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TRANSMITTAL

DATE: April 27, 2011

REFERENCE NO.: 240933

PROJECT NAME: 15275 Washington Avenue, San Leandro

TO: Jerry Wickham
Alameda County Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

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QUANTITY	DESCRIPTION
1	Memorandum: Development of Site Specific Soil Vapor Criteria for Volatile Constituents of Concern for Former Shell Service Station, 15275 Washington Avenue, San Leandro, California

- ☐ As Requested
- ☐ For Your Use
- ☒ For Review and Comment
- ☐
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COMMENTS:
If you have any questions regarding the contents of this document, please call Peter Schaefer at (510) 420-3319.

Copy to: Denis Brown, Shell Oil Products US (electronic copy)
Frank Salel, Salel Enterprises, P.O. Box 5099, Oakland, CA 94605
Mike Bakaldin, City of San Leandro, 835 East 14th Street, San Leandro, CA 94577
Johnny Vierra, Big O Tire, 2201 Washington Avenue, San Leandro, CA 94577

Completed by: Peter Schaefer Signed: Peter Schaefer

Filing: **Correspondence File**

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Mr. Jerry Wickham
Alameda County Environmental Health
1131 Harbor Bay Parkway, Suite 250
Alameda, California 94502-6577

Re: Former Shell Service Station
15275 Washington Avenue
San Leandro, California
SAP Code 129460
Incident No. 97093412
ACEH No. RO0000372

Dear Mr. Wickham:

The attached document is provided for your review and comment. Upon information and belief, I declare, under penalty of perjury, that the information contained in the attached document is true and correct.

If you have any questions or concerns, please call me at (707) 865-0251.

Sincerely,

Denis L. Brown
Senior Program Manager

CONESTOGA-ROVERS & ASSOCIATES

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MEMORANDUM

TO:	Jerry Wickham, Alameda County Environmental Health	REF. NO.:	240933
FROM:	Peter Schaefer/Chris West/ Tina LePage/April Gowing/jh/1	DATE:	April 27, 2011
RE:	**Development of Site Specific Soil Vapor Criteria for Volatile Constituents of Concern for Former Shell Service Station, 15275 Washington Avenue, San Leandro, California**		

1.0 INTRODUCTION

This memorandum discusses the development of site-specific soil vapor criteria for volatile chemicals of concern (COCs) in soil vapor at the Former Shell service Station located at 15275 Washington Boulevard, San Leandro, California (Figure 1). Former service station features included an underground storage tank complex, three dispenser islands and a station building (Figure 2). Currently, the site is occupied by an automotive emission testing facility (Speedy Smog Check) and tire repair facility (Big O Tire). Salel's Mobile Home Park is located to the west of the site. The estimated soil vapor criteria are intended to protect human health from soil vapor migration to the indoor air of an overlying building. Based on current and anticipated future land use, soil vapor criteria were developed for current residential and commercial land use receptors.

Four rounds of soil vapor sampling have been completed at the site (June 2008, September 2009, March 2010, and September 2010) since soil vapor remediation was conducted in the area of the former UST complex in 1999. Soil vapor samples were collected from 3.0 to 8.0 feet below grade (fbg) throughout Salel's Mobile Home Park. Soil vapor samples were analyzed for total petroleum hydrocarbons as gasoline (TPHg), benzene, toluene, ethylbenzene, xylenes (BTEX), methyl tertiary-butyl ether (MTBE), and tertiary-butyl alcohol (TBA). It should be noted that the San Francisco Bay Regional Water Quality Control Board's (RWQCB's) *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, California Regional Water Quality Control Board, San Francisco Bay Region, Interim Final* (November 2007 [Revised May 2008]) states that "TPH ESLs must be used in conjunction with ESLs for related chemicals", in this case BTEX, MTBE, and TBA. For BTEX, MTBE, and TBA, site-specific soil vapor criteria were modeled based on a conservative sampling depth of 3 fbg and compared to the maximum detected concentration in order to determine if exceedances of the estimated soil vapor criteria existed.

Soil vapor criteria were developed using inputs from the RWQCB's environmental screening document (RWQCB, 2008) and the Johnson and Ettinger (1991) model (J&E Model) as implemented by the United States Environmental Protection Agency (USEPA, 2004). The approach applied by the USEPA in their document entitled, "*Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils*" (Subsurface Vapor Intrusion Guidance) (USEPA, 2002) was followed in the development of the soil vapor criteria.

Section 2.0 presents a summary of the analytical data applied in the estimation of the site-specific soil vapor criteria. The methodology for developing the site-specific soil vapor criteria are presented in Section 3.0. Summaries of the site-specific input parameters applied, the site-specific soil vapor criteria results, and a summary of the findings of the soil vapor evaluation are presented in Section 4.0. References cited in this memo are listed in Section 5.0.

2.0 SOIL VAPOR ANALYTICAL DATA

The soil vapor data set used to develop the site-specific soil vapor criteria includes data obtained since soil vapor remediation was conducted in the area of the former UST complex in 1999 from the soil vapor probes and soil vapor wells located within Salel's Mobile Home Park to the west of the site (P-10, P-11, P-12, P-15, P-24, P-25, P-26, P-27, P-28, P-29, SVG-4, SVG-5, SVG-6, SVG-7, SVG-8, and SVG-9) collected in June 2008, September 2009, March 2010, and September 2010. Soil vapor samples were analyzed BTEX, MTBE, TBA, and TPHg.

As stated above, it should be noted that the RWQCB (2008) guidance advises that "TPH ESLs must be used in conjunction with ESLs for related chemicals (e.g., BTEX, polynuclear aromatic hydrocarbons, oxidizers, etc.)." In this case, BTEX and fuel oxygenates would be the appropriate related chemicals and TPHg was not evaluated further. A summary of historical soil vapor analytical data collected as part of these investigative activities is presented in Table 1 and historical soil vapor sampling locations are shown on Figure 2.

3.0 METHODOLOGY

Soil vapor criteria were developed using the approach applied in USEPA (2002), which is based on the J&E Model. Johnson and Ettinger (1991) present a model for estimating the degree of attenuation occurring as volatile chemicals in soil vapor migrate upward through the vadose zone, enter an overlying building, and mix with building indoor air. The degree of attenuation is quantified through the calculation of an attenuation factor, α, after Johnson and Ettinger (1991; Equation 21). The equations and exposure assumptions applied in the estimation of the soil vapor criteria using the J&E Model are described in Section 3.1. A description of several conservative features inherent to the J&E Model is provided in Section 3.2.

3.1 DERIVATION OF ESTIMATED SOIL VAPOR CRITERIA

The target risk-based indoor air concentrations were derived for the volatile COCs identified in soil vapor (see Tables 2 [resident] and 3 [commercial worker]) using the following equations (after RWQCB [2008]).

Carcinogenic endpoints:

$$RBC_{ia} = \frac{TR \times ATc \times 365\ days/yr}{EF \times ED \times URF}$$

Non-carcinogenic endpoints:

$$RBC_{ia} = \frac{THQ \times ATnc \times 365\ days/yr}{EF \times ED \times (1/RfC)}$$

Where:

RBC_{ia} = Risk-based indoor air concentration (milligrams per cubic meter [mg/m^3])
TR = Target risk level (1.0×10^{-6})
FT = Fraction of time exposed (hours per 24 hours exposed) (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
URF = Reference concentration (mg/m^3)
RfC = Unit risk factor (mg/m^3)
ATc = Averaging time – cancer [period over which exposure is averaged] (years)
ATnc = Averaging time – non-cancer [period over which exposure is averaged] (years)

The selected RBC_{ia} is the lower of the carcinogenic-based and non-carcinogenic-based concentrations. For residential receptors carcinogenic exposure considered both adult and child receptors; however, non-carcinogenic exposure only considered child receptors.

Exposure Assumptions

As indicated above, the site is located in an area of mixed residential and commercial land use with Salel's Mobile Home Park located to the west of the site. For the purposes of calculating indoor air exposure, a default residential building size of 34.8 feet (ft) (10 metres [m]) x 34.8 ft (10 m) x 8 ft (2.44 m) with a 6 inch (15 centimeter [cm]) foundation slab was applied.

Exposure Frequency and Duration

The resident (adult and child) and commercial worker exposure assumptions utilized in the estimation of the magnitude of their exposure to indoor air are summarized in the following table.

RECEPTOR CHARACTERISTICS				
Parameter	*Resident*		*Commercial Worker*	*Reference*
	Adult	*Child*		
Fraction of Time Exposed - Inhalation of Indoor Air	24 hr/24 hr	24 hr/24 hr	8 hr/24 hr	RWQCB, 2008; Professional Judgment (1)
Exposure Frequency – Indoor Air	350 days/year	350 days/year	250 days/year	RWQCB, 2008
Exposure Duration	24 years	6 years	25 years	RWQCB, 2008
Averaging Time (Cancer)	25,550 days	25,550 days	25,550 days	RWQCB, 2008
Averaging Time (Non-Cancer)	2,190 days	2,190 days	9,125 days	RWQCB, 2008

Notes:
1 Professional judgment: assumes the commercial worker will only work 8 hours per day.
hr hour

All exposure assumptions and equations utilized in the calculation of the risk-based concentrations for COCs in indoor air for residents and commercial workers are also summarized in Tables 2 and 3, respectively.

