TETRA TECH EBA

May 9, 2014

ISSUED FOR USE
FILE: ENVIND03354-01
Via Email: Barons@figment.ca

Village of Barons
P.O. Box 129
Barons, AB T0L 0G0

Attention: Ms. Laurie Beck

Dear Ms. Beck:

Subject: Calculating Soil Vapour Partitioning – 202 Main Street Barons, Alberta (AMA Site 9557)

1.0 INTRODUCTION

Tetra Tech EBA Inc. (Tetra Tech EBA) was retained by the Village of Barons (Barons) to conduct a soil vapour assessment (SVA) for the above-mentioned address. This letter is the first stage of the SVA and is based on previous environmental site assessments (ESAs) conducted at the site by Tetra Tech EBA which identified concentrations of petroleum hydrocarbons (PHCs) in the soil and groundwater greater than the applicable Alberta Environment (AENV)[1] 2010 *Alberta Tier 1 and 2 Soil and Groundwater Remediation Guidelines*, and more specifically, in excess of the Tier 1 vapour inhalation (VI) guidelines.

The objective of the SVA is to identify potential risks to occupants working at the site and residing at the adjacent dwelling to the east from exposure to soil vapours containing potential contaminants of concern (PCOC) including benzene, ethylbenzene, toluene, and xylenes (BTEX) and PHC fractions F1 and F2. Tetra Tech EBA understands that the adjacent residential property to the east has a bare earth basement floor. The first stage of the SVA involved partition calculations of the existing soil and groundwater data to determine if PHC concentrations are such that partitioning of vapours could occur creating a risk due to inhalation of indoor air. The British Columbia Ministry of Environment (MoE) and Health Canada partitioning models are more robust than the Alberta models; therefore, the BC MoE and Health Canada models were used in the determination of potential risk.

2.0 PARTITION MODELLING METHODOLOGY

For this assessment, Tetra Tech EBA used soil vapour partitioning equations found in Exhibit 2 of Health Canada's "Federal Contaminated Site Risk Assessment in Canada: Part VII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites" published by Health Canada, dated September, 2010, and MoE approved vapour attenuation factors for potential intrusion via an earthen basement. The equations and coefficients allowed an estimation of vapour PCOC concentrations in subsurface soil pore spaces using known groundwater and soil concentrations obtained during previous ESAs.

The soil vapour partitioning calculation considers soil type (coarse or fine-grained), depth of impact, and the measured concentrations of the PCOC. The outdoor and indoor vapour concentrations were calculated using the appropriate MoE attenuation factors for each PCOC. Site-specific information for model input, such as depth to groundwater, soil stratigraphy, building characteristics, etc. were used as model input, wherever possible, with the remainder of the input used being default values for residential land use.

[1] Currently Alberta Environment and Sustainable Resource Development (ESRD).

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The British Columbia Contaminated Sites Regulation (BC CSR) vapour standards from Schedule 11 are provided in Table 1 for comparison purposes. Table 1 also indicates a maximum acceptable air concentration value (MAC) for non-carcinogens for BTEX. The equations used to calculate the MAC are provided below and were taken from Health Canada (2012) Preliminary Quantitative Risk Assessment (PQRA) Guidance. Tolerable concentrations and unit risk values are taken from the Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines (CEQG) and, for petroleum hydrocarbons, from the Canada-Wide Standards for Petroleum Hydrocarbons.

MAC = (HQ x SAF x TC)/ET

Where:

MAC = maximum acceptable concentration (mg/m^3)

HQ = hazard quotient (dimensionless)

SAF = soil allocation factor (dimensionless)

TC = tolerable concentration (mg/m^3)

ET = exposure term for residential land use (dimensionless)

The calculation for carcinogens is shown for benzene in Section 2.1.

2.1 Benzene

MAC = RsC/ET

= **0.003 mg/m^3**

Where:

HQ = not used for carcinogens

SAF = not used for carcinogens

RsC = 0.003 mg/m^3

ET = 1.0 for residential land use

Carcinogens like benzene have a risk-specific concentration (RsC) rather than a TC value. The calculated RsC for benzene was derived using the method provided in the Health Canada PQRA(2012).

