas standards were of gaseous phase volatile organic compounds trapped onto a Tenax filled Tekmar LSC-2 trap tube. The standard compounds included the contaminants of interest for the study: perchlorethene and 1,1,1-trichlorethane. The standards were used to calibrate the GC instrumentation so that proper compound identification and quantification could be accomplished when analyzing soil gas samples.

To prepare a soil gas standard, a one-liter Tedlar air sampling bag was filled to capacity with prepurified nitrogen gas. An aliquot (usually one or five microliters) of a premixed standard solution was then injected into the Tedlar bag. The standard solution, which was prepared in methanol, would quickly vaporize once in the bag. Then, as done when acquiring soil gas samples, the contents of the bag were purged through a trap tube with an SKC pump as shown in Figure 25. The trap tube was connected to the Tedlar bag with a small piece of Teflon tubing.

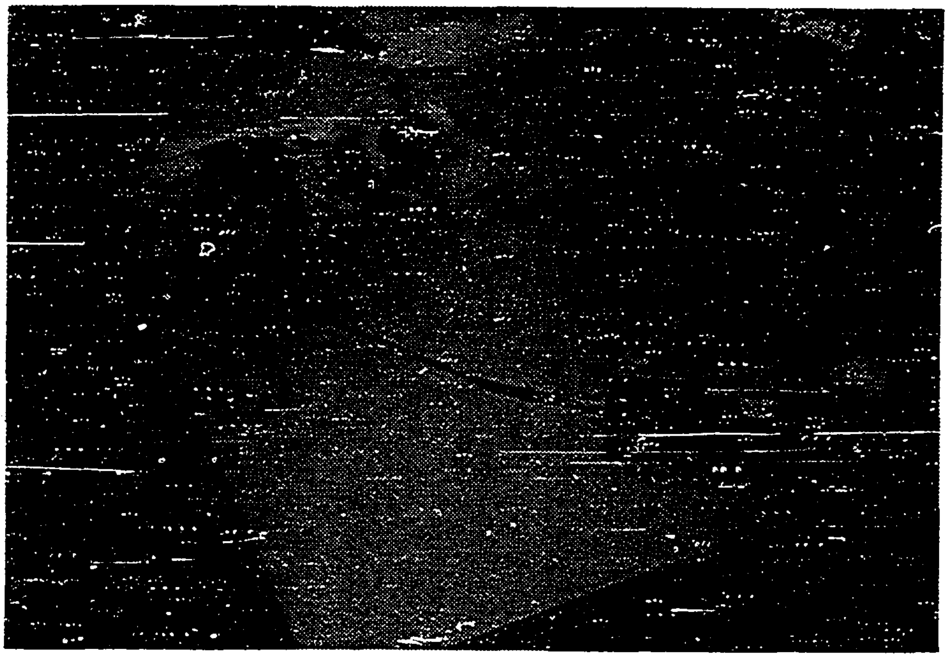


Figure 25. Purging Soil Gas Standard Mixture into Trap Tube.

The soil gas standard tubes were analyzed in the same manner as the actual soil gas sample tubes. However, the chromatogram for a standard was used to calibrate the GC instrumentation. Because the concentration of each compound in the standard was known prior to analysis, it was possible to establish a response factor (RF) for each compound which could be used to quantify the responses of the soil gas sample analysis that were subsequent to the standard analysis. This RF is calculated by dividing the known concentration of each compound by the area under, or height of the peak, or chromatographic response of that compound produced during the GC analysis and integration of the standard. An identification file consisting of peak identification numbers, peak compound names, retention times (RT) and concentrations for each standard compound was programmed into the Shimadzu C-R3A and was used as the integration, or internal, standard.

The internal standard calibration was used to quantify samples analyzed on the same day of, and after the standard analysis, initially. However, an inspection of the soil gas standard chromatograms for this study revealed that the relationship between peak heights or area responses and the concentration of each target compound in the standards was non-linear. As a result, samples obtained on different days that exhibited similar

PCE and TCA peak heights and area responses were calculated to have concentrations of these compounds differing from each other as much as five and three times, respectively. These calculations were carried out using the RFs'as determined by the daily standards, that were programmed into the integrator. However, the concentrations of PCE and TCA in the standards were not constant from day to day. Therefore, the quantification of the samples by this method yielded non-linear values for these samples.

Consequently, the quantification of the samples from each set of data was accomplished by establishing calibration curves. These curves were constructed for both PCE and TCA. The PCE and TCA calibration curves were established for both the winter and summer soil gas data sets.

The standard calibration curves were prepared by plotting the concentration of each compound against the corresponding peak height or area response for that compound. The curve made for the winter data utilized peak areas. Peak heights were used for the summer data. From these plots, best-fit straight lines were approximated, visually, through the points (Figures 26 through 28). Equations were calculated for each line. These equations (Figures 26 through 28) were used to establish the concentration of each compound in each sample.

An example of a typical chromatogram of a five microliter soil gas standard is presented in Figure 29. The target compounds for this study are shown to be eluting at 13.06 minutes (PCE) and 7.97 minutes (TCA).

After analyzing a soil gas standard, the chromatographic system was demonstrated to be free of contamination by the generation of an acceptable system, or method blank. The method blank was accomplished by the analysis of the soil gas standard trap tube after the initial standard analysis.

The analysis of all soil gas samples, and standards, began by inserting the sample trap tube into the LSC-2 device (Figure 30). Then one to three microliters of an aqueous surrogate compound (2-bromo-1-chloropropane) was mixed into ten milliliters of organic-free water. The water and surrogate solution was then injected into the fritted, glass sparging unit on the LSC-2. The water was purged for four minutes with prepurified nitrogen gas. In the process, the surrogate was stripped from the water, carried in the gaseous phase from the sparging unit and subsequently adsorbed into the Tenax material as the gas stream passed through the sample trap tube.

After the purge cycle was completed, the trap tube was heated to 180 Deg. C. This heating action caused the contaminants adsorbed onto the Tenax to revolatilize.

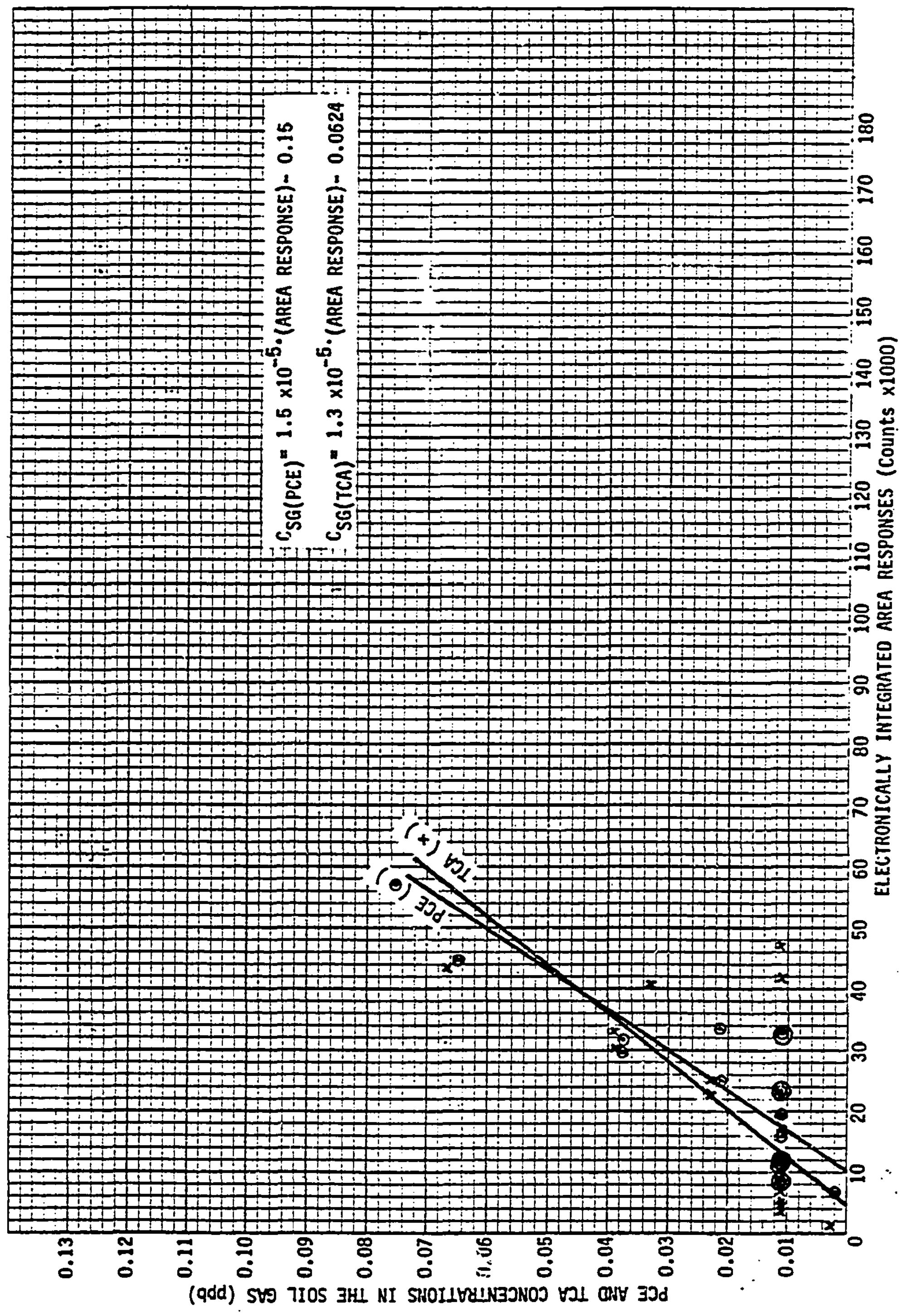


Figure 26. Soil Gas Calibration Curve for PCE and TCA, January, 1987.

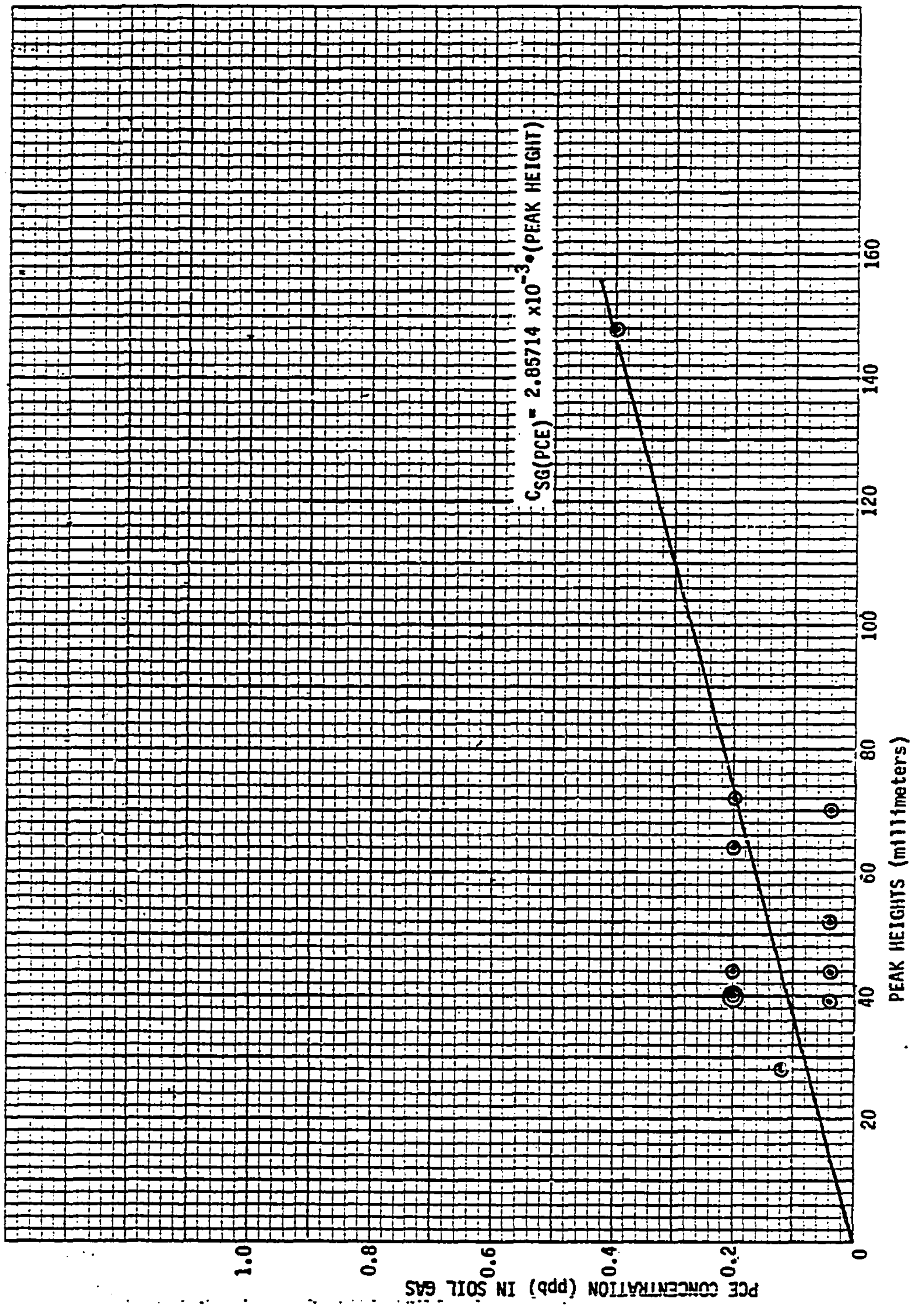


Figure 27. Soil Gas Calibration Curve for PCE, June and July, 1987.

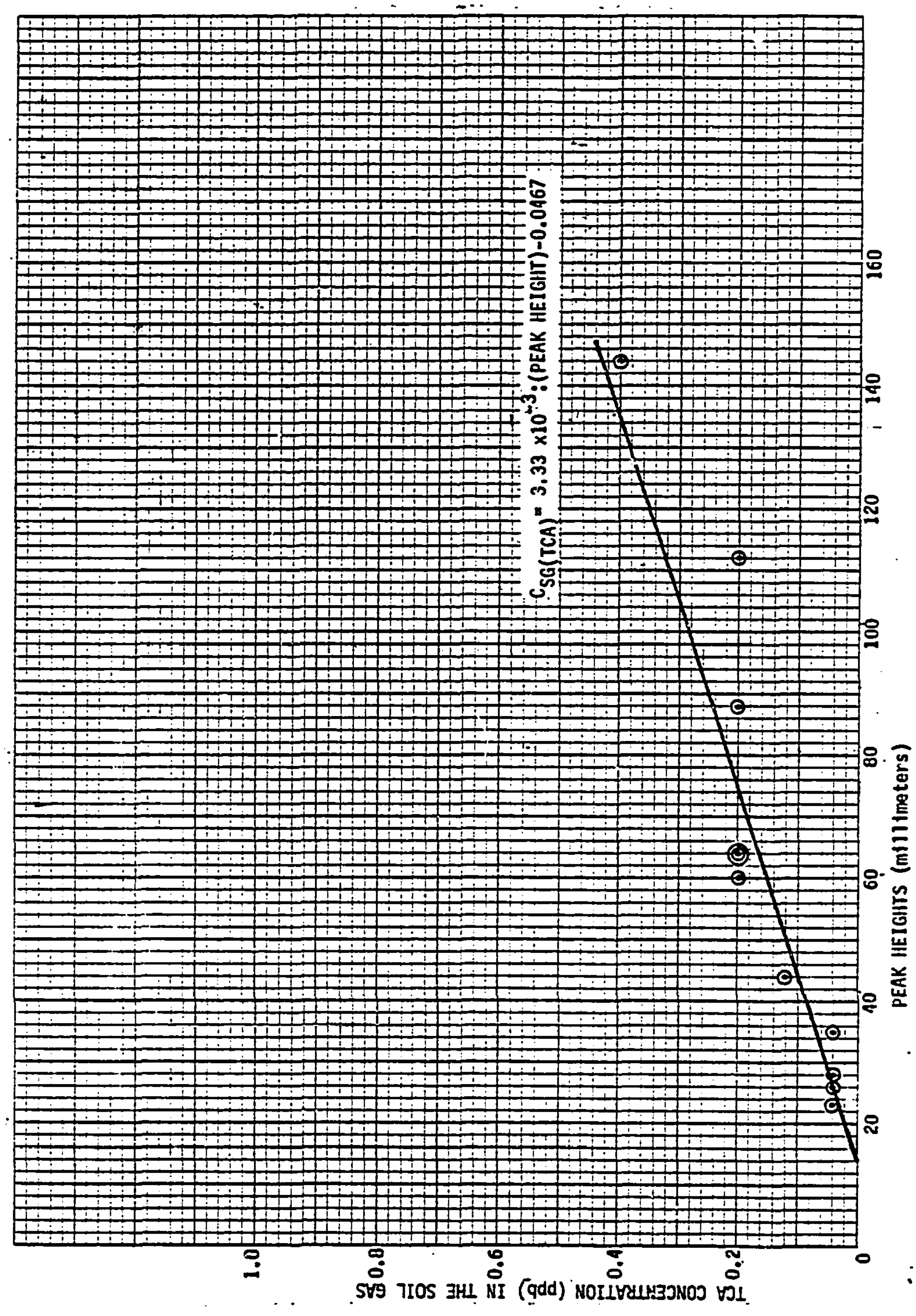


Figure 28. Soil Gas Calibration Curve for TCA, June and July, 1987.

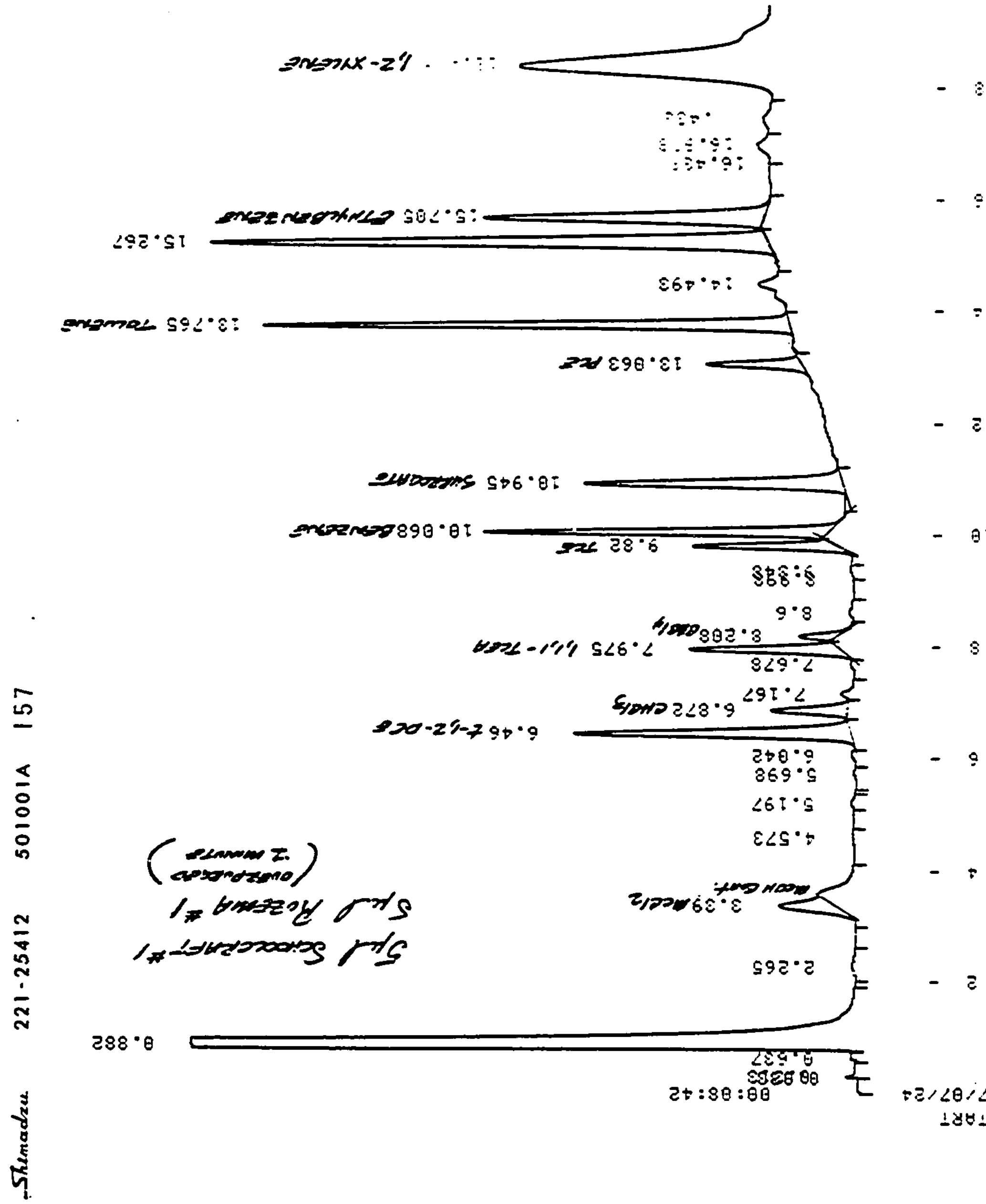


Figure 29. Soil Gas Standard Chromatogram.

The vaporous contents of the sample were then desorbed for five minutes by a back flush of nitrogen gas onto the GC. The GC/FID was used to detect the contents of the sample or standard vapors which were resolved by a six meter long, two millimeter (inside diameter) diameter glass analytical column packed with 1% SP-1000 on 60/80 mesh carbopack B. The GC temperature program used to analyze the soil gas samples is given in Table 3. The rate of flow of the nitrogen carrier gas was 38.4 milliliters per minute.

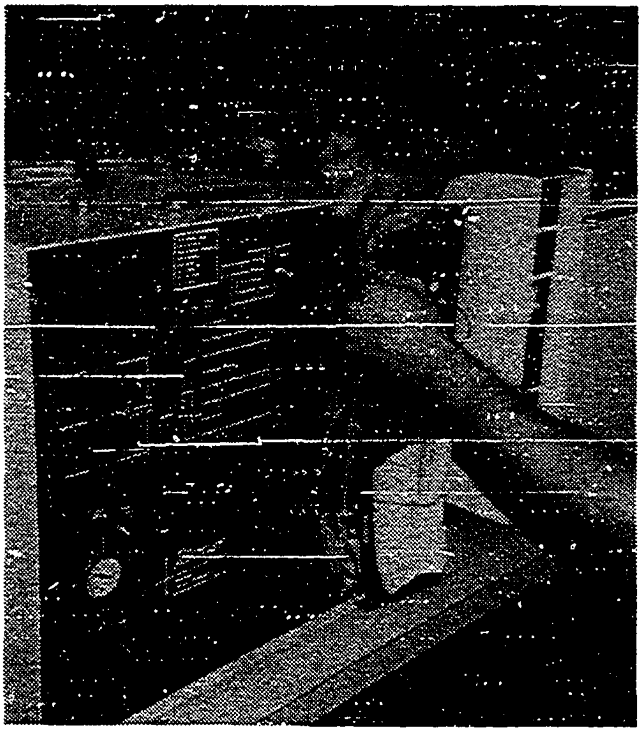


Figure 30. Inserting Trap Tube into LSC-2 Unit.

For each sample, PCE and TCA area responses, or

Table 3

Gas Chromatographic Programming

Gas Chromatograph	HP5890A
Flow rate	38.4 ml/min
Attenuation	0
Range	3
Column	1% SP-1000 on CP-B
Detector	FID
Initial temperature	60 Deg. C
Initial time	3 min.
Temperature ramp	15 Deg. C/min.
Final temperature	220 Deg. C
Final time	10.0 min.
Injection temperature	275 Deg. C
Detector temperature	290 Deg. C

peak heights (for summer data) were measured (peak heights had to be estimated proportionally with well integrated peak areas for some highly contaminated soils). These values were used with the respective calibration equations to calculate the PCE and TCA concentrations for this study. It should be emphasized that this method, although valid, is not precise. Therefore, all concentrations presented in this study are average values.

An example of a chromatogram from the analysis of a soil gas sample (RZ-SG-60) is shown in Figure 31.

After the analysis of each soil gas sample was complete, the sample trap tube was baked at 205 Deg. C for eight minutes to remove any remnant contamination or other impurities from the tube.

Each soil gas sample was analyzed a second time immediately after the initial analysis. This was done in order to determine that the tube was clean and ready to be used for sampling again. If the tube was determined to be clean, it was removed from the LSC-2, recapped and placed in a new one liter plastic storage bag. The "clean" chromatogram from the second sample analysis was then placed in a smaller plastic storage bag which would be kept with the clean sample trap tube. These clean chromatograms served as a record for the condition of each trap tube during its period of use. Consequently,

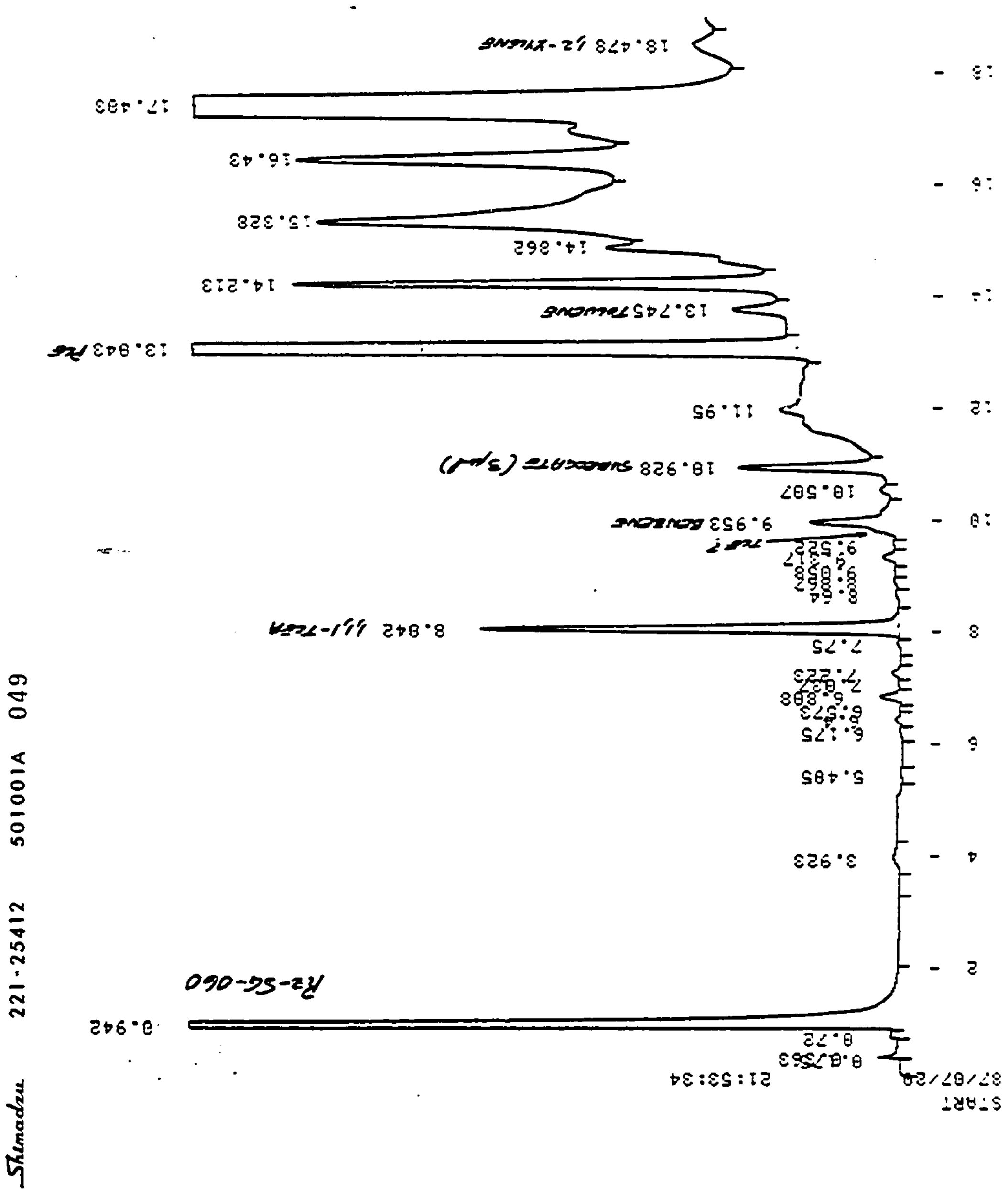


Figure 31. Soil Gas Sample Chromatogram.

