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Alameda County
Environmental Health

Casimiro Damele
3750 Victor Avenue
Oakland CA 94619

5 August 2008

Project No. P257

Workplan for Soilgas Sampling
4401 Market Street
Oakland CA
Fuel Leak Case No. RO0000132

Dear Mr. Damele:

This workplan describes proposed soilgas sampling at and near 4401 Market Street. The proposed sampling has been designed to evaluate vapor intrusion risks associated with residual soil and groundwater contamination at the site and potential future residential development of the site. Soilgas sampling was mandated by the Alameda County Health Care Services Agency in its letter dated 20 June 2008 (ACHCSA 2008).

This workplan describes proposed soilgas sampling activities consistent with the following guidance documents:

- Department of Toxic Substances Control and Los Angeles Regional Water Quality Control Board: *Advisory - Active Soil Gas Investigations* (2003).
- Department of Toxic Substances Control: *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion To Indoor Air* (2005).
- Air Toxics: *Guide to Air Sampling and Analysis*.

BACKGROUND (Tables 1-2, Figures 1-3)

Table 1 provides a chronology of environmental activities associated with the site. Table 2 provides a bibliography.

The subject property is located approximately three miles north of downtown Oakland CA. The surrounding land use is primarily residential with some commercial (Figures 1 and 2).

The structure at 4401 Market Street was reportedly constructed in 1943 and used as a gasoline station until the 1970s. The exact installation date of the four underground gasoline storage tanks is unknown.

In June 1990, Environmental Bio-Systems removed one 1,000-gallon underground gasoline tank and three 500-gallon underground gasoline tanks from the southeast portion of 4401 Market Street. During tank removal, soil samples were collected from beneath the tanks and associated piping.

In October 1994, seven soil borings were drilled and three of the borings were completed as 2-inch diameter monitoring wells (MW1, MW2, and MW3). Soil samples were collected from each of the borings and groundwater samples were collected from the monitoring wells. Groundwater monitoring was conducted periodically between November 1994 and June 1997.

In April and July 1999, nine soil borings were drilled. Soil and grab groundwater samples were collected from each of the borings. The investigation encountered free product, presumably gasoline, in boring SB2 at the southeast corner of the 4401 Market Street.

In January 2001, four 2-inch diameter monitoring wells (MW4, MW5, MW6, and MW7) were installed. Soil samples were collected during drilling.

From February to November 2001, free product monitoring was conducted monthly for monitoring wells MW4, MW5, and MW6; free product was not detected.

Groundwater monitoring was conducted periodically between February 2001 and September 2003 for all seven monitoring wells.

SUBSURFACE CONDITIONS (Table 3, Figures 3-6)

Soils encountered in the borings typically consisted of the following:

- Layers of silt and clay with varying amounts of sand, starting at the ground surface and extending to a depth of approximately 17 to 20 feet.
- Layers of sand containing varying amounts of gravel, clay, and silt; starting at a depth of approximately 17 to 20 feet and extending to the maximum depth drilled (25 feet).

A cross-section of subsurface conditions is presented on Figure 4 (cross-section location shown on Figure 3).

Groundwater has historically been measured at depths between approximately 12 and 16 feet. The groundwater gradient has historically been directed toward the southwest, with a magnitude of approximately 0.01.

The groundwater gradient and magnitude from the most recent monitoring event (29 September 2003) are summarized on Figure 5. Groundwater level and gradient information are summarized in Table 3. A rose diagram depicting historic groundwater gradient data is presented on Figure 6.

NATURE AND EXTENT OF RESIDUAL SOIL AND GROUNDWATER CONTAMINATION (Tables 4-7, Figures 3 and 7)

Historic soil and groundwater sampling locations are shown on Figure 3.

Groundwater samples were collected from the monitoring wells from November 1994 through September 2003. Groundwater samples were analyzed for TPH-gasoline, BTEX, and fuel oxygenates. Groundwater purging and sampling information is summarized in Table 4 and groundwater analytical results are summarized in Table 5.

Groundwater analytical results at the time of the most-recent monitoring event (29 September 2003) revealed the following:

- Groundwater contamination was confined to wells MW2, MW4, and MW5.
- Groundwater contamination consisted of TPH-gasoline and BTEX; fuel oxygenates were nondetect.

Soil samples were collected during tank removal and during the drilling of soil borings and monitoring wells. In total, 58 soil samples were collected from 26 locations at depths between approximately 7.5 to 21.5 feet. Soil samples were analyzed for TPH-gasoline, BTEX, and fuel oxygenates. Soil analytical results are summarized in Tables 6 and 7.

Soil analytical results revealed the following:

- The maximum measured soil concentrations were:
  - TPH-gasoline = 1,300 mg/kg in B10 at a depth of 15-15.5 feet.
  - Benzene = 12 mg/kg in B10 at a depth of 15-15.5 feet.
  - Toluene = 24 mg/kg in S5 and S6 at depths of 8-8.5 feet.
  - Ethylbenzene = 26 mg/kg in S6 at a depth of 8.5 feet.
  - Xylenes = 100 mg/kg in B10 at a depth of 15-15.5 feet.
- Fuel oxygenates were not detected.

As reported in the Site-Specific Risk Assessment and Site Conceptual Model, dated 16 January 2004 (Streamborn 2004), soil contamination existed beneath the former tanks and extended laterally approximately 50 feet downgradient of the former tanks. In the area of the former tanks, soil contamination extended vertically from the base of the former tanks to the groundwater table/smear zone (from approximately 7 to 16 feet deep). Downgradient of the former tanks, soil contamination was generally coincident with the groundwater table/smear zone (approximately 10-16 feet deep).

The predominant and most elevated contaminant has been TPH-gasoline. Accordingly, TPH-gasoline serves as a reliable indicator of the extent of groundwater contamination. Figure 7 provides our interpretation of the extent of TPH-gasoline in groundwater based on the most recent measurements (29 September 2003). Figure 7 indicates that, as of 29 September 2003, groundwater contamination extended approximately 100 feet downgradient of the former tanks.

The Site-Specific Risk Assessment and Site Conceptual Model, dated 16 January 2004 (Streamborn 2004), identified vapor intrusion of benzene as a potential risk for future site development. Streamborn evaluated this risk on the basis of measured soil and groundwater concentrations and vapor transport equations and concluded the risks were within acceptable limits. However, recent guidance from the San Francisco Bay Regional Water Quality Control Board (San Francisco Bay Regional Water Quality Control Board 2008) indicates that calculations are not sufficient and direct measurement of soilgas is required.

OBJECTIVES OF THE PROPOSED SOILGAS SAMPLING

The proposed soilgas sampling is intended to:

- Determine soilgas concentrations in the vicinity of known soil and groundwater contamination.
- Compare measured soilgas concentrations with environmental screening levels for vapor intrusion (San Francisco Bay Regional Water Quality Control Board 2008). Previous investigations and risk evaluations indicate benzene poses the greatest risk for vapor intrusion.

The soilgas sampling will evaluate whether residential development anywhere on or near the site will pose unacceptable risks.

SCOPE OF WORK FOR THE PROPOSED SOILGAS SAMPLING AND RATIONALE FOR THE PROPOSED SAMPLING LOCATIONS (Table 8, Figure 8)

Sampling will be scheduled during the summer-fall dry season (prior to November 2008), thereby avoiding the complicating influences of rainfall.

Prior to initiating fieldwork, the following activities will be conducted:

- Permits will be obtained from Alameda County.
- 811 will be notified to clear the proposed boring locations.

Rationale for Proposed Soilgas Sampling Locations

Six soilgas sampling locations (SG1 through SG6) are proposed. The rationale for selecting each location is summarized in Table 8 and the sampling locations are presented on Figure 8.

- SG1: Background location, located upgradient of the former underground gasoline tanks.
- SG2 - SG4: Located within the area of the former underground gasoline tanks, where the greatest concentration of benzene in soil was measured during tank removal (location S6 measured benzene of 5 mg/kg at a depth of 8.5 feet).
- SG5: Located downgradient of the former underground gasoline tanks, adjacent to monitoring well MW2. Monitoring well MW2 measured the highest concentration of benzene in groundwater at the site.
- SG6: Located downgradient of the former underground gasoline tanks, adjacent to boring B10. Boring B10 measured the highest benzene concentration in soil (12 mg/kg) in 1999.

Purge Test at SG3

Soilgas location SG3 will be conducted first to evaluate purge volume versus concentration and ensure subsequent sample collection techniques are representative. Soilgas location SG3 has been located where soilgas is expected to be at or near the highest concentration. A step purge test will be conducted at one, three, and seven purge volumes. The purge test will be conducted at a low flow rate (less than 200 milliliters per minute). A flow control valve will control the flow. Concentrations of volatile organic compounds will be measured for each purge volume using a photoionization (PID) vapor meter. The purge volume providing the highest PID reading will be used as the purge volume for all subsequent soilgas samples.

Boreholes and Setting the Probe

A direct-push drill rig will be used to install 0.75-inch diameter steel sample probes at each sampling location. The sampling probes will be installed to a depth of approximately five feet (groundwater expected at a depth of approximately 13 feet). A ±0.5-inch diameter tube will be inserted into the steel probe for sample collection.

A hydrated bentonite seal will be placed around the drive probe at ground surface to prevent ambient air intrusion. The probe will be allowed to equilibrate for a at least 20 minutes prior to purging and sampling.

Leak Test

A leak test will be performed during the collection of each soilgas sample using butane as a tracer gas. The tracer gas will be exposed to the bentonite seal, purge valves, fittings, and anywhere else serving as a potential conduit for cross-contamination or ambient air intrusion.

Sampling

Once the probe has been set and the bentonite seal applied, the probe will be left alone for at least 20 minutes in order to facilitate equilibration. After 20 minutes, the probe will be purged of the sample volume determined during the purge test. Purging and sampling will be conducted at the same low flow rate (less than 200 milliliters per minute) used during the purge test.

Samples will be collected in 1-Liter Summa canisters which will be connected to the sample tubing by means of a three-way valve and flow controller assembly (including a vacuum gauge and particulate filter). A syringe will be used to purge the required volume as determined during the purge test. Once the probe has been purged, the canister valve will be opened and allowed to fill. Each canister will be equipped with a vacuum gauge. The vacuum reading will be recorded (1) prior to sampling and (2) after the sample has been collected.

Samples will be transported to Air Toxics (Folsom CA) for analysis of volatile organic compounds (EPA Method TO-14A). The samples will also be analyzed for butane (ASTM D-Method 1945).

Completion

All boreholes will be backfilled upon completion with cement-bentonite grout (1 sack/94 pounds cement and 5 pounds bentonite to 7.5 gallons water).

Investigation-Derived Waste

The activities described in this workplan will generate decontamination wastewater. Decontamination wastewater will be discharged to the sanitary sewer.

QUALITY ASSURANCE/QUALITY CONTROL (Attachment 3)

Soil gas sampling will be performed in accordance with the following document:

- Department of Toxic Substances Control and Los Angeles Regional Water Quality Control Board's *Advisory - Active Soil Gas Investigations* (2003).
- Department of Toxic Substances Control *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion To Indoor Air* (2005).
- Air Toxics. *Guide to Air Sampling and Analysis.*

Quality Control Samples

The laboratory will include laboratory blank, laboratory replicate, and laboratory spike quality control samples during soil gas analysis. Field quality control samples will not be collected.

Field Meter Quality Control Procedures

The field organic vapor monitor (used for site safety and to screen soil gas) will be calibrated using a standard gas prior to the beginning of each field day. Recalibration may be appropriate if unusual measurements are noticed.

HEALTH AND SAFETY

The attached Site Safety Plan presents the procedures to be followed to protect the safety of workers during planned fieldwork. Physical and chemical hazards are addressed, such as working around equipment and exposure to chemicals. Although the proposed fieldwork does not necessarily require adherence to safety protocols for hazardous waste sites, the procedures in the Site Safety Plan are intended to comply with the pertinent sections of 29 CFR 1910.120 Hazardous Waste Operations and Emergency Response.

Please contact us with any questions or comments.

Sincerely,

STREAMBORN

Juli A. Brady, PE
Environmental Engineer

REGISTERED PROFESSIONAL ENGINEER
JULI A. BRADY
C 72579
EXP. 04/30/10
CIVIL
STATE OF CALIFORNIA

Attachments

cc: Paresh Khatri/Alameda County Health Care Services Agency, Alameda CA (ecopy and hardcopy)

This workplan was uploaded to Geotracker (geotracker.swrcb.ca.gov)

Table 1 (Page 1 of 2)

Environmental Chronology

4401 Market Street, Oakland CA

Date	Activities Performed By	Description
Unknown	Unknown	• Four underground gasoline tanks (one 1,000-gallon and three 500-gallon tanks) were installed. • W.A. Craig reported that the structure at 4401 Market Street was constructed in 1943 and used as a gasoline station until the 1970s.
22 June 1990	Environmental Bio-Systems	• The 4 underground gasoline tanks were removed. Removal of the fuel dispensers, product piping, and pump island was not documented. Soil excavated during tank removal was reused to backfill the excavations. • Soil samples were collected from below the tanks. Samples of the excavated soil were also collected. Soil samples were analyzed for TPH-gasoline and BTEX. Soil sampling indicated a release of gasoline.
6 September 1990	W.A. Craig	• Two trenches were excavated to depths of approximately 5 feet in the vicinity of the former dispenser island. • Contaminated soil was observed during excavation but no laboratory analyses were performed. The excavated soil was reused to backfill the trenches.
27 and 28 October 1994	W.A. Craig	• Seven borings were drilled to depths of approximately 25 feet at and near 4401 Market Street (SB1, SB2, SB3, SB4, MW1, MW2, and MW3); three of the borings were completed as monitoring wells (MW1, MW2, and MW3). Soil samples were collected during drilling. • Free product, presumably gasoline, was observed in boring SB2, located near the southwest corner of 4401 Market Street. • Soil samples were analyzed for TPH-gasoline and BTEX.
8 November 1994	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline and BTEX.
14 February 1995	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline and BTEX.
7 June 1995	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline and BTEX.
29 August 1995	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline and BTEX.
8 December 1995	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline and BTEX.
7 March 1996	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline, BTEX, and MtBE.
19 June 1996	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline, BTEX, and MtBE.
20 December 1996	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline, BTEX, and MtBE.
12 June 1997	W.A. Craig	• Groundwater monitoring was conducted for wells MW1, MW2, and MW3. • Samples were analyzed for TPH-gasoline, BTEX, and MtBE.
31 March 1999	Streamborn	• Groundwater levels measured in wells MW1, MW2, and MW3.
April and July 1999	Streamborn	• Nine borings were drilled to depths of approximately 20 feet near 4401 Market Street (B8 through B16). Free product, presumably gasoline, was observed in boring B10, located on the south side of 44th Street, adjacent to 903 44th Street. Soil samples were collected during drilling. Groundwater samples were collected from temporary casings installed in the borings. The borings were grouted upon completion of groundwater sampling. • Soil samples and groundwater samples were analyzed for TPH-gasoline, BTEX, and fuel oxygenates.
4-5 January 2001	Streamborn	• Four monitoring wells (MW4, MW5, MW6, and MW7) were installed to depths of approximately 25 feet near 4401 Market Street. Soil samples were collected during drilling. • Soil samples were analyzed for TPH-Gasoline, BTEX, and fuel oxygenates. • An elevation survey was performed for the newly-installed monitoring wells.

Table 1 (Page 2 of 2)

Environmental Chronology

4401 Market Street, Oakland CA

Date	Activities Performed By	Description
1 February 2001	Streamborn	• Wells MW4, MW5, MW6, and MW7 were developed. • Groundwater samples were collected from wells MW1, MW3, MW4, MW5, MW6, and MW7. Samples were analyzed for TPH-Gasoline, BTEX, and fuel oxygenates. • Water levels were measured in wells MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.
9 March 2001	Streamborn	• Water levels were measured in wells MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.
23 April 2001	Streamborn	• Water levels were measured in MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.
30 May 2001	Streamborn	• Groundwater samples were collected from wells MW1, MW3, MW4, MW5, MW6 and MW7. Samples were analyzed for TPH-Gasoline, BTEX, and fuel oxygenates. • Water levels were measured in wells MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.
19 June 2001	Streamborn	• Water levels were measured in MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.
19 July 2001	Streamborn	• Water levels were measured in MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.
22 August 2001	Streamborn	• Groundwater samples were collected from wells MW1, MW3, MW4, MW5, MW6 and MW7. Samples were analyzed for TPH-Gasoline, BTEX, and fuel oxygenates. • Water levels were measured in wells MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.
29 November 2001	Streamborn	• Groundwater samples were collected from wells MW1, MW3, MW4, MW5, MW6 and MW7. Samples were analyzed for TPH-Gasoline, BTEX, and fuel oxygenates. • Water levels were measured in wells MW1, MW2, MW3, MW4, MW5, MW6, and MW7.
29 September 2003	Streamborn	• Groundwater samples were collected from wells MW1, MW3, MW4, MW5, MW6 and MW7. Samples were analyzed for TPH-Gasoline, BTEX, and fuel oxygenates. • Water levels were measured in wells MW1, MW2, MW3, MW4, MW5, MW6, and MW7. • Wells MW4, MW5, and MW6 were monitored for free product; no free product was detected.

General Note

(a) TPH = total petroleum hydrocarbons. BTEX = benzene, toluene, ethylbenzene, and xylenes. MtBE = methyl tert-butyl ether.

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Bibliography

4401 Market Street, Oakland CA

ACHCSA (1999a). *Leon's Arco, 4401 Market Street, Oakland CA 94608; StId 812.* Correspondence to Casimiro and Josephine Damele, Oakland CA. Correspondence from Don Hwang, Alameda County Environmental Health Services, Alameda CA. 10 December 1999.

ACHCSA (1999b). *Leon's Arco, 4401 Market Street, Oakland CA 94608; StId 812.* Correspondence to Casimiro and Josephine Damele, Oakland CA. Correspondence from Don Hwang, Alameda County Environmental Health Services, Alameda CA. 29 December 1999.

ACHCSA (2000). *Leon's Arco, 4401 Market Street, Oakland CA 94608; StId 812.* Correspondence to Casimiro and Josephine Damele, Oakland CA. Correspondence from Don Hwang, Alameda County Environmental Health Services, Alameda CA. 13 January 2000.

ACHCSA (2001). *Leon’s Arco, 4401 Market Street, Oakland CA 94608, RO0000132.* Correspondence to Casimiro and Josephine Damele, Oakland CA. Correspondence from Don Hwang, Alameda County Environmental Health Services, Alameda CA. 20 September 2001.

ACHCSA (2002). *Fuel Leak Case No. RO0000132, Leon’s Arco, 4401 Market Street, Oakland CA 94608.* Correspondence to Casimiro and Josephine Damele, Oakland CA. Correspondence from Don Hwang, Alameda County Environmental Health Services, Alameda CA. 27 December 2002.

ACHCSA (2003). *Fuel Leak Case No. RO0000132, Leon's Arco, 4401 Market Street, Oakland, CA 94608* Correspondence to Casimiro and Josephine Damele, Oakland CA. Correspondence from Don Hwang, Alameda County Environmental Health Services, Alameda CA. 8 April 2003.

ACHCSA (2008). *Fuel Leak Case No. RO0000132, Arco, 4401 Market Street, Oakland, CA 94608* Correspondence to Casimiro Damele, Oakland CA. Correspondence from Paresh Khatri and Jerry Wickham, Alameda County Environmental Health Services, Alameda CA. 20 June 2008.

Air Toxics. *Guide to Air Sampling and Analysis.*

CalEPA (1999). *Technical Support Document for Describing Available Cancer Potency Factors.* Prepared by California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Air Toxicology and Epidemiology Section, Sacramento CA. April 1999.

Department of Toxic Substances Control and Los Angeles Regional Water Quality Control Board (2003). *Advisory - Active Soil Gas Investigations*. Prepared by the Department of Toxic Substances Control and the Los Angeles Regional Water Quality Control Board, Glendale CA and Los Angeles CA. 28 January 2003.

Department of Toxic Substances Control (2005). *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air (Interim Final - 15 December 2004, Revised 7 February 2005).* Prepared by the Department of Toxic Substances Control, California Environmental Protection Agency, Sacramento CA. 7 February 2005.

Jon B. Marshack (2000). *A Compilation of Water Quality Goals.* Central Valley Regional Water Quality Control Board, Sacramento CA. August 2000.

RWQCB (1996). *Memorandum, To: San Francisco Bay Area Agencies Overseeing UST cleanup, Supplemental Instruction to State Water Board, December 8, 1995, Interim Guidance on Required Cleanup at Low Risk Fuel Sites.* Prepared by San Francisco Bay Regional Water Quality Control Board, Oakland CA. 5 January 1996.

RWQCB (2003). *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, Interim Final - July 2003*. Prepared by the San Francisco Bay Regional Water Quality Control Board, Oakland CA. 21 July 2003.

San Francisco Bay Regional Water Quality Control Board (2008). *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater (Interim Final - November 2007, Revised May 2008).* Prepared by San Francisco Bay Regional Water Quality Control Board, Oakland CA. 27 May 2008. www.waterboards.ca.gov/sanfranciscobay/esl.shtml

Streamborn (1999a). *Workplan, Investigation and Remediation of Gasoline-Contaminated Soil and Groundwater, 4401 Market Street, Oakland CA.* Prepared for Casimiro and Josephine Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. 15 October 1999.

Streamborn (1999b). *Revised Workplan, Investigation and Remediation of Gasoline Contaminated Soil and Groundwater, 4401 Market Street, Oakland CA.* Prepared for Casimiro and Josephine Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. 22 December 1999.

Streamborn (2001a). *Report, Installation and Sampling of Four New Monitoring Wells, 4401 Market Street, Oakland CA.* Prepared for Casimiro and Josephine Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. 23 March 2001.

Streamborn (2001b). *Letter Report, Groundwater Monitoring, 4401 Market Street, Oakland CA.* Prepared for Casimiro and Josephine Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. 18 June 2001.

Streamborn (2001c). *Letter Report, Groundwater Monitoring, 4401 Market Street, Oakland CA.* Prepared for Casimiro and Josephine Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. 14 September 2001.

Streamborn (2001d). *Letter Report, Potential Conduit and Sensitive Receptor Study, 4401 Market Street, Oakland CA. Prepared by Streamborn, Berkeley CA. 3 December 2001.*

Table 2 (Page 2 of 2)

Bibliography

4401 Market Street, Oakland CA

Streamborn (2002). *Letter Report, Groundwater Monitoring Conducted 29 November 2001, 4401 Market Street, Oakland CA.* Prepared for Casimiro and Josephine Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. 18 January 2002.

Streamborn (2003a). *Workplan, Groundwater Monitoring and Site-Specific Risk Assessment, 4401 Market Street, Oakland CA.* Prepared for Casimiro and Josephine Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. 18 March 2003.

Streamborn (2003b). *Letter Report, Groundwater Monitoring Conducted 29 September 2003, 4401 Market Street, Oakland CA.* Prepared for Casimiro Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. Project No. P257. 22 December 2003.

Streamborn (2004). *Letter Report, Site-Specific Risk Assessment and Site Conceptual Model, 4401 Market Street, Oakland CA.* Prepared for Casimiro Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. Project No. P257. 16 January 2004.

Streamborn (2008). *Workplan for Soilgas Sampling, 4401 Market Street, Oakland CA, Fuel Leak Case No. RO0000132*. Prepared for Casimiro Damele, Oakland CA. Prepared by Streamborn, Berkeley CA. Project No. P257. 5 August 2008.

USEPA (2000). *Preliminary Remediation Goals (PRGs), 2000*. USEPA, Region 9, San Francisco CA. 1 December 2000.

Wiedemeier, T.H., Rifai, H.S., Newell, C.J., and Wilson, J.T. (1999). Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface. John Wiley & Sons, New York NY. 1999.

