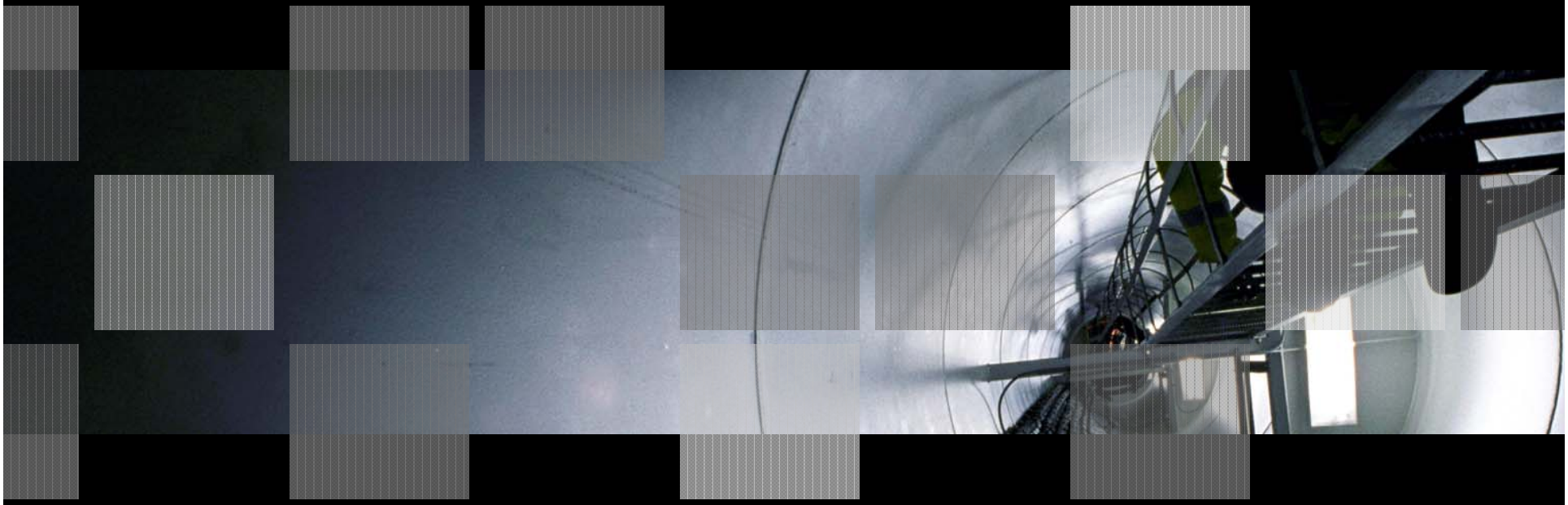


ROLE OF GEOCHEMICAL DATA IN ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT

A Consultant's Perspective

David A. Rae, Halifax, March 17, 2010

What is Risk?

- Risk - the probability and severity of an unplanned loss in the future

Common Lifetime Risks

Death (and taxes)	-	1 in 1
Dying from cancer	-	1 in 4
Dying in an auto accident	-	1 in 85
Dying crossing the road	-	1 in 625
Getting married	-	3 in 4
Eating at McDonalds (daily risk)	-	1 in 12
Regulatory environmental risk goal	-	1 in 100,000
Being struck by lightning	-	1 in 80,000

What is Risk Assessment?

- Risk assessment is the process of estimating the likelihood of undesired effects on human and ecological health resulting from exposure to a chemical or a contaminant source.

- Risk assessment is the part of the integrated risk management process that provides the scientific information used in making risk management decisions.

Why Risk Assessment?

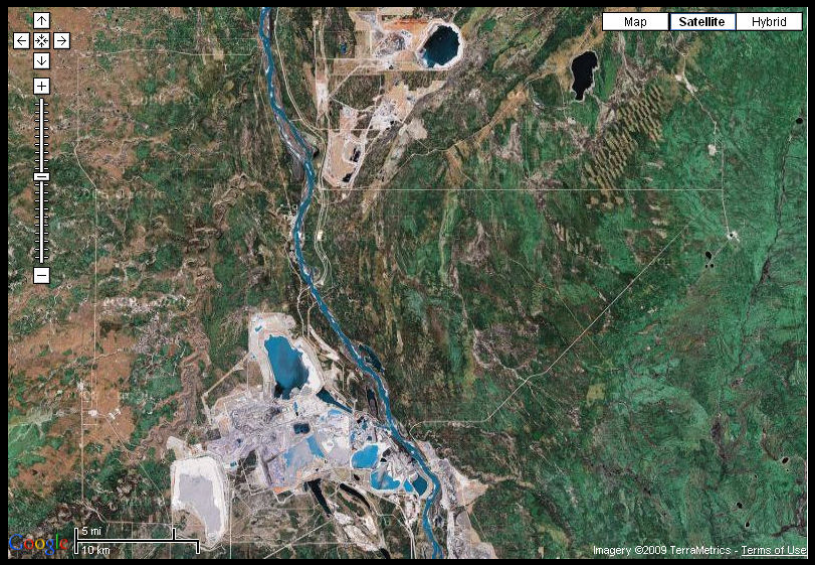
- To determine if there will be a risk.
  - *If we build it, will it cause harm?*
- To determine if there is a risk.
  - *Here's what we have for contaminant concentrations - is there a risk? (i.e., do we have to clean it up?)*
- To determine risk-based clean-up standards.
  - *Here's what we have for receptors/land use – what level do we have to clean up to? (e.g., soil quality guidelines [SQGs])*

Will There Be a Risk?

