Risk-based Approach Supporting the Redevelopment of an Urban Lead-impacted Site

Sylvain Bordenave, Ph.D., P.Biol., QP_{Sask} (He/Him) – Trace Associates Inc.
Karl Bresee, B.Sc., PDB, P.Biol., QP_{Sask} – Intrinsik Corp.

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Outline

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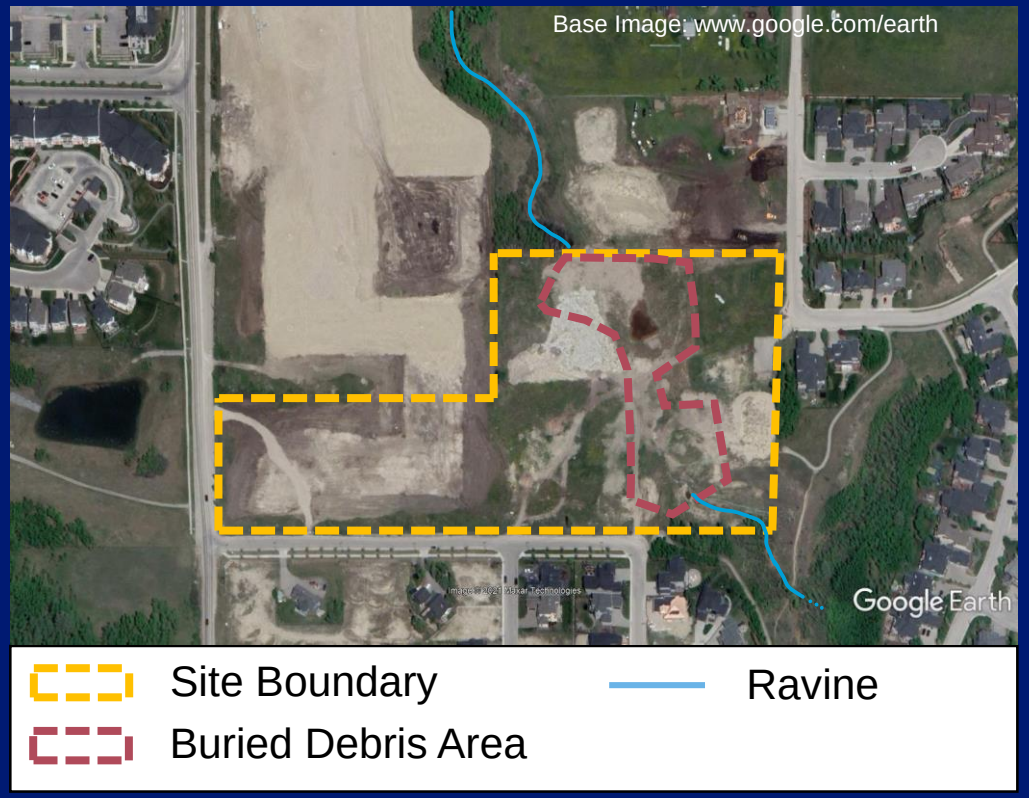
2. Management Goal
3. Partial Remediation
4. Risk Assessment Metal Exceedances
   a) Lead Human Soil Direct Contact
   b) Metal Ecological Soil Direct Contact
5. Conclusion
6. Project Sustainability Summary