Table 3

Groundwater Levels and Gradient Data Since 2001

4401 Market Street, Oakland CA

Location	**MW1**		**MW2**		**MW3**		**MW4**		**MW5**		**MW6**		**MW7**		Groundwater Gradient	
Ground Surface	Elev = 998.74		Elev = 998.07		Elev = 999.64		Elev = 998.18		Elev = 997.78		Elev = 998.02		Elev = 999.12			
Measuring Point	TOC N Side, Elev = 998.22		TOC N Side, Elev = 997.73		TOC N Side, Elev = 998.90		TOC N Side, Elev = 997.87		TOC N Side, Elev = 997.33		TOC N Side, Elev = 997.50		TOC N Side, Elev = 998.69			
Intercepted Interval	Depth	Elev	Depth	Elev	Depth	Elev	Depth	Elev	Depth	Elev	Depth	Elev	Depth	Elev		
	19 to 25.5	972.9 to 979.7	19 to 27.5	970.6 to 979.1	19 to 27.5	972.1 to 980.6	9 to 25	973.2 to 989.2	9 to 25	972.8 to 988.8	9 to 25	973.0 to 989.0	9 to 25	974.1 to 990.1	Direction	Magnitude
1 February 2001	13.77	984.45	13.21	984.52	14.01	984.89	13.22	984.65	13.14	984.19	13.31	984.19	14.76	983.93		
9 March 2001	12.54	985.68	12.30	985.43	13.32	985.58	12.28	985.59	11.70	985.63	12.54	984.96	13.94	984.75	N 130˚ E	0.01
23 April 2001	14.01	984.21	13.36	984.37	14.15	984.75	13.05	984.82	13.30	984.03	13.39	984.11	14.63	984.06		
30 May 2001	14.74	983.48	NM	NM	14.67	984.23	13.93	983.94	14.14	983.19	14.17	983.33	15.79	982.90	N 222˚ E	0.01
19 June 2001	14.83	983.39	13.93	983.80	14.67	984.23	15.47	982.40	14.29	983.04	14.34	983.16	15.87	982.82		
19 July 2001	15.04	983.18	14.51	983.22	14.84	984.06	14.73	983.45	14.48	982.85	14.47	983.03	15.99	982.70		
22 August 2001	15.03	983.19	14.48	983.25	14.83	984.07	14.63	983.24	14.58	982.75	14.57	982.93	16.15	982.54	N 217˚ E	0.01
29 November 2001	12.59	985.63	12.01	985.72	12.66	986.24	12.78	985.09	11.05	986.28	11.42	986.08	12.94	985.75		
29 September 2003	15.05	983.17	14.50	983.23	14.94	983.96	14.53	983.34	14.53	982.80	14.52	982.98	16.19	982.50	N 229˚ E	0.009
Total Depth (last measurement)	24.7		24.6		24.7		24.7		24.7		24.8		24.6			

General Notes

(a) Measurements are cited in units of feet, referenced to a site-specific datum (not Mean Sea Level).

(b) TOC = top of PVC casing. N = north. Measuring points are the top of PVC casing, north side.

(c) The depth to water and total depth were measured relative to the top of PVC casing.

(d) The depth of the intercepted interval was measured relative to the ground surface, and corresponds to the sand pack interval.

Table 4

Groundwater Purging and Sampling Information Since 2001

4401 Market Street, Oakland CA

Location	Sample Date	Sample Type	Dissolved Oxygen (mg/L)	pH	Specific Conductance (µS/cm)	Temper-ature (˚C)	ORP (mV)	Turbidity and Color	Purge Method	Purge Duration (minutes)	Volume Purged (gallons)	Purged Dry ?	Standing Water Casing Volumes Removed
MW1	1 Feb 2001	GB	3.1	6.7	530	18.3	-210	Clear, none	SP	9	±5	Yes	±3
	30 May 2001	GB	1.0	6.8	560	24.2	30	Clear, none	SP	40	±5	Yes	±3
	22 Aug 2001	GB	3.0	6.9	510	20.4	50	Clear, none	SP	8	±5	Yes	±3
	29 Nov 2001	GB	NM	6.7	480	20.9	-170	Clear, none	SP	15	±4	Yes	±2
	29 Sep 2003	GB	1.6	6.3	520	21.5	130	Clear, none	SP	15	±5	Yes	±3
MW2	29 Sep 2003	GB	1.6	6.6	560	21.9	-80	Clear, none	SP	20	±5	No	±3
MW3	1 Feb 2001	GB	5.0	6.7	370	17.4	-230	Clear, none	SP	4	±5	No	±3
	30 May 2001	GB	5.8	7.0	390	23.6	60	Clear, none	SP	26	±5	Yes	±3
	22 Aug 2001	GB	4.5	7.1	370	21.5	90	Cloudy, brown	SP	6	±5	Yes	±3
	29 Nov 2001	GB	NM	6.8	330	19.3	20	Clear, none	SP	10	±6	Yes	±3
	29 Sep 2003	GB	4.5	6.6	370	19.6	190	Clear, none	SP	10	±5	Yes	±3
MW4	1 Feb 2001	GB	5.2	6.8	580	18.2	-210	Cloudy, gray	SP	47	±15	Yes	±9
	30 May 2001	GB	1.5	6.8	700	22.8	20	Clear, none	SP	23	±6	Yes	±3
	22 Aug 2001	GB	2.1	6.9	540	21.2	-20	Clear, none	SP	5	±5	No	±3
	29 Nov 2001	GB	NM	6.7	550	19.5	-170	Clear, none	SP	16	±5	Yes	±3
	29 Sep 2003	GB	1.5	6.5	560	22.4	30	Clear, none	SP	10	±5	No	±3
MW5	1 Feb 2001	GB	0.8	6.7	640	18.1	-250	Turbid, brown	SP	18	±20	No	±10
	30 May 2001	GB	1.2	7.0	630	19.6	20	Clear, none	SP	4	±6	No	±3
	22 Aug 2001	GB	2.2	7.0	600	20.0	-40	Clear, none	SP	5	±5	No	±3
	29 Nov 2001	GB	NM	6.9	610	19.6	-170	Clear, none	SP	8	±7	No	±3
	29 Sep 2003	GB	1.6	6.7	560	21.9	-60	Clear, none	SP	10	±5	No	±3
MW6	1 Feb 2001	GB	2.8	6.7	510	18.7	-360	Opaque, brown	SP	23	±20	No	±11
	30 May 2001	GB	2.9	6.8	470	24.2	80	Turbid, brown	SP	5	±6	No	±3
	22 Aug 2001	GB	2.6	6.9	400	21.0	30	Turbid, green	SP	5	±5	No	±3
	29 Nov 2001	GB	NM	6.8	390	19.5	-160	Clear, none	SP	8	±7	No	±3
	29 Sep 2003	GB	2.1	6.6	470	25.5	180	Clear, none	SP	10	±5	No	±3
MW7	1 Feb 2001	GB	3.0	6.8	430	16.1	-200	Cloudy, brown	SP	25	±17	No	±11
	30 May 2001	GB	3.1	6.8	500	23.6	60	Clear, none	SP	5	±5	No	±3
	22 Aug 2001	GB	4.6	6.9	420	19.3	20	Turbid, gray	SP	5	±5	No	±3
	29 Nov 2001	GB	NM	6.7	400	19.2	-2	Clear, none	SP	6	±6	No	±3
	29 Sep 2003	GB	2.4	6.3	410	19.0	180	Clear, none	SP	10	±4	No	±3

General Notes

(a) ORP = oxidation/reduction potential.

(b) NM = not measured.

(c) Entries in this table correspond to the end of purging (time of sampling).

(d) SP = submersible purge pump.

(e) GB = grab sample collected using a Teflon bailer fitted with a bottom-emptying device.

Table 5 (Page 1 of 2)

Groundwater Analytical Data from Monitoring Wells

4401 Market Street, Oakland CA

Location	Sample Date	TPH-Gasoline (µg/L)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Methyl Tert-Butyl Ether (µg/L)	Tert-Butyl-Alcohol (µg/L)	Other Fuel Oxygenates (µg/L)
MW1	8 Nov 1994	54	<0.5	<0.5	<0.5	1.2	NA	NA	NA
	14 Feb 1995	71	<0.5	<0.5	<0.5	0.97	NA	NA	NA
	7 Jun 1995	540	0.6	<0.5	1.7	1.3	NA	NA	NA
	29 Aug 1995	440	<0.5	<0.5	1.3	1.1	NA	NA	NA
	8 Dec 1995	<50	<0.5	<0.5	<0.5	<0.5	NA	NA	NA
	7 Mar 1996	77	<0.5	<0.5	<0.5	<0.5	44	NA	NA
	19 Jun 1996	500	<0.5	<0.5	0.85	0.36	84	NA	NA
	20 Dec 1996	<50	<0.5	<0.5	<0.5	<0.5	28	NA	NA
	12 Jun 1997	190	<0.5	<0.5	<0.5	<0.5	12	NA	NA
	1 Feb 2001	<50	<0.5	<0.5	<0.5	1.1	<5.0	<5.0	<5.0 to <10
	30 May 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0
	22 Aug 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	100	<5.0 to <10
	29 Nov 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	29 Sep 2003	<50	<0.5	<0.5	<0.5	<1.0	<0.5	<5.0	<0.5 to <1.0
MW2	8 Nov 1994	20,000	1,400	960	980	4,600	NA	NA	NA
	14 Feb 1995	8,600	380	210	410	2,000	NA	NA	NA
	7 Jun 1995	6,200	500	78	270	1,200	NA	NA	NA
	29 Aug 1995	4,100	330	61	210	980	NA	NA	NA
	8 Dec 1995	9,400	360	190	440	2,000	NA	NA	NA
	7 Mar 1996	12,000	790	170	440	2,000	18	NA	NA
	19 Jun 1996	9,000	520	82	350	1,500	<5.0	NA	NA
	20 Dec 1996	13,000	830	180	410	2,200	<16	NA	NA
	12 Jun 1997	5,100	320	32	190	880	<36	NA	NA
	29 Sep 2003	220	5.5	<0.5	2.1	9.1	<0.5	24	DIPE = 1.3 Others = <0.5
MW3	8 Nov 1994	<50	0.71	0.84	1.2	5.8	NA	NA	NA
	14 Feb 1995	<50	<0.5	<0.5	<0.5	<0.5	NA	NA	NA
	7 Jun 1995	<50	<0.5	<0.5	<0.5	1.6	NA	NA	NA
	29 Aug 1995	<50	<0.5	<0.5	<0.5	<0.5	NA	NA	NA
	8 Dec 1995	<50	<0.5	<0.5	<0.5	<0.5	NA	NA	NA
	7 Mar 1996	<50	<0.5	<0.5	<0.5	<0.5	<5.0	NA	NA
	19 Jun 1996	<50	<0.5	<0.5	<0.5	<0.5	<5.0	NA	NA
	20 Dec 1996	<50	<0.5	<0.5	<0.5	<0.5	<5.0	NA	NA
	12 Jun 1997	<50	<0.5	<0.5	<0.5	<0.5	<5.0	NA	NA
	1 Feb 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	30 May 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	22 Aug 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	14	<5.0 to <10
	29 Nov 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	29 Sep 2003	<50	<0.5	<0.5	<0.5	<1.0	<0.5	<5.0	<0.5 to <1.0
MW4	1 Feb 2001	1,500	58	1.3	83	320	<5.0	16	<5.0 to <10
	30 May 2001	1,000	19	<0.5	50	3.4	<5.0	23	<5.0 to <10
	22 Aug 2001	220	<0.5	<0.5	3.2	2.7	<5.0	8.8	<5.0 to <10
	29 Nov 2001	3,100	110	<5.0	120	410	<5.0	<5.0	<5.0 to <10
	29 Sep 2003	140	<0.5	<0.5	<0.5	<1.0	<0.5	<5.0	<0.5 to <1.0
MW5	1 Feb 2001	1,200	57	1.8	45	160	<5.0	<5.0	<5.0 to <10
	30 May 2001	570	20	<0.5	26	22	<5.0	<5.0	<5.0 to <10
	22 Aug 2001	380	19	0.67	31	17	<5.0	<5.0	<5.0 to <10
	29 Nov 2001	1,600	73	2.1	78	180	<5.0	<5.0	<5.0 to <10
	29 Sep 2003	460	2.6	<0.5	0.69	<1.0	<0.5	<5.0	<0.5 to <1.0

Table 5 (Page 2 of 2)

Groundwater Analytical Data from Monitoring Wells

4401 Market Street, Oakland CA

Location	Sample Date	TPH-Gasoline (μg/L)	Benzene (μg/L)	Toluene (μg/L)	Ethyl-benzene (μg/L)	Total Xylenes (μg/L)	Methyl Tert-Butyl Ether (μg/L)	Tert-Butyl-Alcohol (μg/L)	Other Fuel Oxygenates (μg/L)
MW6	1 Feb 2001	260	8.0	<0.5	22	23	<5.0	<5.0	<5.0 to <10
	30 May 2001	53	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	22 Aug 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	29 Nov 2001	130	5.7	<0.5	1.6	5.0	<5.0	<5.0	<5.0 to <10
	29 Sep 2003	<50	<0.5	<0.5	<0.5	<1.0	<0.5	<5.0	<0.5 to <1.0
MW7	1 Feb 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	30 May 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	22 Aug 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	29 Nov 2001	<50	<0.5	<0.5	<0.5	<0.5	<5.0	<5.0	<5.0 to <10
	29 Sep 2003	<50	<0.5	<0.5	<0.5	<1.0	<0.5	<5.0	<0.5 to <1.0

Environmental Screening Level - California Maximum Contaminant Level	1.0	150	300	1,750	13		

General Notes

(a) TPH = total petroleum hydrocarbons. MtBE = methyl tert-butyl ether. DiPE = di-isopropyl ether.

(b) NA = not analyzed.

(c) Environmental Screening Level from: *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater (Interim Final -November 2007, Revised May 2008).* Prepared by San Francisco Bay Regional Water Quality Control Board, Oakland CA. 27 May 2008. www.waterboards.ca.gov/sanfranciscobay/esl.shtml

Table 6

Soil Analytical Data During Tank Removal

4401 Market Street, Oakland CA

Location	Sample Depth (feet)	Location Description	Sample Date	Sample Type	TPH-Gasoline (mg/kg)	Benzene (mg/kg)	Toluene (mg/kg)	Ethyl-benzene (mg/kg)	Total Xylenes (mg/kg)
S2	±8.5	±2-feet below invert of middle 500-gallon gasoline tank	22 June 1990	Grab (liner)	360	0.99	12	9.5	53
S3	±7.5	±2-feet below invert of southern 500-gallon gasoline tank	22 June 1990	Grab (liner)	160	1.2	2.5	2.8	13
S4	±8	±2-feet below invert at non-fill end of 1,000-gallon gasoline tank	22 June 1990	Grab (liner)	210	3.3	9.4	7.6	32
S5	±8	±2-feet below invert at fill end of 1,000-gallon gasoline tank	22 June 1990	Grab (liner)	870	3.2	24	20	110
S6	±8.5	±2-feet below invert of northern 500-gallon gasoline tank	22 June 1990	Grab (liner)	730	5	24	26	140
S8	±15	±8.5-feet below inverts and midway between the two northern 500-gallon gasoline tanks	22 June 1990	Grab (liner)	260	3.7	14	7.1	33

General Note

(a) TPH = total petroleum hydrocarbons.

Table 7

Soil Analytical Data from Borings and Monitoring Wells

4401 Market Street
Oakland CA

Location	Sample Depth (feet)	Sample Date	TPH-Gasoline (mg/kg)	Benzene $^{(c)}$ (mg/kg)	Toluene (mg/kg)	Ethyl-benzene $^{(c)}$ (mg/kg)	Total Xylenes (mg/kg)	MtBE $^{(c)}$ (mg/kg)	Other Fuel Oxygenates (mg/kg)
SB1	10 to 10.5	27 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
	15 to 15.5	27 October 1994	72	<0.01	0.13	0.21	0.18	NM	NM
	20 to 20.5	27 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
SB2	10 to 10.5	27 October 1994	40	0.079	0.034	0.43	4.7	NM	NM
	15 to 15.5	27 October 1994	19	0.46	0.041	0.31	4.2	NM	NM
	20 to 20.5	27 October 1994	5.7	0.006	<0.005	0.010	0.079	NM	NM
SB3	10 to 10.5	27 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
	15 to 15.5	27 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
	19.5 to 20	27 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
SB4	10 to 10.5	28 October 1994	<1	<0.005	0.005	0.006	0.016	NM	NM
	15 to 15.5	28 October 1994	220	<0.01	0.60	0.46	0.93	NM	NM
	19.5 to 20	28 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
MW1	10 to 10.5	27 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
	15 to 15.5	27 October 1994	<1	<0.005	<0.005	0.005	<0.005	NM	NM
	20 to 20.5	27 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
MW2	10 to 10.5	28 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
	15 to 15.5	28 October 1994	97	1.5	1.4	2.3	12	NM	NM
	20 to 20.5	28 October 1994	2.0	<0.005	0.009	0.016	0.062	NM	NM
MW3	10 to 10.5	28 October 1994	1.1	<0.005	0.006	<0.005	0.010	NM	NM
	15 to 15.5	28 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
	20 to 20.5	28 October 1994	<1	<0.005	<0.005	<0.005	<0.005	NM	NM
B8	11.5 to 12	8 April 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	8 April 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
B9	11.5 to 12	8 April 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	8 April 1999	110	<0.62	<0.62	<0.62	<0.62	<0.62	NM
B10	11.5 to 12	8 April 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	8 April 1999	1,300	12	22	25	100	<3.1	NM
B11	11.5 to 12	8 April 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	8 April 1999	140	<0.62	<0.62	1.8	8.9	<0.62	NM
B12	11.5 to 12	8 April 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	8 April 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
B13	11.5 to 12	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
B14	11.5 to 12	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	9 July 1999	3.6	<0.005	<0.005	<0.005	0.036	<0.005	NM
	21 to 21.5	9 July 1999	2.1	<0.005	<0.005	0.059	0.32	<0.005	NM
B15	11.5 to 12	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	17.5 to 18	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
B16	11.5 to 12	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	15 to 15.5	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
	19.5 to 20	9 July 1999	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	NM
MW4	12.5 to 13	5 January 2001	25	<0.62	<0.62	<0.62	<0.62	<0.005	<0.005 to <0.010
	14 to 14.5	5 January 2001	29	<0.62	<0.62	<0.62	<0.62	<0.023	<0.023 to <0.046
	15.5 to 16	5 January 2001	140	<3.1	<3.1	<3.1	5.3	<0.023	<0.023 to <0.046
MW5	12.5 to 13	4 January 2001	120	<3.1	<3.1	<3.1	9.2	<0.019	<0.019 to <0.038
	14 to 14.5	4 January 2001	560	<1.2	<1.2	8.5	43	<0.023	<0.023 to <0.045
	15.5 to 16	4 January 2001	93	<0.62	0.79	1.3	7.6	<0.022	<0.022 to <0.043
MW6	12.5 to 13	4 January 2001	91	<0.62	<0.62	1.0	1.3	<0.016	<0.016 to <0.038
	14 to 14.5	4 January 2001	200	<3.1	<3.1	<3.1	<3.1	<0.020	<0.020 to <0.040
MW7	10 to 10.5	5 January 2001	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005 to <0.010
	15 to 15.5	5 January 2001	<1.0	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005 to <0.010

Environmental Screening Level - Leaching to Drinking Water		0.044	2.9	3.3	2.3	0.023	
Environmental Screening Level - Direct Exposure, Residential Land Use		0.12	63	2.3	31	30	

General Note

(a) TPH = total petroleum hydrocarbons. MtBE = methyl tert-butyl ether. NM = not measured

(b) Environmental Screening Levels from: *Screening For Environmental Concerns at Sites With Contaminated Soil and Groundwater (Interim Final -November 2007, Revised May 2008).* Prepared by San Francisco Bay Regional Water Quality Control Board, Oakland CA. 27 May 2008. www.waterboards.ca.gov/sanfranciscobay/esl.shtml

Footnote

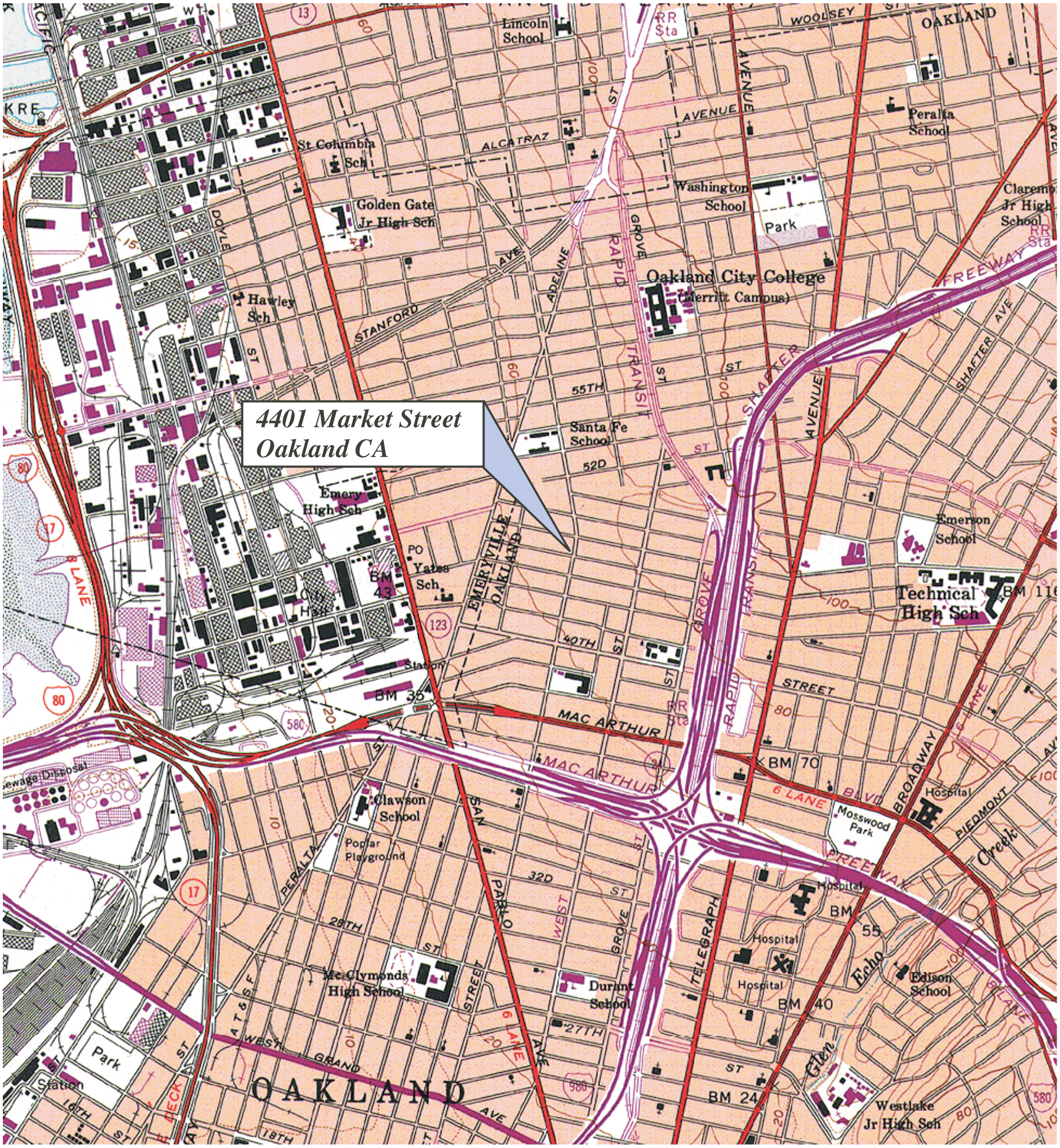
(c) = carcinogen.

