
# A Look Back at the History of Risk Based Guidelines

## Remediation Technologies Symposium 2019

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# Outline

- A bit of history
- An evolution of guidelines in Canada
- Details on how risk we “quantify” risk
- Lists of pathways and receptor endpoints in various jurisdictions
- Examples of guideline calculations
- Myths busted

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# Before Risk Based Guidelines

- *de minimus*
- ‘background’
- analytical detection limits

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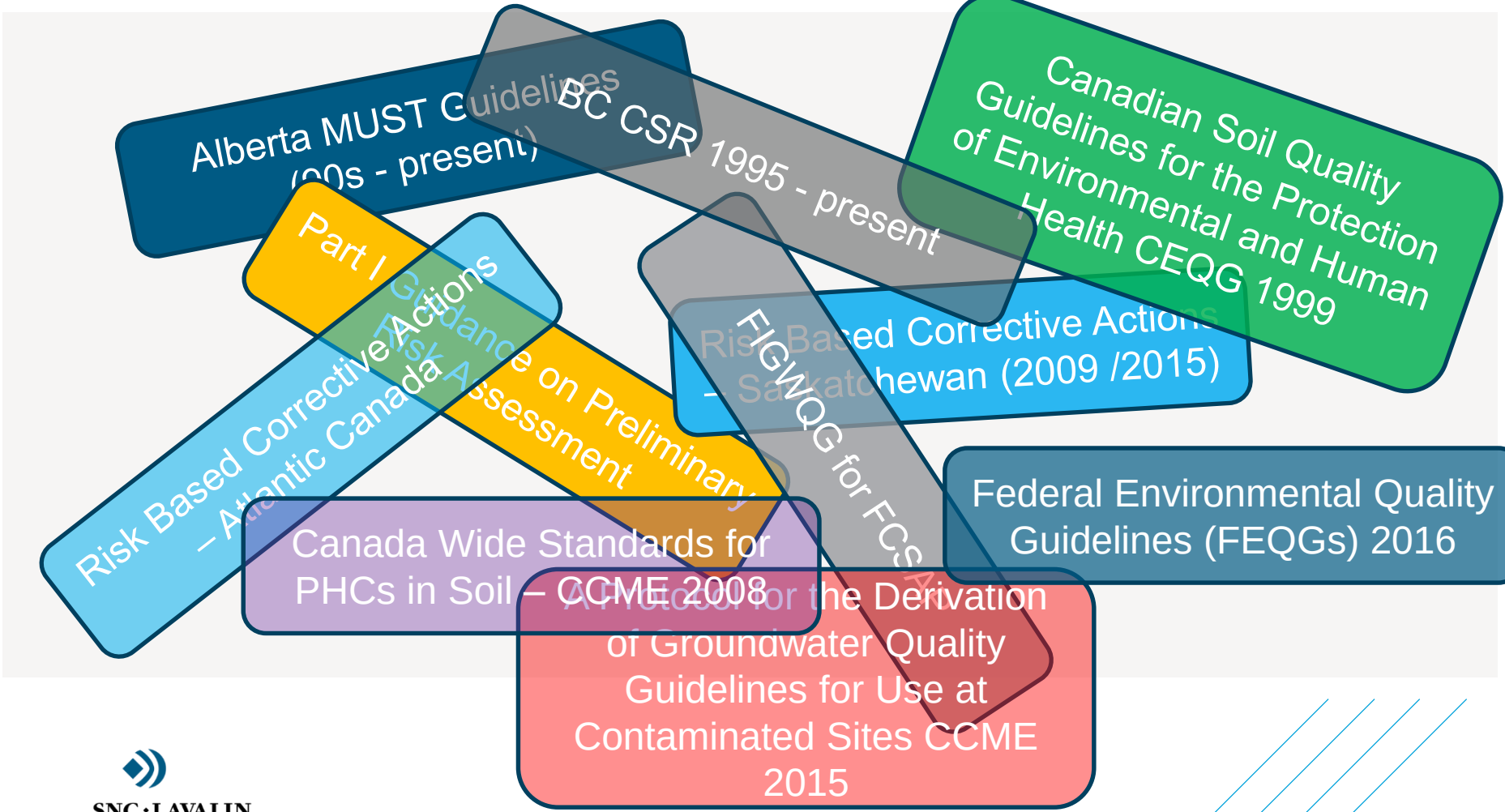
Alberta MUST Guidelines
(90s - present)
BC CSR 1995 - present
Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health CEQG 1999
Part I
Guidance on Preliminary Risk Assessment
Risk Based Corrective Actions – Atlantic Canada
Risk Based Corrective Actions – Saskatchewan (2009 /2015)
FIGWQG for FCSAP
Federal Environmental Quality Guidelines (FEQGs) 2016
Canada Wide Standards for PHCs in Soil – CCME 2008
Protocol for the Derivation of Groundwater Quality Guidelines for Use at Contaminated Sites CCME 2015

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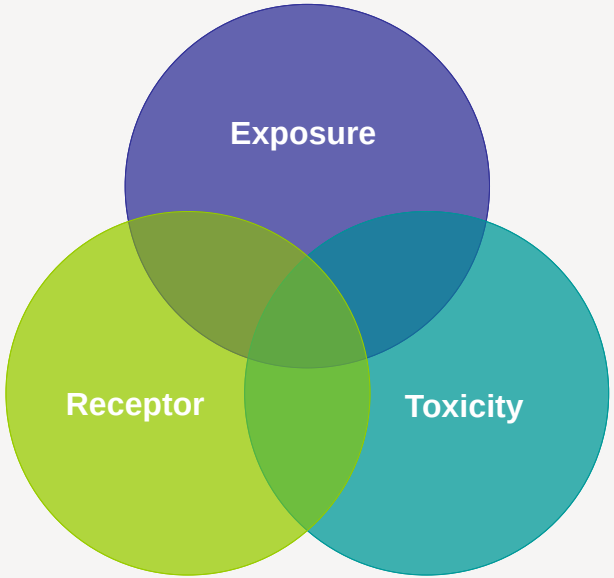
# Risk Assessment

- Used in the Management of Corrective Actions for Spill Response and Reclamation of Impacted Sites
- Risk Assessment used to develop guidelines
- Risk Assessment may rely on different “tools” depending on the pathways that are creating potential risk

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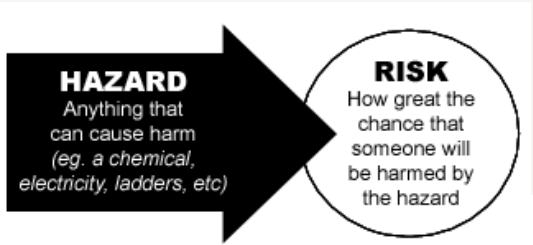
# What is Risk?

