MEMO

ARCADIS Design & Consultancy for natural and built assets

To:
Nate Nemani
USEPA Region 5
77 West Jackson Boulevard
Mail Code: LU-9J
Chicago, Illinois 60604-3507

Copies:
Grant Trigger, RACER
Dave Favero, RACER
Christi Kiker, Arcadis
File

Arcadis U.S., Inc.
132 E. Washington Street
Suite 600
Indianapolis
Indiana 46204
Tel 317 231 6500
Fax 317 231 6514

From:

Rob Uppencamp

Date:

September 1, 2016

Arcadis Project No.:

B0064607.2016

Subject:

DRAFT - Supplemental Soil Gas Data Evaluation – BioVapor Model

RACER Pontiac North Campus, Pontiac, Michigan

INTRODUCTION

Arcadis has prepared this Supplemental Evaluation of Soil Gas Data on behalf of Revitalizing Auto Communities Environmental Response Trust (RACER) for the Pontiac North Campus Site (Site) to accompany the Supplemental Site Characterization Summary report dated July 21, 2016. The purpose of this additional evaluation is to further evaluate the potential for unacceptable indoor air concentrations based on soil gas samples collected in May 2016, taking biodegradation into consideration. The methods and procedures used to collect and analyze soil gas samples, as well as the results, can be found in the Supplemental Site Characterization Summary report.

Summary

A portion of the Pontiac North Campus (PNC) Site is occupied by an active USPS distribution facility that was constructed with a vapor barrier and passive sub-slab venting system. Initial soil gas sampling was conducted in 2005 and 2006 prior to construction of the existing USPS distribution facility. To gain a better understanding of current conditions, in May 2016, a total of seven soil gas samples were collected and analyzed for VOCs from a depth of 5 feet adjacent to the north and west sides of the USPS distribution facility.

The May 2016 soil gas sampling concentrations were below the existing Nonresidential Vapor Intrusion Shallow Soil Gas Screening Values (MDEQ 2013). Soil gas concentrations were also compared to Nonresidential soil gas screening levels that were calculated based on the method described in the MDEQ (2016) Proposed Cleanup Criteria Requirements. In comparison to these calculated nonresidential screening levels, the only exceedance was benzene in soil gas at sample location SG-05 on the north side of the facility.

Groundwater samples were also collected in May 2016 throughout the Site. No benzene concentrations were detected above MDEQ (2016) Proposed Cleanup Criteria for vapor intrusion. Two of these groundwater samples are in the vicinity of soil gas sample SG-05.

Biodegradation Potential

Petroleum related constituents, such as benzene, generally biodegrade rapidly under aerobic conditions and rarely lead to vapor intrusion occurring above risk-based screening levels in indoor air. Analysis of fixed gases (oxygen, carbon dioxide, methane, and nitrogen) are used to evaluate the potential for vapors to biodegrade in the unsaturated soil column. If a pathway is not close to a source area, biodegradable vapors will likely degrade before reaching the pathway and/or within the pathway before reaching the structure. As long as sufficient oxygen is available, biodegradation of benzene vapors can be a very efficient process. Significant biodegradation can occur with as little as 6 percent oxygen present (DeVaull 2007).

Soil gas sampling performed in 2005 indicated that sufficient oxygen levels were present in the subsurface with evidence that aerobic degradation was occurring prior to construction of the existing USPS building. Fixed gas analysis of soil gas samples from the May 2016 soil gas sampling also indicated that sufficient oxygen is available to support biodegradation.

Estimating Indoor Air Concentrations Using the BioVapor Model

The American Petroleum Institute (API) BioVapor model (API 2010) was used to estimate an indoor air concentration for benzene based on the highest soil gas result. The BioVapor model is a one-dimensional analytical model that assumes a steady-state vapor source, diffusion-dominated soil vapor transport, and oxygen-limited aerobic biodegradation in the vadose zone. The BioVapor model is intended to provide an improved understanding of the potential effect of aerobic biodegradation in the vadose zone on the vapor intrusion pathway. The model was used to predict a concentration of benzene in indoor air in a generic building from concentrations detected in soil gas. Based on the depth to groundwater at the Site, there is expected to be approximately 8 feet of vadose zone material, which is made up of fill material, soils conducive for the allowing for some aerobic biodegradation of petroleum hydrocarbon vapors.

The model was run using the most conservative default or published parameters to provide a reasonable worst case scenario. A summary of input parameters used in the model are as follows:

- Exposure and risk factor input parameters are based on the MDEQ 2016 Proposed Cleanup Criteria Requirements using an excess lifetime cancer risk of 10^{-5}, a hazard quotient of 1, and a commercial/industrial (referred to as “nonresidential” by MDEQ) scenario.
- Building and vadose zone input parameters used are the most conservative between the default model parameters and MDEQ (2016) proposed parameters. As suggested by MDEQ when soil conditions are unknown, a soil type of sand was conservatively used as this assumes maximum permeability in the vadose zone.