Table 8

Soilgas Sampling and Testing Requirements

4401 Market Street
Oakland CA

Item	Requirement
Sampling Locations	Six (SG1 through SG6).
Rationale for the Selected Locations	• SG1 was located as the background location. SG1 is located upgradient of the former tanks. • SG2-SG4 were located to measure the residual concentrations in the vicinity of the former tanks. • SG5 was located downgradient of the former underground gasoline tanks, adjacent to monitoring well MW2. Well MW2 had measured the highest concentration of benzene in groundwater at the site. • SG6 was located downgradient of the former underground gasoline tanks and adjacent to boring B10. Boring B10 had measured the highest benzene concentration in soil (12 mg/kg) in 1999.
Boreholes	A rotary drill will be used to drill through the pavement. A direct-push drill rig will be used to install the 0.75-inch diameter steel sample probes at each sampling location.
Depth	Sample probes will be installed at ±5 feet below ground surface.
Seal	A hydrated bentonite seal will be placed around the drive probe at the ground surface to prevent ambient air intrusion.
Purge Test at SG3 (the purge volume will be evaluated at 1, 3, and 7 volumes)	A purge test will be conducted for SG3 at one, three, and seven purge volumes. The purge test will be conducted at a low flow rate (less than 200 milliliters per minute). Concentrations of volatile organic compounds will be measured for each purge volume using a field PID meter. The purge volume providing the highest concentration will be selected for all subsequent soil gas samples.
Leak Test	A leak test will be performed during each soilgas sampling using butane as a tracer gas. Butane will be exposed to the bentonite seal, purge valves, fittings, and anywhere else serving as a potential conduit for cross-contamination or ambient air intrusion.
Field Observations and Measurements	Organic vapor measurements will be recorded. Observations of odor will also be recorded. Upon completing the sampling in each borehole, the atmosphere inside each borehole will be measured with field organic vapor monitor.
Sample Container	1-Liter Summa Canister.
Analytical Testing for Soilgas Samples	Analyze soilgas samples for volatile organic compounds using EPA Method TO14a and butane using Method ASTM D-1945.
Decontamination	Wash downhole equipment between borings. Wash with soap (Alconox or similar), rinse with tap water, and rinse with distilled water.
Sample Handling	Summa Canisters will be labeled with the appropriate ID and sample time and pre-sampling and post-sampling vacuum measurements. No refrigeration is required. Canisters will be immediately shipped overnight.
Field Quality Control	Butane (shaving cream, butane lighters) will be applied to the bentonite seal, sample valves, and fittings in order to detect any potential leaks.
Completion	Backfill boreholes with cement-bentonite grout (1 sack/94 pounds cement and 5 pounds bentonite to 7.5 gallons water).
Investigation-Derived Waste	Only decontamination wastewater will be generated. Decontamination wastewater may be discharged to the sanitary sewer.



Basemap: U.S. Geological Survey, 7.5 Minute Quadrangle, Oakland West CA, 1959 (Photorevised 1980).

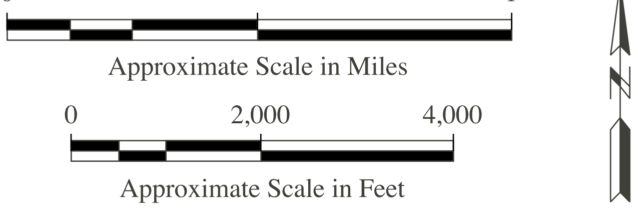
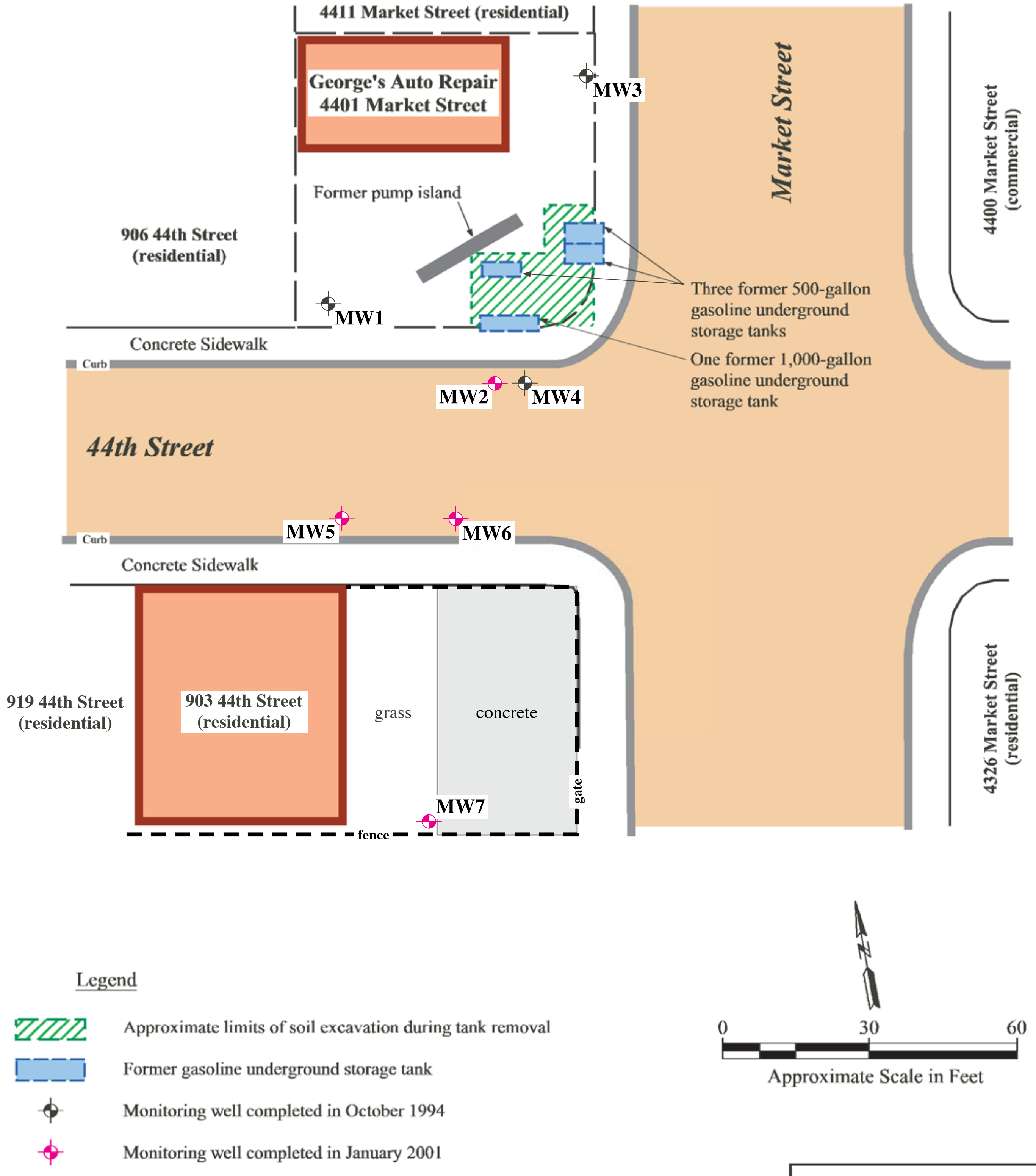


Figure 1

Location Map

4401 Market Street
Oakland CA

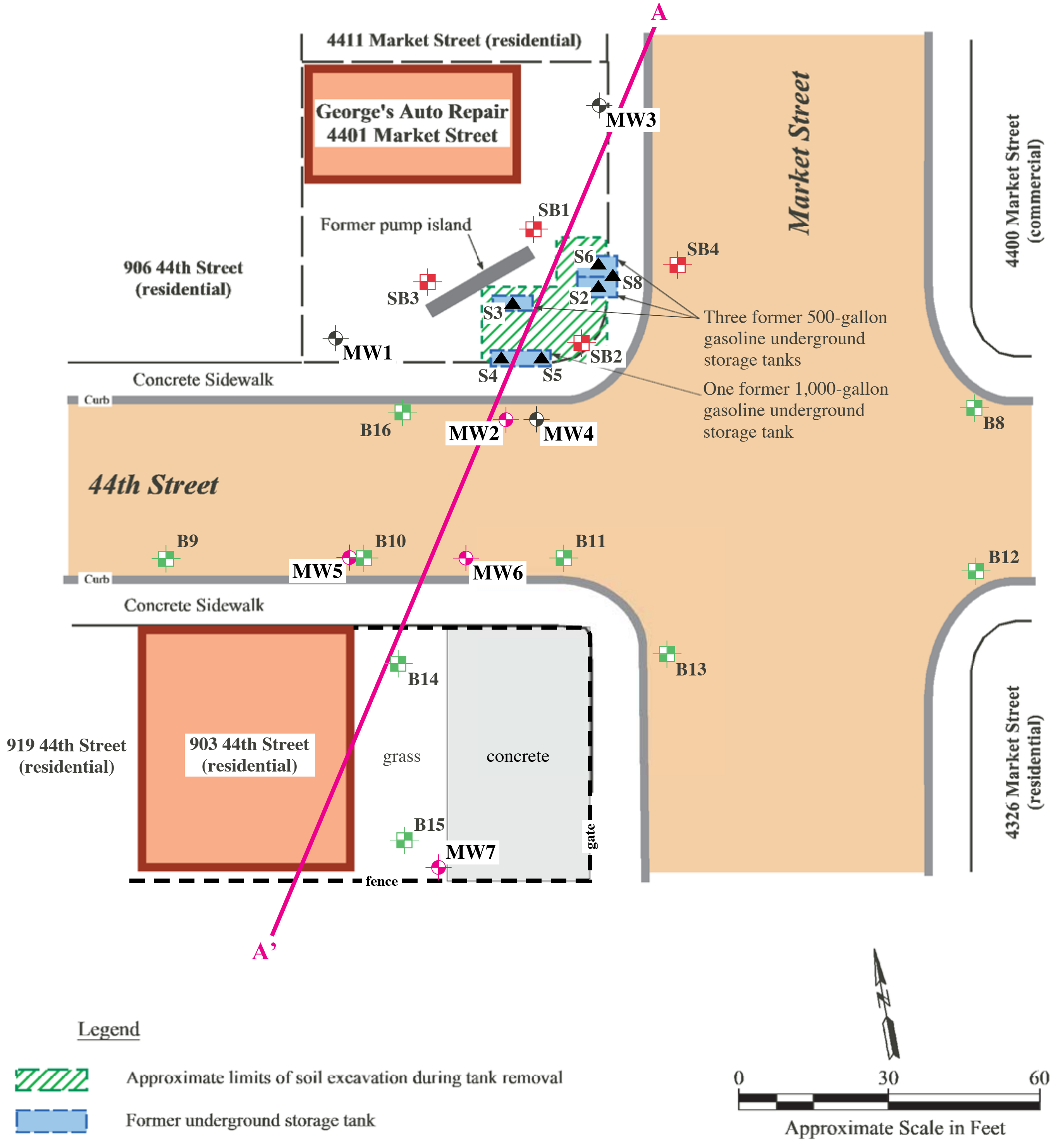


Locations of former underground tanks and pump island from W.A. Craig report dated 1994.

Figure 2

Site Map

4401 Market Street
Oakland CA



Legend

▨	Approximate limits of soil excavation during tank removal
🟦	Former underground storage tank
⊕	Monitoring well completed in October 1994
⊕	Monitoring well completed in January 2001
▲	Soil sample collected during tank removal in June 1990
🟥	Boring completed in October 1994
🟩	Boring completed in April 1999 or July 1999

Locations of former underground tanks and pump island from W.A. Craig report dated 1994.

Figure 3

Exploration and Cross-Section Locations

4401 Market Street
Oakland CA

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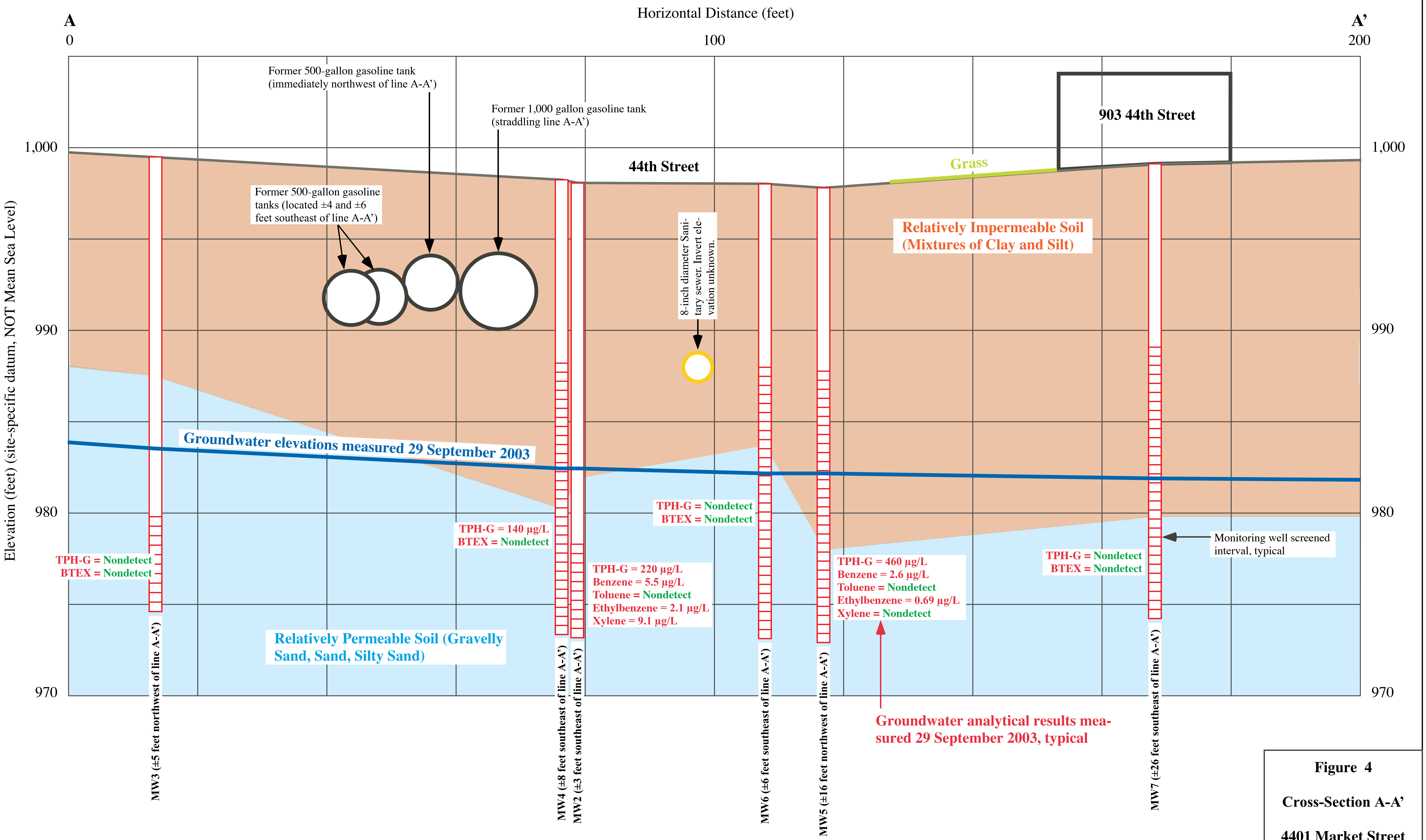

Note: The groundwater gradient has historically been directed from A to A’.

Figure 4

Cross-Section A-A’

4401 Market Street
Oakland CA

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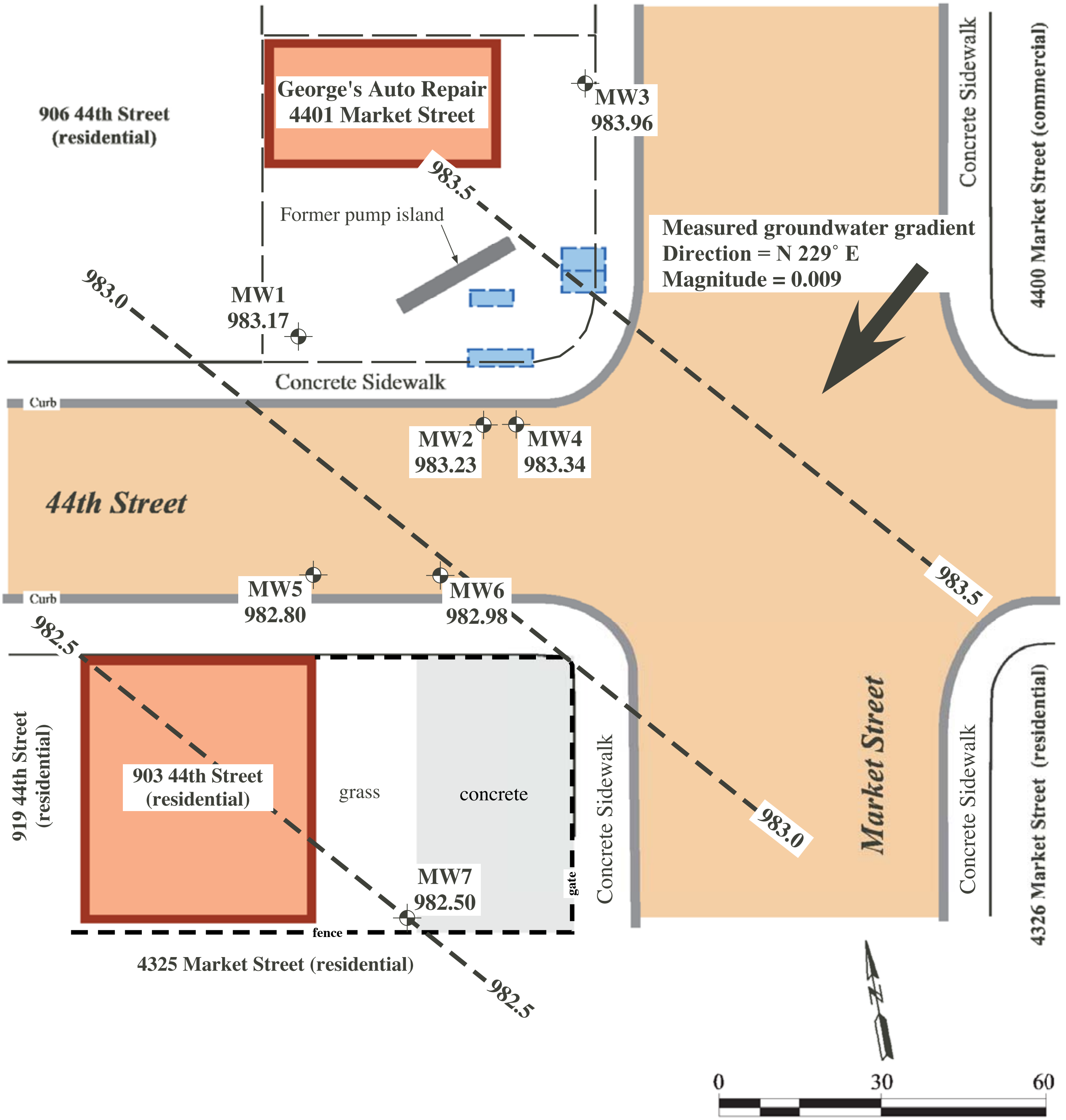


Note: Groundwater elevations cited in units of feet, referenced to site-specific datum (not Mean Sea Level).

Legend

- ⌖ Monitoring well
- ▭ Former gasoline underground tank

Locations of former underground tanks and pump island from W.A. Craig report dated 1994.

Figure 5

Groundwater Levels and Gradient (29 September 2003)

**4401 Market Street
Oakland CA**

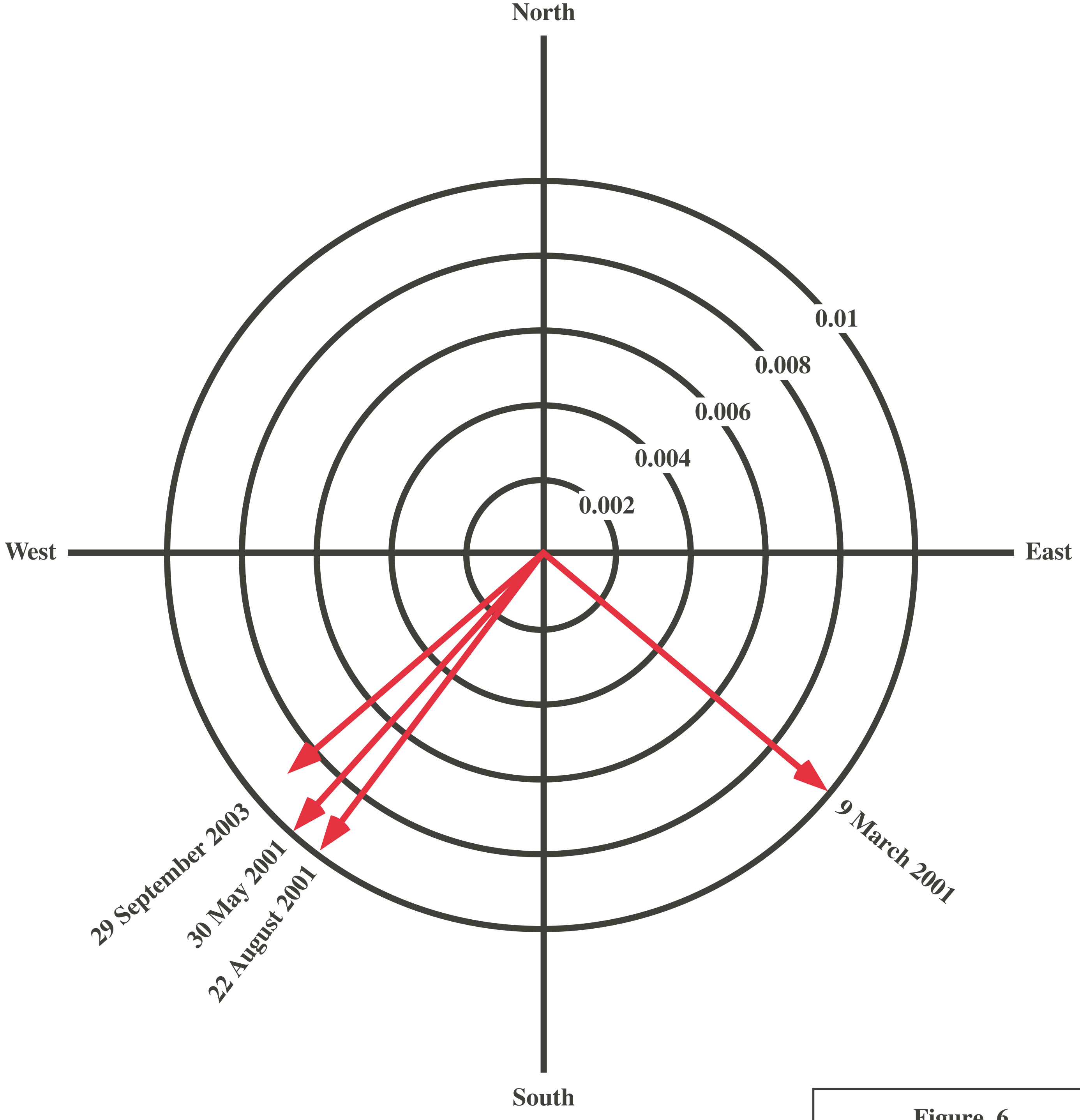
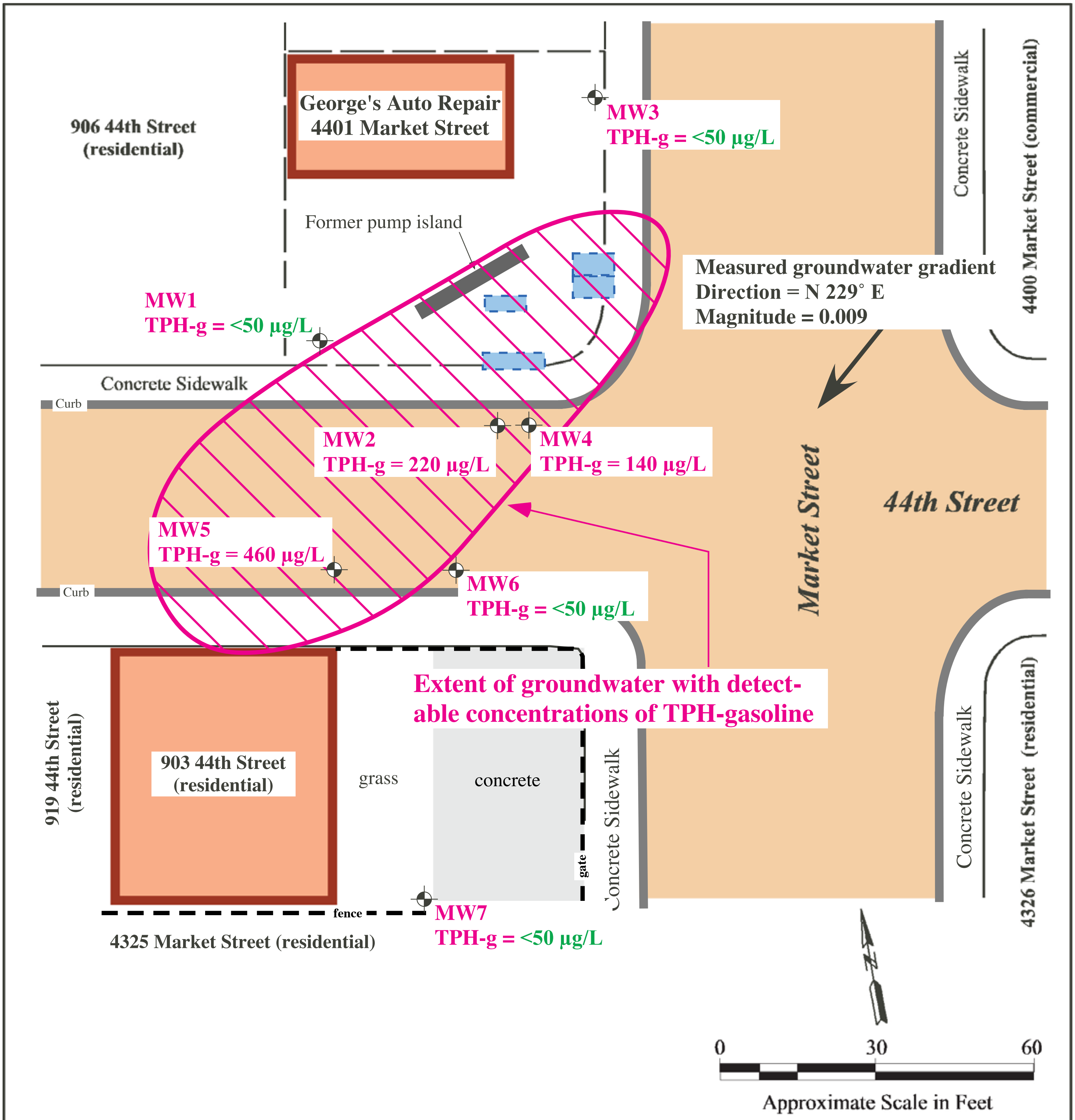