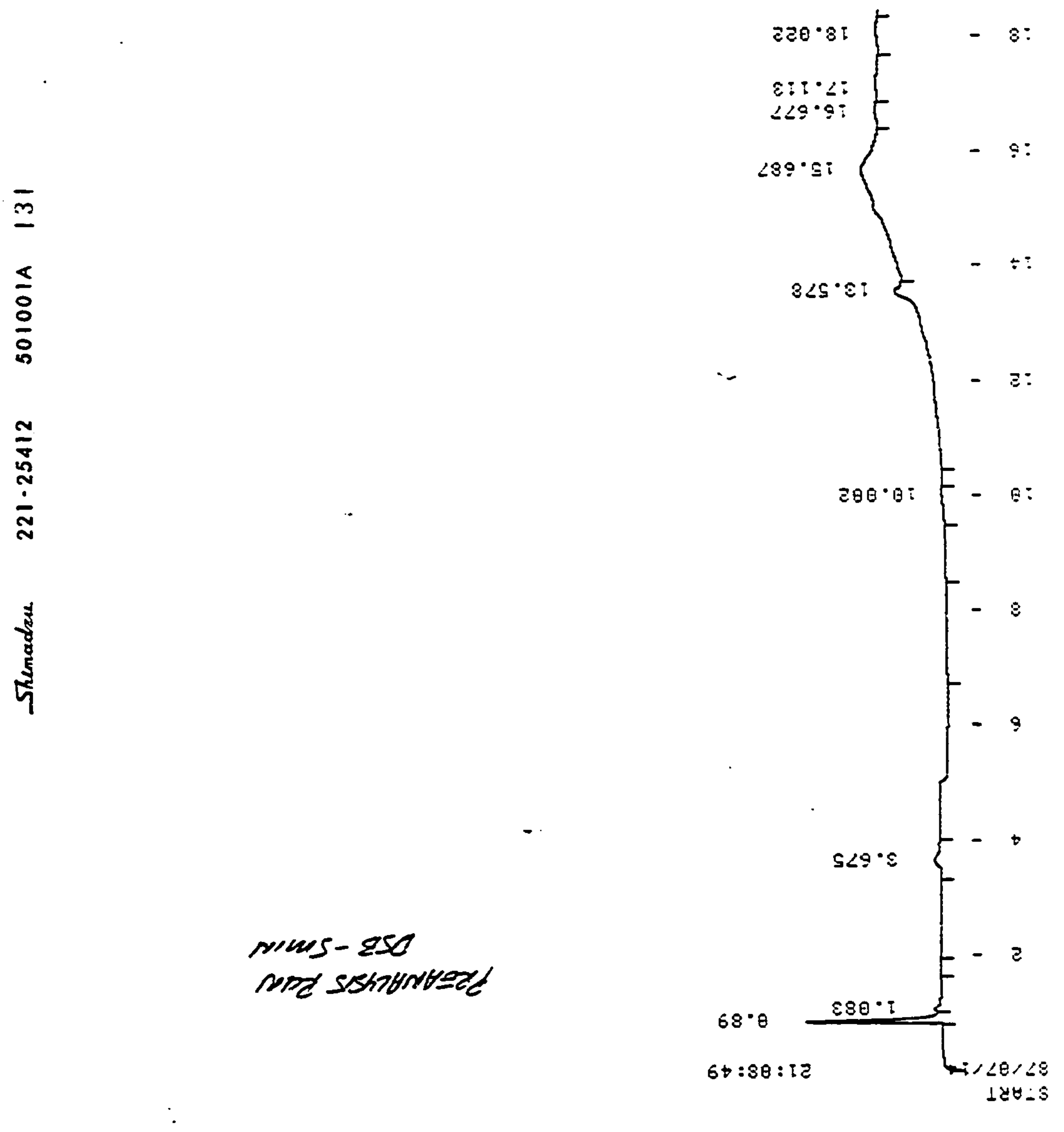


Figure 32. Chromatogram of "Clean" Preanalysis Run.

the second analysis and chromatogram for each sample trap tube was deemed the "preanalysis" run for the tube prior to its use for the next sampling. Figure 32 shows an example of a "clean" preanalysis run generated subsequent to the analysis of soil gas sample RZ-SG-114B.

If a sample trap tube was preanalyzed and was determined to be in poor condition, the tube was repacked with Tenax and conditioned as explained in Appendix C. An example of an "dirty" preanalysis run is given in Figure 33.

An initial inspection of all the sample chromatograms proved that the method used to quantify the samples (i.e. calibration curves) did not introduce any false results. Samples were identified visually to be either contaminated with PCE and TCA, or clean. A summary of this inspection is given in Table 4. A comparison of Table 4 with Table 8 (the quantified soil gas sampling results) reveals that, generally, the qualitative and quantitative data correspond highly, with respect to the presence of contamination. However, the quantitative data have been amended by detection limits established for the PCE and TCA data.

The ambient air blanks obtained during this study were used to determine the background concentrations of PCE and TCA around the study area. Blank samples (RZ-SG-107B and RZ-SG-108B) revealed that as much as 0.20 ppb of

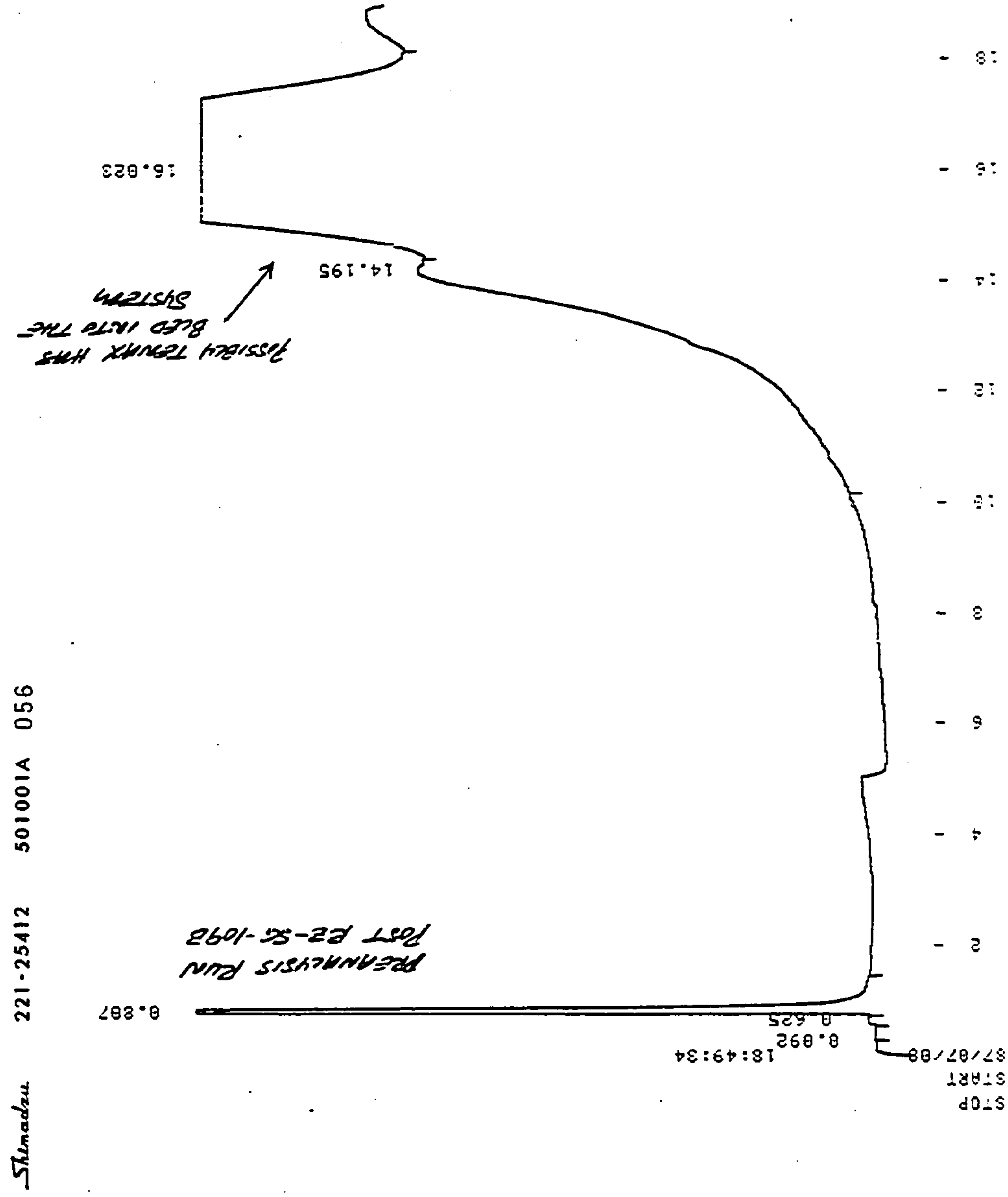


Figure 33. Chromatogram of "Dirty" Preanalysis Run.

Table 4

Samples with Visually Identifiable PCA and TCA Chromatographic Responses

Soil Gas Sample No.	Compounds	
	PCE	TCA
RZ-SG-01	X	X
RZ-SG-02	X	X
RZ-SG-03		X
RZ-SG-04	X	X
RZ-SG-05	X	X
RZ-SG-06	X	X
RZ-SG-07	X	X
RZ-SG-08	X	X
RZ-SG-09	X	X
RZ-SG-10	X	
RZ-SG-11	X	X
RZ-SG-12		
RZ-SG-13	X	X
RZ-SG-14		
RZ-SG-15		
RZ-SG-16	X	X
RZ-SG-17	X	X
RZ-SG-18	X	X

Table 4 — continued

Soil Gas Sample No.	Compounds	
	PCE	TCA
RZ-SG-19	X	X
RZ-SG-20	X	X
RZ-SG-21	X	X
RZ-SG-22		
RZ-SG-23	X	X
RZ-SG-24	X	X
RZ-SG-25	X	
RZ-SG-26	X	X
RZ-SG-27	X	X
RZ-SG-28		X
RZ-SG-29	X	X
RZ-SG-30		
RZ-SG-31		X
RZ-SG-32		
RZ-SG-33	X	X
RZ-SG-34		
RZ-SG-35		
RZ-SG-36		
RZ-SG-37		
RZ-SG-38		

Table 4 — continued

Soil Gas Sample No.	Compounds	
	PCE	TCA
RZ-SG-39		
RZ-SG-40	X	X
RZ-SG-41	X	X
RZ-SG-42	X	X
RZ-SG-43	X	X
RZ-SG-44	NA	NA
RZ-SG-45		
RZ-SG-46		
RZ-SG-47		
RZ-SG-48		
RZ-SG-49		
RZ-SG-50	X	X
RZ-SG-50 Dup	X	X
RZ-SG-51	X	
RZ-SG-52	X	
RZ-SG-53	X	
RZ-SG-54	X	
RZ-SG-55		
RZ-SG-56	X	
RZ-SG-57	X	X

Table 4 — continued

Soil Gas Sample No.	Compounds	
	PCE	TCA
RZ-SG-58		
RZ-SG-59	X	
RZ-SG-60	X	X
RZ-SG-60 Dup	X	X
RZ-SG-61		
RZ-SG-62	X	
RZ-SG-63		
RZ-SG-64		
RZ-SG-65	X	

Note: NA = Not available
X = Compound present

property. This contamination may be coming from the truck painting facility across from the Rozema site on Wilshere Drive. Thus, a site specific method detection limit of 0.20 ppb of PCE has been established for this study.

No TCA contamination was present in the ambient air blanks. Therefore, in order to estimate a detection limit for TCA, chromatographic baseline activity was examined. Any "noise" in this baseline that was present at or near the TCA RT was identified. Peak heights of this "noise" were measured. From these heights, corresponding concentations of TCA were calculated. The detection limit for TCA was then calculated to be two times the level of the average "noise" concentration. This is the minimum signal for TCA that is detectable by the analytical equipment (Lovelock, 1961). The detection limit for TCA was established to be 0.01 ppb from these calculations.

Troubleshooting

An examination of the soil gas sample chromatograms revealed that many compounds of unknown origin were being detected. These compounds were especially evident, and at significant concentrations throughout the last six minutes of the chromatographic analysis. These compounds were not random, but were relatively consistent eluters.

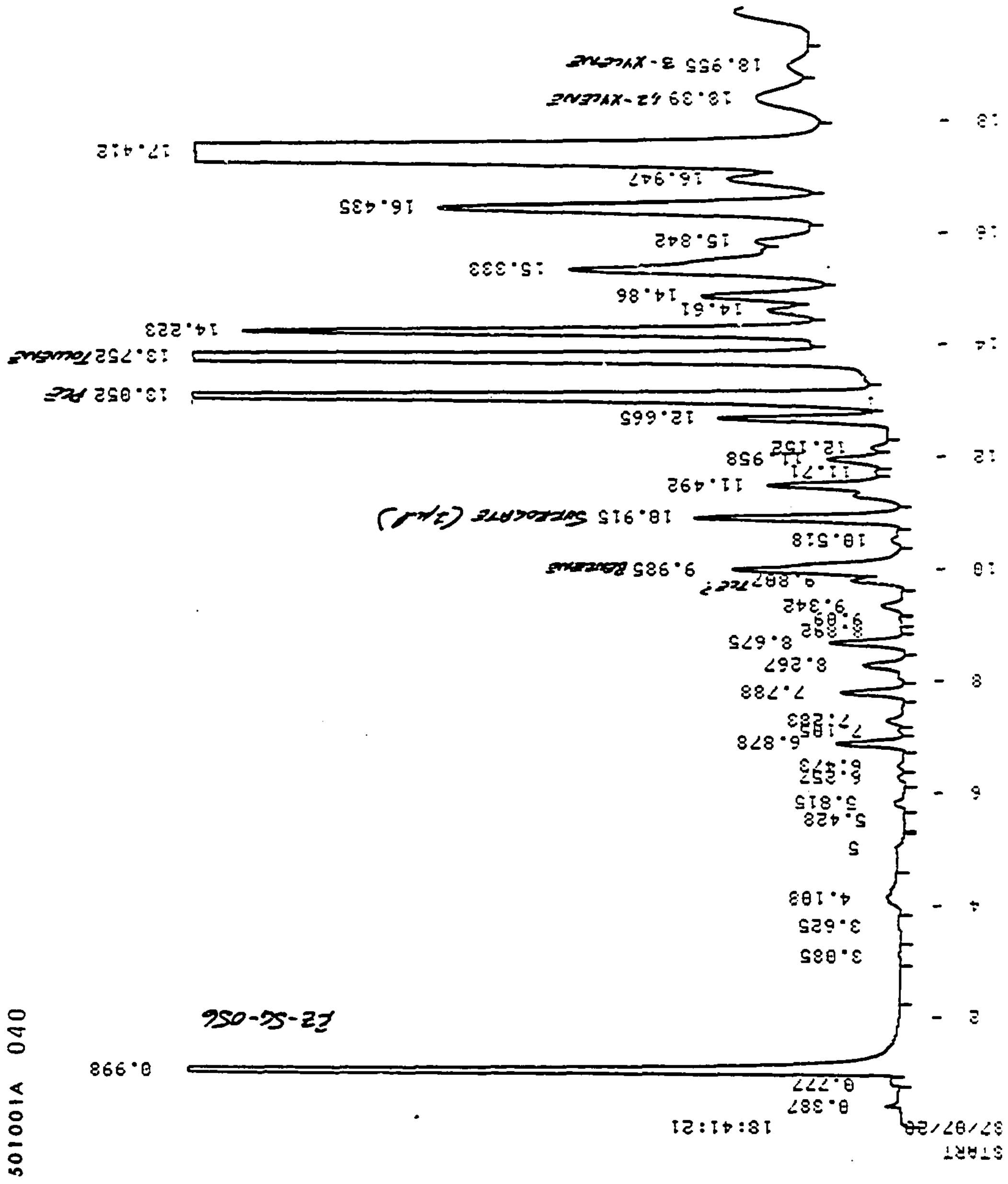


Figure 34. Chromatogram Showing Unknown or Interference Compounds.

Table 5 sumarizes the relative retention time ranges for each of these unknown compounds identified in samples acquired in June and July of 1987. Figure 34 identifies a sample chromatogram which exhibits these unknown compounds. This sample (RZ-SG-56) was obtained in July, 1987. The samples obtained in January, 1987 did not exhibit such unknown contamination.

Several tests were performed in order to isolate the source of these unknown compounds. The first test was an examination of the results of the decontamination water blanks which were obtained periodically throughout the sampling rounds. These blanks were analyzed to determine if any contaminants were present in the water. If so, these contaminants could be carried over onto the sampling equipment. These data revealed that small concentrations of chloroform had been detected in some of the blank samples, but that the concentrations were so low that carry-over would be negligible.

After discounting the carry-over theory, the source for the unknown compounds was speculated to be from the PE tubing used as the vapor transport line. This was deduced when it was discovered that the unknown compounds that were identified in the in-situ soil gas samples were not discovered in ambient air blanks, trip blanks or laboratory blanks obtained and analyzed during the same period of time. Blank samples were not drawn through PE

Table 5

Summary of Interference in Soil Gas Samples

Sample No.	Retention Times of Interference													
	3.3	6.4-7.0	7.5	9.8-10.0	11.4	11.8	13.2	14.05-14.20	14.7-14.9	15.1-15.4	16.2-16.5	17.1-17.5	18.0-18.4	18.6
RZ-SG-42	X	X		X	X			X	X	X	X		X	
RZ-SG-43	X	X		X	X			X	X	X	X	X	X	
RZ-SG-44	X	X	X	X	X	X		X	X	X	X	X		
RZ-SG-45				X	X			X	X	X	X	X	X	
RZ-SG-46					X			X	X	X	X	X	X	
RZ-SG-47	X	X		X	X	X		X	X	X	X	X	X	
RZ-SG-48	X	X	X	X	X	X		X	X	X	X	X	X	
RZ-SG-49	X	X		X	X			X	X	X	X	X	X	
RZ-SG-50	X			X	X			X	X	X	X	X	X	
RZ-SG-50 Dup	X			X	X	X		X	X	X	X	X	X	
RZ-SG-51	X	X		X	X			X	X	X	X	X	X	
RZ-SG-52	X			X	X			X	X	X	X	X	X	
RZ-SG-53				X	X			X	X	X	X	X	X	
RZ-SG-54	X	X	X	X	X			X	X	X	X	X	X	
RZ-SG-55		X										X		
RZ-SG-56			X					X		X	X	X	X	
RZ-SG-57			X					X		X	X	X		
RZ-SG-58			X					X	X	X	X	X		

Table 5 -- continued

Sample No.	Retention Times of Interference													
	3.3	6.4-7.0	7.5	9.8-10.0	11.4	11.8	13.2	14.05-14.20	14.7-14.9	15.1-15.4	16.2-16.5	17.1-17.5	18.0-18.4	18.6
RZ-SG-59								X			X	X		
RZ-SG-60				X				X		X	X	X		
RZ-SG-60 Dup				X				X		X	X	X		
RZ-SG-61								X	X	X	X	X		
RZ-SG-62				X				X	X	X	X	X	X	
RZ-SG-63												X		
RZ-SG-64				X				X	X	X	X	X	X	
RZ-SG-65				X				X	X	X	X	X	X	
RZ-SG-101B														
RZ-SG-102B														
RZ-SG-103B	X													
RZ-SG-104B														
RZ-SG-105B														
RZ-SG-106B														
RZ-SG-107B	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RZ-SG-108B	X	X	X	X	X	X	X	X	X	X	X	X	X	
RZ-SG-109B			X	X	X		X						X	
RZ-SG-110B	X												X	

Table 5 -- continued

Sample No.	Retention Times of Interference													
	3.3	6.4- 7.0	7.5	9.8- 10.0	11.4	11.8	13.2	14.05- 14.20	14.7- 14.9	15.1- 15.4	16.2- 16.5	17.1- 17.5	18.0- 18.4	18.6
RZ-SG-111B														
RZ-SG-112B														
RZ-SG-113B														
RZ-SG-114B														
RZ-SG-115B														
RZ-SG-116B														
RZ-SG-117B														
RZ-SG-118B								X	X	X	X	X	X	
RZ-SG-119B								X	X	X	X	X	X	
RZ-SG-120B														
RZ-SG-121B														
RZ-SG-122B		X		X				X	X	X	X	X	X	
RZ-SG-123B														
RZ-SG-124B														
RZ-SG-125B														

Note: Dup = Duplicate
X = Compound present

tubing.

To establish that these unknown compounds were in fact originating from the PE tubing, additional ambient air blanks were acquired through soil gas probes assembled with the PE tubing (samples RZ-SG-107B, 108B and 122B), and through the PE tubing alone, while other blanks, obtained at the same time, were acquired normally (samples RZ-SG-109B and RZ-SG-123B). The results from the analysis of these blanks (shown in Table 5) was conclusive. The unknown compounds were observed to be present only in the blanks drawn through the PE tubing. Consequently, the unknown compounds were the result of interference introduced into the samples from the PE tubing. This interference may have been caused by compounds that had possibly adsorbed onto the inner surface of the tubing during storage. However, because this interference was not observed in the winter samples, it is believed that the warm temperatures caused some of the components of the PE tubing to break down, vaporize and be purged into the samples obtained in the summer.

Other small tests designed to determine if additional interference could be introduced through sampling errors were performed. These included tests to determine how kinking of the PE tubing may increase the level of interference or restrict soil gas flow to the sample trap tube. In addition, a test was done to determine if the reconnection of tubing assemblages that disconnected during probe implacement could cause additional interference. These tests indicated that no significant interference was added to samples by these means.

The significance of these disoveries is that much of the interference, if not properly accounted for, could cause erroneous interpretations of the soil gas data. Although this interference did not affect the identification and quantification of the target compounds in this study, other target compounds in future studies (i.e. TCE, benzene, toluene, o-xylene, m-xylene, p-xylene) may be affected by this interference.

Temporary Well Sampling

On February 5, 6, 9, and 10, 1987 temporary wells were installed and sampled at, and around the vicinity of the Rozema Garage site. Water quality samples were obtained for volatile organic analysis (VOA) at ten temporary well locations during this period. The objectives of this sampling round were to help determine if the organic contamination in the groundwater was limited to the Rozema site, and to have a preliminary estimate of the downgradient extent of the contamination plume. Any future temporary well sampling was contingent upon accomplishing these objectives.

Fifteen additional temporary wells were installed in the study area on June 18, 19, 24, 25 and July 8, and 9, 1987. Again, groundwater samples were obtained from these wells for volatile organic analysis. The primary objective of this additional sampling was to acquire data to help delineate the downgradient extent of the organic contamination present at the water table. The locations of the 25 temporary wells are presented in Figure 35.

The equipment used to install these temporary wells is listed in Table 6. As with soil gas sampling, all well installation equipment was decontaminated prior to use for sampling. Drilling augers, riser pipe, well screens and pipe couplings were decontaminated by steam cleaning at a local spray car wash. In addition, the equipment used for acquiring water samples from the temporary wells, such as bailers, was steam cleaned. Samples of the decontamination water were obtained, and analyzed with the temporary well samples in order to determine if any contamination was present that could be carried over to the sampling equipment.

At each designated location, the hand operated, hydraulically driven earth auger was used to drill and clear a boring (4-inch diameter) to depth of a few (two to four) feet beneath the water table (Figure 19). This was accomplished by having two operators drill down the full length of each auger flight, then pull back and spin

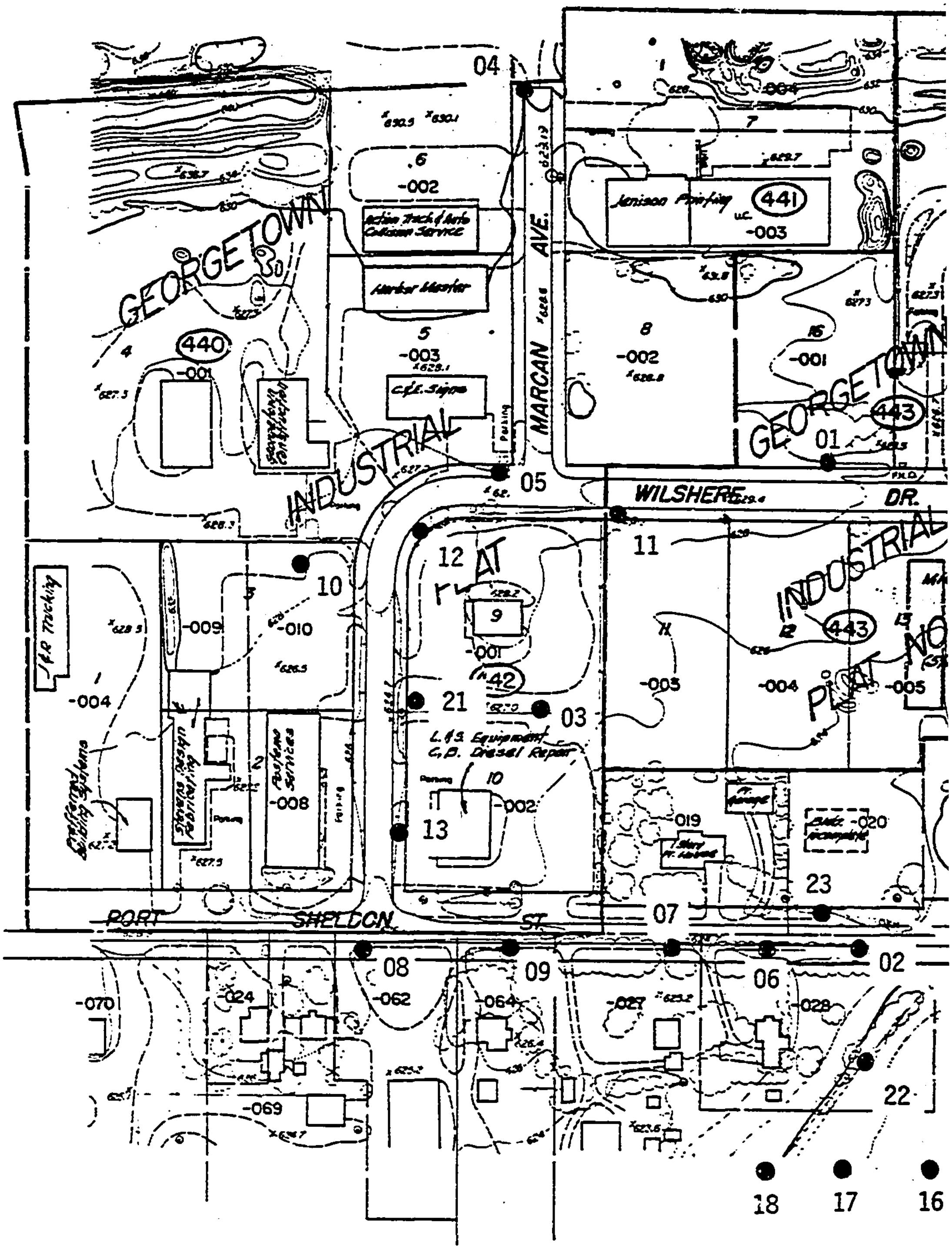
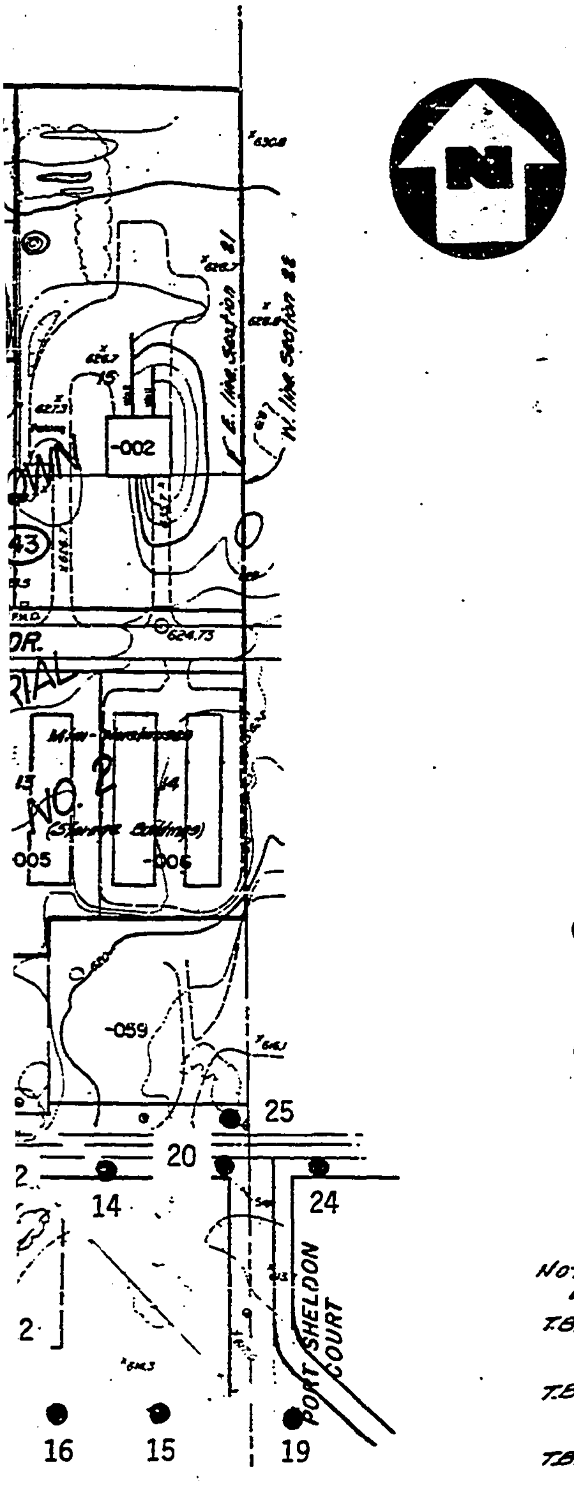


Figure 35. Temporary Well Locations.



