Building a Robust LCSM for Remediation Decision-Making: Next-Generation Tools

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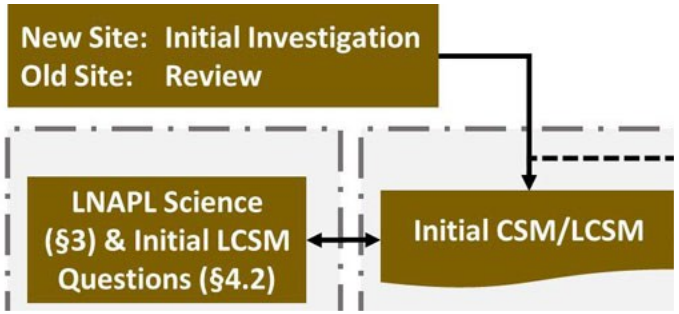
Co-Authors and Acknowledgements

- Elizabeth Haack and Langping Wu (Ecometrix)
- Jonathan Smith, Giulio Scarzella, and Craig Harris (AECOM)
- Tolulope Mafa-Attoye, Dasiel Obregon Alvarez, Kari Dunfield (University of Guelph)

Evolution of the LCSM



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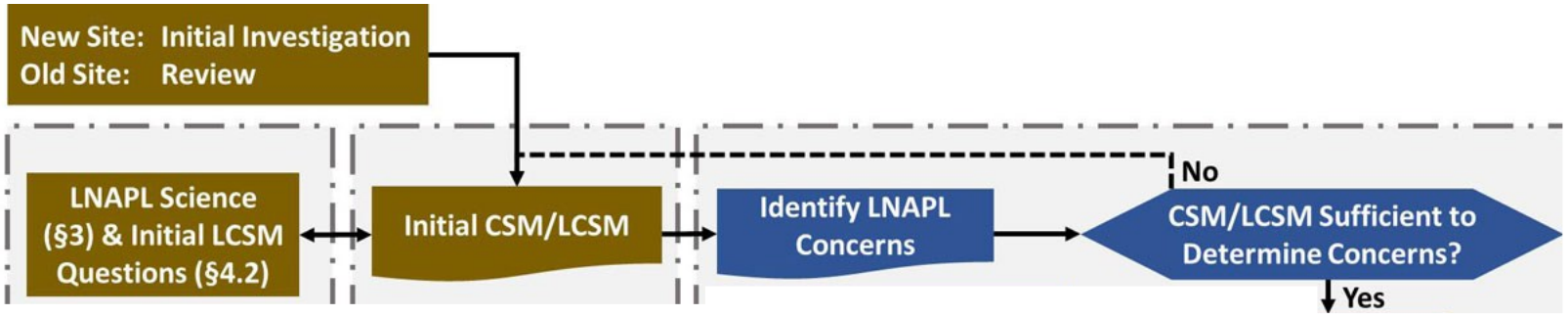

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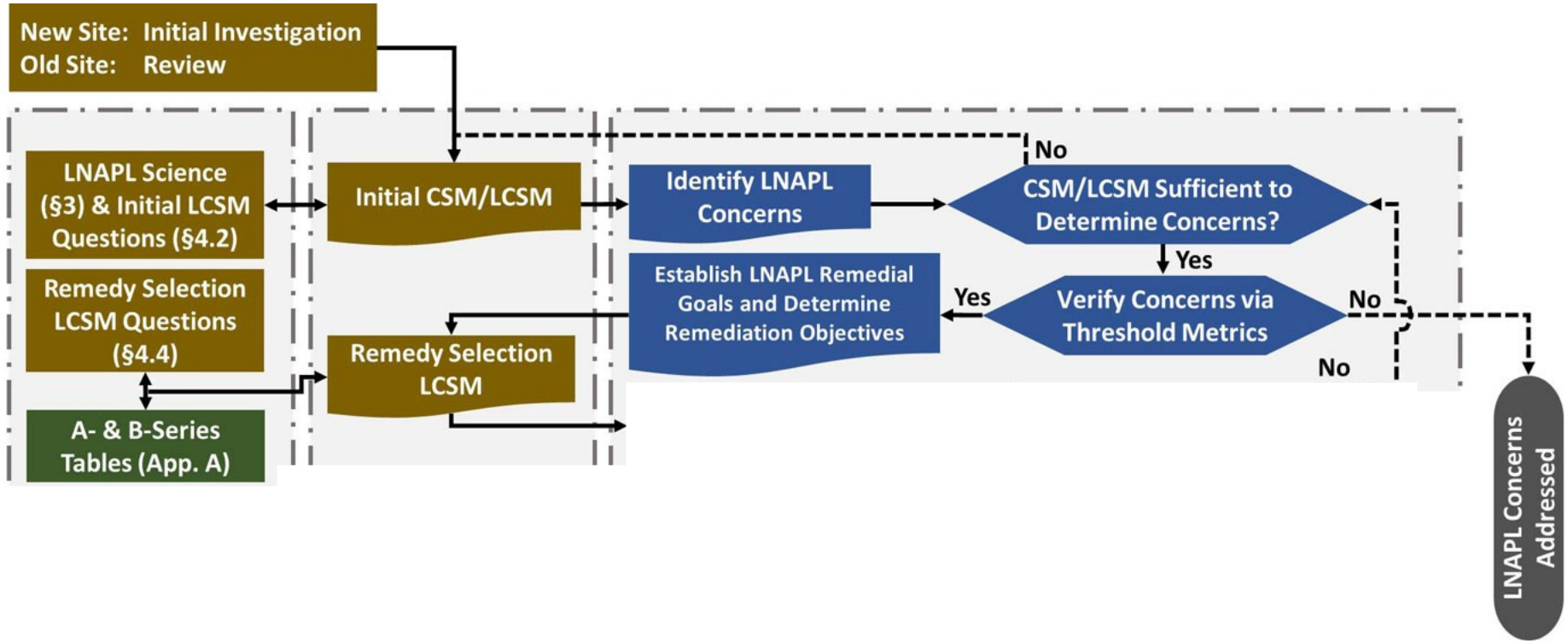

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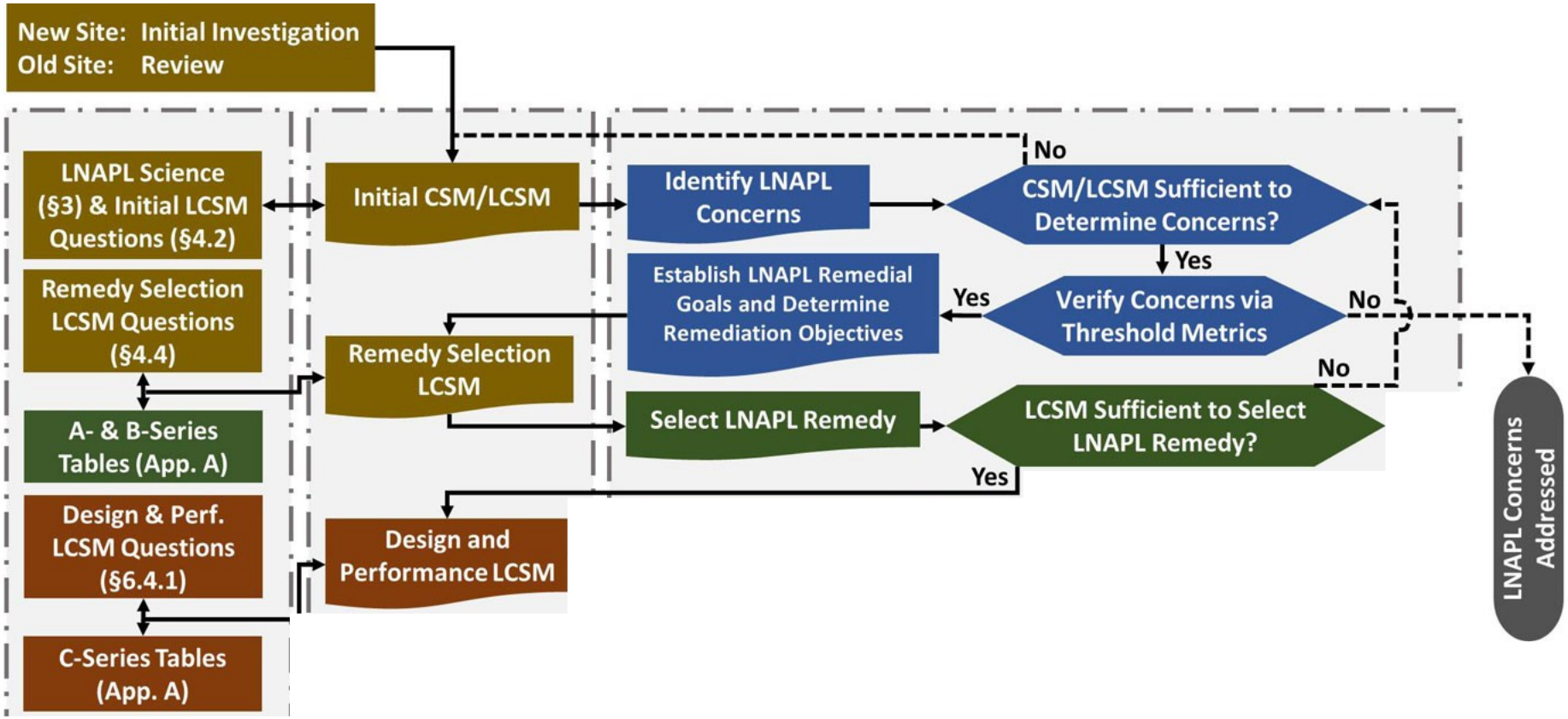

