KerrMcGee

Kerr-McGee Oil & Gas Onshore LP
1099 18th Street, Suite 1800
Denver, Colorado 80202
720-929-6000 Fax 720-929-7000

May 18, 2010

RECEIVED
MAY 19 2010
COGCC

Mr. John Axelson
Colorado Oil & Gas Conservation Commission
1120 Lincoln St, Suite 801
Denver, CO 80203

Re: Site Assessment Report
Kerr-McGee Oil & Gas Onshore LP
Wass #5 Flowline Release
NENE 25-T5N-R66W
Weld County, CO

API # 123-13781
Rem # 4369
Doc # 01761168

Dear Mr. Axelson:

Enclosed please find a copy of the above-referenced Site Assessment report. Results from the assessment activities will be communicated to the adjacent homeowner as well as to the adjacent utility owners. Feel free to contact me at 720-929-6726 if you have any questions regarding this information.

Sincerely,

Kerr-McGee Oil & Gas Onshore LP

Paul D. Schneider, P.G.
Sr. Staff Environmental Analyst

Enclosure

cc: John Cocroft, LT Environmental

COMPLIANCE / ENGINEERING / REMEDIATION

LT Environmental Inc.

4600 West. 60th Avenue
Arvada, Colorado 80003
T 303.433.9788 / F 303.433.1432

01761168

May 17, 2010

RECEIVED
MAY 19 2010
COGCC

Mr. Paul Schneider
Senior Staff Environmental Analyst
Kerr-McGee Oil & Gas Onshore LP
1099 18th Street, Suite 1800
Denver, Colorado 80202

Re: Site Assessment Report
Kerr-McGee Oil & Gas Onshore LP
Wass #5 Flow Line Release
NENE 25-T5N-R66W
Weld County, Colorado

API # 123-13781
Rem # 4369

Dear Mr. Schneider:

LT Environmental, Inc. (LTE) was contracted by Kerr-McGee Oil & Gas Onshore LP (Kerr-McGee) to perform site assessment activities at the Wass #5 flow line release site. The flow line leak was discovered by Kerr-McGee on June 26, 2008. Following excavation of the petroleum hydrocarbon impacted soil, a Form 27 Site Investigation and Remediation Workplan was prepared and submitted to the Colorado Oil and Gas Conservation Commission (COGCC) in September 2009 to request a No Further Action (NFA) status for the site. In a response letter to Kerr-McGee dated January 27, 2010, the COGCC requested additional assessment of the site prior to granting NFA status. Impacted soil was left in place at the conclusion of the 2008 excavation activities with total petroleum hydrocarbons (TPH) concentrations exceeding the COGCC sensitive area standard of 1,000 milligrams/kilogram (mg/kg). The impacted soil (approximately 33 cubic yards) was left in place because a utility corridor prohibited further excavation of impacted soil from the excavation's western sidewall. The COGCC requested additional assessment due the impacted soil left in place.

Based on the agreement reached between the COGCC, Kerr-McGee and LTE during a February 25, 2010 meeting, LTE prepared a Site Assessment Work Plan (Work Plan), which was conditionally approved by the COGCC in an email dated March 5, 2010. The assessment objectives outlined in Work Plan were to: 1) assess impacted soil left in place following the 2008 excavation to determine if petroleum hydrocarbon concentrations exceed the new (April 1, 2009) COGCC standards for TPH and benzene, toluene, ethylbenzene and xylenes (BTEX); 2) assess concentrations of BTEX constituents in soil gas along the utility corridor; and 3) assess indoor air in the adjacent single-family residence for the presence of volatile organic compounds (VOCs - specifically BTEX).

Field activities, field findings and analytical results and conclusions and recommendations are discussed in the following sections of this letter report. A Site

Location Map is provided as Figure 1. A Site Map, depicting the outline of the former flow line excavation, sample locations and the location of the adjacent residence, is provided as Figure 2.

Field Activities

LTE conducted field activities in March and April of 2010. LTE contracted Vironex Environmental Field Services (Vironex) of Golden, Colorado to advance soil borings at the site on March 23, 2010 for the purpose of collecting subsurface soil and soil vapor samples. LTE contracted ACI Environmental Services (ACI) of Englewood, Colorado to install groundwater monitoring wells at the site on April 15, 2010. The monitoring wells were subsequently sampled on April 21, 2010. The sampling activities are described in detail in the following sub-sections.

Soil Sampling

The flow line excavation's northern sidewall sample (N01@9'), collected on June 30, 2008, yielded a TPH concentration of 780 milligrams per kilogram (mg/kg) at a depth of nine feet below ground surface (bgs). Per the Work Plan, two soil borings (SB04 and SB05) were advanced just beyond the north wall of the former excavation to confirm that TPH concentrations are below the COGCC's new TPH (500 mg/kg) and BTEX standards.

Soil borings SB04 and SB05 were advanced to a total depth of 10 feet. The borings were advanced using a truck-mounted GeoProbe (hydraulic push) rig and two-inch diameter rods with lined macro samplers. Grey stained soil with a petroleum hydrocarbon odor was encountered in SB04 from 9.5 to 10 feet bgs. Grey stained soil with a petroleum hydrocarbon odor was observed in SB05 from 7 to 10 feet bgs. Despite the absence of groundwater in the 2008 flow line excavation, saturated soil was encountered in the SB04 borehole samples at approximately seven feet bgs and in the SB05 samples at approximately 5.5 feet bgs. Based on the presence of groundwater, one soil sample was collected from each borehole from immediately above the water table. Samples SB04@7' and SB05@5.5' were submitted to the Summit Scientific (Summit) laboratory in Golden, Colorado for total extractable petroleum hydrocarbons (TEPH) and BTEX analysis by Environmental Protection Agency (EPA) Methods 8015 and 8260B, respectively. Soil boring logs are provided in Appendix A. Soil boring locations are depicted on Figure 2.

A temporary poly-vinyl chloride (PVC) monitoring well was completed in SB05, but there was insufficient groundwater present in the well for sample collection by the conclusion of field activities on March 23, 2010. The temporary well and borehole was properly abandoned prior to exiting the site.

Soil Vapor Sampling

Three soil vapor sampling points (VP1, VP2 and VP3) were advanced immediately to the east of the utility corridor and three vapor sampling points (VP4, VP5 and VP6) were advanced within the utility corridor. Due to the unexpected presence of groundwater, the soil vapor sampling depths were adjusted from the proposed 2-4, 6-8 and 10-12 foot bgs intervals to 2-4 and 4-6 foot bgs intervals to ensure the vapor samples were collected from above the saturated zone. The soil vapor sampling points are depicted on Figure 2.

Soil vapor samples were collected using an expendable point, an expendable point holder, a post run tubing (PRT) adapter and polyethylene tubing ($^3/_8$-inch). The expendable point was placed in the expendable point holder, which in turn was attached to the drive rod and driven to depth. The drive rod and expendable point holder were retracted, separating the expendable point from the point holder, and creating the desired void space in the soil. A PRT adapter and tubing were advanced down the inner rods and threaded into the expendable point holder. At the surface, the tubing was attached to the vacuum system, which was used to purge the tubing and draw the soil vapor sample. Soil vapor samples were collected in tedlar sample bags, which were placed into an air-tight vacuum box that was inserted into the sample train between the borehole and the vacuum system. The vacuum box prevented cross contamination with ambient air by evacuating ambient air from the box prior to collecting the soil vapor sample using the resulting vacuum. A minimum of four liters of vapor were purged from the tubing and void space prior to collecting each soil vapor sample. PID screening of soil vapors was conducted during the purge, as requested by the COGCC in their conditional approval of the Work Plan. The soil vapor samples were submitted to Air Toxics Ltd in Folsom, California for analysis of BTEX constituents by EPA Method TO-15 Modified.

Indoor Air Sampling

As requested by the COGCC in their letter dated January 27, 2010, Kerr-McGee notified the owner of the west adjoining residence of the potential hazards of VOC accumulation in confined spaces and offered to perform indoor air monitoring in the residence located at 2322 Quay Street. LTE contracted Environmental Health & Safety Documents, Inc. (EHS) on Kerr-McGee's behalf to conduct air monitoring in the adjacent residence.

On March 17, 2010 EHS placed four summa canisters with flow regulators at the residence to monitor indoor air for BTEX constituents over a 24-hour sampling period. The canisters were placed in the living room, master bedroom, crawl space and outside the residence. The outdoor summa was used to measure ambient BTEX levels in outdoor air. The summa canisters were shipped overnight under chain-of-custody to Air Toxics in Folsom, California for BTEX analysis by EPA Method TO-15 Modified.

In addition to the summa canisters, real-time air monitoring for percent lower explosive limit (LEL) and organic vapors was performed using a Draeger XAM 7000 monitor and real-time benzene monitoring was performed using a hand-held Gastec pump and benzene detector tubes. A copy of the EHS report is provided in Appendix B.

Groundwater Sampling

LTE personnel returned to the site on April 15, 2010 with an ACI drilling crew and a track-mounted GeoProbe rig to install three permanent groundwater monitoring wells (MW01 through MW03). MW01 was installed within the 2008 flow line excavation. MW02 and MW03 were installed in down-gradient locations to the southeast and south of the former excavation, respectively. The boreholes were advanced to a total depth of 15 feet bgs. One-inch diameter PVC monitoring wells with ten feet of screen (0.01-inch slot) were completed in each borehole. All three wells were dry upon completion. The monitoring well locations are depicted on Figure 2.

LTE personnel returned to the site on April 21, 2010 to sample the monitoring wells. Groundwater was present in all three wells at depths of 8.9 to 14.16 feet bgs. Dedicated disposable tubing and a peristaltic pump were used to purge the wells and collect groundwater samples. The groundwater samples were submitted to Summit for BTEX analysis by EPA Method 8260B.

Field Findings and Analytical Results

Laboratory analytical results for the soil, soil vapor, groundwater and indoor air samples, as well as any relevant field findings, are presented below.

Soil Sample Results

Soil staining and/or elevated photoionization detector (PID) readings were not encountered above the saturated zone in the soil assessment boreholes (SB04 and SB05). Additionally, TPH and BTEX concentrations in soil boring samples SB04@7' and SB05@5.5' were below the COGCC allowable levels and the laboratory reporting limits. The soil sample laboratory results and laboratory reporting limits are summarized in Table 1. The laboratory analytical reports are presented in Appendix C.

Soil Vapor Sample Results

PID readings obtained while purging the vapor sampling points ranged from 0.0 to 1.7 parts per million (ppm). Laboratory analytical results confirmed reportable concentrations of one or more BTEX constituents in 9 of 12 soil vapor samples. However, all the benzene concentrations were below the Colorado Oil and Public Safety's (OPS) residential soil vapor Risk Based Screening Level (RBSL) for benzene (2,700 ug/m^3), as listed in the OPS's Vapor Intrusion Guidance Document. The highest benzene concentration reported was 110 ug/m^3 in VP4@3'. The residential soil vapor RBSL represents the concentration of benzene in soil vapor necessary to complete the indoor air vapor intrusion pathway. The Vapor Intrusion Guidance Document does not list RBSLs for toluene, ethylbenzene or xylenes. A summary of the soil vapor sample analytical results is provided in Table 2. The laboratory analytical reports are presented in Appendix C.

Indoor Air Sample Results

Real time percent LEL and organic vapor measurements were collected in ten locations within the residence, including the crawl space. All the percent LEL and organic vapor measurements were 0.0 ppm. In addition, percent LEL and organic vapor measurements collected outside the residence were also 0.0 ppm.

Three real time benzene detector tube measurements were collected at different locations within the residence, including the crawl space. Test results were 0.0 ppm at all three sampling locations.

BTEX constituents were detected in all four summa canister samples. Benzene concentrations ranged from 2.9 ug/m^3 in the outdoor sample to 4.6 ug/m^3 in the living room sample. There are no regulatory limits for BTEX concentrations within residential structures. The OPS Vapor Intrusion Guidance Document recommends comparing indoor values to exterior concentrations for benzene, but does not address levels of toluene, ethylbenzene or xylenes. Due to the high variability associated with outdoor benzene samples, the OPS considers an associated indoor air benzene concentration within 3 to 5 ug/m^3 of the outdoor sample to be representative of background levels and not indicative of a vapor intrusion pathway. Benzene concentrations in all three indoor air samples were within 1.7 ug/m^3 of the benzene concentration recorded in the outdoor air sample.

Groundwater Sample Results

BTEX analytical results for MW01 through MW03 were reported on April 22, 2010. Benzene concentrations in the MW01 and MW02 groundwater samples exceeded the Colorado Groundwater Quality Standard (CGWQS) for benzene of 5 micrograms per liter (ug/l) at concentrations of 21 and 54 ug/l, respectively. BTEX constituents were not detected in MW03 above the laboratory reporting limit. A summary of the groundwater analytical results and depth to water measurements is provided in Table 3. The laboratory analytical reports are presented in Appendix C.

Conclusions and Recommendations

Based on the soil boring sample analytical results, TPH and BTEX concentrations in unsaturated soil along the former north wall of the excavation are below the COGCC allowable levels. Groundwater, which was not encountered during the excavation of impacted soil in 2008, is now present at depths as shallow as 5.5 feet bgs.

Soil vapor samples collected within the utility corridor indicate the presence of low-level BTEX concentrations. Benzene concentrations in the soil vapor samples are below the OPS RBSL for the residential indoor air vapor intrusion pathway.

Indoor air monitoring (real time and 24-hour summa samples) also indicate that a vapor intrusion pathway does not exist for the residence at 2322 Quay Street and that benzene concentrations recorded in the indoor summa canister samples are representative of and consistent with benzene concentrations present in ambient outdoor air.

Limited quantities of groundwater infiltrated the low-producing monitoring wells constructed at the site. Benzene concentrations exceed the CGWQS in MW01, which was completed inside the excavation and MW02, which was installed down-gradient to the southeast. Additional monitoring wells will be installed down-gradient of MW02 to establish points of compliance (POC) and groundwater monitoring will continue on a quarterly basis.

Please call us at (303) 433-9788 if you have any questions regarding this letter report or require additional information.

Sincerely,

LT ENVIRONMENTAL, INC.

Justin Solomon
Project Environmental Scientist

Reviewed By,

John E. Cocroft
Senior Hydrogeologist/Project Manager

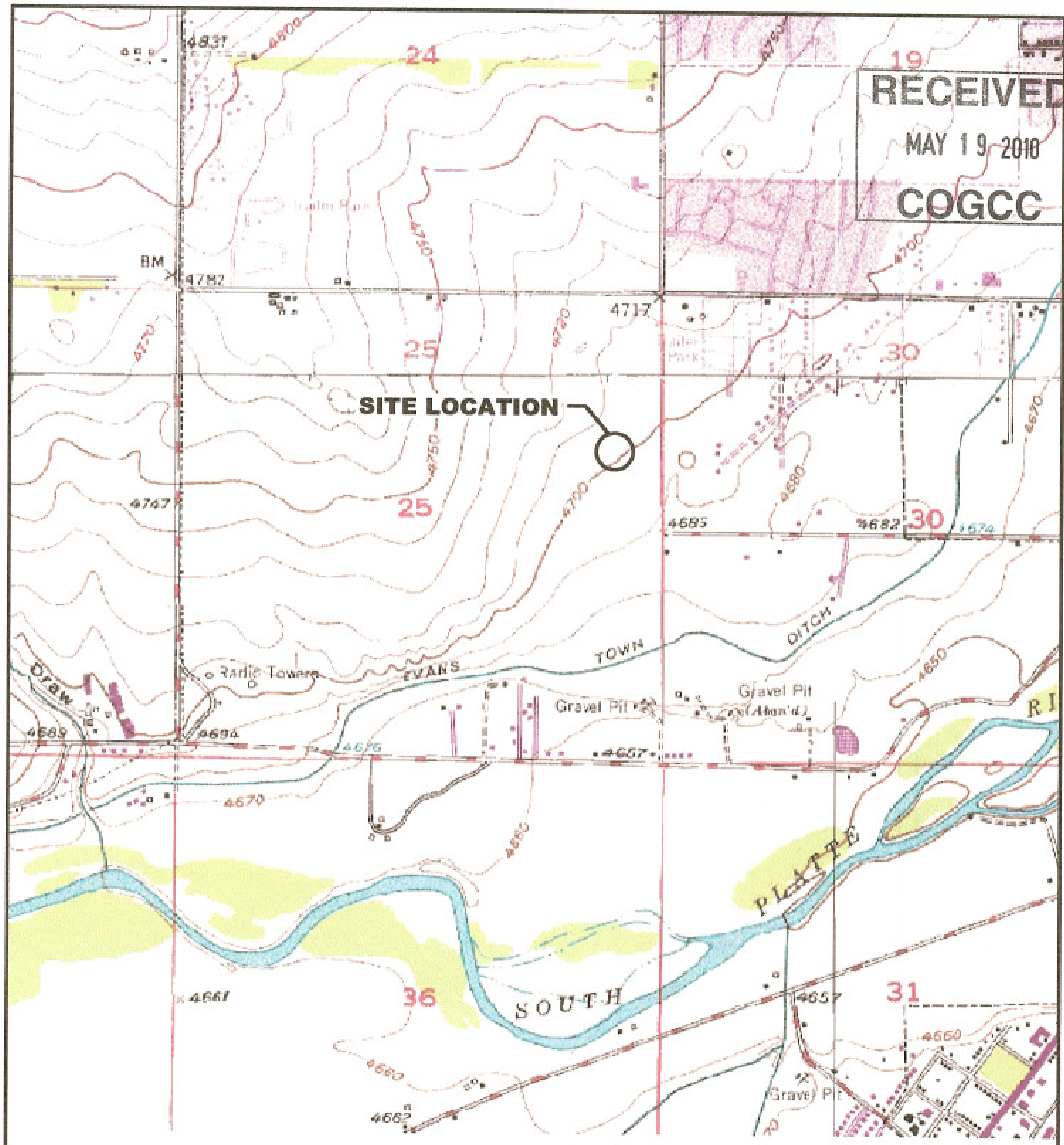
Attachments

Figure 1 – Site Location Map
Figure 2 – Site Map with Sample Locations

Table 1 – Soil Sample Analytical Data
Table 2 – Soil Vapor Sample Analytical Data
Table 3 – Groundwater Analytical and Field Results

Appendix A – Soil Boring Logs
Appendix B – EHS Indoor Air Quality Survey
Appendix C – Laboratory Analytical Reports

FIGURES



LEGEND

○ SITE LOCATION

0 375 750 1500
FEET

SOURCE: TOPOZONE.COM
USGS 7.5' QUADRANGLE
(NAD27)