- Although benzene is the risk driver, all petroleum hydrocarbon constituents reported under the USEPA Compendium Method TO-15, as well as methane, were input into the model to provide for the best possible oxygen mass balance. The highest detected soil gas concentrations for each constituent detected in all soil gas samples was used as the source concentration. If a constituent was not detected above the laboratory reporting limit, half of the detection limit was input.
- Acceptable air values, or indoor air screening levels, were calculated for the commercial/industrial scenario using the toxicity information and method described in the MDEQ (2016) Proposed Cleanup Criteria Requirements.

The input screens, results screens, and detail output of the BioVapor modeling are presented in Attachment 1.

CONCLUSIONS

Multiple lines of evidence suggest that known soil gas concentrations will not pose an unacceptable indoor air concentration to a generic building, which represents a reasonable worst case scenario.

- Benzene, a biodegradable petroleum constituent, is the only chemical detected in soil gas above the nonresidential screening level, calculated from the Proposed MDEQ criteria, at one soil gas sample location.
- Sufficient oxygen levels to promote efficient biodegradation in the subsurface have been demonstrated through several soil gas sampling events, before and after building construction.
- The BioVapor modeling output supports that no unacceptable indoor air concentration would result from known soil gas benzene concentrations.

REFERENCES

Arcadis. 2016. Supplemental Site Characterization Summary. RACER Pontiac North Campus. July 21.

DeVaull, George E. 2007. Indoor vapor intrusion with oxygen-limited biodegradation for a subsurface gasoline source. Environ. Sci. Technol., 41, 3241-3248.

Michigan Department of Environmental Quality (MDEQ), Remediation and Redevelopment Division. 2013. Guidance Document for the Vapor Intrusion Pathway. May

MDEQ, Remediation and Redevelopment Division. 2016. Cleanup Criteria and Screening Levels Development and Application. June DRAFT.

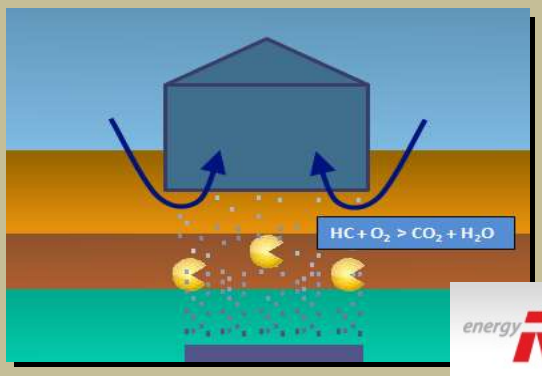
ATTACHMENT 1

BioVapor Model Output Files

BioVapor

A 1-D vapor intrusion Model:

with Oxygen-Limited Aerobic Biodegradation



1) PROJECT INFORMATION

Site ID #:	RACER Pontiac North Campus
Address:	Pontiac, Michigan
Completed by:	Uppencamp
Date:	27-Jul-16
Job ID:	B0064607.2016

BioVapor Version 2.1 beta

2) INPUT SCREENS

1) **Environmental Factors**

2) **Chemicals**

3) **Chemical Concentrations**

Chemical Database

3) RESULTS SCREENS

1) **VI Risk**

2) **Subsurface Profile**

3) **Detailed Results**

Site Name: RACER Pontiac North Campus
Address: Pontiac, Michigan

BioVapor Input

Date: 7/27/2016
Completed By: Uppencamp
Job ID: B0064607.2016

Model Input Screens: Environmental Factors | Chemicals | Chemical Concentrations | Chemical Database

1. Oxygen Surface Boundary Condition

Slab or Basement Foundation (e.g., Specify Airflow)

2. Indoor Target Criteria

- ○ Do not perform backward Calculation
- ○ Based on Indoor Risk / Hazard Target
- ◉ Specified Indoor Air Concentration Target

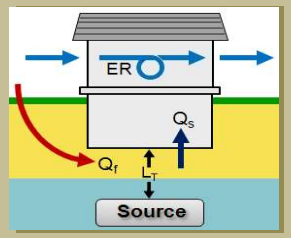
Note: Target indoor air concentrations can be edited on the "Chemical Database" screen

3. Exposure and Risk Factors

Target Hazard Quotient For Individual Chemicals	THQ	1.00	(-)
Target Excess Individual Lifetime Cancer Risk	TR	1.00E-05	(-)
Carcinogen Averaging Time	AT_C	78.00	yrs
Non-carcinogenic Averaging Time	AT_{NC}	20.00	yrs
Body Weight - Adult	BW	70.00	kg
Exposure Duration	ED	20.00	yrs
Exposure Frequency	EF	238.00	days/yr
Indoor Inhalation Rate Exposure Adjustment	CF	1.00	(-)

Legend

80.00	Calculated Value
80.00	User Input Value
80.00	Value Outside Normal Range



4. Building Parameters

Indoor Mixing Height	L_{mix}	300.00	cm
Air Exchange Rate	ER	12.00	1/day
Foundation Thickness	L_{crack}	15.00	cm
Foundation Area	A_b	1060000.00	cm^2
Foundation Crack Fraction	η	3.77E-04	cm^2-cracks/cm^2-total
Total Porosity (Soil-filled Cracks)	$\theta_{T\text{-}crack}$	1.00	cm^3-void/cm^3-soil
Water Filled Porosity (Soil-filled Cracks)	$\theta_{w\text{-}crack}$	0.00	cm^3-void/cm^3-soil
Airflow Through Basement Foundation	Q_s	83.00	cm^3-air/sec
Building Envelope Resistance	L_{mix} * ER	0.04	cm/sec