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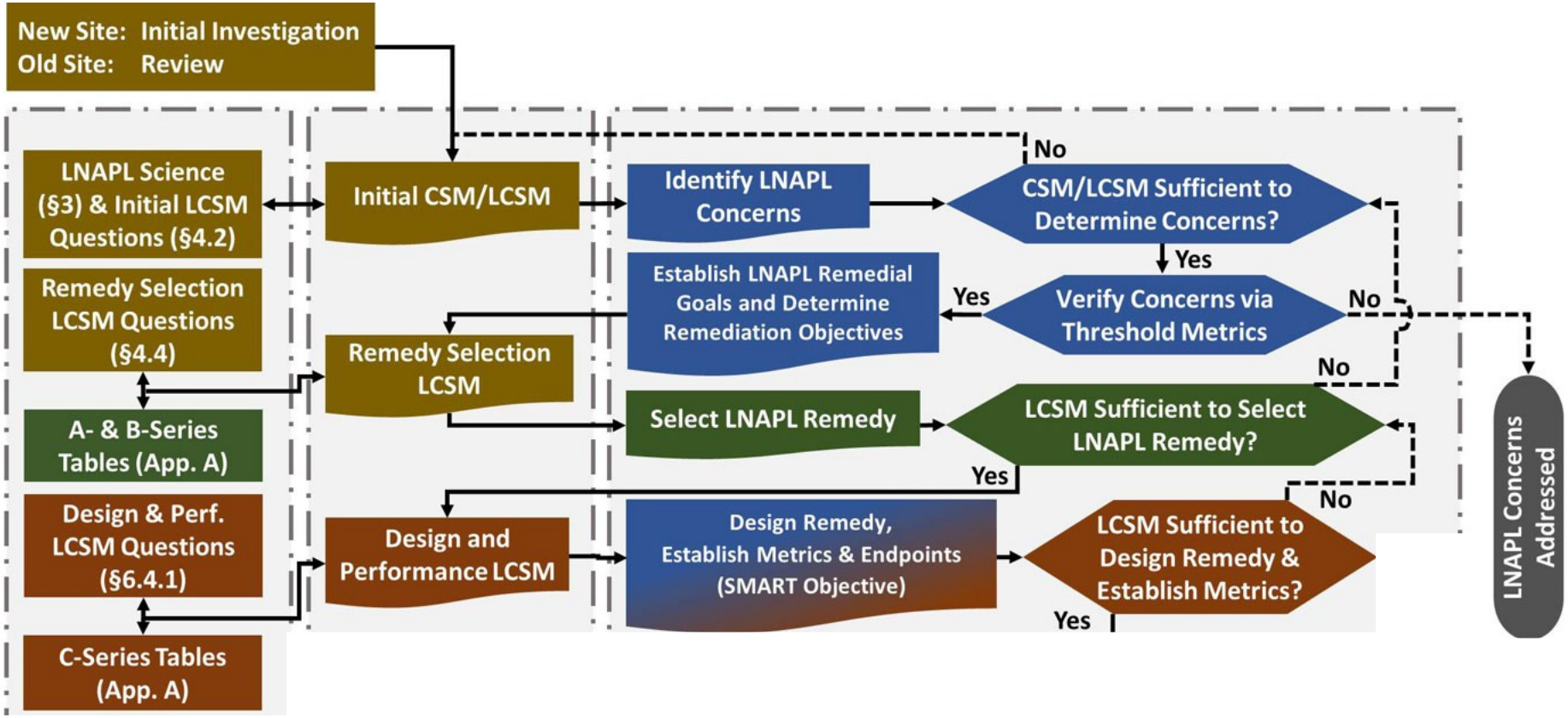

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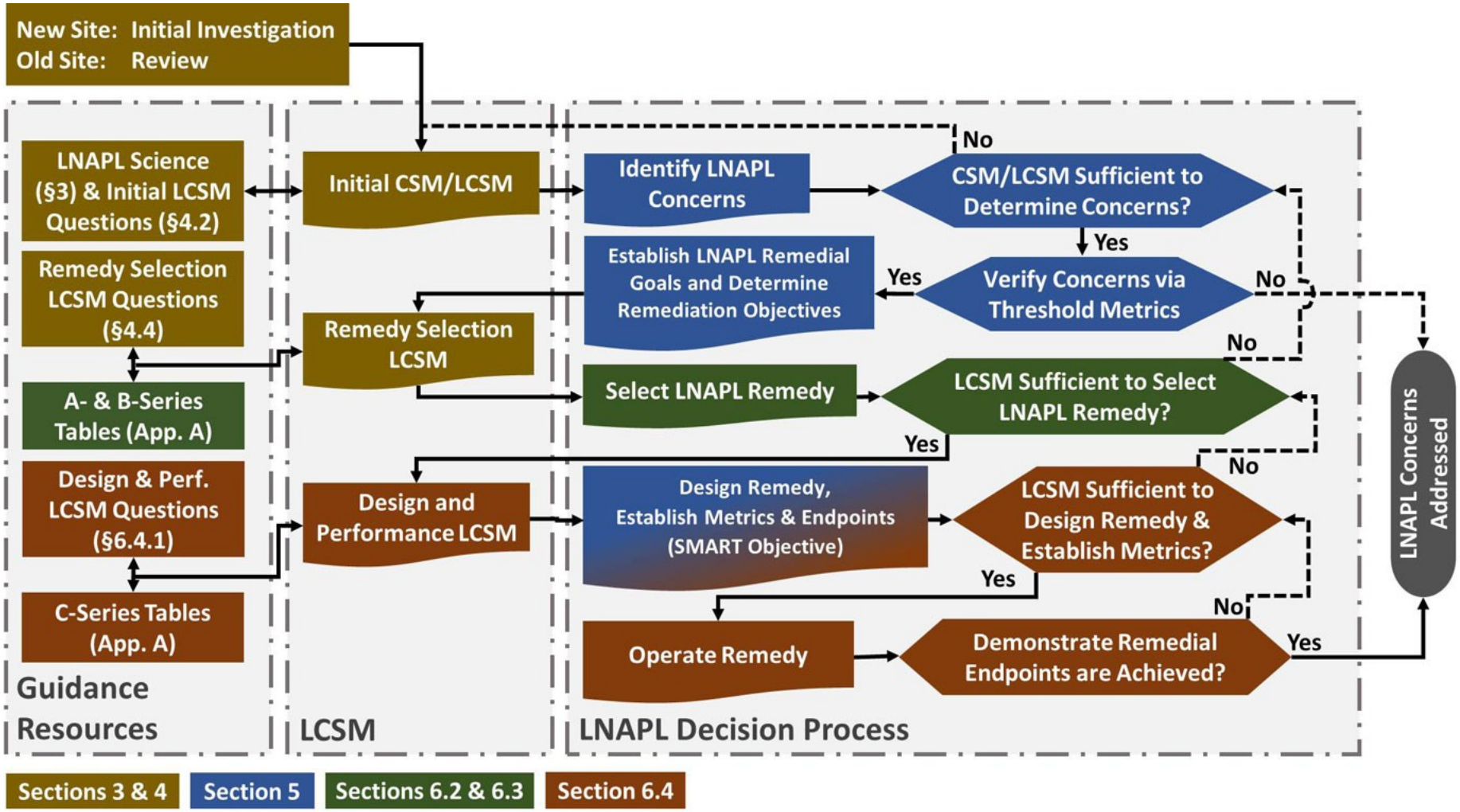

