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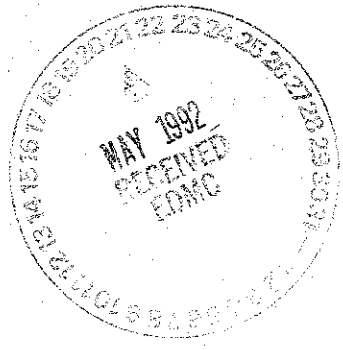
WHC-MR-0378

Soil Gas Sampling and Analysis at the 1100-EM-1 Operable Unit

Prepared for
Westinghouse Hanford Company
by Golder Associates Inc.

Date Published
April 1992



Prepared for the U.S. Department of Energy
Office of Environmental Restoration
and Waste Management

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Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

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1. INTRODUCTION

This report presents the results of a soil gas survey conducted from November 1990 through February 1991 at the 1100-EM-1 Operable Unit by Golder Associates Inc. (Golder). The 1100-EM-1 Operable Unit is one of four operable units within the 1100 Area of the Hanford Site and was placed on the National Priorities List (NPL) in July 1989. This report is part of work described in the draft Remedial Investigation Phase 2 Supplemental Work Plan for the 1100-EM-1 Operable Unit (DOE-RL, 1990a).

1.1 Objectives

The objectives of the soil gas survey conducted at the 1100-EM-1 Operable Unit were to:

- Determine if a source of volatile organic compounds (VOCs) is present at the UN-1100-6 subunit,
- Install and sample a permanent soil gas monitoring network at the Horn Rapids Landfill to monitor for the release of VOCs from suspected buried drums containing carbon tetrachloride (tetrachloromethane, TCM).
- Conduct a test to determine the feasibility of using soil gas to detect VOCs known to be present in the ground water near the Horn Rapids Landfill,
- Perform a soil gas survey to preliminarily delineate the extent of VOCs in ground water near the Horn Rapids Landfill, and
- Conduct a soil gas survey at the South Pit to preliminarily characterize the nature and extent of any VOC contamination.

1.2 Organization of the Report

This report presents information pertaining to the project site and the physical setting, a description of sampling and analysis procedures, the results of the soil gas surveys and a summary with conclusions. Appendix A presents a list of all the soil gas sample locations. Appendix B presents laboratory reports from the contract laboratory. Copies of the technical procedure used for soil gas sampling and analysis are provided in Appendix C.

2. SITE BACKGROUND AND PHYSICAL SETTING

The 1100 Area is the central warehousing, vehicle maintenance, and transportation operations center for the Hanford Site. This area was designated an NPL site in July, 1989, and is divided into four operable units. The first equipment maintenance operable unit, 1100-EM-1, was assigned the highest RI/FS priority within both the 1100 Area and the Hanford Site as a whole.

2.1 1100-EM-1 Operable Unit

A detailed description of the regional and physical characteristics of the operable unit may be found in the Phase I Remedial Investigation report, (DOE-RL, 1990b). The following presents brief summaries of the waste management units within the operable unit that are part of this report. Figure 2-1 provides a map of the 1100-EM-1 Operable Unit and points out the locations of the following study areas.

- UN-1100-6 (Discolored Soil Site)—the location of an apparent disposal event onto the ground surface involving a container of organic waste liquids.
- Horn Rapids Landfill—a solid waste facility used primarily for the disposal of office and construction waste and the burning of classified documents; asbestos, sewage sludge, fly ash, and, potentially, drums of unidentified organic liquids (presumably TCM) were also disposed at this location.
- South Pit—an area south of the Horn Rapids Landfill which apparently was used for disposal of Hanford-site-related municipal-type solid waste.

3. SAMPLING AND ANALYSIS

Field work for this task began November 5, 1990, when the equipment was mobilized to the operable unit. A temporary field laboratory was established on property owned by Advanced Nuclear Fuels Corp. (ANF) near the Horn Rapids Landfill. Site preparation activities and safety training continued until November 7, 1990, and sampling began November 8, 1990. The field laboratory remained on site until December 26, 1990, when it was returned to the Golder office in Redmond (Seattle), Washington. Field activities were completed February 5, 1991, and the field equipment demobilized February 18, 1991. All site work was conducted in compliance with the Hazardous Waste Operations Permit provided by Westinghouse Hanford Company.

For the purposes of this investigation, 1,1,1-trichloroethane (TCA), trichloroethene (TCE) and tetrachloroethene (PCE) were considered the target compounds for quantitation during laboratory analysis of the soil gas samples since the compounds were identified in previous investigations of the study areas (DOE-RL, 1990b). Table 3-1 presents a summary of the sample quantitation limits (SQLs) and other associated physical data for each compound. SQLs reported for the direct injection technique are estimated values based on a value of 2 times the GC detector noise level. SQLs reported for the purge and trap injection technique are values calculated according to Appendix B of 40 CFR Part 136.

Though carbon tetrachloride (TCM) was suspected at the Horn Rapids Landfill, it was not included in the routine calibration standard since during analysis it eluted on the gas chromatograph (GC) very close to TCA. This produced a double peak in the presence of TCA, however, both peaks were resolved and exhibited distinct retention times. A single component standard of TCM was analyzed periodically to check the retention time for this compound and all data were reviewed for evidence of TCM. As detailed in Section 4, TCM was detected in one sample collected at the Horn Rapids Landfill.

All soil gas samples were obtained at depths of approximately 3.5 to 4.0 ft. below ground surface with the exception of samples collected during the soil gas test which were collected at 2 ft., 4 ft. and 8 ft. below ground surface (see Section 4) and samples obtained at UN-1100-6 which were collected at depths of approximately 1.5 to 4.0 ft below ground surface.

All data are reported in units of parts per billion by volume (ppbv) which represents the compound concentration on a volume per unit volume basis at standard temperature and pressure (25°C, 1 atm). Data reported in ppbv may be converted to a micrograms per liter (ug/L) by the following formula (ASTM, 1981):

$$ug/L = (C / 24{,}450) * (MW)$$

where: C = concentration in ppbv
MW = molecular weight of the compound g/mole
24,450 = conversion factor for standard temperature and pressure

Data presented in tabular summaries and figures is reported with the following qualifiers:

U - Indicates the compound was analyzed for but not detected. The value reported is the SQL.

J - Indicates an estimated value where the compound was detected at a concentration less than the SQL but greater than zero.

3.1 Sampling Objectives, Locations and Frequency

This section presents the objectives of the soil gas surveys conducted at the study areas, a description of the sample locations and the dates of sampling. The study areas were geodetically surveyed prior to commencement of field activities. Additional sampling points added as a result of the soil gas analysis were surveyed following completion of the field activities and the data was not available in time to be included into the maps provided in this report, however, a list of all soil gas sample locations and surveyed coordinates is provided in Appendix A.

3.1.1 UN-1100-6 Operable Subunit

Previous investigations have indicated the presence of TCA at low concentrations in the surface soil (DOE-RL, 1990b). The objectives of the soil gas survey at this subunit were to determine if a source of TCA or other VOCs may be present in the vadose zone or ground water. Soil gas probes were installed and sampled at the locations shown in Figure 3-1.

A total of 14 soil gas probes were installed at depths ranging from 1.5 to 4.0 ft. Nine probes were installed and sampled during the time period November 13, 1990, to November 18, 1990. Additional soil gas probes were installed on December 18, 1990, at sample locations N6-2, N6-4, N6-5, N6-6, and N6-8 (see Figure 3-1) at 4 ft, because the first probes installed at these locations could not be advanced to this depth with existing equipment due to dense ground conditions. Following acquisition of a pneumatic probe driver the additional probes were installed to a depth of 4 ft.

3.1.2 Horn Rapids Landfill Operable Subunit

Multiple sampling and analysis activities were planned for the Horn Rapids Landfill as described in the following sections.

3.1.2.1 Permanent Soil Gas Monitoring Network

A permanent monitoring network of 35 soil gas probes were installed to monitor VOCs in soil gas within the landfill that may indicate a release of suspected buried waste(s). Figure 3-2 shows the probe locations. One probe was installed in a temporary location then moved and resurveyed at the proper permanent location. This temporary probe was sampled thus providing a total of 36 sampled locations, 35 of which were permanently

installed. Probe installation was begun December 17, 1990 and completed February 5, 1991. Weather protection monuments were installed around each of the probes in accordance with the technical procedure described in Section 4. After installation of the probes, samples were collected and analyzed one time. Section 4 presents the results of the soil gas analyses.

3.1.2.2 Soil Gas Testing

Tests were conducted to determine if soil gas sampling is an effective method for delineating known TCE ground-water contamination in the vicinity of the Horn Rapids Landfill. Soil gas probes were installed around ground-water monitoring wells MW-12, MW-15, and 699-S29-E12 beginning November 10, 1990. Figure 3-3 shows the locations of these wells. Probe installation and testing was completed December 22, 1990. Installation of probes beyond 4 ft proved difficult due to the dense and rocky ground conditions, and installation of probes to 8 ft required approximately 1 to 2 h each. Finally, dense ground conditions made it necessary to use a backhoe to complete the probe installations at 4 ft and 8 ft near MW-15.

In addition, three sampling probes were installed with the use of a backhoe near a probe driven into visibly undisturbed soil to evaluate the effect of soil disturbance with a backhoe on soil gas concentrations. Sample locations and the results of this test are presented in Section 4.

3.1.2.3 Preliminary Ground-Water Plume Delineation

A total of 53 sampling probes were installed, sampled and analyzed in order to delineate the TCE ground-water contaminant plume in the Horn Rapids Landfill vicinity as shown in Figure 3-4. Results of the soil gas survey are presented in Section 4.

3.1.3 South Pit

The purpose of the soil gas survey was to determine if a near surface source of VOC contamination exists in the South Pit. Initially, 23 sampling probes were installed and sampled on November 28 and 29, 1990. Probe installation was attempted at one location (SP-7) by the use of a vibratory hammer, manual post driver, electrical rock coring drill, and gasoline powered rock coring drill, all of which were unsuccessful. Following acquisition of a pneumatic post driver to facilitate probe installation, four additional locations (SP-7, SP-23, SP-24, and SP-26) were sampled on December 17, 1990, to complete the initial 26 sample locations.

Following a review of the data obtained from the first 26 sample locations, 14 additional probes were installed and samples were collected January 10, 1991, to aid in determining the extent of VOCs detected at the initial sample areas. Figure 3-5 presents all the sampling locations, and the results of the soil gas survey are presented in Section 4.

3.2 Sampling Methods and Sample Handling and Analysis Procedures

Sampling methods and sample handling and analysis procedures are described in the Golder technical procedure TP-2.2-4 included in Appendix C. In general, all samples were collected and analyzed as described in the following paragraphs.

- First, an access hole was installed by driving a 5/8-in diameter steel pilot rod to within 6 in of the target sampling depth (typically 4 ft). The pilot rod was removed and the soil gas sampling probe inserted by hand until refusal. At locations off the landfill boundaries, dense soil conditions required driving the pilot rod with the use of a pneumatic post driver or by excavation of a pit with the use of a backhoe, filling and compacting the pit with the excavated soil, and driving the sampling probe through the recompacted soil to the desired depth. Information on where this was required is presented in Section 4.

- After removal of the pilot rod, the sampling probe was installed to the required depth with the use of a hand sledge, manual post driver, or pneumatic post driver. Once installed, the probe was raised approximately 1/2-in upward to allow soil gas to enter. Prior to sampling, the annulus at the surface of the probe was sealed with modeling clay to prevent atmospheric infiltration and possible dilution of the soil gas.

- Sampling was begun by checking the probe with a vacuum pump and gauge to ensure the probe was not clogged with soil. Clogged probes were removed and replaced. Then a minimum of three sampling probe volumes were evacuated and a sample collected into an evacuated glass vial. During sampling, the vial was slightly pressurized with the soil gas to prevent leakage of outside atmosphere into the vial. An identification label was immediately placed on the vial noting the date and time of sampling, the initials of the sampler, and the sample location. The sample was then placed in a shipping container for transport to the laboratory.

- Samples were returned to the on-site analytical laboratory under chain of custody or shipped by common carrier under chain of custody to the Golder laboratory in Redmond (Seattle), Washington for gas chromatographic analysis. Analyses were completed within 72 h of sample collection, as required by the technical procedure.

- Samples were analyzed by gas chromatography (GC) with photoionization and electron capture detectors connected in series. Analysis was conducted by direct injection of an aliquot of soil gas into the GC or by pre-concentration of an aliquot onto an absorptive trap followed by heating of the trap and transfer of the VOCs into the GC. To obtain lower SQLs the direct injection method of sample analysis was abandoned on November 13, 1990, in favor of the pre-concentration method. The direct injection method was used only for completion of the surface infiltration tests (see Section 4).

3.3 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) procedures implemented during the tasks consisted of analysis of laboratory, equipment, and ambient air blanks, and field duplicates, calibration standards and laboratory confirmation samples. Results for each type of QC analysis are described in the following sections.

3.3.1 Blank Sample Analyses

Laboratory air blanks were analyzed daily and immediately following the analysis of a high concentration standard or sample to determine the presence of target compounds in the analytical system. The concentrations of individual target compounds in the blanks are presented in Table 3-2. The highest laboratory blank concentrations observed for TCA, TCE and PCE were 30, 7, and 20 ppbv, respectively. No laboratory blanks analyzed exceeded 5 times the SQL as required by the technical procedure.

In addition, ambient air blanks were collected and analyzed to compare to the daily equipment blank results to determine if the concentration of target compounds in the equipment blank samples was due to the presence of the compounds in the ambient air. Table 3-3 presents a summary of all ambient blanks analyzed. The highest concentrations of TCA, TCE, and PCE detected in the blanks were 2, 15, and 24 ppbv, respectively.

Equipment blanks were collected at least once per day during installation of the sampling probes. These consisted of assembling the entire sampling system as described in the technical procedure, purging three sampling probe volumes with ambient air and collection of the sample. Table 3-4 presents a summary of all the equipment blanks analyzed. The highest concentrations of TCA, TCE, and PCE detected in the blanks were 5 J, 15, and 12 ppbv, respectively. No equipment blanks analyzed exceeded five times the SQL as required by the technical procedure. Upon comparison, the VOCs observed in the equipment blanks can be attributable to their presence in the ambient air.

3.3.2 Field Duplicate Analyses

Field duplicates were collected on a daily basis to measure sample and laboratory precision. The results are presented in Table 3-5. Precision for TCA and TCE ranged from 11 to 40 and 0 to 35 relative percent difference (RPD). Only one set of field duplicate samples exhibited positive results for PCE and the RPD for these measurements was zero.

3.3.3 Calibration Standards

Daily calibration checks were conducted to determine instrument performance and stability. As required by the technical procedure, standard checks were not to differ from the true standard concentration by greater than 40%. Table 3-6 presents a summary of all calibration checks conducted. When calibration checks exceeded the 40% requirement, the standard was reanalyzed. If the check failed a second time the instrument was recalibrated

with fresh standards, or instrument maintenance performed, if deemed necessary by the project chemist.

3.3.4 Laboratory Confirmation Analyses

Three samples were collected on November 18, 1990, and submitted to Pacific Northwest Environmental Laboratory Inc. (PNELI) of Redmond, Washington for confirmation analysis by gas chromatography/mass spectrometry (GC/MS). The samples were collected from locations TR1-17 (see Figure 3-4), N6-4 (see Figure 3-1), and one ambient air blank. Sample location TR1-17 was selected because TCE had been detected previously; sample location N6-4 was selected because no TCE had been detected previously and the ambient blank sample was submitted to determine a background level of contamination attributable to ambient air and the sample vials.

The contract laboratory performed the analyses similar to the field analyses by using a modification of EPA Method 8240 (EPA 1986). Sample results were reported as total nanograms of compound detected in the sample. Results of the confirmation analyses along with a comparison to the field laboratory results, are presented in Table 3-7. In summary the field result obtained for TCE from sample location TR1-17 was 190 ppbv with a corresponding contract laboratory result of 110 J ppbv. No other valid compounds were reported in sample TR1-17 or the remaining samples analyzed by the contract laboratory.

In addition to the compounds reported in Table 3-7, the contract laboratory identified methylene chloride, acetone, ethylbenzene, xylenes, and four tentatively identified compounds. Since the concentrations of these compounds were reported at less than 5 times the amounts detected in the laboratory and field blanks, they are not presented in Table 3-7. Additional information concerning the contract laboratory confirmation analyses and a copy of the laboratory report are presented in Appendix B.

3.4 Data Validation

All analysis results were validated by review of the GC data and the reduced data as follows:

- Data were reviewed to ensure that positive sample results exhibited GC relative retention times within 5% of the most recent calibration check. Any sample with a reported compound outside the 5% retention time window was qualified as a non-detect.

- All raw data sheets were reviewed against the tabular summary tables to ensure that results were transcribed correctly.

- Sample data were reviewed against the results for the daily laboratory air blanks. Samples with compounds having reported concentrations less than five times the highest daily laboratory air blank concentration were qualified as non-detects.

4. RESULTS OF SOIL GAS SURVEYS

4.1 UN-1100-6 Operable Subunit

No target compounds were detected in any of the samples at sufficient concentrations above the laboratory air blanks to be valid. Table 4-1 presents a summary of all sample results for UN-1100-6.

4.2 South Pit

Table 4-2 presents a summary of the soil gas results at the South Pit. TCA was detected at seven locations ranging in concentration from 3J to 39 ppbv. PCE was detected at 3 sample locations ranging from 8 to 41 ppbv. TCE was detected in 38 of the 40 total locations at concentrations ranging from 5, to 394 ppbv. The highest TCE concentration (394 ppbv) was detected at location SPA-7 (see Figure 3-5). Figure 4-1 presents the distribution of TCE, PCE, and TCA at the South Pit.

4.3 Horn Rapids Landfill

This section presents the results of the permanent soil gas monitoring, the soil gas testing, and the preliminary ground water plume delineation.

4.3.1 Permanent Soil Gas Monitoring Survey

A total of 35 soil gas probes were permanently installed at the landfill using the design detailed in Figure 4-2. Samples were collected and analyzed one time, and the results are presented below.

TCA was not detected at sufficient concentrations above the laboratory air blanks to be valid. TCE was detected at 17 of the 36 sample locations at concentrations ranging from 3 to 233 ppbv. The highest TCE concentration (233 ppbv) was detected at location PSG-16. PCE was detected at one location (PSG-15) at a concentration of 22 ppbv and carbon tetrachloride (TCM) also was detected at one location (PSG-20) at a concentration of 26 ppbv. Probe locations are detailed in Figure 3-2.

Figure 4-3 shows the sample locations with the associated results for TCE, PCE and TCM. Table 4-3 presents a tabular summary of the laboratory results.

4.3.2 Soil Gas Testing

Soil gas probes were installed around ground-water monitoring wells MW-12, MW-15, and 699-S29-E12. A total of nine soil gas probes were installed at 2-, 4-, and 8-ft depths around

each well, as shown in Figure 4-4. Tests were conducted to measure spacial, depth, and purging variability of the soil gas, and to measure atmospheric infiltration effects. Completion of the tests required multiple samples to be obtained from the test probes.

Installation of probes beyond 4 ft proved difficult due to the dense and rocky ground conditions and approximately 1 to 2 hours were required to install each probe to 8 ft. Finally, dense ground conditions made it necessary to use a backhoe to complete the probe installations at 4 ft and 8 ft near well MW-15.

In addition, three sampling probes were installed with the use of a backhoe near a probe driven into visibly undisturbed soil outside the Horn Rapids Landfill boundary (see Figure 4-5) that had showed detectable TCE concentrations (location TR1-17). This was done to evaluate the effect of soil disturbance with a backhoe on soil gas concentrations against concentrations measured from a probe installed in undisturbed soil. Results of this analysis are presented in the following section describing spacial variability.

4.3.2.1 Spacial Variability

Table 4-5 presents the soil gas TCE concentrations detected on January 2, 1991, at wells MW-15 and MW-12, and the mean, standard deviation, and coefficient of variation for the data at each sampling depth. The data indicate that the variability is higher at the 2-ft and 4-ft sampling depths than at the 8-ft sampling depth.

Since dense ground conditions at MW-15 required the use of a backhoe to install sampling probes, a test was conducted to measure the variability of soil gas sampled from probes driven into undisturbed soil and probes driven into disturbed soil. Three sampling probes were installed with the use of a backhoe near sample location TR1-17 (see Figure 4-5). This location was chosen because TCE had been detected in samples from the location throughout the task. Samples were collected and analyzed from all the probes after they had been allowed to equilibrate for 12 h and after 12 d.

The results presented in Table 4-6 indicate that TCE soil gas concentrations measured after 12 h are lower in disturbed soils than the undisturbed soils. After 12 d, the TCE concentrations stabilized in the disturbed soils. However, probe installation with the backhoe has no significant impact on soil gas concentrations when disturbed and undisturbed soil data are compared to field duplicate measurements. The range in relative percent difference (RPD) for the disturbed versus undisturbed soils ranges from <0.4% to 38%, (see Table 4-6) as compared with that observed for field duplicates (0% to 35%, see Table 3-5) and indicates a similar degree of variability as that obtained for sampling and analytical error.

4.3.2.2 Depth Variability

Results for TCE in the soil gas at well locations MW-12 and MW-15 indicate the concentrations increase with depth as depicted in Figure 4-6. At MW-12 the average TCE concentrations detected at the 2-ft, 4-ft, and 8-ft sampling depths were 8, 18, and 24 ppbv, respectively. At MW-15 the average TCE concentrations were 5, 12, and 38 ppbv at these

respective depths. No TCE was detected in the sampling probes placed around well 699-S29-E12.

TCE has been detected in both MW-12 and MW-15 at concentrations of 74 ug/L and 56 ug/L, respectively during the 4th Quarter 1990 ground-water sampling round; no TCE was detected in 699-S29-E12.

4.3.2.3 Purging Variability

The effect of sampling purge volume changes to the soil gas concentrations was measured in the sample probes installed around MW-15 and TR1-17 (see Figure 4-4 and Figure 4-5). This test was conducted by first removing one soil gas probe volume collecting an initial sample, removing two additional probe volumes (for a total of three sampling probe volumes) and then collecting a final sample. Three sampling probe volumes is the normal sample purge requirement, as detailed in the technical procedure. Results of the purging variability analysis are presented in Table 4-7 and indicate low variability with purge volume change. The RPD between different purge samples ranged from 3% to 22% for samples with TCE concentrations a factor of five or more above the SQL as compared to a range of 0% to 35% RPD observed for field duplicates (see Table 3-5). This indicates that sampling by purging three probe volumes versus one probe volume does not significantly impact the results of VOCs in the soil gas samples.

4.3.2.4 Atmospheric Infiltration

Atmospheric infiltration was tested by injecting a tracer gas around the base of the sample probes to determine the sampling depth at which some atmospheric dilution occurred. Figure 4-7 depicts the sampling configuration used for the tracer test. First a sample of the soil gas was collected before the tracer gas was administered, then an empty one-gallon-size metal can was inverted and placed over the sampling probe. While purging, a tracer gas (dichlorodifluoromethane) was sprayed into the can and a sample was collected after three probe volumes were purged. Evidence of tracer gas in the sample was determined by the size of the air peak in the GC trace. Figure 4-8 compares a normal GC analysis where no tracer is detected, to a GC analysis where tracer is detected. Table 4-8 presents the results of all tracer test analyses. Samples from MW-15 showed evidence of tracer at 2 ft, but not at 4 or 8 ft. One sample collected from MW-12 at 4 ft showed evidence of tracer, but not when re-sampled.

4.3.2.5 Conclusions

Based on the results of the soil gas test data the decision was made to continue with the preliminary TCE plume delineation at the Horn Rapids Landfill using 4 ft as the sampling depth. This decision was based on the following results of the soil gas testing:

- Dense and rocky ground conditions outside of the landfill boundaries made it difficult to drive probes beyond the 4-ft sampling depth in an efficient and timely manner thus reducing the effectiveness of soil gas sampling as a cost-effective means of operable unit characterization.

- TCE was detected at concentrations above the SQL at the 4 ft sampling depth at MW-12 and MW-15, where known concentrations of TCE are present in the ground water.