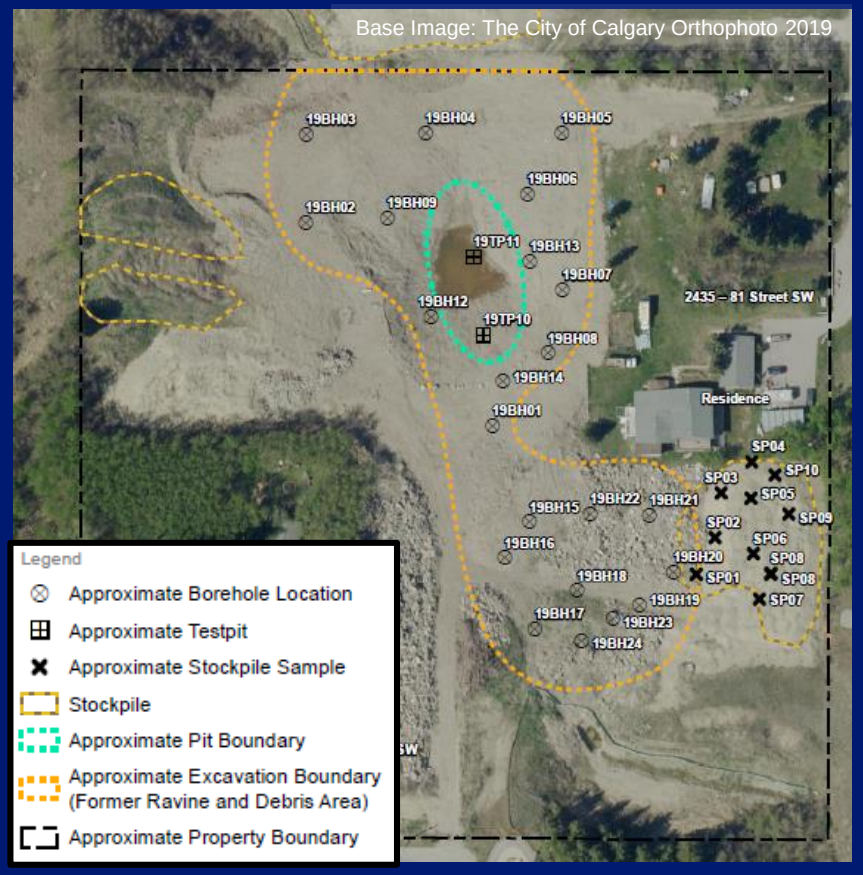
Site Background



- Vacant land subject to residential development with proposed storm water retention pond
- Suspected historical dumping of debris from flour mill demolition in a north-south ravine crossing the Site
- Inert debris (bricks, metal, cloth, concrete, glass, dry lumber, etc.)

Site Management Activities

- 2015 – 2019: Soil and debris characterization; larger debris excavated
- 2019: Soil characterization (maximum depth of 9 mbgs)
- Exceedances of Tier 1 guidelines for PHC F3-F4, metals, and PAHs
- Estimated 23,000 m^3 of soil with exceedances



Preliminary Risk Assessment

Table A: Chemical and Pathways of Concern Summary							
COC	Human Exposure Pathways			Ecological Exposure Pathways			Management Limit
	Soil Direct Contact	Indoor Vapour Inhalation	Domestic Use Aquifer	Soil Ecological Direct Contact	Nutrient/Energy Cycling Check	Freshwater Aquatic Life	
Metals	X	N/A	NA	X	X	N/A	N/A
PAHs	-	-	X	-	N/A	X	N/A
PHC Fractions F3 and F4	X	-	-	X	N/A	-	X

- Risk driver = Human soil direct contact for lead

Site Management Goal

- Remediation to Tier 1 guidelines considered an overly conservative approach
- Preference to avoid Risk Management Plan and associated future liability
- Develop soil Site-specific remediation objectives (SSROs) based on Site-specific risk assessment (Tier 2 SSRA)
- Remediate soil to SSROs and leave in place and/or re-use soil containing inert debris as reclamation material

PAHs and PHCs Exceedances in Soil

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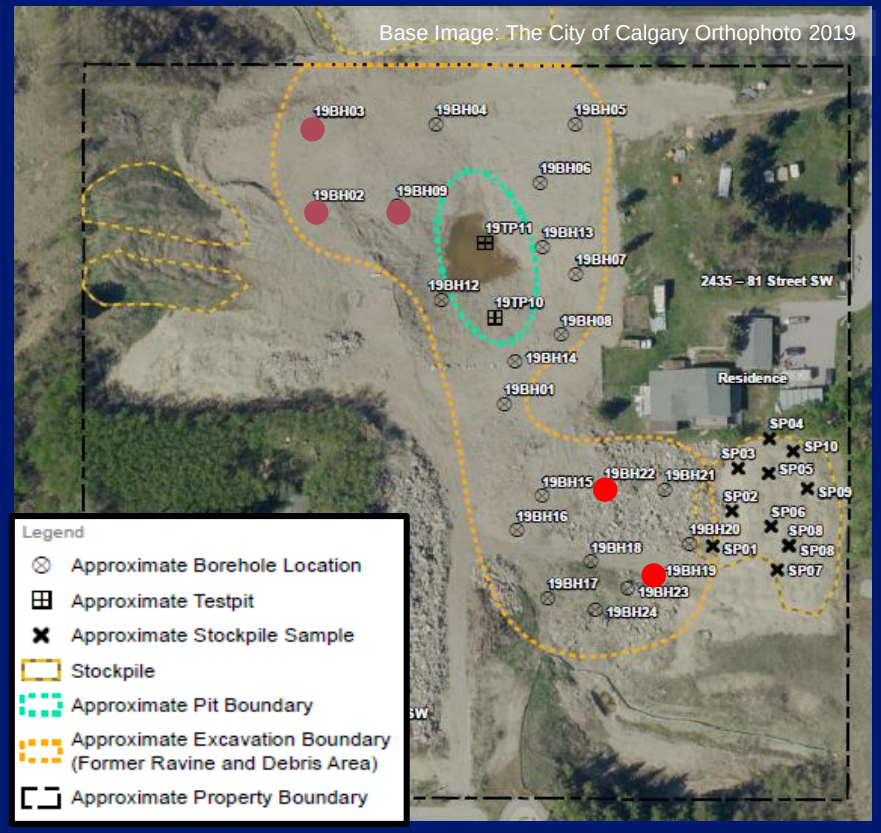
PAHs	-	-	X	-	N/A	X	N/A
PHC Fractions F3 and F4	X	-	-	X	N/A	-	X

