ENVIRONMENT

Comprehensive Tools for Remediation Support - Can You Measure Progress?

Optimization and Monitoring for Remediation of Chlorinated and Related Compounds

Virtual Seminar Series - April 29th 2020

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AGENDA

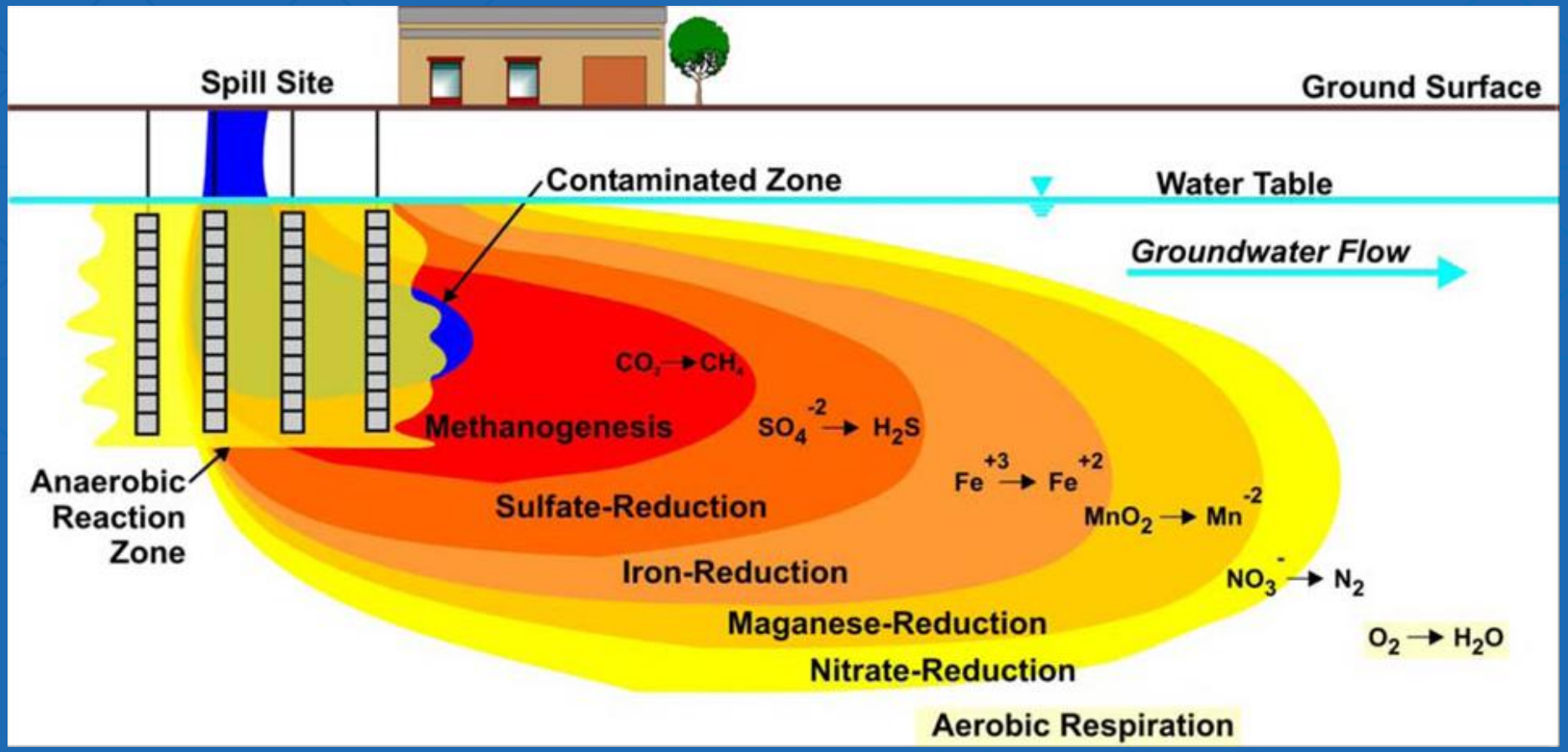
1. Introduction
2. Monitored Natural Attention Parameters
3. Compound Specific Isotope Analysis
4. Chlorinated Forensics
5. Conclusion