- **Oil Sands Environmental Impact Assessment, Fort MacKay, Alberta**: Synenco's Northern Lights Mining and Extraction Project.

- Baseline + Other + Project

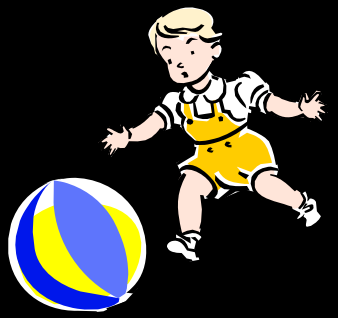
- Limited site-specific sampling for baseline. Relied on regional data (e.g., RAMP)



Is There a Risk?

- This is what's here

What's the risk?



- HC PQRA for FCSAP - Health Canada Preliminary Quantitative Risk Assessment for Federal Contaminated Sites Action Plan
  - Does not include background as part of risk prediction
  - Can lead to elevated risk predictions for concentrations that are simply natural background

What Are My Clean-Up Goals?

- What can be here?

This is my acceptable risk

1 in 100,000

- CCME SQGs and DFO SSCs
  - Includes background as part of SQG
  - Includes background as part of Estimated Daily Intake (EDI)

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

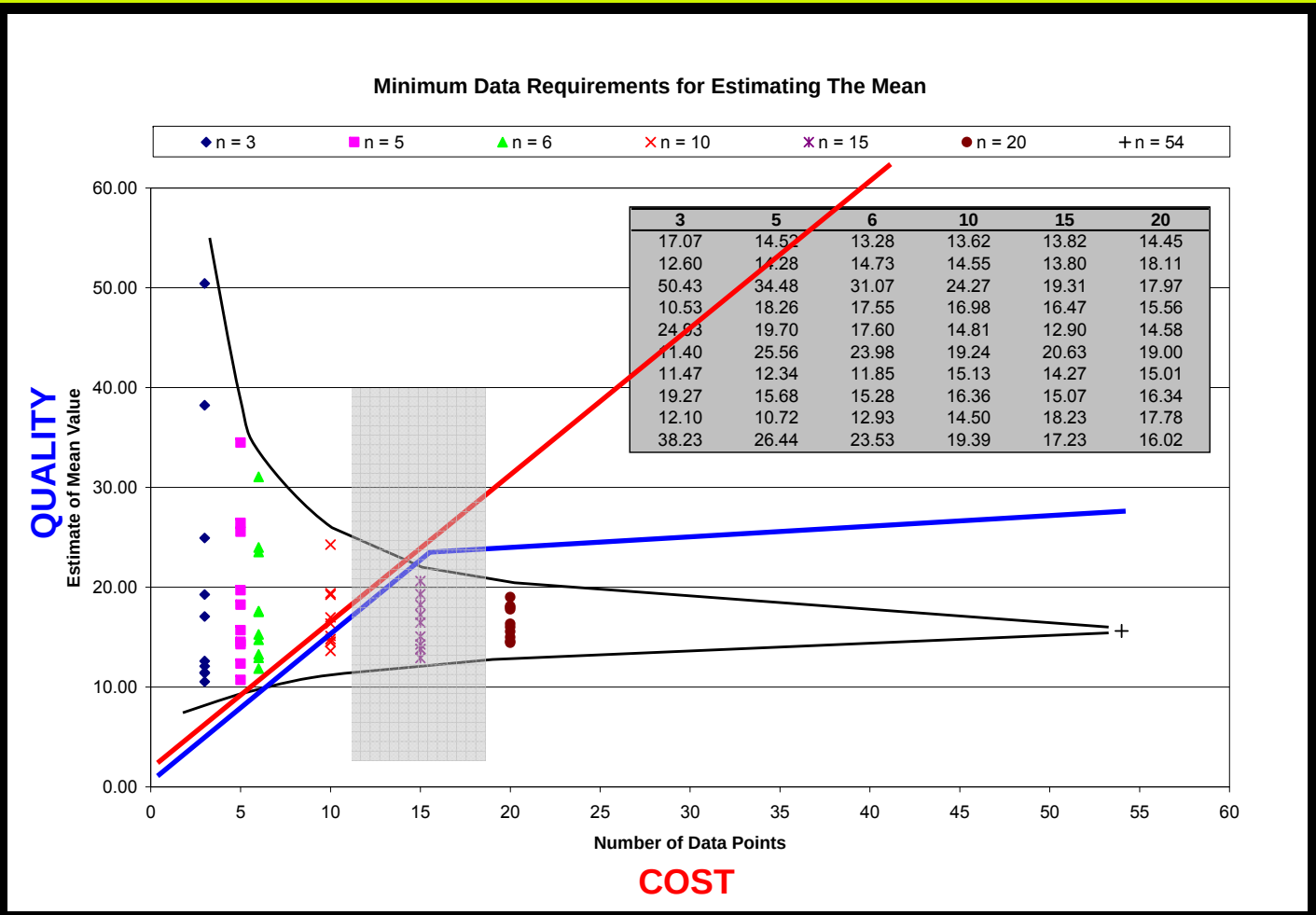
Importance of Background Data

- To assess cumulative effects
- To provide context to risk predictions
- To understand natural exposures
- To develop soil quality guidelines

Issues in Background Soil Data

- Sample size/scale
  - Statistical validity
  - Local vs regional vs national
- Sampling/analytical protocols
  - Particle size fraction
  - Total vs available
- Sample depth
  - PH05, PH30, A, B, C

Sample Size

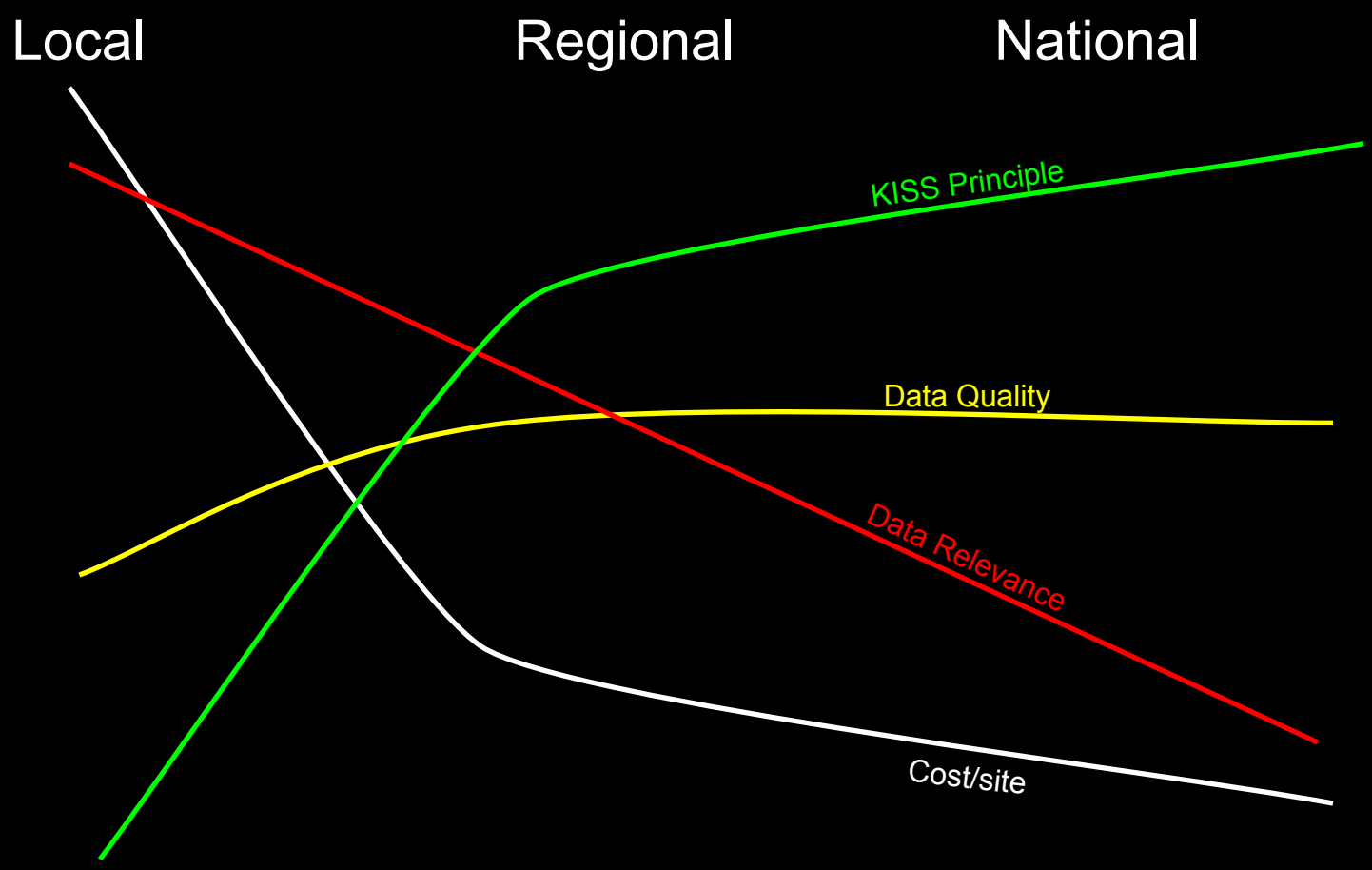


3	5	6	10	15	20
17.07	14.52	13.28	13.62	13.82	14.45
12.60	14.28	14.73	14.55	13.80	18.11
50.43	34.48	31.07	24.27	19.31	17.97
10.53	18.26	17.55	16.98	16.47	15.56
24.93	19.70	17.60	14.81	12.90	14.58
11.40	25.56	23.98	19.24	20.63	19.00
11.47	12.34	11.85	15.13	14.27	15.01
19.27	15.68	15.28	16.36	15.07	16.34
12.10	10.72	12.93	14.50	18.23	17.78
38.23	26.44	23.53	19.39	17.23	16.02