PHCs and PAHs Exceedances in Soil - Remediation



- Excavation of PHC exceedances – Two testpits for a total of approximately 50 m^3 (completed in spring 2021)
- Localized PAHs exceedances are associated with asphalt debris and are considered immobile – To be excavated

Metal Exceedances in Soil

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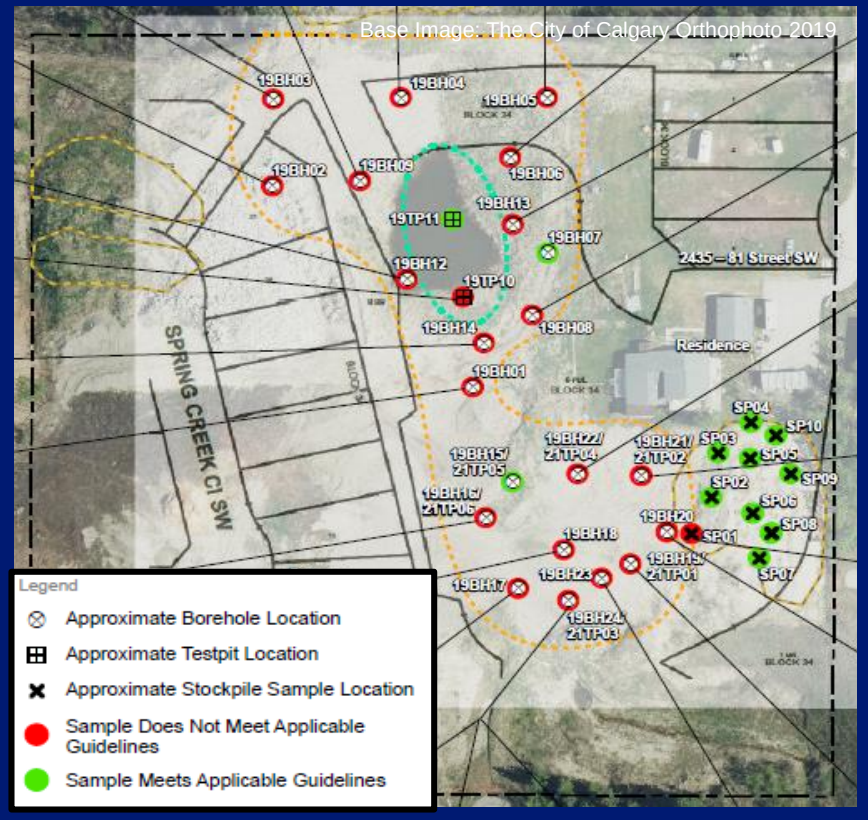
PAHs	-	-	X	-	N/A	X	N/A
PHC Fractions F3 and F4	X	-	-	X	N/A	-	X

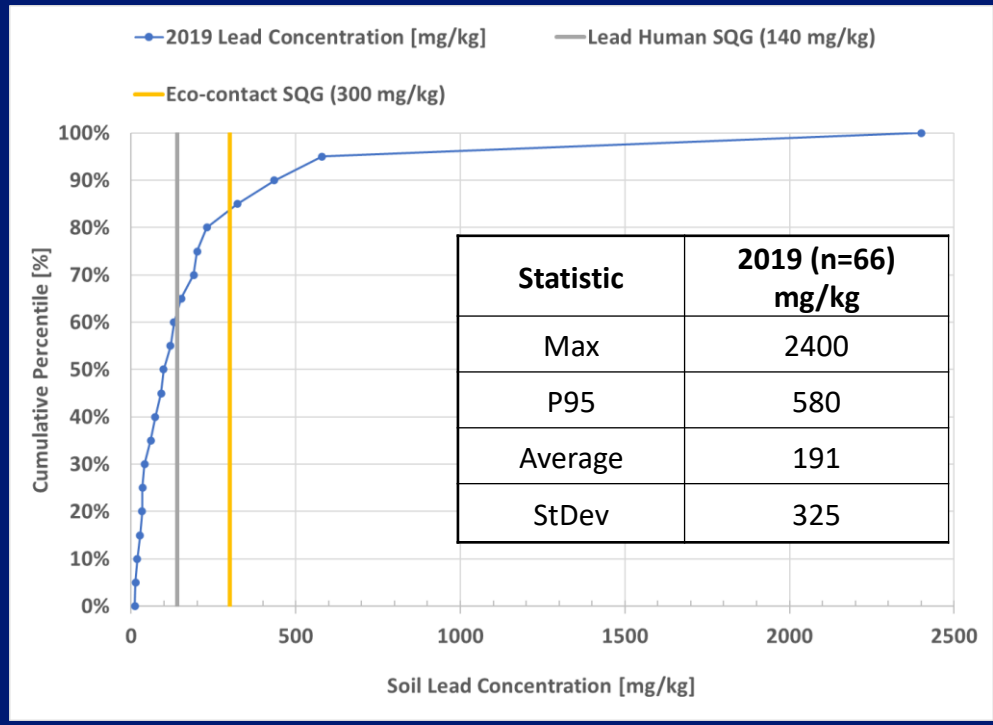
Metal Exceedances in Soil – Spatial Distribution