FIGURE 1
SITE LOCATION MAP
WASS #5
NENE-25-T5N-R66W
WELD COUNTY, CO

KERR-McGEE OIL & GAS ONSHORE LP

KMG0839701_SL 7/08

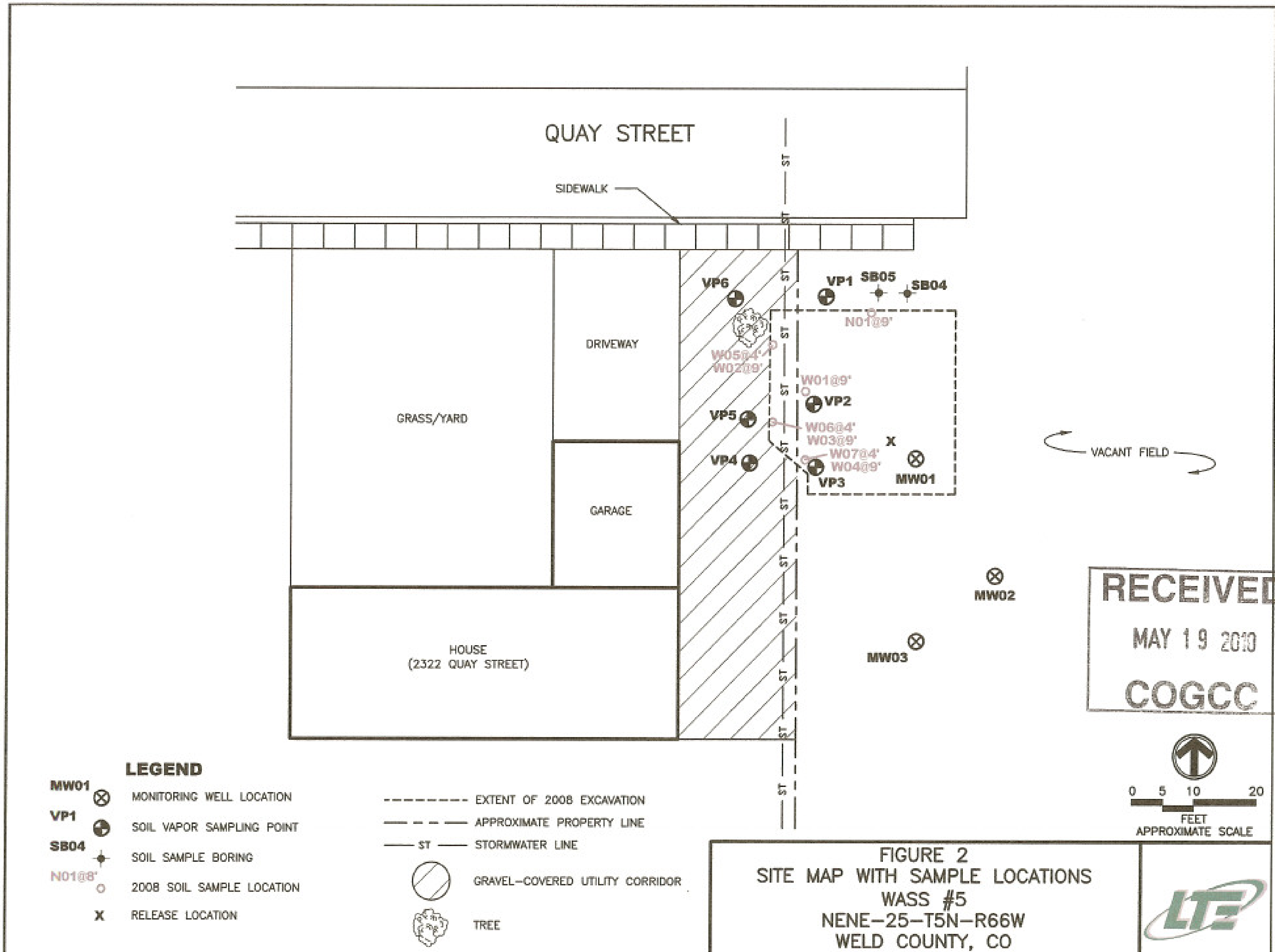


FIGURE 2
SITE MAP WITH SAMPLE LOCATIONS
WASS #5
NENE-25-T5N-R66W
WELD COUNTY, CO
KERR-McGEE OIL & GAS ONSHORE LP

3/10\KMG0839703

RECEIVED
MAY 19 2010
COGCC

TABLES

RECEIVED
MAY 19 2010
COGCC

TABLE 1
SOIL SAMPLE ANALYTICAL DATA

SAMPLE ID	SAMPLE DATE	DEPTH (feet bgs)	BENZENE (mg/kg)	TOLUENE (mg/kg)	ETHYLBENZENE (mg/kg)	XYLENES (Total) (mg/kg)	TPH-GRO (mg/kg)	TEPH DRO+ORO (mg/kg)
SB04@7'	3/23/2010	7.0	<0.005	<0.005	<0.005	<0.005	<50	<50
SB05@5.5'	3/23/2010	5.5	<0.005	<0.005	<0.005	<0.005	<50	<50
COGCC Allowable Level			0.17	85	100	175	500	

< - less than stated laboratory reporting limit.
mg/kg - milligrams per kilogram
bgs - below ground surface
COGCC -Colorado Oil and Gas Conservation Commission
GRO - Gasoline Range Organics
DRO - Diesel Range Organics
ORO - Oil Range Organics
TPH - Total Petroleum Hydrocarbons
TEPH - Total Extractable Petroleum Hydrocarbons
ppm - parts per million
Results noted in bold exceed COGCC allowable levels.

TABLE 2
SOIL VAPOR SAMPLE ANALYTICAL DATA

SAMPLE ID	SAMPLE DATE	DEPTH (feet bgs)	PID (ppm)	BENZENE (ug/m^3)	TOLUENE (ug/m^3)	ETHYLBENZENE (ug/m^3)	XYLENES (Total) (ug/m^3)
VP1@2'	3/23/2010	2.0	1.7	<16	20	<22	<22
VP1@4.5'	3/23/2010	4.5	0.4	55	45	<22	32
VP2@2'	3/23/2010	2.0	0.2	<16	<19	<22	<22
VP2@4.5'	3/23/2010	4.5	0.1	<16	<19	<22	<22
VP3@2'	3/23/2010	2.0	0.0	<16	31	<22	25
VP3@4.5'	3/23/2010	4.5	0.2	<16	<19	<22	<22
VP4@3'	3/23/2010	3.0	0.1	110	46	38	312
VP4@6'	3/23/2010	6.0	0.3	<16	28	<22	25
VP5@3'	3/23/2010	3.0	1.1	32	22	40	176
VP5@6'	3/23/2010	6.0	0.5	49	37	<22	24
VP6@3'	3/23/2010	3.0	0.3	<16	<19	<22	<22
VP6@6'	3/23/2010	6.0	0.2	24	<19	<22	<22
Residential Soil Vapor RBSL				2,700	NA	NA	NA

RBSL - Risk Based Screening Levels from Oil and Public Safety's Vapor Instrusion Guidance Document.

NA - Not applicable, no RBSL is listed by OPS because even at a concentration equal to the vapor pressure of the chemical, a hazrd quotient of 1 is not exceeded.

PID - photoionization detector

ppm - parts per million

ug/m^3 - micrograms per liter

< - Analytical results is less than stated laboratory reporting limit.

3/10\KM00839703

TABLE 3
GROUNDWATER ANALYTICAL AND FIELD RESULTS
WASS #5
WELD COUNTY, COLORADO
KERR-McGEE OIL & GAS ONSHORE LP

Well Name	Date	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Xylenes (ug/L)	Depth Water/ (Depth Product) (ft bgs)
MW01	04/21/2010	**21**	1.0	83	440	13.37
MW02	04/21/2010	**54**	1.0	140	480	8.90
MW03	04/21/2010	<1.0	<1.0	<1.0	4.0	14.16
Colo GW Quality Standards		**5**	**1000**	**700**	**1400**	

Notes: < - less than
ug/L - micrograms per Liter
NA - Not Analyzed/Not Available
GW - Groundwater
Bold numbers indicate result equaled or exceeded standard.
NM - Not Measured
ft bgs - feet below ground surface

RECEIVED
MAY 19 2010
COGCC

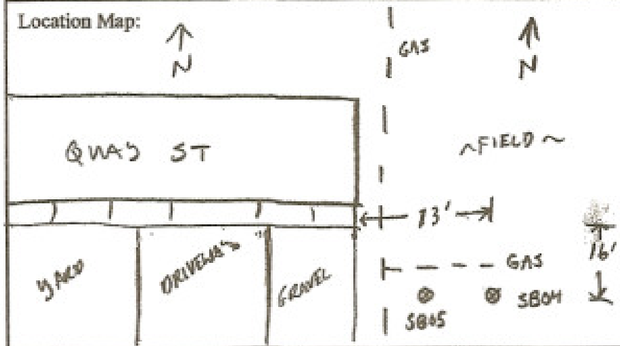
APPENDIX A

SOIL BORING LOGS

Compliance : Engineering : Remediation
LT Environmental, Inc.
4400 West 46th Ave.
Denver, Colorado 80212

BORING LOG/MONITORING WELL COMPLETION DIAGRAM

Location Map:



Boring/Well Number: SB04		Project: WASS #5	
Date: 2/18/2010		Project Number: KMG08357	
Logged By: Justin Solomon		Drilled By: VIRONEX	
Elevation:	Detector: MiniRae 3000 PID	Drilling Method: Direct Push	Sampling Method: Continuous
Gravel Pack: ~~10-20 Silica Sand~~ NA		Seal: NA	Grout: NA
Casing Type: ~~Schedule 40 PVC~~ NA		Diameter: Length:	Hole Diameter: 2" / Depth to Liquid: —
Screen Type: ~~Schedule 40 PVC~~ NA	Slot:	Diameter: Length:	Total Depth: 10' / Depth to Water: 7'

Penetration Resistance	Moisture Content	Vapor (ppm)	Staining	Sample #	Depth (ft. bgs.)	Sample Run	Soil/Rock Type	Lithology/Remarks	Well Completion
					0			TOP SOIL (0-6")	
LOW	MOIST				2	4.5'		SILTY-SAND, F-G SAND, MOIST, BROWN, NO ODOR	NA
		0.3			4				
		0.2			6			SILT W/ SLIGHT PLAST (≤10% CLAY), BROWN, MOIST.	
		0.2						SILTY-CLAY, LOW-MED PLAST, BROWN, NO ODOR.	
LOW		0.2			8	4'		WET @7'	
	WET	96.4	//////		10			GREY STAIN W/ ODOR (9.5-10')	
					12				
					14			TD=10' JJS	
					16				
					18				
					20				
					22				
					24				
					26				
					28				
					30				

SAMPLOG

Location Map:	Compliance , Engineering , Remediation LT Environmental, Inc. 4400 West 46th Ave. Denver, Colorado 80212	
SEE SB04 MAP	**BORING LOG/MONITORING WELL COMPLETION DIAGRAM**	
	Boring/Well Number: SB05	Project: WASS #5
	Date: 2/18/2010	Project Number: KMG08397
	Logged By: Justin Solomon	Drilled By: VIRONEX

Elevation:	Detector: MiniRae 3000 PID	Drilling Method: Direct Push		Sampling Method: Continuous	
Gravel Pack: ~~10-20 Silica Sand~~ NA		Seal:		Grout:	
Casing Type: ~~Schedule 40 PVC~~ NA		Diameter:	Length:	Hole Diameter: 2"	Depth to Liquid: –
Screen Type: ~~Schedule 40 PVC~~ NA	Slot:	Diameter:	Length:	Total Depth: 10'	Depth to Water: ~5.5

Penetration Resistance	Moisture Content	Vapor (ppm)	Staining	Sample #	Depth (ft. bgs.)	Sample Run	Soil/Rock Type	Lithology/Remarks	Well Completion
					0			TOP SOIL (0-6")	NA
					2				
LOW	MOIST	0.6			4	3'		SILTS / SANDS - CLAYS, BROWN, MED PLAST, MOIST	
		0.6		SB05 @5.5'	6				
		16.8			8	2.5		AS ABOVE, WET, STAIN W/ MOD HC ODOR (7-10')	
LOW	WET	1089	stained		10				
					12			TD = 10' bgs	
					14				
					16				
					18				
					20				
					22				
					24				
					26				
					28				
					30				

RECEIVED
MAY 19 2010
COGCC

APPENDIX B

EHS INDOOR AIR QUALITY SURVEY

LTE

EHS Documents, Inc.
2164 South Parfet Drive
Lakewood, CO 80227

April 7, 2010

LT Environmental, Inc.
Mike McKee
4600 W 60th Ave
Arvada, CO 80003-6911

RE: Indoor Air Quality Survey
2322 Quay Street
Evans, CO

Dear Mr. McKee:

EHS Documents, Inc. conducted an indoor air quality (IAQ) survey on March 17, 2010 at the request of LT Environmental, Inc. (LTE) on behalf of their client, Anadarko. The IAQ survey was conducted inside the eastern most unit of a duplex located near an Anadarko flow line. The purpose of the survey was to evaluate basic indoor air quality parameters inside this duplex after a flow line leak in June, 2008 caused petroleum products to impact the utility corridor near the duplex.

This report documents the results of the IAQ survey, including completion of an IAQ Building Survey, collection of Summa Canisters for benzene, toluene, ethylbenzene and xylenes (BTEX), real time air monitoring for percent lower explosive limit (LEL) and organic vapors, and detector tube collection of benzene samples.

Eastern side of duplex located at 2322 Quay Street, Evans, CO

Background:
This IAQ survey was collected in accordance with the Colorado Department of Labor and Employment (CDLE) Division of Oil and Public Safety (OPS) Petroleum Hydrocarbon Vapor Intrusion Guidance Document, located in Attachment A. This document was referenced in this

IAQ survey because it contained specific information about petroleum hydrocarbons as indoor air contaminants versus guidance from the Colorado Department of Public Health (CDPHE) and the Environmental Protection Agency (EPA).

Indoor Air Quality Building Survey Form:
During the course of the indoor air quality survey an informal interview was conducted with the duplex occupant in order to complete the OPS Indoor Air Quality Building Survey Form, included as Attachment B. The purpose of the form was to gather basic information about the unit and evaluate if chemicals stored within the unit may impact the indoor air quality results with respect to BTEX.

The survey form indicated a number of chemicals stored in the garage area in sealed containers and a can containing gasoline.

Real Time Monitoring for % Lower Explosive Limit and Organic Vapors:
Holli Merchant, Certified Industrial Hygienist (CIH), Certified Safety Professional (CSP) used a Draeger XAM 7000 to monitor percent lower explosive limit (LEL) and organic vapors. The results of the survey are documented in Table 1.

Table 1
Real Time Monitoring Lower Explosive Limit and Organic Vapors

Location	%LEL	Organic Vapors Parts per million (PPM)
Living Room	0	0
Kitchen	0	0
Hallway	0	0
First Bedroom	0	0
Bathroom	0	0
2nd Bedroom	0	0
Master Bedroom	0	0
Master Bathroom	0	0
Garage	0	0
Crawl Space	0	0
Outside	0	0

Real Time Monitoring for Benzene:
During the IAQ survey, a Gastec handheld pump was used that was equipped with benzene detector tubes in the measuring range of .1 to 65 parts per million (ppm). Results are detailed in Table 2.

Table 2
Benzene Detector Tubes

Location	Benzene Parts per million (PPM)
Living Room	0
Hallway	0
Crawl Space	0

EHS Documents, Inc.
2164 South Parfet Drive
Lakewood, CO 80227

Summa Canister Sampling:
EHS Documents Inc. also placed four Summa Canisters with 24 hour regulators in the living room, master bedroom, crawl space, and exterior of the unit. The Summa Canisters were then shipped overnight to Air Toxics in Folsom, California for analysis. All canisters were analyzed using modified method TO 15 for BTEX.

Summa Canister in exterior location on east side of duplex unit

Results are located in Table 3 and detailed laboratory reports are included as Attachment C.

Table 3
Summa Canister Results

Sample ID	Location	Results in micrograms/meters cubed ($\mu g/m^3$)	
2322 Quay-BTEX 1	Living Room	Benzene	4.6
		Toluene	23.0
		Ethylbenzene	2.1
		m,p-xylene	7.4
		o-xylene	2.1
2322 Quay-BTEX 2	Outside	Benzene	2.9
		Toluene	5.1
		Ethylbenzene	ND
		m,p-xylene	2.2
		o-xylene	ND
2322 Quay BTEX 3	Master Bedroom	Benzene	4.5
		Toluene	28.0
		Ethylbenzene	ND
		m,p-xylene	7.3
		o-xylene	2.2
2322 Quay BTEX 4	Crawl Space	Benzene	4.5
		Toluene	21.0
		Ethylbenzene	1.8
		m,p-xylene	6.8
		o-xylene	1.9

ND= not detected

EHS Documents, Inc.

2164 South Parfet Drive
Lakewood, CO 80227

Benzene Indoor Air Quality Background Data:
Because no mandatory regulatory limits have been published determining the level at which BTEX concentrations must be maintained within residential structures, the OPS Vapor Intrusion Guidance Document suggests that indoor values are compared to exterior concentrations for benzene. The OPS guidance does not address levels of xylene, ethylebenze or toluene. Because the outdoor samples are very susceptible to environmental conditions and may vary substantially in a 24 hour period, OPS considers 3-5 $\mu g/m^3$ of benzene to be background and not indicative of a vapor intrusion pathway. Attachment D, The Impact of Background Concentration on Vapor Intrusion Assessment, is the document that the background value is based on.

Soil Vapor Sampling:
In accordance with the OPS Vapor Intrusion Guidance Document, soil vapor samples were collected by LT and compared with the Risk Based Screening Levels (RBSLs) listed in the document. The purpose of this sampling was to determine if the potential for an indoor air vapor intrusion pathway could exist. Of the 12 samples collected, none exceeded the RBSL screening level of 2,900 $\mu g/m^3$ for benzene with the highest benzene sample recorded being 110 $\mu g/m^3$. The RBSL for toluene, ethylbenzene, and xylenes are listed as greater than the vapor pressure. These RBSLs were not exceeded in the samples collected.

Conclusions:
Based on the real time monitoring results, Summa Canister samples, and soil vapor samples collected, a vapor intrusion pathway does not appear to exist for this duplex unit. Based on the information given by OPS, analytical results for BTEX inside the unit are considered to be background levels and not indicative of a vapor intrusion pathway.

Thank you for allowing EHS Documents Inc. to assist you with this project. If you have any questions regarding the enclosed information please contact me at (303) 986-1067.

Sincerely,
EHS Documents Inc.