Figure 6

Rose Diagram of the Groundwater Gradient

4401 Market Street
Oakland CA



Legend

⌖ Monitoring well

▭ Former gasoline underground storage tank

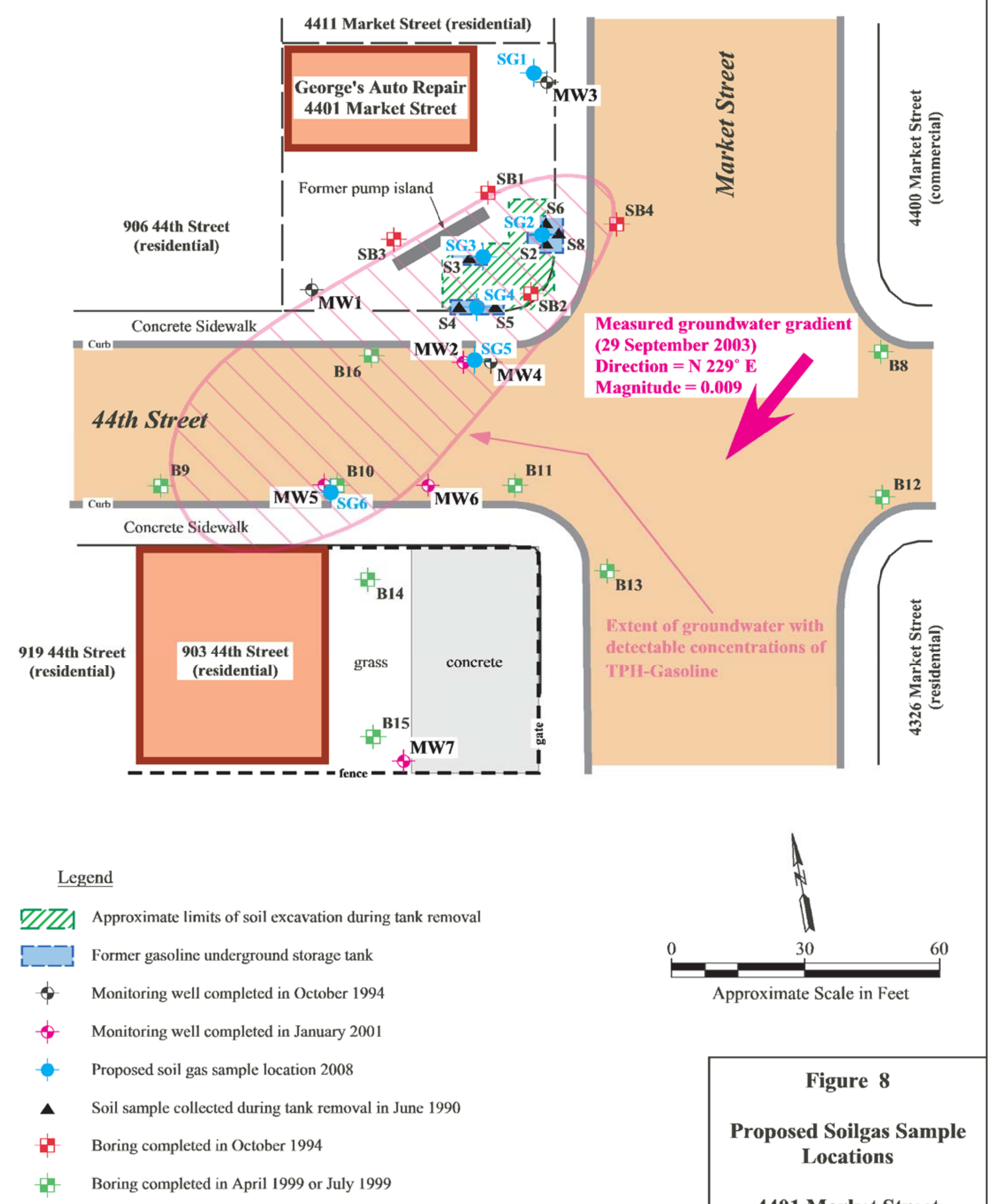
TPH-g = Total Petroleum Hydrocarbons as Gasoline

Locations of former underground tanks and pump island from W.A. Craig report dated 1994.

Figure 7

Extent of TPH-Gasoline in Groundwater (29 September 2003)

**4401 Market Street
Oakland CA**



Locations of former underground tanks and pump island from W.A. Craig report dated 1994.

Figure 8

Proposed Soilgas Sample Locations

4401 Market Street
Oakland CA

ATTACHMENT 1

Site Safety Plan

Site Safety Plan

Soilgas Sampling
4401 Market Street
Oakland CA

Anticipated Fieldwork The anticipated fieldwork includes collecting soilgas samples.

Chemical Hazard Evaluation Gasoline constituents, which have been detected in soil and groundwater during previous investigations at the property, are summarized in Table 1.

Physical Hazard Evaluation Physical hazards which may be encountered include: heavy machinery, heavy lifting, slip-trip-fall, loud noise, and heat exposure.

Health and Safety Responsibilities This site safety plan will be implemented by the site safety officer under the supervision of the project manager and in coordination with an appropriate client representative. Safety personnel and their responsibilities are presented in Table 2.

Work Zone A work zone will be established around the area of work. The work zone is an area of sufficient size to allow safe completion of the work while maintaining control of access to the work area. The work zone will be restricted by requesting people not directly involved in the work to stay out of the immediate work area, and/or by restricting access by other suitable means, such as with a work fence, traffic cones, or barricades.

No smoking, chewing of tobacco or gum, eating, or drinking will be allowed in the work zone.

Personal Protective Equipment Fieldwork will begin in modified Level-D personal protection (Table 3). If air monitoring results of the work zone exceed the action levels specified below, then personal protective equipment will be upgraded to modified Level-C (Table 3).

Monitoring Visual monitoring should be routinely conducted by the workers. Workers should evaluate themselves and co-workers for signs of fatigue as the work progresses. Work breaks should be taken as reasonably required to maintain safety and efficiency.

The breathing zone in the work area will be monitored using a field organic vapor monitor (Thermo Environmental Instruments Model 580B, 10.0 eV photoionization detector, calibrated to 100 ppm v/v isobutylene). If continual readings greater than 5 ppm above background are detected in the breathing zone, personal protection should be upgraded to modified Level-C from modified Level-D. 5 ppm was selected using the exposure criteria in Table 1.

If continual readings greater than 50 ppm above background are recorded in the breathing zone, work should stop. Work should be resumed after consultation with the project manager and possibly the client, and may include additional safety precautions.

Emergency Procedures. These procedures are designed to allow rapid treatment of workers for injuries or exposure to hazardous substances occurring on the worksite. A secondary purpose of these procedures is to allow documentation of emergencies.

Emergency information is summarized in Table 4. The location of the nearest hospital is shown on Figure 1.

If required, first aid will be provided for injured workers.

The site safety officer will be notified immediately of an emergency. It is the site safety officer's responsibility to document the emergency and report it to the project manager and client in a timely manner.

Decontamination Decontamination refers to removal of potential chemical contamination from worker's clothing and from health and safety monitoring equipment. In many instances, removal and thorough cleaning of work clothing is adequate for worker decontamination. However, if skin contact with chemical-containing material occurs during fieldwork, the affected area will be washed thoroughly with soap and water.

Monitoring equipment should be kept clean by wiping as required with a paper towel or other suitable material.

Health and Safety Wastes Wastes generated by health and safety practices include disposable protective equipment such as gloves, tyvek-coveralls, and boot covers, as well as used paper towels. These items may be disposed of with normal municipal refuse.

Liquid wastes from washing may be disposed of in the sanitary sewer.

Table 1

Chemical Hazard Evaluation

4401 Market Street
Oakland CA

Chemical	Maximum Measured in Soil (mg/kg)	Maximum Measured in Groundwater (μg/L)	Odor Threshold (ppm v/v)	Lower Explosive Limit (ppm v/v)	Time Weighted Average or Permissible Exposure Limit (whichever is lower) (ppm v/v)	Immediately Dangerous to Life and Health (ppm v/v)
Total Petroleum Hydrocarbons as Gasoline	1,300	free product	NA	14,000	300	NA
MtBE	not detected	84	NA	NA	NA	NA
Benzene	12	1,400	34 – 119	13,000	1	500 – 1,000
Toluene	24	960	0.16 – 37	12,000	50	2,000
Ethylbenzene	26	980	0.092 – 0.6	10,000	100	800
Xylenes	140	4,600	20	10,000	100	900

General Notes

(a) Exposure criteria from: (1) American Conference of Governmental Industrial Hygienists, *1993-1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*, (2) 3M Occupational Health and Environmental Safety Division, *1996 Respirator Selection Guide*, 1996, (3) American Conference of Governmental Industrial Hygienists, *Guide to Occupational Exposure Values*, Undated (circa 1990), (4) National Institute for Occupational Safety and Health, *Pocket Guide to Chemical Hazards*, June 1990, and (5) *Material Safety Data Sheet, Chevron Unleaded Gasoline*, Chevron Environmental Health Center, Richmond CA, 12 September 1991.

(b) NA = applicable value was not found in the cited references.

Table 2

Safety Personnel and Responsibilities
4401 Market Street
Oakland CA

Personnel	Responsibilities
Project Manager (Douglas W. Lovell)	Development and overall implementation of Site Safety Plan, provide properly trained onsite personnel to complete the work, coordination of safety issues with client.
Site Safety Officer (Darcy Hinkley)	Onsite implementation of Site Safety Plan, coordination and documentation of field safety procedures, communication of safety issues to project manager, delineate work zone, atmospheric monitoring, review site safety procedures with subcontractors, contact Underground Service Alert, clear underground utilities, maintain adequate supply of safety equipment onsite for Streamborn personnel.
Subcontractor's Site Safety Officer (not anticipated)	Understand and obtain subcontracting crews' compliance with Site Safety Plan, maintain onsite supply of safety equipment for subcontractor's personnel, relay safety concerns to Site Safety Officer.

Table 3

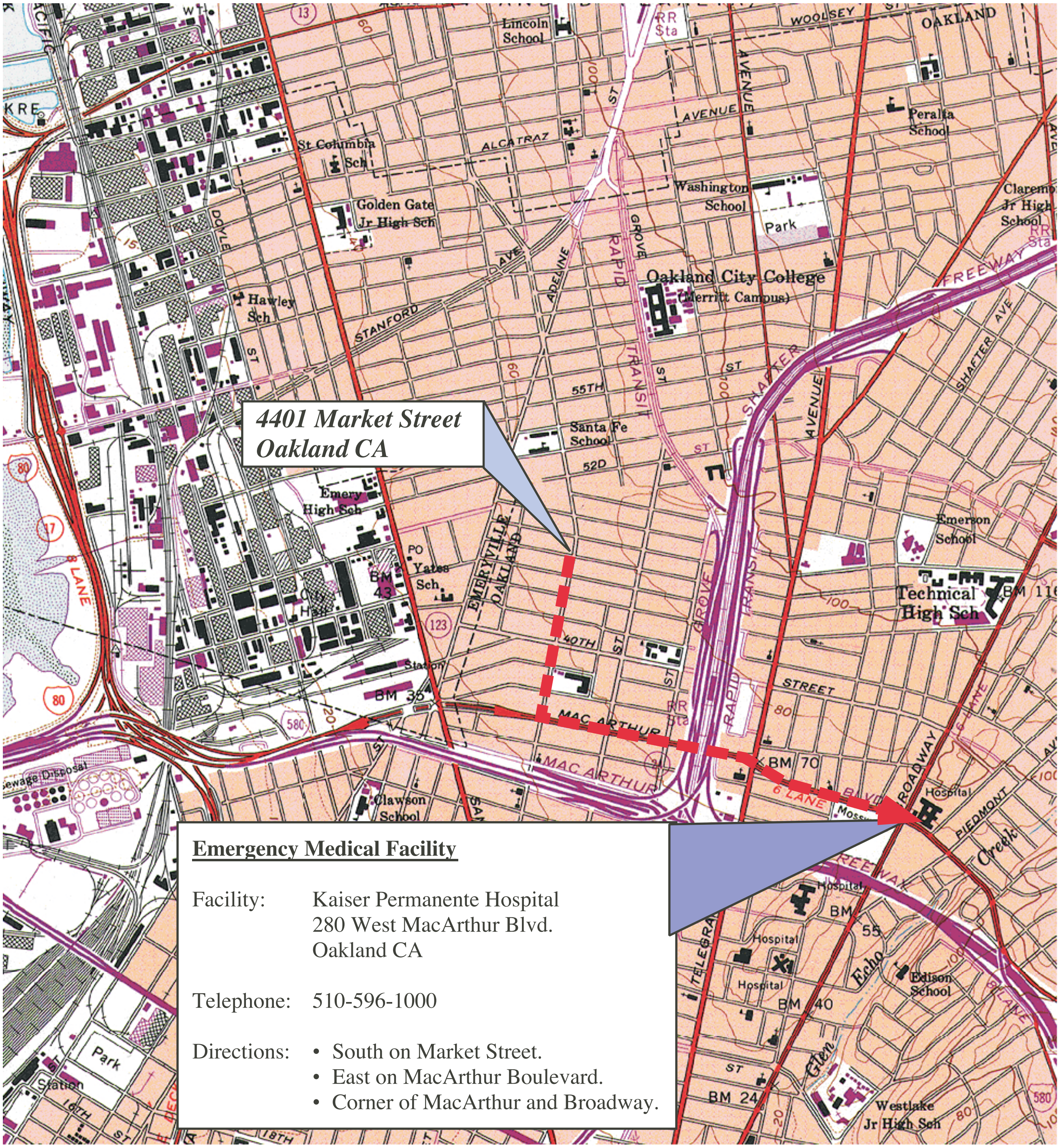
Personnel Protective and Monitoring Equipment
4401 Market Street
Oakland CA

Item	Requirement
Modified Level-D Personal Protective Equipment	Hardhat, dedicated work clothing (cotton coveralls or tyveks), water repellent steel-toed boots, work gloves, latex gloves (as appropriate), nitrile gloves (as appropriate), first aid kit, fire extinguisher, warning tape, optional eye and hearing protection.
Modified Level-C Personal Protective Equipment	Add Half-face respirator with OV-HEPA cartridges and mandatory tyveks to modified Level-D protective equipment. Change respirator cartridges upon detection of breakthrough (by smell), increase in breathing resistance, or daily (whichever is more frequent).
Atmospheric Monitoring	Field organic vapor monitor capable of detecting organic vapor concentrations of 1 ppm (v/v). Field organic vapor monitor to be calibrated to known reference gas daily. Action levels (measurement in the breathing zone of work area): >5 ppm for 10 minutes: upgrade to modified Level C >50 ppm for 10 minutes: stop work, consult with project manager
Visual Monitoring	Evaluate yourself and co-workers for signs of fatigue and visual signs of distress (that may be caused by physical labor and possible chemical exposure).

Table 4

Emergency Information
4401 Market Street
Oakland CA

Emergency Service or Contact	Telephone	Address and Directions
Hospital	510-596-1000	• Kaiser Permanente Hospital 280 W.est MacArthur Boulevard Oakland CA • From property, go south on Market Street. • Turn left on MacArthur Boulevard. • Hospital is on the left, after crossing Broadway. • See Figure 1.
Ambulance	911	
Fire Department	911	
Police Department	911	
Onsite Telephone	none	
Site Safety Officer	Darcy Hinkley 510-528-4234 (work) 408-500-2801 (mobile)	
Project Manager	Douglas W. Lovell 510-528-4234 (work) 510-520-3146 (mobile)	
Property Owner (or Representative)	Casimiro Damele 510-531-0778	
Subcontractors	To be determined	



4401 Market Street
Oakland CA

Emergency Medical Facility

Facility: Kaiser Permanente Hospital
280 West MacArthur Blvd.
Oakland CA

Telephone: 510-596-1000

Directions:
- South on Market Street.
- East on MacArthur Boulevard.
- Corner of MacArthur and Broadway.

Basemap: U.S. Geological Survey, 7.5 Minute Quadrangle, Oakland West CA, 1959 (Photorevised 1980).

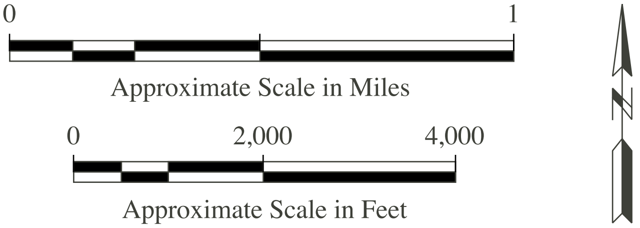


Figure 1

Hospital Location Map

4401 Market Street
Oakland CA

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ATTACHMENT 2

Selected Soilgas Sampling Guidance Documents

Gray Davis, Governor
Winston H. Hickox, Agency Secretary
California Environmental Protection Agency

Department of Toxic Substances Control
Edwin F. Lowry, Director
1011 N. Grandview Avenue
Glendale, California 91201
Phone (818) 551-2800
FAX (818) 551-2832
www.dtsc.ca.gov

California Regional Water Quality Control Board
Los Angeles Region
320 W. 4th Street, Suite 200
Los Angeles, California 90013
Phone (213) 576-6600
FAX (213) 576-6640
www.swrcb.ca.gov/rwqcb4

January 28, 2003

To: Interested Parties

ADVISORY – ACTIVE SOIL GAS INVESTIGATIONS

In a coordinated effort, the Department of Toxic Substances Control (DTSC) and the California Regional Water Quality Control Board – Los Angeles Region (LARWQCB) have jointly developed the "Advisory – Active Soil Gas Investigations" (see the attached). This document is to ensure that consistent methodologies are applied during active soil gas investigations to produce high quality data for regulatory decision-making. The document has been reviewed by other government organizations and by the soil gas consulting community. Their comments have been considered and, where appropriate, incorporated in the document. This is an on-going effort to streamline the characterization of gas phase contaminant sites. As additional knowledge and experience are obtained, this Advisory may be modified as appropriate.

This document is issued by DTSC and LARWQCB as an Advisory subject to review and revision as necessary. The information in this Advisory should not be considered as regulations. Mention of trade names or commercial products does not constitute the Agency's endorsement or recommendation.

If you have any questions regarding this document, please contact the joint-agency project coordinator Mr. Joe Hwong, of DTSC, at (714) 484-5406.

Sincerely,

Edwin F. Lowry

Edwin F. Lowry
Director
Department of Toxic Substances Control

Dennis A. Dickerson
Executive Officer
California Regional Water Quality Control Board
Los Angeles Region

Enclosure

ADVISORY – ACTIVE SOIL GAS INVESTIGATIONS

As a coordinated effort, this document is issued by the California Regional Water Quality Control Board – Los Angeles Region (LARWQCB) and Department of Toxic Substances Control (DTSC) as an Advisory subject to review and revision as necessary. Mention of trade names or commercial products does not constitute the Agency's endorsement or recommendation. The information in this Advisory should not be considered as regulations. In this Advisory, "Agency" should mean LARWQCB and/or DTSC.

1.0 INTRODUCTION

Active soil gas investigations are useful to obtain vapor phase data at sites potentially affected by volatile organic compounds (VOCs), including chlorinated and aromatic hydrocarbons. Active soil gas investigations may also be used to investigate sites potentially affected by methane and hydrogen sulfide, and to measure fixed and biogenic gasses (e.g., oxygen, carbon dioxide, or carbon monoxide). Among other things, the data can be used to identify the source and determine the spatial distribution of VOC contamination at a site, or to estimate indoor air concentrations for risk assessment purposes.

For site characterization, the Agency encourages both soil gas and soil matrix sampling. Typically, soil gas data are more representative of actual site conditions in coarse-grained soil formations while soil matrix data are more representative of actual site conditions in fine-grained soil formations. For evaluating the risk associated with vapor intrusion to indoor air, soil gas data are the preferred contaminant data set, where practicable. Flux chamber and passive sampling methods are not discussed in this Advisory. Any sites where such sampling methods are necessary will be addressed separately.

On February 25, 1997, LARWQCB re-issued the "Interim Guidance for Active Soil Gas Investigation" (ASGI) as guidance for investigating sites with potential VOC contamination. Unless otherwise noted in this Advisory, the active soil gas investigation should be performed in accordance with the most current ASGI.

2.0 SUPPLEMENTAL RECOMMENDATIONS

The following sections supplement the ASGI in an effort to ensure that consistent methodologies are applied during soil gas investigations to produce reliable and defensible data of high quality. All sampling probe installation, sampling, and analytical procedures, whether or not discussed below, are subject to Agency review and approval.

2.1 Project Management
2.2 Soil Gas Sampling Probe Installation
2.3 Purge Volume Test
2.4 Leak Test
2.5 Purge/Sample Flow Rate
2.6 Soil Gas Sampling
2.7 Analysis of Soil Gas Samples

2.1 Project Management

2.1.1 Workplan: An appropriate workplan should be prepared and submitted to the Agency for review and approval at least 30 days prior to its implementation. Any variations or deviations from this Advisory should be specified in the workplan. The soil gas workplan can either be incorporated as part of a comprehensive site investigation workplan or as a stand-alone document, depending on site-specific circumstances.

2.1.2 Field Activities

A. The Agency should be notified 10 working days prior to implementation of field activities. All necessary permits and utility clearance(s) should be obtained prior to conducting any investigations described in this Advisory.

B. All engineering or geologic work (e.g., logging continuous soil cores, soil description) should be performed or supervised by a California Registered Professional in accordance with the Business and Professions Code, Chapters 7 and 12.5, and the California Code of Regulations, Title 16, Chapters 5 and 29.

In addition, for proposed school sites, all work performed should be under the direction and supervision of a project coordinator experienced in soil gas investigations [e.g., an Environmental Assessor as defined in Education Code Section 17210(b)].

C. Evaluation of raw data by Agency staff may occur either in the field or in the office.

1. Hard copies of the complete raw laboratory data, including handwritten data and field notes, should be provided to the Agency staff upon request.

2. Adjustments or modifications to the sampling program may be required by Agency staff to accommodate changes mandated by evaluation of the data set or unforeseen site conditions.

D. Investigation derived wastes (IDWs) should be managed as hazardous waste until proven otherwise or until specifically approved by the Agency as being non-hazardous waste. IDWs should be handled and disposed in accordance with federal, state and local requirements.

