Biogenic Interference Calculation (BIC) Index for Resolving False Exceedences of AB Tier-1 F3 PHC Soil Guidelines Due to Biogenic Interferences in Peat Soils

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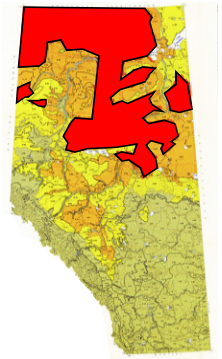
2016 RemTech Conference, Banff Alberta

Alberta Peatlands



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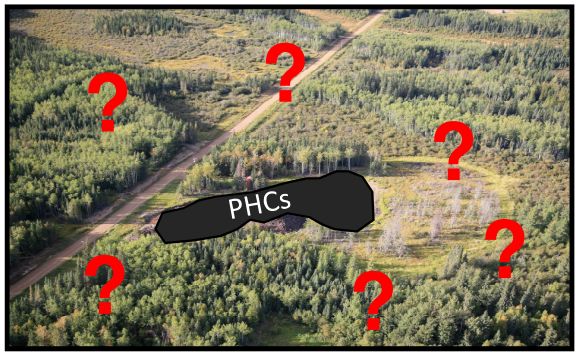
False PHC detections in peat soils surrounding an oil spill



What is the BIC Index?

Pronounced “BIC” like the pen

- Calculation for determining if biogenic interferences have caused organic (peat) samples to falsely exceed the Alberta Tier-1, 300 mg/kg F3 PHC soil guideline.
- [F2/(F2+F3b)] x 100
- <10% = false PHC exceedence
- ≥10% = true PHC exceedence

BIC Index Continues to Evolve After 14 Years of Research

Continuing method development

2004 - 2016 Research Partners

(Village that Raised the BIC Index)

- Alberta Parks and Protected Areas Division
- ALS Laboratory Group
- Canadian Association of Petroleum Producers
- Environment Canada Oil Spills Research Centre
- Canadian Geological Survey
- Husky Energy
- Imperial Oil
- Natural Sciences and Engineering Research Council
- Orphan Well Association
- Petroleum Technology Alliance of Canada
- University of Waterloo

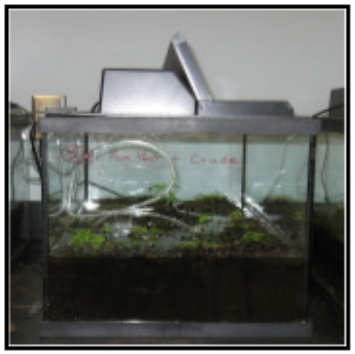
STUDY OBJECTIVES
Comparison of Control Experiment Data to Field Validation Data

To determine if the BIC Index will correctly identify samples that have or have not falsely exceeded the most stringent Alberta Tier 1 F3 PHC soil guideline (300 mg/kg) in all clean and contaminated soil samples

Controlled Training Data Sources

Data Set #1: 300-Day Crude Oil Spiked Peat PhD Experiment

Clean peat and sand were spiked with crude oil and studied for biogenic vs petrogenic carbon distributions over time.



Data Set #2: 300-Day Diesel Spiked Manure PhD Experiment

Compost and sand were spiked with diesel drilling invert and studied for biogenic vs petrogenic carbon distributions over time.

Field Validation Data Sources

Data Set #3: Background PHC survey of 34 sites located in Alberta, BC and Newfoundland

- Canadian Geological Survey collected 34 background soil samples for the biogenic vs petrogenic carbon distribution study

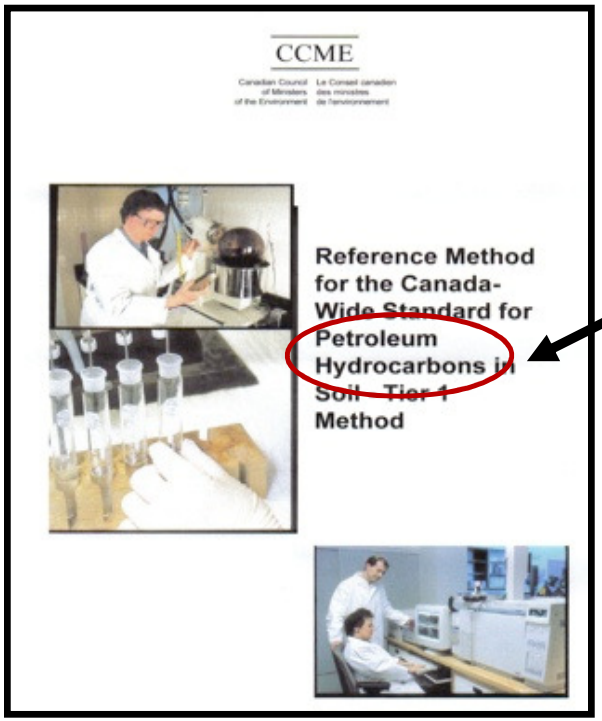
Data Set #4: Orphan Well Association Field Validation Site

- The OWA collected 55 samples from a 35-year old crude oil contaminated Alberta peatland for the biogenic vs petrogenic carbon distribution study.

What are biogenic organic compounds (BOCs)?

- BOCs are carbon-based compounds, which are naturally biosynthesized by living organisms.
- BOC groups containing C, H and O include: lipids, carbohydrates, proteins and nucleic acids.
- BOC hydrocarbon groups containing only C and H include n-alkanes.

Canadian Council of Ministers of the Environment (CCME)
Reference Method for the Canada-Wide Standard (CWS) for Petroleum Hydrocarbons (PHC) in Soil

