Regulatory and Assessment Challenges for Muskeg Soil at Oil and Gas Sites in Northeast BC

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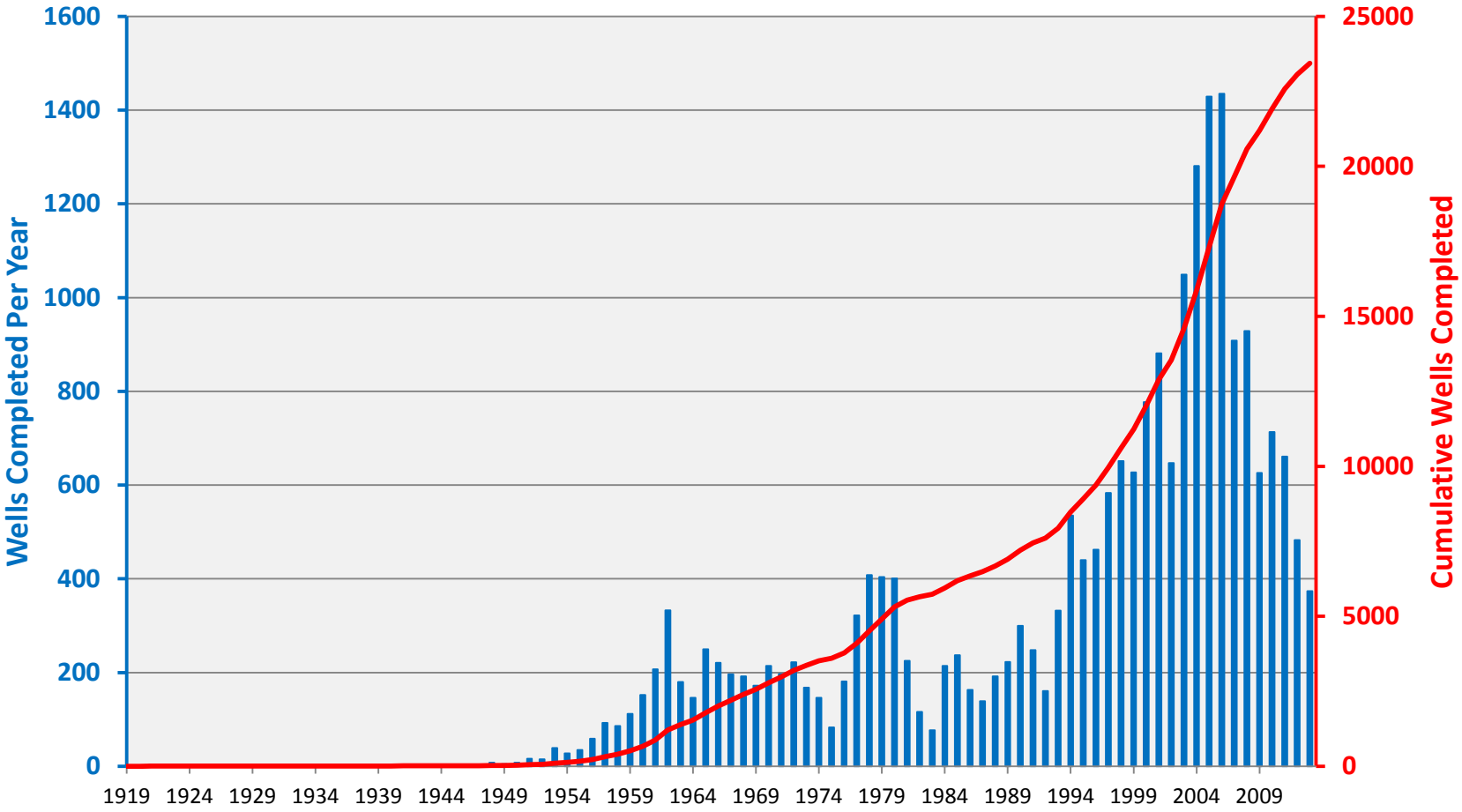
Presentation Overview:

- Oil and Gas in NEBC
- Soil Stratigraphy in NEBC
- Muskeg Soil Characteristics
- Regulatory and Assessment Challenges for Muskeg Soil

Oil and Gas Activity in (Northeast) BC



Source: BC Oil and Gas Commission

Northeast BC - Regions

Northeast BC comprised of two regions:

- Peace River Regional District
    - 40% of ALR in BC
- Northern Rockies Regional Municipality
    - “Shale gas capital of Canada “
- Together, the two regions account for over 21% of BC’s landmass.