RsC = ARL/UR

= 0.003 mg/m^3

Where:

ARL = acceptable risk level (10^{-5})

UR = unit risk (0.0033 m^3/mg)

2.2 Toluene

AC = (HQ x SAF x TC)/ET

= **1.91 mg/m^3**

Where:

HQ = 1.0

SAF = 0.5 (AENV 2010)

TC = 3.8 (mg/m^3)

ET = 1.0

2.3 Ethylbenzene

AC = (HQ x SAF x TC)/ET

= **0.50 mg/m^3**

Where:

HQ = 1.0

SAF = 0.5 (AENV 2010)

TC = 1.0 (mg/m^3)

ET = 1.0

2.4 Xylene

AC = (HQ x SAF x TC)/ET

= **0.090 mg/m^3**

Where:

HQ = 1.0

SAF = 0.5 (AENV, 2010)

TC = 0.18 (mg/m^3)

ET = 1.0

The analytical results from previous ESAs that were greater than the applicable AENV 2010 *Alberta Tier 1 and 2 Soil and Groundwater Remediation Guidelines* during monitoring/sampling events for soil and groundwater were used to calculate soil vapour for fine-grained soils using the Health Canada Partitioning equations, with the exception of PHC fractions F1 and F2. PHC fractions F1and F2 are not Schedule 11 parameters under BC CSR, and therefore no attenuation factor is available. As stated above, the MoE attenuation factor was applied for an earthen basement for screening purposes as there are no similar factors for earthen basements in Alberta and CCME guidelines.

3.0 RESULTS

Non-compliant PCOC concentrations from previous ESAs closest to the residential building occur in 08MW02 in both soil and groundwater for benzene, ethylbenzene, and xylenes. When soil vapour concentrations were calculated at 08MW02, benzene and xylene exceeded maximum acceptable concentrations for soil vapour in both indoor and outdoor air (see Table 1). The calculated soil vapour also exceeded for ethylbenzene in indoor air (see Table 1).

Using the data available the local groundwater flow direction is inferred to be to the south-southwest (cross-gradient to the residence) and the gradient has been described as “relatively flat”. Locally, groundwater has been encountered at approximate depths ranging from 1.7 metres below ground surface (mbgs) – 2.3 mbgs. There are some local variations as only a limited data set was available. The flow direction, depth and gradient imply that significant increases in PCOC vapour concentration from groundwater are less likely than if overall groundwater flow was toward the residence.

Although partitioning is a conservative approach, there are significant exceedences in both indoor and outdoor air such that exceedences in sampled soil vapour would also be likely and could extend to the residence. Some of the parameters for calculated soil vapour from soil exceeded the BC CSR standards up to 6,800 times (i.e., benzene in indoor air at 08MW02, which is one of the closest wells to the residence). In addition, calculated soil vapour from groundwater exceeded the BC CSR standards up to over 3,000 times for benzene.

It is recommended that further soil vapour investigation and/or remediation occur. Given the apparent risk to the residential and possibly commercial receptors via inhalation of indoor air, it is recommended that indoor air quality samples be collected in the near future. Tetra Tech EBA advises that indoor air samples can be compromised in some settings due to occupant activities or materials storage. It is therefore advised that air in the structures be sampled in several locations. It is further recommended that relatively concurrent collection of soil vapour samples be carried out in order to more fully characterize potential false positives in the indoor air samples. PHC fraction F1 and F2 partitioning and attenuation can be evaluated if required using the Health Canada Detailed Quantitative Risk Assessment (DQRA) model. Finally, It is recommended that the groundwater flow direction be confirmed through monitoring the entire groundwater monitoring well network.

