Integrated Site Assessment and Risk Assessment for a Proposed Real Estate Transaction at a PCE-impacted Drycleaner Site

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Presentation Outline

- Project Overview
- Background
- Introduction of Integrated Risk Based Approach and Components
- Supplementary Investigation
- Tier II Modification and Quantitative Risk Assessment
- Discussion and Conclusions

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Project Overview

- Project Period - December 2004 to March 2005
- Project Initiator - Due diligence of a proposed real estate transaction and obtaining required financing and necessary Insurance
- Chemicals of Potential Concern identified from Phase I and II ESAs:

  - PCE

Breakdown products:

- TCE
- DCE (cis/trans)
- VC

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Background

- Previous Environmental Work - 1996 and 2003
- Phase I and II ESA – December 2004 by Jacques Whitford
- Soil stratigraphy – sand/gravel fill to 4.4. meters below grade underlain by fractured sandstone bedrock
- Land use

  - Onsite: Commercial

  - Offsite: commercial (N), commercial (E), residential (W) and Commercial/residential (S)

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Background

- Regional groundwater flow and nearest surface water body

  - West towards Nose Creek, 80 m west of the dry cleaner location
- PCE exceedance in soil and groundwater underneath the dry cleaner location
- Soil: at depths from 2.3 (1.26 mg/kg) to 3.8 meter below grade (2.48 mg/kg) in borehole MW 1 inside the dry cleaning premises
- Groundwater

  - 339 µg/L at MW1 inside the dry cleaner premises

  - 153 µg/L at MW2 east of the dry cleaner premises

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Components of the Integrated Site Assessments and Risk Assessment

- Supplementary Soil and Groundwater Investigation
- Indoor Air Quality Assessment
- Tier II Modification and Quantitative Human Health Risk Assessment

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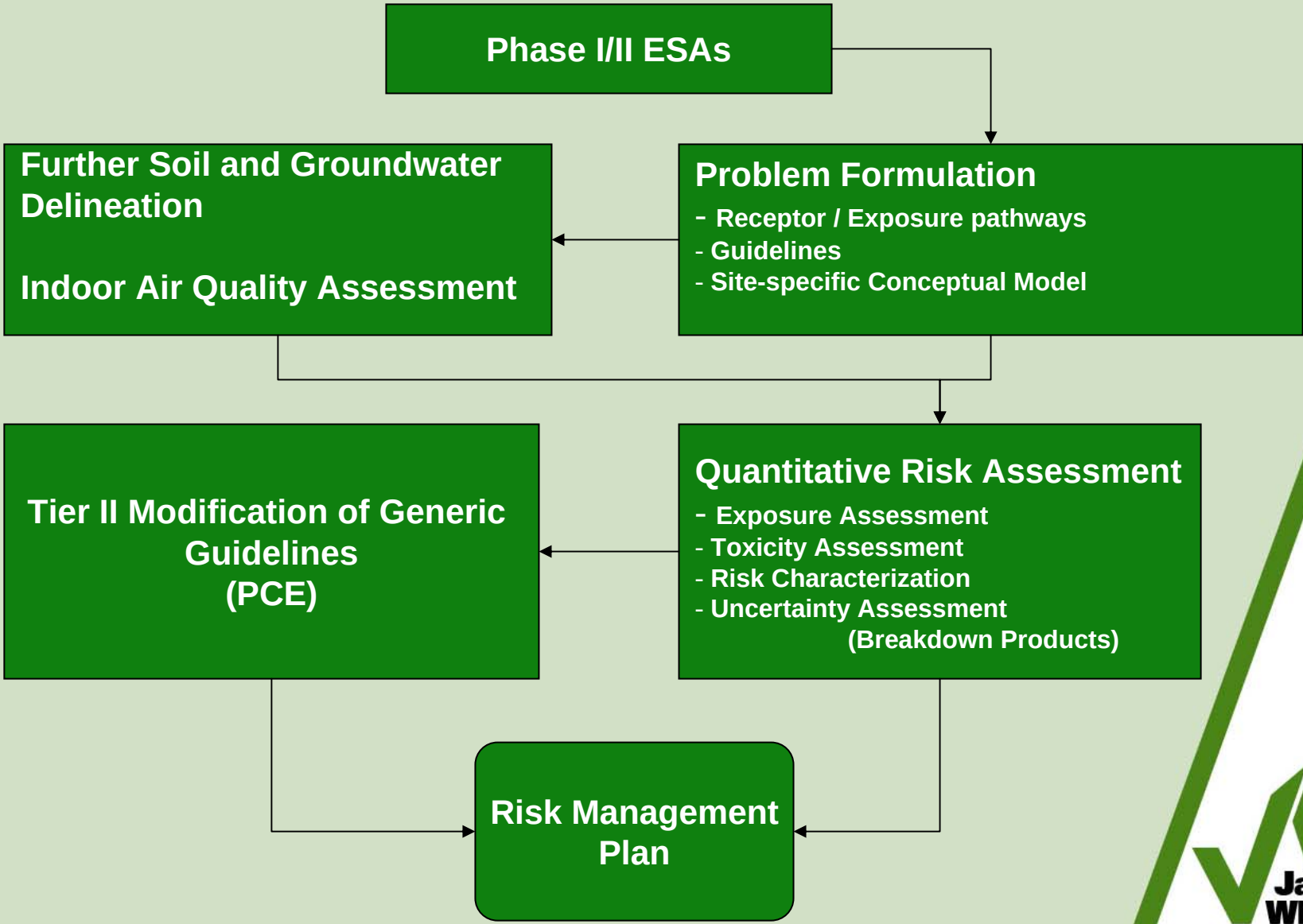
Integrated Site Assessments and Risk Assessment Process