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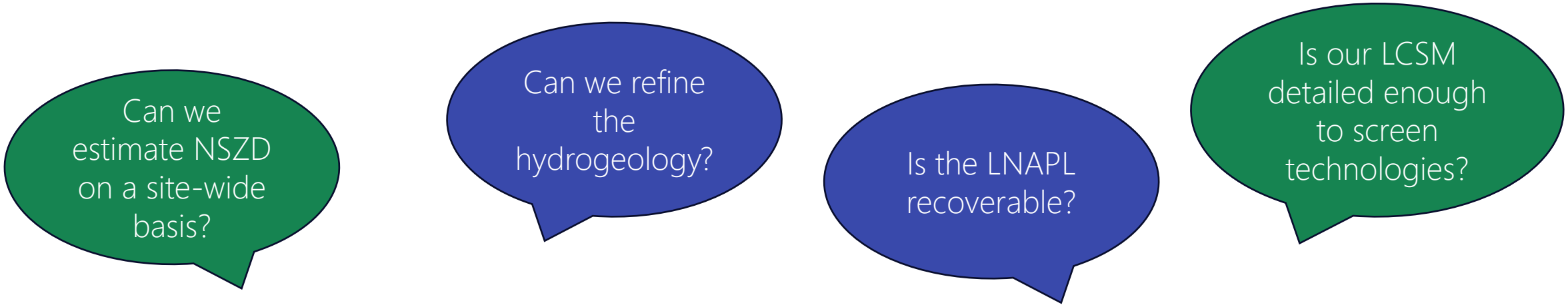
Example of Refining an LCSM

Site Characteristics

- Upper bedrock is Paskapoo Formation
- Aged, complex, and discontinuous LNAPL body
  - Small number of wells where LNAPL is present
- The site has an initial LCSM
- Site managers want to refine the LCSM to support remedy selection

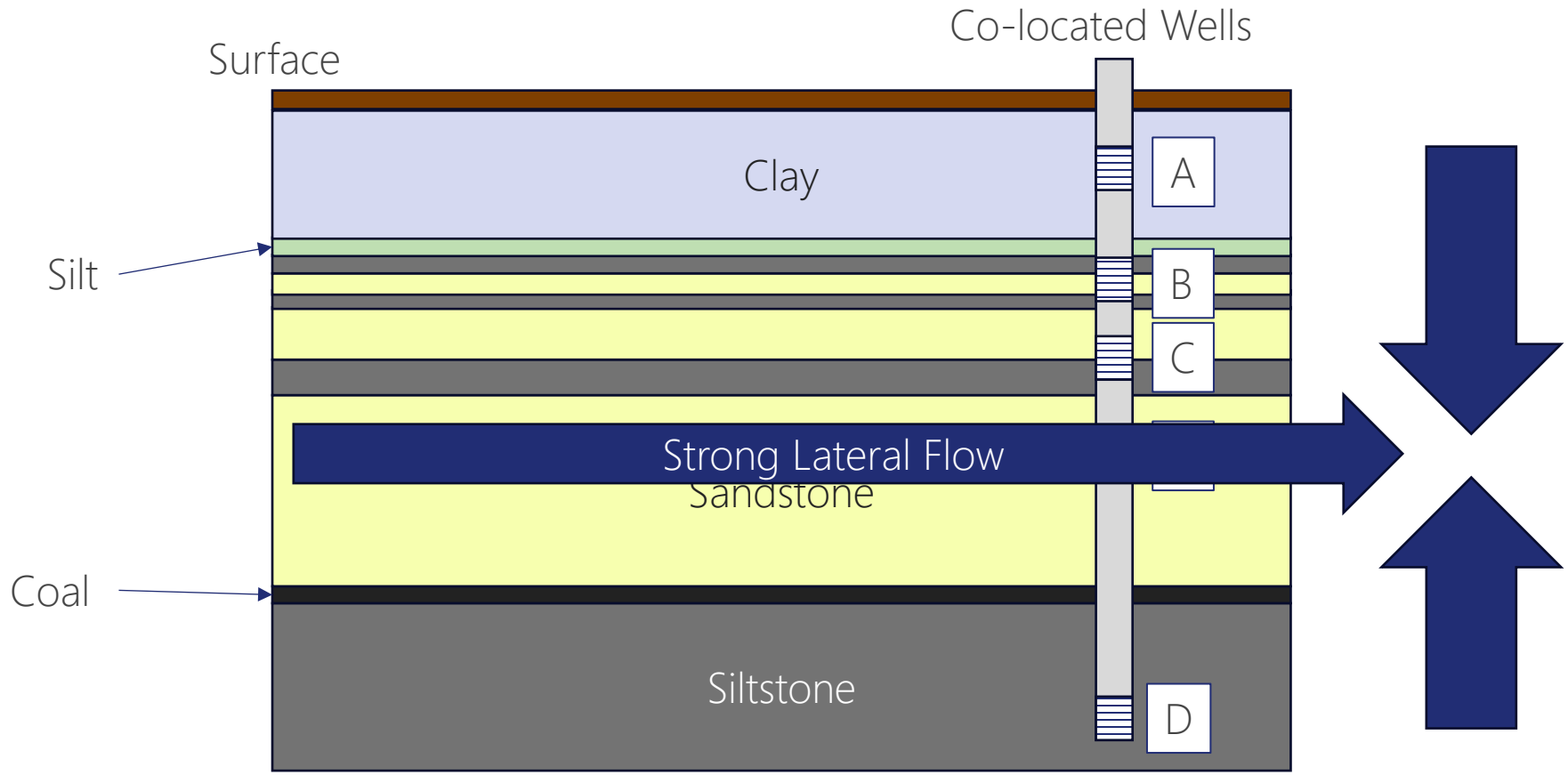


Site-specific LCSM Refinement Objectives

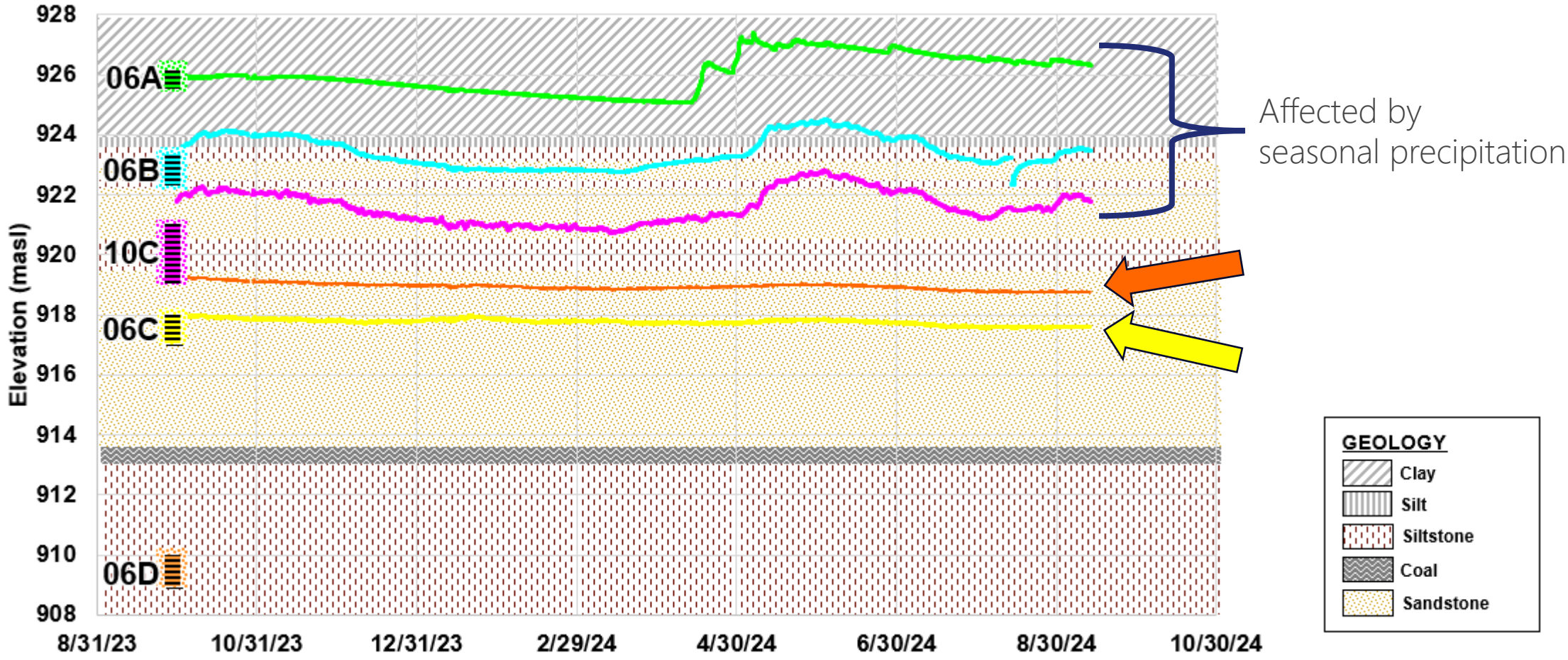
- Develop a process-driven understanding of LNAPL distribution
- Characterize weathering patterns
- Enhance prediction of behavior and future weathering using microbial metrics