5. Vadose Zone Parameters

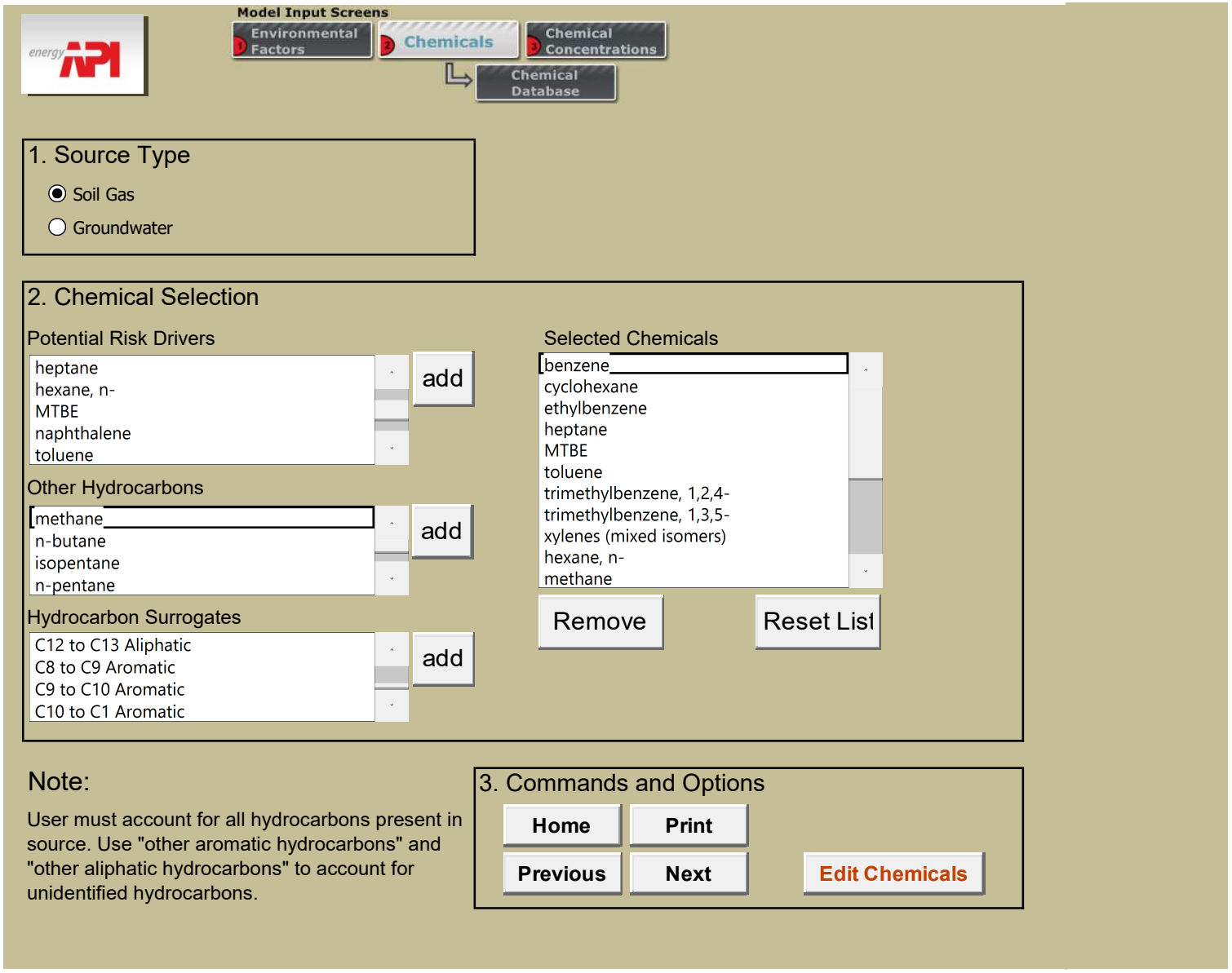
Soil Porosity	$\theta_{T\text{-}soil}$	0.38	cm^3-void/cm^3-soil
Soil Water Content	$\theta_{w\text{-}soil}$	0.05	cm^3-water/cm^3-soil
Soil Organic Carbon Fraction	f_{oc}	2.00E-03	g-oc/g-soil
Soil Density - Bulk	ρs	1.66	g-soil/cm^3-soil
Airflow Under Foundation	Q_f	83.00	cm^3-air/sec
Depth of Aerobic Zone Under Foundation	L_A	-	cm
O_2 Concentration Under Foundation	Co_2-e	-	%
Annual Median Soil Temperature	T	10.00	°C
Baseline Soil Oxygen Respiration Rate (Calculated from Foc)	Λ_{base}	3.912E-08	mg-O_2 / g-soil - sec
Depth to Source (from bottom of foundation)	LT	150.00	cm
Minimum O_2 Conc. For Aerobic Biodegradation		6.00	%