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Advantages of Using Risk Assessment

- Flexibility - risk-based approach allows an examination of management options that best fit with client or site priorities.

- Well-accepted - Process has been approved by regulators and accepted by clients and lenders.

- Remediate only those sites or areas where there is an “actual risk” to either humans or the environment.

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Supplementary Investigation

- Installation of five additional monitoring wells
- CCME Commercial Soil Quality Guidelines
- CCME Drinking Water and Freshwater Aquatic Life Guidelines
- Spatial Distribution of PCE soil impact is localized primary beneath the foot print of the dry cleaning space and east towards the monitoring well location MW2 (5 m east)
- The worst case concentrations appear to exist in the shallow soil layer underlying the dry cleaning machine.

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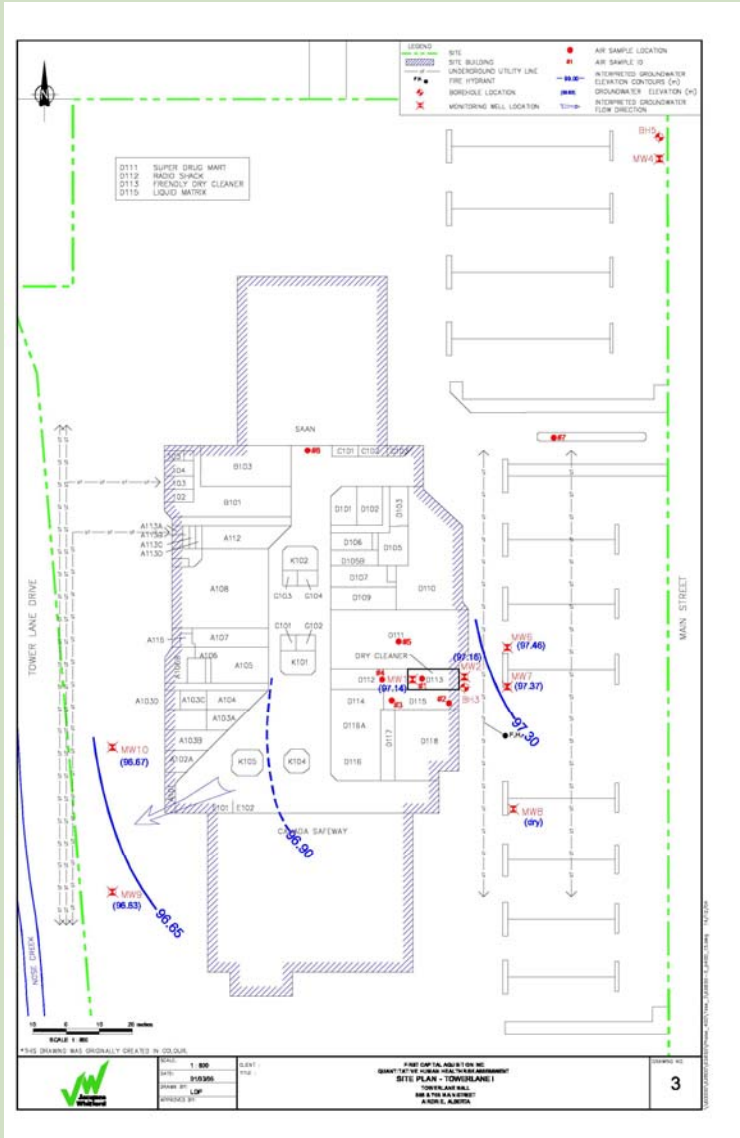
Supplementary Investigation



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Indoor Air Quality Assessment

- Indoor air samples were collected using a SKC Universal XR sample pump and thermal desorption tubes
- Risk based reference values indicating concentrations of the parameters showing no human health adverse effects
- Occupational Health and Safety Guidelines (8 hr Threshold Limit Value)
- Detectable PCE concentrations were recorded in the dry cleaner premises and adjoining tenant locations

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Tier II Modification & Quantitative Risk Assessment

- Alberta Environment allows modification of generic regulatory guidelines by replacing generic parameters with site-specific information
- Modification of generic guidelines is also known as the Tier II approach
- Tier II modification uses similar methods and assumptions as those used to develop the Canadian Soil Quality Guidelines