- Hazard: chemical in environmental medium
- Without receptor/exposure there is no risk
- Risk: potential for harm to individual exposed to hazard (i.e., receptor)





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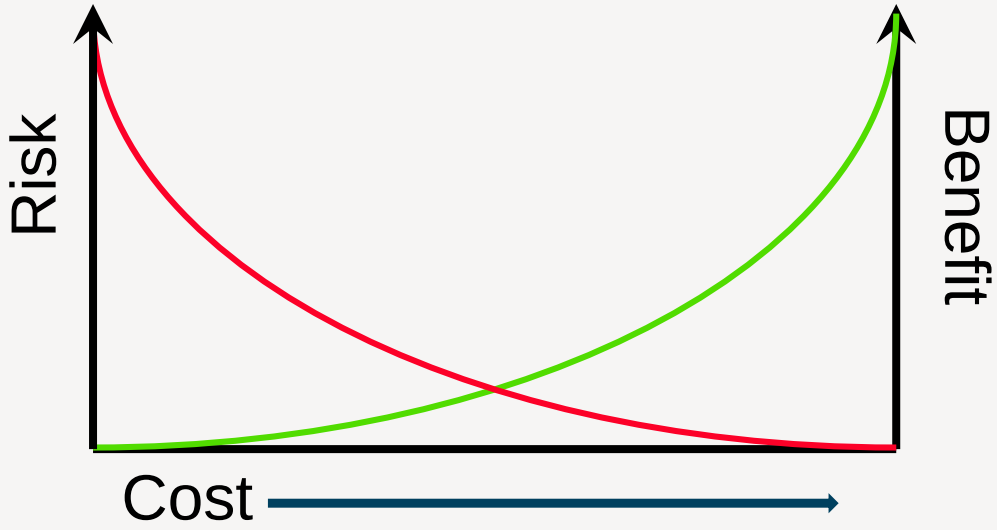
# Relative Risk

**Goal 1:** to find the solution (risk management) that presents the best combination (compromise?) of risk reduction/control and societal benefit

**Goal 2:** to find a balance between the ‘precautionary principle’ and evidence-based risk management decision-making

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# We Choose to Accept Risk in everything we do…

# So what's acceptable?

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# How do we quantify risk?

- Incremental Risk – Incidence of Cancer
- Non-carcinogens (Threshold Compounds)

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# How do we calculate risk?

Zinc Supplement

$$\frac{50\ mg/day}{65\ kg \cdot bw} = 0.77\ \frac{mg}{kg \cdot bw}/day$$

Health Canada *TRV* = *0.57 mg/kg·bw/day* (Adults)

$$HQ = \frac{0.77}{0.57} = 1.35$$

# Risks by Choice vs Not?

- Incremental Risk – of getting cancer
  ILCR = 1 in 100,000 – $10^{-5}$
- Non-carcinogens (Threshold Compounds)
  HQ = 0.2 up to 1

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# Risks that we can’t control…..

## Proportionate Causes of Death in Canadians 2019

- Cancer is the leading cause of death in Canada - 29.6%
- Heart Disease - 19.2%


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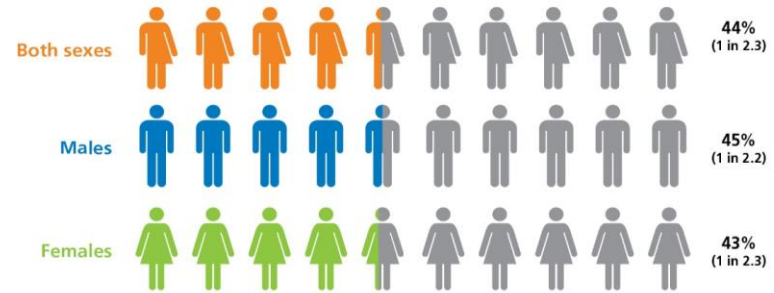
# Probability of Developing Cancer

FIGURE 1.1 Lifetime probability of developing cancer, Canada (excluding Quebec), 2015




**Analysis by:** Centre for Surveillance and Applied Research, Public Health Agency of Canada
**Data sources:** Canadian Cancer Registry and National Cancer Incidence Reporting System databases at Statistics Canada

**Canadian Cancer Statistics 2019**

43,000/100,000 or 0.4347**8**

So we are working on….0.4347**9**

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# Age standardized incidence rates

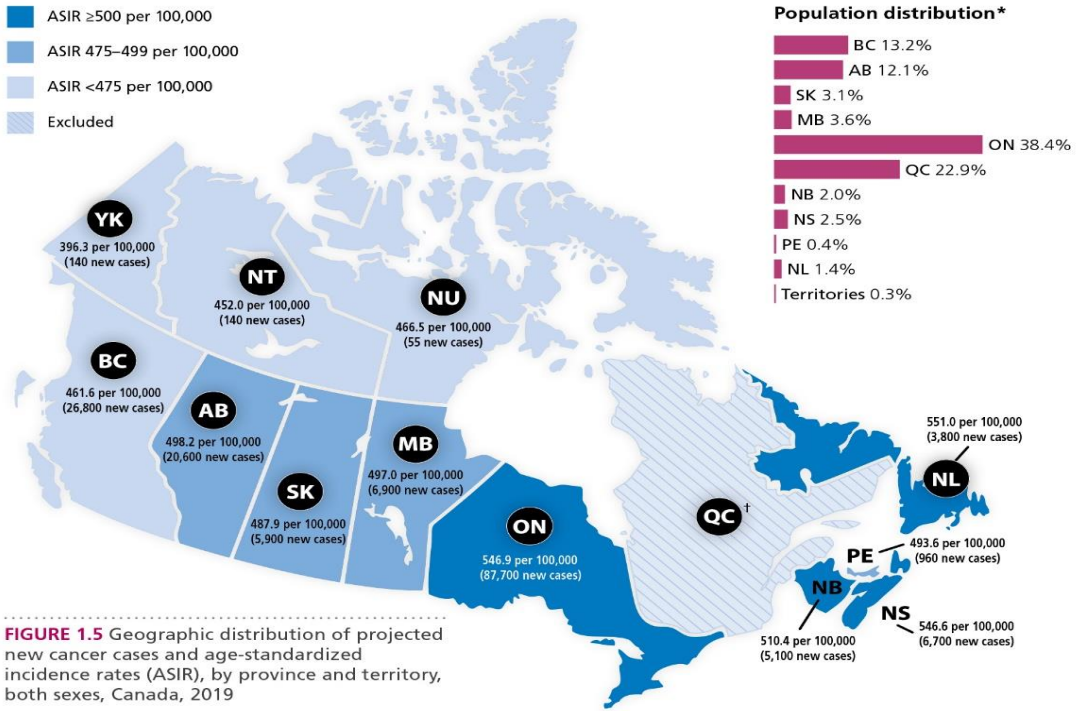


**FIGURE 1.5** Geographic distribution of projected new cancer cases and age-standardized incidence rates (ASIR), by province and territory, both sexes, Canada, 2019

* Based on projected estimates of population size in 2019.

† Quebec was not included because a different projection method was used for Quebec than the other regions, meaning the estimates are not comparable. See *Appendix II: Data source and methods* for additional details.