Refinement 1:
Process-based LNAPL Distribution

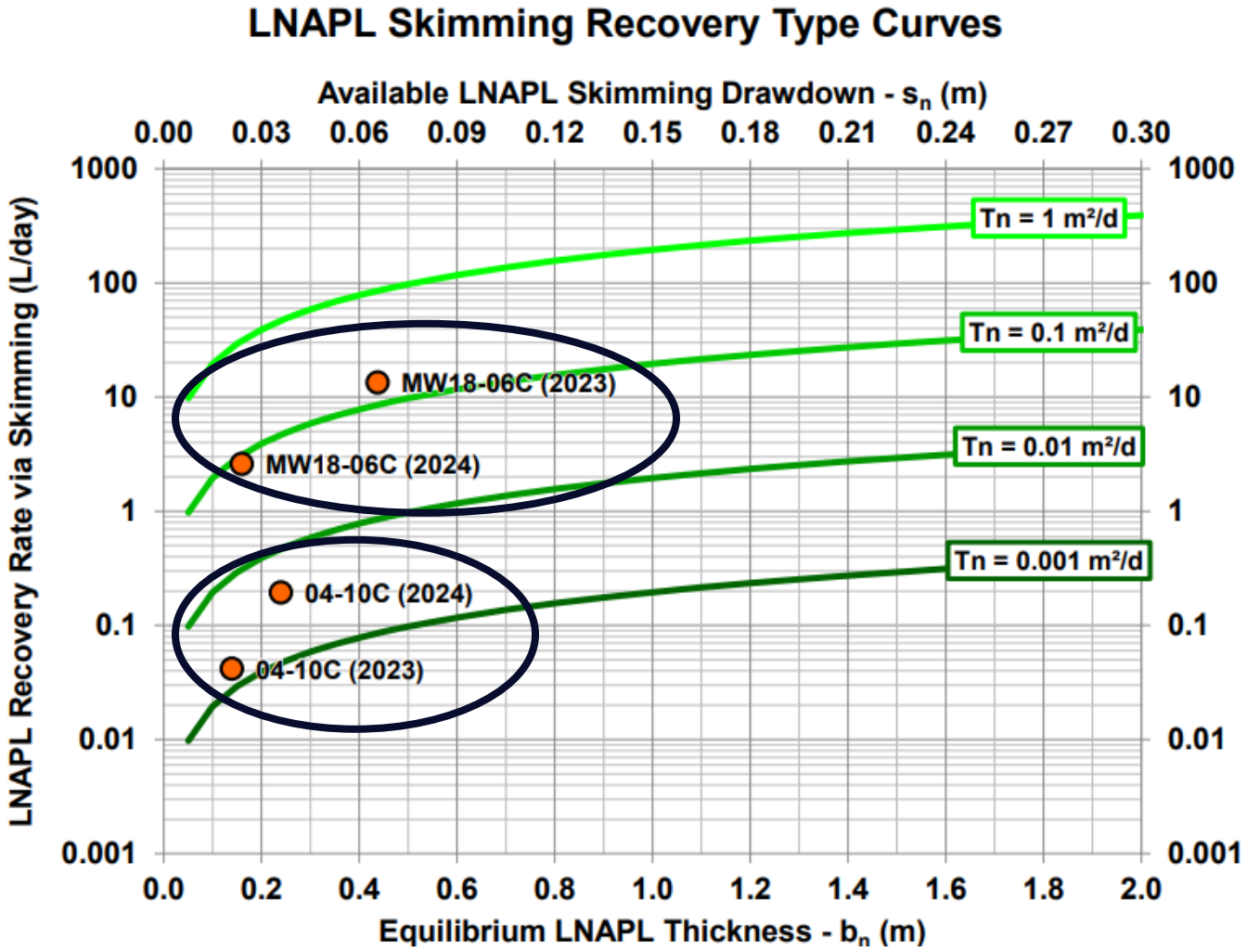
Refining the Hydrogeology



Long-term Water Levels



Transmissivity Testing

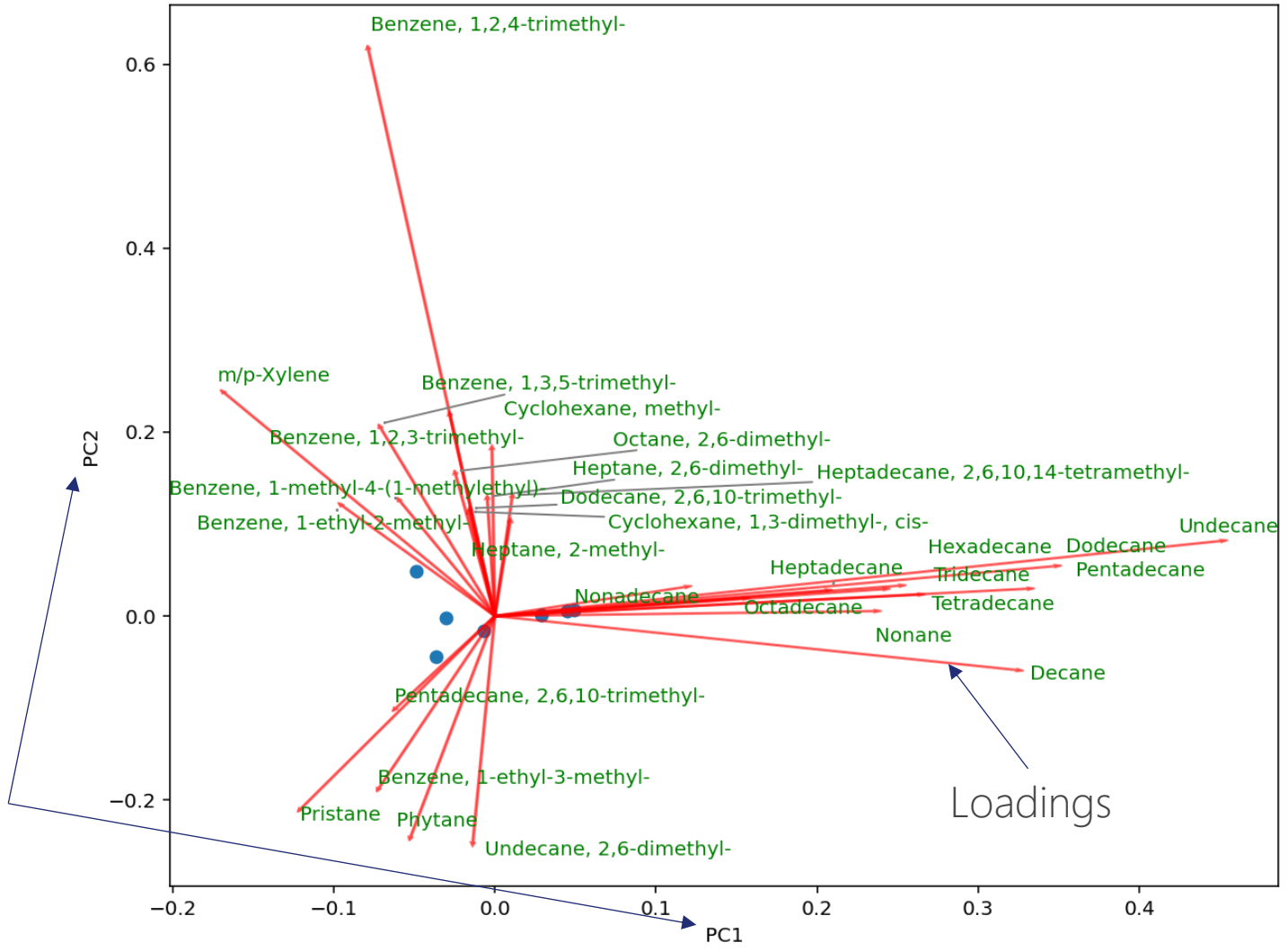


Refinement 2:
Characterize Weathering Patterns

LNAPL Sample Compositional Analysis

- AECOM collected LNAPL samples
- We analyzed them with high-resolution GCMS
- Interpreted compositional differences using Principal Component Analysis (PCA)
- PCA is a statistical technique that simplifies complex datasets