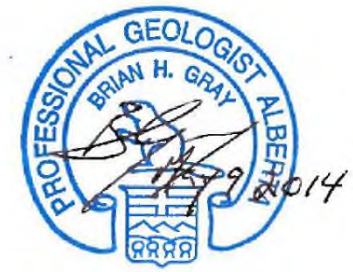
4.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Village of Barons and their agents. Tetra Tech EBA Inc. (Tetra Tech EBA) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Village of Barons, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this report is subject to the terms and conditions stated in Tetra Tech EBA’s Services Agreement. Tetra Tech EBA’s General Conditions are attached.

5.0 CLOSURE

We trust this letter report meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech EBA Inc.



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Attachments Table 1: Vapour Partitioning Results
Tetra Tech EBA's General Conditions

ATTACHMENTS

Table 1: Vapour Partitioning Results

APEC	Location	Matrix	Soil Type	Depth (m)	Parameter	NAPL *	C_{vapour}	MAC	CSR Standard	Coutdoor Air**	Cindoor Air**
1	08MW01	Soil	fine-grained	4.2	Benzene	No	1003044.507	3	1.5	*1.00E+02*	*1.00E+04*
1	08MW01	Soil	fine-grained	4.2	Ethylbenzene	No	767055.9966	500	1000	7.67E+01	*1.53E+04*
1	08MW01	Soil	fine-grained	4.2	Xylenes (total)	No	561684.4756	90	100	5.62E+01	*1.12E+04*
1	08MW01	Groundwater	fine-grained	1.7	Benzene	No	614390.7168	3	1.5	*6.14E+01*	*1.23E+04*
1	08MW01	Groundwater	fine-grained	1.7	Ethylbenzene	Yes	39124.0742	500	1000	3.91E+00	*7.82E+02*
1	08MW01	Groundwater	fine-grained	1.7	Xylenes (total)	Yes	34911.00077	90	100	3.49E+00	*6.98E+02*
1	08MW02	Soil	fine-grained	2.2	Benzene	No	509482.924	3	1.5	*5.09E+01*	*1.02E+04*
1	08MW02	Soil	fine-grained	2.2	Ethylbenzene	No	2419176.605	500	1000	2.42E+02	*4.84E+04*
1	08MW02	Soil	fine-grained	2.2	Xylenes (total)	No	1755263.986	90	100	*1.76E+02*	*3.51E+04*
1	08MW02	Groundwater	fine-grained	2.32	Benzene	No	176485.6637	3	1.5	*1.76E+01*	*3.53E+03*
1	08MW02	Groundwater	fine-grained	2.32	Ethylbenzene	Yes	26222.01227	500	1000	2.62E+00	*5.24E+02*
1	08MW02	Groundwater	fine-grained	2.32	Xylenes (total)	Yes	27492.99845	90	100	2.75E+00	*5.50E+02*
1	08BH03	Soil	fine-grained	1.2	Benzene	No	23882.01206	3	1.5	2.39E+00	*4.78E+02*
1	08BH03	Soil	fine-grained	1.2	Ethylbenzene	No	12390.90456	500	1000	1.24E+00	2.48E+02
1	08BH03	Soil	fine-grained	1.8	Benzene	No	8597524.343	3	1.5	*8.60E+02*	*1.72E+05*
1	08BH03	Soil	fine-grained	1.8	Toluene	No	616410.6703	1910	5000	6.16E+01	*1.23E+04*
1	08BH03	Soil	fine-grained	1.8	Ethylbenzene	Yes	18291335.3	500	1000	*1.83E+03*	*3.66E+05*
1	08BH03	Soil	fine-grained	1.8	Xylenes (total)	Yes	52657919.59	90	100	*5.27E+03*	*1.05E+06*
1	08BH04	Soil	fine-grained	3	Benzene	No	3025054.861	3	1.5	*3.03E+02*	*6.05E+04*
1	08BH04	Soil	fine-grained	3	Ethylbenzene	No	2124155.067	500	1000	2.12E+02	*4.25E+04*
1	08BH04	Soil	fine-grained	3	Xylenes (total)	No	1755263.986	90	100	*1.76E+02*	*3.51E+04*
1	08BH05	Soil	fine-grained	2.4	Benzene	No	175134.7551	3	1.5	*1.75E+01*	*3.50E+03*