6. Commands and Options

Default Values
- ○ Residential
- ◉ Commercial / Industrial

Paste

Home | Print | Reset | Next


Model Input Screens
Environmental Factors
Chemicals
Chemical Concentrations
Chemical Database
1. Source Type
Soil Gas
Groundwater
2. Chemical Selection
Potential Risk Drivers
heptane
hexane, n-
MTBE
naphthalene
toluene
add
Other Hydrocarbons
methane
n-butane
isopentane
n-pentane
add
Hydrocarbon Surrogates
C12 to C13 Aliphatic
C8 to C9 Aromatic
C9 to C10 Aromatic
C10 to C1 Aromatic
add
Selected Chemicals
benzene
cyclohexane
ethylbenzene
heptane
MTBE
toluene
trimethylbenzene, 1,2,4-
trimethylbenzene, 1,3,5-
xylenes (mixed isomers)
hexane, n-
methane
Remove
Reset List
Note:
User must account for all hydrocarbons present in source. Use "other aromatic hydrocarbons" and "other aliphatic hydrocarbons" to account for unidentified hydrocarbons.
3. Commands and Options
Home
Print
Previous
Next
Edit Chemicals

Site Name: RACER Pontiac North Campus
Address: Pontiac, Michigan

BioVapor Results

Date: 7/27/2016
Completed By: Uppencamp
Job ID: B0064607.2016

Model Input Screens: Environmental Factors | Chemicals | Chemical Concentrations | Chemical Database

2. Commands and Options

Home | Print | Previous | Next :: Results

After Clicking "Next :: Results", see status bar in lower left corner for progress on calculations.

1. Soil Gas Source Chemical Concentrations

Chemical	ug/m^3
benzene	5.00E+02
cyclohexane	3.60E+02
ethylbenzene	7.60E+01
heptane	1.44E+03
MTBE	6.00E+00
toluene	7.20E+02
trimethylbenzene, 1,2,4-	1.10E+01
trimethylbenzene, 1,3,5-	8.00E+00
xylenes (mixed isomers)	1.97E+02
hexane, n-	2.00E+03
methane	4.66E+06
ethanol	2.20E+02
trimethylpentane, 2,2,4-	7.50E+00
naphthalene	6.00E+00

4.66E+06 Total Entered Hydrocarbon Concentration (ug/m^3)

Note: The total hydrocarbon concentration should equal the total concentration of all hydrocarbons in the source area

Model Output Screens: VI Risk | Subsurface Profile | Detailed Results

Commands and Options

Home | Print | Previous | Next | Unprotect

Target Hazard Quotient	Target Risk Level
1	1.00E-05

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration	Soil Gas Source Concentration	Soil Gas to Indoor Air Attenuation Factor	Target Indoor Air Concentration	Predicted Indoor Air Concentration	Hazard Quotient	Risk Level
	ug/L	ug/m^3	(-)	ug/m^3-air	ug/m^3-air	(-)	(-)
benzene	-	5.00E+02	9.91E-08	7.67E+00	4.96E-05	3.23E-06	6.39E-11
cyclohexane	-	3.60E+02	1.03E-11	9.20E+03	3.70E-09	4.02E-13	-
ethylbenzene	-	7.60E+01	5.90E-08	2.39E+01	4.48E-06	1.12E-08	1.87E-12
heptane	-	1.44E+03	4.39E-06	5.37E+03	6.32E-03	1.18E-06	-
MTBE	-	6.00E+00	3.18E-04	4.60E+03	1.91E-03	4.15E-07	-
toluene	-	7.20E+02	1.31E-07	7.67E+03	9.42E-05	1.23E-08	-
trimethylbenzene, 1,2,4-	-	1.10E+01	3.18E-09	1.07E+01	3.49E-08	3.25E-09	-
trimethylbenzene, 1,3,5-	-	8.00E+00	1.36E-08	7.67E+01	1.09E-07	1.42E-09	-
xylenes (mixed isomers)	-	1.97E+02	2.85E-08	3.37E+02	5.60E-06	1.66E-08	-
hexane, n-	-	2.00E+03	6.89E-05	1.07E+03	1.38E-01	1.28E-04	-
naphthalene	-	6.00E+00	1.37E-19	1.76E+00	8.24E-19	1.79E-19	4.68E-24