**Note:** Rates are age-standardized to the 2011 Canadian population.

**Analysis by:** Centre for Surveillance and Applied Research, Public Health Agency of Canada

**Data sources:** Canadian Cancer Registry and National Cancer Incidence Reporting System databases at Statistics Canada

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# Risk Assessment is a Methodology

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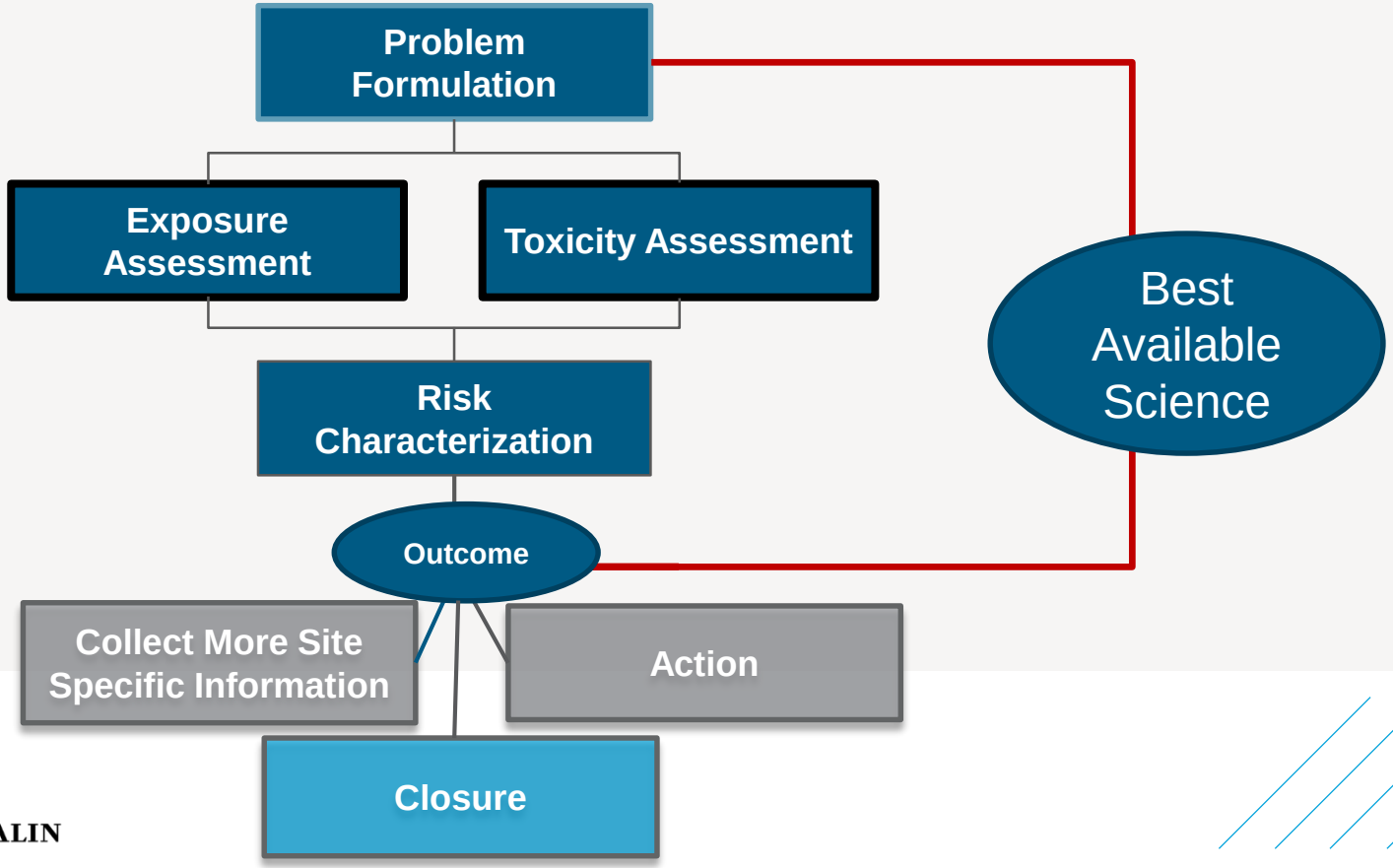
# Risk Assessment is a Methodology

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# Risk Characterization

For non-carcinogens, exposure estimates are compared to TRVs (TDI, RfD) to estimate a Hazard Quotient (HQ):

$$HQ = \frac{\text{Estimated Exposure (µg/kg bw/d)}}{\text{TDI/RfD(µg/kg bw/d)}}$$

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# Risk Characterization

For non-carcinogens:

- Health Canada Negligible Risk Level is: Hazard Quotient <0.2
  - If EDI is available and taken into account in estimation of exposures
  - Then: HQ or 1 may be acceptable
  - HQ of 0.5 to 0.8 considered acceptable for some petroleum hydrocarbons
- Some jurisdictions allow for a HQ <1

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# When Do We Use It?

# When Do We Use It?

- Physical remediation not possible / limited / costly / undesirable
- Limited exposure potential (e.g., deep, localized)
- Identify priorities for risk management / site liabilities

**Pros of Risk Assessment:**

- Sustainable remediation
  - Areas that require physical remediation (hot spots)
  - Areas that can be managed through administrative / risk controls
  - Areas that do not require remediation/risk management
- Typically = cost savings
- Accepted method to obtain site closure

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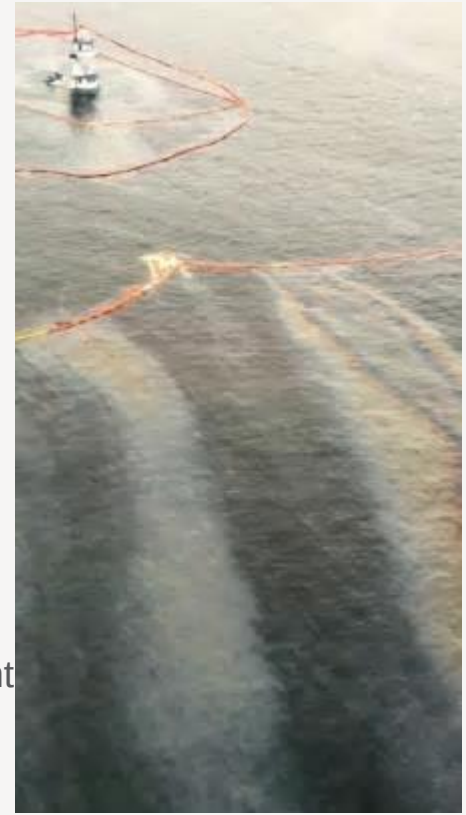
# Where else does it work?

