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When Coal Complicates the Picture: Distinguishing Biogenic and Petrogenic Contamination in Phase II ESAs and Remediation Design

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PRESENTATION AGENDA

1. **SITE INFORMATION** — The site, the areas of potential environmental concern, and why the material made characterization difficult.
2. **BACKGROUND CHARACTERIZATION PROGRAM** — Establishing what occurs naturally on site: background sampling, chromatograms, Fraction 3 A/B and VOC scans.
3. **FIELDWORK** — Field screening and deployment of the AISCT® PETRO unit for real-time results.
4. **LABORATORY & ANALYSIS** — Laboratory methods used to potentially separate the biogenic coal signal from petrogenic contamination.
5. **CONCLUSION** — What worked, what did not, and how we reached defensible assessment decisions on a coal-bearing site.

WHAT IS COAL?

01

SECTION

SITE INFORMATION

Site history, previous assessments and the objectives.

SITE INFORMATION

- Retained by a coal mine to assess Areas of Potential Environmental Concern (APECs) across the site.
- The program was scoped as Phase II ESAs, followed by remediation at any location confirmed to be contaminated.
- Several consultants had assessed these locations previously, so we reviewed all existing data and confirmed that challenges with characterization existed at the site.
- The mine is at a remote location, the field season is short, the rocky and heterogeneous material at the site required alternative assessment measures.
- The client indicated historical environmental site assessment work was not successfully moving sites towards closure and delaying reclamation activities.
- Presence of coal throughout the substrate was noted to potentially yield analytical results above guidelines when no contaminant was present.

KEY POINTS

- Difficulty characterizing site material
- Difficulty obtaining closure on assessed sites
- Remote location and a short field season
- Test pit sampling due to rocky heterogeneous material

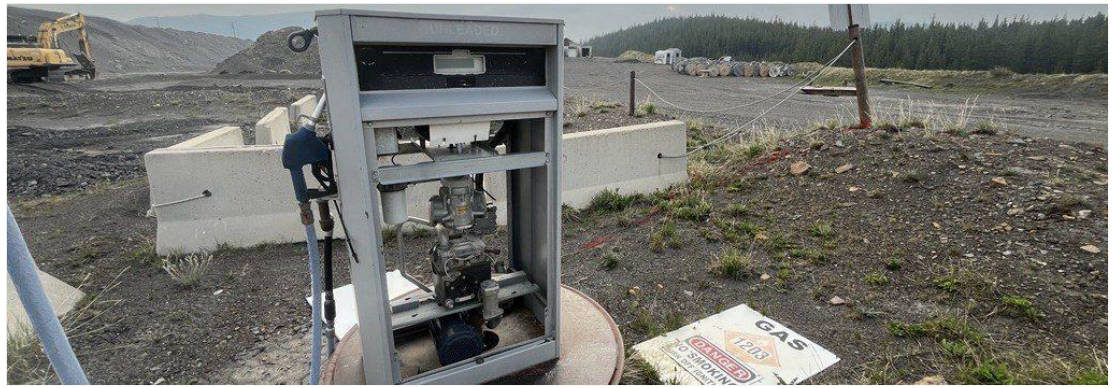


Photograph 1 — Haul trucks at the mine

HYDROCARBON APEC EXAMPLES



Photograph 2 — Service bay



Photograph 3 — Fuel bay



Photograph 4 — Storage areas, shovel pads and laydown yards



Photograph 5 — Mine equipment storage area

HETEROGENEOUS MATERIAL



Photograph 6 — Heterogeneous waste rock and till at a location on the mine

FIGURE NOTES

- Mix of coal, till, waste rock and gravel
- Occasional patches of clay and sand
- No construction records available
- Locations built up with waste rock material
- Non-permeable containment liners on some sites in various condition at ~ 0.5 to 1.5 mbgs
- Coal seams throughout the profile

Waste Rock: the non-coal rock and soil removed to reach coal seams within the mine.

DUPLICATE SAMPLE DISAGREEMENT

	F1 – BTEX	F2 (C10–C16)	F3 (C16–C34)
Sample 1	72	485	525
DUP 1	405	3,460	2,690
RPD	**140%**	**151%**	**135%**
Sample 2	11	397	460
DUP 2	44	261	268
RPD	**120%**	**41%**	**53%**
Sample 3	79	549	11,600
DUP 3	5	29	31,800
RPD	**176%**	**180%**	**93%**
Sample 4	32	75	163
DUP 4	5	105	319
RPD	**146%**	**33%**	**65%**

WHAT THE DUPLICATES SHOW

180%

- **All 12** RPDs are above the ~30% alert limit; 10 are above 50%.
- **No consistent direction** — the duplicate is higher in some pairs and lower in others.

Table 1 — Example of disagreement in duplicate samples (laboratory analyzed)

All concentrations in mg/kg. RPD (relative percent difference) = |sample − duplicate| ÷ mean of the pair × 100. Soil duplicate RPDs are commonly screened against alert limits of roughly 30%.

TEST PIT SAMPLING



Photograph 7 — Example of a test pit completed at the mine



Photograph 8 — Example of an excavator advancing test pit at the mine

FIGURE NOTES

- Material is unstable and prone to sloughing
- Soil profile is not consistent
- Test pit samples not as accurate as drilling boreholes
- Size of excavator required to dig through rock
- Appropriate bucket on machine
- Operator insight
- ‘Unconventional’ Assessment

CONTAMINANTS OF POTENTIAL CONCERN

Tier 1 Screening

- This presentation will mention hydrocarbons as a contaminant of potential concern (CoPC), and the methods we used to distinguish petroleum contamination from coal influence in the material we were sampling.
- Other CoPCs were assessed across the program based on location and site history but are outside the scope of this presentation.



Photograph 9 — Chain oils labelled on the wall at a Phase II ESA location

Note: hydrocarbons are the only CoPC discussed in this presentation.

REVIEW OF HISTORICAL ESAs



Photograph 10 — Proposed test pit location within the mine

PLANNING

- Full review of all existing data before boots hit the ground.
- A **background characterization program** proposed to the client, ensuring that remediation targets would be achievable and we would not be remediating potential biogenic material as disposal = costly.
- Early conversations with the laboratory about analytical options, limitations of sampling rocky material, and what occurs naturally in coal.

02

SECTION

BACKGROUND CHARACTERIZATION PROGRAM

Determining which constituents occur naturally, and addressing the challenges identified in previous investigations at the site.

BIOGENIC VS PETROGENIC

BIOGENIC

Naturally occurring hydrocarbons from recent decay of materials such as peat and compost which can cause false petroleum hydrocarbon guideline exceedances.

- The Biogenic Interference Calculation (BIC) Scale (AEP, 2018) is a tool used to identify false exceedances.
- Naturally occurring PHCs in coal are not well understood in the literature.



Photograph 11 — Coal on-site and potential biogenic source, later determined to be petrogenic in nature.

Source: Alberta Environment and Protected Areas. 2024. Alberta Tier 1 Soil and Groundwater Remediation Guidelines. Edmonton, AB.

PETROGENIC

Hydrocarbons that originate from crude oil and refined petroleum products; diesel, gasoline, lubricating and hydraulic oils, and greases.

- These are the products we were tasked to find, delineate and remediate.
- On a coal-bearing site, coal and hydrocarbons overlap in the APECs assessed.



Photograph 12 — Fuel jerry cans at a service area, a petrogenic source

SAMPLING DESIGN

The design of the background characterization program proposed to:

- Sample at locations both away from and adjacent to the proposed Phase II ESA sites, to confirm whether hydrocarbons occur naturally across the site.
- Sampling at locations unaffected by mine operations.
- Multiple samples within each sampling location around the mine.
- Trialling additional laboratory tests to see which could separate natural from petrogenic hydrocarbons.
- Samples of coal taken directly from coal-containing material.

The program had to account for coal occurring naturally within the soil profile and for mined, ex-situ coal handled and moved around the site.