- Exceedances spread across the Site
- Exceedances of the Tier 1 human direct contact guidelines (140 mg/kg) for lead (risk driver)
- Exceedances of the ecological direct contact guidelines for arsenic, chromium, copper, lead, nickel, tin, and zinc



Metal Exceedances in Soil – Data Distribution

- 38% of samples (25/66) with exceedance of human direct contact for lead
- Low frequency of ecological direct contact exceedances (<5% of 66 samples) except for lead (17%) and zinc (30%)

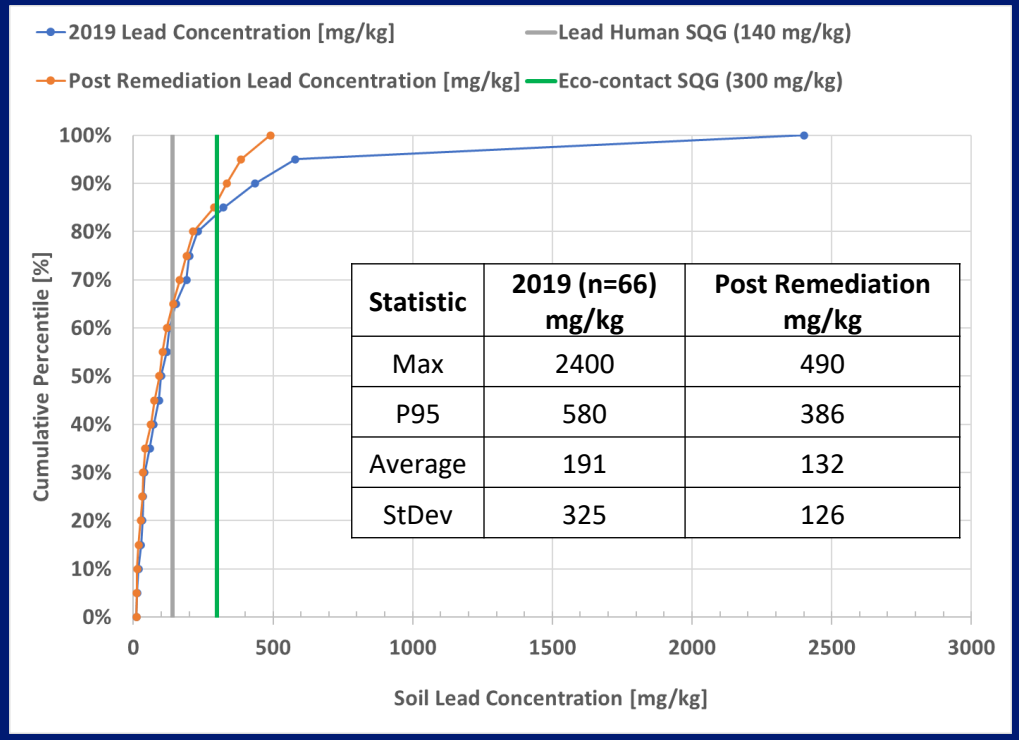


Statistic	2019 (n=66) mg/kg
Max	2400
P95	580
Average	191
StDev	325

Metal Exceedances in Soil – Post Remediation

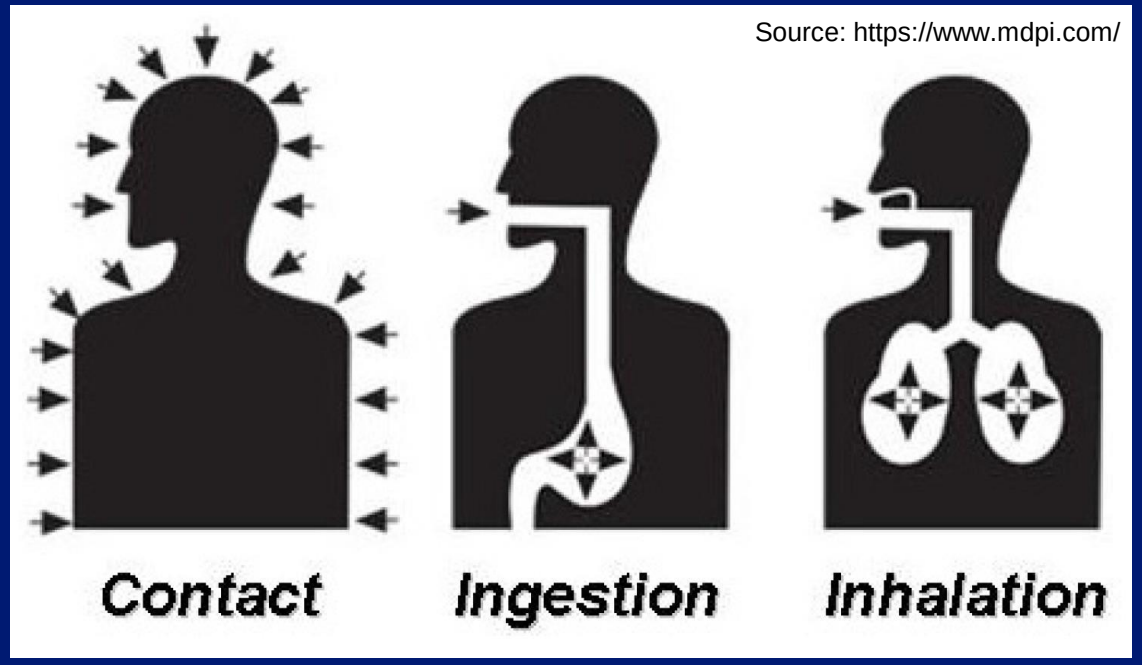
- "Hot spots" remediation of lead exceedances
- 35% of samples remain above the human direct contact guideline
- 14% of samples remain above the ecological direct contact guideline

➢ Site-specific risk assessment