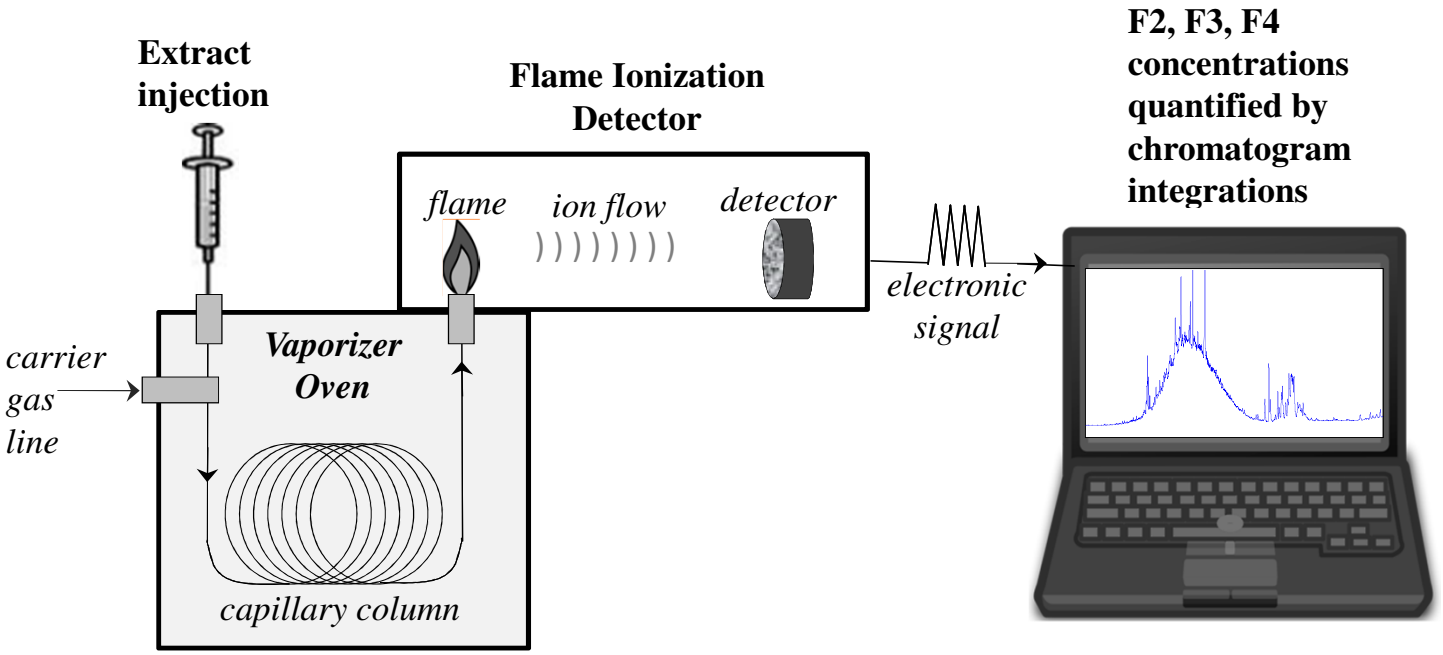


Methods can produce false positives in uncontaminated organic materials (e.g. peat, manure, etc.).

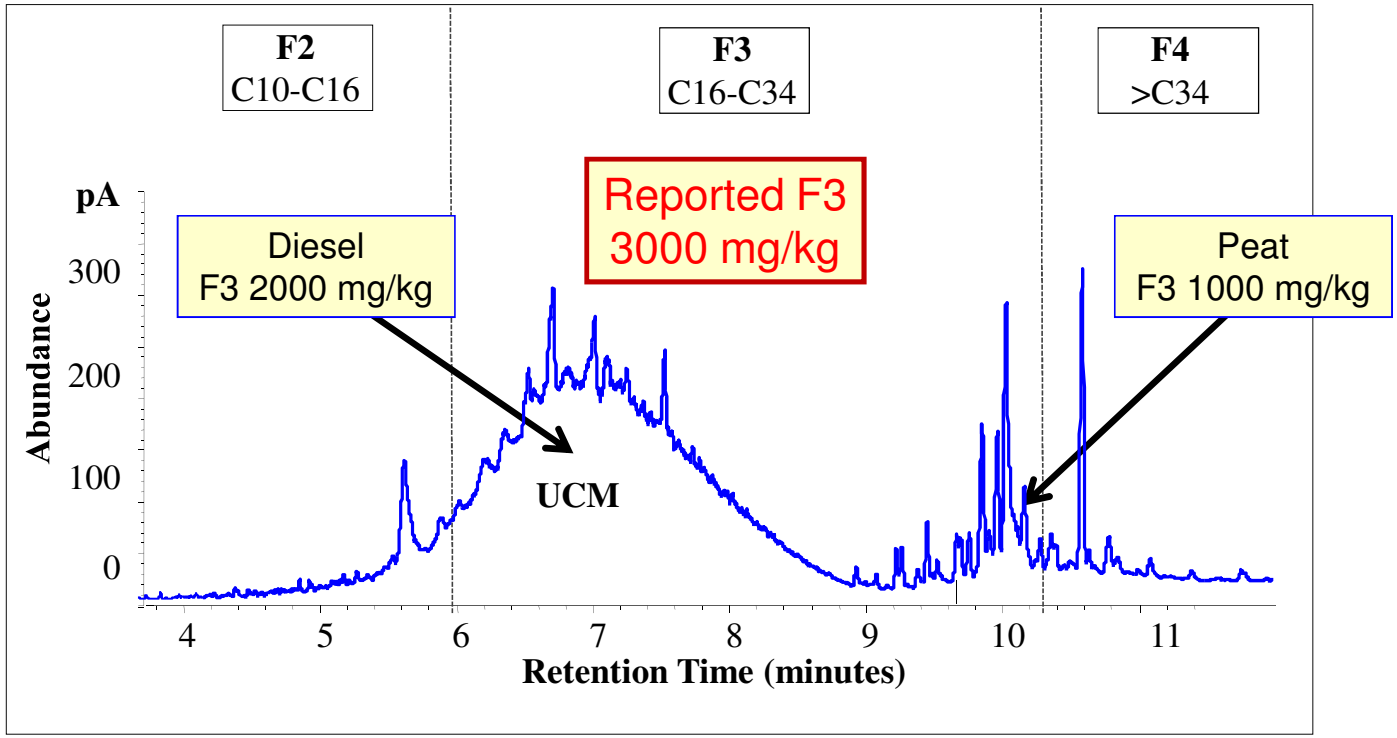
The problem is that the hexane and acetone solvents indiscriminately extract all carbon from petroleum and biological sources.

The goal is to “capture” petroleum hydrocarbons. However, background biogenic organic compounds are inadvertently “captured” as well.

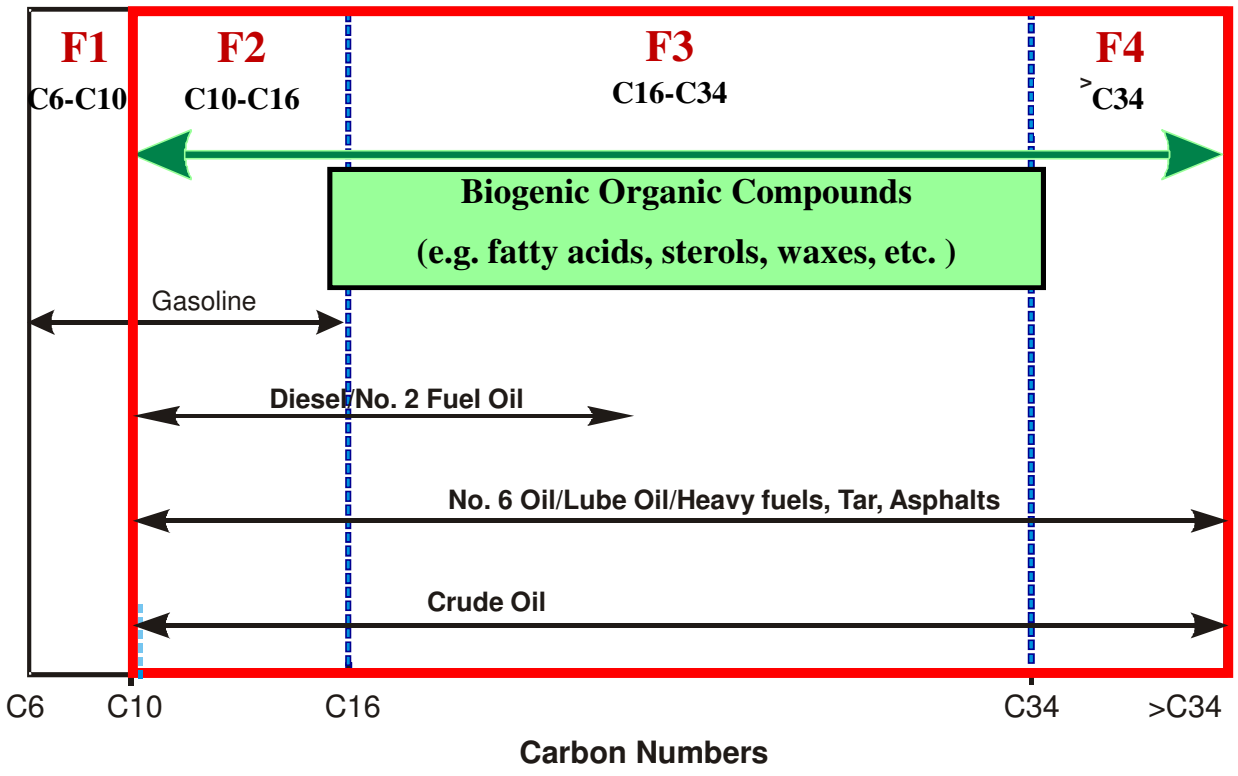
GC-FID Analysis of Sample Extract



Diesel-Spiked Peat GC-FID Chromatogram

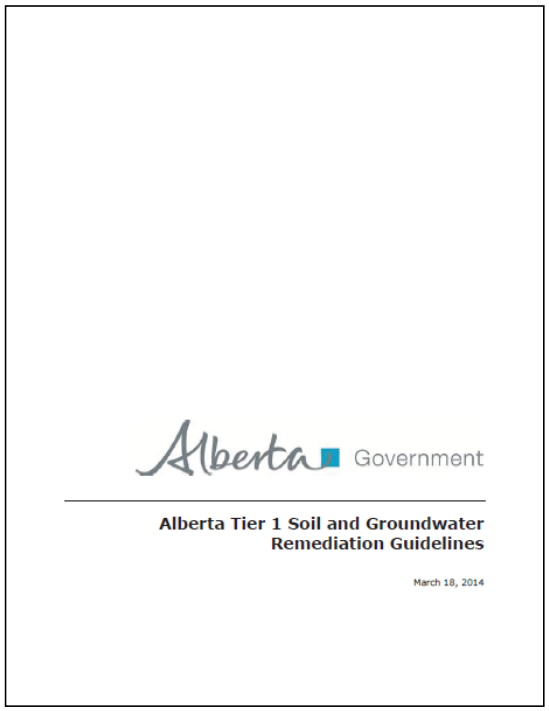


Classification of Petroleum Hydrocarbon Sources by Carbon Number Range



Comparison of Background Soil Survey Results to Alberta Tier-1 Soil and Groundwater Remediation Guidelines

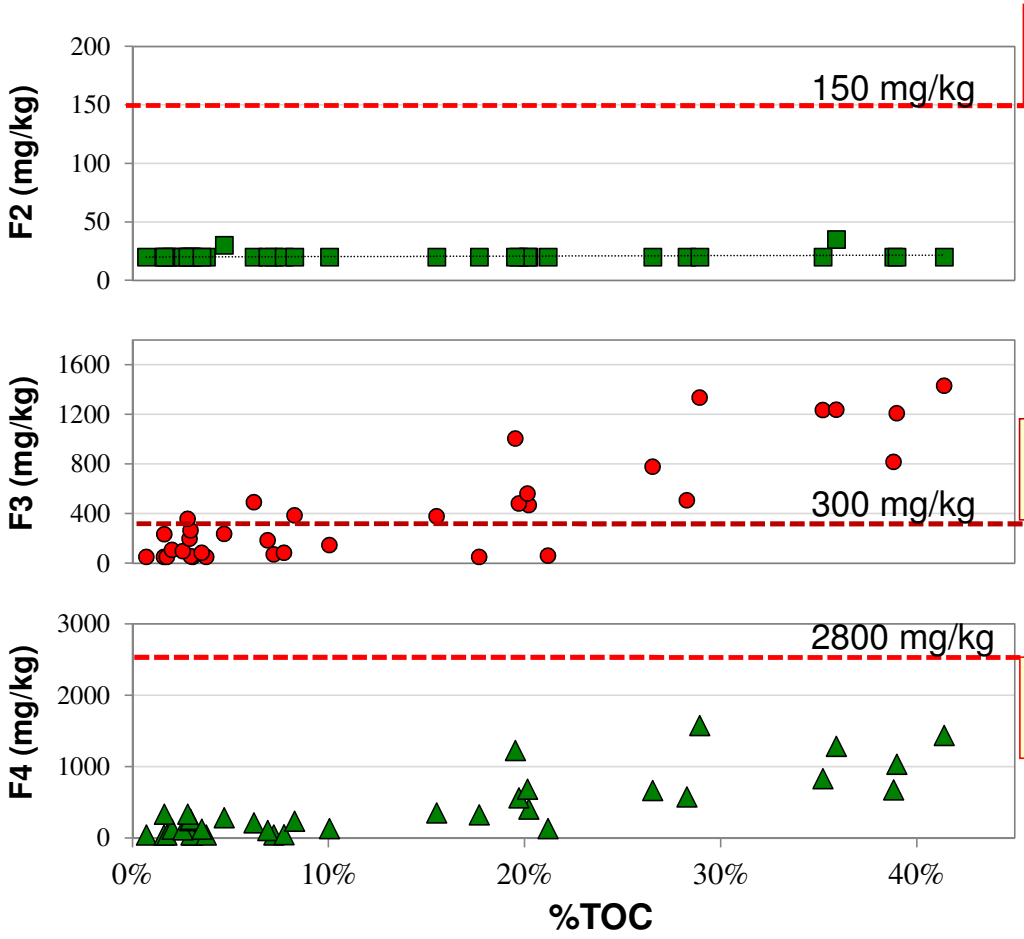
Alberta Tier-1 Soil Remediation Guidelines



"Coarse textured soil remediation guidelines may be used for organic contaminants in organic soils"

34 Background Soil Samples: Alberta, BC, Newfoundland

Comparisons of F2, F3, F4 Concentrations to AB Tier-1 Soil Remediation Guidelines
Surface Soils Natural/Agricultural/Residential/Parkland Guidelines



0 samples exceeded
F2 course soil standards

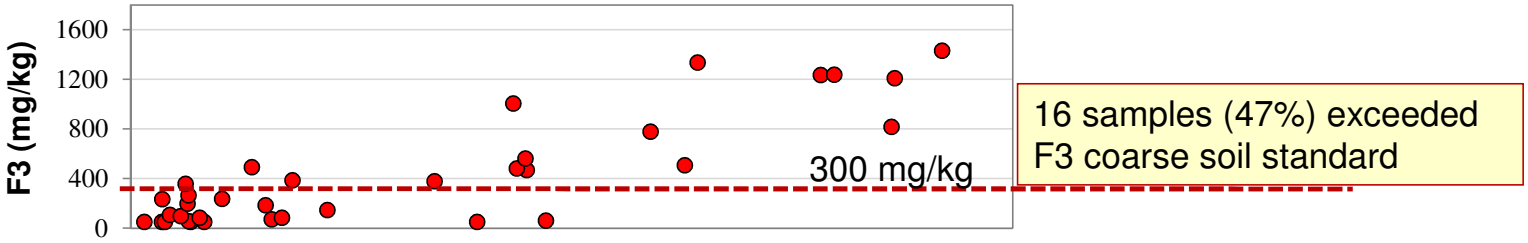
16 samples (47%) exceeded
F3 coarse soil standard

0 samples exceeded F4
course soil standards

34 Background Soil Samples: Alberta, BC, Newfoundland

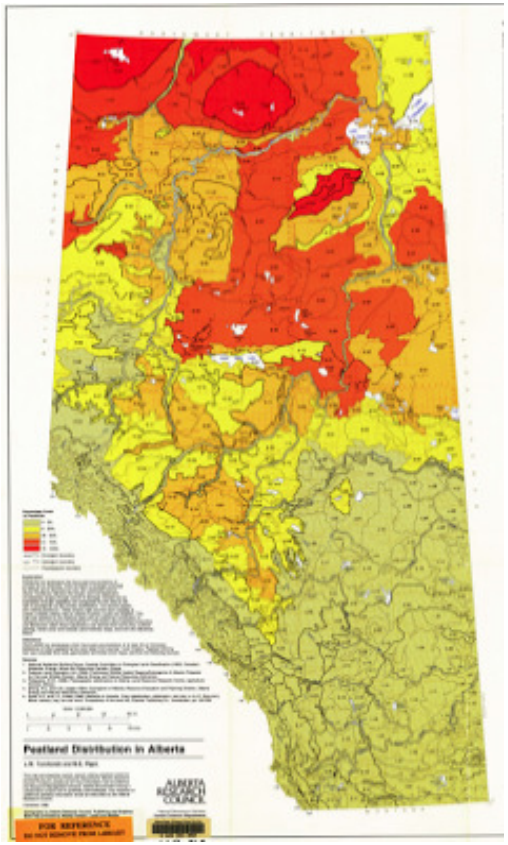
Comparisons of F2, F3, F4 Concentrations to AB Tier 1 Soil Remediation Guidelines
Surface Soils Natural/Agricultural/Residential/Parkland Guidelines

Only F3 exceeded the guideline



- All soils with >28% TOC exceeded the F3 coarse soil standards
- Peat soils have >40% TOC

Peat soils cover 18% of Alberta



source: Alberta Geological Survey

But there is a light at the end of the tunnel!

Biogenic Interference Calculation for Identifying False Exceedences of the AB Tier-1, F3 PHC 300 mg/kg Soil Guideline

Formula

[F2/(F2+F3b)] x 100

F2 = measured F2 (C10-C16) concentration

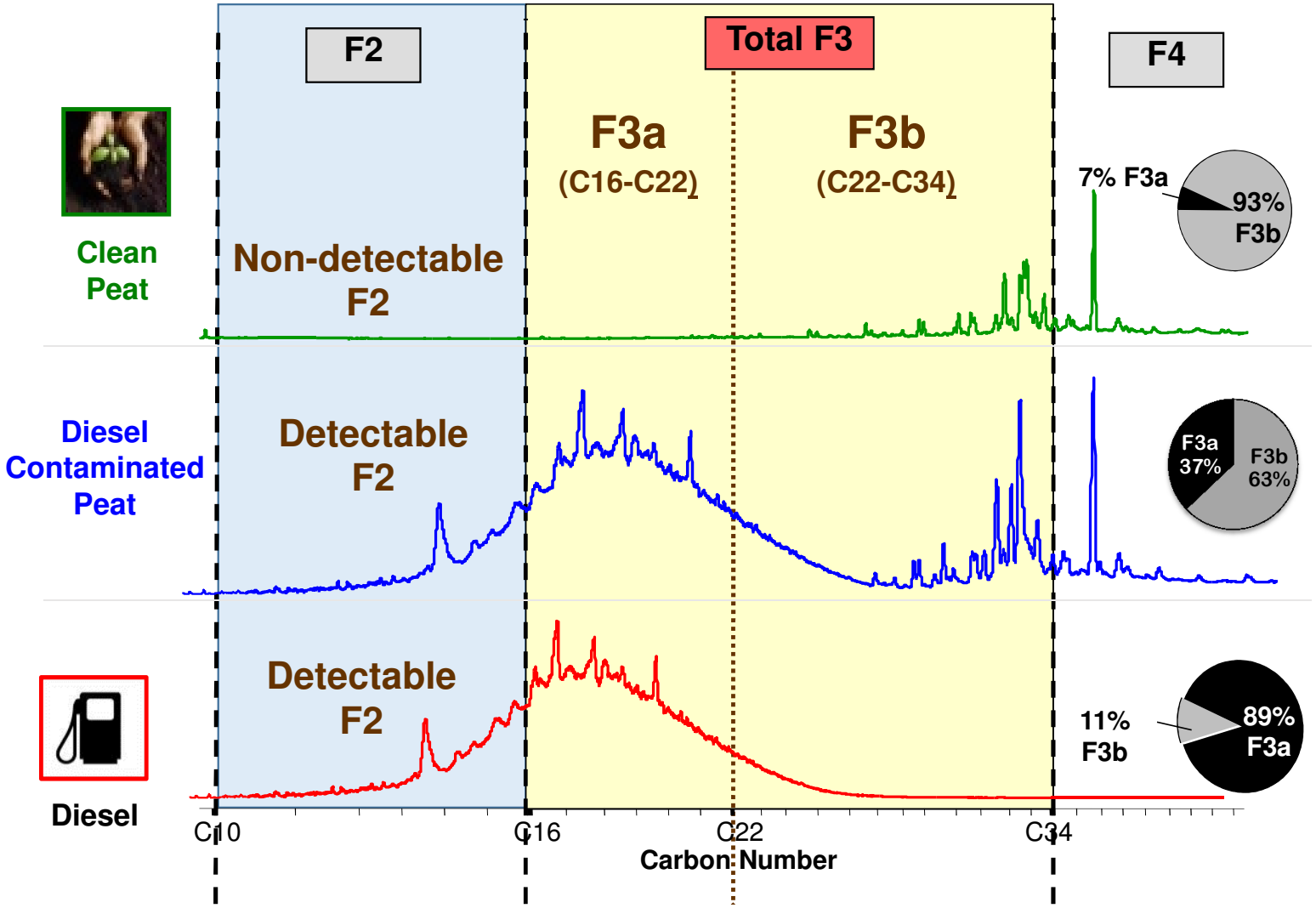
F3b = measured F3b (C22-C34) concentration

Index Values

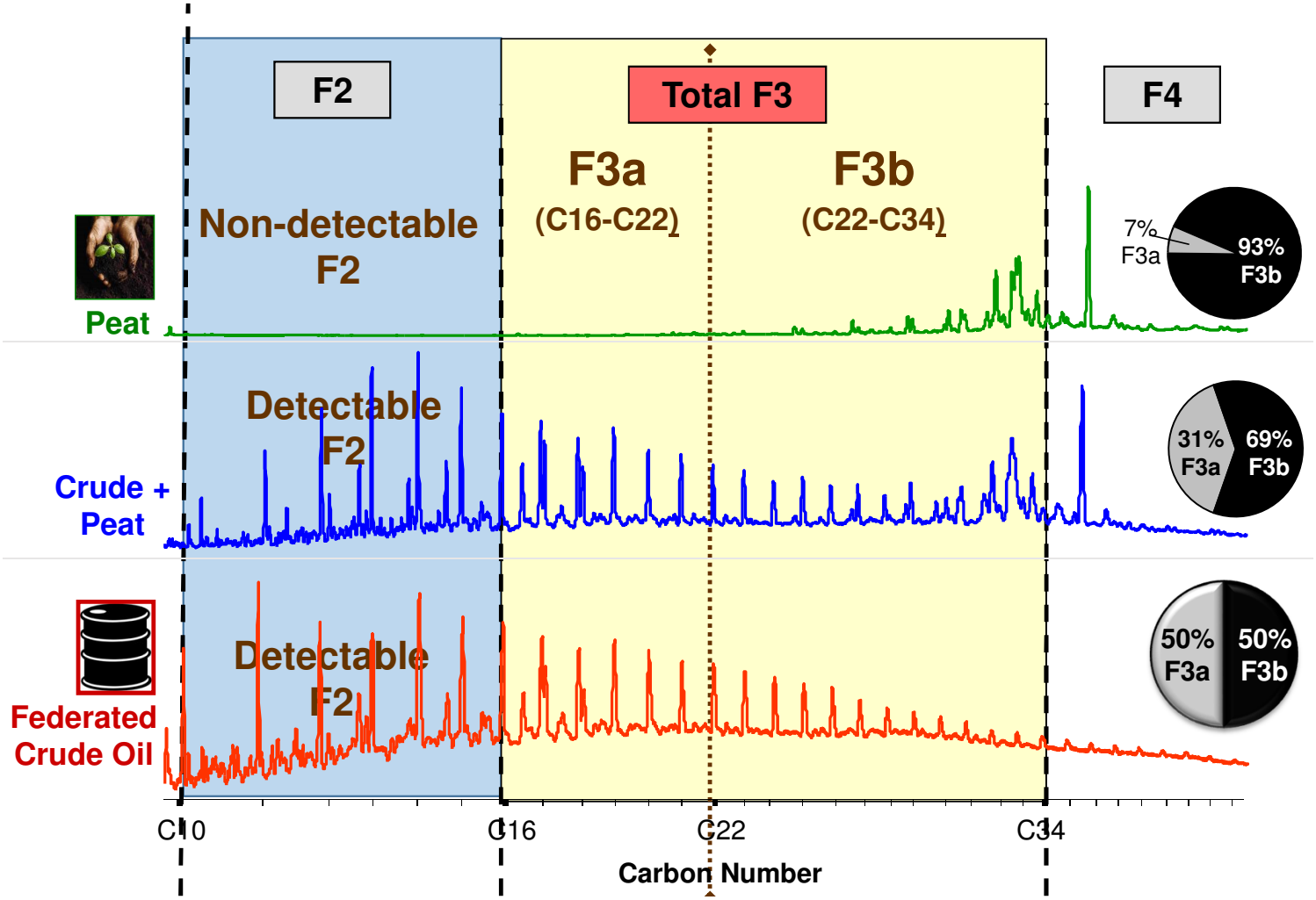
<10% indicates that BOCs have caused false exceedences of F3 PHC guideline

≥10% indicates true exceedences of the F3 PHC guideline

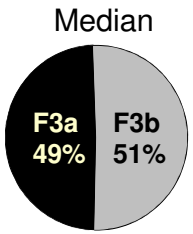
F3a (C16-C22) and F3b (C22-C34) Distributions in Diesel and Clean Peat

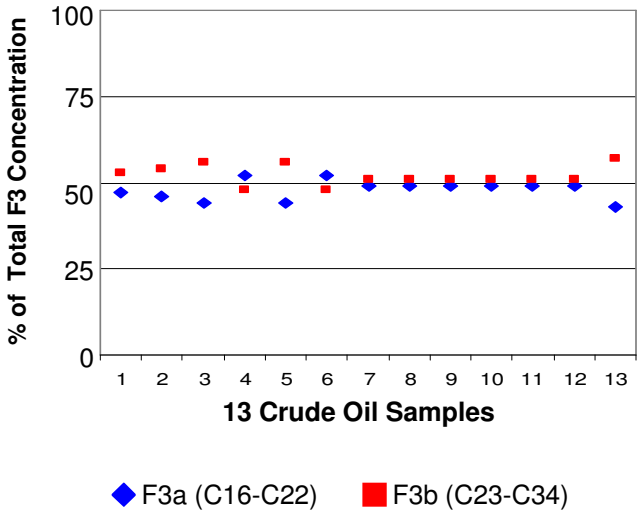


F3a (C16-C22) and F3b (C22-C34) Distributions in Crude Oil and Clean Peat

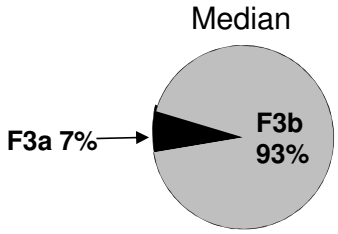


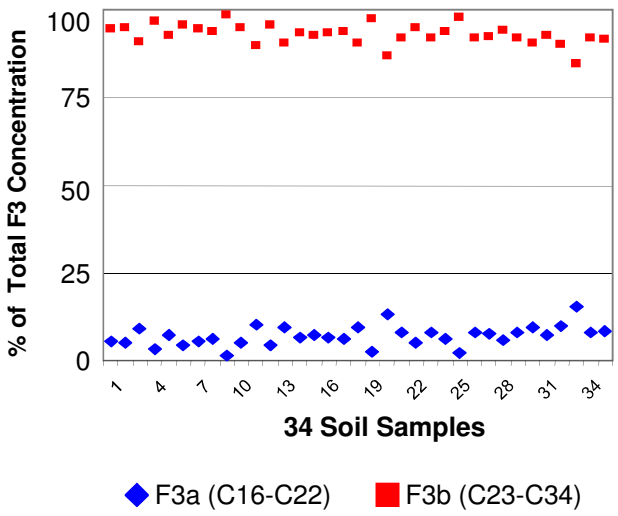
13 Fresh Crude Oil Samples



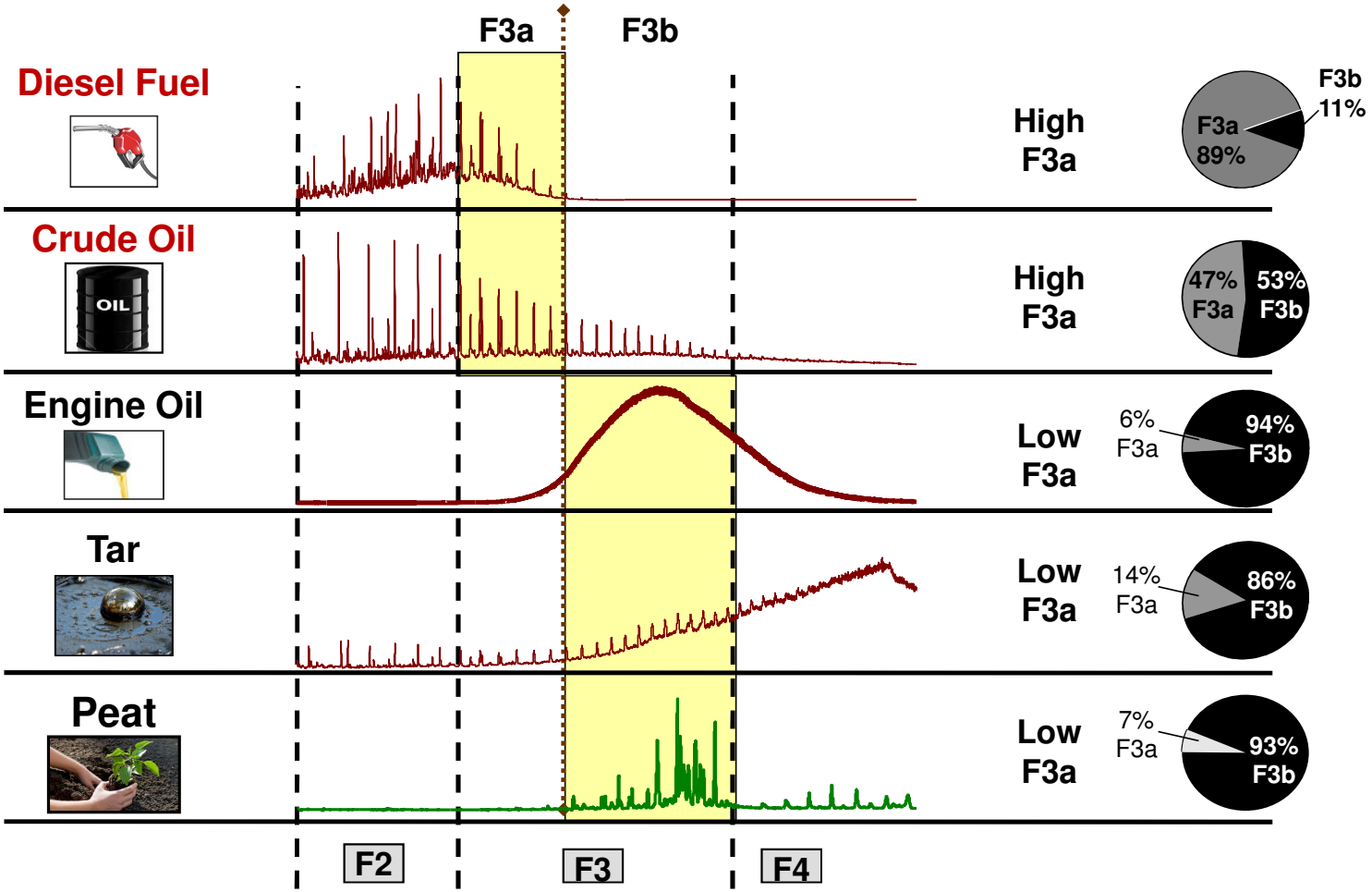


34 Background Soil Samples

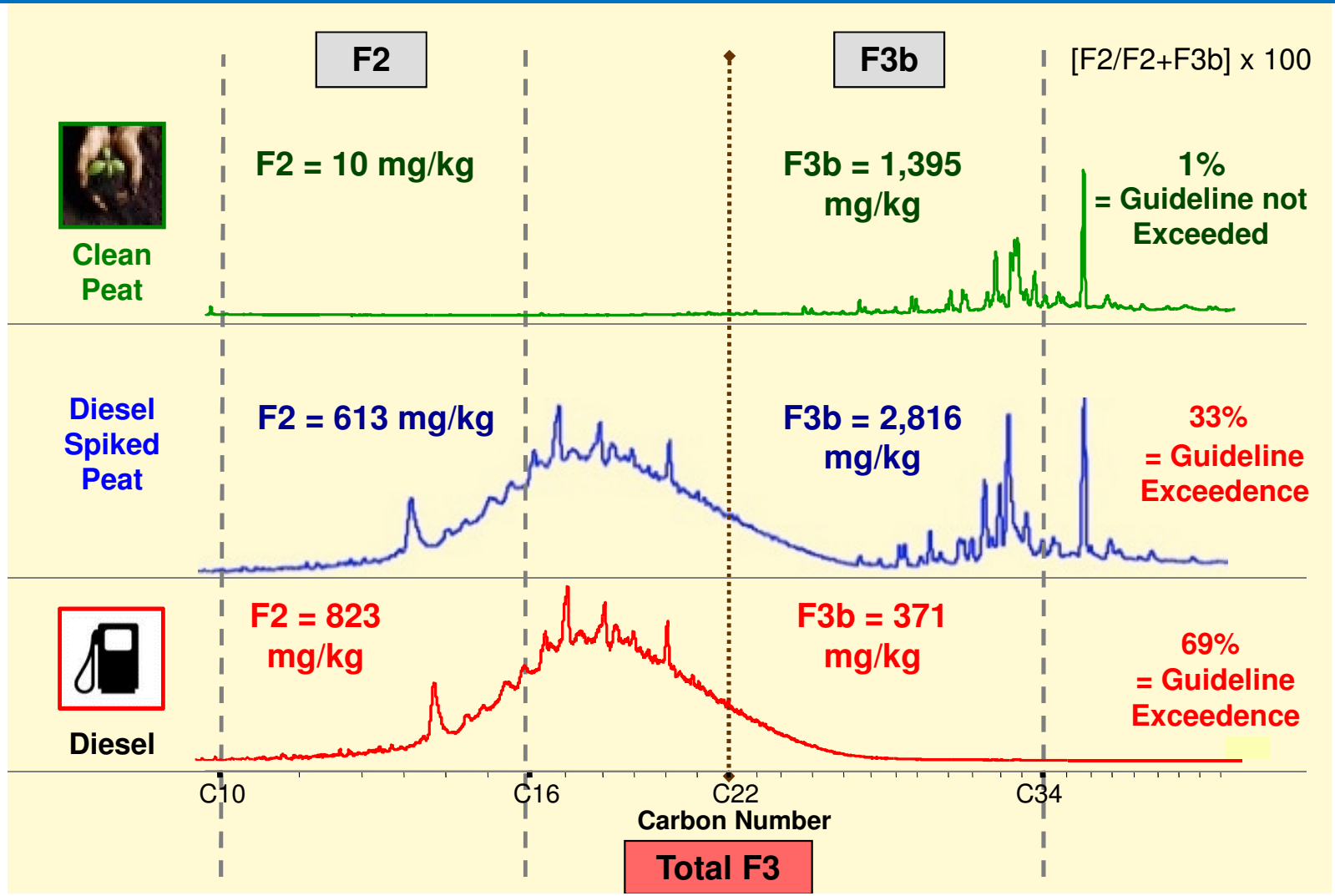




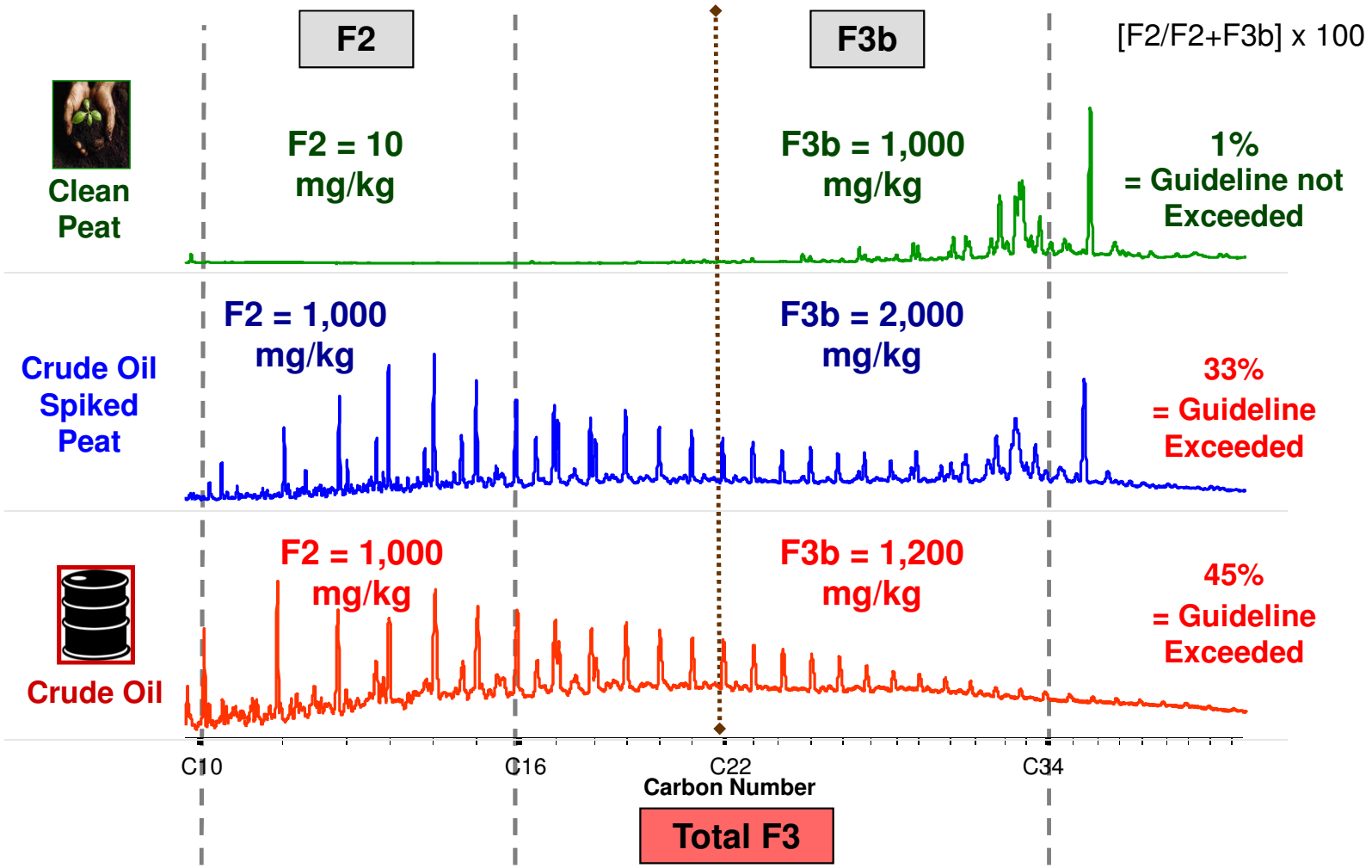
F2, F3, F4, F3a, F3b Carbon Distributions in PHC Products and Clean Peat



Example of BIC Index for Diesel PHCs



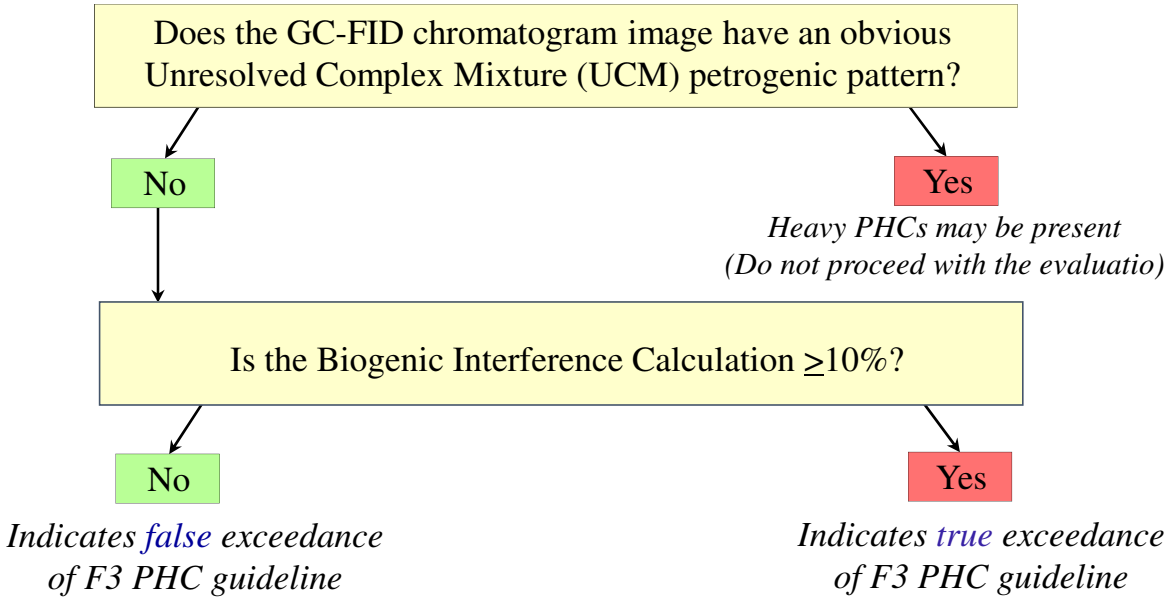
Example of BIC Index for Crude Oil PHCs



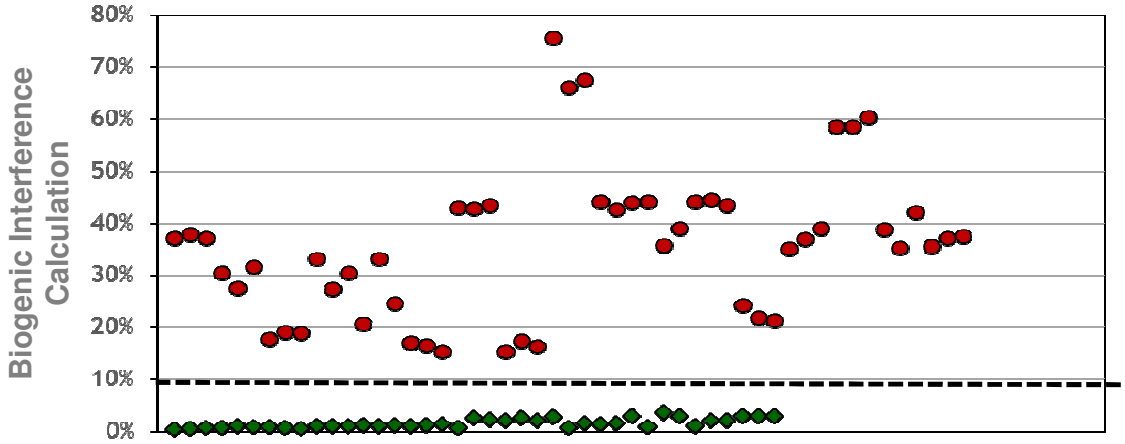
BIC Index Decision Tree for Identifying False Exceedences of AB Tier-1 F3 PHC 300 mg/kg Soil Guideline

Pre-screening criteria: only include samples that meet these criteria

1) F2 concentration is less than laboratory method detection limit (<20 mg/kg)
2) F3 concentration exceeds the 300 mg/kg guideline, F4 concentration does not exceed any guidelines
3) The released PHC product(s) must extend into the light F2 (C10-C16) carbon range (e.g. diesel, crude oil, etc.)
4) A qualified person must confirm that the GC-FID chromatogram does not have a heavy PHC pattern (e.g. asphalt, bitumen, motor oil, etc.).



BIC Index Testing of Control Samples: Clean and Spiked Soil and Compost



≥ 10% indicates true F3 PHC guideline exceedences

<10% indicates false F3 PHC guideline exceedences

● Peat spiked with crude oil; compost spiked with diesel invert

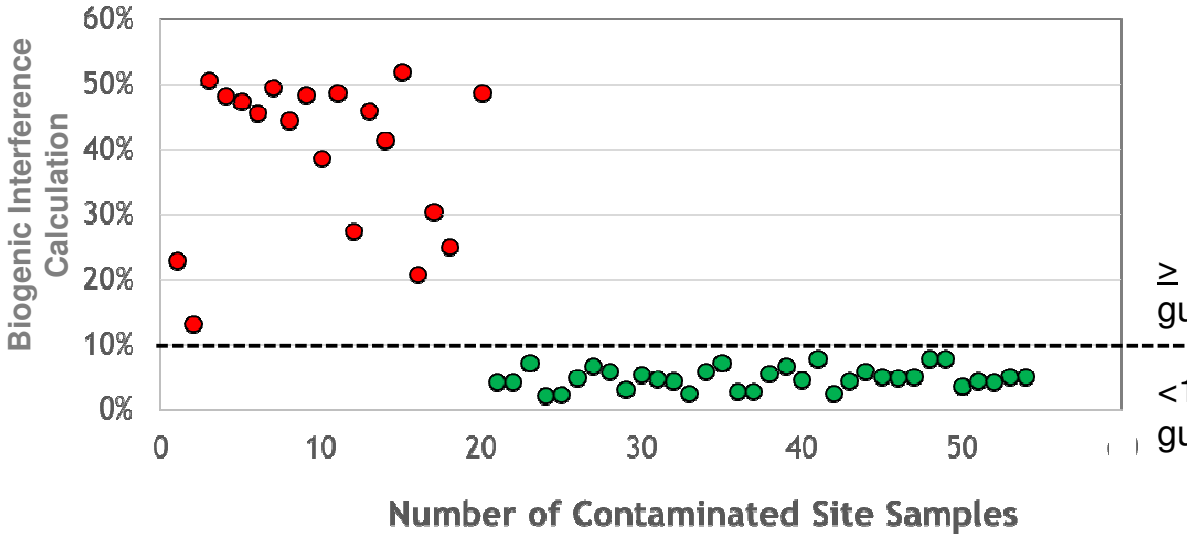
◆ Clean soils and compost

BIC Index Testing of Control Samples: Clean and Spiked Soil and Compost

- BIC Index correctly identified true F3 PHC guideline exceedences in all crude oil and diesel spiked samples

- BIC Index correctly identified false F3 PHC guideline exceedences in all clean samples

Field Validations of 37 Year Old OWA Crude Oil Contaminated Peatland



≥ 10% indicates true F3 PHC guideline exceedences

<10% indicates false F3 PHC guideline exceedences

- Peat samples with detectable F2 and >300 mg/kg F3 concentrations
- Peat samples with non-detectable F2 and >300 mg/kg F3 concentrations

Field Validations of 37 Year Old OWA Crude Oil Contaminated Peatland

- All samples with >300 mg/kg F3 and non-detectable F2 concentrations were identified as false PHC guideline exceedences

- All samples with >300 mg/kg F3 and detectable F2 concentrations were identified as true PHC guideline exceedences

BIC Index Statistical Probability Test Results

The BIC Index is a highly conservative/cautious tool.

0% probability of missing true exceedences.

10% probability of missing false exceedences.

Next Steps?

- CH2M is currently expanding the BIC Index to include heavy PHCs (e.g. asphalt, bitumen, motor oil, etc.) as well.

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