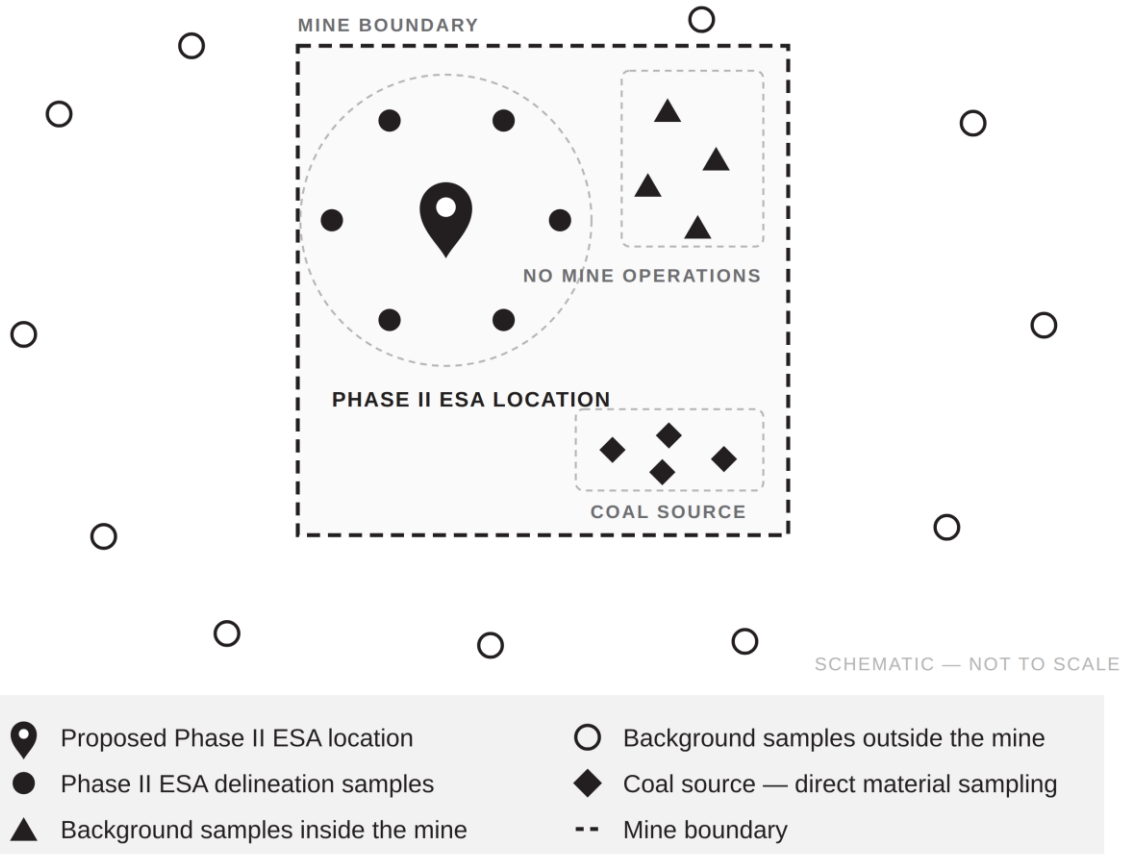


Figure 1 — Background characterization sampling design (schematic, not to scale)

RESULTS OF BACKGROUND CHARACTERIZATION

CoPC	Result
Benzene	Concentrations of benzene were more than **two (2) times** higher than the AT1 criteria.
Toluene	The highest samples were more than **two (2) times** higher than the AT1 criteria.
Ethylbenzene	While most samples had results marginally above AT1 criteria (less than two times higher), the highest sample was more than **five (5) times** AT1.
Xylenes	The highest sample was almost **four (4) times** AT1 criteria.
F1 - F4 PHCs	All samples from the mine background locations were well **below** AT1 criteria for Fraction 1 to Fraction 4 hydrocarbons.

Table 2 — Summary of initial background characterization results against Alberta Tier 1 (AT1) criteria



Photograph 13 — Mine tires present within the assessed location

CHROMATOGRAM INTERPRETATION

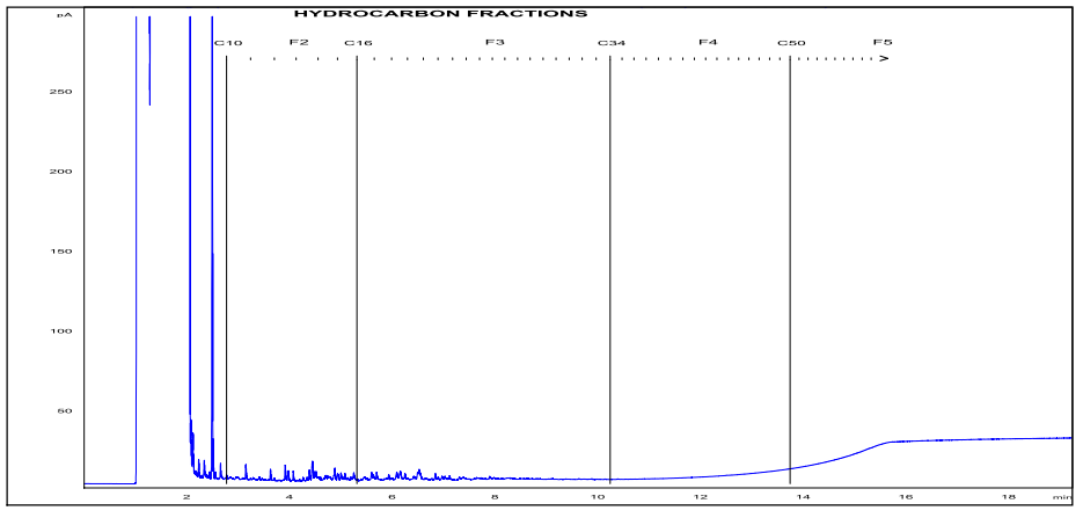


Figure 2 — Unimpacted background location

Background soil from the mine. BTEX and a light F2 response, with essentially no F3.

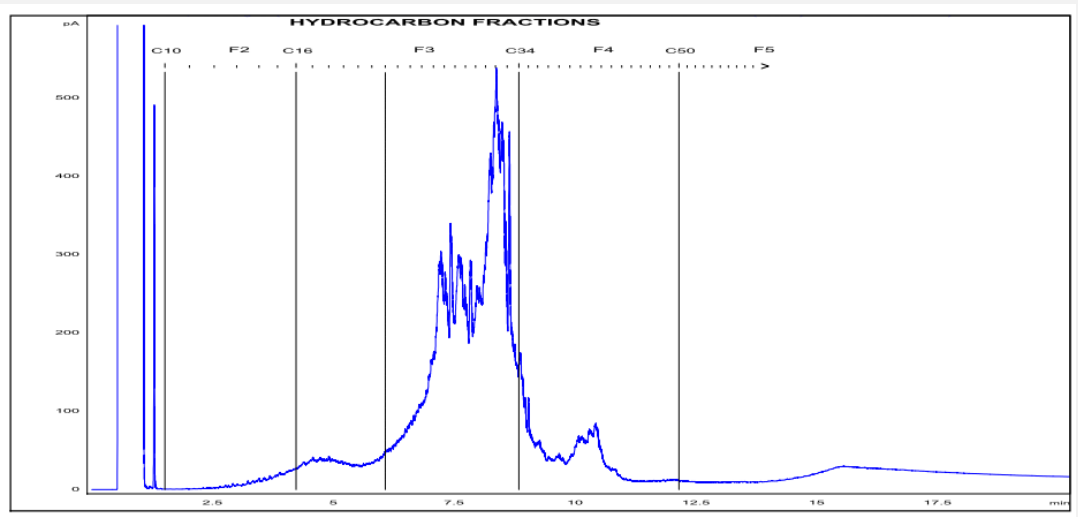


Figure 3 — Petrogenic hydrocarbon

Petrogenic example of a sample. Notable peaks in the F3 range peaking near C34, with a small hump in the F4 range. This sample was noted to contain both diesel and lubricating oils.

Coal and background samples give scattered light-end peaks and no hump, while petroleum products give distinct curves.

TYPICAL HYDROCARBON CURVES

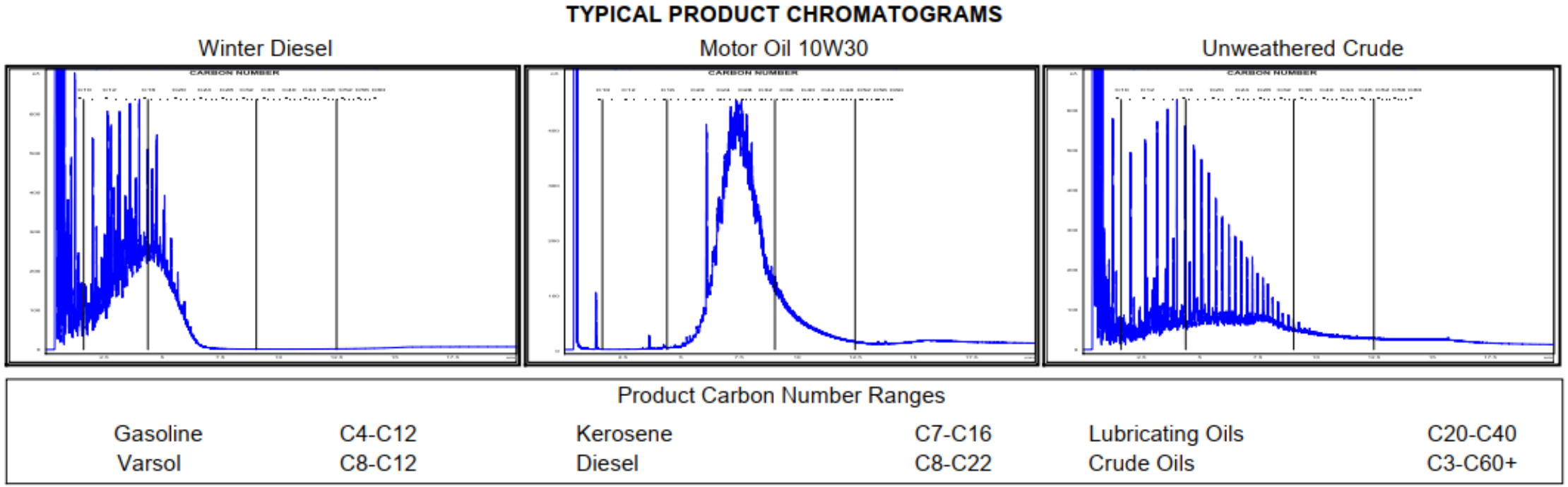


Figure 4 — Typical product chromatograms and the carbon-number ranges of the PHC fractions