Statistic	2019 (n=66) mg/kg	Post Remediation mg/kg
Max	2400	490
P95	580	386
Average	191	132
StDev	325	126

Human Soil Direct Contact

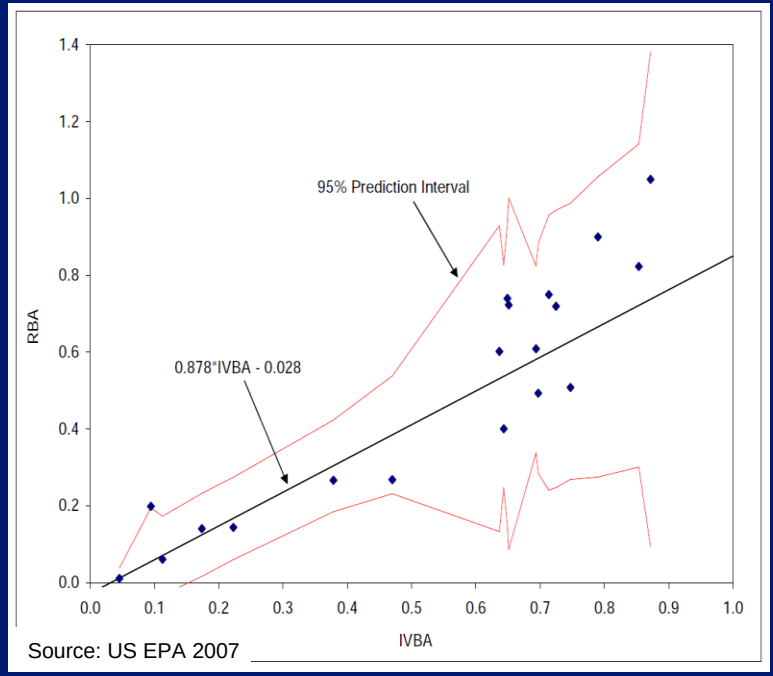


Lead Human Soil Direct Contact – Toxicity Assessment

- Toxicity profile
  - Reduced cognitive development and intellectual performance
  - Infants and children are most susceptible subpopulation
- AEP human soil direct contact guideline from CCME (1999) based on tolerable daily intake of 0.00357 mg/kg-day (threshold effect)
- Guideline based on lead bio accessibility of 100% (highly variable in soil)

In Vitro Bio Accessibility Test

- Approved testing protocol
  (Health Canada 2017 and US EPA 2017)
- Considers only dissolution in stomach (acid extraction) but excludes adsorption rate in small intestine
- Established empirically relationship between the in vivo and in vitro results