Basis of Breakdown

e^- donors + e^- acceptors ⟶ by products + energy

Tersus products	TCE, PCE, etc.	Dis. gas, Cl^-	H_2
Existing available carbon in GW			

Plume Evolution Model



Source: Parsons. 2004. Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents. AFCEE, NFEC, ESTCP 457 pp, August 2004

Common MNA Parameters

Parameter	Data use	Analyte trend	Values of Degrade.	Process
Dissolved Oxygen	Generally indicate anaerobic pathway	Decreases	<0.5 mg/L	Aerobic Respiration
Nitrate	Electron acceptor for microbial resp.	Decreases	<1 mg/L	Denitrification
Fe 2+	Indication of Fe3+ reduction during microbial degradation of organic compounds in the absence of dissolved oxygen, nitrate, and Mn(IV).	Increases	> 1 mg/L	Fe 3+ reduction
Sulfate	Electron acceptor for anaerobic respiration	Decreases	<20 mg/L	Sulfate Red.
Methane	The presence of methane suggests the geochem of the water is favorable for RD	Increases	>0.5 mg/L	Methanogenesis
Chloride	General water quality parameter used as a marker to verify that site samples are obtained from the same ground water system. Final product of chlorinated solvent reduction	Increases	>2 times background	Reductive Dechlorination or Direct Oxidation of Chlorinated Compound

Source: Adapted from Guidance on Developing a Monitored Natural Attenuation Remedial Proposal for Chlorinated Organics in Ground Water, North Carolina Hazardous Waste Section, October 4, 2000

MNA – Cont’d

What to do if a stall happens?

- Microbial Analysis
  - Qualification and Quantification
  - Ensuring you have the right bugs at the right site – dhc, dhb
- Electron Donor
  - Re-amendment

MNA – Dissolved gases

- Methane, ethene, ethane (MEE)
  - Methane – by product of the reactions that facilitate reductive dechlorination
  - Ethane/Ethene – end products of dechlorination
- Hydrogen – monitors degradation of specific redox processes
  - Concentration lends better understanding of stage
- Carbon dioxide – Petroleum hydrocarbons (aerobic)

Dissolved Gases – Reporting Limit Comparison

Analyte	RSK-175 Method	Pace Energy – AM 20 GAX
Methane	10 µg/L	0.5 µg/L
Ethane	10 µg/L	0.1 µg/L
Ethene	10 µg/L	0.1 µg/L
Acetylene	N/A	0.5 µg/L
Carbon Dioxide	N/A	5 mg/L
Carbon Monoxide	N/A	1 mg/L
Nitrogen	N/A	2 mg/L
Oxygen	N/A	0.5 mg/L
Propane	N/A	0.1 µg/L
Propene	N/A	0.1 µg/L
Iso-Butane	N/A	0.2 µg/L
N-Butane	N/A	0.2 µg/L

MNA – Volatile Fatty Acids (VFAs)

Volatile Fatty Acids (VFAs) are created when and injected substrates are broken down by microbial community via fermentation

e.g., CH_2Cl_2 + dehalobacter $\longrightarrow$ acetate + H = acetic acid

e.g., CH_2Cl_2 + dehalobacter $\longrightarrow$ formate + H = formic acid

MNA – Cont'd

Analyte	LL VFA – AM23 G
Acetic	0.2 mg/L
Propionic	0.1 mg/L
Butyric	0.1 mg/L
Pyruvic	0.1 mg/L
Lactic	0.1 mg/L
Iso-Pentanoic	0.1 mg/L
Pentanoic	0.1 mg/L
iso-Hexanoic	0.2 mg/L
Hexanoic	0.2 mg/L
Formic	0.1 mg/L