Northeast BC -
Oil and Gas Fields and Ecoprovinces

Oil (green) and Gas (pink) Fields

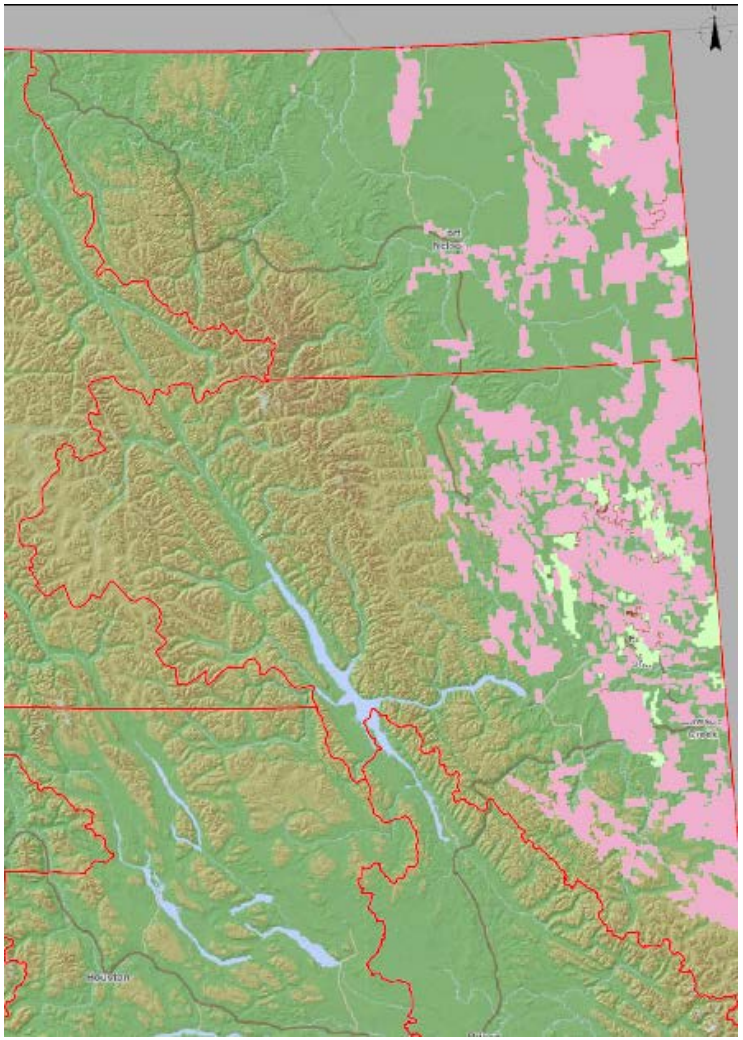
Ecoprovinces (east of the Rockies):

Taiga Plains (Northern Rockies)

- Alberta Plateau extension. Dissected by Liard River and tributaries.
- Vegetation: boreal white & black spruce zone; extensive black spruce bogs & wetlands

Boreal Plains (Peace River)

- On Alberta Plateau. Dissected by Peace River and tributaries. Upland drainage poorly organized, large areas of muskeg, streams meander across surface.
- Vegetation: boreal white & black spruce zone, muskeg throughout most of the upland, aspen parkland in the Peace River lowland.



Common Soil Stratigraphy in NEBC

organic layer (muskeg)

clays and silts (mineral soil)

Common NEBC Soil Types

Muskeg

- complex of wetland types (bogs, fens, marshes, swamps)
- occurs in cool, northern climates - boreal forests
- muskeg ecosystems predominantly bogs and fens
  - Peat > 40 cm, pH 3 – 5, sphagnum moss predominates

Mineral Soil

- predominantly of mineral or rock derivatives (clay, silt, sand, gravel)

Common NEBC Soil Types

Peat or Muskeg

- organic matter from incomplete decomposition of plant matter
- situated in a water saturated environment with anaerobic conditions

Environmental Site Assessment at Oil and Gas Sites

- Oil and gas sites undergo environmental site assessments as part of closure for the property – similar to the manner in which urban setting sites that are administered under the BC Ministry of Environment.
- Successful site closure at oil and gas sites are represented by a Certificate of Restoration which is administered by the Oil and Gas Commission.