Source: US EPA 2007

➢ Mean site-specific lead bio-accessibility (n=11) of 77%

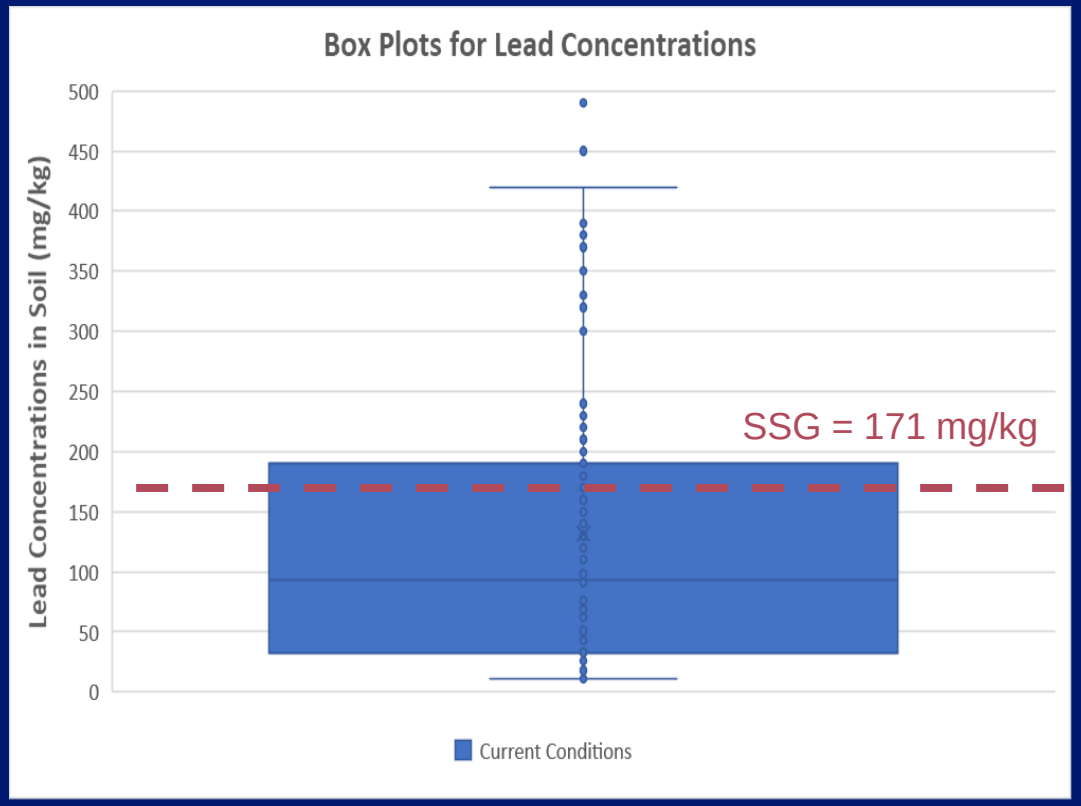
Lead Human Soil Direct Contact – Site-specific Guideline

- AEP (2019) equation for threshold substances using default parameters with the following exceptions:
  - Site-specific lead bio accessibility (100% > 77%)
  - Dermal absorption (3% > 0.6% based on Wilson and Richardson 2013)

$$SSG_{Pb,HDC} = \frac{(TDI - EDI) \times SAF \times BW}{[(AF_G \times SIR) + (AF_L \times IR_S \times ET_2) + (AF_D \times (SA_H \times DL_H + SA_O \times DL_O) \times EF)] \times ET_1} + BSC$$