VOC SCAN & FORENSIC FOR BIOGENIC TOLUENE

The VOC scan was run on multiple coal and background samples for biogenic biomarkers:

- The initial scan could not separate petrogenic from biogenic origins.
- Additional polycyclic aromatic hydrocarbon (PAH) analysis was completed.
- The final scan returned either both biogenic and petrogenic markers, or too little data in the chromatogram to interpret.

CONCLUSION:

Many petrogenic markers were detected and confirmed by BTEX, VOC and PAH methods. Small amounts of biogenic markers were found (e.g., p-cymene) but were not easily distinguished. The samples analyzed contained coal but results suggested the presence of a petroleum signature. The contribution to the toluene is inferred to be both biogenic and petrogenic in origin.

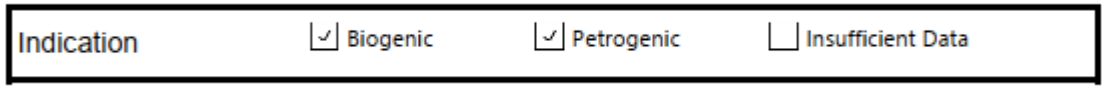


Figure 5 — Laboratory source indication for toluene (excerpt from the forensic report)

This further reinforces that we are dealing with complicated material at this site.

BACKGROUND CHARACTERIZATION SUMMARY

BIOGENIC

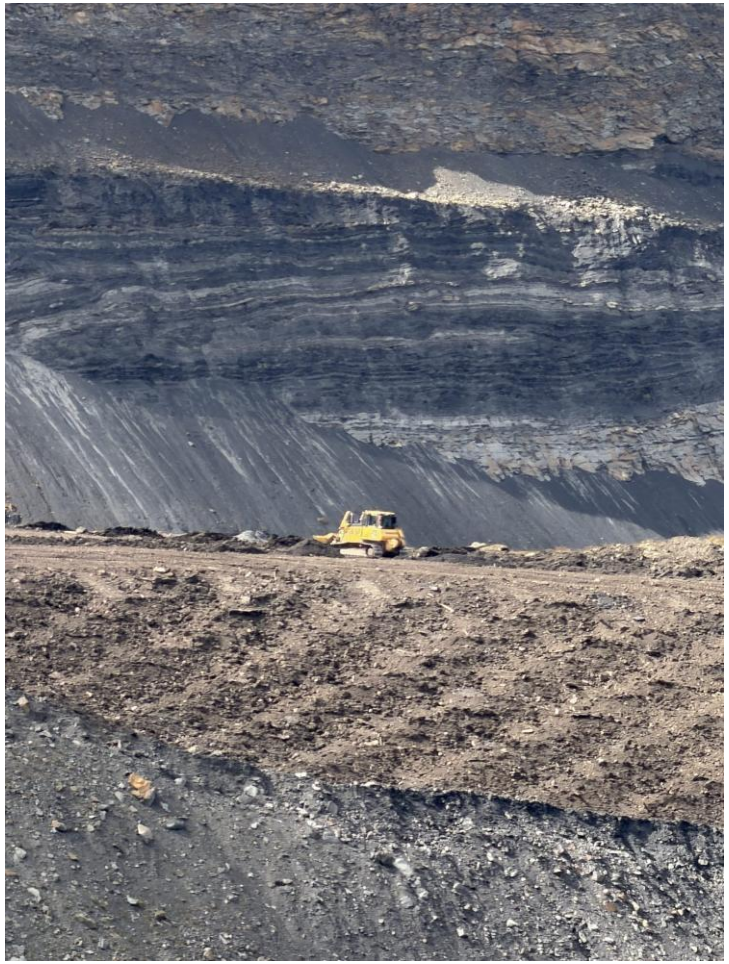
- BTEX was present above applicable AT1 criteria in unimpacted background samples and in direct coal.
- Fraction 1 to Fraction 4 hydrocarbons were well below AT1 criteria in every background and coal sample.

WHAT THIS MEANT FOR THE PROGRAM

- BTEX alone could not be used to call a location contaminated.
- Chromatogram interpretation, supported by the magnitude of the F1-F4 results, became the primary line of evidence.

PETROGENIC

- Elevated F1-F4 results, with diesel and lubricating-oil patterns visible in the chromatogram.
- Fraction 3 exceedances were carried forward as contaminants of concern, not as biogenic interference.



Photograph 14 — Dozer reclamation in progress

03

SECTION

FIELDWORK

Completing assessments at the site, field screening, sampling design.

FIELD SCREENING

After the first round of assessments, we found that field screening with a volatile organic compound (VOC) meter was not reliable in this material.

- Correlation between field screening and laboratory results was close to zero. Trialled different calibrations for the site and no luck.
- With BTEX confirmed in the samples, the meter could not differentiate between background and contaminated locations at the site.
- Heavier hydrocarbons are generally odourless, are CoPCs within the areas assessed at the site, and are generally not picked up by the VOC meter.
- **Coal is a hydrocarbon sorbent** and can trap hydrocarbons on particle surfaces and inside their micropores, so very little is released for the meter to read.
- Presented challenges with additional mobilizations during short field season and reliability of screening at the site.



Photograph 15 — VOC meter used for typical hydrocarbon field screening

Photograph 15: RKI Instruments, Eagle 2 gas detector product page, rkiinstruments.com.

AISCT® FIELD SCREENING

A key part of addressing these challenges was deploying Trium Environmental Inc.'s AISCT® PETRO field screening unit on site.

- Provides rapid on-site hydrocarbon (F1-F3) results to guide sampling and decisions in real time for both Phase II ESA and remedial work.
- Promoted fewer mobilizations and use of time in short field season.
- Enabled duplicate and triplicate sampling designs and screening to improve accuracy in highly heterogeneous material.
- Secondary line of evidence to laboratory data, indicating better confidence in delineating the contamination boundary.



Photograph 16 — AISCT® PETRO unit set up for on-site analysis

Source: Trium Environmental Inc. AISCT® Petro field screening system. triuminc.com

AISCT® FIELD SCREENING

AISCT® screening is a five-step process (simplified for this presentation):

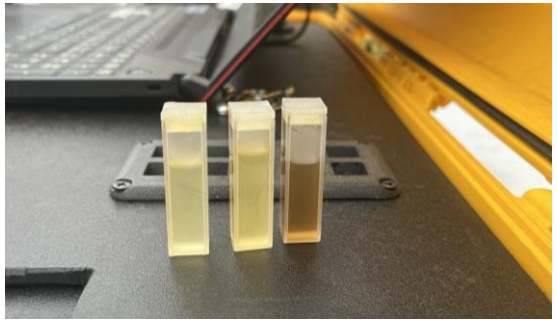
1. Collect the sample into a centrifuge tube and add the appropriate AISCT® extraction liquid.

2. Shake the sample.

3. Spin the sample.

4. Transfer the extract into a cuvette for analysis.

5. Analyze the cuvette to determine PHCs in the sample.



Photograph 17 — Extract transferred to cuvettes



Photograph 18 — AISCT® kit and centrifuge



Photograph 19 — Field screening station set up at the mine

AISCT® FIELD SCREENING CONSIDERATIONS

BENEFITS:

- Real-time data supports decisions on the spot.
- Confidence in the numbers you are acting on.
- Biogenic interference is flagged as a warning in the software.
- Detects heavier petroleum with no odour.
- Improved field guidance compared with the VOC meter.

CHALLENGES:

- Fast field decisions can be overwhelming.
- Remote site setup challenges (generator, Starlink, etc.).
- False negatives from coal-bearing material.