Environmental Site Assessment at Oil and Gas Sites with Muskeg

An often encountered scenario at oil and gas sites with muskeg:

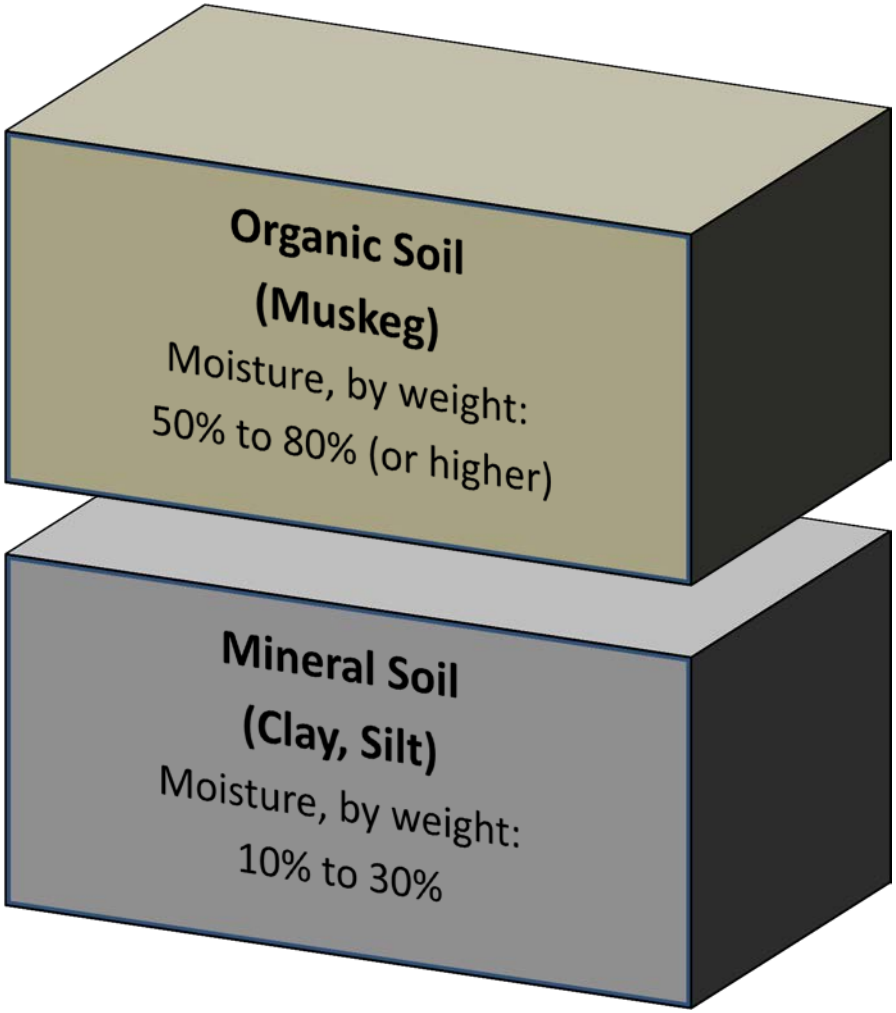
- Drilled and abandoned well site. Well did not produce, therefore low risk of contamination.
- Elevated metals (e.g., arsenic, cadmium, selenium) detected in soil samples collected from muskeg.
- Elevated metals not detected in underlying mineral soil.
- No other elevated PCOCs (hydrocarbons or salinity) were detected in soil samples at the site.

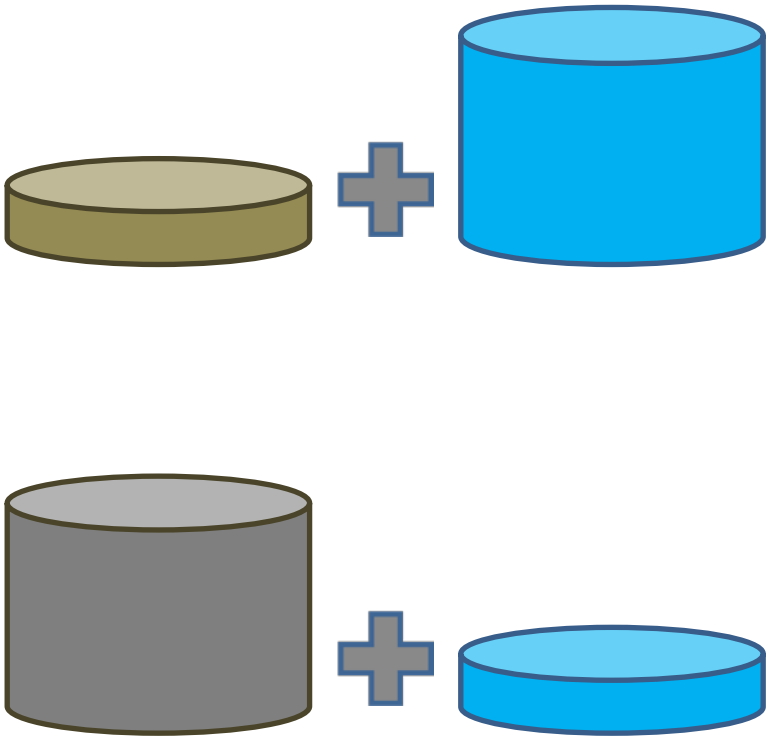
Environmental Site Assessment - Soil Analysis and Soil Moisture