➢ Site-specific guideline $SSG_{Pb,HDC}$ = 171 mg/kg

Lead Distribution vs Site-Specific Guideline



- 29% of samples remaining above the human direct contact SSG

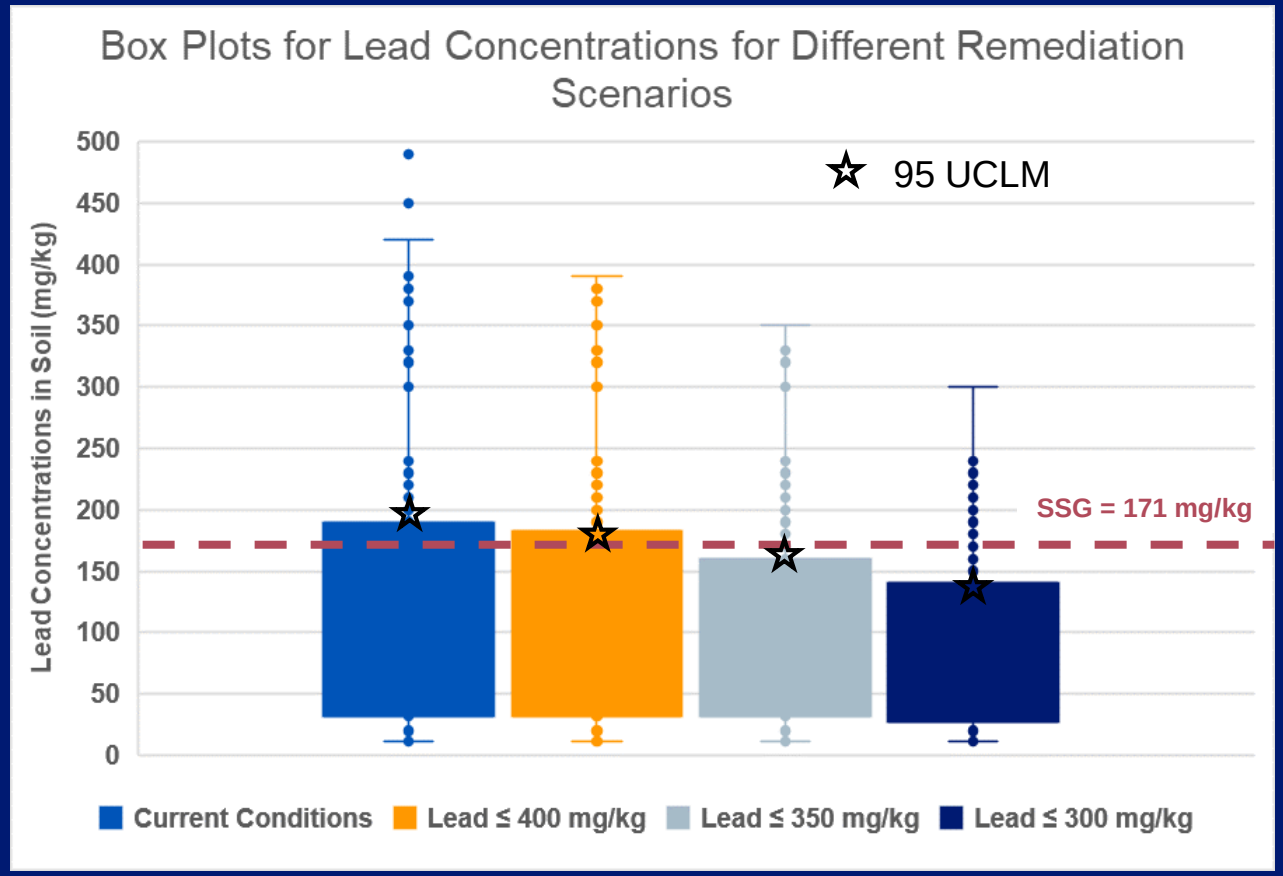
Statistic	Lead Concentrations mg/kg
Max	490
P95	386
Average	132
StDev	126

Lead Human Soil Direct Contact – Exposure Assessment

- Four remediation scenarios considered
- 95UCLM as exposure point concentration (EPC) (Health Canada 2021)
- EPC range from 130 to 198 mg/kg (n>59)

Lead Exposure Concentrations Statistics Summary				
Lead Remediation Objective	**No Further Remediation**	**400 mg/kg**	**350 mg/kg**	**300 mg/kg**
Number of Data Points	69	66	63	59
Maximum Concentration (mg/kg)	490	390	350	300
95% Upper Confidence Limit of the Mean (mg/kg)	**198**	**174**	**154**	**130**
Geometric Mean (mg/kg)	77	71	66	59
Standard Deviation (mg/kg)	126	108	93	73

Lead Distribution vs Site-Specific Remediation Objective



- 95UCLM < SSG for SSRO between 350 and 400 mg/kg
- SSRO of 350 mg/kg considered acceptable level of lead that does not present risk of adverse effect to humans
- Future exposure barrier not accounted for in assessment

Ecological Soil Direct Contact


Source: https://blogs.maryville.edu/


Source: https://www.arche-consulting.be/


Source: http://bioweb.uwlax.edu/

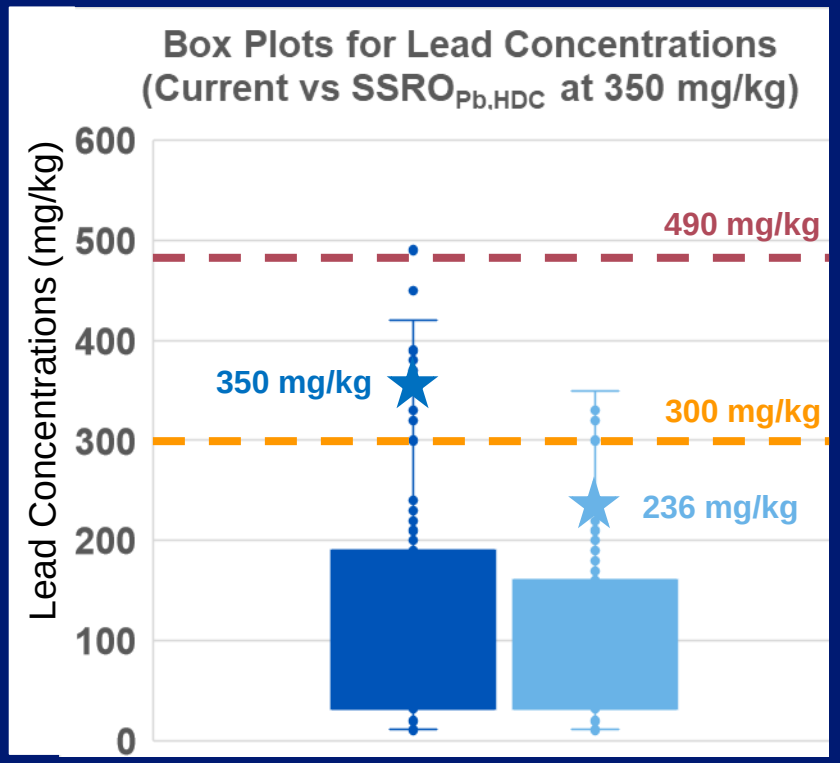
Metal Ecological Direct Contact – Risk Assessment