Photograph 20 — Sample preparation at the field station



Photograph 21 — Screening beside an active excavation



Photograph 22 — Recording AISCT® results in the field

AISCT® PHASE II ESA FIELD SCREENING RESULTS

Sample ID	AISCT F2	Lab F2	AISCT F3	Lab F3	AISCT call	Lab result	Agreement
TP01 0.0–0.5	<70	<25	<195	60	M.C.	M.C.	Correct
TP04 1.0–1.5	72	<25	224	<50	M.C.	M.C.	Correct
TP05 0.5–1.0	<70	30	<195	789	M.C.	E.C.	False negative
TP06 0.0–0.5	<70	161	<195	2,400	M.C.	E.C.	False negative
TP06 1.0–1.5	71	<25	<195	170	M.C.	M.C.	Correct
TP07 0.0–0.1	40,881	3,650	21,648	68,500	E.C.	E.C.	Correct
TP07 2.0–2.5	<70	<25	<195	78	M.C.	M.C.	Correct
TP08 0.0–0.5	<70	30	<195	256	M.C.	M.C.	Correct
TP15 0.0–0.1	35,398	19,700	21,087	30,000	E.C.	E.C.	Correct
TP18 0.0–0.1	28,948	7,520	17,192	27,900	E.C.	E.C.	Correct
						Overall agreement at this location:	94%

Table 3 — AISCT® field screening vs laboratory results, Phase II ESA example site

All concentrations in mg/kg. M.C. = meets criteria, E.C. = exceeds criteria. Selected samples shown; 33 of the 76 screened had paired laboratory results.

Overall agreement was 94% — 31 of 33 samples matched the laboratory outcome, with no false positives. The two false negatives were TP05 0.5–1.0 and TP06 0.0–0.5; contributing factors include soil heterogeneity, incomplete F3 extraction and biogenic influence.

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AISCT® REMEDIATION FIELD SCREENING RESULTS

Sample ID	AISCT F2	Lab F2	AISCT F3	Lab F3	AISCT call	Lab result	Agreement
B11-1.5	614	<25	221	411	E.C.	E.C.	Correct
B12-0.75	<55	304	<150	468	M.C.	E.C.	False negative
B16-1.0	547	877	154	1,350	E.C.	E.C.	Correct
EW8-0.5	68	439	170	624	M.C.	E.C.	False negative
NW10-0.75	17,765	1,340	26,229	9,700	E.C.	E.C.	Correct
WW7-0.75	8,477	76	178	2,640	E.C.	E.C.	Correct
B25_0–2.5	56	103	<125	230	M.C.	M.C.	Correct
NW20_0–0.75	<50	359	<125	839	M.C.	E.C.	False negative
SW11_0–0.75	<50	31	157	1,000	M.C.	E.C.	False negative
WW13_0–0.75	1,738	—	258	—	E.C.	—	Field duplicate
WW13_0–0.75 DUP	2,224	—	252	—	E.C.	—	Field duplicate
					Overall agreement at this location:		89%

Table 4 — AISCT® field screening vs laboratory results, remediation example site

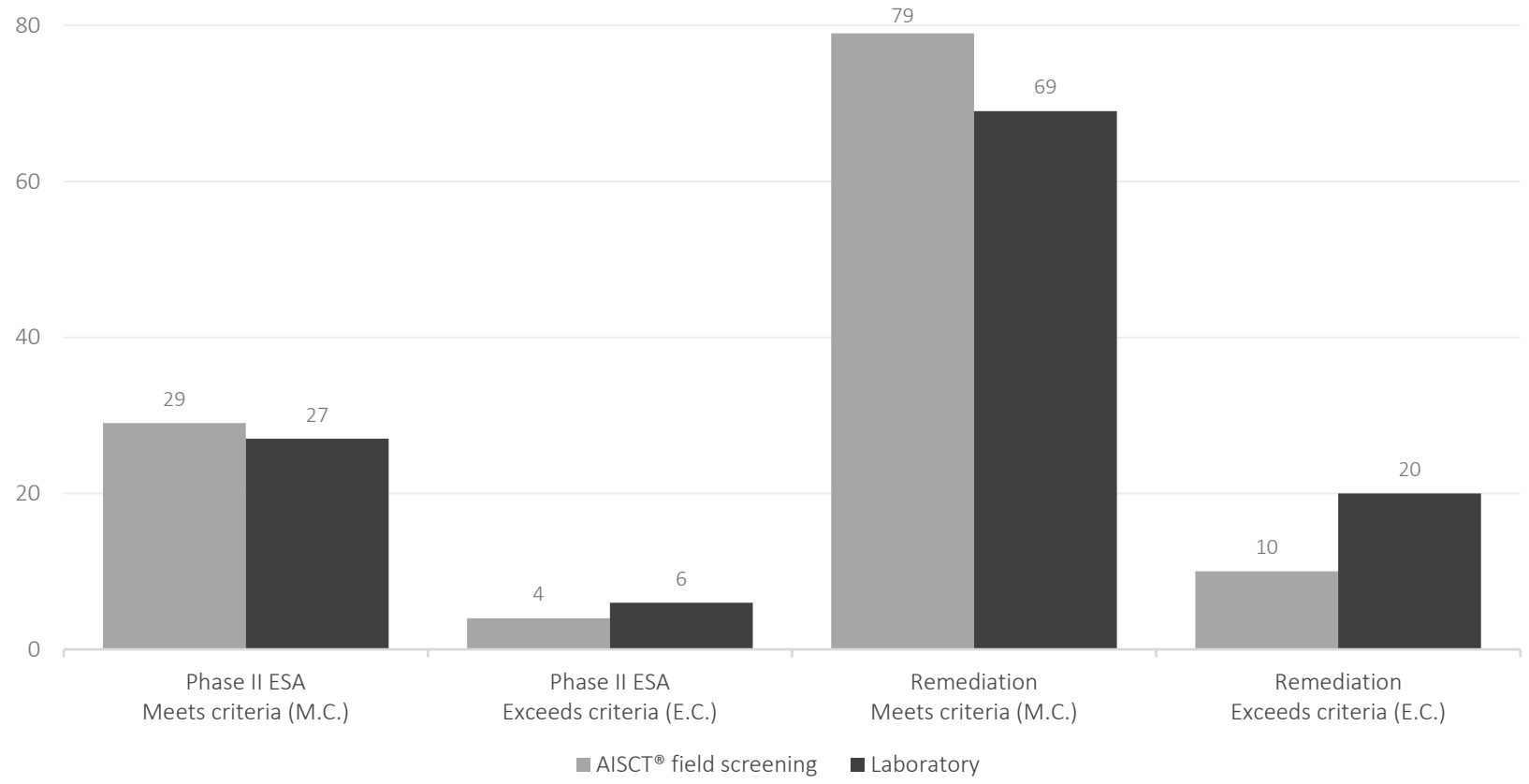
All concentrations in mg/kg. M.C. = meets criteria, E.C. = exceeds criteria. Across both rounds 120 samples were screened and 89 had paired laboratory results: 79 matched the laboratory outcome (89%), with 10 false negatives and no false positives.

Field duplicate WW13_0–0.75 returned 1,738 and 2,224 mg/kg F2 — a 25% spread in a heterogeneous, coal-bearing sample, but the same E.C. call from both splits (driving parameter F2, 90–91% probability of exceedance).

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AISCT® CORRELATION AND BENEFITS

Figure 6 — Sample outcomes: AISCT® field screening vs laboratory (paired samples; remediation = both rounds)



94%

PHASE II ESA AGREEMENT WITHIN EXAMPLE SITE
31 OF 33 PAIRED SAMPLES

89%

REMEDIATION AGREEMENT WITHIN EXAMPLE SITE
79 OF 89 PAIRED SAMPLES

0

FALSE POSITIVES

12

FALSE NEGATIVES

Note: across these two case studies presented, AISCT® agreement has been higher in non-coal environments.

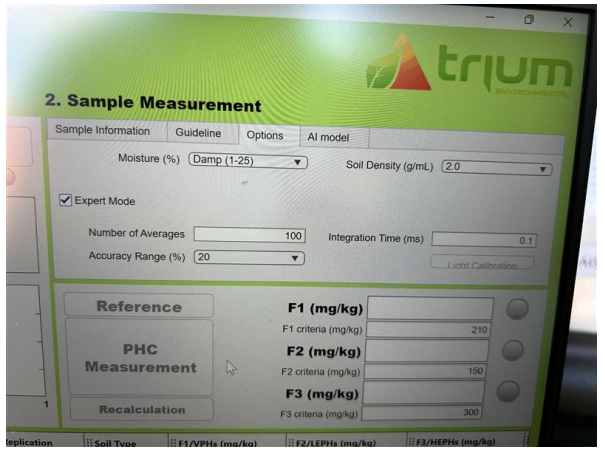
FIELD CHALLENGES #1 - AISCT®

SITUATION #1:

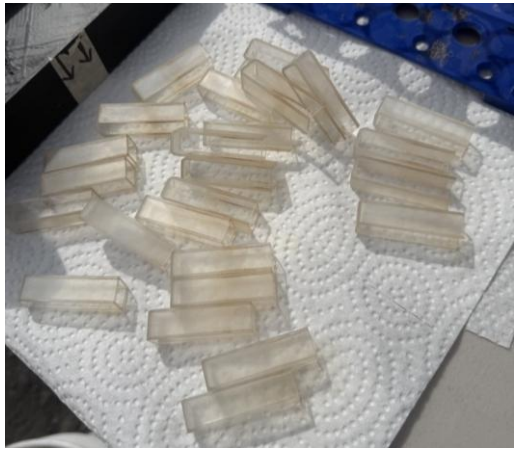
What do you do when learning new field screening?