Holli Merchant, CIH, CSP
Principal Industrial Hygienist

DEPARTMENT OF LABOR AND EMPLOYMENT
Division of Oil and Public Safety
Remediation Section
633 17th Street, Suite 500
Denver, Colorado 80202-3660
(303) 318-8500; Fax (303) 318-8546
Website: http://oil.cdle.state.co.us

Petroleum Hydrocarbon Vapor Intrusion Guidance Document

The Colorado Department of Labor and Employment
Division of Oil and Public Safety

December 11, 2007

Table of Contents

Figures

Tables

Appendices

1.0 Introduction

Vapor intrusion has been defined by the U. S. Environmental Protection Agency (EPA) as the "migration of volatile chemicals from the subsurface into overlying buildings". Over the past several years, vapor intrusion has become an issue of concern at thousands of sites across the nation. Vapor intrusion can occur when a substance containing volatile organic compounds (VOCs), many of which are known carcinogens, is released into the subsurface impacting soil and possibly groundwater. Following such a release, a portion of these VOCs go into the vapor phase, whether emitted from the released material itself or from contaminated groundwater containing dissolved VOCs. These vapors can then migrate from contaminated media through subsurface soils and into overlying buildings, creating a potentially unsafe environment for building occupants.

The contaminants associated with vapor intrusion usually enter the environment as a direct result of a release to soil and groundwater from properties such as gas stations, dry cleaners and industrial facilities. As indicated by the title of this guidance document and in accordance with the general mission of the Remediation Section of the Division of Oil & Public Safety (OPS), this document only addresses the vapor intrusion problem as it relates to the release of petroleum products into the environment. This document is not intended to provide an exhaustive discussion of all aspects of the vapor intrusion problem, even as it relates to petroleum releases. Beyond providing an overview of the problem, the primary focus and intent of this document is provide guidance to the regulated community regarding the best ways to assess the vapor intrusion pathway. To that end, information is provided on the conditions which would trigger the need for a vapor intrusion assessment, the proper methods of construction and sampling soil vapor wells and sub-slab installations, the issues and challenges of indoor air evaluation and sampling, the analysis of collected vapor samples, and the evaluation of laboratory data. The subject of vapor intrusion mitigation is beyond the intended scope of this document. However, useful references are provided that address this subject in detail. This document should not be viewed as a "stand alone" text but should be referred to and used in conjunction with the Petroleum Storage Tank Owner/Operator Guidance Document.

Biodegradation of petroleum constituents and the evaluation of attenuation factors that might allow for expedited assessments of the vapor intrusion pathway have both been the subjects of recent research. However, at this time, there is no general consensus on the rates of contaminant biodegradation or the degree of contaminant attenuation one can expect in a given subsurface environment. Given the available data, OPS is not prepared to assign or accept attenuation factors. Therefore, this issue is not addressed in this document.

This document is a practical tool to assist the regulated community and their environmental consultants in the assessment of potential vapor intrusion issues at their sites of interest. A flow chart (Figure 1) is included to aid in decision-making during the characterization of the vapor intrusion pathway. Also, the Appendices include a Checklist designed to assure that the vapor intrusion pathway is properly and completely evaluated and a Building Survey form that must be used when conducting an initial screening prior to performing an indoor air sampling event.

OPS would like to thank the many environmental professionals that have given their advice and assistance in preparing this document. Special thanks to Dr. Blayne Hartman of H&P Mobile Geochemistry and David Folkes and Dr. Jeff Kurtz of EnviroGroup Limited for providing thorough and thoughtful reviews of a preliminary draft of this document.

2.0 Vapor Intrusion Program Overview

OPS requires evaluation of the soil vapor to indoor air inhalation pathway when a structure is present within the influence of hydrocarbon impacted soils or groundwater, and regular operations at that structure do not involve the dispensing of petroleum products. A structure is considered within the influence of a contaminant plume if the structure lies directly over or adjacent to the plume, i.e., where contaminant concentrations in groundwater exceed the groundwater to indoor air Risk Based Screening Levels (RBSLs). If there are potential preferential pathways (e.g. utility corridors) connected to a structure that pass through or over a contaminant plume, that structure is also considered within the influence of the plume. The steps involved in the OPS soil vapor and indoor air assessment process are illustrated in Figure 1 and are described below.

2.1 Site Characterization – Step 1

A site characterization is completed to assess potential exposure pathways. The site characterization includes gathering information and data that fully defines the type and magnitude of the contamination source and the horizontal and vertical extent of contamination in soil, groundwater, and soil vapor. All potential points of exposure (POE) are also identified, which include structures of concern and potential preferential pathways for vapor migration, as described above. **In emergency situations where impact to indoor air has been identified (i.e. petroleum odors), indoor air mitigation activities (Step 9) should be conducted immediately.**

Table 1 lists the OPS RBSLs for concentrations in groundwater that would prompt an evaluation of the potential for soil vapor to impact structures within the influence of the contamination. Also in Table 1 are the RBSLs for the soil vapor to indoor air inhalation pathway. The RBSLs may be modified in the future as more empirical data is obtained. Refer to Appendix C of the OPS Petroleum Storage Tank Owner/Operator's Guidance Document for more information regarding the determination and calculation of the RBSLs.

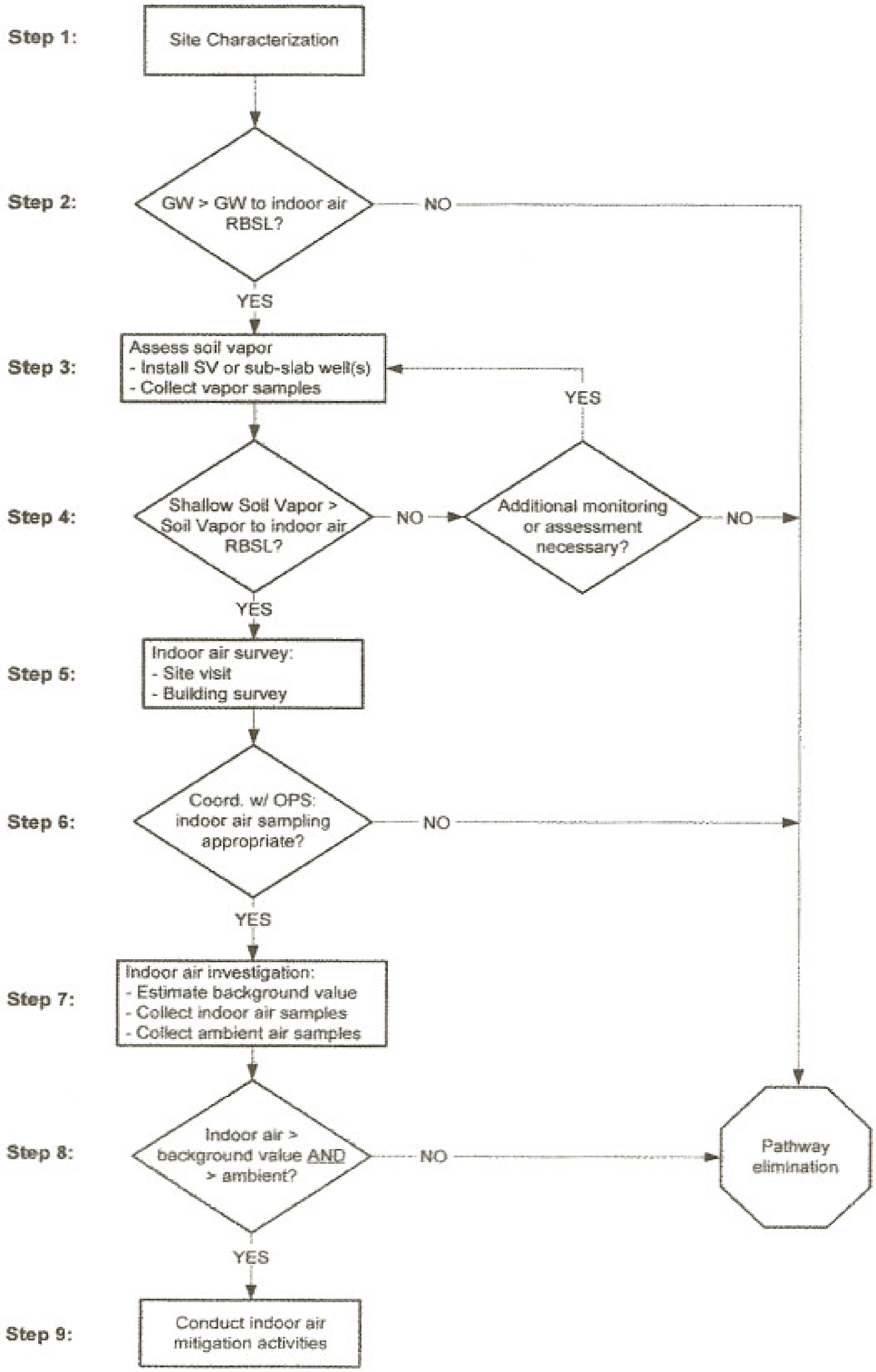
Table 1. RBSLs for Evaluation of the Indoor Air Exposure Pathway

Media	Units	Land Use	Benzene	Toluene	Ethyl-benzene	Xylenes
Groundwater	mg/L	Residential	0.016	10	26	2.9
		Industrial	0.41	490	>Sol	140
Soil Vapor	µg/m³	Residential	2,900	>VP	>VP	>VP
		Industrial	37,000	>VP	>VP	>VP

>VP denotes that even at a concentration equal to the vapor pressure of the chemical, a hazard quotient of 1 is not exceeded.

>Sol denotes that even at a concentration equal to the solubility of the chemical, a hazard quotient of 1 is not exceeded.

Figure 1. OPS Soil Vapor and Indoor Air Evaluation Process



2.2 Groundwater to Indoor Air RBSL – Step 2

Based on site characterization information and data, determine whether benzene concentrations in groundwater exceed the RBSL for groundwater to indoor air (0.016 mg/L) listed in Table 1. If this RBSL is exceeded or if preferential pathways exists that could cause impact to indoor air of a structure, the soil vapor to indoor air pathway must be assessed. If the RBSL is not exceeded and OPS has not requested additional soil vapor investigation, the groundwater to indoor air pathway is eliminated.

2.3 Soil Vapor Assessment – Step 3

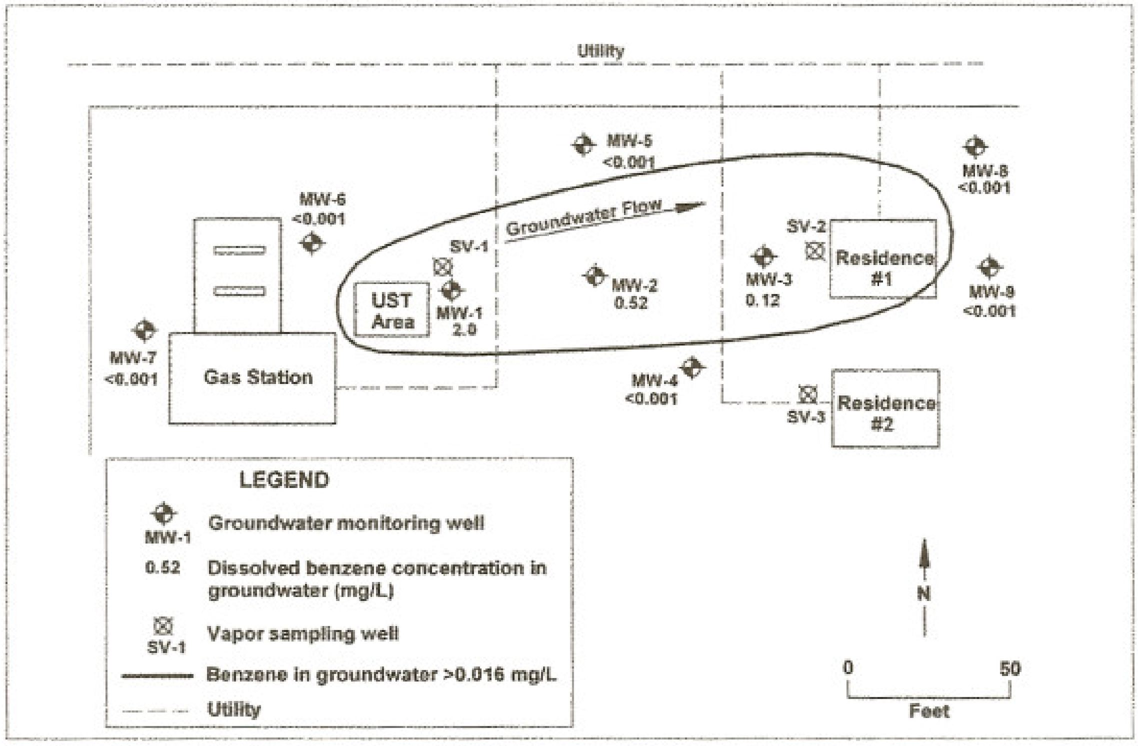
The soil vapor to indoor air pathway is assessed by installing soil vapor and/or sub-slab sampling wells. Construction of these wells is described in Section 3.0 (soil vapor wells) and Section 5.0 (sub-slab wells) of this document. A checklist that presents all components of soil vapor assessment is provided in Appendix A.

If the contamination source is not directly below a structure of concern, soil vapor monitoring wells should be installed in the source area and adjacent to the side of the structure that is closest to the source area. If the contamination source is located directly below a structure, vapor samples should be collected immediately below the structure's foundation if possible (i.e., sub-slab samples). Sufficient samples should be collected to get a representative value under the footprint of the structure, with locations selected to provide an indication of the spatial distribution of the contamination. If sub-slab samples are not possible, samples should be collected adjacent to the structure at strategic locations to determine the distribution of contaminants and thereby get an idea of possible contamination levels under the structure.

A typical scenario where a soil vapor assessment would be necessary is illustrated in Figure 2. The source area in this example is the UST area. Therefore, a soil vapor well (SV-1) is installed as close to the source area as possible. Notice that monitoring well MW-3 is located near Residence #1 and that MW-3 has a benzene concentration that exceeds the benzene groundwater to indoor air RBSL. Under this scenario, a soil vapor well or a nested set of soil vapor wells (SV-2) should be installed adjacent to the upgradient side of this structure. Also shown in Figure 2 is a utility corridor which passes through the plume and could therefore serve as a preferential pathway that allows contaminant vapors to migrate to Residence #2. To evaluate this potential impact, a soil vapor well or a nested set of soil vapor wells (SV-3) should be installed adjacent to the utility corridor near the point where the utility enters Residence #2.

Biodegradation of petroleum hydrocarbon vapor occurs at variable rates throughout migration from the source (groundwater or soil) upwards through soil, into sub-slab vapor, across the structure foundation slab and then into the structure. This biodegradation or attenuation usually occurs at a greater rate throughout the soil column than across the structure slab. Therefore, concentrations less than the soil vapor to indoor air RBSL could potentially impact indoor air.

Figure 2. Example Groundwater Contamination Plume Requiring Soil Vapor Assessment



2.4 Soil Vapor to Indoor Air RBSL – Step 4

Based on the evaluation of soil vapor sample results, determine if benzene concentrations in the shallow soil vapor interval exceed the soil vapor to indoor air RBSL of 2,900 μg/m^3 (see Table 1) in a vapor monitoring well located adjacent to a structure, or if soil vapor concentrations are present in sub-slab samples that indicate potential vapor intrusion from the contaminant plume. If one or both of these conditions exist, an indoor air evaluation (possibly including indoor air sampling) must be performed. If the soil vapor to indoor air RBSL is not exceeded in the shallow sampling interval of the vapor well (or in sub-slab samples) throughout four consecutive quarters of monitoring and preferential pathways for vapor migration still do not exist, the soil vapor to indoor air pathway can be eliminated with OPS's concurrence.

In the event that soil vapor concentrations exceed the soil vapor to indoor air RBSL in the deep and/or intermediate sampling intervals but not in the shallow sampling interval, additional monitoring may be required to ensure that the RBSL is not exceeded throughout seasonal changes in the subsurface. Conditions may exist where benzene concentrations in the shallow sampling interval exceed the soil vapor to indoor air RBSL and are significantly greater than those concentrations in the deep or intermediate sampling intervals. This situation will require additional investigation to determine the source of the shallow contamination (i.e. shallow soil source, leak in the deeper sampling point, etc.)

2.5 Indoor Air Survey – Step 5

The indoor air survey includes a site visit to interview the occupants of the structure and conduct a building survey (see Section 6.0 and Appendix B).

2.6 Is Indoor Air Sampling Appropriate? – Step 6

Information obtained from the site visit is then evaluated and, in coordination with OPS, the determination is made as to whether results of indoor air sampling will identify vapor intrusion from the subsurface contaminant source, considering any additional sources of benzene identified in the structure.

2.7 Indoor Air Investigation – Step 7

If it is determined that indoor air sampling may provide an accurate assessment of vapor intrusion (i.e., the building survey did not identify complications from other possible sources within the structure), indoor air sampling should proceed (see Section 6.3). An outdoor ambient air sample must also be collected during the indoor air sampling event. Background indoor air concentrations are site specific. Therefore, in some cases, it may be necessary to sample background indoor air in nearby structures of similar construction to the one where indoor air is being evaluated.

2.8 Indoor Air Quality Evaluation – Step 8

Based on the evaluation of indoor air and ambient outdoor air sample results, determine if benzene concentrations in indoor air exceed the estimated background value and are greater than the ambient outdoor value. If the benzene concentrations in indoor air do not exceed the background value throughout four consecutive quarters, the indoor air exposure pathway is eliminated.

2.9 Indoor Air Mitigation – Step 9

If benzene concentrations in indoor air exceed the ambient and estimated background values, contamination has been identified in indoor air and must be mitigated. Mitigation of indoor air contamination is addressed in Section 9.0.

OPS should be contacted at any time during the investigation if the next appropriate step is unclear.

3.0 Soil Vapor Well Construction

3.1 Permanent Soil Vapor Well Construction

Depending upon the depth to groundwater, from one to three soil vapor wells with discrete sampling intervals will be required. These wells may be nested within the same borehole or installed in separate borings located adjacent to one another (see Figure 3).

<u>3.1.1 Depth to groundwater < 10 feet</u>

If depth to groundwater (or to the contamination if in the vadose zone) is less than ten feet below ground surface (bgs), only one sampling interval located a minimum of three feet below the base of the at-grade or below-grade slab or foundation of the potentially impacted structure (and preferably at least five feet bgs) is required. This depth restriction is necessary to minimize the effects of changes in barometric pressure and surface temperatures, as well as limiting the breakthrough of ambient air from the surface.

3.1.2 Depth to groundwater between 10 and 20 feet

If depth to groundwater (or a vadose contaminated zone) is between ten and twenty feet bgs, two discrete sampling intervals are required: one located as described above and a second located above the seasonal high water table (or the vadose zone contamination). The groundwater seasonal high can be determined by review of existing historical data or estimated by utilizing the typical capillary rise based on soil type.

If contaminated groundwater is the vapor source, a third well may be installed and screened across the groundwater surface to facilitate groundwater sample collection. Soil vapor may also be sampled from this well to get an indication of vapor concentrations partitioning from the groundwater, but the collected sample probably will not accurately reflect soil gas concentrations. A groundwater monitoring well, as described above, must be installed in a separate borehole than the soil vapor wells to avoid interfering with the deep soil vapor sampling interval.