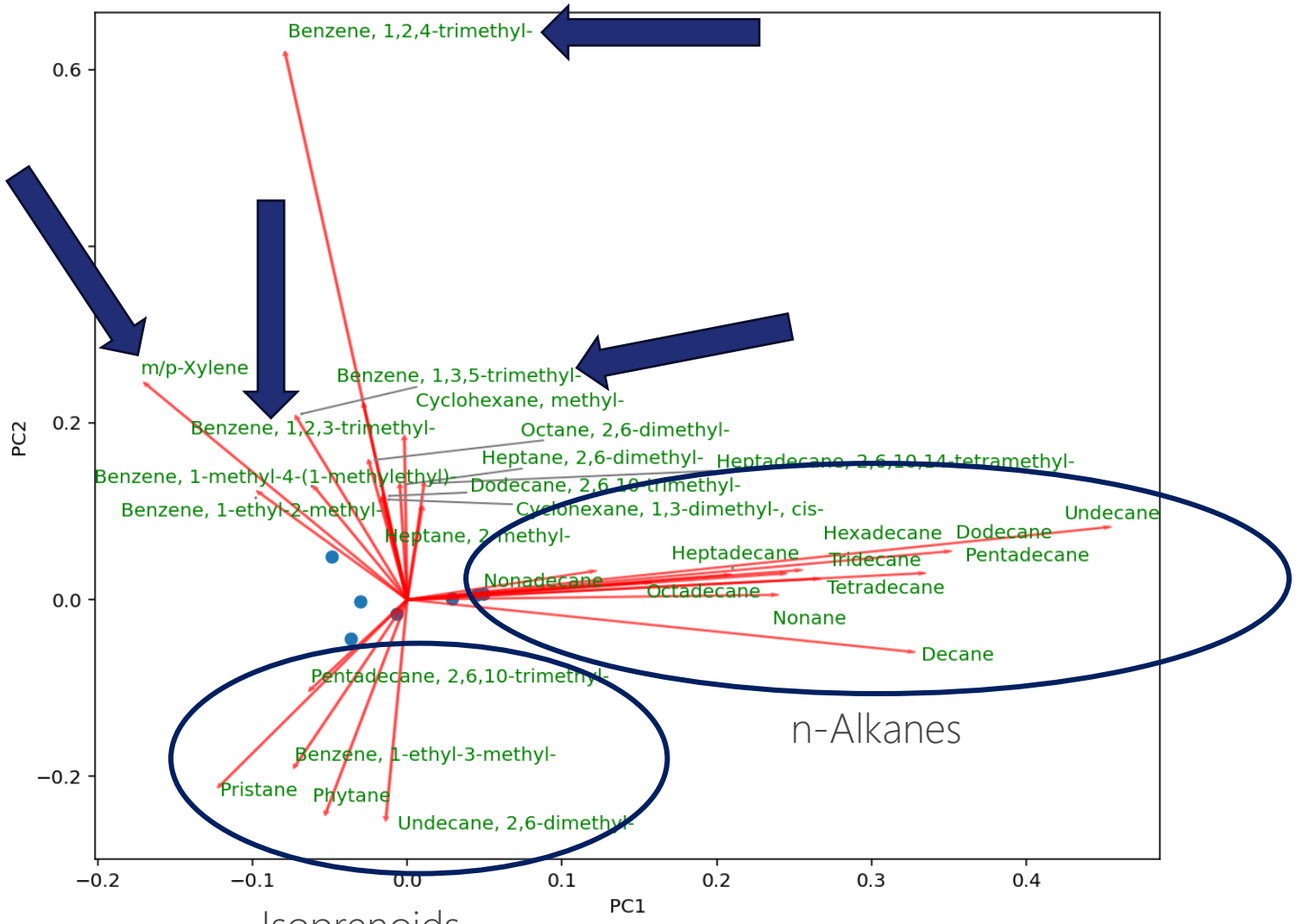
Biplot Visualization



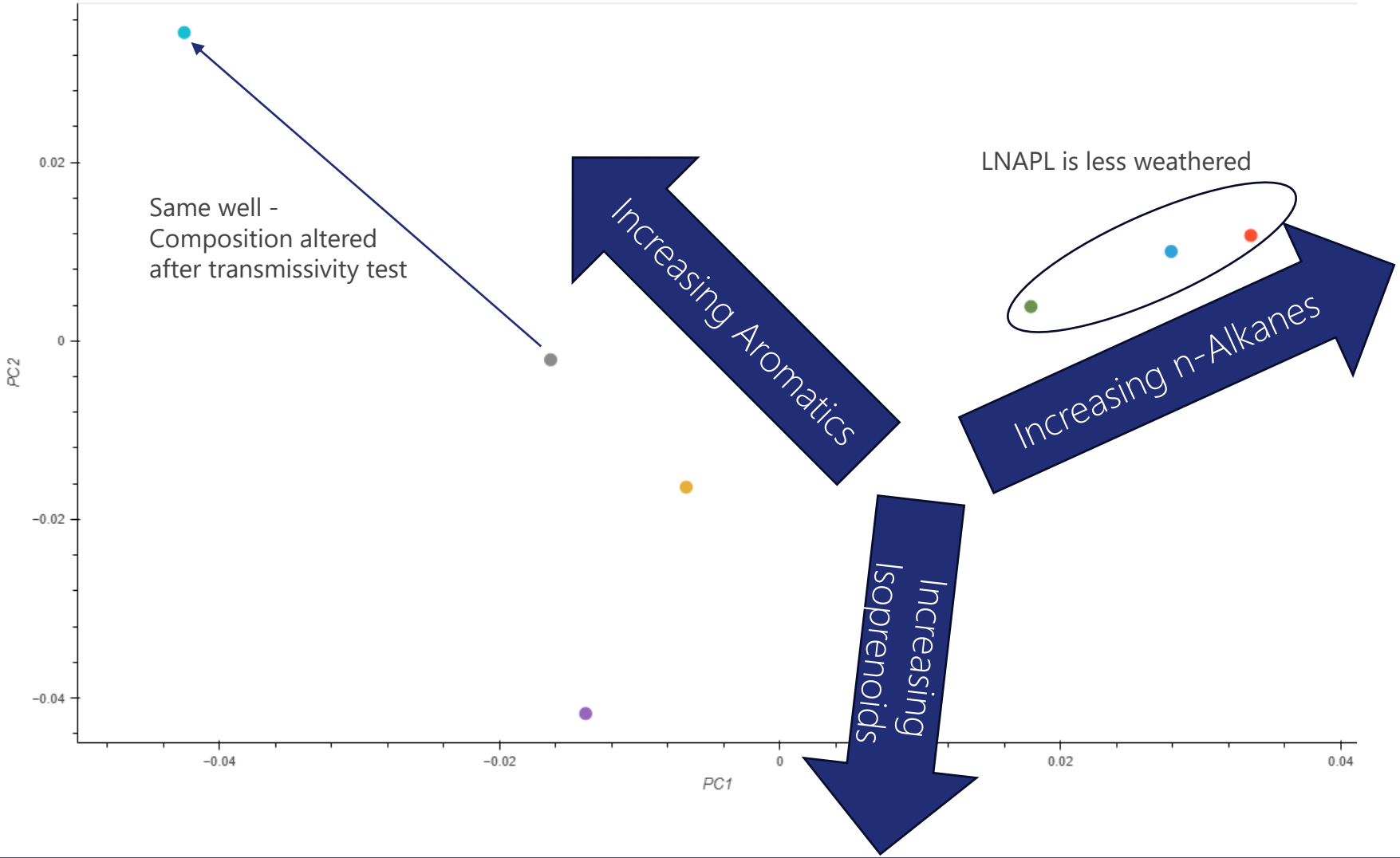
Principal Components

Loadings

Compositional Analysis

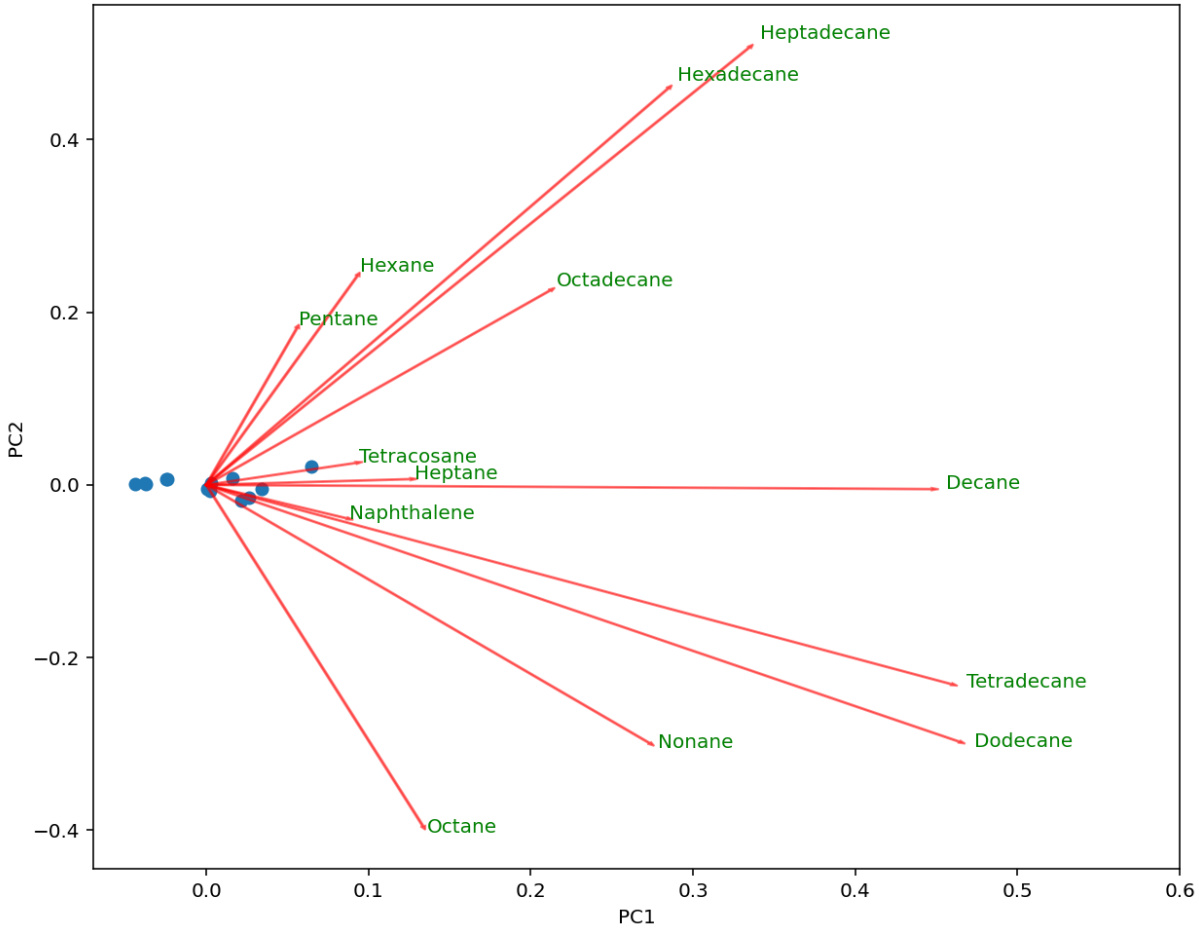


LNAPL Compositional Differences