● 21 Temporary Well Locations (i.e. RZ-TW-21)

NOTE:
Elevations are based on N.G.V.D. (1929).
T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 600'± E. of 28th Ave.
1.25' above ground Elev. 628.82.
T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 1000'± E. of 28th Ave.
0.8' above ground Elev. 627.30.
T.B.M.#3 - N. rim of Michigan Consolidated Gas Co.
manhole N.E. corner Port Sheldon St. &
Wilshere Drive Elev. 625.70.

Table 6

Temporary Well Sampling Equipment

Item Number	Description
1.	18.0 ft. x 2 in. galvanized steel pipe
2.	3.0 ft. x 2 in. x 7-slot stainless steel well screen
3.	2 in. (I.D.) galvanized steel cap
4.	Little Beaver hydraulically powered earth auger with 25 ft. of 4 in. (o.d.) auger flights
5.	Pipe wrenches
6.	Electronic water level indicator
7.	Polypropylene rope
8.	3.0 ft. x 1in. (I.D.) stainless steel bailers
9.	Water quality sample logs
10.	Chain-of-custody forms
11.	40 ml. septum capped glass VOA vials
12.	Ruler
13.	Sample bottle lables
14.	Pen
15.	Cooler
16.	Surgical gloves
17.	5 gallon bucket
18.	Trash bags
19.	Paper toweling
20.	Sledge hammer

out the drill cuttings from the hole. On occasion, a tripod mounted winch was used to facilitate the hole cleaning process.

Auger cutting samples were collected at five foot depth intervals at temporary well locations RZ-TW-11 through RZ-TW-25. These samples were later used to describe the soil characteristics at these locations. Soil descriptions and classifications were done on boring logs following the Unified Soil Classification System. These boring logs are provided in Appendix 1.

After a hole was adequately cleaned out, the temporary well was installed. The well screen and riser pipe was assembled and hoisted down the hole by hand. Once the well screen was resting on the bottom of the boring, it was pushed or hammered down until the screen intersected the water table.

After installation, each well was developed with a stainless steel bailer. A new segment of polypropylene rope was used as bailing cord in each well. Approximately 10 gallons of water and fine grained sediments were removed from each well during development.

Water quality samples for volatile organic analysis (VOA) were obtained after development. Two forty milliliter septum capped glass VOA vials were filled with water from the development bailer. When sampling some wells, duplicate VOA samples were also obtained. At these locations, two additional VOA vials were filled with well water.

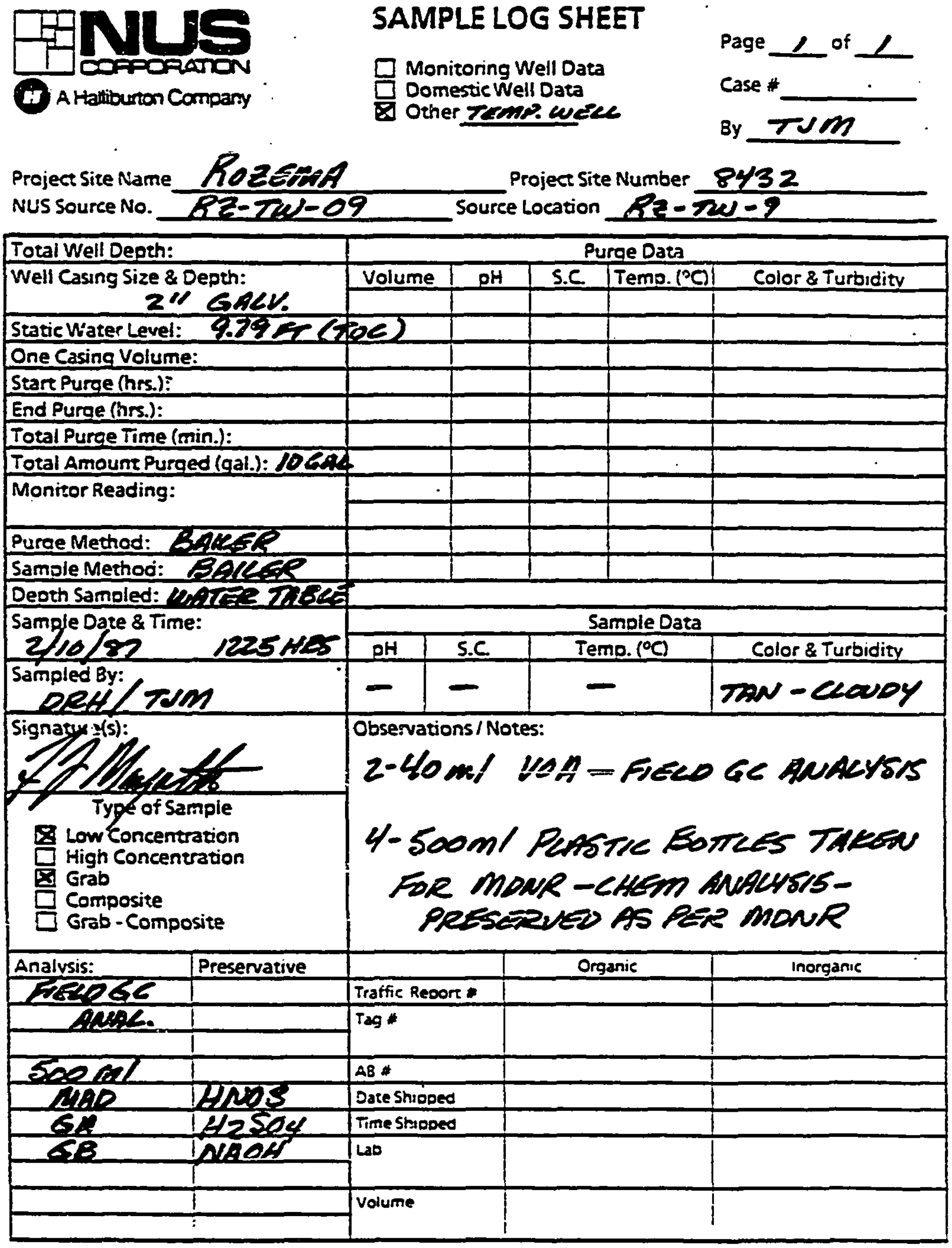
After sampling the well, the water level in the well was determined to the nearest 0.01 foot. This was done using electronic tape measured from the top of the riser on the well. The static water level (SWL) was then entered into a sample log.

Sample log sheets were filled out for every sample acquired from temporary wells during the study. The information contained on these logs include the sample number, location, date, time, sampling personnel, sample depth, static water level, and notes on sampling problems or procedural digressions. An example of a completed sample log sheet for the water quality samples is shown in Figure 36.

Each temporary well was surveyed into a reference point of known elevation from the U. S. Geological Survey Datum before it was removed.

The water quality samples were packed in freezer bags, placed in coolers filled with ice, and were transported to the place of analysis. Before handing over the VOA samples for analysis, a Chain-of-Custody form was filled out as was done with the soil gas samples.

All water quality samples were stored in a refrigerator at the place of analysis and cooled at 4.0



NUS CORPORATION
A Halliburton Company

SAMPLE LOG SHEET

☐ Monitoring Well Data
☐ Domestic Well Data
☒ Other TEMP. WELL

Page 1 of 1
Case #
By TJM

Project Site Name ROZEMA
Project Site Number 8432
NUS Source No. RZ-TW-09
Source Location RZ-TW-9

	Purge Data				
Total Well Depth:					
Well Casing Size & Depth: 2" GALV.	Volume	pH	S.C.	Temp. (°C)	Color & Turbidity
Static Water Level: 9.79 FT (TOC)					
One Casing Volume:					
Start Purge (hrs.):					
End Purge (hrs.):					
Total Purge Time (min.):					
Total Amount Purged (gal.): 10 GAL					
Monitor Reading:					
Purge Method: BAILER					
Sample Method: BAILER					
Depth Sampled: WATER TABLE					

	Sample Data			
Sample Date & Time: 2/10/87 1225 HRS	pH	S.C.	Temp. (°C)	Color & Turbidity
Sampled By: DRH / TJM	—	—	—	TAN - CLOUDY

Signature(s):

Type of Sample

☒ Low Concentration
☐ High Concentration
☒ Grab
☐ Composite
☐ Grab - Composite

Observations / Notes:

2-40 ml VOA = FIELD GC ANALYSIS

4-500 ml PLASTIC BOTTLES TAKEN FOR MDNR - CHEM ANALYSIS - PRESERVED AS PER MDNR

Analysis:	Preservative		Organic	Inorganic
FIELD GC		Traffic Report #		
ANAL.		Tag #		
500 ml		AB #		
MAD	HNO_3	Date Shipped		
GM	H_2SO_4	Time Shipped		
GB	NAOH	Lab		
		Volume		

Figure 36. Temporary Well Sample Log Sheet.

Deg. C prior to analysis.

Temporary Well Sample Analysis

The analysis of the water quality samples obtained from the temporary wells was also performed in the NUS mobile laboratory using purge and trap, gas chromatography. These samples were analyzed using the NUS Corporation's field screening methodology for the rapid field analysis of purgeable organic compounds. This methodology is based upon EPA Method 624 and is outlined in Appendix E.

The analytical detection limits for PCE and TCA in water samples for this study were 1.0 ppb for each compound.

CHAPTER V

RESULTS AND DISCUSSION

The results from the analysis of soil gas samples obtained at the 65 locations, and water quality samples from the 25 temporary well locations were used as the basis of this study. However, additional data were used to supplement the conclusions based on this soil gas and temporary well data. This includes water quality data from three monitoring wells (RZ-MW-01, RZ-MW-02 and RZ-MW-03), three additional temporary wells (RZ-TW-28, RZ-TW-30, and RZ-TW-34) and two soil sampling data points (RZ-SO-01, RZ-SO-02). The supplementary well and soil samples were acquired for the NUS RI after the data acquisition for this study was completed. The locations of these data points are provided in Figure 37. The results from the analysis of these samples are presented in Table 7.

Soil Gas Sampling Results

The results from the analysis of the 65 soil gas samples collected on, and around the Rozema Garage site, as well as all blank and duplicate soil gas samples, are listed in Table 8. The concentrations of PCE in the soil

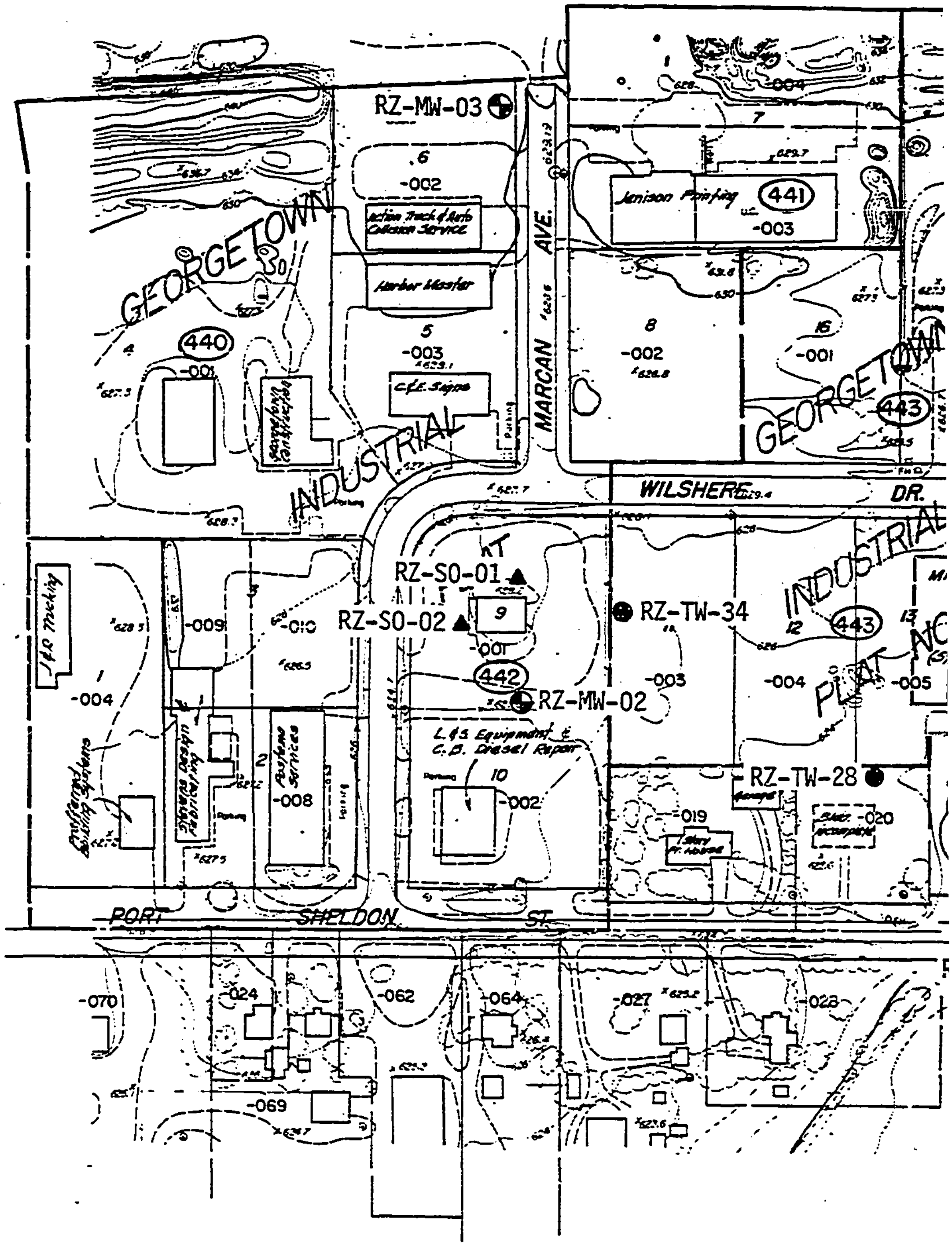
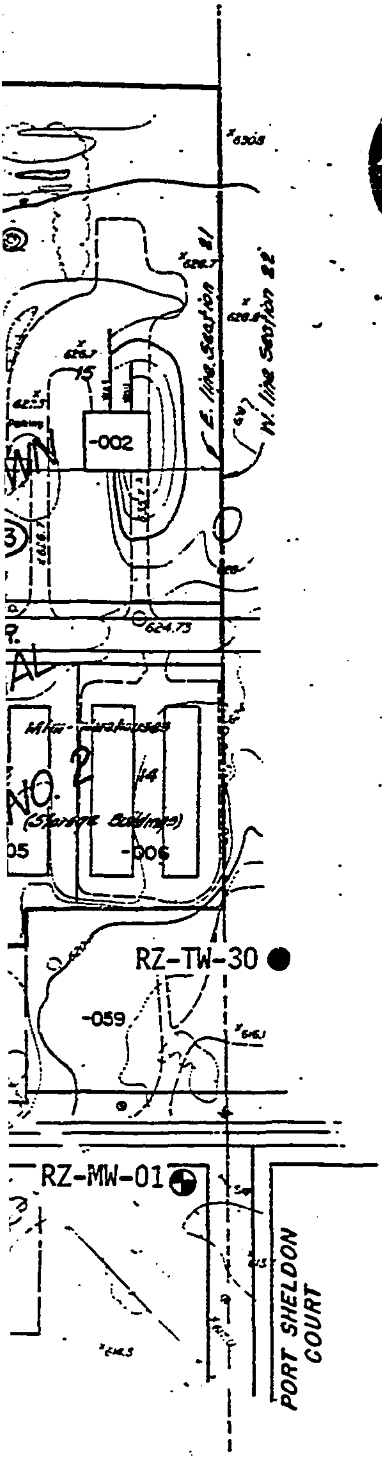


Figure 37. Supplementary Data Locations.



●	RZ-MW-02	Monitoring Well Locations
●	RZ-TW-34	Temporary Well Locations
▲	RZ-SO-02	Soil Sampling Locations

0 200 400
SCALE IN FEET

NOTE:
. Elevations are based on N.G.V.D. (1929).
T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 600'± E. of 28th Ave.
1.25' above ground Elev. 628.82.
T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 1000'± E. of 28th Ave.
0.8' above ground Elev. 627.30.
T.B.M.#3 - N. rim of Michigan Consolidated Gas Co.
manhole N.E. corner Port Sheldon St. &
Wilshere Drive Elev. 625.70.

Table 7

Analytical Results of Supplimentary Data

Sample Type Sample Number	Concentrations (ppb) PCE	 TCA
Soil Samples *		
RZ-SO-01	382.0	114.0
RZ-SO-02	1318.0	39.0
Temporary Well Samples **		
RZ-TW-28	ND	ND
RZ-TW-28D	ND	ND
RZ-TW-30	ND	ND
RZ-TW-34	36.0	1.0
Monitoring Well Samples * (Depth)**		
RZ-MW-01 (9.5-12.5 ft)	300.0J	4.0
RZ-MW-01 (19.0-22.0 ft)	300.0J	10.0
RZ-MW-01 (23.5-26.5 ft)	320.0J	13.0
RZ-MW-01 Dup (same)	320.0J	13.0
RZ-MW-02 (11.0-14.0 ft)	600.0J	50.0
RZ-MW-03 (10.0-13.0 ft)	ND	ND
RZ-MW-03 Dup (same)	ND	ND

Note: * = Sampled on 7/9/87, analyzed on 7/14/87
** = Sampled and analyzed during 12/14-18/87
*** = Sampled on 9/1/87, analyzed on 9/2/87
Dup = Duplicate
J = Average value
ND = Not detected

Table 8

Soil Gas Sampling Results

Sample No.	Date	Concentrations (ppb)*	
		PCE	TCA
RZ-SG-01	12/17/86	32.66	23.910
RZ-SG-02	1/15/87	2.64	0.500
RZ-SG-03	1/16/87	ND	0.200
RZ-SG-04	1/16/87	28.06	4.160
RZ-SG-05	1/19/87	1.11	0.130
RZ-SG-06	1/19/87	0.06	0.011
RZ-SG-07	1/20/87	314.40	123.740
RZ-SG-08	1/20/87	282.01	98.950
RZ-SG-09	1/20/87	208.01	10.130
RZ-SG-10	1/20/87	0.71	ND
RZ-SG-11	1/20/87	174.47	0.550
RZ-SG-12	1/20/87	ND	ND
RZ-SG-13	1/21/87	16.90	0.040
RZ-SG-14	1/21/87	ND	ND
RZ-SG-15	1/21/87	ND	ND
RZ-SG-16	1/21/87	4.88	0.390
RZ-SG-17	1/21/87	4.69	2.010
RZ-SG-18	1/21/87	204.17	46.760
RZ-SG-19	1/21/87	54.02	5.720
RZ-SG-20	1/21/87	35.28	7.790
RZ-SG-21	1/22/87	28.03	2.890
RZ-SG-22	1/22/87	ND	ND
RZ-SG-23	1/22/87	2.04	ND
RZ-SG-24	1/22/87	38.55	2.470

Table 8 — continued

Sample No.	Date	Concentrations (ppb)*	
		PCE	TCA
RZ-SG-25	1/22/87	ND	ND
RZ-SG-26	1/27/87	0.25	ND
RZ-SG-27	1/27/87	6.01	0.015
RZ-SG-28	1/27/87	ND	ND
RZ-SG-29	1/27/87	0.17	ND
RZ-SG-30	1/28/87	ND	ND
RZ-SG-31	1/28/87	ND	0.002
RZ-SG-32	1/28/87	ND	ND
RZ-SG-33	1/28/87	7.50	0.096
RZ-SG-34	1/28/87	ND	ND
RZ-SG-35	1/29/87	ND	ND
RZ-SG-36	1/29/87	ND	ND
RZ-SG-37	1/29/87	ND	ND
RZ-SG-38	1/29/87	ND	ND
RZ-SG-39	1/29/87	ND	ND
RZ-SG-40	1/29/87	10.57	1.170
RZ-SG-41	1/29/87	5.26	0.390
RZ-SG-42	6/28/87	0.76	0.020
RZ-SG-43	6/23/87	6.40	1.550
RZ-SG-44	6/14/87	NA	NA
RZ-SG-45	6/24/87	ND	ND
RZ-SG-46	6/23/87	0.13	ND
RZ-SG-47	6/24/87	ND	ND
RZ-SG-48	6/23/87	ND	ND

Table 8 — continued

Sample No.	Date	Concentrations (ppb)*	
		PCE	TCA
RZ-SG-49	6/24/87	ND	ND
RZ-SG-50	6/28/87	1.06	0.117
RZ-SG-50 Dup	6/28/87	1.17	0.260
RZ-SG-51	6/28/87	0.35	ND
RZ-SG-52	7/7/87	0.286	ND
RZ-SG-53	7/7/87	5.47	0.182
RZ-SG-54	7/7/87	1.98	ND
RZ-SG-55	7/7/87	ND	ND
RZ-SG-56	7/19/87	1.75	ND
RZ-SG-57	7/19/87	4.26	0.153
RZ-SG-58	7/19/87	0.130	ND
RZ-SG-59	7/19/87	0.69	ND
RZ-SG-60	7/19/87	6.03	0.990
RZ-SG-60 Dup	7/19/87	6.28	1.210
RZ-SG-61	7/22/87	ND	ND
RZ-SG-62	7/22/87	0.263	ND
RZ-SG-63	7/22/87	ND	ND
RZ-SG-64	7/22/87	ND	ND
RZ-SG-65	7/22/87	0.240	ND
RZ-SG-101B	6/14/87	NA	NA
RZ-SG-102B	6/23/87	ND	ND
RZ-SG-103B	6/28/87	ND	ND
RZ-SG-104B	6/28/87	ND	ND
RZ-SG-105B	7/7/87	ND	ND

Table 8 -- continued

Sample No.	Date	Concentrations (ppb)*	
		PCE	TCA
RZ-SG-106B	7/7/87	ND	ND
RZ-SG-107B	7/7/87	0.20	ND
RZ-SG-108B	7/7/87	0.20	ND
RZ-SG-109B	7/7/87	ND	ND
RZ-SG-110B	7/9/87	ND	ND
RZ-SG-111B	7/9/87	ND	ND
RZ-SG-112B	7/9/87	ND	ND
RZ-SG-113B	7/9/87	ND	ND
RZ-SG-114B	7/9/87	ND	ND
RZ-SG-115B	7/9/87	ND	ND
RZ-SG-116B	7/9/87	ND	ND
RZ-SG-117B	7/9/87	ND	ND
RZ-SG-118B	7/19/87	ND	ND
RZ-SG-119B	7/19/87	ND	ND
RZ-SG-120B	7/19/87	ND	ND
RZ-SG-121B	7/19/87	ND	ND
RZ-SG-122B	7/22/87	ND	ND
RZ-SG-123B	7/22/87	ND	ND
RZ-SG-124B	7/22/87	ND	ND
RZ-SG-125B	7/22/87	ND	ND

Note: * = Analysis completed within 24 hours after sample acquisition
ND = Not detected
NA = Not available
Dup = Duplicate
B = Blank

gas are consistently higher than the levels of TCA throughout the study area. The concentrations of PCE in the soil gas range from a high of 314.0 ppb at sample location RZ-SG-07 to a low of 0.240 ppb at location RZ-SG-65. The concentrations of TCA range from 123.74 ppb (RZ-SG-07) to 0.015 ppb (RZ-SG-27).

The distributions of the PCE and TCA contamination detected in the soil gas are presented in Figures 38 and 39, respectively. The concentrations of both compounds were observed to be highest at the north-central portion of the Rozema property. The concentration levels decrease in all directions outward from this area. However, the decrease is more gradual in the southeast direction.