The soil vapor criteria (C_{sg}) were calculated by applying a site-specific attenuation factor (α) to the target risk-based indoor air concentrations (RBC_{IA}) to estimated soil vapor criteria beneath a site building, as follows:

$$C_{sg} = RBC_{IA} \times \alpha$$

Where:

C_{sg} - The calculated soil vapor criteria (micrograms per cubic meter [$\mu g/m^3$]).

RBC_{IA} - The calculated allowable risk-based target indoor air concentration (see Table 2/3) ($\mu g/m^3$).

α - The calculated soil vapor attenuation factor, which relates the indoor air concentration to the concentration in soil vapor directly above the source based on the heuristic model developed by Johnson and Ettinger (1991; Equation 21). The soil vapor attenuation factor accounts for the advective-diffusive migration of chemicals in soil vapor through the vadose zone soil and building foundation, and the subsequent mixing of chemicals with building indoor air.

The estimation of soil vapor criteria was conducted through the application of the J&E Model for soil vapor incorporated into a Microsoft Excel spreadsheet by the USEPA (USEPA, 2004a; "SG-ADV-Feb04.xls, Version 3.1"). The site-specific compound, vadose zone soil, and building properties applied in the estimation of soil vapor criteria are presented below.

Compound Properties

The compound properties applied in the estimation of the soil vapor criteria consist of a Henry's Law constant, a water diffusion coefficient, and an air diffusion coefficient. The majority of the applied compound properties were obtained from the chemical properties database implemented in USEPA (2004). The applied chemical properties for TBA were obtained from the Wyoming Department of Environmental Quality (WDEQ, 2009). The applied chemical properties for xylenes (total) were obtained from RWQCB (2008). The Henry's Law constant and air diffusion coefficient were corrected to a vadose zone temperature of 22 degrees Celsius, which corresponds to the highest average soil temperature for California, as presented in CalEPA (2005).

Vadose Zone Conditions

The boring logs for the soil vapor probes advanced within Salel's Mobile Home Park (P-10, P-11, P-12, P-15, P-24, P-25, P-26, P-27, P-28, P-29, SVG-4, SVG-5, SVG-6, SVG-7, SVG-8, and SVG-9) indicated that the soil vapor probes are screened in primarily silty clay and/or silty sand soils. Based on these descriptions, and considering the U.S. Soil Conservation Service Classification Chart presented in USEPA (2004), the vadose zone at the site was conservatively determined to consist primarily of silty clay loam. The vadose zone soil physical properties applied in the development of indoor air concentrations were therefore selected to be consistent with a silt loam unit. Ideally, the J&E attenuation factors for the site would be estimated using

the J&E Model with site-specific vadose zone soil properties however, since site-specific soil physical properties were not available; default values for a silty clay loam were conservatively applied.

The site-specific vadose zone soil physical properties applied in the development of the soil vapor criteria consisted of the following:

- porosity, ε_T:
  A porosity value of 48.2 percent was applied, corresponding to the default value for a silty clay loam soil, as implemented in USEPA (2004).
- moisture-filled porosity, ε_M:
  A moisture-filled porosity of 0.198 was applied, and corresponds to the default value for a silty clay loam soil, as implemented in USEPA (2004).
- dry bulk soil density, ρ_{db}:
  A dry bulk soil density value of 1.37 grams per cubic cemtimeter was applied, and corresponds to the default value for a silty clay loam soil, as implemented in USEPA (2004).
- soil vapor sampling depth below grade, L_S:
  A distance of 0.9144 m (3 feet) was applied, based on the minimum measured depth to the top of the screen of the vapor probes (P-24, P-26 to P-29).

Building Properties

Construction details of the mobile homes located within Salel's Mobile Home Park indicate that the mobile homes are not in direct contact with the ground surface rather the mobile homes are elevated approximately 1 ft above the ground surface. As a result, potential soil vapor COCs will migrate along a preferential pathway around the building with only limited amounts moving to the indoor air of the overlying buildings. However, as a conservative evaluation of the indoor air pathway the mobile homes were assumed to be in direct contact with the ground surface. The building properties applied in the development of the site-specific soil vapor criteria consist of the following:

- Enclosed space floor length, L_B:
  An enclosed floor space length of 1,000 cm (34.8 ft) was applied, based on the default building dimensions indicated in RWQCB (2008).
- Enclosed space floor width, W_B:
  An enclosed floor space width of 1,000 cm (34.8 ft) was applied, based on the default building dimensions, as indicated in RWQCB (2008).
- Enclosed space height, H_B:
  An enclosed space height of 244 cm (8 ft) was applied, based on the default building dimensions indicated in RWQCB (2008).
- Building indoor air exchange rate, T_{air}:
  Commercial Land Use Scenario: A building indoor air exchange rate of 2.0 building volume per hour was applied for the commercial building scenario consistent with the commercial air exchange rates

reported in Table B-7 of the Human-Exposure Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil (CalEPA, 2005).

Residential Land Use Scenario: A building indoor air exchange rate of 1.0 building volume per hour was applied for the residential building scenario consistent with the residential air exchange rates reported in Table B-7 of the Human-Exposure Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil (CalEPA, 2005).

- Foundation thickness, L_{crack}:

  A foundation thickness of 15 cm (6 inches) was applied, based on the default foundation thickness, as indicated in RWQCB (2008).

- Depth below grade to bottom of enclosed space floor, L_F:

  A depth below grade to the bottom of enclosed space floor of 15 cm (6 inches) was applied, consistent with the default depth below grade for a slab-on-grade building indicated in RWQCB (2008).

- Floor-wall seam crack width, w:

  A floor-wall seam crack width of 0.1 cm was applied, consistent with the default floor-wall seam crack width indicated in RWQCB (2008).

- Vadose zone/building pressure differential, ΔP:

  A pressure differential value of 4 Pascal (Pa) is applied consistent with CalEPA (2005) and USEPA (2002).

- Average soil vapor flow rate into building, Q_{soil}:

  An average soil vapor flow rate into the building of 5 L/min was applied, consistent with the default average flow rate into a building, as indicated in RWQCB (2008).

3.2 CONSERVATIVE FEATURES OF J&E MODEL

It is important to note that the J&E Model used to develop the soil vapor criteria includes several conservative assumptions. The key conservative aspects incorporated into the development of the estimated soil vapor criteria are described below:

- The J&E Model assumes that all chemical vapor below a building migrate vertically upward into the building and do not move laterally, or in three-dimensions, around the building to vent to the atmosphere.
- The J&E Model assumes that no chemical vapor migrates around the sides of buildings through preferential pathways, such as granular foundation bedding material, to vent to the atmosphere.
- The soil vapor criteria are developed assuming a constant and continuous source of COCs in soil vapor. Source depletion due to naturally occurring biological or chemical degradation of chemicals is not considered.

The conservative aspects described above combine to develop more conservative soil vapor criteria values.

4.0 CALCULATION OF SITE-SPECIFIC SOIL VAPOR CRITERIA

Soil vapor criteria values were calculated in accordance with the USEPA (2002) methodology and the J&E Model using site-specific compound, vadose zone soil, and building properties, as presented in Section 3.1.

4.1 ESTIMATED SOIL VAPOR CRITERIA RESULTS

The estimated soil vapor criteria for residents are presented in Table 4. The estimated soil vapor criteria for commercial workers are presented in Table 5. The applied vadose zone soil, building, and chemical properties are summarized in the aforementioned tables. The soil vapor criteria for residents and commercial workers were estimated only for the volatile COCs identified in site soil vapor samples. The estimated soil vapor criteria are protective of potential health risks/hazards posed by the resident and commercial worker indoor air inhalation exposure pathway.

Resident

Table 4 presents the soil vapor criteria for each COC along with the maximum detected/detection limit concentration collected during the four post-remediation sampling events (June 2008, September 2009, March 2010, and September 2010) at three depths (3 ft, 5.5 ft, and 8 ft). The parameters that exceed the conservative residential soil vapor criteria are also identified. The soil vapor criteria conservatively developed based on a 3 ft sampling depth and the maximum detected/detection limit concentration for all depths are summarized in the table below.