The moisture content of soils, sediments, sludge and plant tissue can vary significantly and, while the analysis is more appropriately performed on the sample "as received", it affords a more consistent basis for interpretation of results if they are reported on a "dry weight" basis.

– BC Environmental Laboratory Manual (2009)

Moisture Content for NEBC Soil Types



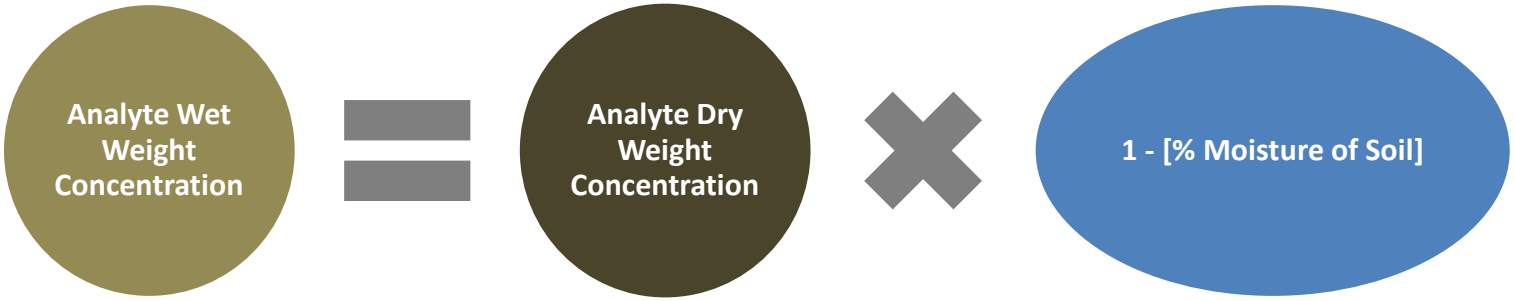


High Moisture Content Soil and Overestimation of Analyte Concentrations

- There is a tendency for soil containing high moisture and organic matter to bias high for analyte soil concentration when reported on a dry weight basis.
- The greater the soil moisture content, the greater the difference between dry weight and wet weight concentration.