- The 4-ft sampling depth was generally unaffected by atmospheric infiltration during the tracer test.

4.3.3 Preliminary Ground-Water Plume Delineation

A total of 53 sampling probes were installed, sampled, and analyzed to preliminarily delineate the TCE contaminant plume in the vicinity of the Horn Rapids Landfill. Figure 3-4 presents the location and identification for each of the sampling probes. Figure 4-9 presents the concentrations of TCE in the soil gas sampled from the probes, and Table 4-9 presents a summary of the test results.

TCE was detected at concentrations from 2 ppbv to 255 ppbv in 36 of the 53 probes from an area near and east of the ANF pretreatment ponds to an area approximately 2,000 feet northeast of the center of the Horn Rapids Landfill. The highest TCE concentrations were observed at location TR1-17, which is just outside the eastern boundary of the Horn Rapids Landfill. TCA was detected in six of the 53 probes, at concentrations ranging from 5 to 41 ppbv. All the detections for TCA were in probes installed in the boundaries of the Horn Rapids Landfill. PCE was detected in four of the 53 probes ranging in concentration from 5 to 28 ppbv. All the detections for PCE were outside the Horn Rapids Landfill boundaries.

4.4 Discussion

The results of the soil gas surveys conducted at the Horn Rapids Landfill and vicinity including the South Pit, do not indicate the presence of a concentrated vadose zone source for TCE or other VOCs near the locations sampled. If a vadose zone source (in the form of a free liquid) was present near the sampling locations, the TCE concentrations would be expected to be many orders of magnitude above the concentrations observed. An approximate concentration for TCE in the vadose zone if present as a free liquid can be estimated from it's vapor pressure (EPA 1987). The concentration immediately above the liquid would be expected to be about 7%, or 70,000,000 ppbv. This concentration is determined by taking the vapor pressure of TCE divided by the sum of the vapor pressure and atmospheric pressure or: 7% TCE per liter of air = 60 / (760 + 60) x 100 where 60 is the vapor pressure of TCE (in mm Hg at 25°C) and 760 is atmospheric pressure (at sea level elevation and 25°C.). Results of the soil gas surveys at the sampling areas indicated TCE present ranging from non-detect to a high of 394 ppbv as compared to an estimated maximum of 70,000,000 ppbv if a liquid TCE source were present near any of the sample locations.

TCE has been detected over a wide area at the Horn Rapids Landfill and vicinity both in the soil gas and the ground water as evidenced by previous ground-water analyses from wells in the area and depicted in Figure 4-10. Figure 4-10 indicates the approximate locations of ground-water monitoring wells and soil gas sample points where TCE has been

detected. The TCE concentrations detected in the soil gas do not indicate a source has been identified in the vadose zone at the study areas since concentrations would be expected many orders of magnitude above the observed levels.

5. SUMMARY AND CONCLUSIONS

This section presents a summary, conclusions, and recommendations based on the results of soil gas surveys conducted at the 1100-EM-1 Operable Unit. A summary of the results is presented in Section 5.1. Section 5.2 presents conclusions based on the interpretation of the data. Finally, Section 5.3 presents recommendations for further operable unit investigation.

5.1 Summary

A total of 165 soil gas probes were installed and sampled at the 1100-EM-1 Operable Unit during the period beginning November 8, 1990, through February 5, 1991. Soil gas samples were collected and analyzed for TCE, TCA, and PCE. Results of the soil gas surveys are summarized below:

- At UN-1100-6 soil gas samples were collected and analyzed from nine locations. No target compounds were detected at sufficient concentrations above the laboratory blanks to be valid.

- At the South Pit, TCE was detected in 38 of the 40 total locations at concentrations ranging from 5 to 394 ppbv. TCA was detected at seven locations ranging from 3 to 39 ppbv and PCE was detected at three locations ranging from 4 to 41 ppbv.

- The soil gas test data indicated that 4 and 8 ft sampling depths were acceptable because the surface infiltration test did not indicate atmospheric dilution was occurring during sampling. TCE was also detected at concentrations above the SQLs in samples collected from the probes placed around ground-water monitoring wells MW-12 and MW-15, where TCE has been detected in the groundwater.

- The soil gas test data indicated that the 8-ft sampling depth provided the least amount of spacial variability, but due to the dense and rocky ground conditions at the operable unit, sampling at 8 ft was not an efficient and cost-effective depth for soil gas sampling.

- TCE was detected in 17 of the 35 permanent monitoring probes installed at the Horn Rapids Landfill at concentrations ranging from 3 to 233 ppbv. PCE (22 ppbv) and carbon tetrachloride (26 ppbv) each were detected at a single sample location, PSG-22 and PSG-20, respectively.

- The preliminary plume delineation soil gas survey indicated low concentrations of TCE extending from near the ANF pretreatment ponds to an area approximately 2,000 ft northeast of the Horn Rapids Landfill. TCE was detected at concentrations ranging from 2 to 255 ppbv in 36 of the 53 soil gas probes installed. TCA was detected in six of the 53 probes ranging from 5 to 41 ppbv. PCE was detected in four of the 53 probes ranging from 5 to 28 ppbv.

5.2 Conclusions

TCE has been detected over a large area in the soil gas and ground water in the vicinity of the Horn Rapids Landfill and the South Pit. No defined vadose zone source of the TCE contamination can be identified at either the Horn Rapids Landfill or the South Pit. If a free, liquid source of TCE existed within the vadose zone at either area, soil gas concentrations would be expected to be many orders of magnitude above the concentrations observed during this survey.

A plume of contaminated ground water is known to exist downgradient from the ANF pretreatment lagoons due to past leakage. Because of this leakage the lagoon liners all were replaced with double liners around 1979 or 1980, (DOE-RL, 1990b). When the liners were replaced TCE was used to clean the liner seams prior to sealing (Malody, C., Advanced Nuclear Fuels Corp. [Personal communication] October 17, 1990). Currently, ANF does not use TCE as part of their manufacturing process but no information is available regarding its use by the previous owner of the facility, Exxon Nuclear.

In the absence of a defined source for TCE at the Horn Rapids Landfill and vicinity and the South Pit, existing soil gas and ground-water data indicate an upgradient source for TCE as shown in Figure 4-10.

5.3 Recommendations

- It is recommended that no further soil gas or ground water investigations be conducted at UN-1100-6.

- It is recommended that no additional ground water investigation be conducted for the Horn Rapids Landfill and vicinity and the South Pit because no source for TCE has been identified at the sites.

- In anticipation of future closure activities, it is recommended that the permanent monitoring probes at the Horn Rapids Landfill be sampled on a regular basis to monitor changes in the concentrations of VOCs detected during this soil gas survey that may indicate releases from suspected buried wastes. This recommendation is consistent with closure measures recommended in the Phase I RI report (DOE-RL, 1990b).

- Since the South Pit was included as part of the draft Phase II RI work plan activities (DOE-RL, 1990a) and due to the similarity in results obtained during the soil gas survey, the area should be incorporated as part of the Horn Rapids Landfill in anticipation of future closure activities. As part of such closure activities, the installation of permanent soil gas probes should be considered to monitor changes in the concentrations of VOCs detected during the soil gas survey.

6. REFERENCES

DOE-RL 1990a, Remedial Investigation Phase 2 Supplemental Work Plan for the Hanford Site 1100-EM-1 Operable Unit, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

DOE-RL 1990b, Phase I Remedial Investigation Report for the Hanford Site 1100-EM-1 Operable Unit, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

EPA 1987, Soil Gas Sensing for Detection and Mapping of Volatile Organics, U.S. Environmental Protection Agency, Environmental Monitoring and Systems Laboratory, Las Vegas, Nevada.

ASTM 1981, 1981 Annual Book of ASTM Standard, Part 26 Gaseous Fuels; Coal and Coke; Atmospheric Analysis, American Society for Testing and Materials, Philadelphia, Pennsylvania.

EPA, 1986, Test Methods for Evaluating Solid Waste, SW-846, Volume 2, 3rd Ed., U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C.

TABLE 3-1

TARGET COMPOUND LIST, SAMPLE QUANTITATION LIMITS AND PHYSICAL CONSTANTS

Compound	Sample Quantitation Limit (ppbv)		Molecular Weight (1)	Vapor Pressure, mm Hg, 20°C (2)	Henry's Law Constant (2)
	Direct Injection	Purge and Trap GC			
1,1,1-Trichloroethane (TCA)	30	26	133.41	100	0.77
Trichloroethene (TCE)	30	8	131.39	60	0.42
Tetrachloroethene (PCE)	18	4	165.83	14.3	0.34

(1) - CRC Handbook of Chemistry and Physics, 60th Ed., 1980, CRC Press, Boca Raton, FL.

(2) - Handbook of Chemical Property Estimation Methods, Environmental Behavior of Organic Compounds, McGraw-Hill Book Company, New York, New York, 1982.

TABLE 3-2

LABORATORY BLANK SUMMARY

Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
11/8/90	30 U 11	30 U 30 U	18 U 18 U
11/9/90	30 U	30 U	18 U
11/10/90	30 U 30 U	30 U 30 U	18 U 18 U
11/11/90	20 18	7 30 U	4 18 U
11/12/90	30	30 U	18 U
11/13/90	30 U	30 U	18 U
11/17/90	26 U	3	4 U
11/18/90	26 U	2	4 U
11/28/90	3 2 26 U 2	8 U 8 U 8 U 8 U	1 20 2 0.7
11/29/90	2.5 26 U 1	8 U 8 U 8 U	0.9 4 14
11/30/90	3 2	8 U 3	4 8
12/11/90	26 U 1 26 U	8 U 8 U 8 U	0.5 4 0.6
12/12/90	26 U 26 U 26 U 6 26 U 26 U 26 U	8 U 8 U 8 U 8 U 8 U 8 U 8 U	4 U 4 U 0.8 4 U 4 U 0.5 4 U

TABLE 3-2 (continued)

LABORATORY BLANK SUMMARY

Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
12/13/90	26 U	8 U	4 U
	26 U	8 U	4
	26 U	8 U	0.3
	26 U	8 U	4 U
	26 U	8 U	4 U
	26 U	8 U	9
	26 U	8 U	0.4
	26 U	8 U	0.9
12/17/90	26 U	8 U	0.9
	26 U	8 U	6
	26 U	8 U	0.7
12/18/90	26 U	8 U	0.6
	7	8 U	9
	26 U	8 U	4U
	30 U	30 U	18U
12/20/90	26 U	8 U	5
	26 U	8 U	4U
12/21/90	30 U	30 U	18U
	26 U	8 U	4U
	26 U	8 U	4U
12/22/90	26 U	8 U	0.7
	26 U	8 U	4U
12/29/90	3.2	8 U	0.6
	26 U	8 U	1.3
1/3/91	26 U	8 U	2
	26 U	8 U	3
	3	8 U	0.4
	2	8 U	2
	3	8 U	3
	2	8 U	1
1/4/91	26 U	8 U	2.4
	26 U	8 U	4 U
	26 U	8 U	0.6
	26 U	8 U	4
	26 U	8 U	2

TABLE 3-2 (continued)

LABORATORY BLANK SUMMARY

Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
1/5/91	26 U 2 26 U	8 U 8 U 8 U	7 4 U 1
1/8/91	4 3 26 U 1.7	8 U 8 U 8 U 8 U	3 3 1.4 0.5
1/9/91	2.6 2	8 U 8 U	0.9 2
1/11/91	3 5 1.6 5	8 U 8 U 8 U 8 U	3 10 4 U 3
1/12/91	2 3 26 U	8 U 8 U 8 U	4 U 7 9
1/15/91	5	8 U	2
1/18/91	39 16 4 4	8 U 8 U 8 U 8 U	0.7 1.3 4 3
1/19/91	2 2 8	8 U 8 U 8 U	0.8 0.6 8
2/7/91	11 12 10	8 U 8 U 2	1 1 3

TABLE 3-3

AMBIENT AIR BLANK SUMMARY

Sample ID	Date Collected	TCA ppbv	TCE ppbv	PCE ppbv
TR1-27-AB	11/8/90	30 U	30 U	18 U
TR1-15-AB	11/9/90	30 U	30 U	18 U
TR4-1-AB	11/10/90	30 U	30 U	18 U
TR1-25-AB	11/11/90	30 U	30 U	18 U
15-AB	11/12/90	30 U	30 U	18 U
TR4-1-AB	11/13/90	30 U	30 U	18 U
S29-AB	11/13/90	30 U	30 U	18 U
12A-AB N6-1-AB	11/17/90	26 U 26 U	8 U 8 U	4 U 4 U
SP-3-AB	11/28/90	26 U	8 U	4 U
SP-13-AB	11/29/90	26 U	8 U	4 U
15-AB	11/30/90	26 U	8 U	4 U
12-AB	12/11/90	26 U	8 U	4 U
12-AB	12/12/90	26 U	1 J	4 U
TR1-12-AB	12/13/90	26 U	8 U	4 U
12-AB	12/14/90	30 U	30 U	18 U
SP7-AB	12/17/90	26 U	8 U	4 U
TR1-26-AB	12/18/90	26 U	8 U	4 U
15-AB	12/20/90	26 U	2 J	4 U
TR1-17-AB	12/21/90	26 U	3 J	4 U
TR1-17-AB	12/22/90	2 J	8 U	4 U
TEST1-AB	12/28/90	26 U	8 U	4 U
12-AB S29-AB	1/2/91	26 U 26 U	8 U 15	4 U 4 U
TR3-8-AB	1/3/91	26 U	22	4 U
TR5-3-AB	1/4/91	26 U	8 U	4 U

TABLE 3-3 (continued)

AMBIENT AIR BLANK SUMMARY

Sample ID	Date Collected	TCA ppbv	TCE ppbv	PCE ppbv
TR5-6-AB	1/7/91	26 U	8 U	4 U
ANF-AB	1/8/91	26 U	8 U	4 U
ANF-AB	1/9/91	26 U	8 U	4 U
SPA-1-AB TR3-15-AB	1/10/91	26 U 26 U	8 U 23	4 U 24
ANF-AB	1/11/91	26 U	8 U	4 U
TR3-15-AB	1/11/91	26 U	8 U	4 U
ANF-AB	1/14/91	26 U	8 U	4 U
PSG-9-AB	1/15/91	26 U	8 U	4 U
ANF-W-AB PSG-1-AB	1/16/91	26 U 26 U	8 U 8 U	4 U 4 U
PSG-17-AB	1/17/91	26 U	8 U	4 U
PSG-36-AB	2/5/91	26 U	8 U	4 U

TABLE 3-4

EQUIPMENT BLANK SUMMARY

Sample ID	Date Collected	TCA ppbv	TCE ppbv	PCE ppbv
TR1-24-EB	11/8/90	30 U	30 U	18 U
TR1-23-EB		30 U	30 U	18 U
TR1-22-EB		30 U	30 U	18 U
TR1-21-EB		30 U	30 U	18 U
TR1-21-EB2		30 U	30 U	18 U
TR1-20-EB		30 U	30 U	18 U
TR1-15-EB	11/9/90	30 U	30 U	18 U
TR4-1-EB	11/10/90	30 U	30 U	18 U
15A-EB	11/12/90	30 U	30 U	18 U
15A-EB2		30 U	30 U	12
12A-EB	11/13/90	30 U	30 U	18 U
SP-13-EB	11/29/90	26 U	8 U	4 U
15B-4-EB	12/11/90	26 U	6 J	4 U
12A-8-EB	12/12/90	26 U	8 U	4 U
PSG-7-EB	12/17/90	26 U	8 U	4 U
TR1-26-EB	12/18/90	26 U	8 U	4 U
15A-4-EB	12/20/90	26 U	5 J	4 U
15A-8-EB		5 J	8 U	4 U
TR1-17D-EB	12/21/90	26 U	8 U	4 U
S29-8-EB	12/27/90	26 U	8 U	4 U
S29-4-EB		26 U	8 U	4 U
12-EB	1/2/91	2 J	8 U	4 U
S29-EB		26 U	8	4 U
TR3-8-EB1	1/3/91	2 J	15	4 U
TR3-8-EB2		26 U	7 J	4 U
TR3-8-EB3		26 U	10	4 U
TR5-3-EB1	1/4/91	26 U	11	4 U
TR5-3-EB2		26 U	10	4 U
TR5-3-EB3		26 U	12	4 U
TR5-6-EB1	1/7/91	26 U	8 U	4 U
TR5-6-EB2		26 U	8 U	4 U
TR5-6-EB3		26 U	8 U	4 U

TABLE 3-4 (continued)

EQUIPMENT BLANK SUMMARY

Sample ID	Date Collected	TCA ppbv	TCE ppbv	PCE ppbv
ANF-EB1	1/8/91	26 U	8 U	4 U
ANF-EB2		26 U	8 U	4 U
ANF-EB3		26 U	8 U	4 U
ANF-EB1	1/9/91	26 U	8 U	4 U
ANF-EB2		26 U	8 U	4 U
ANF-EB3		26 U	8 U	4 U
TR3-EB1	1/10/91	26 U	16	4 U
TR3-EB2		26 U	21	4 U
TR3-EB3		26 U	4 J	4 U
ANF-EB1	1/11/91	26 U	8 U	4 U
ANF-EB2		26 U	8 U	4 U
ANF-EB3		26 U	8 U	4 U
ANF-EB1	1/14/91	26 U	8 U	4 U
ANF-EB2		26 U	8 U	4 U
ANF-EB3		26 U	8 U	4 U
PSG-9-EB	1/15/91	26 U	8 U	4 U
PSG-30-EB	1/16/91	26 U	8 U	4 U
PSG-36-EB1	2/5/91	26 U	8 U	4 U
PSG-36-EB2		26 U	8 U	4 U

TABLE 3-5

FIELD DUPLICATE ANALYSIS SUMMARY

Sample Location	Date Sampled	TCA (ppbv)			TCE (ppbv)			PCE (ppbv)		
		A	B	RPD	A	B	RPD	A	B	RPD
TR1-25	11/8/90	30 U	30 U	NC	30 U	30 U	NC	18 U	18 U	NC
TR1-24		30 U	30 U	NC	39	55	34	18 U	18 U	NC
TR1-15	11/9/90	30 U	30 U	NC	30 U	30 U	NC	18 U	18 U	NC
TR4-2	11/10/90	30 U	30 U	NC	30 U	30 U	NC	18 U	18 U	NC
TR4-1		30 U	30 U	NC	30 U	30 U	NC	18 U	18 U	NC
TR1-17		36	54	40	120	144	18	18 U	18 U	NC
TR1-23		41	30 U	NC	76	65	16	18 U	18 U	NC
TR1-17	11/11/90	45	38	16	167	147	13	18 U	18 U	NC
15B-2	11/12/90	30 U	30 U	NC	30 U	30 U	NC	18 U	18 U	NC
S29C-2	11/13/90	30 U	30 U	NC	30 U	30 U	NC	18 U	18 U	NC
15B-2	11/17/90	26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
N6-4		26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
SP-1	11/28/90	26 U	26 U	NC	114	109	4	4 U	4 U	NC
SP-13	11/29/90	26 U	26 U	NC	111	109	2	4 U	4 U	NC
12A-2	11/30/90	26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
12A-4	12/11/90	26 U	26 U	NC	21	25	17	4 U	4 U	NC

A Indicates the observed value for the sample.
B Indicates the observed value for the duplicate sample.
RPD Relative percent difference.
NC Indicates the result can not be calculated due to one or both results being non-detects.

TABLE 3-5 (Continued)

FIELD DUPLICATE ANALYSIS SUMMARY

Sample Location	Date Sampled	TCA (ppbv)			TCE (ppbv)			PCE (ppbv)		
		A	B	RPD	A	B	RPD	A	B	RPD
12A-8	12/12/90	26 U	26 U	NC	22	26	17	4 U	4 U	NC
12A-4	12/14/90	30 U	18	NC	26	37	35	4 U	4 U	NC
TR1-26	12/18/90	26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
N6-2		26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
15A-4	12/21/90	2 J	3 J	40	15	19	24	4 U	4 U	NC
TR1-17	12/22/90	21 J	17 J	21	235	179	27	4 U	4 U	NC
TR1-17F		18	20	11	185	197	6	4 U	4 U	NC
15C-8	1/2/91	26 U	26 U	NC	40	39	3	4 U	4 U	NC
TR1-11	1/3/91	6 J	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
TR5-2	1/4/91	26 U	26 U	NC	98	98	0	4 U	4 U	NC
TR5-5	1/7/91	26 U	26 U	NC	35	38	8	22	22	0
SPA-1	1/10/91	26 U	26 U	NC	5 J	6 J	18	4 U	4 U	NC
TR3-14	1/11/91	26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
TR7-4	1/14/91	26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC
PS6-1	1/16/91	26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC

A Indicates the observed value for the sample.
B Indicates the observed value for the duplicate sample.
RPD Relative percent difference.
NC Indicates the result can not be calculated due to one or both results being non-detects.

TABLE 3-5 (Continued)

FIELD DUPLICATE ANALYSIS SUMMARY

Sample Location	Date Sampled	TCA (ppbv)			TCE (ppbv)			PCE (ppbv)		
		A	B	RPD	A	B	RPD	A	B	RPD
PS6-17	1/17/91	26 U	26 U	NC	8 U	8 U	NC	4 U	4 U	NC

A Indicates the observed value for the sample.
B Indicates the observed value for the duplicate sample.
RPD Relative percent difference.
NC Indicates the result can not be calculated due to one or both results being non-detects.

TABLE 3-6

CALIBRATION CHECK SUMMARY

Date Analyzed	TCA			TCE			PCE		
	True	Obs.	%D	True	Obs.	%D	True	Obs.	%D
11/9/90	76	107	41	90	94	4	79	139	76
11/10/90	76	78	3	90	67	-26	79	97	23
	76	86	13	90	99	10	79	108	37
11/11/90	76	84	11	90	71	-21	79	88	11
11/13/90	76	72	-5	90	74	-18	79	80	1
	76	76	0	90	83	-8	79	81	3
11/18/90	92	117	29	108	125	16	94	104	11
11/27/90	92	92	0	108	118	9	94	106	13
11/28/90	92	112	22	108	147	36	94	101	7
	92	89	-3	108	129	19	94	100	6
11/29/90	92	100	9	108	139	29	94	128	36
11/30/90	92	89	-3	108	143	32	94	108	15
12/11/90	92	98	7	108	109	1	94	97	3
12/12/90	92	70	-24	108	93	-14	94	75	-20
	92	108	17	108	119	10	94	104	11
12/13/90	92	97	5	108	121	12	94	88	-6
	92	117	27	108	118	9	94	94	0
12/17/90	92	85	-8	108	103	-5	94	93	-1
12/18/90	92	104	13	108	105	-3	94	86	-9
	92	83	-10	108	101	-6	94	75	-20
12/20/90	92	75	-18	108	102	-6	94	85	-10
12/21/90	92	93	1	108	89	-18	94	79	-16
	92	80	-13	108	98	-9	94	77	-18
12/22/90	92	74	-20	108	94	-13	94	84	-11
12/29/90	92	79	-14	108	116	7	94	79	-16
	92	87	-5	108	104	-4	94	100	6
1/3/91	92	50	-46	108	74	-31	94	85	-10
	92	137	49	108	143	32	94	105	12
	92	125	36	108	129	19	94	87	-7
	92	80	-13	108	104	-4	94	62	-34
1/4/91	92	101	10	108	97	-10	94	75	-20
	92	82	-11	108	121	12	94	91	-3
	92	86	-7	108	111	3	94	85	-10
	92	111	21	108	113	5	94	107	14
1/5/91	92	53	-42	108	91	-16	94	58	-38
	92	85	-8	108	120	11	94	72	-23
1/8/91	92	107	16	108	125	16	94	103	10

True - Indicates the theoretical true concentration of the calibration standard in ppbv.
Obs. - Indicates the observed concentration of the calibration standard in ppbv.
%D - Indicates the percent difference between the true and observed concentrations.