RESIDENT SOIL VAPOR TO INDOOR AIR PATHWAY					
COC	*Soil Vapor Criteria ($\mu g/m^3$)*	*Post-Remediation Maximum Soil Vapor Concentration ($\mu g/m^3$)[1]*	*Detected Concentrations > Soil Vapor Criteria (%)*		
	3 ft bgs (0.9144 mbgs)		*3 ft bgs*	*5 ft bgs*	*8 ft bgs*
Benzene	**145**	**ND (130,000) [SVG-6]**	**2 (5 %)**	**3 (7 %)**	0 (0 %)
Toluene	545,070	ND (150,000) [SVG-6]	0 (0 %)	0 (0 %)	0 (0 %)
Ethylbenzene	**1,840**	**ND (170,000) [SVG-6]**	**1 (2 %)**	0 (0 %)	0 (0 %)
Xylenes (total)	**202,844**	**ND (350,000) [SVG-6]**	0 (0 %)	0 (0 %)	0 (0 %)
MTBE	**14,989**	**ND (290,000) [SVG-6]**	0 (0 %)	0 (0 %)	0 (0 %)
TBA	NV	ND (240,000) [SVG-6]	0 (0 %)	0 (0 %)	0 (0 %)

Notes:
ND (1), Non-detect (maximum detection limit).
Bold Maximum concentration exceeds the minimum calculated soil vapor criteria.
[SVG-6] Location of maximum detected/detection limit concentration.
NV No value due to a lack of toxicity information.
1 Maximum soil concentration is either the maximum detected concentration or the maximum detection limit, whichever is greater.

As indicated in the table above, the maximum detected/detection limit concentrations for benzene, ethylbenzene, xylenes (total), and MTBE exceed their respective soil vapor criterion developed for the protection of the residential indoor air pathway.

Commercial Worker

Table 5 presents the soil vapor criteria for each COC along with the maximum detected/detection limit concentration collected during four sampling events (June 2008, September 2009, March 2010, and September 2010) at three depths (3 ft, 5.5 ft, and 8 ft). The parameters that exceed the commercial worker soil vapor criteria are also identified. The soil vapor criteria conservatively developed based on a 3 ft sampling depth and the maximum detected/detection limit concentration for all depths are summarized in the table below.

COMMERCIAL WORKER SOIL VAPOR TO INDOOR AIR PATHWAY					
COC	*Soil Vapor Criteria ($\mu g/m^3$)*	*Maximum Soil Vapor Concentration ($\mu g/m^3$)[1]*	*Detected Concentrations > Soil Vapor Criteria (%)*		
	3 ft bgs (0.9144 mbg)		*3 ft bgs*	*5 ft bgs*	*8 ft bgs*
Benzene	**488**	**ND (130,000) [SVG-6]**	**2 (5 %)**	**3 (3 %)**	0 (0 %)
Toluene	1,526,195	ND (150,000) [SVG-6]	0 (0 %)	0 (0 %)	0 (0 %)
Ethylbenzene	**6,184**	**ND (170,000) [SVG-6]**	**1 (2 %)**	0 (0 %)	0 (0 %)
Xylenes (total)	567,964	ND (350,000) [SVG-6]	0 (0 %)	0 (0 %)	0 (0 %)
MTBE	**50,363**	**ND (290,000) [SVG-6]**	0 (0 %)	0 (0 %)	0 (0 %)
TBA	NV	ND (240,000) [SVG-6]	0 (0 %)	0 (0 %)	0 (0 %)

Notes:
ND (1), Non-detect (maximum detection limit).
Bold Maximum concentration exceeds the minimum calculated soil vapor criteria.
[SVG-6] Location of maximum detected/detection limit concentration.
NV No value due to a lack of toxicity information.
1 Maximum soil concentration is either the maximum detected concentration or the maximum detection limit, whichever is greater.

As indicated in the table above, the maximum detected concentration for benzene, ethylbenzene, xylenes, MTBE, and TPHg exceed their respective soil vapor criterion developed for the protection of the commercial worker indoor air pathway.

4.2 INTERPRETATION OF SOIL VAPOR CRITERIA

As indicated in Section 4.1, benzene, ethylbenzene, xylenes (total), and MTBE had soil vapor concentrations greater than the soil vapor criteria developed for the protection of residential and/or commercial worker indoor air. However, xylenes (total) and MTBE were not detected in any of the soil vapor samples collected and ethylbenzene was only detected in 1 of 44 soil vapor samples collected in the residential area. As a result, xylene (total), MTBE, and ethylbenzene are not likely to result in unacceptable risks/hazards to human health. Therefore, benzene is the primary COC of interest within Salel's Mobile Home Park.

For benzene, several soil vapor sample results exceeded the soil vapor criterion at depths ranging from 3 ft to 5.5 fbg. The soil vapor profile from 3 fbg and 5 fbg in soil vapor probe SVG-6 has shown similar benzene concentrations at 3 and 5 fbg. Soil vapor exceedances observed based on impacted groundwater typically exhibit decreasing soil vapor concentrations as the soil vapor moves from the source area through the soil strata to the ground surface. Historical groundwater investigations have indicated the presence of

dissolved benzene impacts migrating from the former Shell service station to the off-site residential area; however, well S-9 located in the Salel's Mobile Home Park contained only 28 micrograms per liter benzene during the October 2010 groundwater monitoring event. It should be noted that depth to water averaged 6 fbg in site wells during the October 2010 groundwater monitoring event and has been as shallow as 4.5 fbg in monitoring well S-9, which may indicate that the source of soil vapor is a residual "smear" zone in soils between 4.5 and 6 fbg.

Therefore, the following additional investigations are recommended in order to determine the source of the soil vapor impacts:

- Additional shallow soil vapor sampling within the upper 3 ft at soil vapor probes SVG-6, P-10, P-11, P-12, and P-15 to obtain shallow soil vapor profiles to document attenuation of soil vapor concentrations in the upper 3 ft.
- Surface flux testing in these areas to evaluate actual soil vapor discharge to ambient air. Because the mobile homes are not on the ground, comparisons with ESLs or interpretation using J-E model included in this memo do not give an accurate estimation of the potential risk of vapor intrusion to the mobile homes.
- Re-sampling of existing soil vapor probes.
- Collection of vadose zone soil samples in the vicinity of P-24 to P-29 and SVG-4 to SVG-9.
- Continued semiannual groundwater sampling following the established groundwater monitoring program.

Shallow soil vapor and vapor flux analysis will be completed using certified mobile lab to enable real-time decisions on where to put flux chambers and additional soil gas sampling locations/depths.

5.0 REFERENCES

CalEPA, 2005. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Integrated Risk Assessment Section, Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil, January 2005 Revision.

RWQCB, 2008. Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, California Regional Water Quality Control Board, San Francisco Bay Region, Interim Final, November 2007 (Revised May 2008).

Johnson, P.C. and R.A. Ettinger, 1991. Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings, Environmental Science and Technology, 25(8), pp. 1445-145.

USEPA, 2002. Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (Subsurface Vapor Intrusion Guidance), EPA Report No. EPA530-F-02-052, Office of Solid Waste and Emergency Response, November.

USEPA, 2004. User's Guide for Evaluating Subsurface Vapor Intrusion into Buildings, Office of Emergency and Remedial Response, Washington, DC, February 22.

WDEQ, 2009. Wyoming Department of Environmental Quality, Solid and Hazardous Waste Division, Storage Tank Program, Guidance Document #7, Revised June 4, 2009, Available online: http://deq.state.wy.us/shwd/STP/STPDownloads/Guidance/Guidance_7.pdf.

All of Which is Respectfully Submitted,
CONESTOGA-ROVERS & ASSOCIATES

Peter Schaefer, CHG, CEG

PROFESSIONAL GEOLOGIST
PETER L SCHAEFER
NO. 5612
STATE OF CALIFORNIA

April Gowing, Ph.D.

