Vapour Intrusion Risk Assessment Methodology: A Comparison of Empirical versus Modeled (J&E) Soil Vapour and Indoor Air Concentrations

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January 29, 2015

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Outline

- Introduction
- Vapour Intrusion and Risk Assessments under O. Reg. 153/04
- J&E Model vs Indoor Air data
- J&E Model (Source Vapour) vs Soil Gas data

Who are we?

- **Exp** heritage dates back to 1906.
- In 2011 Trow Global became **exp**.
- **Exp** provide professional, technical and strategic services in six key practice areas:
  - Buildings
  - Earth & Environment
  - Energy
  - Industrial
  - Infrastructure
  - Sustainability
- Today, **exp** has over 95 offices across North America and around the globe

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Key Environmental Services

- Due Diligence Assessments
- Compliance Audits
- Phase One ESA
- Phase Two ESA
- Site Remediation
  - Various methods both in-situ, ex-situ
- **Risk Assessment (RA)**
  - **Screening Level, MGRA or RA in accordance with O. Reg. 153/04**
- Regulatory (RSC, CofAs)
- Legal Work
  - Expert Opinions
  - Forensic Investigations
- Peer Review

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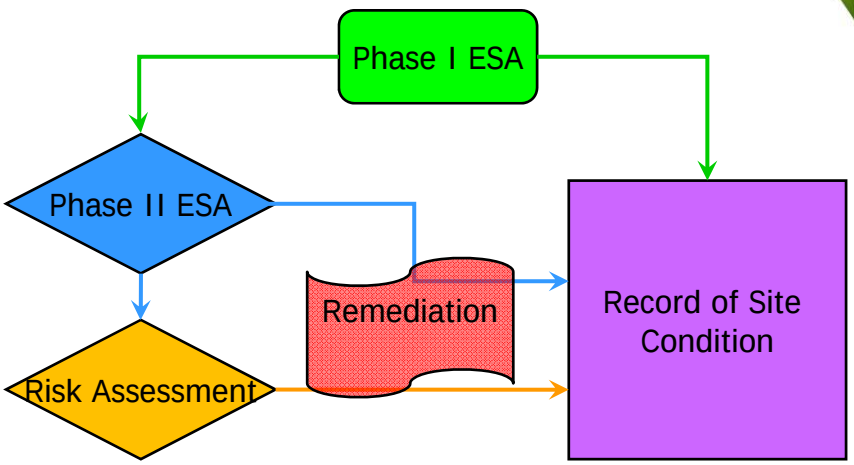
Ontario Regulation 153/04

Record of Site Condition - Part XV.1 OF the Act



From MOE, October 2004

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Risk Assessment

Main Components

- Site characterizations
- Human Health Risk Assessment
  - **Vapour Intrusion Pathway**
- Ecological Risk Assessment
- Development of Site Specific Standards
- Remediation / **Risk Management Plan**

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Common Chemicals of Concern

- Petroleum hydrocarbons: BTEX, PHC F1 and F2, MTBE, dibromoethane, etc.
- Chlorinated hydrocarbons associated with degreasers, dry cleaning & other industries including:
  - Chloro-ethenes such as PCE and TCE
  - Chloro-ethanes such as carbon tetrachloride or 1,1,1- trichloroethane
- Semi-volatiles: polycyclic aromatic hydrocarbons (PAHs) (naphthalene)
- Biologically-generated gases from organics: methane, carbon dioxide & in some cases hydrocarbon sulphide

Adopted from Soil Vapour Presentation by Dr. Ian Hers

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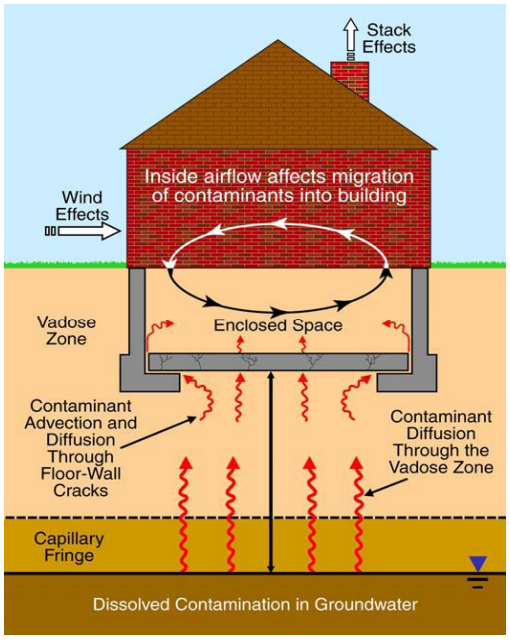