TABLE 3-6 (Continued)

CALIBRATION CHECK SUMMARY

Date Analyzed	TCA			TCE			PCE		
	True	Obs.	%D	True	Obs.	%D	True	Obs.	%D
1/9/91	92	97	5	108	116	7	94	115	22
1/11/91	92	104	13	108	79	-27	94	76	-19
	92	140	52	108	97	-10	94	97	3
	92	96	4	108	97	-10	94	107	14
	92	66	-28	108	79	-27	94	62	-34
1/12/91	92	88	-4	108	102	-6	94	83	-12
	92	92	0	108	99	-8	94	90	-4
1/15/91	92	74	-20	108	101	-6	94	81	-14
1/18/91	92	72	-22	108	97	-10	94	82	-13
	92	71	-23	108	103	-5	94	73	-22
	92	75	-18	108	89	-18	94	79	-16
1/19/91	92	80	-13	108	107	-1	94	82	-13
	92	80	-13	108	98	-9	94	84	-11
2/7/91	92	78	-15	108	111	3	94	67	-29

True - Indicates the theoretical true concentration of the calibration standard in ppbv.
Obs. - Indicates the observed concentration of the calibration standard in ppbv.
%D - Indicates the percent difference between the true and observed concentrations.

9 2 1 2 6 4 2 0 1 3 0

TABLE 3-7

LABORATORY CONFIRMATION ANALYSIS RESULTS

Sample Location	Date Sampled	TCA (ppbv)		TCE (ppbv)		PCE (ppbv)	
		Golder Result	PNEL Result	Golder Result	PNEL Result	Golder Result	PNEL Result
TRI-17	11/18/90	26 U	460 U	190	110 J	4 U	370 U
N6-4	11/18/90	26 U	460 U	8 U	470 U	4 U	370 U
Ambient Air Blank	11/18/90	26 U	460 U	8 U	470 U	4 U	370 U

TABLE 4-1

UN-1100-6 SOIL GAS SURVEY RESULTS

Laboratory Sample ID	Sample Location	Date Collected	Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
131	N6-1	11/17/90	11/17/90	26 U	8 U	4 U
132	N6-2	11/17/90	11/18/90	26 U	8 U	4 U
247	N6-2	12/18/90	12/18/90	26 U	8 U	4 U
133	N6-3	11/17/90	11/18/90	26 U	8 U	4 U
134	N6-4	11/17/90	11/18/90	26 U	8 U	4 U
249	N6-4	12/18/90	12/18/90	26 U	8 U	4 U
136	N6-5	11/17/90	11/18/90	26 U	8 U	4 U
250	N6-5	12/18/90	12/18/90	26 U	8 U	4 U
137	N6-6	11/17/90	11/18/90	26 U	8 U	4 U
251	N6-6	12/18/90	12/18/90	26 U	8 U	4 U
138	N6-7	11/17/90	11/18/90	26 U	8 U	4 U
139	N6-8	11/17/90	11/18/90	26 U	8 U	4 U
252	N6-8	12/18/90	12/18/90	26 U	8 U	4 U
140	N6-9	11/17/90	11/18/90	26 U	8 U	4 U

TABLE 4-2

SOUTH PIT SOIL GAS RESULTS

Laboratory Sample ID	Field Sample Location	Date Collected	Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
144	SP-1	11/28/90	11/28/90	26 U	109	4 U
145	SP-2	11/28/90	11/28/90	26 U	171	4 U
147	SP-3	11/28/90	11/28/90	26 U	18	4 U
149	SP-4	11/28/90	11/28/90	26 U	12	4 U
150	SP-5	11/28/90	11/28/90	26 U	57	18
151	SP-6	11/28/90	11/28/90	26 U	48	41
152	SP-8	11/28/90	11/28/90	26 U	67	4 U
153	SP-9	11/28/90	11/28/90	26 U	62	4 U
154	SP-10	11/28/90	11/28/90	26 U	12	4 U
155	SP-11	11/28/90	11/28/90	26 U	11	4 U
156	SP-12	11/28/90	11/28/90	26 U	45	8
159	SP-13	11/29/90	11/29/90	26 U	111	4 U
161	SP-14	11/29/90	11/29/90	26 U	78	4 U
162	SP-15	11/29/90	11/29/90	26 U	28	4 U
163	SP-16	11/29/90	11/29/90	26 U	42	4 U
164	SP-17	11/29/90	11/29/90	26 U	8	4 U
165	SP-18	11/29/90	11/29/90	26 U	15	4 U
166	SP-19	11/29/90	11/29/90	26 U	32	4 U
167	SP-20	11/29/90	11/29/90	26 U	7 J	4 U
168	SP-21	11/29/90	11/29/90	26 U	26	4 U
169	SP-22	11/29/90	11/29/90	26 U	8 U	4 U
170	SP-23	11/29/90	11/29/90	26 U	24	4 U
237	SP-7	12/17/90	12/17/90	6 J	96	4 U
239	SP-2	12/17/90	12/17/90	9 J	88	4 U
240	SP-24	12/17/90	12/17/90	4 J	25	4 U
241	SP-25	12/17/90	12/17/90	3 J	9	4 U
242	SP-26	12/17/90	12/17/90	3 J	14	4 U
382	SPA-1	01/10/91	01/11/91	26 U	5 J	4 U
384	SPA-2	01/10/91	01/11/91	26 U	14	4 U
385	SPA-3	01/10/91	01/11/91	39	31	4 U
386	SPA-4	01/10/91	01/11/91	26 U	29	4 U
387	SPA-5	01/10/91	01/11/91	26 U	31	4 U
388	SPA-6	01/10/91	01/11/91	27	27	4 U
389	SPA-7	01/10/91	01/11/91	26 U	394	4 U
390	SPB-1	01/10/91	01/11/91	26 U	15	4 U
391	SPB-2	01/10/91	01/11/91	26 U	8 U	4 U
392	SPB-3	01/10/91	01/11/91	26 U	10	4 U
393	SPB-4	01/10/91	01/11/91	26 U	56	4 U
394	SPB-5	01/10/91	01/11/91	26 U	72	4 U
395	SPB-6	01/10/91	01/11/91	26 U	8	4 U
396	SPB-7	01/10/91	01/11/91	26 U	11	4 U

TABLE 4-3

PERMANENT SOIL GAS PROBE RESULTS

Laboratory Sample ID	Field Sample Location	Date Sampled	Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
433	PSG-1	01/16/91	01/18/91	26 U	8 U	4 U
435	PSG-2	01/16/91	01/18/91	26 U	8 U	4 U
436	PSG-3	01/16/91	01/18/91	26 U	8 U	4 U
437	PSG-4	01/16/91	01/18/91	26 U	8 U	4 U
438	PSG-5	01/16/91	01/18/91	26 U	8 U	4 U
439	PSG-6	01/16/91	01/18/91	26 U	8 U	4 U
440	PSG-7	01/16/91	01/18/91	26 U	8 U	4 U
441	PSG-8	01/16/91	01/18/91	26 U	8 U	4 U
442	PSG-9	01/16/91	01/18/91	26 U	8 U	4 U
443	PSG-10	01/16/91	01/18/91	26 U	15	4 U
444	PSG-11	01/16/91	01/18/91	26 U	154	4 U
445	PSG-12	01/16/91	01/18/91	26 U	16	4 U
446	PSG-13	01/16/91	01/18/91	26 U	8 U	4 U
447	PSG-14	01/16/91	01/18/91	26 U	8 U	4 U
448	PSG-15	01/16/91	01/18/91	26 U	8 U	22
449	PSG-16	01/16/91	01/18/91	26 U	233	4 U
450	PSG-17	01/17/91	01/19/91	26 U	8 U	4 U
453	PSG-18	01/17/91	01/19/91	26 U	3 J	4 U
454	PSG-19	01/17/91	01/19/91	26 U	24	4 U
455	PSG-20[1]	01/17/91	01/19/91	26 U	79	4 U
456	PSG-21	01/17/91	01/19/91	26 U	8 U	4 U
457	PSG-22	01/17/91	01/19/91	26 U	119	4 U
458	PSG-23	01/17/91	01/19/91	26 U	6 J	4 U
459	PSG-24	01/17/91	01/19/91	26 U	8 U	4 U
460	PSG-25	01/17/91	01/19/91	26 U	159	4 U
461	PSG-26	01/17/91	01/19/91	26 U	8 U	4 U
462	PSG-27	01/17/91	01/19/91	26 U	8 U	4 U
463	PSG-28	01/17/91	01/19/91	26 U	8 U	4 U
464	PSG-29	01/17/91	01/19/91	26 U	4 J	4 U
465	PSG-30	01/17/91	01/19/91	26 U	8 U	4 U
466	PSG-31	01/17/91	01/19/91	26 U	10	4 U
467	PSG-32	01/17/91	01/19/91	26 U	120	4 U
468	PSG-33	01/17/91	01/19/91	26 U	26	4 U
469	PSG-34	01/17/91	01/19/91	26 U	12	4 U
470	PSG-35[2]	01/17/91	01/19/91	26 U	88	4 U
474	PSG-35	02/05/91	02/07/91	26 U	34	4 U

1 Carbon tetrachloride was detected at this sample location at a concentration of 26 ppbv.

2 This was a temporary sample location, the final permanent location was moved, resurveyed and sampled 2/5/91.

TABLE 4-4

SUMMARY OF SOIL GAS TEST ANALYSIS

Well Location	Sample Location	Sample Depth (feet)	Date Sampled	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
MW-15	15A-2	2	11/12/90 11/17/90 11/30/90 12/21/90 1/2/91	30 U 26 U 26 U 26 U 2 J	30 U 8 U 8 U 4 J 3 J	18 U 4 U 4 U 4 U 4 U
	15B-2	2	11/12/90 11/17/90 11/30/90 12/21/90 1/2/91	30 U 26 U 26 U 26 U 26 U	30 U 8 U 8 U 4 J 13	18 U 4 U 4 U 4 U 4 U
	15C-2	2	11/12/90 11/17/90 11/30/90 12/21/90 1/2/91	30 U 26 U 26 U 26 U 26 U	30 U 8 U 8 U 3 J 8 U	18 U 4 U 4 U 4 U 4 U
	15A-4	4	12/21/90 1/2/91	2 J 3 J	15 21	4 U 15
	15B-4	4	12/21/90 1/2/91	26 U 26 U	9 5 J	4 U 4 U
	15C-4	4	12/21/90 1/2/91	26 U 26 U	3 J 21	4 U 4 U
	15A-8	8	12/21/90 1/2/91	2 J 4 J	15 36	4 U 4 U
	15B-8	8	12/21/90 1/2/91	7 J 26 U	44 58	4 U 29
	15C-8	8	12/21/90 1/2/91	4 J 26 U	33 40	4 U 4 U
MW-12	12A-2	2	11/13/90 11/17/90 12/11/90 1/2/91	30 U 26 U 26 U 2 J	30 U 8 U 8 U 5 J	18 U 4 U 4 U 4 U
	12B-2	2	11/13/90 11/17/90 12/11/90 1/2/91	30 U 26 U 26 U 26 U	30 U 8 U 8 U 6 J	18 U 4 U 4 U 18

TABLE 4-4 (continued)

SUMMARY OF SOIL GAS TEST ANALYSIS

Well Location	Sample Location	Sample Depth (feet)	Date Sampled	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
MW-12 (continued)	12C-2	2	11/13/90 11/17/90 12/11/90 1/2/91	20 U 26 U 26 U 26 U	30 U 8 U 8 U 13	18 U 4 U 4 U 4 U
	12A-4	4	12/11/90 1/2/91	26 U 6 J	25 32	4 U 4 U
	12B-4	4	12/11/90 1/2/91	26 U 26 U	8 U 10	4 U 4 U
	12C-4	4	12/11/90 1/2/91	26 U 26 U	8 U 5 J	4 U 4 U
	12A-8	8	12/12/90 1/2/91	26 U 2 J	22 39	4 U 4 U
	12B-8	8	12/12/90 1/2/91	26 U 26 U	8 U 20	4 U 4 U
	12C-8	8	12/12/90 1/2/91	26 U 26 U	14 23	4 U 4 U
699-S29-E12	S29A-2	2	11/13/90 1/2/91	30 U 26 U	30 U 8 U	18 U 4 U
	S29B-2	2	11/13/90 1/2/91	30 U 26 U	30 U 8 U	18 U 4U
	S29C-2	2	11/13/90 1/2/91	30 U 26 U	30 U 8 U	18 U 4 U
	S29A-4	4	1/2/91	26 U	8 U	4 U
	S29B-4	4	1/2/91	26 U	8 U	4 U
	S29C-4	4	1/2/91	26 U	8 U	4 U
	S29A-8	8	1/2/91	8 U	8 U	4 U
	S29B-8	8	1/2/91	8 U	8 U	4 U
	S29C-8	6	1/2/91	8 U	8 U	4 U

TABLE 4-5

SPACIAL VARIABILITY OF TCE IN THE SOIL GAS AT THE HORN RAPIDS LANDFILL

Well: MW-15 TCE in soil gas (ppbv) on 1/2/91						
Sample Depth, feet	Sample Locations 15A-2,4,8	Sample Locations 15B-2,4,8	Sample Locations 15C-2,4,8	Mean	S	Coefficient of Variance
2	3 J	13	8 U (*)	7	6	86
4	21	5 J	21	16	9	56
8	36	58	40	45	12	27
Well: MW-12 TCE in soil gas (ppbv) on 1/2/91						
Sample Depth, feet	Sample Locations 12A-2,4,8	Sample Locations 12B-2,4,8	Sample Locations 12C-2,4,8	Mean	S	Coefficient of Variance
2	5 J	6 J	13	8	4	50
4	32	10	5 J	16	14	88
8	39	20	23	27	10	37

S Indicates the standard deviation.

(*) - Indicates a value of one-half the sample quantitation limit was used in the calculation of the mean and standard deviation.

TABLE 4-6

SOIL GAS RESULTS FOR THE COMPARISON OF DISTURBED VERSUS UNDISTURBED SAMPLE LOCATIONS

Sample Location	TCE, ppbv	
	12/22/90	1/2/91
Undisturbed Area	235	255
Disturbed Area		
TR1-17D	177 (24)	254 (0.4)
TR1-17E	182 (23)	158 (38)
TR1-17F	185 (21)	238 (7)

(24) Indicates the relative percent difference (RPD) between the undisturbed area measurement and the disturbed area measurements.

TABLE 4-7

VARIABILITY IN SOIL GAS CONCENTRATIONS DUE TO SAMPLE PURGE VOLUME

Sample Location	Date Sampled	TCA			TCE			PCE		
		1PV	3PV	RPD	1PV	3PV	RPD	1PV	3PV	RPD
TR1-17	11/10/90	36	54	40	120	144	18	18 U	18 U	N/A
TR1-23		41	30 U	N/A	76	65	16	18 U	18 U	N/A
TR1-17	1/2/91	21	25	17	205	255	22	18	17	6
TR1-17D		29	32	10	263	254	3	4 U	18	N/A
TR1-17E		26 U	12 J	N/A	198	158	22	4 U	4 U	N/A
TR1-17F		26	28	7	248	238	4	4 U	4 U	N/A
15A-4		3 J	3 J	0	8	21	90	4 U	4 U	N/A
15B-4		26 U	3 J	N/A	9	5	57	4 U	4 U	N/A
15C-4		2 J	26 U	N/A	5	21	123	4 U	4 U	N/A

1PV Soil gas result observed for one purge volume.
3PV Soil gas result observed for three purge volumes.
RPD Percent difference between the 1PV and 3PV results.
N/A Percent difference value is not calculable due to one or both results being non-detects.

TABLE 4-8

SUMMARY OF SOIL GAS SURVEY
TRACER TEST RESULTS

Well Location	Sample Location	Sample Depth	Date Sampled	Tracer Detected ?
MW-15	A	2 feet	11/13/90	yes
	B	2 feet	11/13/90	yes
	C	2 feet	11/13/90	yes
MW-15	A	2 feet	11/16/90	no
	B	2 feet	11/16/90	yes
	C	2 feet	11/16/90	no
MW-12	A	4 feet	12/14/90	no
	B	4 feet	12/14/90	no
	C	4 feet	12/14/90	yes
MW-12	A	8 feet	12/14/90	no
	B	8 feet	12/14/90	no
	C	8 feet	12/14/90	no
MW-12	C	4 feet	12/18/90	no
MW-15	A	4 feet	12/21/90	no
	B	4 feet	12/21/90	no
	C	4 feet	12/21/90	no
MW-15	A	8 feet	12/21/90	no
	B	8 feet	12/21/90	no
	C	8 feet	12/21/90	no

TABLE 4-9

PRELIMINARY GROUND-WATER PLUME DELINEATION SOIL GAS RESULTS

Laboratory Sample ID	Field Sample Location	Date Sampled	Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
348	TR1-9	01/03/91	01/05/91	26 U	6 J	4 U
347	TR1-10	01/03/91	01/05/91	26 U	4 J	4 U
345	TR1-11	01/03/91	01/04/91	6 J	8 U	4 U
30	TR1-12	11/09/90	11/09/90	30 U	30 U	18 U
64	TR1-12	11/12/90	11/12/90	30 U	30 U	18 U
200	TR1-12	12/13/90	12/13/90	26 U	8 U	4 U
27	TR1-13	11/09/90	11/09/90	30 U	30 U	18 U
203	TR1-13	12/13/90	12/13/90	26 U	8 U	4 U
26	TR1-14	11/09/90	11/09/90	30 U	30 U	18 U
202	TR1-14	12/13/90	12/13/90	26 U	3 J	4 U
23	TR1-15	11/09/90	11/09/90	30 U	30 U	18 U
204	TR1-15	12/13/90	12/13/90	26 U	3 J	4 U
19	TR1-16	11/08/90	11/08/90	30 U	30 U	18 U
47	TR1-16	11/11/90	11/11/90	30 U	30 U	18 U
205	TR1-16	12/13/90	12/13/90	26 U	4 J	4 U
18	TR1-17	11/08/90	11/08/90	30 U	207	18 U
29	TR1-17	11/09/90	11/09/90	30 U	132	18 U
41	TR1-17	11/10/90	11/10/90	36	120	18 U
50	TR1-17	11/11/90	11/11/90	38	147	18 U
60	TR1-17	11/12/90	11/12/90	30 U	129	18 U
77	TR1-17	11/13/90	11/13/90	23 J	101	5
125	TR1-17	11/17/90	11/17/90	18 J	190	4 U
206	TR1-17	12/13/90	12/13/90	8 J	93	4 U
277	TR1-17	12/22/90	12/22/90	21 J	235	4 U
306	TR1-17	01/02/91	01/03/91	25 J	255	17
17	TR1-18	11/08/90	11/08/90	30 U	30 U	18 U
54	TR1-18	11/11/90	11/11/90	41	86	18 U
63	TR1-18	11/12/90	11/12/90	30 U	30 U	18 U
207	TR1-18	12/13/90	12/13/90	26 U	8 U	4 U
16	TR1-19	11/08/90	11/08/90	30 U	30 U	18 U
208	TR1-19	12/13/90	12/13/90	26 U	2 J	4 U
15	TR1-20	11/08/90	11/08/90	30 U	30 U	18 U
209	TR1-20	12/13/90	12/13/90	26 U	5 J	4 U
14	TR1-21	11/08/90	11/08/90	30 U	30 U	18 U
210	TR1-21	12/13/90	12/13/90	26 U	7 J	4 U

TABLE 4-9 (Continued)

PRELIMINARY GROUND-WATER PLUME DELINEATION SOIL GAS RESULTS

Laboratory Sample ID	Field Sample Location	Date Sampled	Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
13	TR1-22	11/08/90	11/08/90	30 U	30 U	18 U
211	TR1-22	12/13/90	12/13/90	26 U	10	4 U
12	TR1-23	11/08/90	11/08/90	30 U	227	18 U
28	TR1-23	11/09/90	11/09/90	30 U	78	18 U
43	TR1-23	11/10/90	11/10/90	41	76	18 U
55	TR1-23	11/11/90	11/11/90	42	76	18 U
212	TR1-23	12/13/90	12/13/90	5 J	51	4 U
10	TR1-24	11/08/90	11/08/90	30 U	39	18 U
213	TR1-24	12/13/90	12/13/90	7 J	23	4 U
8	TR1-25	11/08/90	11/08/90	30 U	30 U	18 U
214	TR1-25	12/13/90	12/13/90	8 J	5 J	4 U
245	TR1-26	12/18/90	12/18/90	26 U	8 U	4 U
344	TR3-8	01/03/91	01/04/91	26 U	9	4 U
343	TR3-9	01/03/91	01/04/91	26 U	8	4 U
342	TR3-10	01/03/91	01/04/91	26 U	43	17
341	TR3-11	01/03/91	01/04/91	26 U	47	28
410	TR3-12	01/11/91	01/12/91	26 U	8 U	4 U
409	TR3-13	01/11/91	01/12/91	26 U	8 U	4 U
407	TR3-14	01/11/91	01/12/91	26 U	8 U	4 U
406	TR3-15	01/11/91	01/12/91	26 U	8 U	4 U
38	TR4-1	11/10/90	11/10/90	30 U	30 U	18 U
35	TR4-1	11/10/90	11/10/90	30 U	30 U	18 U
48	TR4-1	11/11/90	11/11/90	30 U	30 U	18 U
215	TR4-1	12/13/90	12/13/90	26 U	18	4 U
36	TR4-2	11/10/90	11/10/90	30 U	30 U	18 U
216	TR4-2	12/13/90	12/13/90	26 U	9	4 U
40	TR4-3	11/10/90	11/10/90	30 U	30 U	18 U
217	TR4-3	12/13/90	12/13/90	26 U	4 J	4 U
358	TR4-4	01/04/91	01/05/91	26 U	23	4 U
359	TR4-5	01/04/91	01/05/91	26 U	18	4 U
360	TR4-6	01/04/91	01/05/91	26 U	9	4 U
411	TR4-7	01/11/91	01/12/91	26 U	8 U	4 U

TABLE 4-9 (Continued)

PRELIMINARY GROUND-WATER PLUME DELINEATION SOIL GAS RESULTS

Laboratory Sample ID	Field Sample Location	Date Sampled	Date Analyzed	TCA (ppbv)	TCE (ppbv)	PCE (ppbv)
412	TR4-8	01/11/91	01/12/91	26 U	8 U	4 U
413	TR4-9	01/11/91	01/12/91	26 U	8 U	4 U
414	TR4-10	01/11/91	01/12/91	26 U	8 U	4 U
353	TR5-1	01/04/91	01/05/91	26 U	17	4 U
354	TR5-2	01/04/91	01/05/91	26 U	98	4 U
356	TR5-3	01/04/91	01/05/91	26 U	23	4 U
357	TR5-4	01/04/91	01/05/91	26 U	153	4 U
366	TR5-5	01/07/91	01/08/91	26 U	35	22
368	TR5-6	01/07/91	01/08/91	26 U	51	4 U
369	TR5-7	01/07/91	01/08/91	26 U	42	4 U
370	TR5-8	01/07/91	01/08/91	26 U	18	4 U
371	TR5-9	01/07/91	01/08/91	26 U	4 J	4 U
415	TR6-1	01/11/91	01/12/91	26 U	8 U	4 U
416	TR6-2	01/11/91	01/12/91	26 U	8 U	4 U
417	TR6-3	01/11/91	01/12/91	26 U	8 U	4 U
418	TR6-4	01/11/91	01/12/91	26 U	8 U	4 U
427	TR7-1	01/14/91	01/15/91	26 U	30	4 U
426	TR7-2	01/14/91	01/15/91	26 U	24	4 U
425	TR7-3	01/14/91	01/15/91	26 U	41	4 U
423	TR7-4	01/14/91	01/15/91	26 U	8 U	4 U

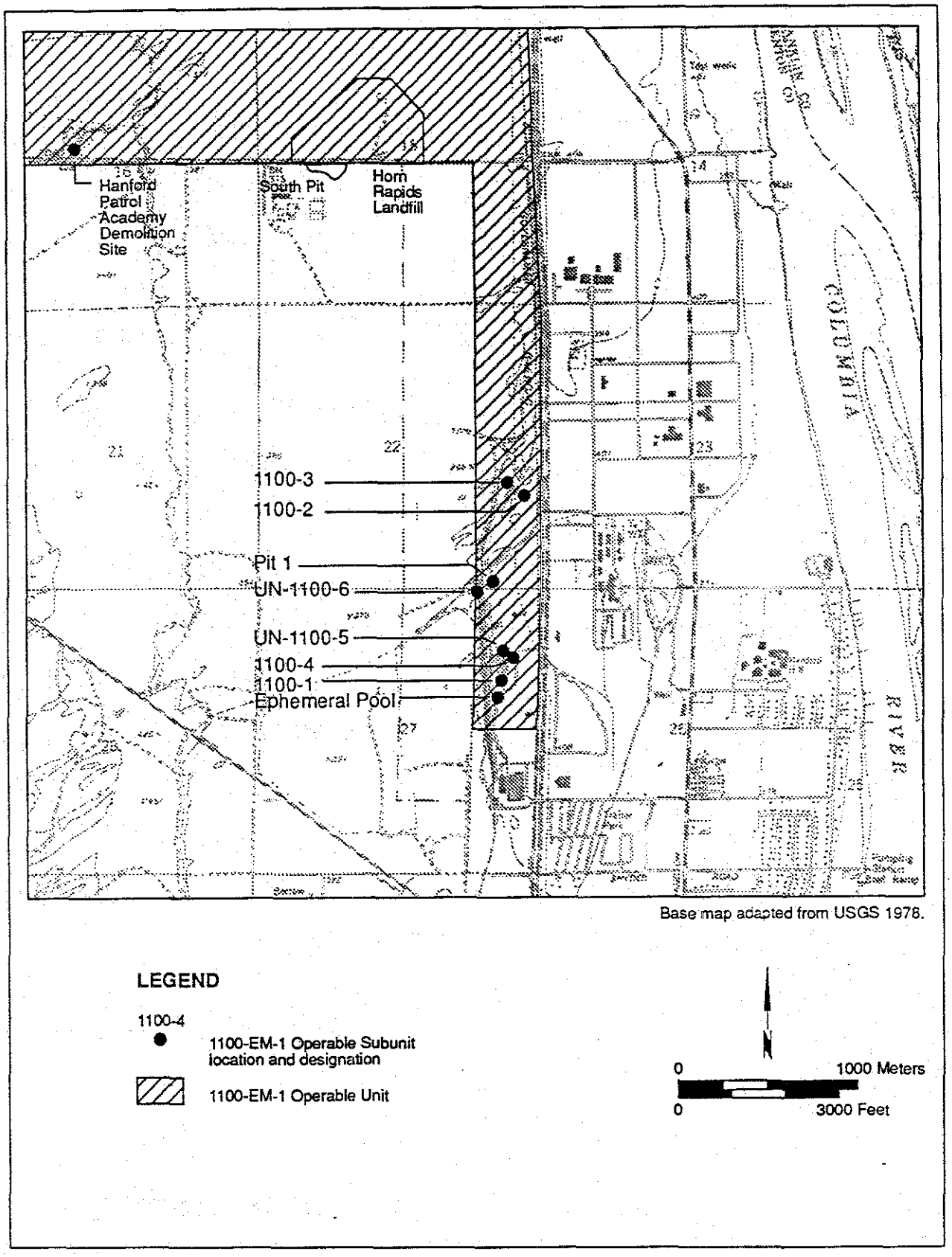


Figure 2-1. 1100-EM-1 Operable Unit.