Sample Size

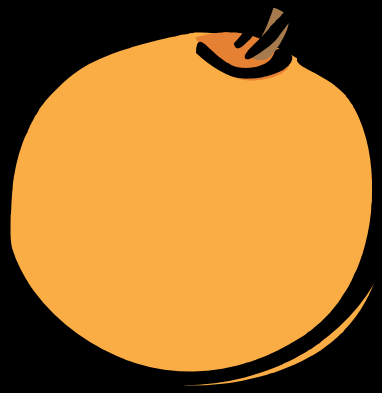
- Ontario Ministry of the Environment:
  - "To establish local background conditions, a sampling program requiring sample collection from not less than 30 separate sampling sites from at least 10 different geographical locations must be completed. A minimum of 2 replicate samples must be taken at each of the 30 (or more) sample sites."
- Ballpark cost - $5-10K/site
- PWGSC/DFO program assesses 300-400 sites/year in Atlantic Canada

Sample Scale



Sampling/Analytical Protocols

- Current situation:



Sampling/Analytical Protocols

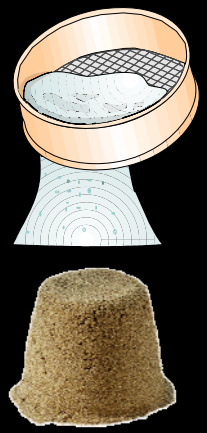
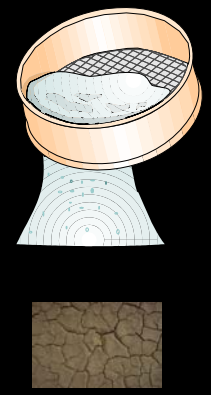
- CCME Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites:
  - Methods 3050, 6010
    - 2mm (#10) sieve
    - HNO_3 / H_2O_2 digestion (available metals)
- This is current standard practice in most major commercial laboratories. Methodology being used by Environment Canada for current background sampling.
- Till geochemistry mapping:
  - 0.063 mm sieve
    - HF digestion (total metals)

Sampling/Analytical Protocols

- Health Canada PQRA Part I 2009
  - "The particle size range of soil is an important factor to control in sampling, chemical analysis and HHRA ... chemical concentrations are not uniform across all soil particle size fractions, often increasing as particle size decreases ... chemical concentrations for the <65 µm fraction of soil may be considered for sampling and analysis, and these results employed for screening and HHRA."
- US EPA (2000) concluded that 250 µm represents a reasonable upper bound for the size range of ingested soil particles.

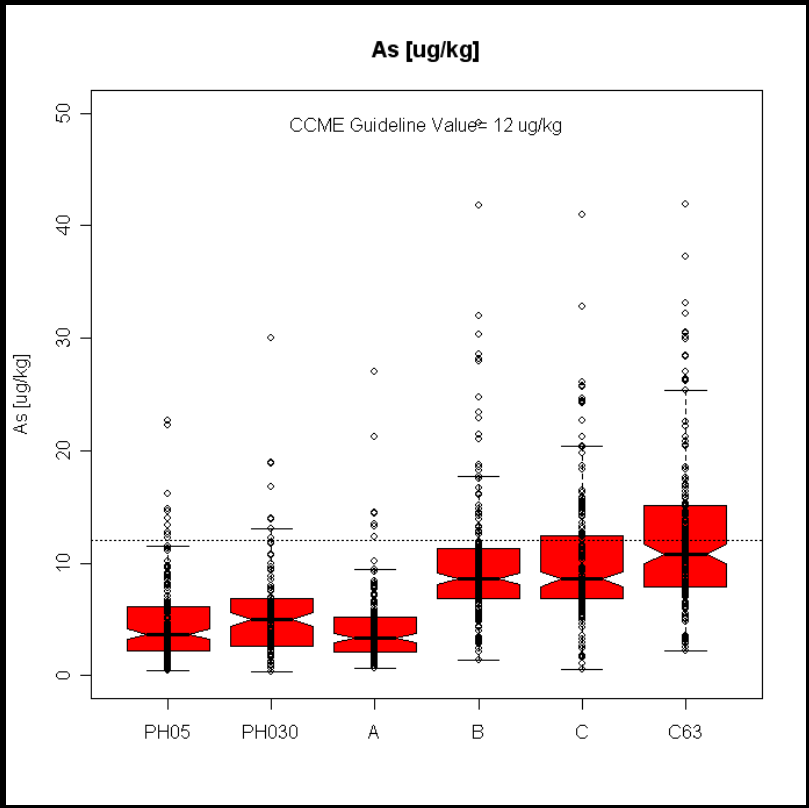
Sampling Protocols: Mathematical Remediation