1	08BH05	Soil	fine-grained	2.4	Ethylbenzene	No	371727.1368	500	1000	3.72E+01	*7.43E+03*
1	08MW06	Soil	fine-grained	2.4	Benzene	No	318426.8275	3	1.5	*3.18E+01*	*6.37E+03*
1	08MW06	Soil	fine-grained	2.4	Ethylbenzene	No	1239090.456	500	1000	1.24E+02	*2.48E+04*
1	08MW06	Soil	fine-grained	2.4	Xylenes (total)	No	1088263.671	90	100	*1.09E+02*	*2.18E+04*
1	08MW06	Groundwater	fine-grained	0	Benzene	Yes	214600.7655	3	1.5	*2.15E+01*	*4.29E+03*
1	08MW06	Groundwater	fine-grained	0	Ethylbenzene	Yes	5914.194325	500	1000	5.91E-01	1.18E+02
1	08MW06	Groundwater	fine-grained	0	Xylenes (total)	Yes	7370.160877	90	100	7.37E-01	*1.47E+02*
1	08MW07	Groundwater	fine-grained	0	Benzene	No	6176.99823	3	1.5	6.18E-01	*1.24E+02*
1	09MW10	Groundwater	fine-grained	2.33	Benzene	No	14339.46018	3	1.5	1.43E+00	*2.87E+02*
1	09BH12	Soil	fine-grained	3	Benzene	No	238820.1206	3	1.5	*2.39E+01*	*4.78E+03*
1	09BH12	Soil	fine-grained	3	Ethylbenzene	No	708051.6891	500	1000	7.08E+01	*1.42E+04*
1	09BH12	Soil	fine-grained	3	Xylenes (total)	No	631895.035	90	100	6.32E+01	*1.26E+04*
1	09MW13	Soil	fine-grained	4.8	Benzene	No	8597.524343	3	1.5	8.60E-01	*1.72E+02*
1	09MW13	Groundwater	fine-grained	0	Benzene	Yes	116854.0496	3	1.5	*1.17E+01*	*2.34E+03*
1	09MW13	Groundwater	fine-grained	0	Ethylbenzene	Yes	4674.161986	500	1000	4.67E-01	9.35E+01
1	09MW13	Groundwater	fine-grained	0	Xylenes (total)	Yes	5180.76067	90	100	5.18E-01	*1.04E+02*
1	09BH17	Soil	fine-grained	3	Benzene	No	154437.0113	3	1.5	*1.54E+01*	*3.09E+03*
1	09BH17	Soil	fine-grained	3	Ethylbenzene	No	1121081.841	500	1000	1.12E+02	*2.24E+04*
1	09BH17	Soil	fine-grained	3	Xylenes (total)	No	1018053.112	90	100	*1.02E+02*	*2.04E+04*
1	09MW19	Groundwater	fine-grained	0	Benzene	No	25369.81416	3	1.5	2.54E+00	*5.07E+02*
1	09BH20	Soil	fine-grained	3	Benzene	No	1544370.113	3	1.5	*1.54E+02*	*3.09E+04*
1	09BH20	Soil	fine-grained	3	Ethylbenzene	No	1239090.456	500	1000	1.24E+02	*2.48E+04*
1	09BH20	Soil	fine-grained	3	Xylenes (total)	No	1263790.07	90	100	*1.26E+02*	*2.53E+04*
1	09BH20	Soil	fine-grained	3.6	Benzene	No	84383.10929	3	1.5	*8.44E+00*	*1.69E+03*
1	09BH20	Soil	fine-grained	3.6	Ethylbenzene	No	11800.86149	500	1000	1.18E+00	2.36E+02
1	11MW01	Soil	fine-grained	2.4	Ethylbenzene	No	324523.6909	500	1000	3.25E+01	*6.49E+03*
1	11MW01	Soil	fine-grained	2.4	Xylenes (total)	No	561684.4756	90	100	5.62E+01	*1.12E+04*
1	North Wall	Soil	fine-grained	4.9	Benzene	No	60501.09723	3	1.5	*6.05E+00*	*1.21E+03*
1	North Wall	Soil	fine-grained	4.9	Ethylbenzene	No	76705.59966	500	1000	7.67E+00	*1.53E+03*
1	South Wall	Soil	fine-grained	4.9	Ethylbenzene	No	12390.90456	500	1000	1.24E+00	2.48E+02
1	East Wall	Soil	fine-grained	4.9	Benzene	No	66869.63378	3	1.5	*6.69E+00*	*1.34E+03*
1	East Wall	Soil	fine-grained	4.9	Ethylbenzene	No	590043.0743	500	1000	5.90E+01	*1.18E+04*