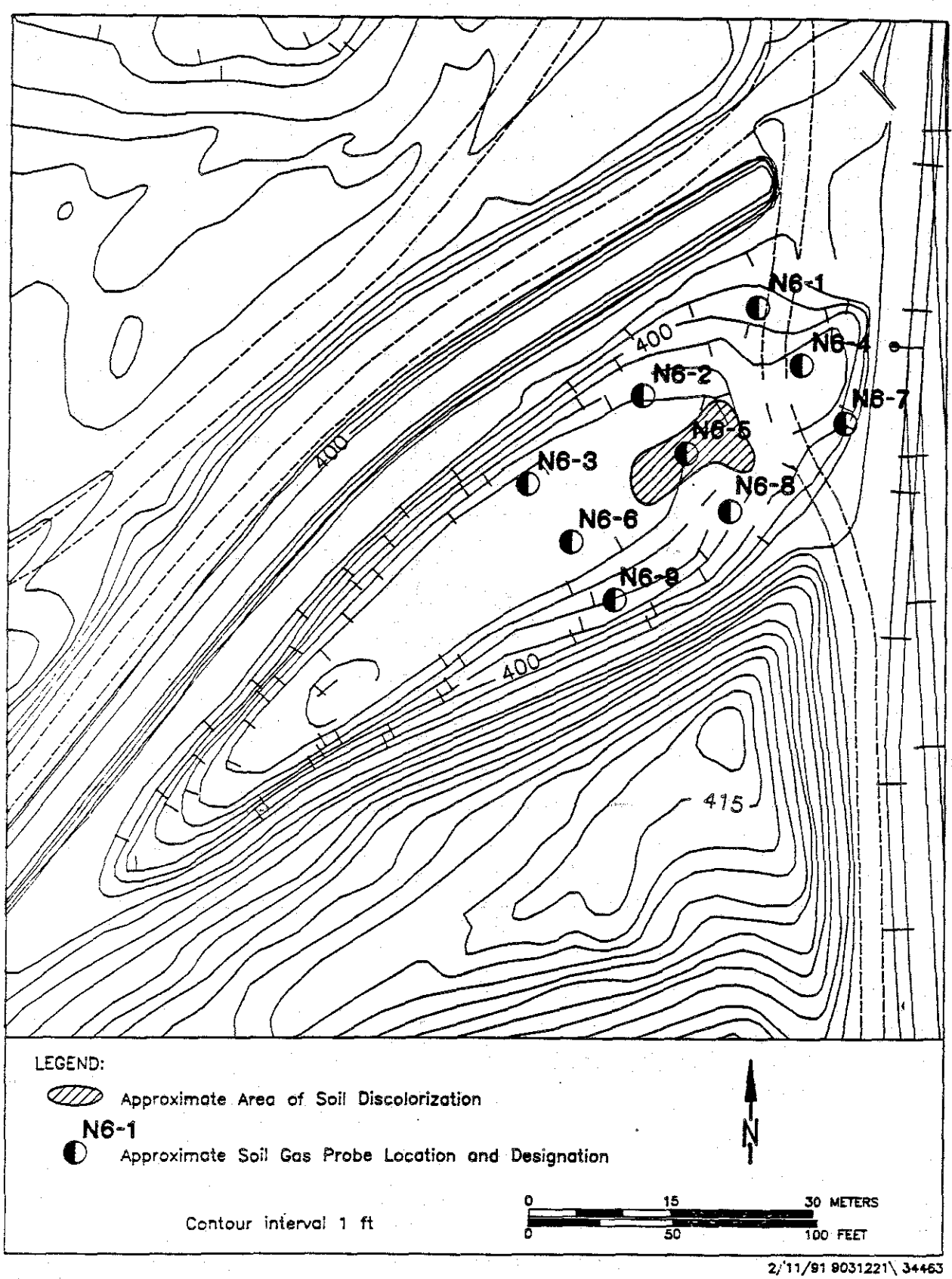


Figure 3-1. Soil Gas Probe Locations at the UN-1100-6 Operable Subunit.

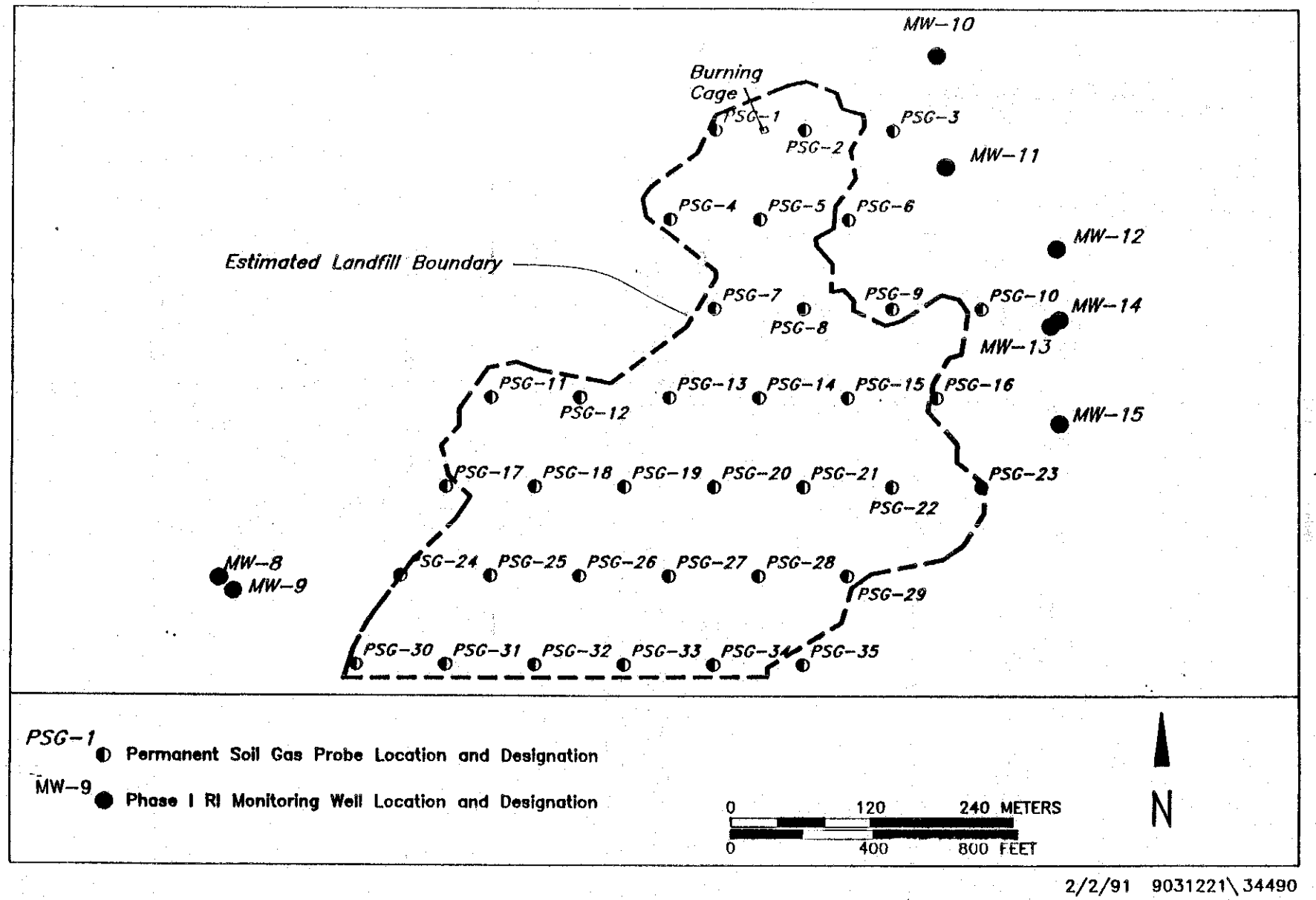


Figure 3-2. Permanent Soil Gas Probe Locations at the Horn Rapids Landfill Operable Subunit.

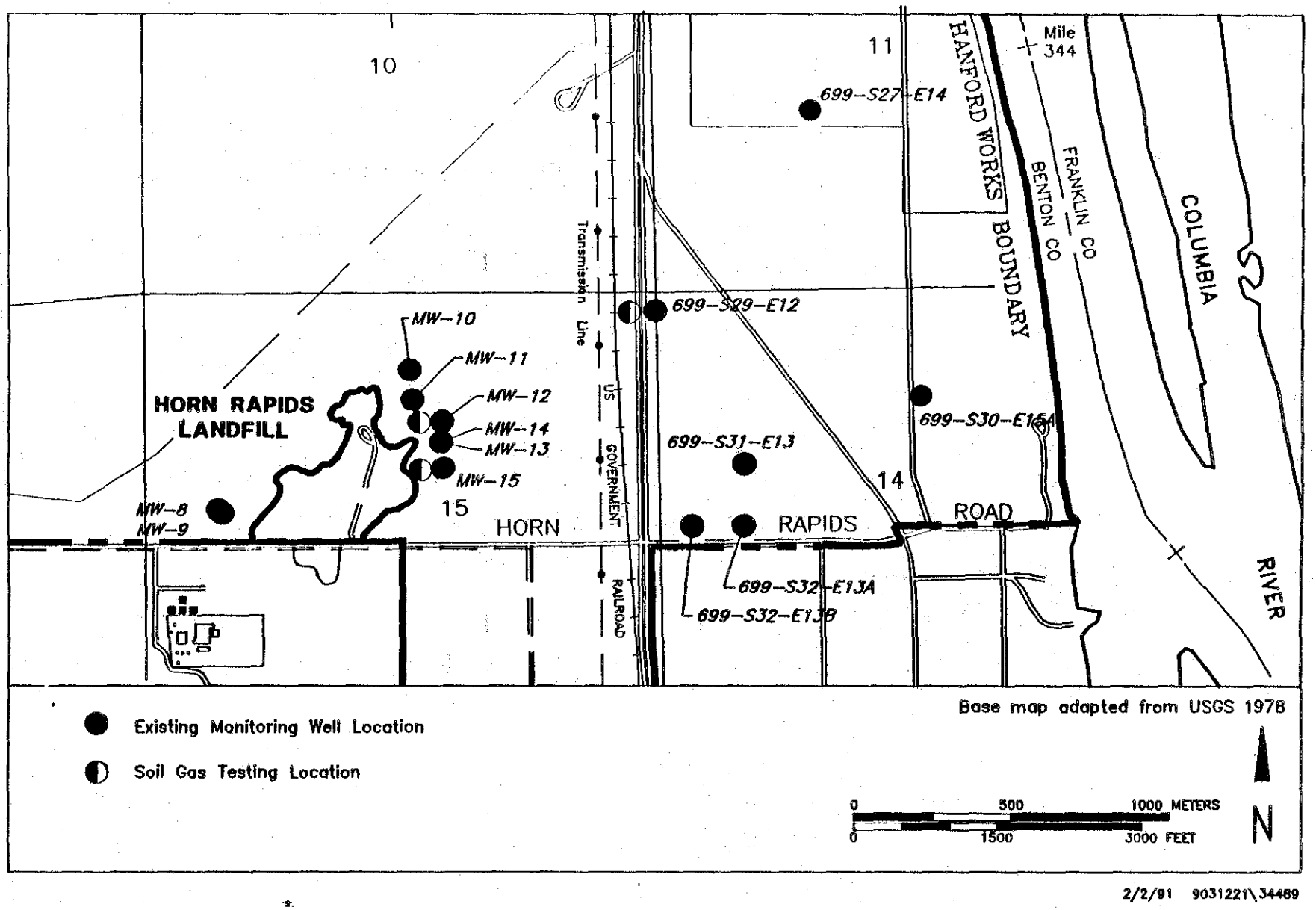


Figure 3-3. Soil Gas Testing Locations at the Horn Rapids Landfill Operable Subunit.

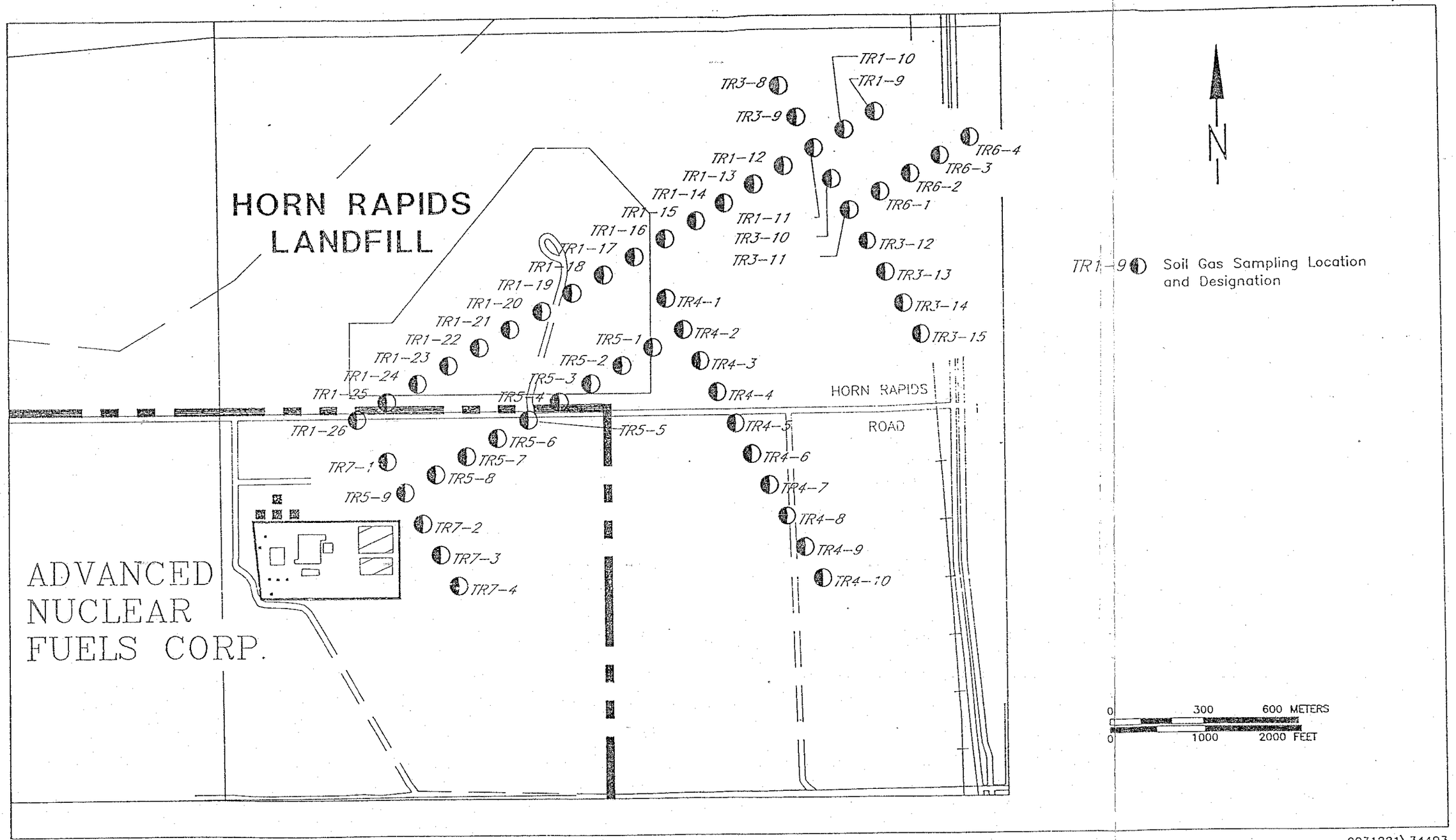


Figure 3-4. Soil Gas Probe Locations for Preliminary Ground Water Plume Delineation at the Horn Rapids Landfill Operable Subunit.

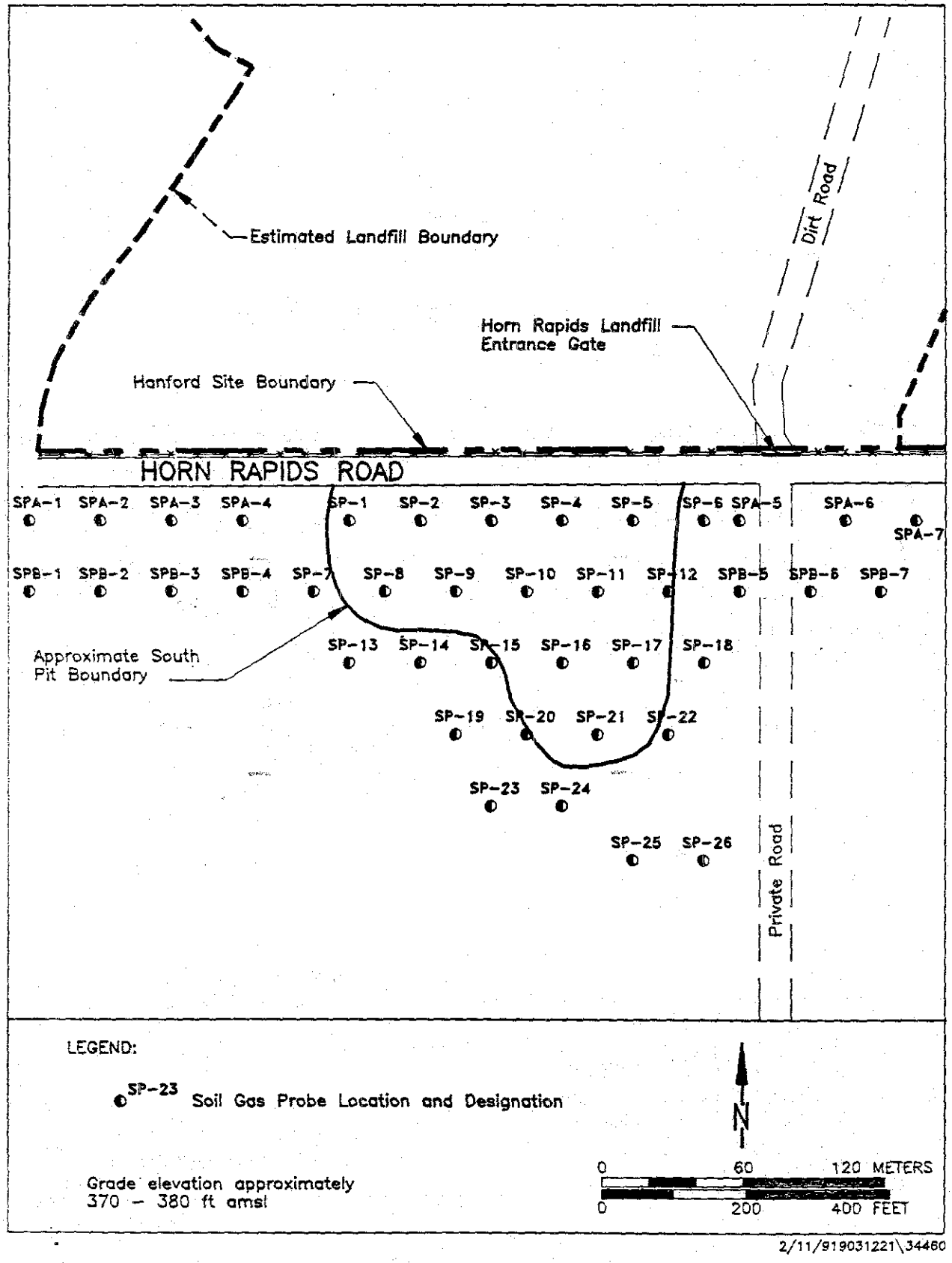


Figure 3-5. Soil Gas Probe Locations for the South Pit.