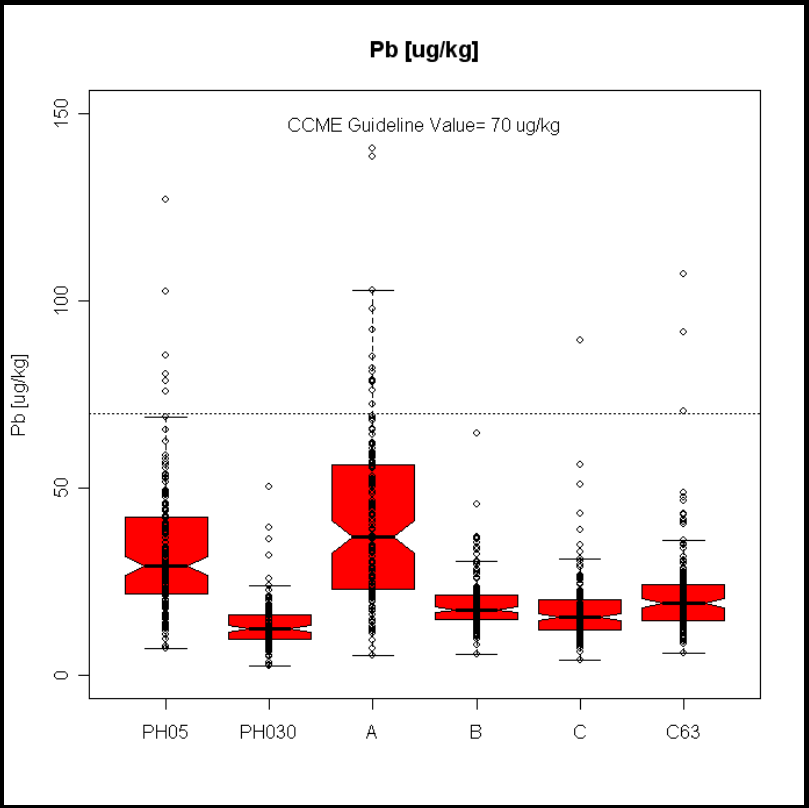
Fairmount Developments Inc. v. Nova Scotia (Environment and Labour), 2004 NSSC 126
http://decisions.courts.ns.ca/nssc/2004/2004nssc126.html