- The modified criteria must be protective of both current and reasonably foreseeable future land uses

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Tier II Modification & Quantitative Risk Assessment

- Chemicals of Potential Concern identified from Phase I and II ESAs

Chemicals of Potential Concern					
Chemicals of Concern	**Potential Source**	**Maximum Measured Concentration**			**Carried Forward in Risk Assessment**
		Indoor Air (mg/m^3)	**Soil (mg/kg)**	**Groundwater (mg/L)**	
PCE	Operations associated with the on-site dry cleaner.	0.056	2.48	0.339	Yes
TCE		< 0.002	< 0.03	0.003	Yes
1,1-DCE		NS	< 0.03	< 0.002	Yes
cis-1,2-DCE		< 0.002[1]	< 0.03	< 0.002	Yes
Trans-1,2-DCE			< 0.03	< 0.002	Yes
Vinyl Chloride		< 0.003	< 0.03	< 0.002	Yes

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Receptor Identification

- Human Receptors
  - Non-carcinogens – Toddler (6 months – 4 years)
  - Carcinogens – Adult Worker (56 years)
  - Receptors assumed to be on the site 10 hr/day, 5 day/yr, 48 wks/yr
- Ecological Receptors
  - Based on site conditions no ecological receptors are anticipated to be impacted by the CoPCs
  - Ecological receptors were not assessed further

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Exposure Pathway Evaluation

Potential Exposure Scenarios			
Exposure Pathway Description (On-site and Off-site)	**Likelihood of Exposure**	**Carried Forward for Quantitative Analysis?**	**Justification**
Inhalation of subsurface soil vapours indoors	Possible on-site Nothing off-site.	Yes	•soil & groundwater vapours may migrate into the on-site buildings
Inhalation of groundwater vapours indoors			
Inhalation of subsurface soil vapours outdoors	Unlikely	No	•soil & groundwater vapours may migrate into outdoor air becoming diluted •exposure minimal when compared to indoor air
Inhalation of groundwater vapours outdoors			