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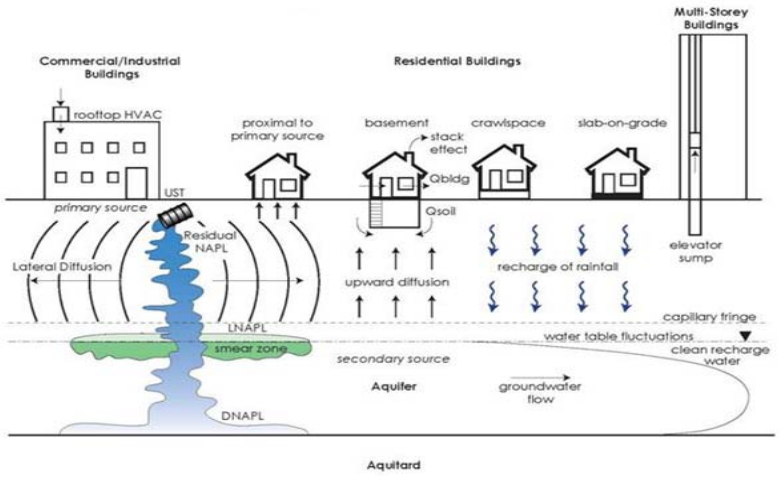
Vapour Intrusion Pathway – General Conceptual Site Model



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Johnson and Ettinger (J&E) Model

- J&E model is a screening-level model that incorporates both convective and diffusive mechanisms for estimating the transport of contaminant vapors emanating from either subsurface soils or ground water into indoor spaces located directly above the source of contamination.
- This model is used by MOE in development of Standards protective of the VI pathway.

$$C_{IA} = \text{Attenuation Factor } (\alpha) \times C_{source}$$

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Risk Management Options

- Vapour Barriers
- Venting Systems:
  - new vs existing buildings
  - passive vs active
  - combined with vapour barrier
- HVAC System Modifications
- Other allowances (parking garage; no 1st floor residential occupancy etc.)

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At What Cost?

RMP Objectives	Option	Proposed RMM	Estimated Incremental Cost[a]
New Building	1	Vapour barrier	$421,000 - 630,000
	2	Aerated floor	$251,000 - 290,000
	3	Parking garage	$6 - 8,000 per year 1-5 years
	4	Sub-slab depressurization	$111,000 - 200,000
Existing Building	1	Sub-slab depressurization	$211,000 - 300,000
	2	HVAC adjustments	$16,000 - 22,000

[a] An 80,000 square foot building footprint (0.74 ha) is assumed per existing building specifications.

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Draft MOE VI Guidance (2013)

Key Components / Changes in Direction

- Increased reliance on multiple lines of evidence assessments to address spatial and temporal variability
- More cautious screening evaluation
- Less reliance on VI modeling/ greater use of indoor air/soil vapour sampling
- Increased emphasis on engineering controls and preventive mitigation measures

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Indoor Air and Soil Gas Sampling

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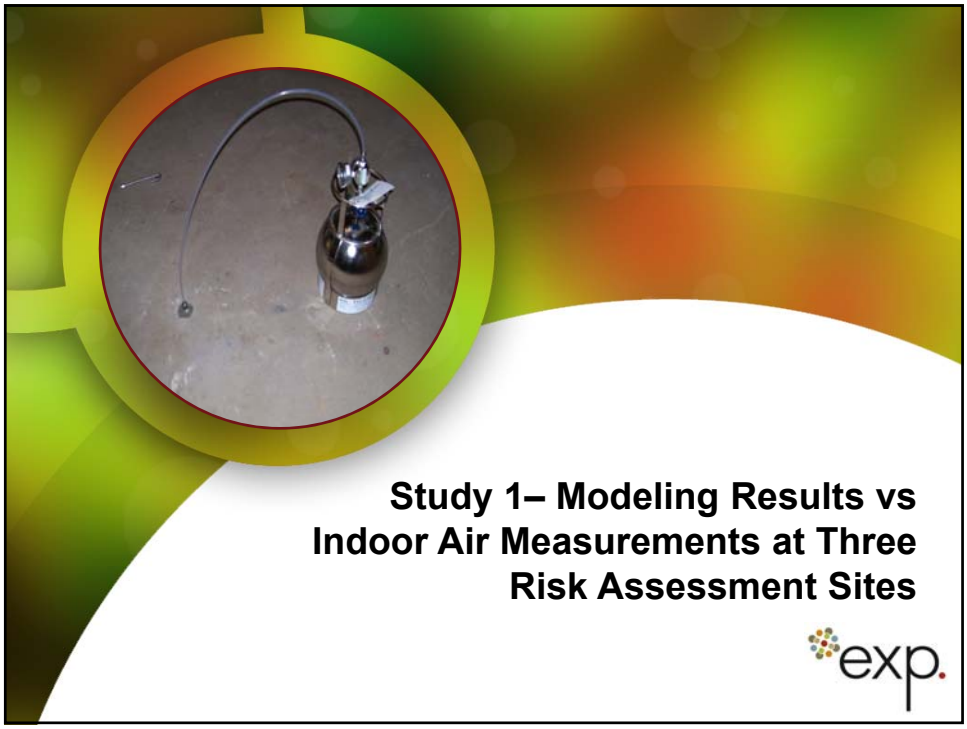