FIGURES

04/04/2011

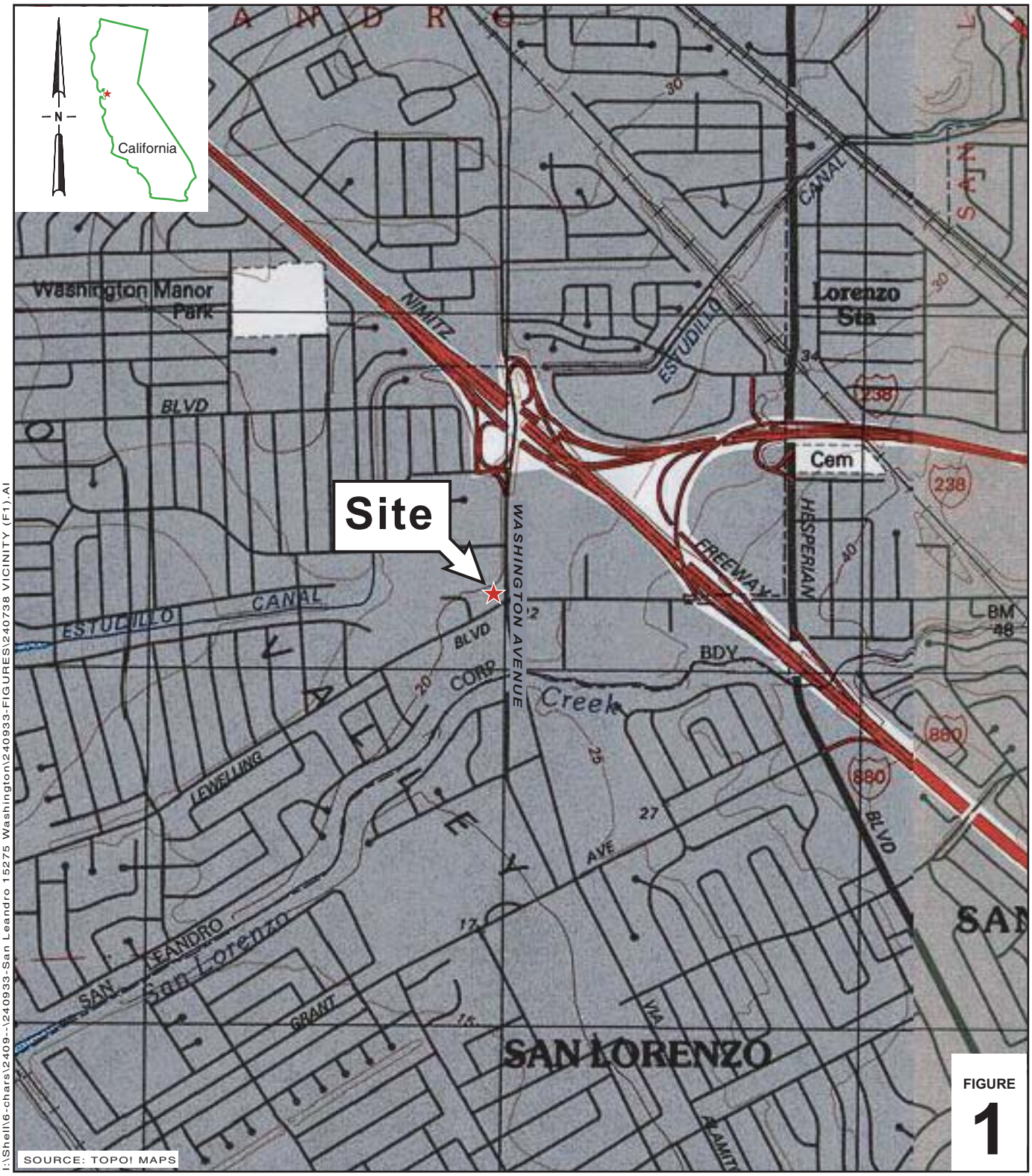

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FIGURE 1

0 1/8 1/4 1/2 1

SCALE : 1" = 1/4 MILE

Former Shell Service Station

15275 Washington Avenue

San Leandro, California

CONESTOGA-ROVERS & ASSOCIATES

Vicinity Map

EXPLANATION

- S-3 — Monitoring well location (Shell)
- S-1 — Monitoring well modified for soil vapor extraction (Shell)
- SV-1 — Soil vapor extraction well location (Shell)
- SVG-1 — Soil vapor well location (Shell)
- P-10 — Soil vapor probe location (Shell)
- MW-1 — Monitoring well location (Arco)
- RW-1 — Soil vapor extraction well location (Arco)
- B-1 — Soil vapor probe location (Arco)

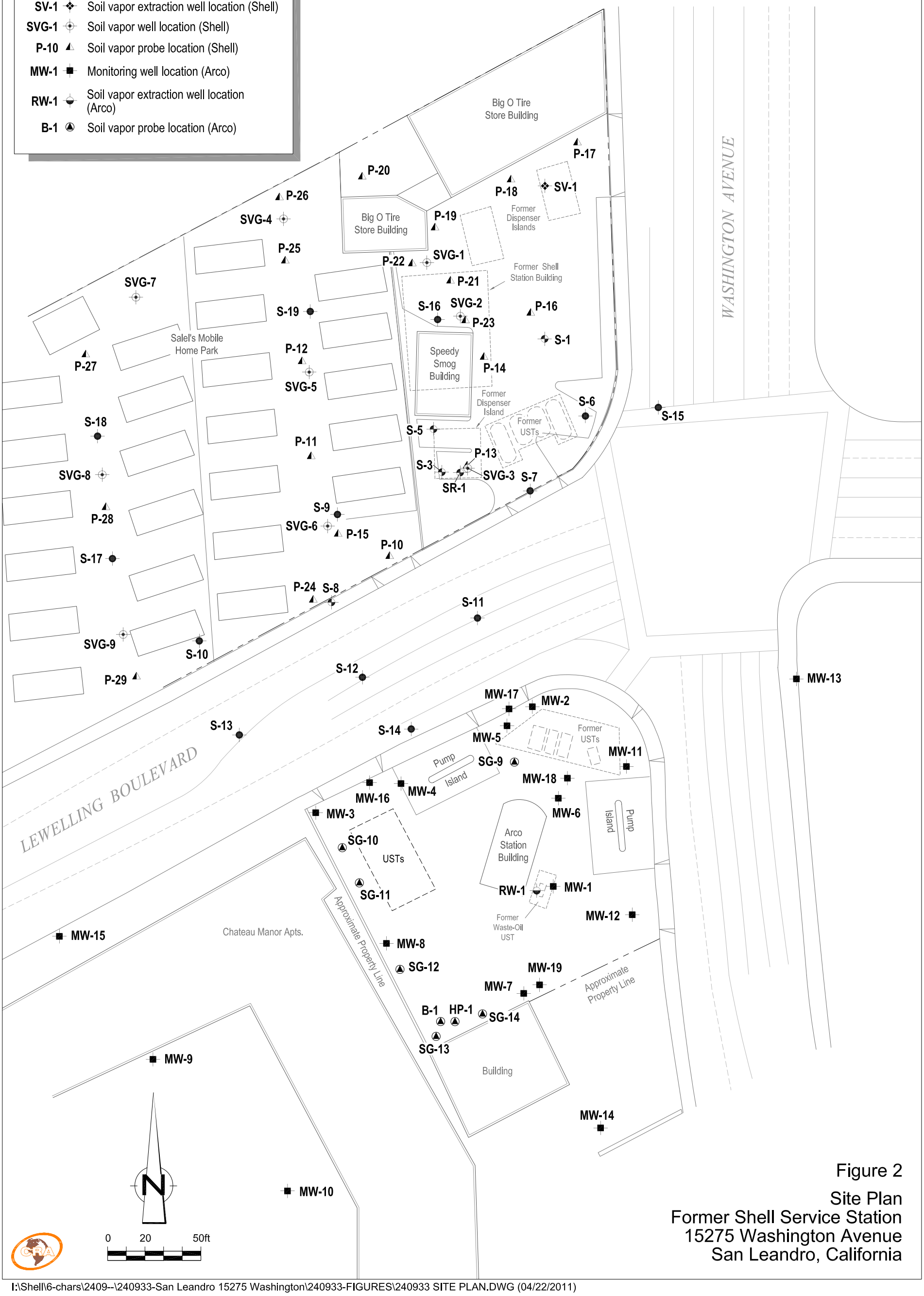

Figure 2

Site Plan
Former Shell Service Station
15275 Washington Avenue
San Leandro, California

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TABLES

TABLE 1

HISTORICAL SOIL VAPOR ANALYTICAL DATA
FORMER SHELL SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA

Sample ID	*Date*	*Depth (fbg)*	*TPHg*	*Benzene*	*Toluene*	*Ethyl-benzene*	*Total Xylenes*	*MTBE*	*TBA*	*Methane (%v)*	*Carbon Dioxide (%v)*	*Oxygen + Argon (%v)*	*Nitrogen (%v)*	*1,1-Difluoroethane*	*Isopropanol*
SG-1	10/4/1988	UNK	**460,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-2	10/4/1988	UNK	**90,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-3	10/4/1988	UNK	**45,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-4	10/4/1988	UNK	**2,400,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-5	10/4/1988	UNK	**1,800,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-6	10/4/1988	UNK	**820,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-7	10/4/1988	UNK	**690,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-8	10/4/1988	UNK	**5,800,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-9	10/4/1988	UNK	**3,700,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-10	10/4/1988	UNK	**5,600,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-11	10/4/1988	UNK	22,000	—	—	—	—	—	—	—	—	—	—	—	—
SG-12	10/4/1988	UNK	**810,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-13	10/4/1988	UNK	**1,100,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-14	10/4/1988	UNK	630	—	—	—	—	—	—	—	—	—	—	—	—
SG-15	10/4/1988	UNK	**2,000,000**	—	—	—	—	—	—	—	—	—	—	—	—
SG-1	5/4/1993	4	**100,000,000**	**750,000**	**280,000**	**370,000**	**1,300,000**	**700,000**	—	7.8	19.7	3.9	68.6	—	—
SG-2	5/4/1993	2	**46,000**	250	96	250	880	73	—	<0.1	9.2	11.3	79.5	—	—
SG-3	5/4/1993	2	**54,000,000**	**390,000**	**190,000**	**370,000**	**310,000**	**260,000**	—	1.6	15.8	3.8	78.9	—	—
SG-3	5/4/1993	4	**33,000,000**	**230000**	110,000	**210,000**	**330,000**	**150,000**	—	<0.1	1.6	18.1	80.3	—	—
SG-3	5/4/1993	6	**5,000,000**	**39,000**	18,000	**71,000**	**190,000**	16,000	—	<0.1	4.7	16.4	78.9	—	—
SG-4	5/4/1993	2	**220,000**	**420**	150	1,700	3,200	310	—	<0.1	0.7	19.8	79.4	—	—
SG-4	5/4/1993	4	**350,000**	**1,000**	2,300	2,600	4,400	550	—	<0.1	1.4	19.2	79.4	—	—
SG-4	5/4/1993	6	**310,000**	**1,000**	2,200	**4,000**	4,800	200	—	<0.1	1.2	19.5	79.3	—	—
SG-4 (duplicate)	5/4/1993	6	—	—	—	—	—	—	—	<0.1	1.0	19.2	79.8	—	—
SG-5	5/4/1993	4	**8,700,000**	**20,000**	42,000	**75,000**	**130,000**	6,200	—	<0.1	0.3	20.3	79.4	—	—
SG-6	5/4/1993	4	**66,000**	8	150	380	790	22	—	<0.1	0.5	19.9	79.6	—	—