- Wide range of contaminated sites (mines, landfills, upstream O&G, harbours, maintenance yards, military bases…)
- Environmental assessments for proposed projects
  - Evaluate potential effects to human health or ecological health from proposed project construction, operations, maintenance etc.
- Spill response
  - Understand short- and long-term impacts resulting from a spill
  - Inform decision-making process throughout clean-up, monitoring and recovery phases
  - New RA-based guidance: Environmental Monitoring & Impact Assessment Guidance for Marine Oil Spills on the Pacific Coast (DFO/SNC-Lavalin/Azimuth)



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# What's in a Guideline?

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# What's in a Guideline?

- 3 Tiers – each incorporating different amount of information
- Additional site-specific information increases with Tiers
- Protection goals **DO NOT** change between Tiers.

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# Alberta Framework

- Tier 1 – generic remediation guidelines
- Tier 2 – site specific remediation guidelines based on the modifications of Tier 1 guidelines
- Exposure Control (Tier 3????)

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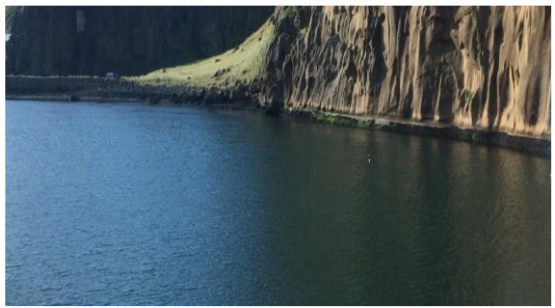
# Requirements for Tier 1

## Land use and Sensitivity Factors

- Proximity of site to surface water and drinking water supplies
- Actual and potential uses of groundwater
- Human and Ecological Receptors

## Physical Conditions

- Soil particle size
- Stratigraphy and properties of surficial materials
- Depth to groundwater
- Presence and types of building and infrastructure



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# Land Uses - 5 vs 4 Generic Categories

## Alberta Tier 1

- Agricultural
- Residential/Parkland
- Commercial
- Industrial
- Natural Areas

## CCME

- Agricultural
- Residential/Parkland
- Commercial
- Industrial

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# Human Health Exposure Pathways

- Soil Ingestion (<1.5 m)
- Dermal Contact (<1.5 m)
- Vapour Inhalation (<30 m)
- Protection of Potable Water

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# Ecological Exposure Pathways

- Protection of Groundwater for Aquatic Life (500 m for PHCs)
- Ecological Direct Contact
- Non-Potable Groundwater Standards
- Management Limits (PHC Fractions)

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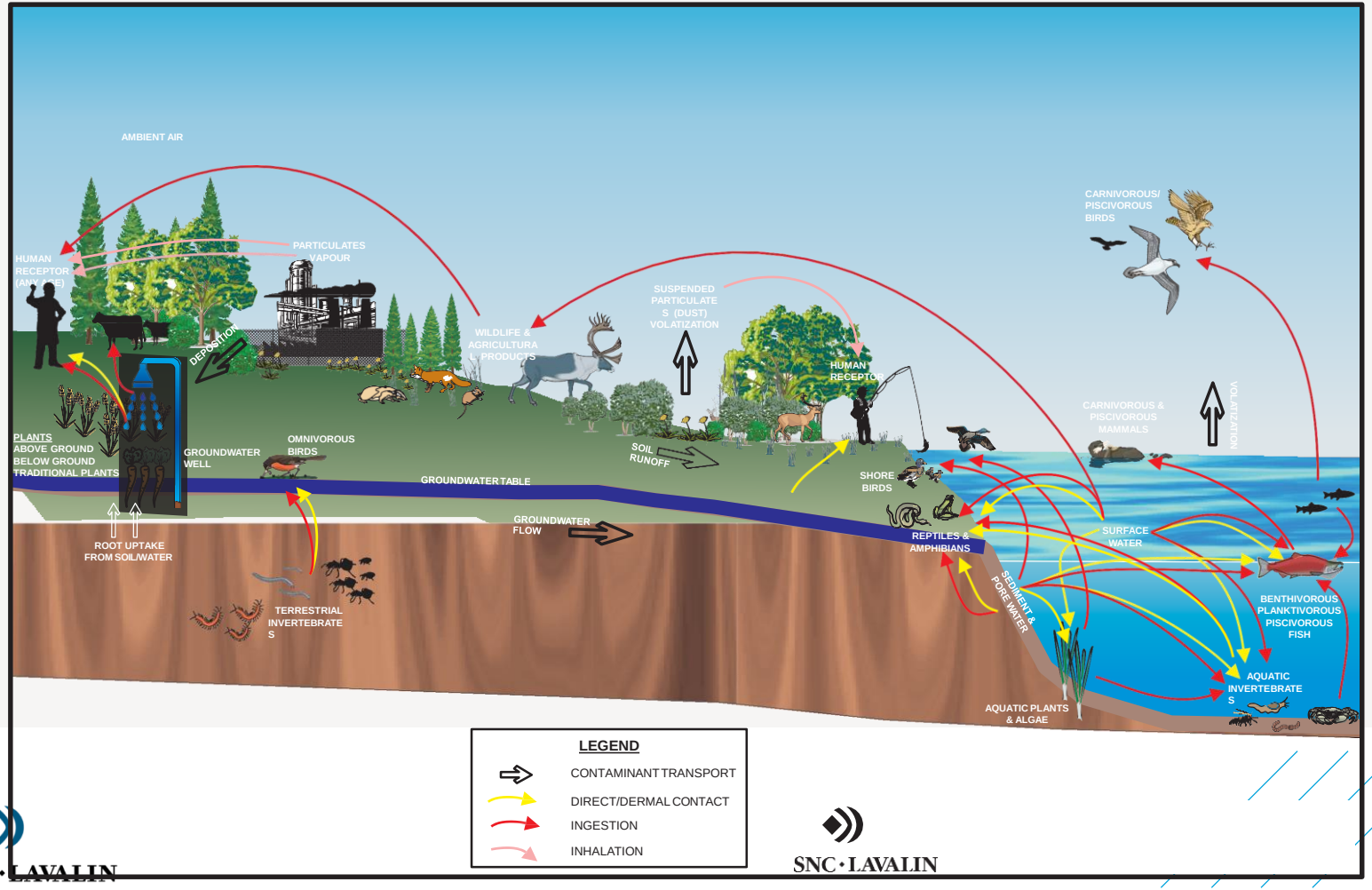


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# What's in a Guideline Calculation?