Study 1– Modeling Results vs Indoor Air Measurements at Three Risk Assessment Sites

Modeling Results vs Indoor Air Measurements

Three Properties

- St. Catharines
- Simcoe
- Toronto

- Chlorinated VOCs in soil and/or ground water
- Existing buildings (slab-on-grade)
- No HVAC
- Clients do not wish to demo

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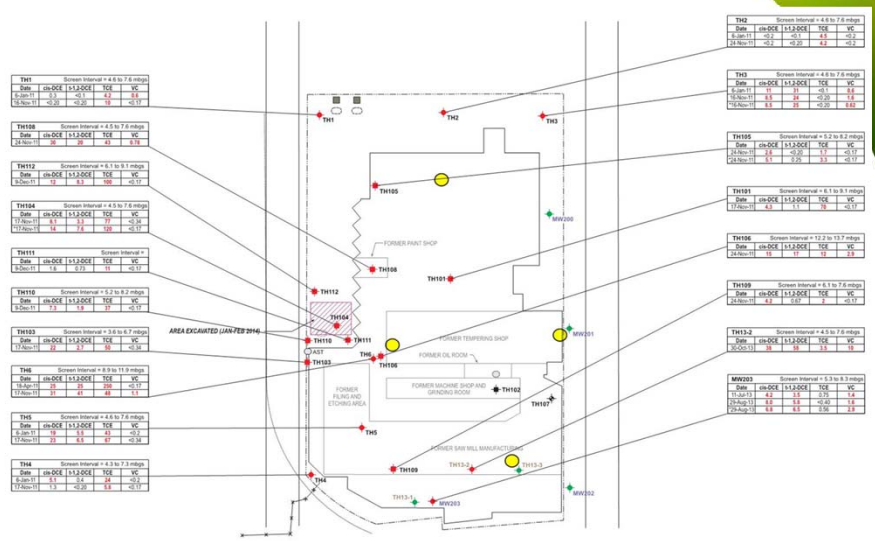
Toronto – VOCs in Ground Water



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J&E Predictions vs. Empirical – Indoor Air

Site	Indoor Air Concentration (ug/m³)		
	Predicted Using GW Data	***Predicted Using Soil Data***	***Measured***
PCE		***14***	
St. Catharines	37/ 4.2	ND	58
Simcoe	29	4770	19
TCE		***1.79***	
St. Catharines	0.08	ND	<0.27
Simcoe (deep)	22/ 6.7	1900	17
Simcoe (shallow)	7.3	NA	17
Toronto	8.6/ 1.7	66	0.53
VC		***0.406***	
St. Catharines	0.43	ND	<0.05
Simcoe	0.16	48	<0.05
Toronto	1.4	ND	<0.06

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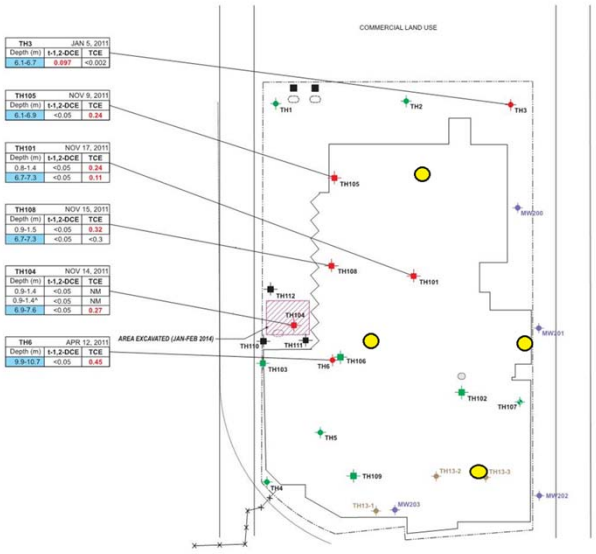
Toronto – VOCs in Soil