3.1.3 Depth to groundwater > 20 feet

If depth to groundwater (or a vadose contaminated zone) is greater than twenty feet bgs, a third well should be installed to enable sampling at an intermediate depth.

3.2 Installation of Soil Vapor Wells

Soil vapor wells should be constructed in the same manner at all sampling locations to minimize data variations. The following procedures should be followed when constructing a permanent soil vapor well, unless otherwise instructed or approved by OPS.

3.2.1 Drilling method

Vapor wells can be installed using an auger drill rig, direct-push rig, or hand auger. Please note that depending on the drilling method used, sample collection may need to be delayed to allow subsurface conditions to equilibrate (see Section 4.0). Schematic drawings of auger and direct-push well constructions are shown in Figure 3. The presence of cobbles or highly compacted, fine-grained soils may preclude the use of direct-push technologies. In addition, direct-push samplers sometimes have difficulty collecting soil gas samples in finer-grained units (relative to augured installations with a more significant volume of permeable backfill). Detailed lithologic logs and construction diagrams should be prepared for all well installations.

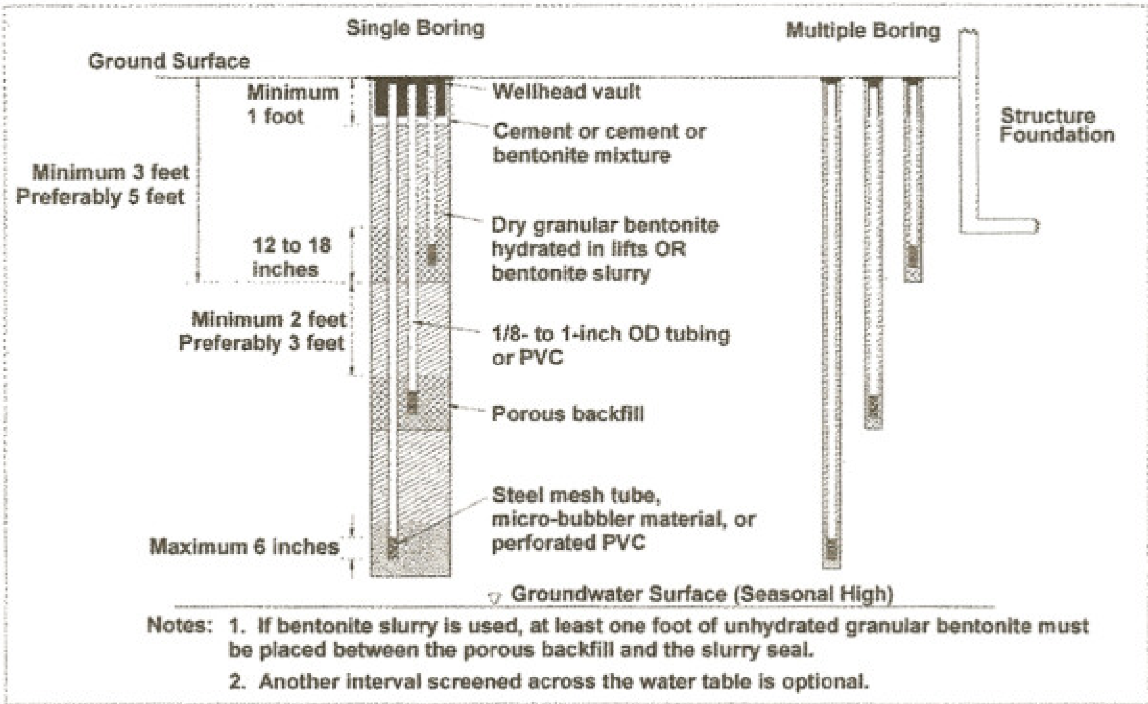
3.2.2 Soil samples

Soil samples should be collected and submitted for laboratory analysis for contaminants of concern (COC) from depths showing elevated field instrument readings or from just above the water table if no elevated readings are noted.

3.2.3 Sampling interval (screen length)

Unless installing a well designed to intersect the water table for groundwater sampling purposes, screen intervals of six inches or less should be used.

Figure 3. Soil Vapor Sampling Wells



3.2.4 Soil vapor well casing and sampling point materials

A vapor sampling well is generally comprised of a solid section of small diameter (1/8- to 1/2-inch) rigid, inert tubing (e.g., high-density polyethylene, nylon, stainless steel or Teflon®) that is connected to a sampling point through which the sampled vapor is drawn from the subsurface. Alternatively, PVC pipe up to one inch in diameter can be used for the soil vapor well casing, with a six-inch section of slotted screen at the target sampling depth. Soil vapor well casing diameters of less than one inch are advised to minimize the dead volume that must be purged prior to sampling. Sample tubing should be color coded, labeled, or cut to various lengths at the surface to clearly differentiate sample intervals.

When using rigid tubing, a variety of sampling points or tips can be used. These points can include 6-inch lengths of 1/8- to 1/2-inch diameter stainless steel mesh tubing, 1/4-inch diameter micro-bubbler material commonly used in fish tanks, or perforated, stainless-steel anchors placed by direct-push rods.

3.2.5 Sand or filter pack

A layer of the porous backfill (e.g., sand that is coarser grained that the native formation materials) should be added to the bottom of the borehole below the sampling screen and placed around the screen to create a sampling zone of 12- to 18-inches in length. The screen should be located in the middle of the interval of porous backfill.

3.2.6 Sampling interval seal

The borehole seal above the sand pack consists of granular bentonite installed by one of the following methods:

- At least one foot of dry granular bentonite should be placed on top of the sand pack to prevent bentonite slurry, which is placed on top of the dry granular bentonite, from infiltrating into the sand pack, or
- Dry granular bentonite can be placed in 6-inch lifts (layers) and hydrated following each lift. The initial lift above the sand pack must be at least 6 inches (preferably one foot) thick, with minimal water used for hydration so that hydration water does not infiltrate into the sand pack.

The bentonite seal should be a minimum of three feet (preferably five feet) thick to prevent ambient air infiltration to the sampling point. The boring can be filled with a clean backfill material (or bentonite) to approximately (but no less than) one foot from the ground surface.

3.2.7 Protective surface seal

A protective surface seal (cement or a cement/bentonite mixture) should be set around the top of the well tubing to prevent infiltration of water and ambient air into the completed borehole. It is recommended that the surface seal is at least one foot thick and extends horizontally from the vapor well for a distance of at least six inches in all directions.

3.2.8 Vapor-tight connections in the sampling apparatus

When using the preferred rigid nylon tubing, leakage is less likely if self-sealing, quick-connect, brass or stainless steel, threaded or compression fittings are used as opposed to barbed fittings. If barbed fittings are used, some other means of ensuring a leak-proof cap to the tubing is required.

3.2.9 Locking vault

Install a locking utility vault or meter box with ventilation holes to prevent accidental damage or vandalism. If the completion is not flush with the ground surface, consider installing guard posts or bollards to protect the well.

3.3 Single Event Sampling

Temporary wells may be acceptable with prior approval from OPS. In general, a temporary soil vapor well is installed by driving the direct-push rod to a predetermined depth and then pulling it back to expose the inlets of the perforated tip of the vapor well, usually made of stainless steel. After sample collection, both the drive rod and tubing are removed and the hole is properly abandoned. For shallow depths (3-5 feet) and finer grained soils which do not readily collapse around the driving rod, the wells should be carefully installed with minimal lateral movement to prevent leakage of ambient air down along the outside of the well. In addition, hydrated granular bentonite or bentonite slurry should be used to seal around the drive rod at the ground surface, and a rubber seal should be placed between the sample tubing and the inside wall of the rod to further prevent ambient air intrusion from occurring.

4.0 Soil Vapor Sampling Methodology

Refer to the Checklist included in Appendix A to assure that the vapor intrusion pathway is adequately evaluated and that proper sampling procedures are followed. OPS requires that the following practices be followed in association with soil vapor sampling.

4.1 Subsurface Equilibration

During well installation, subsurface conditions are disturbed to varying degrees depending upon the installation method. Therefore, prior to sampling, allow subsurface conditions to equilibrate. Otherwise, the soil gas samples may not be representative of subsurface conditions. For wells installed by direct-push methods, sampling should not occur for at least 20-30 minutes after well installation. If utilities are nearby and it is necessary to clear a borehole by a method that disturbs the soil gas, such as with an air knife or hydro-knife, or if wells are installed using hollow-stem drilling methods, sampling should not be performed on the same day as well installation.

4.2 Feasibility Testing

After the vapor well has been installed, testing should be performed to determine if a representative soil vapor sample can be collected. Excessive vacuum may cause the transfer of sorbed contaminants into the vapor phase or a breach in the bentonite seal which would allow ambient air to infiltrate into the sample. Feasibility testing can be accomplished by applying a vacuum to the vapor well using a 20-100 cubic centimeter (cc) syringe connected to the end of the sampling tubing and pulling the syringe's plunger. If the plunger does not hold its position, collection of a soil vapor sample at that location is not feasible. In this case, a new well may need to be installed at a different depth or location.

4.3 Leak Testing

Leakage during soil vapor sampling may dilute samples with ambient air and produce results that underestimate actual site concentrations. Therefore, leak testing must be performed to determine whether leakage is occurring. Leak testing is crucial for identifying leaks from the surface to the shallow soil vapor sample interval or around the sample train (fittings, etc.). With deeper sampling intervals, it is unlikely that surface air will be drawn down the full depth of the well to the sampling interval.

During the initial stages of a soil vapor sampling program, leak testing should be conducted at each of the sampling wells. When using permanent soil vapor wells as part of a long-term monitoring program, annual testing of well integrity is recommended. If leakage is confirmed and the problem cannot be corrected by enhancing the annular seal, the soil vapor well should be properly abandoned, and a replacement well should be installed at least five feet from the decommissioned well. Discussion regarding liquid and gas tracers is included in the following sub-sections.

4.3.1 Gas Tracers

Gas tracers can be used for leak testing by enriching the atmosphere in the area where the well intersects the ground surface with helium, difluoroethane, or sulfur hexafluoride. Difluoroethane (a component of air dusters) is widely used as a leak detection chemical and is much less expensive than sulfur hexafluoride. Place a shroud (e.g., plastic pail, cardboard box, or a garbage bag) over the area to keep the tracer in contact with the well. Purge the sample point using a sampling pump or a syringe.

Helium or sulfur hexafluoride is preferred by many professionals as a tracer gas because you can utilize a portable monitoring device to measure their concentrations. However, because of the small molecular size of helium, it may permeate sampling materials and be detected in the sample at low concentrations. One disadvantage of using difluoroethane is that it must be analyzed by a laboratory.

One should measure a vapor sample from the well for the presence of the tracer gas before and after sampling for the chemicals of concern. If measured concentrations in the sample exceed 10% of the concentration under the shroud, the well seal should be enhanced to reduce infiltration of ambient air prior to collecting analytical sample.

4.3.2 Liquid Tracers

An alternative method of leak testing is to use a liquid tracer by applying the liquid to a clean towel wrapped around the sample tubing and fittings at the surface of a well. This method is particularly well suited for sampling temporary soil vapor points (sampling through probe rod) since it can be applied where the rod meets the ground surface and at the top of the rod. Common liquid tracers include isopropyl alcohol and butane (found in shaving cream). If the tracer is detected at a high concentrations (i.e., >100 µg/L) in the soil vapor sample, it is likely that there is a leak.

Liquid tracers, while easier to use than gas tracers, may leave residue on the sampling apparatus and must be analyzed in the laboratory. If the tracer will be analyzed in the laboratory (i.e. difluorethane, isopropanol, and butane), these compounds must be included in the list of analytes reported by the laboratory.

4.4 Purging

To ensure that ambient or stagnant air is removed from the sampling system and samples collected are representative of subsurface conditions, purging must be performed.

4.4.1 Purging equipment

Purging equipment may consist of an electric- or hand-powered vacuum pump, syringe, or a peristaltic pump. All equipment, including associated valves and fittings, should be checked for leaks before purging the sampling system.

4.4.2 Purge volume

Purging requires the removal of at least three sample tubing volumes. Before purging, calculate the purge volume (or "dead space volume") based on the length and diameter of the sampling tubing and the connected sampling tubing and equipment. Do not include the volumes of the syringe and sample container (e.g., Tedlar® bags, summa canisters) when calculating purge volume. You can assume the following approximate quantities to calculate three purge volumes:

- 5 cc per linear foot of 1/8-inch diameter tubing
- 20 cc per linear foot of 1/4-inch diameter tubing
- 40 cc per linear foot for 1/2-inch diameter tubing (sch 40 PVC)
- 85 cc per linear foot for 3/4-inch diameter tubing (sch 40 PVC)
- 310 cc per linear foot for 1-inch diameter tubing (sch 40 PVC)

If sampling must be performed within 48 hours of well installation using a hollow-stem auger, approximately two to three dead volumes of the sand pack should also be purged prior to collecting a sample. In order to minimize surface leakage, excessive purging should be avoided for collection of near surface samples (e.g., less than 5 feet).

4.4.3 Flow rates

Flow rates for purging (as well as sampling) should generally not exceed 0.2 liters per minute (L/min) to minimize air infiltration (short-circuiting) and to limit stripping or partitioning of chemicals of concern from soil. However, a recent study has indicated that no significant difference was detected in soil vapor concentrations for flow rates ranging from 0.1 L/min to 100 L/min in relatively coarse-grained soils.

4.5 Additional Required Measurements

OPS requires the field measurement or laboratory analysis of oxygen and carbon dioxide during the sampling procedure. This data can assist in determining the soil vapor profile at the site and in assessing data quality of the samples (consistency across purge volumes). In general, carbon dioxide concentrations increase with depth while oxygen concentrations decrease with depth and approach zero directly above the soil or groundwater source. Analysis for methane is required in situations where light non-aqueous phase liquid (LNAPL) is present or oxygen content is less than 10%; otherwise, it is optional. High concentrations of total petroleum hydrocarbons in vapor may require the use of a filter on the analyzer sampling probe to allow for accurate measurement of methane concentrations. These additional required measurements are summarized in Table 2.

Oxygen, carbon dioxide, and methane data can also indicate that biodegradation is occurring and, if so, what type of biodegradation (aerobic or anaerobic). Besides indicating biodegradation, a decrease in oxygen concentration may also be partially due to background oxygen demand (e.g. in soils with high natural organic matter). Background oxygen demand can be assessed in areas with no contamination.

When aerobic biodegradation results in the depletion of oxygen from soil gas, an equivalent amount of carbon dioxide should be generated, resulting in the sum of oxygen and carbon dioxide concentrations being approximately 21% (i.e., atmospheric oxygen concentration). Soil gas analytical results where the sum of oxygen and carbon dioxide is less than 18% may suggest sample collection or analysis problems. However, under anaerobic conditions, high levels of methane may be generated, potentially displacing other gasses. High concentrations of carbon dioxide are also typically present under anaerobic conditions.

Table 2. Additional Required Measurements

Compound	Required by OPS?	Field Instrument	Laboratory Analytical Method	General Trend
Oxygen	Yes	Field meter w/ electrochemical cell	3810M/D1946	Usual decrease closer to source
Carbon Dioxide	Yes	Field meter w/ infrared analyzer	3810M/D1946	Usual increase closer to source
Methane	Yes*	Field meter	3810M/D1946	Possible increase closer to source

*Only required if LNAPL is present or O_2 is <10%

4.6 Other Measurements

Radon gas is present in all soils. Therefore, radon data can be useful in assessing the potential for vapor intrusion in a given structure. However, OPS does not require the analysis of indoor air samples for radon as part of a hydrocarbon vapor intrusion investigation.

OPS does not require measurement of the air pressure differential between the interior of a structure and beneath the foundation slab. However, doing so may help determine whether or not "barometric pumping" is occurring. This measurement can be performed by utilizing pressure transducers. If a significantly higher pressure exists in the sub-slab compared to the interior of the building, the potential exists for vapors to be drawn into the structure by advection due to the lower air pressure inside compared to outside the structure.

4.7 Sample collection and sample containers

Use fresh tubing between the soil vapor sampling tubing and the sample container at each sampling location. Sample containers chosen for a specific site will depend on site conditions, sample depth, and analytical requirements (see Section 7.0). OPS recommends that soil vapor samples be collected in a 1-liter summa canister, 400cc mini-can, or glass bulb if the sample will be shipped. If the samples will be analyzed at a local laboratory, samples may be collected in a Tedlar® bag or canister. Tedlar® bag samples are generally not considered reliable if more than 48 hours have passed since sample collection. If analyses will be performed onsite, collection into a syringe or Tedlar® bag is acceptable. Sample containers with volumes greater than 1-liter should be avoided for collection of near surface samples (e.g., less than 5 feet bgs). Section 7.0 includes information on sample containers and associated holding times.

Regardless of which sample collection device is used, the soil vapor well must be appropriately purged before collecting a vapor sample (see Section 4.4 above). When using 1-liter summa canisters, 400 cc mini-cans, or any container under vacuum, the container is connected to the tubing from the soil vapor well and then the container is opened. A syringe, a vacuum box with Tedlar® bags, or a peristaltic pump may also be used to obtain vapor samples. The use of other types of pumps that do not have dedicated tubing is discouraged, due to probable cross-contamination of the collected sample. A glass bulb with a pit-cock on both ends to seal the bulb after sample collection can also be utilized for vapor sample collection. The tubing from the soil vapor well is connected to one end of the bulb, and the other end of the bulb is connected to tubing from a vacuum pump which draws the sample into the glass bulb. When using the sample containers discussed above, always follow the instructions provided by the manufacturer.

4.8 Sample shipment

Soil vapor samples should not be chilled during sample shipping to a laboratory because the volatiles may condense out of the vapor phase at the lower temperature. Tedlar® bags should not be shipped due to pressure differentials (causing the bag to explode or deflate) and the potential for diffusion through the bag wall, puncturing of the bag, or valve leakage. Exposure of the Tedlar® bag sample to direct sunlight or excessive heat should be minimized.