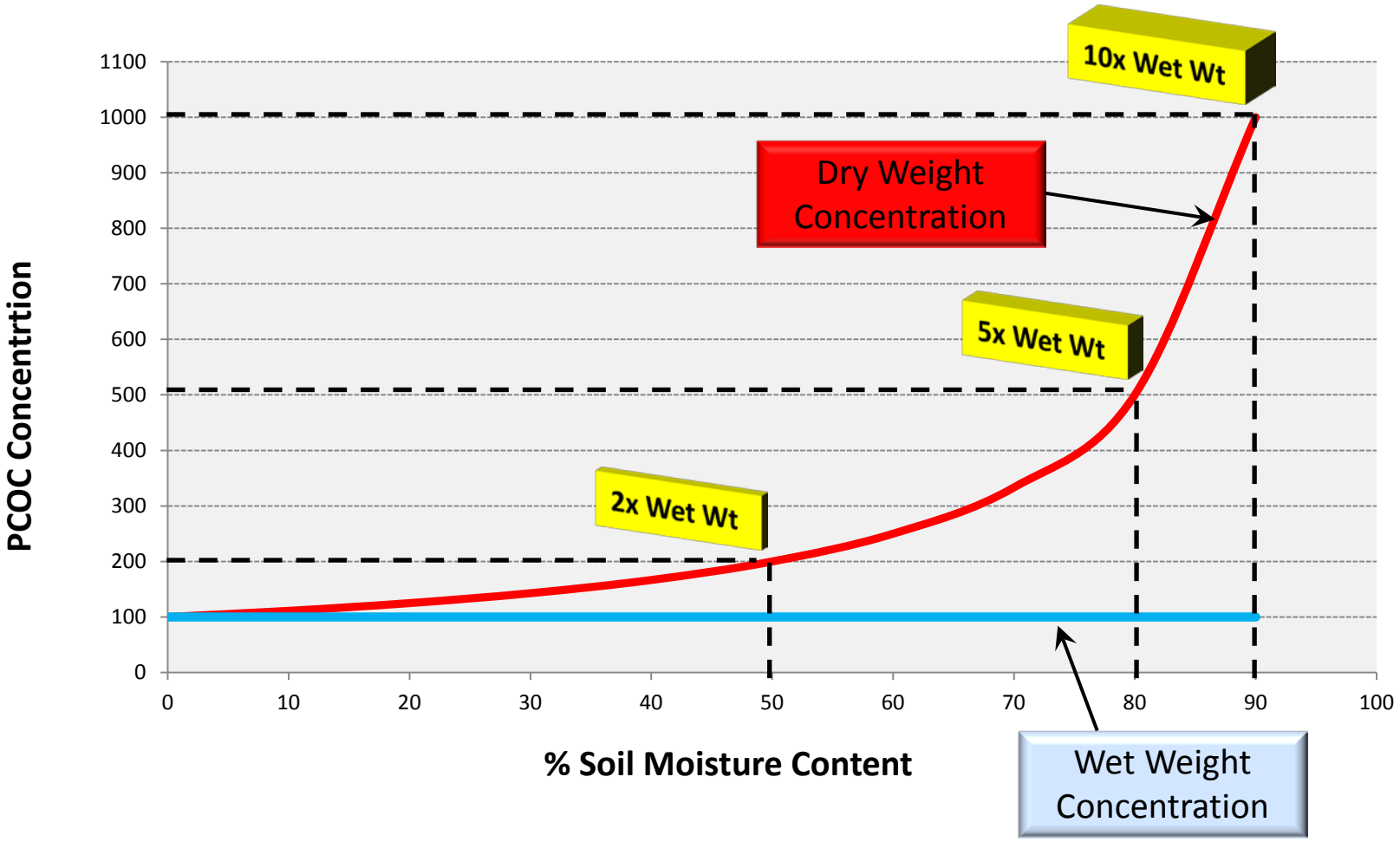
High Moisture Content Soil and Overestimation of Analyte Concentrations

- For high moisture content soil samples, presenting the analyte concentration as a wet weight concentration would provide a closer representation of the field conditions and therefore, the analyte concentrations in the soil sample.