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Exposure Pathway Evaluation

Potential Exposure Scenarios Considered Very Unlikely		
Exposure Pathway Description (On-site and Off-site)	**Carried Forward for Further Analysis?**	**Justification**
Ingestion, Dermal Contact, Inhalation of surface soil/dust	No	•Site is Covered •CoPCs at a depth of 2.0 m
Ingestion, Dermal Contact of surface water	No	•no surface water bodies on-site •transport to surface water is not expected •closest surface water is Nose Creek
Ingestion, Dermal Contact of groundwater	No	•Groundwater not used as a potable drinking water source.
Ingestion of vegetation, garden produce	No	•soil and groundwater impacts below the root uptake zone •commercial site with no grown produce

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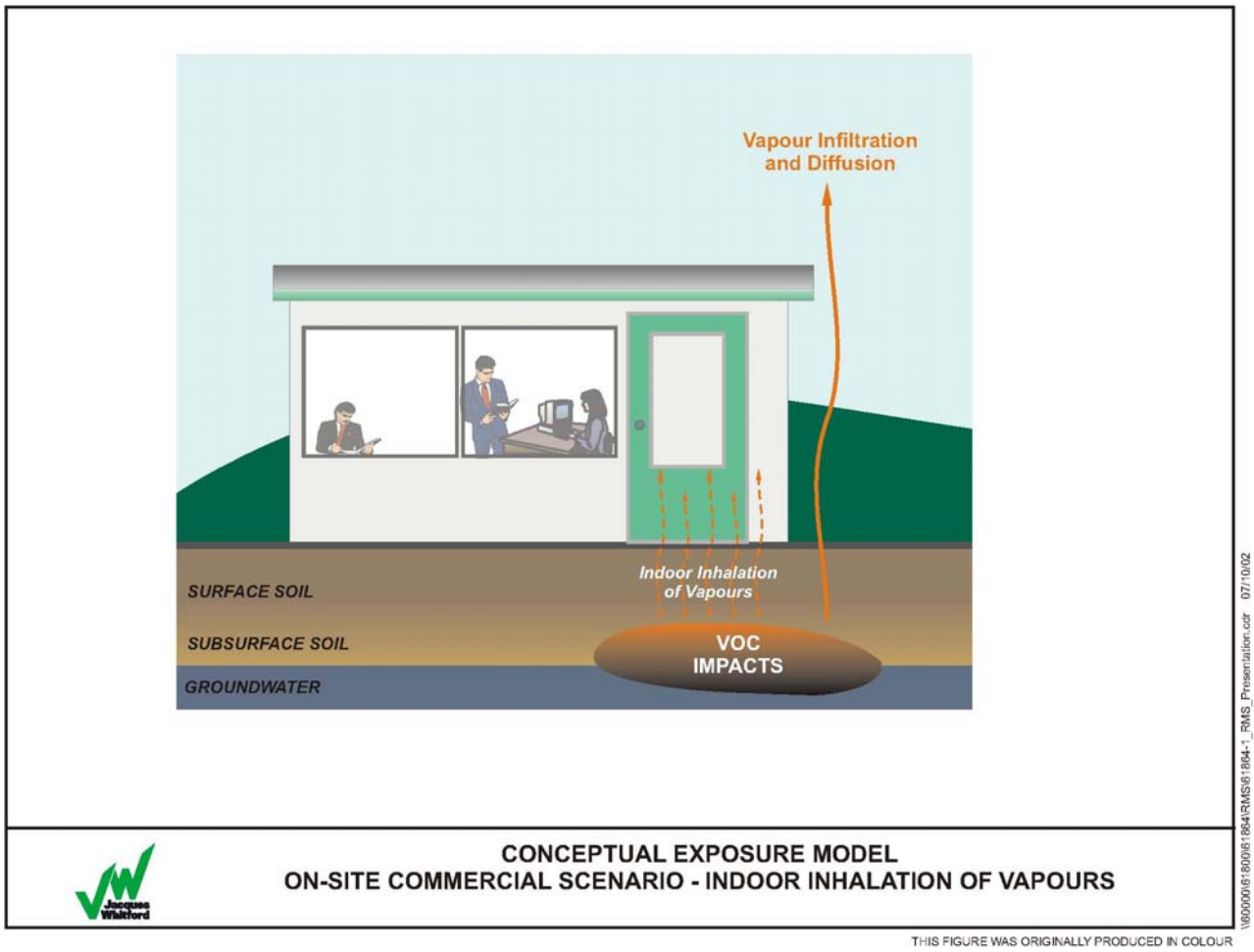
Conceptual Exposure Model