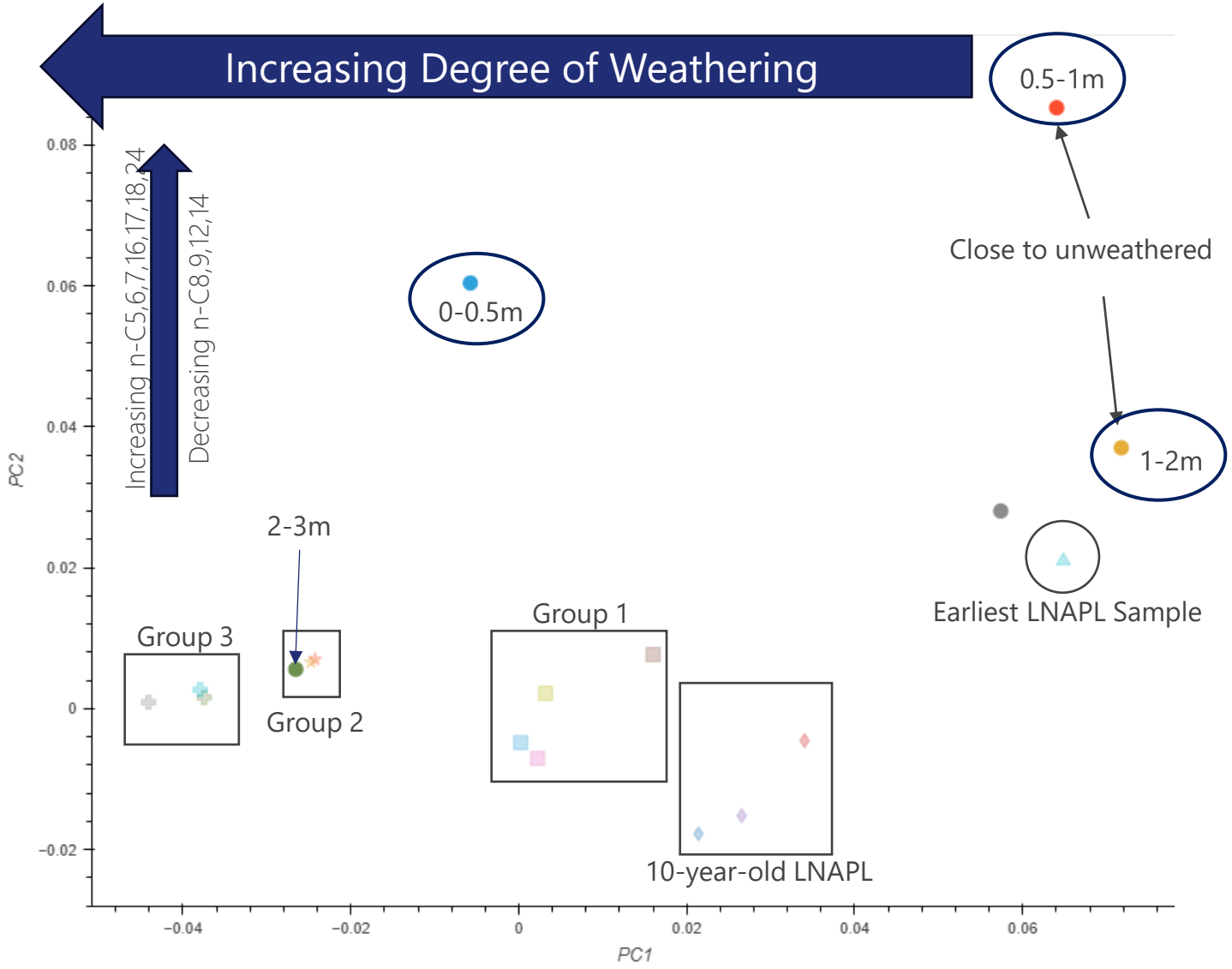


Incorporating Historical Data

- Historical data was available
- But, only for the n-Alkanes
- That's OK!
- Trained a model on that subset
  - Limited to the phase of weathering with n-alkane depletion