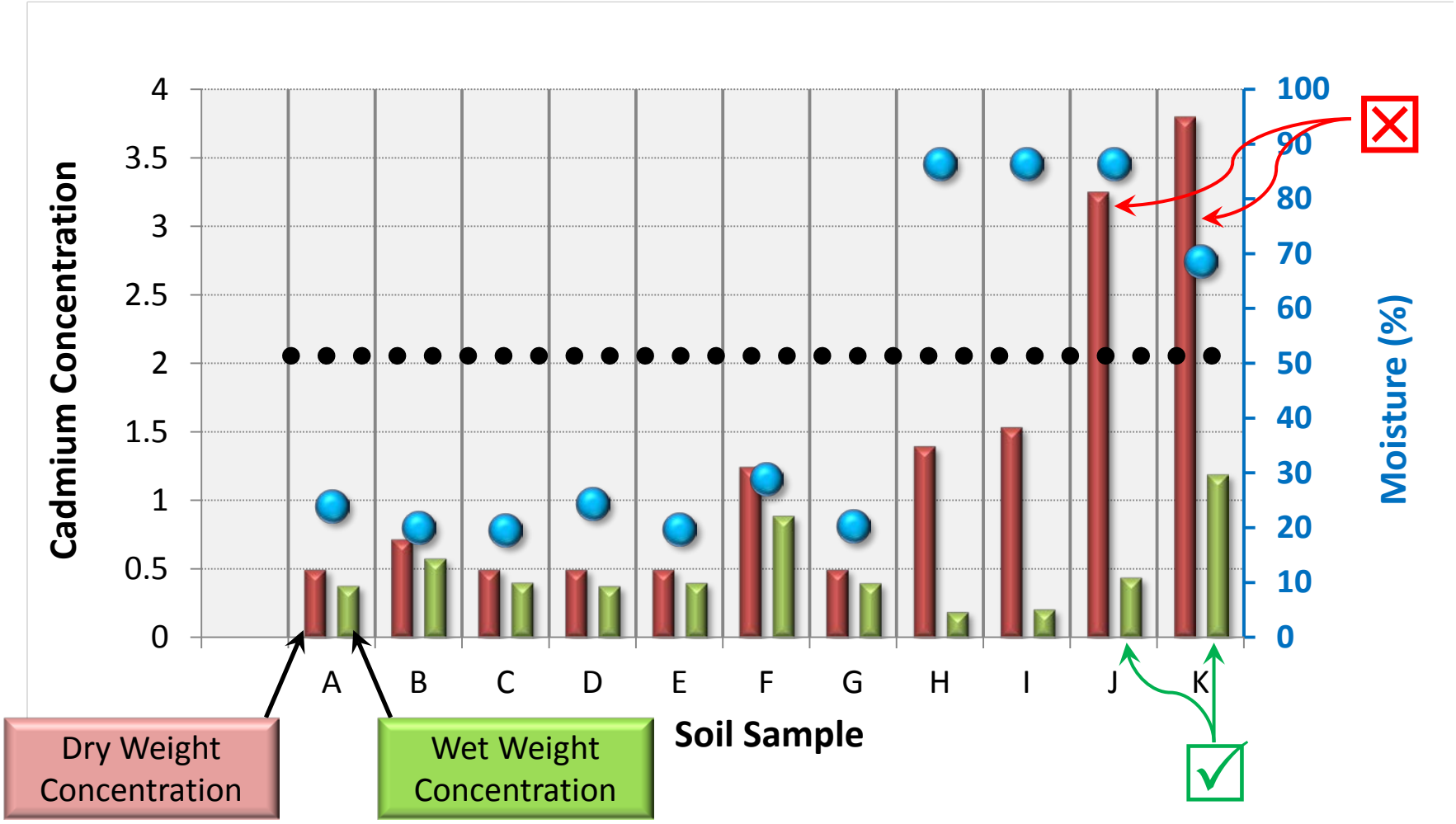


Substance Concentration Comparison:

Dry Weight Concentration Derived from Soil Moisture Content and 100 mg/kg Wet Weight Concentration Constant

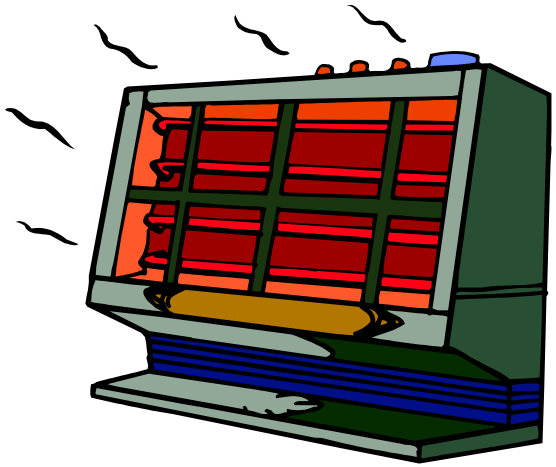


High Moisture Content Soil
Wet Weight – Dry Weight Comparison



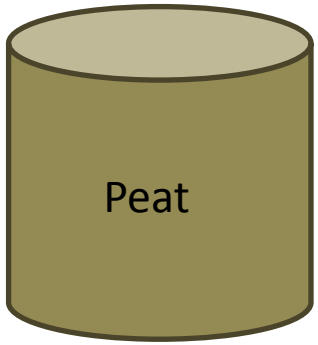
Related Challenge #1: Formation of Contaminant Salts

- As the water portion of high moisture content soil is removed by heating the sample as part of sample preparation in the lab, dissolved analytes may leave solution and form salts.
- The salt formations become part of the dried soil matrix which can increase the concentration of the analyte in the solid phase of the sample.
- The greater the moisture content, the greater opportunity for analyte salt formation as the sample is dried.