MNA – Cont’d

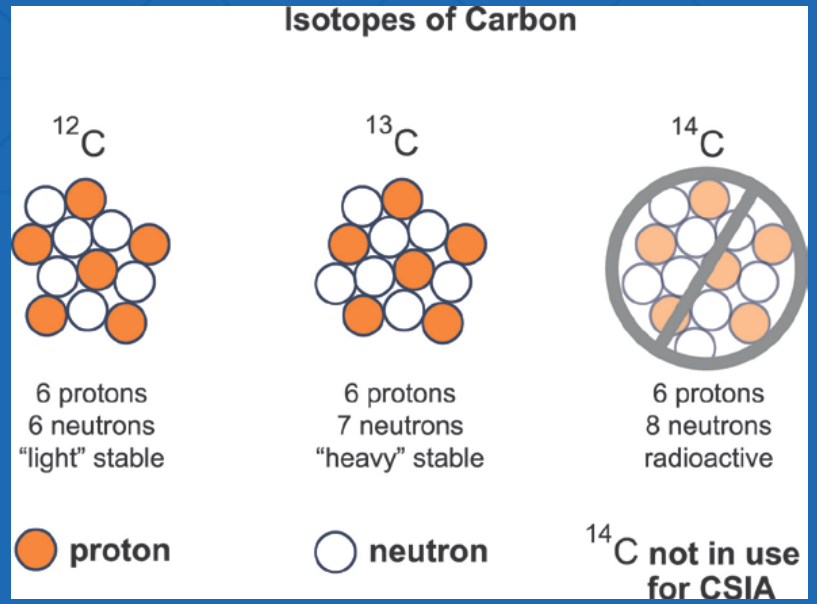
Pace Energy provides the lowest detection limits for MEE and VFAs in the industry

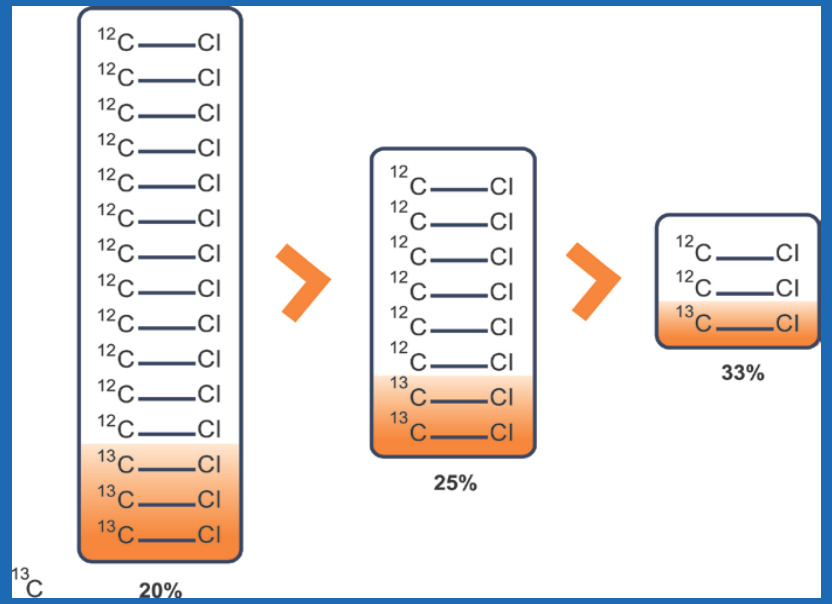
What does this mean?

- Edge of plume amendment detection
- Is degradation still occurring?
- Is plume properly constrained
- Monitoring of hardest 5-10%