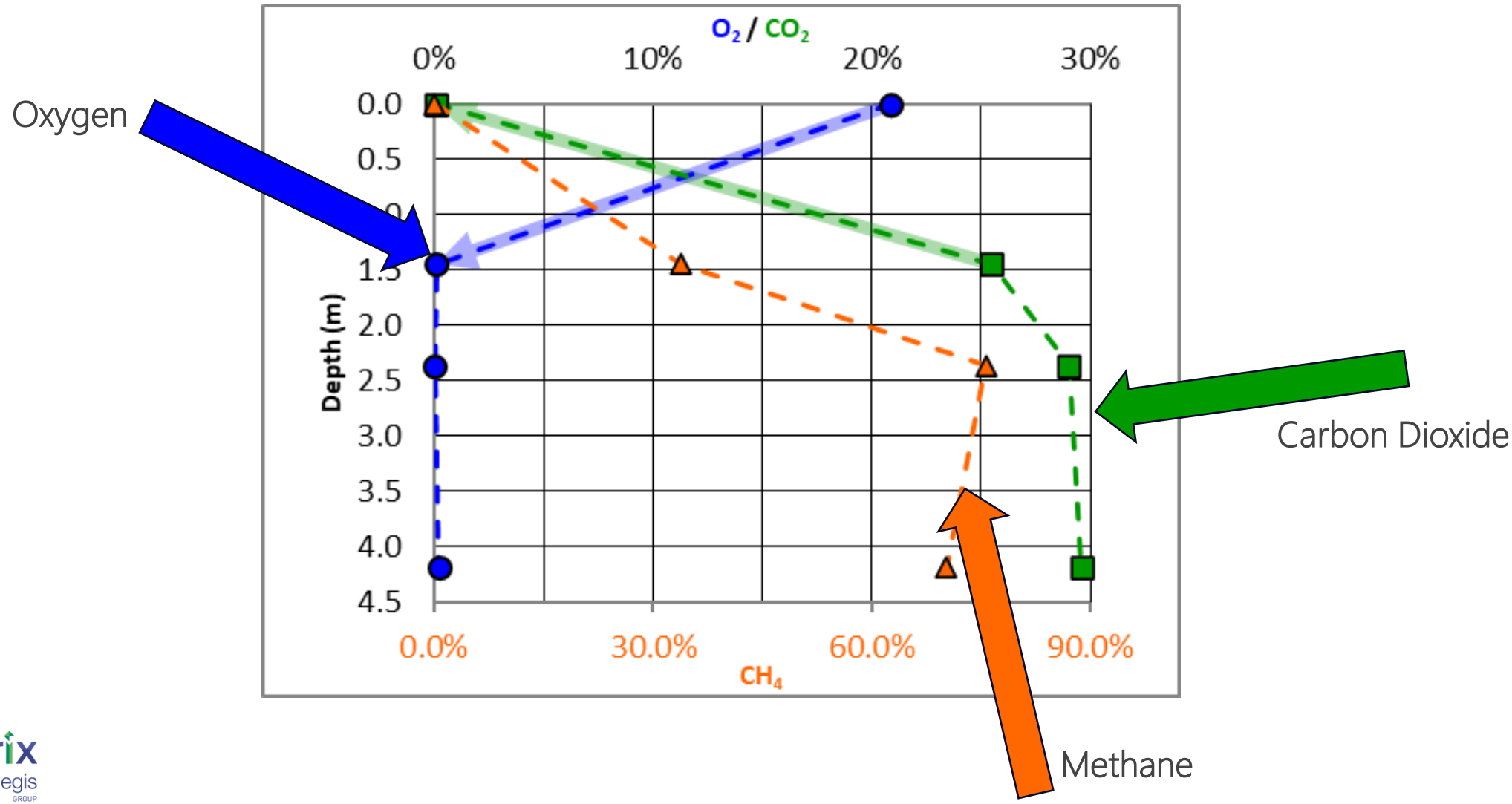


Grouping Soil Samples

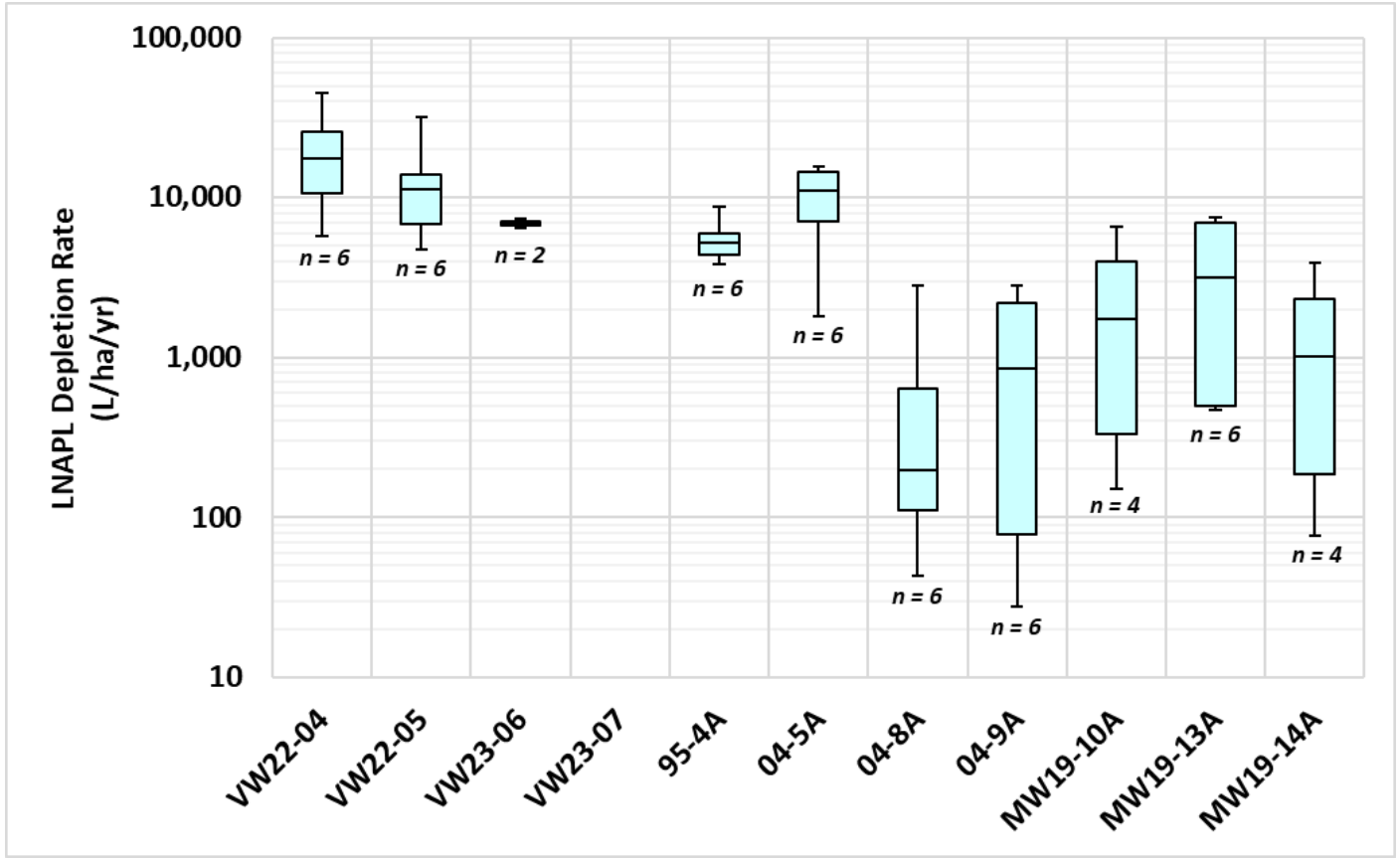


Refinement 3: Enhance Prediction of LNAPL Behavior and Future Weathering using Microbial Metrics