NOTES:

All vapour concentrations are presented in ug/m^3.

* NAPL presence was calculated using Health Canada Protocol 16. For DNAPLs in groundwater, if the concentration of the substance is 0.1 * the pure substance solubility, NAPL was assumed to be present. For LNAPLs in groundwater, NAPLs were assumed to be present when the molar fraction of a compound exceeded the pure substance solubility. For soil, if the concentration exceeded the soil saturation value, NAPL was assumed to be present.

** Indoor and Outdoor concentrations have been multiplied by an applicable BC Ministry of Environment attenuation factor based on the depth to determine final concentrations

APEC Area of Potential Environmental Concern

MAC Maximum acceptable air concentration value (MAC) for non-carcinogens for BTEX taken from Health Canada, 2012, Preliminary Quantitative Risk Assessment (PQRA) Guidance

CSR BC Contaminated Sites Regulation (BC Reg. 375/96, includes amendments up to B.C. Reg. 4/2014, January 31, 2014 - Schedule 11).

C_{vapour} Vapour concentration without attenuation

$C_{vapour,s,i}$ Vapour concentration for soils beneath buildings at a depth of less than 1 m

Italics Italics and shaded indicates an exceedance of the MAC.

1 As recommended in Technical Guidance 4 on Contaminated Sites "*Vapour Investigation and Remediation*", published by BC Ministry of Environment September 2010, the vapour concentrations in the breathing zone can be estimated from soil and groundwater concentrations using the equations found in Exhibit 2 of "*Federal Contaminated Site Risk Assessment in Canada: Part VII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites*" published by Health Canada, dated September, 2010, and by using MOE-approved vapour attenuation factors.

2 Chemical-specific parameters have been taken from Health Canada Detailed Quantitative Risk Assessment (DQRA) Spreadsheet Tool dated May 1, 2009. Where not available, chemical specific parameters were then taken from BC MOE Protocol 13 "*Screening Level Risk Assessment*" Table A-1.

3 Vapour Attenuation Factors have been taken from Table 2 - Default vapour attenuation factors of BC Ministry of Environment Technical Guidance 4 on Contaminated Sites "*Vapour Investigation and Remediation*" Version 1, Sept. 2010.

4 Air concentrations are compared to Environmental Management Act, Contaminated Sites Regulation (BC Reg. 375/961 including amendments up to B.C. Reg. 4/2014, January 31, 2014 Schedule 11, Generic Numerical Vapour Standards.

5 Temperature corrected Henry's Law constants are adjusted as follows: If soil partitioning is used, the Henry's Law constant is calculated at the median soil temperature of the region indicated for outdoor air, and the average of this value and an indoor air temperature of 20 degrees Celsius for indoor air. For groundwater, the Henry's Law constant has been calculated using a groundwater temperature of 10 degrees Celsius. All temperatures used in calculations use the same temperatures for the situations described.

GENERAL CONDITIONS

GEOENVIRONMENTAL REPORT

This report incorporates and is subject to these “General Conditions”.

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This report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site or proposed development would necessitate a supplementary investigation and assessment.

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During the performance of the work and the preparation of the report, TETRA TECH may rely on information provided by persons other than the Client. While TETRA TECH endeavours to verify the accuracy of such information when instructed to do so by the Client, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information which may affect the report.