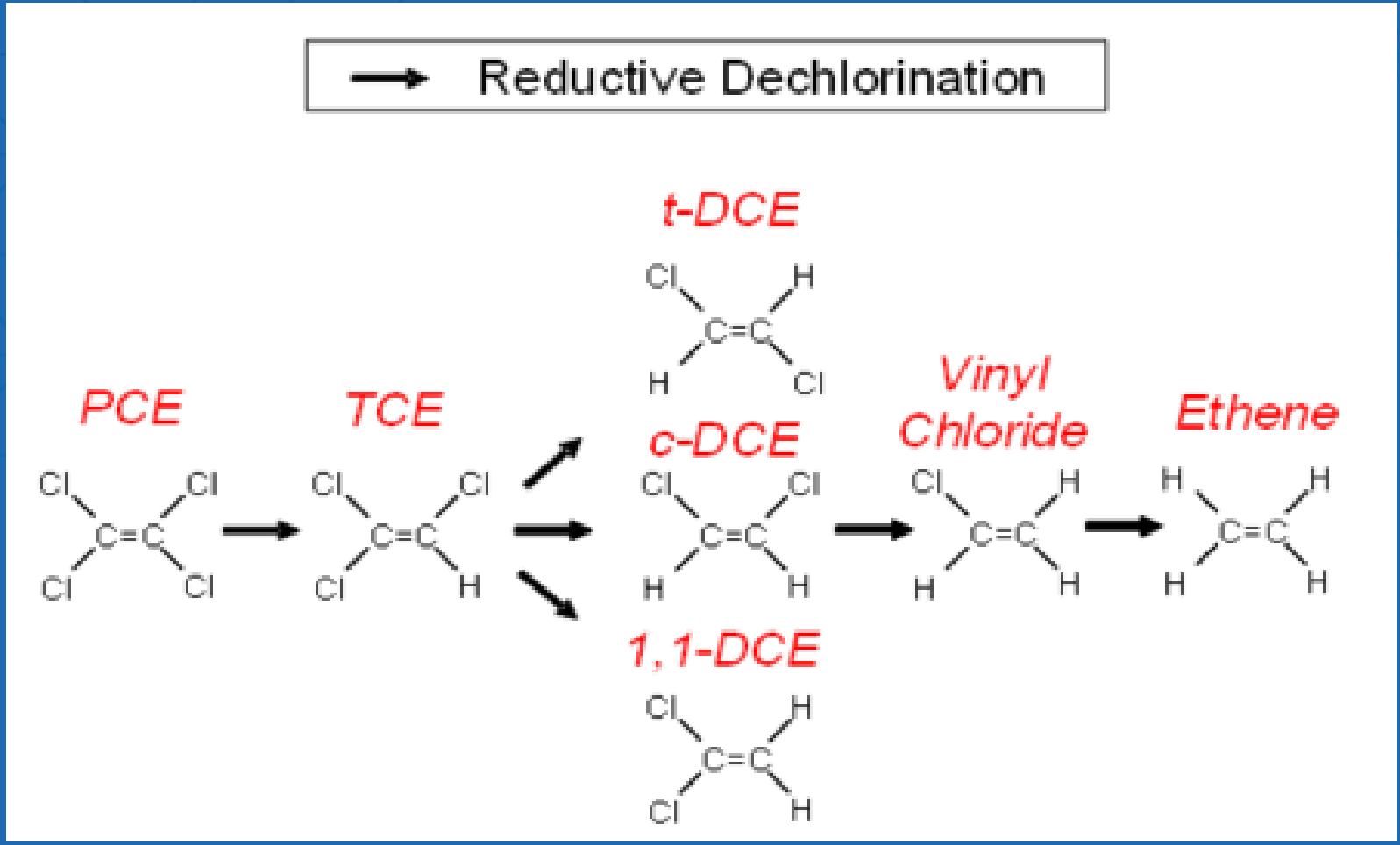
Compound Specific Isotope Analysis (CSIA)

Using isotopic ratios of certain elements within distinct compounds provides information that analytical concentrations cannot
Ratios reflect relationship of heavier isotopes to lighter isotopes





CSIA – Degradation Pathway



CSIA – cont'd

For remediation efforts:
Use of carbon isotopes to prove degradation
Rate of degradation via
    Microbial degradation
    Recognizes impact of electron donor
Can be used to understand multiple sources, which could impact perceived MNA success

CSIA – cont'd

Additionally, CSIA can add clarification of contaminant rebound – i.e., desorbed mass