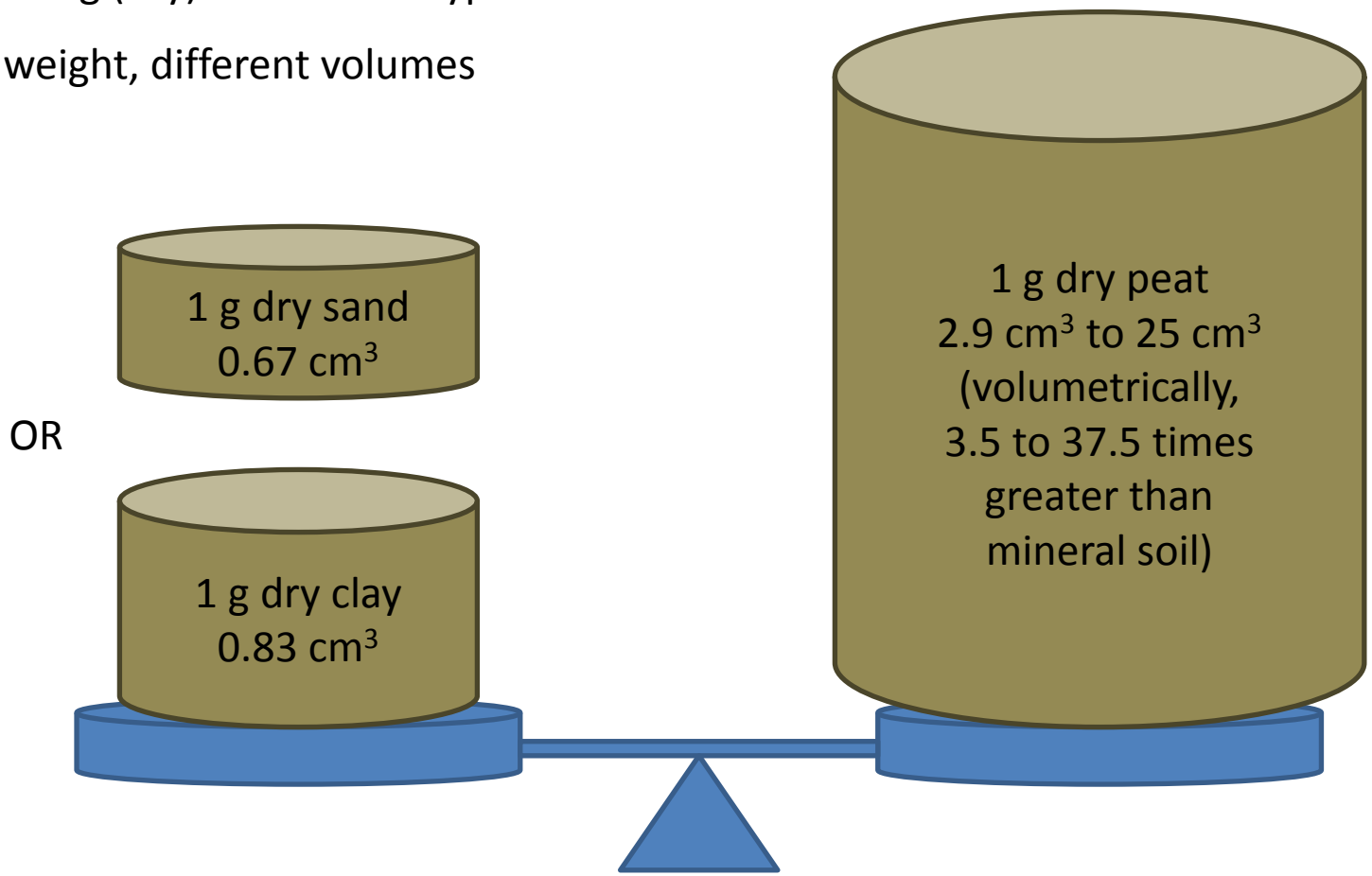
Related Challenge #2:
Soil Density and Contaminant Concentration

- Analytical methods for metals include preparation of a dry sample that is gravimetrically measured to obtain an aliquot.
- Soil density can be a significant factor to determine contaminant concentrations, especially with low density organic soil.

Soil Type:			
Density (dry):	1.2 g/cm^3	1.5 g/cm^3	0.04 to 0.34 g/cm^3

Related Challenge #2:
Soil Density and Contaminant Concentration

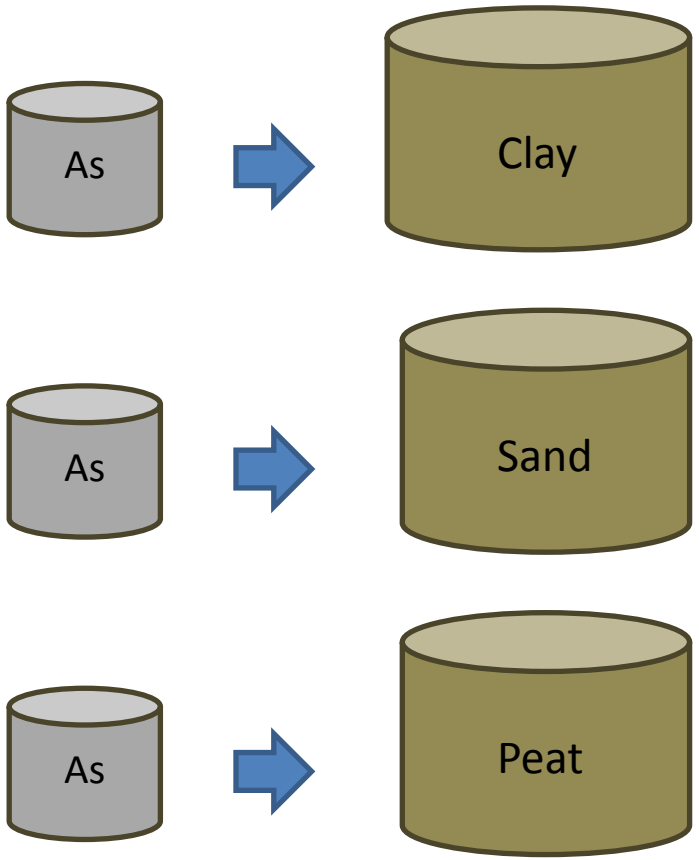
- Assume 1 g (dry) of each soil type
- Same weight, different volumes