E. Field Variations

1. To expedite the completion of field activities and avoid potential project delays, contingencies should be proposed and included in the project workplan (e.g., soil matrix samples will also be collected if clayey soils [as defined in the Unified Soil Classification System (USCS)] are encountered during the proposed soil gas investigation).

2. The Agency field staff should be informed of any problems, unforeseen site conditions, or deviations from the approved workplan. When it becomes necessary to implement modifications to the approved workplan, the Agency should be notified and a verbal approval should be obtained before implementing changes.

F. Soil Matrix Sampling Requirements: Companion soil matrix sampling may be conducted concurrently with a soil gas investigation (in accordance with the ASGI, Section 5.0), except where extremely coarse-grained soils (as defined in USCS) are encountered or when specifically excluded by the Agency.

2.1.3 Soil Gas Investigation Reports: A soil gas investigation report including a discussion of field operations, deviations from the approved workplan, data inconsistencies, and other significant operational details should be prepared. The report may either be a stand-alone document in a format recommended by the Agency or be included within a site-specific assessment report. At a minimum, the report should contain the following:

A. Site plan map and probe location map at an appropriate scale as specified in the workplan (e.g., scale: one inch = 40 feet);

B. Final soil gas iso-concentration maps for contaminants of concern at the same scale as the site plan map;

C. Summary tables for analytical data, in micrograms per liter (µg/L), in accordance with the ASGI;

D. Legible copies of field and laboratory notes or logs;

E. All analytical results and Quality Assurance/Quality Control (QA/QC) information including tables and explanations of procedures, results, corrective actions and effect on the data, in the format specified by the Agency; and

F. Upon request, all raw data including chromatograms and calibration data should be submitted to the Agency.

2.2 Soil Gas Sampling Probe Installation

2.2.1 Lithology: Site soil or lithologic information should be used to select appropriate locations and depths for soil gas probes. If on-site lithologic information is not available prior to conducting the soil gas investigation, at least one (1) continuously cored boring to the proposed greatest depth of the soil gas investigation should be installed at the first sampling location, unless specifically waived or deferred by Agency. Depending on site conditions, additional continuously cored borings may be necessary.

A. Lithologic logs should be prepared for all borings (e.g., continuously cored borings, soil matrix sampling, geotechnical sampling, etc.). Note: This does not apply to direct-push soil gas probe installations.

B. Information gathered from the continuously cored borings may include soil physical parameters, geotechnical data and contaminant data.

C. If low-flow or no-flow conditions (e.g., fine-grained soil, clay, soil with vacuum readings that exceed approximately 10 inches of mercury or 136 inches of water) are encountered, soil matrix sampling using EPA Method 5035A should be conducted in these specific areas. Also see Section 4 of LARWQCB's "General Laboratory Testing Requirements for Petroleum Hydrocarbon Impacted Sites" on use of EPA Method 5035A.

D. If the bottom five (5) feet of a continuously cored boring is composed of clay or soil with a vacuum exceeding approximately 10 inches of mercury or 136 inches of water, the continuously cored boring should be extended an additional five (5) feet to identify permeable zones. If the extended boring is also composed entirely of clay, the boring may be terminated. Special consideration should always be given to advancing borings and ensuring that a contaminant pathway is not being created through a low permeability zone.

2.2.2 Sample Spacing: A scaled site plan depicting potential or known areas of concern (e.g., existing or former sumps, trenches, drains, sewer lines, clarifiers, septic systems, piping, underground storage tanks [USTs], chemical or waste management units) should be provided in the project workplan. Sample spacing should be in accordance with the most current ASGI and may be modified based on site-specific conditions with Agency approval. To optimize detecting and delineating VOCs, the grid spacing should be modified to include biased sampling locations.

2.2.3 Sample Depth: Sample depths should be chosen to minimize the effects of changes in barometric pressure, temperature, or breakthrough of ambient air from the surface; and to ensure that representative samples are collected. Consideration should be given to the types of chemicals of concern and the lithology encountered.

A. At each sample location, soil gas probes should be installed at a minimum of one sample depth, generally at five (5) feet below ground surface (bgs), in accordance with the most current ASGI.

B. Samples should be collected near lithologic interfaces or based on field instrument readings (e.g., Flame Ionization Detector [FID], Photo Ionization Detector [PID]) from soil cuttings and/or cores to determine the location of maximum analyte concentrations at the top or bottom of the interface depending upon the analyte.

C. Multi-depth sampling is appropriate for any of the following locations:

   1. Sites identified with subsurface structures (e.g., USTs, sumps, clarifiers, waste or chemical management units), subsurface sources (e.g., oil fields, artificial fill, buried animal waste), changes in lithology, and/or contaminated groundwater. Soil gas probes should be emplaced below the base of any subsurface structures, sources or backfilled materials in the vadose zone. Collection of deeper samples should be done in consultation with Agency staff;

   2. Areas with significantly elevated VOC concentrations detected during shallow or previous vapor sampling;

   3. Areas where elevated field instrument readings are encountered from soil matrix cuttings, cores or samples; or

   4. In the annular space of groundwater monitoring wells during construction, where an assessment of the vertical extent of soil gas contamination is necessary.

D. If no lithologic change or contamination is observed, default sampling depths may be selected for multi-depth sampling. For example, soil gas samples may be collected at 5, 15, 25, 40 feet bgs, etc., until either the groundwater is encountered or VOCs are not detected, whichever comes first.

   1. Additional samples may be necessary based on site conditions.

   2. For Preliminary Endangerment Assessments: When 40 feet bgs is reached, collection of deeper samples may be waived.

However, assessment and/or characterization of the deeper vadose zone may be required in the future to protect groundwater resources.

2.2.4 Sampling Tubes: Sampling tubes should be of a small diameter (1/8 to 1/4 inch) and made of material (e.g., nylon, polyethylene, copper or stainless steel) which will not react or interact with site contaminants. For example, metal tubes should not be used for collection of hydrogen sulfide samples.

A. Clean, dry tubing should be utilized at all times. If moisture, water, or an unknown material is present in the probe prior to insertion, the tubing should be decontaminated or replaced.

B. After use at each location:

1. Non-reusable (e.g., nylon or polyethylene) sampling tubes should be discarded; or

2. Reusable sampling tubes should be properly decontaminated as specified in Section 2.2.7.

C. A drawing of the proposed probe tip design and construction should be included in the project workplan.

2.2.5 Soil Gas Probe Emplacement Methods

A. Permanent or Semi-permanent Soil Gas Probe Methods: Permanent or semi-permanent soil gas probes may be installed, using a variety of drilling methods. Please note that the mud rotary drilling method is not acceptable for soil gas probe emplacement. Other drilling methods such as air rotary and rotosonic can adversely affect soil gas data during and after drilling and will require extensive equilibration times. Therefore, they are not recommended. Other soil gas probe designs and construction (e.g., soil gas wells or nested wells) may be appropriate and should be discussed with Agency staff prior to emplacement. When additional sampling is not anticipated per consultation with the Agency, such probes may be properly removed or decommissioned after completion of the soil gas investigation.

1. The probe tip should be emplaced midway within a minimum of one (1) foot of sand pack. The sand pack should be appropriately sized (e.g., no smaller than the adjacent formation) and installed to minimize disruption of airflow to the sampling tip. See Figure 1 for more information.

2. At least one (1) foot of dry granular bentonite should be emplaced on top of each sand pack to preclude the infiltration

of hydrated bentonite grout. The borehole should be grouted to the surface with hydrated bentonite. With respect to deep probe construction with multiple probe depths, the borehole should be grouted between probes. One (1) foot of dry granular bentonite should be emplaced between the filter pack and the grout at each probe location. See Figure 2 for more information.

3. The use of a downhole probe support may be required for deep probe construction (e.g., 40 feet bgs for direct push probes).

   a. Such probe support may be constructed from a one-inch diameter bentonite/cement grouted PVC pipe or other solid rod, or equivalent, allowing probes to be positioned at measured intervals.

   b. The support should be properly sealed or solid (internally or externally) to avoid possible cross-contamination or ambient air intrusion.

   c. The probes should be properly attached to the exterior of the support prior to placement downhole.

   d. Alternative probe support designs should be described in the project workplan. If probe support will not be used for deep probes, justification should be included in the project workplan.

4. Tubing should be properly marked at the surface to identify the probe location and depth.

5. As-built diagrams for probes or wells should be submitted with the soil gas investigation report detailing the well identification and corresponding probe depths. A typical probe construction diagram may be submitted for probes with common design and installation.

6. Unless soil gas probes are removed or decommissioned, probes should be properly secured, capped and completed to prevent infiltration of water or ambient air into the subsurface and to prevent accidental damage or vandalism. For surface completions, the following components may be installed:

   a. Gas-tight valve or fitting for capping the sampling tube;

   b. Utility vault or meter box with ventilation holes and lock;

   c. Surface seal; and

   d. Guard posts.

B. Temporary Soil Gas Probe Emplacement Method: In general, the drive rod is driven to a predetermined depth and then pulled back to expose the inlets of the soil gas probe. After sample collection, both the drive rod and tubing are removed.

1. During installation of the probe, hydrated bentonite should be used to seal around the drive rod at ground surface to prevent ambient air intrusion from occurring.

2. The inner soil gas pathway from probe tip to the surface should be continuously sealed (e.g., a sampling tube attached to a screw adapter fitted with an o-ring and connected to the probe tip) to prevent infiltration.

2.2.6 Equilibration Time: During probe emplacement, subsurface conditions are disturbed. To allow for subsurface conditions to equilibrate, the following equilibration times are recommended:

A. For probes installed with the direct push method where the drive rod remains in the ground, purge volume test, leak test, and soil gas sampling should not be conducted for at least 20 minutes following probe installation.

B. For probes installed with the direct push method where the drive rod does not remain in the ground, purge volume test, leak test, and soil gas sampling should not be conducted for at least 30 minutes following probe installation.

C. For probes installed with hollow stem drilling methods, purge volume test, leak test, and soil gas sampling should not be conducted for at least 48 hours (depending on site lithologic or drilling conditions) after the soil gas probe installation.

D. Probe installation time should be recorded in the field log book.

2.2.7 Decontamination: After each use, drive rods and other reusable components should be properly decontaminated to prevent cross contamination. These methods include:

A. 3-stage wash and rinse (e.g., wash equipment with a non-phosphate detergent, rinse with tap water, and finally rinse with distilled water); and/or

B. Steam cleaning process.

2.3 Purge Volume Test

To ensure stagnant or ambient air is removed from the sampling system and to assure samples collected are representative of subsurface conditions, a purge volume versus contaminant concentration test should be conducted as the first soil gas sampling activity at the selected purge test point. The purge volume test is conducted by collecting and analyzing a sample for target compounds after the removal of appropriate purge volumes.

2.3.1 Purge Test Locations: The purge test location should be selected as near as possible to the anticipated or confirmed contaminant source, and in an area where soil gas concentrations are expected to be greatest based on lithology (e.g., coarse-grained sediments). The first purge test location should be selected through the workplan approval process or as a field decision in conjunction with Agency staff.

2.3.2 Purge Volume: The purge volume or "dead space volume" can be estimated based on a summation of the volume of the sample container (e.g., glass bulbs), internal volume of tubing used, and annular space around the probe tip. Summa™ canisters, syringe, and Tedlar™ bags are not included in the dead space volume calculation. The Agency recommends step purge tests of one (1), three (3), and seven (7) purge volumes be conducted as a means to determine the purge volume to be applied at all sampling points.

A. The appropriate purge volume should be selected based on the highest concentration for the compound(s) of concern detected during the step purge tests. The purge volume should be optimized for the compound(s) of greatest concern in accordance with Section 2.2 of the ASGI.

B. If VOCs are not detected in any of the step purge tests, a default of three (3) purge volumes should be extracted prior to sampling.

C. The step purge tests and purging should be conducted at the same rate soil gas is to be sampled (see Section 2.5).

D. The purge test data (e.g., calculated purge volume, rate and duration of each purge step) should be included in the report to support the purge volume selection.

2.3.3 Additional Purge Volume Test

A. Additional purge volume tests should be performed to ensure appropriate purge volumes are extracted if:

1. Widely variable or different site soils are encountered; or

2. The default purge volume is used and a VOC is newly detected.

B. If a new purge volume is selected after additional step purge tests are conducted, the soil gas investigation should be continued as follows:

   1. In areas of the same or similar lithologic conditions:

      a. Re-sample 20 percent of the previously completed probes. This re-sampling requirement may be reduced or waived in consultation with Agency staff, depending on site conditions. If re-sampling indicates higher detections (e.g., more than 50 percent difference in samples detected at greater than or equal to 10 μg/L), all other previous probes should be re-sampled using the new purge volume.

      b. Continue the soil gas investigation with the newly selected purge volume in the remaining areas.

   2. In areas of different lithologic conditions: Continue the soil gas investigation with the newly selected purge volume in the remaining areas.

2.4 Leak Test

Leakage during soil gas sampling may dilute samples with ambient air and produce results that underestimate actual site concentrations or contaminate the sample with external contaminants. Leak tests should be conducted to determine whether leakage is present (e.g., the leak check compound is detected and confirmed in the test sample after its application).

2.4.1 Leak tests should be conducted at every soil gas probe.

2.4.2 Leak Check Compounds: Tracer compounds, such as pentane, isopropanol, isobutene, propane, and butane, may be used as leak check compounds, if a detection limit (DL) of 10 μg/L or less can be achieved. These compounds may be contained in common products such as shaving cream.

2.4.3 A leak check compound should be placed at any location where ambient air could enter the sampling system or where cross contamination may occur, immediately before sampling. Locations of potential ambient air intrusion include:

A. Sample system connections;

B. Surface bentonite seals (e.g., around rods and tubing); or

C. Top of the Temporary Soil Gas Probe (see Section 2.2.5.B).

2.4.4 The leak test should include an analysis of the leak check compound. If a leak check compound is detected in the sample, the following actions should be followed:

A. The cause of the leak should be evaluated, determined and corrected through confirmation sampling;

B. If the leak check compound is suspected or detected as a site-specific contaminant, a new leak check compound should be used;

C. If leakage is confirmed and the problem can not be corrected, the soil gas probe should be properly decommissioned;

D. A replacement probe should be installed at least five (5) feet from the original probe decommissioned due to confirmed leakage, or consult with Agency staff; and

E. The leak check compound concentration detected in the soil gas sample should be included and discussed in the report.

2.5 Purge/Sample Flow Rate

Sampling and purging flow rates should not enhance compound partitioning during soil gas sampling. Samples should not be collected if field conditions as specified in Section 2.6.4 exist.

2.5.1 The purging or sampling flow rate should be attainable in the lithology adjacent to the soil gas probe.

A. To evaluate lithologic conditions adjacent to the soil gas probe (e.g., where no-flow or low-flow conditions), a vacuum gauge or similar device should be used between the soil gas sample tubing and the soil gas extraction devices (e.g., vacuum pump, Summa™ canister).

B. Gas tight syringes may also be used to qualitatively determine if a high vacuum soil condition (e.g., suction is felt while the plunger is being withdrawn) is present.

2.5.2 The Agency recommends purging or sampling at rates between 100 to 200 milliliters per minute (ml/min) to limit stripping, prevent ambient air from diluting the soil gas samples, and to reduce the variability of purging rates. The low flow purge rate increases the likelihood that representative samples may be collected. The purge/sample rate may be modified based on conditions encountered in individual soil gas probes. These modified rates should be documented in the soil gas report.

2.6 Soil Gas Sampling

After the soil gas probe is adequately purged, samples should be collected by appropriate methodologies.

2.6.1 Sample Container: Samples should be collected in gas-tight, opaque/dark containers (e.g., syringes, glass bulbs wrapped in aluminum foil, Summa™ canisters), so that light-sensitive or halogenated VOCs (e.g., vinyl chloride) will not degrade.

A. If a syringe is used, it should be leak-checked before each use by closing the exit valve and attempting to force ambient air through the needle.

B. If syringe samples are analyzed within five (5) minutes of collection, aluminum foil wrapping may not be necessary.

C. EPA Method TO-14A, TO-15, or an equivalent air analysis method, requires samples be collected in Summa™ canisters.

D. If a Summa™ canister is used, a flow regulator should be placed between the probe and the Summa™ canister to ensure the Summa™ canister is filled at the flow rate as specified in Section 2.5.2.

E. Tedlar™ bags should not be used to collect VOC samples.

F. Specific requirements for methane and hydrogen sulfide sample containers are specified in Section 2.7.9.

2.6.2 Sample Collection

A. Vacuum Pump: When a vacuum pump is used, samples should be collected on the intake side of the vacuum pump to prevent potential contamination from the pump. Vacuum readings or qualitative evidence of a vacuum should be recorded on field data sheets for each sample.

B. Shallow Samples: Care needs to be observed when collecting shallow soil gas samples to avoid sample breakthrough from the surface. Extensive purging or use of large volume sample containers (e.g., Summa™ canisters) should be avoided for collection of near-surface samples [e.g., shallower than five (5) feet bgs].

2.6.3 Sample Container Cleanliness and Decontamination

A. Prior to its first use at a site, each sample container should be assured clean by the analytical laboratory as follows:

   1. New containers should be determined to be free of contaminants (e.g., lubricants) by either the supplier or the analytical laboratory; and

   2. Reused/recycled containers: Method blank(s), as specified in Section 2.7.1.A, should be used to verify sample container cleanliness.

B. After each use, reusable sample containers should be properly decontaminated.

   1. Glass syringes or bulbs should be disassembled and baked at 240º C for a minimum of 15 minutes or at 120º C for a minimum of 30 minutes, or be decontaminated by an equivalent method.

   2. Summa™ canisters should be properly decontaminated as specified by appropriate EPA analytical methods.

   3. During sampling activities using reused/recycled sampling containers (e.g., glass syringes, glass bulbs), at a minimum one (1) decontaminated sample container per 20 samples or per every 12 hours, whichever is more often, should be used as a method blank (as specified in Section 2.7.1.A) to verify and evaluate the effectiveness of decontamination procedures.

C. Plastic syringes should be used only once and then properly discarded.

2.6.4 Field Conditions: Field conditions, such as rainfall, irrigation, fine-grained sediments, or drilling conditions may affect the ability to collect soil gas samples.

A. Wet Conditions: If no-flow or low-flow conditions are caused by wet soils, the soil gas sampling should cease. In addition, the Agency recommends that the soil gas sampling should not be conducted during or immediately after a significant rain event (e.g., 1/2 inch or greater) or onsite watering.

B. If low flow conditions are determined to be from a specific lithology, a new probe should be installed at a greater depth or a new lateral location should be selected after evaluation of the site lithologic logs (See Section 2.2.1) or in consultation with Agency staff.

C. If moisture or unknown material is observed in the glass bulb or syringe, soil gas sampling should cease until the cause of the problem is determined and corrected.

D. If refusal occurs during drilling, soil gas samples should be collected as follows or in consultation with Agency staff.

   1. For sample depths less than five feet, collect a soil gas sample following the precautions outlined in Section 2.6.2.B.

   2. For sample depths greater than five feet, collect a soil gas sample at the depth of refusal.

   3. A replacement probe should be installed within five (5) feet laterally from the original probe decommissioned due to refusal. If refusal still occurs after three tries, the sampling location may be abandoned.

2.6.5 Chain of Custody Records: A chain of custody form should be completed to maintain the custodial integrity of a sample. Probe installation times and sample collection times should be included in the soil gas report.

2.7 Analysis of Soil Gas Samples

2.7.1 Quality Assurance/Quality Control (QA/QC): The soil gas analytical laboratory should comply with the project Quality Assurance Project Plan (QAPP) and follow the QA/QC requirements of the most current ASGI and the employed EPA Method. If there is any inconsistency, the most restrictive and specific requirements should prevail. The analytical data should be consistent with the Data Quality Objectives (DQOs) established for the project. The Agency staff may inspect the field and/or laboratory QA/QC procedures. Copies of the QA/QC plan and laboratory calibration data should be presented to the Agency field staff upon request.

Field QC samples should be collected, stored, transported and analyzed in a manner consistent with site samples. The following QC samples should be collected to support the sampling activity:

A. Sample Blanks

   1. Method Blanks: Method blanks should be used to verify the effectiveness of decontamination procedures as specified in Section 2.6.3.B.3 and to detect any possible interference from ambient air.

   2. Trip Blanks for Off-site Shipments: Whenever VOC samples are shipped offsite for analysis, a minimum of one (1) trip blank

per day should be collected and analyzed for the target compounds. Trip blanks, consisting of laboratory grade ultra pure air, are prepared to evaluate if the shipping and handling procedures are introducing contaminants into the samples, and if cross contamination in the form of VOC migration has occurred between the collected VOC samples. Trip blank containers and media should be the same as site samples.

B. Duplicate Samples: At least one (1) duplicate sample per laboratory per day should be field duplicate(s). Duplicate samples should be collected from areas of concern.

   1. Duplicate samples should be collected in separate sample containers, at the same location and depth.

   2. Duplicate samples should be collected immediately after the original sample.

C. Laboratory Control Samples and Dilution Procedure Duplicates: Laboratory Control Samples (LCS) and Dilution Procedure Duplicates (DPD) should be done in accordance with the most recent ASGI (Sections 3.5.0 and 3.12.4, respectively).

D. Split Samples: The Agency staff may request that split samples be collected and analyzed by a separate laboratory.

2.7.2 Laboratory Certification: Although the California Department of Health Services, Environmental Laboratory Accreditation Program (ELAP) does not currently require certification for soil gas analytical laboratories, the Agency recommends laboratories utilizing EPA Methods 8260B, 8021B, and 8015B for analyses of soil gas samples obtain ELAP certifications for such EPA analytical methods accordingly. The Agency or DTSC's Hazardous Materials Laboratory (HML) staff may inspect the laboratory.

2.7.3 Detection Limits for Target Compounds: Analytical equipment calibration should be in accordance with the most current ASGI. Consideration and determination of appropriate DLs should be based on the DQOs of the investigation.

A. The DL for leak check compounds should be 10 μg/L or less (see Section 2.4.2). The DL for oxygen (O_2) and carbon dioxide (CO_2) should be one (1) percent or less. The DLs for methane and hydrogen sulfide are specified in Section 2.7.9.

B. If the investigation is being conducted to delineate the extent of contamination, a DL of 1 μg/L is appropriate for all targeted VOCs.

C. If the soil gas data are to be used to support risk assessment activities, a DL of 1 μg/L may be appropriate for the initial screening when evaluating all targeted VOCs. If the data are non-detect for all targeted VOCs, additional sampling with lower DLs is not required. If VOCs are detected, additional sampling, using a DL of 0.1 μg/L, may be required to confirm the non-detection of carcinogenic VOCs [see the Toxicity Criteria Database of the California Environmental Protection Agency, Office of Environmental Health Hazard (OEHHA), or the Integrated Risk Information System (IRIS) Database of the United States Environmental Protection Agency]. A DL of 0.1 μg/L may be proposed and used for all carcinogenic target VOCs from the beginning of the investigation.

D. Based on site-specific DQO needs, lower DLs may be required. Examples of sites requiring site-specifc DQO needs include, but are not limited to, chlorinated solvents sites, former industrial facilities and landfills. Several less common VOCs, not included on the ASGI-targeted compound list, may require lower detection limits [e.g., bis(chloromethyl)ether, DBCP (1,2-dibromo-3-chloropropane), or ethylene dibromide] when they are known or suspected to be present.

E. If the required DLs cannot be achieved by the proposed analytical method, additional sample analysis by a method achieving these DLs [e.g., EPA Method 8260B with selective ion method (SIM), TO-14A, TO-15] may be required. Use of these methods should comply with the QA/QC requirements as specified in Section 2.7.1.

F. For results with a high DL reported (e.g., due to matrix interference or dilution), the laboratory should provide a written explanation. Re-sampling and analyses may be required at the appropriate DL for a specific compound.

2.7.4 Sample Handling: Exposure to light, changes in temperature and pressure will accelerate sample degradation. To protect sample integrity:

A. Soil gas samples should not be chilled;

B. Soil gas samples should not be subjected to changes in ambient pressure. Shipping of sample containers by air should be avoided; and

C. If condensation is observed in the sample container, the sample should be discarded and a new sample should be collected.

2.7.5 Holding Time: All soil gas samples (e.g., samples of VOCs, methane, fixed gases, or biogenic gases), with the exception of hydrogen sulfide samples, should be analyzed within 30 minutes by an on-site mobile laboratory. Hydrogen sulfide samples should be analyzed as specified in Section 2.7.9.B.2. Under the following conditions, holding times may be extended and analyses performed off-site:

A. Soil gas samples collected in glass bulbs with surrogates added within 15 minutes of collection may be analyzed within 4 hours after collection;

B. Soil gas samples collected in Summa™ canisters may be analyzed within 72 hours after collection; and

C. Methane samples may be analyzed as specified in Section 2.7.9.A.2.

2.7.6 Analytical Methods

A. VOC Samples: All VOC samples should be analyzed using only a Gas Chromatograph/Mass Spectrometer (GC/MS) method (e.g., EPA Method 8260B, used for analysis of soil gas samples, EPA Method TO-14A or TO-15, or equivalent), except at well-characterized sites (e.g., VOCs are known to be present and confirmed based on previous GC/MS analyses). A non-GC/MS method (e.g., EPA Method 8021B, used for analysis of soil gas samples) may be used only for routine monitoring of VOC contamination at well-characterized sites.

If during routine monitoring, new VOC(s) were detected by a non-GC/MS method, then at least 10 percent of the samples with each newly identified VOC should be confirmed by a GC/MS method. Thereafter, routine monitoring can resume with the non-GC/MS method, including the new analyte(s).

B. Methane and Hydrogen Sulfide Samples: These gas samples should be analyzed using methods specified in Section 2.7.9.

2.7.7 Auto samplers may be used if:

A. One (1) sample is introduced at a time;

B. The sample vials are gas-tight and never opened after the sample is added;

C. Proper holding times are maintained (see Section 2.7.5); and

D. All samples are secured and under proper custody.

2.7.8 Target Compounds

A. VOCs

1. ASGI-Targeted Compounds: The ASGI (dated February 25, 1997) includes 23 primary and four (4) other target VOCs. All quantifiable results should be reported.

2. Others: The estimated results of all Tentatively Identified Compounds [TICs]) or non-AGSI-targeted compounds detected should be included in the report. If TICs or non-ASGI-targeted compounds are identified, contact the Agency to determine whether additional action is required (e.g., running additional standards to quantify TICs or non-ASGI compounds) and whether the use of these estimated data for risk evaluation is appropriate.

B. Leak Check Compounds: All quantifiable results should be reported as specified in Section 2.4.4.E.

C. Specific Compounds: Based on the site history and conditions, analyses for specific compounds may be required by the Agency staff. Examples include:

1. In areas where USTs or fuel pipelines are identified, soil gas samples should be analyzed for oxygenated compounds [e.g., methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), di-isopropyl ether (DIPE), tertiary amyl methyl ether (TAME), tertiary butyl alcohol (TBA), and ethanol];

2. At oilfield sites where semi-VOCs or Total Petroleum Hydrocarbons (TPHs) are detected in the soil gas samples, fixed and biogenic gas (O_2, CO_2, and CH_4) data should be obtained using a Thermal-Conductivity Detector (TCD) or a hand-held instrument;

3. At petroleum contaminated sites (including oilfields), dairies, wetlands, landfills or other sites where the presence of methane and/or hydrogen sulfide is suspected, soil gas samples should be analyzed for methane and/or hydrogen sulfide;

4. At sites where use of chlorinated solvents with 1,4-dioxane is suspected or known to exist, soil gas samples may be analyzed for 1,4-dioxane with a detection limit of 1 µg/L; or

5. See Section 2.7.9.A.4 below.

2.7.9 Methane and Hydrogen Sulfide Sampling Programs: If the presence of methane and/or hydrogen sulfide is suspected, they should also be included in the analytical plan. After evaluating the initial soil gas data, the Agency may recommend that testing for methane or hydrogen sulfide cease.

A. Methane Sampling Program: Methane samples may be analyzed by a GC using modified EPA Method 8015B, EPA Method TO-3, or ASTM 3416M (EPA 3C), or by an appropriate hand-held instrument (e.g., Land Tech Gas Analyzer GA-90, Gas Emissions Monitor GEM-500, GEM-2000).

   1. Detection Limit: The DL for methane analysis should not exceed 500 parts per million by volume (ppmv).

   2. Methane Sample Containers: In addition to the gas-tight sample containers previously specified in Section 2.6.1, Tedlar™ bags may be used for collection of methane samples with a holding time of no more than 24 hours.

   3. Methane Screening Level: When methane is detected at 1,000 ppmv or more, additional sampling and/or further investigation is recommended to identify the source(s).

   4. At sites where methane is investigated and detected at a level of 5,000 ppmv or more, fixed and biogenic gas (O_2, CO_2, and CH_4) data should be obtained using a Thermal-Conductivity Detector (TCD) or a hand-held instrument.

   5. To determine that the area is pressurized by migration of gases, pressure readings of each sampling tube system should be recorded in the field logs and reported along with the methane concentration.

   6. Special GC Requirements: The GC method requires calibration curves for analytes such as methane since it is not a normal target analyte for such an analytical method.

   7. Special Hand-Held Instruments Requirements: Hand-held instruments should be calibrated in accordance with the manufacture's instructions. When a hand-held instrument is used to analyze methane samples, the Agency recommends that at least 10 percent of all positive methane samples (e.g., more than 5,000 ppmv), rounded to the nearest whole number, be confirmed by another hand-held instrument (different unit or brand) or by a GC method.

B. Hydrogen Sulfide Sampling Program: Hydrogen sulfide may be analyzed by a GC using the South Coast Air Quality Management District (SCAQMD) Method 307-91 or EPA Method 16, or by an appropriate hand-held instrument (e.g., LTX-310 calibrated for hydrogen sulfide or Jerome 631-X).

1. Detection Limit: The DL should be equal to or less than 0.5 ppmv or be sensitive enough to allow for a modeled ambient air concentration (at least one microgram per cubic meter) at the soil surface.

2. Holding Time: Hydrogen sulfide samples should be extracted directly into a hand-held analyzer within 30 minutes of collection to minimize the risk of losing the hydrogen sulfide due to reaction with active surfaces. If a hand-held instrument is not used, hydrogen sulfide samples should be analyzed as below:

   a. Within 30 minutes of collection, using the GC procedures; or

   b. Within 24 hours of collection, if a surrogate is added to the samples, or 100 percent duplicate samples are collected.

3. Sample Containers: The following sample containers are recommended:

   a. Minimum one (1) liter black Tedlar™ bag fitted with polypropylene valves or the equivalent;

   b. 100-ml gas-tight syringe fitted with an inert valve and wrapped in aluminum foil;

   c. Gas-tight glass bulb wrapped in aluminum foil; or

   d. Glass-lined or silicon coated Summa™ canister.

4. Precautions

   a. Since hydrogen sulfide is extremely unstable in the presence of oxygen and moisture, contact of hydrogen sulfide samples with them should be avoided.

   b. Due to the high reactivity of hydrogen sulfide gas, contact of hydrogen sulfide samples with metallic or other non-passive surfaces should be avoided during sample collection, storage and analysis.

   c. Care must be taken so that GC components do not react with the sample. Typically glass-lined injection ports and Teflon™ tube packed columns are used to avoid loss of hydrogen sulfide due to reaction with active surfaces.

3.0 SOIL PARAMETERS

If the soil gas data will be used in a health risk assessment, an estimation of the indoor air concentration should be performed using soil gas data with an Agency approved or modified predictable indoor air model. Default values of input parameters may be used in accordance with the approved indoor air modeling guidance and in consultation with Agency staff. If default values are not used, site-specific soil parameters should be obtained as discussed below.

To assess health risk, indoor air quality, the threat of groundwater contamination from VOCs, or to evaluate the effectiveness of a proposed remedial technology, the following soil matrix parameters should be obtained from a minimum of three (3) sample locations (at depths* corresponding to or associated with the detected VOCs) for each soil type in association with the soil gas investigation:

3.1 Soil description performed and presented in accordance with the Unified Soil Classification System (USCS);

3.2 Density;

3.3 Organic carbon content of the soil** (by the Walkee Black Method);

3.4 Soil moisture;

3.5 Effective permeability***;

3.6 Porosity; and

3.7 Grain size distribution analysis (curve) and evaluation of fine-grained soil content (by wet sieve analysis and any supplementary methods as necessary) to determine the percent clay, silt and sand. (The grain size distribution analysis will be used to classify the soil in accordance with the U. S. Soil Conservation Service [SCS] soil type, which is the same as the U. S. Department of Agriculture soil type.)

* Samples may be collected from proposed depths at the continuously cored boring.

** This input parameter is required for soil matrix VOC samples only. This parameter sample should not be collected from an impacted area.

*** As an alternative, the measurements of saturated hydraulic conductivity may be used to estimate vapor permeability.

4.0 REFERENCES

Additional information may be found in the following documents:

American Society for Testing and Materials (ASTM), “Standard Guide for Soil Gas Monitoring in the Vadose Zone, ASTM Standard D 5314-92,” January 1993; Reapproved 2001; website http://www.astm.org

California Regional Water Quality Control Board, Los Angeles Region, “Interim Guidance for Active Soil Gas Investigation,” February 25, 1997

California Regional Water Quality Control Board, Los Angeles Region, “General Laboratory Testing Requirements for Petroleum Hydrocarbon Impacted Sites,” June 22, 2000

U.S. Environmental Protection Agency, “Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA Publication SW-846, Third Edition,” November 1986, as amended by Updates I (Jul. 1992), II (Sep. 1994), IIA (August 1993), IIB (Jan. 1995), III (Dec. 1996), IIIA (Apr. 1998), IVA (Jan. 1998) and IVB (Nov. 2000); website http://www.epa.gov/SW-846/main.html

U.S. Environmental Protection Agency, “U.S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA 540/R-94/012,” February 1994; website http://www.epa.gov/region09/qa/superfundclp.html

U.S. Environmental Protection Agency, “Soil Gas Sampling, SOP#: 2042, Revision #: 0.0,” June 1, 1996; website http://www.ert.org/respns_resrcs/sops.asp

U.S. Environmental Protection Agency, “Summa Canister Cleaning Procedures, SOP #1703, Rev. #: 0.0,” 09/01/94; website http://www.ert.org/respns_resrcs/sops.asp

California Environmental Protection Agency (Cal/EPA), Office of Environmental Health Hazard (OEHHA), Toxicity Criteria Database; website http://www.oehha.ca.gov/risk/ChemicalDB/index.asp

United States Environmental Protection Agency, Integrated Risk Information System (IRIS) Database; website http://www.epa.gov/iris/

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FOR MORE INFORMATION

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Figures – Soil Gas Probe Emplacement Methods

Figure 1 – Permanent/Semi-permanent Gas Probe Construction Diagram

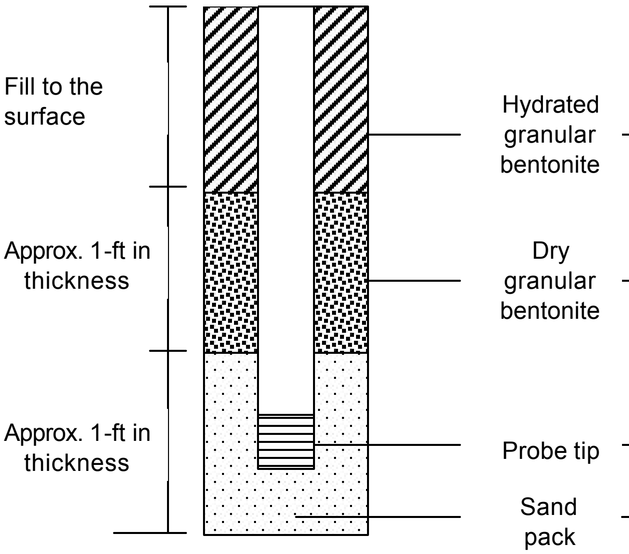
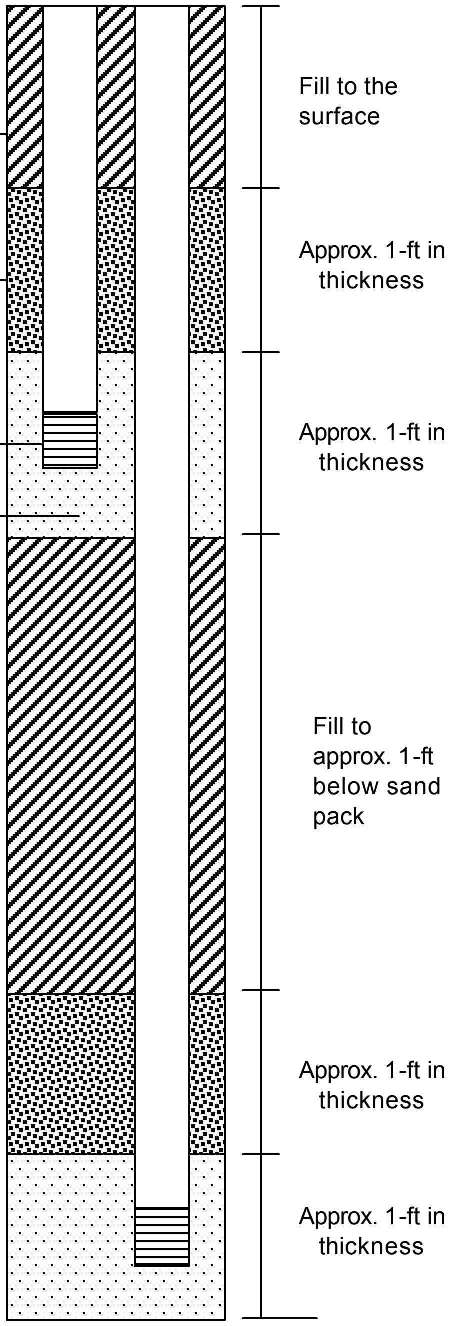
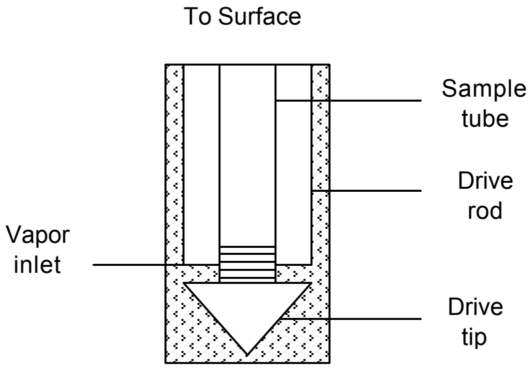


Figure 2 – Multi-depth Gas Probe Construction Diagram



Temporary Gas Probe Method



INTERIM FINAL

GUIDANCE FOR THE EVALUATION AND MITIGATION OF SUBSURFACE VAPOR INTRUSION TO INDOOR AIR

Department of Toxic Substances Control
California Environmental Protection Agency

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nearby potential sources of VOCs, such as soil vapor extraction systems. As additional data are collected and analyzed through the evaluation of the vapor intrusion pathway, the CSM should be updated and distributed to interested parties. The CSM should be an essential decision-making and communication tool for all interested parties. Additional information on the development of a CSM be found in guidance published by the United States Department of Energy (1997).

Soil Gas

Soil gas data should be used to evaluate vapor intrusion to indoor air. Soil gas data are recommended over other data, such as soil matrix and groundwater data, because soil gas data represent a direct measurement of the contaminant that will migrate into indoor air. In order to evaluate vapor intrusion, soil matrix and groundwater data must be converted to vapor concentrations using assumptions about the partitioning of the contaminant into the gas phase. While partitioning equations are readily available, using them increases the uncertainty in evaluating vapor intrusion. DTSC views this increased uncertainty as unacceptable in any indoor air evaluation. Hence, soil gas is the preferred contaminant data to use for calculating the risk from the vapor intrusion pathway. This preference for soil gas data to evaluate vapor intrusion is shared by USEPA (2002) and Johnson and Deize-Abreu (2003). In addition, it may be necessary to collect soil gas samples at two distinct time intervals to compensate for the effects of weather events, such as recent rainfall or barometric fluctuations. Ideally, for sites subject to vapor intrusion, permanent vadose monitoring points for sample collection should be installed to evaluate the long-term behavior of contaminated soil gas.

The California Environmental Protection Agency's (Cal-EPA) Soil Gas Advisory (2003) provides procedures for obtaining high-quality soil gas samples for use in risk assessments. The Advisory recommends the following field activities during the collection of soil gas samples:

- Sample greater than 5 feet below grade to reduce the effects of barometric pumping.
- Seal the surface around the soil gas sampler to prevent ambient air intrusion.
- Conduct leak tests using tracer gas to evaluate ambient air intrusion.
- Conduct tests to determine the optimal purge volume for sampling.
- Purge and sample at low flow rates (less than 200 milliliters per minute).
- Collect samples in Summa™ canisters (USEPA TO Methods), glass bulbs, or glass syringes.
- Avoid soil gas sample collection following significant rainfall events.

Soil gas samples should be collected to delineate the lateral and vertical extent of the subsurface contamination. Open areas at sites should be sampled first, and the sampling should continue towards buildings as indicated by the field data. Also, open areas that are covered with pavement should be sampled as a way to determine if vapors can accumulate underneath structures. When contaminated soil gas is encountered near buildings, soil gas samples should be collected around the perimeter of the building, as close as possible to the foundation. Soil gas samples from preferential pathways, such as utility corridors, should also be collected. Characterization should continue until non-detectable concentrations of VOCs are encountered in the subsurface laterally and vertically. The soil gas samples should be analyzed by gas chromatography / mass spectrometry (GC/MS) methods.

The minimum amount of soil gas sampling needed in the vertical direction to evaluate vapor intrusion is the collection of soil gas samples at 5 and 15 to 20 feet below surface grade. Ideally, subsurface plumes should be delineated laterally and vertically with soil gas samples. In cases where previous characterization activities have taken place with soil matrix sampling without regard for vapor intrusion, additional characterization with soil gas sampling may be warranted. In these cases, the minimum level of soil gas sampling would be sample collection at 5 and 15 to 20 feet below surface grade.

Soil gas samples should not be collected depths shallower than 5 feet in order to minimize barometric pumping effects. Deeper samples should be collected as needed to define vertical trends in vapor concentrations. For sites that overlie contaminated groundwater, an effort should be made to collect soil gas samples from immediately above the capillary fringe zone and half-way to the surface. For sites where the depth to groundwater is less than five feet, an attempt should be made to collect soil gas samples from beneath existing building foundations or similar settings, such as garage floors, patios, parking lots, roads, and other areas that are covered with pavement, concrete or a similar material, as a mechanism to evaluate the potential for vapor accumulation.

The following should be considered when collecting soil gas samples:

1) <u>Soil Gas Probes.</u> As appropriate, permanent, semi-permanent, or temporary vadose zone probe points should be installed and monitored to determine temporal soil gas trends. However, during probe installation, subsurface conditions are disturbed. To allow for subsurface conditions to equilibrate, sampling from direct-push probes should not occur for at least 20 to 30 minutes after probe installation and sampling from probe installed with hollow-stem drilling methods should not occur for at least 48 hours after probe installation. Otherwise, the soil gas samples may not be representative of subsurface conditions. For soil gas sample collection, the quality assurance and quality control procedures in Cal-EPA (2003) and Los Angeles RWQCB (1997) should be followed.

2) <u>Sampling Density.</u> For sites seeking agency closure with unrestricted future land use, the residual concentrations of VOCs in the subsurface should be protective of residential receptors. Therefore, soil gas sampling locations should be sufficiently dense to effectively evaluate residential building scenarios. Ideally, there should be a soil gas sample for every potential future residential building. The parcel size for most residential housing tracts in California is approximately a quarter acre. Hence, soil gas sampling for future residential developments should be conducted on a quarter acre spacing. Soil gas samples should be collected until the soil gas contaminant plume is fully delineated and a clean zone of 100 feet beyond the extent of the soil gas plume is demonstrated (see Step 3, Criterion Two). For sites where current and future land use will be restricted by a land use covenant, the soil gas sampling density can be increased as a function of the size of the future buildings pursuant to the land use covenant.

3) <u>Collection of Duplicates.</u> When collecting soil gas samples with glass bulbs or glass syringes and analyzing the gas samples for VOCs by Method 8260B (USEPA, 1996) modified for air analysis with a mobile laboratory, the results of the field work should be independently confirmed through the collection of duplicate soil gas samples in Summa™ canisters. The collection of duplicates will confirm the mobile laboratory

detection limits and identify other potential COCs at the site. DTSC recommends that ten percent of the soil gas samples collected in the field be confirmed with Summa™ canisters that are analyzed using TO-14A (USEPA, 1999a) or TO-15 (USEPA, 1999b), as appropriate. The Summa™ canister duplicates should be collected in areas of both high and low VOC concentrations.

4) Analytical Detection Limits. The analytical detection limits for the soil gas samples should be sufficiently low to adequately evaluate the vapor intrusion pathway. As a conservative approach, the analytical detection limits should be no higher than five hundred times the acceptable indoor air concentrations. Setting a detection limit at this level implies that a soil gas measurement taken at five feet below surface grade that has a non-detectable concentration of a VOC with a detection limit of five hundred times the acceptable indoor air concentration is protective of public health. This assumption is based upon the data gathered by OEHHA (2004). Hence, detection limits derived from this generic attenuation factor should be protective of public health in California. However, in certain site-specific situations, the analytical detection limits must be set lower than five hundred times the acceptable indoor air concentrations if the estimated vapor intrusion attenuation factor dictates the change. This may be the case for soil gas samples collected from depths shallower than five feet or for soil gas samples collected directly below foundation slabs. For chemicals known to exist in the subsurface, whether determined through direct measurement or historical records review, the chemicals should be evaluated for vapor intrusion even if the concentrations in soil gas concentrations are non-detectable. In these cases, the chemical should be evaluated at concentrations equal to the method detection limit. If the chemical is postulated to no longer exist in the subsurface due to biodegradation or volatilization, the analytical detection limits should be appropriately low to demonstrate that circumstance.

5) Low Flow Conditions. Since soil gas is the preferred data for making vapor intrusion evaluations, every attempt should be made to collect representative samples. However, it may not be possible to collect soil gas samples from the subsurface in some instances. Some examples include sites with a saturated vadose zone due to a shallow water table or sites underlain with clay-rich soil. For sites with postulated low air permeability, an attempt should always be made to collect soil gas rather than default to another sampling method. However, if soil gas sampling fails, soil matrix samples should be collected pursuant to USEPA Method 5035 (see below) and the vapor intrusion pathway must then be evaluated with soil matrix data along with the groundwater contaminant data, as appropriate. At a given soil gas sampling location point, two attempts should be made to obtain a gas sample. If the first attempt fails, the sampling probe should be withdrawn and redriven a few feet over from the original location. DTSC considers soil gas sampling to fail when subsurface air flow rates are less than 10 milliliters per minute or when vacuum of 10 inches of mercury (136 inches of water) or greater is obtained. These low flow conditions must exist at numerous sampling points at a site before DTSC will consider the sampling efforts a failure.

If groundwater is encountered during the collection of soil gas samples and it appears that the contamination is in close proximity to the water table, groundwater grab samples should be collected pursuant to USEPA (1997a) to evaluate the potential contaminant impact to the aquifer. If groundwater contamination exists at a site as documented by groundwater grab samples, the installation and sampling of permanent groundwater monitoring wells may be required by DTSC.

During soil gas sampling, the collection of soil matrix samples should be considered for the evaluation of the physical character of the subsurface, such as total porosity, soil moisture, and dry bulk density (see Step 6).

Canisters
and
Tedlar Bags

Air Toxics LTD.

Laboratory Services Since 1989

Guide to Air Sampling & Analysis

Always Air, Always Accurate

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Tables

Section 1.0 Introduction

Air Toxics Ltd. presents this guide as a resource for individuals engaged in air sampling. Air sampling can be more involved than water or soil sampling due to the reactivity of chemical compounds in the gas matrix and sample interaction with the equipment and media used. Ensuring that air samples are collected properly is an important step in acquiring meaningful analytical results. This guide is not a substitute for experience and cannot sufficiently address the multitude of field conditions. Note that this guide is intended for projects involving whole air sampling of volatile organic compounds (VOCs) in canisters and Tedlar® bags. Air Toxics Ltd. provides the "Guide to Sorbent-Based Sampling - Volatiles and Semi-Volatiles" for other types of sampling.

1.1 Whole Air Sampling of VOCs

This guide focuses on collecting a sample in the most common air sampling containers, Summa canisters and Tedlar® bags. The sample may be collected in the container either passively (i.e., by evacuating the canister prior to sampling) or actively (i.e., using a pump). The sample is referred to as a "whole air sample" and the compounds remain in the gas matrix (e.g., ambient air) inside the container.

1.2 Choosing Between Canisters and Tedlar® Bags

Table 1.2 compares the features of canisters and Tedlar® bags. Canisters have superior inertness, hold time to analysis and ruggedness. They also do not require a sampling pump. Tedlar® bags can be purchased inexpensively in bulk, carried to a sampling site in a briefcase, filled in seconds and shipped easily to the laboratory for analysis. Call Client Services at 800-985-5955 if you have questions regarding the appropriate sampling media.

Table 1.2 Comparison of Canisters to Tedlar® Bags

	Canisters	**Tedlar® Bags**
Common Volumes	1 and 6 L	1, 3, and 5 L
Type of Sampling	Passive (vacuum)	Active (pump required)
Sample Handling	Room temperature	Room temperature
Media Hold Time	Up to 30 days recommended	Indefinite
Hold Time to Analysis	Up to 30 days	Up to 3 days
Surface Inertness	Excellent	Fair
Cleanliness	10% or 100% certified to ppbv/pptv levels	Some VOCs present at 0.5 to 45 ppbv
Sampling Application	Ambient/indoor air, soil/landfill gas, stationary source	Ambient air (fixed gases only), soil/landfill gas, stationary source
Rule of Thumb	“ppbv device”	“ppmv device”
Advantages	Inertness, hold time, ruggedness, no pump	Purchase/shipping cost, availability, convenience

Section 2. Canisters and Associated Media

This section provides a description of air sampling canisters, practical considerations for sampling, and step-by-step sampling instructions. Tables provide detailed information on many operational factors that ultimately influence the quality of the data obtained from a canister sample.

2.1 Introduction to Canisters

The canister is prepared for sampling by evacuating the contents to a vacuum of approximately 29.9 inches of Mercury (in. Hg). Opening the stainless steel bellows valve allows the air sample to enter the canister. When the target volume of sample is collected, the valve is closed and the canister is returned to the laboratory. Canisters range in volume from less than 1 liter (L) to greater than 6 L. At Air Toxics Ltd., 6 L canisters are used for ambient air samples and for taking integrated samples. One liter canisters are generally used for taking high concentration (i.e., greater than 5 ppbv) grab samples, although exceptions to these guidelines are common.

2.1.1 Summa Canister

A Summa canister is a stainless steel container that has had the internal surfaces specially passivated using a “Summa” process. This process combines an electropolishing step with a chemical deactivation step to produce a surface that is nearly chemically inert. A Summa surface has the appearance of a mirror: bright, shiny and smooth. The degree of chemical inertness of a whole air sample container is crucial to minimizing reactions with the sample and maximizing recovery of target compounds from the container.

2.1.2 Canister Cleaning

Air Toxics Ltd. provides two types of canister cleaning certification, 10% and 100%, depending upon the requirements of the project. The 10% certification process is appropriate for routine ambient air applications and high concentration applications such as soil vapor and landfill gas monitoring. The 10% certification process begins by cleaning canisters using a combination of dilution, heat and high vacuum. Canisters are certified for approximately 60 VOCs using GC/MS. As part of our quality control plan we perform a 10% process certification which requires that target compound concentrations be below 0.2 ppbv using GC/MS analysis. Alternatively, the 100% certification (i.e., individual certification) process is appropriate for ambient and indoor air applications driven by risk assessment or litigation requiring pptv (parts per trillion by volume) sensitivity. Similar to the 10% certification, the 100% certification also begins with the canister cleaning process. The difference with the 100% certification is that canisters are individually certified for a client-specific list of target compounds using GC/MS. When the 100% certified canisters are shipped the analytical documentation demonstrating that they are free of the target compounds down to the project reporting limits is emailed to the client. When sampling with certified media it is important to note that all media is certified as a train and must be sampled as such (i.e., a particular flow controller goes with a particular canister and is labeled as such).

Specify whether your project requires
10% or 100% canister cleaning certification

2.1.3 Canister Hold Time

Media Hold Time : Canister sampling differs considerably from collecting a water sample in a VOA vial or a soil sample in an amber jar in that the container (valued at over $500) is cleaned and reused. Air Toxics Ltd. requires that our canisters be returned within 14 days of receipt to effectively manage our inventory. Once a canister is cleaned, certified and evacuated we recommend the canister be used for sample collection within 30 days. Over time, low-level (pptv) concentrations of typical VOCs may off-gas from the canister surface resulting in potential artifacts in the sample results.

Sample Hold Time: Although 30 days is the most commonly cited hold time for a canister sample, the hold time is compound-specific. For example, compounds such as chloroform, benzene, and vinyl chloride are stable in a canister for at least 30 days. In fact, EPA Method TO-15 states, “Fortunately, under conditions of normal usage for sampling ambient air, most VOCs may be recovered from canisters near their original concentrations for after storage times of up to thirty days”. However, some VOCs such as bis(chloromethyl)ether degrade quickly and demonstrate low recovery even after 7 days. The standard VOC list reported by Air Toxics is stable up to 30 days after sample collection. Some projects require a more rigorous 14-day hold time.

2.2 Associated Canister Hardware

Associated hardware used with the canister includes the valve, brass cap, particulate filter and vacuum gauge.

2.2.1 Valve

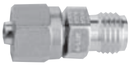
An industry standard, 1/4 in. stainless steel bellows valve (manufactured by Swagelok or Parker Instruments) is mounted at the top of the canister. The valve allows a vacuum to be maintained in the canister prior to sampling and seals off the canister once the sample has been collected. No more than a half turn by hand is required to open the valve. Do not over-tighten the valve after sampling or it may become damaged. A damaged valve can leak, possibly compromising the sample. Some canisters have a metal cage near the top to protect the valve.

2.2.2 Brass Cap

Each canister comes with a brass cap (i.e., Swagelok 1/4 in. plug) secured to the inlet of the valve assembly. The cap serves two purposes: first, it ensures that there is no loss of vacuum due to a leaky valve or a valve that is accidentally opened during handling; second, it prevents dust and other particulate matter from fouling the valve. The cap is removed prior to sampling and replaced following sample collection.

Always replace the brass cap following canister sampling.

7 Micron



2 Micron

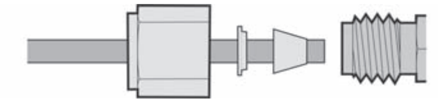
2.2.3 Particulate Filter

Particulate filters should always be used when sampling with a canister. Separate filters are provided to clients taking a grab sample and filters are built into the flow controllers for clients taking integrated samples. Air Toxics Ltd. provides either a 2 micron filter or a 7 micron filter. These devices filter particulate matter greater than 2 and 7 microns in diameter respectively. The shorter 2 micron filter is a fritted stainless steel disk that has been pressed into a conventional Swagelok adapter and is disposed of after each use. This device has a relatively high pressure drop across the fritted disk and restricts the flow into the canister. The 2 micron filter is standard for clients taking integrated samples. The longer 7 micron filter is cleaned in a similar manner as the stainless steel canisters after each single use, and does not significantly restrict the flow rate into the canister. The 7 micron filter is primarily used with grab samples. **Both the 2 and 7 micron filters are not calibrated devices and therefore the flow rates can and do vary for each filter**.

Always use the particulate filter for canister sampling.

2.2.4 Fittings

All fittings on the sampling hardware are 1/4 in. Swagelok; a 9/16 in. wrench is used to assemble the hardware. Compression fittings should be used for all connections; never use tube in tube connections. It is critical to avoid leaks in the sampling train. Leaks of ambient air through fittings between pieces of the sampling train (e.g., tubing to particulate filter) will dilute the sample and cause the canister to fill at a faster rate than desired. Air Toxics can provide the necessary fittings and ferrules if requested.



2.2.5 Vacuum Gauge

A vacuum gauge is used to measure the initial vacuum of the canister before sampling, and the final vacuum upon completion. A gauge can also be used to monitor the fill rate of the canister when collecting an integrated sample. Air Toxics Ltd. provides 2 types of gauges. For grab sampling, a test gauge checks initial and final vacuums only and is not to be sampled through. For integrated sampling a gauge is built into the flow controller and may be used for monitoring initial and final vacuums, as well as monitoring the fill rate of the canister. Both gauges are not calibrated and are considered to be equally rough gauges, which also means they can provide you with differing numbers for the same canister. In special cases a pressure/vacuum gauge can be provided upon request. Air Toxics Ltd.'s gauges are provided only to obtain a relative measure of "change." Individuals with work plans that outline specific gauge reading requirements are strongly encouraged to purchase and maintain their own gauges.

The gauges that Air Toxics Ltd. provides are for rough estimates only. If the project plan requires a certain level of gauge accuracy the use of a calibrated gauge is highly recommended.

Table 2.2.3 Approximate Fill Times for Canisters

CANISTER VOLUME	7 micron filter	2 micron filter
6 L	16 sec	3 min
1 L	3 sec	30 sec

Section 3.0 Sampling with Canisters

There are two basic modes of canister sampling: grab and integrated. A grab sample is taken over a short interval (i.e., 1-5 minutes) while an integrated sample is taken over an extended period (e.g., 0.5-24 hours). In both modes the canister vacuum is used to draw the sample into the canister.

3.1 Considerations for Grab Sampling With Canisters

The following are some considerations for collecting a grab sample in a canister.

- **Verify Initial Vacuum of the Canister:** Prior to shipment, each canister is checked for mechanical integrity. However, it is still important to check the vacuum of the canister prior to use. Air Toxics recommends doing this before going to the field if possible. The initial vacuum of the canister should be greater than 25 in. Hg. If the canister vacuum is less than 25 in. Hg, do not use it. Call Client Services at 800-985-5955 and arrange for a replacement canister. If sampling at altitude there are special considerations for gauge readings and sampling (see Section 5.2). The procedure to verify the initial vacuum of a canister is simple but unforgiving:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove the brass cap
3. Attach gauge
4. Attach brass cap to side of gauge tee fitting, if one is not already there, to ensure a closed train
5. Open and close valve quickly (a few seconds)
6. Read vacuum on the gauge
7. Record gauge reading on “Initial Vacuum” column of chain-of-custody
8. Verify the canister valve is closed and remove gauge
9. Replace the brass cap

3.1.1 Step-By-Step Procedures for Canister Grab Sampling

These procedures are for a typical ambient air sampling application; actual field conditions and procedures may vary.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, canister, particulate filter, and gauge – if requested)
2. Verify the gauge is working properly
3. Verify the initial vacuum of canister

When ready to sample:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove brass cap
3. Attach particulate filter to canister
4. Open valve 1/2 turn (6 L canister normally takes about 16 sec to fill)
5. Close valve by hand tightening knob clockwise
6. Verify and record final vacuum of canister (repeat steps used to verify initial vacuum)
7. Replace brass cap
8. Fill out canister sample tag (make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC exactly)
9. Return canister in box provided (unreturned canister charge of $500 each)
10. Return sample media in packaging provided (unreturned equipment charges: $45 per particulate filter; $45 per gauge)
11. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
12. Place chain-of-custody in box and retain pink copy
13. Tape box shut and affix custody seal at each opening (if applicable)
14. Ship accordingly to meet method holding times

• **Leave Residual Vacuum**: A grab sample can be collected either by allowing the canister to reach ambient conditions or by leaving some residual vacuum (e.g., 5 in. Hg) in the canister. In either case, the final vacuum should be noted in the "Final Vacuum" column on the chain-of-custody. This will enable the laboratory to compare the final vacuum with the receipt vacuum (i.e., the vacuum measured upon arrival at the laboratory).

3.2 Integrated Sampling with Canisters and Flow Controllers

An air sample collected over more than a few minutes is referred to as an integrated sample and can provide information on compound concentrations in air averaged or composited over time. An 8- or 10-hour integrated sample can be used to determine indoor air quality in the workplace. Similarly, a 24-hour integrated sample may be an economical and practical approach to determine residential exposure to indoor or outdoor air sources. The most common hardware configurations used to take an integrated sample are illustrated above.

Flow controllers are devices that regulate the flow of air during sampling into an evacuated canister. Also known as flow restrictors, these devices enable a sampler to achieve a desired flow rate and thus, a sampling interval. Air Toxics Ltd. provides two general types of flow controllers: mass flow controllers and critical orifice devices. Both devices are driven by differential pressure between ambient conditions and the vacuum in the canister.

3.2.1 Mass Flow Controller

A mass flow controller employs a diaphragm that actively compensates to maintain a constant mass flow rate. As the differential pressure decreases, the flow rate tends to decrease and the diaphragm responds by opening up to allow more air to pass through. Mass flow controllers can provide integrated samples with intervals ranging from hours to days. Air Toxics Ltd. provides a fixed mass flow controller that is calibrated at the laboratory for 24-hour sampling. Adjustable mass flow controllers have a knob that can be adjusted in the field to provide integrated samples with intervals ranging from 1 to 24 hours. The rugged conditions of field sampling are not usually compatible with adjustable mass flow controllers and Air Toxics Ltd. has designed a more reliable flow controller based on a critical orifice design.

3.2.2 Critical Orifice Device

Air Toxics Ltd. designed a critical orifice flow controller to provide time-weighted samples with intervals from 0.5 to 12 hours into a 6 L canister and 4 min. to 2 hrs. in a 1 L canister. The device restricts air flow by forcing the sample to enter a capillary column of minute radius. This device is passive compared to an actively compensating diaphragm and the flow rate decreases as the driving force (differential pressure) decreases. For sampling intervals from 0.5 to 12 hours, however, the flow rate is time weighted. The main advantages of the Air Toxics Ltd. flow controllers are improved ruggedness and cleanliness. With no moving or adjustable parts, the Air Toxics Ltd. design is unlikely to lose its flow setting. In addition, a vacuum gauge is built into the device to monitor sampling progress.

3.2.3 Sampling Interval and Flow Controller Setting

When you request canisters and flow controllers from Air Toxics Ltd., you will be asked for the sampling interval, and the flow controllers will be pre-set prior to shipment according to the table below. The flow controller is set to collect a 5 L sample over the sampling interval. Final canister vacuum is targeted at 5 in. Hg. The flow rate is set at standard atmospheric conditions (approximately sea level). If the air sample is from a process (pressurized or under vacuum) or is collected at elevation, the canister will fill faster or slower depending on sample conditions. If you specify the source at project set-up, we can set the flow controller accordingly. See Section 5.2 for a discussion of collecting a sample at elevation. The 24-hr flow controllers should not be used for process or source samples.

Table 3.2.3 Flow Rates for Selected Sampling Intervals (mL/min)

Sampling Interval (hrs)	**4 min.**	**0.5**	**1**	**2**	**4**	**8**	**12**	**24**
6 L Canister	**na**	**167**	**83.3**	**41.7**	**20.8**	**11.5**	**7.6**	**3.8**
1 L Canister	**166.7**	**26.6**	**13.3**	**6.7**	**-**	**-**	**-**	**-**

Note: Target fill volumes for 6 L and 1 L canisters are 5,000 mL and 800 mL, respectively.

$$\textbf{Flow Rate(mL/min)} = \frac{\textbf{Target Fill Volume (mL)}}{\textbf{Sampling Interval (min)}}$$

3.2.4 Final Canister Vacuum and Flow Controller Performance

Ideally, the final vacuum of a 6 L canister should be between 5-10 in. Hg or greater. As long as the differential pressure is greater than 4 in. Hg ambient pressure, then the flow through the device will remain approximately constant as the canister fills. If there is insufficient differential pressure, the flow through the controller will decrease as the canister pressure approaches ambient. Because of the normal fluctuations in the flow rate (due to changes in ambient temperature, pressure and diaphragm instabilities) during sampling, the final vacuum will range between 2 and 10 in. Hg.

- **If the residual canister vacuum is greater than 5 in. Hg** (i.e., more vacuum), less than 5 L of sample was collected. When the canister is pressurized to 5 psig prior to analysis, sample dilution will be greater than normal. This will result in elevated reporting limits.
- **If the residual canister vacuum is less than 5 in. Hg** (i.e., less vacuum), the initial flow rate was high or there was a leak in the connection. Once the vacuum decreases below 5 in.Hg, the flow rate begins to drop significantly. This scenario indicates that the sample is skewed in favor of the first portion of the sampling interval.
- **If the final vacuum is near ambient** (i.e., less than 1 in. Hg), there is inadequate differential pressure to drive the flow controller. The sampler cannot be certain the desired sampling interval was achieved before the canister arrived at ambient conditions. Although the actual sampling interval is uncertain, the canister still contains a sample from the site.

Table 3.2.4 Relationship Between Final Canister Vacuum, VolumeSampled, and Dilution Factor (6 L Canister)

Final Vacuum (in. Hg)	**0**	**2.5**	**5**	**7.5**	**10**	**12.5**	**15**	**17.5**	**20**
Volume Sampled (L)	**6**	**5.5**	**5.4**	**5**	**4**	**3.5**	**3**	**2.5**	**2**
Dilution Factor*	**1.34**	**1.46**	**1.61**	**1.79**	**2.01**	**2.30**	**2.68**	**3.22**	**4.02**

*** Canister pressurized to 5 psig for analysis**

$$\begin{array}{c}\textbf{Final}\\ \textbf{Reporting}\\ \textbf{Limit}\end{array} = \begin{array}{c}\textbf{Method}\\ \textbf{Reporting}\\ \textbf{Limit}\end{array} \times \begin{array}{c}\textbf{Dilution}\\ \textbf{Factor}\\ \text{(Canister Pressurization)}\end{array} \times \begin{array}{c}\textbf{Dilution}\\ \textbf{Factor}\\ \text{(Sample Concentration)}\end{array}$$

$$\begin{array}{c}\textbf{Dilution}\\ \textbf{Factor}\\ \text{(Canister Pressurization)}\end{array} = \frac{\textbf{Pressurization for Analysis}}{\textbf{Receipt Vacuum}} = \frac{\textbf{14.7 psig + Press. for Analysis (psig)}}{\textbf{14.7 psig}\left[1 - \dfrac{\textbf{Rec. Vac (in Hg)}}{\textbf{29.9 in. Hg}}\right]}$$

3.2.5 Considerations for Integrated Sampling with Canisters

Collecting an integrated air sample is more involved than collecting a grab sample. Sampling considerations include verifying that the sampling train is properly configured, monitoring the integrated sampling progress, and avoiding contamination.

- **Avoid Leaks in the Sampling Train:** See Section 3.1 for instructions on how to securely assemble sampling hardware. A leak in any one of these connections means that some air will be pulled in through the leak and not through the flow controller. A final pressure reading near ambient is one indication that there may have been a leak.
- **Verify Initial Vacuum of Canister:** See Section 3.1 for instructions on verifying initial canister vacuum. If you are using an Air Toxics Ltd. critical orifice flow controller, note that you can use the built-in gauge.
- **Monitor Integrated Sampling Progress:** It's a good idea to monitor the progress of the integrated sampling during the sampling interval. The volume of air sampled is a linear function of the canister vacuum. For example, halfway (4 hours) into an 8-hour sampling interval, the canister should be half filled (2.5 L) and the gauge should read approximately 17 in. Hg. More vacuum than 17 in. Hg indicates that the canister is filling too slowly; less than 17 in. Hg and the canister is filling too quickly. If the canister is filling too slowly, a valid sample can still be collected (see Section 3.2.4). If the canister is filling too quickly because of a leak or incorrect flow controller setting, corrective action can be taken. Ensuring all connections are tight may eliminate a leak. It is possible to take an intermittent sample.
- **Avoid Contamination:** Flow controllers should be cleaned between uses. This is done by returning them to the laboratory.
- **Caution Against Sampling in Extreme Temperatures:** There can be some flow rate drift if the temperature of the controllers is allowed to vary significantly.

3.2.6 Step-by-Step Procedures for Integrated Sampling

These procedures are for a typical ambient air sampling application; actual field conditions and procedures may vary.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, canister, particulate filter and flow controller)
2. Verify the gauge is working properly
3. Verify the initial vacuum of the canister

When ready to sample:

1. Confirm the valve is closed (knob should already be tightened clockwise)
2. Remove brass cap from canister
3. Attach flow controller to canister
4. Place the brass cap at the end of the flow controller creating an air tight train, and quickly open and close the canister valve in order to check for leaks. If the needle on the gauge drops, your train is not airtight. In this case, try refitting your connections and/or tightening them until the needle holds steady
5. Once the sample train is airtight remove the brass cap from the flow controller and open the canister valve, 1/2 turn
6. Monitor integrated sampling progress periodically
7. Verify and record final vacuum of canister (simply read built-in gauge)
8. Close valve by hand tightening knob clockwise
9. Replace brass cap
10. Fill out canister sample tag (make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC exactly)
11. Return canisters in boxes provided (unreturned canister replacement charge of $500 each)
12. Return sample media in packaging provided (unreturned equipment charges: $45 per particulate filter; $50-500 per flow controller)
13. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
14. Place chain-of-custody in box and retain pink copy
15. Tape box shut and affix custody seal at each opening (if applicable)
16. Ship accordingly to meet method holding times

Important Information for Canister Sampling

@ DO NOT use canister to collect explosive substances, radiological or biological agents, corrosives, extremely toxic substances or other hazardous materials. It is illegal to ship such substances and you will be liable for damages.

@ ALWAYS use a filter when sampling. NEVER allow liquids (including water) or corrosive vapors to enter canister.

@ DO NOT attach labels to the surface of the canister or write on the canister; you will be liable for cleaning charges.

@ DO NOT over tighten the valve and remember to replace the brass cap.

@ IF the canister is returned in unsatisfactory condition, you will be liable for damages.

For assistance call Client Services at 800-985-5955.

Section 4. Sampling with Tedlar® Bags

This section provides a description of Tedlar® bags, practical considerations for sampling, and step-by-step instructions for collecting a grab sample. A photograph illustrates the correct way to assemble the various sampling components.

4.1 Introduction to Tedlar® Bags

The Tedlar® bag is best suited for projects involving analysis of compounds in the ppmv range. However, Tedlar® bags may be used for other applications such as ambient air monitoring for atmospheric/ fixed gases. They can be used to collect sulfur compounds, but only if the fittings are non-metallic (e.g., polypropylene, Teflon®, or Nylon). A Tedlar® bag is made of two plies of Tedlar® film sealed together at the edges, and features a valve that allows for filling. Sample collection requires a pressurized sampling port, a low flow rate pump or a lung sampler. The bag expands as the sample enters. Air Toxics Ltd. maintains Tedlar® bags in 1, 3 and 5 L volumes.

4.1.1 Tedlar® Film

Tedlar® is a trade name for a polyvinyl fluoride film developed by DuPont Corporation in the 1960's. This patented fluoropolymer has been used in a wide variety of applications including protective surfacing for signs, exterior wall panels and aircraft interiors. Tedlar® film is tough yet flexible and retains its impressive mechanical properties over a wide range of temperatures (from well below freezing to over 200°F). Tedlar® exhibits low permeability to gases, good chemical inertness, good weathering resistance and low off-gassing.

4.1.2 How "Active" is the Surface of a Tedlar® Bag?

The surface of a Tedlar® bag is a work in progress. The surface of a new bag is essentially free of VOCs at the single digit ppbv level. Compounds detected from analyzing new Tedlar® bags include methylene chloride, toluene, acetone, ethanol and 2-propanol. Note that 2-propanol has been detected in some new bags up to 45 ppbv. Once the Tedlar® bag is used, however, the surface has been exposed to moisture and possible

VOCs. It may irreversibly adsorb many VOCs at the low ppbv level. A series of purges with certified gas may not remove the VOCs from the surface. $10 for a new bag is a small price to pay for peace of mind.

Never reuse a Tedlar® bag when sampling for ppbv level compounds.

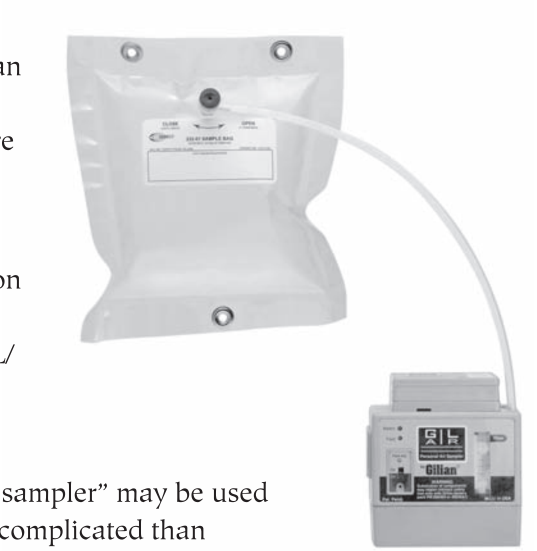
4.1.3 Hold Time for a Tedlar® Bag

The media hold time for a Tedlar® bag is indefinite if stored out of sunlight in a cool, dry location. Tedlar® bags may be used to collect samples containing common solvents, hydrocarbons, chlorinated solvents, sulfur compounds and many other classes of compounds. The sample hold time to analysis varies for different classes of compounds:

- **24 hours:** Sulfur compounds (e.g., hydrogen sulfide and methyl mercaptan) and chemically active compounds (e.g., 1,3-butadiene)
- **72 hours:** Chlorinated solvents, aromatic compounds and atmospheric/fixed gases (oxygen, nitrogen, carbon dioxide)

4.2 Tedlar® Bag Sampling

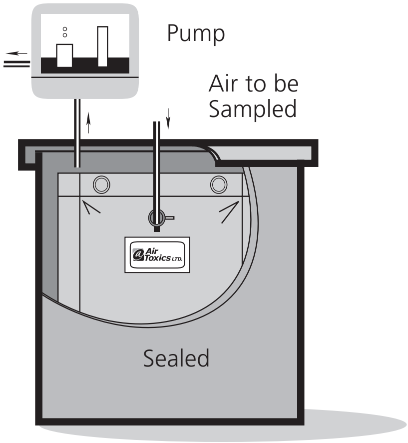
Using a Tedlar® bag to collect an air sample normally involves "active" sampling, unlike an evacuated canister that can be filled "passively" by simply opening the valve. There are two methods commonly used to fill a Tedlar® bag: a pump or a lung sampler.



- **Sampling with a Pump:** The most common method for filling a Tedlar® bag is to use a small pump with low flow rates (50-200 mL/min) and tubing to fill the bag. Air Toxics Ltd. does not provide pumps.

- **Sampling with a Lung Sampler:** A "lung sampler" may be used to fill a Tedlar® bag. Although a little more complicated than simply using a pump, the main advantage to using a lung sampler to fill a Tedlar® bag is that it avoids potential pump contamination.

A Tedlar® bag with attached tubing is placed in a small airtight chamber with the tubing protruding from the chamber. The sealed chamber is then evacuated via a pump, causing the bag to expand and draw the sample into the bag through the protruding tube. The sample air never touches the wetted surfaces of the pump. Air Toxics Ltd. does not provide lung samplers.



4.2.1 Considerations for Tedlar® Bag Sampling

Some considerations for collecting a Tedlar® bag sample:

- **Fill the Tedlar® bag no more than 2/3 full**: Allow for possible expansion due to an increase in temperature or decrease in atmospheric pressure (e.g., the cargo hold of a plane)
- **Keep the Tedlar® bag out of sunlight**: Tedlar® film is transparent to ultraviolet light (although opaque versions are available) and the sample should be kept out of sunlight to avoid any photochemical reactions
- **Protect the Tedlar® bag**: Store and ship the Tedlar® bag samples in a protective box at room temperature. An ice chest may be used, but DO NOT CHILL
- **Fill out the Tedlar® bag label**: It is much easier to write the sample information on the label before the Tedlar® bag is inflated
- **Provide a second Tedlar® bag**: Consider filling two bags per location in the rare occasion that a defective bag deflates before analysis. The "hold" sample does not need to be documented on the Chain-of-Custody and should have an identical sample ID to the original sample indicating that it is the "hold" sample
- **Avoid Contamination**: Care should be taken to avoid contamination introduced by the pump or tubing. Begin sampling at locations with the lowest compound concentrations (e.g., sample the SVE effluent before the influent). Decontaminate the pump between uses by purging with certified air for an extended period; better yet, use a lung sampler. Use the shortest length possible of Teflon® tubing or other inert tubing. DO NOT REUSE TUBING. If long lengths of tubing are used, consider purging the tubing with several volumes worth before sampling. If you are concerned about sampling for trace compounds, you shouldn't be using a Tedlar® bag (see Section 1.2)
- **Don't Sample Dangerous Compounds in a Tedlar® Bag**: Do not ship any explosive substances, radiological or biological agents, corrosives or extremely hazardous materials to Air Toxics Ltd. Tedlar® bag rupture during transit to the laboratory is possible and the sampler assumes full liability

4.2.2 Step-by-Step Procedures for Tedlar® Bag Sampling (Pump)

Note: These procedures are for a typical stationary source (e.g., SVE system) sampling application; actual field conditions and procedures may vary. See additional sampling considerations in Section 5.3 for sampling soil gas or landfill gas.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, Tedlar® bag, and tubing/fittings – if requested)
2. Verify pump cleanliness and operation (Air Toxics Ltd. does not provide pumps)

When ready to sample:

3. Purge sample port
4. Attach new Teflon® tubing from sample port or probe to low flow rate pump
5. Purge tubing
6. Fill out Tedlar® bag sample tag
7. Attach additional new Teflon® tubing from the pump outlet to the Tedlar® bag valve
8. Open Tedlar® bag valve
9. Collect sample (FILL NO MORE THAN 2/3 FULL)
10. Close Tedlar® bag valve by hand tightening valve clockwise
11. Return Tedlar® bag in boxes provided (DO NOT CHILL)
12. Fill out chain-of-custody and relinquish samples properly.
13. Place chain-of-custody in box and retain pink copy
14. Tape box shut and affix custody seal as both openings (if applicable)
15. Ship priority overnight to meet method holding times.

Section 5. Special Sampling Considerations

This section provides considerations for special sampling configurations that a sampler may collect in the field such as field duplicates or an ambient blank. This section also provides considerations for sampling at altitude, as well as soil gas and landfill gas sampling.

5.1 Special Sampling Configurations

Special sampling configurations include a field duplicate, field split, field blank, ambient blank, and a trip blank. Call Client Services at 800-985-5955 if your project involves any of these special sampling configurations.

5.1.1 Field Duplicate

A field duplicate is a second sample collected in the field simultaneously with the primary sample at one sampling location. The results of the duplicate sample may be compared (e.g., calculate relative percent difference) with the primary sample to provide information on consistency and reproducibility of field sampling procedures. Due to the nature of the gas phase, duplicate samples should be collected from a common inlet. The configuration for collecting a field duplicate includes stainless steel or Teflon® tubing connected to a Swagelok "T". If integrated samples are being collected and the sample duration is to be maintained, the sample train should be assembled as follows: each canister should have a flow controller attached, then the duplicate sampling T should be attached to the flow controllers. If the collection flow rate from the sample port is to be maintained then the duplicate sampling T should be connected to the canisters; then the flow controller is connected to the inlet of the sampling T.

5.1.2 Field Blank

A field blank is a sample collected in the field from a certified air source. Analysis of the field blank can provide information on the decontamination procedures used in the field. Clean stainless steel or Teflon® tubing and a certified regulator should be used. It is imperative that individually certified canisters (the sample canister and the source canister/cylinder, if applicable) be used to collect a field blank.

5.1.3 Ambient Blank

An ambient blank is an ambient air sample collected in the field. It is usually used in conjunction with soil gas or stationary source (e.g., SVE system) sampling. Analysis of the ambient blank can provide information on the ambient levels of site contaminants. It is recommended that an individually certified canister be used to collect an ambient blank.

5.1.4 Trip Blank

When sampling for contaminants in water, the laboratory prepares a trip blank by filling a VOA vial with clean, de-ionized water. The trip blank is sent to the field in a cooler with new sample vials. After sampling, the filled sample vials are placed back in the cooler next to the trip blank and returned to the laboratory. Analysis of the trip blank provides information on decontamination and sample handling procedures in the field as well as the cleanliness of the cooler and packaging.

When sampling for compounds in air, a trip blank provides little, if any, of the information above. A trip blank canister can be individually certified, evacuated, and sent to the field in a box with the sample canisters. Since the valve is closed and the brass cap tightened, it is questionable if the trip blank canister contents are ever "exposed" to sampling conditions. **Air Toxics Ltd. does not recommend analyzing a trip blank for air sampling.**

5.2 Considerations for Sampling at Altitude

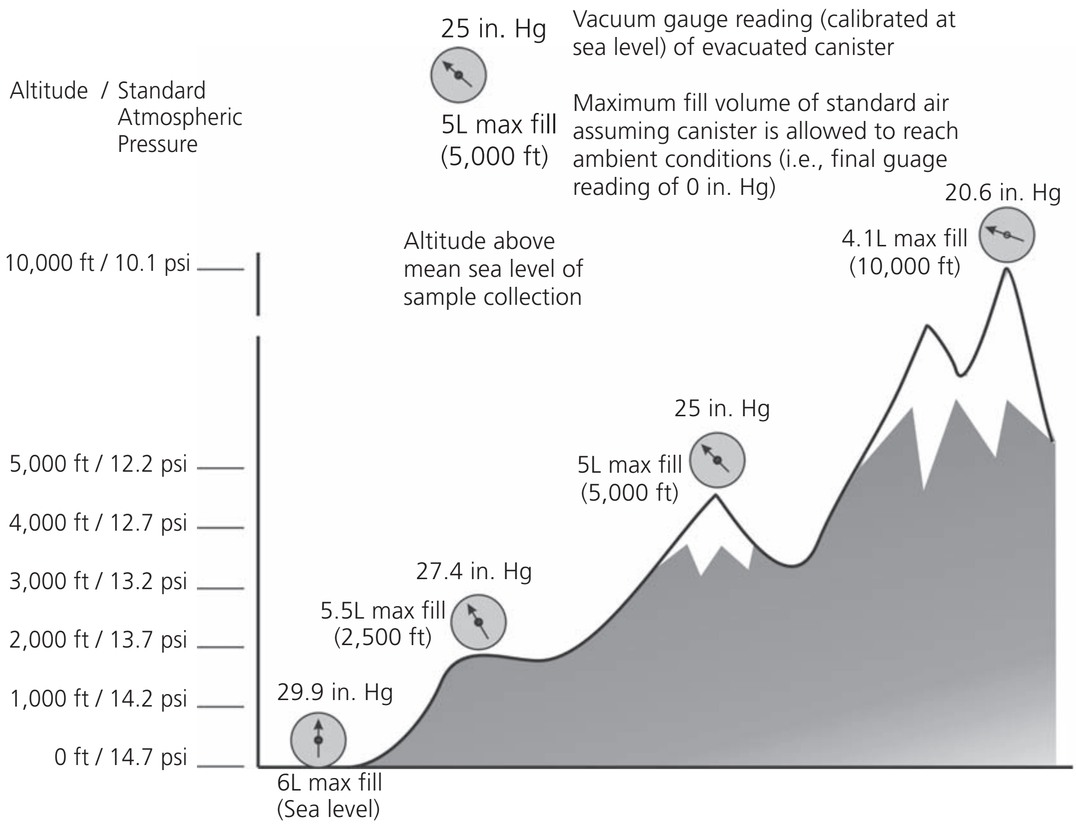
Sampling at altitudes significantly above sea level is similar to sampling a stationary source under vacuum, in that target fill volumes may be difficult to achieve. The figure below illustrates the relationship between increasing altitude and decreasing atmospheric pressure. Ambient conditions in Denver at 5,000 ft altitude are quite different from ambient conditions at sea level. Canister sampling is driven by the differential pressure between ambient conditions and the vacuum in the canister.

There is less atmospheric pressure in Denver and 5 L is the maximum fill volume of standard air assuming the canister is allowed to reach ambient conditions (i.e., final gauge reading of 0 in. Hg). Theoretically, if you sample high enough (e.g., in space), no sample would enter the canister because there is no pressure difference between the evacuated canister and ambient conditions. To fill a canister to 6 L in Denver, you would need to use an air pump.

Sampling at altitude also affects gauge readings. The gauges supplied by Air Toxics Ltd. (see Section 2.2.4) measure canister vacuum relative to atmospheric pressure and are calibrated at approximately sea level. Before sampling at altitude, the gauges should be equilibrated (see Section 3.1). But even after equilibrating the gauge, verifying the initial vacuum of a canister at altitude is misleading. In Denver at 5,000 ft, expect the gauge to read 25, not 29.9 in. Hg. You do not have a bad canister (i.e., leaking or not evacuated properly). The canister is ready for sampling and the gauge is working properly.

Rule of Thumb: For every 1,000 ft of elevation, the gauge will be off by 1 in. Hg and the fill volume will be reduced by 1/5 L.

If you have questions about sampling at altitude, please call Client Services at 800-985-5955.



5.3 Considerations for Soil Gas / Landfill Gas Sampling

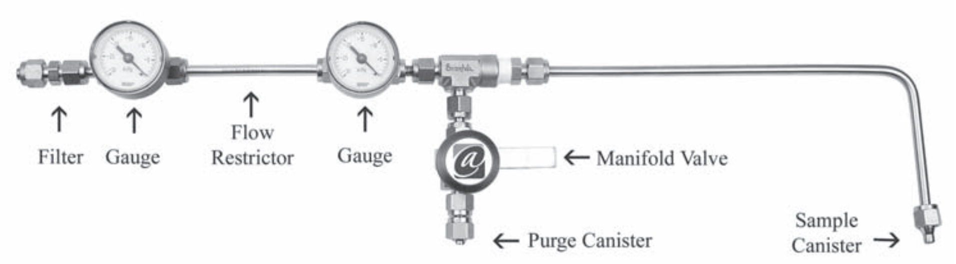
There are some additional sampling considerations for collecting grab samples (canister or Tedlar® bag) from a soil boring, landfill boring, SVE system or landfill gas (LFG) collection system. The general challenge with these samples arises from the need to employ long lengths of tubing to direct the soil gas, landfill gas or process air to the canister or Tedlar® bag. Tubing introduces the potential for contamination and diluting the sample.

5.3.1 Collecting Soil Gas Samples with Sampling Manifolds

Air Toxics provides soil gas sampling manifolds in order to facilitate meeting the numerous quality control guidelines for collecting soil gas data. Two of the most critical aspects of soil gas sampling are purging the lines and preventing leaks. The manifold setup allows for automatic leak-checking of the canister sample train without the application of a leak check compound to the canister fittings. When the purge can is opened and closed, it creates a vacuum within the canister lines and fittings. If this vacuum is maintained, the train is considered leak-free. Because there is only one connection – the probe tubing to sample train – the chance for leaks is greatly reduced.

The manifold's in line gauge system used with a purge canister enables the sampler to determine the appropriate purge volume. Typically, purge volumes of 3 to 5 times the volume of the train tubing are used, and once the purge volume is calculated the lines can be purged by opening the purge canister valve and monitoring the decrease in vacuum. This decrease in vacuum is proportional to the volume purged through the lines. There is a suggested flow rate of between 100 and 200 milliliters per minute, a step thought to prevent ambient air intrusion as a result of taking the sample too quickly. Our manifold has a "built-in" flow restrictor; a frit of stainless steel tubing between the two gauges that is calibrated to 167 milliliters per minute.

The first gauge, located prior to the flow restrictor, is a vacuum gauge that informs the sampler if sufficient vapor is being collected from the soil or if the substrate is too compacted. Because this is not a flow meter but a measure of pressure/vacuum, the gauge should read at zero if there is sufficient flow from the soil. If the gauge begins to read a vacuum, then the flow is being restricted. The second gauge, in line after the flow controller and prior to the purge canister, is a vacuum gauge that indicates to the sampler whether or not the canister is filling properly at the expected rate. This setup enables the sampler to evaluate the lithologic conditions at the site and determine if a valid soil gas sample is being taken. Finally, when duplicate samples are required, the manifold can be used as a duplicate sampling "T" by simply replacing the purge canister with another sample canister.



5.3.2 Step-by-Step Procedures for Soil Gas Sampling Using Sampling Manifolds

These procedures are for a typical soil gas sampling application; actual field conditions and procedures may vary.

Before you get to the field:

1. Verify contents of the shipped package (e.g., chain-of-custody, canister, particulate filter and flow controller)
2. Verify the gauge is working properly
3. Verify the initial vacuum of canister

When ready to sample:

Leak Check Test

1. Confirm that canister valves are closed (knob should already be tightened clockwise)
2. Remove brass caps from both the sample canister and the purge canister (unless using certified media there is no difference between the two)
3. Attach manifold to canisters
4. Confirm that there is a brass cap secured at the inlet of the manifold creating an air tight train, make sure the manifold valve above the purge canister is open, and quickly open and close the purge canister valve in order to check for leaks. If the needle on the gauge drops, your train is not airtight. In this case, try refitting your connections and/or tightening them until the needle holds steady

Purging

5. Once the sample train is airtight remove the brass cap from the manifold inlet, connect the tubing from the sample port using a compression fitting and open the purge canister valve, 1/2 turn
6. Monitor integrated sampling progress periodically. *Please note, because the purge canister is inline after the flow restrictor the line will not purge faster than at a rate of 167mls/min
7. Once the desired purge volume is met close both the manifold valve and the purge canister valve by hand tightening the knobs clockwise
8. If sampling at multiple locations, the purge canister can be disconnected from the manifold and used to begin purging the next sample location without compromising the sample train

Sampling

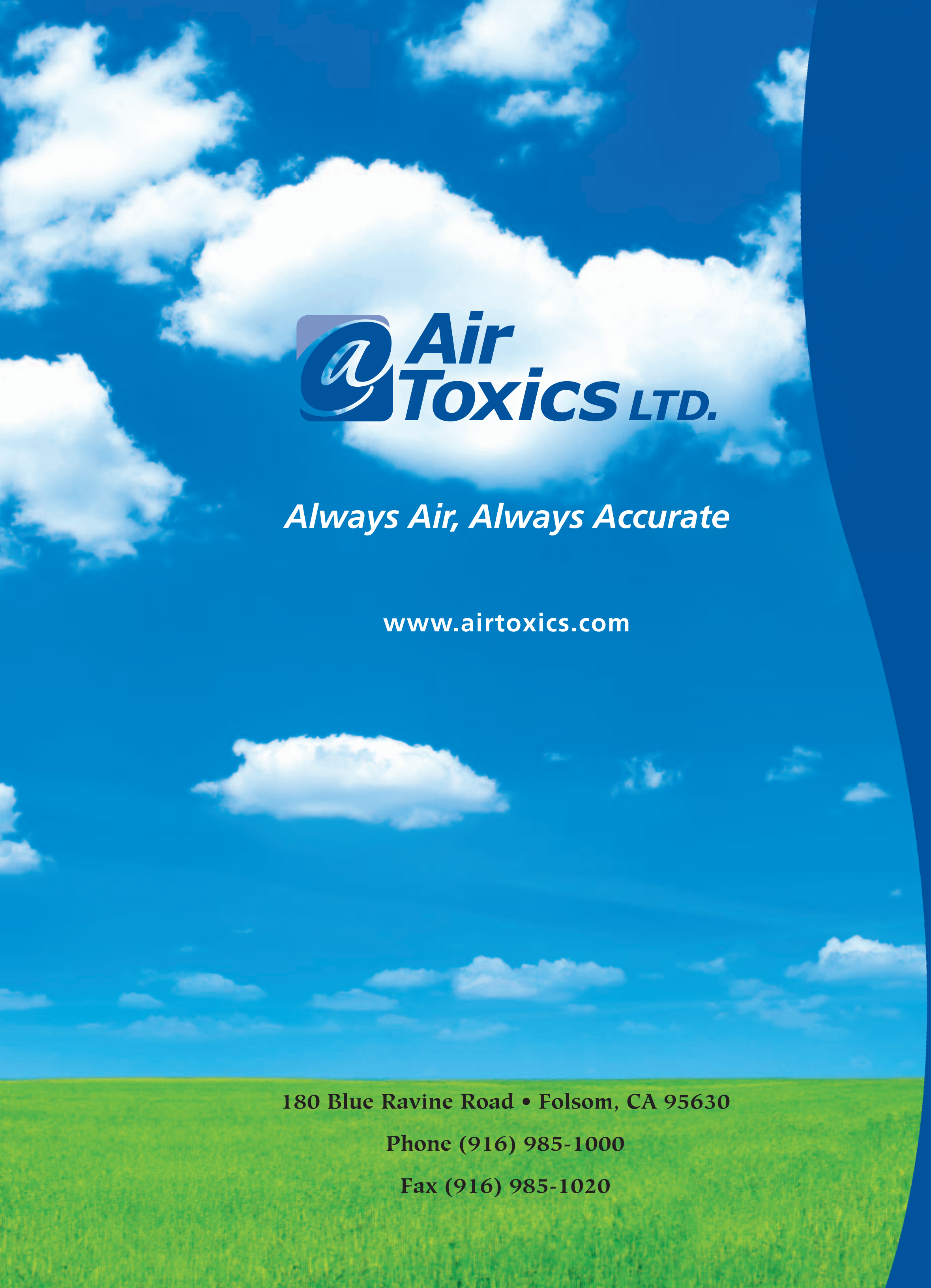
9. The line is now ready to be sampled. Open the sample canister valve and monitor sampling progress periodically.
10. When the sampling is complete close the valve and replace the brass cap on the canister; record final vacuum of canister (simply read built-in gauge)
11. Fill out canister sample tag (make sure the sample ID and date of collection recorded on the sample tag matches what is recorded on the COC exactly)
12. Return canisters in boxes provided (Unreturned canister replacement charge of $500 each)
13. Return sample media in packaging provided (Unreturned equipment charges: $45 per particulate filter; $50-500 per flow controller)
14. Fill out chain-of-custody and relinquish samples properly (it is important to note the canister serial numbers on the chain-of-custody)
15. Place chain-of-custody in box and retain pink copy
16. Ship accordingly to meet method holding times

5.3.3 Special Considerations for Soil Gas and Landfill Gas Sampling

- **Use inert tubing**. Teflon® tubing is recommended. Tubing with an outer diameter of 1/4 in. works best with the fittings on the particulate filter.
- **Do not reuse tubing**. $2 per foot for new tubing is a small price to pay for peace of mind.
- **Purge tubing adequately**. A long length of tubing has significant volume of "dead air" inside.
  Without purging, this air will enter the canister and dilute the sample. Consider using a handheld PID/FID to confirm that you have purged the tubing and are drawing sample air through the tubing.
- **Avoid leaks in the sampling train**. Leaks of ambient air through fittings between pieces of the sampling train (e.g., tubing to particulate filter) will dilute the sample. Always use compression fittings for all connections; never use tube in tube connections.
- **Don't sample water**. If moisture is visible in the sample tubing, the soil gas sample may be compromised. Soil gas probes should be at an appropriate depth to avoid reaching the water table. Additionally, subsurface vapor should not be collected immediately after measurable precipitation.
- **Purge the sample port**. A sample port on an SVE system or LFG collection system can accumulate solids or liquids depending upon the location of the port in the process and the orientation of the port. An influent sample port located upstream of a filter or moisture knock-out can be laden with particulates or saturated with water vapor. Heavy particulate matter can clog the particulate filter and foul the canister

valve. It is important to prevent liquids from entering the canister. A sample port oriented downward may have liquid standing in the valve. Purge the sample port adequately before connecting the sampling train.

- **Consider the effects of sampling a process under vacuum or pressure**. When collecting a grab sample from a stationary source such as an SVE system or LFG collection system, some sample ports may be under vacuum or pressure relative to ambient conditions. When the sample port is under vacuum, such as the header pipe from the extraction well network, it may be difficult to fill the canister with the desired volume of sample. A vacuum pump may be used to collect a canister grab sample from a sample port under considerable vacuum. See the related discussion on sampling at altitude in Section 5.2. When the sample port is under pressure, such as the effluent stack downstream of the blower and treatment system, you may inadvertently pressurize the canister. Only a DOT-approved sample cylinder should be used to transport pressurized air samples. Under no circumstances should an Air Toxics Ltd. canister be pressurized more than 5 psig for a 6 L canister and 15 psig for a 1 L canister. Bleed off excess pressure by opening the valve temporarily while monitoring the canister with a pressure gauge.



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