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Tier II Modification & Quantitative Risk Assessment

- Conceptual Exposure Model
  - VOC vapours from the impacted soil and groundwater diffuse upward through the soil and into the dry cleaner building through cracks in the floor slab. On-site receptors may inhale the vapours in indoor air.

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Tier II Modification Procedures – Indoor Inhalation Pathway

$$SQG_{II} = \frac{(RfC - C_a) \times \left(\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + \left(\frac{H}{RT} \times \theta_a \right) \right) SAF \times DF_i \times 10^3 \, g/kg}{\frac{H}{RT} \times \rho_b \times 10^6 \, cm^3/m^3 \times ET} + BSC$$

Where:

SQGII	= soil quality guideline by indoor infiltration for volatiles using RfC	mg/kg
RfC	= reference air concentration	mg/m^3
Ca	= background indoor/outdoor air concentration	mg/m^3
SAF	= soil allocation factor	unitless
θa	= vapour filled porosity	unitless
θw	= moisture filled porosity	unitless
Koc	= organic carbon partition coefficient	mL/g
foc	= soil organic carbon fraction in contaminant partitioning zone	g/g
ρb	= soil dry bulk density in contaminant partitioning zone	g/cm^3
H	= Henry's Law Constant	$atm\text{-}m^3/mol$
R	= universal gas constant	$atm\text{-}m^3/mol\text{-}K$
T	= annual average soil temperature	K
DFi	= dilution factor from soil gas to indoor air	unitless
ET	= exposure term (8/24*5/7*48/52)	unitless
BSC	= background soil concentration (CCME, 1996b)	mg/kg

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Tier II Modification

- Maximum concentrations of PCE in both soil and groundwater were below Risk Based Quality Guidelines (RBQG)

Modified Risk-Based Soil and Groundwater Quality Guidelines for Inhalation of Vapours in Indoor Air				
Parameter	Soil (mg/kg)		Groundwater (mg/L)	
	Maximum Measured Concentration	RBQG	Maximum Measured Concentration	RBQG
PCE	2.48	18	0.339	22

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Tier II Modification vs. Generic Guidelines

Comparison of Generic to Modified Risk-Based Quality Guidelines			
Parameter	Generic		Modified Risk Based
	Guideline	Source	
Subsurface Soil (mg/kg)			
PCE	0.5[1]	CCME, 2004 Soil Quality Guidelines for Commercial Land Use	18
Groundwater (mg/L)			
PCE	0.111	CCME, 2004 Canadian Guidelines for Freshwater Aquatic Life	22

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Quantitative Risk Assessment

- Conducted to derive risk based remediation criteria (RBRC) for PCE breakdown products
- Assumed maximum CoPC concentrations in soil and groundwater present beneath the entire floor slab
- Predicted indoor air concentrations were greater than measured indoor air concentrations indicating the conservatism of the modelling