NOTE A: "< 1E-100" means calculated attentuation factor is less than IE-100

Backward Risk Calculation

Critical Chemical for Backward Risk Calculation: benzene

Chemical Name	Target Hazard Quotent	Target Cancer Risk	Target Indoor Air Concentration	Soil Gas Source Concentration	Effective Saturated Vapor Concentration	Groundwater Source Concentration	Effective Solubility
	(-)	(-)	ug/m^3-air	ug/m^3	ug/m^3	ug/L	ug/L
benzene	-	-	7.67E+00	1.22E+04	5.40E+04	-	-
cyclohexane	-	-	9.20E+03	8.78E+03	3.88E+04	-	-
ethylbenzene	-	-	2.39E+01	1.85E+03	8.20E+03	-	-
heptane	-	-	5.37E+03	3.51E+04	1.55E+05	-	-
MTBE	-	-	4.60E+03	1.46E+02	6.47E+02	-	-
toluene	-	-	7.67E+03	1.76E+04	7.77E+04	-	-
trimethylbenzene, 1,2,4-	-	-	1.07E+01	2.68E+02	1.19E+03	-	-
trimethylbenzene, 1,3,5-	-	-	7.67E+01	1.95E+02	8.63E+02	-	-
xylenes (mixed isomers)	-	-	3.37E+02	4.81E+03	2.13E+04	-	-
hexane, n-	-	-	1.07E+03	4.88E+04	2.16E+05	-	-
naphthalene	-	-	1.76E+00	1.46E+02	6.47E+02	-	-

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

NOTE C: Red value indicates source concentration greater than saturation limit

NOTE D: Backward Risk Calculation not applicable when aerobic depth directly specified

NOTE E: Backward Calculation not completed due to Excel calculation error

Model Output Screens

VI Risk | Subsurface Profile | Detailed Results

Commands and Options

Home | Print | Previous | Next

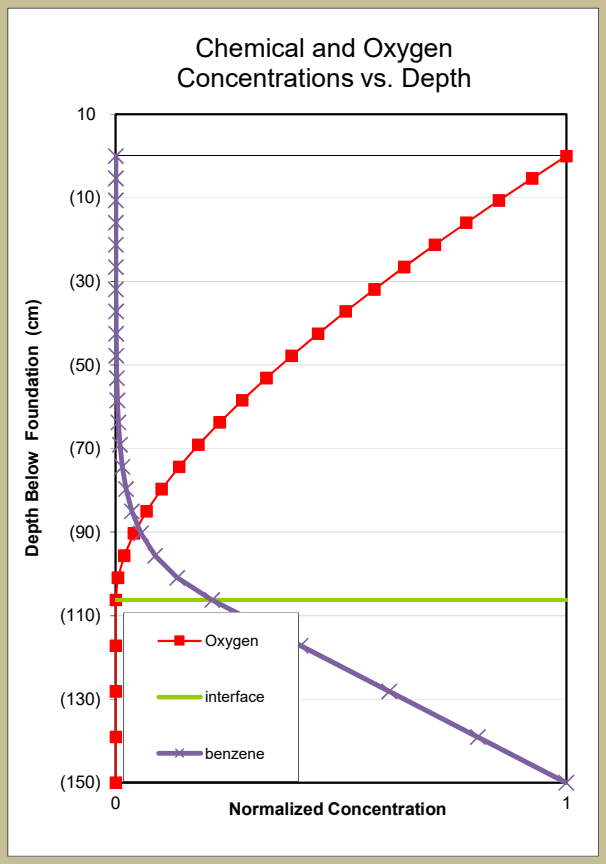
Select Chemical to View

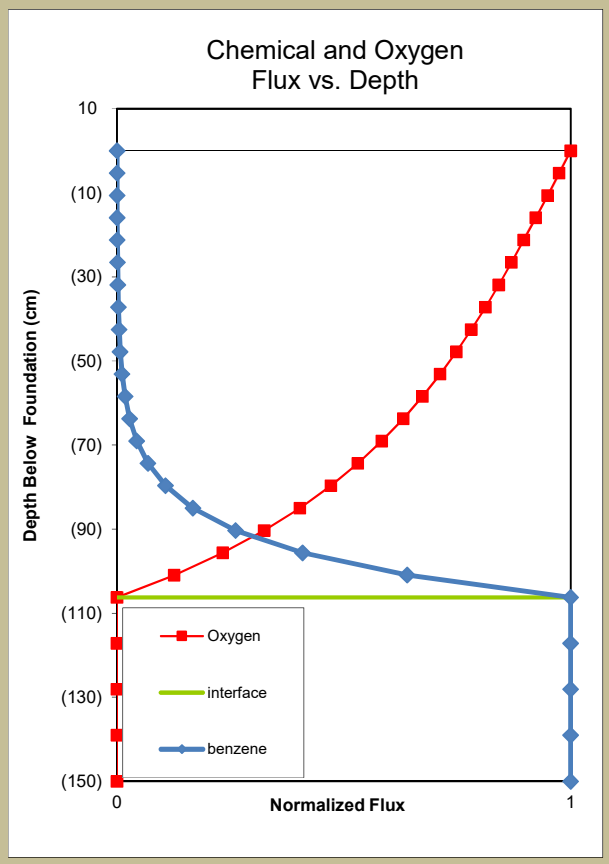
benzene

Update Charts

Results Charts (Forward Calculation)

Predicted concentration profile below building foundation





Model Output Screens: VI Risk | Subsurface Profile | Detailed Results

Commands and Options: Home | Print | Previous | Unprotect

General Results - Forward Calculations

Depth from building foundation to aerobic/anaerobic interface	Depth from aerobic/anaerobic interface to source	Total Depth
cm	cm	cm
106.26	43.74	150.00