5.0 Sub-Slab Soil Vapor Well Construction and Sampling

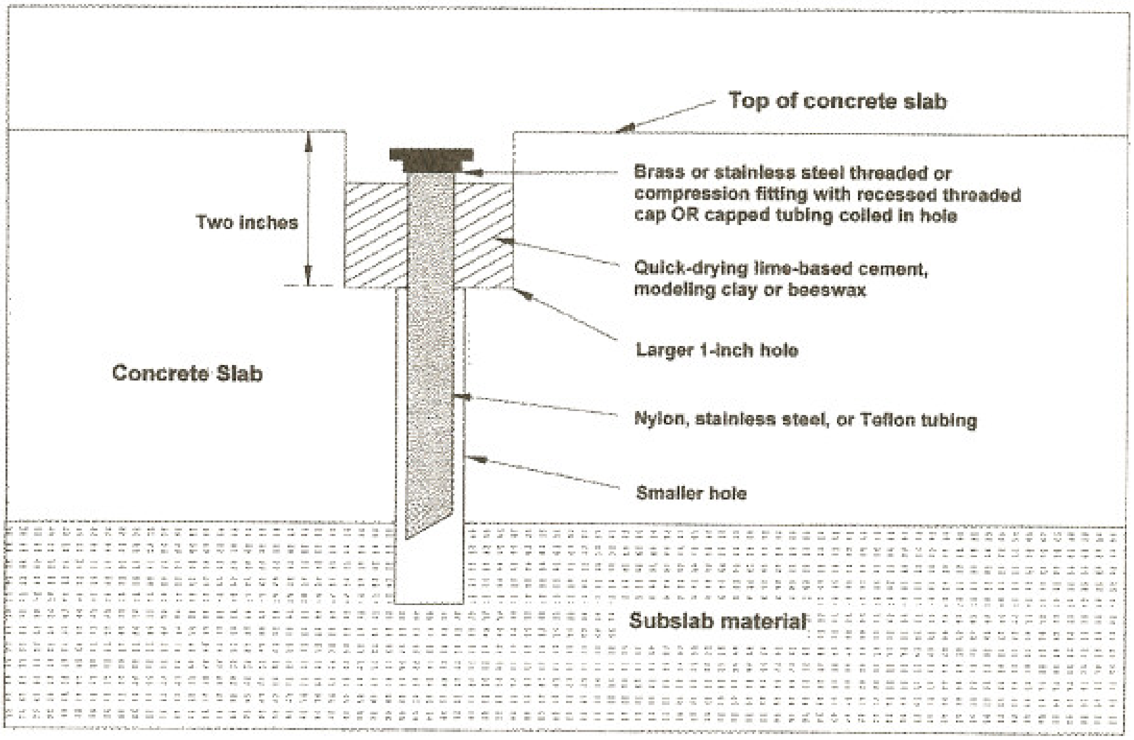
If a structure is located directly over a source of contamination, vapor samples should be collected immediately below the structure's foundation slab. The installation and sampling of a sub-slab soil vapor sampling point can determine whether vapors are present beneath the structure slab that could be drawn into the indoor air by advection. However, sub-slab vapor sampling may not be possible because of its intrusive nature and related access issues.

Methods of construction of a sub-slab sampling point are similar to those described for vapor wells in Section 3.0 of this document (Soil Vapor Well Construction), although the sampling point is installed through the structure's slab and extends only into the engineered fill directly beneath the foundation. A schematic of a sub-slab sample point is shown in Figure 4. Key components in sub-slab sample point installation and special considerations for sub-slab sampling are listed below.

5.1 Sub-slab well location

Sample points should be installed in central locations away from foundation footings and utilities. For a typical single-family residence, the installation and sampling of one sub-slab vapor point should be adequate to evaluate sub-slab conditions.

Figure 4. Sub-slab Soil Vapor Sampling Well



5.2 Sample point construction

Water should not be used when drilling through the concrete slab. If dust prevention is necessary when drilling through the slab, cover the location with a towel and drill through a pre-cut hole in the cloth. If a flush or recessed surface termination with a permanent point is required, a 1-inch diameter hole in the upper two inches of the slab will leave space for installation of a brass or stainless steel threaded or compression fitting. A hole slightly larger than the sample tubing is then drilled in the center of the 1-inch hole. Cut tubing (nylon, stainless steel, or Teflon®) to an appropriate length to reach the base of the slab. Sand can be added to fill the void in the sub-slab material to the base of the sample tubing and, if necessary, in the void between the sample tubing and small hole. A quick-drying, lime-based cement may be placed within the 1-inch hole (and on top of the sand, if present) to seal the well. As an alternative, modeling clay or beeswax may be placed above the sandpack to form an air-tight seal.

5.3 Leak testing

Leak testing should be conducted during purging as described in Section 4.3 of this document. If cement is used to seal the well, be sure that the cement is allowed to dry and set up before testing the wellhead for leaks.

5.4 Purging

If cement was used to seal the sub-slab installation, wait an adequate amount of time for the seal to set up before purging the sample point. If clay or beeswax is used to seal the installation, the sample point can be purged and sampled immediately after construction. The purge volume should include the total internal volume of all sampling tubing and fittings, the open hole in the slab below the tubing, and the cavity created in the sub-slab material during drilling. Refer to Section 4.4 for information on purging equipment, purge volumes, and vacuum and flow rates.

5.5 Sample collection

If the sample will be submitted for laboratory analysis, it should be collected using a 1-liter summa canister, 400cc mini-can, glass vial, Tedlar® bag, or an equivalent collection vessel. For onsite analysis, a syringe may be used for sample collection. Refer to Section 4.7 of this document for sampling procedures.

5.6 Sample shipment

Refer to Section 4.8 for information on shipping samples. Always follow laboratory instructions for sample shipping of canisters or other collection vessels.

5.7 Additional considerations

Sub-slab samples should be avoided in areas where groundwater might intersect the slab. Also, if a vapor barrier exists under the slab, a sub-slab sample point should not be installed, since doing so might result in damage to the barrier.

6.0 Indoor Air Evaluation and Sampling

In the event that the soil vapor and/or groundwater concentrations are greater than the appropriate RBSLs, or if other conditions (such as the presence of hydrocarbon odors) suggest that vapor intrusion is occurring, OPS will require a site-specific indoor air evaluation. This evaluation will include the following components.

6.1 Site visit

A site visit should be conducted to confirm the location, use, and occupancy of all potentially impacted structures.

6.2 Building Survey

Before performing an indoor air sampling event, a survey of all potentially impacted structures, including interviews with the occupants, owners, and landlords (if applicable) must be conducted and must include gathering information on the following topics:

- Type of building construction
- Foundation characteristics
- HVAC system layout
- Potential indoor sources of contaminant vapor
- Inventory of household chemical products
- Water and sewage systems; utility corridors leading to the structure; types of drains, etc.
- Locations of sub-slab utilities in the event that sub-slab sampling is necessary

An example of a building survey form which covers the above topics is included in Appendix B.

In addition, a walkthrough of all potentially impacted structures should be conducted to identify potential "background" sources, eliminate them, and educate the occupants on those activities that should be avoided immediately before and during the sample collection. It is extremely important to identify all consumer products, household cleaners, supplies used for personal hobbies, or building supplies that may be used in the structures, many of which contain volatile chemicals. If practical, all background sources (or at least gas tanks, lawn mowers and vehicles) should be removed from the structures and attached garages prior to indoor air sampling. If applicable, these products should not be used inside the buildings within 24 hours of the sampling event or, depending on the impacts to carpeting, drapes, etc., within two weeks of the sampling event. The occurrence of smoking (a source of benzene) in the building should clearly be noted during the interview. Although not comprehensive, the National Institutes of Health Household Products Database (http://householdproducts.nlm.nih.gov/) contains information on common household products that cause measurable levels of volatile chemicals in indoor air.

6.3 Indoor air sampling

If information from the building survey indicates that indoor air sampling will provide an accurate assessment of vapor intrusion, indoor air sampling must be conducted. The sampling protocol is described below.

6.3.1 Access agreement

Because of the intrusive nature of indoor air sampling, it is always necessary to execute an access agreement for each structure before proceeding with the sampling.

6.3.2 Sample container

Because of the low detection limits required for indoor air samples, a summa canister is the preferred sample container for laboratory analysis. If real-time onsite analyses will be conducted, other sample containers could include gas-tight glass or stainless steel vials, syringes, or glass-lined canisters (other than summa canister).

6.3.3 Sample locations

The sample canisters should be placed in the occupied living areas and the basement. Canisters should be placed in the breathing zone, usually 3-5 feet off the floor, and in high use areas. If small children occupy a particular area or room within the structure, a sample canister should be placed on the floor. If there is concern for damage or disturbance of the canister in high use areas, the canister may be moved from these areas but away from doors, windows, and vents. For multi-storied residential buildings, one sample should be collected in the basement level or first floor (if slab-on-grade construction). Crawl spaces that are not ventilated can be sampled to determine if contaminant vapors are present that could potentially impact indoor air.

6.3.4 Sample collection period

Residential indoor air samples are typically collected over a 24-hour period. However, in certain situations (e.g., commercial or industrial settings), it may be more appropriate to sample over an 8-hour period. During the sampling period, exterior doors and windows should generally be kept closed. Heating/ventilation/air conditioning (HVAC) systems should be operated normally to be representative of actual living conditions. HVAC operation should be noted and considered when evaluating whether additional tests are required (e.g. during different seasons). Indoor air concentrations due to vapor intrusion will vary over time and are likely to be (but not necessarily) higher during winter season.

6.3.5 Ambient air sampling

An outdoor ambient sample must be collected simultaneously with the indoor air samples to provide a baseline against which the indoor air sample concentrations can be compared. Outdoor ambient air samples should be collected from a representative location, preferably upwind and away from any wind obstructions such as trees or buildings.

6.3.6 Background air sampling

In some situations, it may be necessary to collect background indoor air samples. Such samples should be collected inside a non-impacted structure located away from the contaminant plume that is similar in construction to the structure where indoor air is being evaluated. OPS does not have an RBSL for indoor air. However, OPS does consider benzene concentrations that are greater than background levels to be an indicator of possible vapor intrusion.

6.3.7 Additional measurements

As stated in Section 4.6, radon and/or air pressure may be measured for comparison with sub-slab measurements to assist in the determination of the presence of vapor intrusion.

6.3.8 Sample shipment

Refer to Section 4.8 for information on shipping samples. Always follow laboratory instructions for shipping of sample canisters.

7.0 Laboratory Analysis

OPS requires that all soil vapor, sub-slab vapor, and indoor air samples be analyzed for BTEX. Several analytical methods are available to measure soil gas samples, all of which can give accurate results when followed with appropriate Quality Assurance and Quality Control (QA/QC) measures. Table 3 includes laboratory methods and associated collection methods for analysis of petroleum-based contaminants and other analytes in soil vapor and indoor air samples.

Table 3. Soil Vapor and Indoor Air Analytical Methods

Analytes	Method Reference	Description	Sample Container	Container Holding Time	Detection Limit
Soil Vapor Sample Analysis					
BTEX	8021B [1,2]	GC/PID analysis	G, MC, SC	30 days	10-100 µg/m³
			T	48 hours	
			SY	Onsite analysis	
BTEX	8260B [1,2]	GC/MS analysis	G, MC, SC	30 days	50-200 µg/m³
			T	48 hours	
			SY	Onsite analysis	
BTEX	TO-1	Tenax® adsorption, GC/FID, although sometimes equipped with GC/MS analysis	SC	30 days	1-3 µg/m³
			T	48 hours	
BTEX	TO-3	Cryogenic pre-concentration, GC/FID analysis	SC	30 days	1-3 µg/m³
			T	48 hours	
			T	48 hours	
Sub-slab Vapor and Indoor Air Sample Analysis					
BTEX	TO-15 [1]	GC/MS analysis	SC	30 days	1-3 µg/m³
BTEX	TO-14A	GC/FID/ECD or GC/MS analysis	SC	30 days	1-3 µg/m³
BTEX	TO-15 SIM	GC/MS (SIM mode) analysis (5 to 10 compound subset of TO-15)	SC	30 days	0.1-0.5 µg/m³
BTEX	TO-17	Air pump drawing air through adsorbent tube, thermal desorption & GC/MS with FID analysis	AT	30 days	1-3 µg/m³

1 - OPS preferred method
2 - Must be calibrated with a vapor standard

T = Tedlar Bag SC = Summa canister G = glass bulb SY = Syringe
MC = stainless steel vial (400 ml mini-can) AT = Multi-bed adsorbent tube

Note: Detection limits listed in Table 3 are realistic or practical detection limits, which are dependent upon sample volume.

There are several websites that provide a wide range of unit conversions. Listed below are useful conversions for commonly reported laboratory units to the OPS-required unit of µg/m³ for soil vapor and indoor air analytical results.

Parts per billion by volume (ppbv) x 3.25 = µg/m³ (for benzene only)
Parts per million by volume (ppmv) x 3,250 = µg/m³ (for benzene only)
Micrograms per liter (µg/L) x 1,000 = µg/m³
Milligrams per liter (mg/L) x 1,000,000 = µg/m³
Milligrams per cubic meter (mg/m³) x 1,000 = µg/m³

For any compound, the conversion of ppbv to μg/m³ is obtained by use of the Ideal Gas Law as follows:

$$C(ppbv)\frac{MW_v Pv}{1000RT} = C\left(\frac{\mu g}{m^3}\right)$$

Where: MW_v = molecular weight (g/mole)

Pv = vapor pressure (atm)

T = temperature (°K)

R = the universal gas constant (8.204E-05 atm m³/°K mole)

8.0 Data Validation

The following equations can be used to estimate the maximum benzene concentration expected in soil vapor ($C_{max,vapor}$) adjacent to dissolved contamination in groundwater or free-product (light non-aqueous phase liquid [LNAPL]). If benzene concentrations in soil vapor are significantly higher than the estimated maximum concentrations, the data should be further evaluated for potential errors or unknown source(s).

Expected maximum benzene in soil vapor ($C_{max,vapor}$) adjacent to **contaminated groundwater**:

$$C_{max\ vapor}\left(\frac{ug}{m^3}\right) = H * C_{max\ GW}\left(\frac{ug}{L}\right)\left(\frac{L}{10^3 ml}\right)\left(\frac{ml}{cm^3}\right)\left(\frac{10^6 cm^3}{m^3}\right)$$

Where: H = Henry's Constant for benzene = 0.23 (dimensionless)

$C_{max,GW}$ = maximum benzene concentration in groundwater

For example, a concentration of 100 μg/L benzene in groundwater could yield a benzene soil vapor concentration of:

$$C_{max\ vapor}\left(\frac{ug}{m^3}\right) = 0.23 * 100\left(\frac{ug}{L}\right) * 10^3 = 23{,}000\ \mu g/m^3$$

Expected maximum benzene in soil vapor ($C_{max,vapor}$) adjacent to **LNAPL**:

$$C_{max\ vapor}\left(\frac{ug}{m^3}\right) = NMF_{benzene} * \left(\frac{Pv(atm) * MW_{benzene}\left(\frac{g}{mole}\right) * 10^6\left(\frac{ug}{g}\right)}{R\left(\frac{atm - m^3}{mole - {}^\circ K}\right) T({}^\circ K)}\right) = 6.9E + 06$$

Where: Pv = vapor pressure of benzene = 0.1 atm

$MW_{benzene}$ = molecular weight of benzene = 78.1 g/mole

R = universal gas constant = 8.204E-05 atm m³/°K mole

T = Standard temperature = 298 °K

$NMF_{benzene}$ = estimated mole fraction of benzene in LNAPL = 0.02 (dimensionless)

$$NMF_{benzene} = \frac{(MF_{benzene} * MW_{benzene})}{MW_{LNAPL}}$$

Where:

$MF_{benzene}$ = mass fraction of benzene in LNAPL = 0.025 g/g
$MW_{benzene}$ = molecular weight of benzene = 78.1 g/mole
MW_{LNAPL} = molecular weight of LNAPL (all components) = 103 moles

9.0 Mitigation Measures

Remediation of petroleum hydrocarbon contamination sources in soil and groundwater is the most effective way to mitigate soil vapor intrusion into indoor air. If source remediation (i.e. soil excavation, soil vapor extraction, etc.) does not immediately mitigate the vapor intrusion problem, additional mitigation methodologies must be implemented. As in the case of petroleum hydrocarbon source remediation systems, it is also necessary in vapor mitigation systems to include intrinsically safe equipment when potentially explosive situations are present. An example of this situation is when LNAPL is very close to the building and vapor concentrations exceed 10% of the Lower Explosive Limit (LEL).

Below are selected references associated with indoor air mitigation. Since most vapor intrusion mitigation design has been based on radon control systems, many of the references below pertain to the control of radon.

9.1 Existing buildings

Passive or active venting systems, and sub-slab depressurization and pressurization systems.

References:

Massachusetts DEP. 1995. *Guidelines for the Design, Installation, and Operation of Sub-slab Depressurization Systems.*

New Jersey Dept of Environmental Protection. 2005. *Vapor Intrusion Guidance.* www.state.nj.us/dep/srp/guidance/vaporintrusion/vig.htm

USEPA. 1991. *Sub-slab Depressurization Handbook for Low-permeability Fill Material* (for home radon reduction). EPA /625/6-91/029.

USEPA. 1993. *Radon Reduction Techniques for Existing Detached Houses, technical guidance for active soil depressurization systems*. EPA 625/R-93/011.

USEPA. Revised April 1994. *Radon Mitigation Standards*. EPA 402-R-93-078. Accessible at http://www.epa.gov/iaq/radon/pubs/index.html

USEPA. Revised February 2003. *A Consumer's Guide to Radon Reduction.* EPA 402-K-03-002. Accessible at http://www.epa.gov/iaq/radon/pubs/index.html

9.2 Future buildings

Passive and active venting systems using gas barrier/membrane technology.

References:

ASTM. 1992. *Radon Control Options for the Design and Construction of New Low-Rise Residential Buildings.* ASTM Standard Guide, E14655-92.

USEPA. March 1994. *Model Standards and Techniques for Control of Radon in New Residential Buildings*. EPA 402-R-94-009. Air and Radiation (6604-J). Accessible at http://www.epa.gov/iaq/radon/pubs/newconst.html

USEPA. January 1993. *Radon Prevention in the Design and Construction of Schools and Other Large Buildings.* Office of Research and Development. EPA 625-R-92-016.

USEPA. May 1995. *Passive Radon Control System for New Construction.* Indoor Environmental Division, Office of Radiation and Indoor Air. EPA 402-95012.

Also, the Interstate Technology and Regulatory Council (ITRC) published a document in January 2007 titled "Vapor Intrusion Pathway: A Practical Guide". The ITRC document can be found at (http://www.itrcweb.org/teamresources_vapor.asp). This reference provides valuable information on the topic of vapor intrusion mitigation. An extensive list of references covering most issues related to vapor intrusion is included in this document.