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Toronto	8.6/ 1.7	2.5	0.53
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Toronto – VOCs in Soil

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J&E Predictions vs. Empirical – Indoor Air

Site	Indoor Air Concentration (ug/m³)	
	Predicted	***Measured***
TCE	***1.79***	
Soil max (0.45 mg/kg)	66	0.53**
Soil max above wt (0.32 mg/kg)	47	
Soil max adjusted bldg dimensions	3.5	
Soil above wt adjusted bldg dimensions	2.5	
GW max*	8.6	
GW beneath bldg	2.4	
GW beneath bldg, adjusted bldg dimensions	0.43	

*GW max was measured at edge of building

**Measurements at other locations = 0.48 and 0.40 ug/m³

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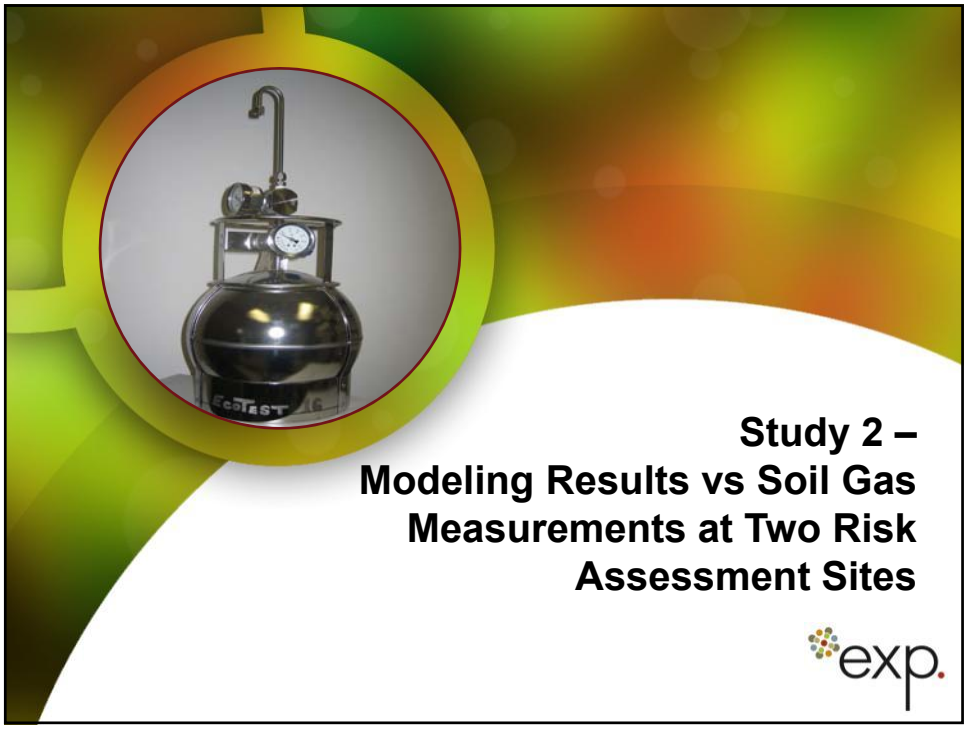

Study 2 – Modeling Results vs Soil Gas Measurements at Two Risk Assessment Sites

Modeling Results vs Soil Gas Measurements

Two Properties

- Ottawa (BTEX/ PHCs)
- Mississauga (Chlorinated VOCs)
- No existing buildings
- J&E modeling with soil/ ground water concentrations predicts unacceptable risk levels

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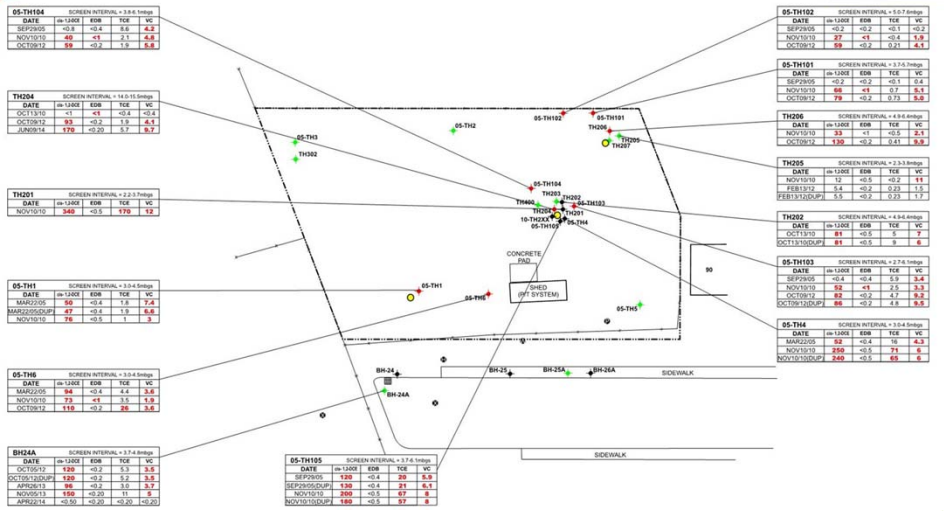
Mississauga – VOCs in Ground Water

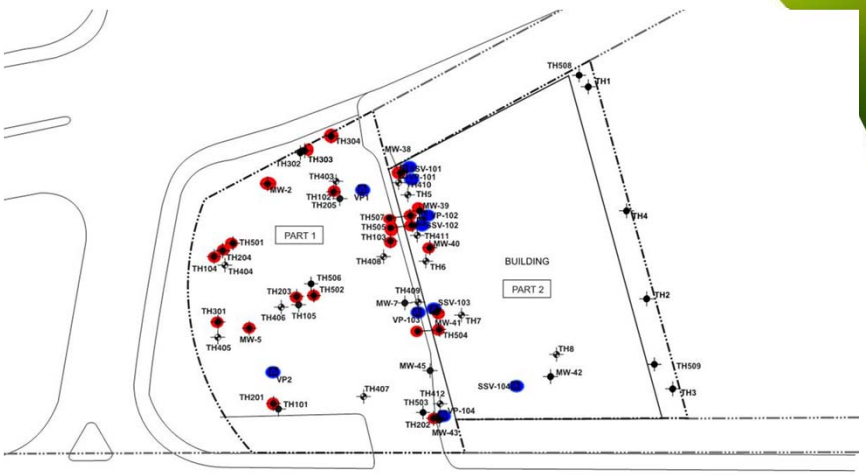


Mississauga VOCs at VP2

Parameter	*Concentration*	*Predicted Source Vapour*	*Measured Soil Gas (VP2; Nov. 2010)*	*Predicted IA Based on Soil/ GW**	*Predicted IA Based on Max Soil Gas Across Site**	*MOECC Criteria*
Ground Water (TH201; Oct. 2010)	*ug/L*	*mg/m^3*	*ug/m^3*	*ug/m^3*	*ug/m^3*	*ug/m^3*
TCE	170	45	ND (<1.6)	0.92	5.19E-03	1.79
cis-1,2-DCE	340	37	ND (<0.82)	0.84	2.38E-03	107
VC	12	10	ND (<0.46)	0.27	1.75E-03	0.41
Soil (TH4 or 05-TH105)	*mg/kg*					
TCE	0.76	430	ND (<1.6)	**100**	5.19E-03	1.79
1,1-DCE	0.60	1380	ND (<0.99)	**347**	3.40E-03	50

* predicted for slab on grade buildings

Ottawa – BTEX/PHC Sample Locations



Ottawa – PHCs and Benzene at VP-101 and VP-102

Parameter	*Concentration*	*Predicted Source Vapour*	*Measured Soil Gas (VP-101 or VP-102; May 2013)*	*Predicted IA Based on Soil/ GW**	*Predicted IA Based on Soil Gas**	*MOECC Criteria*
Benzene	*ug/L*	*mg/m³*	*ug/m³*	*ug/m³*	*ug/m³*	*ug/m³*
MW38 (June 2013)	690	101	4.35 (VP-101)	**19**	1.46E-03	1.63
MW39 (June 2013)	1500	219	1.07 (VP-102)	**41**	3.60E-04	
PHC F1						
MW39 (June 2013)	ND (<130)	4770	1574 (VP-102)	583	0.39	8540
MW40 (June 2013)	2100	77045	1574 (VP-102)	**9412**	0.39	
PHC F2						
MW39 (June 2013)	470	42918	450 (VP-102)	227	0.11	1610
MW40 (June 2013)	940	3319	450 (VP-102)	405	0.11	

* predicted for slab on grade buildings

Conclusions

- J&E model predictions using ground water data are not as conservative as we thought.
- J&E model predictions using soil data are very conservative compared to indoor air measurements or predictions using soil gas data.
- Adjusting the model for actual building dimensions has a large influence on results.
- Model may not account for sufficient natural attenuation in some cases.

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QUESTIONS?

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