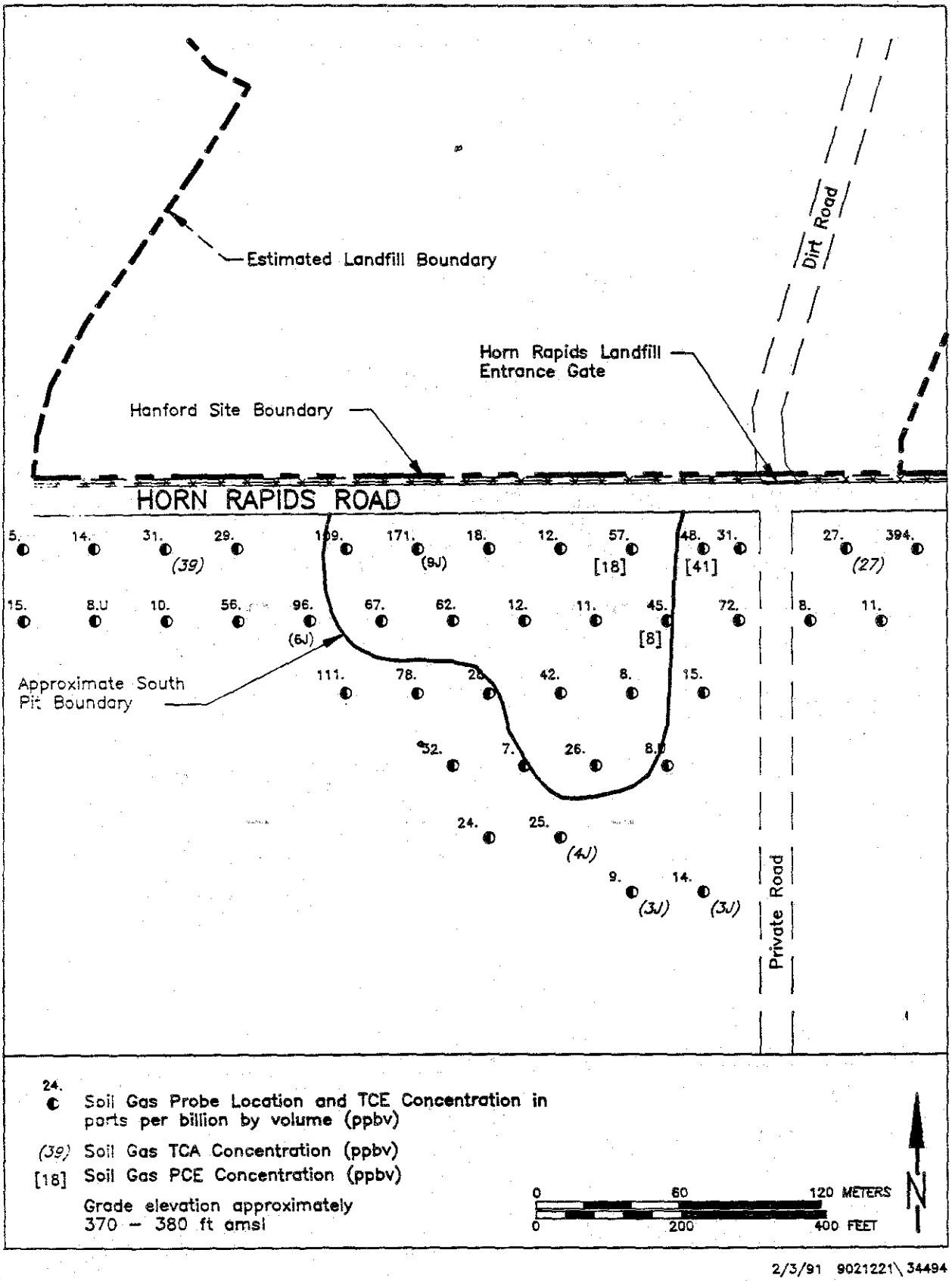


Figure 4-1. Soil Gas TCE Concentrations at the South Pit.

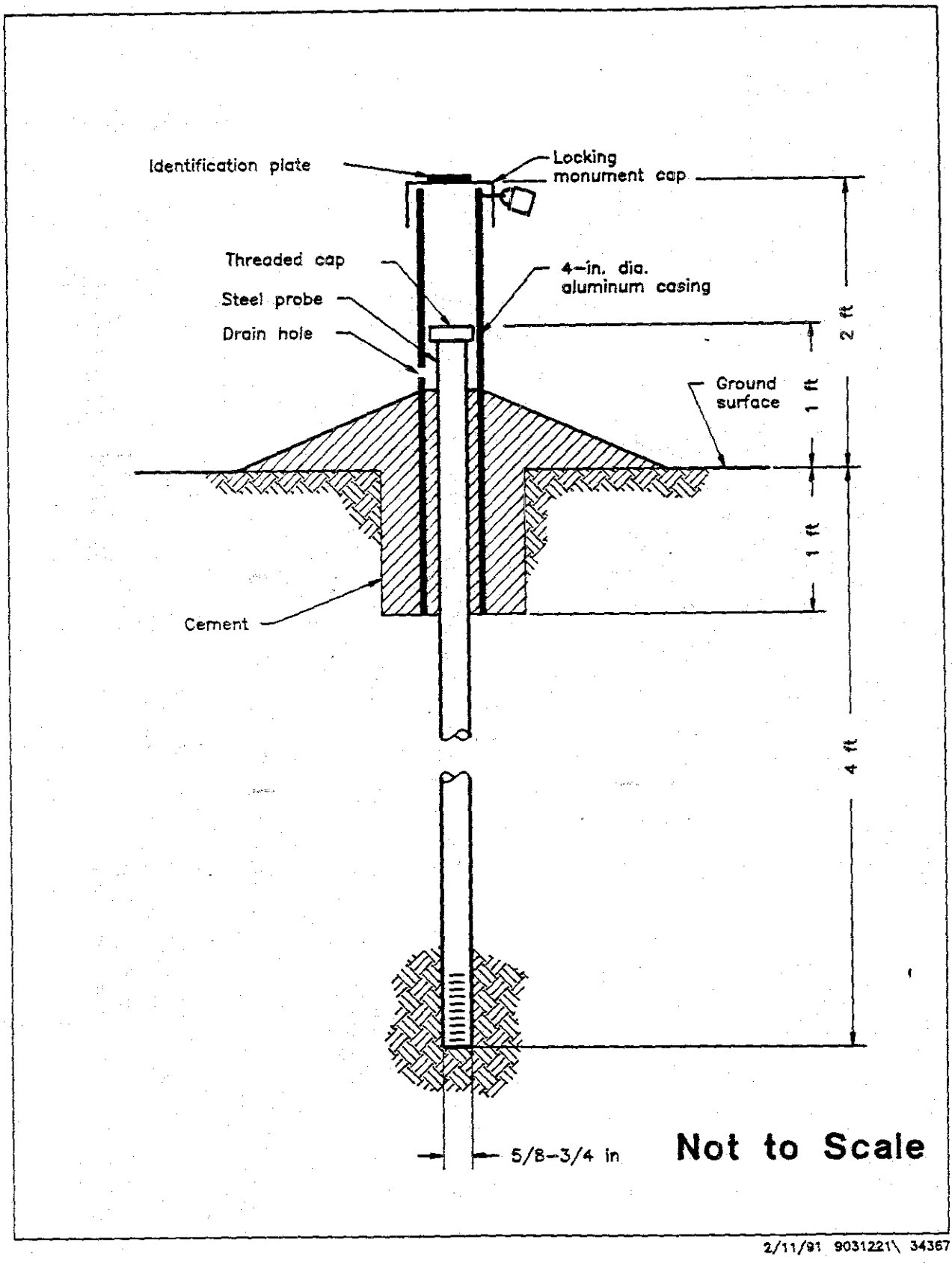


Figure 4-2. Permanent Soil Gas Probe Installation.

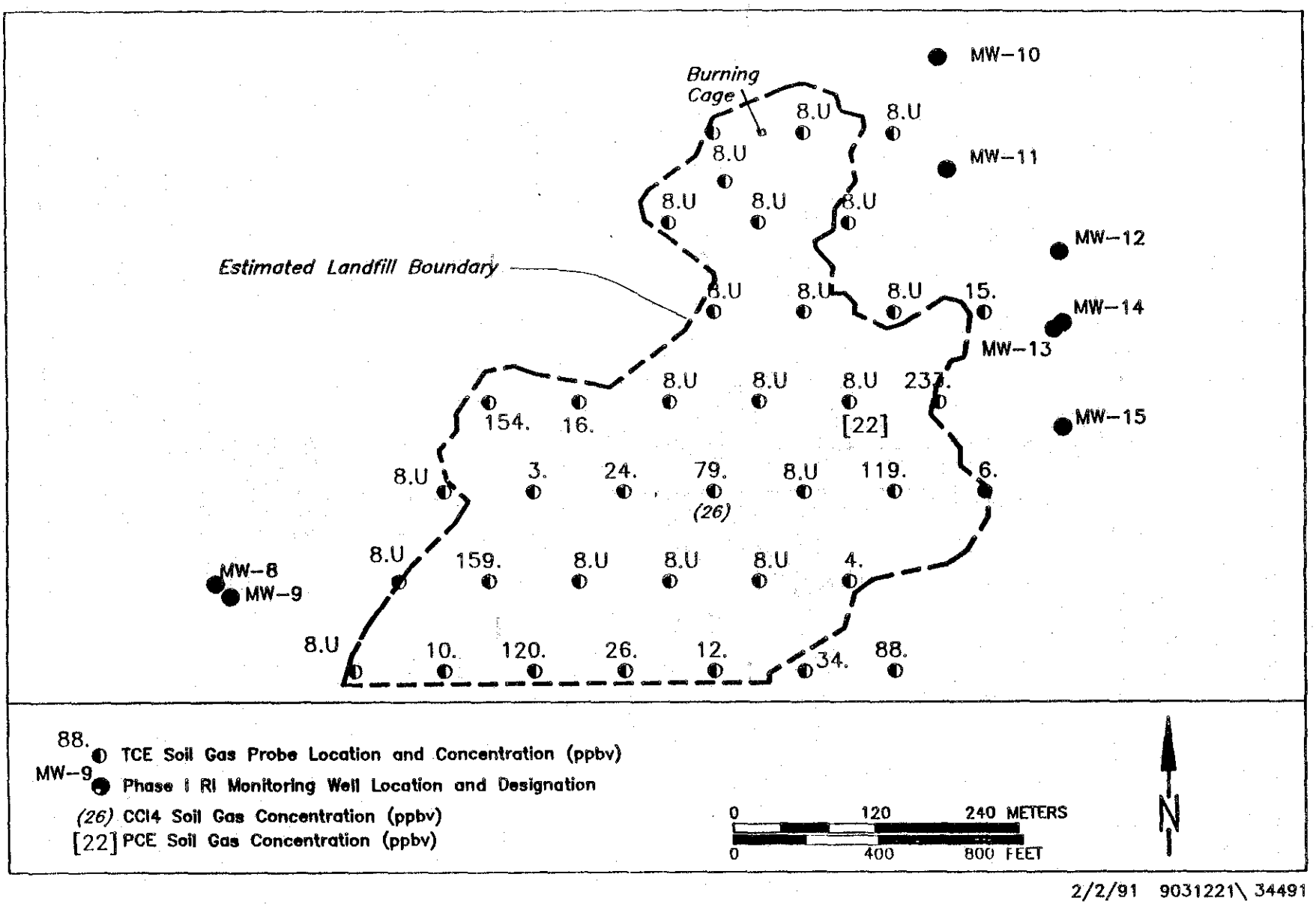
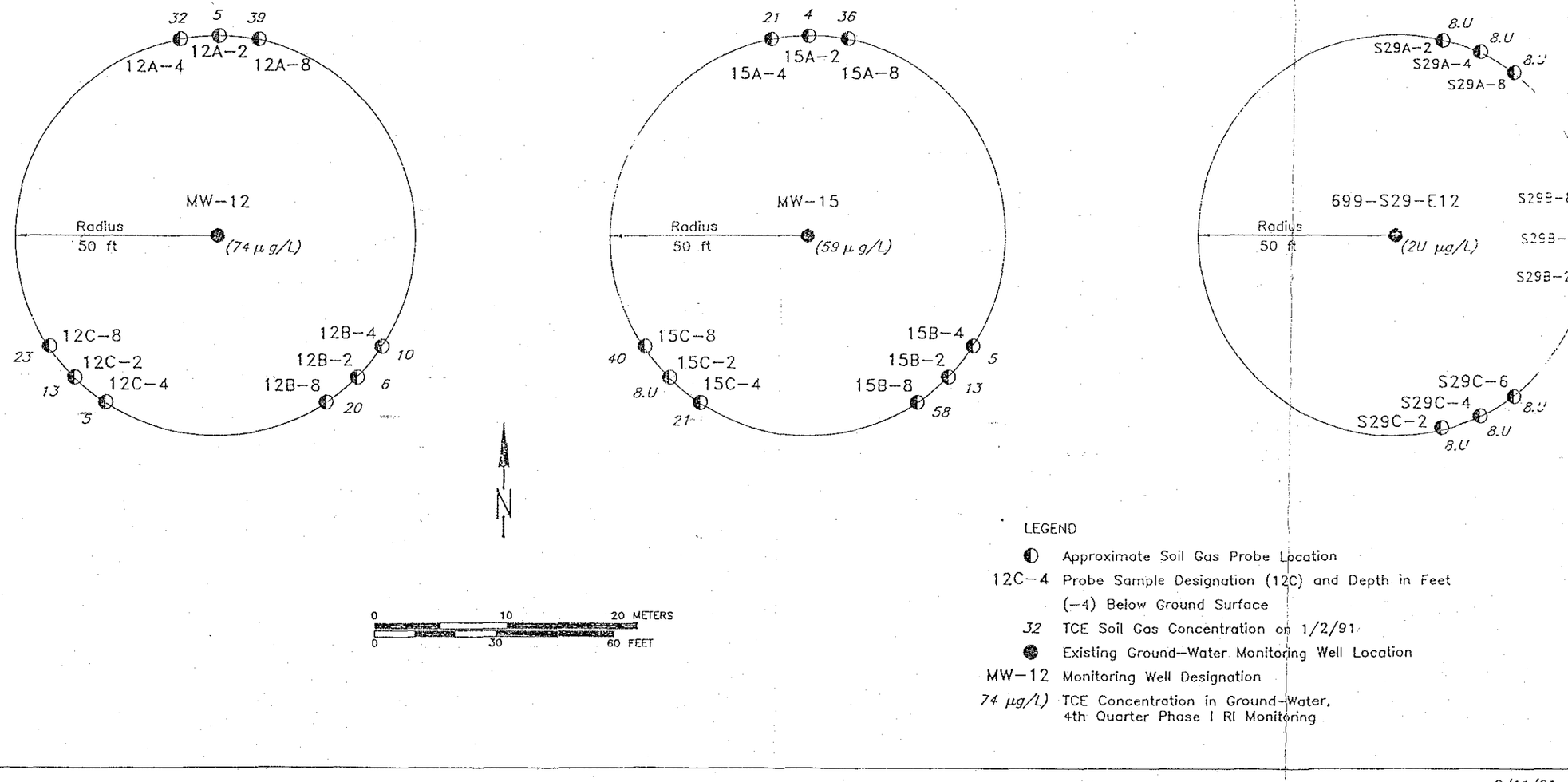


Figure 4-3. TCE, PCE, and Carbon Tetrachloride (CCl4) Soil Gas Concentrations in Permanent Probes, Horn Rapids Landfill Operable Subunit.



2/11/91 9031221\34464

Figure 4-4. Soil Gas Test Probe Locations and TCE Concentrations at the Horn Rapids Landfill Operable Subunit.

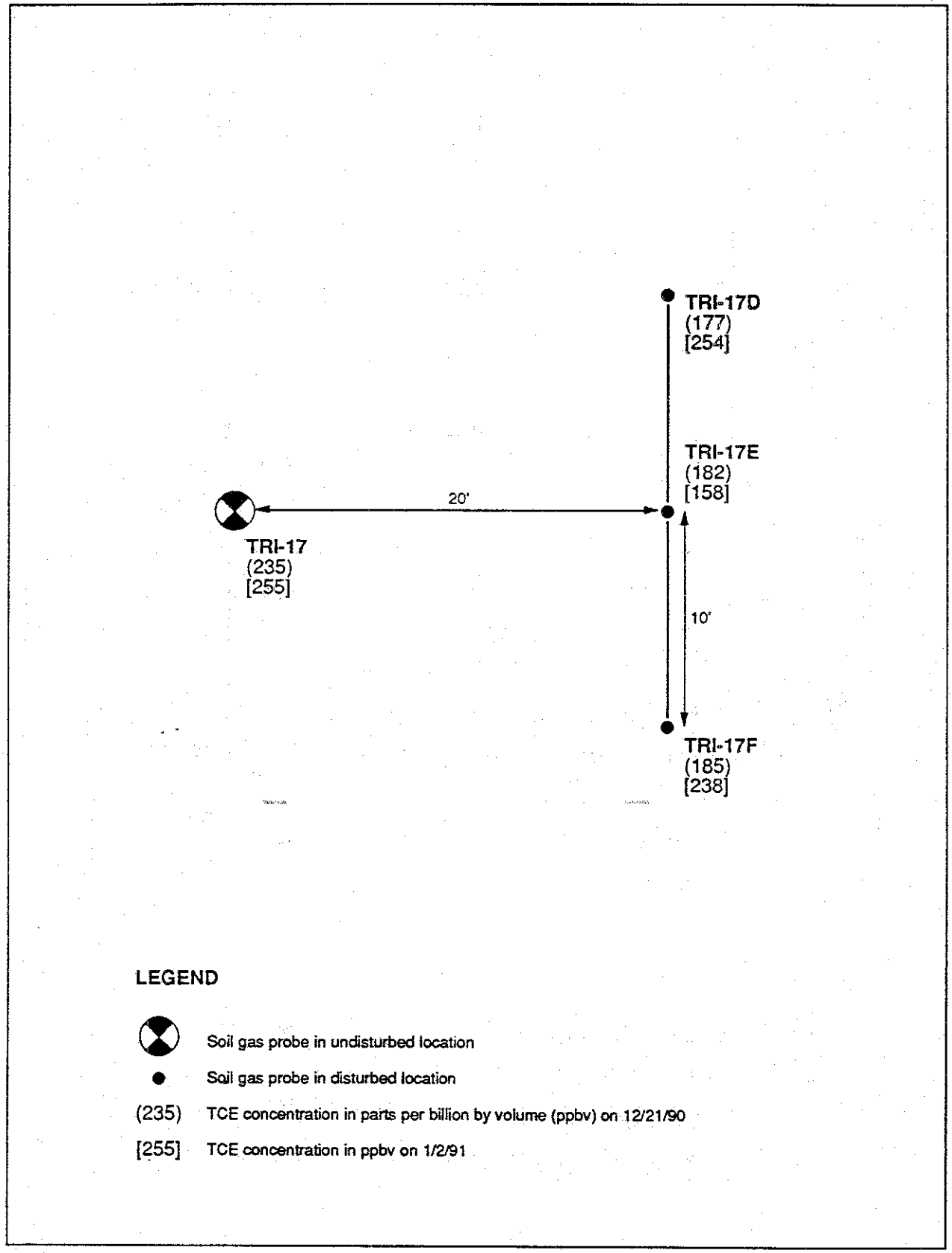
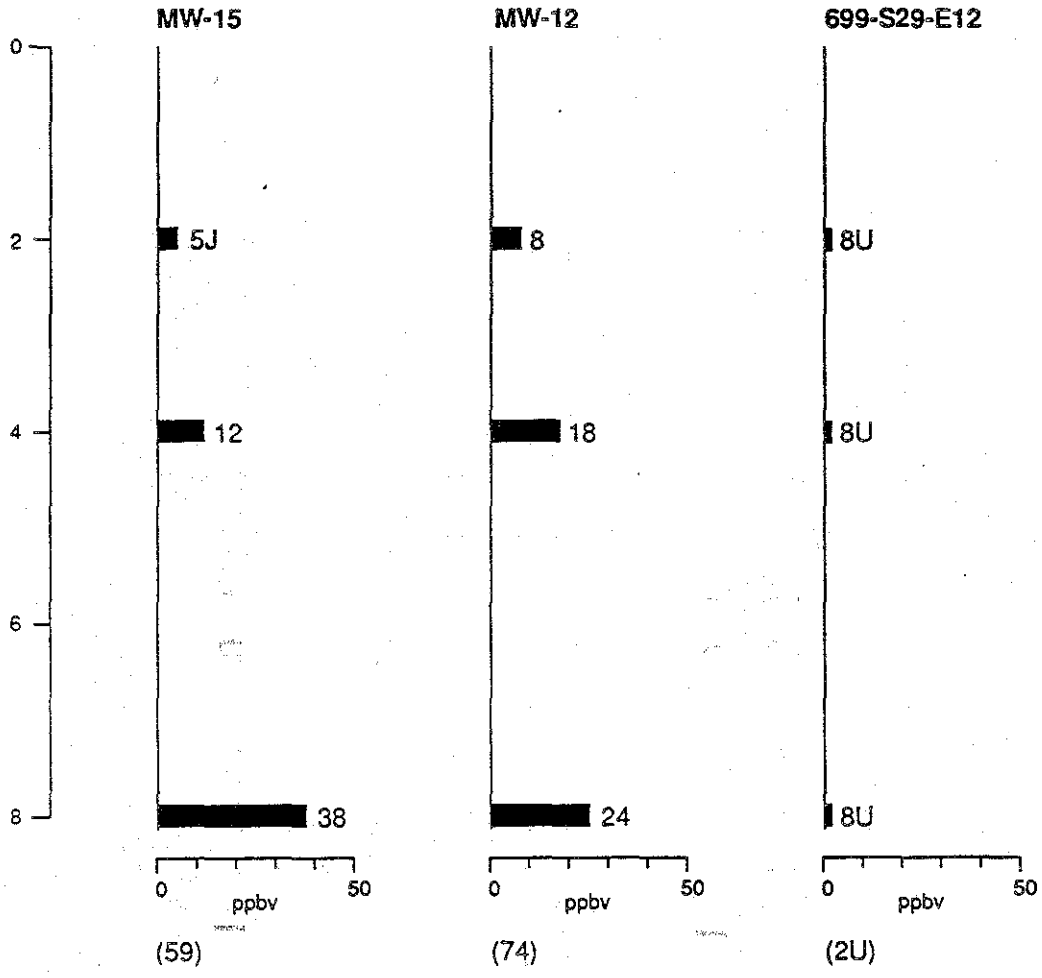


Figure 4-5. Soil Gas Sample Locations for the Comparison of Disturbed vs. Undisturbed Sampling Areas.