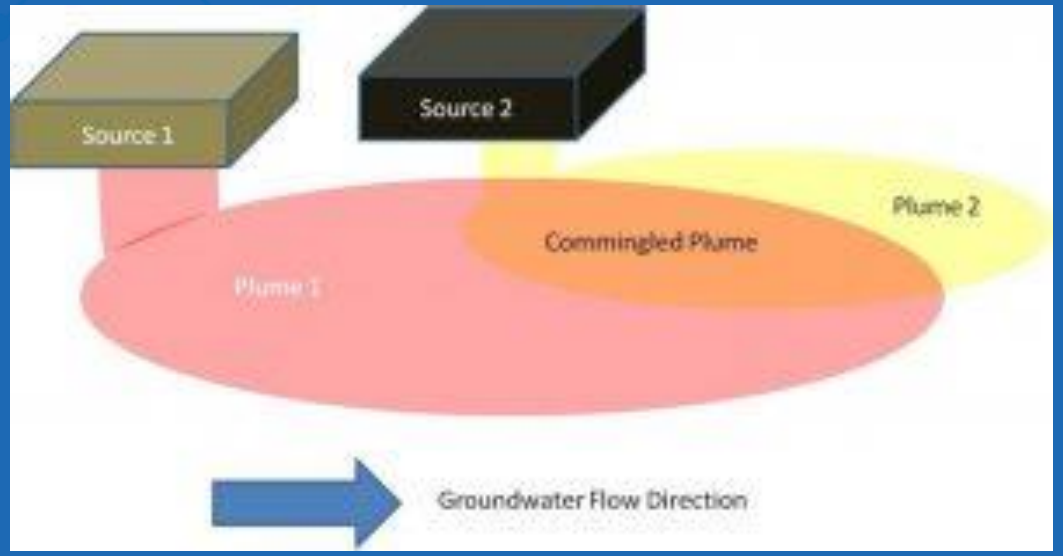
Ideal implementation for 1-D CSIA is center plume analysis tying near source samples with edge of plume samples

Additionally, CSIA can supplement data detailing plume evolution – earlier slide

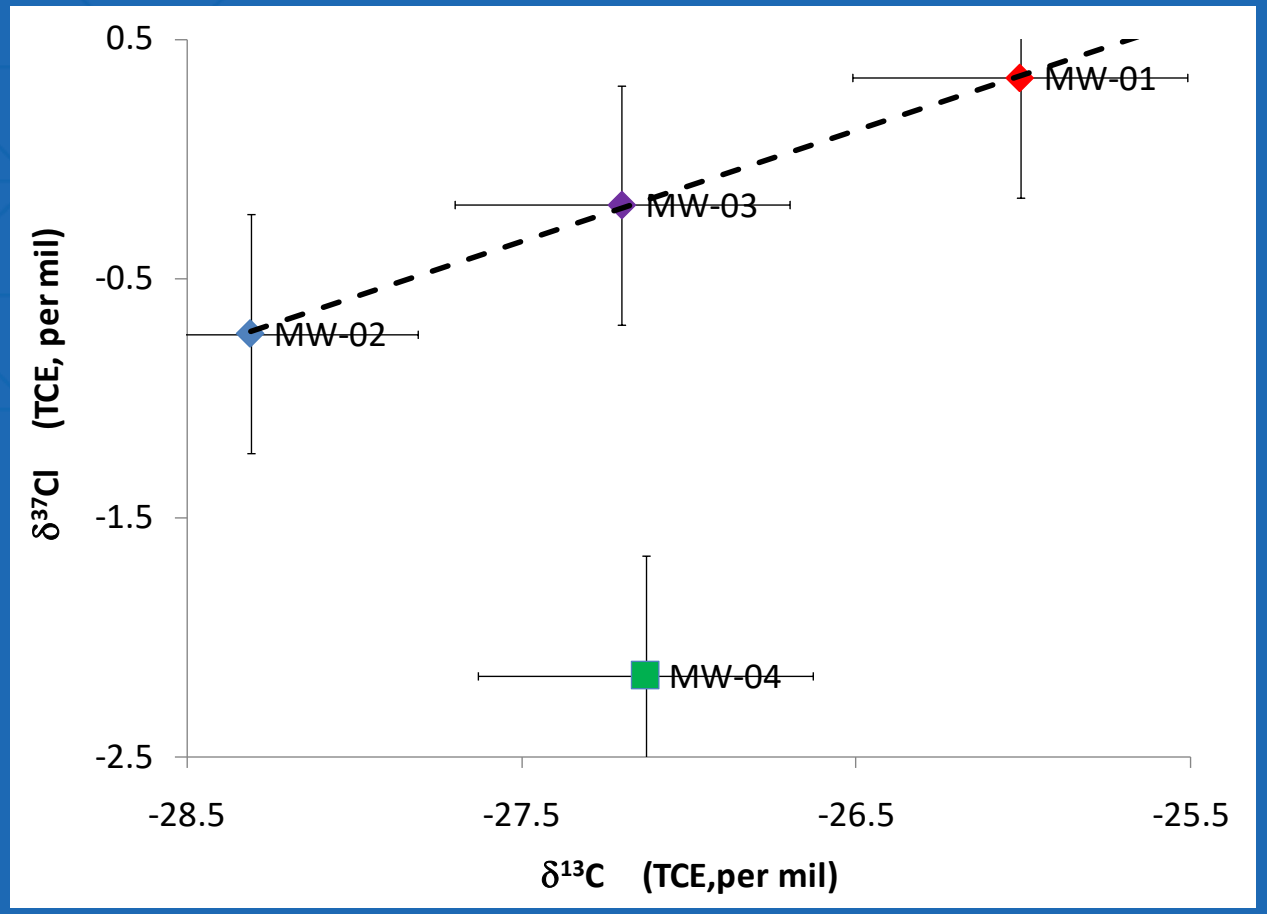
CSIA Forensics

By adding additional isotopes to the analysis, isotopic signatures (fingerprints) can be determined

Adding the forensic aspect provides support in identification of multiple sources, off site contribution (co-mingled plumes)