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Dose-Response Assessment

Toxicity Reference Values		
Chemical	**RfC (inhalation) (mg/m^3)**	**RSC (inhalation) (mg/m^3)**
TCE	NA	1.64E-02 [c]
cis-1,2-DCE	1.77E-02 [b]	NA
trans-1,2-DCE	3.55E-02 [a]	NA
1,1-DCE	2.00E-01 [a]	NA
Vinyl Chloride	NA	2.30E-03 [a]

Notes:

[A] US EPA IRIS database, 2004

[b] US EPA PPRTV, 2002

[c] Health Canada, 2003

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Estimation of Receptor Dose

$$CDI = \frac{C \times CR \times EF \times ED}{BW \times AT}$$

Where

CDI = Chronic Daily Intake (mg per kg of body weight per day)

C = Exposure Point Concentration (e.g. mg/L or mg/kg)

CR = Contact rate (e.g. L/day or m^3/day)

EF = Exposure frequency (days/year)

BW = Body weight (kg)

AT = Average time (days)

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Hazard Assessment (non-carcinogens)

$$\text{Hazard Quotient (HQ)} = \frac{\text{Chronic Daily Intake (CDI)}}{\text{Tolerable Daily Intake (TDI)}}$$

Acceptable Hazard Levels

HQ < 1.0 if all pathways are considered, then the intake is not considered to pose a health threat.

HQ < 0.2 to account for 80% of exposure to a CoPC from the background environment.

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Hazard Assesment (Carcinogens)

Incremental Life Cancer Risk (ILCR)

= Lifetime Average Daily Dose x Cancer Slope Factor

The ILCR is typically expressed:

e.g. $3x10^{-6}$ for three additional cases in a million

- Acceptable level of risk
  - 1 additional cancer case in 100 000 people (1×10^{-5})
- NOTE: 1 in 3 Canadians will get cancer in their lifetime so risk assessment allows for 0.40001 instead of 0.40000 cases in a population

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SUMMARY OF RISK ESTIMATES

Summary of Risk Estimates		
Parameter	**HQ**	**ILCR**
Total		
TCE	NA	8.57E-08
cis-1,2-DCE	1.01E-02	NA
trans-1,2-DCE	8.58E-03	NA
1,1-DCE	3.41E-03	NA
Vinyl Chloride	NA	5.31E-06

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Risk Based Soil and Groundwater Criteria

Risk Based Soil and Groundwater Remediation Criteria [1]				
Parameter	**Non-Carcinogen**		**Carcinogen**	
	Maximum Measured Concentration	**RBRC**	**Maximum Measured Concentration**	**RBRC**
Sub-Surface Soil (mg/kg)				
TCE	NA		ND	2.06
cis-1,2-DCE	ND	1.10	NA	
trans-1,2-DCE	ND	1.30	NA	
1,1-DCE	ND	3.30	NA	
Vinyl Chloride	NA		ND	0.029
Groundwater (mg/L)				
TCE	NA		0.003	2.4
cis-1,2-DCE	ND	4.51	NA	
trans-1,2-DCE	ND	3.79	NA	
1,1-DCE	ND	7.35	NA	
Vinyl Chloride	NA		ND	0.10

Notes:

[1] based on HI of 0.2 and ILCR of 1E-05 targets in coarse-grained soil.

NA – not applicable

ND – not detected

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Conclusions

- Use of site-specific data to generate modified risk-based guidelines resulted in an increase of the generic guidelines.
- QRA did not predict unacceptable risks to receptors at the site under current land use scenario for any of the CoPCs.
- Using conservative assumptions presented in this report, there are no potential adverse health effects associated with the exposure of receptors to the maximum concentrations of CoPCs measured to date.

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Project Postscript

- The integrated site assessment and risk assessment approach was successfully implemented to meet project stakeholders' needs.

- The end result was "Win-Win" as the real estate transaction was completed and the purchaser was successful in obtaining the necessary insurance and financing to complete the transaction.

- A Risk Management Plan including groundwater monitoring and ventilation upgrading, was developed and is being implemented.

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Questions?

Thank you!

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