	60%	30%	10%
			
Pb: 400	10	200	500

$$(10 \times 0.6) + (200 \times 0.3) + (500 \times 0.1) = 116$$

Sample Depth

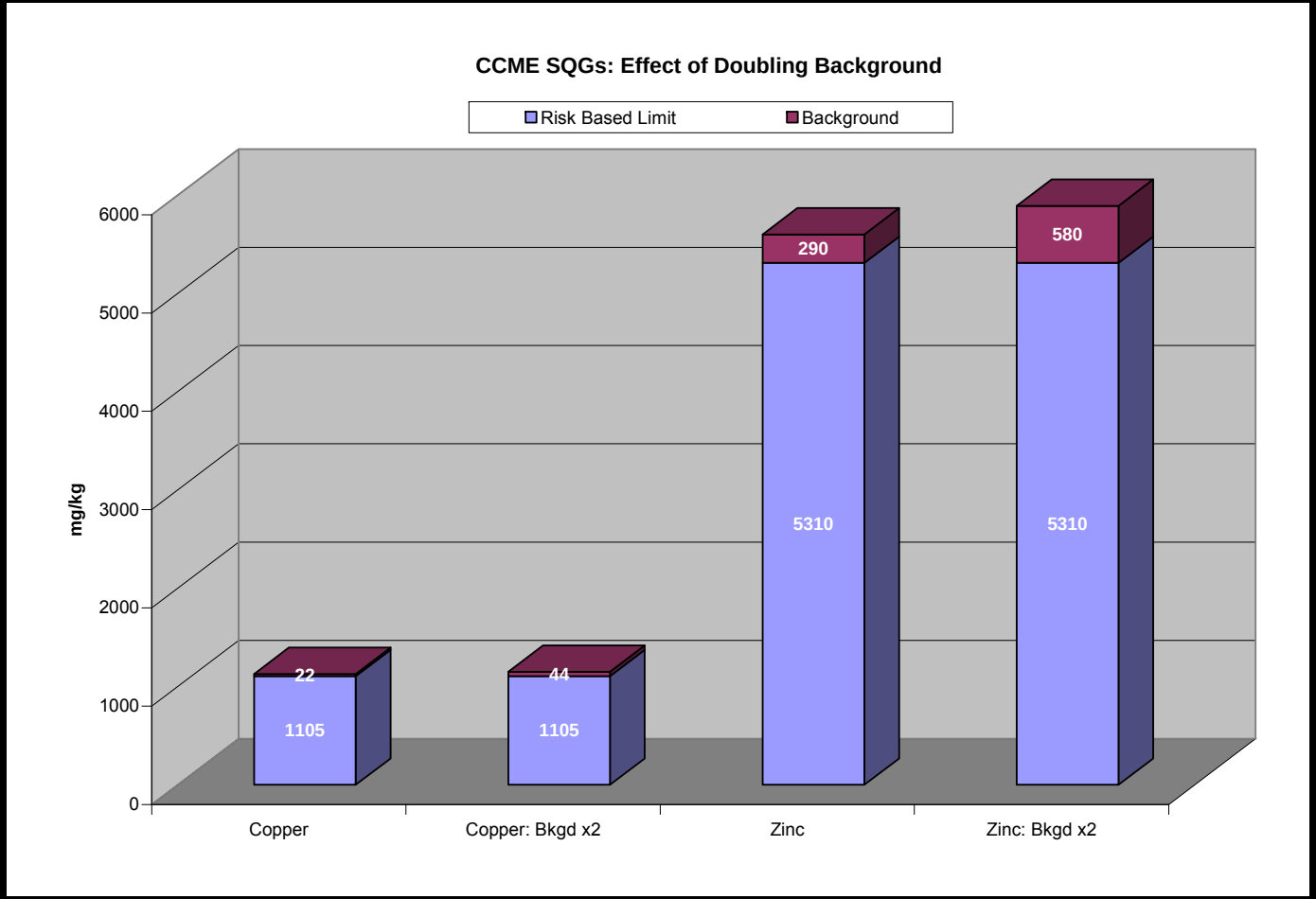




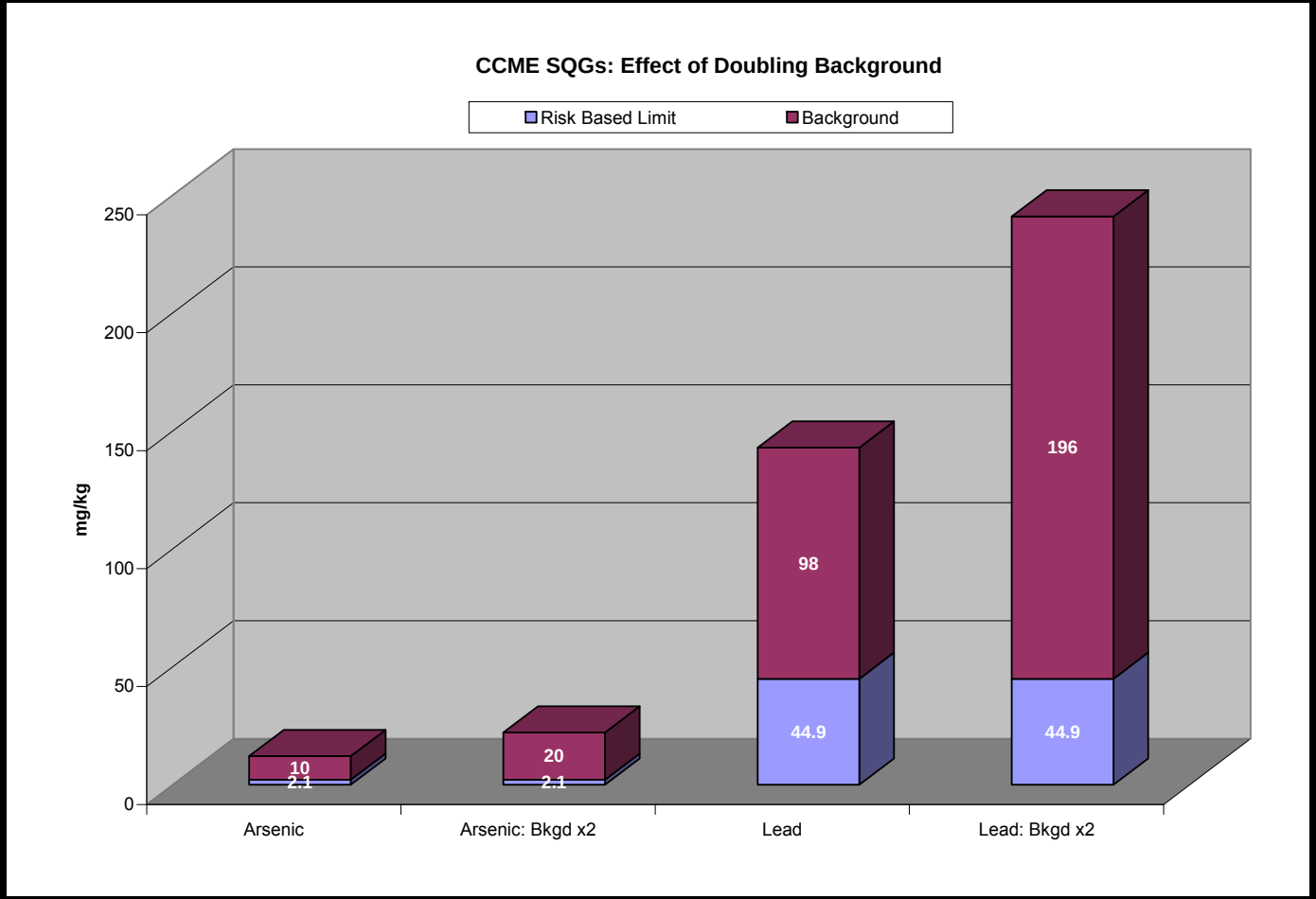
Forest and the Trees

- How much does it all really matter?