TABLE 1

HISTORICAL SOIL VAPOR ANALYTICAL DATA
FORMER SHELL SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA

Sample ID	*Date*	*Depth (fbg)*	*TPHg*	*Benzene*	*Toluene*	*Ethyl-benzene*	*Total Xylenes*	*MTBE*	*TBA*	*Methane (%v)*	*Carbon Dioxide (%v)*	*Oxygen + Argon (%v)*	*Nitrogen (%v)*	*1,1-Difluoroethane*	*Isopropanol*
SG-7	5/4/1993	2	**62,000,000**	**220,000**	**210,000**	**230,000**	**110,000**	**330,000**	—	<0.1	0.9	19.7	79.4	—	—
SG-7	5/4/1993	4	**130,000,000**	**450,000**	**420,000**	**440,000**	**180,000**	**510,000**	—	9.3	13.4	9.5	67.9	—	—
SG-7	5/4/1993	6	**3,000,000**	**19,000**	6,500	**20,000**	6,600	17,000	—	1.0	1.9	18.7	78.5	—	—
SG-7 (duplicate)	5/4/1993	6	**3,400,000**	**21,000**	7,300	**22,000**	7,500	19,000	—	—	—	—	—	—	—
SG-8	5/5/1993	2	15,000	10	38	190	220	22	—	<0.1	0.1	20.6	79.3	—	—
SG-8	5/5/1993	4	**7,100,000**	**15,000**	46,000	**44,000**	**62,000**	3,200	—	<0.1	12.6	4.8	82.7	—	—
SG-8	5/5/1993	6	**20,000,000**	**49,000**	130,000	**140,000**	**290,000**	8,400	—	<0.1	0.3	20.0	79.7	—	—
SG-8 (duplicate)	5/5/1993	6	—	—	—	—	—	—	—	<0.1	0.2	20.0	79.8	—	—
SG-9	5/4/1993	4	**540,000**	**18,000**	610	17,000	15,000	1,600	—	<0.1	0.9	20.0	79.1	—	—
SG-10	7/31/1997	4	1,700	<7.0	11	<9.5	22	11	—	—	—	—	—	—	—
SG-11	7/31/1997	4	660	<6.7	<7.9	<9.0	<9.0	<7.5	—	—	—	—	—	—	—
SG-12	7/31/1997	4	5,000	16	8.3	13	22	29	—	—	—	—	—	—	—
SG-13	7/31/1997	4	5,000	<71	<84	<97	<97	<81	—	—	—	—	—	—	—
P-10	6/11/2008	5.5	**100,000**	<2.7	14	3.9	12	<3.0	43	—	—	—	—	—	<8.2
P-11	6/11/2008	5.5	**8,000,000**	**1,100**	240	<180	<180	<150	<520	—	—	—	—	—	<420
P-12	6/11/2008	5.5	**7,800,000**	**810**	<630	<730	<730	<600	<5,100	—	—	—	—	—	<1,600
P-13	6/11/2008	5.5	5,300	<2.5	5.6	<3.4	3.6	<2.8	<24	—	—	—	—	—	<7.8
P-14	6/11/2008	5.5	**2,100,000**	**1,400**	<130	**4,700**	280	<120	<1,000	—	—	—	—	—	<340
P-15	6/11/2008	5.5	**160,000**	<54	<63	<73	<73	<60	<150	—	—	—	—	—	<160
P-16	6/11/2008	5.5	**130,000**	<13	<15	26	<17	<14	<120	—	—	—	—	—	<120
P-17	6/11/2008	5.5	450	<2.5	5.4	<3.4	3.6	<2.8	<23	—	—	—	—	—	<7.6
P-17 (duplicate)	6/11/2008	5.5	1,100	<2.5	4.0	<3.4	<3.4	<2.8	<24	—	—	—	—	—	<7.8

TABLE 1

HISTORICAL SOIL VAPOR ANALYTICAL DATA
FORMER SHELL SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA

Sample ID	*Date*	*Depth (fbg)*	*TPHg*	*Benzene*	*Toluene*	*Ethyl-benzene*	*Total Xylenes*	*MTBE*	*TBA*	*Methane (%v)*	*Carbon Dioxide (%v)*	*Oxygen + Argon (%v)*	*Nitrogen (%v)*	*1,1-Difluoroethane*	*Isopropanol*
P-18	6/11/2008	5.5	13,000	3.2	6.0	<3.6	4.0	<3.0	36	—	—	—	—	—	<8.2
P-19	6/11/2008	5.5	**9,000,000**	**600**	270	<180	<180	<510	<410	—	—	—	—	—	<410
P-20	6/11/2008	5.5	26,000	<2.5	240	<3.4	<3.4	<2.8	55	—	—	—	—	—	27
P-20 (lab duplicate)	6/11/2008	5.5	26,000	<2.5	230	<3.4	<3.4	<2.8	52	—	—	—	—	—	29
P-21	6/11/2008	5.5	**8,200,000**	**6,400**	280	**27,000**	3,500	<100	<340	—	—	—	—	—	<280
P-22	6/11/2008	5.5	**8,200,000**	**1,400**	<320	**14,000**	<360	<300	<1,000	—	—	—	—	—	<820
P-23	6/11/2008	5.5	**6,500,000**	**12,000**	190	**46,000**	25,120	<56	<190	—	—	—	—	—	<150
P-23 (lab duplicate)	6/11/2008	5.5	**6,500,000**	**11,000**	180	**44,000**	23,110	<56	<190	—	—	—	—	—	<150
P-24	9/23/2009	3	**160,000**	1.9	25	<2.2	<8.7	<7.2	<15	—	—	—	—	570,000	—
P-24	9/23/2009	5	**340,000**	<3.2	<38	<4.3	<15	<14	<30	—	—	—	—	1,000,000	—
P-24	9/23/2009	8	**48,000**	1.7	<19	<2.2	<8.7	<7.2	<15	—	—	—	—	3,900,000	—
P-25	9/23/2009	3	**2,900,000**	<64	<750	<87	<350	<290	<610	—	—	—	—	2,600,000	—
P-25	9/23/2009	5	<5,700	<1.6	<19	<2.2	<8.7	<19	<15	—	—	—	—	4,300	—
P-25	9/23/2009	8	<5,700	<1.6	<19	<2.2	<8.7	<7.2	<15	—	—	—	—	210	—
P-26	9/23/2009	3	<5,700	2	21	<2.2	<8.7	<7.2	<15	—	—	—	—	28	—
P-26	9/23/2009	5	**610,000**	<6.4	<75	<8.7	<35	<29	<61	—	—	—	—	1,300,000	—
P-26	9/23/2009	8	**2,600,000**	<64	<750	<87	<350	<350	<610	—	—	—	—	4,800,000	—
P-27	9/24/2009	3	**410,000**	<4	<47	<5.4	<22	<18	<38	—	—	—	—	710,000	—
P-27	9/24/2009	5	**120,000**	<1.6	<19	<2.2	<8.7	<7.2	<15	—	—	—	—	14,000	—
P-27	9/24/2009	8	**570,000**	<4	<47	<5.4	<22	<18	<38	—	—	—	—	860,000	—
P-28	9/24/2009	3	**1,200,000**	<8	<94	<11	<43	<36	<76	—	—	—	—	2,200,000	—
P-28	9/24/2009	5	**58,000**	2	<19	<2.2	<8.7	<7.2	<15	—	—	—	—	11,000	—
P-28	9/24/2009	8	**270,000**	<3.2	<38	<4.3	<17	<14	<30	—	—	—	—	42,000	—