Threshold Substance

$$SEQS_{HH} = \frac{(TDI - EDI) \times SAF \times BW}{[(AF_G \times SIR) + (AF_L \times IR_S \times ET_2) + (AF_S \times SR)] \times ET_1} + [BSC]$$

Background soil concentration

Exposure Terms
$ET_1$ = (d/wk)/7*(wk/yr)/52
$ET_2$ = (hr/d)/24

Soil Ingestion

Inhalation of Particulate Matter

Dermal Contact

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# Vapour Inhalation Equation

Soil Guidelines for Threshold Substances

$$SRG_I = \frac{(TC - C_a) \times [\theta_w + (K_{oc} \times f_{oc} \times \rho_b) + (H' \times \theta_a)] \times SAF \times DF_i \times 10^3 \times AF}{H' \times \rho_b \times ET \times 10^6} + BSC$$

Groundwater Guidelines for Threshold Substances

$$GWRG_I = \frac{(TC - C_a) \times SAF \times DF_i \times AF}{H' \times ET \times 10^3}$$

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# Vapour Inhalation Equation (cont'd)

Dilution Factor Calculation:

$$DF_i = \frac{1}{\alpha} \qquad \alpha = \frac{\left(\frac{D_T^{eff} A_B}{Q_B L_T}\right) exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right)}{exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right) + \left(\frac{D_T^{eff} A_B}{Q_B L_T}\right) + \left(\frac{D_T^{eff} A_B}{Q_B L_T}\right)\left[exp\left(\frac{Q_{soil} L_{crack}}{D_{crack} A_{crack}}\right) - 1\right]}$$

Calculation of $D_T^{eff}$:

$$D_T^{eff} \approx D_a \times \left(\frac{\theta_a^{10/3}}{\theta_t^2}\right)$$

**Warning: Do Not Try This At Home**

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# SVSLs

## Soil Vapour Screening Levels

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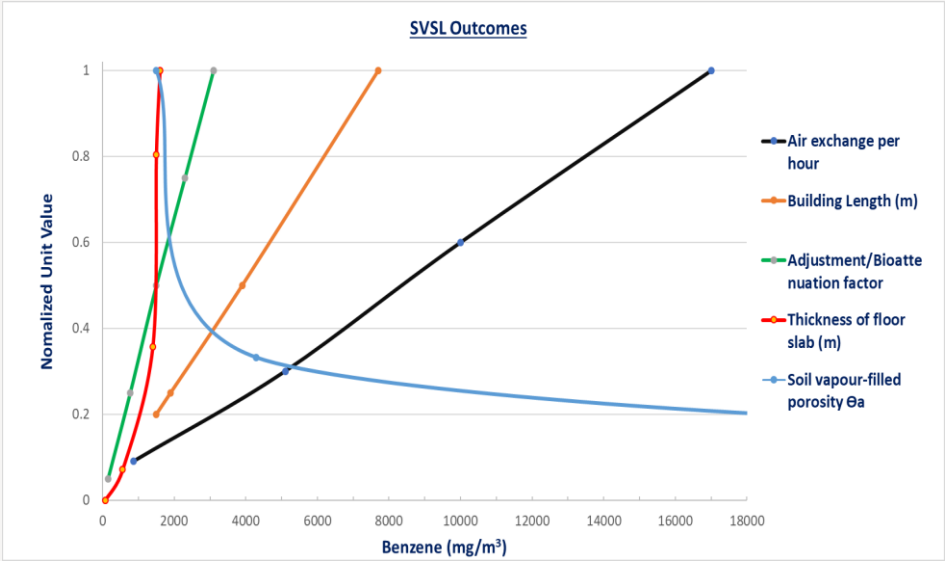
# Soil Vapour Screening Levels

## What Matters?

- Building Factors (Length 20 m – 100 m)
- Air Exchange Rate (0.9 – 10 air ex./h)
- Bioattenuation Factor (1 – 20)
- Thickness of Floor Slab (0 – 0.14 m)
- Vapour Filled Soil Porosity (0.302 – 0.03)

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# CCME FAL SSTL Equation

$$SSTL_{FAL} = C_L(DF1)$$

$C_L$ – Concentration of allowable leachate

DF1 – Soil to soil leachate dilution factor

A , B, C and D – Calculated by distances to surface water, soil and hydraulic parameters, physicochemical properties of contaminant

DF3 – Vertical transport of leachate to groundwater table dilution factor

DF4 – Horizontal groundwater transport to discharge point dilution factor

$$DF1 = K_{oc} \times f_{oc} + \frac{\theta_w + H' \times \theta_a}{\rho_b}$$

$$C_L = C_{gw}(DF3)$$

$$DF3 = 1 + \frac{Z_d \times V}{I \times X}$$

$$Z_d = r + s$$

$$s = d_a \left\{1 - exp\left(\frac{-2.178 \times X \times I}{V \times d_a}\right)\right\}$$

$$V = K \times i$$

$$C_{gw} = C_w(DF4)$$

$$DF4 = \frac{4}{\exp(A) \times \mathrm{erfc}(B) \times [\mathrm{erf}(C) - \mathrm{erf}(D)]}$$

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# CCME FAL SSTL Equation - Groundwater

SWQG – Surface water quality guideline for COPC

DF4 – Horizontal groundwater transport to discharge point dilution factor

$$SSTL_{FAL} = SWQG_{FAL} \times DF4$$

$$DF4 = \frac{4}{\exp(A) \times \operatorname{erfc}(B) \times [\operatorname{erf}(C) - \operatorname{erf}(D)]}$$

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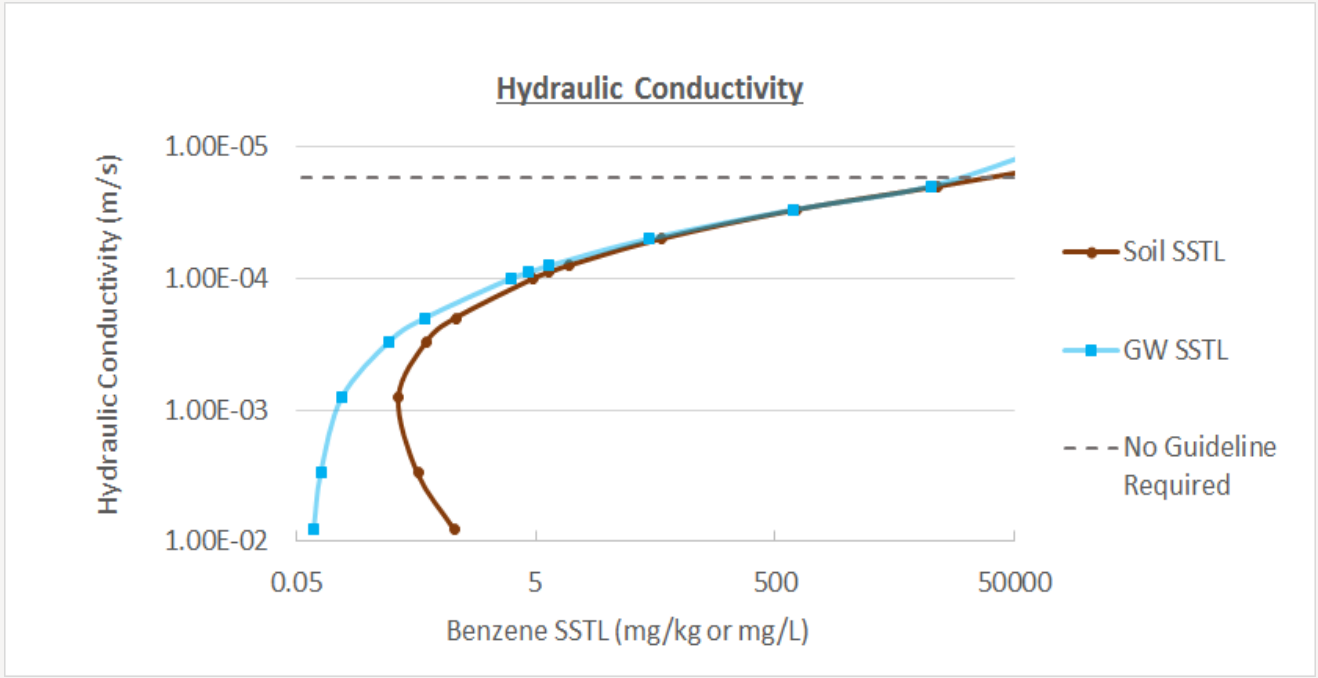
# CCME FAL – Guideline Modification