Chemical Specific Results - Forward Calculations

Chemical	Foundation Mass Transfer Resistance	Soil Resistance	Sub-slab to indoor air attenuation factor	Aerobic/anaerobic interface to sub-slab attenuation factor	Source to aerobic/anaerobic interface attenuation factor	Source to indoor air attenuation factor	Source to indoor air attenuation factor (if no biodegradation)
	cm/sec	cm/sec	(-)	(-)	(-)	(-)	(-)
benzene	7.84E-05	9.65E-05	1.88E-03	2.47E-04	2.14E-01	9.91E-08	1.04E-03
cyclohexane	7.84E-05	8.62E-05	1.88E-03	4.50E-08	1.21E-01	1.03E-11	9.85E-04
ethylbenzene	7.84E-05	7.38E-05	1.88E-03	1.53E-04	2.05E-01	5.90E-08	9.12E-04
heptane	7.84E-05	6.99E-05	1.88E-03	7.56E-03	3.09E-01	4.39E-06	8.87E-04
MTBE	7.84E-05	8.54E-05	1.88E-03	2.79E-01	6.08E-01	3.18E-04	9.80E-04
toluene	7.84E-05	9.38E-05	1.88E-03	3.18E-04	2.19E-01	1.31E-07	1.02E-03
trimethylbenzene, 1,2,4-	7.84E-05	6.51E-05	1.88E-03	1.01E-05	1.67E-01	3.18E-09	8.53E-04
trimethylbenzene, 1,3,5-	7.84E-05	6.49E-05	1.88E-03	3.92E-05	1.84E-01	1.36E-08	8.52E-04
xylenes (mixed isomers)	7.84E-05	7.69E-05	1.88E-03	7.80E-05	1.94E-01	2.85E-08	9.31E-04
hexane, n-	7.84E-05	2.16E-04	1.88E-03	8.33E-02	4.40E-01	6.89E-05	1.38E-03
methane	7.84E-05	2.34E-04	1.88E-03	3.38E-02	3.77E-01	2.39E-05	1.41E-03
ethanol	7.84E-05	6.36E-05	1.88E-03	7.95E-03	3.11E-01	4.65E-06	8.42E-04
trimethylpentane, 2,2,4-	7.84E-05	6.19E-05	1.88E-03	1.62E-02	3.44E-01	1.04E-05	8.29E-04
naphthalene	7.84E-05	6.36E-05	1.88E-03	1.13E-15	6.48E-02	1.37E-19	8.42E-04

Chemical	Concentration in indoor air	Concentration in sub-slab gas	Concentration at aerobic/anaerobic interface	Concentration at source	Concentration in indoor air (if no biodegradation)	Flux into enclosure	Flux from source
	ug/m^3-air	ug/m^3-air	ug/m^3-air	ug/m^3-air	ug/m^3-air	ug/sec	ug/sec
benzene	4.96E-05	2.64E-02	1.07E+02	5.00E+02	5.19E-01	2.19E-06	1.4E-01
cyclohexane	3.70E-09	1.97E-06	4.37E+01	3.60E+02	3.55E-01	1.63E-10	9.9E-02
ethylbenzene	4.48E-06	2.39E-03	1.56E+01	7.60E+01	6.93E-02	1.98E-07	1.6E-02
heptane	6.32E-03	3.36E+00	4.44E+02	1.44E+03	1.28E+00	2.79E-04	2.5E-01
MTBE	1.91E-03	1.02E+00	3.65E+00	6.00E+00	5.88E-03	8.44E-05	7.3E-04
toluene	9.42E-05	5.01E-02	1.57E+02	7.20E+02	7.37E-01	4.16E-06	1.9E-01
trimethylbenzene, 1,2,4-	3.49E-08	1.86E-05	1.84E+00	1.10E+01	9.38E-03	1.54E-09	2.2E-03
trimethylbenzene, 1,3,5-	1.09E-07	5.78E-05	1.47E+00	8.00E+00	6.81E-03	4.80E-09	1.5E-03
xylenes (mixed isomers)	5.60E-06	2.98E-03	3.82E+01	1.97E+02	1.83E-01	2.48E-07	4.4E-02
hexane, n-	1.38E-01	7.33E+01	8.81E+02	2.00E+03	2.76E+00	6.09E-03	8.8E-01
methane	1.11E+02	5.93E+04	1.75E+06	4.66E+06	6.56E+03	4.92E+00	2.5E+03
ethanol	1.02E-03	5.44E-01	6.85E+01	2.20E+02	1.85E-01	4.52E-05	3.5E-02
trimethylpentane, 2,2,4-	7.83E-05	4.17E-02	2.58E+00	7.50E+00	6.22E-03	3.46E-06	1.1E-03
naphthalene	8.24E-19	4.38E-16	3.89E-01	6.00E+00	5.05E-03	3.64E-20	1.3E-03
Totals	1.12E+02	5.93E+04	1.76E+06	4.66E+06	6.56E+03	4.93E+00	2.47E+03