Appendix A
Soil Vapor and Indoor Air Sampling Checklist

SOIL VAPOR AND INDOOR AIR SAMPLING CHECKLIST

RECEIVED
MAY 19 2010
COGCC

Vapor Well Location			Response	Comment
Is the contaminant volatile?			Yes	
			No	
Are there occupied structures within the influence of the plume which do not dispense petroleum products?			Yes	
			No	
What is the construction of the structure?			Slab-on-grade	
			Basement	
			Crawlspace	
What is the use of the structure?			Commercial	
			Residential SFH	
			Residential MFH	
			School/daycare	
			Other	
Is a nested vapor point located within the source?			Yes	
			No	
Are nested vapor point(s) planned or located at all qualifying structures within the influence of the plume?			Yes	
			No	
Are sub-slab vapor points planned or located in any structure?			Yes	
			No	
Permanent Vapor Well Installation			**Response**	**Comment**
Soil vapor well installation method.			Direct push	
			HSA	
			Hand auger	
			Other	
Was a soil sample collected from the well boring?			Yes	
			No	
At what depth was the soil sample collected?				
What material was used to construct the sample collection point?			Steel mesh	
			Micro-bubbler	
			Perforated stainless steel	
			Other	
What material was used to connect the well sample collection point to the surface?			Stainless steel	
			Nylon	
			Teflon	
			PVC	
			Other	
What is the diameter of the soil vapor sample point?				
What is the screened interval of each sample port?	Shallow			
	Intermediate			
	Deep			
Is the depths of nested sample collection points clearly identified on each tube?			Yes	
Was is the depth interval of the porous backfill? (12 to 18 inches thick)	Shallow			
	Intermediate			
	Deep			
What is the depth interval of the annular seal? (minimum 2 feet & preferably 3 feet thick)	Shallow			
	Intermediate			
	Deep			
What is the material of the annular seal?			Granular bentonite	
			Bentonite slurry	
			Other	

If the well is a subslab well, what is the material of the annular seal?	Cement	
	Modeling clay	
	beeswax	
What is the material of the protective seal at the surface?	Cement	
	Native soil	
	Other	
What is the thickness of the protective seal? (min 1 foot)		
Were vapor tight connections applied to sampling ports?	Yes	
Was a protective vault installed at ground surface?	Yes	
	No	
Soil Vapor Sample Collection	**Response**	**Comment**
Did it rain shortly before the sampling event?	Yes	
	No	
Was a sampling feasibility test conducted?	Yes	
	No	
Was leak testing conducted prior to sampling?	Yes	
	No	
What was the leak testing tracer chemical used?	Helium	
	difluoroethane	
	sulfur hexafluoride	
	Other	
What method was used to purge well?	Electric pump	
	Peristaltic pump	
	Hand pump	
	Syringe	
	Other	
Was the flow rate for purging and sampling ≤ 0.2 L/min?	Yes	
	No	
Were at least three dead volumes of the well purged?	Yes	
	No	
Sample collection container	Summa canister	
	Tedlar bag	
	Syringe	
	Glass bulb	
	Other	
Were O_2 and CO_2 measurements collected?	Yes	
	No	
Was methane measured? (O^2 < 10% or LNAPL present)	Yes	
	No	
What method was used to analyze for BTEX/TVPH	8021B	
	8260B	
	TO-1	
	TO-3	
	TO-15 (subslab)	
	TO-17 (subslab)	
	18M	
	Other	

Indoor Air Sampling		Response	Comment
Is the indoor air sampling location in an occupied structure within the influence of the plume that does not dispense petroleum products?		Yes	
		No	
Was an access agreement executed with the building occupant(s)?		Yes	
		No	
Was the OPS Indoor Air Quality Building Survey form completed prior to sampling?		Yes	
		No	
Location and number of indoor living areas where an indoor air sample was collected?		Main floor	
		Upper floor	
		Basement	
		Crawlspace	
		Other	
What was the sample collection period for the summa canister?		Instantaneous	
		8 hours	
		24 hours	
		Other	
What method was used to analyze for BTEX/TVPH?		TO-14A	
		TO-15	
		TO-15 SIM	
		TO-17	
		18M	
		Other	
Was an ambient air sample collected from a location outside the structure?		Yes	
		No	

Acronyms:
SFH = single family home
MFH = multi-family home
HSA - hollow-stem auger

Appendix B
Building Survey Form

RECEIVED
MAY 1 9 2010
COGCC

RECEIVED
MAY 19 2010
COGCC

COLORADO DIVISION OF OIL AND PUBLIC SAFETY
INDOOR AIR QUALITY BUILDING SURVEY FORM

This form must be completed for each residence involved in indoor air testing.

Based on the New York State Department of Health's Guidance for Evaluating Vapor Intrusion (2005)

Preparer's Name Holli Merchant Date/Time Prepared 3/17/2010 2:30 p.m
Preparer's Affiliation EHS Documents Inc Phone No. 303-986-1067
Purpose of Investigation Indoor Air Quality Survey

1. OCCUPANT:

Interviewed: (Y)/N
Last Name: Hartsock First Name: Ellen
Address: 2322 Quay St. Evans, CO
County: weld
Cell ~~Home~~ Phone: 720-339-6432 Office Phone: ________
Number of Occupants/persons at this location 1 Age of Occupants 27

2. OWNER OR LANDLORD: (Check if same as occupant ___)

Interviewed: Y (N)
Last Name: Norton First Name: Byron & Carol
Address: 2160 45th Ave, Greeley, CO 80634
County: weld
Home Phone: 970-330-2581 Office Phone: ________

3. BUILDING CHARACTERISTICS

Type of Building: (Check appropriate response)

- [x] Residential
- [ ] School
- [ ] Commercial/Multi-use
- [ ] Industrial
- [ ] Church
- [ ] Other: ________

If the property is residential, type? (Check appropriate response)

- [ ] Ranch
- [ ] Multi-family
- [ ] Raised Ranch
- [ ] Split Level
- [ ] Colonial
- [ ] Cape Cod
- [ ] Contemporary
- [ ] Mobile Home
- [x] Duplex
- [ ] Apartment House
- [ ] Townhouses/Condos
- [ ] Modular
- [ ] Log Home
- [ ] Other: ________

If multiple units, how many? 2

If the property is commercial, type?

Business Type(s) ____________

Does it include residences (i.e., multi-use)? ☐ Yes ☐ No If yes, how many? ______

Other characteristics:

Number of floors 1 Building age 2002

Is the building insulated? ☒ Yes ☐ No

How air tight? ☐ Tight ☐ Average ☒ Not Tight

4. AIRFLOW

Use air current tubes or tracer smoke to evaluate airflow patterns and qualitatively describe airflow between floors, airflow near source, outdoor air infiltration, and infiltration into air ducts.

N/A

5. BASEMENT AND CONSTRUCTION CHARACTERISTICS

Check all that apply

a. Above grade construction:	☒ wood frame	☐ concrete	☐ stone	☐ brick
b. Basement type: ☐ full	☒ crawlspace	☐ slab	☐ other ______	
c. Basement floor: ☐ concrete	☒ dirt	☐ stone	☐ other ______	
d. Basement floor: ☒ uncovered	☐ covered	☐ covered with ______		
e. Concrete floor: ☐ unsealed	☐ sealed	☐ sealed with ______		
f. Foundation walls: ☒ poured	☐ block	☐ stone	☐ other ______	
g. Foundation walls: ☒ unsealed	☐ sealed	☐ sealed with ______		
h. The basement is: ☐ wet	☐ damp	☐ dry	☒ moldy	
i. The basement is: ☐ finished	☒ unfinished	☐ partially finished		
j. Sump present? ☒ Yes	☐ No			
k. Water in sump? ☒ Yes	☐ No	☐ Not applicable		

l. Basement/Lowest level depth below grade: ________ feet

Identify potential soil vapor entry points and approximate size (e.g., cracks, utility ports, drains)

e. Is a kerosene or non-vented gas space heater present? ☐ Yes ☒ No
Where? ______

f. Is there a workshop or hobby/craft area? ☒ Yes ☐ No MEK
Where & Type? Garage – glues, acetone, etc. (sealed containers)

g. Is there smoking in the building? ☐ Yes ☒ No
How frequently? ______

h. Have cleaning products been used recently? ☒ Yes ☐ No If yes, list on table in Sect 13

i. Have cosmetic products been used recently? ☐ Yes ☒ No If yes, list on table in Sect 13

j. Has painting/staining been done in the last 6 months? ☐ Yes ☐ No If yes, list on table in Sect 13 unknown

k. Is there new carpet, drapes or other textiles? ☐ Yes ☒ No If yes, list on table in Sect 13

l. Have air fresheners been used recently? ☒ Yes ☐ No If yes, list on table in Sect 13

m. Is there a kitchen exhaust fan? ☒ Yes ☐ No
If yes, where vented? out roof ?

n. Is there a bathroom exhaust fan? ☒ Yes ☐ No
If yes, where vented? unknown

o. Is there a clothes dryer? ☒ Yes ☐ No If yes, is it vented outside? ☒ Yes ☐ No

p. Has there been a pesticide application? ☐ Yes ☒ No
When & Type? ______

q. Are there odors in the building? ☒ Yes ☐ No
If yes, describe: mildew

r. Do any of the building occupants use solvents at work? ☐ Yes ☒ No
(e.g., chemical manufacturing or laboratory, auto mechanic or auto body shop, painting, fuel oil delivery, boiler mechanic, pesticide application, cosmetologist)
If yes, what types of solvents are used? ______
If yes, are their clothes washed at work? ☒ Yes ☒ No ~~[illegible]~~ MM

s. Do any of the building occupants regularly use or work at a dry-cleaning service?
☒ No
☐ Unknown
☒ Yes, use dry-cleaning regularly (weekly) uniform sly cleaned
☐ Yes, use dry-cleaning infrequently (monthly or less)
☐ Yes, work at a dry-cleaning service

t. Is there a radon mitigation system for the building/structure? ☐ Yes ☒ No
If yes, date of Installation: ______

u. Is the system active or passive? ☐ Active ☐ Passive

9. WATER AND SEWAGE

Water Supply:
☒ Public Water ☐ Drilled Well ☐ Driven Well ☐ Dug Well ☐ Other: ______

Sewage Disposal:
☒ Public Sewer ☐ Septic Tank ☐ Leach Field ☐ Dry Well ☐ Other: ______

10. RELOCATION INFORMATION

a. Provide reasons why relocation is recommended: ______

b. Residents choose to:
☐ remain in home ☐ relocate to friends/family ☐ relocate to hotel/motel

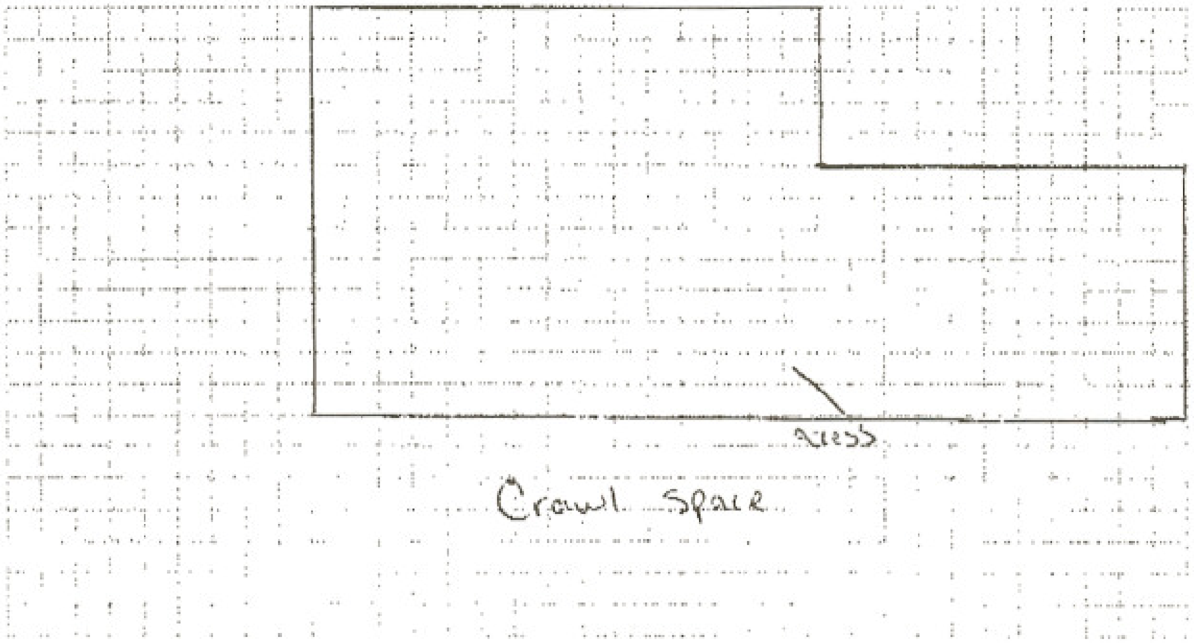
c. Responsibility for costs associated with reimbursement explained? ☐ Yes ☐ No

d. Relocation package provided and explained to residents? ☐ Yes ☐ No

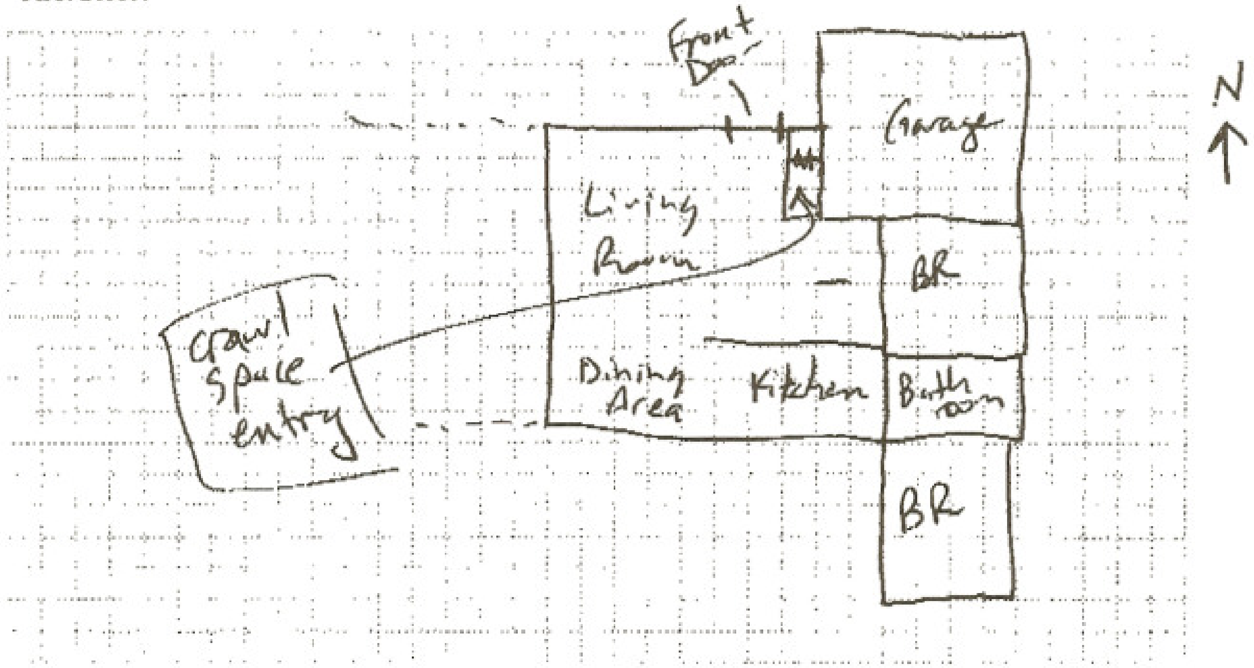
11. FLOOR PLANS

Draw a plan view sketch of the basement and first floor of the building. Indicate air sampling locations, possible indoor air pollution sources and PID meter readings. If the building does not have a basement, please note.

Basement:



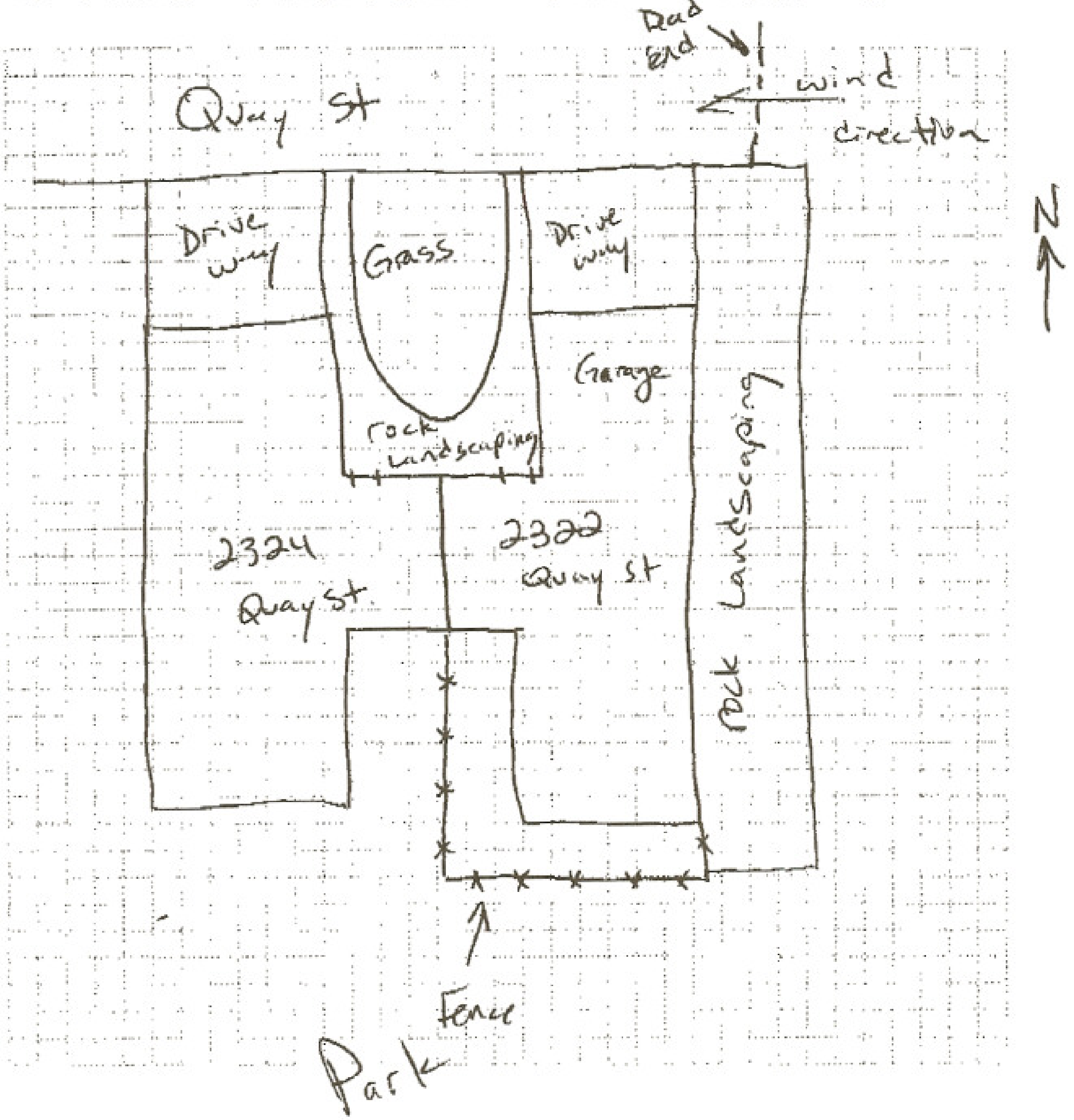
First Floor:



12. OUTDOOR PLOT

Draw a sketch of the area surrounding the building being sampled. If applicable, provide information on spill locations, potential air contamination sources (industries, gas stations, repair shops, landfills, etc.), outdoor air sampling location(s) and PID meter readings.