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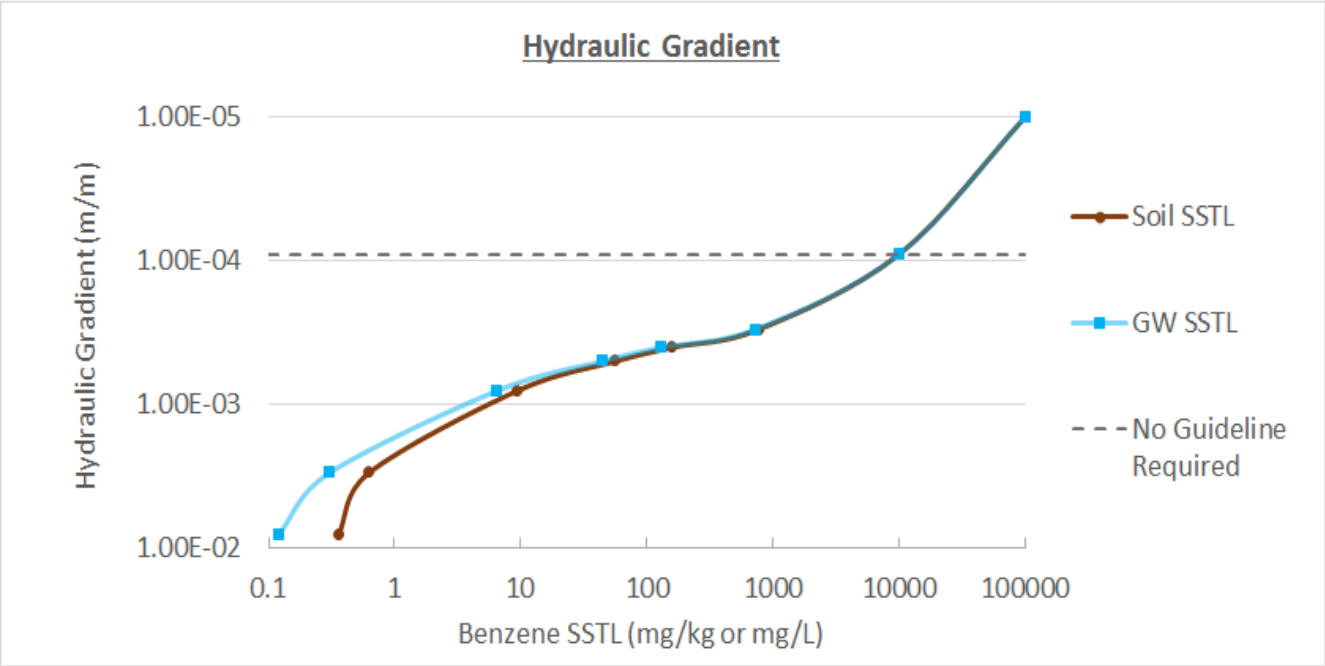
# CCME FAL – Guideline Modification

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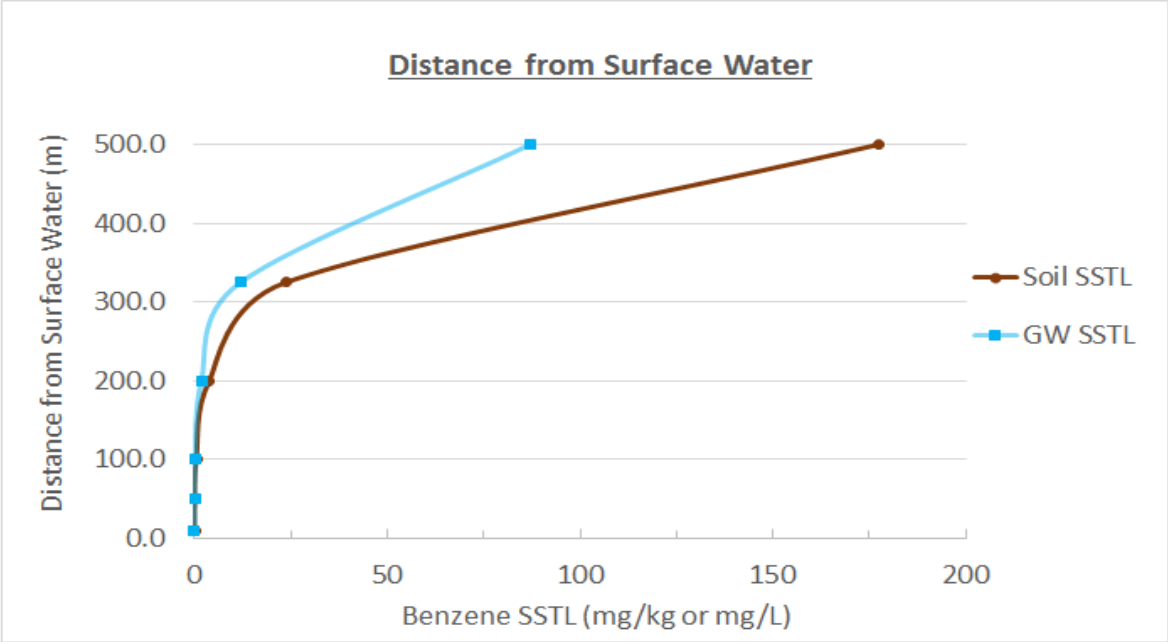
# CCME FAL – Guideline Modification