Chemical	Oxygen Demand in Vadose Zone	Minimum O_2 Concentration at top of aerobic zone (i.e., below building foundation)	Oxygen mass flow at the top of aerobic zone
	% of total demand	%	ug/sec
benzene	0.00%		
cyclohexane	0.00%		
ethylbenzene	0.00%		
heptane	0.01%		
MTBE	0.00%		
toluene	0.00%		
trimethylbenzene, 1,2,4-	0.00%		
trimethylbenzene, 1,3,5-	0.00%		
xylenes (mixed isomers)	0.00%		
hexane, n-	0.02%		
methane	67.14%		
ethanol	0.00%		
trimethylpentane, 2,2,4-	0.00%		
naphthalene	0.00%		
Baseline Soil Oxygen Demand	32.82%		
Totals	100.00%	8.87%	1.71E+04

Date: 7/27/2016
Completed By: Uppencamp
Job ID: B0064607.2016

Target Hazard Quotient	Target Risk Level
1	0.00001

Forward Risk Calculation

Chemical Name	Groundwater Source Concentration	Soil Gas Source Concentration	Soil Gas to Indoor Air Attenuation Factor	Target Indoor Air Concentration	Predicted Indoor Air Concentration	Hazard Quotient	Risk Level
	ug/L	ug/m^3	(-)	ug/m^3-air	ug/m^3-air	(-)	(-)
benzene	-	5.00E+02	9.91E-08	7.67E+00	4.96E-05	3.23E-06	6.39E-11
cyclohexane	-	3.60E+02	1.03E-11	9.20E+03	3.70E-09	4.02E-13	-
ethylbenzene	-	7.60E+01	5.90E-08	2.39E+01	4.48E-06	1.12E-08	1.87E-12
heptane	-	1.44E+03	4.39E-06	5.37E+03	6.32E-03	1.18E-06	-
MTBE	-	6.00E+00	3.18E-04	4.60E+03	1.91E-03	4.15E-07	-
toluene	-	7.20E+02	1.31E-07	7.67E+03	9.42E-05	1.23E-08	-
trimethylbenzene, 1,2,4-	-	1.10E+01	3.18E-09	1.07E+01	3.49E-08	3.25E-09	-
trimethylbenzene, 1,3,5-	-	8.00E+00	1.36E-08	7.67E+01	1.09E-07	1.42E-09	-
xylenes (mixed isomers)	-	1.97E+02	2.85E-08	3.37E+02	5.60E-06	1.66E-08	-
hexane, n-	-	2.00E+03	6.89E-05	1.07E+03	1.38E-01	1.28E-04	-
naphthalene	-	6.00E+00	1.37E-19	1.76E+00	8.24E-19	1.79E-19	4.68E-24

NOTE A: "< 1E-100" means calculated attenuation factor is less than IE-100

Backward Risk Calculation

Chemical Name	Target Hazard Quotient	Target Cancer Risk	Target Indoor Air Concentration	Soil Gas Source Concentration	Effective Saturated Vapor Concentration	Groundwater Source Concentration	Effective Solubility
	(-)	(-)	ug/m^3-air	ug/m^3	ug/m^3	ug/L	ug/L
benzene	-	-	7.67E+00	1.22E+04	5.40E+04	-	-
cyclohexane	-	-	9.20E+03	8.78E+03	3.88E+04	-	-
ethylbenzene	-	-	2.39E+01	1.85E+03	8.20E+03	-	-
heptane	-	-	5.37E+03	1.85E+03	8.20E+03	-	-
MTBE	-	-	4.60E+03	1.46E+02	6.47E+02	-	-
toluene	-	-	7.67E+03	1.76E+04	7.77E+04	-	-
trimethylbenzene, 1,2,4-	-	-	1.07E+01	2.68E+02	1.19E+03	-	-
trimethylbenzene, 1,3,5-	-	-	7.67E+01	1.95E+02	8.63E+02	-	-
xylenes (mixed isomers)	-	-	3.37E+02	4.81E+03	2.13E+04	-	-
hexane, n-	-	-	1.07E+03	4.88E+04	2.16E+05	-	-
naphthalene	-	-	1.76E+00	1.46E+02	6.47E+02	-	-

NOTE B: Target indoor air concentrations can be edited on the "Chemical Database" screen

Date: 7/27/2016
Completed By: Uppencamp
Job ID: B0064607.2016

General Results - Forward Calculations

Depth from building foundation to aerobic/anaerobic interface	Depth from aerobic/anaerobic interface to source	Total Depth
cm	cm	cm
106.26	62.25	168.50