The distribution of the PCE and TCA concentrations in the soil gas on the Rozema property most likely reflect the distribution of localized source areas for these contaminants. Two main source areas can be estimated from the soil gas data. The zone of the highest PCE and TCA contamination corresponds to the position at which the tanker, used to store industrial solvent wastes, was buried. It is speculated that liquid solvent wastes were frequently spilled around this area, and that the tanker was damaged and leaked its contents while buried. A second, less significant source area can

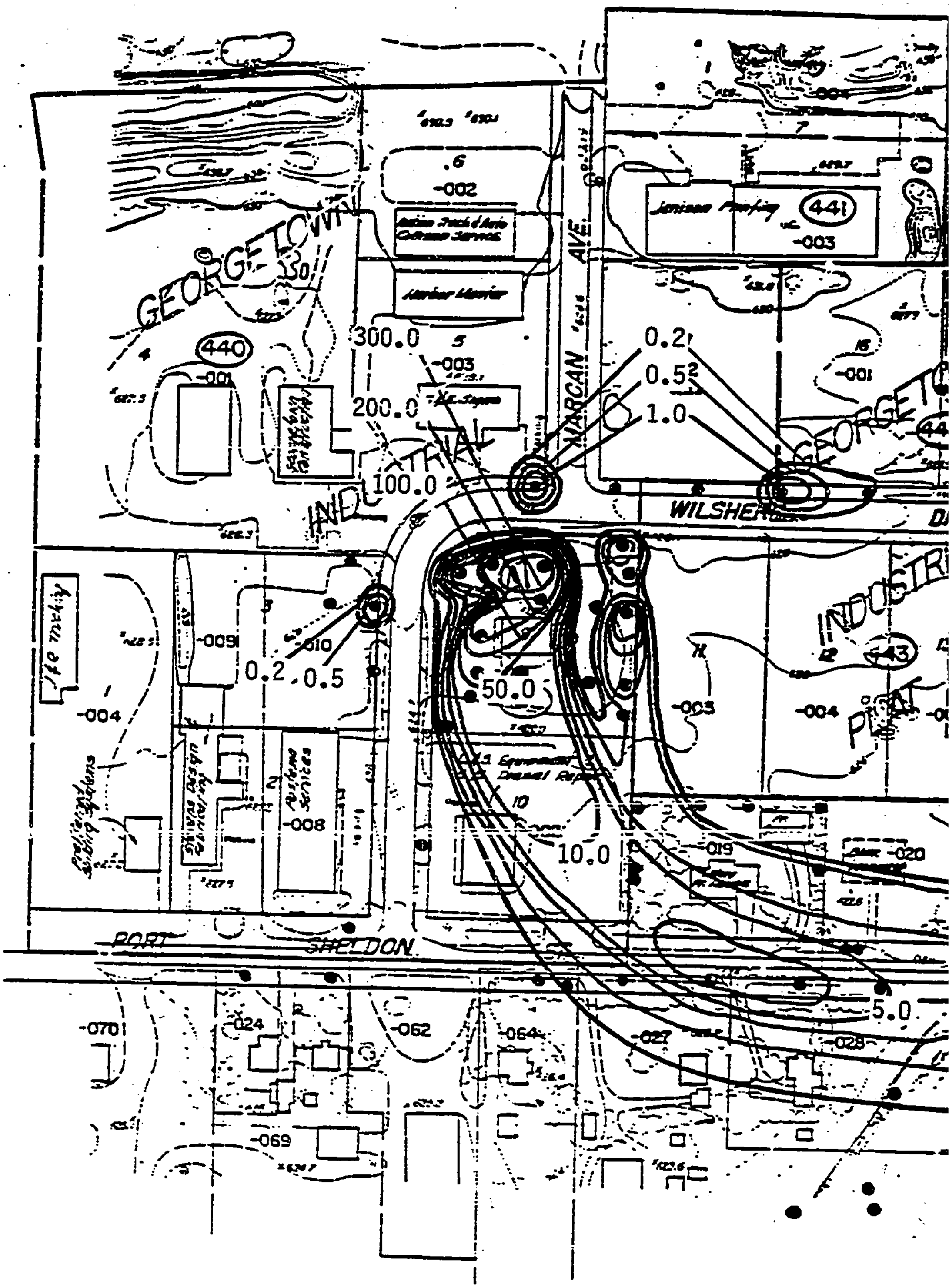
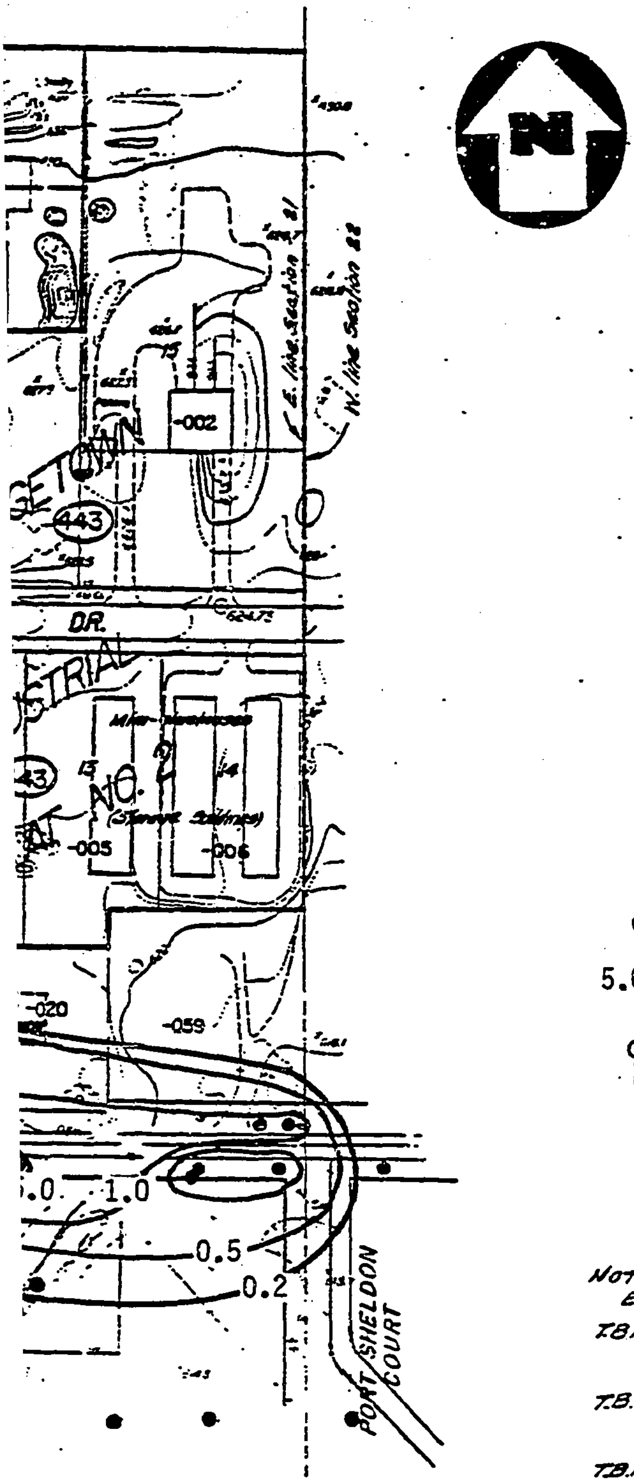


Figure 38. Isoconcentration Contours of PCE in the Soil Gas.



● Soil Gas Sampling Locations (Figure 12)

5.0-Concentration (ppb)

0 200 400
SCALE IN FEET

NOTE:
Elevations are based on N.G.V.D. (1929).
T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 600'± E. of 28th Ave. 1.25' above ground Elev. 628.82.
T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 1000'± E. of 28th Ave. 0.8' above ground Elev. 627.32.
T.B.M.#3 - N. rim of Michigan Consolidated Gas Co. manhole N.E. corner Port Sheldon St. & Wilshere Drive Elev. 625.70.

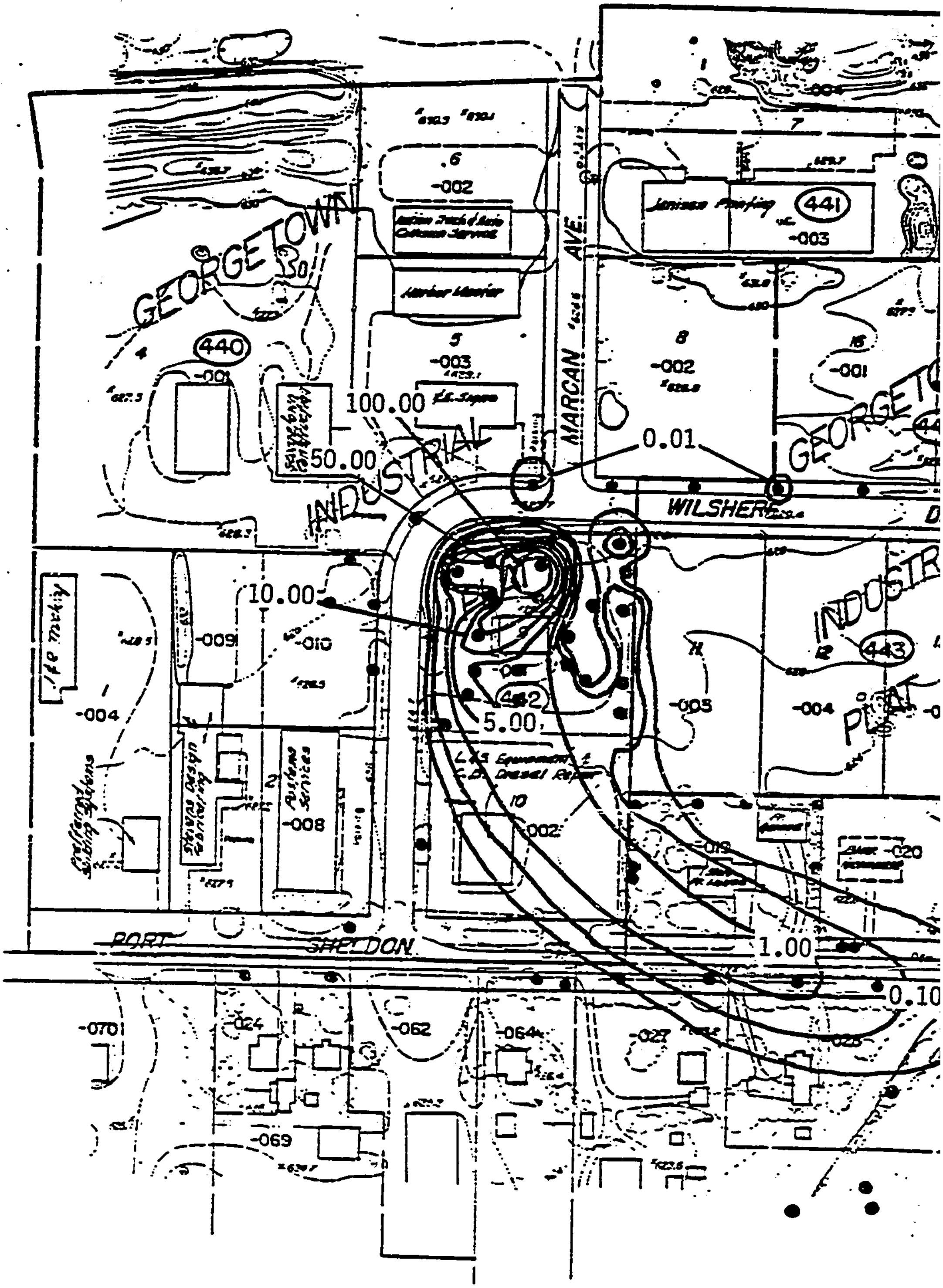
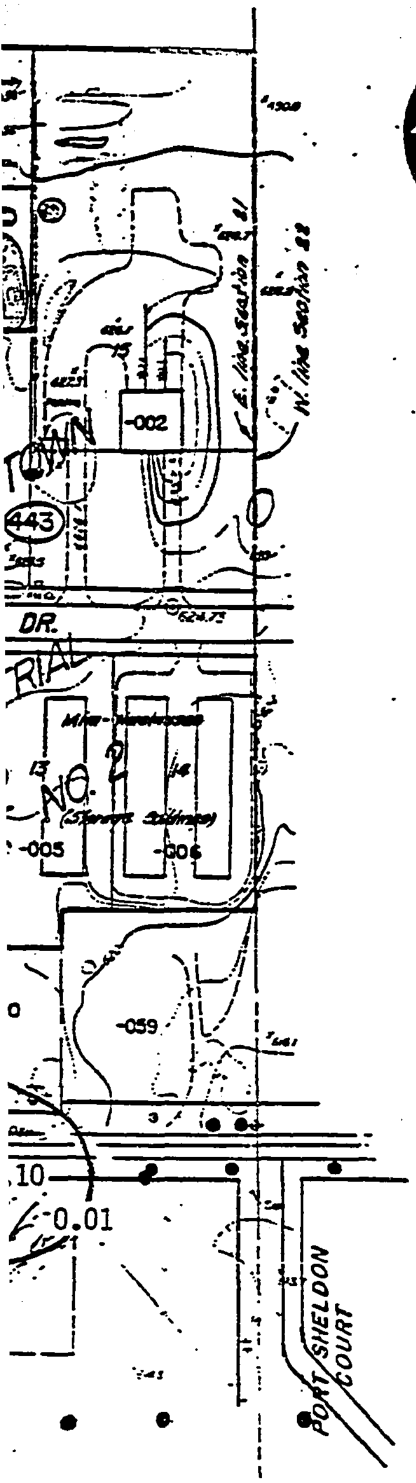


Figure 39. Isoconcentration Contours of TCA in the Soil Gas.



● Soil Gas Sampling Locations

5.00-Concentration (ppb)

0 200 400

SCALE IN FEET

NOTE:

Elevations are based on N.G.V.D. (1929).

T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 600'± E. of 28th Ave. 1.25' above ground Elev. 628.82.

T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side Port Sheldon St. 1000'± E. of 28th Ave. 0.8' above ground Elev. 627.30.

T.B.M.#3 - N. rim of Michigan Consolidated Gas Co. manhole N.E. corner Port Sheldon St. & Wilshire Drive Elev. 625.70.

be identified along, and inside the eastern fence line of the Rozema site. Here, concentrations of PCE are higher than at soil gas sampling locations immediately surrounding this area. This second source area is believed to be where the open-top dumpster was located. Historical information noted that the soils around this dumpster were discolored. This probably indicates that wastes were spilled or leaked here.

Other zones where high concentrations of PCE and TCA were identified in the soil gas on the Rozema site correspond to areas where truck trailers and tankers were parked most frequently, and where trucks would enter and exit the service garage. More specifically, these zones include the west entrance to the garage on, and the northwest corner of the Rozema property.

Away from the Rozema site the distribution of the soil gas contamination follows the direction of groundwater flow and is believed to define a plume of groundwater contamination originating from the two source areas on the site. PCE and TCA concentrations in the soil gas extend toward the southeast from the identified sources to Port Sheldon Street. At Port Sheldon Street the zone of soil gas contamination tends to be redirected to the east (Figures 38 and 39). The zone of detectable concentrations of PCE in the soil gas is defined by the 0.20 ppb contour line, as shown in

Figure 38. The limit of TCA contamination in the soil gas is defined by the 0.01 ppb contour line (Figure 39).

Upgradient of the Rozema site, three localized zones of soil gas contamination were identified. These zones are located on Wilshere Drive northeast, north and west of the site (Figures 38 and 39). The three pockets of contamination are speculated to be the result of small spills, or discharges of solvent wastes from tankers leaving and arriving at the Rozema facility.

Temporary Well Sampling Results

The results from the analysis of VOA samples from the 25 temporary well locations are summarized in Table 9. These data include the results of the blank and duplicate VOA sample analysis as well. As with the soil gas data, the concentrations of PCE in the groundwater are consistently higher than the concentrations of TCA at the same locations. The concentration of PCE in the groundwater ranges from 314.40 ppb at RZ-TW-07 to 0.24 ppb at RZ-TW-65. The levels of TCA are from 123.74 ppb at RZ-TW-07 to 0.015 ppb at RZ-TW-06.

The distributions of the PCE and TCA contamination in the groundwater across the study area are presented in Figures 40 and 41, respectively. Because of the lack of water quality data from the Rozema site, the upgradient extent of the groundwater plume is inferred

Table 9

Temporary Well Sampling Results

Sample No.	Date	Concentrations (ppb)	
		PCE	TCA
RZ-TW-01	2/05/87	ND	ND
RZ-TW-02	2/05/87	46.0	6.0
RZ-TW-03	2/05/87	210.0	24.0
RZ-TW-04	2/06/87	ND	ND
RZ-TW-05	2/06/87	ND	ND
RZ-TW-06	2/09/87	110.0	22.0
RZ-TW-07	2/09/87	151.0	50.0
RZ-TW-08	2/10/87	ND	ND
RZ-TW-09	2/10/87	ND	ND
RZ-TW-10	2/10/87	ND	ND
RZ-TW-10 Dup	2/10/87	ND	ND
RZ-TW-11	6/18/87	ND	ND
RZ-TW-12	6/18/87	ND	ND
RZ-TW-13	6/19/87	ND	ND
RZ-TW-14	6/19/87	30.0J	3.0
RZ-TW-15	6/24/87	ND	ND
RZ-TW-15 Dup	6/24/87	ND	ND
RZ-TW-16	6/24/87	ND	ND
RZ-TW-17	6/24/87	ND	ND
RZ-TW-18	6/25/87	ND	ND
RZ-TW-19	6/25/87	ND	ND

Table 9 — continued

Sample No.	Date	Concentrations (ppb)	
		PCE	TCA
RZ-TW-20	6/25/87	100J	ND
RZ-TW-21	6/26/87	ND	ND
RZ-TW-22	7/08/87	3.0	1.0
RZ-TW-23	7/08/87	41.0	3.0
RZ-TW-24	7/08/87	3.0	ND
RZ-TW-24 Dup	7/08/87	3.0	ND
RZ-TW-25	7/09/87	33.0	ND
RZ-BLANK-04	6/18/87	ND	ND
RZ-BLANK-06	6/24/87	ND	ND
RZ-BLANK-07	6/25/87	ND	ND
RZ-BLANK-08	7/08/87	ND	ND
RZ-DECON-01	2/05/87	ND	ND
RZ-DECON-02	2/09/87	ND	ND
RZ-DECON-04	6/18/87	ND	ND
RZ-DECON-05	6/19/87	ND	ND
RZ-DECON-07	6/24/87	ND	ND
RZ-DECON-09	7/09/87	ND	ND
RZ-DECON-0A	6/25/87	ND	ND

Note: ND = Not detected
Dup = Duplicate
J = Average value

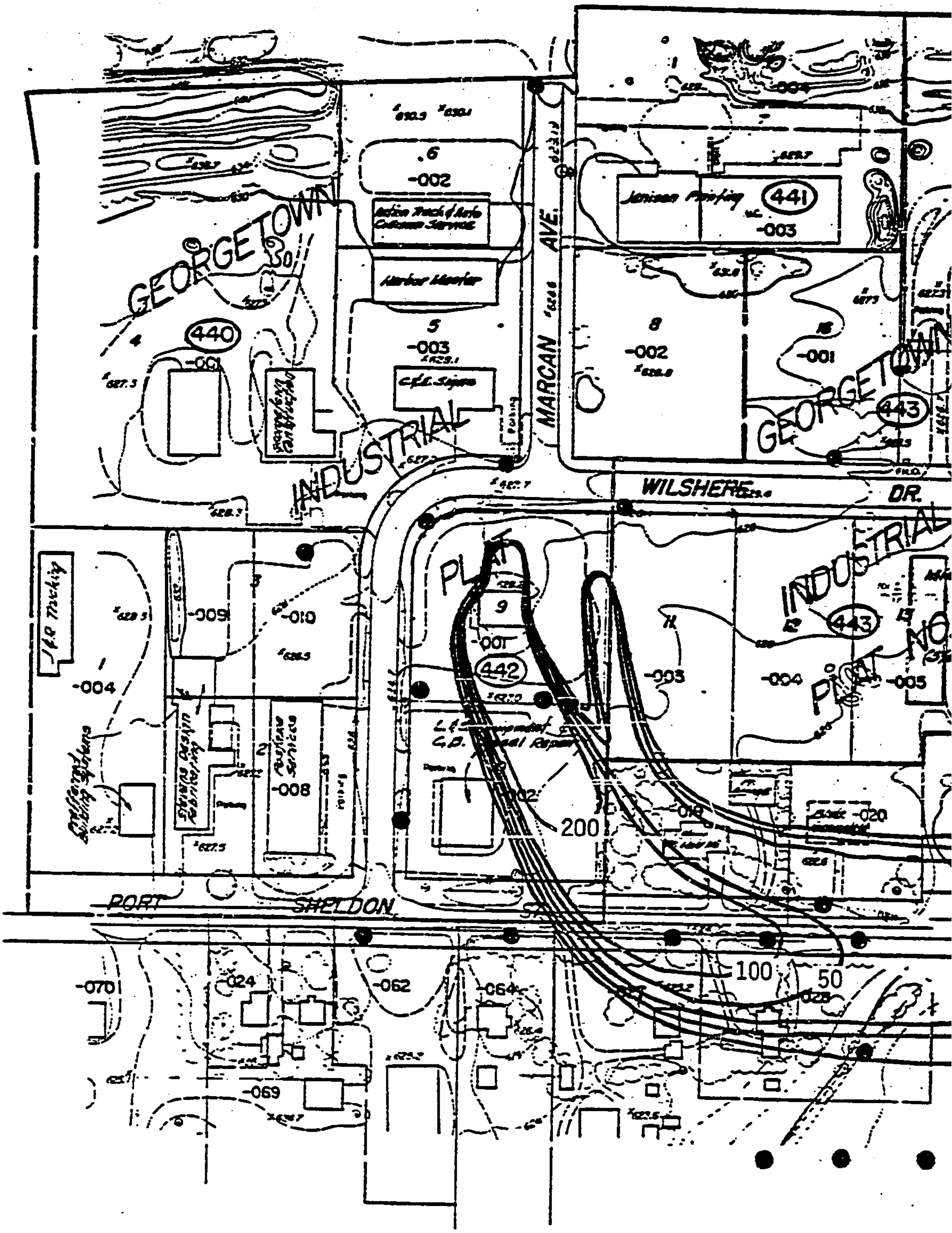
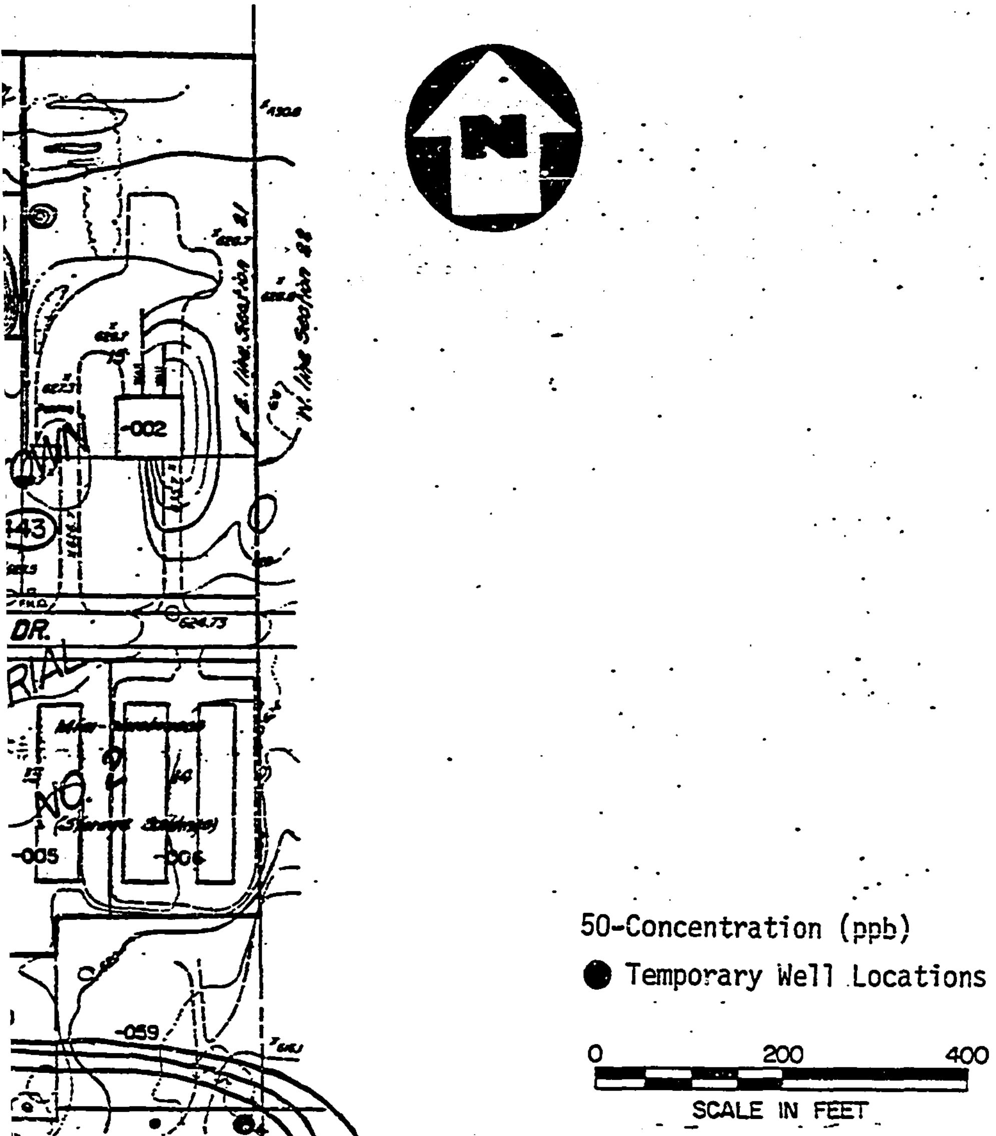


Figure 40. Isoconcentration Contours of PCE in the Groundwater.



50-Concentration (ppb)

● Temporary Well Locations (Figure 35)

NOTE:
Elevations are based on N.G.V.D. (1929).
T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 600'± E. of 28th Ave.
1.25' above ground Elev. 628.82.
T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 1000'± E. of 28th Ave.
0.8' above ground Elev. 627.30.
T.B.M.#3 - N. rim of Michigan Consolidated Gas Co.
manhole N.E. corner Port Sheldon St. &
Wilshere Drive Elev. 625.70.

