Alberta’s Environmental Monitoring Standards and Protocols

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Credible and Relevant Data/Information

• Consistent and comparable Standard Operating Procedures (SOPs).

• Comprehensive data QA/QC programs including independent external audit that are open and transparent.

• Forward looking, take advantage of new/emerging science and technologies.
You Can’t Manage What You Don’t Measure

1971 first province in Canada with Environment Department

First Clean Air Act in Canada

Environmental Protection and Enhancement Act (EPEA) 1992

1982: Lodgepole Sour Gas Blowout, H2S Research

CASA

Canada-wide Standards for PM$_{2.5}$ and Ozone

CASA PM and Ozone Management Framework

CAAQS 2012
Science Is The Reduction of Uncertainties

• Type I: There is a true value to be determined. SOP execution affects accuracy and precision.

• Type II: Variability (e.g., spatial and temporal variances) + Type I uncertainties.

• Type III: Complex causal relationships and random factors (e.g., Heisenberg’s Uncertainty Principle)
Project Rosetta Stone
US EPA Data Quality Objective for Relating FRM and CM to Report AQI

• CM may be used to report AQI if a linear relationship can be established by statistical linear regression against FRM ($R^2 > 0.8$).

• Statistical linear regression can be used to transform CM data into FRM-like data.

PM2.5 Measurements Show significant discrepancies between CM and FRM in Cold Weather Conditions especially in Alberta
Removal of Type II Scientific Uncertainty for PM2.5 Measurements

The Discrepancies between CM and FRM is a function of temperature

\[ \text{FRM} = \text{CM} + \text{CM} \times F(T) \]

Temperature induced discrepancies can be corrected

\[ \frac{\text{FRM}}{\text{CM}} = \alpha + \beta T + \varepsilon \]

“A two-step approach for relating tapered element oscillating microbalance and dichotomous air sampler PM2.5 measurements”

J of A&WMA September 2014

Co-authors: Long Fu, Thompson Nunifu and Bonnie Leung.
Sample Data from Toronto – Etona Region

FRM = 0.1755 + 0.9628 * CM’

$R^2 = 0.9053$
Data Quality Issues In The Oil Sands Region

• LICA Reference #291462, #291464, #291461

• Elk Point TEOM FDMS had less than 90% operational time during the month of September 2014

• For the month of July and September 2014, St. Lina TEOM FDMS had less than 90% uptime.

• LICA-AEMERA Joint PM Data Quality Study for 2014-2016
Particulate Matter Data at Cold Lake South
(December 2014 - October 2015)

\[ y = 1.1213x + 2.7747 \]

\[ R^2 = 0.9838 \]
Project Color Pink
Naphthenic acids (NAs)

- Unspecific mixture of cyclic carboxylic acids

- Formed during oil sands extraction process
  - NAs show toxicity to fish and other organisms

Liquid tailings, a by product of the oil sands mining process, contain naphthenic acids

Naphthenic Acids Speciation

Orbitrap-MS

GC-MS
Comparison of FTIR, GC-MS and Orbitrap (ESI-)

Naphthenic acid concentration (µg/L)

Analytical Methods
Spatial Variation of GC-MS/Orbitrap Ratio

\[ y = 1.7252x^{-0.496} \]
\[ R^2 = 0.5759 \]
The Needs for a Standard Reference Material and Better Extraction Process

High resolution mass spectrometry vs. Design Value

\[
\begin{align*}
\text{NA029} & : y = 5.693x + 0.2703, \quad R^2 = 0.9993 \\
\text{NA012} & : y = 1.7807x + 0.3695, \quad R^2 = 0.9974 \\
\text{NA038} & : y = 1.0901x - 0.2475, \quad R^2 = 0.9775 \\
\text{NA005} & : y = 15.21x - 0.026, \quad R^2 = 0.9874 \\
\text{NA010} & : y = 3.5139x + 0.3291, \quad R^2 = 0.999 \\
\text{NA028} & : y = 0.7453x + 0.3245, \quad R^2 = 0.9979 \\
\end{align*}
\]
Recommendations from the NA Method Workshop – March 14, 2016

ECCC, AEMERA, COSIA, AER, AEP

• A simple NA definition: simple carboxylic acids with two oxygen atoms detected using ESI negative-ion mode; R group can be multi-cyclic and aromatic, but does not include heteroatoms, nor any other functionalities.

• The current GC/MS method should be replaced with more suitable technologies such as FTIR, QToF, and Orbitrap. NA quantification methods and field sampling procedures are priorities for development.

• Bitumen relevant standard reference materials for method development and toxicity tests were highlighted as a current “ultra high” priority.
Machine Intelligence: Enigma Code, Deep Blue, Watson, and AlphaGo

- Enigma code
  - $1.59 \times 10^{20}$

- Deep Blue
  - Chess: 50 digits

- Watson
  - Wiki: 4 TB RAM

- AlphaGo
  - Value Network
  - Policy Network
  - Monte Carlo Tree Search
  - Go: 80 digits
The Hand of God – considering Types I, II, and III uncertainties
Credible and Relevant Data/Information
The Changing Environment

Natural Environment

Built Environment

Augmented Environment
What Big Science Has to Offer?

• Big Data and Supercomputers
• Remote Sensing and Advanced Sensor Technology
• Epigenetics and Advanced DNA Technology
• Intelligent Machines and Robotics
• Social Network
The Little Robot That Could
Time Series of CH4 and CO2 Fluxes
Science offers little in the way of cheap thrills. The standards of evidence are strict. But when followed they allow us to see far, illuminating even a great darkness.