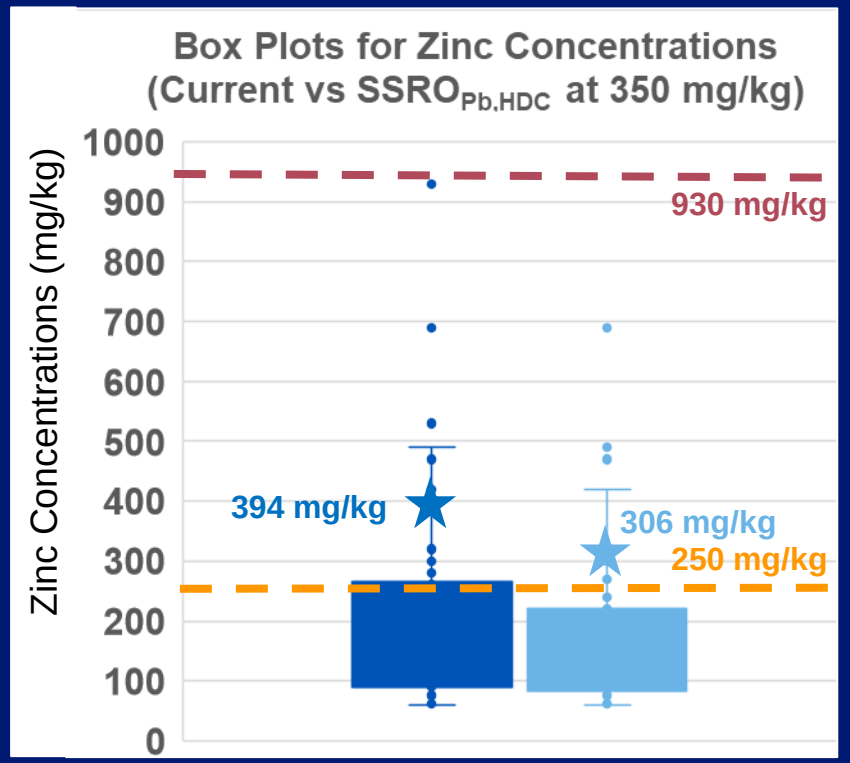
- Exposure assessment using 90th percentile

Metals Ecological Direct Contact Exposure Assessment - Statistics Summary							
Metals of Potential Concern	Arsenic	Chromium	Copper	Lead	Nickel	Tin	Zinc
Ecological Direct Contact Guideline for Residential Land Use (mg/kg)	17	64	63	300	45	5	250
Frequency of Exceedances (n=69)	1%	4%	4%	15%	1%	9%	26%
90th Percentile (mg/kg)	**7**	**53**	**41**	**350**	**28**	**5**	**394**

- Guidelines derived from toxicity data based on:
  - Sensitive species (e.g., agricultural plants)
  - Sensitive endpoints (e.g., reproduction, growth)
  - Conservative benchmarks values (e.g., no adverse effect levels)

Metal Ecological Direct Contact – Risk Characterization





- 90th Percentile
- Residential Guideline (P25 of tox data distribution)
- Commercial Guideline (P50 of tox data distribution)
- No Remediation
- Remediation to SSRO$_{Pb,HDC}$

- Severe adverse effects on plant and invertebrate populations not expected

Conclusion

- Partial remediation (PHCs and Lead “Hot Spots”)
- SSROs for lead based on SSG for human soil direct contact
- No severe adverse effects expected on plant and invertebrate populations after remediation to SSROs
- Importance of open communication with regulator and stakeholders
- Safety, environmental, and financial benefits of the SSRA approach

Project Sustainability Summary

23,000 m^3 using Tier 1 vs 8,000 m^3 using $SSRO_{Pb,HDC}$

Acknowledgements

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Questions? We're here to help

Sylvain Bordenave, Ph.D., P.Biol.
Principal Risk Assessor - Trace
sbordenave@traceassociates.ca

Karl Bresee, B.Sc., PDB, P.Biol.
Senior Scientist - Intrinsik Corp.
kbresee@intrinsik.com

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