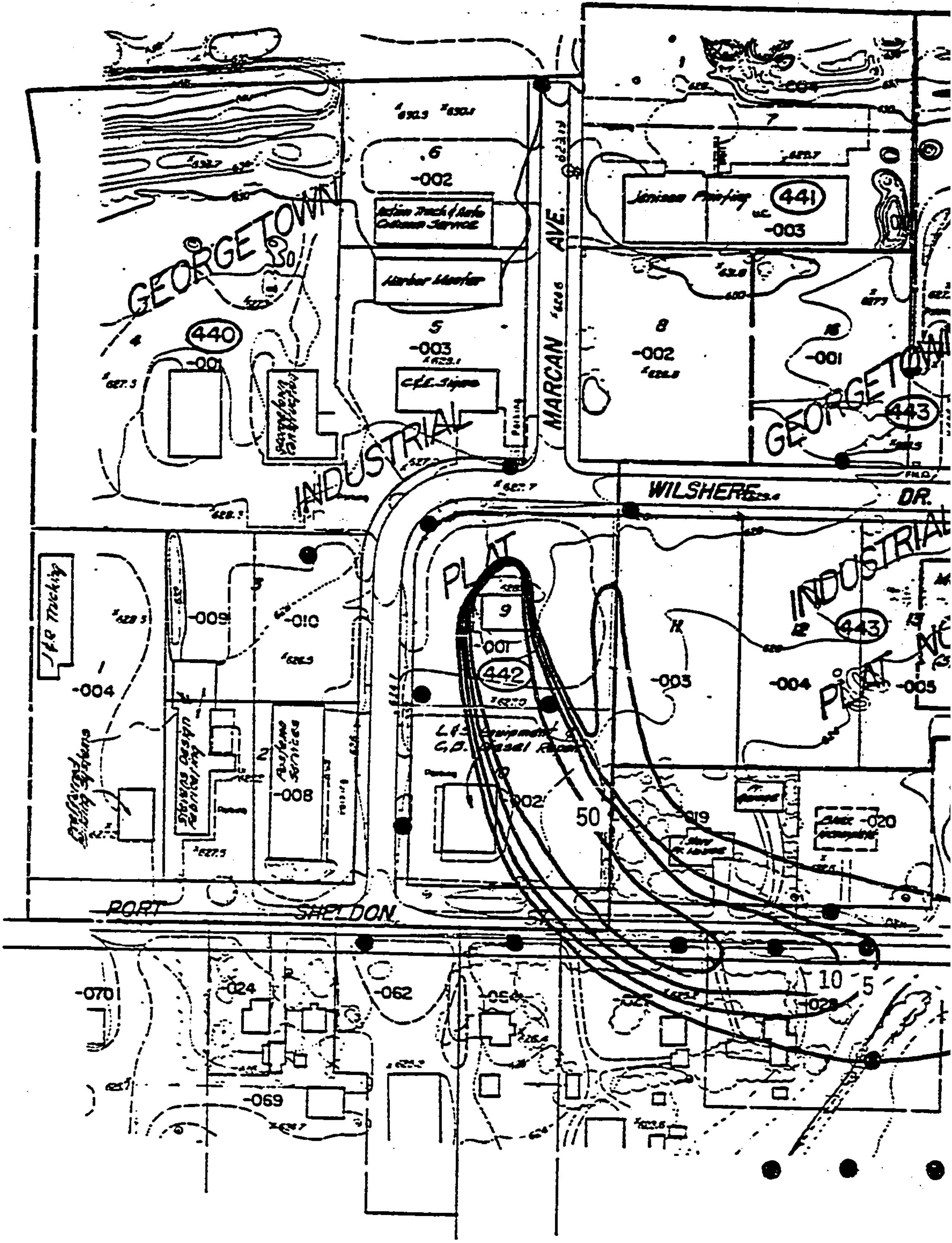
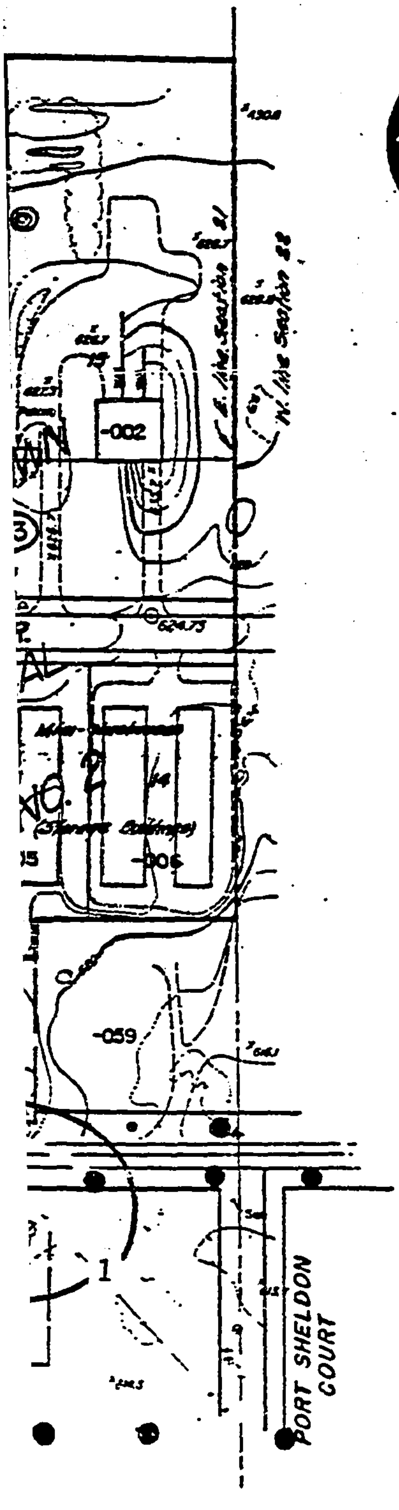


Figure 41. Isoconcentration Contours of TCA in the Groundwater.



50-Concentration (ppb)

● Temporary Well Locations (Figure 35)

0 200 400

SCALE IN FEET

NOTE:
Elevations are based on N.G.V.D. (1929).
T.B.M.#1 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 600'± E. of 28th Ave.
1.25' above ground Elev. 628.82.
T.B.M.#2 - N.N.W. bolt on flange of hydrant N. side
Port Sheldon St. 1000'± E. of 28th Ave.
0.8' above ground Elev. 627.30.
T.B.M.#3 - N. rim of Michigan Consolidated Gas Co.
manhole N.E. corner Port Sheldon St. & Wilshere Drive Elev. 625.70.

from the data from soil samples RZ-SO-01 and RZ-SO-02, and temporary wells RZ-TW-01, RZ-TW-04, RZ-TW-05, RZ-TW-10 through RZ-TW-12, and RZ-TW-34.

The concentrations of PCE and TCA detected in the groundwater decrease in all directions from the source areas on the Rozema site. As with the soil gas data the decrease is more gradual in the southeast direction from the site.

Figures 40 and 41 identify two plumes of PCE and TCA contamination that originate on the Rozema site. The plume of the highest concentrations of PCE and TCA is shown to be originating from the location of the buried tanker. The soil sample (RZ-SO-02) obtained at this location, which was a composite sample of the top three feet of soil, indicates that these soils are contaminated with PCE and TCA (Table 7). The concentrations in this sample suggest that the volume of contaminant liquid in the soil was probably significant enough such that the residual saturation of the liquid in the vadose zone was exceeded. Consequently, the liquid was able to infiltrate to the groundwater at this location.

An additional, less significant, plume was inferred to be originating from the location of the open-top Temporary well sample RZ-TW-34 indicates that there is PCE and TCA contamination present in the groundwater along the fence line near this location (Table 7). This second plume most likely coalesces with the first plume downgradient of the Rozema site, as shown in Figures 40 and 41.

Other sources of the contamination may include the west entrance to the service garage on, and the northwest corner of, the Rozema property, as identified by the soil gas results. An additional soil sample (RZ-SO-01) which was acquired near the garage entrance confirmed the presence of soil contamination at that location (Table 7). No soil sampling or groundwater data is available for the northwest corner of the site. As a result, the extent of the groundwater contamination on the site was estimated to be confined to the general area around the locations of the known soil contamination and temporary well RZ-TW-34.

Water quality samples obtained from temporary wells RZ-TW-01, RZ-TW-05, RZ-TW-10, RZ-TW-11 and RZ-TW-12 (Figures 40 and 41) indicate that no PCE or TCA contamination was detected upgradient of the Rozema site.

The migration of the groundwater contamination plume is estimated from the water quality data to follow the direction of groundwater flow. The plume extends offsite towards the southeast to Port Sheldon Street where the plume then turns towards the east following the direction of the road.

The data acquired for this study were not adequate to define the detectable limits of the plume downgradient from the Rozema site. However, the data do indicate a significant decrease in PCE and TCA levels in the groundwater near the corner of Port Sheldon Street and Port Sheldon Court. Consequently, the downgradient extent of the groundwater contamination near the water table is inferred to be just east of the intersection of these two roads (Figures 40 and 41).

Water quality data from NUS monitoring wells RZ-MW-01 and RZ-MW-02 indicate that PCE and TCA levels are higher near the base of the aquifer than near the water table (Table 7). This fact suggests that the main body of the solvent plume is traveling over top of the sandy clay and sandy silt unit.

From these observations, it is speculated that the volumes of liquid solvent wastes that were introduced into the groundwater beneath the buried tanker and possibly the dumpster, were significant enough such that the main fluid body migrated downward to the bottom of the aquifer. Solvent liquids were likely held in residual saturation in the vadose zone and in the saturated zone behind the migrating fluid body. This residual contamination was probably the source of the PCE and TCA in the shallow groundwater and at the water table downgradient from the Rozema site. The flow of groundwater is believed to follow the topography of the sandy clay and sandy silt unit and the main solvent body is likely to be travelling along the same path of migration as the shallow contamination.

Discussion of the Results

The soil gas data corresponds well with the water quality data across the study area. The zone of soil gas contamination, shown in Figures 38 and 39, conforms to the groundwater contamination plume outlined in Figures 40 and 41 with only a few exceptions.

The initial examination and comparison of the soil gas and water quality data confirms a definite qualitative correlation between the two data sets. The distribution of both the PCE and TCA contamination in the soil gas adequately defined the plume of these contaminants in the groundwater. The concentration gradients of these two compounds identified in the soil gas were useful for estimating the areas of high groundwater contamination as well.

The soil gas data did not correspond to the predicted groundwater conditions at a few locations. PCE and TCA contamination was detected in the soil gas at locations RZ-SG-23, RZ-SG-26, RZ-SG-27, and RZ-SG-33. However, no groundwater contamination was identified in water samples obtained from temporary wells installed at, or near these locations. In addition, no soil gas contamination was discovered at locations RZ-SG-38 and RZ-SG-39 which correspond to well RZ-TW-07 where groundwater contamination was detected, and where PCE was identified in soil gas sample RZ-SG-65, located nearby (Figure 38). Finally, no soil gas contamination was present in samples RZ-SG-12, RZ-SG-14, and RZ-SG-15. These samples were acquired at locations close to zones of known groundwater and vadose zone contamination.

As mentioned previously, the PCE and TCA contamination in samples RZ-SG-23, RZ-SG-26, RZ-SG-27, and RZ-SG-33 is believed to have resulted from localized spills, or discharges of liquid solvent wastes from tankers being hauled into and out of the Rozema facility. However, the groundwater beneath these soil gas sample locations was determined to be clean. This leads to the conclusion that the spills or discharges were relatively small in volume and, as a result, the solvent liquids must have penetated only the first meter or two of the soil before being retained in the soil matrix under residual saturation. Dissolved PCE and TCA carried down to the water table by infiltrating waters most likely were of low, undetectable concentrations. Therefore, the soil gas contamination at these locations must have originated from a surface or vadose zone source.

Marrin, 1986 suggests that some of the initial indicators of a surface or vadose zone source include an abrupt increase in soil gas contamination compared to surrounding sampling points, and a significant deviation from the soil gas/groundwater concentration ratio estimated for the overall site. The contamination identified in these four soil gas samples do indicate abrupt or anamolous increases in PCE and TCA in the soil gas as compared to surrounding samples. In addition, the majority of the soil gas samples obtained in this study correspond to groundwater contamination at the respective sample locations. Soil gas samples RZ-SG-23, RZ-SG-26, RZ-SG-27, and RZ-SG-33 do not indicate groundwater contamination; therefore, these samples are likely to be indicators of vadose zone contamination.

Sampling errors may have been the main reason why no PCE or TCA contamination was discovered in soil gas sample RZ-SG-39. This sample corresponds to temporary well location RZ-TW-07 which yielded groundwater samples exhibiting PCE and TCA concentrations of 151 ppb and 50 ppb, respectively. The air sampling pump used to acquire RZ-SG-39 was determined to be faulty subsequent to obtaining the sample. In fact, it wasn't until four months later, while preparing soil gas standards, that it was discovered that this pump would not draw air normally when a trap tube was attached to it. The fact that the sample was taken during a period of sub-zero weather probably also added to the loss of power in the pump. The restriction of air flow from the sample tube, and the cold air may have worked together to disable the pump from purging any soil gas vapors while sampling RZ-SG-39.

Samples RZ-SG-35, RZ-SG-37, RZ-SG-42, and RZ-SG-123B were also obtained with this pump. For samples RZ-SG-35, RZ-SG-37 and RZ-SG-123B, the problem was most likely inconsequential. Other soil gas samples acquired adjacent to, and water quality samples corresponding with these locations indicate that contamination was not likely to have been present at these sampling points. However, contamination was detected, as was expected, in RZ-SG-42, which was obtained in June, 1987. The concentrations present in this sample are likely to be much less than what would have been detected in a sample obtained at the same location with a properly operating pump. Yet, because the weather was not cold, the power of the pump was not diminshed further. Thus, some vapors were probably drawn into the tube by the faulty pump.

The lack of contamination in sample RZ-SG-38 is probably attributable to the weather conditions at the time of sampling. Sample RZ-SG-38 was taken just prior to RZ-SG-39 in January, 1987.

The vapor pressure of most CH's will increase with an increase in temperature as is the case with PCE and TCA (Table 1). Farmer, et al, 1980 demonstrated how hexachlorobenzene in contaminated soils exhibited an increase in vapor pressure from 0.42 to 22.40 mm Hg ($X10^{-5}$) with a temperature increase from 15 Deg. C to 45 Deg. C. This rise in vapor pressure induces an increase in the concentration gradient near the source and, correspondingly, an increase in the diffusive flux of solvent vapors from the source. Knowing this, one may expect that the diffusion of CH vapors is less significant during periods of cold weather as opposed to during the warm summer months. In July, PCE was discovered in RZ-SG-65 (located about 50 feet west of RZ-SG-38) at a concentration of 0.24 ppb. This contamination is speculated to be from the lateral diffusion of PCE vapors volatilizing off the water table near the western edge of the plume (Figure 38). The concentration of PCE detected in RZ-SG-65 was very low (near the detection limit); thus, it seems reasonable that the cold weather could have caused a slight decrease in the vapor pressure of PCE which, in turn, may have caused the contamination to go undetected in RZ-SG-38.

A combination of factors most likely was the cause for not detecting soil gas contamination in samples RZ-SG-12, RZ-SG-14, and TZ-SG-15. The most significant factor may have been that these sampling points were not located directly over solvent residuals in the vadose zone, and were probably adjacent to the main groundwater plumes. However, these facts alone, if true, do not account for why lateral diffusion of the CH vapors did not occur such that contamination could be detected at these sample locations.

These three samples were obtained in the soils of the truck pathway on the Rozema property (Figure 12). Trucks circle the garage on site numerous times daily as they have for several years. The samples were also acquired during a period of extremely cold weather in January, 1987. The sample acquisition required a pilot hole to be bored in the frozen soil at these locations. From these facts it is believed that not only are the soils under the truck path over-consolidated, but that the frost zone beneath the path may have been much deeper there than in the adjacent soils. As a result, if contamination was not present in the soils , or in the groundwater beneath these sample locations, the diffusion of CH vapors from adjacent sources may have been significantly impeded by the decrease in the total air filled porosity of the soil caused by frost and over-consolidation. Slight lithologic changes such as an increase in clay or silt content in the sand may have been present at these locations as well. These changes would enhance the impedance of gaseous diffusion. In addition, the fact that these samples may not have been obtained directly over a plume or in a zone of vadose zone contamination helps explain the absence of PCE or TCA vapors in these samples.

Marrin, 1986 explains how a radial distance equal to three times the depth to water approximates the extent of significant lateral diffusion from a surface or vadose zone source. Samples collected beyond this distance are usually representative of the underlying aquifer. The depth to water at locations RZ-SG-12, RZ-SG-14, and RZ-SG-15 is between 8 and 9 feet. Thus, 24 to 27 feet is the approximate radial distance from areas of vadose zone or groundwater contamination over which significant diffusion may occur. The sample locations are all about 25 feet away from these contamination sources as inferred by the best available data. Therefore, it seems reasonable to expect that no PCE or TCA would be detected in these soil gas samples.

Statistical Analysis

The subsurface variability of parameters that control gas phase diffusion is such that a theoretical prediction of concentrations of CH's in the groundwater from CH concentrations in the soil gas is probably not feasible. However, site specific calibration of the soil gas method can provide at least a semi-quantitative prediction of groundwater concentrations across a site (Lappala and Thompson, 1984). The soil gas data obtained during this study can be used to make such predictions.

The correlation of the concentrations of PCE in the soil gas with PCE levels in the groundwater at 11 temporary well locations is shown in Figure 42. The data points shown in Figure 42 are of corresponding soil gas and temporary well sample locations. A regression analysis performed on the data indicated a linear relationship between the two data sets with a correlation coefficient of r=0.89. This indicates a high degree of correlation between the soil gas and water quality data for PCE.

The correlation between TCA concentrations at the water table and in the soil gas is also high. A regression analysis was also performed for the two data sets to establish the correlation between TCA levels in the two media at seven locations. Figure 43 presents the results of this analysis. A correlation coefficient of r=0.91 was calculated for the TCA data.

Using the linear regression data, semi-quantitative predictions of the concentrations of PCE and TCA at the water table can be estimated from the soil gas data. The equations from the linear regression analysis of the PCE and TCA data are

$$C_{GW(PCE)} = 24.34 + 6.56C_{SG(PCE)}, \text{ and}$$

$$C_{GW(TCA)} = 3.40 + 5.79C_{SG(TCA)}.$$

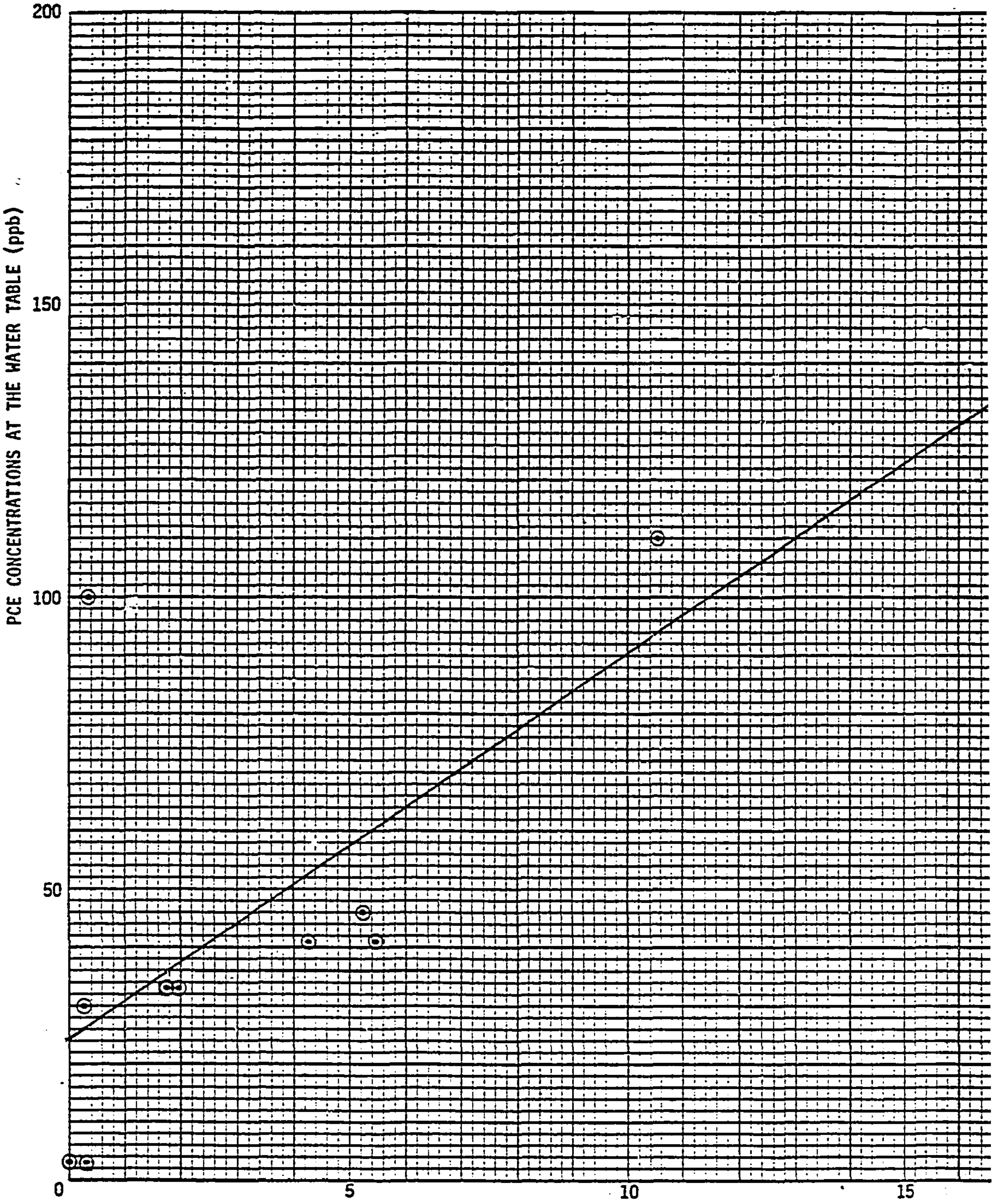
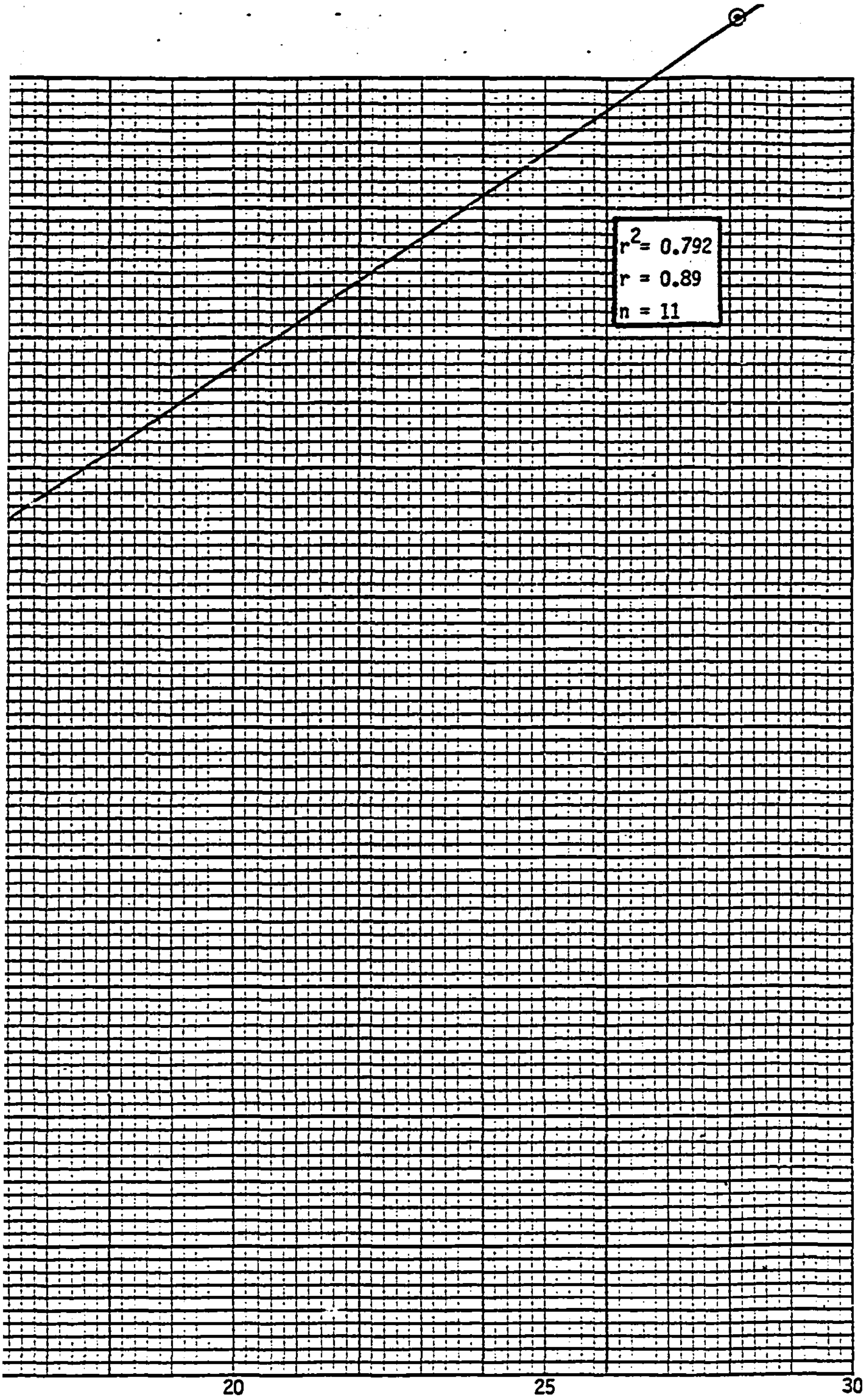


Figure 42. Correlation of PCE in the Soil Gas and Groundwater.