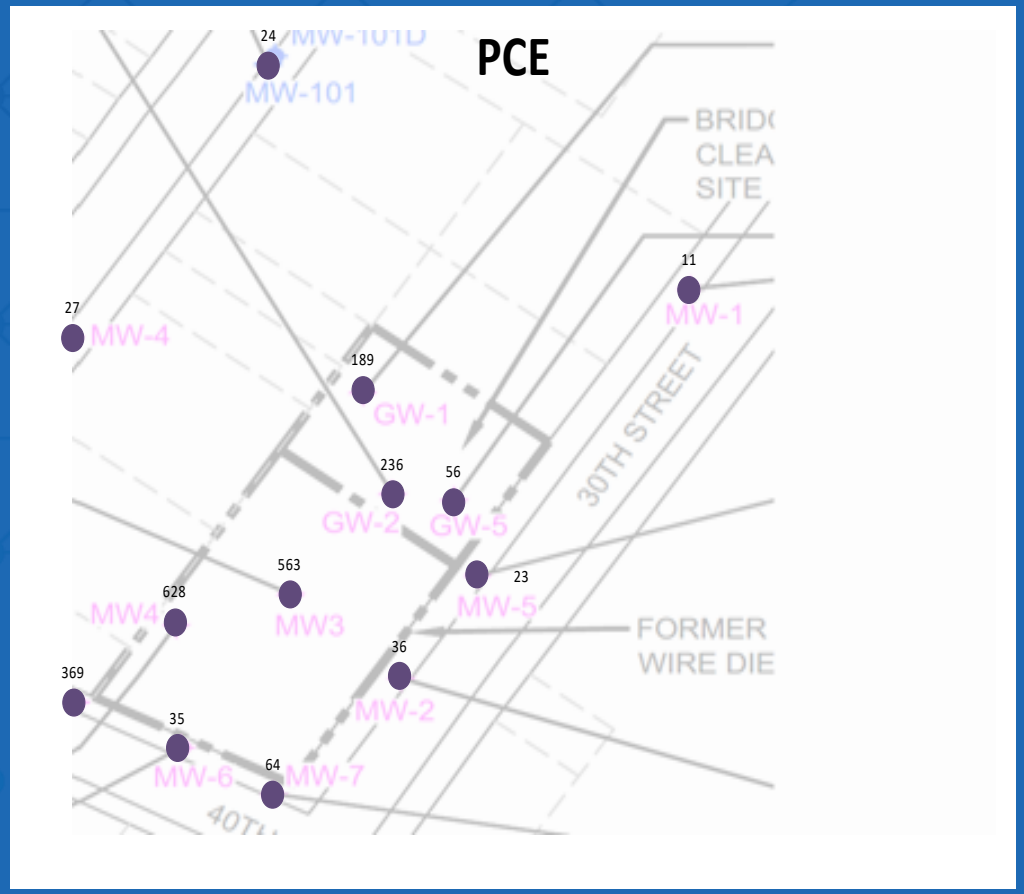
CSIA Forensics – Base Information

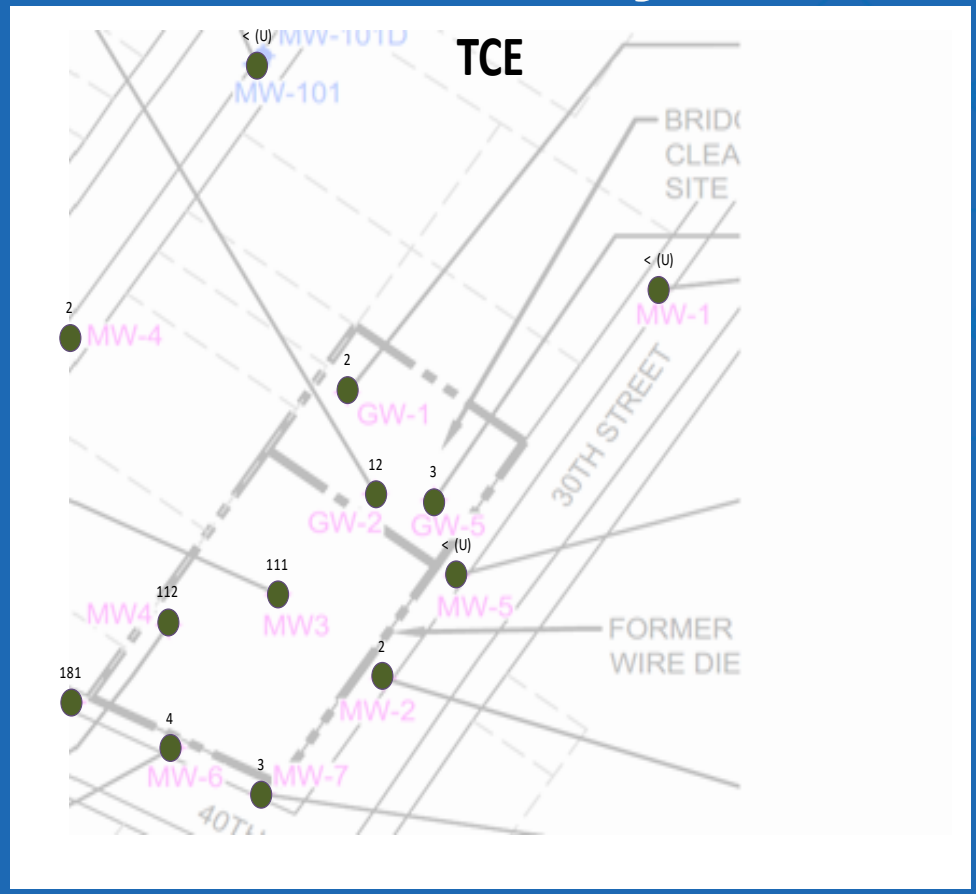


CSIA Forensics – Case Study

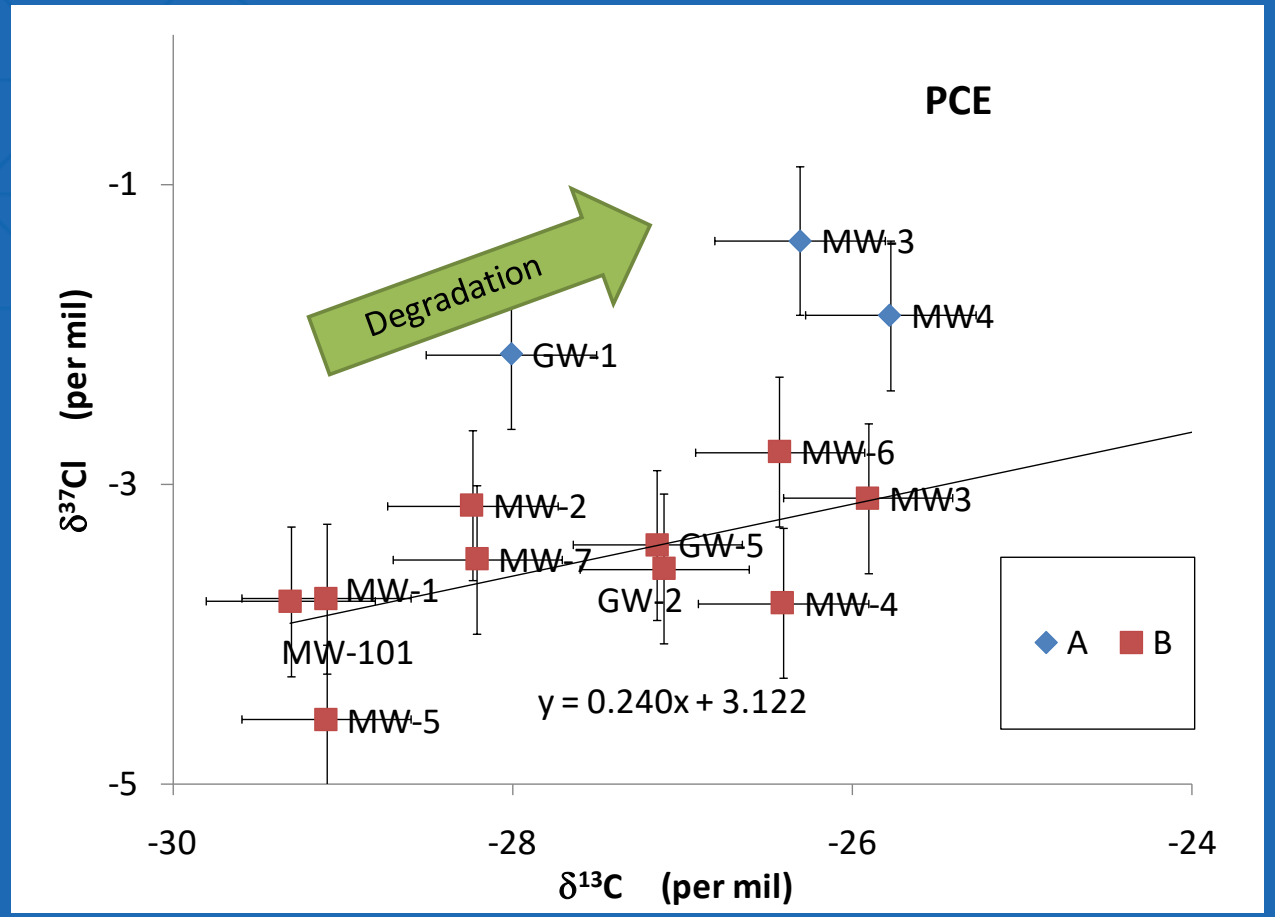
- Site near New York City
  - Industrial area
  - PCE and TCE issues
- Associated vapor intrusion issue
- Groundwater flow complex both vertically and horizontally
- Inconsistent concentrations lead to CSIA being evaluated
- Questions to be answered

CSIA Forensics – Case Study





CSIA Forensics – Case Study



CSIA Forensics – Case Study

Conclusions – cont'd:

Physical location of the two PCE sources suggested the client was not the responsible party.

Cost of analysis and interpretive reporting was around $26,000.

The cost of the remediation was shared saving the client upwards of six figures.

Conclusions

Monitoring Natural Attenuation at remediation sites is key to move towards the ultimate goal of closure and ensuring efforts are streamlined

Low level analysis provides a more distinct picture than standard analysis with high reporting limits

CSIA can facilitate information for CSM data gaps and streamline remediation efficiency

Use of forensic analysis can contribute to understanding “outside” influences

Pace will deliver unmatched value and customer service. We will develop our talents and innovative culture to become the clear choice for our customers, employees and business partners.

THANK YOU

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