Related Challenge #2:
Soil Density and Contaminant Concentration

With soil density in mind, consider the following:

- Volumetrically, assume each soil type has the same concentration of arsenic
- Each soil type contains As /cm^3



Related Challenge #2:
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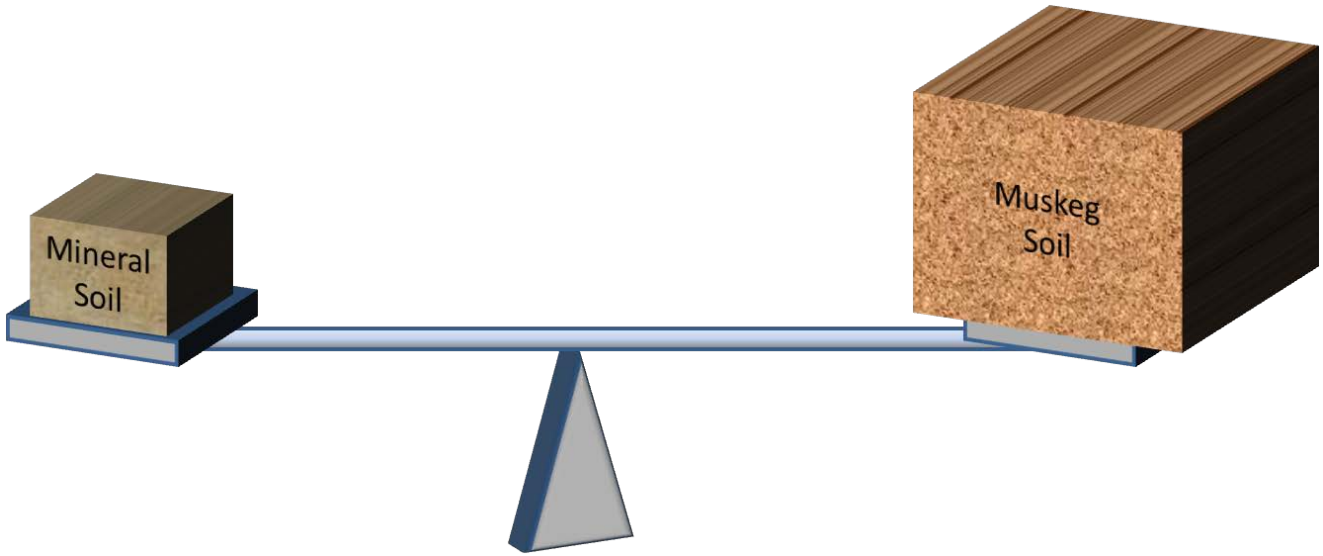

Each soil type contains the same concentration of As on a volumetric basis

Soil analytical method specifies a gravimetric amount (1 g) of dry sample for analysis

Gravimetrically, the concentration of As in each soil type is:

- 0.67 As/g of sand
- 0.83 As/g of clay
- 2.9 to 25 As/g of peat

Approach to Manage the Assessment of High Moisture Content Soil (Conclusion)

Regulatory authority (OGC) acknowledges the tendency to overestimate analyte concentrations in high moisture soil.

Providing a comparison of dry weight concentration with wet weight concentration for high moisture soil demonstrates the overestimation of analyte concentrations.

The analyte overestimate rationale has been presented as part of a multiple lines of evidence approach to support successful site closure applications (CoRs) for well sites.

Approach to Manage the Assessment of High Moisture Content Soil (Conclusion)

Wet weight approach benefits

- Further investigation and unnecessary remediation of sites averted.
- Significant cost savings to the client.
- Site becomes simple closure.
- Prevent significant soil disturbance to sites that have already been reclaimed.

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