Chemical Specific Results - Forward Calculations

Chemical	Foundation Mass Transfer Resistance	Soil Resistance	Sub-slab to indoor air attenuation factor	Aerobic/anaerobic interface to sub-slab attenuation factor	Source to aerobic/anaerobic interface attenuation factor	Source to indoor air attenuation factor	Source to indoor air attenuation factor (if no biodegradation)
	cm/sec	cm/sec	(-)	(-)	(-)	(-)	(-)
benzene	7.84E-05	9.65E-05	1.88E-03	2.47E-04	2.14E-01	9.91E-08	1.04E-03
cyclohexane	7.84E-05	8.62E-05	1.88E-03	4.50E-08	1.21E-01	1.03E-11	9.85E-04
ethylbenzene	7.84E-05	7.38E-05	1.88E-03	1.53E-04	2.05E-01	5.90E-08	9.12E-04
heptane	7.84E-05	6.99E-05	1.88E-03	7.56E-03	3.09E-01	4.39E-06	8.87E-04
MTBE	7.84E-05	8.54E-05	1.88E-03	2.79E-01	6.08E-01	3.18E-04	9.80E-04
toluene	7.84E-05	9.38E-05	1.88E-03	3.18E-04	2.19E-01	1.31E-07	1.02E-03
trimethylbenzene, 1,2,4-	7.84E-05	6.51E-05	1.88E-03	1.01E-05	1.67E-01	3.18E-09	8.53E-04
trimethylbenzene, 1,3,5-	7.84E-05	6.49E-05	1.88E-03	3.92E-05	1.84E-01	1.36E-08	8.52E-04
xylenes (mixed isomers)	7.84E-05	7.69E-05	1.88E-03	7.80E-05	1.94E-01	2.85E-08	9.31E-04
hexane, n-	7.84E-05	2.16E-04	1.88E-03	8.33E-02	4.40E-01	6.89E-05	1.38E-03
methane	7.84E-05	2.34E-04	1.88E-03	3.38E-02	3.77E-01	2.39E-05	1.41E-03
ethanol	7.84E-05	6.36E-05	1.88E-03	7.95E-03	3.11E-01	4.65E-06	8.42E-04
trimethylpentane, 2,2,4-	7.84E-05	6.19E-05	1.88E-03	1.62E-02	3.44E-01	1.04E-05	8.29E-04
naphthalene	7.84E-05	6.36E-05	1.88E-03	1.13E-15	6.48E-02	1.37E-19	8.42E-04

Chemical	Concentration in indoor air	Concentration in sub-slab gas	Concentration at aerobic/anaerobic interface	Concentration at source	Concentration in indoor air (if no biodegradation)	Flux into enclosure	Flux from source
	ug/m^3-air	ug/m^3-air	ug/m^3-air	ug/m^3-air	ug/m^3-air	ug/sec	ug/sec
benzene	4.96E-05	2.64E-02	1.07E+02	5.00E+02	5.19E-01	2.19E-06	1.4E-01
cyclohexane	3.70E-09	1.97E-06	4.37E+01	3.60E+02	3.55E-01	1.63E-10	9.9E-02
ethylbenzene	4.48E-06	2.39E-03	1.56E+01	7.60E+01	6.93E-02	1.98E-07	1.6E-02
heptane	6.32E-03	3.36E+00	4.44E+02	1.44E+03	1.28E+00	2.79E-04	2.5E-01
MTBE	1.91E-03	1.02E+00	3.65E+00	6.00E+00	5.88E-03	8.44E-05	7.3E-04
toluene	9.42E-05	5.01E-02	1.57E+02	7.20E+02	7.37E-01	4.16E-06	1.9E-01
trimethylbenzene, 1,2,4-	3.49E-08	1.86E-05	1.84E+00	1.10E+01	9.38E-03	1.54E-09	2.2E-03
trimethylbenzene, 1,3,5-	1.09E-07	5.78E-05	1.47E+00	8.00E+00	6.81E-03	4.80E-09	1.5E-03
xylenes (mixed isomers)	5.60E-06	2.98E-03	3.82E+01	1.97E+02	1.83E-01	2.48E-07	4.4E-02
hexane, n-	1.38E-01	7.33E+01	8.81E+02	2.00E+03	2.76E+00	6.09E-03	8.8E-01
methane	1.11E+02	5.93E+04	1.75E+06	4.66E+06	6.56E+03	4.92E+00	2.5E+03
ethanol	1.02E-03	5.44E-01	6.85E+01	2.20E+02	1.85E-01	4.52E-05	3.5E-02
trimethylpentane, 2,2,4-	7.83E-05	4.17E-02	2.58E+00	7.50E+00	6.22E-03	3.46E-06	1.1E-03
naphthalene	8.24E-19	4.38E-16	3.89E-01	6.00E+00	5.05E-03	3.64E-20	1.3E-03
Totals	1.12E+02	5.93E+04	1.76E+06	4.66E+06	6.56E+03	4.93E+00	2.47E+03

Chemical	Oxygen Demand in Vadose Zone	Oxygen Concentration at top of aerobic zone (i.e., below building foundation)	Oxygen Flux at the top of aerobic zone
	% of total demand	%	ug/sec
benzene	0.00%		
cyclohexane	0.00%		
ethylbenzene	0.00%		
heptane	0.01%		
MTBE	0.00%		
toluene	0.00%		
trimethylbenzene, 1,2,4-	0.00%		
trimethylbenzene, 1,3,5-	0.00%		
xylenes (mixed isomers)	0.00%		
hexane, n-	0.02%		
methane	67.14%		
ethanol	0.00%		
trimethylpentane, 2,2,4-	0.00%		
naphthalene	0.00%		
Baseline Soil Oxygen Demand	32.82%		
Totals	100.00%	8.87%	1.71E+04