TABLE 1

HISTORICAL SOIL VAPOR ANALYTICAL DATA
FORMER SHELL SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA

Sample ID	*Date*	*Depth (fbg)*	*TPHg*	*Benzene*	*Toluene*	*Ethyl-benzene*	*Total Xylenes*	*MTBE*	*TBA*	*Methane (%v)*	*Carbon Dioxide (%v)*	*Oxygen + Argon (%v)*	*Nitrogen (%v)*	*1,1-Difluoroethane*	*Isopropanol*
P-29	9/24/2009	3	**1,200,000**	<8	<94	<11	<43	<36	<76	—	—	—	—	2,000,000	—
P-29	9/24/2009	5	**660,000**	<6.4	<75	<8.7	<35	<29	<61	—	—	—	—	1,300,000	—
P-29	9/24/2009	8	**46,000**	<1.6	<19	<2.2	<8.7	<7.2	<15	—	—	—	—	83,000	—
SVG-1	3/18/2010	3	**8,700,000**	<8,000	<9,400	**11,000**	<22,000	<18,000	<15,000	—	0.971	2.32	—	—	<6,100
SVG-1	9/9/2010	3	**15,000,000**	**3,400**	<2,400	<2,700	<5,400	<4,500	<3,800	—	—	—	—	—	<1,500
SVG-1	3/18/2010	5	**8,200,000**	<8,000	<9,400	<11,000	<22,000	<18,000	<15,000	—	4.22	2.06	—	—	<6,100
SVG-2	3/18/2010	3	**11,000,000**	**21,000**	<19,000	**62,000**	<43,000	<36,000	<30,000	—	0.519	2.31	—	—	<12,000
SVG-2	9/9/2010	3	**17,000,000**	**32,000**	<19,000	**150,000**	<43,000	<36,000	<30,000	1.33	13.9	2.66	—	—	<12,000
SVG-2	3/18/2010	5	**7,500,000**	<8,000	<9,400	**54,000**	<22,000	<18,000	<15,000	—	4.91	11.2	—	—	<6,100
SVG-2	9/9/2010	5	**18,000,000**	**17,000**	<19,000	**200,000**	44,000	<36,000	<30,000	1.19	16.9	2.22	—	—	<12,000
SVG-3	3/18/2010	3	**39,000**	<51	<60	460	230	<120	<97	—	3.38	15.1	—	—	<39
SVG-3	9/9/2010	3	**86,000**	<80	<94	1,100	220	<180	<150	—	—	—	—	—	<61
SVG-3	3/18/2010	5	**49,000**	<64	<75	520	250	<140	<120	—	3.43	15.0	—	—	<49
SVG-4	3/18/2010	3	28,000	<16	<19	420	250	<36	<30	—	7.63	6.75	—	—	100
SVG-4	9/9/2010	3	**50,000**	<16	<19	610	160	<36	<30	—	—	—	—	—	<12
SVG-5	3/18/2010	3	**27,000,000**	<32,000	<38,000	<43,000	<87,000	<72,000	<61,000	—	2.22	2.74	—	—	<25,000
SVG-5	9/9/2010	3	**37,000,000**	**2,700**	<2,400	**9,300**	<5,400	<4,500	<3,800	1.20	7.63	2.28	—	—	<1,500
SVG-5	3/18/2010	5	**13,000,000**	<16,000	<19,000	<22,000	<43,000	<36,000	<30,000	—	<0.500	21.5	—	—	<12,000
SVG-5	9/9/2010	5	**32,000,000**	<4,800	<5,700	<6,500	<13,000	<11,000	<9,100	1.11	16.5	1.97	—	—	<3,700
SVG-6	3/18/2010	3	**110,000,000**	<130,000	<150,000	<170,000	<350,000	<290,000	<240,000	—	3.64	2.36	—	—	<98,000
SVG-6	9/9/2010	3	**140,000,000**	**44,000**	<30,000	<35,000	<69,000	<58,000	<49,000	1.89	8.57	2.11	—	—	<20,000
SVG-6	3/18/2010	5	**75,000,000**	<8,000	<94,000	<11,000	<22,000	<18,000	<15,000	—	6.36	2.27	—	—	<6,100
SVG-6	9/9/2010	5	**160,000,000**	**46,000**	<30,000	<35,000	<69,000	<58,000	<49,000	1.87	9.09	2.43	—	—	<20,000
SVG-7	3/18/2010	3	**170,000**	<160	<190	<220	<430	<360	<300	—	0.816	16.7	—	—	<120
SVG-7	9/9/2010	3	**97,000**	<80	<94	300	<220	<180	<150	—	—	—	—	—	<61

TABLE 1

HISTORICAL SOIL VAPOR ANALYTICAL DATA
FORMER SHELL SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA

Sample ID	*Date*	*Depth (fbg)*	*TPHg*	*Benzene*	*Toluene*	*Ethyl-benzene*	*Total Xylenes*	*MTBE*	*TBA*	*Methane (%v)*	*Carbon Dioxide (%v)*	*Oxygen + Argon (%v)*	*Nitrogen (%v)*	*1,1-Difluoroethane*	*Isopropanol*
SVG-8	3/18/2010	3	**70,000**	<80	<94	170	<220	<180	<150	—	8.28	2.12	—	—	<61
SVG-8	9/9/2010	3	**100,000**	<80	<94	300	<220	<180	<150	<0.500	12.4	1.97	—	—	<61
SVG-8	3/18/2010	5	**140,000**	<80	<94	300	<220	<180	<150	—	7.93	2.45	—	—	210
SVG-8	9/9/2010	5	**81,000**	<80	<94	240	<220	<180	<150	<0.500	12.6	1.97	—	—	<61
SVG-8	9/9/2010	7.5	**62,000**	<51	<60	230	<140	<120	<97	<0.500	12.5	1.97	—	—	<39
SVG-9	3/18/2010	3	**67,000**	<80	<94	300	<220	<180	<150	—	10.7	4.25	—	—	<61
SVG-9	9/9/2010	3	**57,000**	<51	<60	230	<140	<120	<97	<0.500	15.1	7.01	—	—	<39
SVG-9	3/18/2010	5	**55,000**	<64	<75	220	<170	<140	<120	—	10.4	4.27	—	—	<49
SVG-9	9/9/2010	5	7,900	<16	32	32	<43	<36	<30	<0.500	1.54	20.4	—	—	99
SVG-9	9/9/2010	7.5	**36,000**	<64	<75	95	<170	<140	<120	<0.500	16.8	5.52	—	—	<49
ESLs [a]			***29,000***	***280***	***180,000***	***3,300***	***58,000***	***31,000***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***NA***

Notes:

All results in micrograms per cubic meter ($\mu g/m^3$) unless otherwise indicated.
TPHg = Total petroleum hydrocarbons as gasoline by EPA Method TO-3M on 9/23/09, 3/18/10, and 9/9/10, by EPA Method TO-14A on 6/10/08, and by GC/FID on 7/31/97; 10/4/88 and 5/4 & 5/5/93 sampling event: analytical method unknown.
Benzene, toluene, ethylbenzene, and xylenes by EPA Method 8260B (M) on 3/18/10 and 9/9/10, by EPA Method TO-15M on 9/23/09, by EPA Method TO-14A on 6/10/08, and by EPA Method TO-3 on 7/31/97; 5/4 & 5/5/93 sampling event: analytical method unknown.
MTBE = Methyl tertiary-butyl ether analyzed by EPA Method 8260B (M) on 3/18/10 and 9/9/10, by EPA Method TO-15M on 9/23/09, by EPA Method TO-14A on 6/10/08, and by EPA Method TO-3 on 7/31/97; 5/4 & 5/5/93 sampling event: analytical method unknown.
TBA = Tertiary-butyl alcohol by EPA Method 8260B (M) on 3/18/10 and 9/9/10, by EPA Method TO-15M on 9/23/09, and by EPA Method TO-14A on 6/10/08.
Methane, carbon dioxide, and oxygen + argon analyzed by ASTM D-1946 on 3/18/10, and 9/9/10; May 1993 did not include argon and the analytical method is unknown.
Nitrogen analysis method unknown.
Isopropanol analyzed by EPA Method 8260B (M) on 9/23 & 9/24/09, and by EPA Method TO-14A on 6/10/08.
1,1-Difluoroethane analyzed by EPA Method TO-15M.
fbg Feet below grade.
%v Percentage by volume.
<x Not detected at reporting limit x.
— Not analyzed.
ESL Environmental screening level.
NA No applicable ESL.
Results in **bold** exceed environmental screening level.
a = San Francisco Bay Regional Water Quality Control Board (RWQCB) shallow soil gas screening level for evaluation of potential vapor intrusion concerns - commercial/industrial land use from RWQCB's *Screening for Environmental Concerns at Sites With Contaminated Soil and Groundwater,* California Regional Water Quality Control Board, Interim Final - November 2007 (Revised May 2008).

TABLE 2

DERIVATION OF RISK-BASED CONCENTRATION FOR INDOOR AIR - RESIDENT INHALATION EXPOSURE
FORMER SHELL-BRANDED SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA
SHELL OIL PRODUCTS U.S.