Also indicate compass direction, wind direction and speed during sampling, the locations of the well and septic system, if applicable, and a qualifying statement to help locate the site on a topographic map.



13. PRODUCT INVENTORY FORM

List specific products found in the residence that have the potential to affect indoor air quality.

Location	Product Description	Size (units)	Condition*	Chemical Ingredients	Photo ** Y / N
	Scrubbing Bubbles				
↑	white paint	2 gal	good U		
Garage	Roll on fly protectant	2oz	good U		
	wipe fly protectant	1qt	good U		
	windshield washer fluid	1.5 gal	good U		
	Anti freeze	1/2 gal	good U		
↓	STP Power Steering Fluid	32 oz	good U		
↑	Dow Corning 4-gel	5.3 oz	good U		
	Pneumatic tool oil	2 oz	good U		
Garage toolbox	LPS 2 lubricant	11 oz	good U		
	Lok-cease 20/20	11 oz	good U		
	Pliobond contact cement	1/2 pt	good U		
	Free	12 oz	good U		
	Aero Kroil	13 oz	good U		
	Loctite 567	1.7 oz	good U		
	Imron Activator	1qt	good U		
	Zepreserve NC	18 oz	good U		
↓	Acetone	8 oz	good U		

* Describe the condition of the product containers as Unopened (UO), Used (U), or Deteriorated (D)
** Photographs of the front and back of product containers can replace the handwritten list of chemical ingredients. However, the photographs must be of good quality and ingredient labels must be legible.

Over ↓

RECEIVED
MAY 19 2010
COGCC

Scrubbing Bubbles - 12 oz		good - U
" " Flushable wips		good - U
Lysol Toilet bowl cleaner	24 oz	good - U
Chlorox wipes	12 oz	good - U
Pledge	12 oz	good - U
Air freshener	9 oz	good - U
Spray n wash	30 oz	good - U
Carpet cleaner	60 oz	good - U
Laundry detergent Tide	150 oz	good - U
chlorox	1 gal	good - U
windex	26 oz	good - U
409	32 oz	good - U
Pine Sol	60 oz	good - U
Folex Spot remover	32 oz	good - U
Personal Touch cleaner	1 qt	good - U
Scrub Free Arm & Hammer	48 oz	good - U
Comet w/ Bleach	17 oz	good - U
Cameo Stainless Steel cleaner	14 oz	good - U

APPENDIX C

LABORATORY ANALYTICAL DATA

Air Toxics LTD.
Laboratory Services Since 1989

4/1/2010
Mr. Mike McKee
LT Environmental
4600 W. 60th Ave

Arvada CO 80003

RECEIVED
MAY 19 2010
COGCC

Project Name: KMG-WASS #5
Project #: KMG 08397
Workorder #: 1003540

Dear Mr. Mike McKee

The following report includes the data for the above referenced project for sample(s) received on 3/25/2010 at Air Toxics Ltd.

The data and associated QC analyzed by Modified TO-14A (5&20 ppbv) are compliant with the project requirements or laboratory criteria with the exception of the deviations noted in the attached case narrative.

Thank you for choosing Air Toxics Ltd. for your air analysis needs. Air Toxics Ltd. is committed to providing accurate data of the highest quality. Please feel free to contact the Project Manager: Kyle Vagadori at 916-985-1000 if you have any questions regarding the data in this report.

Regards,

Kyle Vagadori

Kyle Vagadori
Project Manager

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000 .FAX (916) 985-1020
Hours 6:30 A.M to 5:30 PST

Air Toxics LTD.
Laboratory Services Since 1989

WORK ORDER #: 1003540

Work Order Summary

CLIENT:	Mr. Mike McKee LT Environmental 4600 W. 60th Ave Arvada, CO 80003	**BILL TO:**	Mr. Mike McKee LT Environmental 4600 W. 60th Ave Arvada, CO 80003
PHONE:	303-433-9788	**P.O. #**	
FAX:	303-433-1432	**PROJECT #**	KMG 08397 KMG-WASS #5
DATE RECEIVED:	03/25/2010	**CONTACT:**	Kyle Vagadori
DATE COMPLETED:	03/31/2010		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	FINAL PRESSURE
01A	VP3@4.5'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
02A	VP1@4.5'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
02AA	VP1@4.5' Lab Duplicate	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
03A	VP4@3.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
04A	VP5@3.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
05A	VP5@6.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
06A	VP6@6.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
07A	VP2@4.5'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
08A	VP3@2.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
09A	VP2@2.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
10A	VP6@3.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
11A	VP4@6.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
12A	VP1@2.0'	Modified TO-14A (5&20 ppb	Tedlar Bag	Tedlar Bag
13A	Lab Blank	Modified TO-14A (5&20 ppb	NA	NA
13B	Lab Blank	Modified TO-14A (5&20 ppb	NA	NA
14A	CCV	Modified TO-14A (5&20 ppb	NA	NA
14B	CCV	Modified TO-14A (5&20 ppb	NA	NA

Continued on next page

Air Toxics LTD.
Laboratory Services Since 1989

WORK ORDER #: 1003540

Work Order Summary

CLIENT:	Mr. Mike McKee LT Environmental 4600 W. 60th Ave Arvada, CO 80003	**BILL TO:**	Mr. Mike McKee LT Environmental 4600 W. 60th Ave Arvada, CO 80003
PHONE:	303-433-9788	**P.O. #**	
FAX:	303-433-1432	**PROJECT #**	KMG 08397 KMG-WASS #5
DATE RECEIVED:	03/25/2010	**CONTACT:**	Kyle Vagadori
DATE COMPLETED:	03/31/2010		

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	FINAL PRESSURE
15A	LCS	Modified TO-14A (5&20 ppb	NA	NA
15B	LCS	Modified TO-14A (5&20 ppb	NA	NA

CERTIFIED BY: Linda L. Fruman DATE: 04/01/10

Laboratory Director

Certfication numbers: CA NELAP - 02110CA, LA NELAP/LELAP- AI 30763,
NY NELAP - 11291, UT NELAP - 9166389892, AZ Licensure AZ0719
Name of Accrediting Agency: NELAP/Florida Department of Health, Scope of Application: Clean Air Act,
Accreditation number: E87680, Effective date: 07/01/09, Expiration date: 06/30/10
Air Toxics Ltd. certifies that the test results contained in this report meet all requirements of the NELAC standards

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000 . (800) 985-5955 . FAX (916) 985-1020

LABORATORY NARRATIVE
Modified TO-14A Soil Gas
LT Environmental
Workorder# 1003540

Twelve 1 Liter Tedlar Bag samples were received on March 25, 2010. The laboratory performed analysis via modified EPA Method TO-14A using GC/MS in the full scan mode. The method involves concentrating up to 50 mLs of air. The concentrated aliquot is then flash vaporized and swept through a water management system to remove water vapor. Following dehumidification, the sample passes directly into the GC/MS for analysis.

This workorder was independently validated prior to submittal using 'USEPA National Functional Guidelines' as generally applied to the analysis of volatile organic compounds in air. A rules-based, logic driven, independent validation engine was employed to assess completeness, evaluate pass/fail of relevant project quality control requirements and verification of all quantified amounts.

Method modifications taken to run these samples are summarized in the table below. Specific project requirements may over-ride the ATL modifications.

Requirement	*TO-14A*	*ATL Modifications*
Initial Calibration	+- 30 % RSD	</= 30 % RSD with 2 compounds allowed out to < 40 %.
Daily CCV	+- 30 % D	</= 30 % D with 2 allowed out up to 40%; flag and narrate associated sample results
BFB Tune Absolute Abundance Criteria	Within 10% of that from the previous day.	CCV Internal Standard area counts are compared to the ICAL; corrective action for > 40 %D
Blank acceptance criteria	< 0.2 ppbv	< RL
Sampling Drying System	Nafion Dryer	Multisorbent concentrator
Sample collection media	Summa canister	ATL recommends use of summa canisters to insure data defensibility, but will report results from Tedlar bags at client request

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

There were no analytical discrepancies.

Definition of Data Qualifying Flags

Eight qualifiers may have been used on the data analysis sheets and indicates as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction no performed).

J - Estimated value.

E - Exceeds instrument calibration range.

Air Toxics LTD.
Laboratory Services Since 1989

S - Saturated peak.
Q - Exceeds quality control limits.
U - Compound analyzed for but not detected above the reporting limit.
UJ- Non-detected compound associated with low bias in the CCV
N - The identification is based on presumptive evidence.

File extensions may have been used on the data analysis sheets and indicates as follows:
a-File was requantified
b-File was quantified by a second column and detector
r1-File was requantified for the purpose of reissue

Air Toxics LTD.
Laboratory Services Since 1989

Summary of Detected Compounds
MODIFIED EPA METHOD TO-15 GC/MS

Client Sample ID: VP3@4.5'

Lab ID#: 1003540-01A

No Detections Were Found.

Client Sample ID: VP1@4.5'

Lab ID#: 1003540-02A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	17	16	55
Toluene	5.0	12	19	45
m,p-Xylene	5.0	7.4	22	32

Client Sample ID: VP1@4.5' Lab Duplicate

Lab ID#: 1003540-02AA

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	9.8	16	31
Toluene	5.0	11	19	41
m,p-Xylene	5.0	7.4	22	32

Client Sample ID: VP4@3.0'

Lab ID#: 1003540-03A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	35	16	110
Toluene	5.0	12	19	46
Ethyl Benzene	5.0	8.8	22	38
m,p-Xylene	5.0	68	22	290
o-Xylene	5.0	5.1	22	22

Client Sample ID: VP5@3.0'

Lab ID#: 1003540-04A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	10	16	32
Toluene	5.0	5.8	19	22
Ethyl Benzene	5.0	9.3	22	40
m,p-Xylene	5.0	35	22	150

Air Toxics LTD.
Laboratory Services Since 1989

Summary of Detected Compounds
MODIFIED EPA METHOD TO-15 GC/MS

Client Sample ID: VP5@3.0'

Lab ID#: 1003540-04A

o-Xylene	5.0	6.1	22	26

Client Sample ID: VP5@6.0'

Lab ID#: 1003540-05A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	15	16	49
Toluene	5.0	9.9	19	37
m,p-Xylene	5.0	5.5	22	24

Client Sample ID: VP6@6.0'

Lab ID#: 1003540-06A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	7.6	16	24

Client Sample ID: VP2@4.5'

Lab ID#: 1003540-07A

No Detections Were Found.

Client Sample ID: VP3@2.0'

Lab ID#: 1003540-08A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Toluene	5.0	8.3	19	31
m,p-Xylene	5.0	5.7	22	25

Client Sample ID: VP2@2.0'

Lab ID#: 1003540-09A

No Detections Were Found.

Client Sample ID: VP6@3.0'

Lab ID#: 1003540-10A

No Detections Were Found.

Air Toxics LTD.
Laboratory Services Since 1989

Summary of Detected Compounds
MODIFIED EPA METHOD TO-15 GC/MS

Client Sample ID: VP4@6.0'

Lab ID#: 1003540-11A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Toluene	5.0	7.6	19	28
m,p-Xylene	5.0	5.9	22	25

Client Sample ID: VP1@2.0'

Lab ID#: 1003540-12A

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Toluene	5.0	5.3	19	20

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP3@4.5'

Lab ID#: 1003540-01A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032527**	**Date of Collection: 3/23/10 12:25:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 12:00 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	92	70-130
Toluene-d8	98	70-130
4-Bromofluorobenzene	100	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP1@4.5'

Lab ID#: 1003540-02A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032528**	**Date of Collection: 3/23/10 11:00:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 12:29 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	17	16	55
Toluene	5.0	12	19	45
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	7.4	22	32
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	94	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	100	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP1@4.5' Lab Duplicate

Lab ID#: 1003540-02AA

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032529**	**Date of Collection: 3/23/10 11:00:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 12:58 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	9.8	16	31
Toluene	5.0	11	19	41
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	7.4	22	32
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	94	70-130
Toluene-d8	99	70-130
4-Bromofluorobenzene	97	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP4@3.0'

Lab ID#: 1003540-03A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032530**	**Date of Collection: 3/23/10 12:55:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 01:28 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	35	16	110
Toluene	5.0	12	19	46
Ethyl Benzene	5.0	8.8	22	38
m,p-Xylene	5.0	68	22	290
o-Xylene	5.0	5.1	22	22

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	95	70-130
Toluene-d8	104	70-130
4-Bromofluorobenzene	100	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP5@3.0'

Lab ID#: 1003540-04A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032531**	**Date of Collection: 3/23/10 1:40:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 01:57 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	10	16	32
Toluene	5.0	5.8	19	22
Ethyl Benzene	5.0	9.3	22	40
m,p-Xylene	5.0	35	22	150
o-Xylene	5.0	6.1	22	26

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	93	70-130
Toluene-d8	102	70-130
4-Bromofluorobenzene	99	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP5@6.0'

Lab ID#: 1003540-05A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032532**	**Date of Collection: 3/23/10 1:45:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 02:57 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	15	16	49
Toluene	5.0	9.9	19	37
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	5.5	22	24
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	92	70-130
Toluene-d8	99	70-130
4-Bromofluorobenzene	101	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP6@6.0'

Lab ID#: 1003540-06A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032533**	**Date of Collection: 3/23/10 2:40:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 03:24 AM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	7.6	16	24
Toluene	5.0	Not Detected	19	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	94	70-130
Toluene-d8	99	70-130
4-Bromofluorobenzene	98	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP2@4.5'

Lab ID#: 1003540-07A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032610**	**Date of Collection:**	**3/23/10 11:40:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis:**	**3/26/10 12:58 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	102	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	104	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP3@2.0'

Lab ID#: 1003540-08A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032611**	**Date of Collection:**	**3/23/10 12:10:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis:**	**3/26/10 01:17 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	8.3	19	31
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	5.7	22	25
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	78	70-130
Toluene-d8	110	70-130
4-Bromofluorobenzene	104	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP2@2.0'

Lab ID#: 1003540-09A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032612**	**Date of Collection: 3/23/10 11:35:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 01:38 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	103	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	104	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP6@3.0'

Lab ID#: 1003540-10A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032613**	**Date of Collection: 3/23/10 2:25:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 01:58 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	97	70-130
Toluene-d8	111	70-130
4-Bromofluorobenzene	104	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP4@6.0'

Lab ID#: 1003540-11A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032614**	**Date of Collection: 3/23/10 1:15:00 PM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 02:21 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	7.6	19	28
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	5.9	22	25
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	103	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	104	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: VP1@2.0'

Lab ID#: 1003540-12A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032615**	**Date of Collection: 3/23/10 10:48:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 02:51 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	5.3	19	20
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: 1 Liter Tedlar Bag

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	104	70-130
Toluene-d8	99	70-130
4-Bromofluorobenzene	104	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: Lab Blank

Lab ID#: 1003540-13A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032506**	**Date of Collection: NA**	
Dil. Factor:	**1.00**	**Date of Analysis: 3/25/10 10:00 AM**	

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	94	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	101	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: Lab Blank

Lab ID#: 1003540-13B

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032609**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 12:04 PM**

Compound	Rpt. Limit (ppbv)	Amount (ppbv)	Rpt. Limit (ug/m3)	Amount (ug/m3)
Benzene	5.0	Not Detected	16	Not Detected
Toluene	5.0	Not Detected	19	Not Detected
Ethyl Benzene	5.0	Not Detected	22	Not Detected
m,p-Xylene	5.0	Not Detected	22	Not Detected
o-Xylene	5.0	Not Detected	22	Not Detected

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	102	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	103	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: CCV

Lab ID#: 1003540-14A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032504**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 3/25/10 08:52 AM**

Compound	%Recovery
Benzene	109
Toluene	113
Ethyl Benzene	107
m,p-Xylene	106
o-Xylene	106

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	90	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	101	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: CCV

Lab ID#: 1003540-14B

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032602**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 09:03 AM**

Compound	%Recovery
Benzene	104
Toluene	105
Ethyl Benzene	108
m,p-Xylene	109
o-Xylene	109

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	102	70-130
Toluene-d8	100	70-130
4-Bromofluorobenzene	104	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: LCS

Lab ID#: 1003540-15A

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**b032505**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 3/25/10 09:19 AM**

Compound	%Recovery
Benzene	102
Toluene	103
Ethyl Benzene	101
m,p-Xylene	101
o-Xylene	99

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	89	70-130
Toluene-d8	101	70-130
4-Bromofluorobenzene	100	70-130

Air Toxics LTD.
Laboratory Services Since 1989

Client Sample ID: LCS

Lab ID#: 1003540-15B

MODIFIED EPA METHOD TO-15 GC/MS

File Name:	**w032603**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 3/26/10 09:24 AM**

Compound	%Recovery
Benzene	107
Toluene	102
Ethyl Benzene	116
m,p-Xylene	115
o-Xylene	114

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
1,2-Dichloroethane-d4	102	70-130
Toluene-d8	101	70-130
4-Bromofluorobenzene	106	70-130

Air Toxics LTD.

CHAIN-OF-CUSTODY RECORD

Sample Transportation Notice
Relinquishing signature on this document indicates that sample is being shipped in compliance with all applicable local, State, Federal, national, and international laws, regulations and ordinances of any kind. Air Toxics Limited assumes no liability with respect to the collection, handling or shipping of these samples. Relinquishing signature also indicates agreement to hold harmless, defend, and indemnify Air Toxics Limited against any claim, demand, or action, of any kind, related to the collection, handling, or shipping of samples. D.O.I. Hotline (800) 467-4922

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX (916) 985-1020

Project Manager: John Conrad
Collected by: (Print and Sign) Justin Solomon
Company: ~~Summit Scientific~~ LT Environmental Email: jshrewsbury@52southflorida.com
Address ______ City ______ State ____ Zip ______
Phone ______ Fax ______

Project Info:
P.O. # ______
Project # KMG 08397
Project Name KMG-Wass #5

Turn Around Time: ☐ Normal ☑ Rush — 5 Day TAT (specify)

Lab Use Only — Pressurized by: ____ Date: ____ Pressurization Gas: N_2 He

Lab I.D.	Field Sample I.D. (Location)	Can #	Date of Collection	Time of Collection	Analyses Requested	Canister Pressure/Vacuum Initial	Final	Receipt	Final (psi)
01A	VP3@ 4.5'	Tedlar	3-23-10	12:25	TO-14A - BTEX				
02A	VP1@ 4.5'	↓	↓	11:10	↓				
03A	VP4 @ 3.0'			12:55					
04A	VP5 @ 3.0'			13:40					
05A	VP5@ 6.0'			13:45					
06A	VP6@ 6.0'			14:40					
07A	VP2@ 4.5'			11:40					
08A	VP3@ 2.0' (limited volume)			12:10					
09A	VP2@ 2.0'			11:35					
10A	VP6@ 3.0'			14:25					

Relinquished by: (signature) Date/Time	Received by: (signature) Date/Time	Notes:
[signature] 3-23-10 17:30	Monica Freggen ATL 3/25/10 900	
Relinquished by: (signature) Date/Time	Received by: (signature) Date/Time	
Relinquished by: (signature) Date/Time	Received by: (signature) Date/Time	

RECEIVED
MAY 19 2010
COGCC

Lab Use Only	Shipper Name	Air Bill #	Temp (°C)	Condition	Custody Seals Intact?	Work Order #
	Fed Ex		NA	Good	Yes No (None)	1003540

Form 1293 rev.11

Air Toxics LTD.