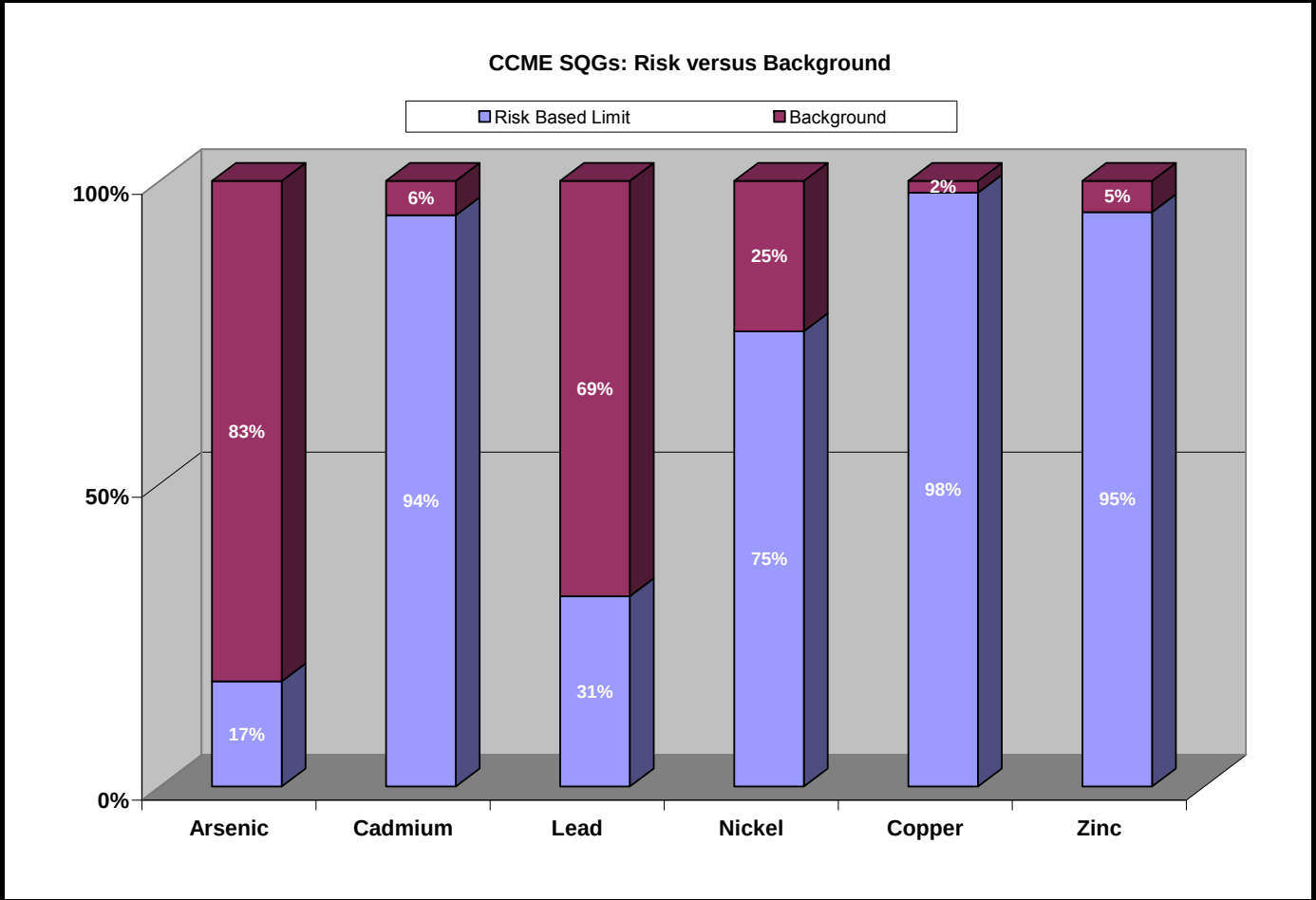
SQGs and Background Variation



SQGs and Background Variation



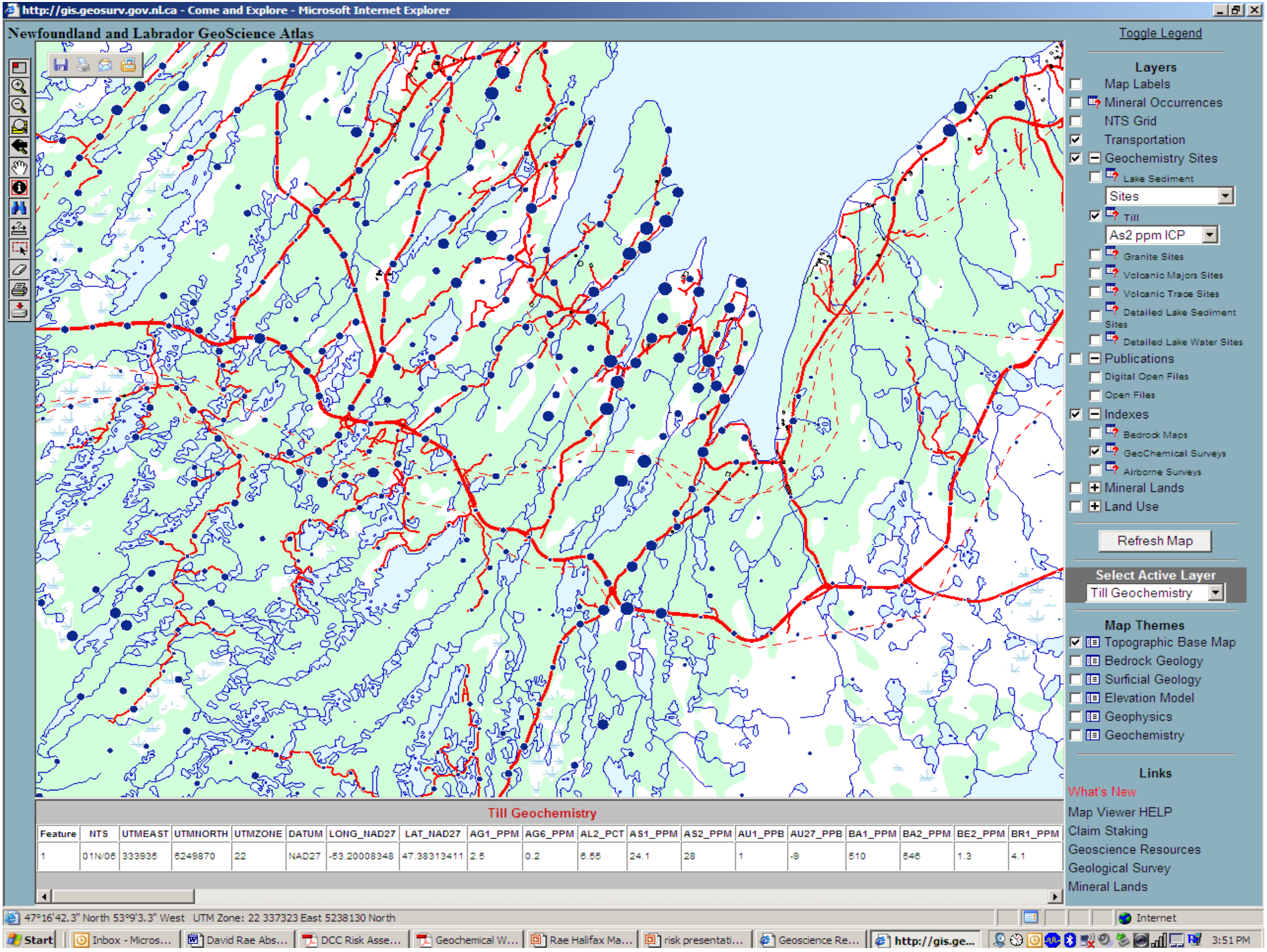
SQGs and Background Variation



Conclusions

- Regional background data sets needed
  - Too costly to get site-specific background at every site
  - Too generic to use “national” data
  - Must be easy to implement on a broad scale
- Sampling and analytical protocols should be harmonized

- Background data should be geo-referenced, web-based, and interactive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Mineral Occurrences
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Lake Sediment
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Volcanic Majors Sites
Volcanic Trace Sites
Detailed Lake Sediment Sites
Detailed Lake Water Sites
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Surficial Geology
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Abbreviations Explained

- RAMP: Regional Aquatic Monitoring Program
- DFO: Department of Fisheries and Oceans
- CCME: Canadian Council of Ministers of the Environment
- PWGSC: Public Works and Government Services Canada
- AF_G: Absorption factor for gut
- AF_L: AF for lung
- AF_S: AF for skin
- BSC: Background soil concentration
- BW: Body weight
- EDI: Estimated daily intake
- ET: Exposure term
- IR_S: Inhalation rate for soil
- RSD: Risk specific dose
- SAF: Soil allocation factor
- SIR: Soil ingestion rate
- SQG_{HH}: Soil Quality Guideline for Human Health
- SR: Soil dermal contact
- TDI: Tolerable daily intake
- PH05, PH30: "Public Health" sample depth intervals of 0-5 cm and 0-30 cm
- A, B, C: Soil horizons
- C63: <63 micron fraction of C-horizon
- HHRA: Human Health Risk Assessment