Contaminant of Concern (COC)	URF inhalation $1/(mg/m^3)$	Ref (1)	RfC inhalation (mg/m^3)	Ref (1)	Resident Carcinogen TR (mg/m^3)	Resident Non-Carcinogen THQ (mg/m^3)	Risk-Based Concentration for Indoor Air RBC_{ia} (2) (mg/m^3)	Risk-Based Concentration for Indoor Air RBC_{ia} (2) $(\mu g/m^3)$
Volatile Organic Compounds (VOCs)								
Benzene	2.90E-02	a	6.00E-02	a	8.39E-05	6.26E-02	8.39E-05	8.39E-02
Toluene	--		3.00E-01	a	NV	3.13E-01	3.13E-01	3.13E+02
Ethylbenzene	2.50E-03	a	2.00E+00	a	9.73E-04	2.09E+00	9.73E-04	9.73E-01
Xylenes (total)	--		1.00E-01	b	NV	1.04E-01	1.04E-01	1.04E+02
Methyl tert-butyl ether (MTBE)	2.60E-04	a	3.00E+00	b	9.36E-03	3.13E+00	9.36E-03	9.36E+00
Tert-butyl alcohol (TBA)	--		--		NV	NV	NV	NV

Notes:

-- = Not Available

NV = No Value

(1) a - CalEPA: Cal EPA Toxicity Criteria Database, Office of Environmental Health Hazard Assessment, July 2009.

b - RWQCB: Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, California Regional Water Quality Control Board, Interim Final, November 2007 (Revised May 2008).

(2) The selected RBC is the lower of the carcinogenic-based concentration and the non-carcinogenic-based concentration.

Residential Assumptions

Risk-Based Concentration for Indoor Air (mg/m^3)	RBC_{ia}	calculated	
Target Risk Level (unitless)	TR	1.0E-06	RWQCB, 2008
Target Hazard Level (unitless)	THQ	1	RWQCB, 2008
Unit Risk Factor (per mg/m^3)	URF	chemical-specific	RWQCB, 2008
Reference Concentration (mg/m^3)	RfC	chemical-specific	RWQCB, 2008
Exposure Frequency (days/year)	EF	350	RWQCB, 2008
Exposure Duration (years) - child	EDc	6	RWQCB, 2008
Exposure Duration (years) - adult	EDa	24	RWQCB, 2008
Averaging Time (days) - carc.	ATc	25,550	RWQCB, 2008
Averaging Time (days) - non-carc.	ATnc	2,190	RWQCB, 2008

Exposure Equations

Carcinogenic Endpoints:

$$RBC_{ia} = \frac{TR \times Atc \times 365\ days/yr}{EF \times [(EDc \times URF) + (EDa \times URF)]}$$

Non-Carcinogenic Endpoints:

$$RBC_{ia} = \frac{THQ \times Atnc \times 365\ days/yr}{EF \times ED \times (1/RfC)}$$

References:

RWQCB, 2008: Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, California Regional Water Quality Control Board, Interim Final, November 2007 (Revised May 2008).

TABLE 3

DERIVATION OF RISK-BASED CONCENTRATION FOR INDOOR AIR - COMMERCIAL WORKER INHALATION EXPOSURE
FORMER SHELL-BRANDED SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA
SHELL OIL PRODUCTS U.S.

					Commercial Worker		*Risk-Based*	
	URF		*RfC*		*Carcinogen*	*Non-Carcinogen*	*Concentration for Indoor Air*	
Contaminant of Concern	*inhalation*	*Ref*	*inhalation*	*Ref*	*TR*	*THQ*	*RBC $_{ia}$ (2)*	
(COC)	*1/(mg/m ^{3})*	*(1)*	*(mg/m ^{3})*	*(1)*	*(mg/m ^{3})*	*(mg/m ^{3})*	*(mg/m ^{3})*	*(µg/m ^{3})*
Volatile Organic Compounds (VOCs)								
Benzene	2.90E-02	a	6.00E-02	a	1.41E-04	8.76E-02	1.41E-04	1.41E-01
Toluene	--		3.00E-01	a	NV	4.38E-01	4.38E-01	4.38E+02
Ethylbenzene	2.50E-03	a	2.00E+00	a	1.64E-03	2.92E+00	1.64E-03	1.64E+00
Xylenes (total)	--		1.00E-01	b	NV	1.46E-01	1.46E-01	1.46E+02
Methyl tert-butyl ether (MTBE)	2.60E-04	a	3.00E+00	b	1.57E-02	4.38E+00	1.57E-02	1.57E+01
Tert-butyl alcohol (TBA)	--		--		NV	NV	NV	NV

Notes:

-- = Not Available

NV = No Value

(1) a - CalEPA: Cal EPA Toxicity Criteria Database, Office of Environmental Health Hazard Assessment, July 2009.
b - RWQCB: Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, California Regional Water Quality Control Board, Interim Final, November 2007 (Revised May 2008).

(2) The selected RBC is the lower of the carcinogenic-based concentration and the non-carcinogenic-based concentration.

(3) Professional Judgment; assumed 8 hour work day.

Commercial Worker Assumptions

Risk-Based Concentration for Indoor Air (mg/m ^{3})	RBC_{ia}	calculated	
Target Risk Level (unitless)	TR	1.0E-06	RWQCB, 2008
Target Hazard Level (unitless)	THQ	1	RWQCB, 2008
Unit Risk Factor (per mg/m ^{3})	URF	chemical-specific	RWQCB, 2008
Reference Concentration (mg/m ^{3})	RfC	chemical-specific	RWQCB, 2008
Fraction Time Exposed (unitless)	FT	8/24	Professional Judgement (3)
Exposure Frequency (days/year)	EF	250	RWQCB, 2008
Exposure Duration (years)	EDa	25	RWQCB, 2008
Averaging Time (days) - carc.	ATc	25,550	RWQCB, 2008
Averaging Time (days) - non-carc.	ATnc	9,125	RWQCB, 2008

Exposure Equations

Carcinogenic Endpoints:

$$RBC_{ia} = \frac{TR \times Atc \times 365\ days/yr}{FT \times EF \times ED \times URF}$$

Non-Carcinogenic Endpoints:

$$RBC_{ia} = \frac{THQ \times Atnc \times 365\ days/yr}{FT \times EF \times ED \times (1/RfC)}$$

References:

RWQCB, 2008: Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater, California Regional Water Quality Control Board, Interim Final, November 2007 (Revised May 2008).

TABLE 4

CALCULATION OF SOIL GAS CRITERIA FOR SOIL GAS BASED ON PROTECTION OF INDOOR AIR QUALITY - RESIDENT
3 FEET BELOW GROUND SURFACE
FORMER SHELL-BRANDED SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA
SHELL OIL PRODUCTS U.S.

Contaminant of Concern (COC)	Chemical Properties (1): Henry's Law Constant, H_L (atm m³/mol)		Water Diffusion Coefficient, D^{H2O} (cm²/s)		Air Diffusion Coefficient, D^{air} (cm²/s)		Johnson & Ettinger Attenuation Factor, α (2)	Indoor Air Risk-Based Concentration RBC_{ia} (3) (µg/m³)	Soil Gas Criteria C_{sg} (4) (µg/m³)	Maximum Soil Gas Concentration (5) (µg/m³)
Volatile Organic Compounds (VOCs)										
Benzene	4.83E-03	(22 °C)	9.80E-06	(25 °C)	8.67E-02	(22 °C)	5.77E-04	8.39E-02	145	130,000
Toluene	6.62E-03	(22 °C)	7.80E-06	(25 °C)	7.39E-02	(22 °C)	5.74E-04	3.13E+02	545,070	150,000
Ethylbenzene	5.52E-04	(22 °C)	1.05E-05	(25 °C)	1.01E-01	(22 °C)	5.29E-04	9.73E-01	1,840	170,000
Xylenes (total)	7.53E-06	(22 °C)	1.00E-05	(25 °C)	8.86E-02	(22 °C)	5.14E-04	1.04E+02	202,844	350,000
Methyl tert-butyl ether (MTBE)	5.67E-03	(22 °C)	8.60E-06	(25 °C)	8.57E-02	(22 °C)	6.24E-04	9.36E+00	14,989	290,000
Tert-butyl alcohol (TBA)	4.41E-03	(22 °C)	9.34E-06	(25 °C)	7.03E-02	(22 °C)	6.16E-04	NV	NV	240,000

Notes:

NV No value due to a lack of toxicity information

[ ] Concentration exceeds C_{sg}.

(1) The applied chemical properties were obtained from the chemical properties database implemented in USEPA (2004), WDEQ (2009), and RWQCB (2008). The Henry's Law constant and air diffusion coefficient were corrected for an average vadose zone temperature of 22°C. The reference temperature for the water diffusion coefficient is 25°C and, considering its low value, a correction to 22°C was considered negligible.

(2) The soil gas attenuation factor α is based on the solution for soil gas migration to building indoor air presented in Johnson and Ettinger [1991; Equation (21)], the vadose zone and building properties listed below, and a 4 Pa pressure difference between the vadose zone and the building (ΔP) as applied by USEPA (2002: Appendix G, Table G-3). The calculation of the soil gas attenuation factor was conducted using the Excel spreadsheet "SG-ADV-Feb04.xls" developed by USEPA (2004) and the following Site-specific vadose zone and building properties.