LEGEND

(59)	TCE concentrations (in ug/L) in groundwater during 4th quarter sampling round
ppbv	parts per billion per volume
J	indicates an estimated quantity where the value reported is below the sample quantitation limit
U	indicates the compound was analyzed for but not detected, the value reported is the sample quantitation limit

903-1221/24645

Figure 4-6. Soil Gas Test Average TCE Concentrations

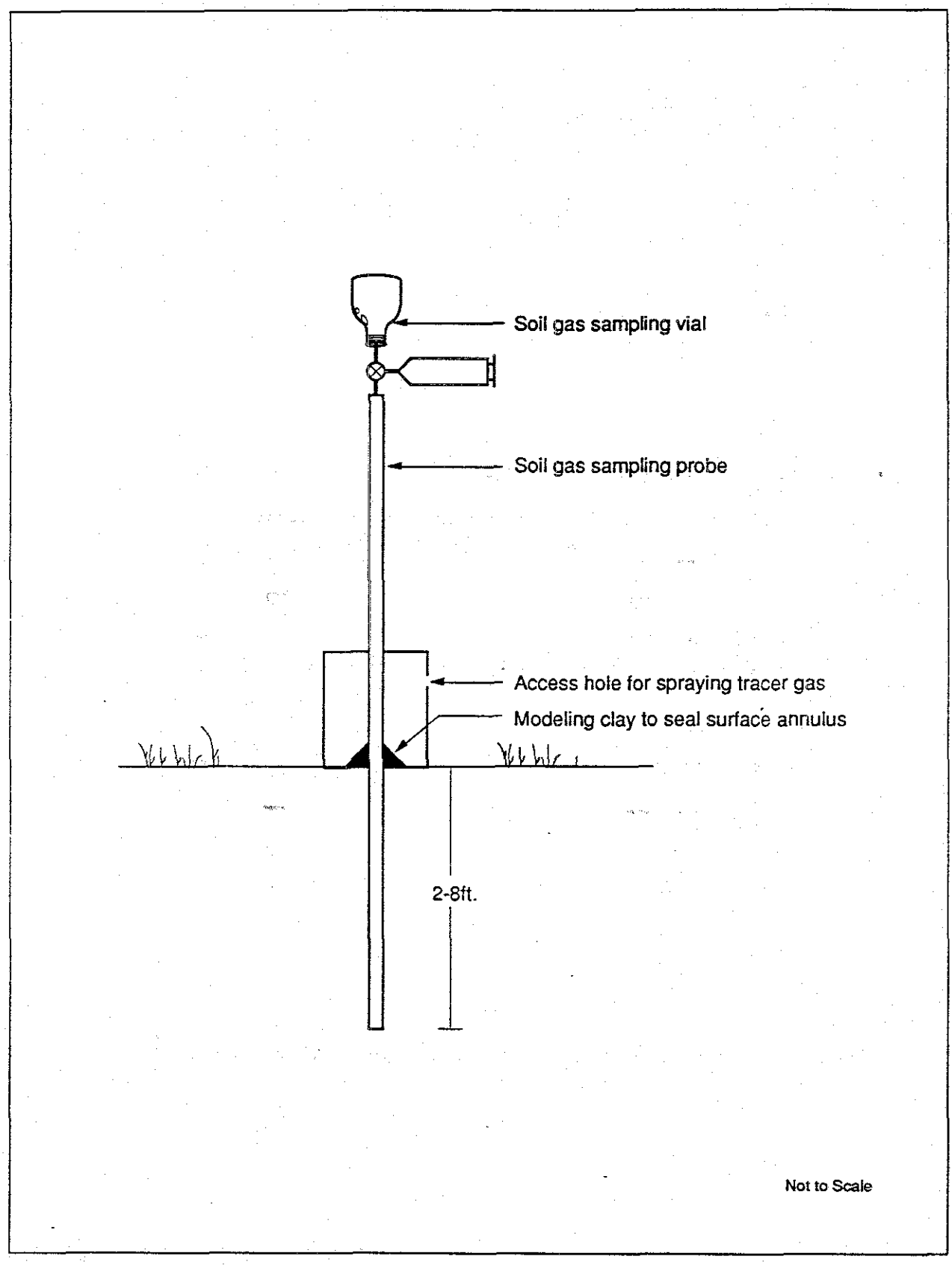
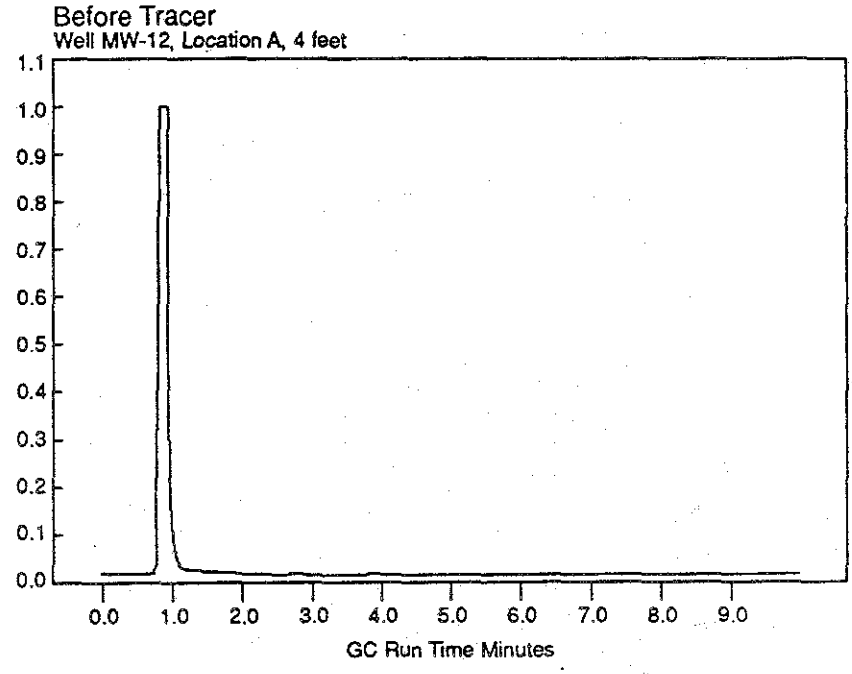
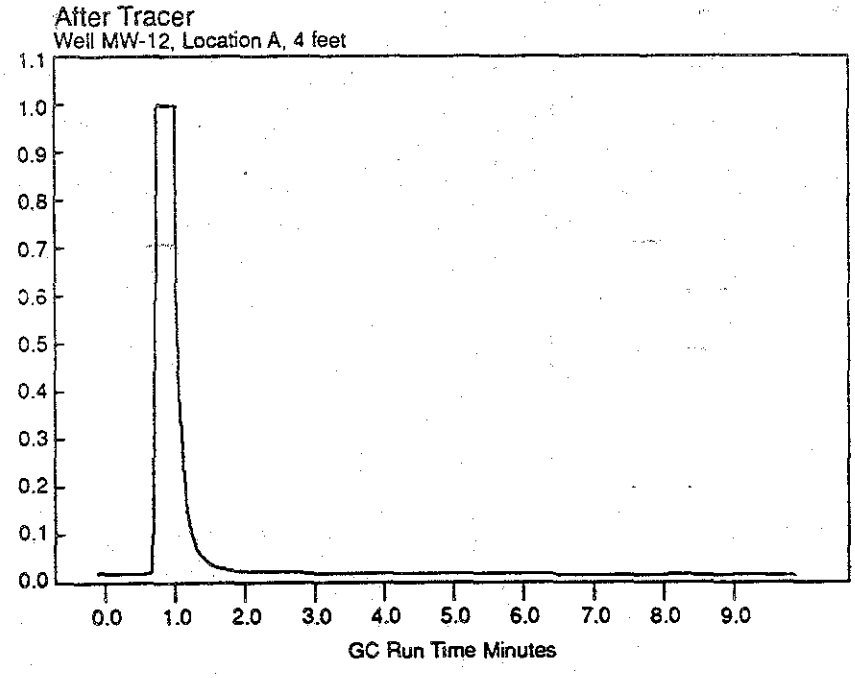


Figure 4-7. Test Configuration for the Soil Gas Survey Tracer Test





903-1221/24648

Figure 4-8. Example of Tracer Test Analysis Results.

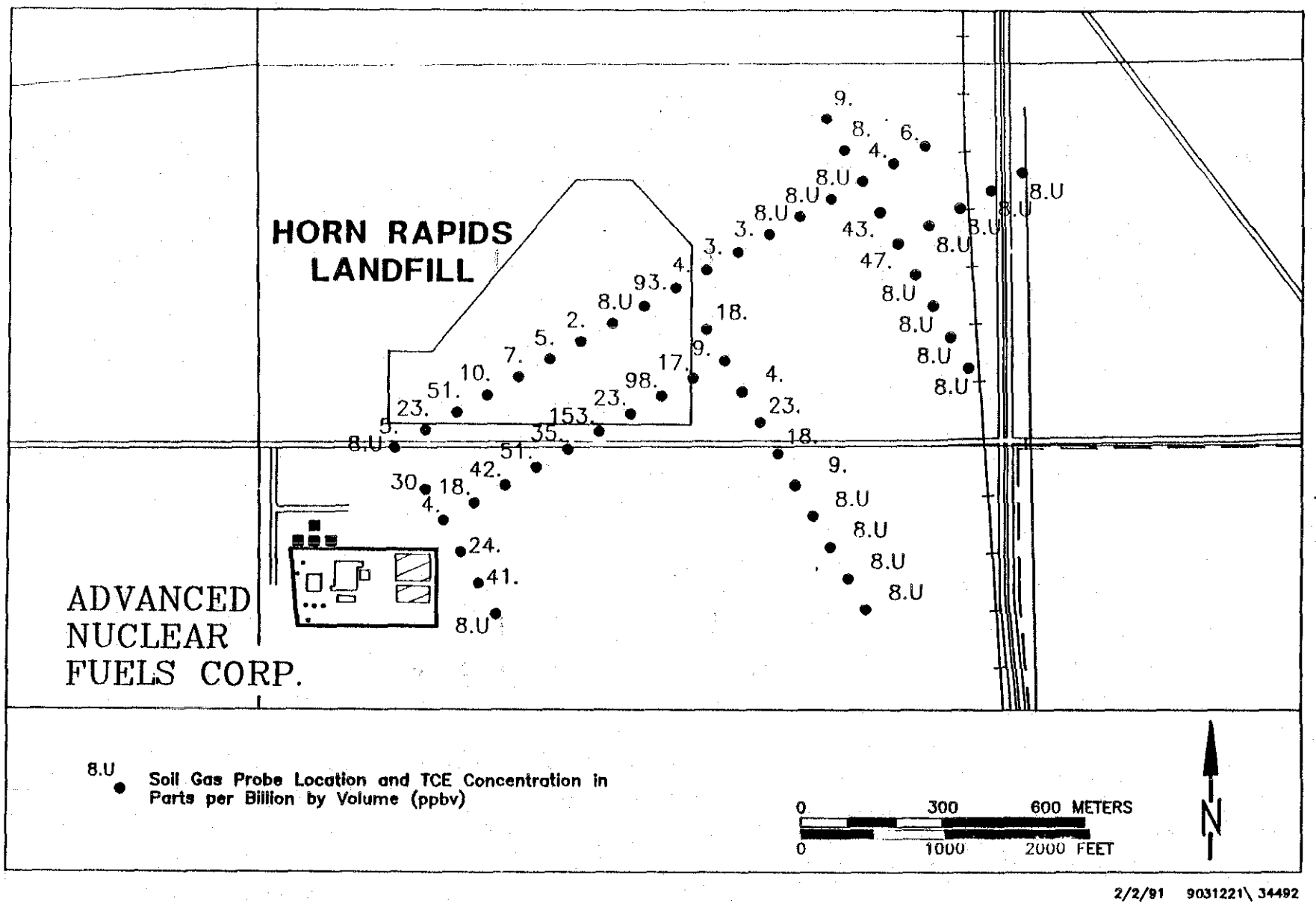


Figure 4-9. TCE Soil Gas Concentrations for Preliminary Ground-Water Contaminant Plume Delineation at the Horn Rapids Landfill Operable Subunit.

60

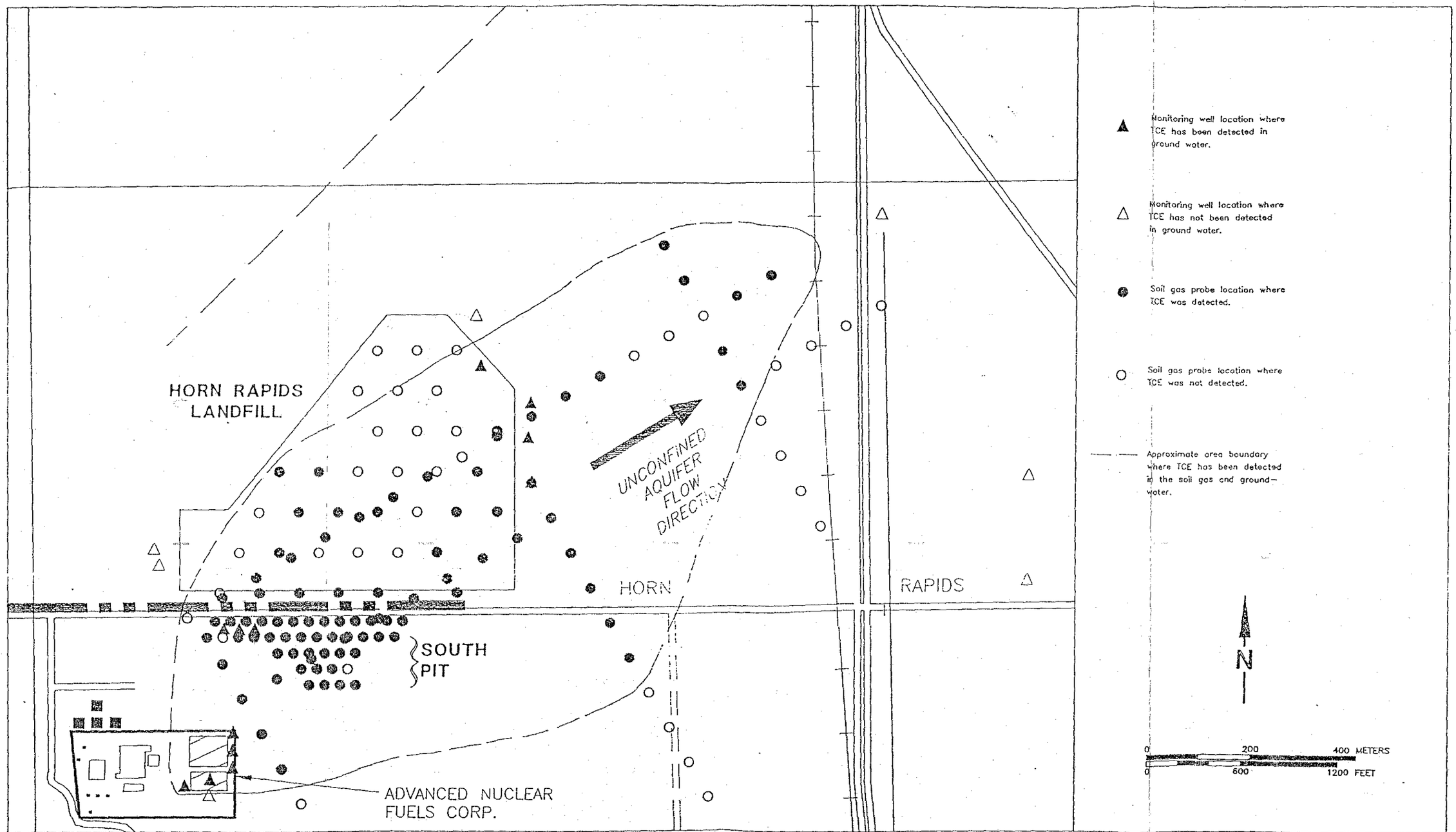


Figure 4-10. Summary of TCE Detections in Soil Gas and Ground-Water Samples at the Horn Rapids Landfill Operable Subunit.

APPENDIX A

PROBE LOCATIONS AND COORDINATES

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SOIL GAS SURVEY PROBE LOCATIONS
1100-EM-1 OPERABLE UNIT

Project No. 903-1221
02/22/91

Soil Gas Probe ID	NAD 83 Coordinates (feet) Easting	Northing
12A-2	1945397.51	374767.1
12A-4	1945387.04	374765.62
12A-8	1945407.18	374765.75
12B-2	1945433.3	374680.84
12B-4	1945438.78	374689.67
12B-8	1945423.59	374675.76
12C-2	1945372.21	374674.64
12C-4	1945381.66	374670.71
12C-8	1945365.19	374682.06
15A-2	1945391.21	374274.91
15A-4	1945381.99	374270.68
15A-8	1945401.34	374280.88
15B-2	1945455.15	374208.05
15B-4	1945455.15	374220.58
15B-4	1945459.25	374220.58
15B-8	1945451.87	374201.75
15C-2	1945385.4	374178.72
15C-4	1945396.72	374179.93
15C-8	1945380.9	374188.26
N6-1	1946482.96	365640.85
N6-2	1946443.25	365610.47
N6-3	1946403.53	365580.1
N6-4	1946498.15	365620.99
N6-5	1946458.43	365590.61
N6-6	1946418.71	365560.24
N6-7	1946513.34	365601.13
N6-8	1946473.62	365570.75
N6-9	1946433.9	365540.38
PSG-1	1944441.58	375047.93
PSG-10	1945189.6	374549.25
PSG-11	1943818.23	374299.91
PSG-12	1944067.57	374299.91
PSG-13	1944316.91	374299.91
PSG-14	1944566.25	374299.91
PSG-15	1944815.59	374299.91
PSG-16	1945064.93	374299.91

Project No. 903-1221
02/22/91

Soil Gas Probe ID	NAD 83 Coordinates (feet) Easting	Northing
PSG-17	1943693.56	374050.57
PSG-18	1943942.9	374050.57
PSG-19	1944192.24	374050.57
PSG-2	1944690.92	375047.93
PSG-20	1944441.58	374050.57
PSG-21	1944690.92	374050.57
PSG-22	1944940.26	374050.57
PSG-23	1945189.6	374050.57
PSG-24	1943568.89	373801.23
PSG-25	1943818.23	373801.23
PSG-26	1944067.57	373801.23
PSG-27	1944316.91	373801.23
PSG-28	1944566.25	373801.23
PSG-29	1944815.59	373801.23
PSG-3	1944940.26	375047.93
PSG-30	1943444.22	373551.89
PSG-31	1943693.56	373551.89
PSG-32	1943942.9	373551.89
PSG-33	1944192.24	373551.89
PSG-34	1944441.58	373551.89
PSG-35	1944940.26	373551.89
PSG-4	1944316.91	374798.59
PSG-5	1944566.25	374798.59
PSG-6	1944815.59	374798.59
PSG-7	1944441.58	374549.25
PSG-8	1944690.92	374549.25
PSG-9	1944940.26	374549.25
S29A-2	1947585.44	375927.35
S29A-4	1947595.12	375929.39
S29A-8	1947606.3	375930.24
S29B-2	1947618.38	375875.94
S29B-4	1947616.57	375886.73
S29B-8	1947614.77	375896.31
S29C-2	1947583.9	375833.06
S29C-4	1947593.74	375835.36
S29C-6	1947603.52	375837.52
SP-1	1943808.06	373375.71
SP-10	1944054.12	373277.29
SP-11	1944152.54	373277.29
SP-12	1944250.96	373277.29
SP-13	1943808.06	373178.86
SP-14	1943906.48	373178.86
SP-15	1944004.9	373178.86

Project No. 903-1221
02/22/91

Soil Gas Probe ID	NAD 83 Coordinates (feet) Easting	Northing
SP-16	1944103.33	373178.86
SP-17	1944201.75	373178.86
SP-18	1944300.18	373178.86
SP-19	1943955.69	373080.44
SP-2	1943906.48	373375.71
SP-20	1944054.12	373080.44
SP-21	1944152.54	373080.44
SP-22	1944002.87	372983.78
SP-23	1944102.87	372981.19
SP-24	1944201.33	372931.42
SP-25	1944299.49	372933.62
SP-26	1944300.18	372982.01
SP-3	1944004.9	373375.71
SP-4	1944103.33	373375.71
SP-5	1944201.75	373375.71
SP-6	1944300.18	373375.71
SP-7	1943758.84	373277.29
SP-8	1943857.27	373277.29
SP-9	1943955.69	373277.29
SPA-1	1943360.75	373374.95
SPA-2	1943460.09	373374.95
SPA-3	1943559.57	373376.76
SPA-4	1943659.44	373376.5
SPA-5	1944358.67	373376.56
SPA-7	1944598.37	373381.29
SPB-1	1943359.31	373280.7
SPB-2	1943458.36	373279.68
SPB-3	1943559.44	373278.66
SPB-4	1943659.47	373279.09
SPB-5	1944349.39	373277.29
SPB-6	1944450.11	373277.42
SPB-7	1944549.65	373276.24
TR1-10	1946703.69	375383.89
TR1-11	1946487.49	375259.87
TR1-12	1946271.28	375135.53
TR1-13	1946055.08	375011.52
TR1-14	1945838.87	374887.5
TR1-15	1945622.67	374763.49
TR1-16	1945406.46	374639.15
TR1-17	1945189.93	374515.13
TR1-18	1944973.72	374391.12
TR1-19	1944757.52	374267.1
TR1-20	1944541.31	374142.76

Project No. 903-1221
02/22/91

Soil Gas Probe ID	NAD 83 Coordinates (feet) Easting	Northing
TR1-21	1944325.11	374018.75
TR1-22	1944108.91	373894.73
TR1-23	1943892.7	373770.72
TR1-24	1943676.5	373646.38
TR1-25	1943460.29	373522.36
TR1-26	1943243.76	373398.35
TR1-9	1946919.89	375507.9
TR3-10	1946611.5	375043.34
TR3-11	1946735.84	374827.13
TR3-12	1946859.86	374610.93
TR3-13	1946983.87	374394.73
TR3-14	1947107.88	374178.52
TR3-15	1947232.23	373962.32
TR3-7	1946115.11	375908.49
TR3-8	1946239.46	375692.28
TR3-9	1946363.47	375476.08
TR4-1	1945407.77	374227.4
TR4-10	1946524.56	372281.23
TR4-2	1945531.79	374011.2
TR4-3	1945655.8	373795.
TR4-4	1945779.82	373578.79
TR4-5	1945904.16	373362.59
TR4-6	1946028.17	373146.38
TR4-7	1946152.19	372930.18
TR4-8	1946276.2	372713.64
TR4-9	1946400.54	372497.44
TR5-1	1945315.58	373887.19
TR5-2	1945099.38	373763.17
TR5-3	1944882.85	373638.83
TR5-4	1944666.64	373514.81
TR5-5	1944450.44	373390.8
TR5-6	1944234.23	373266.79
TR5-7	1944018.03	373142.44
TR5-8	1943801.82	373018.43
TR5-9	1943585.62	372894.42
TR6-1	1946967.2	374925.79
TR6-2	1947179.64	375023.52
TR6-3	1947203.32	375035.37
TR6-4	1947371.73	375135.23
TR7-1	1944549.65	373097.1
TR7-2	1943696.18	372773.68
TR7-3	1943947.13	372534.28
TR7-4	1944127.08	372345.9

APPENDIX B

CONTRACT LABORATORY RESULTS

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B-1

NATEX
Pacific Northwest Environmental Laboratory, Inc.
3820 159th Avenue, N.E.
Redmond, WA 98052
(206) 885-0083
FAX (206) 867-2214

November 29, 1990

Kent Angelos
Golder Associates Inc.
4104 148th Avenue NE
Redmond WA 98052

NARRATIVE FOR PNEL 2781

Enclosed are data summary sheets and supporting documentation for the samples received on November 19, 1990 of the Westinghouse project. The samples were received as follows:

FIELD ID	LAB ID	DATE COLLECTED
N6-4-SG-RS	2781-01	11-18-90
HR-TR1-17-RS	2781-02	11-18-90
V BLANK	2781-03	11-18-90

Listed below are anomalies and narratives associated with the receipt and/or analysis of the samples.

Sample Receiving

There were no anomalies associated with the receipt of these samples.

Volatiles Analysis

The samples were analyzed according to a modified EPA Method 8240 procedure. Standards were spiked into a 5 mℓ aliquot of deionized water and purged as usual. During the purge cycle, 10 mℓ aliquots of gaseous sample were injected slowly from a 10 mℓ gas-tight syringe into the purge helium stream through a stainless steel tee fitted with a GC septum. A 10 mℓ aliquot of laboratory air was used as the method blank.

The field blank and samples showed traces of xylenes and several tentatively identified compounds. No unusual problems were encountered with the analyses.

Results are reported in total nanograms (NG) as per instructions (Kent Angelos).

Release of the data contained in this hardcopy data package has been authorized by the Laboratory Manager or designee, as verified by the following signature.