Soil Gas Gradient Measurements



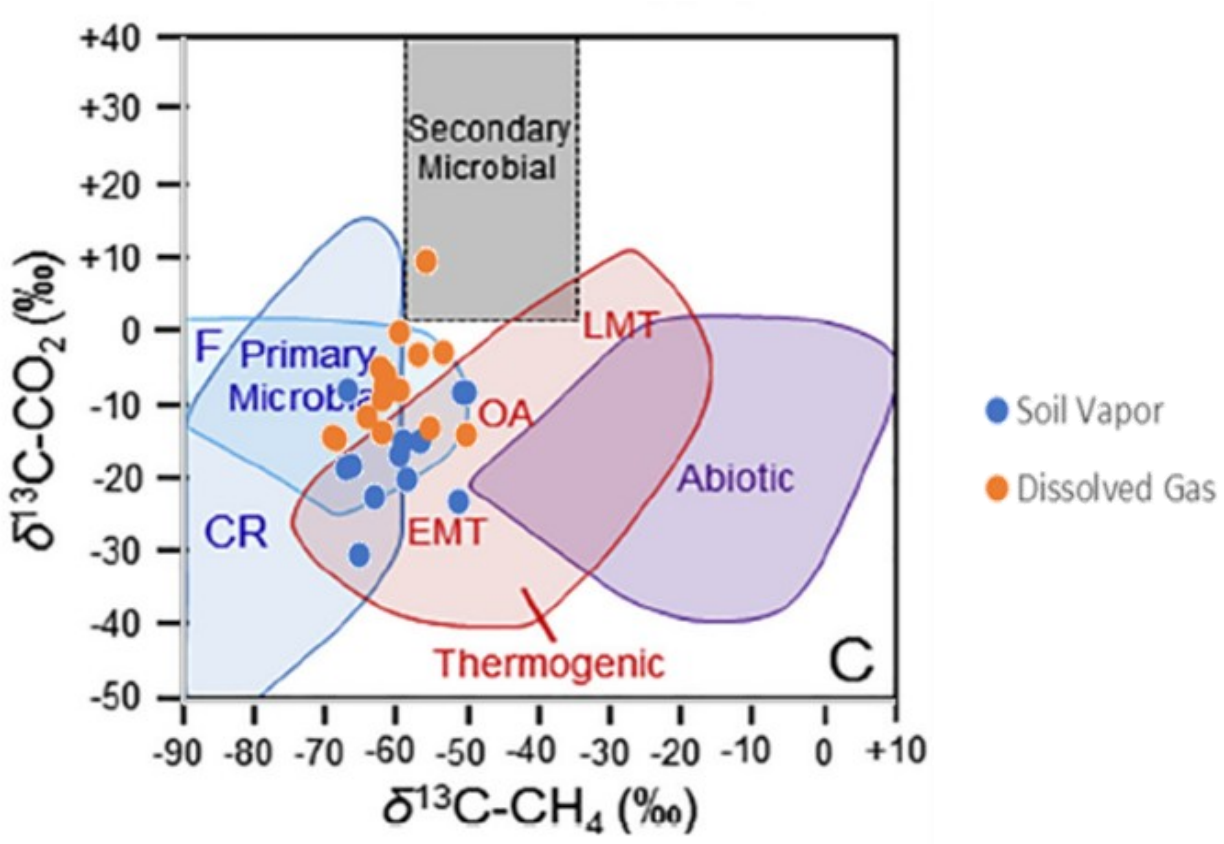
NSZD Rates



Calculated assuming decane as the contaminant

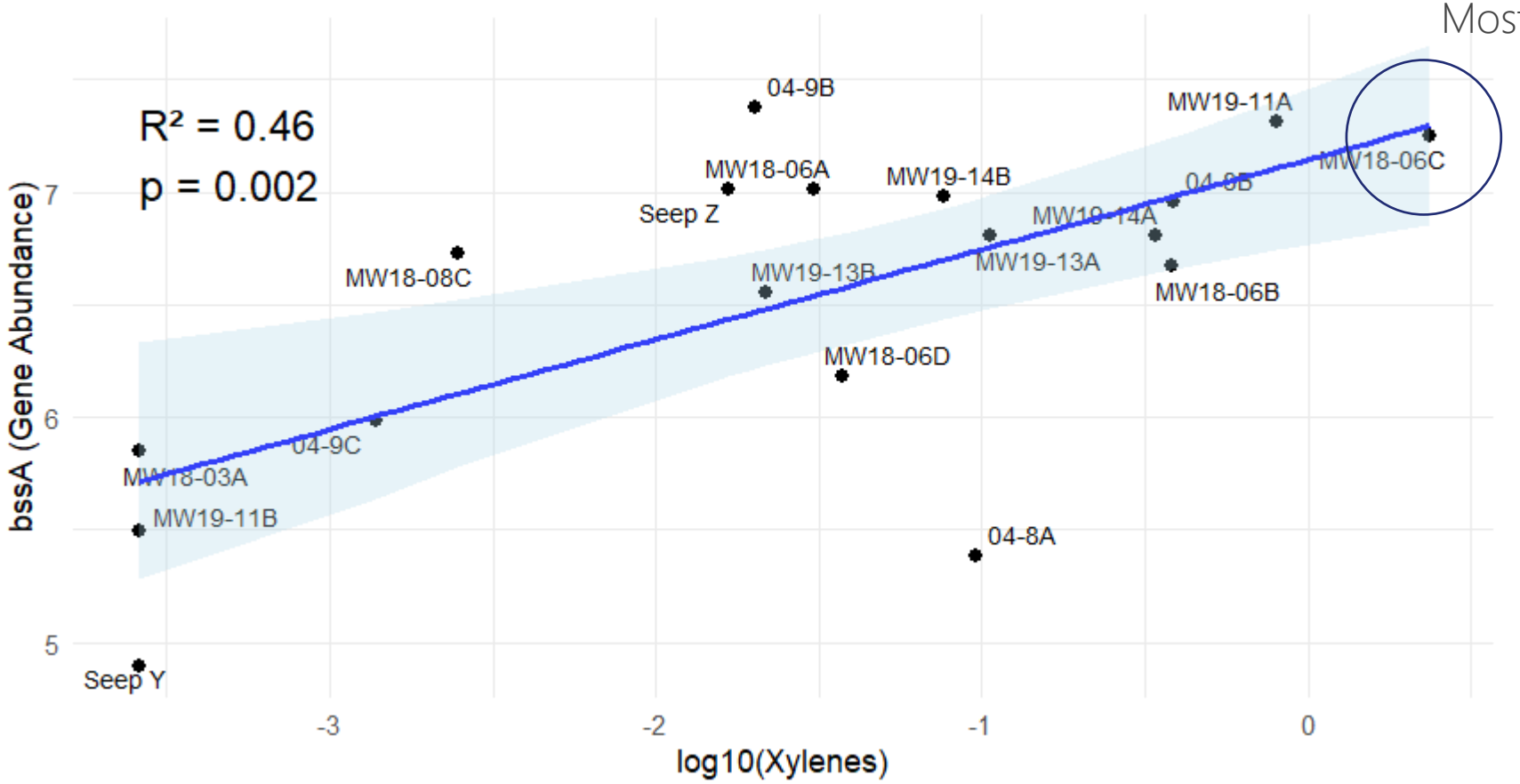
Assumed processes:
Methogensis
Aerobic oxidation of methane
Direct aerobic oxidation

Isotope Fractionation Evidence



Microbial Metrics: Functional Gene Correlations

N-alkanes depleted
Mostly TMBs and xylene



Multiple Lines of Evidence for NSZD

- Compositional analysis identifies how the LNAPL varies chemically
  - It weathers heterogeneously across the site
- Gas gradients suggest that NSZD due to bioremediation is occurring
  - Also estimated bulk rates of depletion
- Isotope fractionation suggests that biodegradation is the source of the carbon dioxide and methane
- Microbial metrics are providing evidence as to what members of the microbial community are contributing to NSZD
  - Community sequencing and additional metrics continue to be investigated

How is this Changing our LCSM?

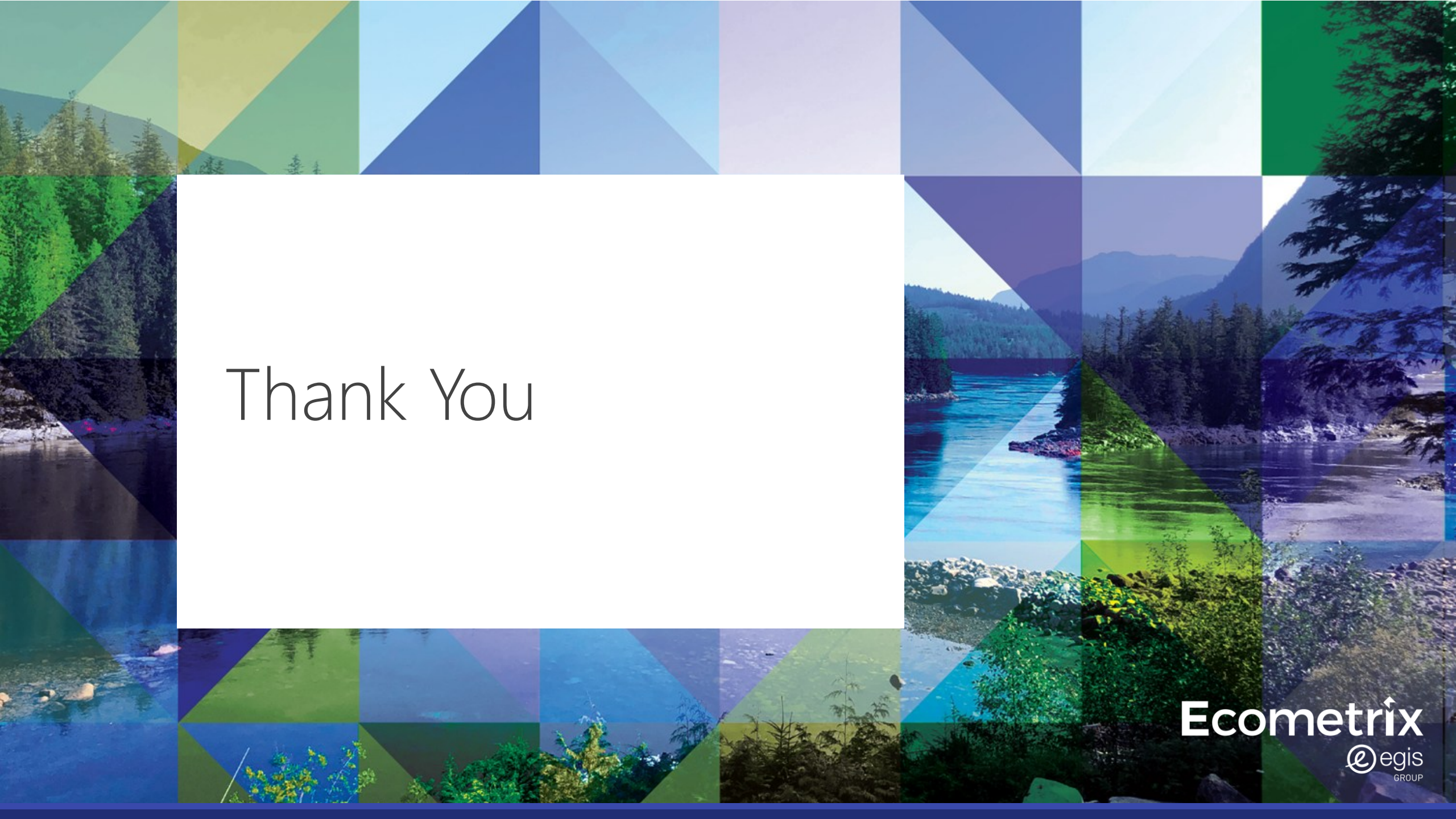
- Refining our understanding of the hydrogeologic conditions
- Updated model of how the LNAPL is weathering across the site
- Multiple lines of evidence helping establish NSZD rates for baseline comparison
- Gaps in the data that are critical to remedy selection for the site are being closed

Summary of Next-Generation Tools

Tool	What Does it Offer the LCSM?	How are we Using it?

Key Takeaways

- The LCSM is a living document that should be refined over the project lifecycle
- LNAPL evolution over time is controlled by many interrelated local factors
  - Matrix properties
  - Hydrogeological conditions
  - NSZD
- High-resolution, advanced approaches can significantly improve the LCSM refinement process
- Advanced chemical and microbial techniques are powerful tools to help refine the LCSM for remedy selection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