- Trial and error: a new system comes with challenges that were not anticipated.
- Acetone used to clean the cuvettes was skewing results; the fix was to let cuvettes dry fully (no rushing) and check results for high F2.
- Decision-making speeds up dramatically once confident results come back in minutes rather than the next day or two on rush.
- Constant communication within the field team is essential; decision-making is more reliable with the unit on site.
- Send samples to the screening crew in even numbers.

OVERALL: NO MORE GUESSING, RELY ON THE DATA.



Photograph 23 — Screen showing the Trium AISCT® unit prior to starting screening



Photograph 24 — Dirty cuvettes from the AISCT® PETRO unit

FIELD CHALLENGES #2 - DELINEATION

SITUATION #2:

What do you do when you are delineating for remediation and hit a coal seam, coal-bearing material or coal mixed with diesel?

- Keep digging where coal and diesel are mixed.
- Treat results carrying a biogenic interference warning as provisional.
- Record the material description within samples so the data can be correlated later.
- Step out and screen or sample again rather than calling a boundary on a single result.
- Complete duplicate and triplicate sampling as necessary to confirm the result, as heterogeneity of the material may be a factor.

Samples in remediation with high F3 and low F2?



Photograph 25 — Coal encountered at digging location

04

SECTION

LABORATORY & ANALYSIS TECHNIQUES

Laboratory and analysis techniques to determine potential biogenic compounds causing interference in samples.

F3 – SAMPLE EXAMPLE

Sample ID	F1	F2	F3	F3a	F3b	F4	Comments
XX-SW11	<10	31	1,000	52	948	338	

Table 5 — PHC fraction results for sample SW11 (mg/kg)

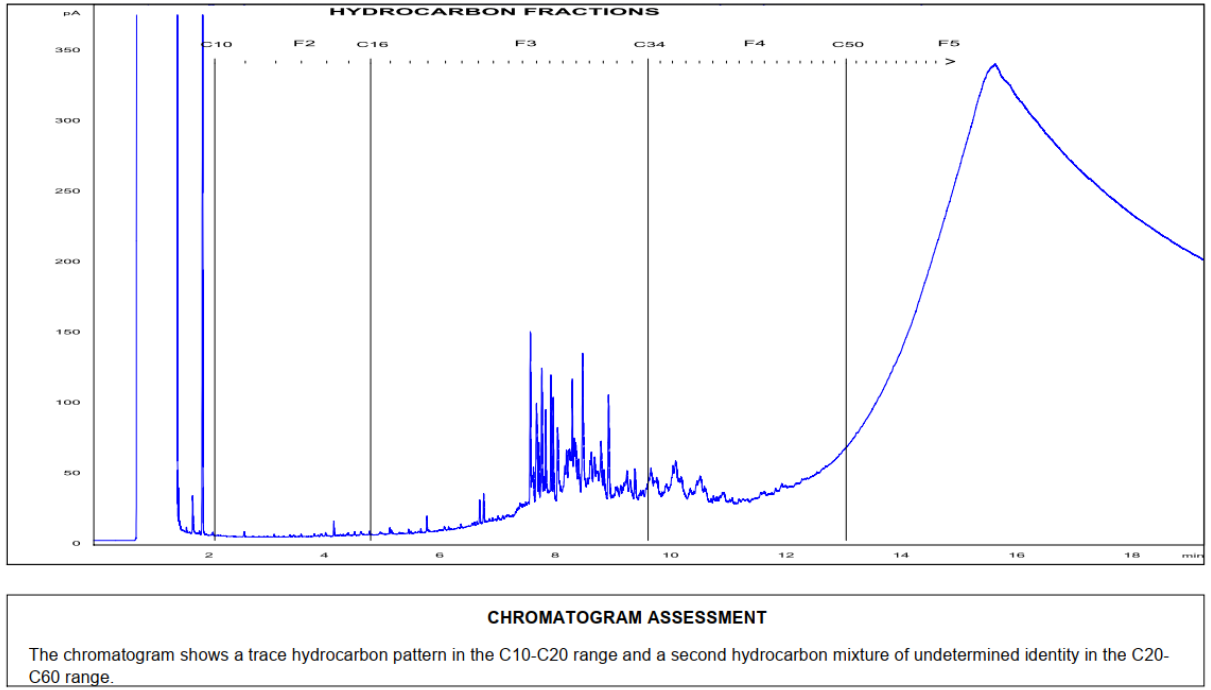


Figure 7 — Chromatogram for sample SW11 showing elevated F3 and C50+ response

BIOGENIC INTERFERENCE CALCULATION (BIC)

The BIC Scale is a mathematical scale used to identify false petroleum hydrocarbon exceedances caused by natural biogenic organic compounds. It is written for organic soils. We looked at whether it could apply to our samples with high F3.

The calculation applies where:

- PHC F2 is less than 30 mg/kg and does not exceed the Tier 1 soil guidelines;
- PHC F3 is detectable and may exceed the Tier 1 soil guidelines;
- PHC F4 is detectable but does not exceed the Tier 1 soil guidelines; and
- more than 85% of the total PHC F3 range falls within the F3b range.

Restriction to heavy PHCs

The BIC Scale is not applicable at this site for two reasons. First, it is limited to light PHC products, such as gasoline and diesel, where detectable F2 serves as a marker of contamination. Motor oil, a heavy product identified as a CoPC at the APECs assessed, does not meet this condition. Second, the APECs contain heavy PHCs of both coal and petrogenic origin, and their overlapping carbon ranges prevent the two sources from being distinguished.

<u>What this helped us identify is that most of our samples contained F3 in the F3b region.</u>

Source: Alberta Environment and Parks. 2018. Biogenic Interference Calculation (BIC) Scale for Petroleum Hydrocarbons in Soils. Edmonton, AB.

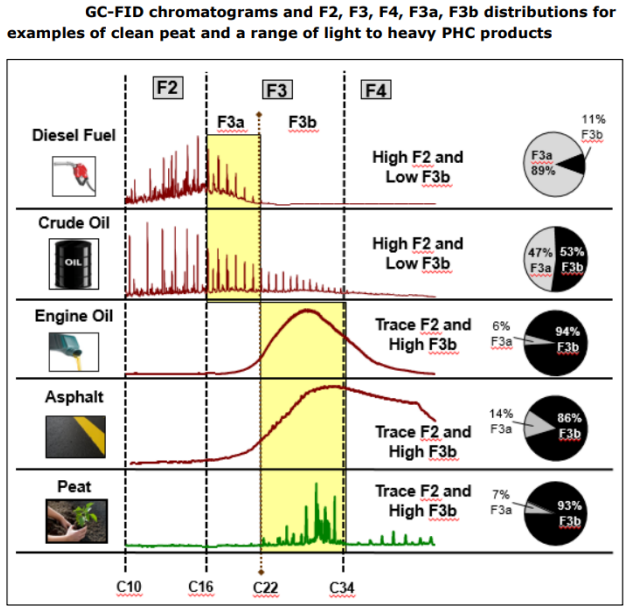


Figure 8 — GC-FID chromatograms and F2 / F3 / F4 / F3b distributions for clean peat and a range of light to heavy PHC products

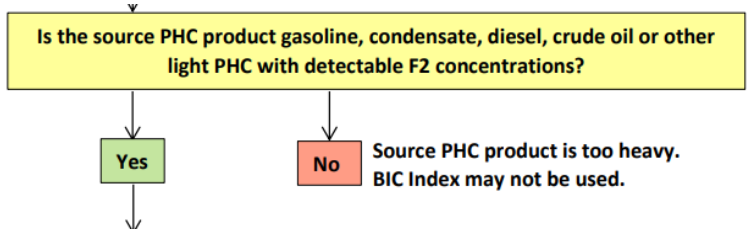


Figure 9 — Guidance on heavy PHC products within BIC

ATTEMPTS TO REDUCE POTENTIAL INTERFERENCE

Biogenic organic compounds (BOCs) are generally more polar than PHCs, and silica gel is a polar substance laboratories use to strip polar BOCs out of a PHC extract. CCME (2008) allows a controlled amount of silica gel for this purpose. Highly organic peat and compost can exceed the saturation capacity of the silica gel, which produces false exceedances of the Alberta Tier 1 F3 guidelines and relatively small amounts of non-polar BOCs can do the same.