Sincerely,

Rand G. Jenkins

\NAR-1002.781
Enclosures

1A B-2

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

HR-TRI-17-RS

Lab Name: PNELI_____ Contract: WESTINGHOUS

Lab Code: PNELI__ Case No.: 2781__ SAS No.: _____ SDG No.: 2781__

Matrix: (soil/water) AIR___ Lab Sample ID: 2781-02_____

Sample wt/vol: 10.0 (g/mL) ML__ Lab File ID: A5698_____

Level: (low/med) LOW___ Date Received: 11/19/90

% Moisture: not dec. ____ Date Analyzed: 11/20/90

Column: (pack/cap) CAP___ Dilution Factor: 1.0_____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) NG___	Q
74-87-3	Chloromethane	50	U
74-83-9	Bromomethane	50	U
75-01-4	Vinyl Chloride	50	U
75-00-3	Chloroethane	50	U
75-09-2	Methylene Chloride	320	B
67-64-1	Acetone	170	B
75-15-0	Carbon Disulfide	25	U
75-35-4	1,1-Dichloroethene	25	U
75-34-3	1,1-Dichloroethane	25	U
540-59-0	1,2-Dichloroethene (total)	25	U
67-66-3	Chloroform	25	U
107-06-2	1,2-Dichloroethane	25	U
78-93-3	2-Butanone	50	U
71-55-6	1,1,1-Trichloroethane	25	U
56-23-5	Carbon Tetrachloride	25	U
108-05-4	Vinyl Acetate	50	U
75-27-4	Bromodichloromethane	25	U
78-87-5	1,2-Dichloropropane	25	U
10061-01-5	cis-1,3-Dichloropropene	25	U
79-01-6	Trichloroethene	6	J
124-48-1	Dibromochloromethane	25	U
79-00-5	1,1,2-Trichloroethane	25	U
71-43-2	Benzene	25	U
10061-02-6	Trans-1,3-Dichloropropene	25	U
75-25-2	Bromoform	25	U
108-10-1	4-Methyl-2-Pentanone	50	U
591-78-6	2-Hexanone	50	U
127-18-4	Tetrachloroethene	25	U
79-34-5	1,1,2,2-Tetrachloroethane	25	U
108-88-3	Toluene	25	U
108-90-7	Chlorobenzene	25	U
100-41-4	Ethylbenzene	8	J
100-42-5	Styrene	25	U
1330-20-7	Xylene (total)	79	

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.
HR-TRI-17-RS

Lab Name: PNELI_____ Contract: WESTINGHOUS

Lab Code: PNELI__ Case No.: 2781__ SAS No.: _____ SDG No.: 2781__

Matrix: (soil/water) AIR___ Lab Sample ID: 2781-02_____

Sample wt/vol: _10.0 (g/mL) ML__ Lab File ID: A5698_____

Level: (low/med) LOW___ Date Received: 11/19/90

% Moisture: not dec. ____ Date Analyzed: 11/20/90

Column (pack/cap) CAP___ Dilution Factor: 1.0_____

Number TICs found: __4

CONCENTRATION UNITS:
(ug/L or ug/Kg) NG___

	CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	541059	Cyclotrisiloxane, hexamethyl	12.24	30	J
2.	556672	Cyclotetrasiloxane, octameth	16.29	20	J
3.		UNKNOWN	17.39	70	J
4.		UNKNOWN	20.47	90	J

1A B-4

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.: VBLANK

Lab Name: PNELI_____ Contract: WESTINGHOUS

Lab Code: PNELI__ Case No.: 2781__ SAS No.: _____ SDG No.: 2781__

Matrix: (soil/water) AIR___ Lab Sample ID: 2781-03_____

Sample wt/vol: _10.0 (g/mL) ML__ Lab File ID: A5696_____

Level: (low/med) LOW___ Date Received: 11/19/90

% Moisture: not dec. ____ Date Analyzed: 11/20/90

Column: (pack/cap) CAP___ Dilution Factor: 1.0_____

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) NG___	Q
74-87-3	Chloromethane	50	U
74-83-9	Bromomethane	50	U
75-01-4	Vinyl Chloride	50	U
75-00-3	Chloroethane	50	U
75-09-2	Methylene Chloride	94	B
67-64-1	Acetone	97	B
75-15-0	Carbon Disulfide	25	U
75-35-4	1,1-Dichloroethene	25	U
75-34-3	1,1-Dichloroethane	25	U
540-59-0	1,2-Dichloroethene (total)	25	U
67-66-3	Chloroform	25	U
107-06-2	1,2-Dichloroethane	25	U
78-93-3	2-Butanone	50	U
71-55-6	1,1,1-Trichloroethane	25	U
56-23-5	Carbon Tetrachloride	25	U
108-05-4	Vinyl Acetate	50	U
75-27-4	Bromodichloromethane	25	U
78-87-5	1,2-Dichloropropane	25	U
10061-01-5	cis-1,3-Dichloropropene	25	U
79-01-6	Trichloroethene	25	U
124-48-1	Dibromochloromethane	25	U
79-00-5	1,1,2-Trichloroethane	25	U
71-43-2	Benzene	25	U
10061-02-6	Trans-1,3-Dichloropropene	25	U
75-25-2	Bromoform	25	U
108-10-1	4-Methyl-2-Pentanone	50	U
591-78-6	2-Hexanone	50	U
127-18-4	Tetrachloroethene	25	U
79-34-5	1,1,2,2-Tetrachloroethane	25	U
108-88-3	Toluene	25	U
108-90-7	Chlorobenzene	25	U
100-41-4	Ethylbenzene	7	J
100-42-5	Styrene	25	U
1330-20-7	Xylene (total)	68	

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.: VBLANK

Lab Name: PNELI_____ Contract: WESTINGHOUS

Lab Code: PNELI__ Case No.: 2781__ SAS No.: _____ SDG No.: 2781__

Matrix: (soil/water) AIR___ Lab Sample ID: 2781-03_____

Sample wt/vol: _10.0 (g/mL) ML__ Lab File ID: A5696_____

Level: (low/med) LOW___ Date Received: 11/19/90

% Moisture: not dec. ____ Date Analyzed: 11/20/90

Column (pack/cap) CAP___ Dilution Factor: 1.0_____

Number TICs found: __4 CONCENTRATION UNITS: (ug/L or ug/Kg) NG___

	CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	541059	Cyclotrisiloxane, hexamethyl	12.20	25	J
2.	556672	Cyclotetrasiloxane, octameth	16.24	15	J
3.		UNKNOWN	17.34	50	J
4.		UNKNOWN	20.44	55	J

9212642017

1A B-6

VOLATILE ORGANICS ANALYSIS DATA SHEET

EPA SAMPLE NO.

N6-4-SG-RS

Lab Name: PNELI Contract: WESTINGHOUS

Lab Code: PNELI Case No.: 2781 SAS No.: SDG No.: 2781

Matrix: (soil/water) AIR Lab Sample ID: 2781-01

Sample wt/vol: 10.0 (g/mL) ML Lab File ID: A5697

Level: (low/med) LOW Date Received: 11/19/90

% Moisture: not dec. Date Analyzed: 11/20/90

Column: (pack/cap) CAP Dilution Factor: 1.0

CAS NO.	COMPOUND	CONCENTRATION UNITS: (ug/L or ug/Kg) NG	Q
74-87-3	Chloromethane	50	U
74-83-9	Bromomethane	50	U
75-01-4	Vinyl Chloride	50	U
75-00-3	Chloroethane	50	U
75-09-2	Methylene Chloride	200	B
67-64-1	Acetone	150	B
75-15-0	Carbon Disulfide	25	U
75-35-4	1,1-Dichloroethene	25	U
75-34-3	1,1-Dichloroethane	25	U
540-59-0	1,2-Dichloroethene (total)	25	U
67-66-3	Chloroform	25	U
107-06-2	1,2-Dichloroethane	25	U
78-93-3	2-Butanone	50	U
71-55-6	1,1,1-Trichloroethane	25	U
56-23-5	Carbon Tetrachloride	25	U
108-05-4	Vinyl Acetate	50	U
75-27-4	Bromodichloromethane	25	U
78-87-5	1,2-Dichloropropane	25	U
10061-01-5	cis-1,3-Dichloropropene	25	U
79-01-6	Trichloroethene	25	U
124-48-1	Dibromochloromethane	25	U
79-00-5	1,1,2-Trichloroethane	25	U
71-43-2	Benzene	25	U
10061-02-6	Trans-1,3-Dichloropropene	25	U
75-25-2	Bromoform	25	U
108-10-1	4-Methyl-2-Pentanone	50	U
591-78-6	2-Hexanone	50	U
127-18-4	Tetrachloroethene	25	U
79-34-5	1,1,2,2-Tetrachloroethane	25	U
108-88-3	Toluene	25	U
108-90-7	Chlorobenzene	25	U
100-41-4	Ethylbenzene	9	J
100-42-5	Styrene	25	U
1330-20-7	Xylene (total)	90	

1E B-7

VOLATILE ORGANICS ANALYSIS DATA SHEET
TENTATIVELY IDENTIFIED COMPOUNDS

EPA SAMPLE NO.: N6-4-SG-RS

Lab Name: PNELI_____ Contract: WESTINGHOUS

Lab Code: PNELI__ Case No.: 2781__ SAS No.: _____ SDG No.: 2781__

Matrix: (soil/water) AIR___ Lab Sample ID: 2781-01_____

Sample wt/vol: _10.0 (g/mL) ML__ Lab File ID: A5697_____

Level: (low/med) LOW___ Date Received: 11/19/90

% Moisture: not dec. ____ Date Analyzed: 11/20/90

Column (pack/cap) CAP___ Dilution Factor: 1.0_____

Number TICs found: __4 CONCENTRATION UNITS: (ug/L or ug/Kg) NG___

	CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	541059	Cyclotrisiloxane, hexamethyl	12.20	40	J
2.	556672	Cyclotetrasiloxane, octameth	16.24	25	J
3.		UNKNOWN	17.34	80	J
4.		UNKNOWN	20.45	95	J

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APPENDIX C

TECHNICAL PROCEDURES

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Golder Associates Inc.

Technical Procedure

Number: TP-2.2-4
Title: SAMPLING AND ANALYSIS OF SOIL GASES

Prepared By:	Approved	Approved	Effective Date	Rev. Level
			10/16/90	-1-
			11/2/90	-2-

WHC-MR- 0378
C-2

TP-2.2-4
RECORD OF REVISIONS

Revision Level -2-

Page	Section	Revision
All	All	Completely rewritten

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

1. PURPOSE

This technical procedure shall be used to detect the presence of volatile organics in soil gas samples retrieved from temporary and permanent soil probe installations. Analytical data so obtained may be used to guide subsequent investigations using more intrusive analytical techniques involving soil sampling, monitoring well installation, or groundwater sampling.

2. APPLICABILITY

When invoked by QA plans, work plans, or work instructions, this technical procedure shall apply to all soil gas sampling activities performed by Golder Associates Inc. (GAI) personnel.

3. DEFINITIONS

3.1 Soil Gas Probe

A soil gas probe is a device used to penetrate the soil horizon for the purposes of extracting soil gas atmospheres for subsequent chemical analysis. For purposes of this procedure, soil gas probes will be constructed of decontaminated 3/8 IPS Schedule 40 steel pipe (.675 in OD X .493 in. ID) with removable tips, 5/8 inch OD x 3/8 inch ID stainless steel, 5/8 inch slotted tip, PVC or other materials compatible with the chemicals being sampled. Permanent installations shall be protected with lockable monuments as shown in Figure 3-1. All probes shall be decontaminated prior to installation in accordance with the procedures outlined in Section 8.4.4.

3.2 Equipment Blank

An equipment blank for a temporary soil probe installation is a sample of air collected from a decontaminated, soil gas probe assembly prior to probe insertion. Equipment blanks are collected as an overcheck on the adequacy of decontamination procedures. A sample of the ambient air will be collected in tandem with the equipment blank in order to monitor and correct for the presence of compounds found in the ambient air.

3.3 Method Blank

A method blank is a sample of ambient laboratory air from a glass sampling vial that is analyzed under the same conditions as the soil gas samples. Method blanks are analyzed in order to assess potential interferences or artifacts from the sample container, the sample injection system, or chromatographic analytical system.

gas sample. Consultation with and specific training by knowledgeable GAI staff is required before proceeding to the field.

6. RESPONSIBILITIES

6.1 Sampling Technician

Sampling Technicians are responsible for soil probe decontamination, probe installation, sample acquisition, field chain of custody, maintenance of bound field logs, and other activities as directed by the Senior Chemist.

6.2 Chemist

Chemists are responsible for performing gas chromatographic (GC) analysis of soil gas samples under the direction of the Senior Chemist in compliance with the requirements of this procedure.

6.3 Senior Chemist

The Senior Chemist is responsible for the technical performance of all soil gas sampling and analysis activities conducted under the requirements of this procedure. The Senior Chemist shall serve as the primary technical liaison with the client.

6.4 Field Manager

The Field Manager is responsible for coordination and direction of daily activities. In the absence of the Senior Chemist, the Field Manager shall serve as primary technical liaison as described in 6.3 above.

6.5 Technical Reviewer

The Technical Reviewer is responsible for reviewing and approving all deliverable reports and accompanying data packages produced as a result of the implementation of this procedure, in compliance with applicable project and/or client requirements.

6.6 Health and Safety Officer

The Health and Safety Officer is responsible for preparing a project health and safety plan for all soil-gas sampling and analysis activities conducted by project personnel. The Health and Safety Officer is responsible for obtaining all required project and client approvals prior to plan implementation, and for conducting and documenting all the necessary training for the designated Site Safety Officer and other project personnel as needed.

6.7 Site Safety Officer

The Field Manager shall normally serve as the Site Safety Officer. The Site Safety Officer is responsible for conducting and documenting daily safety briefings for all on-site project staff and for the on-site monitoring of compliance with the project health and safety plan.

6.8 Quality Assurance Manager

The Quality Assurance Manager (QA) Manager is responsible for the distribution and control of this procedure in compliance with the applicable project or site specific QA Program Plan (QAPP). The QA Manager may also conduct surveillance inspections of onsite activity at his discretion or upon request by the Project Manager or Senior Chemist.

7. REQUIREMENTS

7.1 Project Work Plan Requirements

At the Project Manager's or client's direction, this procedure shall be implemented as a project technical requirement and may be incorporated into any applicable project work plan, QA plan, or work instruction.

7.2 Distribution, Change Control, and Field Change Control Requirements

This procedure shall be reviewed, approved, and distributed in compliance with the requirements of applicable QA plan requirements.

Variation from procedure requirements may be necessary due to unique circumstances encountered on individual projects. All variations from established procedures shall be documented on Procedure Alteration Checklists (Figure 7-1) and reviewed by the Project Manager and the QA Manager.

The Senior Chemist may authorize individual Field Managers to initiate necessary variations. If possible, the request for variation shall be reviewed by the Project Manager and the QA Manager prior to implementation. If prior review is not possible, the variation may be implemented immediately at the direction of the authorized Field Manager, provided that the Senior Chemist is notified of the variation within 24 hours of the implementation, and the Procedure Alteration Checklist is forwarded to the Project Manager and QA Manager within 2 working days of implementation. PAC activity shall be noted in the appropriate field logbook. If the variation is unacceptable to either reviewer, the activity shall be reperformed or action shall be taken as indicated in the Comments section of the reviewed Checklist. All completed Procedure Alteration Checklist shall be maintained in project records and provided to the client as part of final activity reports.

Figure 7-1

PROCEDURE ALTERATION CHECKLIST

Job/Task Number: _____

Procedure Reference: _____

Requested Variation: _____

_____

_____

_____

_____

_____

_____

Reason for Variation: _____

_____

_____

_____

_____

Special Equipment, Material or Personnel Required: _____

_____

_____

_____

Alteration Requested By: _____ **Date:** _____

Title: _____

_____

Reviewed By: _____ **Date:** _____

Title: GAI Project Manager

Comments: _____

_____

_____

_____

Reviewed By: _____ **Date:** _____

Title: GAI QA Manager

Comments: _____

_____

_____

_____

7.3 Safety Requirements

All project staff shall be trained in any client site safety requirements. In addition, all project staff shall be trained in the requirements of the site safety plan prepared by the Health and Safety Officer, and, when assigned on-site responsibilities, shall attend safety briefings as part of the daily meetings held by the Senior Chemist or Field Manager.

7.4 Equipment and Materials Requirements

Equipment and materials required to conduct soil gas sampling shall include the following items:

- Temporary office space, electrical power, water, sanitary facilities, portable gas chromatograph (GC), refrigerator, and all required accessories for operation in the field;
- Stakes and colored flagging;
- Syringes, 10 - 1000 µl;
- 3/8 IPS schedule 40 steel, or .675 nominal OD stainless steel or PVC probe tubing, with NPT threading equipment and removable tips, end caps, and fittings;
- 5/8 inch diameter solid hardened steel pilot probes with appropriate fittings.
- Soil gas sampling and calibration vials, 125 ml pyrex glass serum vials with butyl rubber septa, for sample collection and extraction for analysis;
- Stock reference standards; use certified (96% purity or better) reference standard mixtures at the appropriate concentration for preparation of calibration standards. Alternatively, prepare stock standards from "neat" (96% purity or better) reference materials as follows:

  1. Fill a 50 ml volumetric flask to the mark with purge and trap grade methanol.
  2. Fill a certified capillary tube (1 to 10 µl size with 1% accuracy) end to end with the authentic material of interest and drop the filled tube into the filled volumetric flask.
  3. Calculate the concentration of each component in the mixture as follows:

$$\text{Concentration, } \mu g/mL = \frac{D \times V}{Vf/1000}$$

Where: D = density of "neat" material
V = volume of capillary tube in µl
Vf = volumetric flask size in ml

Document the preparation of the standard in the field logbook, and label the standard with the date and initials of the preparer and with the following notation, NNN-PPP-SSS where:

NNN is the field logbook number where the standard preparation is documented;

PPP is the page number of the logbook where the standard preparation information is documented and SSS is a sequential number indicating the number of the standard if more than one standard has been documented on the same page of the field logbook.

After completing and affixing the label to the standard, store in the storage refrigerator at 4°C.

This standard preparation procedure enables stock reference standards for volatile organic liquids to be prepared quickly and accurately in the field.

- Rotary impact drill and 5/8 inch x 24 inch drill for drilling a pilot hole for installation of the temporary soil gas probe.

- Soil gas probe driver, impact hammer and extension cord; an impact hammer is normally used to drive temporary soil gas probes. The hammer is equipped with an adapter to fit an anvil which threads to the top of the probe assembly. The hammer adapter is set over the anvil and the hammer switched on to drive the probe. If fixed power sources are available, use them in lieu of the portable generation. Permanent installations may require the additional use of a subcontractor-operated auger drilling rig or backhoe.

- Gasoline powered generator, for supplying power to the soil gas probe driver. Important: Position the generator downwind of the sampling site so as not to introduce the exhaust into the sampling area.

- Decontamination water (i.e., commercially available distilled deionized water for decontamination of the soil gas probes).

- Reagent methanol, for decontamination of the soil gas probes.

- Purge and trap grade methanol, for preparation of stock standards.

- Dry nitrogen supply (ultrahigh purity (UHP) grade).

- Alconox (or other equivalent, anionic, biodegradable detergent), for decontamination of the soil gas probes.
- Field documentation and support equipment, including sprayers, towels, plastic bags, buckets, waste containers, and tools for decontamination and probe assembly/disassembly.
- Vacuum pump, for purging the soil gas probe prior to sample collection. The pump can be a high-capacity electrically powered pump (10-200 L/min to 25" Hg), or a low-volume battery operated pump (1-2 L/min to 25" Hg).
- Hand-operated vacuum pump (36 cc/stroke to 25" Hg), for evacuating glass sampling vials.
- Disposable luer-tip 60 ml syringes, three-way valves, connectors and 20-22 gauge needles for sample collection.
- Mechanical jack, for removing the sampling probes from the access holes.

7.5 Records

Soil gas sampling activities shall be documented chronologically in bound logbooks. One set of logbooks shall be dedicated to sample acquisition and onsite activity monitoring, and shall provide a chronological record of all onsite activity external to the mobile laboratory operations. Another set of logbooks shall be dedicated to the mobile laboratory and shall serve as a chronological run log for GC operations. All logbook entries shall be copied at least weekly, and copies forwarded to the project quality records for retention in compliance with the applicable work plan or QA plan requirements; all other supporting records (e.g., training records, chromatograms, GC data output sheets, and chain of custody records) shall be retained in a temporary working file in the mobile laboratory. Upon completion of all actions related to individual records, they may be accumulated for no longer than a week prior to transmittal to the project quality records. All logbook and field-generated handwritten records shall be made in indelible black or blue ink; corrections shall be made by single lines and initialed and dated. All logbook entries shall be signed and dated at the end of each day's activity, or upon transfer of logging responsibilities to other personnel.

8. PROCEDURE

8.1 Daily Briefing

The Senior Chemist or Field Manager shall conduct a daily briefing for all project personnel on site. The meeting shall address the proposed scope of the day's activities; location, number, and type of samples to be taken; specific personnel assignments; and shall include a review of pertinent health and safety considerations. Minutes and attendance shall be documented on standard training memoranda and routed to the project records.

8.2 Definition of Sampling Areas

Sampling areas and permanent soil probe locations shall be as defined in the project planning documents or as directed by the Project Manager, Senior Chemist or Field Manager.

8.3 Temporary Probe Installation

If the portable generator is required, position it away from the immediate working area in a downwind direction from any sampling or analytical support activities. Ensure that all activities involving flammable or ignitable materials/vapors are at least 50 feet away from the generator. Use a long power cord rated with proper amperage to distance the generator from the work area. Keep the generator well ventilated, and take all necessary precautions to avoid electrical shock.

Install each probe in the following sequence:

Step 1: Provide an access hole for inserting the sampling probe by drilling a 5/8 inch diameter x 2 foot deep hole at the sampling point with a rotary impact hammer and drill. Alternately, provide an access hole by driving a 5/8 inch solid steel pilot probe to within 1 foot of the target sampling depth (typically 4 feet).

Step 2: Assemble the sampling probe by first taping all fittings with non-adhesive teflon tape (Note: the sampling probe must be completely decontaminated prior to assembly according to the procedures outlined in Step 10 below). Assemble one 5-foot section with the 6-inch blunt hammer tip and tighten the fittings with a wrench. Collect an equipment blank as noted in Step 7 below.

Step 3: Place a removable steel drive point in the end of the probe assembly and insert the probe into the access hole.

Step 4: Drive the probe into the access hole to a depth of 4 feet, attach the removal jack to the probe and lift the probe out of the access hole about 1/2 inch to separate the probe tip from the end of the probe and allow the soil gas to enter.

Step 5: Remove the blunt driver tip from the tip of the probe and attach the luer-tip valve and connectors. Seal the top of the annulus between the probe and the formation with modeling clay.

Step 6: Connect the vacuum pump to the top of the probe and pump for a minimum of 3 purge volumes from the installation; additional purging may be authorized at the direction of the Senior Chemist if the installation response indicates that such action is appropriate. Purging details, including date, time and volume purged, shall be recorded in the field logbook.

Step 7: Close the soil gas probe off from the ambient air with the three-way valve and remove the vacuum hose to the pump. Attach a clean 60 mL syringe to the side port of the three-way valve and turn the valve so as to close off exposure of the soil gas probe to the ambient air (Figure 8-1, Position 1). Attach an evacuated sampling vial to the top of the three-way valve using a clean 20-22 gauge needle. Open the sampling valve to allow soil gas to enter the vial (Figure 8-1, Position 2). Draw up 60 mls of soil gas into the syringe (Figure 8-1, Position 3) and slightly pressurize the vial with ≈20 ml of soil gas (Figure 8-1, Position 4), close off the valve to the vial and remove the vial. Collect a duplicate sample for every 10 samples obtained or at least once per day. Discard all the luer-tip fittings, valves, needles and syringe.

Step 8: Affix a plain paper label to the vial or cartridge and identify the sample with the sample location, date and time of sampling, and the initials of the person collecting the sample. Record the sample identifier, sample location, date and time of sampling and the name of the person collecting the sample in the field logbook.

Immediately place the sample in a cooler in the dark at 4° C, complete a field chain of custody form (see Figure 8-2) and transport the sample directly to the on-site or close support laboratory and the chemist's custody.

Step 9: If sampling is only being done at 4 feet, immediately remove the soil probe from the access hole with the mechanical jack and plug the access hole with a bentonite plug. If required, stake the access hole for subsequent survey. If sampling at additional depths is required, remove the sampling nipple, attach another 4-foot probe section along with the blunt driver tip, and drive the probe into the desired depth, repeating the previous steps until complete. Note that if the sampling depth exceeds 4 feet, the probes must be removed one section at a time in order to prevent damage to the probes.

Step 10: Once the probe is removed from the access hole it must be decontaminated prior to use at another location. The procedure for decontamination is as follows:

- Remove all teflon tape from the probe threads.
- Brush out any soil particles from the interior of the probe with a narrow wire brush (a gun barrel cleaning brush is suitable for this purpose).
- Rinse the probe exterior and interior with a solution of alconox and decontamination water, scrubbing the interior and exterior with brushes.
- Rinse with decontamination water.
- Rinse with reagent-grade methanol and finally with decontamination water.

