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Date: February 28, 1996
Refer to: EM/ER:96-082

Mr. David Neleigh
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EPA, Region 6, 6PD-N
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Phase I Report

MAR 1996 RECEIVED

SUBJECT: SUBMITTAL OF RESOURCE CONSERVATION AND RECOVERY ACT FACILITY INVESTIGATION (RFI) REPORT FOR SOLID WASTE MANAGEMENT UNIT (SWMU) 0-039

Dear Mr. Neleigh:

Enclosed are two copies of the Los Alamos National Laboratory's RFI Report concerning SWMU 0-039, the site of the former dry cleaning solvent underground storage tanks. The report documents the fieldwork performed as detailed in the approved RFI Work Plan Addendum, Operable Unit 1071, SWMU 0-039, and the results of the sampling.

Please ask your office to contact Garry Allen at (505) 667-6080 or Bonnie Koch at (505) 665-7202 if you have any questions.

Sincerely,

sen, Program Manager
ıental Restoration

for Theodore J. Taylor, Program Manager
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e: RFI Report Concerning SWMU 0-039

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RFI Report for
Potential Release Sites

0-039

Field Unit 1

Environmental
Restoration
Project

February 1996

A Department of Energy
Environmental Cleanup Program

Los Alamos
NATIONAL LABORATORY

LA-UR-96-694

2-27-96

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EXECUTIVE SUMMARY

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Report describes the Phase 1 investigation performed at Technical Area (TA) 0, potential release site (PRS) 0-039.

PRS 0-039 is located in Los Alamos townsite, in an area known locally as the Community Center. Although, the site is currently outside the boundaries of Los Alamos National Laboratory (LANL), from approximately 1945 until 1968 the property was owned by the federal government. Since at least 1958, a building located at the site was leased to a dry cleaning business. Engineering drawings dated February 20, 1947, show that two underground storage tanks (USTs) were installed to store dry cleaning solvent. It is the location of these tanks, their adjoining pipelines, and the area immediately surrounding the site of the tanks that is specifically referred to as PRS 0-039. On November 1, 1968 the building and underlying real property were sold by the federal government into the private sector.

The tanks were removed from the site by private property owners in 1993. It was observed at the time of removal that some amount of chemical appeared to have been released from the tanks. Analysis of soil samples at that time indicated the presence of perchloroethylene (PCE), naphthalene, 1-methylnaphthalene, 2-methylnaphthalene, and unidentified organics.

The RFI Work Plan for OU 1071 Addendum identified the following as chemicals of potential concern (COPCs): Stoddard solvent™ (a dry cleaning solvent), volatile organic compounds (VOCs), and methylnaphthalene. The objective of the Phase 1 investigation of PRS 0-039 was to assess the nature and extent of organic chemicals potentially present at the site and to ascertain whether or not there were any human health or ecological risks associated with any COPCs that may be present.

The chemicals resulting from the AEC leased dry cleaning facility and retained as COPCs by the screening process at PRS 0-039 were determined by the risk assessment to be present only at levels that are more than an order of magnitude below the lowest observed adverse effect level.

Although a PCE plume was detected in the area, the PCE is not retained as a COPC for PRS 0-039. The PCE plume is not associated with the UST system used for Stoddard solvent™ storage or with previous AEC operations at this site. Evidence that LANL has no responsibility for the PCE plume includes transport calculations that demonstrate that the PCE plume substantially post-dates the AEC's ownership of the site.

Results of the Phase I investigation indicate there are no COPCs present at concentrations that present a human health risk, therefore PRS 0-039 is recommended for no further action (NFA).

TABLE ES-1

SUMMARY OF PROPOSED ACTIONS

		PROPOSED ACTION			
PRS	HSWA	NFA Criteria	Further Action	Rationale	Section #
0-039	X	4		No Human Health Risk	5.1.7

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1.0 INTRODUCTION

This report presents the results of the Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) at Technical Area 0 (TA-0), potential release site (PRS) 0-039. This report includes the site-specific investigation activities, data assessment, and analysis approach used in the Phase I investigation. Also included are the site-specific results, conclusions, and recommendations for PRS 0-039.

1.1 General Site History

PRS 0-039 is located within the townsite of Los Alamos, New Mexico (Fig. 1.1-1). It is in an area known locally as the Community Center which is outside the current boundaries of the Los Alamos National Laboratory (LANL) (Fig. 1.1-2). The Community Center (the area bounded by 15 th St., 19 th St., Myrtle St., and Central Ave.) was owned by the Atomic Energy Commission (AEC) following the Manhattan Project, i.e., from approximately 1945 until 1968. Sometime prior to 1958, two 700-gallon underground storage tanks were installed to store dry cleaning solvent. Subsequently, specific locations at the site were leased to private business operators by the AEC through its property management contractor. The building and certain improvements located at 1324 17 th St. were leased to Roger Corbett doing business as (d/b/a) Corbett Cleaning Company, a private retailer who owned and operated a dry cleaning business. The Community Center was sold into the private sector in November 1968. It is the location of the above referenced tanks, their adjoining pipelines, and the area immediately surrounding the site of the underground storage tanks that is specifically referred to as PRS 0-039. Federal regulations include the tank and associated underground piping under the designation underground storage tank (UST).

Removal of the tanks was commissioned in 1993 by the current owners of the Community Center, but the pipelines were not removed and still remain. A walkway currently exists above the site of the former tanks and remaining pipelines. The walkway passes between the building located at 1324 17 th St., and a newer building located at 1400 17 th Street. During June 1993, an environmental assessment was conducted by Glorieta Geoscience, Inc. on behalf of certain private parties, including the current property owners. Solvents were detected in the soil in the immediate vicinity of the tanks during their removal (GGI 1993, 05-0222). An assessment indicated that the contamination extended to an area that was greater than first expected; therefore, the excavation was halted and the excavation was backfilled with clean fill material (GGI 1993, 05-0222). The New Mexico Environmental Department (NMED) UST Bureau has not granted closure on the site.

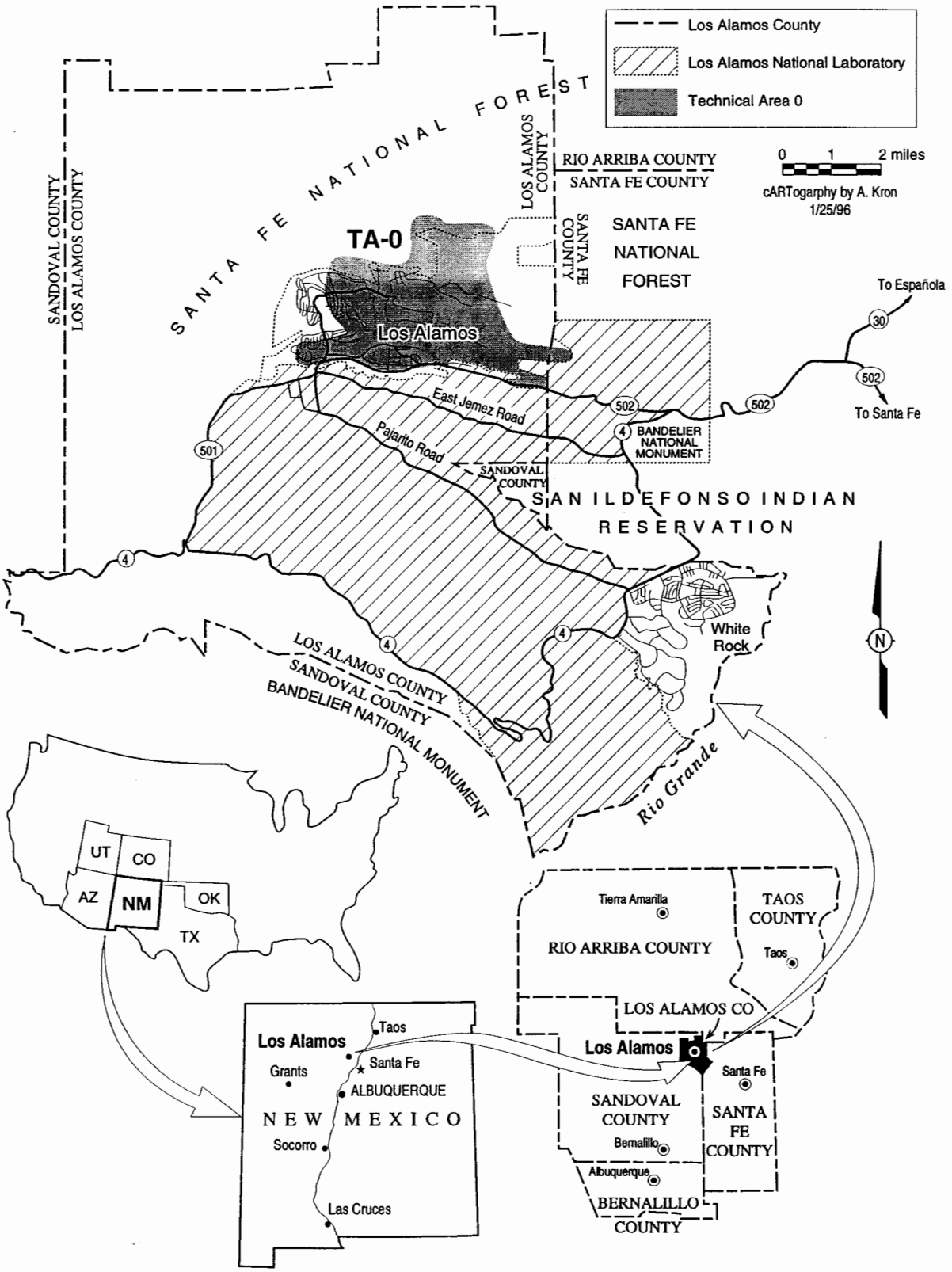

Fig. 1.1-1. Location map of TA-0 within Los Alamos National Laboratory, Los Alamos County, New Mexico.

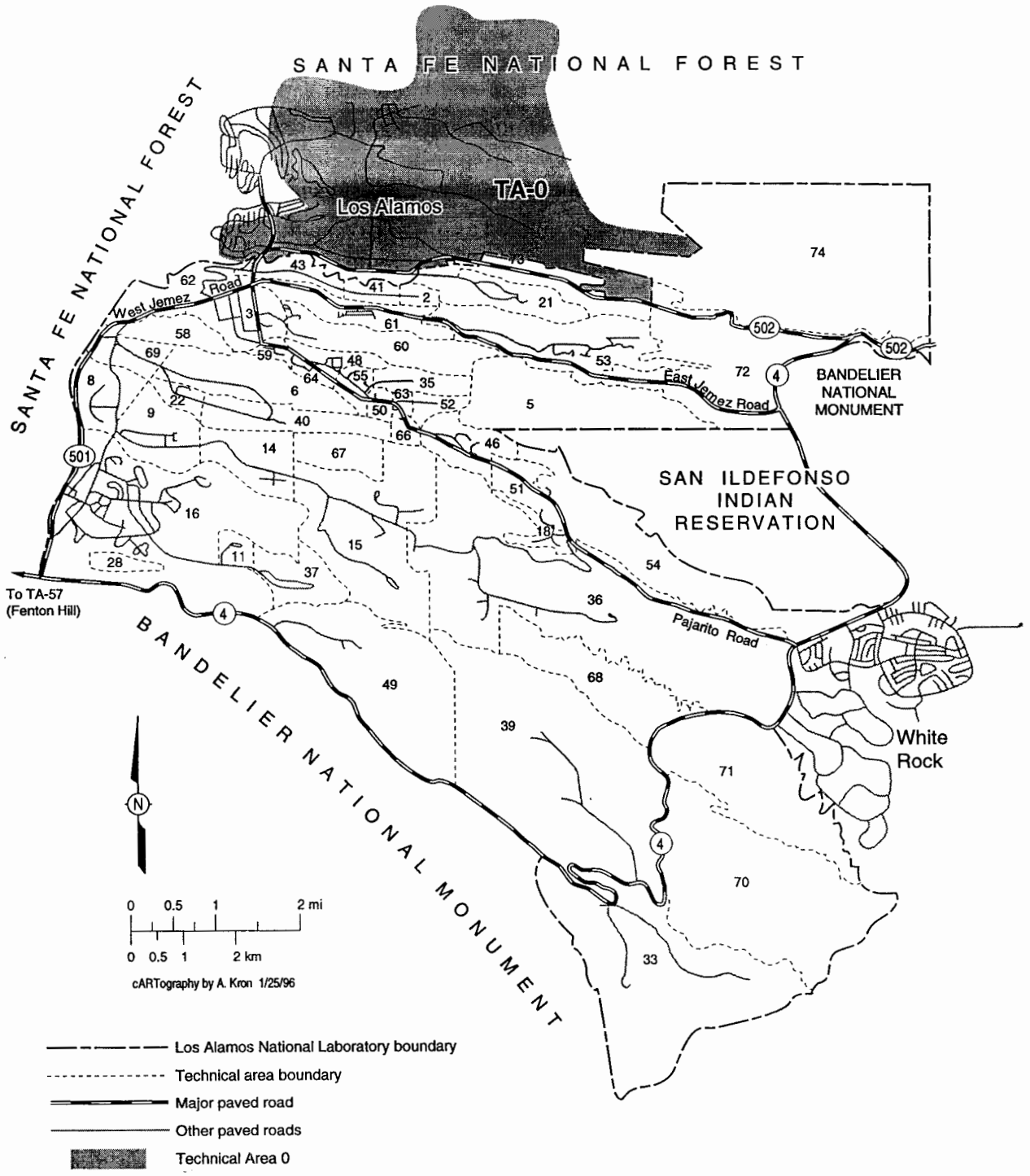

Fig. 1.1-2. Location of TA-0 with respect to Laboratory TAs and surrounding landholdings.

Prior to this Phase I RFI, information regarding the nature and vertical extent of contaminants in subsurface soil/tuff in the vicinity of the former dry cleaning solvent USTs was based on analytical data collected during the Glorieta Geoscience environmental assessment (GGI 1993, 05-0222).

Additional sources of information collected over the course of the investigation includes correspondence from the NMED UST Bureau and interviews with the current owner of the property, an employee of the former dry cleaning company, and other individuals.

As a result of the 1993 investigation and environmental assessment, chemicals of potential concern (COPCs) for PRS 0-039 were identified as organic components of Stoddard solvent™, a solvent that had been widely used for dry cleaning. Stoddard solvent™ is a mixture of 1) total petroleum hydrocarbons (TPHs) including hydrocarbon-substituted cyclic hydrocarbons (mainly cyclohexanes, cyclopentanes, and cyclooctanes), substituted decahydronaphthalene compounds (Decalin™), and trace amounts of substituted benzene compounds (including trimethylbenzenes and tert-butylbenzene); 2) polycyclic aromatic hyrocarbons (PAHs), specifically naphthalene, 1-methylnaphthalene and 2-methylnaphthalene; and 3) other volatile organic compounds (VOCs). Another VOC of potential concern is perchloroethylene (PCE; also known as tetrachloroethylene).

On July 5, 1994, the DOE requested that the US Environmental Protection Agency (EPA) add the USTs, designated as PRS 0-039, to the Laboratory's operating permit (DOE 1994, 05-0220). This request was granted by the EPA on July 21, 1994 (EPA 1994, 05-0221).

1.2 Phase I Work Plan Overview

The objective of the Phase I investigation at PRS 0-039 was to assess the nature and extent of any contaminants that may have been released from the former dry cleaning solvent USTs or any associated pipelines. Soil at the PRS potentially contains the following COPCs: Stoddard solvent™, naphthalene, 1-methylnaphthalene and 2-methylnaphthalene and PCE. To assess the nature and define the extent of contaminant migration, exploratory boreholes were to be drilled and cored or hand-augered to investigate the UST system.

A conceptual exposure model was developed describing the potential sources of contamination, potential pathways for contaminant migration, and potential pathways to human receptors (LANL 1994, 1287). The conceptual model provides a basis for the proposed field investigations. Based on previous sampling results and other available information, chemicals asssociated with dry cleaning processes (Stoddard solvent™ and PCE) are present in the subsurface soil/tuff. These chemicals may leach/disperse through the vadose zone, migrate upward by vapor phase diffusion, and enter the atmosphere. Exposure pathways include inhalation of volatilized organic compounds in air, ingestion of soil particles, and dermal contact with soil. COPCs to be considered in a risk assessment were identified through a screening assessment, and a human health risk assessment was performed by considering concentration, extent of contamination, and reasonable pathways of exposure to potential contaminants.

1.3 Field Activities

The RFI fieldwork activities at PRS 0-039 began May 25, 1995, and were completed by August 1, 1995. The fieldwork consisted of exploratory borehole drilling and core sampling to define the extent of the release from the USTs. In addition, holes were hand-augered adjacent to and beneath the subsurface piping in order to determine whether or not a release occurred from the piping. Drilling and sampling operations were conducted following appropriate LANL Environmental Restoration (ER) Project Standard Operating Procedures (SOPs) (LANL 1993, 0875) and were in compliance with the NMED UST Bureau regulations. Samples were field screened using headspace analyses and then delivered under chain-of-custody to a mobile chemical analytical laboratory (MCAL) for further analysis.

2.0 ENVIRONMENTAL SETTING

The environmental setting for the Laboratory is described in Section 2.4 of the Installation Work Plan (IWP) for Environmental Restoration (LANL 1995, 1164). A detailed discussion of the environmental setting for the Community Center area, including climate, geology, hydrology, and a conceptual hydrogeologic model for the area and its surroundings, is presented in the RFI Work Plan for Operable Unit 1071 and its addendum (LANL 1992, 0781; LANL 1994, 1287). A summary is presented in the following sections.

2.1 Climate

Los Alamos County has a semiarid, temperate, mountain climate. Summers are generally sunny with moderate, warm days and cool nights. High altitude, light winds, clear skies, and dry atmosphere allow summer temperatures to range from 50°F to 90°F for the Community Center area. During the winter, temperatures typically range from 15°F to 50°F. The average annual rainfall in the area of the Community Center is estimated as 18 in. Of this total, approximately 40% occurs as brief, intense thunderstorms during July and August.

2.2 Geology

2.2.1 Geologic Setting

A detailed discussion of the geology of the entire Los Alamos area can be found in Section 2.5.1.3 of the IWP (LANL 1995, 1164). A summary of that material, emphasizing conditions expected near the Community Center, is presented below.

Los Alamos townsite is located on the Pajarito Plateau. PRS 0-039 is on East Mesa at an elevation of 7 308 ft. The area is bounded on the south by Los Alamos Canyon and on the north by Pueblo Canyon. The natural drainage from this site is to the south and southeast toward Los Alamos Canyon, a distance of 1 800 ft from the site to the canyon. Bedrock at the site is Bandelier Tuff (Fig. 2.2.1-1), composed of air fall and ash flow deposits of silicic volcanic rock from eruptions 1.5–1.2 million years ago. For mesa-top sites, about 1 200 ft of unsaturated tuff and volcaniclastic sediments separate the surface from the main aquifer discussed in Section 2.3.2 .

2.2.2 Soils

A detailed discussion of the soils in the Los Alamos area can be found in Section 2.5.1.3 of the IWP (LANL 1995, 1164). A summary of that material specific to PRS 0-039 is presented below.

The soil at PRS 0-039 is composed of moderately well developed B and C horizons on Bandelier Tuff, composed of compacted air-fall and ash-flow deposits of silicic volcanic rock (Fig. 2.2-1). When the USTs were excavated in 1993, a backfill material was deposited onto the site above the Bandelier tuff. Soils around the townsite probably belong to either the Carjo or Pogna Soil Series (Nyhan et al. 1978, 0161). Carjo soils consist of moderately deep, well drained, and moderately developed soils that form an A–Bt–C horizon sequence. Soil textures can range from clay loam to fine sandy loams. The Pogna soils consists of shallow, well drained, and weakly developed soils that comprise an A–C horizon sequence. The soil texture

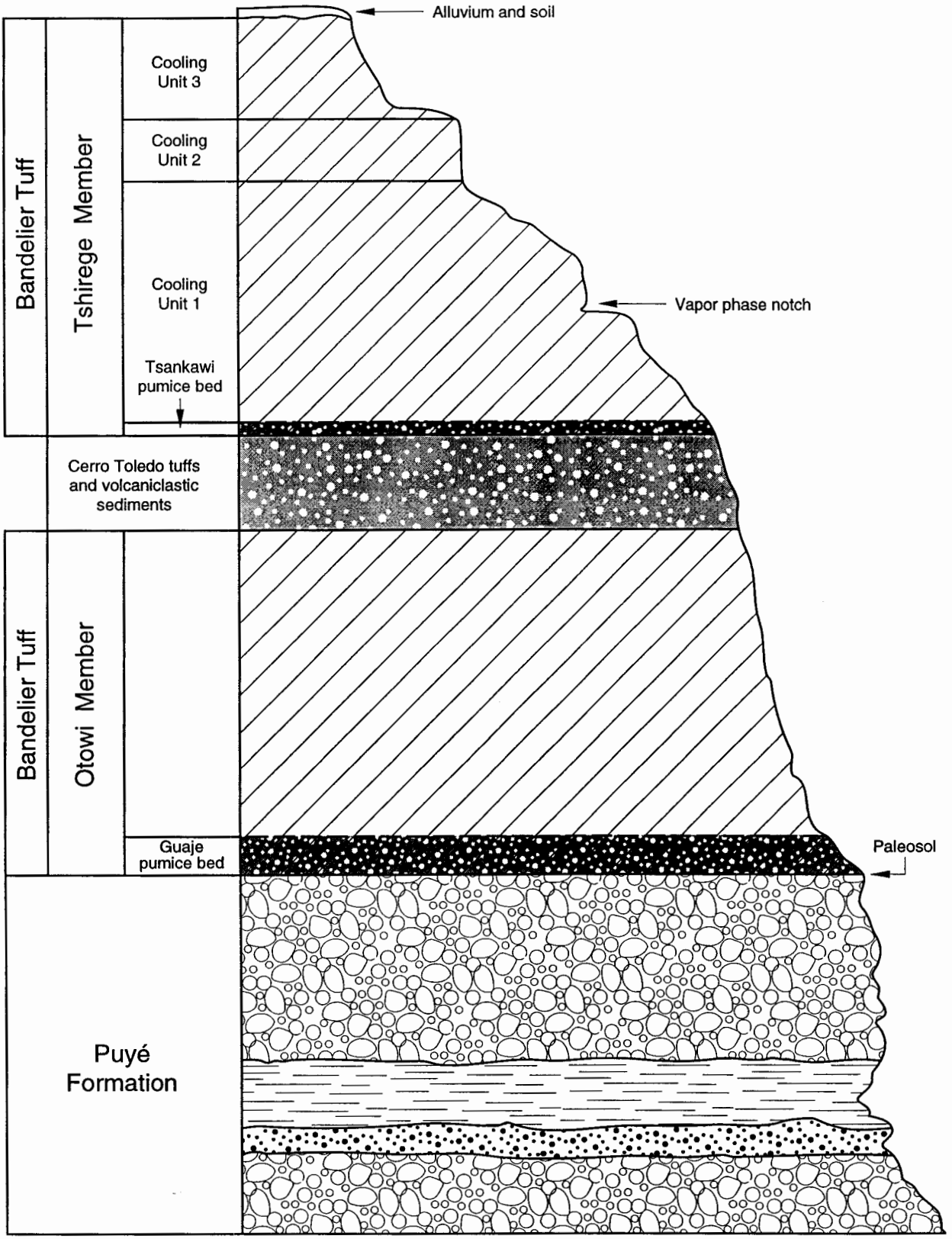

Fig. 2.2.1-1. Stratigraphy of TA-0.

of Pogna soil is usually fine sandy loams. The substrate underlying these soils may range from Bandelier Tuff to stratigraphic sequences of alluvium/colluvium interstratified with moderately developed to well developed buried soils. Other soil types may also exist within the townsite area. Site-specific geotechnical properties of soil were observed for samples collected in borehole B4 (presented in Section 5.1.4)

2.3 Hydrology

The hydrology of the Parjarito Plateau is summarized in Section 2.5.2 of the IWP (LANL 1995, 1164). Site-specific conditions are summarized below.

2.3.1 Surface water

PRS 0-039 is a commercially developed area located on a mesa top. There is no surface water present at this site other than run off following a rain storm or from snowmelt.

2.3.2 Ground water

The main aquifer beneath East Mesa is at an elevation of approximately 6 000 ft in the sediments of the Puyé and Totavi Formations. At mesa-top sites such as PRS 0-039, the surface is separated from the main aquifer by an unsaturated zone that is 1 000 ft to 1 300 ft thick. Although no perched aquifers are known to exist in the immediate vicinity of PRS 0-039, a perched aquifer has been located at an intermediate depth (325 ft below Los Alamos Canyon) in drill hole LADP-3 at nearby TA-21 approximately 2 mi (3 km) east of the site. A shallow alluvial aquifer is present in nearby Los Alamos Canyon. The lateral continuity of these aquifers is not known, although there is no reason to believe that a perched aquifer is present beneath PRS 0-039 (Broxton and Eller 1995, 1162).

2.4 Biological Surveys

Comprehensive plant and animal inventories are required by the Federal Endangered Species Act of 1973; the New Mexico Wildlife Conservation Act; Executive Order 11990, "Protection of Wetlands"; Executive Order 11988, "Floodplain Management"; 10 CFR 1022; Compliance With Floodplain/Wetlands Environmental Review Requirements (DOE 1979, 0633) and DOE order 5400.1, General Environmental Protection Program (DOE 1988, 0075). PRS 0-039 is characterized by heavy commercial development and urban disturbance from the Los Alamos townsite. Because of this high level of disturbance, plant and animal inventories are not relevant and were not performed for this site.

2.5 Cultural Surveys

The National Historic Preservation Act requires a cultural resource survey. However, a survey was not conducted in the area of PRS 0-039 because the site is a commercially developed, urban area, and a survey would be irrelevant.

3.0 APPROACH TO DATA ASSESSMENT AND ANALYSIS

The decision approach used for the Community Center, PRS 0-039, involves a series of quantitative steps that occur after the field investigation, chemical analyses, and data reporting are complete. These steps begin with routine data validation and continue with more focused data validation, if necessary. Routine validation involves validating each data item against specific targets and adding qualifier flags to the data signifying a potential deficiency. Focused validation consists of analyzing quality assurance/quality control (QA/QC) data for their potential impact on the succeeding data assessment steps: i.e., verifying the identities of detected organic chemicals, comparing site data to SALs for human health impacts, and performing human health risk assessments when necessary. The following subsections provide overviews of the methods used to complete these quantitative steps. Further details can be found in Technical Approach to RFI reports (LANL in preparation, 1281).

3.1 Sample Analysis

All samples requiring chemical analysis and chain-of-custody documentation are submitted to the the MCAL for analysis. Only the MCAL form of analysis was used at the Community Center.

3.1.1 Analytical Methods

All samples were analyzed using modified Environmental Protection Agency (EPA) SW-846 Methods or equivalent (see Section 4.0).

3.1.2 Data Validation

Data verification and validation procedures are used to determine whether data packages have been generated according to specifications, are of known quality, and contain the information necessary to determine data sufficiency for decision making.

Data verification is a check of data deliverables against a set of stated requirements to ensure that what has been ordered has been delivered, thus indicating that the laboratories can be paid. All analytical data generated in support of the ER Project are verified.

Data validation is the process of determining whether individual results (a datum) can be reliably used to support the decision-making process. During the process, validators determine whether data should be qualified or used with caution because of the potential impact of noted flaws or the failure to achieve analytical precision or bias constraints.

Routine validation is the comparison of quality indicators (such as surrogate recovery, measurements of method blanks, holding times, and differences between replicate measurements) with clearly defined limits to determine whether limitations may need to be placed on the use of the data. Routine validation is most suitable for routine analyses and for those nonroutine analyses for which clearly defined limits have been established.

The focused data validation process addresses those characteristics of the data (e.g., precision and bias) that directly affect the decisions to be based on the data. The same data set may undergo different focused validations for different decisions.

3.2 Background Comparisons

Samples were not analyzed for inorganic or radionuclide constituents; therefore, background comparisons are not necessary.

3.3 Evaluation of Organic Constituents

The preliminary evaluation of organic chemicals considers detected chemicals and chemicals that were analyzed for but not detected in any sample. The purpose of this decision step is to determine if organic chemicals should be retained as COPCs or eliminated from further consideration based on detection status. Detection status is determined by the analytical laboratory on a sample-by-sample, analyte-by-analyte basis. Estimated quantitation limits (EQLs) have been established for each analyte as reporting limits when the analyte is not detected. It should be noted that the EQLs reported for individual samples are dependent on a number of factors and may vary from sample to sample and from analysis to analysis. Therefore, the sample-specific EQL for a chemical must be used in this comparison.

If a chemical has a reported concentration that exceeds its estimated quantitation limits, then that chemical is generally carried forward through the screening assessment process. If a chemical does not have a reported concentration that exceeds its estimated quantitation limits, then that chemical is generally removed from further consideration. Exceptions to these general rules may be made if site-specific process knowledge so indicates. A chemical that is

detected may be removed from further consideration if it can be determined that its presence is not due to Laboratory operations, and a chemical that is not detected in any sample may be carried through the decision process if the chemical can be expected to be present at the site based on historical operations.

3.4 Human Health

3.4.1 Screening Assessment

The purpose of this decision step is to determine if chemicals should be retained as COPCs or eliminated from further consideration based on comparisons with SALs. This is the last step in the screening assessment process for human health concerns. If COPCs remain after this step, then further action may be proposed. If no COPCs remain after this step, then no further action (NFA) may be proposed based on human health concerns. SALs are medium-specific concentrations that are calculated using chemical-specific toxicity information and conservative, default exposure assumptions. For those chemicals for which SALs are available, each observed concentration datum is compared to the chemical's SAL. If a chemical has a reported concentration greater than its SAL, then that chemical is retained as a COPC pending further analysis. If a chemical does not have a reported concentration greater than its SAL, then that chemical is generally removed from further consideration. If more than one chemical is present at the site, this decision is deferred pending the results of the multiple chemical evaluation (described below). The decision to identify a chemical as a COPC when a SAL is not available is made on a case-by-case basis, taking into account the availability of process knowledge and toxicological information.

It is possible that COPCs should be retained because of the combined adverse health effects of several chemicals. This possibility is evaluated in the multiple chemical evaluation (MCE), in which the reported concentration for each chemical is divided by its respective SAL, and the resulting "normalized" values are incorporated into a simple additive model. If the sum of the normalized values (i.e., the total normalized value) is less than one, then the chemicals are removed from further consideration. If the total normalized value is greater than one, then chemicals having an individual normalized value greater than or equal to 0.1 are retained as COPCs pending further evaluation.

Only those organic chemicals that exceed reporting limits in at least one sample are included in the multiple chemical evaluation. These chemicals are divided into three classes: noncarcinogens, chemical carcinogens, and radionuclides. Additive effects are assumed within each class, but each class is evaluated separately. For further information on the calculation of multiple chemical evaluations see Technical Approach to RFI Reports (LANL in preparation, 1281).

3.4.2 Risk Assessment

The human health risk assessment(s) presented in Chapter 5 follow the guidance document Risk-Based Corrective Action Process (LANL/SNL 1996, 1277). The human health risk assessment process consists of the following four steps:

- identification of COPCs,
- exposure assessment,
- toxicity assessment, and
- risk characterization.

A human health risk assessment was performed for PRS 0-039 and is presented in Subsection 5.1.7.2.

3.5 Ecological

The Community Center is a mesa-top site surrounded by disturbed areas. The area provides limited habitat for biota, does not contain sensitive habitats, and threatened or endangered species are not present there (Ebinger et al. 1994, 01-0007). Therefore, there is no immediate ecological risk at this site.

4.0 RESULTS OF QUALITY ASSURANCE/QUALITY CONTROL ACTIVITIES

Samples from drilled boreholes, surface soil locations, and hand-auger borings were collected at the PRS 0-039 site. Soil was screened in the field for potential organic contaminants by headspace analysis using a photoionization detector (PID). Samples were also taken to the MCAL for further analysis. The samples were analyzed for Stoddard solvent™ and VOCs including PCE and trichloroethylene (TCE; a breakdown product of PCE). In addition, the hand-auger samples were analyzed for 1-methylnaphthalene and 2-methylnaphthalene. The presence of Stoddard solvent™ can be determined by the occurrence of certain peaks apparent in the chromatogram that are indicative of the solvent by TPH analysis. TPH analyses were performed using gas chromatography (GC)/flame ionization detector (FID) and a modified SW-846 method 8015. The only QC parameters included with these TPH analyses were a daily performance standard and blank sample. Analysis of the blank sample ascertains whether any contamination is present as a laboratory or method artifact and the daily performance sample provides an instrument calibration check. The VOCs analyses were performed using GC/mass spectroscopy (MS) following a modified SW-846 method 8260. The MCAL provided internal daily standard and blank data, along with quantitation sheets, chromatograms, and mass spectra for all samples. The internal daily standards provide linear instrument calibrations. The methylnaphthalene analyses were performed following a modified SW-846 method 8015 using GC/FID with a methylene chloride shake-out. The method did not include the use of internal standards or surrogates which would have indicated extraction efficiency.

As a result of QA/QC activities, qualifiers are added to the data when necessary as part of routine data validation activities. The following is a list of the qualifiers used in this RFI Report and their definitions:

U = Undetected quantity. The analyte was not detected in the sample above the EQL.

J = Estimated quantity. The analyte was detected in the sample, but there were one or more QC parameters associated with this sample that were outside allowed limits.

UJ = Estimated undetected quantity. The analyte was not detected in the sample, but there were one or more QC parameters associated with this sample that were outside allowed limits.

R = Rejected quantity. The data are deemed not usable because one or more of the QC parameters for the analyte were outside allowed limits to the point that the analyte value is highly questionable.

E = The detected level of concentration was above the linear calibration range of the instrument.

UB =The analyte was detected in the sample and the blank at similiar concentrations and the EQL was raised to the detected concentration.

There can be many reasons for qualifying analytical data. For example, there is a set of QC parameters which are sample specific that can cause analytes from individual samples to be qualified, such as surrogate recoveries or duplicate results. There are also batch-specific parameters such as blind QC samples and method blanks which affect all of the samples analyzed in a particular group. Often, the quantity of QA/QC data available for site-specific investigations is inadequate for estimating components of measurement error because statistics cannot be defined for sample sizes of one, and cannot be estimated well with small sample sizes. Consequently, QA/QC data for site-specific investigations will rarely be used to adjust data.

4.1 Inorganic Analyses

No inorganic analyses were performed at this site.

4.2 Organic Analyses

The sample analyses were reviewed in logical groups based on the delivery of the data from the MCAL. These groups were assigned a number related to the date the MCAL delivered the data for review and are referred to as group designation numbers. Organic analyses were performed using the three methods of analyses stated above. Both TPH and VOC analyses can indicate the presence of Stoddard solvent™, PCE, and TCE, COPCs under investigation. The detection of methylnaphthalenes can also indicate the presence of Stoddard solvent™.

4.2.1 Stoddard Solvent Analyses

For all of the Stoddard solvent™ analyses the performance standards were within allowed limits. The group designations and number of samples associated with each sample group are as follows: 25May95, 7 samples; 26May95, 2 samples; 30May95, 11 samples; 31May95, 4 samples; 01June95, 8 samples; 02June95, 4 samples; 05June95, 9 samples; 06June95, 7 samples; 07June95, 7 samples; 08June95, 5 samples; 12June95, 15 samples; 14June95, 12 samples; 19June95, 7 samples; 20June95, 10 samples; 27June95, 12 samples; 28June95, 10 samples; 07July95, 8 samples; 12July95, 22 samples; 17July95, 1 sample; 20July95, 9 samples; 21July95, 6 samples; 26July95, 6 samples; 28July95, 6 samples; and 01August95, 8 samples. All data are valid without qualification except as noted below.

For 06June95, five soil and two water rinsate samples were analyzed for Stoddard solvent™. Although the instrument quantitation page indicated that between 1.9 mg/kg and 14 mg/kg of TPH were detected in samples 0100-95-0069, -0071, -0072, -0073, and -0080, the detections were not reported as such because the peaks did not match the pattern for Stoddard solvent™. The peaks appeared to be some other type of hydrocarbon mixture that included light to heavy hydrocarbons. These were reported as tentatively identified compounds (TICs) because they were not part of the target analyte compounds in the analysis. The only occurrence of TICs is in this group designation.

For 07July95, seven soil samples were analyzed for Stoddard solvent™. The highest value detected by the MCAL was 91 mg/kg. Because the correlation between the headspace and the Stoddard solvent™ analytical results predicted higher concentrations of the solvent than detected, the MCAL results were less than expected. The samples were rerun and higher concentrations were detected (up to 270 mg/kg). These values were still not as high as expected considering a screening value detected during headspace analysis using a PID, was 1 200 ppm. The data appear to be correct as reported. The variation in the results is likely due to the heterogeneity of the soil samples.

For 12July95, 22 soil samples were analyzed for Stoddard solvent™. The instrument quantitation page showed a single peak indicating between 1.9 mg/kg and 49 mg/kg of TPH were detected in the samples 0100-95-0206 through -0211. These detections were not reported as such because the single peak detected did not match the pattern for the solvent. The peak appeared to correlate with the PCE detected in these samples by GC/MS.

For 21July95, six soil samples were analyzed for Stoddard solvent™. Although samples 0100-95-0224 and -0226 were originally reported as containing high levels of Stoddard solvent™ in the samples, the final results were reported as containing only 46 mg/kg and 154 mg/kg of Stoddard solvent™, respectively. The data were changed by the analyst because of a single peak in each chromatogram that did not match the pattern for Stoddard solvent™. The peak appeared to correlate with the PCE detected in these samples by GC/MS. The data were corrected by subtracting the area for the large peak in the chromatograms indicating PCE from the Stoddard solvent™ response, thereby lowering the reported concentrations of Stoddard solvent™.

For 01August95, eight soil samples were analyzed for Stoddard solvent™. The samples were analyzed using GC/MS using instead of the GC/FID that was used for all other Stoddard solvent™ analyses. The standard that was provided by the laboratory did not include an area response for Stoddard solvent™. Because of the change in method and the missing

documentation on the standard results, the data are considered only for the purpose of screening. Review of the data provided indicates that Stoddard solvent™ was not present in the samples at or above the reported quantitation limit (1 mg/kg).

4.2.2 VOCs Analyses

For VOC analyses the group designations and number of samples associated with each sample group are as follows: 25May95, 7 samples; 26May95, 2 samples; 30May95, 11 samples; 31May95, 4 samples; 01June95, 8 samples; 02June95, 4 samples; 05June95, 10 samples; 06June95, 7 samples; 07June95, 7 samples; 08June95, 5 samples; 12June95, 15 samples; 14June95, 12 samples; 19June95, 7 samples; 21June95, 10 samples; 27June95, 11 samples; 28June95, 10 samples; 29June95, 1 sample; 07July95, 8 samples; 12July95, 21 samples; 13July95, 1 sample; 20July95, 21 samples; 27July95, 7 samples; 25July95, 6 samples; and 01August95, 8 samples.

One characteristic of all of the analyses for VOCs is that levels of analytes found in the method blanks have been subtracted from the sample data by the MCAL analyst. If the concentration of an analyte in a sample was within the range of the blank levels, the analyst assigned a qualifier of not detected (ND) for the analyte with the detection limit as the concentration value. This gives a low estimate for the detection limit. To calculate a more realistic detection limit for these compounds, the value in the blank should be multiplied by the appropriate dilution factors for each sample and then the amount in the sample should be reported as a detection limit if it is less than 5 times the blank amount (or 10 times the blank for acetone, methylene chloride, and toluene). For many of the samples, the analyst raised the detection limit for methylene chloride and acetone to mitigate the effects of the blank contamination. Only cases of blank contamination that impact the reported data are discussed in the summaries below.

Another characteristic of the data reported is that the data are censored to the estimated quantitation limits. The estimated quantitation limits given for the samples does not account for the sample size; therefore, the number reported is the same for all samples of the same dilution. It is more common to report a sample quantitation limit and report results that are below this limit if the detection meets the specified detection criteria . Because mass chromatograms were not provided for detections below the reporting limit, there was no way to determine if the instrument detections met the detection criteria or not. The data are not qualified for this deficiency; however, it is important to note the censoring of the data.

Many of the sample results indicated the presence of a major peak not related to any target analytes. This peak was in most samples at levels ranging from less than 10% of the internal standard area to greater than 100 times the internal standard height. These peaks were

identified as siloxane by the analyst. The analyst further explained that these peaks are instrumental contamination related to breakdown of coatings within the instrument. These (TICs) are not discussed in the following summaries, except where the TICs impact the reported results.

For most calibrations conducted for the VOCs analyses, several compounds indicated possible problems. The compound pairs 2-chlorotoluene/4-chlorotoluene, t-butylbenzene/ isopropylbenzene, 1,3-dichlorobenzene/1,4-dichlorobenzene, and cis-1,2-dichloroethene/ trans-1,2-dichloroethene either coeluted or were misidentified by the GC/MS software. Because these compounds were not detected, no data are qualified for this deficiency. In addition, 1,2,3-trichloropropene was found to be improperly quantitated on the bromofluorobenzene (BFB) peak for most standards and samples analyzed. Again, because this compound was not identified in the investigative samples, data are not qualified for this deficiency.

For the group designations, 26May95, 31May95, and 13Jul95, all QC results reported are within acceptable limits. All data are valid without qualification. For the remaining group designations the pertinent review comments follow.

For 25May95, seven samples were analyzed for VOCs. Two samples (0100-95-0000 and -0004) were re-analyzed because of low internal standard recoveries. For both samples the internal standard recoveries remained below 20%, indicating a possible matrix interference. All results for samples 0100-95-0000 and -0004 are qualified as estimated (UJ). Several samples showed the possible presence of non-target compounds that were not reported. All other data are valid without qualification.

For 30May95, ten soil samples and one water rinsate sample were analyzed for VOCs. Several samples (the method blank, 0100-95-0020, -0025, -0026, and -0283) had high surrogate recoveries for 1,2-dichloroethane-d4, one sample (0100-95-0022) had a high recovery for toluene-d8, and one sample (0010-95-0023) had a 0% recovery for BFB. The reported results for the method blank and samples -0020, -0025, -0026, -0283 were acceptable because none of the samples had detections of compounds that could be related to 1,2-dichloroethane-d4. In addition, the second internal standard recovery remained below acceptable levels in the rerun of sample 0100-95-0022, indicating a possible matrix interference. All results for samples 0100-95-0022 and 0023 are qualified as estimated (UJ or J) for potential low bias. For sample 0100-95-0022, the xylenes and trimethylbenzenes are reported from analytical results that are over the instrument calibration range. These results are also qualified as estimated (J) for potential low bias. Several samples showed the possible presence of non-target compounds that were not reported, possibly Stoddard solvent™. All other data are valid without qualification.

For 01June95, eight samples were analyzed for VOCs. The method blank and sample numbers 0100-95-0044 and -0045, had high surrogate recoveries for 1,2-dichloroethane-d4. In addition, the internal standard recoveries remained below acceptable levels in the rerun of sample 0100-95-0046, indicating a possible matrix interference. All results for sample 0100-95-0046 are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 02June95, four soil samples were analyzed for VOCs. Sample 0100-95-0051 had a low surrogate recovery for 1,2-dichloroethane-d4. In addition, the analyst blank subtracted the detected methylene chloride in all four samples. Because these results were less than 10 times the amount detected in the blank, the detections are probably related to blank contamination; however, the results are reported improperly (as discussed above). All results for sample 0100-95-0051 and for methylene chloride (in all samples) are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 05June95, 10 soil samples were analyzed for VOCs. Several samples (0100-95-0061, -0063, -0064, and -0081) had high surrogate recoveries for 1,2-dichloroethane-d4. In addition, the first internal standard recovery remained below acceptable levels in the rerun of sample 0100-95-0069, indicating a possible matrix interference. Methylene chloride was detected in all twelve samples analyzed, but reported as not detected because it was assumed by the analyst to be a laboratory contaminant. All results for sample 0100-95-0069 and for methylene chloride (in all samples) are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 06June95, five soil samples and two water samples were analyzed for VOCs. Methylene chloride was detected in all samples analyzed, but reported as not detected because it was assumed by the analyst to be a laboratory contaminant. All results for methylene chloride (in all samples) are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 07June95, seven soil samples were analyzed for VOCs. All seven samples and the method blank had high surrogate recoveries for 1,2-dichloroethane-d4. In addition, the internal standard recoveries remained below acceptable levels in the rerun of samples 0100-95-0085 and -0087, indicating a possible matrix interference. All results for samples 0100-95-0085 and -0087 are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 08June95, five soil samples were analyzed for VOCs. All five samples and the method blank had high surrogate recoveries for 1,2-dichloroethane-d4. Samples contained unidentified peaks up to ten times the internal standard height. These peaks were explained by the analyst as 'siloxane' as discussed above. All data are valid without qualification.

For 12June95, 13 soil samples and two water samples were analyzed for VOCs. All 15 samples and the method blank had high surrogate recoveries for 1,2-dichloroethane-d4 and BFB. In addition, the internal standard recoveries remained below acceptable levels in the rerun of samples 0100-95-0110, -0111, -0113, and -0119, indicating possible matrix interferences. All results for these samples are qualified as estimated (UJ) for potential low bias. Acetone and 2-butanone were detected in samples 0100-95-0110, -0112, and -0113, but reported as not detected. For acetone, the detection limits were raised to accommodate the amount detected in the samples that was greater than the amount detected in the blank. All results for acetone and 2-butanone in samples 0100-95-0110, -0112, and -0113 are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 14June95, 10 soil samples and two water samples were analyzed for VOCs. Samples 0100-95-0123, -0124, -0127, -0128, -0129, -0130, and -0139 had high surrogate recoveries for 1,2-dichloroethane-d4. In addition, the internal standard recoveries remained below acceptable levels in the rerun of sample 0100-95-0127, indicating a possible matrix interference. All results for samples 0100-95-0127 are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 19June95, seven soil samples were analyzed for VOCs. Samples 0100-95-0145, -0148, and several blanks had high surrogate recoveries for 1,2-dichloroethane-d4. In addition, the internal standard recoveries remained below acceptable levels in the rerun of sample 0100-95-0148, indicating a possible matrix interference. All results for sample 0100-95-0148 are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 21June95, eight soil and two water samples were analyzed for VOCs. Nine of the 10 samples had high surrogate recoveries for 1,2-dichloroethane-d4. Samples 0100-95-0163 and -0164 had low recoveries of BFB. In addition, the internal standard recoveries remained below acceptable levels in the rerun of samples 0100-95-0167, -0179, -0180, and -0181, indicating a possible matrix interference. The matrix interference appears to be from the 'siloxane' peaks identified by the analyst as instrument contamination. The 'siloxane' peaks in

these samples are as much as 100 times the internal standard height. All results for samples 0100-95-0167, -0179, -0180, and -0181 are qualified as estimated (UJ) for potential low bias. All other data are valid without qualification.

For 27June95, 11 soil samples were analyzed for VOCs. Samples 0100-95-0290, -0291, and -0292 had high surrogate recoveries for BFB due to a large interference from the 'siloxane' peak. In addition, the third internal standard recoveries were below acceptable levels in samples 0100-95-0290 and -0291, indicating a possible matrix interference from the same interfering peak. These samples were not rerun. Samples 0100-95-0282, -0284, -0286, and -0287 all had tetrachloroethene over calibration. Samples 0100-95-0286 and -0287 showed severe electron multiplier saturation. Samples 0100-95-0282 and -0284 showed lesser levels of electron multiplier saturation. The results for tetrachloroethene in these samples are biased low, possibly by an order of magnitude or more. Therefore, samples were collected from surrounding areas and were analyzed in order to confirm the actual concentrations in the area. All other data are valid without qualification.

For 28June95, eight soil samples and two water samples were analyzed for VOCs. Sample 0100-95-0295 had a high surrogate recovery for BFB and sample 0100-95-0384 had a low surrogate recovery for BFB. Samples 0100-95-0295 and -0384 had trimethylbenzene results reported from diluted samples with the results near the instrument detection limit. These results are qualified as estimated (J) because the errors near the detection limit are multiplied by the dilution factor for these two samples. These samples were diluted for the large Stoddard solvent™ component in the samples; therefore, more accurate results may not be available because of the large matrix interference represented by the Stoddard solvent™. All other data are valid without qualification.

For 29June95, one sample was analyzed for VOCs. The surrogate BFB was recovered at 163% because of a large interfering peak that appeared to be related to Stoddard solvent™. The results were qualified as undetected and estimated (UJ) for all analytes except PCE. PCE was qualified as estimated (J) because of the high BFB recovery.

For 07July95, eight soil samples were analyzed for VOCs. Sample 0100-95-0194 should be reported as having acetone not detected at 120 mg/kg and methylene chloride not detected at 14 mg/kg. Sample 0100-95-0392 had a high surrogate recovery for BFB and sample 0100-95-0393, had a low surrogate recovery for BFB. The results for 0100-95-0393 are qualified as estimated (UJ) because of low surrogate recovery. All other data are valid without qualification.

For 12July95, 21 soil samples and one water sample were analyzed for VOCs. The samples were contaminated with high levels of acetone, 2-butanone, and methylene chloride due to the use of methanol to extract the soils. Several samples were diluted to the point that the highest detected target compound was less than 20 µg/L in the extract, causing a larger dilution error than typically acceptable. No analytical reasons (such as large TICs) for the high dilution were found in the data provided. The data were not qualified for the high dilution because no bias was apparent. All data are valid without qualification.

On 20July95, 21 soil samples were analyzed for VOCs. Samples 0100-95-0214, -0217, -0219, -0222, -0223, -0224, -0225, -0226, -0227, -0228, and -0233 had PCE results over the calibration range of the instrument. Samples 0100-95-0222, -0224, -0225, and -0226 showed indications that the instrument detector was saturated for PCE. PCE results for all of the samples that exceeded the calibration range are qualified (E). The chromatograms in the data packages were carefully reviewed and the three chemistry reviewers concluded that the reported values qualified (E) appear to be no more than 30% underestimated. Samples 0100-95-0214 and -0222 had low internal standard recoveries, therefore, all results for these samples are qualified (J). The detections of PCE reported in samples 0100-95-0220, -0221, and -0232 are qualified as undetected and estimated for blank contamination (UB). All other data are valid without qualification. Several of the samples were reanalyzed to confirm the results reported because of potential sample contamination problems. The reanalyses are discussed in the following paragraph.

Samples 0100-95-0216, -0221, -0229, -0230, -0231, -0233, and -0234 were reanalyzed on July 25, 1995. The results for the samples agreed quite well with the first analyses; therefore, the first analyses were used for all samples except for samples 0100-95-0221 and -0233. The first PCE result for -0221 was qualified (UB) for blank contamination, because the second result was not qualified, it was used. Sample -0233 was analyzed twice on July 20, 1995 with results of over 400 µg/kg and 21 µg/kg for PCE. The reanalysis on July 27, 1995 indicated a PCE result of 17 µg/kg. This value was used because there were two values that agreed closely and the other analysis may have been contaminated by other high level samples.

For 25July95, six samples, including four soil and two water samples, were analyzed for VOCs. Samples 0100-95-0235, -0236, and -0240 had PCE results over the calibration range of the instrument. There were no indications that the instrument detector was saturated for PCE. PCE results for all of the samples that exceeded the calibration range are qualified (E). The detection of acetone reported in sample 0100-95-0235 was qualified as undetected and estimated for blank contamination (UJ). All other data are valid without qualification.

For 01August95, eight samples, including six soil and two water samples were analyzed for VOCs. The first surrogate was recovered in a range around 70% for most samples and blanks. Because this was consistent, the data are not qualified. All data are valid without qualification.

4.2.3 Methylnaphthalene Analyses:

For all of the methylnaphthalene analyses the performance standards were within allowed limits. The analyses were not conducted using internal standards or surrogates, so there is no way to check the validity of any individual analysis. The results should be considered for the purpose of screening only and qualified as estimated (J) or (UJ) for a lack of QC data. The analysis date and number of samples analyzed on that day are as follows: 29June95-1, 7 samples; 29June95-2, 15 samples; 07July95, 8 samples; 12July95, 22 samples; 20July95, 9 samples; 21July95, 6 samples; 26July95, 6 samples; 28July95, 6 samples; and 01August95, 8 samples. Methylnaphthalenes were not detected in any samples except as discussed below.

For 29June95-2, 15 soil samples were analyzed for methylnaphthalenes. Samples 0100-95-0295 and -0384 had detections of methylnaphthalenes at levels up to 0.6 mg/kg. The results for the methylnaphthalenes were associated with a large peak in the chromatogram. This large peak appeared to be related to the Stoddard solvent™ component in the samples. The methylnaphthalene peaks co-eluted with the tail end of the Stoddard solvent™ peak. All methylnaphthalene data are qualified as estimated (J) or (UJ) because of a lack of QC data.

On 07July95 eight soil samples were analyzed for methylnaphthalenes. No methylnaphthalenes were detected. All methylnaphthalene data are qualified as estimated (UJ) because of a lack of QC data.

4.3 Radiochemistry Analyses

No radiochemistry analyses were performed at this site.

5.0 SPECIFIC INVESTIGATIONS, RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

5.1 PRS 0-039

5.1.1 History

Few records have been found to assemble a history of the dry cleaning operations in the Community Center prior to 1967. Engineering drawings dated February 20, 1947, show that a dry cleaning operation had been established in that location and two underground storage tanks had been installed to store dry-cleaning solvent. Los Alamos became an open community February 18, 1957, when the East Gate entrance barrier was removed. The AEC began transferring government lands shortly thereafter, but the land containing PRS 0-039 was retained until 1968. This property has been leased by private parties since at least 1958 when a lease agreement between the Zia Company, acting for the AEC, and Roger Corbett, doing business as Corbett Cleaning Company, commenced April 1, 1958. On November 1, 1968, the building and the underlying real property at 1324 17 th St. were sold by the federal government into the private sector. Corbett Cleaning Company continued operating its dry cleaners until 1985. The dry cleaning equipment was subsequently removed to make way for other businesses leasing the property.

In July 1993 the property was sold to the current owner, Netuschil Development Corporation. The property is now leased by Mountainair Cleaners, also a dry cleaning business which began operations in May 1993. It is LANL's understanding that Mountainair Cleaners has never used any equipment formerly leased by Corbett Cleaners.

During the AEC's establishment of the community dry cleaning facility, two underground tanks were installed to store dry cleaning solvent. A former employee of Corbett Cleaning Company said in an interview that during Corbett's tenure there were difficulties transferring solvents from the tanks into the plant, so the tanks, were emptied and abandoned. The use of the USTs was reported to have ceased sometime prior to 1969 (LANL 1994, 1287). The tanks were removed in 1993 as part of a Phase I environmental assessment (GGI 1993, 05-0222).

Additional appurtenant structures for the former tanks include the existing subsurface piping for supplying the tanks. During removal of the tanks some of these underground pipelines were filled with concrete and abandoned in place, where they remain in the subsurface between the two existing buildings (LANL 1994, 1287). According to Mr. Netuschil, fill ports for the UST system were formerly located near the northeast corner of the current Mountainair Dry Cleaners. These fill ports were removed prior to the 1995 RFI.

During the course of removing the tanks, "dark" soil stains were observed indicating a possible release, or releases, of the tanks' contents to the soil surrounding the tanks (GGI 1993, 05-0222). Samples collected at the time of excavation were analyzed, and PAHs and PCE were detetected (see Section 5.1.3). Concentrations of unspecified chemicals were also discovered as the excavation progressed (GGI 1993, 05-0222). Mr. Netuschil stated that the chemicals detected could be Stoddard solvent™, a mixture of petroleum hydrocarbons, that was commonly used in the past as a dry cleaning solvent. Further excavation was stopped because the extent of contamination was greater than anticipated and exceeded the limitations of the equipment (backhoe) being used by the construction company hired to remove the tanks (GGI 1993, 05-0222). The excavation was backfilled in September 1993 (GGI 1993, 05-0222). The NMED requested additional investigation activities be conducted in order to define the extent of contaminant migration away from the release area adjacent to and beneath the tanks (DOE 1994, 05-0220).

On July 5, 1994, the DOE requested that the US Environmental Protection Agency (EPA) add the USTs, designated as PRS 0-039, to the Laboratory's operating permit (DOE 1994, 05-0220). This request was granted by the EPA on July 21, 1994 (EPA 1994, 05-0221).

LANL conducted the field investgations discussed herein beginning in May 1995. In summary, two separate types of contamination were found at this PRS, TPH (Stoddard solvent™) and PCE. TPH contamination associated with the Stoddard solvent™ is discussed in detail in Section 5.1. A human health assessment for TPH indicates that there are no adverse human health effects associated with the very low level exposure potential resulting from Stoddard solvent at the site (see Section 5.1.7).

A PCE plume was also discovered during this RFI in July 1995. Since its discovery, LANL has investigated the source of the release. The plume was detected on the east end of the walkway, adjacent to the building located at 1400 17 th St., on the north side of the walkway.

A former employee of the Corbett Cleaning Company was interviewed on several occasions and the following information was provided. The Corbett Cleaning Company used only Stoddard solvent™ for fabric cleaning. PCE became available as an alternative cleaning agent, but Corbett did not replace equipment, as would have been required to convert from Stoddard solvent™. The only likely use of PCE in the Corbett operation was for waterproofing garments. This was a minor use of PCE and it is highly improbable that it resulted in any significant contamination.

As the former Corbett employee explained, a dip tank held a mixture of carrier solvents and a waxy substance that was heated before the strainer baskets of garments were lowered into the 50-gallon tank that held 25 gallons of the mixture. The carrier solvents included PCE, but the volume of PCE used in waterproofing was insignificant when compared to the amount of Stoddard solvent™ used for cleaning. There were two pathways for PCE getting from the waterproofing dip tank into the Stoddard solvent™ system. The first was by placing garments from the dip tank basket into one of the extractors, which was most often used for removing excess Stoddard solvent™ from garments before putting the garments into the dryers. The fluids removed in the extractors went into the dirty solvent tank. The second way for PCE to show up with Stoddard solvent™ was from the still used to recycle the cleaning plant fluids, because it was used for both washer solvents and waterproofing mixtures. Engineering drawings were also examined to identify pathways for PCE contaminating Stoddard solvent™. The information provided by the former employee was supported by those drawings. Therefore, it is inferred that the trace levels of PCE found in and around the USTs and in the Stoddard solvent™ plume were the result of processes affecting the dirty solvent in Corbett Cleaners.

The PCE plume against the north building (maximum concentrations in hand-auger locations HA12 and HA15) must be from a surface release that was independent of the Corbett Cleaner operation. A surface release is inferred from transport modeling, the nature of the plume, and the absence of solvent plumbing components near the vertical axis of the plume. Transport calculations demonstrate that the PCE plume substantially post-dates the AEC's ownership of the site. As discussed earlier in this report, the AEC sold this site in 1968, over 25 years ago. In a 25 year period, calculations show that PCE would have been transported a vertical distance of approximately 73 ft. However sampling shows that the PCE plume adjacent to the north building has a vertical depth of only approximately 25 ft. This is substantially less than the depth PCE would have migrated if it had been released during or before 1968. Therefore, it is clear that the PCE was released after 1968 and LANL has no responsibility for the PCE plume (Appendix D).

One possible source of this plume is from the decommissioning of coin-operated dry cleaning washers from the laundromat located in the middle of the north building. The north building, located at 1400 17 th St., was built in 1960 by a private party. Originally, the land on which the building stood was owned by the AEC and, since at least 1960, this real property was leased to a private party. On November 1, 1968, the land was deeded into private ownership. The north building housed a variety of businesses, including a laundromat which has had several owners/operators. The first laundromat business located there opened in 1960. The laundromat had coin-operated dry cleaning machines that used PCE as the cleaning fluid. In approximately

1967 the laundromat business was sold and the new owners were reported to have removed the coin-operated machines. Later owners installed other coin-operated dry cleaning machines that used PCE and were in service in the early 1980s. These machines have since been removed. Those washers were known to have used PCE, but there are conflicting statements as to whether the PCE was drained from those machines, and/or whether the machines were placed on the ground above where the plume concentrations are greatest. The trace amounts of PCE found in soil samples taken from soil cores collected south and east of the presumed surface release could be due to vapor transport. The transport modeling indicates that a surface release occurred more than a decade after the first coin-operated machines were decommissioned.

The location of the PCE plume and the extent to which the PCE has been transported over time are evidence that the release of PCE to soil occurred after November 1968 when the property was transferred to private ownership. The information set forth above demonstrates that PCE may have been released during the course of some recent activity or activities not associated with the USTs or the United States' operation or ownership of the property. Therefore, LANL has no association with or responsibility for the PCE plume and the plume has not been characterized in the body of this report. Instead, the PCE is described extensively in Appendix D.

5.1.2 Description

See Chapter 2 for a description of geological setting, soils, and hydrology pertinent to this report.

5.1.3 Previous Investigations

On June 2, 1993, the two 700-gallon tanks were removed. (LANL 1994, 1287). Prior to removal of the tanks, absorbent material was placed in each tank to absorb any residual liquid. Soil samples were collected from the excavation and beneath each tank for headspace analyses. The samples were collected at the base of the four walls of the excavation and also from an area of "dark" soil between the two tanks at the bottom of the excavation. Soil samples were collected from depths ranging between 10 ft and 11 ft below ground surface (bgs). Seven soil samples and one sample of the absorbent material were submitted for laboratory analysis of PAHs (EPA SW-846 method 8310) and halogenated hydrocarbons (EPA SW-846 method 8010). The analytical results for these samples were as follows: PCE was detected in four of the seven soil samples at concentrations ranging from 0.011 to 0.78 mg/kg; and, three PAHs

(naphthalene, 1-methylnaphthalene, and 2- methylnaphthalene) were detected in one soil sample at concentrations of 0.21 mg/kg, 0.05 mg/kg, and 0.6 mg/kg, respectively (GGI 1993, 05-0222). PCE and naphthalene were also detected in the absorbent material from the southern UST at concentrations of 6.6 mg/kg and 0.3 mg/kg, respectively (GGI 1993, 05-0222). The southern UST was likely the "dirty" solvent tank, as inferred from the engineering drawing.

5.1.4 Field Investigation and Sampling Activities

The OU 1071 RFI Work Plan Addendum (LANL 1994, 1287) outlines the approach used to investigate the former UST system adjacent to the current Mountainair Dry Cleaners in the Los Alamos Community Center. Field activities conducted at PRS 0-039 consisted of a geodetic survey, soil sampling, and an exploratory borehole and hand-auger borehole sampling program designed to characterize contamination adjacent to and beneath the subsurface piping and surrounding underground storage tank system. A surface geophysical survey (magnetic and ground penetrating radar) was specified in the OU 1071 RFI Work Plan Addendum to identify subsurface piping and underground utilities. However, this survey was not conducted because of the proximity to the buildings and subsurface features that would potentially result in interference and erroneous results. All field activities were conducted in accordance with appropriate LANL ER Project SOPs (LANL 1993, 0875). Sampling began May 25, 1995, and continued through August 1, 1995. A summary of samples collected and analyses performed is presented in Table 5.1.4-1 below.

TABLE 5.1.4-1

SUMMARY OF SAMPLES TAKEN

LOCATION ID	HOLE DESIGNA-TION	SAMPLE ID	DEPTH (ft.)	MATRIX	TPH	1-METHYL-NAPTHALENE 2-METHYL-NAPTHALENE	VOCs
00-4055	B1	0100-95-0000	4.5-5	Soil	X[a]		X
00-4055	B1	0100-95-0001	9.5-10	Soil	X		X
00-4055	B1	0100-95-0002	14.5-15	Soil	X		X
00-4055	B1	0100-95-0003	19.5-20	Tuff	X		X
00-4055	B1	0100-95-0004	24.5-25	Tuff	X		X
00-4055	B1	0100-95-0005	29.5-30	Tuff	X		X
00-4055	B1	0100-95-0006	34.5-35	Tuff	X		X
00-4055	B1	0100-95-0007	39.5-40	Tuff	X		X
00-4055	B1	0100-95-0008	44.5-45	Tuff	X		X
00-4056	B2	0100-95-0020	4.5-5	Soil	X		X
00-4056	B2	0100-95-0021	9.5-10	Soil	X		X
00-4056	B2	0100-95-0022	14.5-15	Tuff	X		X
00-4056	B2	0100-95-0023	19.5-20	Tuff	X		X
00-4056	B2	0100-95-0024	24.5-25	Tuff	X		X
00-4056	B2	0100-95-0025	29.5-30	Tuff	X		X
00-4056	B2	0100-95-0026	34.5-35	Tuff	X		X
00-4056	B2	0100-95-0027	39.5-40	Tuff	X		X
00-4056	B2	0100-95-0028	44.5-45	Tuff	X		X
00-4056	B2	0100-95-0029	49.5-50	Tuff	X		X
00-4056	B2	0100-95-0030	54.5-55	Tuff	X		X
00-4056	B2	0100-95-0031	59.5-60	Tuff	X		X
00-4056	Duplicate of 0100-95-0025	0100-95-0283	29.5-30	Tuff	X		X
NA[b]	B2	0100-95-0296	Rinsate	Water	X		X
NA	B2	0100-95-0354	Field Blank	Water	X		X
00-4057	B3	0100-95-0041	4.5-5	Soil	X		X
00-4057	B3	0100-95-0042	9.5-10	Soil	X		X
00-4057	B3	0100-95-0043	14.5-15	Tuff	X		X
00-4057	B3	0100-95-0044	19.5-20	Tuff	X		X
00-4057	B3	0100-95-0045	24.5-25	Tuff	X		X
00-4057	B3	0100-95-0046	29.5-30	Tuff	X		X
00-4057	B3	0100-95-0047	34.5-35	Tuff	X		X
00-4057	B3	0100-95-0048	39.5-40	Tuff	X		X
00-4057	B3	0100-95-0049	44.5-45	Tuff	X		X
00-4057	B3	0100-95-0050	49.5-50	Tuff	X		X
00-4057	B3	0100-95-0051	54.5-55	Tuff	X		X
00-4057	B3	0100-95-0052	59.5-60	Tuff	X		X
00-4058	B4	0100-95-0081	0-0.5	Soil	X		X
00-4058	B4	0100-95-0061	4.5-5	Soil	X		X
00-4058	B4	0100-95-0062	9.5-10	Soil	X		X
00-4058	B4	0100-95-0063	14.5-15	Soil	X		X
00-4058	B4	0100-95-0064	19.5-20	Tuff	X		X
00-4058	B4	0100-95-0065	24.5-25	Tuff	X		X
00-4058	B4	0100-95-0066	29.5-30	Tuff	X		X
00-4058	B4	0100-95-0067	34.5-35	Tuff	X		X
00-4058	B4	0100-95-0068	39.5-40	Tuff	X		X
00-4058	B4	0100-95-0069	44.5-45	Tuff	X		X

TABLE 5.1.4-1 (CONTINUED)

SUMMARY OF SAMPLES TAKEN

LOCATION ID	HOLE DESIGNA-TION	SAMPLE ID	DEPTH (ft.)	MATRIX	TPH	1-METHYL-NAPTHALENE 2-METHYL-NAPTHALENE	VOCs
00-4058	B4	0100-95-0070	49.5-50	Tuff	X		X
00-4058	B4	0100-95-0071	54.5-55	Tuff	X		X
00-4058	B4	0100-95-0073	59.5-60	Tuff	X		X
00-4058	Duplicate of 0100-95-0071	0100-95-0072	54.5-55	Tuff	X		X
NA	NA	0100-95-0080	Rinsate	Water	X		X
NA	NA	0100-95-0079	Field Blank	Water	X		X
00-4059	B5	0100-95-0082	4.5-5	Soil	X		X
00-4059	B5	0100-95-0083	9.5-10	Soil	X		X
00-4059	B5	0100-95-0084	14.5-15	Soil	X		X
00-4059	B5	0100-95-0085	19.5-20	Tuff	X		X
00-4059	B5	0100-95-0086	24.5-25	Tuff	X		X
00-4059	B5	0100-95-0087	29.5-30	Tuff	X		X
00-4059	B5	0100-95-0088	34.5-35	Tuff	X		X
00-4059	B5	0100-95-0089	39.5-40	Tuff	X		X
00-4059	B5	0100-95-0090	44.5-45	Tuff	X		X
00-4059	B5	0100-95-0091	49.5-50	Tuff	X		X
00-4059	B5	0100-95-0092	54.5-55	Tuff	X		X
00-4059	B5	0100-95-0093	59.5-60	Tuff	X		X
00-4060	B6	0100-95-0102	4.5-5	Soil	X		X
00-4060	B6	0100-95-0103	9.5-10	Soil	X		X
00-4060	B6	0100-95-0104	14.5-15	Tuff	X		X
00-4060	B6	0100-95-0105	19.5-20	Tuff	X		X
00-4060	B6	0100-95-0106	24.5-25	Tuff	X		X
00-4060	B6	0100-95-0107	29.5-30	Tuff	X		X
00-4060	B6	0100-95-0108	34.5-35	Tuff	X		X
00-4060	B6	0100-95-0109	39.5-40	Tuff	X		X
00-4060	B6	0100-95-0110	44.5-45	Tuff	X		X
00-4060	B6	0100-95-0111	49.5-50	Tuff	X		X
00-4060	B6	0100-95-0112	54.5-55	Tuff	X		X
00-4060	B6	0100-95-0113	59.5-60	Tuff	X		X
00-4060	Duplicate of 0100-95-0104	0100-95-0119	14.5-15	Tuff	X		X
00-4060	B6	0100-95-0121	Rinsate	Water	X		X
00-4060	B6	0100-95-0120	Field Blank	Water	X		X
00-4061	B7	0100-95-0122	4.5-5	Soil	X		X
00-4061	B7	0100-95-0123	9.5-10	Soil	X		X
00-4061	B7	0100-95-0124	14.5-15	Soil	X		X
00-4061	B7	0100-95-0125	19.5-20	Tuff	X		X
00-4061	B7	0100-95-0126	24.5-25	Tuff	X		X
00-4061	B7	0100-95-0127	29.5-30	Tuff	X		X
00-4061	B7	0100-95-0128	34.5-35	Tuff	X		X
00-4061	B7	0100-95-0129	39.5-40	Tuff	X		X
00-4061	B7	0100-95-0130	44.5-45	Tuff	X		X

TABLE 5.1.4-1 (CONTINUED)

SUMMARY OF SAMPLES TAKEN

LOCATION ID	HOLE DESIGNA-TION	SAMPLE ID	DEPTH (ft.)	MATRIX	TPH	1-METHYL-NAPTHALENE 2-METHYL-NAPTHALENE	VOCs
00-4061	Duplicate of 0100-95-0123	0100-95-0139	9.5-10	Soil	X		X
NA	B7	0100-95-0141	Rinsate	Water	X		X
NA	B7	0100-95-0140	Field Blank	Water	X		X
00-4062	B8	0100-95-0142	4.5-5	Soil	X		X
00-4062	B8	0100-95-0143	9.5-10	Soil	X		X
00-4062	B8	0100-95-0144	14.5-15	Tuff	X		X
00-4062	B8	0100-95-0145	19.5-20	Tuff	X		X
00-4062	B8	0100-95-0146	24.5-25	Tuff	X		X
00-4062	B8	0100-95-0147	29.5-30	Tuff	X		X
00-4062	B8	0100-95-0148	34.5-35	Tuff	X		X
00-4063	B9	0100-95-0162	4.5-5	Soil	X		X
00-4063	B9	0100-95-0163	9.5-10	Soil	X		X
00-4063	B9	0100-95-0164	14.5-15	Soil	X		X
00-4063	B9	0100-95-0165	19.5-20	Tuff	X		X
00-4063	B9	0100-95-0166	24.5-25	Tuff	X		X
00-4063	B9	0100-95-0167	29.5-30	Tuff	X		X
00-4063	B9	0100-95-0168	34.5-35	Tuff	X		X
00-4063	Duplicate of 0100-95-0163	0100-95-0179	9.5-10	Soil	X		X
00-4063	B9	0100-95-0180	Field Blank	Water	X		X
00-4063	B9	0100-95-0181	Rinsate	Water	X		X
00-4069	HA1-1	0100-95-0282	0.7-1	Soil	X	X	X
00-4069	HA1-3	0100-95-0284	2.7-3	Soil	X	X	X
00-4069	HA1-4	0100-95-0285	3.7-4	Soil	X	X	X
00-4082	HA1a-1	0100-95-0395	0.7-1	Soil	X	X	X
00-4082	HA1a-3	0100-95-0396	2.7-3	Soil	X	X	X
00-4082	HA1a-5	0100-95-0397	4.7-5	Soil	X	X	X
00-4082	HA1a-5 Duplicate	0100-95-0202	4.7-5	Soil	X	X	X
00-4070	HA2-1	0100-95-0286	0.7-1	Soil	X	X	X
00-4070	HA2-2	0100-95-0287	1.7-2	Soil	X	X	X
00-4070	HA2-4	0100-95-0288	3.7-4	Soil	X	X	X
00-4083	HA2a-1	0100-95-0398	0.7-1	Soil	X	X	X
00-4083	HA2a-3	0100-95-0197	2.7-3	Soil	X	X	X
00-4083	HA2a-5	0100-95-0198	4.7-5	Soil	X	X	X
00-4071	HA3-1	0100-95-0289	0.7-1	Soil	X	X	X
00-4071	HA3-3	0100-95-0290	2.7-3	Soil	X	X	X
00-4071	HA3-4	0100-95-0291	3.7-4	Soil	X	X	X
00-4072	HA4-1	0100-95-0292	0.7-1	Soil	X	X	X
00-4072	HA4-5	0100-95-0293	4.7-5	Soil	X	X	X
00-4072	HA4-6	0100-95-0294	5.7-6	Soil	X	X	X

TABLE 5.1.4-1 (CONTINUED)

SUMMARY OF SAMPLES TAKEN

LOCATION ID	HOLE DESIGNA-TION	SAMPLE ID	DEPTH (ft.)	MATRIX	TPH	1-METHYL-NAPTHALENE 2-METHYL-NAPTHALENE	VOCs
00-4073	HA5-2	0100-95-0295	1.7-2	Soil	X	X	X
00-4073	HA5-5	0100-95-0383	4.7-5	Soil	X	X	X
00-4073	HA5-7	0100-95-0384	6.7-7	Soil	X	X	X
00-4073	HA5-9	0100-95-0392	8.7-9	Soil	X	X	X
00-4073	HA5-11	0100-95-0393	10.7-11	Soil	X	X	X
00-4074	HA6-1	0100-95-0385	0.7-1	Soil	X	X	X
00-4074	HA6-3	0100-95-0386	2.7-3	Soil	X	X	X
00-4074	HA6-4	0100-95-0387	3.7-4	Soil	X	X	X
00-4075	HA7-1	0100-95-0388	0.7-1	Soil	X	X	X
00-4075	HA7-4	0100-95-0389	3.7-4	Soil	X	X	X
00-4075	HA7	0100-95-0390	Rinsate	Water	X	X	X
00-4075	HA7	0100-95-0391	Field Blank	Water	X	X	X
00-4076	HA8-1	0100-95-0394	0.7-1	Soil	X	X	X
00-4076	HA8-7	0100-95-0191	6.7-7	Soil	X	X	X
00-4076	HA8-9	0100-95-0192	8.7-9	Soil	X	X	X
00-4077	HA9-1	0100-95-0193	0.7-1	Soil	X	X	X
00-4077	HA9-4	0100-95-0194	3.7-4	Soil	X	X	X
00-4077	HA9-6	0100-95-0195	5.7-6	Soil	X	X	X
00-4078	HA10-1	0100-95-0199	0.7-1	Soil	X	X	X
00-4078	HA10-3	0100-95-0200	2.7-3	Soil	X	X	X
00-4078	HA10-5	0100-95-0201	4.7-5	Soil	X	X	X
00-4079	HA11-1	0100-95-0203	0.7-1	Soil	X	X	X
00-4079	HA11-3	0100-95-0204	2.7-3	Soil	X	X	X
00-4079	HA11-5	0100-95-0205	4.7-5	Soil	X	X	X
00-4080	HA12-1	0100-95-0206	0.7-1	Soil	X	X	X
00-4080	HA12-4	0100-95-0207	3.7-4	Soil	X	X	X
00-4080	HA12-6	0100-95-0208	5.7-6	Soil	X	X	X
00-4080	HA12-9	0100-95-0209	8.7-9	Soil	X	X	X
00-4080	HA12-10	0100-95-0210	9.7-10	Soil	X	X	X
00-4080	HA12-13	0100-95-0211	12.7-13	Soil	X	X	X
00-4080	HA12-15	0100-95-0212	14.7-15	Soil	X	X	X
00-4080	HA12-17	0100-95-0213	16.7-17	Tuff	X	X	X
00-4080	HA12	0100-95-0297	Rinsate	Water	X	X	X
00-4080	HA12	0100-95-0325	Field Blank	Water	X	X	X
00-4095	HA13-1	0100-95-0214	0.7-1	Soil	X	X	X
00-4095	HA13-4	0100-95-0215	3.7-4	Soil	X	X	X
00-4095	HA13-6	0100-95-0216	5.7-6	Soil	X	X	X
00-4096	HA14-1	0100-95-0217	0.7-1	Soil	X	X	X
00-4096	HA14-4	0100-95-0218	3.7-4	Soil	X	X	X
00-4096	HA14-6	0100-95-0219	5.7-6	Soil	X	X	X
00-4096	HA14-10	0100-95-0220	9.7-10	Soil	X	X	X
00-4096	HA14-13	0100-95-0221	12.7-13	Soil	X	X	X
00-4096	HA14-15	0100-95-0222	14.7-15	Soil	X	X	X

TABLE 5.1.4-1 (CONTINUED)

SUMMARY OF SAMPLES TAKEN

LOCATION ID	HOLE DESIGNA-TION	SAMPLE ID	DEPTH (ft.)	MATRIX	TPH	1-METHYL-NAPTHALENE 2-METHYL-NAPTHALENE	VOCs
00-4097	HA15-1	0100-95-0223	0.7-1	Soil	X	X	X
00-4097	HA15-4	0100-95-0224	3.7-4	Soil	X	X	X
00-4097	HA15-6	0100-95-0225	5.7-6	Soil	X	X	X
00-4097	HA15-10	0100-95-0226	9.7-10	Soil	X	X	X
00-4097	HA15-13	0100-95-0227	12.7-13	Soil	X	X	X
00-4097	HA15-14	0100-95-0228	13.7-14	Soil	X	X	X
00-4097	HA15-16	0100-95-0243	15.7-16	Soil	X	X	X
00-4097	HA15-19	0100-95-0244	18.7-19	Tuff	X	X	X
00-4097	HA15-20	0100-95-0245	19.7-20	Tuff	X	X	X
00-4097	HA15-22	0100-95-0246	21.7-22	Tuff	X	X	X
00-4097	HA15-25	0100-95-0247	24.7-25	Tuff	X	X	X
00-4097	Duplicate of 0100-95-0245	0100-95-0248	19.7-20	Tuff	X	X	X
00-4097	HA15	0100-95-0300	Rinsate	Water	X	X	X
00-4097	HA15	0100-95-0326	Field Blank	Water	X	X	X
00-4098	HA16-1	0100-95-0229	0.7-1	Soil	X	X	X
00-4098	HA16-4	0100-95-0230	3.7-4	Soil	X	X	X
00-4098	HA16-6	0100-95-0231	5.7-6	Soil	X	X	X
00-4098	HA16-10	0100-95-0232	9.7-10	Soil	X	X	X
00-4098	HA16-13	0100-95-0233	12.7-13	Soil	X	X	X
00-4098	HA16-14	0100-95-0234	13.7-14	Soil	X	X	X
00-4099	HA17-1	0100-95-0235	0.7-1	Soil	X	X	X
00-4099	HA17-4	0100-95-0236	3.7-4	Soil	X	X	X
00-4099	HA17-6	0100-95-0237	5.7-6	Soil	X	X	X
00-4099	HA17-10	0100-95-0238	9.7-10	Soil	X	X	X
00-4099	HA17-13	0100-95-0239	12.7-13	Soil	X	X	X
00-4099	HA17-14	0100-95-0240	13.7-14	Soil	X	X	X

[a] Analysis requested.
[b] NA = Not available.

Borehole Drilling

The first borehole was drilled near the estimated center of the release from the two former underground storage tanks on the western side of the site. This borehole was drilled in order to identify COPCs and to assess vertical extent of the COPCs near the center of the release. Subsequently, additional peripheral boreholes were drilled around the initial borehole to assess the lateral extent of contaminant migration away from the release area. If contamination was detected in any peripheral borehole, additional borehole(s) were to be drilled in the direction(s) where contamination was detected until the extent of contamination was bounded. In order to assess the eastern end of the UST system adjacent to the former fill ports, three boreholes were drilled in a semicircle around the estimated location of the former fill ports for the UST system. A total of nine boreholes [location IDs 00-4055 (B1), 00-4056 (B2), 00-4057 (B3), 00-4058 (B4), 00-4059 (B5), 00-4060 (B6), 00-4061 (B7), 00-4062 (B8), and 00-4063 (B9)] were drilled with a Failing F-10™ drill rig equipped with an 8.25-in. outside diameter (O.D.) hollow-stem auger. These boreholes are illustrated in Fig. 5.1.4-1. Continuous 3.125-in. O.D. core samples were retrieved using 5 ft stainless steel split-barrel samplers in conjunction with a wire-line retrieval system. Cores were screened for organic vapors using a PID and were checked for ionizing radiation using Eberline™ rate meters with scintillation and Geiger-Mueller (GM) probes. During drilling operations a combustible gas indicator (CGI) meter was used continuously to monitor for potential explosive atmospheres emanating from the borehole. The cores were logged and checked for visible signs of contamination.

Headspace analyses were performed on samples collected from the bottom of each five-foot section of core, as required by NMED UST Bureau regulation. Discrete core samples were collected for chemical analysis from the bottom of each five-ft interval. The samples were submitted to LANL's Chemical, Science, and Technology Division (CST), MCAL for analyses. The samples were analyzed for VOCs and Stoddard solvent™. Analytical data from the MCAL were used to make field decisions concerning the depth of each borehole. The total depth of each borehole extended 10 ft below the last detectable concentration of any contaminant. If contamination was not detected, the depth was determined from the B2 borehole which defined the vertical extent of contaminant migration near the release.

Boreholes B1 through B6 were drilled on the west end of PRS 0-039, in the vicinity of the former solvent tanks, to determine the vertical and horizontal extent of contamination released from the USTs. Boreholes B7 through B9 were drilled on the east end of PRS 0-039 in the vicinity of the former fill ports, to determine if any releases occurred from this area. Soil and backfill material were encountered in each borehole from the surface to depths ranging from 11 ft to

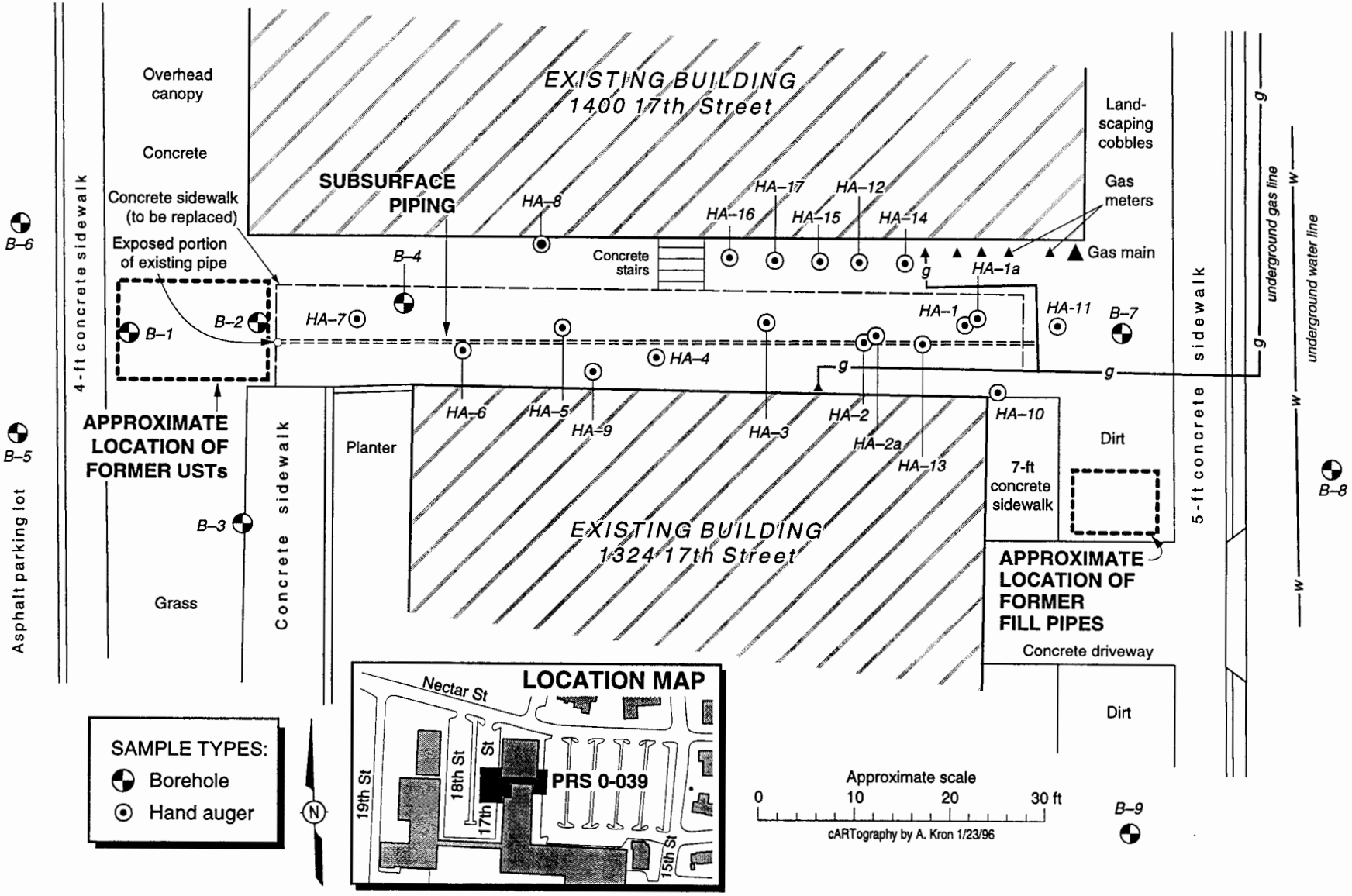

Fig. 5.1.4-1. Locations of boreholes and hand auger holes at the Community Center PRS 0-039.

18 ft bgs. The Tshirege Member of the Bandelier Tuff lies beneath the soil and backfill material. All nine boreholes were completed at depths ranging from 35 ft to 60 ft bgs in the Bandelier Tuff. In order to minimize the amount of waste generated from sampling activities, drill cuttings were returned to the borehole instead of grouting the entire borehole as described in the RFI Work Plan Addendum (LANL 1994, 1287). The boreholes B1, and B3 through B9 were plugged and abandoned by returning the cuttings to the borehole in reverse order (to best preserve original stratigraphy), and placing a cement/bentonite plug in the top five feet of each borehole. Borehole B2 was completely backfilled with a bentonite/cement grout mixture using a pump and tremie method from total depth to ground surface.

Hand Auger Samples.

The pipes between the former fill pipes and the former tanks reportedly were abandoned in place by filling them with concrete during removal of the USTs. Therefore, instead of excavating and removing the piping as described in the RFI Work Plan Addendum, hand-augered holes were bored adjacent to and beneath the subsurface piping to determine whether or not a release occurred from the piping. The pipes were found using photographs taken during removal of the USTs and digging shallow trenches at the estimated east and west ends of the subsurface piping. The pipes for both UST systems consisted of six steel pipes; four 2.25-in. O.D. pipes and two 3.25-in. O.D. pipes. The 3.25-in. O.D. pipes were observed to have been filled with concrete, while the 2.25-in. O.D. pipes were hollow.

A total of nineteen auger holes [location IDs 00-4069 (HA1), 00-4082 (HA1a), 00-4070 (HA2), 00-4083 (HA2a), 00-4071 (HA3), 00-4072 (HA4), 00-4073 (HA5), 00-4074 (HA6), 00-4075 (HA7), 00-4076 (HA8), 00-4077 (HA9), 00-4078 (HA10), 00-4079 (HA11), 00-4080 (HA12), 00-4095 (HA13), 00-4096 (HA14), 00-4097 (HA15), 00-4098 (HA16), and 00-4099 (HA17)] were bored. Initially, eight shallow (< 10.0 ft) and one deep (>10.0 ft) borings were hand-augered along both sides of the subsurface pipes to determine if a release occurred from the pipes (Fig. 5.1.4-1). The shallow augerholes are identified as HA1, HA1a, HA2, HA2a, HA3, HA4, HA6, and HA7 and the deep boring is identified as HA5. To investigate two separate releases detected in the initial augerholes, two additional augerholes (HA8 and HA9) were drilled adjacent to HA5, and eight additional augerholes (HA10 through HA17) were drilled near the east end of the alley and adjacent to the wall of the north building. Boring was usually accomplished with a stainless steel handauger; however, an electric rotary hammer equipped with 2-in. O.D. solid-stem augers, was used when gravel and tuff were encountered at greater depths.

Soil samples were collected from the bottom of each one-foot sample interval and field screened for organic vapors with headspace analyses according to NMED UST Bureau regulations. Borings were advanced until headspace results for a given interval were below the field screening criteria of 50.0 ppm or until auger refusal was encountered. A minimum of three samples was submitted for analyses from each hand-augered borehole. The general guidelines used to determine which samples would be submitted for analyses were as follows: The first sample collected for analysis was from the interval where the first organic vapor headspace reading was recorded for each borehole; the second sample was collected from the interval where the headspace reading was highest for that borehole; and, the third sample was collected from the bottom of each borehole. The samples were submitted to the MCAL for analyses and were analyzed for VOCs, Stoddard solvent™, and 1-methylnaphthalene and 2-methylnaphthalene. Analytical results from headspace analyses and from the MCAL were used to determine the total depth for any given borehole unless auger refusal was encountered.

The shallow hand-auger borings were completed in soil/backfill materials and the boreholes deeper than 14 ft were completed at the soil/tuff interface or in the Tshirege Member of the Bandelier Tuff. Most drill cuttings were returned to the shallow boreholes. The deeper boreholes were filled with bentonite/cement grout mixture.

Geotechnical Samples: Three core samples were collected in brass sleeves from borehole B4 at depths of 8.5 ft to 9.5 ft, 17.5 ft to 18.5 ft, and 59.0 ft to 60.0 ft. The samples were submitted to a materials testing laboratory and were analyzed for bulk density, dry density, water content and porosity, organic carbon, permeability, specific gravity, pH, oxidation/reduction, and void ratio. The results are presented in Tables 5.1.4-2 and 5.1.4-3. These samples were collected to provide site-specific data for the preliminary health risk assessment and were used in the PCE transport model calculation.

TABLE 5.1.4-2

GEOTECHNICAL RESULTS FOR BOREHOLE B4 AT PRS 0-039

SAMPLE DESCRIPTION	SAMPLE LOCATION	ORGANIC CARBON (LOI)%	REDOX (mV)	PERMEABILITY (cm/s)	DENSITY (lb/cu ft)
Upper sample 8.5-9.0 ft	00-4058	1.6	323	NA[a]	75.90
Lower sample 8.5-9.0 ft	00-4058	1.2	316	4.07670×10^{-4}	79.19
Upper sample 17.5-18.5 ft	00-4058	<1.0	324	NA	81.90
Lower sample 17.5-18.5 ft	00-4058	<1.0	316	1.31900×10^{-4}	83.82
Upper sample 59.0-60.0 ft	00-4058	<1.0	237	NA	87.60
Lower sample 59.0-60.0 ft	00-4058	<1.0	294	1.01800×10^{-4}	86.88

[a] NA = Not available

TABLE 5.1.4-3

GEOTECHNICAL RESULTS FOR BOREHOLE B4 AT PRS 0-039

SAMPLE DESCRIPTION	SAMPLE LOCATION	MOISTURE CONTENT (%)	SPECIFIC GRAVITY	POROSITY	VOID RATIO	pH
Upper sample 8.5-9.0 ft	00-4058	15.83	2.4817	0.4120	0.7010	7.7
Lower sample 8.5-9.0 ft	00-4058	20.17	2.4817	0.4886	0.9554	7.6
Upper sample 17.5-18.5 ft	00-4058	18.07	2.5100	0.4770	0.9119	8.6
Lower sample 17.5-18.5 ft	00-4058	18.88	2.5100	0.4648	0.8685	8.8
Upper sample 59.0-60.0 ft	00-4058	11.94	2.5627	0.4519	0.8244	8.1
Lower sample 59.0-60.0 ft	00-4058	12.10	2.5627	0.4643	0.8406	8.0

Geodetic Surveys: Initial geodetic survey work was completed on June 30, 1995, and a preliminary site map was generated. Additional surveys were completed in July and August 1995 to include additional site features and sample locations. A final map was generated with all surveyed points and scaled data. The survey data has been provided to Facility for Information Management Analysis and Display (FIMAD) for digitizing and plotting as required for public review.

5.1.5 Background Comparisons

Samples were not analyzed for inorganic or radionuclide constituents; therefore, background comparisons are not necessary.

5.1.6 Evaluation of Organic Constituents

One-hundred eighty subsurface soil samples collected from PRS 0-039 were analyzed for Stoddard solvent™ and VOCs. Of these, 98 were from boreholes, including 5 duplicates, and 82 were from hand-auger borings, including two duplicates. The analytes that were detected in soil samples are shown in Table 5.1.6-1 and are discussed below.

- Ethyl benzene was detected in one borehole sample at a concentration of 0.28 mg/kg.
- p-Isopropylbenzene was detected in one hand-auger boring sample at a concentration of 0.08 mg/kg.
- p-Isopropyltoluene was detected in two hand-auger boring samples at concentrations of 0.065 mg/kg and 0.027 mg/kg.
- Tert-butylbenzene was detected in three hand-auger boring samples at concentrations of 18 mg/kg, 2.7 mg/kg and 0.092 mg/kg.
- 1,2,4-Trimethylbenzene was detected in six hand-auger boring samples at concentrations ranging from 0.058 mg/kg to 18 mg/kg, and in one borehole sample at a concentration of 0.43 mg/kg.
- 1,3,5-Trimethylbenzene was detected in three hand-auger boring samples at concentrations of 12 mg/kg, 0.046 mg/kg and 0.013 mg/kg.
- Total xylene was detected in one borehole sample at a concentration of 3.21 mg/kg.

- TPH as Stoddard solvent™, was detected in 12 hand-auger boring samples at concentrations ranging from 2 mg/kg to 6 062 mg/kg, and in four borehole samples at concentrations ranging from 2 mg/kg to 676 mg/kg.

In this data set most of the QA/QC problems are sample specific and the qualifying of data was done mainly on a sample-by-sample basis. For this reason, PRS 0-039 site-specific data are not adjusted based on the data qualifiers applied to the sample data at this site (see Section 4.0).

On the basis of on these comparisons, these eight detected organic chemicals are carried forward through the screening assessment process. For the locations of samples showing detections see Fig. 5.1.6-1.

PCE was also detected in 70 subsurface samples, including three duplicates and trichloroethylene (TCE) was detected in one subsurface sample. It has been assumed the analytes detected in these 70 samples are not present as the result of dry cleaning operations during the period of time the AEC leased property to a dry cleaning facility, therefore, they are not considered in the screening assessment process. A discussion of the presence of these analytes at this site is presented in Appendix D.

TABLE 5.1.6-1

PRS 0-039 SOIL CONCENTRATIONS FOR ORGANIC ANALYTES WITH VALUES GREATER THAN THE EQL

SAMPLE ID	Depth (ft)	1,2,4 Trimethylbenzene	1,3,5 Trimethylbenzene	Ethylbenzene	p-Isopropylbenzene	p-Isopropyltoluene	Tertbutylbenzene	TPH	Xylenes
CRQL	N/A	NA	NA	0.01	NA	NA	NA	NA	0.01
SAL	N/A	8	6.4	690[a]	NA	NA	130	NA	990[a]
0100-95-0022	14.5-15	0.43 (J[b])	<0.01	0.28 (J)	<0.01	<0.01	<0.01	676	3.21 (J)
0100-95-0023	19.5-20	<25	<25	<25	<25	<25	<25	570	<25
0100-95-0024	24.5-25	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	15	<0.01
0100-95-0028	44.5-45	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2	<0.01
0100-95-0191	6.7-7	0.114	0.046	<0.01	0.08	<0.01	0.092	91	<0.01
0100-95-0194	3.7-4	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	8	<0.01
0100-95-0224	3.7-4	<0.05	<0.05	<0.1	<0.1	<0.5	<0.5	46	<0.1
0100-95-0226	9.7 - 10	12	<0.05	<0.1	<0.1	<0.5	<0.5	154	<0.1
0100-95-0230	3.7 - 4	0.058	<0.01	<0.01	<0.01	0.065	<0.01	<0.01	<0.01
0100-95-0231	5.7 - 6	<0.01	<0.01	<0.01	<0.01	0.027 (J)	<0.01	15	<0.01
0100-95-0232	9.7-10	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	3	<0.01
0100-95-0234	13.7 - 14	0.086 (J)	<0.01	<0.01	<0.01	<0.01	<0.01	10	<0.01
0100-95-0293	4.7-5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	2	<0.01
0100-95-0295	1.7-2	18 (J)	12 (J)	<10	<10	<10	<10	6062	<10
0100-95-0383	4.7-5	<0.01	<0.01	<0.5	<0.5	<0.5	<0.5	12	<0.5
0100-95-0384	6.7-7	3.1 (J)	<2.5	<2.5	<2.5	<2.5	2.7	1368	<2.5
0100-95-0392	8.7-9	<0.01	0.013	<0.01	<0.01	<0.01	<0.01	13	<0.01

[a] These SAL concentrations are based on soil saturation equations.
[b] J = Estimated quantity.

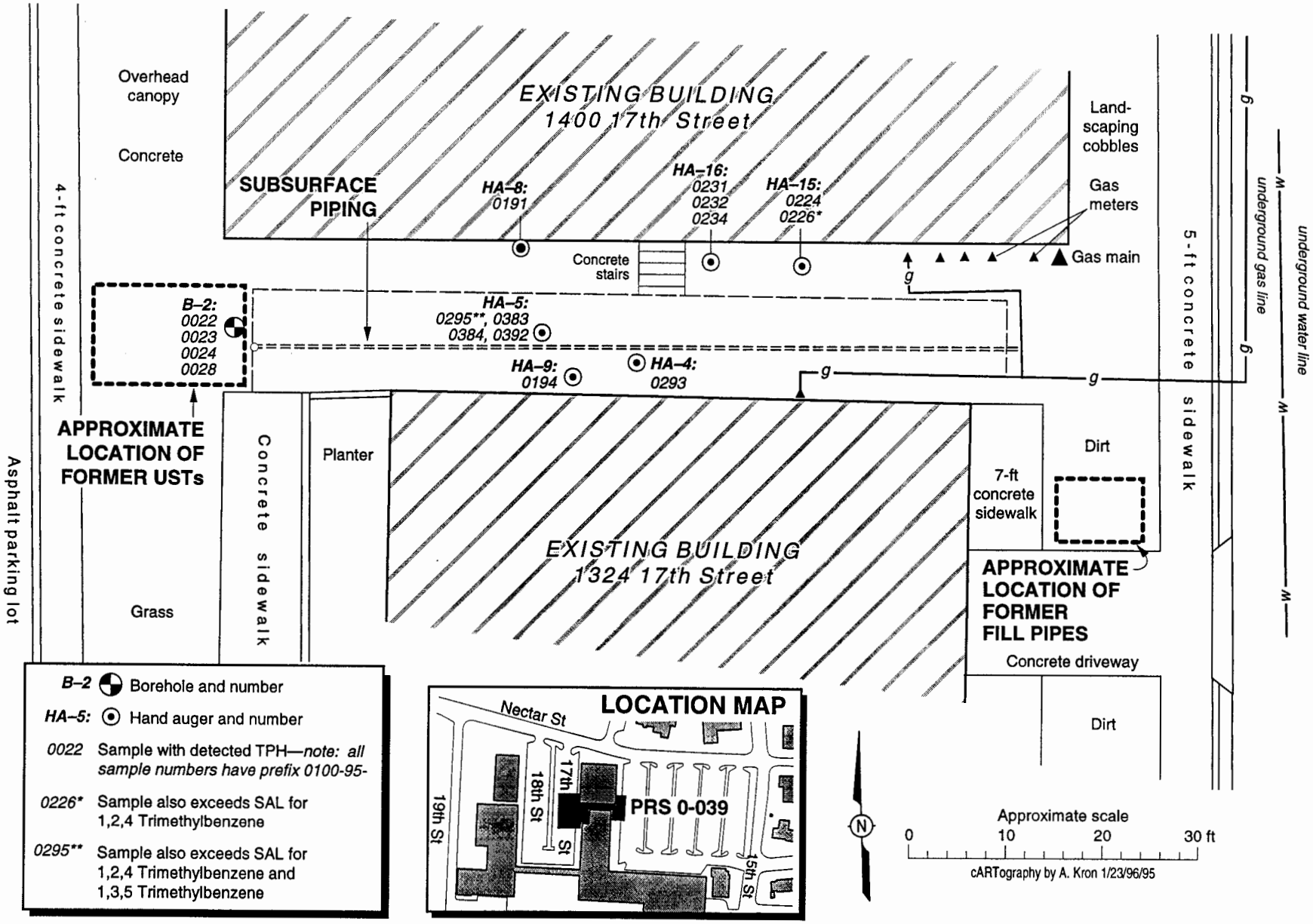

Fig. 5.1.6-1. Boreholes and hand auger holes showing samples with COPCs.

Of the VOCs that were not detected in any soil sample collected from PRS 0-039, 20 had EQLs that were higher than their respective SALs (i.e., chloromethane, vinyl chloride, bromomethane, 1,1-dichloroethane, carbon disulfide, methylene chloride, chloroform, carbon tetrachloride, benzene, 1,2-dichloroethane, 1,2-dichloropropane, bromodichloromethane, c-1,3-dichloropropene, t-1,3-dichloropropene, 1,1,2-trichloroethane, 1,1,1,2-tetrachloroethane, 1,2,3-trichloropropane, 1,1,2,2-tetrachloroethane, 1,4-dichlorobenzene, 1,2-dibromo-3-chloropropane). Of these 20 VOCs, two chemicals (carbon disulfide and methylene chloride) had EQLs above their SALs for only two samples, 0100-95-0023 and 0100-95-0207. Thirteen others do not have SALs to which the EQLs can be compared (i.e., iodomethane, 2,2-dichloropropane, bromochloromethane, 1,1-dichloropropene, 1,3-dichloropropane, chlorodibromomethane, 2-hexanone, 1,2-dibromomethane, bromobenzene, n-propylbenzene, 4-chlorotoluene, sec-butylbenzene, and n-butylbenzene). None of these organic chemicals are expected to be present at concentrations of concern resulting from operations at the AEC-leased facility. Therefore, these chemicals are not carried forward in the decision-making process for this site.

5.1.7 Human Health Assessment

5.1.7.1 Screening Assessment

This subsection presents a discussion of the results of the screening assessment for the chemicals detected at PRS 0-039. Eight organic chemicals were carried forward from the preliminary evaluation of organic chemicals (i.e., ethyl benzene, p-isopropylbenzene, p-isopropyltoluene, tert-butylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, total xylenes, and TPH). All of these are components of Stoddard solvent™. Only two of these analytes, the trimethylbenzenes, were detected above their SALs as discussed below and shown in Table 5.1.7.1-1.

- 1,2,4-Trimethylbenzene was detected in two hand-auger boring samples at concentrations of 12 mg/kg and 18 mg/kg, which exceed its SAL of 8 mg/kg.
- 1,3,5-Trimethylbenzene was detected in one hand-auger boring sample at a concentration of 12 mg/kg, which exceed its SAL of 6 mg/kg.

TABLE 5.1.7.1-1

PRS 0-039 SOIL CONCENTRATIONS FOR ORGANIC ANALYTES THAT EXCEED SALS

SAMPLE ID	Depth (ft)	1,2,4 Trimethylbenzene	1,3,5 Trimethylbenzene
CRQL	N/A	NA	NA
SAL	N/A	8	6.4
0100-95-0226	9.7 - 10	12	<0.05
0100-95-0295	1.7-2	18 (J)	12 (J)

[a] Sample Ids all prefixed with 0100-95- in FIMAD.

Of the remaining six chemicals only ethyl benzene, tert-butylbenzene, and total xylenes have SALs. These three chemicals, all of which are classed as noncarcinogens, are included in a MCE. Table 5.1.7.1-2 presents the results. The total normalized value is 0.13, indicating that these three chemicals are not expected to pose an unacceptable threat to human health. Consequently, these three chemicals are removed from further consideration.

TABLE 5.1.7.1-2

MULTIPLE CHEMICAL EVALUATION FOR TA-0 PRS 0-039

Analyte	Sample ID[a]	Sample Value (mg/kg)	SAL (mg/kg)	Normalized Value (Maximum Observed Concentration/SAL)
Ethyl benzene	0022	0.28	2 900	0.0001
Tert-butylbenzene	0384	18	140	0.13
Xylenes	0022	3.21	980	0.0033
			Normalized Sum	0.13

The remaining three organic chemicals that were detected do not have corresponding SALs. Isopropylbenzene and isopropyltoluene were detected infrequently and at very low concentrations and, consequently, are not expected to pose an unacceptable threat to human health. These two chemicals are removed from further consideration. TPH was detected relatively frequently, and occasionally at high concentrations. Although all of the detected organics are components of TPH, the specifically identified compounds account for only a small percentage of the TPH concentration. It was also determined that most of the TPH constituents are consistent with Stoddard solvent™ fraction of TPH. As such, Stoddard solvent™ (measured as TPH) will be further evaluated as a COPC.

As a result of the human health screening assessment process, three COPCs are identified: TPH, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene. These chemicals are considered further in the following section.

5.1.7.2 Risk Assessment

A residential land use was assumed in the development of SALs used for the screening assessment in order to create a conservative screening process. However, because the PRS is a narrow walkway located between two buildings, it is not feasible for this land to be used for residential purposes. The reasonable maximum exposure use for this area would be for workers to walk through this area several times a day. The potential risks associated with this land use are calculated in this risk assessment.

5.1.7.2.1 Review of COPCs

Three COPCs were identified by the screening assessment; 1,2,4-trimethylbenzene (2 times SAL), 1,3,5-trimethylbenzene (1.7 times SAL), and TPH. The sample with the highest TPH was further evaluated by GC/MS to identify the major components. The earliest eluting peaks were identified as hydrocarbon-substituted cyclic hydrocarbons, mainly cyclohexanes, cyclopentanes, and cyclooctanes. These first three peaks were estimated to be approximately 58% of the TPH. The later eluting peaks were identified as substituted decahydronaphthalene compounds (Decalin™) constituting approximately 40% of the TPH. Trace amounts of substituted benzene compounds were also identified, including trimethylbenzenes and tert-butylbenzene. These are estimated to be present at a maximum concentration of 2% of the TPH sample. These compounds are all consistent with the hydrocarbon fractions found in Stoddard solvent™.

5.1.7.2.2 Exposure Assessment

The COPCs are volatile and semivolatile chemicals that were detected relatively near the surface (the maximum value at 1.7 to 2 ft). Therefore, the primary exposure pathway for pedestrians through the area is inhalation. The potential airborne concentrations of these chemicals were modeled using EPA's Volatilization Factor Model (EPA 1991, 0302). The assumptions for this model and the resulting volatilization factors are given in Table 5.1.7.2.2-1.

TABLE 5.1.7.2.2-1

VOLATILIZATION FACTOR MODEL FOR PEDESTRIAN SCENARIO

$$VF(m^3/kg) = \frac{(LS \times V \times DH)}{A} \times \frac{(3.14 \times a \times T)^{1/2}}{(2 \times D_{ei} \times P_{air} \times K_{as} \times 10^{-3}\ kg/g)}$$

where:

$$P_{air} = 1 - (\beta/\rho_s) - (\theta/\beta)$$

$$D_{ei} = D_i \times P_{air}^{3.33}/P_{tot}^{2}$$

$$\alpha\ (cm^2/s) = \frac{(D_{ei} \times P_{air})}{P_{air} + (\rho_s)(1-P_{air})/K_{as}}$$

PARAMETER	VALUE	UNITS	DESCRIPTION
LS	6.1	m	length of side of exposure area
V	3	m/s	wind speed in mixing zone
DH	3	m	diffusion height
A [a]	$1.49X10^6$	cm^2	area of contamination
β	1.285	kg/L	bulk soil density
θ	0.1	kg_{water}/kg_{soil}	soil moisture content
ρ_s	2.65	kg/L	particle density
P_{tot} (calculated)	0.46	L_{pore}/L_{soil}	total soil porosity
P_{air} (calculated)	0.33	L_{air}/L_{soil}	air-filled soil porosity
T	$7.88X10^8$	sec	= 25 yrs
OC	0.016	g_{carbon}/g_{soil}	organic carbon content
H	chem-specific	$atm\text{-}m^3/mol$	Henry's law constant
K_{oc}	chem-specific	cm^3/g	organic carbon partition coefficient
K_d	chem-specific	cm^3/g	soil-water partition coefficient
D_i	chem-specific	cm^2/s	molecular diffusivity
K_{as}	$(H/K_d) \times 41$	g_{soil}/cm^3_{air}	soil/air partition coefficient

Contaminant	H ($atm\text{-}m^3/mol$)	K_{oc} (L/kg)	K_d (Koc*OC) (L/kg)	D_i (cm^2/s)	D_{ei} (calc) (cm^2/s)	K_{as} (calc) (g_{soil}/cm^3_{air})	α (cm^2/s)	VF (m^3/kg)
methylcyclohexane	$4.35X10^{-1}$	650	10.4	0.087	$1.0X10^{-2}$	1.7	$2.5X10^{-3}$	$7.8X10^3$
1,2,4-trimethylbenzene	$6.04X10^{-3}$	271	4.336	0.072	$8.6X10^{-3}$	$5.7X10^{-2}$	$9.1X10^{-5}$	$5.4X10^4$
1,3,5-trimethylbenzene	$6.04X10^{-3}$	271	4.336	0.072	$8.6X10^{-3}$	$5.7X10^{-2}$	$9.1X10^{-5}$	$5.4X10^4$
decalin	$4.70X10^{-1}$	7150	114.4	0.059	$7.1X10^{-3}$	$1.7X10^{-1}$	$2.2X10^{-4}$	$3.4X10^4$

[a] Area of entire walkway is assumed to be uniformly contaminated for this screening.

The potential exposure to these COPCs is estimated by the following equation and assumptions:

Intake (mg/kg) = (CS x IR x ET x EF x ED) / (BW x AT x VF)

Where:

CS = soil concentration (mg/kg) based on the assumption that 40% of the TPH is Decalin™, 58% are cyclic alkanes (methyl cyclohexane used as a surrogate for this fraction), and 1% of each trimethylbenzene isomer

IR = inhalation rate of 1.25 m^3/hr

ET = exposure time of 1 hour per day assuming 4 trips through the area

EF = exposure frequency of 250 days/year assuming 5 days per week for 50 weeks for a worker

ED = exposure duration of 25 years for a worker

BW = body weight of 70 kg for an adult

AT = averaging time of 25 years x 365 days/year

VF = volatilization factor modeled

Based on these assumptions, estimated intakes for the COPCs are shown in Table 5.1.7.2.2-2.

TABLE 5.1.7.2.2-2

AMBIENT AIR INHALATION EXPOSURE ESTIMATE

Contaminant	Concentration[a] (mg/kg)	RfD_i[b] (mg/kg-d)	Intake (mg/kg-d)	HQ[c]
methylcyclohexane	1624	0.857	$2.5X10^{-3}$	0.0030
1,2,4-trimethylbenzene	28.0	0.05	$6.4X10^{-6}$	0.0001
1,3,5-trimethylbenzene	28.0	0.05	$6.4X10^{-6}$	0.0001
decalin	1 120	0.04	$4.0X10^{-4}$	0.0100

EF (d/yr)	250
ET (hr/d)	1
IR (m^3/hr)	1.25
ED (yr)	30
BW (kg)	70
AT-nc (d)	10950
AT-c (d)	25550

HI[d]
0.01

[a] Based on the 95% UCL of the mean stoddard solvent concentration (2800 ppm) in a 0-3 ft deep, 20 x 20 ft hot spot area, assuming 58% methylcyclohexane, 40% decalin, and 1% of each trimethylbenzene isomer.
[b] Oral RfD used as inhalation RfD for trimethylbenzenes and decalin.
[c] Hazard quotient.
[d] Hazard index.

5.1.7.2.3 Toxicity Assessment

Toxicity assessment involves determining whether exposure to an agent can lead to adverse health effects in humans. The amount of a chemical that would not be associated with adverse health effects over a chronic exposure period is called a reference dose. Reference doses are determined by EPA, and are published in the Integrated Risk Information System (EPA 1994, 1167) and the Health Affects Assessment Summary Tables (Miller 1994, 1169), with interim values provided by the National Center for Environmental Assessment. Other toxicity information described in this section was obtained from the Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profiles for Stoddard solvent™ and naphthalene (Clement International Corporation 1993, 05-0223; Clement International Corporation 1993, 05-0224)

The reference doses used for the COPCs are given in Table 5.1.7.2.2-2. Methyl cyclohexane is the only cyclic alkane that has a reference dose; therefore, that reference dose was used as a surrogate value for the entire fraction containing cyclic alkanes. Decahydronaphthalene (Decalin™) does not have a reference dose; therefore, the reference dose for naphthalene was used for this fraction. The reference doses for both naphthalene and the trimethylbenzenes are oral values that are used in this assessment for inhalation values.

Because the reference doses used in this assessment are surrogate values and/or oral values for inhalation exposures, the potential toxicity is also evaluated qualitatively. Naphthalene, used as a surrogate for the decahydronaphthalene fraction, is considered appropriate based on comparison of the following toxicity benchmarks:

- the oral lethal doses are comparable (LD_{50} in rats of 4 200 mg/kg for decahydronaphthalene versus 2 400 mg/kg for naphthalene, indicating naphthalene is more toxic), and
- metabolic pathways and toxicity endpoints are similar.

Comparison of inhalation exposure guidelines for Stoddard solvent™ with exposure guidelines for naphthalene indicates that naphthalene is considered more toxic with a threshold limit value (TLV), time-weighted average (TWA) of 10 ppm compared with a TLV TWA of 100 ppm for Stoddard solvent™ (ACGIH 1995, 1286). Further, states within the US that have acceptable ambient air concentrations for both of these chemicals consistently allow higher levels of Stoddard solvent™ than naphthalene. It is also noted that the air concentrations estimated for the site using the EPA's Volatilization Factor Model would fall below all of these ambient air guidelines and regulations.

A review of toxicology literature for inhalation exposure to decahydronaphthalene is summarized in Table 5.1.7.2.3-1. The estimated air concentrations at this site do not come within two orders of magnitude of the lowest-observed-adverse-effect levels in these studies.

TABLE 5.1.7.2.3-1

INHALATION TOXICITY STUDIES SUMMARIES FOR DECALIN™[a]

TOXICITY MEASURE	CONCENTRATION (ppm)	DURATION	EFFECT	SPECIES
TC_{lo}[b]	5	24 hr/90 days	Lung and liver effects; endocrine tumors	Rat
TC_{lo}	5	24 hr/90 days	Lung and liver effects; hyperthyroid	Mouse
TC_{lo}	50	24 hr/90 days	Endocrine, liver, and kidney tumors	Mouse
TC_{lo}	100	NS[c]	Olfactory and conjunctiva irritation	Human
TC_{lo}	125	22 hr/31 days	Liver and kidney effects	Rat
LC_{lo}[d]	319	8 hr	Death	Guinea pig
LC_{50}[e]	710	4 hr	Death	Rat
LC_{lo}	993	4 hr	Death	Mouse

[a] From Registry of Toxic Effects Chemical Substances (RTECS).
[b] Lowest concentration at which toxicity was observed.
[c] Not specified.
[d] Lowest concentration at which death was observed.
[e] Lethal concentration for 50% of the test population.

5.1.7.2.4 Risk Characterization

In order to determine the potential for adverse effects, the estimated intakes are compared to reference doses. The ratio of the estimated intake of a COPC to its reference dose is the hazard quotient. A hazard quotient above one indicates a potential for toxicity from exposure to that chemical. Because the toxicity of several COPCs may be additive, the hazard quotients of the COPCs are added to determine a hazard index. A hazard index greater than one indicates the potential for toxicity from the combination of COPC exposures. As shown on Table 5.1.7.2.2-2, neither the hazard quotients nor the hazard index exceeds one. The hazard index of 0.01 indicates the combined exposure is approximately 1% of the level considered acceptable.

Although there are uncertainties inherent to any environmental risk evaluation, the assumptions made to compensate for uncertainty in this assessment are expected to result in over estimating risks. These uncertainties include the following:

- Environmental sampling: This uncertainty is low because the area is fairly small and the spatial coverage of sampling locations is relatively thorough.
- Sample analysis: This uncertainty could lead to a moderate low estimate because there was interference in several measurements forcing elevated detection limits.
- Fate and transport modeling: The volatilization factor model is a rough approximation that typically over estimates air concentration; although this is somewhat mitigated by using site-specific soil properties.
- Exposure parameter estimation: The exposure assumptions are likely to over estimate exposure, because it is unlikely that the area would be used routinely for an hour per day for 25 years. Also, the estimated mean concentrations are conservative because they are based only on the first three feet of contamination, and on a 20 ft by 24 ft subsection of the walkway. See Section 5.1.9 for further discussion.
- Toxicity information: Toxicity data for Stoddard solvent™ are not complete and are complicated by the fact that it is a variable mixture of compounds. Extrapolation of toxicity data from animal studies to humans, or from short-term to long-term exposures, or high doses to low doses creates uncertainty that could result in either an over estimation or under estimation of risk. Also, the use of oral toxicity values for inhalation exposures adds uncertainty to the risk estimate.

Because the estimated exposure is well below any threshold of toxicity, these uncertainties are not expected to significantly affect the results of this evaluation.

In summary, there appears to be no adverse human health effects associated with the very low level exposure potential resulting from Stoddard solvent™ found below the surface at the site.

5.1.8 Ecological Assessment

5.1.8.1 Ecotoxicological Screening Assessment

No ecological screening assessment was performed for PRS 0-039 because the site is a commercially developed, urban area.

5.1.8.2 Ecological Risk Assessment

An ecological risk assessment has not been conducted in the area of PRS 0-039 because the site is a commercially developed, urban area.

5.1.9 Extent of Contamination

Spatial statistical analysis was performed using the TPH data to model the extent of Stoddard solvent™ contamination and is presented here. Summary statistics to support the risk assessment included in Section 5.1.7 were estimated using the spatial models that were generated. (Spatial statistical analysis and transport calculations were also used to model the extent of PCE contamination and are presented in Appendix D.)

5.1.9.1 Spatial Statistics for TPH at PRS 0-039

One hundred eighty subsurface soil samples collected from PRS 0-039 were analyzed for TPH. TPH was detected in 16 of these samples at concentrations ranging from 2 mg/kg to 6 062 mg/kg. The detected TPH concentrations for PRS 0-039 are in Table 5.1.6-1.

Spatial images of the TPH concentrations are presented in Figs. 5.1.9.1-1 and 5.1.9.1-2. The concentration contours used on these figures represent cut-offs of 250, 500, 1 000, 2 000, and 4 000 mg/kg. Figures 5.1.9.1-1 presents TPH concentration images at nine distinct depths to provide a three-dimensional representation of TPH contamination. For spatial orientation, each image contains points that mark the sampling locations of the boreholes and hand augerholes used in the analyses, although observed TPH data may not be available at each depth for the illustrated sampling locations. Figure 5.1.9.1-2 shows nine distinct north-facing profiles of the same area. These profiles are indexed by their corresponding northings. The area of interest corresponds to a walkway between two buildings that is approximately 80 ft

long by 20 ft wide. The nine north-facing profiles are two feet apart. The contours represent the concentration of TPH across the area. For nondetects, half the detection limit was used. The data set used to produce the figures was generated through the statistical interpolation process known as kriging. Kriging allows for estimating concentrations throughout a three-dimensional volume, provided adequate observations exist for reasonable estimation of a spatial model. The kriging process uses the correlation structure present in the data to estimate concentrations at locations for which there are no data. The process is outlined in Appendix C. The figures present slightly different overall representations of the TPH contamination as a result of the graphical contouring method used to picture the kriged data. Table 5.1.9-1 shows the data used to support the concentration images.

TABLE 5.1.9.1-1

TPH RESULTS FOR PRS 0-039

BOREHOLES

	BOREHOLE NUMBER								
DEPTH (ft)	B1	B2	B3	B4	B5	B6	B7	B8	B9
0–0.5				<1					
4.5–5	<1[a]	<1	<1	<1	<1	<1	<1	<1	<1
9.5–10	<1	<1	<1	<1	<1	<1	<1	<1	<1
14.5–15	<1	676	<1	<1	<1	<1	<1	<1	<1
19.5–20	<1	570	<1	<1	<1	<1	<1	<1	<1
24.5–25	<1	15	<1	<1	<1	<1	<1	<1	<1
29.5–30	<1	<1	<1	<1	<1	<1	<1	<1	<1
34.5–35	<1	<1	<1	<1	<1	<1	<1	<1	<1
39.5–40	<1	<1	<1	<1	<1	<1	<1		
44.5–45	<1	2	<1	<1	<1	<1	<1		
49.5–50		<1	<1	<1	<1	<1			
54.5–55		<1	<1	<1	<1	<1			
59.5–60		<1	<1	<1	<1	<1			

HAND-AUGER HOLES (1)

	HAND-AUGER HOLE NO.								
DEPTH (ft)	HA1	HA1a	HA2	HA2a	HA3	HA4	HA5	HA6	HA7
0.7–1	<1	<1	<1	<1	<1	<1		<1	<1
1.7–2			<1				6 062		
2.7–3	<1	<1		<1	<1			<1	
3.7–4	<1		<1		<1			<1	<1
4.7–5		<1		<1		2	12		
5.7–6						<1			
6.7–7							1 368		
8.7–9							13		
9.7–10									
10.7–11							<1		
12.7–13									
13.7–14									
14.7–15									
15.7–16									
16.7–17									
18.7–19									
19.7–20									
21.7–22									
24.7–25									

HAND-AUGER HOLES (2)

	HAND-AUGER HOLE NO.									
DEPTH (ft)	HA8	HA9	HA10	HA11	HA12	HA13	HA14	HA15	HA16	HA17
0.7–1	<1	<1	<1	<1	<1	<1	<1	<10	<1	<1
1.7–2										
2.7–3			<1	<1						
3.7–4		8			<1	<1	<1	46	<1	<1
4.7–5			<1	<1						
5.7–6		<1			<1	<1	<1	<10	15	<1
6.7–7	91									
8.7–9	<1				<1					
9.7–10					<1		<1	154	3	<1
10.7–11										
12.7–13					<1		<1	<10	<1	<1
13.7–14								<10	10	<1
14.7–15					<1		<1			
15.7–16								<1		
16.7–17					<1					
18.7–19								<1		
19.7–20								<1		
21.7–22								<1		
24.7–25								<1		

[a] Units for TPH concentrations are µg/kg

The concentration images demonstrate the existence of two TPH plumes. The first plume starts at the surface and is centered at hand augerhole 5 (HA5). The plume spreads out and becomes less concentrated in the 3-ft and 6-ft depth intervals and fades to nondetect by the 12-ft depth interval. The second plume is centered at Borehole 2 within the 15 ft depth interval and ranges between 12 ft and 21 ft. The concentrations for this plume start to fade in the 21-ft depth interval. The spatial images indicate that the two plumes are distinct and do not overlap.

The impression created by the TPH concentration images at the successive depth intervals is consistent with process knowledge of this site. The deeper plume to the west end of the site may be associated with a leak from one of the underground storage tanks prior to removal. The plume is consistent with the location and depths of the tanks and the depth of excavation when the tanks were removed. The plume from the site, which starts near the surface, may be associated with a leak in the piping system that served the tanks. The plume is consistent with the depth of the pipes (about two to three feet near the central part below ground surface), and with the location of a potential source for leakage from the piping system. In both cases, the plumes have probably spread from these initial sources to greater depths over time.

The kriged model was also used to generate estimates of the mean TPH concentrations under the walkway, including an upper confidence limit (UCL) on the mean. Details are provided in Appendix C. The mean concentrations are used in the human health risk assessment in Section 5.1.7. The estimated mean concentrations are conservative because they are based only on the first three feet of contamination, and on a 20 ft x 24 ft subsection of the walkway. The TPH plume under the walkway reaches a depth of approximately 10 ft, although the higher concentrations are near the surface. If a larger volume was used as the basis for estimation, then the mean concentrations would be lower.

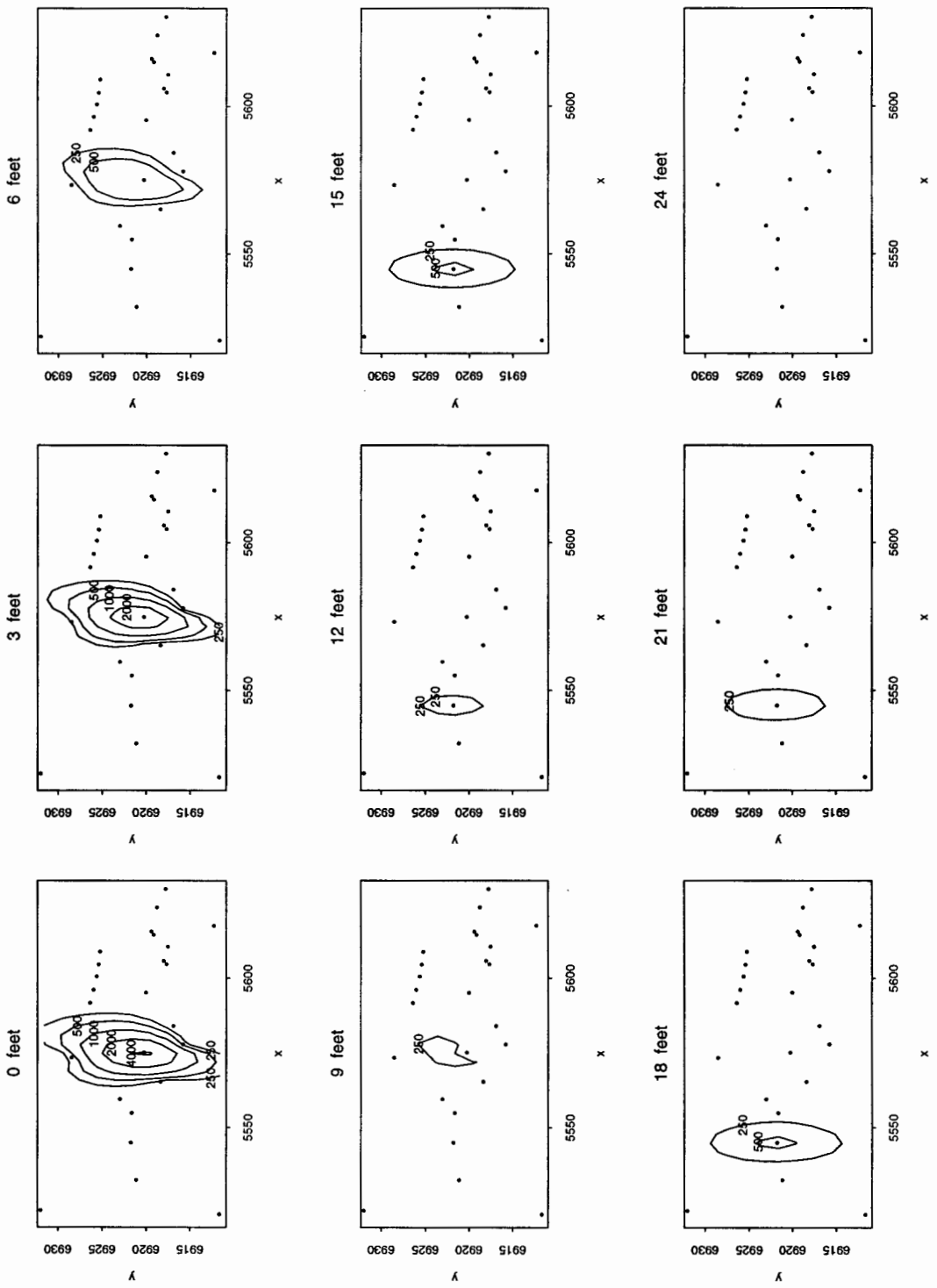

Fig. 5.1.9.1-1. TPH spatial image plots by depth for PRS 0-039.

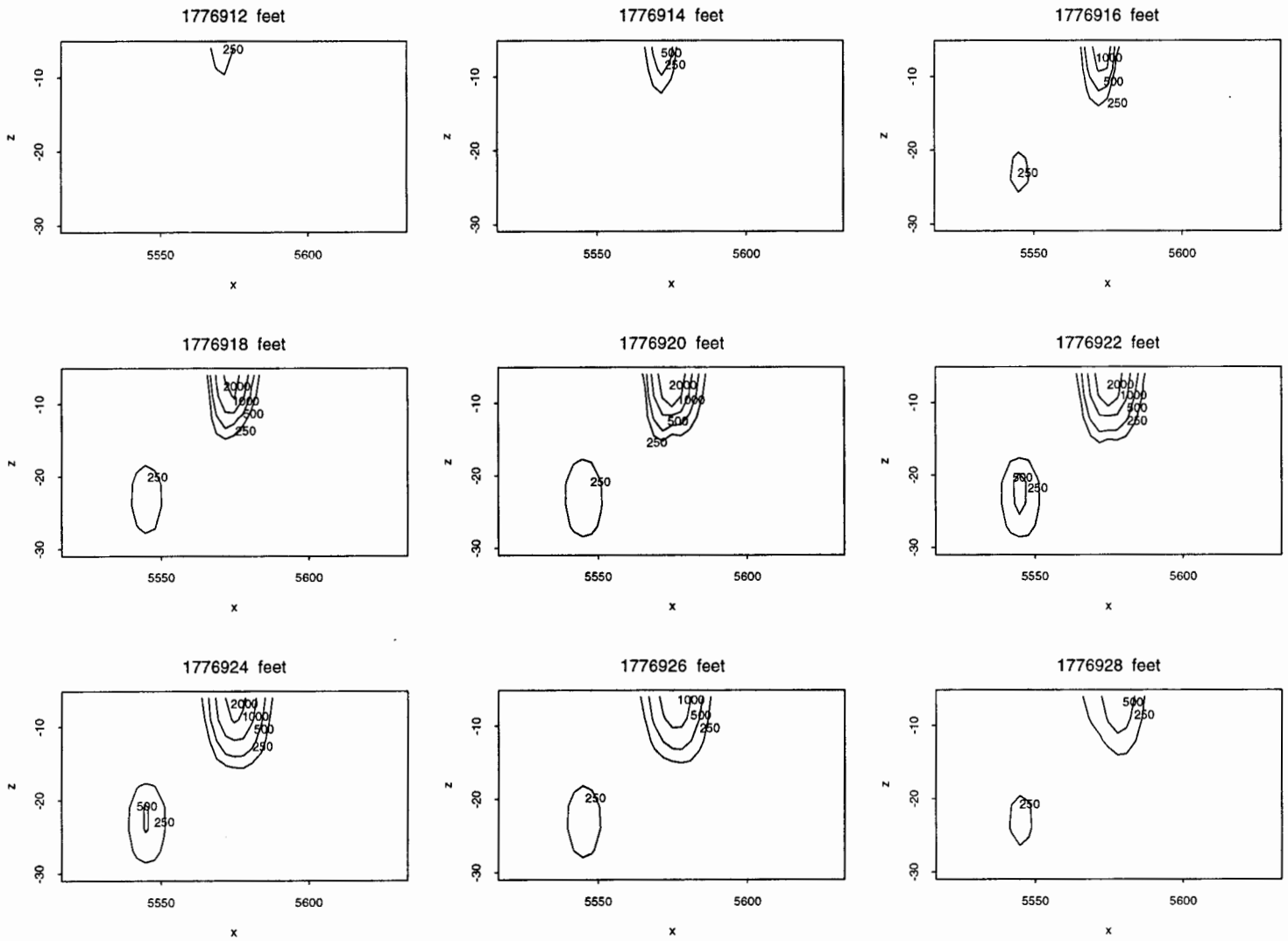

Fig. 5.1.9.1-2. TPH spatial image plots by northing for PRS 0-039.

5.1.10 Conclusions and Recommendations

The chemicals resulting from the AEC-leased dry cleaning facility retained as COPCs by the screening process at PRS 0-039 were determined by the risk assessment to be present only at levels that were more than an order of magnitude below lowest observed adverse effect level. Therefore, PRS 0-039 is recommended for no further action (NFA) based on LANL's NFA Criteria Policy, criterion 4 (which states that the PRS has been characterized in accordance with current applicable state or federal regulations, and that COPCs are not present in concentrations that would pose an unacceptable risk under the present and projected future land use). A Class III permit modification will be requested to remove PRS 0-039 from the Hazardous Solid Waste Ammendments (HSWA) Module of LANL's RCRA operating permit (Environmental Restoration Project 1995, 1173).

Although a PCE plume was detected in the area, the PCE is not retained as a COPC for PRS 0-039. Transport calculations demonstrate that the PCE plume substantially post-dates the AEC's ownership of the site. As discussed earlier in this report, the AEC sold this site in 1968, over 25 years ago. In a 25-year period, calculations show that PCE would have transported a vertical distance of approximately 73 ft. However, sampling shows that the PCE plume adjacent to the north building has a vertical depth of only approximately 25 ft. This is substantially less than the depth that PCE would have migrated if it had been released during or before 1968. Therefore, it is clear that the PCE was released after 1968.

Additionally, it is clear that the PCE plume is not associated with the UST system used for Stoddard solvent™ storage or with previous AEC operations at this site. This premise is also supported by the following facts: 1) during the time of AEC's ownership of the property, the lessee, Corbett, only used PCE as a minor constituent of an agent used for waterproofing clothing; 2) the USTs were used to store Stoddard solvent™; 3) during the time of AEC's ownership of the property, the lessee's dry cleaning equipment was not converted or replaced so that the lessee could to use PCE; and 4) the PCE plume is located away from the solvent storage system used by the dry cleaner business. Therefore, LANL has no association with and no responsibility for the PCE plume (Appendix D).

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APPENDIX A ANALYTICAL DATA

All analytical data are available in the Facility for Information Management, Analysis, and Display (FIMAD) database. If FIMAD is not accessible, data will be provided upon request. A hard copy of the data is available from the records processing facility (RPF) under "Analytical Data for the Phase I Investigation of PRS 0-039."

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APPENDIX B DATA QUALITY EVALUATION TABLE

TABLE B-1

DATA QUALITY EVALUATION FOR PRS 0-039 SAMPLES

SAMPLE NUMBER	SUITE	QUALITY CONTROL (QC) COMMENTS
0100-95-0000	VOCs[a]	Internal standard recoveries low, all results qualified UJ[b]; all data valid
0100-95-0004	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0022	VOCs	Internal standard recoveries low and xylenes and trimethylbenzene results above calibration range, all results qualified UJ or J[c]; all data valid
0100-95-0023	TPH[d]	QC results within allowable limits; all data valid
0100-95-0023	VOCs	BFBe recovery low, all results qualified UJ or J; all data valid
0100-95-0046	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0051	VOCs	Surrogate recoveries low, all results qualified UJ; all data valid
0100-95-0069	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0085	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0087	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0110	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0111	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0113	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0119	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0127	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0148	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0167	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0180	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid

TABLE B-1 (CONTINUED)

DATA QUALITY EVALUATION FOR PRS 0-039 SAMPLES

SAMPLE NUMBER	SUITE	QUALITY CONTROL (QC) COMMENTS
0100-95-0181	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0179	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0282	Naphthalenes	No QC results; all data screening level only
0100-95-0282	VOCs	PCE[f] saturated detector, result qualified J because of low bias (possibly as much as 10 times). All other QC results within allowable limits; all data valid
0100-95-0284	Naphthalenes	No QC results; all data screening level only
0100-95-0284	VOCs	PCE saturated detector, result qualified J because of low bias (possibly as much as 10 times). All other QC results within allowable limits; all data valid
0100-95-0285	Naphthalenes	No QC results; all data screening level only
0100-95-0285	VOCs	PCE saturated detector, result qualified J because of low bias (possibly as much as 10 times). All other QC results within allowable limits; all data valid
0100-95-0286	Naphthalenes	No QC results; all data screening level only
0100-95-0287	Naphthalenes	No QC results; all data screening level only
0100-95-0287	VOCs	PCE saturated detector, result qualified J because of low bias (possibly as much as 10 times). All other QC results within allowable limits; all data valid
0100-95-0288	Naphthalenes	No QC results; all data screening level only
0100-95-0289	Naphthalenes	No QC results; all data screening level only
0100-95-0290	Naphthalenes	No QC results; all data screening level only
0100-95-0290	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0291	Naphthalenes	No QC results; all data screening level only
0100-95-0291	VOCs	Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0292	Naphthalenes	No QC results; all data screening level only
0100-95-0293	Naphthalenes	No QC results; all data screening level only
0100-95-0294	Naphthalenes	No QC results; all data screening level only
0100-95-0393	Naphthalenes	No QC results; all data screening level only
0100-95-0393	VOCs	BFB recovery low (72%), all results qualified UJ; all data valid
0100-95-0295	Naphthalenes	No QC results; all data screening level only
0100-95-0295	VOCs	Trimethylbenzenes qualified J for high dilution. All other QC results within allowable limits; all data valid

TABLE B-1 (CONTINUED)

DATA QUALITY EVALUATION FOR PRS 0-039 SAMPLES

SAMPLE NUMBER	SUITE	QUALITY CONTROL (QC) COMMENTS
0100-95-0383	Naphthalenes	No QC results; all data screening level only
0100-95-0384	Naphthalenes	No QC results; all data screening level only
0100-95-0384	VOCs	Trimethylbenzenes qualified J for high dilution. All other QC results within allowable limits; all data valid
0100-95-0392	Naphthalenes	No QC results; all data screening level only
0100-95-0385	Naphthalenes	No QC results; all data screening level only
0100-95-0386	Naphthalenes	No QC results; all data screening level only
0100-95-0387	Naphthalenes	No QC results; all data screening level only
0100-95-0390	Naphthalenes	No QC results; all data screening level only
0100-95-0391	Naphthalenes	No QC results; all data screening level only
0100-95-0388	Naphthalenes	No QC results; all data screening level only
0100-95-0389	Naphthalenes	No QC results; all data screening level only
0100-95-0394	Naphthalenes	No QC results; all data screening level only
0100-95-0191	Naphthalenes	No QC results; all data screening level only
0100-95-0192	Naphthalenes	No QC results; all data screening level only
0100-95-0193	Naphthalenes	No QC results; all data screening level only
0100-95-0194	Naphthalenes	No QC results; all data screening level only
0100-95-0195	Naphthalenes	No QC results; all data screening level only
0100-95-0199	Naphthalenes	No QC results; all data screening level only
0100-95-0200	Naphthalenes	No QC results; all data screening level only
0100-95-0201	Naphthalenes	No QC results; all data screening level only
0100-95-0203	Naphthalenes	No QC results; all data screening level only
0100-95-0204	Naphthalenes	No QC results; all data screening level only
0100-95-0205	Naphthalenes	No QC results; all data screening level only
0100-95-0297	Naphthalenes	No QC results; all data screening level only
0100-95-0325	Naphthalenes	No QC results; all data screening level only
0100-95-0206	Naphthalenes	No QC results; all data screening level only
0100-95-0210	Naphthalenes	No QC results; all data screening level only
0100-95-0211	Naphthalenes	No QC results; all data screening level only
0100-95-0212	Naphthalenes	No QC results; all data screening level only
0100-95-0213	Naphthalenes	No QC results; all data screening level only
0100-95-0207	Naphthalenes	No QC results; all data screening level only
0100-95-0208	Naphthalenes	No QC results; all data screening level only
0100-95-0209	Naphthalenes	No QC results; all data screening level only
0100-95-0395	Naphthalenes	No QC results; all data screening level only

TABLE B-1 (CONTINUED)

DATA QUALITY EVALUATION FOR PRS 0-039 SAMPLES

SAMPLE NUMBER	SUITE	QUALITY CONTROL (QC) COMMENTS
0100-95-0396	Naphthalenes	No QC results; all data screening level only
0100-95-0397	Naphthalenes	No QC results; all data screening level only
0100-95-0202	Naphthalenes	No QC results; all data screening level only
0100-95-0398	Naphthalenes	No QC results; all data screening level only
0100-95-0197	Naphthalenes	No QC results; all data screening level only
0100-95-0198	Naphthalenes	No QC results; all data screening level only
0100-95-0214	Naphthalenes	No QC results; all data screening level only
0100-95-0214	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0215	Naphthalenes	No QC results; all data screening level only
0100-95-0216	Naphthalenes	No QC results; all data screening level only
0100-95-0217	Naphthalenes	No QC results; all data screening level only
0100-95-0217	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier. Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0220	Naphthalenes	No QC results; all data screening level only
0100-95-0220	VOCs	PCE qualified UB[g] for blank contamination; all data valid
0100-95-0221	Naphthalenes	No QC results; all data screening level only
0100-95-0221	VOCs	PCE qualified UB for blank contamination (see text); all data valid
0100-95-0222	Naphthalenes	No QC results; all data screening level only
0100-95-0222	VOCs	Detector saturated for PCE, see text for discussion of corrective actions. Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0218	Naphthalenes	No QC results; all data screening level only
0100-95-0219	Naphthalenes	No QC results; all data screening level only
0100-95-0219	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0248	Naphthalenes	No QC results; all data screening level only
0100-95-0300	Naphthalenes	No QC results; all data screening level only
0100-95-0326	Naphthalenes	No QC results; all data screening level only
0100-95-0223	Naphthalenes	No QC results; all data screening level only
0100-95-0223	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0226	TPH	Results corrected for PCE interference, QC results within allowable limits; all data valid

TABLE B-1 (CONTINUED)

DATA QUALITY EVALUATION FOR PRS 0-039 SAMPLES

SAMPLE NUMBER	SUITE	QUALITY CONTROL (QC) COMMENTS
0100-95-0226	Naphthalenes	No QC results; all data screening level only
0100-95-0226	VOCs	Detector saturated for PCE, see text for discussion of corrective actions. Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0227	Naphthalenes	No QC results; all data screening level only
0100-95-0227	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0228	Naphthalenes	No QC results; all data screening level only
0100-95-0228	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0243	Naphthalenes	No QC results; all data screening level only
0100-95-0244	Naphthalenes	No QC results; all data screening level only
0100-95-0245	Naphthalenes	No QC results; all data screening level only
0100-95-0246	Naphthalenes	No QC results; all data screening level only
0100-95-0247	Naphthalenes	No QC results; all data screening level only
0100-95-0224	TPH	Results corrected for PCE interference, QC results within allowable limits; all data valid
0100-95-0224	Naphthalenes	No QC results; all data screening level only
0100-95-0224	VOCs	Detector saturated for PCE, see text for discussion of corrective actions. Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0225	TPH	Results corrected for PCE interference, QC results within allowable limits; all data valid
0100-95-0225	Naphthalenes	No QC results; all data screening level only
0100-95-0225	VOCs	Detector saturated for PCE, see text for discussion of corrective actions. Internal standard recoveries low, all results qualified UJ; all data valid
0100-95-0229	Naphthalenes	No QC results; all data screening level only
0100-95-0232	Naphthalenes	No QC results; all data screening level only
0100-95-0232	VOCs	PCE qualified UB for blank contamination; all data valid
0100-95-0233	Naphthalenes	No QC results; all data screening level only
0100-95-0233	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0234	TPH	QC results within allowable limits; all data valid
0100-95-0234	Naphthalenes	No QC results; all data screening level only
0100-95-0230	Naphthalenes	No QC results; all data screening level only

TABLE B-1 (CONTINUED)

DATA QUALITY EVALUATION FOR PRS 0-039 SAMPLES

SAMPLE NUMBER	SUITE	QUALITY CONTROL (QC) COMMENTS
0100-95-0231	Naphthalenes	No QC results; all data screening level only
0100-95-0235	Naphthalenes	No QC results; all data screening level only
0100-95-0235	VOCs	Over calibration for PCE, PCE qualified J; acetone qualified UJ for blank contamination; all data valid
0100-95-0238	Naphthalenes	No QC results; all data screening level only
0100-95-0239	Naphthalenes	No QC results; all data screening level only
0100-95-0240	Naphthalenes	No QC results; all data screening level only
0100-95-0240	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0236	Naphthalenes	No QC results; all data screening level only
0100-95-0236	VOCs	Over calibration for PCE, see text for discussion of corrective actions and qualifier; all data valid
0100-95-0237	Naphthalenes	No QC results; all data screening level only
0100-95-0296	Naphthalenes	No QC results; all data screening level only
0100-95-0354	Naphthalenes	No QC results; all data screening level only
0100-95-0140	Naphthalenes	No QC results; all data screening level only
0100-95-0141	Naphthalenes	No QC results; all data screening level only
0100-95-0079	Naphthalenes	No QC results; all data screening level only
0100-95-0080	Naphthalenes	No QC results; all data screening level only

[a] VOC = Volatile organic compound.
[b] UJ = Estimated undetected quantities.
[c] J = Estimated detected quantities.
[d] TPH = Total petroleum hydrocarbons.
[e] BFB = Bromofluorobenzene.
[f] PCE = Perchloroethylene.
[g] UB = The analyte was detected in the sample and the blank at similar concentrations, and the reporting limit was raised to the detected concentration.

APPENDIX C SPATIAL STATISTICS METHODS

Spatial statistical methods, or kriging methods (Isaaks and Srivastava 1989, 0765), were applied to the TPH and PCE data available from the investigation of PRS 0-039, also known as the Community Center. The purpose of this appendix is to provide an outline of the kriging process used to generate the spatial plots of TPH and PCE contamination presented in the main body of the text or Appendix D, and to indicate the process by which mean estimates of contaminant concentrations were calculated to support the human health risk assessment.

Approximately 180 TPH and PCE data points are available from the Community Center PRS 0-039 investigation. These points directly represent only a small portion of the site. The kriging process is used to generate predicted concentrations, based on the observed data points, for all other locations within the investigated volume. The kriging process is used to calculate the weights, using weighted least squares estimation, for estimating a value at an unsampled location. The weights are calculated using the observed correlation structure between observations, with the constraint that the weights must sum to one. Two assumptions are often invoked for the kriging process. The first is that observations are independent; and, the second is that the correlation structure is isotropic, that is, the correlation between observations the same distance apart is the same in all directions. In the case of the Community Center, neither the independence assumption nor the isotropic assumption hold. The data collected at the Community Center are not independent, as is true for most data collected at Los Alamos National Laboratory (LANL). The data originate from boreholes, which makes all data from the same borehole dependent, although the locations of the boreholes themselves may be approximately independent. The data also appear to be anisotropic (i.e., a correlation structure that depends on both distance and direction), which is a common characteristic of data derived from taking samples like those from the Community Center.

Under ideal circumstances, independence and isotropy assumptions can be verified and kriging methods can be used with relative confidence. It is not practical to assume otherwise until software exists to easily introduce the effects of dependence and anisotropy in kriging problems. Some qualitative verification of these assumptions can be performed by considering the end results of the kriging process with respect to expectations based on process knowledge.

Once the assumptions are examined, the next step in kriging is to estimate a functional form of the correlation structure. A form of the correlation structure is required for calculating the weights needed to predict concentrations for the unsampled locations. This correlation function is derived by estimating the form of a related function called the semi-variogram function.

The semi-variogram is a function of distance, so the distances between the sampling locations are calculated first. Rather than calculating the semi-variogram for every observed distance, which is very calculation intensive, the observed distances are ordered and divided into groups called bins. The average distance is calculated for each bin, then the average correlation is calculated across each pair of data points contained in a bin. The semi-variogram estimate is calculated directly from the correlation. The number of bins is specified by the statistician, and is one of the most subjective parts of the process. In some cases, the number of bins determines whether the parameters of the semi-variogram function can be estimated, thus determining whether the correlation function can be specified.

The average semi-variogram values are plotted against the average bin distance, resulting in a plot called a semi-variogram cloud. Figure C-1 shows the semi-variogram cloud for TPH at the Community Center. The line through the data is the function selected, via nonlinear least squares methods, to model the cloud. There are several functions that may be used to model the variogram cloud; the model in Fig. C-1 is the exponential model, which takes the form

$$G(h) = \sigma^2(1 - \exp(h/h_0)),$$

where σ^2 is defined as the range, or population variance, h is distance between observations, and h_o is the sill, or the distance at which the data become uncorrelated. It is important to plot and examine the cloud before deciding which model may be appropriate. For the TPH data, the nonlinear least squares estimates of the range and sill are 8.42 and 4.6 x 10^5, respectively.

The correlation function, $C(h)$, and semi-variogram function have the following relationship:

$$C(h) = \sigma^2 - G(h).$$

From this relationship, the estimated correlation function, denoted $\tilde{C}(h)$, may be determined.

Once the correlation function has been estimated, the next step in the kriging process is to set up the system of kriging equations that determine the system of weights assigned to the observed values that are used to estimate, or predict, concentrations at unsampled locations. In matrix form, the kriging equations appear as follows:

$$Cw = D$$

where C is an $(n+1)$ x $(n+1)$ matrix of $C(h)$ for all distances, h, illustrated by the data. In other words, C is a matrix of correlation estimates for all binned distances between observations in the original data set. The w vector is a $(n+1)$ vector of weights used to estimate a value at a specified location, and D is the $(n+1)$ vector of estimated correlations between the value to be

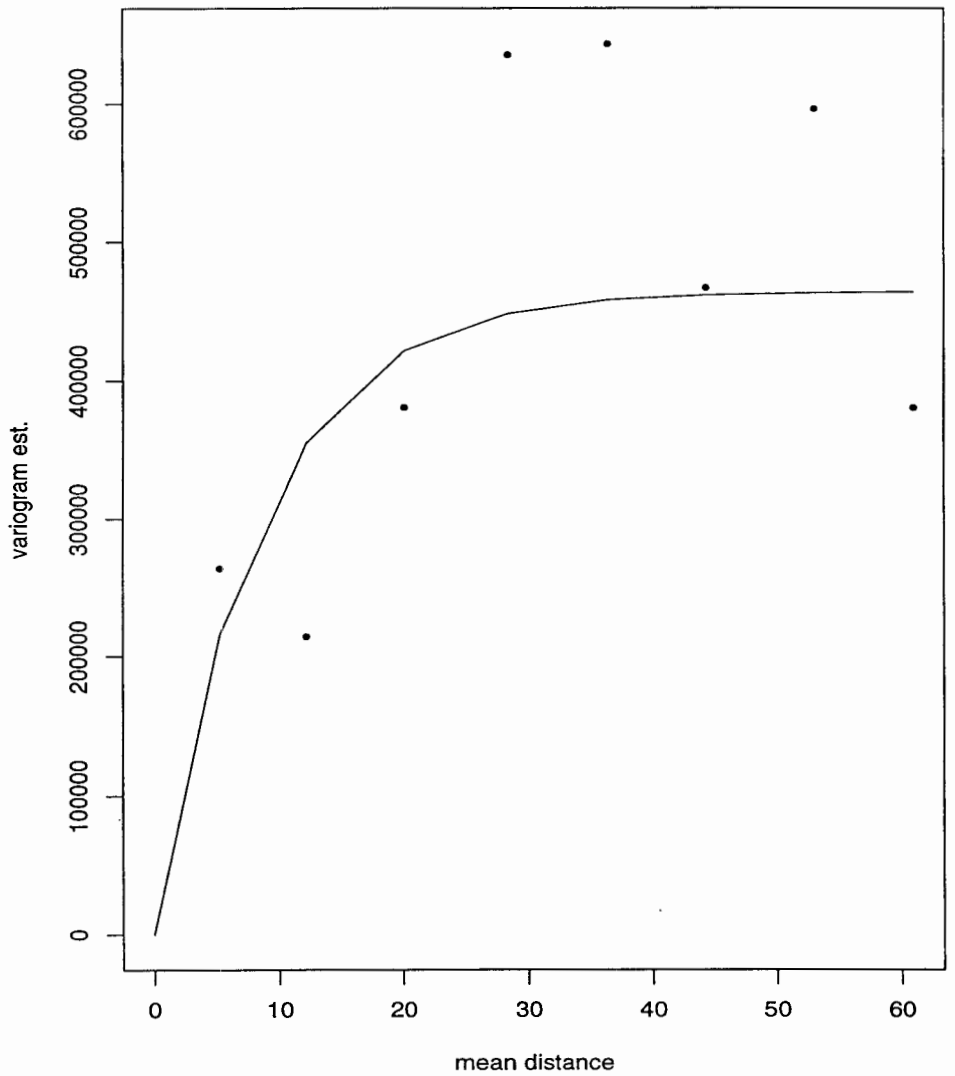

Fig. C-1. Variogram cloud and nonlinear least squares model for the Community Center TPH data.

estimated and the actual observations. The weights are calculated by inverting C and solving for the weights:

$$w = C^{-1}D.$$

If there are very few observations taken from a large area, or many nondetects in the data, inverting C becomes difficult computationally. For example, the PCE data from the Community Center showed such large variability within small distances that the kriging equations could not be solved without first truncating the data. That is, a value of 10 000 ppm was chosen as the truncation level, and all data values greater than 10 000 ppm were set to this value in order to solve the kriging equations. This truncation may be thought of as a variance stabilization. This decreased the short range variability enough for C to be invertible computationally so that kriging weights could be determined. Once the weights are calculated, the observed values replace the truncated values for the further modeling.

Once the kriging equations are solved, if the observations are denoted $v_i, i = 1,\ldots,n$, and their respective weights are denoted w_i, then the estimate of concentration at an unsampled location is:

$$\hat{v} = \sum_{i=1}^{n} w_i v_i .$$

By dividing the three-dimensional volume defined by the sample locations and depths of the boreholes into small cubic volumes and calculating a kriged value for each small volume, estimates of the volume of contamination and of the mean concentration within that volume may be established. Once again, however, the validity of these estimates depends on the appropriateness of the kriging assumptions and the semi-variogram model specified.

Mean estimates of the TPH contaminant plume are required for the human health risk assessment presented in the main body of the text. These estimates are based on the spatial model generated through the kriging process. The risk assessment required estimation of mean TPH concentration within a 20 ft x 24 ft area, down to a depth of three feet. Figure C-2 shows the area used.

The estimate of the mean is calculated directly from the kriged data points (to include the observed values) that are contained within the approximately 20 ft x 24 ft subsection of the walkway that composes the area of concern. Only five observed concentrations are included in the required volume; however, the kriged model includes information from all 180 data points.

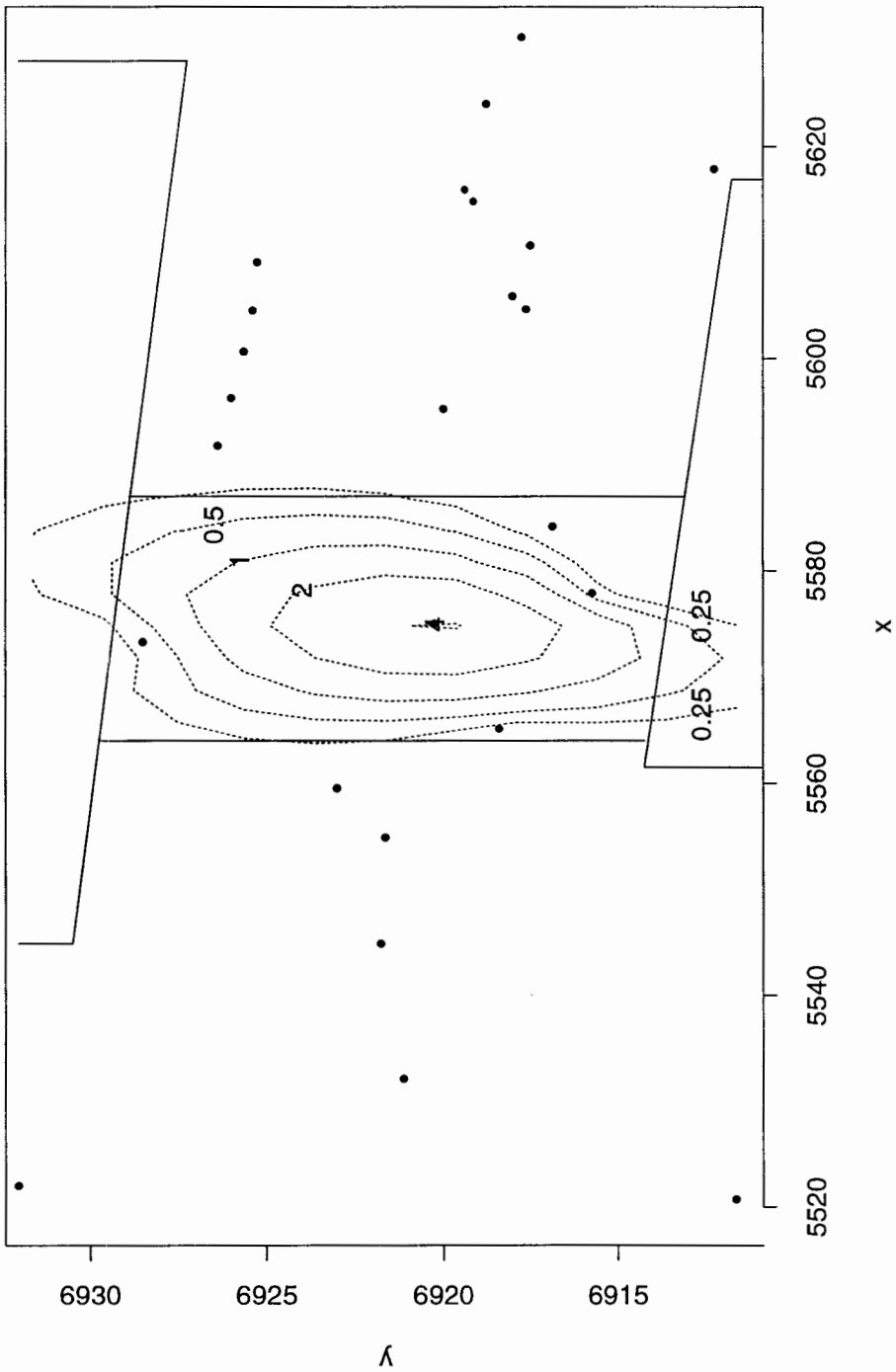

Fig. C-2. Area used as basis for risk assessment.

The kriged data are approximated very well using a lognormal distribution, in which case lognormal assumptions were made to estimate a mean and an upper confidence limit (UCL) on the mean. The approach taken was to estimate the mean and variance of the lognormal distributions using the minimum variance unbiased estimators (MVUE) of these parameters (Gilbert 1987, 0312). This method of estimation is preferred to the method indicated in the EPA's "Supplemental Guidance to RAGS: Calculating the Risk Term" (EPA 1992, 1120; Gilbert 1987, 0312), because the latter method results in a positive (statistically) biased estimate of the mean, and the positive bias is exaggerated in any associated UCL. Once the lognormal distribution, including its mean, has been estimated for a contaminant of potential (COPC) in an area, the 95% UCL is estimated by simulation. These values are then passed to the risk assessment. An estimate of the UCL on the mean was calculated by simulation of the estimated lognormal distribution, using five data points in each simulation. This method of estimation of the UCL probably results in overestimation compared with a more spatially oriented approach, partly because sample sizes of five are used in the simulations, whearas the area used includes 75 futher predicted data points.

Table C-1 provides estimates of the mean and 95% UCLs on the mean for TPH. These mean estimates are used in the risk assessment presented in the main body of the text. The estimated mean concentrations are conservative because they are based only on the first three feet of contamination, and on a 20 ft x 24 ft subsection of the walkway. The TPH plume under the walkway reaches a depth of approximately 10 ft, although the higher concentrations are near the surface. If a larger volume was used as the basis for estimation, then the mean concentrations would be lower.

TABLE C-1

ESTIMATED MEAN AND 95% UPPER CONFIDENCE LIMIT FOR TOTAL PETROLEUM HYDROCARBON (TPH) CONTAMINATION AT PRS 0-039

CHEMICAL OF POTENTIAL CONCERN	ESTIMATED MEAN	ESTIMATED (95% UPPER CONFIDENCE LIMIT)
TPH	980 mg/kg	2 800 mg/kg

APPENDIX C REFERENCES

EPA (US Environmental Protection Agency), May 1992. "Supplemental Guidance to RAGS: Calculating the Concentration Term," OSWER Publication 9285.7-08I, Washington, DC. **(EPA 1992, 1120)**

Gilbert, R. O., 1987. *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York, New York. **(Gilbert 1987, 0312)**

Isaaks, E., and R. M. Srivastava 1989. *An Introduction to Applied Geostatistics*, Oxford University Press, New York, New York. **(Isaaks and Srivastava 1989, 0765)**

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APPENDIX D EVALUATION OF PCE RESULTS

One hundred eighty subsurface soil samples collected from PRS 0-039 were analyzed for PCE and trichloroethylene (TCE). Of these, 98 were from boreholes, including 5 duplicates, and 82 were from hand-auger borings, including two duplicates. PCE was detected in 70 subsurface samples, including three duplicates, at concentrations as high as 190 mg/kg, and TCE was detected in one subsurface sample at a concentration of 0.012 mg/kg. As discussed above, these analytes are believed not to be a result of historical Laboratory operations and were, consequently, not considered in the screening assessment process. Table D-1 provides details of the samples in which PCE was detected. Figure 5.1-1 in the main text shows the locations of the boreholes and hand-auger holes from which samples were collected at this site. Figure D-1 indicates the locations of the PCE detections. PCE was detected frequently in most of the hand-auger holes in the northeast area of the walkway through the investigated site.

TABLE D-1

PRS 0-039 SAMPLES IN WHICH PCE WAS DETECTED

ANALYTE	FIMAD SITE ID	SAMPLE ID	SAMPLE VALUE (mg/kg)	EQL (mg/kg)	SAL (mg/kg)	DEPTH (ft)
PCE[a]	00-4055	0100-95-0006	0.01	0.01	7	34.5-35
PCE	00-4056	0100-95-0029	0.018	0.01	7	49.5-50
PCE	00-4057	0100-95-0041	0.01	0.01	7	4.5-5
PCE	00-4057	0100-95-0042	0.016	0.01	7	9.5-10
PCE	00-4057	0100-95-0043	0.015	0.01	7	14.5-15
PCE	00-4058	0100-95-0061	0.01	0.01	7	4.5-5
PCE	00-4058	0100-95-0063	0.019	0.01	7	14.5-15
PCE	00-4059	0100-95-0082	0.021	0.01	7	4.5-5
PCE	00-4061	0100-95-0123	0.031[b]	0.01	7	9.5-10
PCE	00-4061	0100-95-0126	0.011	0.01	7	24.5-25
PCE	00-4062	0100-95-0142	0.072	0.01	7	4.5-5
PCE	00-4062	0100-95-0143	0.11	0.01	7	9.5-10
PCE	00-4062	0100-95-0144	0.011	0.01	7	14.5-15
PCE	00-4063	0100-95-0163	0.017	0.01	7	9.5-10
PCE	00-4063	0100-95-0164	0.037	0.01	7	14.5-15

TABLE D-1 (CONTINUED)

PRS 0-039 SAMPLES IN WHICH PCE WAS DETECTED

ANALYTE	FIMAD SITE ID	SAMPLE ID	SAMPLE VALUE (mg/kg)	EQL (mg/kg)	SAL (mg/kg)	DEPTH (ft)
PCE	00-4069	0100-95-0282	1.5[c]	0.01	7	0.7-1
PCE	00-4069	0100-95-0284	0.84[c]	0.01	7	2.7-3
PCE	00-4069	0100-95-0285	0.27[c]	0.01	7	3.7-4
PCE	00-4070	0100-95-0286	1[c]	0.01	7	0.7-1
PCE	00-4070	0100-95-0287	1.1[c]	0.01	7	1.7-2
PCE	00-4070	0100-95-0288	0.75[c]	0.01	7	3.7-4
PCE	00-4072	0100-95-0293	0.05	0.01	7	4.7-5
PCE	00-4072	0100-95-0294	0.53[c]	0.01	7	5.7-6
PCE	00-4076	0100-95-0191	0.016	0.01	7	6.7-7
PCE	00-4078	0100-95-0199	0.24	0.1	7	0.7-1
PCE	00-4078	0100-95-0200	0.04	0.01	7	2.7-3
PCE	00-4078	0100-95-0201	0.024	0.01	7	4.7-5
PCE	00-4079	0100-95-0203	0.14	0.01	7	0.7-1
PCE	00-4079	0100-95-0204	0.97	0.1	7	2.7-3
PCE	00-4079	0100-95-0205	0.017	0.01	7	4.7-5
PCE	00-4080	0100-95-0206	7	5	7	0.7-1
PCE	00-4080	0100-95-0207	160	50	7	3.7-4
PCE	00-4080	0100-95-0208	1.6	0.5	7	5.7-6
PCE	00-4080	0100-95-0209	23	5	7	8.7-9
PCE	00-4080	0100-95-0210	5.6	0.5	7	9.7-10
PCE	00-4080	0100-95-0211	27	5	7	12.7-13
PCE	00-4080	0100-95-0212	0.3	0.1	7	14.7-15
PCE	00-4082	0100-95-0395	2.7	0.5	7	0.7-1
PCE	00-4082	0100-95-0396	0.034	0.01	7	2.7-3
PCE	00-4082	0100-95-0397	0.014[d]	0.01	7	4.7-5
PCE	00-4083	0100-95-0197	0.12	0.1	7	2.7-3
PCE	00-4083	0100-95-0198	0.024	0.01	7	4.7-5
PCE	00-4083	0100-95-0398	2.7	0.5	7	0.7-1
PCE	00-4095	0100-95-0214	0.82[c]	0.01	7	0.7-1
PCE	00-4095	0100-95-0215	0.041	0.01	7	3.7-4
PCE	00-4095	0100-95-0216	0.018	0.01	7	5.7-6
PCE	00-4096	0100-95-0217	1.4[c]	0.01	7	0.7-1
PCE	00-4096	0100-95-0218	0.199	0.01	7	3.7-4

TABLE D-1 (CONTINUED)

PRS 0-039 SAMPLES IN WHICH PCE WAS DETECTED

ANALYTE	FIMAD SITE ID	SAMPLE ID	SAMPLE VALUE (mg/kg)	EQL (mg/kg)	SAL (mg/kg)	DEPTH (ft)
PCE	00-4096	0100-95-0219	0.49[c]	0.01	7	5.7-6
PCE	00-4096	0100-95-0221	0.051	0.01	7	12.7-13
PCE	00-4096	0100-95-0222	1.8[c]	0.01	7	14.7-15
PCE	00-4097	0100-95-0223	50[c]	0.05	7	0.7-1
PCE	00-4097	0100-95-0224	110[c]	0.1	7	3.7-4
PCE	00-4097	0100-95-0225	52[c]	0.05	7	5.7-6
PCE	00-4097	0100-95-0226	190[c]	0.1	7	9.7-10
PCE	00-4097	0100-95-0227	55[c]	0.05	7	12.7-13
PCE	00-4097	0100-95-0228	45[c]	0.05	7	13.7-14
PCE	00-4097	0100-95-0243	21	5	7	15.7-16
PCE	00-4097	0100-95-0244	3.3	5	7	18.7-19
PCE	00-4097	0100-95-0245	2.2[e]	5	7	19.7-20
PCE	00-4097	0100-95-0246	3.3	5	7	21.7-22
PCE	00-4097	0100-95-0247	0.041	0.01	7	24.7-25
PCE	00-4098	0100-95-0229	0.067	0.01	7	0.7-1
PCE	00-4098	0100-95-0230	0.041	0.01	7	3.7-4
PCE	00-4098	0100-95-0231	0.078	0.01	7	5.7-6
PCE	00-4098	0100-95-0233	0.017	0.01	7	12.7-13
PCE	00-4098	0100-95-0234	0.36	0.01	7	13.7-14
PCE	00-4099	0100-95-0235	0.68	0.01	7	0.7-1
PCE	00-4099	0100-95-0236	1.88[c]	0.01	7	3.7-4
PCE	00-4099	0100-95-0237	0.166	0.01	7	5.7-6
PCE	00-4099	0100-95-0238	0.296	0.01	7	9.7-10
PCE	00-4099	0100-95-0240	0.74[c]	0.01	7	13.7-14
PCE	00-4099	0100-95-0239	0.161	0.01	7	12.7-13
TCE[f]	00-4062	0100-95-0142	0.012	0.01	7.1	4.5-5

[a] PCE = Perchloroethylene
[b] A duplicate of this sample reported a detected value of 0.063 mg/kg PCE.
[c] A duplicate of this sample reported a detected value of 0.027 mg/kg PCE.
[d] A duplicate of this sample reported a detected value of 2.1 mg/kg PCE.
[e] Instrument was beyond calibration for these measurements. The reported values may be underestimates.
[f] TCE = Trichloroethylene

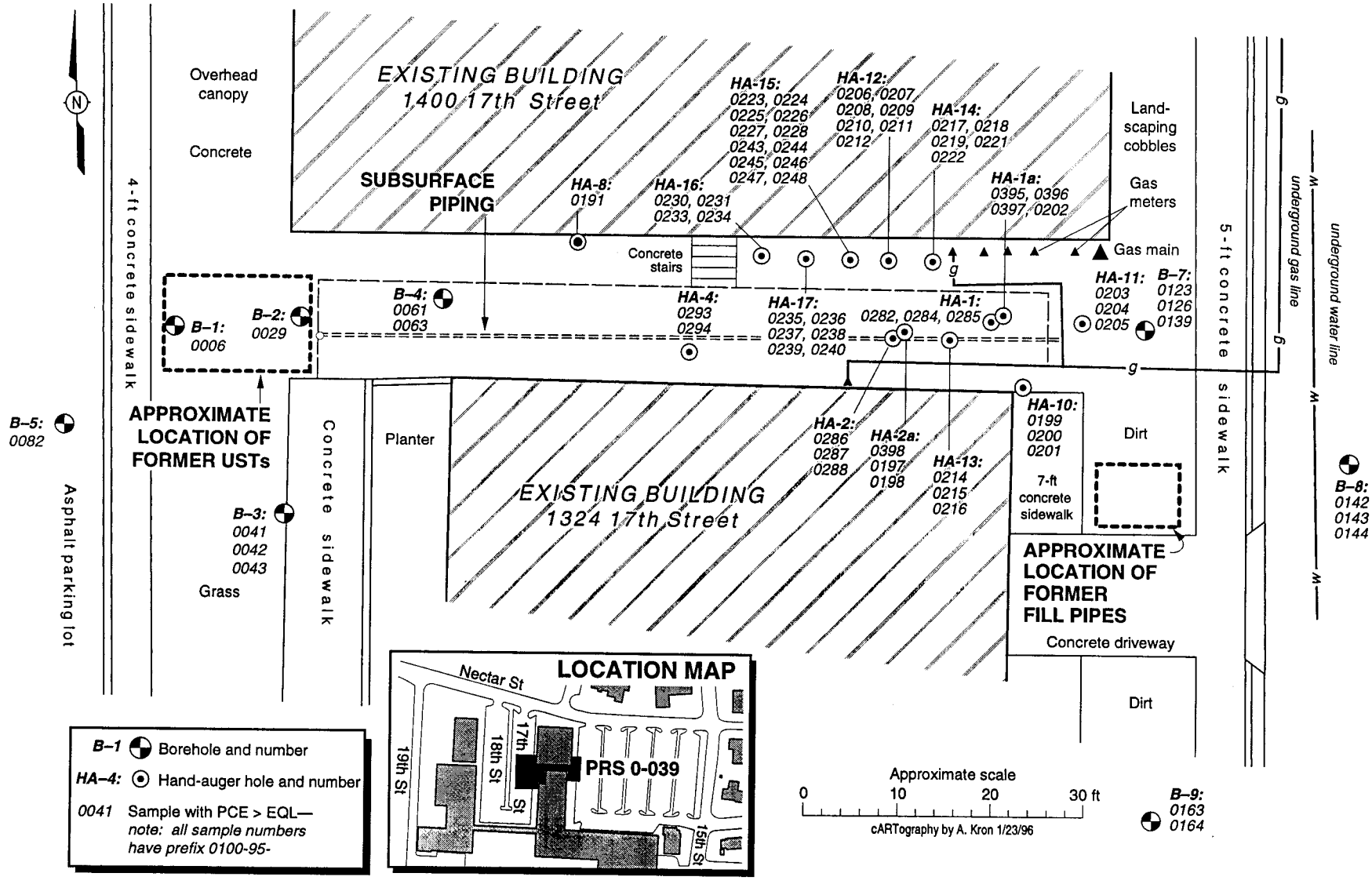

Fig. D-1. Locations of boreholes and hand-auger holes showing PCE detections.

Figures D-2 and D-3 represent spatial images of the PCE contamination. Figure D-2 presents PCE concentration images at nine distinct depths to provide a three-dimensional representation of PCE contamination under the walkway. For spatial orientation, each image contains points that mark the sampling locations of the boreholes and hand-auger holes used in the analyses, although PCE data may not be available at each depth for the illustrated sampling locations. Figure D-3 shows nine distinct north-facing subsurface profiles of the same area at distances that are two feet apart. These profiles are indexed by their corresponding northings. The contours represent the concentration of PCE across the area. For nondetects, half the detection limit was used. The data set used to produce the figures was generated through the statistical interpolation process known as kriging. Kriging allows for estimation of concentration throughout a three-dimensional volume without requiring data at every depth for each sampling location. The kriging process uses the correlation structure present in the data to estimate concentrations at locations for which there are no data. The process is discussed in Appendix C. The figures present slightly different overall representations of the PCE contamination as a result of the graphical contouring method used to picture the kriging process. The data used to support the concentration images are presented in Table D-2.

The plots illustrate one PCE plume that emanates from the surface against the wall of the existing building structure to the north of the walkway. The plume is most evident in the hand-auger holes to the north and east end of the site, with the highest concentrations occurring in hand-auger holes located along the northern building wall. The concentrations remain high in these holes to depths of 15 ft and 25 ft respectively (see Table D-2). The concentrations in the holes further away from the building decrease more rapidly. There is some evidence of much lower levels of PCE contamination further to the west of the site. These low levels may be associated with the same plume, but could also be associated with the south tank in which there was evidence of low levels of PCE. If there is a second plume associated with the UST, it is at concentrations lower than approximately 0.02 mg/kg. Given the depth, small volume, and comparatively low levels of PCE associated with this possible second plume, it is not expected to pose an unacceptable threat to human health. The primary plume that is clearly depicted on the spatial plots is of more concern.

TABLE D-2

PCE RESULTS FOR PRS 0-039

BOREHOLES	BOREHOLE NUMBER								
DEPTH (ft)	B1	B2	B3	B4	B5	B6	B7	B8	B9
0–0.5				<10					
4.5–5	<10[a]	<10	10	10	21	<10	<10	72	<10
9.5–10	<10	<10	16	<10	<10	<10	47	110	17
14.5–15	<10	<10	15	19	<10	<10	<10	11	37
19.5–20	<10	<25 000	<10	<10	<10	<10	<10	<10	<10
24.5–25	<10	<10	<10	<10	<10	<10	11	<10	<10
29.5–30	<10	<10	<10	<10	<10	<10	<10	<10	20
34.5–35	10	<10	<10	<10	<10	<10	<10	<10	<10
39.5–40	<10	<10	<10	<10	<10	<10	<10		
44.5–45	<10	<10	<10	<10	<10	<10	<10		
49.5–50		18	<10	<10	<10	<10			
54.5–55		<10	<10	<10	<10	<10			
59.5–60		<10	<10	<10	<10	<10			
HAND-AUGER HOLES (1)	HAND-AUGER HOLE NUMBER								
DEPTH (ft)	HA1	HA1A	HA2	HA2A	HA3	HA4	HA5	HA6	HA7
0.7–1	1 500	2 700	1 000	2 700	<10	<10		<10	<10
1.7–2			1 100				<10 000		
2.7–3	840	34		120	<10			<10	
3.7–4	270		750		<10			<10	<10
4.7–5		20.5		24		50	<500		
5.7–6						530			
6.7–7							<2 500		
8.7–9							<10		
9.7–10									
10.7–11							<10		
12.7–13									
13.7–14									
14.7–15									
15.7–16									
16.7–17									
18.7–19									
19.7–20									
21.7–22									
24.7–25									

TABLE D-2 (CONTINUED)

PCE RESULTS FOR PRS 0-039

HAND-AUGER HOLES (2)	HAND-AUGER HOLE NUMBER									
DEPTH (ft)	HA8	HA9	HA10	HA11	HA12	HA13	HA14	HA15	HA16	HA17
0.7–1	<10	<10	240	140	7 000	820	1 400	50 000	67	680
1.7–2										
2.7–3			40	970						
3.7–4		<10			160 000	41	199	110 000	41	1 880
4.7–5			24	17						
5.7–6		<10			1 600	18	490	52 000	78	166
6.7–7	16									
8.7–9	<10				23 000					
9.7–10					5 600		54	190 000	36	296
10.7–11										
12.7–13					27 000		51	55 000	17	161
13.7–14								45 000	360	740
14.7–15					300		1800			
15.7–16								21 000		
16.7–17					<10					
18.7–19								3 300		
19.7–20								2 150		
21.7–22								3 300		
24.7–25								41		

[a] Units for PCE concentrations are µg/kg.

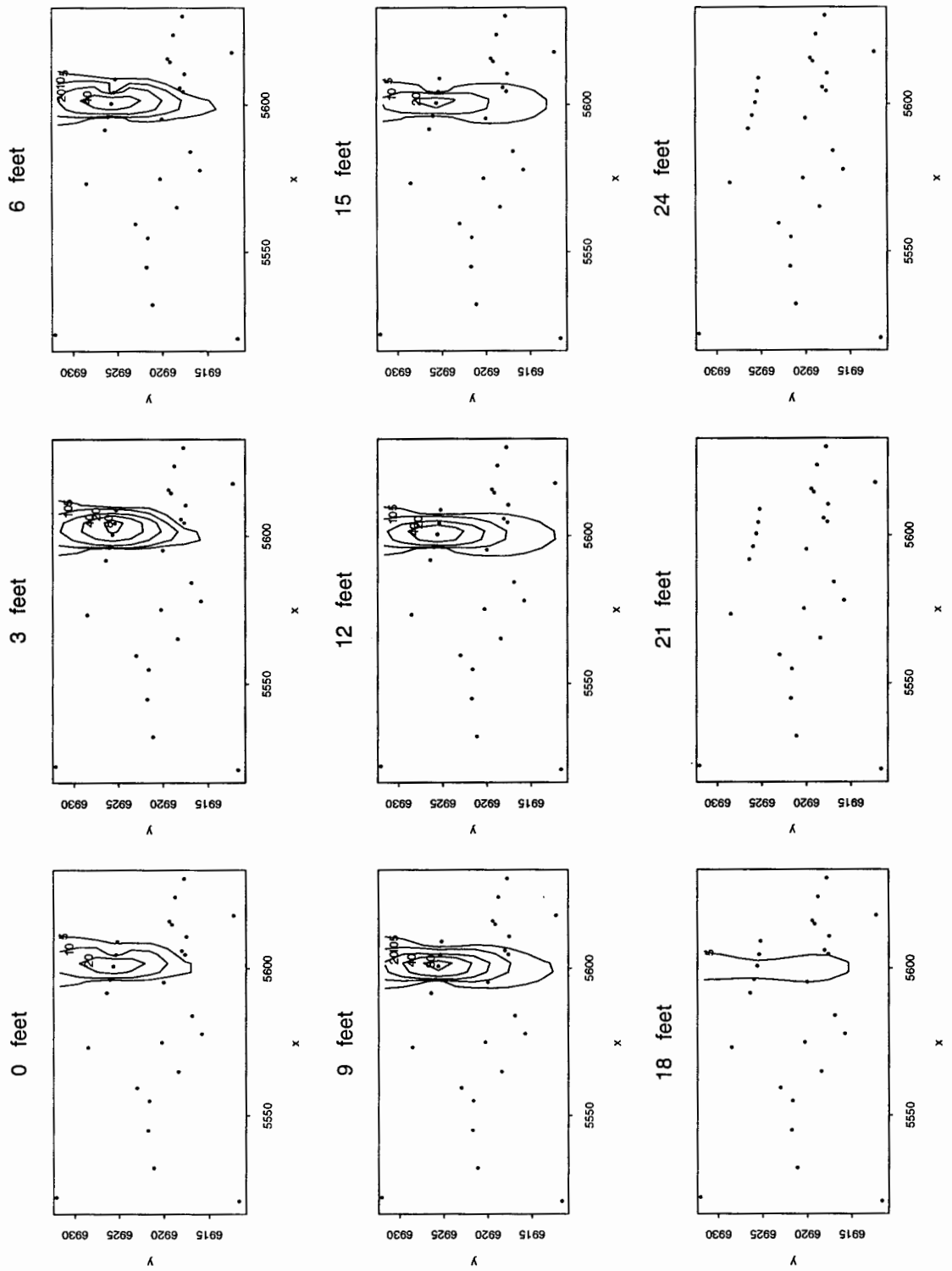

Fig. D-2. PCE views by depth.

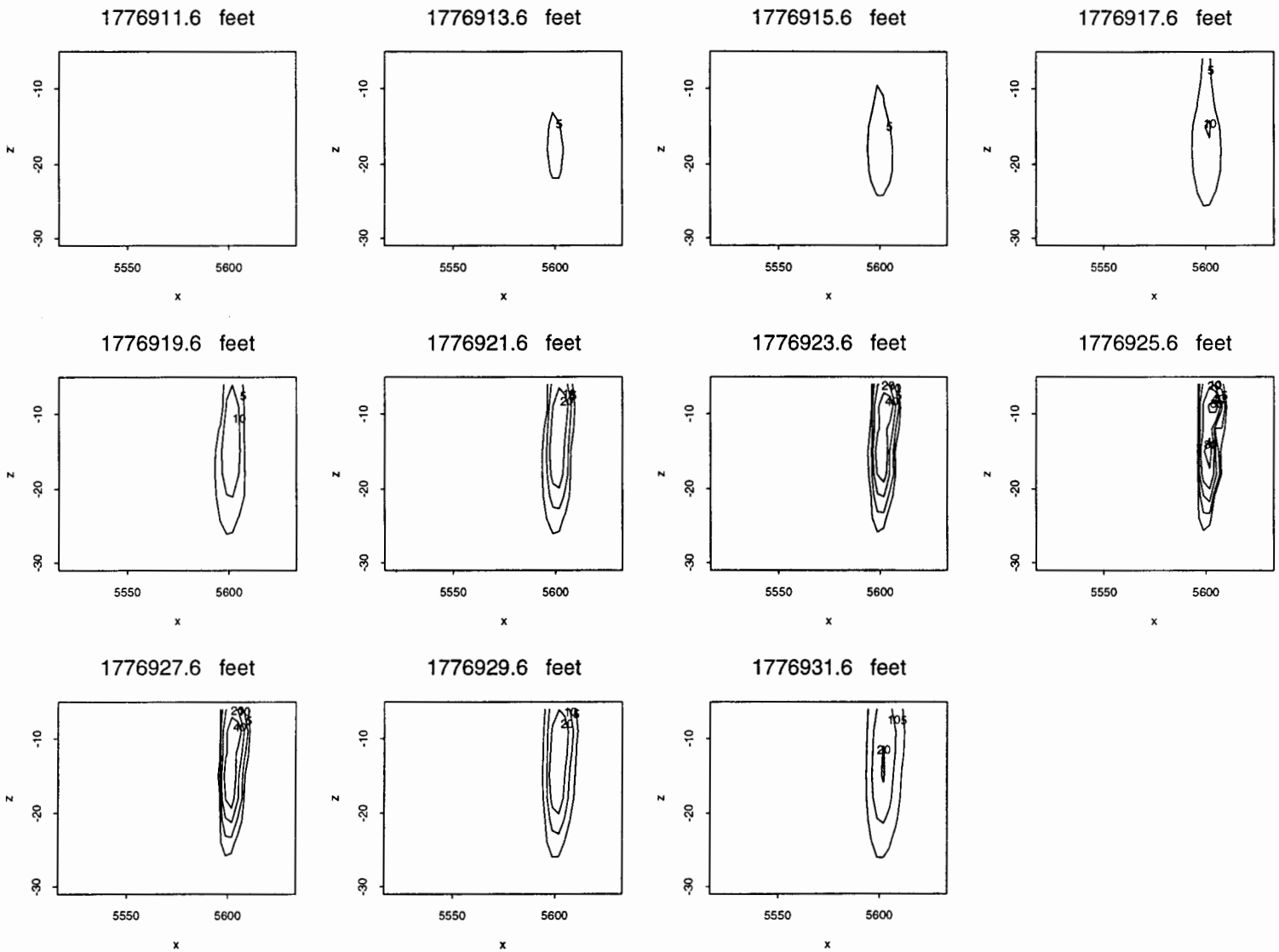

Fig. D-3. PCE views by northing.

Transport calculations support the contention that the PCE is most likely not the result of activities occurring at the Corbett Cleaning Company. The following calculations demonstrate differences in penetration depths as they occur over time, indicating the probable source of PCE release.

PCE is a volatile organic compound that can be transported though the soil as PCE liquid, by water as a soluble component, and by gas through volatilization. PCE liquid introduced as a spill redistributes relatively rapidly. The high saturation vapor pressure of PCE means that volatilization occurs when the liquid is exposed to the atmosphere. Water that infiltrates into the soil and moves as unsaturated flow through the spill zone transports soluble PCE. This last mode of PCE transport is considered in the following calculations, and the potential consequences of gas phase transport are discussed.

The basic assumption is that unsaturated flow and steady-state conditions describe the water flux in order to obtain a water velocity for PCE transport at the PRS 0-039. Geotechnical data (Tables 5.1.4-1 and 5.1.4-2) collected from borehole B4 supply some of the needed data. The mean of the samples collected from the fill material in the borehole (two samples at the 8.5 ft—9.5 ft and two at the 17.5 ft - 18.5 ft intervals) was used for each parameter.

The mean values in Tables 5.1.4-2 and 5.1.4-3 will be used to represent steady-state conditions. The trends indicate that saturated hydraulic conductivity (Ks), porosity, and water content decrease with depth and the bulk density increases with depth.

Additional hydraulic properties needed for the calculation of the unsaturated water flux can be estimated using the texture class to obtain the Brooks and Corey (Brooks and Corey 1964, 05-0225) parameters for the unsaturated hydraulic conductivity and the average volumetric water content value in Table 5.1.4-3. The texture class of the fill material was assumed to be a sandy loam. Clay material was observed during drilling, but the percentage was not determined. The Brooks-Corey equations are:

$$Se = (\theta - \theta_r) / (\theta_s - \theta_r) = (\psi_b / \psi)^{\lambda} \quad (1)$$

for water retention and

$$Kr = Se^{(3+2/\lambda)} \quad (2)$$

for the relative conductivity where:

Se = the effective saturation;

θ = the volumetric water content;

θ_r = the residual volumetric water content;

θ_s = the saturated volumetric water content;

λ = pore size distribution index parameter;

ψ = soil water pressure head (cm); and

ψ_b = soil bubbling pressure head (cm).

Estimates are needed for θ_r, and λ for the PCE calculation. McCuen et al. (1981, 05-0227) presented the following values for the parameters in Equation 1 for the sandy loam texture class:

θ_r = 0.048,

λ = 2.646, and

ψ_b = 16.78 cm.

The mean porosity from Table 5.1.4-3 is used as the value for θ_s in Equation 1.

From Equation 2 the relative hydraulic conductivity is $((0.235-0.048)/(0.4606-0.048))^{(3+(2/2.646))}$ or 0.0512. The hydraulic conductivity is the relative conductivity at the mean volumetric water content multiplied by the saturated hydraulic conductivity (Ks). Therefore, the hydraulic conductivity is 0.0512 x 85.08 or 4.36 m/yr. This is the steady-state water flux or q at the site. The water velocity (v) is calculated as q/θ or 4.36/0.235 = 18.55 m/yr.

The soluble PCE velocity needs to include retardation of the PCE by its interaction with the soil material. The retardation factor (R) is estimated by the hydrophobic sorption model (Westall 1987, 05-0228). The hydrophobic model assumes that the sorption of organic compounds is driven by its incompatibility with water. Therefore, if an organic sorbent is available, then the organic compound will readily adsorb. Another feature is that two properties, the octanol-water partition constant (Kow) and the fraction of the soil that is organic carbon (foc), describe the adsorption reaction for a wide range of both compounds and sorbents. The sorption reaction is linear. The Kd is calculated as

$$Kd = Koc \times foc \qquad (3)$$

where: Koc = organic-carbon partition coefficient; and

foc = the fraction of organic carbon.

The PCE value for Koc is 363. That is the measured value in Table III in Karickhoff. Values for foc are given in Table 5.1.4-2 for the four samples (Karickhoff 1981, 05-0226). The higher values observed at the 8.5 ft to 9.5 ft depth are partially attributed to the PCE spill. The < 1% observed at the next sample depth appears to be a lower bound of the analytical chemistry technique. Without any more information and to account for the clay that was observed in the fill, a value of 0.01 is used for foc. The value for Kd is 363 x 0.01 or 3.63. The retardation factor is calculated by

$$R = 1 + Kd \times \rho_b/\theta \qquad (4)$$

where: ρ_b is the bulk density found in Table 5.1.4-2. The value for R is 1+(3.63 x 1.285)/0.235 or 20.85.

The velocity for the PCE is $v_{(water)}/R$ or 18.55/20.85 = 0.89 m/yr.

For a 5-year period the PCE will be transported by water a distance of 0.89 x 5 or 4.45 m (14.6 ft). For a 25-year period, the PCE will have moved 22.25 m (73 ft).

These calculations estimate the depth of the center of mass of the PCE plume for the conditions assumed. These estimates do not include hydrodynamic dispersion which is a function of water velocity distribution in the pores and heterogeneous soil properties. Hydrodynamic dispersion may be one reason that some PCE may be detected beyond the plume boundary.

PCE can be detected beyond the estimated depths because of transport in the gas phase. Gas phase movement occurs by both diffusion and advection. A vapor halo forms around the contaminated zone through volatilization and diffusion. The gas phase interacts with both the soil particles in an adsorption reaction (much like that previously described by the water transported PCE) and water in the soil by partitioning PCE between the gas and liquid phases. The PCE left on the soil by vapor adsorption or in the soil water may be transported by either gas or water depending on the conditions.

APPENDIX D REFERENCES

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McCuen, R. H., W. J. Rawls, and D. L. Brakensiek, 1981. Statistical Analysis of the Brooks-Corey and the Green-Ampt Parameters Across Soil Textures. Water Resources Research, 17:1005-1013. **(McCuen, et al. 1981, 05-0227)**

Westall, J. C., 1987. "Adsorption Mechanisms in Aquatic Surface Chemistry." in *Aquatic Surface Chemistry Chemical Processes at the Particle-Water Interface*, W. Stumm, ed. John Wiley and Sons, NY. **(Westall 1987, 05-0228)**