Silica gel - In-situ clean-up

The simplest is the “in-situ” or dispersive clean-up, where silica gel adsorbent is added directly to a sample extract prior to analysis; it is the most common and regulatory-accepted method.

Silica gel - Column clean-up

Column-based silica gel clean-ups are more complex but are more effective at removing some types of interferences. In a column clean-up, a sample extract is passed slowly through a vertical column of silica gel, which gives more potential for interaction with fresh, active silica gel than with an in-situ clean-up.

GOAL: compare in-situ and column clean-up results to see if F3 differs

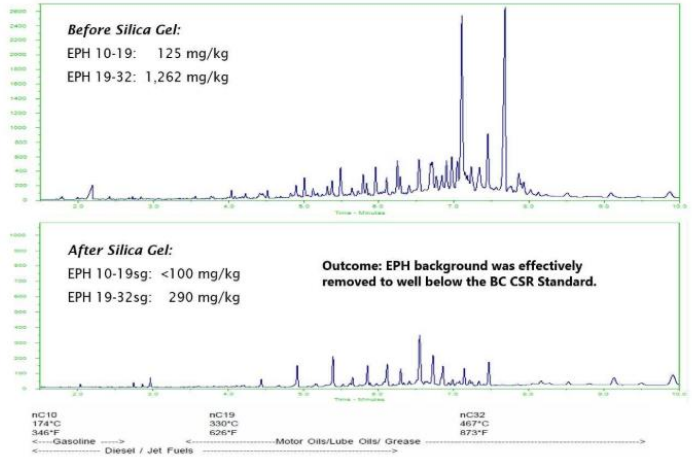


Figure 10 — Reduction in ‘noise’ of chromatograms with column clean-up



Figure 11 — Column clean-up laboratory image

Sources: CCME. 2008. Canada-Wide Standard for Petroleum Hydrocarbons in Soil. ALS Global. 2023. EnviroMail 52 Canada — False petroleum hydrocarbon detection. alsglobal.com/en/News-and-publications/2023/10/Enviromail-52-Canada-False-Petroleum-Hydrocarbon-Detection

COLUMN CLEAN-UP

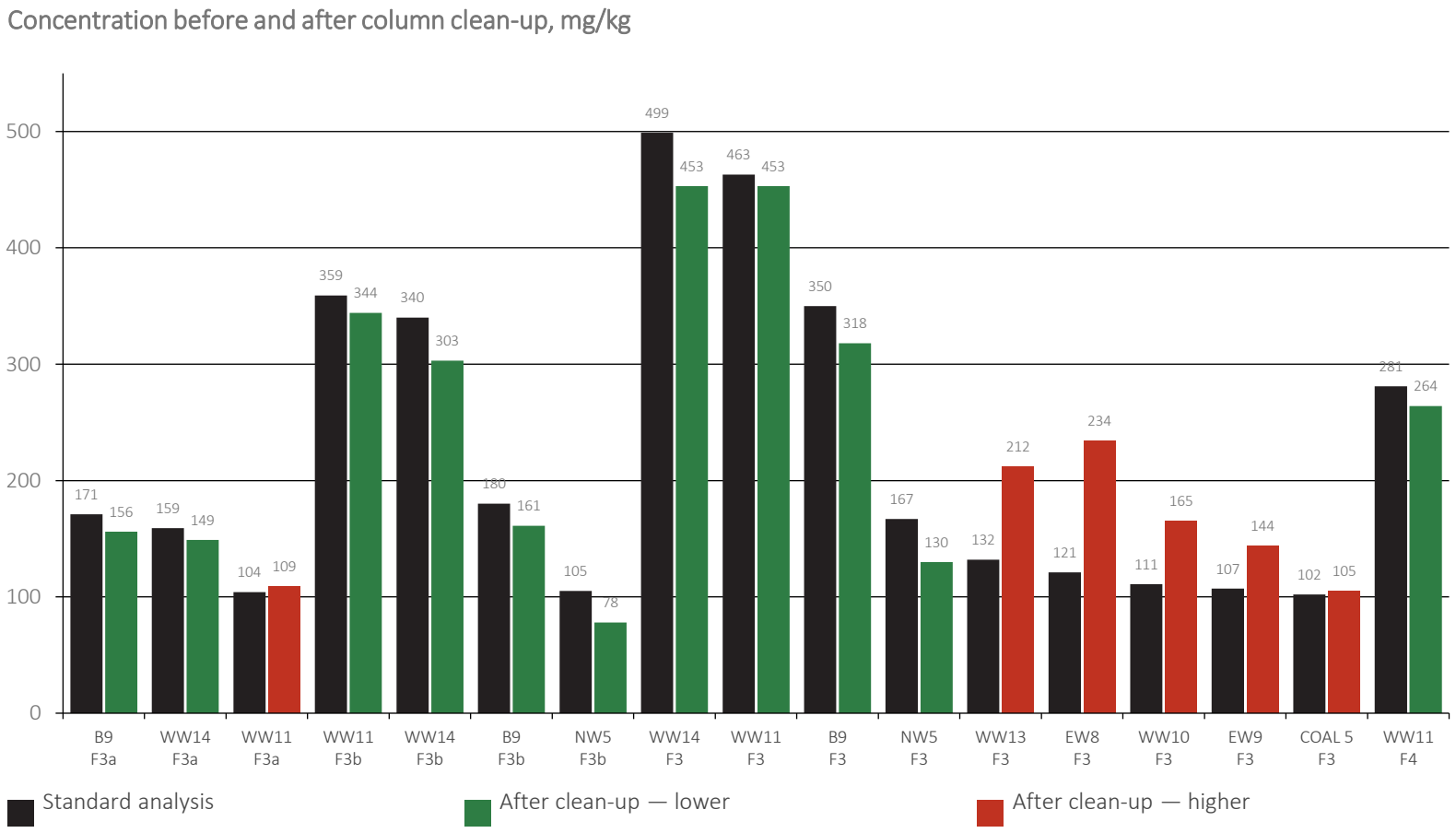
Silica gel column clean-up was run as a paired duplicate on sixteen (16) samples to see if the results contained more or less interference by potential removal of additional compounds present in coal-containing samples leading to false F3 exceedances.

Sample	F2	F3a	F3b	F3	F4	%C50+
WW11	43	104	359	463	281	24
WW11 — clean-up	45	109	**344**	**453**	**264**	**17.1**
WW14	58	159	340	499	<100	<5
WW14 — clean-up	61	**149**	**303**	**453**	<100	<5
B9	83	171	180	350	<100	<5
B9 — clean-up	**82**	**156**	**161**	**318**	<100	<5
NW5	35	63	105	167	<100	<5
NW5 — clean-up	**31**	**52**	**78**	**130**	<100	<5
WW13	<25	<50	90	132	<100	<5
WW13 — clean-up	37	70	142	212	<100	<5
EW8	26	<50	76	121	<100	<5
EW8 — clean-up	47	92	142	234	<100	<5
EW9	33	<50	70	107	<100	<5
EW9 — clean-up	35	<50	96	144	<100	<5
WW10	33	<50	69	111	<100	<5
WW10 — clean-up	43	62	103	165	<100	<5

Sample	F2	F3a	F3b	F3	F4	%C50+
COAL 5	62	<50	53	102	<100	<5
COAL 5 — clean-up	**53**	51	53	105	<100	<5
EW7	<25	<50	<50	90	<100	<5
EW7 — clean-up	48	63	82	145	<100	<5
B10	<25	<50	<50	63	<100	<5
B10 — clean-up	<25	<50	65	97	<100	<5
WW12	<25	<50	<50	59	<100	<5
WW12 — clean-up	34	<50	54	85	<100	<5
COAL 2	35	<50	<50	66	<100	<5
COAL 2 — clean-up	52	<50	70	116	<100	<5
COAL 3	29	<50	<50	<50	<100	<5
COAL 3 — clean-up	56	<50	60	107	<100	<5
COAL 4	39	<50	<50	84	<100	<5
COAL 4 — clean-up	46	50	72	122	<100	<5
COAL 1	<25	<50	<50	<50	<100	<5
COAL 1 — clean-up	37	<50	<50	57	<100	<5

Table 6 — Paired standard and silica-gel column clean-up results (16 samples)
All concentrations in mg/kg except %C50+, which is a percentage. “<25”, “<50”, “<100” and “<5” are below the laboratory detection limit and are treated as half the limit when a comparison is made. Clean-up values in green are lower than the standard run directly above them. F1 was not analyzed on the clean-up duplicates. Source: paired standard and silica-gel column clean-up laboratory analyses; CCME. 2008. Canada-Wide Standard for Petroleum Hydrocarbons in Soil.