PCE CONCENTRATIONS IN THE SOIL GAS (ppb)

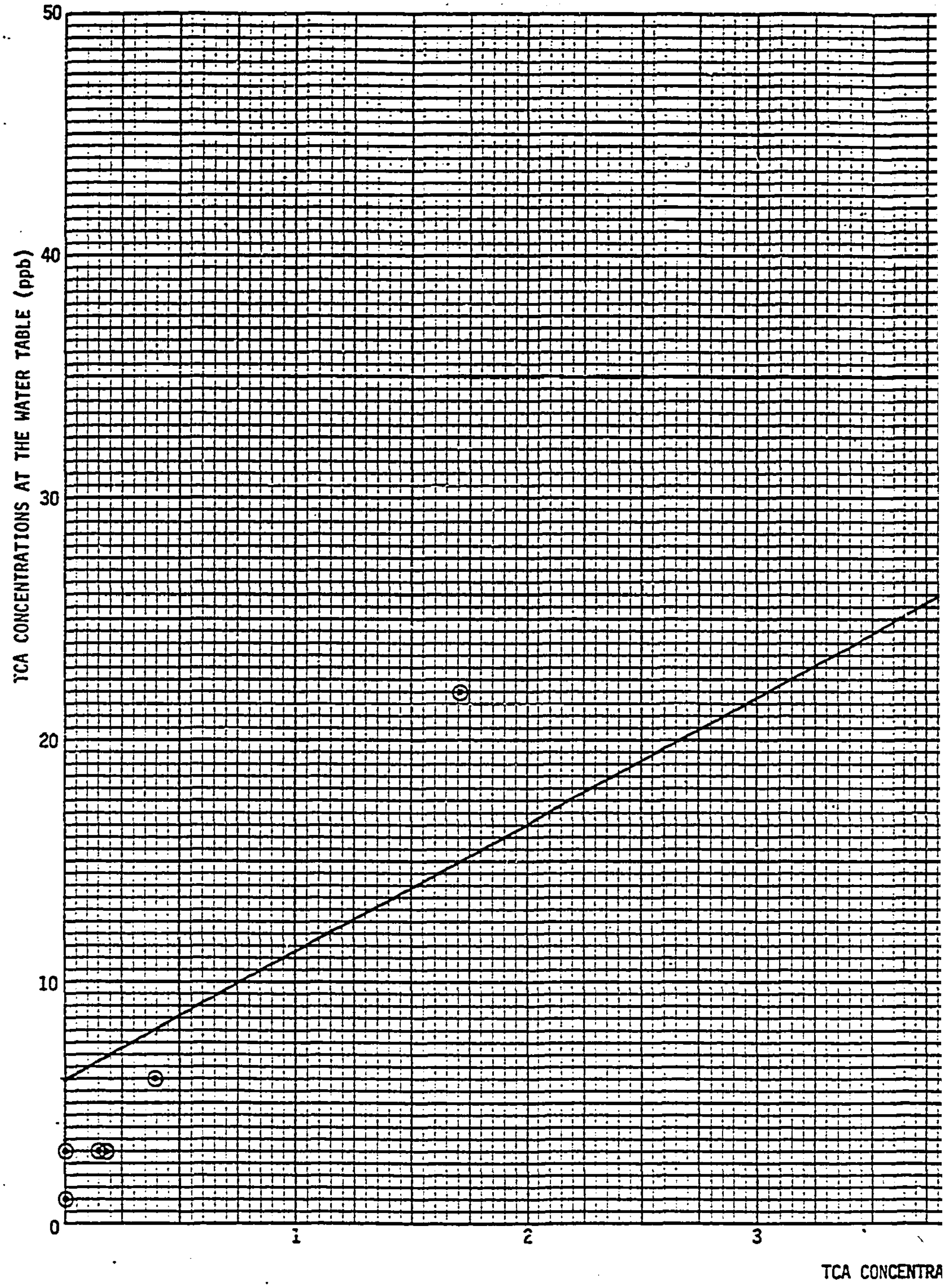
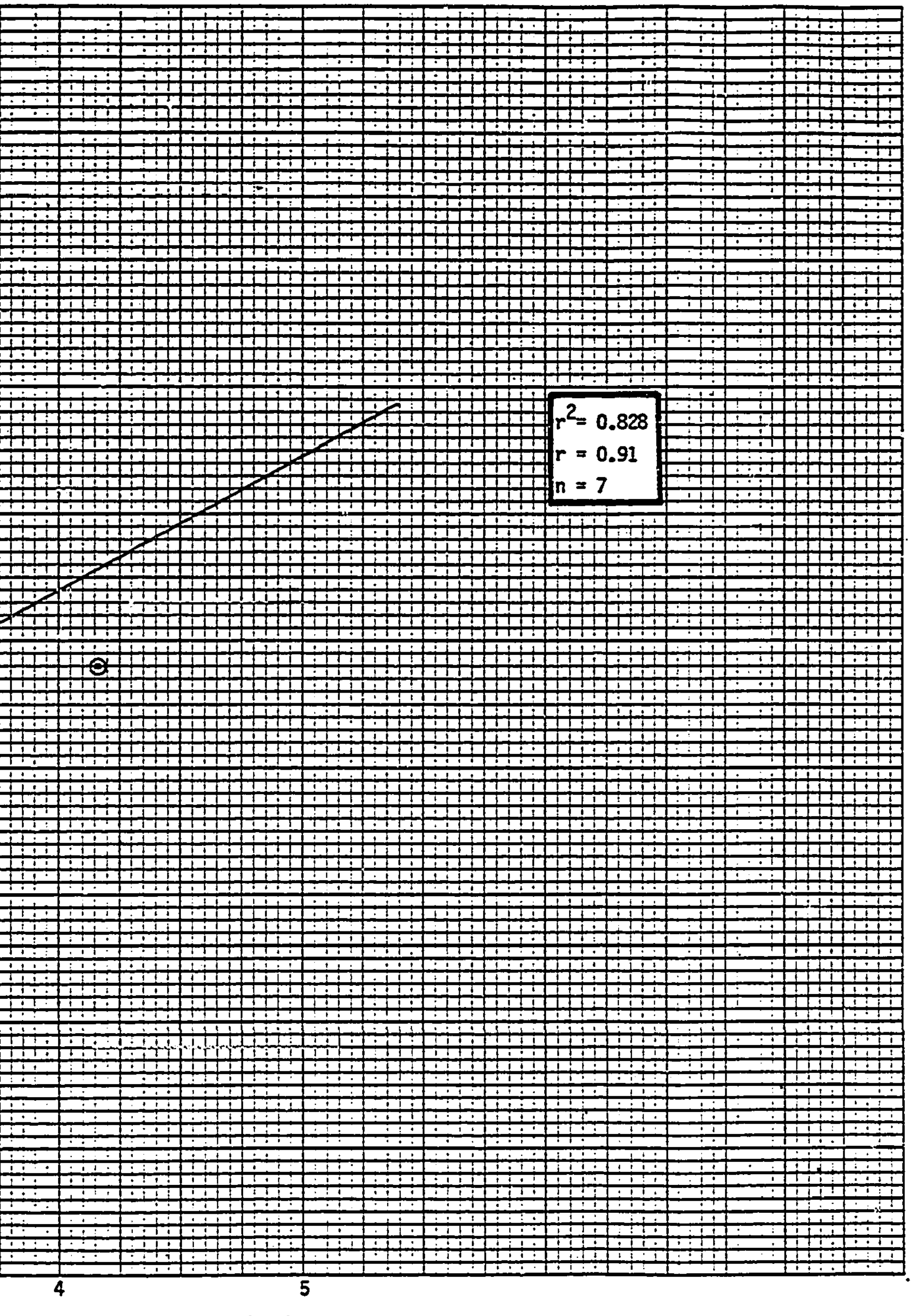


Figure 43. Correlation of TCA in the Soil Gas and Groundwater.


r^2= 0.828
r = 0.91
n = 7
4
5
RATIONS IN THE SOIL GAS (ppb)

respectively. These equations can be used to determine unknown concentrations for corresponding soil gas or water quality sampling locations across the study area.

The calculations for the regression analysis of both the PCE and TCA soil gas and water quality data are provided in Appendix F.

Site specific and compound specific ratios between soil gas and groundwater (water table) concentrations can be useful for identifying vadose zone versus groundwater contamination sources (Marrin, 1985). Table 10 is a presentation of the concentration ratios of PCE and TCA in the soil gas as compared to the levels of these compounds in the groundwater at the corresponding temporary well locations. The range of the ratios for PCE is from 0.003 to 0.134; the mean and standard deviation were calculated to be 0.071 and 0.050, respectively. The range of the TCA ratios was from 0 to 0.173. The mean ratio value was 0.061 and the standard deviation was 0.058.

For this specific study area, ratios that fall below at least plus two standard deviations of each calculated mean probably indicate that the soil gas levels are from vapors diffusing from contaminated groundwater only. Ratios higher than this may indicate that vadose zone or surface sources of the contaminant vapors are also present.

Table 10

Concentrations and Ratios of PCE and TCA in the Soil Gas and Shallow Groundwater

Corresponding Sample Locations		Concentrations (ppb)					
		PCE			TCA		
Soil Gas	Groundwater	Soil Gas	Ground-water	Ratio	Soil Gas	Ground-water	Ratio
RZ-SG-04	RZ-TW-03	28.06	210	0.134	4.16	24	0.173
RZ-SG-40	RZ-TW-06	10.57	110	0.096	1.71	22	0.078
RZ-SG-41	RZ-TW-02	5.26	46	0.110	0.39	6	0.065
RZ-SG-51	RZ-TW-20	0.35	100	0.0035	----	--	-----
RZ-SG-52	RZ-TW-22	0.286	3	0.09	0	1	0
RZ-SG-53	RZ-TW-23	5.47	41	0.13	0.182	3	0.061
RZ-SG-54	RZ-TW-25	1.98	33	0.06	----	--	-----
RZ-SG-55	RZ-TW-24	0	3	0	----	--	-----
RZ-SG-56	RZ-TW-25	1.75	33	0.053	----	--	-----
RZ-SG-57	RZ-TW-23	4.26	41	0.10	0.153	3	0.051
RZ-SG-62	RZ-TW-14	0.263	30	0.0088	0	3	0
Mean				0.071			0.061
Standard deviation				0.050			0.058

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The method of concentrating soil gas vapors from a point source onto a sorbent material has been proven to be successful in detecting vapors emanating from PCE and TCA concentrations as low as 3.0 ppb, each, at or near the water table at depths up to 10 feet below the ground surface.

2. Ambient air, trip blank and analytical blank soil gas sample analysis provided site specific detection limits of 0.20 ppb and 0.01 ppb for PCE and TCA, respectively, in soil gas samples obtained from the study area.

3. Calibration curves established from soil gas standards made from vapor phase CH constituents were used successfully to semi-quantitatively determine the concentrations of PCE and TCA in soil gas samples.

4. The polyethylene tubing used for the transport line between the sampling point and the sample trap tube was determined to have introduced interference compounds into these samples. This interference, however, did not affect the PCE and TCA results.

5. The soil gas data were successful in identifying the approximate locations of the source areas, direction of migration, areal extent and chemical composition of the plumes of contamination in the groundwater emanating from the Rozema Garage site.

6. The soil gas sampling data identified two main source areas for the PCE and TCA contamination in the groundwater beneath the Rozema property.

7. The relative concentration distributions of the PCE and TCA levels detected in soil gas samples closely reflect the distribution of the concentrations of those compounds identified in the groundwater (water table) across the study area.

8. The soil gas data also helped identify three areas where vadose zone or surficial sources of PCE and TCA contamination are believed to be present.

9. High degrees of correlations ($r = 0.89$, $n = 11$) exist between the concentration levels of PCE identified in soil gas samples and PCE concentrations detected at the water table at approximately the same locations and the same time.

10. High correlations ($r = 0.91$, $n = 7$) also were observed between TCA levels in the soil gas and in the corresponding water quality samples. TCA concentrations were much less than PCE levels in the groundwater over the study area.

11. Site specific and compound specific average concentration ratios between PCE and TCA levels in the soil gas and at the water table were calculated to be 0.071 and 0.061, respectively. These ratios can be used for identifying the presence of vadose zone, surface or groundwater contamination sources.

12. The advantage of using a soil gas sampling technique, as confirmed by Marrin and Thompson, 1984, is that obtaining data from numerous and closely-spaced sampling points prevent small scale geologic or hydrologic anomalies from distorting overall plume characteristics. The soil gas data used for this study enabled the accurate delineation of the contamination plumes.

13. In this study, soil gas sampling appears to be unsuitable for sampling in frost impacted, overconsolidated granular soils.

14. The soil gas data acquired during January, 1987, when temperatures averaged 21.0 Deg. C, were used to delineate the PCE and TCA sources on, and to estimate the plume migration off, the Rozema Site. The soil gas data obtained in June and July, 1987, when the average daily temperature was 79.6 Deg. C., were used successfully to delineate the extent of the water table contamination downgradient of the site. Thus, although temperature fluctuations may have slightly affected the

flux of soil gas contaminants in the vadose zone at some sampling locations, the effects were not significant enough to cause large differences between these two data sets. Therefore, the versatility of the technique was not limited significantly by temperature fluctuations.

Recommendations

1. It is recommended that further studies be performed to evaluate the suitability of other tubing materials through which soil gas samples are drawn. The polyethyene tubing used for this study has been proven to introduce interference in soil gas samples obtained while atmospheric temperatures ranged from 70 Deg. F to 92 Deg. F. The material that is believed to be most suitable to replace this tubing is Teflon.

2. A different, more versatile, type of air sampling pump should be used instead of the SKC Model 222 air pumps used for this study. The new pump should be more powerful and should allow for the accurate regulation of the flow, or purging rates. A peristaltic pump may be inherently more suitable for this type of sampling.

3. A new method for preparing soil gas analytical standards should be investigated. The method used in this study has been shown to cause analytical inconsistencies. As a result, standard calibration

curves were used to calculate the sampling results. However, results from this method of calibration are only semi-quantitative.

4. Additional research must be carried out to evaluate the versatility of this soil gas sampling technique for detecting CH plumes in unconfined aquifers with water table depths exceeding 10 feet below ground level.

5. Anomalous soil gas contamination that has been detected over contaminant free groundwater should be verified with composite soil samples obtained at that location.

6. When analyzing soil gas samples, calibration should be accomplished with a daily series of standards. This series should be comprised of a range of standard concentrations. The concentrations of the target compounds should be at or close to the analytical detection limit, and at levels of the average and high concentrations expected for the soil gas data, as based on the background water quality data for a site. This will allow for a more accurate estimation of the external standard calibration curve used to quantify the daily sample results.

7. Duplicate samples should be obtained once daily instead of with every tenth sample. The duplicate sample is a quality assurance measure that should be obtained

with every daily batch of samples to insure data replication.

8. Handles should be welded onto the slide hammers on the soil gas probes. These handles will minimize the abuse to the palm of the hands when driving the probes through tight, or over-consolidated materials.

APPENDIX A

Boring Logs

NUS CORPORATION
A Halliburton Company

PROJECT ROZ FARM
PROJECT NO. 8432 BORING RZ-TW-11
ELEVATION DATE 6-22-87
FIELD GEOLOGIST TIMOTHY J. MAYOTTE

SAMPLE NO.,TYPE* & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION* SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS
0								
5.0			DRY		LIGHT BROWN	SILTY FINE TO MEDIUM	SP	
						SAND, TRACE FINE GRAVEL		
10.0			DRY		LIGHT BROWN	SILTY FINE TO MEDIUM SAND,	SW	
						SOME COARSE SAND TO		
						COARSE GRAVEL		
15.0			WET		LIGHT BROWN	MEDIUM SAND, TRACE COARSE	SP	
						SAND		

REMARKS

BORING RZ-TW-11

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT Rozema
PROJECT NO. 8432 BORING R2-TW-12
ELEVATION ______ DATE 6-22-87
FIELD GEOLOGIST Timothy J. Mayotte

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
0								
5.0			MOIST		LIGHT BROWN	FINE SAND, SOME MEDIUM	SP	GENERALLY
						SAND, TRACE COARSE SAND		VERY UNIFORM
						AND FINE GRAVEL.		
10.0			WET		LIGHT BROWN	SILTY FINE SAND, TRACE	SP	
						MEDIUM SAND		
15.0			WET		LIGHT BROWN	FINE TO MEDIUM SAND.	SP	
						TRACE COARSE SAND AND		
						FINE GRAVEL		

REMARKS ______

BORING R2-TW-12

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT Rozema
PROJECT NO. 8452 BORING RZ-TW-13
ELEVATION ______ DATE 6-22-87
FIELD GEOLOGIST Timothy J. Mayotte

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
0								
5.0			MOIST		BROWN	FINE SAND, TRACE FINE	SP	
						GRAVEL		
10.0			MOIST		BROWN	FINE SAND TO FINE	SW	LACKING ALOT
						GRAVEL		OF MED. SAND
15.0			MOIST		BROWN	SAME	SW	LACKING ALOT
								OF COARSE
								SAND

REMARKS ______

BORING RZ-TW-13

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT ROZEMA
PROJECT NO. 8432 BORING RZ-TW-14
ELEVATION DATE 6-22-87
FIELD GEOLOGIST TIMOTHY J. MAYOTTE

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
0								
5.0			MOIST		DARK BROWN	FINE SAND, SOME FINE	SP	
						TO COARSE GRAVEL		
10.0			DAMP		DARK BROWN	CLAYEY SILTY FINE SAND,	SC	
						TRACE FINE GRAVEL		
15.0			WET		DARK BROWN	SILTY FINE SAND TO MED.	SM	
						SAND WITH FINE GRAVEL,		
						TRACE COARSE GRAVEL		

REMARKS

BORING RZ-TW-14

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING R2-TW-15
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO.,TYPE* & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			WET		LIGHT BROWN	FINE TO MEDIUM SAND	SP	
10.0			WET		LIGHT BROWN	SAME	SP	

REMARKS

BORING R2-TW-15

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT ____
PROJECT NO. ____ BORING RZ-TW-16
ELEVATION ____ DATE ____
FIELD GEOLOGIST ____

SAMPLE NO., TYPE * & DEPTH (ft)	BLOWS/SIX INCHES OR RQD (%)	SAMPLE RECOVERY/ SAMPLE LENGTH (ft)	MATERIAL MOISTURE & WATER DEPTH (ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			DAMP		LIGHT BROWN	FINE SAND TRACE	SP	
						MEDIUM SAND		
10.0			WET		LT. BROWN	SILTY MEDIUM SAND TO	SW	
						FINE GRAVEL		

REMARKS ____

BORING RZ-TW-16

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING R2-TW-17
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			WET		MOTTLED BROWN	SILTY FINE SAND, TRACE	SP	
						MEDIUM SAND		
10.0			DAMP		LIGHT BROWN	MEDIUM SAND, TRACE	SP	
						COARSE SAND AND FINE		
						GRAVEL		

REMARKS

BORING R2-TW-17

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING RZ-TW-18
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO., TYPE & DEPTH (ft)	BLOWS/SIX INCHES OR RQD (%)	SAMPLE RECOVERY/ SAMPLE LENGTH (ft)	MATERIAL MOISTURE & WATER DEPTH (ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			MOIST		GRAY-BROWN	FINE TO MEDIUM SAND	SP	
						SOME COARSE SAND TO		
						FINE GRAVEL		
10.0			WET		LIGHT BROWN	SILTY FINE SAND TO	SW	
						FINE GRAVEL		

REMARKS

BORING RZ-TW-18

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING RZ-TW-19
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO., TYPE* & DEPTH (ft)	BLOWS/SIX INCHES OR RQD (%)	SAMPLE RECOVERY/ SAMPLE LENGTH (ft)	MATERIAL MOISTURE & WATER DEPTH (ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			DRY		GRAY BROWN	SILTY FINE SAND, SOME	SM	
						MED. SAND, TRACE FINE		
						GRAVEL		
10.0			WET		LIGHT BROWN	MEDIUM SAND, SOME	SP-SW	
						COARSE SAND AND FINE		
						GRAVEL		

REMARKS

BORING RZ-TW-19

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. . BORING RZ-TW-2C
ELEVATION: DATE
FIELD GEOLOGIST

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			MOISTE		BROWN	FINE SAND, TRACE COARSE	SP	
						GRAVEL		
10.0			MOISTE		LIGHT BROWN	FINE TO MEDIUM SAND,	SP	
						SOME FINE TO COARSE		
						GRAVEL		

REMARKS
BORING RZ-TW-2C

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING 22-TW-21
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO., TYPE* & DEPTH (ft)	BLOWS/SIX INCHES OR RQD (%)	SAMPLE RECOVERY/ SAMPLE LENGTH (ft)	MATERIAL MOISTURE & WATER DEPTH (ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			DRY		LIGHT BROWN	FINE SAND, TRACE	SP	
						COARSE SAND AND FINE		
						GRAVEL		
10.0			DRY		LT. BROWN	FINE TO MEDIUM SAND	SP	
						SOME COARSE SAND,		
						TRACE FINE GRAVEL		
15.0			MOIST		BROWN	MEDIUM SAND, TRACE	SP	
						FINE GRAVEL		

REMARKS

BORING 22-TW-21

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING RZ-TW-22
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			DRY		BROWN	FINE TO MEDIUM SAND,	SP	
						TRACE COARSE SAND		
						TO COARSE GRAVEL		
16.0			DAMP		BROWN	MEDIUM SAND, SOME	SP	
						COARSE SAND AND FINE		
						GRAVEL, TRACE SILT		

REMARKS

BORING RZ-TW-22

PAGE 1 OF 1

*SEE LEGEND ON BACK

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING R2-TW-23
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO. TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
5.0			MOIST		LIGHT BROWN	FINE TO MEDIUM SAND,	SP	
						TRACE FINE GRAVEL		
13.0			MOIST		LIGHT BROWN	MEDIUM SAND TRACE	SP	
						FINE GRAVEL		

REMARKS

BORING R2-TW-23

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING RZ-TW-24
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/6IN INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
6.5			WET		LIGHT BROWN	FINE TO MEDIUM SAND	SP	
						WITH CORESE GRAVEL		
10.5			WET		LIGHT BROWN	FINE TO MEDIUM SAND;	SP	
						TRACE FINE GRAVEL		

REMARKS

BORING RZ-TW-24

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT
PROJECT NO. BORING RZ-TW-25
ELEVATION DATE
FIELD GEOLOGIST

SAMPLE NO. TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION* SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS
5.0			DAMP		LIGHT BROWN	FINE TO MEDIUM SAND,	SP	
						TRACE FINE GRAVEL		
10.0			DAMP		LIGHT BROWN	FINE TO MEDIUM SAND,	SP	
						LITTLE FINE GRAVEL,		
						TRACE SILT		

REMARKS

BORING RZ-TW-25

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT [illegible]
PROJECT NO. 8432 BORING RZ-01
ELEVATION
DATE 9/1/87
FIELD GEOLOGIST DANIEL R HAMEL

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION* SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS
S-1	11-9-7	1.5/1.5	DAMP	MEDIUM DENSE	BROWN	FINE SAND, TRACE ROCK FRAGMENTS	(SP)	
4.5-6.0FT						TRACE SILT		
						7.0FT		
S-2	5-5-7	1.5/1.5	WET	MEDIUM DENSE	GRAY BROWN	FINE TO COARSE SAND, TRACE	(SW)	
9.5-11.0 FT						FINE GRAVEL		
S-3	6-9-9	1.5/1.5	WET	MEDIUM DENSE	GRAY BROWN	SAME, LITTLE FINE GRAVEL	(SW)	
14.5-16.0FT								
S-4	8-7-11	0.1/1.5	WET	MEDIUM DENSE	GRAY BROWN	SAME (GRAVEL BLOCKED	(SW)	
19.5-21.0 FT						BARREL - NO RECOVERY)		
						23.0FT		

REMARKS

BORING RZ-01

*SEE LEGEND ON BACK

PAGE 1 OF 2

NUS CORPORATION
A Halliburton Company

PROJECT Rosema
PROJECT NO. 8432 BORING RZ-01
ELEVATION DATE 9/1/87
FIELD GEOLOGIST DANIEL R HAMEL

SAMPLE NO., TYPE * & DEPTH (ft)	BLOWS/SIX INCHES OR RQD (%)	SAMPLE RECOVERY/ SAMPLE LENGTH (ft)	MATERIAL MOISTURE & WATER DEPTH (ft)	MATERIAL DESCRIPTION*			USCS OR ROCK BROKENNESS	REMARKS
				SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION		
S-5	5-9-13	1.0/1.5	WET	MEDIUM DENSE	BROWN	FINE SAND	(SP)	
24.5-26.0 FT						↓ ↓ 27.0 FT		
S-6	7-9-17	1.5/1.5	DAMP	VERY STIFF	GRAY	CLAY, TRACE FINE SAND	(CL)	
29.5-31.0 FT								
S-7		1.5/1.5	MOIST		BROWN	FINE SAND AND SILT	(ML-SM)	
31-32.5 FT								
						BOH 32.5 FT		

REMARKS

BORING RZ-01

*SEE LEGEND ON BACK

PAGE 2 OF 2

NUS CORPORATION
A Halliburton Company

PROJECT KOSEMA
PROJECT NO. 8432 BORING RZ-02
ELEVATION
DATE 9/2/87
FIELD GEOLOGIST DANIEL P. HAMEL

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION* SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	COLOR	MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS
S-1	3-4-4	1.5/1.5	DAMP	LOOSE	BROWN ORG BRN	MEDIUM SAND	(SP)	
4.0-5.5FT								
S-2	10-15-20	1.1/1.5	WET	DENSE	GRAY BROWN	FINE TO MEDIUM SAND	(SP)	
9.0-10.5								
S-3	14-14-14	1.3/1.5	WET	MEDIUM DENSE	GRAY BROWN	FINE TO MEDIUM SAND TRACE	(SP)	
14.0-15.5FT						COARSE SAND		
* S-3A	7-9-16	1.5/1.5	DAMP	VERY STIFF	BROWN	SILT AND FINE SAND	(ML)	
15.5-16.0								
S-3B	16.0-17.0					CLAY, TRACE FINE SAND	(CL)	
S-4	9-9-12	1.3/1.5	DAMP	VERY STIFF	GRAY	CLAY, TRACE FINE SAND	(CL)	
19.0-20.5FT								
S-5	6-3-10	1.3/1.5	DAMP	VERY STIFF	GRAY	CLAY, TRACE FINE SAND	(CL)	
20.5-22.0FT								
						BOH 22.0FT		

REMARKS * THIS SAMPLE (S-3A 3B) TAKEN IN OFFSET BORING.
TEMPORARY WELL IN ORIGINAL BORING WAS NOT PRODUCING WATER.

BORING RZ-02

*SEE LEGEND ON BACK

PAGE 1 OF 1

NUS CORPORATION
A Halliburton Company

PROJECT RCEEMA
PROJECT NO. 8432 BORING RE-03
ELEVATION DATE 9/2/87
FIELD GEOLOGIST DANIEL R HAMEL

SAMPLE NO.,TYPE * & DEPTH(ft)	BLOWS/SIX INCHES OR RQD(%)	SAMPLE RECOVERY/ SAMPLE LENGTH(ft)	MATERIAL MOISTURE & WATER DEPTH(ft)	MATERIAL DESCRIPTION* SOIL DENSITY/ CONSISTENCY OR ROCK HARDNESS	MATERIAL DESCRIPTION* COLOR	MATERIAL DESCRIPTION* MATERIAL CLASSIFICATION	USCS OR ROCK BROKENNESS	REMARKS
S-1	3-4-4	1.5/1.5	DAMP	LOOSE	BROWN	FINE SAND. TRACE FINE	(SP)	
4.0-5.5FT						GRAVEL		
						8.0FT		
S-2	4-6-8	1.1/1.5	WET	MEDIUM DENSE	GRAY BROWN	FINE TO COARSE SAND,	(SW)	
9.0-10.5FT						TRACE COARSE SAND		
						12.0 FT		
S-3	10-13-15	1.0/1.5	MOIST TO WET	MEDIUM DENSE	GRAY BROWN	FINE SAND, TRACE MED TO COARSE SAND	(SP)	
14.5-15.5						TRACE FINE GRAVEL		
S-4	5-7-13	1.5/1.5	MOIST	VERY STIFF	GRAY	SILT, TRACE FINE SAND	(ML)	
15.5-17.0FT								
S-5	9-3-13	0.3/1.5	WET	MEDIUM DENSE	BROWN	FINE SAND	(SP)	
17-19.5FT								
S-6	9-8-11	1.5/1.5	MOIST	VERY STIFF	GRAY	SILT. TRACE FINE SAND	(ML)	
19.5-21.0FT								
S-7	5-7-7	1.5/1.5	MOIST	STIFF	GRAY	SILT. TRACE FINE SAND	(ML)	
21.0-22.5FT								
						BOH 22.5FT		

REMARKS LOG - 14.0 FT 22.5FT - NOT TO SCALE ON LOG SHEET.

BORING RE-03

*SEE LEGEND ON BACK

PAGE 1 OF 1

APPENDIX B

Soil Gas Sample Logs

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-001A & 001B

DATE SAMPLED: 12-17-86

TIME SAMPLED: 0958-1048, 1138

DATE ANALYZED:

SAMPLE DEPTH: 3'

SURVEY COORDINATE:

SAMPLE LOCATION: NW CORNER OF SITE - NEAR WELL MW3

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP578A

COMMENTS:

001A - 2 LITER PILOT SAMPLE
001B - 4 LITER PILOT SAMPLE

* USING 12" TEKMAR TRAP TUBES & NEW SG TIPS

SAMPLING PERSONNEL: DRH/RHC

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

001B - Retaken on 1-16-87 - Start @ 0855 - 1050

436800

SOIL GAS SAMPLE DATA SHEET

R2

SITE NAME: Rozema

SAMPLE NUMBER: RG-SG-002A & 002B

DATE SAMPLED: 7-15-87

TIME SAMPLED: 1345-1445, 1512

DATE ANALYZED:

SAMPLE DEPTH: 3'

SURVEY COORDINATE: NE CORNER OF SITE-NEAR WELL MW2

SAMPLE LOCATION:

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

002A - 2 LITER PILOT SAMPLE
002B - 4 LITER PILOT SAMPLE

SAMPLING PERSONNEL: DRH/RHC

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-003A & 003B

DATE SAMPLED: 1-16-86

TIME SAMPLED: 0900-1050 (003B) / 003A-1100-1207

DATE ANALYZED:

SAMPLE DEPTH: 3'

SURVEY COORDINATE:

SAMPLE LOCATION: SE CORNER OF SITE - AMONG DEBRIS - ADJACENT to WELL MW1

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

4l PILOT SAMPLE - 003B

2l PILOT SAMPLE - 003A

SAMPLING PERSONNEL: RHC/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROOZEMA
SAMPLE NUMBER: RZ-SG-004A
DATE SAMPLED: 1-16-87
TIME SAMPLED: 1105-1207
DATE ANALYZED:
SAMPLE DEPTH: 3'
SURVEY COORDINATE:
SAMPLE LOCATION: SOUTH EDGE OF PROPERTY ALONG FENCE - MIDWAY BTWN. E & W FENCES
ANALYSIS METHOD - DIRECT INJECTION
ABSORPTION TUBE ✓
VOLUMETRIC CONTAINER USED:
GAS CHROMATOGRAPH USED: HP5890A
COMMENTS:

2L PILOT STUDY SAMPLE

SAMPLING PERSONNEL: RHC/DRL

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-005A + 005B

DATE SAMPLED: 1-19-87

TIME SAMPLED: 12:15

DATE ANALYZED:

SAMPLE DEPTH: 3'

SURVEY COORDINATE:

SAMPLE LOCATION: NORTH FENCE LINE, DIRECTLY NORTH OF MIDDLE OF GARAGE 108FT FROM NE CORNER 89 FT FROM NW CORNR

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE TENAX

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: CLOUDY, COLD (~20°F)

005A - 2 l SAMPLE

005B - 1 l SAMPLE

Pump #3 (005A)

END # — 458894

Pump #4 (005B)

END # — 770016

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

770016

9920

779936

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-006A + 006B

DATE SAMPLED: 1/19/87

TIME SAMPLED:

DATE ANALYZED:

SAMPLE DEPTH: 3'

SURVEY COORDINATE:

SAMPLE LOCATION:

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE TENAX

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: CLOUDY, COLD (~20°F)

006 A 2Liter

006B 1 liter

Pump # 4 (006A) END 799897
800233
336

Pump #3 (006B) END 492701
493411
710

006A 33.87 ml over |2 liter sample

006B 63.16 ml over |1 liter sample

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

4 3

[illegible] .GG 4C [illegible] 461 1 240

[illegible]

SOIL GAS SAMPLE DATA SHEET

SITE NAME: REZZINA

SAMPLE NUMBER: RZ-SG-007

DATE SAMPLED: 1-20-87

TIME SAMPLED: 10:00

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: DIRECTLY SOUTH OF RZ-SG-005A

+005A

30FT NORTH FROM 008

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE TENAX

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

CLOUDY, COLD

pump #3 START-493495

11 240

END-504735

(504840)

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME:

SAMPLE NUMBER: RZ-SG-008

DATE SAMPLED: 9:45 AM

TIME SAMPLED: 1/20/87

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: SOUTH OF RZ-SG-007, NORTH OF ROZEMA GARAGE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE TENAX

VOLUMETRIC CONTAINER USED: HP5890A

GAS CHROMATOGRAPH USED:

COMMENTS:

COLD, SNOWY

Pump # 4 START - 800326
9.9 2c
END 810.246
25½ FT FROM NW CORNER
OF BLDG AND
23 FT DIRECTLY
NORTH OF BLDG

SAMPLING PERSONNEL: TVM/DZH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-009

DATE SAMPLED: 1-20-87

TIME SAMPLED: 11:30 AM

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION:

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SNOWY, COLD (~20°)

Pump #3 START 504923

11240

END 516163

SAMPLING PERSONNEL: TJM / DZH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-010

DATE SAMPLED: 1-20-87

TIME SAMPLED: 1430

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 35.58FT SOUTH OF NE CORNER MONITORING WELL. 9FT WEST OF EAST FENCELINE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP 5890 A

COMMENTS:

Cloudy, cold (~20°)

Pump #3 START - 516268
71240
END - 527508

SAMPLING PERSONNEL: TJM/DEH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-011

DATE SAMPLED: 1-20-87

TIME SAMPLED: ~~1430~~ 1530

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 40 FT SOUTH OF SAMPLE 010. 9 FT WEST OF EAST FENCELINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890 A

COMMENTS:

CLOUDY, COLD (<20°)

Pump #4 START — ~~810365~~ 816695

9920 9920

END — ~~800445~~ 826605

HAD TO START OVER W/NEW TUBE
DUE TO WIND BLOWING ORIGINAL OFF THE PROBE

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZETTA

SAMPLE NUMBER: RZ-SG-012

DATE SAMPLED: 1-20-87

TIME SAMPLED: 1620

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 50FT WEST OF EAST FENCE LINE. 60 FT NORTH OF SOUTH FENCE LINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

CLOUDY, COLD (~15°)

Pump #3 START — 527580
11240
END — 538820

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-013

DATE SAMPLED: 1/21/87

TIME SAMPLED: 0925

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 6.5 FT WEST OF EAST FENCE LINE. 56 FT NORTH OF SOUTH FENCE LINE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP 5890A

COMMENTS:

Pump #4 START —— 826772
9920
END —— 836692

(Replaced intake seal on pump. Cold air seems to have made plastic hard and deformable such that a proper seal between it and the tube is not insured.)

(As a result there may not have been a full liter pulled through the tube)

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-014

DATE SAMPLED: 1/21/87

TIME SAMPLED:

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 47 FT WEST OF EAST FENCE LINE. 7 FT NORTH OF SAMPLE OIL LINE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP 5890A

COMMENTS:

CLOUDY, COLD (~20°)

Pump #4 ST - 538917

11240 -

END - 550157

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-015

DATE SAMPLED: 1-21-87

TIME SAMPLED:

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 27 FT EAST OF BLDG, 72 FT WEST OF EAST FENCE LINE & 31 FT FROM SOUT CORNER BLDG.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, COLD (~20°)

pump #3 START — 550324

11240

END — 561564

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-016

DATE SAMPLED: 1/21/87

TIME SAMPLED: 1141 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 35 FT SOUTH OF SAMPLE 015. 32.5 FT SE FROM SE CORNER OF BLDG

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY
COLD (~20°F) Pump # 4

START -	837292
-	-9920
END	847212

~~START~~ CLIP TIP AFTER EVACUATION

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-017

DATE SAMPLED: 1/21/87

TIME SAMPLED: 1530 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 69.5 FT SOUTH OF NORTH FENCELINE. 50FT EAST OF WEST FENCELINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

PUMP # 4 START 847319
\+ 9920
END 857239

CUT TIP AFTER EVACUATION

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-018

DATE SAMPLED: 1/21/87

TIME SAMPLED: 1555

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 45 SOUTH OF SAMPLE RZ-SG-017. 31 FT WEST OF BLDG.

ANALYSIS METHOD - DIRECT INJECTION -

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

Pump #3 START 561653
+ 11240
END 572893

SAMPLING PERSONNEL: TJM | DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-019

DATE SAMPLED: 1-21-87

TIME SAMPLED: 1625

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 40FT SOUTH OF SAMPLE RZ-SG-018. 73FT NORTH OF SOUTH FENCELINE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: Sunny, Windy, Cold (~20°)

Pump #4 START — 857349
9920
END — 867269

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-020

DATE SAMPLED: 1-21-87

TIME SAMPLED: 1705

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 445 FT NORTH OF SOUTH FENCELINE. 46 FT EAST OF WEST FENCE LINE

ANALYSIS METHOD -- DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

Sunny, COLD (~20°), WINDY

Pump #3 START — 573012
11240
END — 584252
578317
5935

Pump #3 Died ?

Pump #4
866270
5935
872205

ACTUAL
873107
902 CTS OVER

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

Pump #3 CALIBRATION

261 CTS / 25 ML
OR 11240 CTS/1000 ML

SAMPLE * VOLUME 1080

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-021

DATE SAMPLED: 1/22/87

TIME SAMPLED: 1035HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 71 FT N FROM SOUTH FENCELINE, 104 FT EAST FROM WEST FENCELINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED:

COMMENTS:

Pump #2 START 378022
\+ 8373
END 386395

SAMPLING PERSONNEL: RJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-022

DATE SAMPLED: 1/22/87

TIME SAMPLED: 1100 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: POSTMA PROPERTY · 45 FT WEST OF NE CORNER OF POSTMA NORTH FENCE. 4 FT SOUTH OF NORTH FENCE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED:

COMMENTS:

Pump #1 START 417834

+7813

END 425647

ACTUAL READING 426033

386 CTS OVER

SAMPLING PERSONNEL: TJM/DRH

SAMPLE VOLUME 1049 ml

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

Pump #1 781.3 CTS/100 mL

*

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-023

DATE SAMPLED: 1/22/87

TIME SAMPLED: 1120 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: POSTMA PROPERTY | 57.5 FT SOUTH OF NE POSTMA FENCE CORNER. 65 FT WEST OF JANSEN WEST FENCELINE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED:

COMMENTS:

Pump #2 START 386491
+8373
END 394864

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-024

DATE SAMPLED: 1-22-87

TIME SAMPLED: 1500

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: JANSEN PROPERTY, 39 FT NORTH OF SOUTH FENCE LINE, 404 FT EAST OF WEST FENCELINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: CLOUDY, COLD (20°)

Pump #1 ST — 426327
7813
END — 434140

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-025

DATE SAMPLED: 1-22-87

TIME SAMPLED: 1540

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: POSTMA PROPERY. 55 FT SOUTH OF NORTH FENCELINE
52 FT WEST OF RZ-SG-023.

SAMPLE LOCATION: POSTMA PROPERY. 55 FT SOUTH OF NORTH FENCELINE
53 FT WEST OF RZ-SG-023.

ANALYSIS METHOD - DIRECT INJECTION

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, COLD (~25°), BREEZY

Pump #2 START 394957
8373

END - ~~403330~~

ACTUAL 403640

310 CTS OVER

SAMPLING PERSONNEL: DRH / TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

PUMP #1 781.3 CTS / 100 ml

PUMP #2 837.3 CTS / 100 ml

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-026

DATE SAMPLED: 1/27/87

TIME SAMPLED: 1534 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 330 FT EAST OF EDGE (EAST) OF MARCAN STREET. 25 FT NORTH OF CENTER LINE OF WILSHERE BL

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

COLD, CLOUDY (~13°)

Pump # 1

START 434216
+ 7813
END 442029

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-027

DATE SAMPLED: 1-27-87

TIME SAMPLED: 1540 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 230 FT EAST OF EDGE (EAST) OF MARCAN STREET. 25FT NORTH OF CENTERLINE OF WILSHERE DRIVE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, BREEZY, COLD (~20°)

PUMP #2 START — 403786

8373

END — 412159

SAMPLING PERSONNEL: DRH / TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Bozeman

SAMPLE NUMBER: BZ-SG-028

DATE SAMPLED: 1-27-87

TIME SAMPLED: 1630HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 130FT EAST OF EDGE (EAST) EDGE OF MARCAN STREET. 25 FT NORTH OF CENTER LINE (C/L) OF WILSHERE DRIVE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: Cloudy, snowy, cold (~15°)

Pump #1 ST. — 442114
7813
END — 449927

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA
SAMPLE NUMBER: RZ-SG-029
DATE SAMPLED: 1/27/87
TIME SAMPLED: 1640 HRS
DATE ANALYZED:
SAMPLE DEPTH: 4'
SURVEY COORDINATE:
SAMPLE LOCATION: 30FT EAST OF EDGE(EAST) OF MARCAN STREET. 25FT NORTH OF ℄ OF WILSHERE DRIVE.
ANALYSIS METHOD - DIRECT INJECTION
ABSORPTION TUBE ✓
VOLUMETRIC CONTAINER USED:
GAS CHROMATOGRAPH USED: HP5890A
COMMENTS:

SNOW, CLOUDS, COLD, (~15-20°F) PUMP #2 START → 412256
8373
END → 420629

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-030A

DATE SAMPLED: 1/28/87

TIME SAMPLED: 1148 HRS.

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: ADJACENT TO THE MAILBOX OF THE C&E SIGN COMPANY. NORTH OF THE ROZEMA SITE. 28 FT FROM C/L OF WILSHERE DRIVE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

PARTLY CLOUDY, MILD (~30°F)

PUMP # 1 START 450008

7813

END 457821

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-031

DATE SAMPLED: 1/28/89

TIME SAMPLED: 1500HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 130FT SOUTH OF SW FENSE CORNER OF JANSEN PROPERY (ROZEMA PROPERTY). 24FT EAST OF C/L OF WILSHERE DR. DIRECTY IN FRONT OF E.B DIESEL REPAIR

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: PARTLY CLOUDY, MILD (in 30's F

PUMP #1 START - 457902

+7813

465715

SAMPLING PERSONNEL: TJM/DK

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZELLA

SAMPLE NUMBER: RZ-SG-032

DATE SAMPLED: 1-28-87

TIME SAMPLED: 1520

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 70FT NORTH OF POSTMA SERVICES BUILDING. 35FT WEST OF C/L OF WILSHIRE DR.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5840A

COMMENTS: Partly Cloudy, mild (~30°)

Pump #2 START — 430001
8373
FINISH — 438374
ACTUAL 437730
556 CTS OVER

SAMPLING PERSONNEL: TJM / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SAMPLE VOLUME
1066

*

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-33

DATE SAMPLED: 1/25/87

TIME SAMPLED: 1555

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 28 FT WEST OF EDGE OF MARCAN AVE. 25 FT NORTH OF CENTER LINE OF WILSHERE AVE.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

PUMP #2 START 439033
\+ 8373
END 447406
ACTUAL 447427
21 CTS OVER

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

*

SOIL GAS SAMPLE DATA SHEET

SITE NAME: RUZEMA

SAMPLE NUMBER: RZ-SG-034

DATE SAMPLED: 1/28/88

TIME SAMPLED: 1635 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 35 FT WEST OF EDGE OF WILSHERE DR. 32 FT NORTH OF C/L OF PORT SHELDON STREET.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

PUMP #1 465816

~~[illegible]~~

~~[illegible]~~

PUMP DIED — 467268 = 1186 ml

6361

Pump #2

~~447438~~

~~8373~~

447438

~~6361~~

453799

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SAMPLE VOLUME 1186 ml

447438

8373

455811

*

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-035

DATE SAMPLED: 1/29/87

TIME SAMPLED: 1415 HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 160FT WEST OF EDGE (WESTERN) WILSHIRE DRIVE 21 FT SOUTH OF CENTERLINE OF PORT SHELDON STREET.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SNOW, WINDY
COLD (~20's F)

PUMP #6 START 638985
+ 12040
END 651025
ACTUAL 651394
369 CTS OVER
SAMPLE = 1031 ML

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM.

9360*

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-036

DATE SAMPLED: 1/29/87

TIME SAMPLED: 1420HRS

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 60FT WEST OF EDGE (WESTERN) OF WILSHERE DRIVE. 21 FT SOUTH OF CENTERLINE OF PORT SHELDON.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

pump #1 START 482922
+9360
END 492282

SNOW, WINDY
COLD (~20°F)

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-037

DATE SAMPLED: 1-29-87

TIME SAMPLED: 1505

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 150 FT EAST OF EAST EDGE OF WILSHERE DRIVE. 21 FT SOUTH OF CENTERLINE OF PORT SHELDON STREET.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890 A

COMMENTS: Snowy, windy, cold (~20°)

Pump #6

ST — 651489
12040
END — 663529

SAMPLING PERSONNEL: DRH/TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-038

DATE SAMPLED: 1-29-87

TIME SAMPLED: ~~[illegible]~~ 1510

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 250 FT EAST OF EASTERN EDGE OF WILSHERE DRIVE. 21 FT SOUTH OF CENTERLINE OF PORT SHELDON STREET

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SNOWY, WINDY, COLD (~20°)

Pump #1 ST — 492403
9360
END — 501763

SAMPLING PERSONNEL: DRH / TOM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-039

DATE SAMPLED: 1-29-87

TIME SAMPLED: 1605

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 100' E. OF RZ-SG-038 ON PORT SHELDON 21 FT SOUTH ~~RIGHT OF WAY~~ CENTERLINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SNOW, COLD (~20°), WINDY

PUMP #6 ST — 662750

·12040

END — 674790

ACTUAL 674890

100 CTS OVER

SAMPLE

1008 mL

SAMPLING PERSONNEL: DRH/TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

*

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-040

DATE SAMPLED: 1-29-87

TIME SAMPLED: 1605

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 100' EAST OF RZ-SG-039 ON PORT SHELDON 21 FT ~~South [illegible]~~ CENTERLINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: ~~HP5890A~~

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SNOW, WINDY, COLD (~20°)

Pump #1 ST — 501854
9360
END 511214

SAMPLING PERSONNEL: DRH / TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-041

DATE SAMPLED: 1-29-87

TIME SAMPLED: 1655

DATE ANALYZED:

SAMPLE DEPTH: 4'

SURVEY COORDINATE:

SAMPLE LOCATION: 100' E. OF RZ-88-040, 21' S OF CENTERLINE OF PORT SHELDON ST.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP 5890A

COMMENTS: SNOWY, WINDY, COLD (~20°)

Pump #1 ST-511354

9360

END 520714

SAMPLING PERSONNEL: TJM/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-042

DATE SAMPLED: 6-28-87

TIME SAMPLED: 1710

DATA ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT NW CORNER OF 2461 PORT SHELDON, 12.5 FT S. OF CORNER STAKE

ANALYSIS METHOD - **DIRECT INJECTION**

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: PARTLY CLOUDY, WARM (~75°F), BREEZY

PUMP #6 ST — 931642
10500
F — 942142

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-043

DATE SAMPLED: 6-28-87

TIME SAMPLED: ~~[illegible]~~ (TJM) 1720

DATA ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT NW CORNER OF 2461 PORT SHELDON ST., 65' S. OF RZ-SG-042.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: PARTLY CLOUDY, WARM (~75°F), BREEZY

PUMP #1 ST-838165

8613

F-846778

NOTE: TUBING CAME OFF AT PROBE TIP PRIOR TO INITIAL PURGE. WAS RECONNECTED w/o DECON, PUT BACK IN HOLE, PURGED AND THEN THE TENAX TUBE WAS CONNECTED.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-044

DATE SAMPLED: 6-14-87

TIME SAMPLED: 8:15 pm

DATA ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: ON PORT SHELDON RD., 32.5' S OF PORT SHELDON CENTERLINE, 17.5' N. OF UTILITY BOX AT CORNER OF PORT SHELDON AND PORT SHELDON CT.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, HOT (~85°F)

Pump #1 START – 705386

8080

STOP – 713466

SAMPLING PERSONNEL: TJM / KAM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-045

DATE SAMPLED: 6-24-87

TIME SAMPLED: 2035 HRS

DATA ANALYZED:

SAMPLE DEPTH: 1.5 FT

SURVEY COORDINATE:

SAMPLE LOCATION: ≈ 250' S. OF AND 30' E. OF RZ-TW-14 IN PASTURE

ANALYSIS METHOD - DIRECT INJECTION TENAX TUBE

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED:

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (~80°F), CALM

PUMP # 1

START 802297
8613

FINISH 81091~~2~~
810909

(RE-SAMPLE TAKEN ~10' W OF RZ-TW15)

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA
SAMPLE NUMBER: RZ-SG-046
DATE SAMPLED: 6-23-87
TIME SAMPLED: 2120
DATA ANALYZED:
SAMPLE DEPTH: 5.0FT (3.0FT)
SURVEY COORDINATE:
SAMPLE LOCATION: ~ 100.0 FT DUE W. OF RZ-SG-045 IN PASTURE
ANALYSIS METHOD - DIRECT INJECTION
ABSORPTION TUBE ✓
VOLUMETRIC CONTAINER USED: TENAX TUBE
GAS CHROMATOGRAPH USED: HP5890A
COMMENTS:

SUNNY, WARM (~80°F), CALM

PUMP #2 START 755802 757329
9093 9093

END 766472

pulled water at 5.0FT, pulled probe back to 3.5FT. Water in line (small amounts)

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

probe/[illegible] tip connection
[illegible] probe - [illegible]

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-047

DATE SAMPLED: 6-23-87

TIME SAMPLED: 2155 HRS
2140 HRS at first try

DATA ANALYZED:

SAMPLE DEPTH: 1.5 FT

SURVEY COORDINATE:

SAMPLE LOCATION: 100' DUE W. OF RZ-SG-046

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, WARM, CALM. (≈75°F)

~~791859~~
~~8613~~
~~800472~~

793492
8613
802105

TIP CAME DISCONECTED FROM PE. AIR WAS DRAW THROUGH. TIP/CONNECTIONS SET BACK IN HOLE. — UNDESIGNED. AS A REJECT.

SAMPLING PERSONNEL: TJM/PJJ/DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-048

DATE SAMPLED: 6-23-87

TIME SAMPLED: 2215

DATA ANALYZED:

SAMPLE DEPTH: 1.25 FT

SURVEY COORDINATE:

SAMPLE LOCATION: 100' W. OF RZ-SG-047 (DUE WEST).

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

DUSK, WARM (~75°F), CALM

Pump #2 766610
9093
775703

SAMPLING PERSONNEL: TJM / PJJ / DRH

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-049

DATE SAMPLED: 6-24-87

TIME SAMPLED: 2/25 HRS

DATA ANALYZED:

SAMPLE DEPTH: 1.5 FT

SURVEY COORDINATE:

SAMPLE LOCATION: DUE E. OF RZ-SG-045, 25' DUE E. OF BARBED WIRE FENCE, 55' W. OF PORT SHELDON CT.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, WARM (~75°F), CALM

PUMP #1 START - 811101
8613

FINISH - 819714
819716

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-050 AND RZ-SG-050DUP

DATE SAMPLED: 6-28-86

TIME SAMPLED: 1450 HRS

DATA ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT JANSEN TRANS. SW. CORNER, INSIDE FENCE ON EITHER SIDE OF RZ-TW 21, 3.5 FT APART (E-W)

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

TJM

SUNNY, WARM (~75°F), BREEZY

PUMP #1 (050) START-820061
8613
FINISH-828674 828677

PUMP #2 (050DUP) START-785236
9093
FINISH-794329

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-051

DATE SAMPLED: 6-28-87

TIME SAMPLED: 1540 HRS

DATA ANALYZED:

SAMPLE DEPTH: 3.0 FT - 3.5 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT CORNER OF PORT SHELDON ST. & PORT SHELDON CT. 7' NW OF STREET SIGN, NEXT TO RZ-TW20

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

PARTLY CLOUDY, WARM (~75°F), BREEZY

PUMP #1 START- 828813

8613

FINISH - 837426

837429

NOTE: PE TUBING KINKED AT TOP OF PROBE; MAY HAVE VOLATILIZED TUBING, OR RESTRICTED FLOW. ~~WILL PURGE OVER FINISH VALUE~~ TJM ~~100 CLICKS~~

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-052

DATE SAMPLED: 7-7-87

TIME SAMPLED: 1930 HRS

DATA ANALYZED:

SAMPLE DEPTH: ~2.0FT (HIT HARD (COMPACTED) ZONE ~2.0FT)

SURVEY COORDINATE:

SAMPLE LOCATION: ~100 FT S. OF RZ-TW2, NEXT TO FENCE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS C SUNNY, HOT (~80°F), MUGGY, CALM (SLIGHT BREEZE - EASTERLY)

COMMENTS:

SUNNY, HOT (~80°F), MUGGY, CALM (SLIGHT BREEZE - EASTERLY)

Pump #4 ST - 215310

9760

F - 225070

225072

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-053

DATE SAMPLED: 7-7-87

TIME SAMPLED: ~1940 HRS

DATA ANALYZED:

SAMPLE DEPTH: 5.0 FT (UNDER NEWLY SEEDED LAWN)

SURVEY COORDINATE:

SAMPLE LOCATION: ON PORT SHELDON, 5' N. OF RD., ~50' W. OF RZ-TW2

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: (~85°F)

SUNNY, HOT (~80°F), MUGGY; BREEZE = SLIGHT TO EAST; MOSTLY CALM

PUMP # 1 S- 866023
8040
F- 874063
874064

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-054

DATE SAMPLED: 7-7-87

TIME SAMPLED: ~12055 HRS

DATA ANALYZED:

SAMPLE DEPTH: ~4.5 FT

SURVEY COORDINATE:

SAMPLE LOCATION: ON PORT SHELDON, ACCROSS FROM N. OF RZ-TW20, 10' E OF RZ-TW20

ANALYSIS METHOD - **DIRECT INJECTION**

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, HOT (~80°F), MUGGY, CALM

PUMP #4 S- 225466
9760
F- 235226

235907

(PE END WAS NOT CLIPPED)

*NOTE: SOME GLASS WOOL CAME OUT OF UNFRITTED END. ABOUT ([illegible]). NO TENAX OBSERVED
TAPPED ON SLIDE HAMMER

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-055

DATE SAMPLED: 7-7-87

TIME SAMPLED: ~2100 HRS

DATA ANALYZED:

SAMPLE DEPTH: ~3.5 FT (VERY TIGHT)

SURVEY COORDINATE:

SAMPLE LOCATION: 100' E OF RZ-TW20, ON SAME SIDE OF PORT SHELDON

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, HOT (~80°F), MUGGY, CALM

PUMP #15-874322
8040
F-882362
882374

(NOTE: PUMP FELL OFF PROBE PINCHING OFF PE TUBING AT TOP OF SLIDE HAMMER; WAS REATTACHED. [illegible])

SAMPLING PERSONNEL: TIM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-056

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1510

DATE ANALYZED:

SAMPLE DEPTH: 5.0FT

SURVEY COORDINATE:

SAMPLE LOCATION: LOCATED AT RZ-TW , 30FT W. OF RZ-SG-054

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, HOT (~85-90°F), BREEZY (NNE)

Pump #4 ST.-271111
8600
F-279711
279712

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-057

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1515

DATE ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT RZ-TW), SAME LOCATION AS RZ-SG-053

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, HOT (~85-90°F), BREEZY (NNE)

PUMP #2 S- 816247
7700
F- 823947
824023

* RESAMPLE OF RZ-SG-053

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-058

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1615

DATE ANALYZED:

SAMPLE DEPTH: 5.0FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT NE CORNER OF 2461 PORT SHELDON PROP. LINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (85-90°F), BREEZY (NNE)

PUMP # 4 S- 279947
8600
F - 288547
288600

* PROBE IN DISTURBED SOIL (SAND) IN A EVERGREEN KNOLL. NEXT TO A FOUNDATION.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA
SAMPLE NUMBER: RZ-SG-059
DATE SAMPLED: 7-19-87
TIME SAMPLED: 1620
DATE ANALYZED:
SAMPLE DEPTH: 5.0 FT
SURVEY COORDINATE:
SAMPLE LOCATION: ALONG E. BORDER OF 2461 PORT SHELDON AND VANDENBERGS
ANALYSIS METHOD - DIRECT INJECTION
ABSORPTION TUBE ✓
VOLUMETRIC CONTAINER USED: TENAX TUBE
GAS CHROMATOGRAPH USED: HP5890A
COMMENTS: SUNNY, HOT (85-90°F) BREEZY (NNE)

Pump #2 S-824186
7200
F-831886
831701

* PROBE IN DISTURBED SOIL. NEXT TO AN EVERGREEN KNOLL.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-060

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1730

DATE ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT RZ-SG-043

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (85-90°F), BREEZY (NNE)

PUMP # 2 S- 832165
7700
F - 839 ~~865~~
839906

* RESAMPLE OF RZ-SG-043

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEWIA

SAMPLE NUMBER: RZ-SG-060 DUP

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1730

DATE ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT RZ-SG-043

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (85-90°F), BREEZY (NNE)

PUMP #4 S-288812

8600

F-297412

* DUPLICATE

SAMPLING PERSONNEL: TVM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-061

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2025

DATE ANALYZED:

SAMPLE DEPTH: 2.5 FT

SURVEY COORDINATE:

SAMPLE LOCATION: 1FT W. OF RZ-SG-047, 20FT N. OF RZ-SG-047

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (~80°F), MUGGY, CALM

PUMP # 4 309798
8600
318398
318402

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-062

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2030

DATE ANALYZED:

SAMPLE DEPTH: 4.5 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT RZ-SG-044

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP 5890 A

COMMENTS: SUNNY, HOT (~80°F), MUGGY, CALM

Pump #6 194832
11440
206272

RESAMPLE OF RZ-SG-044

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-063

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2120

DATE ANALYZED:

SAMPLE DEPTH: 5.0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT 2461 PORT SHELDON, 70 FT DUE W. OF RZ-SG-058 ALONG N. PROP. LINE

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (~80°F), MUGGY, CALM

Pump #5 206384
11440
217824
217833

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-064

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2125

DATE ANALYZED:

SAMPLE DEPTH: 5.0FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT 2461 PORT SHELDON, 65FT DUE W. OF RZ-SG-063, ~70FT E. OF RZ-SG-042.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (~80°F), MUGGY, CALM

PUMP #4 318537
8600
327137
327139

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-065

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2215

DATE ANALYZED:

SAMPLE DEPTH: 5.0FT

SURVEY COORDINATE:

SAMPLE LOCATION: ALONG PORT SHELDON RIGHT-OF-WAY AT NE CORNER OF 2514 P.S., 10 FT E. OF TREE AT THAT LOCATION.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: DUSK, HOT (~80°F), MUGGY, CALM

PUMP # 4 327278
8600
335878
335891

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-101B (TRIP BLANK)

DATE SAMPLED: 6-14-87

TIME SAMPLED:

DATA ANALYZED:

SAMPLE DEPTH:

SURVEY COORDINATE:

SAMPLE LOCATION:

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HS 5890A

COMMENTS: SUNNY, HOT (90-95°F)

SAMPLE LEFT IN COOLER AT ALL TIMES.

SAMPLING PERSONNEL: TJM/KAM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-102B

DATE SAMPLED: 6-23-87

TIME SAMPLED: 2245

DATA ANALYZED:

SAMPLE DEPTH: —

SURVEY COORDINATE:

SAMPLE LOCATION: TRIP BLANK

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: ZB-SG-103B

DATE SAMPLED: 6-28-87

TIME SAMPLED: 1545

DATA ANALYZED:

SAMPLE DEPTH: 0'FT

SURVEY COORDINATE:

SAMPLE LOCATION: AMBIENT AIR BLANK PLACED ON FENCE, 2 LUNGS FROM TREE DIRECTLY S. OF RZ-TW14 ON PORT SHELDON.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

PARTLY CLOUDY, BREEZY, WARM (~75°F)

mP #2 START - 794329
9093
FINISH - 803422
803423

*NOTE: AMBIENT AIR BLANK #1

SAMPLING PERSONNEL: TJW

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMNT

SAMPLE NUMBER: RZ-SG-104B

DATE SAMPLED: 6-28-87

TIME SAMPLED: ✓

DATA ANALYZED:

SAMPLE DEPTH: ✓

SURVEY COORDINATE:

SAMPLE LOCATION: TRIP BLANK

ANALYSIS METHOD - **DIRECT INJECTION**

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

TRIP BLANK

COOLER USED TO TRANSPORT SAMPLES; ICE PLACED IN COOLER AT AROUND 1800 HRS.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-005B AMBIENT AIR BLANK

DATE SAMPLED: 7-7-87

TIME SAMPLED: 1945

DATA ANALYZED:

SAMPLE DEPTH: 0 FT (AMBIENT AIR BLANK)

SURVEY COORDINATE:

SAMPLE LOCATION: AT RZ-SG-052, HANGING OFF FENCE 1.5 FT ABOVE GROUND

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, HOT (~80-85°F), MUGGY, CALM (SLIGHT E. BREEZE)

PUMP #3 S-856385
10320

F 866705

866707

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-106B TRIP BLANK

DATE SAMPLED:

TIME SAMPLED: 2015 (PLACED w/SAMPLES)

DATA ANALYZED:

SAMPLE DEPTH: —

SURVEY COORDINATE:

SAMPLE LOCATION: —

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

SUNNY, HOT (~80°F), CALM, MUGGY

TRIP BLANK

PUNCHED THROUGH BAG (2015)

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-1073 (PROBE/AMBIENT AIR BLANK)

DATE SAMPLED: 7-7-87

TIME SAMPLED: 2200

DATA ANALYZED:

SAMPLE DEPTH: 0' (~1FT ABOVE GROUND)

SURVEY COORDINATE:

SAMPLE LOCATION: NEXT TO FENCE ON WILSHIRE AT JANSENS SW CORNER

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: DUSK, CLEAR, WARM (75-80°F), MUGGY, CALM

PUMP #4 S- 236006
9760
F- 245766
246200

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA
SAMPLE NUMBER: RZ-SG-108B (PROBE/AMBIENT AIR BLANK)
DATE SAMPLED: 7-7-87
TIME SAMPLED: 2200
DATA ANALYZED:
SAMPLE DEPTH: 0' (~1FT ABOVE GROUND)
SURVEY COORDINATE:
SAMPLE LOCATION: SAME AS RZ-SG-107B.
ANALYSIS METHOD - **DIRECT INJECTION**
ABSORPTION TUBE ✓
VOLUMETRIC CONTAINER USED: TENAX TUBE
GAS CHROMATOGRAPH USED: HP5890A
COMMENTS:

DUSK, CLEAR, WARM (75-80°F), MUGGY, CALM

PUMP #1 S-882457
8040

F-890497 (890501)

(NOTE: PROBE TIP DISCONNECTED- RECONNECTED W/O DECON.)

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-109B (AMBIENT AIR BLANK)

DATE SAMPLED: 7-7-87

TIME SAMPLED: 2200

DATA ANALYZED:

SAMPLE DEPTH: 0' (~ 1FT ABOVE GROUND)

SURVEY COORDINATE:

SAMPLE LOCATION: SAME AS RZ-SG-107B

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS:

DUSK, CLEAR, WARM (75-80°F), MUGGY, CALM

PUMP #2 S - 805519

8560

F - 814079

814119

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-118B

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1805

DATE ANALYZED:

SAMPLE DEPTH: 0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT SW CORNER OF 2461 PORT SHELDON, 30 FT S. OF PAVEMENT.

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (85-90°F), WINDY (NNE)

PUMP #4 297642
8600
306242

*AMBIENT AIR BLANK PULLED THROUGH A NORMALLY RIGGED PROBE.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: Rozema

SAMPLE NUMBER: RZ-SG-119B

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1805

DATE ANALYZED:

SAMPLE DEPTH: 0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: SAME A RZ-SG-118B

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (85-90°F), WINDY (NNE)

Pump #2 840047
7700
847747
847801

✓ AMBIENT AIR BLANK PULLED THROUGH A NORMALLY RIGGED PROBE W/KINKED PE TUBING

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-120B

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1805

DATE ANALYZED:

SAMPLE DEPTH: 0'

SURVEY COORDINATE:

SAMPLE LOCATION: SAME AS RZ-SG-118B

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890 A

COMMENTS: SUNNY, HOT (85-90°F), WINDY (NNE)

PUMP # 3 ~~869564~~ ~~9313~~ ~~878877~~ TO 872200.

PUMP # 5 184200
11440
195640
GO TO 194640
194641.

* AMBIENT AIR BLANK PULLED THROUGH THE TENAX TUBE ALONE.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-121B

DATE SAMPLED: 7-19-87

TIME SAMPLED: 1800 (PUNCHED TUBE THROUGH BAG)

DATE ANALYZED:

SAMPLE DEPTH: 0'

SURVEY COORDINATE:

SAMPLE LOCATION: TRIP BLANK

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (85-90°F), BREEZY (NNE)

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-122B

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2225

DATE ANALYZED:

SAMPLE DEPTH: 0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: AT RZ-SG-065

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: DUSK, HOT (~80°F), MUGGY, CALM

PUMP # 5 ~~218270~~ ← PUMP DIED
~~11440~~
~~229710~~

PUMP #4 335891
6000
341891
342398

*AMBIENT AIR BLANK PULLED THROUGH PE-TUBING,

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA
SAMPLE NUMBER: RZ-SG-123B
DATE SAMPLED: 7-22-87
TIME SAMPLED: 2225
DATE ANALYZED:
SAMPLE DEPTH: 0'
SURVEY COORDINATE:
SAMPLE LOCATION: AT RZ-SG-065
ANALYSIS METHOD - DIRECT INJECTION
ABSCRPTION TUBE ✓
VOLUMETRIC CONTAINER USED: TENAX TUBE
GAS CHROMATOGRAPH USED: HP5890A
COMMENTS: DUSK, HOT (~80°F), MUGGY, CALM

PUMP #6 961843
8600
970443
971283

* AMBIENT AIR BLANK PULLED THROUGH TENAX TUBE ALONE.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-124B

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2130 TUBE POKED THROUGH BAG

DATE ANALYZED:

SAMPLE DEPTH: 0 FT

SURVEY COORDINATE:

SAMPLE LOCATION: TRIP BLANK

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: SUNNY, HOT (~80°F), MUGGY, CALM

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

SOIL GAS SAMPLE DATA SHEET

SITE NAME: ROZEMA

SAMPLE NUMBER: RZ-SG-125B

DATE SAMPLED: 7-22-87

TIME SAMPLED: 2130

DATE ANALYZED:

SAMPLE DEPTH: 0'

SURVEY COORDINATE:

SAMPLE LOCATION: TRIP BLANK W/CAPS REMOVED

ANALYSIS METHOD - DIRECT INJECTION

ABSORPTION TUBE ✓

VOLUMETRIC CONTAINER USED: TENAX TUBE

GAS CHROMATOGRAPH USED: HP5890A

COMMENTS: DUSK, HOT (~80°F), MUGGY, CALM

TRIP BLANK, NIBS REMOVED, TUBE PLACED BACK IN UNPUNCTURED BAG.

SAMPLING PERSONNEL: TJM

ATTACH COPY OF CHROMATOGRAM AND REPORT FORM

APPENDIX C

Calibration of the Air Sampling Pumps

The SKC air sampling pumps were calibrated before each sampling round. This was done to determine the number of counts that elapse on the odometer of a pump when one liter of air is drawn through a tenax filled trap tube. By knowing this, a pump can be properly monitored to determine accurately when one liter of soil gas has been purged through a trap tube during sampling.

An estimate of the number of counts that expire per minute was also made during calibration. This helps to determine approximately how long it will take a pump to purge the specified volume of soil gas.

Calibration is done by attaching a pipet bubblometer filled with a soap solution to the exhaust port of the air pump. A Tenax filled trap tube is then attached to the pump intake.

The pump is turned on and allowed to run until bubbles form in the soap solution. Some of these bubbles will rise inside the bubblometer while the pump is running. On the bubblometer is marked the distance over which 25 milliliters of air has been purged by the pump. As a bubble reaches the bottom hash mark, a note is taken of the counts on the pump odometer at that instant. At the same time, a stopwatch is engaged. When the bubble reaches the top hash mark, or the 25 milliliter mark, the stopwatch is disengaged and the pump shut off. The odometer reading at that time is then recorded.

This process is repeated four to five times per pump. The entries are made in a calibration log. The counts at the end of each run are subtracted from the count at the beginning of each run. This difference gives the count that expire while purging 25 milliliters of air thourgh the trap tube. The average of the differences from the tests of each pump is calculated. This average, multiplied by four and then by 10, gives the counts required to purge one liter through the sampling medium for given pump.

The average time from the air pump tests is also multiplied by 40 to give an approximation of the time that will elapse while purging one liter of soil gas with each pump.

APPENDIX D

Packing and Conditioning of Sample Trap Tubes

The Tekmar trap tubes used for the acquisition of soil gas samples were packed with Tenax (60/80 mesh) material and conditioned prior to each period of sampling.

One end of a tube was packed with clean glass wool. Tenax material was then poured into the tube until it was brimming. The Tenax was then packed down tightly into the tube with a small, two prong tamping rod. Glass wool was then pushed down tightly into the end used to fill the tube with Tenax. Care should be taken to pack each tube in as consistent a manner as possible. The amount, and packing of the Tenax material must be the same in each tube in order to minimize sampling and analytical inconsistencies.

After each trap tube was packed, it was necessary to bake the tubes in the Tekmar LSC-2 purge and trap device at 205 Deg. C for 20 minutes. This was done to remove any impurities in the tube. The tube was then desorbed in the LSC-2 and analyzed with the HP5890A Gas Chromatograph. This analysis determined the background integrity of each tube prior to sampling. It also provided a background, or preanalysis, chromatogram for each tube which served as a record of the quality of each tube.

APPENDIX E

Water Quality Sample Analysis Methodology

NUS CORPORATION/FIELD SCREENING

METHODOLOGY

Rapid Field Analysis of Purgeable Volatile Organic Compounds

1.0 SCOPE AND APPLICATION

This methodology uses purge and trap gas chromatography to accomplish the rapid analysis of volatile organic contaminants in aqueous matrices. Based upon EPA Method 624, allowances are made for field laboratory conditions and differences in analytical instrumentation/apparatus. (Because of the field screening focus, only PID/Hall or FID detection is used; mass spectrometric detection is not provided).

2.0 SUMMARY OF METHOD

A twenty ml aliquot of sample or sample dilution is placed into a fritted glass sparger and purged at ambient temperatures using inert nitrogen gas. As the nitrogen gas bubbles through the frit and matrix, it effectively strips the volatile organic contaminants from the sample. The stripped contaminants, now vaporous, exit the purge vessel and are passed onto a packed sorbent tube. The special packing within the sorbent tube adsorbs the organic contaminants while permitting the inert nitrogen gas to continue through the tube (and be vented into the atmosphere).

After the prescribed purging is complete, the sorbent tube is heated and backflushed for desorption into an awaiting pre-programmed gas chromatograph (GC). The contaminants are then separated and resolved chromatographically and an appropriate detector is used to detect the components of interest. GC peak integration is accomplished using a Shimadzu C-R3A data system or equivalent.

3.0 CALIBRATION; ANALYSIS AND QUANTIFICATION

Calibration standards containing the compounds of interest are prepared from commercially purchased stock standard mixes or pure solvent. All VOA standards are made in methanol by introducing appropriate ul aliquots of each compound. The ul injections required represent dilutions or are calculated from each parameter's density with consideration given to the individual response factors. The solvent-flush technique is utilized for all injections; surrogate spike standards are prepared in the same manner.

NUS CORPORATION/FIELD SCREENING

Calibration of the instrumentation is achieved via an absolute external standard calibration curve, where each parameter's response factor is calculated by analysing a mixed standard of known concentrations. Response factor (RF) = concentration divided by peak area or peak height. An identification file consisting of peak identification numbers, names, retention times (RT), RF's and concentrations is maintained and used as the integration standard. Sample concentration = sample peak area or height x parameter's RF (as determined from the calibration runs).

4.0 QUALITY ASSURANCE/QUALITY CONTROL

Each calibration standard is verified against a commercially available (Supelco) standard with regard to RT and RF. Certain standard operating procedures such as the thorough conditioning of columns and sorbent tubes prior to each day's analysis, periodic runs of standards and method blanks, use of surrogate spiking compounds, sample duplicates, dilutions and matrix spikes all serve to ensure the quality of results generated. An outline of QA/QC practices is depicted in the attached Figure 1.

5.0 REFERENCES

EPA Method 624; 44 CFR, No. 233

Bellar, T.A. and J.J. Lichtenburg. "Determining Volatile Organics at Microgram-per-liter Levels by Gas Chromatography." Journal AWWA; Volume 66, December 1974. Pages 739-744.

Figure-1

- Samples logged-in promptly upon receipt
- Samples stored at 4°C until analysis
- Analysis within seven (7) days of receipt
- Only stainless steel or borisilicate glass implements used
- Surrogate-spike compounds used in all analysis runs
- One duplicate run per ten (10) samples analysed
- One matrix spike run per ten (10) samples analysed
- Standard run after every ten (10) samples for continuing calibration
- Method blank analysis following every standard
- Standard response, surrogate-spike and matrix-spike recoveries calculated and tracked
- All computations double-checked
- Thorough and organized system for reporting data
- Formal validation or reported field screening results

APPENDIX F

Statistical Calculations

NUS CORPORATION AND SUBSIDIARIES | **STANDARD CALCULATION SHEET**

CLIENT:	FILE NO.:	BY: TJM	PAGE 1 OF 3
SUBJECT: STATISTICAL CALCULATIONS		CHECKED BY:	DATE: 1/22/88

CALCULATIONS OF REGRESSION EQUATIONS AND CORRELATION COEFFICIENTS FOR PCE AND TCA SOIL GAS AND WATER QUALITY DATA

DATA (PCE):

WELL/SOIL GAS SAMPLE	n	y	y^2	x	x^2	xy
	1	3	9	0	0	0
	2	100	10,000	0.35	0.1225	35
	3	30	900	0.263	0.069169	7.89
	4	33	1089	1.75	3.0625	57.75
	5	33	1089	1.98	3.9204	65.34
	6	41	1681	5.47	29.9209	224.27
	7	41	1681	4.26	18.1476	174.66
	8	46	2116	5.26	27.6676	241.96
	9	110	12,100	10.57	111.7249	1162.70
	10	210	44,100	28.06	787.3636	5892.60
	11	3	9	0.286	0.081796	0.858
TOTALS:		650	74774	58.249	982.081	7863.028

DATA (TCA):

	n	y	y^2	x	x^2	xy
	1	3	9	0	0	0
	2	3	9	0.153	0.023409	0.459
	3	3	9	0.182	0.033124	0.546
	4	1	1	0	0	0
	5	6	36	0.390	0.15210	2.34
	6	22	484	1.710	2.9241	37.62
	7	24	576	4.160	17.3056	99.84
TOTALS:		62	1124	6.595	20.438	140.805

(x = SOIL GAS CONCENTRATIONS
y = GROUNDWATER CONCENTRATIONS)

NUS 1554 REVISED 0285

NUS CORPORATION AND SUBSIDIARIES — *STANDARD CALCULATION SHEET*

CLIENT:	FILE NO.:	BY:	PAGE 2 OF 3
SUBJECT:		CHECKED BY:	DATE:

- CALCULATION OF REGRESSION EQUATIONS:

REGRESSION EQ. $y = A + BX$, WHERE

$$B = \frac{n\Sigma xy - \Sigma x \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}, \text{AND}$$

$$A = \frac{\Sigma y - B\Sigma x}{n}$$

PCE

$$B = \frac{11(7863.028) - (58.249)(650)}{11(982.081) - (58.249)^2} = 6.563$$

$$A = \frac{[(650) - (6.563)(58.249)]}{11} = 24.34$$

$$\boxed{y = 24.34 + 6.563\,x}$$

TCA

$$B = \frac{7(140.805) - (6.595)(62)}{7(20.43833) - (6.595)^2} = 5.792$$

$$A = \frac{[(62) - (5.792)(6.595)]}{7} = 3.400$$

$$\boxed{y = 3.4 + 5.792\,x}$$

NUS CORPORATION AND SUBSIDIARIES — **STANDARD CALCULATION SHEET**

CLIENT:	FILE NO.:	BY:	PAGE 3 OF 3
SUBJECT:		CHECKED BY:	DATE:

- CALCULATION OF CORRELATION COEFFICIENT:

$$\text{EQ.}\quad r = \frac{n\sum(xy) - \sum(x)\sum(y)}{\sqrt{\left[n\sum x^2 - (\sum x)^2\right] \times \left[n\sum y^2 - (\sum y)^2\right]}}$$

PLE

$$r = \frac{11(7863.028) - (58.249)(650)}{\sqrt{\left[11(982.081) - (58.249)^2\right] \times \left[11(74774) - (650)^2\right]}} = \boxed{0.893}$$

TCA

$$r = \frac{7(140.805) - (6.595)(62)}{\sqrt{\left[7(20.43833) - (6.595)^2\right] \times \left[7(1124) - (62)^2\right]}} = \boxed{0.9111}$$

NUS 155A REVISED 0285

BIBLIOGRAPHY

Anderson, M.P., 1984, Movement of contaminants in groundwater: Groundwater transport advection and dispersion, in Groundwater contaminantion, studies in geophysics: Washington, D.C., National Academy Press, p. 37-45.

Baver, L.D., Gardner, W.H., and Gardner, W.R., 1940, Soil physics: New York, John Wiley and Sons, 498 p.

Bear, J., 1972, Dynamics of fluids in porous media: New York, American Elsevier, 764 p.

Bear, J. 1979, Hydraulics of groundwater: New York, McGraw-Hill, 569 p.

Bedient, P.B., Borden, R.C., and Leib, D.I., 1985, Basic concepts for groundwater transport modeling, in Ward, C.H., Giger, W., and McCarty, P.L., (Ed.s), Groundwater quality: New York, John Wiley and Sons, p. 512-531.

Buckingham, E., 1904, Contributions to our knowledge of the aeration of soils: U.S. Bur. Soils Bull. 25, 52 p.

Chemical Rubber Company, 1974, Handbook of chemistry and physics: Cleveland, OH, CRC Press, 2280 p.

Cherry, J.A., 1987, Contaminant behavior in sand and gravel aquifers: Conference on groundwater quality, contaminants and movement, 8th, East Lansing, MI, 1987.

de Marsily, G., 1986, Groundwater hydrology for engineers: Orlando, FL, Academic Press, 440 p.

Eklund, B., 1985, Detection of hydrocarbons in groundwater by analysis of shallow soil gas/vapor: Washington D.C., American Petroleum Institute, 73 p.

Evans, D.D., 1965, Gas movement, in Black, C.A., (Ed.), Methods of soil analysis: Madison, Wisconsin, American Society of Agronomy, p. 319-330.

Farmer, W.J., Yang, M.S., Letey, J., and Spencer, W.F., 1980, Hexachlorobenzene: its vapor pressure and vapor phase diffusion in soil: Soil Science Society of America Journal, v. 44, p. 676-680.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, NJ, Prentice-Hall, 604 p.

Gillham, R.W., and Cherry, J.A., 1982, Contaminant migration in saturated unconsolidated geologic deposits, in Recent trends in hydrogeology: Geological Society of America Special Paper 189, p. 31-62.

Hillel, D., 1980, Fundamentals of soil physics: New York, Academic Press.

Hillel, D., 1982, Introduction to soil physics: Orlando, FL, Academic Press, 364 p.

Hinds, W.C., 1982, Aerosol technology, properties, behavior and measurement of airborne particles: New York, John Wiley and Sons, 408 p.

Jury, W.A., Spencer, W.F., and Farmer, W.J., 1983, Behavior assessment model for trace organics in soil: I. Model description: Journal of Environmental Quality, v. 12, no. 4, p. 558-564.

Karimi, A.A., Farmer, W.J., and Cliath, M.M., 1987, Vapor-phase diffusion of benzene in soil: Journal of Environmental Quality, v. 16, no. 1, p. 38-43.

Lapin, L., 1980, Statistics, meaning and method: New York, Harcourt Brace Jovanovich, Inc., 543 p.

Lappala, E.G., and Thompson, G.M., 1984, Detection of groundwater contamination by shallow soil gas sampling in the vadose zone, theory and applications: National Conference on the Management of Uncontrolled Hazardous Waste Sites, 5th, Washington, D.C., 1984, Proceedings, p. 20-28.

Lovelock, J.E., 1961, Ionization methods for analysis of gases and vapors: Journal of Analytical Chemistry, v. 33, no. 2, p. 162-178.

Mabey, W.R., Smith, J.H., Podoll, R.T., Johnson, H.L., Mill, T., Chou, T.W., Gates, J., Partridge, I., Jaber, H. and Vandenberg, D., 1982, Aquatic fate process data for organic priority pollutants: Final draft report: U.S. Environmental Protection Agency Report No. 440/4-81-014, Washington, D.C., Office of Water Regulations and Standards, 434 p.

Mackay, D.M., Freyberg, D.L., and Roberts, P.V., 1986, A natural gradient experiment on solute transport in a sand aquifer: 1. Approach and overview of plume movement: American Geophysical Union Water Resources Research, v. 22, no. 13, p. 2017-2029.

Marrin, D.L., 1985, Delineation of gasoline hydrocarbons in groundwater by soil gas analysis: The Hazardous Materials Management Conference/West, Long Beach, CA, 1985, Proceedings, p. 112-119.

---, 1986, Differences in remote detection of soil and groundwater contamination using soil gas analysis: Symposium on Engineering Geology and Soils Engineering, 22nd, Boise, Idaho, 1986, Proceedings, p. 422-431.

Marrin, D.L., and Thompson, G.M., 1984, Remote detection of volatile organic contaminants in groundwater via shallow soil gas sampling: Petroleum Hydrocarbons and Organic Chemicals in Groundwater Conference, Houston, Texas, 1984, Proceedings, p. 172-187.

Marshall, T.J., 1959, The diffusion of gases through porous media: Journal of Soil Science, v. 10, no. 1, p. 79-82.

Masterton, W.L., and Slowinski, E.J., 1973, Chemical Principals: Philadelphia, W.B. Saunders Company, 715 p.

Millington, R.J. and Quirk, J.M., 1961, Permeability of porous soilds: Transcripts of the Faraday Society, v. 57, p. 1200-1207.

Mills, W.R., 1986, Use of static soil vapor collectors to identify subsurface contamination in Southern California groundwater basins: National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, 6th, Columbus, Ohio, 1986, Proceedings, p. 71-87.

NUS Corporation, 1988, Groundwater contamination source investigation of the Rozema Garage Site, Ottawa County, Michigan: Unpublished Consulting Engineers report, 52 p.

Penman, H.L., 1940, Gas and vapor measurements in soil: I. The diffusion of vapors through porous solids: Journal of Agricultural Science, v. 30, p. 437-461.

Rommel, L.G., 1922, Luftväxlingen i marken som ekologisk faktor: Medd. Statens Skogsfarsöks-anstalt, v. 19, no. 2, 125 p.

Scheib; D.A., 1987, Personal communication.

Schwarzenbach, R.P., and Giger, W., 1985, Behavior and fate of halogenated hydrocarbons in ground water, in Ward, C.H., Giger, W., and McCarty, P.L. (Ed.s), Groundwater quality: New York, John Wiley and Sons, 547 p.

Schwille, F., 1984, Migration of organic fluids immiscible with water in the unsaturated zone, in Yaron, B., Dagan, G., and Goldshmid, J. (Ed.s), Pollutants in porous media: The unsaturated zone between the soil surface and the groundwater, London, Springer-Verlag, p. 27-48.

Schwille, F., 1988, Dense chlorinated solvents in porous and fractured media: Chelsea, MI, Lewis Publishers Inc., 146 p.

Shearer, R.C., Millington, R.J., and Quirk, J.P., 1966, Oxygen diffusion through sands in relation to capillary hysteresis: 2. Quasi-steady state diffusion of oxygen through partially saturated sand: Soil Science, v. 101, p. 432-436.

Sudicky, E.A., Gillham, R.W., and Frind, E.O., 1985, Experimental investigation of solute transport in stratified porous media: 1. The nonreactive case: American Geophysical Union Water Resources Research, v. 21, no. 7, p. 1035-1041.

Troeh, F.R., Jabro, J.P., and Kirkham, D., 1982, Gaseous diffusion equations for porous materials: Geoderma, v. 27, p. 239-253.

United States Department of Agriculture, Soil Conservation Service, 1972, Soil survey of Ottawa County, Michigan: Washington, D.C., U.S. Government Printing Office, 139 p.

United States Environmental Protection Agency, Appendix A to Part 136- Methods for organic chemical analysis of municipal and industrial wastewater: Federal Register, v. 49, no. 209, Part VIII, Friday, October 26, 1984, p. 141-154.

Verschueren, K., 1983, Handbook of environmental data on organic chemicals: New York, Van Norstrand Reinhold Company, 1310 p.

Walton, W.C., 1984, Practical aspects of groundwater modeling: National Water Well Association, 566 p.

Weeks, E.P., Earp, D.E., and Thompson, G.M., 1982, Use of atmospheric fluorocarbons F-11 and F-12 to determine the diffusion parameters of the unsaturated zone in the southern high plains of Texas: American Geophysical Union Water Resources Research, v. 18, no. 5, p. 1365-1378.

Zachara, J., 1986, Subsurface chemistry of hydrophobic and hydrophobic ionizable organic compounds: Short course notes, Kalamazoo, MI, 1986, 67 p.