CHAIN-OF-CUSTODY RECORD

Sample Transportation Notice
Relinquishing signature on this document indicates that sample is being shipped in compliance with all applicable local, State, Federal, national, and international laws, regulations and ordinances of any kind. Air Toxics Limited assumes no liability with respect to the collection, handling or shipping of these samples. Relinquishing signature also indicates agreement to hold harmless, defend, and indemnify Air Toxics Limited against any claim, demand, or action, of any kind, related to the collection, handling, or shipping of samples. D.O.T. Hotline (800) 467-4922

180 BLUE RAVINE ROAD, SUITE B
FOLSOM, CA 95630-4719
(916) 985-1000 FAX (916) 985-1020

Project Manager: John Corrett
Collected by: (Print and Sign) Justin Selzer
Company: LT environmental Email:
Address: City: State: Zip:
Phone: Fax:

Project Info:
P.O. #:
Project # KMG 08397
Project Name: KMG - Wass #5

Turn Around Time: ☐ Normal ☑ Rush 5 DAY TAT (specify)

Lab Use Only: Pressurized by: Date: Pressurization Gas: N_2 He

Lab I.D.	Field Sample I.D. (Location)	Can #	Date of Collection	Time of Collection	Analyses Requested	Canister Pressure/Vacuum Initial	Final	Receipt	Final (psi)
11A	V1 4 @ 6.0'	Tedlar	3-23	13:15	TO-14A - BTEX				
12A	V21 @ 2.0'	↓	↓	10:45	↓				

Relinquished by: (signature)	Date/Time	Received by: (signature)	Date/Time	Notes:
[signature]	3-23-10 1330	Monica Gregen AIL	3/25/10 900	
Relinquished by: (signature)	Date/Time	Received by: (signature)	Date/Time	
Relinquished by: (signature)	Date/Time	Received by: (signature)	Date/Time	

RECEIVED
MAY 19 2010
COGCC

Lab Use Only	Shipper Name	Air Bill #	Temp (°C)	Condition	Custody Seals Intact?	Work Order #
	Fed Ex		NA	Good	Yes No (None)	1003540

Form 1293 rev.11

Summit Scientific

741 Corporate Circle – Suite I ♦ Golden, Colorado 80401
303.277.9310 - laboratory ♦ 303.277.9531 - fax

March 25, 2010

John Cocroft
LT Environmental, Inc.
4600 West 60th Avenue
Arvada, CO 80003

RE: KMG - Wass #5

Enclosed are the results of analyses for samples received by Summit Scientific on 03/24/10 17:00. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Logan Shrewsbury For Ben Shrewsbury
President / Laboratory Director

S2

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: 08397.02 Project Manager: John Cocroft	Reported: 03/25/10 13:18

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
SB04@7'	R003141-01	Soil	03/23/10 09:20	03/24/10 17:00
SB05@5.5'	R003141-02	Soil	03/23/10 10:00	03/24/10 17:00

RECEIVED
MAY 19 2010
COGCC

Summit Scientific

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Summit Scientific L003141

741 Corporate Circle Suite I ♦ Golden, Colorado 80401
303-277-9310 ♦ 303-277-9531 Fax

Page 1 of 1

Client: LT Environmental, Inc.
Address: 4600 West 60th Avenue
City/State/Zip: Arvada, CO 80003
Phone: (303) 433-9788 Fax: (303) 433-1432
Sampler Name: J. Solomon

Project Manager: Cocroft
E-Mail:
Project Name: Wass #5
Project Number: KMG08397.02

Sample Description	Date Sampled	Time Sampled	Number of Containers	HCl	HNO_3	None	Other (Specify)	Groundwater	Soil	Air - Canister Serial #	Other (Specify)	GBTEX	ORO / DRO	Special Instructions
Preservative								Matrix				Analyze For:		
SB04@7'	3/23/10	0920	1			X			X			X	X	
SB05@5.5'	3/23/10	1000	1			X			X			X	X	

Relinquished by: Justin Solomon Date/Time: 3/24/10 1700
Received by: Date/Time:
Relinquished by: Date/Time:
Received by: Date/Time:
Relinquished by: Date/Time:
Received in Lab by: Date/Time: 3-24-10 17:00

Turn Around Time (Check)
Same Day [ ] 72 Hours [ ]
24 Hours [X] Standard [ ]
48 Hours [ ]

Sample Integrity:
Temperature Upon Receipt: 4.5
Intact: (Yes) No

Notes:

RECEIVED
MAY 19 2010
COGCC

www.s2scientific.com

S2

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: 08397.02 Project Manager: John Cocroft	Reported: 03/25/10 13:18

SB04@7'
R003141-01 (Soil)

RECEIVED
MAY 19 2010
COGCC

Summit Scientific

Extractable Petroleum Hydrocarbons by 8015

Date Sampled: **03/23/10 09:20**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
C10-C28 (TEPH-DRO)	ND	50	mg/kg	1	0032404	03/24/10	03/24/10	8015 Full Carbon Chain	
C28-C36 (TEPH-ORO)	ND	50	"	"	"	"	"	"	

Date Sampled: **03/23/10 09:20**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Surrogate: o-Terphenyl		*118 %*	*88.8-124*		"	"	"	"	

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **03/23/10 09:20**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	ND	0.0050	mg/kg	1	0032403	03/24/10	03/24/10	EPA 8260B	
Toluene	ND	0.0050	"	"	"	"	"	"	
Ethylbenzene	ND	0.0050	"	"	"	"	"	"	
Xylenes (total)	ND	0.0050	"	"	"	"	"	"	
Gasoline Range Hydrocarbons	ND	0.50	"	"	"	"	"	"	

Date Sampled: **03/23/10 09:20**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Surrogate: 1,2-Dichloroethane-d4		*103 %*	*74-135*		"	"	"	"	
Surrogate: Toluene-d8		*91.4 %*	*84.3-112*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*101 %*	*79.6-120*		"	"	"	"	

SB05@5.5'
R003141-02 (Soil)

Summit Scientific

Extractable Petroleum Hydrocarbons by 8015

Date Sampled: **03/23/10 10:00**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
C10-C28 (TEPH-DRO)	ND	50	mg/kg	1	0032404	03/24/10	03/24/10	8015 Full Carbon Chain	
C28-C36 (TEPH-ORO)	ND	50	"	"	"	"	"	"	

Date Sampled: **03/23/10 10:00**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Surrogate: o-Terphenyl		*119 %*	*88.8-124*		"	"	"	"	

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **03/23/10 10:00**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	ND	0.0050	mg/kg	1	0032403	03/24/10	03/24/10	EPA 8260B	
Toluene	ND	0.0050	"	"	"	"	"	"	
Ethylbenzene	ND	0.0050	"	"	"	"	"	"	
Xylenes (total)	ND	0.0050	"	"	"	"	"	"	
Gasoline Range Hydrocarbons	ND	0.50	"	"	"	"	"	"	

Date Sampled: **03/23/10 10:00**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Surrogate: 1,2-Dichloroethane-d4		*101 %*	*74-135*		"	"	"	"	
Surrogate: Toluene-d8		*92.0 %*	*84.3-112*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*98.1 %*	*79.6-120*		"	"	"	"	

S2

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: 08397.02 Project Manager: John Cocroft	Reported: 03/25/10 13:18

Extractable Petroleum Hydrocarbons by 8015 - Quality Control

Summit Scientific

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 0032404 - EPA 3550A										
Blank (0032404-BLK1)				Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	ND	50	mg/kg							
C28-C36 (TEPH-ORO)	ND	50	"							
Surrogate: o-Terphenyl	*14.0*		"	*12.5*		*112*	*88.8-124*			
LCS (0032404-BS1)				Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	ND	50	mg/kg				85-129		11.8	
LCS (0032404-BS2)				Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	551	50	mg/kg	500		110	85-129		11.8	
LCS Dup (0032404-BSD1)				Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	ND	50	mg/kg				85-129		11.8	
LCS Dup (0032404-BSD2)				Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	570	50	mg/kg	500		114	85-129	3.26	11.8	
Matrix Spike (0032404-MS1)	**Source: R003137-01**			Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	ND	50	mg/kg		ND		77.3-134		8.39	
Matrix Spike (0032404-MS2)	**Source: R003137-01**			Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	527	50	mg/kg	500	ND	105	77.3-134		8.39	
Matrix Spike Dup (0032404-MSD1)	**Source: R003137-01**			Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	ND	50	mg/kg		ND		77.3-134		8.39	
Matrix Spike Dup (0032404-MSD2)	**Source: R003137-01**			Prepared: 03/24/10 Analyzed: 03/25/10						
C10-C28 (TEPH-DRO)	554	50	mg/kg	500	ND	111	77.3-134	5.05	8.39	

Volatile Organic Compounds by EPA Method 8260B - Quality Control

Summit Scientific

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 0032403 - EPA 5030 Soil MS										
Blank (0032403-BLK1)				Prepared & Analyzed: 03/24/10						
Benzene	ND	0.0050	mg/kg							
Toluene	ND	0.0050	"							
Ethylbenzene	ND	0.0050	"							
Xylenes (total)	ND	0.0050	"							
Gasoline Range Hydrocarbons	ND	0.50	"							
Surrogate: 1,2-Dichloroethane-d4	*0.0376*		"	*0.0400*		*94.0*	*74-135*			
Surrogate: Toluene-d8	*0.0364*		"	*0.0400*		*91.0*	*84.3-112*			
Surrogate: 4-Bromofluorobenzene	*0.0396*		"	*0.0400*		*99.1*	*79.6-120*			
LCS (0032403-BS1)				Prepared & Analyzed: 03/24/10						
Benzene	0.101	0.0050	mg/kg	0.100		101	70.2-125		11.1	
Toluene	0.0950	0.0050	"	0.100		95.0	74-123		10.9	
Ethylbenzene	0.102	0.0050	"	0.100		102	70-130		20	
m,p-Xylene	0.196	0.010	"	0.200		98.1	70-130		20	
o-Xylene	0.0949	0.0050	"	0.100		94.9	70-130		20	
Surrogate: 1,2-Dichloroethane-d4	*0.0394*		"	*0.0400*		*98.5*	*74-135*			
Surrogate: Toluene-d8	*0.0382*		"	*0.0400*		*95.6*	*84.3-112*			
Surrogate: 4-Bromofluorobenzene	*0.0368*		"	*0.0400*		*92.1*	*79.6-120*			
LCS Dup (0032403-BSD1)				Prepared & Analyzed: 03/24/10						
Benzene	0.103	0.0050	mg/kg	0.100		103	70.2-125	1.21	11.1	
Toluene	0.0970	0.0050	"	0.100		97.0	74-123	2.03	10.9	
Ethylbenzene	0.102	0.0050	"	0.100		102	70-130	0.147	20	
m,p-Xylene	0.196	0.010	"	0.200		97.9	70-130	0.230	20	
o-Xylene	0.0952	0.0050	"	0.100		95.2	70-130	0.347	20	
Surrogate: 1,2-Dichloroethane-d4	*0.0394*		"	*0.0400*		*98.4*	*74-135*			
Surrogate: Toluene-d8	*0.0386*		"	*0.0400*		*96.4*	*84.3-112*			
Surrogate: 4-Bromofluorobenzene	*0.0365*		"	*0.0400*		*91.3*	*79.6-120*			

S2

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: 08397.02 Project Manager: John Cocroft	Reported: 03/25/10 13:18

Volatile Organic Compounds by EPA Method 8260B - Quality Control
Summit Scientific

Analyte	Result	Reporting Limit	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Notes
Batch 0032403 - EPA 5030 Soil MS										
Matrix Spike (0032403-MS1)		**Source: R003141-01**		Prepared & Analyzed: 03/24/10						
Benzene	0.0803	0.0050	mg/kg	0.100	ND	80.3	67.1-125		17.9	
Toluene	0.0757	0.0050	"	0.100	ND	75.7	68.6-124		11.9	
Ethylbenzene	0.0800	0.0050	"	0.100	ND	80.0	70-130		20	
m,p-Xylene	0.156	0.010	"	0.200	ND	78.0	70-130		20	
o-Xylene	0.0764	0.0050	"	0.100	ND	76.4	70-130		20	
Surrogate: 1,2-Dichloroethane-d4	*0.0420*		"	*0.0400*		*105*	*74-135*			
Surrogate: Toluene-d8	*0.0378*		"	*0.0400*		*94.6*	*84.3-112*			
Surrogate: 4-Bromofluorobenzene	*0.0374*		"	*0.0400*		*93.4*	*79.6-120*			
Matrix Spike Dup (0032403-MSD1)		**Source: R003141-01**		Prepared & Analyzed: 03/24/10						
Benzene	0.0734	0.0050	mg/kg	0.100	ND	73.4	67.1-125	9.10	17.9	
Toluene	0.0687	0.0050	"	0.100	ND	68.7	68.6-124	9.69	11.9	
Ethylbenzene	0.0742	0.0050	"	0.100	ND	74.2	70-130	7.59	20	
m,p-Xylene	0.145	0.010	"	0.200	ND	72.6	70-130	7.21	20	
o-Xylene	0.0707	0.0050	"	0.100	ND	70.7	70-130	7.79	20	
Surrogate: 1,2-Dichloroethane-d4	*0.0388*		"	*0.0400*		*97.1*	*74-135*			
Surrogate: Toluene-d8	*0.0379*		"	*0.0400*		*94.8*	*84.3-112*			
Surrogate: 4-Bromofluorobenzene	*0.0366*		"	*0.0400*		*91.4*	*79.6-120*			

Notes and Definitions

DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference

Summit Scientific

741 Corporate Circle – Suite I ◆ Golden, Colorado 80401
303.277.9310 - laboratory ◆ 303.277.9531 - fax

April 22, 2010

John Cocroft
LT Environmental, Inc.
4600 West 60th Avenue
Arvada, CO 80003
RE: KMG - Wass #5

Enclosed are the results of analyses for samples received by Summit Scientific on 04/21/10 17:00. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Paul Shrewsbury For Ben Shrewsbury
President / Laboratory Director

S2

RECEIVED

MAY 19 2010

COGCC

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: KMG 08397 Project Manager: John Cocroft	Reported: 04/22/10 07:34

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW01	R004121-01	Water	04/21/10 10:00	04/21/10 17:00
MW02	R004121-02	Water	04/21/10 10:10	04/21/10 17:00
MW03	R004121-03	Water	04/21/10 10:20	04/21/10 17:00

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Summit Scientific 2004121

S2

741 Corporate Circle Suite I ♦ Golden, Colorado 80401
303-277-9310 ♦ 303-277-9531 Fax

0412

Page 1 of 1

Client: LT Environmental, Inc.
Address: 4600 West 60th Avenue
City/State/Zip: Arvada, CO 80003
Phone: (303) 433-9788 Fax: (303) 433-1432
Sampler Name: Jacob Evans

Project Manager: John Cocroft
E-Mail: jcocroft@ltenv.com
Project Name: WASS #5
Project Number: KMG08397

Sample Description	Date Sampled	Time Sampled	Number of Containers	Preservative: HCl	HNO_3	None	Other (Specify)	Matrix: Groundwater	Soil	Air - Canister Serial #	Other (Specify)	Analyze For: DRO/ORO	GBTEX	BTEX	Table 9.10 Full	Table 9.10 Short	pH / EC	SAR		Special Instructions
MW01	4-21-10	1000	1	X				X						X						
MW02	↓	1010	1	X				X						X						
MW03	↓	1020	1	X				X						X						

Relinquished by: Jacob Date/Time: 4-21-10 1700
Received by: [signature] Date/Time: 4-21-10 1700

Relinquished by: Date/Time:
Received by: Date/Time:

Relinquished by: Date/Time:
Received in Lab by: Date/Time:

Turn Around Time (Check)
Same Day ☐ 72 Hours ☐
24 Hours ☒ Standard ☐
48 Hours ☐

Sample Integrity:
Temperature Upon Receipt: 4.5
Intact: (Yes) No

Notes: (Winston on Labels)

www.s2scientific.com

S2

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: KMG 08397 Project Manager: John Cocroft	Reported: 04/22/10 07:34

MW01

R004121-01 (Water)

Summit Scientific

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **04/21/10 10:00**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	**21**	1.0	ug/l	1	0042102	04/21/10	04/22/10	EPA 8260B	
Toluene	**1.0**	1.0	"	"	"	"	"	"	
Ethylbenzene	**83**	1.0	"	"	"	"	"	"	
Xylenes (total)	**440**	1.0	"	"	"	"	"	"	

Date Sampled: **04/21/10 10:00**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Surrogate: 1,2-Dichloroethane-d4		*95.2 %*	*70.4-127*		"	"	"	"	
Surrogate: Toluene-d8		*98.2 %*	*85.7-111*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*108 %*	*83.9-116*		"	"	"	"	

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: KMG 08397 Project Manager: John Cocroft	**Reported:** 04/22/10 07:34

MW02

R004121-02 (Water)

Summit Scientific

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **04/21/10 10:10**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	**54**	1.0	ug/l	1	0042102	04/21/10	04/22/10	EPA 8260B	
Toluene	**1.0**	1.0	"	"	"	"	"	"	
Ethylbenzene	**140**	1.0	"	"	"	"	"	"	
Xylenes (total)	**480**	1.0	"	"	"	"	"	"	

Date Sampled: **04/21/10 10:10**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Surrogate: 1,2-Dichloroethane-d4		*96.8 %*	*70.4-127*		"	"	"	"	
Surrogate: Toluene-d8		*97.3 %*	*85.7-111*		"	"	"	"	
Surrogate: 4-Bromofluorobenzene		*103 %*	*83.9-116*		"	"	"	"	

Summit Scientific

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

LT Environmental, Inc. 4600 West 60th Avenue Arvada CO, 80003	Project: KMG - Wass #5 Project Number: KMG 08397 Project Manager: John Cocroft	**Reported:** 04/22/10 07:34

MW03

R004121-03 (Water)

Summit Scientific

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **04/21/10 10:20**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	ND	1.0	ug/l	1	0042102	04/21/10	04/22/10	EPA 8260B	
Toluene	ND	1.0	"	"	"	"	"	"	
Ethylbenzene	ND	1.0	"	"	"	"	"	"	
Xylenes (total)	**4.0**	1.0	"	"	"	"	"	"	

Date Sampled: **04/21/10 10:20**