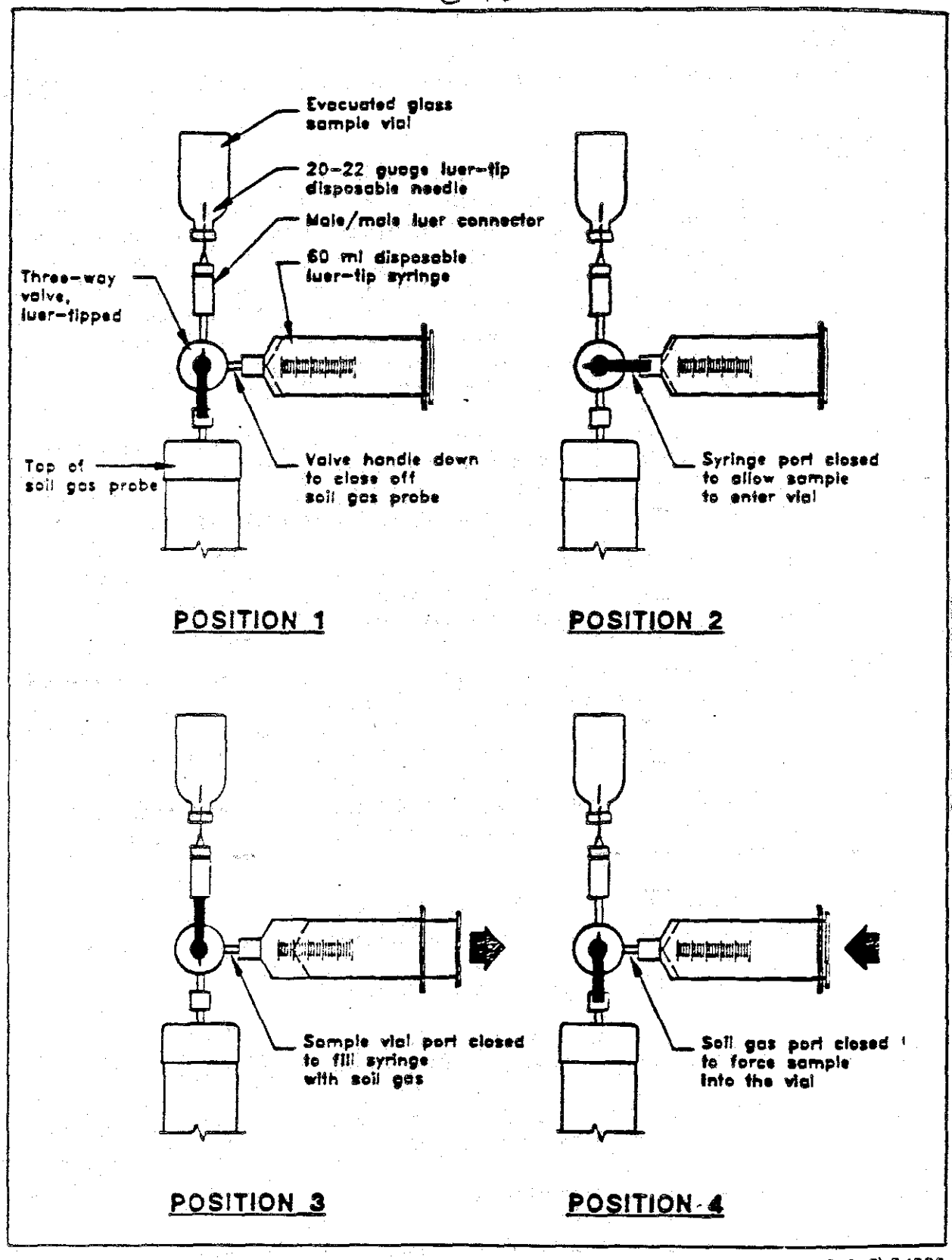
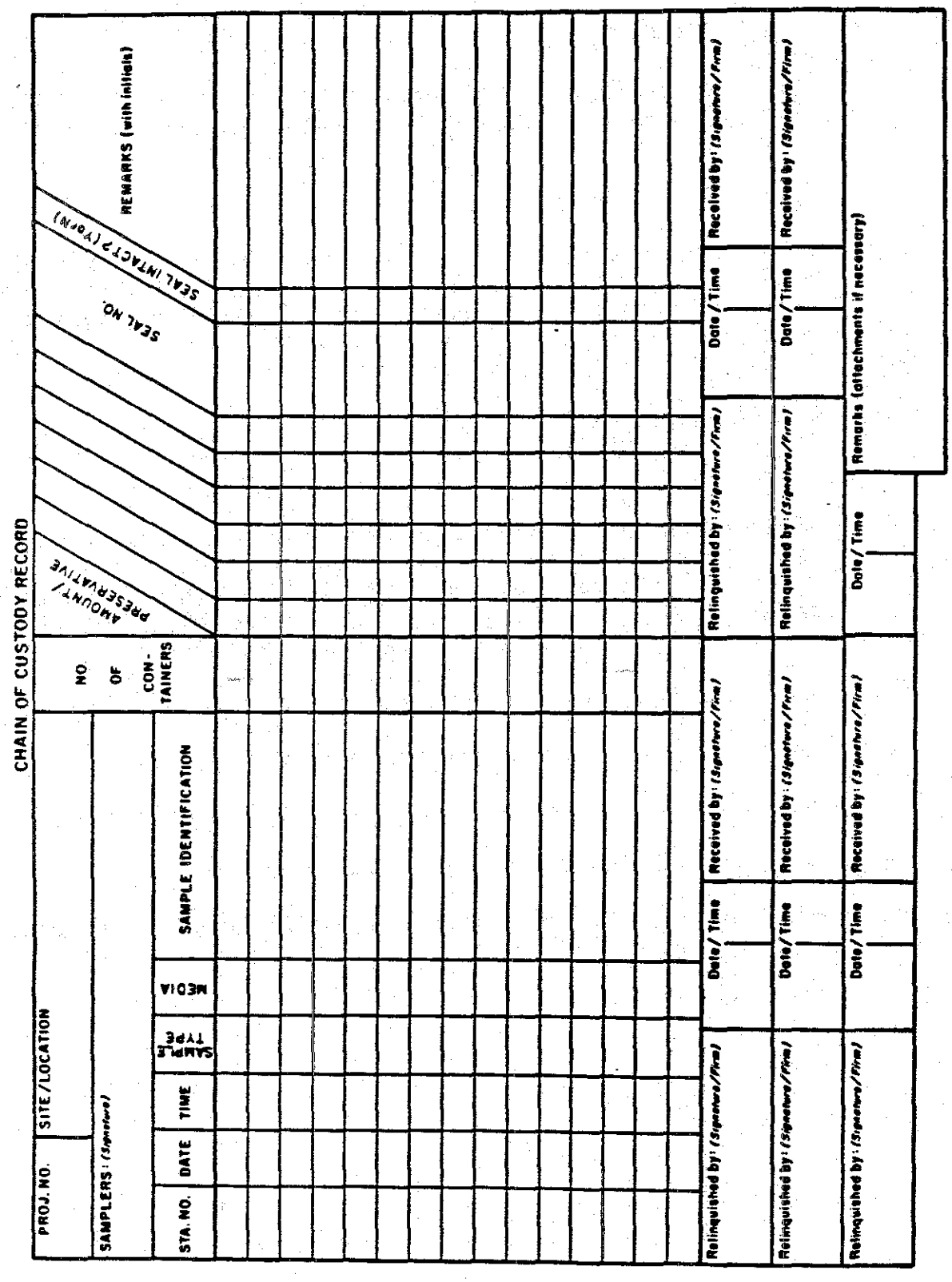


Figure 8-1. High Concentration Soil Gas Sampling Detail.

Figure 8-2


CHAIN OF CUSTODY RECORD
PROJ. NO.
SITE/LOCATION
SAMPLERS: (Signature)
STA. NO.
DATE
TIME
SAMPLE TYPE
MEDIA
SAMPLE IDENTIFICATION
NO OF CONTAINERS
AMOUNT/ PRESERVATIVE
SEAL NO.
SEAL INTACT? (Y or N)
REMARKS (with initials)
Relinquished by: (Signature/Firm)
Date/Time
Received by: (Signature/Firm)
Relinquished by: (Signature/Firm)
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Date/Time
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Relinquished by: (Signature/Firm)
Date/Time
Received by: (Signature/Firm)
Remarks (attachments if necessary)

- Dry the equipment by allowing it to air dry or by blowing a stream of dry nitrogen through the probes. Immediately cover the probe ends and sections with plastic to prevent contamination from the environmental conditions on-site. Once the probes are decontaminated, additional sampling may continue as described above.

- At least once per day, following decontamination and prior to use, assemble all the probe sections and collect an equipment blank and ambient air blank as noted in Step 7 above.

8.4 Permanent Probe Installation

The method of permanent installations shall depend on the site conditions and may require the use of a hollow stem auger/mobile auger unit or backhoe operated by a client-approved site contractor or GAI subcontractor or shall be installed by GAI personnel manually as described in the foregoing sections. When site contractors are used GAI personnel shall direct the installation activity as described in the following sections.

8.4.1 Hollow Stem Auger Procedure

Step 1: Auger to 4 feet in depth;

Step 2: Assemble the sampling probe by first taping all fittings with non-adhesive teflon tape (Note: the sampling probe must be completely decontaminated prior to assembly according to the procedures outlined in Section 8.4.4). Assemble one section with cap and slotted tip, tighten the fittings as necessary, and collect an equipment blank from the assembled probe as described in Step 7 of Section 8.3 above.

Step 3: Place 1 to 2 inches of 8 to 10 mesh silica sand in the bottom of the hole;

Step 4: Insert the soil probe assembly into the hollow stem;

Step 5: Place 12 to 18 inches of sand pack into the hole as the auger is retracted;

Step 6: Place 2 to 3 inches of dry bentonite chips into the hole.

Step 7: Add bentonitic grout and continue retracting the auger in one foot increments until 1 foot below the surface of the ground;

Step 8: Remove the auger;

Step 9: Fill the remainder of the hole with cement. Insert the weather protection monument casing and construct a concrete pad approximately 1 foot in diameter as shown in Figure 3-1. The concrete should slope away from the soil gas probe. Drill a 1/4-inch diameter drain hole in the monument casing directly above the concrete;

Step 10: Place a locking cap on the monument casing;

Step 11: When the cement is cured, paint the cement and monument casing a bright color to identify the monument specifically as a soil-gas probe installation. The color or colors used shall be visually different from the colors of other monuments in the area. Place a location identifier on the top of the monument casing;

Step 12: Sample acquisition, identification, and chain of custody considerations shall be as specified for the temporary installations in Step 7 of Section 8.3 above;

8.4.2 Manual Installation Procedure

Step 1: Provide an access hole for inserting the sampling probe by drilling or driving a 3/4 inch diameter x 3.5 foot deep hole at the sampling point with a rotary impact hammer and drill or solid steel pilot probe.

Step 2: Assemble the sampling probe by first taping all fittings with teflon tape (Note: the sampling probe must be completely decontaminated prior to assembly according to the procedures outlined in Section 8.4.4). Assemble one section with cap and slotted tip and tighten the fittings as necessary and collect an equipment blank from the assembled probe;

Step 3: Place a removeable steel drive point in the end of the probe assembly and insert the probe into the access hole.

Step 4: Drive the probe into the access hole to a depth of 4 feet, attach the removal jack to the probe and lift the probe out of the access hole about 1/2 inch to separate the probe tip from the end of the probe and allow soil gas to enter.

Step 5: Immediately attach the luer-tip valve and connectors and temporarily seal the top of the annulus between the probe and the formation with modeling clay.

Step 6: Connect the hand-operated vacuum pump to the top of the probe and verify that soil gas is entering the probe by pumping two strokes on the vacuum pump. Acceptable flow into the probe will be that the gauge on the vacuum pump indicates atmospheric pressure inside the probe within 5 minutes of drawing a vacuum on the probe assembly. If unacceptable vacuum is indicated the probe will have to be retracted and repositioned until acceptable flow is achieved.

Step 7: Remove the seal from around the probe annulus and excavate a hole around the probe one foot in diameter by one foot in depth.

Step 8: Fill the remainder of the hole with cement. Insert the weather protection monument casing and construct a concrete pad approximately 1 foot in diameter as shown in Figure 3-1. The concrete should slope away from the soil gas probe. Drill a 1/4-inch diameter drain hole in the monument casing directly above the concrete;

Step 9: Place a locking cap on the monument casing;

Step 10: When the cement is cured, paint the cement and monument casing a bright color to identify the monument specifically as a soil-gas probe installation. Place a location identifier tag on the top of the monument casing;

Step 11: Sample acquisition, identification, and chain of custody considerations shall be as specified for the temporary installations in Step 7 of Section 8.3 above.

8.4.3 Backhoe Installation Procedure

The backhoe installation procedure is to be used only if all other installation options are determined to be unsuitable for the site conditions. Prior to use of the procedure throughout the project site a permanent well should be installed using this procedure near a temporary monitoring point where known concentrations of the compounds to be monitored have been detected. This will enable comparison of the effectiveness of the backhoe installation procedure with the temporary monitoring probe procedures. Acceptance of the procedure shall be results comparable within 50 percent difference.

Step 1: Open a backhoe trench approximately 2 ft. W x 4 ft. L x 4 ft in depth;

Step 2: Assemble the sampling probe by taping all fittings with teflon tape (Note: the sampling probe must be completely decontaminated prior to assembly according to the procedures outlined below). Assemble one section with cap and slotted tip and tighten the fittings as necessary and collect an equipment blank from the assembled probe;

Step 3: Place a 6 inch diameter x 5 foot L section of PVC pipe into the trench and add 1 to 2 inches of 8 to 10 mesh silica sand in the bottom of the pipe;

Step 4: Insert the sampling probe into the pipe centering it within the annulus of pipe;

Step 5: Place 12 to 18 inches of sand pack into the hole;

Step 6: Backfill the trench with the soil removed to a depth of two feet up from the bottom of the trench and tamp the soil around the pipe with a tamper;

Step 7: Place 2 to 3 inches of dry bentonite chips.

Step 8: Add bentonitic grout and continue backfilling and tamping the soil around the installation in one foot increments until 1 foot below the surface of the ground;

Step 9: Backfill the trench with the remaining soil and tamp the soil around the pipe with the tamper;

Step 10: Remove the PVC pipe;

Step 11: Fill the remainder of the hole with cement. Insert the weather protection monument casing and construct a concrete pad approximately 1 foot in diameter as shown in Figure 3-1. The concrete should slope away from the soil gas probe. Drill a 1/4-inch diameter drain hole in the monument casing directly above the concrete;

Step 12: Place a locking cap on the monument casing;

Step 13: When the cement is cured, paint the cement and monument casing a bright color to specifically identity the monument as a soil-gas probe installation. Place a location identifier on the top of the monument casing;

Step 14: Sample acquisition, identification, and chain of custody considerations shall be as specified for the temporary installations;

8.4.4 Decontamination Procedures

Step 1: Brush out any soil particles from the interior and exterior of the auger flight(s), probe or backhoe bucket with a wire brush (a gun barrel cleaning brush is suitable for cleaning the soil-gas probes). Capture all waste soil particles and cuttings in a waste basket designated for soil cuttings.

Step 2: Rinse the exterior and interior of the auger flight(s), probe, or backhoe bucket with a solution of detergent and water; scrub with brushes or with a pressurized cleaner, and capture all wash solution in an appropriate container.

Step 3: Rinse the auger flight(s), probe or backhoe bucket with decontamination water and capture all rinseate in an appropriate container.

Step 4: Allow the equipment to air dry or dry by blowing a stream of dry nitrogen through the probes. Immediately wrap the probe sections with plastic to prevent contamination prior to installation.

8.5 Sample Analysis

8.5.1 Instrument Settings for Sample Analysis by Gas Chromatography with PID/ECD Detectors in Series

8.5.1.1 GC Analysis of Glass Sample Vials

Oven temp:	65 deg. C isothermal
Injector/detector:	200 deg. C
ECD Temp:	250 deg. C
Carrier:	He or N2 at ≈6 mL/min
Makeup:	N2 at ≈30 mL/min
PID:	10.2 eV lamp
Column:	15 meter x 0.52 mm DB-624 or VOCOL
Data System:	PE-Nelson data system using an external calibration method
Total Run Time:	≈10 minutes

8.5.2 Standards Preparation - Vials

Prepare a series of three standards in 125 ml glass sample vials by injecting appropriate volumes of a methanolic multi-standard for chlorinated hydrocarbons the concentrations of the standards should range from 0.5 to 2.0 µg/L (wt/vol). Determine the concentration of the standards in ppb (vol/vol) by the following formula:

ppb = 24,470 x (Cs ÷ MW) where

Cs is the concentration (in µg/L) of the compound in the vial and
MW is the molecular weight of the compound.

8.5.3 Injection Syringe Cleaning

Rinse the injection syringe completely in methanol followed by air drying or by blowing dry with a stream of UHP grade dry nitrogen.

8.5.4 Blank Injection

Inject 500 microliters of laboratory ambient air into the system and analyze as for the standards and samples to check the syringe for artifacts. This will serve as a GC system method blank.

8.5.5 Standard Injection

Inject 500 microliters of each standard sequentially and record the peak responses. Prior to injection, heat each standard for at least 15 minutes under a heat lamp to ensure that the methanolic standard has volatilized and mixed completely within the vial.

8.5.6 Evaluation of Response Factors

Update the response factors in the method files using the calibration update software program and compare to the initial calibration run. The peak response for each standard should not differ by greater than 40% difference from the initial calibration. If not, re-analyze one or more of the standards and recalculate the response factors.

8.5.7 Sample Analysis

Begin analysis of samples. For every 10 samples analyzed, analyze a syringe blank and a mid-range calibration standard check and compare the results to the following criteria:

- Acceptable blank analysis shall be interpreted as no component detected at greater than 5 times the detection limit.
- Standard checks must agree within 40% of the initial calibration.
- If the blank or standard check is not within acceptable limits the syringe must be cleaned as described in Section 8.5.3 and the calibration standards re-checked. All samples up to the last in-control point must be re-analyzed.
- Samples that produce off-scale readings must be re-injected using small injection volumes and the results corrected with the appropriate dilution factor.

8.5.8 Blank Analysis

Following the analysis of a high concentration sample, a minimum of one method blank must be analyzed to determine the possibility of carryover.

8.5.9 Holding Time Limitations

All sample analyses must be completed within 72 hours of sample collection.

9. REPORTING REQUIREMENTS

Report all concentrations of the chlorinated hydrocarbons to a detection limit of 0.5 ug/L. Report all BTEX compounds to a detection limit of 5 ug/L. Summarize the data on a daily basis in a tabular format including all blank and standard results; append all the chromatograms and GC output data and present to the Senior Chemist for review. The Senior Chemist, shall, in turn summarize the analytical results in a formal report appended with all applicable supporting data.

Present the concentration reports for each sample with all chromatograms and GC output data, to the Senior Chemist for review. The Senior Chemist, shall, in turn, summarize the analytical results in a formal report appended with all applicable supporting data.

WHC-MR- 0378

C-24

PROCEDURE ALTERATION CHECKLIST p1 of 2

Job/Task Number: 903-1221

Procedure Reference: TI 7.2-4

Requested Variation: Modify sample analysis as follows: Calibration will be by injection of standard directly into purge vessel, sample quantities will be calculated by calculation on a wt/vol (10 ml) basis. GC will be temp. programmed from 45 to 85 °C. Purge will be 5 mins, desorb will be 4 mins. Temp. as follows: 45 °C, 5 mins 50 °C, 2 mins, 55 °C 2 mins, 85 °C, 4 mins.

Reason for Variation: All samples will be analyzed by purging 10 mls onto the trap rather than direct injection of 0.5 mls to improve detection limits by a factor of 20 or more.

Special Equipment, Material or Personnel Required: use of a glass purge vessel with a special port that meets the specs on attached sheet.

Alteration Requested By: [signature] Date: 11/26/90

Title: Senior Chemist

Reviewed By: [signature] Date: 11/26/90

Title: GAI Project Manager

Comments:

Reviewed By: [signature] Date: 11/27/90

Title: GAI QA Manager

Comments: incorporate into next version of procedure GAA 11/27/90

cc: J. Gorman

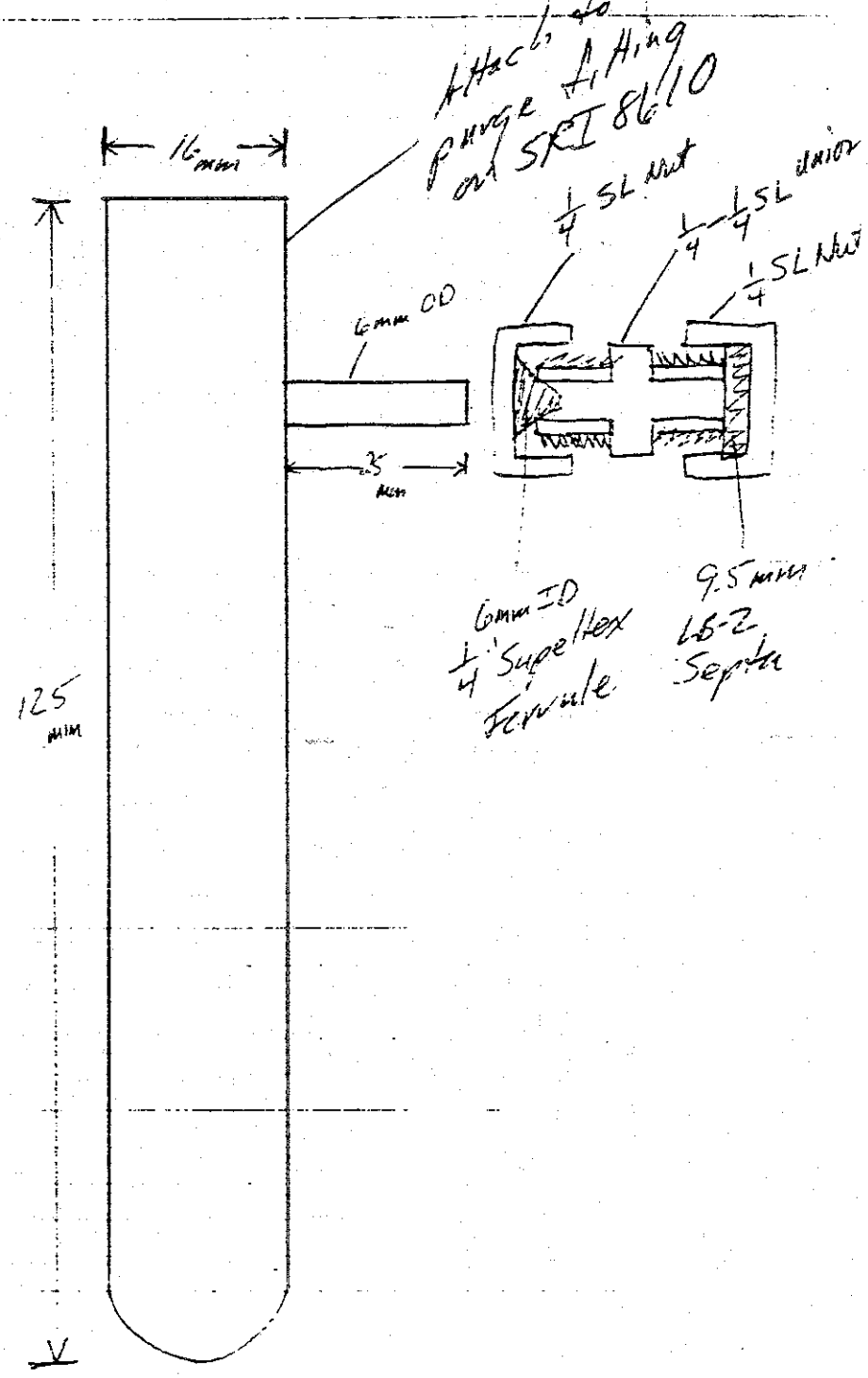
9212642019 6

Golder Associates

WHC-MR- 0378 C-25

Golder Associates

SUBJECT	Purge Vessel for Soil Cap		
Job No. 913-9221 Ref.	Made by [illegible] Checked	Reviewed [illegible] 11/27/90	Date 11/24/90 Sheet 2 of 2



WHC-MR- 0378

C-26

PROCEDURE ALTERATION CHECKLIST

Job/Task Number: 903-1221

Procedure Reference: TP 2.2-4

Requested Variation: Reduce frequency of equipment blank and field duplicate to one per day for all the temporary installations

Reason for Variation: Laboratory results show that field duplicate are acceptable and that probes are adequately decontaminated

Special Equipment, Material or Personnel Required: N/A

Alteration Requested By: [signature] Date: 11/4/91

Title: Senior Chemist

Reviewed By: [signature] Date: 11/4/91

Title: GAI Project Manager

Comments:

Reviewed By: [signature] Date: 2-4-91

Title: GAI QA Manager

Comments: