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MECP Proposed Excess Soil Beneficial Reuse Exemption for Asphalt Contaminated Soil & SWM Pond Sediment:

How can AI be used to identify asphalt sources?

Source to Stream Conference
March 26, 2025

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North America Advanced Analytics & Artificial Intelligence

Discussion Topics

- QP perspective on the proposed asphalt exemption rule
- Case studies on how petroleum hydrocarbon (PHC) forensics has been used to obtain approvals for beneficial reuse of asphalt contaminated sediment
- How AI can be used to semi-automate the PHC forensics process
- Municipalities are invited to participate in an Ontario-wide asphalt chemistry survey

Ontario
Ministry of the Environment, Conservation and Parks

MECP Proposed Asphalt Exemption for Greater Flexibility on Beneficial Reuse Options

Enabling greater beneficial reuse of excess soil

Proposed amendments to O. Reg. 406/19, including related amendments to Regulation 347 and O. Reg. 153/04 under the *Environmental Protection Act* (EPA)

Ontario Ministry of the Environment, Conservation and Parks (MECP)

October 2024

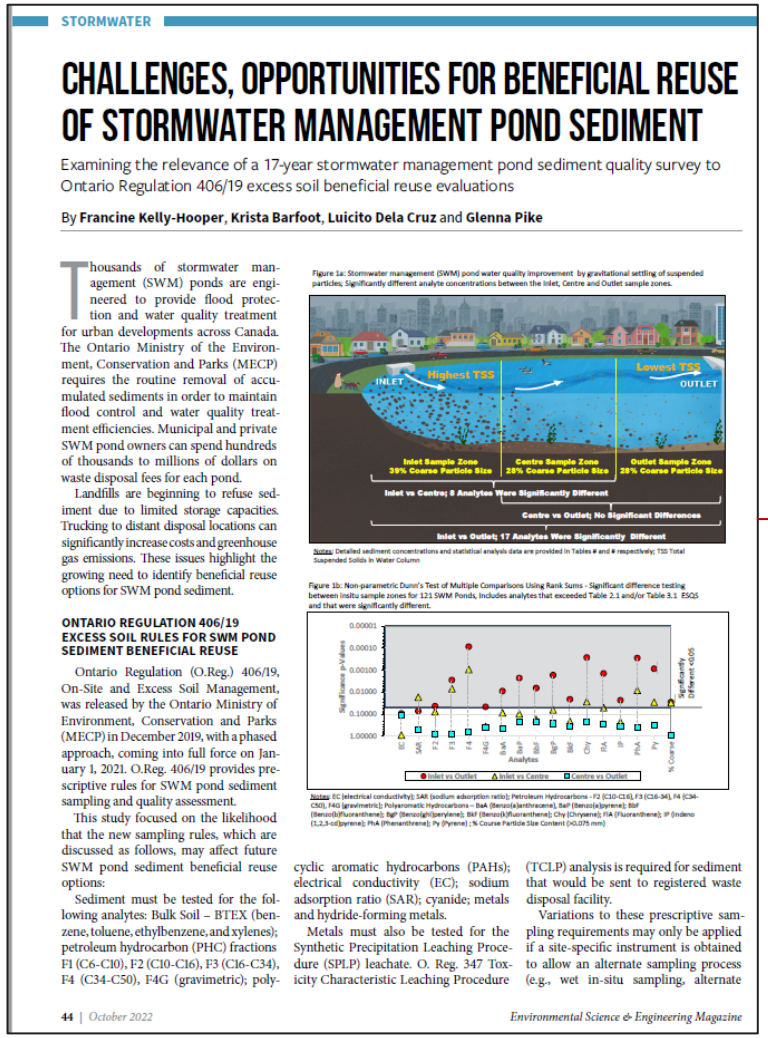
Environmental Registry of Ontario: #019-9196

Purpose: This document describes proposed amendments to O. Reg. 406/19, On-Site and Excess Soil Management, as part of ERO proposal posting #019-9196.

GHD

17-Year Sediment Asphalt Forensics Study of 121 SWM Ponds

- 99% failed Table 1 SCS for F4G PHCs
- 87% failed Table 2.1 ESQS for F3 PHCs
- 77% failed Table 3.1 ESQS for F3 PHCs



STORMWATER

CHALLENGES, OPPORTUNITIES FOR BENEFICIAL REUSE OF STORMWATER MANAGEMENT POND SEDIMENT

Examining the relevance of a 17-year stormwater management pond sediment quality survey to Ontario Regulation 406/19 excess soil beneficial reuse evaluations

By **Francine Kelly-Hooper**, **Krista Barfoot**, **Luicito Dela Cruz** and **Glenna Pike**

Thousands of stormwater management (SWM) ponds are engineered to provide flood protection and water quality treatment for urban developments across Canada. The Ontario Ministry of the Environment, Conservation and Parks (MECP) requires the routine removal of accumulated sediments in order to maintain flood control and water quality treatment efficiencies. Municipal and private SWM pond owners can spend hundreds of thousands to millions of dollars on waste disposal fees for each pond.

Landfills are beginning to refuse sediment due to limited storage capacities. Trucking to distant disposal locations can significantly increase costs and greenhouse gas emissions. These issues highlight the growing need to identify beneficial reuse options for SWM pond sediment.

ONTARIO REGULATION 406/19 EXCESS SOIL RULES FOR SWM POND SEDIMENT BENEFICIAL REUSE

Ontario Regulation (O.Reg.) 406/19, On-Site and Excess Soil Management, was released by the Ontario Ministry of Environment, Conservation and Parks (MECP) in December 2019, with a phased approach, coming into full force on January 1, 2021. O.Reg. 406/19 provides prescriptive rules for SWM pond sediment sampling and quality assessment.

This study focused on the likelihood that the new sampling rules, which are discussed as follows, may affect future SWM pond sediment beneficial reuse options:

Sediment must be tested for the following analytes: Bulk Soil – BTEX (benzene, toluene, ethylbenzene, and xylenes); petroleum hydrocarbon (PHC) fractions F1 (C6-C10), F2 (C10-C16), F3 (C16-C34), F4 (C34-C50), F4G (gravimetric); polycyclic aromatic hydrocarbons (PAHs); electrical conductivity (EC); sodium adsorption ratio (SAR); cyanide; metals and hydride-forming metals.

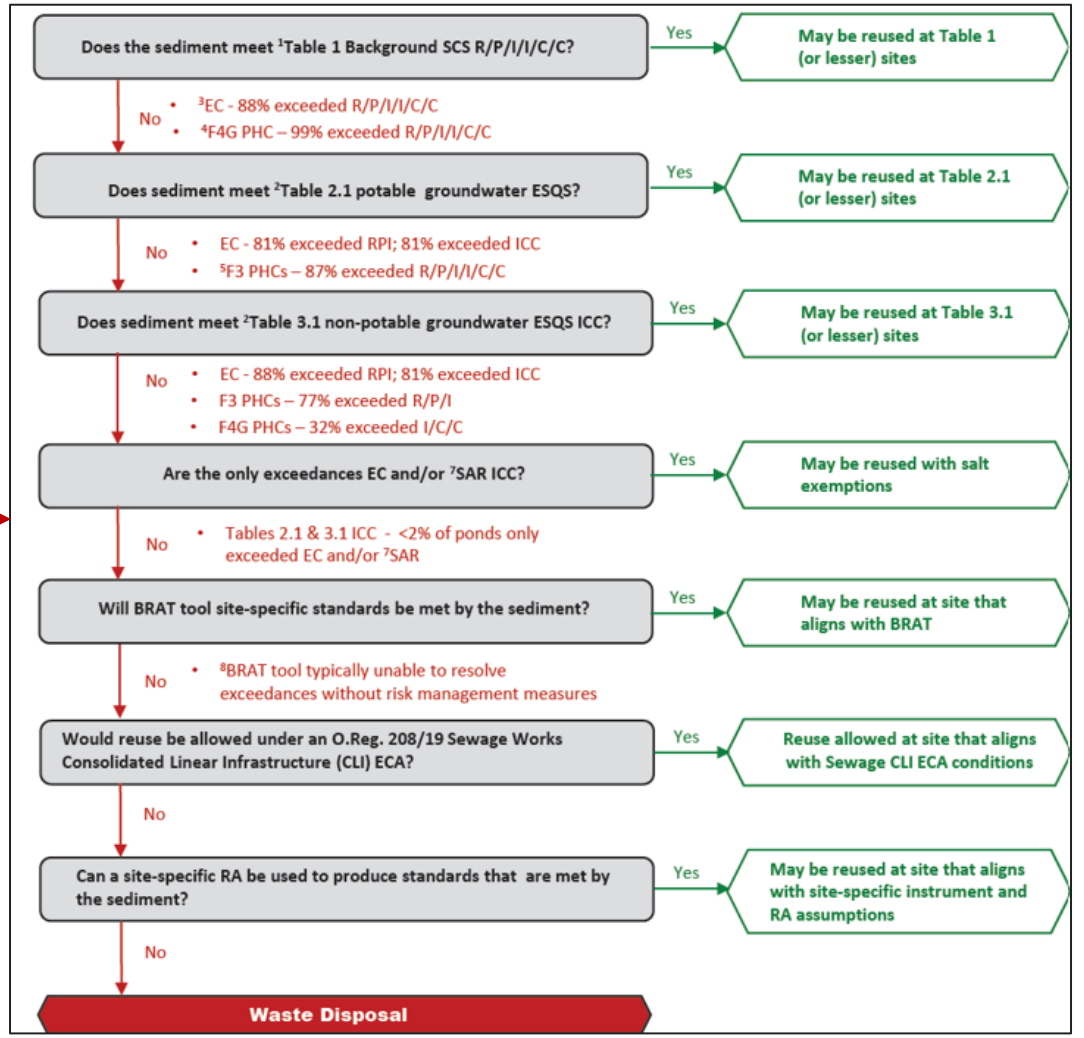
Metals must also be tested for the Synthetic Precipitation Leaching Procedure (SPLP) leachate. O. Reg. 347 Toxicity Characteristic Leaching Procedure (TCLP) analysis is required for sediment that would be sent to registered waste disposal facility.

Variations to these prescriptive sampling requirements may only be applied if a site-specific instrument is obtained to allow an alternate sampling process (e.g., wet in-situ sampling, alternate

Figure 1a: Stormwater management (SWM) pond water quality improvement by gravitational settling of suspended particles; Significantly different analyte concentrations between the Inlet, Centre and Outlet sample zones.

Figure 1b: Non-parametric Dunn's Test of Multiple Comparisons Using Rank Sums - Significant difference testing between Insitu sample zones for 121 SWM Ponds. Includes analytes that exceeded Table 2.1 and/or Table 3.1 ESQS and that were significantly different.

At least 77% of ponds would not meet any excess soil standards due to inert asphalt PHCs



2016 - 2020 Plant and Earthworm Ecotoxicity Tests of Asphalt Contaminated SWM Pond Sediment

- Growth and reproduction were as good or better in the sediment mixed with 20% compost than in the clean control soil.
- Earthworm tissue analysis did not indicate PHC uptake

Ontario
Ministry of the Environment, Conservation and Parks

Proposed Amendment - Discussion Points

3) Enhanced reuse opportunities for aggregate and stormwater management pond (SWMP) sediment

It is proposed that excess soil that is part of engineered aggregate as well as SWMP sediment, that is either being reused as engineered aggregate or in an infrastructure-related undertaking, would be provided flexibility in respect of the excess soil quality standards for asphalt road-related contaminants and naturally occurring exceedances, as follows:

- Asphalt-road impacted aggregate or stormwater management pond (SWMP) sediment:
  - Excess soil that is part of engineered aggregate material or SWMP sediment with exceedances of the excess soil quality standards applicable to a reuse site that can be attributed specifically to an asphalt road (e.g., from asphalt, tire wear), being F3 and F4 petroleum hydrocarbons (PHC) and polycyclic aromatic hydrocarbons (PAHs), is deemed to meet the standards for those listed parameters if:
    - Excess soil is being reused beneficially as engineered aggregate and finally placed in an asphalt road undertaking, or the SWMP sediment is being reused and finally placed within the road right-of-way associated with an asphalt road, either directly from a project area or following storage at a Class 1 site, Class 2 site or local waste transfer facility (LWTF); and
    - A qualified person determines that the excess soil exceeds the standards for these parameters solely due to the presence of the asphalt road (either by exclusion of other potentially contaminating activities (PCAs) and areas of potential environmental concern (APECs) at the project area, or sampling results consistent with those expected for asphalt-related contamination).
  - Additional rules for final placement may be contemplated to ensure there is no adverse impact, including possible setbacks from water bodies.

1

2

- PHC forensics Subject Matter Experts (SME) are required to identify asphalt sources
- QP's would work with SME's on beneficial reuse evaluations

Complex asphalt forensics identification process requires an SME

Examples of Sediment Reuse Approvals that Required PHC Forensic SME Evaluations

2022 Sediment Reuse on Highway Right-of-Ways

Transportation Association of Canada Environmental Achievement Award

2019

2020

- Reused 3000 truckloads of sediment
- $3.3 million waste disposal savings

2016 Sediment Reuse as Tree Nursery Soil Amendment Material

Ontario Public Works Association Environmental Project of the Year

- Reused 60 truckloads of sediment
- $60,000 waste disposal savings

PHC Forensic Weight-of-Evidence Tools Used for Previous Approvals?

- Bulk soil and leachable PHC and PAH concentrations & distributions

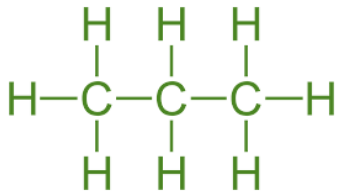
- F2-F4G PHC Gas Chromatogram Flame Ionization Detector (GC-FID) chromatogram patterns

PHC Content

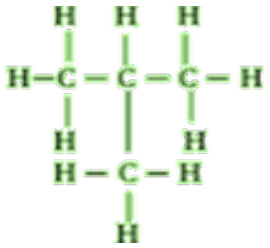
1) Aliphatic PHC Examples

Straight chains, branched chains, non-aromatic rings (non-polar)

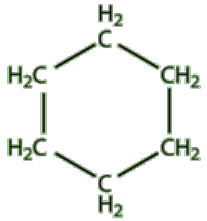
Propane

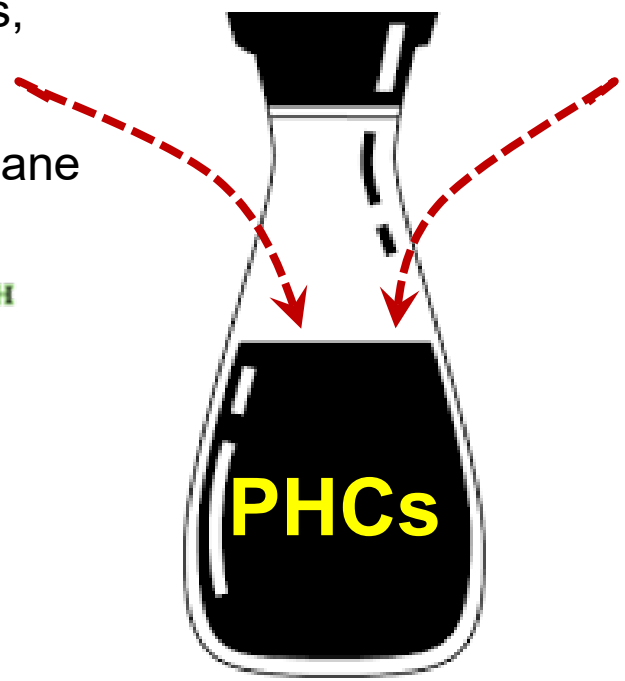


2-methyl-propane



Cyclohexane

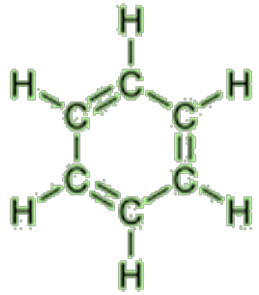




2) Aromatic PHC Examples (Benzene Rings)

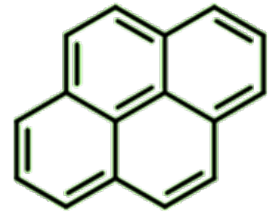
Single and Multiple Benzene Rings (polar)

Benzene (single ring)



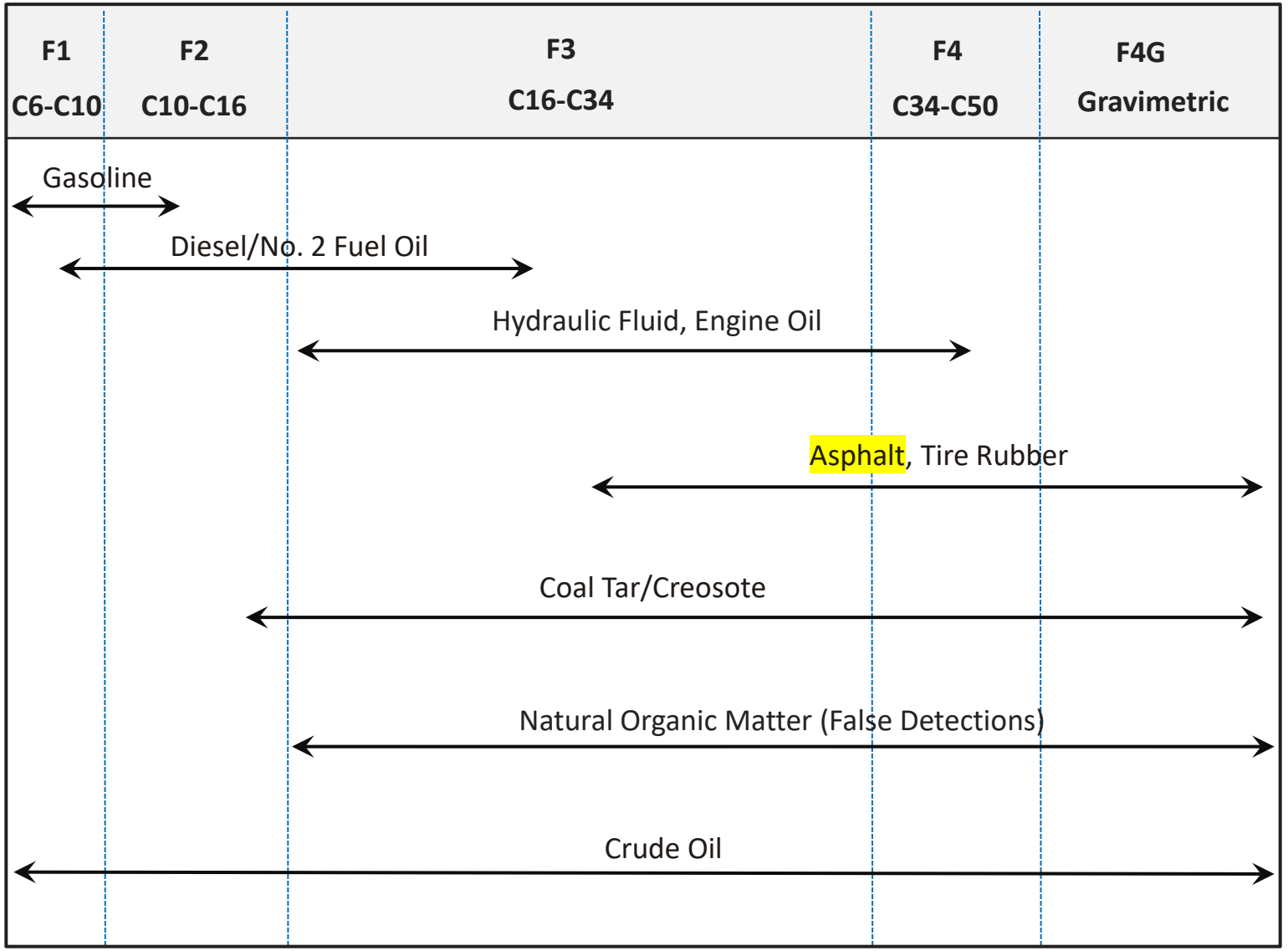
Polyaromatic Hydrocarbons (PAHs)

Multiple Benzene Rings

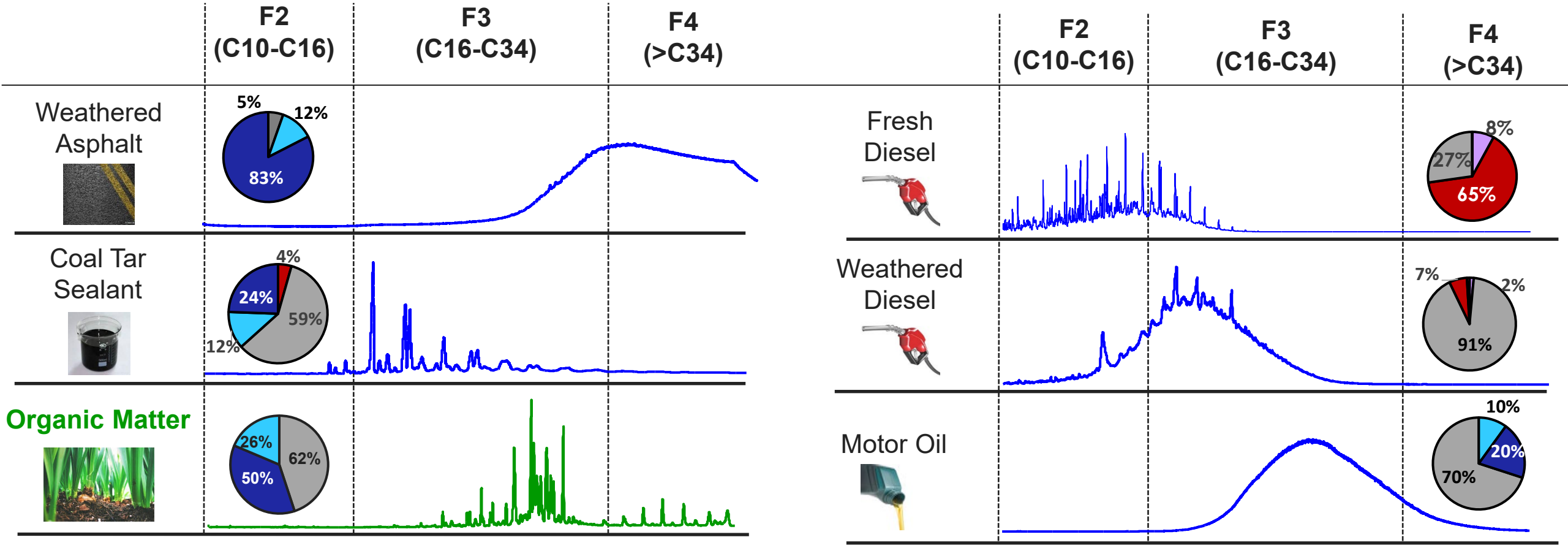


Pyrene

PHC Sources Organized by Carbon Ranges



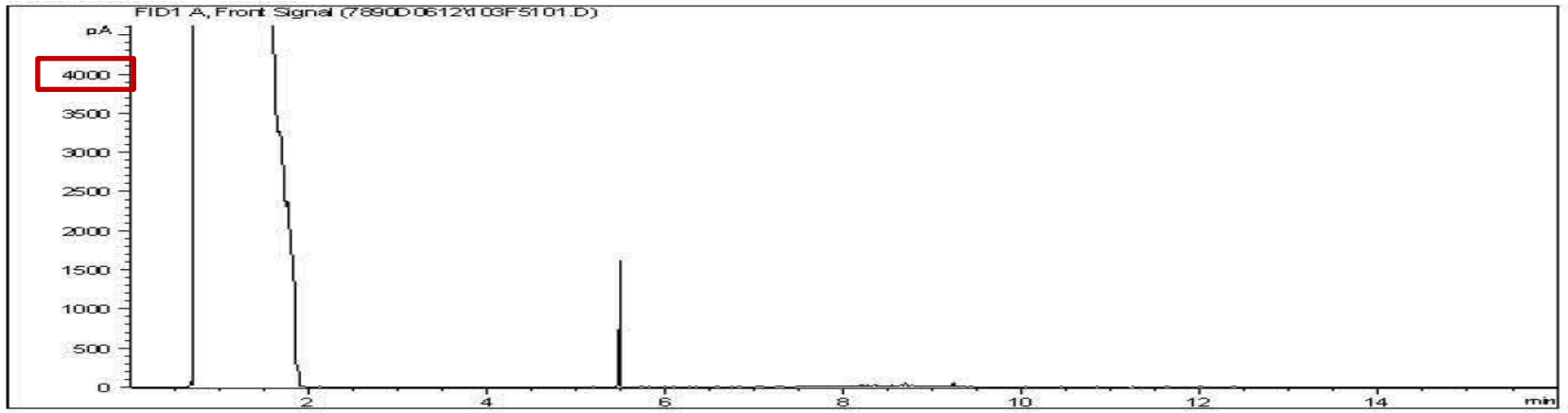
Examples of GHD's PHC Source Library



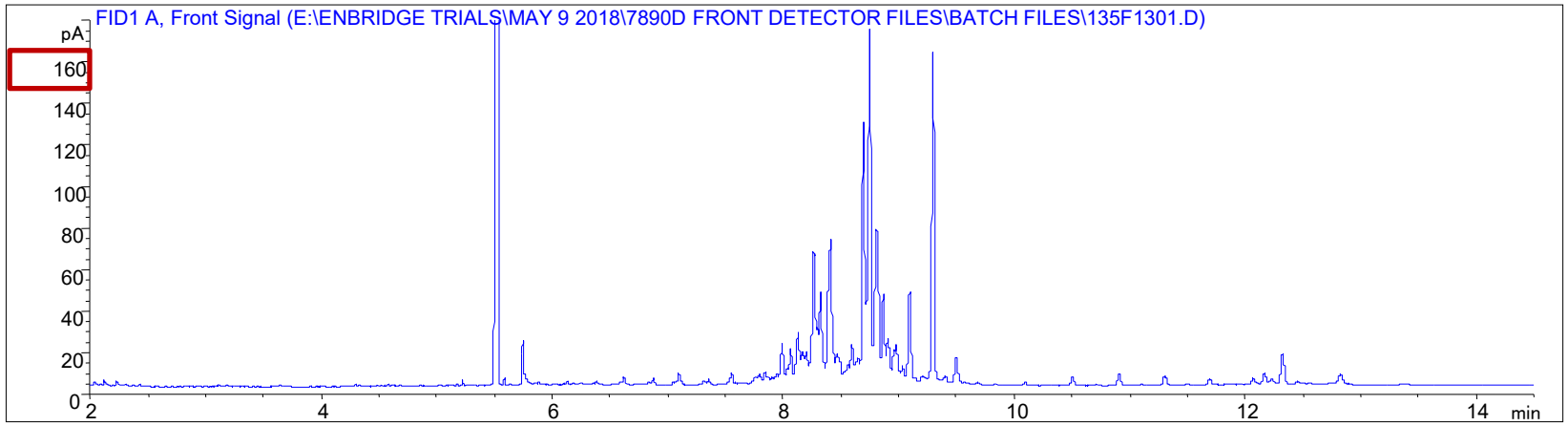
Chromatograms with Appropriate y-scales are Essential for Asphalt Identifications

Sample ‘A’ → Different Chromatogram y-Scales

Sample ‘A’
Laboratory PDF report
4000 pA y-scale

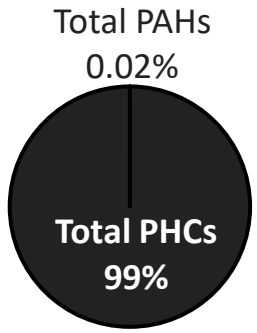


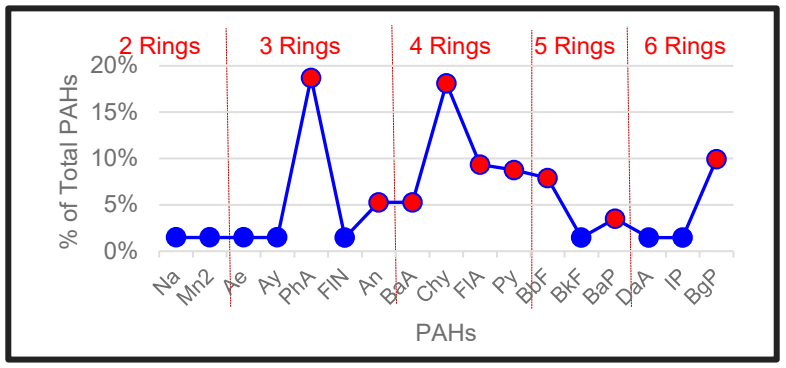
Sample ‘A’
GHD adjusted
160 pA y-scale



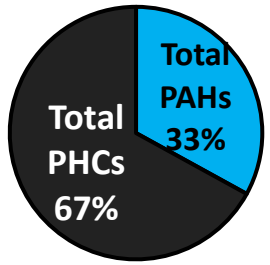
Examples of PAH Percentages of F1-F4 PHC Concentrations

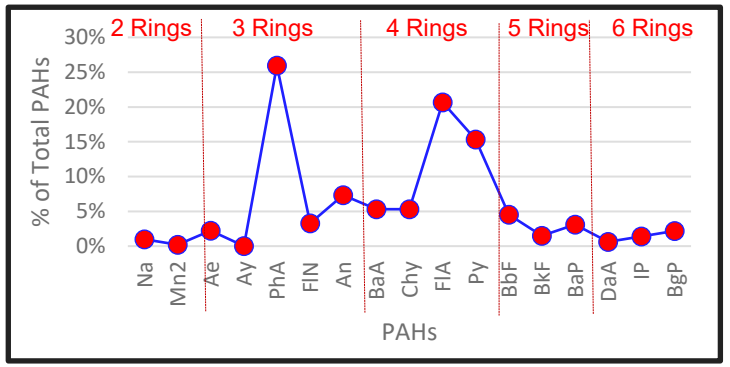
Asphalt



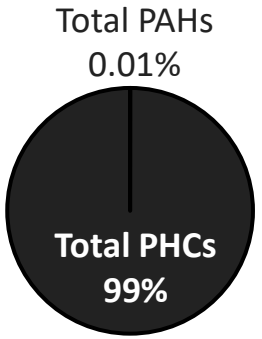


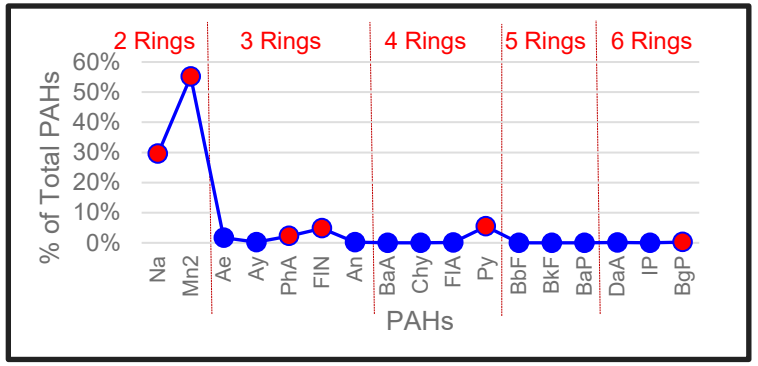
Coal Tar Sealant





Fresh Diesel



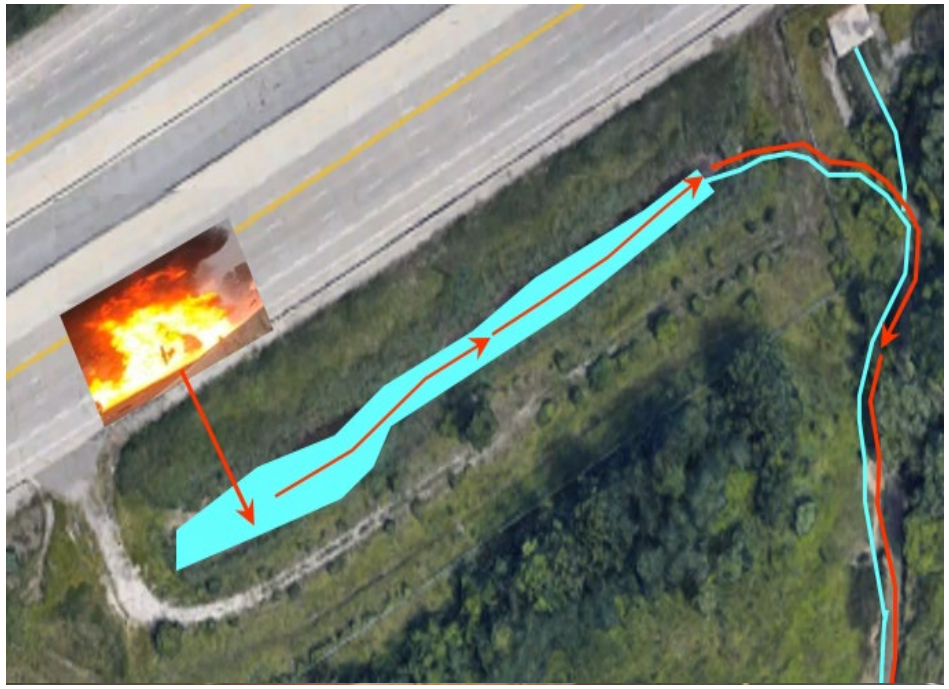


Detectable PAHs Non-detectable PAHs

GHD

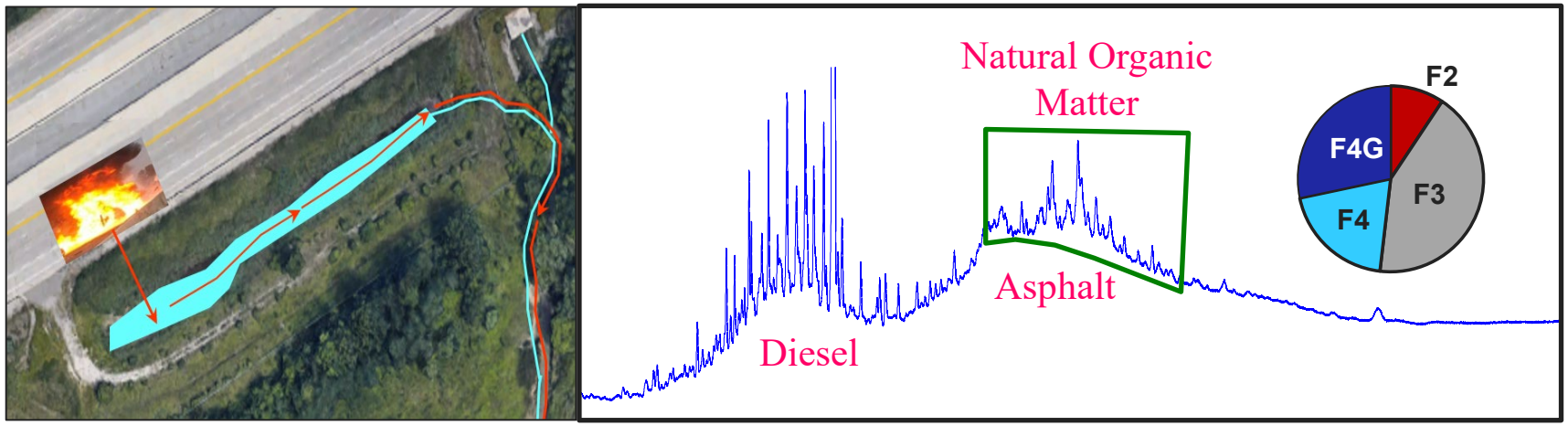
Case Study: Highway 407 ETR diesel tanker fuel spill into a SWM pond

- 40,000 litres of diesel spilled into a SWM pond
- Forensics demonstrated that the sediment contained diesel from the tanker spill mixed with historical asphalt.

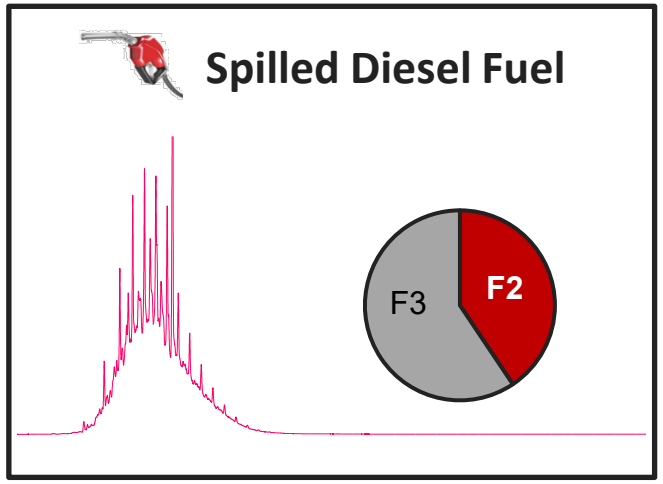


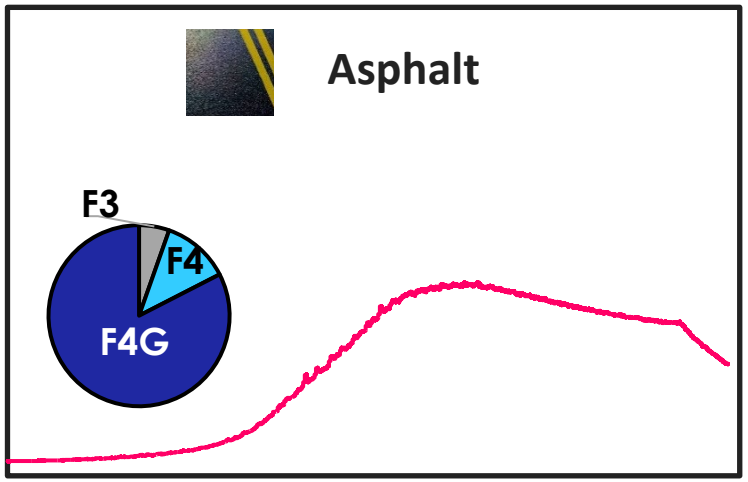
Comparison of Impacted Sediment to GHD Reference Library Sources

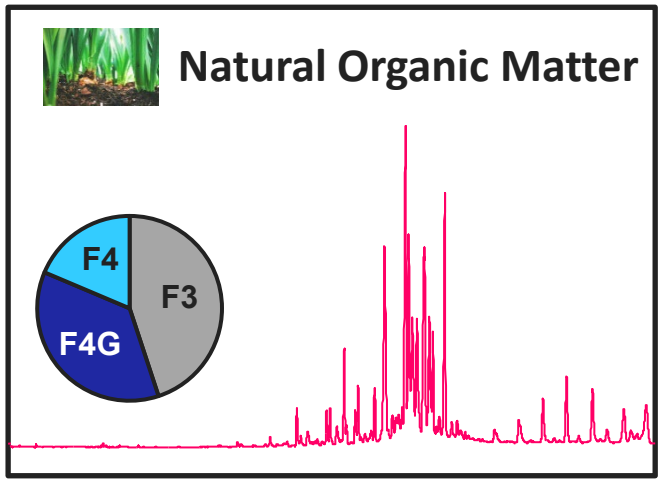
Diesel Impacted SWM Pond Sediment



GHD Reference PHC Library Sources

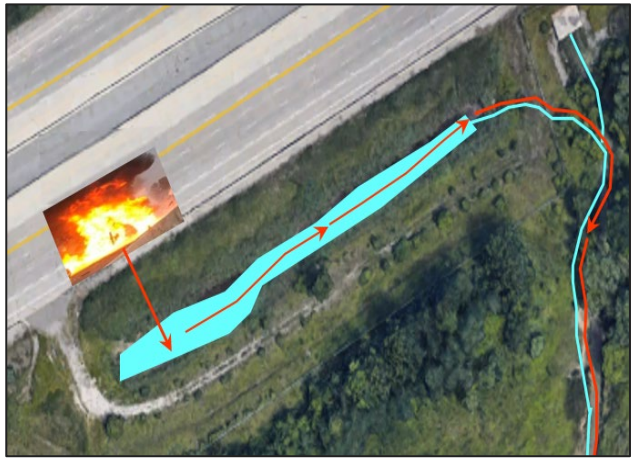


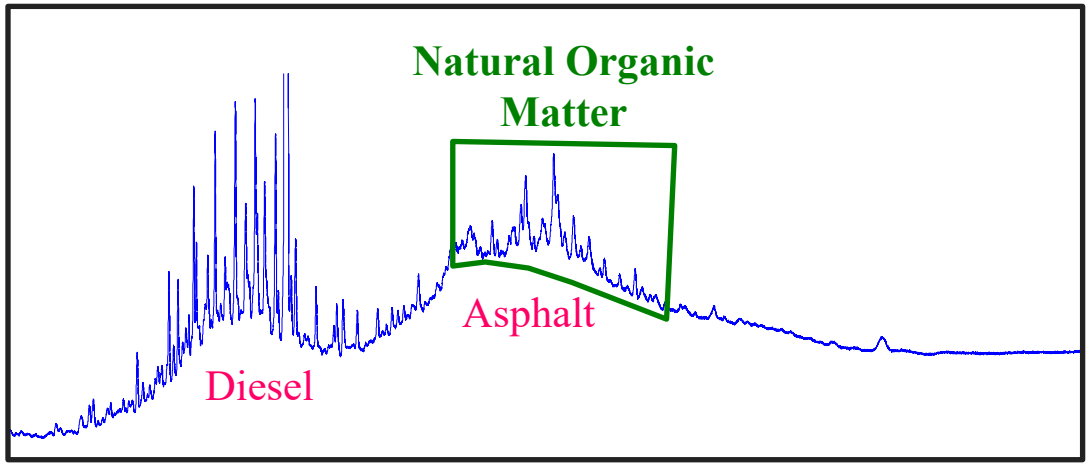




Comparison of Impacted Sediment to GHD Reference Library Sources

Impacted SWM Pond Sediment





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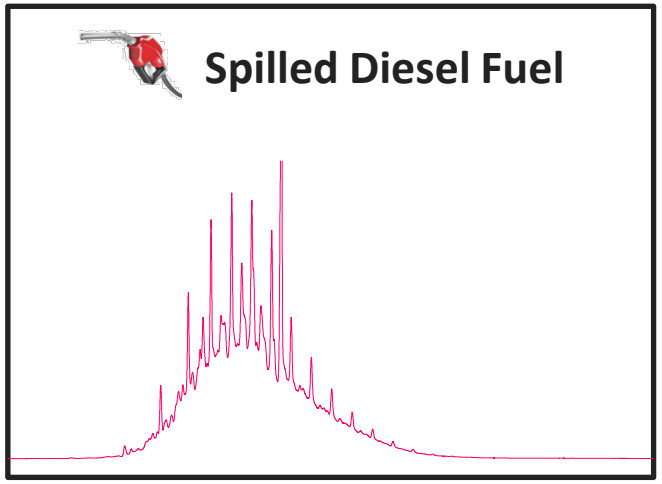
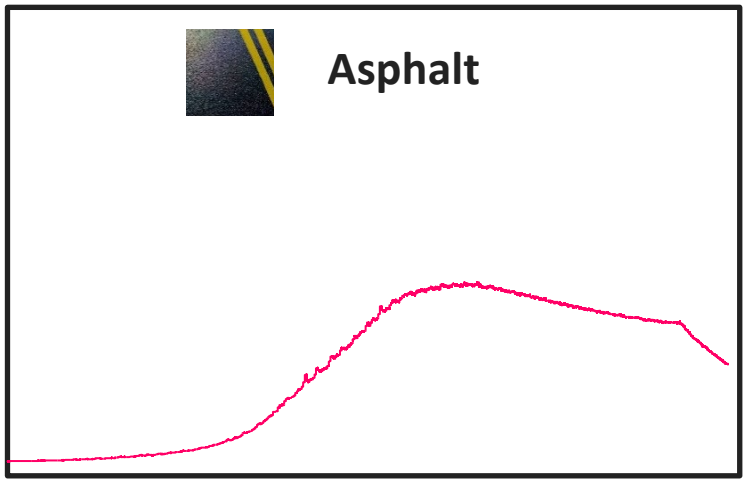
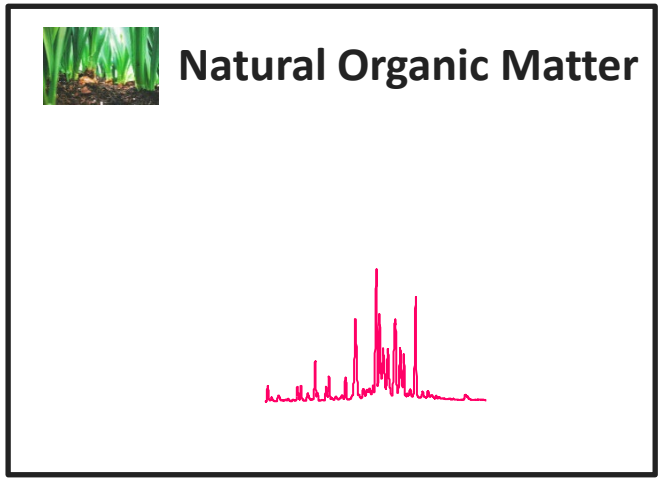
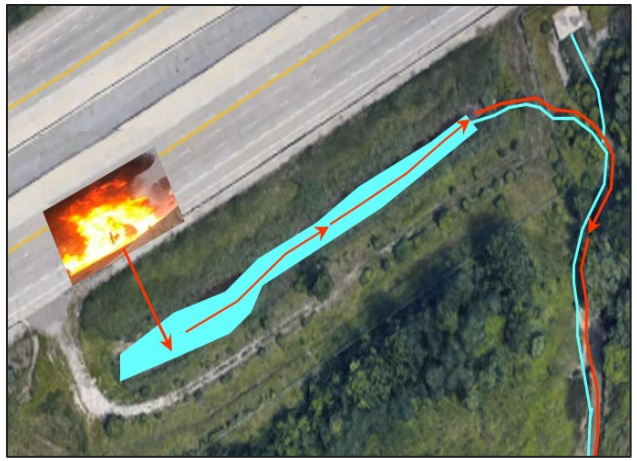


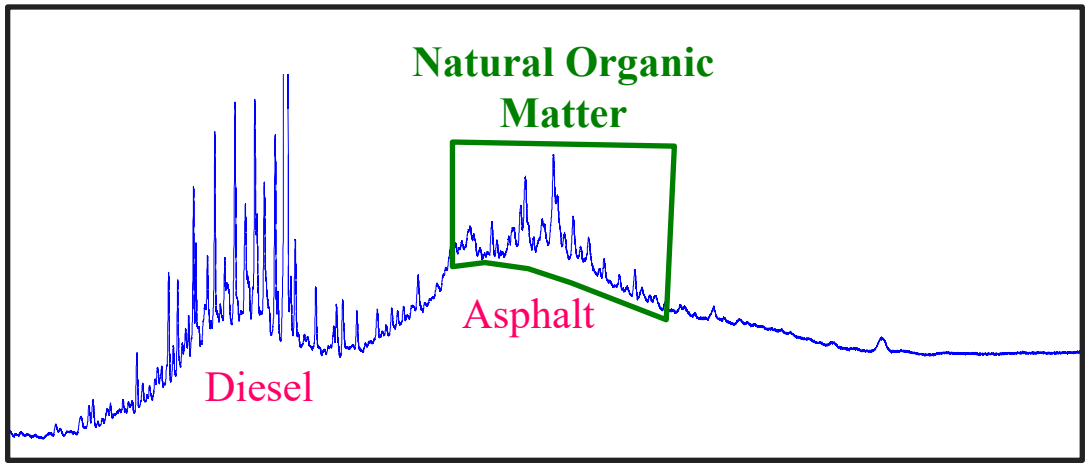




Comparison of Impacted Sediment to GHD Reference Library Sources

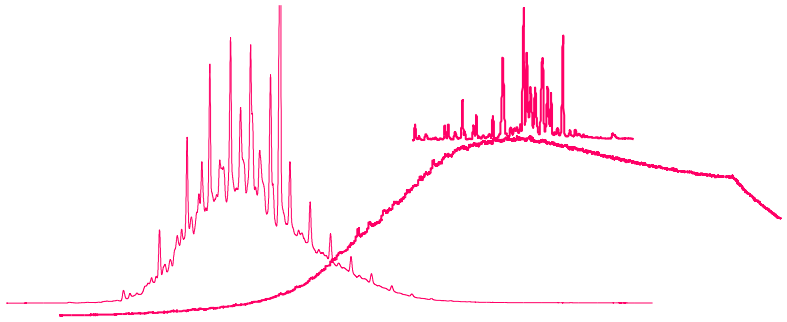
Impacted SWM Pond Sediment





Spilled Diesel Fuel

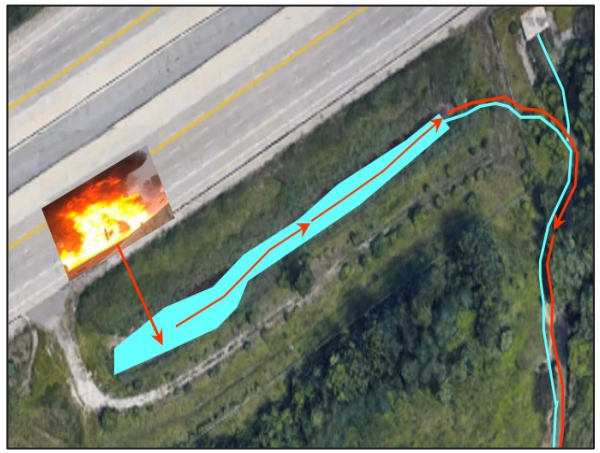
Asphalt

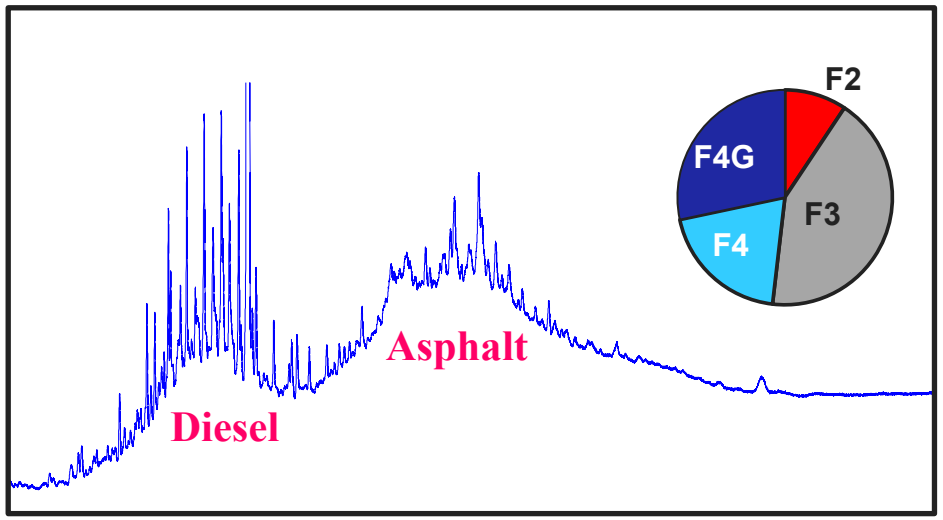


Natural Organic Matter

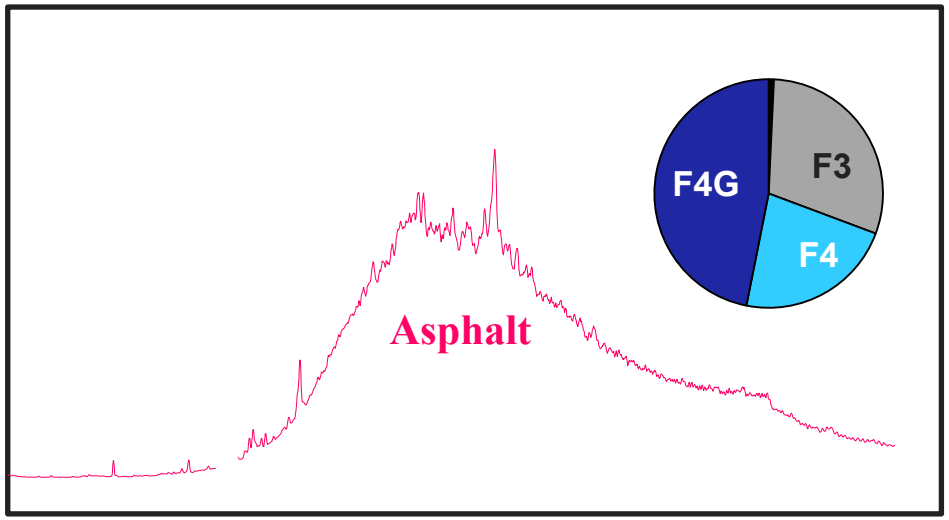
Comparison of Diesel Impacted SWM Pond Sediment to Offsite SWM Pond Sediment

Diesel Impacted SWM Pond





Offsite SWM Pond



Benefits of Semi-automating Forensic Tools?


- All 121 SWM ponds were manually evaluated, which was very time consuming
- GHD is developing domain informed Artificial Intelligence (AI) to semi-automate the asphalt identification process, which would always require SME guidance and review.
- GHD's reference library would be linked to sediment characteristics

AI Feature Engineering

Feature Engineering: Conversion of raw data to machine learning inputs that a statistical model can use to create a decision boundary

What should the features be?

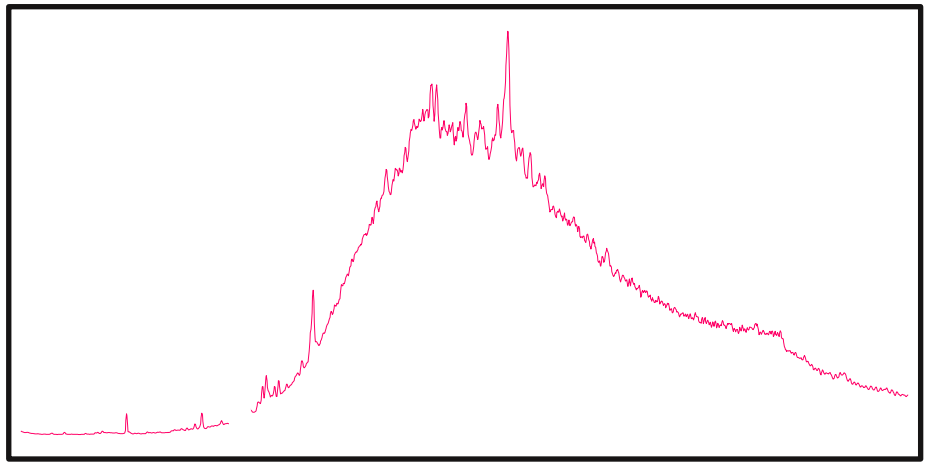
Sample	Feature 1	Feature 2	…	Feature n	Source
1					Asphalt
2					Diesel
3					Sediment
…					…
N					Coal Tar

Machine Learning uses features to predict a target variable for each observation

AI Feature Engineering

Required Data Sources

Chromatogram Response Data



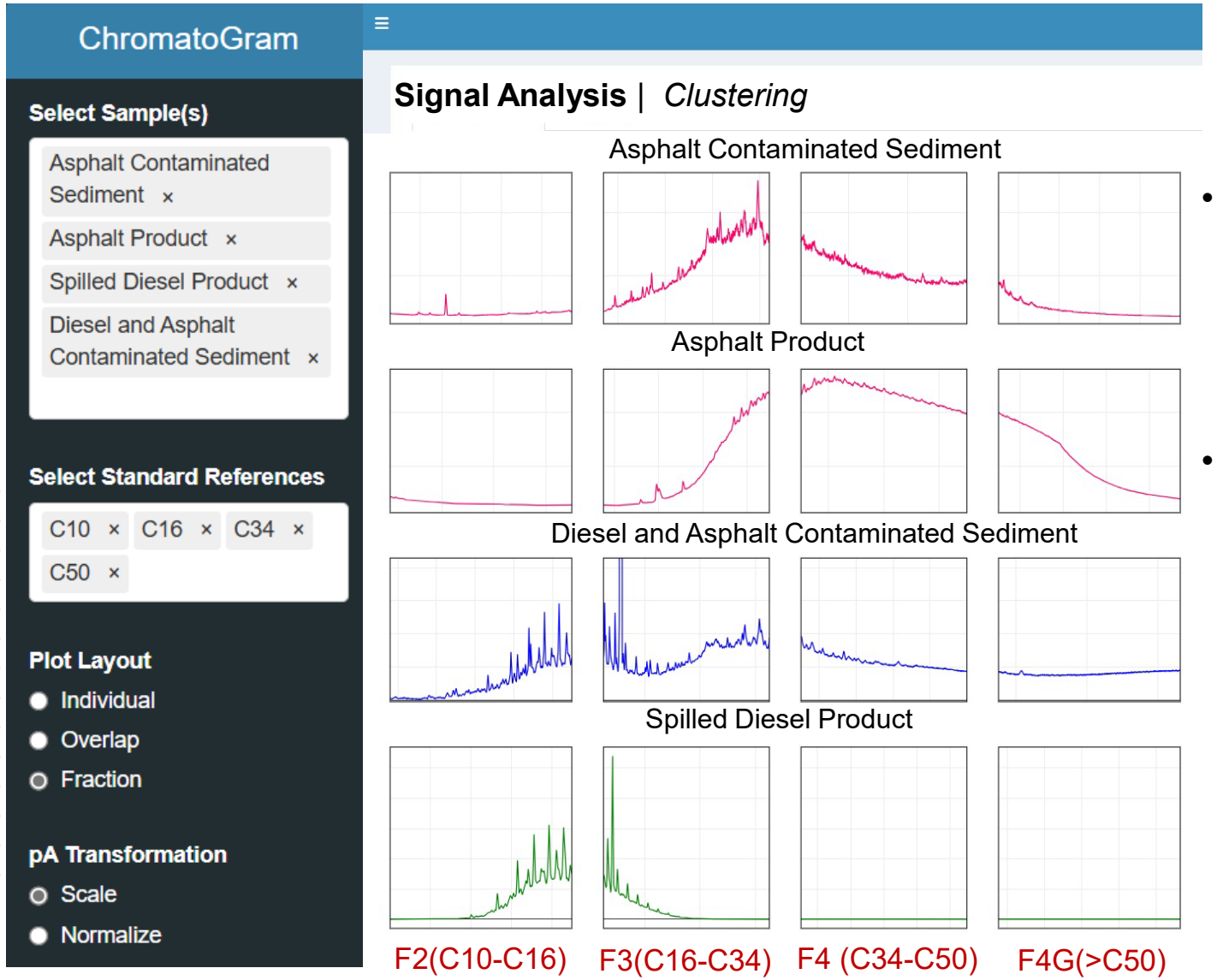
+

PHC & PAH Percentages

Web-based Chromatogram Processing Tool

Sample/Product Database

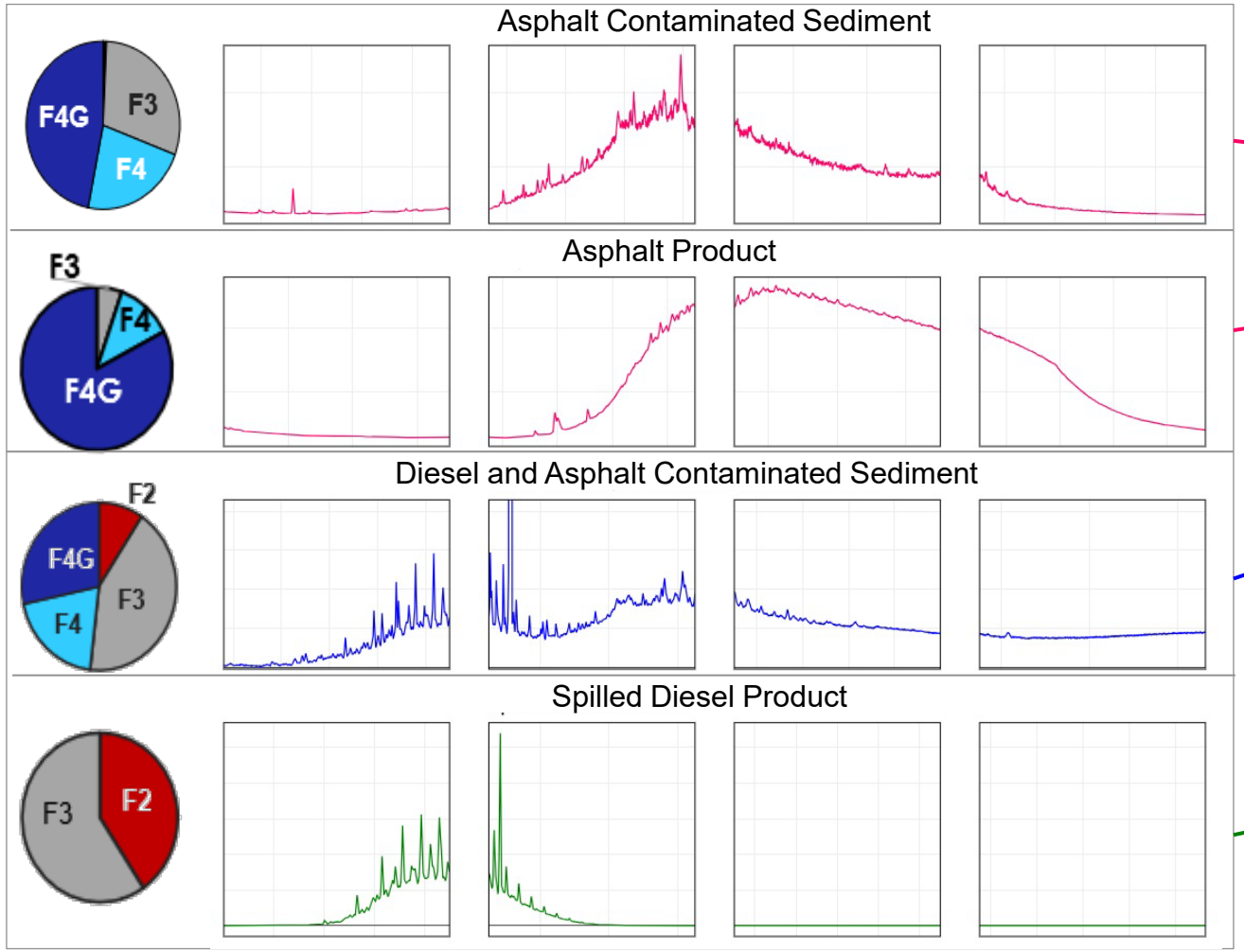
Time	Signal				
0.000342	3.40013			C10	2
0.001175	3.394922			C16	3.75
0.002008	3.392839			C22	5.25
0.002842	3.394792			C30	7
0.003675	3.397136			C34	7.5
0.004508	3.397787			C40	8.75
0.005342	3.394401			C50	10.5
0.006175	3.389453				
0.007008	3.386328				
0.007842	3.390495				
0.008675	3.396745				
0.009508	3.401563				
0.010342	3.400521				
0.011175	3.39987				

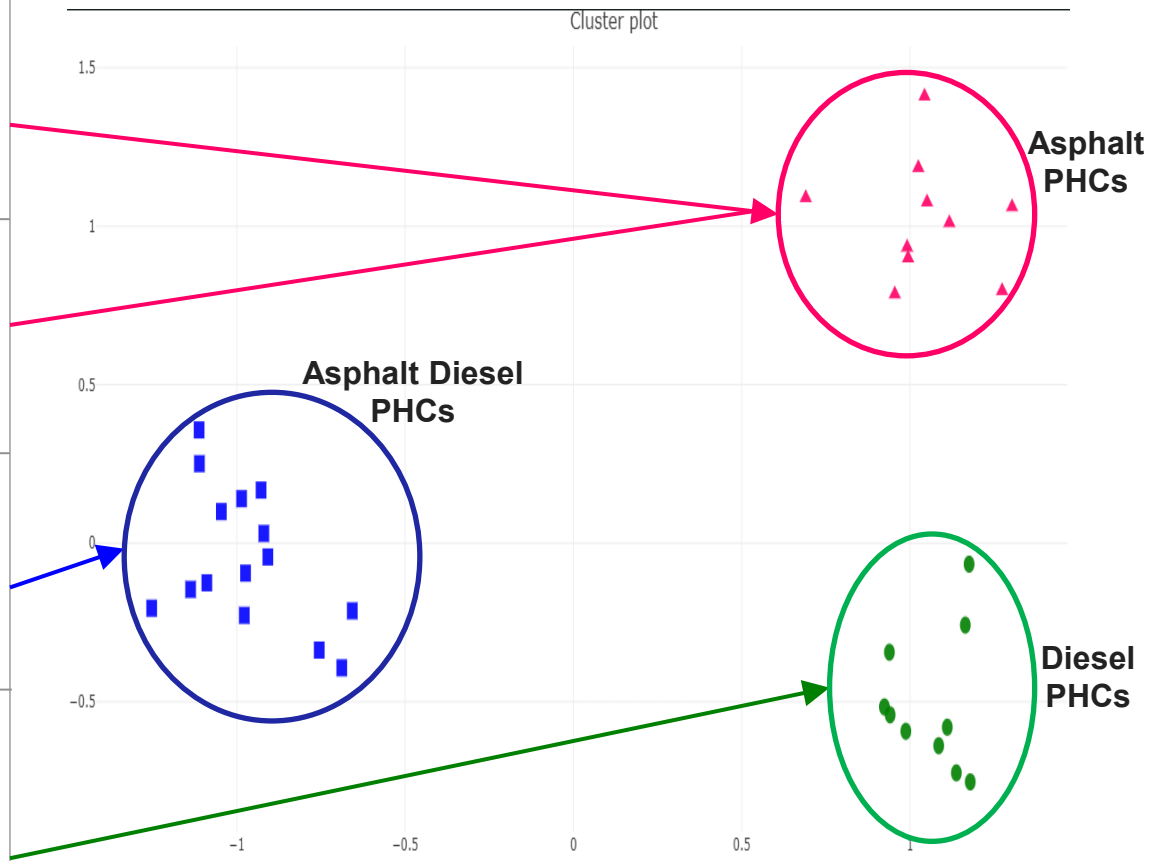


- Create chromatograms and PHC fraction charts from data
- Additional tab for clustering included to group similar samples

Cluster Plot Conceptual Case Study

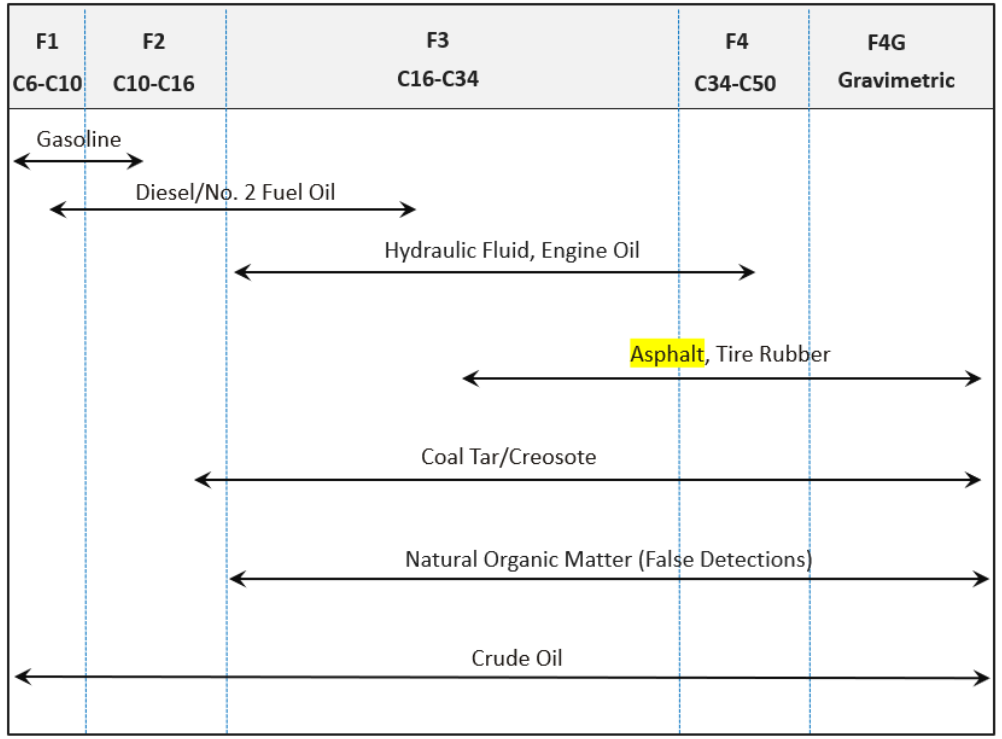
- Created automated process to create PHC distributions from chromatography and concentration data
- Performed k-means cluster analysis, which groups samples together
- This indicates PHC fraction distributions create useful features for a machine learning classification model





Future Road Map: Leveraging Computer Vision for Advanced Feature Extraction in Signal Analysis

- Based on Reference (Fig. A-2), certain compounds are presumed to dominate specific fractions.
- We assume that **patterns** in the region can indicate **the type of PHC product** present.
- By analyzing these **patterns**, we expect to determine the **product** associated with each signal.
- This approach assumes a **consistent correlation** between pattern characteristics and compound dominance.
- Further validation will be required to confirm these **assumptions and interpretations**.



Summary

- PHC Forensic SMEs would determine if exceedances are due to asphalt or different source(s).
- QPs would use SME findings to identify beneficial reuse options.
- GHD is developing AI to semi-automate the asphalt identification process, which will always require PHC Forensic SME guidance and reviews.

- **Municipalities are invited to participate in an Ontario-wide asphalt chemistry survey**.

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Questions?

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