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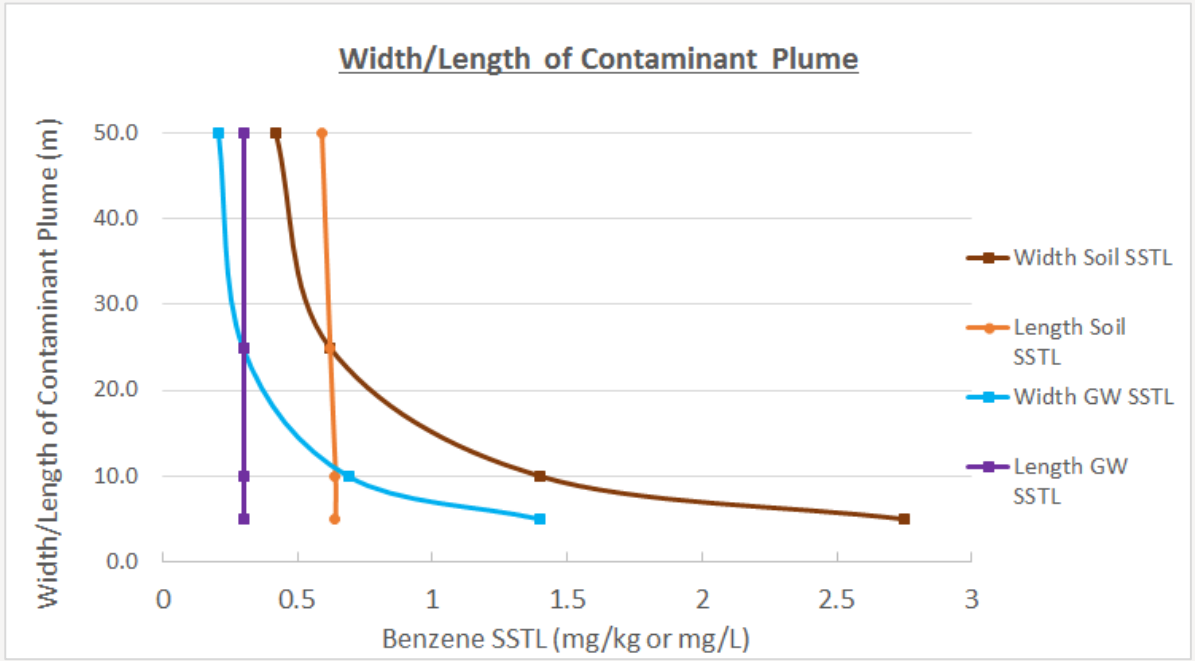


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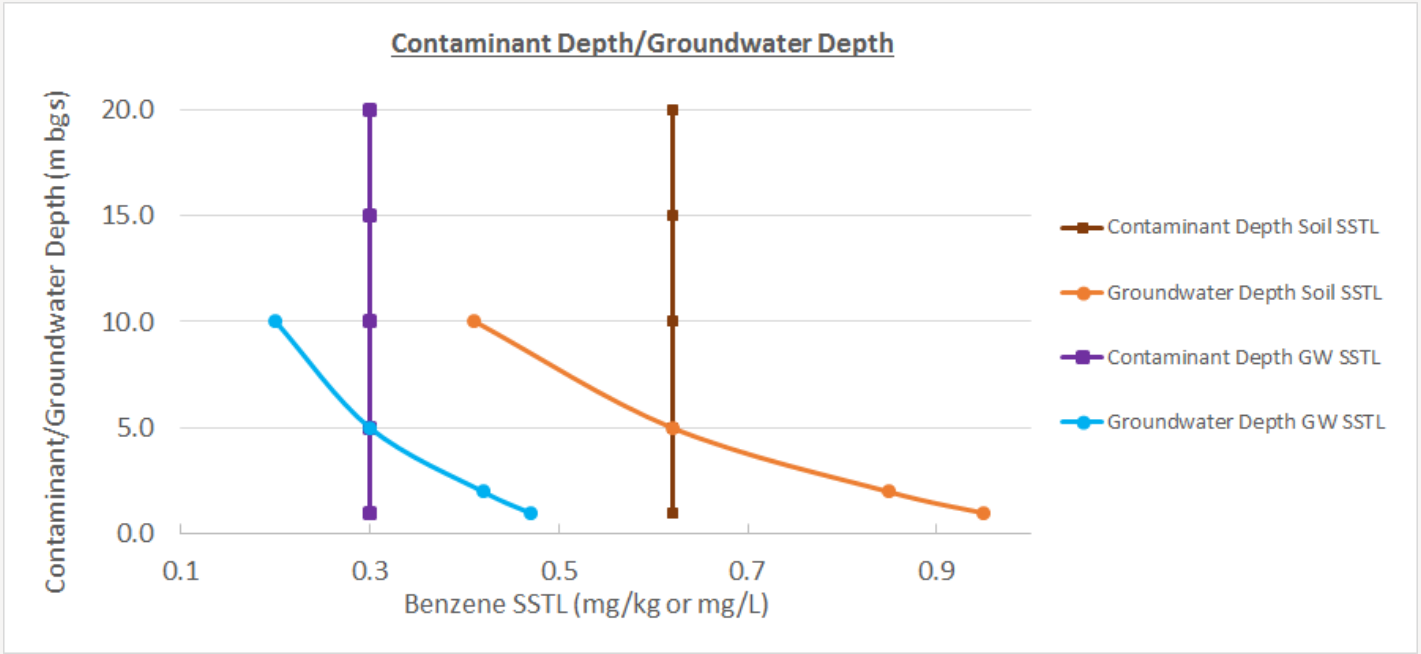


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# Myths Busted

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# Fact or Fiction?  Tier 1 vs. Tier 2 vs. Tier 3

Is Tier 3 more protective or less protective than Tier 1?

a) More

b) Less

c) Same

d) Not sure

**Answer: c**

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# Fact or Fiction? Vapour Inhalation Pathway

What is the maximum science based distance to receptors for PHC  vapour Intrusion?

a) 30 m

b) 15 m

c) 0 – 2 m

d) 5 m

**Answer: c or d**


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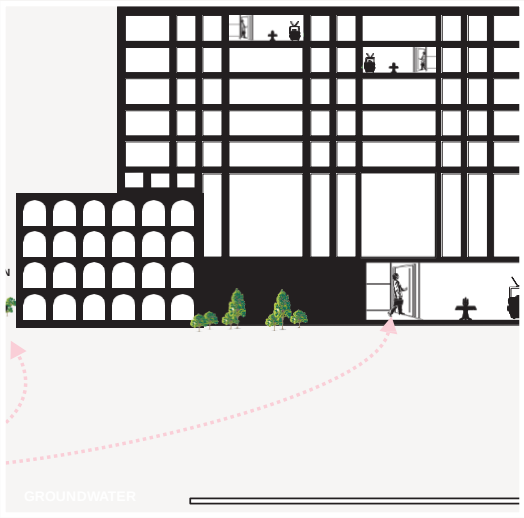
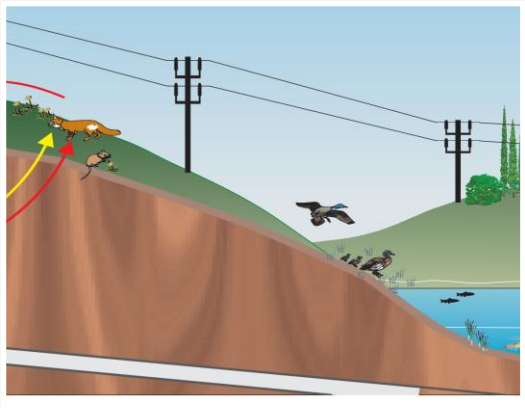
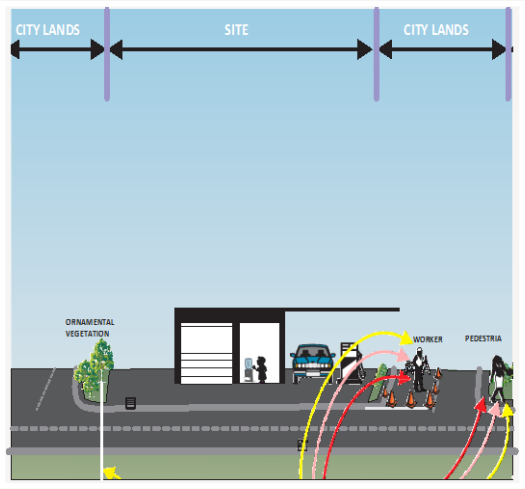
# Vapour Intrusion Inclusion Zone vs. Sensitive Land Use Buffer