CLEAN-UP EFFECT ABOVE 100 MG/KG



WHERE THE REDUCTIONS SIT

F3a: 2 of 3 pairs above 100 were reduced (WW14, B9); WW11 rose slightly.

F3b: 4 of 4 pairs at or above 100 mg/kg were reduced: WW11, WW14, B9 and NW5.

F3 total: 4 of the 9 pairs at or above 100 were reduced, the same four samples. The other five rose.

F4: the single pair above 100, WW11, fell 281 → 264. Its %C50+ fell 24 → 17.

CONCLUSION: In general, the results of the column clean-up were not conclusive in determining a reduction or increase in potential F3 interference at the site.

Figure 12 — Every sample and fraction with a standard result at or above 100 mg/kg, before and after the silica-gel column clean-up duplicate. Green marks a clean-up result lower than the standard run; red marks one that rose. F2 is absent because no pair reached 100 mg/kg.

DUAL GAS CHROMATOGRAPHY

Other laboratory methods were explored, such as dual gas chromatography (GC×GC), to determine whether F3 could be attributed to a natural source.

DUAL GC×GC

Provides a second dimension to traditional gas chromatography, separates very complex mixtures using two different column phases, increasing resolution and peak capacity through the addition of the second column with more lines of evidence, generally more accurate for complex material with interferences.

INTERPRETATION

Coal from background samples at the mine was more similar to crude oil, indicating a naturally occurring petrogenic signature at the location.

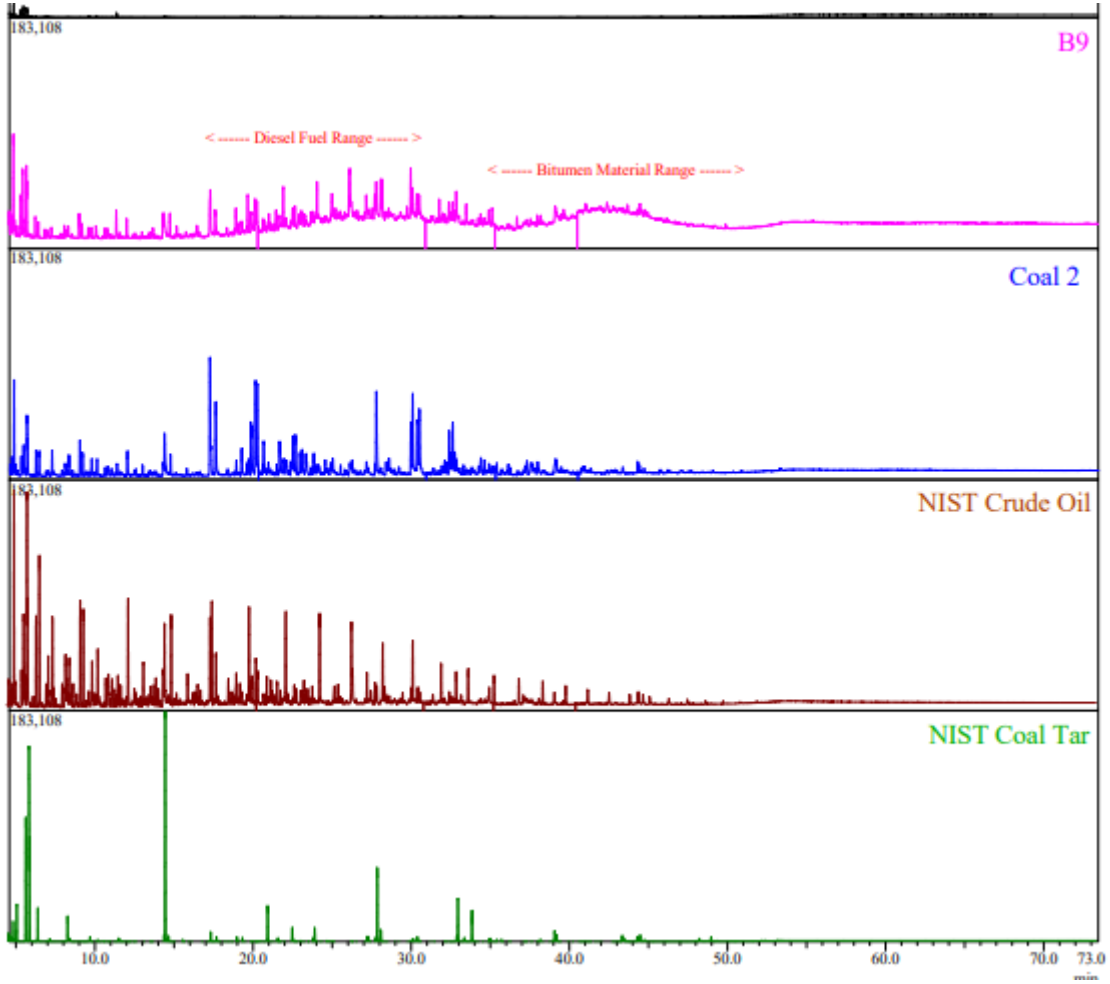


Figure 13 — Comparison of chromatograms for the B9 and Coal 2 samples

Sources: CCME. 2008. Canada-Wide Standard for Petroleum Hydrocarbons in Soil. AGAT Laboratories. GC×GC (two-dimensional gas chromatography) analysis. agatlabs.com/wp-content/uploads/agat-labs-gcxgc-analysis.pdf

DUAL GAS CHROMATOGRAPHY

INTERPRETATION

- PAHs were nearly identical in the two (2) samples (bottom-left graph).
- A cluster of peaks around C23 is consistent in both samples.
- Even GC×GC has limits: results showed limited applicability as GC×GC did not help distinguish natural PHCs in coal from the CoPCs.

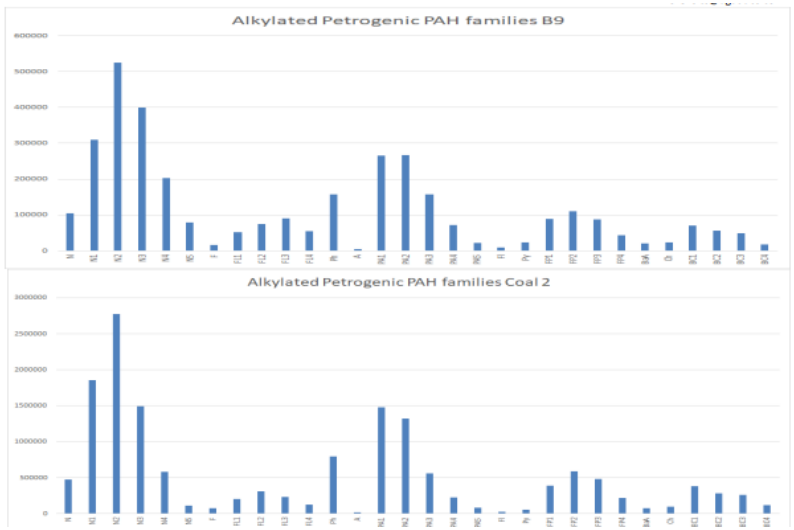


Figure 14 — Comparison of PAHs between the B9 and Coal 2 samples

Source: CCME. 2008. Canada-Wide Standard for Petroleum Hydrocarbons in Soil.

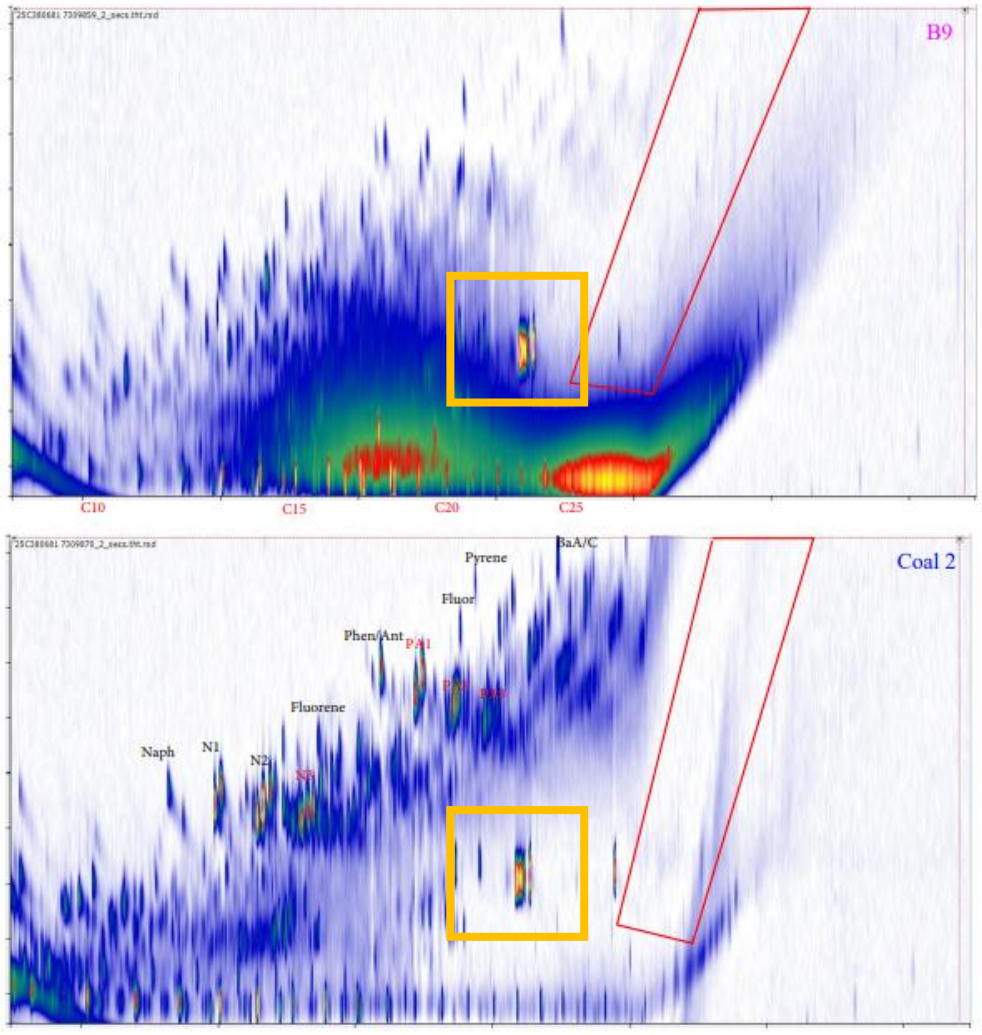


Figure 15 — GC×GC comparison between the B9 and Coal 2 samples

05

SECTION

CONCLUSION

A summary of what worked, and what did not.

THE MOST EFFECTIVE WAY

WHAT WORKED

- A background characterization program run before the assessment, so we knew what signatures were present naturally at the site.
- Chromatogram interpretation as the primary line of evidence for separating coal-bearing material from petroleum sources.
- AISCT® PETRO field screening for real-time delineation and on-site results, 94% and 89% agreement with the laboratory, and minor false negatives.
- Early and continuing conversations with both the laboratory and the client.

WHAT DID NOT

- VOC meter field screening, effectively no correlation in coal-bearing material.
- Biomarker scans and GC×GC, which indicated both source materials were petrogenic in nature.
- Silica gel column clean-up, inconclusive; F3 fell in some samples and rose in others.



Photograph 26 — Excavator within the mine location

A DEFENSIBLE PATH TO CLOSURE

The client came to us because these sites had been difficult to close. Layering the methods that worked let us:

PHASE II ESA

- Assess APECs more efficiently, using AISCT® field decisions and our background characterization data.
- Delineate impacts on-site in real time, with fewer return trips to a remote site (deeper, more test pits).
- Make same-day calls on contamination status and remedial planning.

REMEDIATION

- Find the contaminant boundary and estimate excavation volumes in the field, confirmed by laboratory samples.
- Reduce equipment standby time and unnecessary hauling and disposal.

WHAT REMAINS

Whether coal itself produces F3 is still an open question due to overlap of carbon with heavier hydrocarbons as CoPCs at the site.



Photograph 27 — Test pit with liner during Phase II ESA



Photograph 28 — Excavation during remediation at the site

BACK TO OUR QUESTION

How do you tell the difference between a sample with diesel, a sample with coal and diesel, and a sample that's only coal?

DIESEL ONLY
Petrogenic

- F2 and/or F3 above AT1 criteria.
- A recognizable product curve on the chromatogram (diesel, lube oil).
- Flagged in the field by the AISCT®.
- Contamination, removed during Phase II ESA and dug up in Remediation

COAL + DIESEL
Mixed: the hardest case

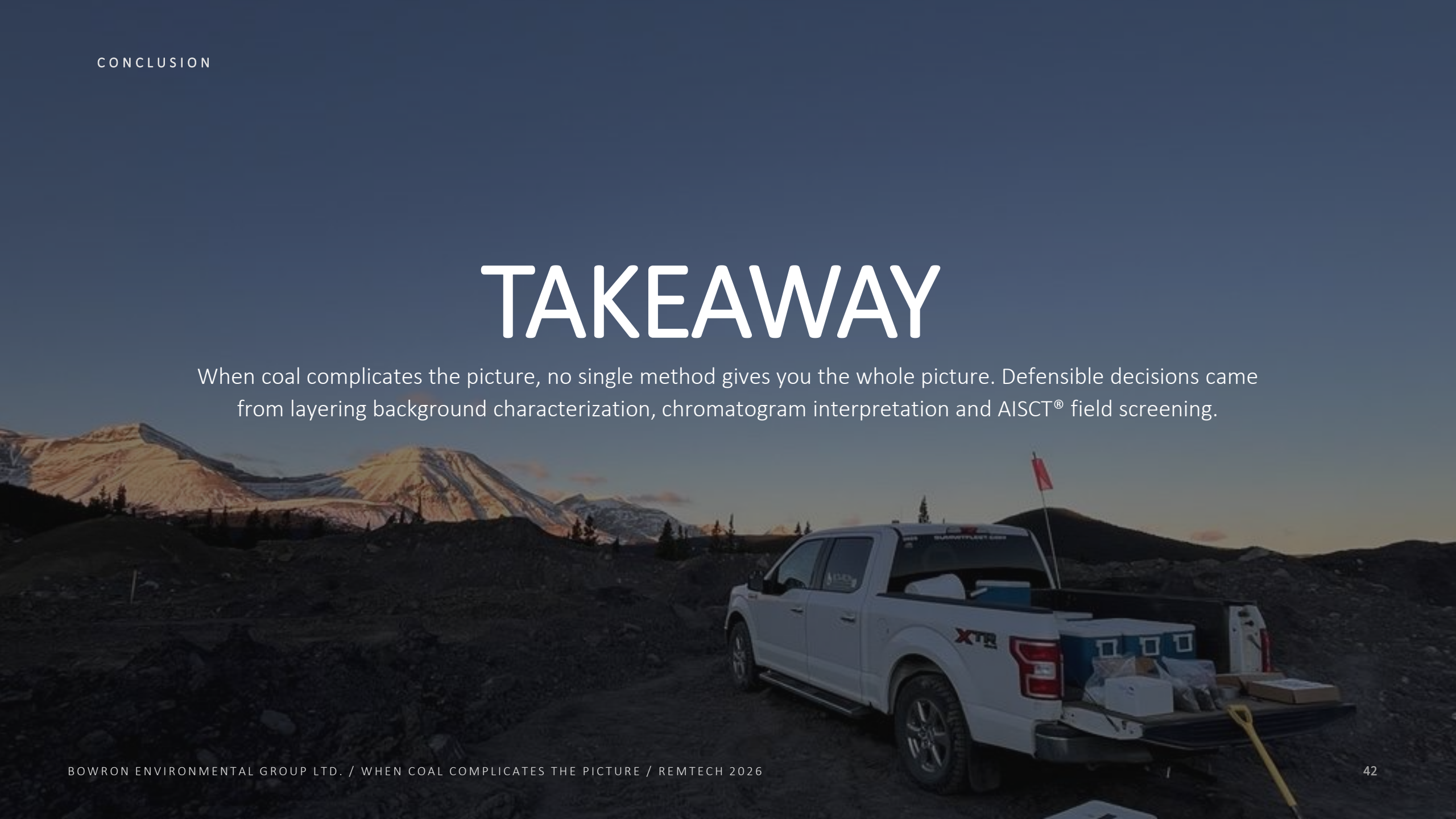
- A product curve + coal signal in the chromatogram. Differentiation between petrogenic (coal) and petrogenic (diesel).
- AISCT® biogenic warnings treated as provisional.
- Duplicate and triplicate samples and step-outs before calling a boundary.
- High F3 with low F2 still needs a line of evidence.

COAL ONLY
Natural background

- BTEX above AT1 criteria, but F1–F4 well below.
- Scattered light-end peaks and no product hump, high C50+.
- BTEX alone not used to call a location contaminated, review of chromatograms.

TAKEAWAY

When coal complicates the picture, no single method gives you the whole picture. Defensible decisions came from layering background characterization, chromatogram interpretation and AISCT® field screening.



BOWRON
environmental group

Questions?

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