Vadose Zone Soil Properties:

Vadose Zone Temperature (°C)	22	Conservatively applied highest average California soil temperature of 22°C, as presented in CalEPA (2005).
Soil Gas Sampling Depth Below Grade, L_S (cm)	91.44	Based on minimum depth to soil vapor impacts of 3 feet (0.9144 m) measured in soil vapor probes (P-24, P-26 to P-29, and SVG-1 to SVG-9).
Total Porosity, ε_T (%)	48.2	Default total porosity for a silty clay loam soil type, as implemented in USEPA (2004).
Moisture-Filled Porosity, ε_m	0.198	Default moisture-filled porosity for a silty clay loam soil type, as implemented in USEPA (2004).
Vapour-Filled Porosity, ε_v	0.284	Default vapor-filled porosity for a silty clay loam soil type, as implemented in USEPA (2004).
Dry Bulk Soil Density, ρ_{db} (g/cm³)	1.37	Default dry bulk density for a silty clay loam soil type, as implemented in USEPA (2004).
Thickness of Soil Stratum A, h_A (cm)	91.44	Based on the soil gas sampling depth below grade.

Building Properties:

Enclosed Floor Space Length, L_B (cm)	1,000	Based on the default building dimensions of 34.8 feet (10 m), as indicated in RWQCB (2008).
Enclosed Floor Space Width, W_B (cm)	1,000	Based on the default building dimensions of 34.8 feet (10 m), as indicated in RWQCB (2008).
Enclosed Space Height, H_B (cm)	244	Based on the default building dimensions of 8 feet (2.44 m), as indicated in RWQCB (2008).
Building Air Exchange Rate, T_{air} (1/hr)	1.0	Residential indoor air exchange rate indicated in CalEPA (2005).
Floor-Wall Seam Crack Width, w (cm)	0.1	Default floor-wall seam crack width indicated in RWQCB (2008).
Foundation Thickness, L_{crack} (cm)	15	Based on a typical slab depth of 0.15 m below grade (6 inches), as indicated in RWQCB (2008).
Depth Below Grade to Bottom of Enclosed Space Floor, Ls (cm)	15	Based on a typical slab depth of 0.15 m below grade (6 inches), as indicated in RWQCB (2008).
Average Vapour Flow Rate Into Building, Q_{soil} (L/min)	5	Default flow rate into building, as indicated in CalEPA (2005).

(3) Refer to Table 2 for acceptable indoor air concentrations.

(4) The site-specific soil gas criteria beneath the existing Site building is calculated from, $C_{sg} = C_{ia} / \alpha$.

(5) Maximum soil gas concentration is either the maximum detected concentration or the maximum detection limit whichever one is greater.

(6) TPHg is a mixture of aliphatic and aromatic hydrocarbons, and was conservatively evaluated using the chemical-physical properties of the Aromatic C11-C22 fraction, as per RWQCB (2008).

TABLE 5

CALCULATION OF RISK-BASED CONCENTRATIONS (RBCs) FOR SOIL GAS BASED ON PROTECTION OF INDOOR AIR QUALITY - COMMERCIAL WORKER
3 FEET BELOW GROUND SURFACE
FORMER SHELL-BRANDED SERVICE STATION
15275 WASHINGTON AVENUE, SAN LEANDRO, CALIFORNIA
SHELL OIL PRODUCTS U.S.

Contaminant of Concern (COC)	*Chemical Properties (1)*						*Johnson & Ettinger Attenuation Factor, α (2)*	*Indoor Air Risk-Based Concentration RBC$_{ia}$ (3) (µg/m³)*	*Soil Gas Criteria C$_{sg}$ (4) (µg/m³)*	*Maximum Soil Gas Concentration (5) (µg/m³)*
	Henry's Law Constant, H$_L$ (atm m³/mol)		*Water Diffusion Coefficient, D^{H2O} (cm²/s)*		*Air Diffusion Coefficient, D^{air} (cm²/s)*					
Volatile Organic Compounds (VOCs)										
Benzene	4.83E-03	(22 °C)	9.80E-06	(25 °C)	8.67E-02	(22 °C)	2.89E-04	1.41E-01	488	130,000
Toluene	6.62E-03	(22 °C)	7.80E-06	(25 °C)	7.39E-02	(22 °C)	2.87E-04	4.38E+02	1,526,195	150,000
Ethylbenzene	5.52E-04	(22 °C)	1.05E-05	(25 °C)	1.01E-01	(22 °C)	2.64E-04	1.64E+00	6,184	170,000
Xylenes (total)	7.53E-06	(22 °C)	1.00E-05	(25 °C)	8.86E-02	(22 °C)	2.57E-04	1.46E+02	567,964	350,000
Methyl tert-butyl ether (MTBE)	5.67E-03	(22 °C)	8.60E-06	(25 °C)	8.57E-02	(22 °C)	3.12E-04	1.57E+01	50,363	290,000
Tert-butyl alcohol (TBA)	4.41E-03	(22 °C)	9.34E-06	(25 °C)	7.03E-02	(22 °C)	3.08E-04	NV	NV	240,000

Notes:

NV No value due to a lack of toxicity information

[ ] Concentration exceeds C_{sg}.

(1) The applied chemical properties were obtained from the chemical properties database implemented in USEPA (2004), WDEQ (2009), and RWQCB (2008). The Henry's Law constant and air diffusion coefficient were corrected for an average vadose zone temperature of 22°C. The reference temperature for the water diffusion coefficient is 25°C and, considering its low value, a correction to 22°C was considered negligible.

(2) The soil gas attenuation factor α is based on the solution for soil gas migration to building indoor air presented in Johnson and Ettinger [1991; Equation (21)], the vadose zone and building properties listed below, and a 4 Pa pressure difference between the vadose zone and the building (ΔP) as applied by USEPA (2002: Appendix G, Table G-3). The calculation of the soil gas attenuation factor was conducted using the Excel spreadsheet "SG-ADV-Feb04.xls" developed by USEPA (2004) and the following Site-specific vadose zone and building properties.

Vadose Zone Soil Properties:		
Vadose Zone Temperature (°C)	22	Conservatively applied highest average California soil temperature of 22°C, as presented in CalEPA (2005).
Soil Gas Sampling Depth Below Grade, L_S (cm)	91.44	Based on minimum depth to soil vapor impacts of 3 feet (0.9144 m) measured in soil vapor probes (P-24, P-26 to P-29, and SVG-1 to SVG-9).
Total Porosity, ε_T (%)	48.2	Default total porosity for a silty clay loam soil type, as implemented in USEPA (2004).
Moisture-Filled Porosity, ε_m	0.198	Default moisture-filled porosity for a silty clay loam soil type, as implemented in USEPA (2004).
Vapour-Filled Porosity, ε_v	0.284	Default vapor-filled porosity for a silty clay loam soil type, as implemented in USEPA (2004).
Dry Bulk Soil Density, ρ_{db} (g/cm³)	1.37	Default dry bulk density for a silty clay loam soil type, as implemented in USEPA (2004).
Thickness of Soil Stratum A, h_A (cm)	91.44	Based on the soil gas sampling depth below grade.
Building Properties:		
Enclosed Floor Space Length, L_B (cm)	1,000	Based on the default building dimensions of 34.8 feet (10 m), as indicated in RWQCB (2008).
Enclosed Floor Space Width, W_B (cm)	1,000	Based on the default building dimensions of 34.8 feet (10 m), as indicated in RWQCB (2008).
Enclosed Space Height, H_B (cm)	244	Based on the default building dimensions of 8 feet (2.44 m), as indicated in RWQCB (2008).
Building Air Exchange Rate, T_{air} (1/hr)	2	Commercial indoor air exchange rate indicated in CalEPA (2005).
Floor-Wall Seam Crack Width, w (cm)	0.1	Default floor-wall seam crack width indicated in RWQCB (2008).
Foundation Thickness, L_{crack} (cm)	15	Based on a typical slab depth of 0.15 m below grade (6 inches), as indicated in RWQCB (2008).
Depth Below Grade to Bottom of Enclosed Space Floor, Ls (cm)	15	Based on a typical slab depth of 0.15 m below grade (6 inches), as indicated in RWQCB (2008).
Average Vapour Flow Rate Into Building, Q_{soil} (L/min)	5	Default flow rate into building, as indicated in CalEPA (2005).

(3) Refer to Table 2 for acceptable indoor air concentrations.

(4) The site-specific soil gas criteria beneath the existing Site building is calculated from, $C_{sg} = C_{ia} / \alpha$.

(5) Maximum soil gas concentration is either the maximum detected concentration or the maximum detection limit whichever one is greater.

(6) TPHg is a mixture of aliphatic and aromatic hydrocarbons, and was conservatively evaluated using the chemical-physical properties of the Aromatic C11-C22 fraction, as per RWQCB (2008).