Vapour Transport Model



Adjacent Sensitive Land Use




Ontario (15 m lateral)
CCME 30 m

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# Fact or Fiction? Distance of FAL/PW Receptor

- What distance applies to the dissolved PHC Plume in Groundwater?
- 300 m Downgradient
- 100 m Upgradient

a) Is this Unique to all COPCs?

b) Is this unique to AB Regs?

**Answer: No and Yes**


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# Fact or Fiction? Management Limits Unveiled

## What is the original basis for the Management Limit Guidelines?

a) Solubility

b) Half Solubility

c) Soil Gas Saturation Concentration

d) None of the Above

**Answer: d**

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# Management Limits Described CCME 2008

- Management Limits stated to include considerations such as free phase formation, explosive hazards, and buried infrastructure effects – **Not Health Risk Based**
- **CCME Reference:** Eco soil contact: For depths between 0 and 1.5 m bgs, the terrestrial ecological pathway must be applied.
- A management limit has been developed for PHCs that must be applied at all depths ***if the ecological pathway is removed***.
- CCME does not specify for depths between 1.5 m and 3 m.

PHC Technical Supplement CCME, 2008

**“ML are an artifact from a loop hole”**

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# Fact or Fiction? Guideline Values

What does a numeric exceedance of a Tier 1 or Tier 2 Guideline Mean?

a) Adverse effect?
b) Someone will die soon?
c) Nothing will happen?
d) Take a closer look?

**Answer: d**

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# Summary

- Risk Assessment is intended to be a systematic quantitative process to help in making good decisions
- Risk Assessment is a powerful tool - ***dynamic***
- HIGHLY CONSERVATIVE when used for guidelines (first principles) - ***static***
- Important to understand the process - ***Reality Check***
- Guidelines – screening mechanism and check balance

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# Take Away

An Exceedance of  a Guideline or any other reference value does not mean an adverse effect

Questions?

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# Acknowledgements

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*Our values are the essence of our company's identity. They represent how we act, speak and behave together, and how we engage with our clients and stakeholders.*

## SAFETY

*We put safety at the heart of everything we do, to safeguard people, assets and the environment.*

## INTEGRITY

*We do the right thing, no matter what, and are accountable for our actions.*

## COLLABORATION

*We work together and embrace each other's unique contribution to deliver amazing results for all.*

## INNOVATION

*We redefine engineering by thinking boldly, proudly and differently.*

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# In Perspective

- The biggest risk for cancer is **age**
  - **96% of cancer deaths occur >50**
  - Females are more likely to be diagnosed with cancer in their prime of their lives (age 20  to 59)
- Canada now has a greater proportion of seniors (>65 years of age)

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# Key findings

- 1 in 2.3 Canadians will get diagnosed with Cancer; 1 in 4 Canadians will die from Cancer
- 82,100 Canadians are expected to die from cancer in 2019
  - (comparison: 12,200 hospitalizations from influenza and 3,500 death ~5%)
- The mortality rates for **all cancers combined peaked in 1988** and have been decreasing ever since.

**The number of cancer deaths continues to increase each year due to the growing and aging population.**

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# Ecological Exposure Pathways

| Groundwater Quality Guidelines | Soil Quality Guidelines |
|---|---|
| Protection of soil dependent organisms (plants and inverts) from direct contact with contaminated groundwater | Protection of soil dependent organisms (plants, inverts, and nutrient cycling processes (i.e. microbes) from direct contact with contaminated soil. |
| Protection of aquatic life (SW) from contact with contaminated groundwater after discharge to a SW body | Protection of aquatic life (surface water) from contaminated soil after leaching into groundwater and discharging to surface water. |
| Protection of agricultural uses of water from contaminated groundwater (irrigation and livestock watering) | Protection of agricultural uses of water from soil contamination (livestock, irrigation). |
| | Protection of livestock and wildlife (mammals and birds) from ingestion of contaminated soil and food. |

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# Receptors of Concern (CCME, 1999)

| Route of Exposure | Agricultural | Residential Parkland | Commercial | Industrial |
|---|---|---|---|---|
| Soil Contact | › Crops/plants<br>› Invertebrates<br>› Nutrient Cycling Processes<br>› Livestock/wildlife | › Plants<br>› Invertebrates<br>› Nutrient Cycling Processes<br>› Wildlife | › Plants<br>› Invertebrates<br>› Nutrient Cycling Processes | › Plants<br>› Invertebrates<br>› Nutrient Cycling Processes |
| Soil and food Ingestion | › Livestock/wildlife | | | |
| Multimedia exposure (human health) | › Toddler | › Toddler | › Toddler | › Adult |

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# Soil Exposure Pathways by Land Use - SK

| | PW | Dermal Contact | VI (bas/ SOG) | FAL | ECO | LW | Soil Ingestion | ML |
|---|---|---|---|---|---|---|---|---|
| Agricultural | ? | Y | Y | Y | Y | Y | Y | Y |
| Residential | ? | Y | Y | ? | ? | | Y | Y |
| Commercial | ? | Y | Y | ? | ? | | Y | Y |
| Industrial | ? | Y | Y | ? | Y | | Y | Y |

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# Guidelines – Groundwater

| | Health Canada | FIGQGs | | | |
|---|---|---|---|---|---|
| | DUA | VI | DC (Soil Organisms) | FAL | LW or WW |
| Agricultural | Y | Y | Y | Y | Y |
| Residential/Parkland | Y | Y | Y | | |
| Commercial/Industrial | Y | Y | Y | | |
| Natural Lands (AB) | **AB** | | | Y | Y |

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# Groundwater Exposure Pathways by Land Use - SK

| | PW | VI | FAL | ECO | LW | Irrigation | Non-Potable |
|---|---|---|---|---|---|---|---|
| Agricultural | If App | Y | If App | Y | Y | Y | Y |
| Residential | If App | Y | If App | Y | | | Y |
| Commercial | If App | Y | If App | ? | | | Y |
| Industrial | If App | Y | If App | ? | | | Y |

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