Project 1007 Investigation Update

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February 2022

Project 1007 Agenda

Investigation Process

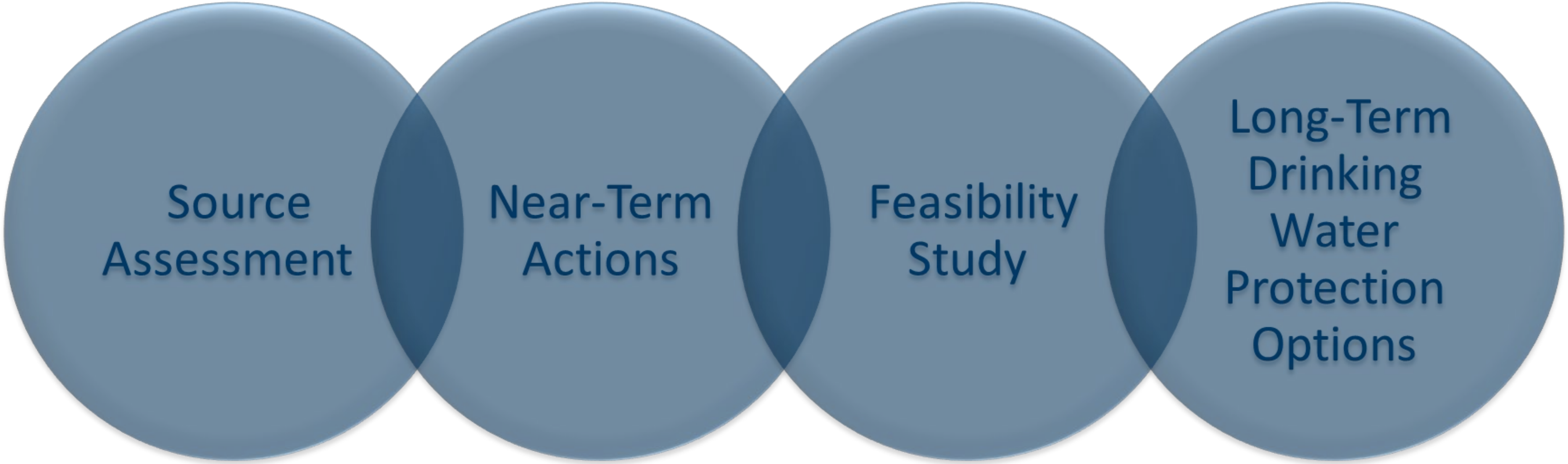
Results To-Date

Risk Assessment

Modeling

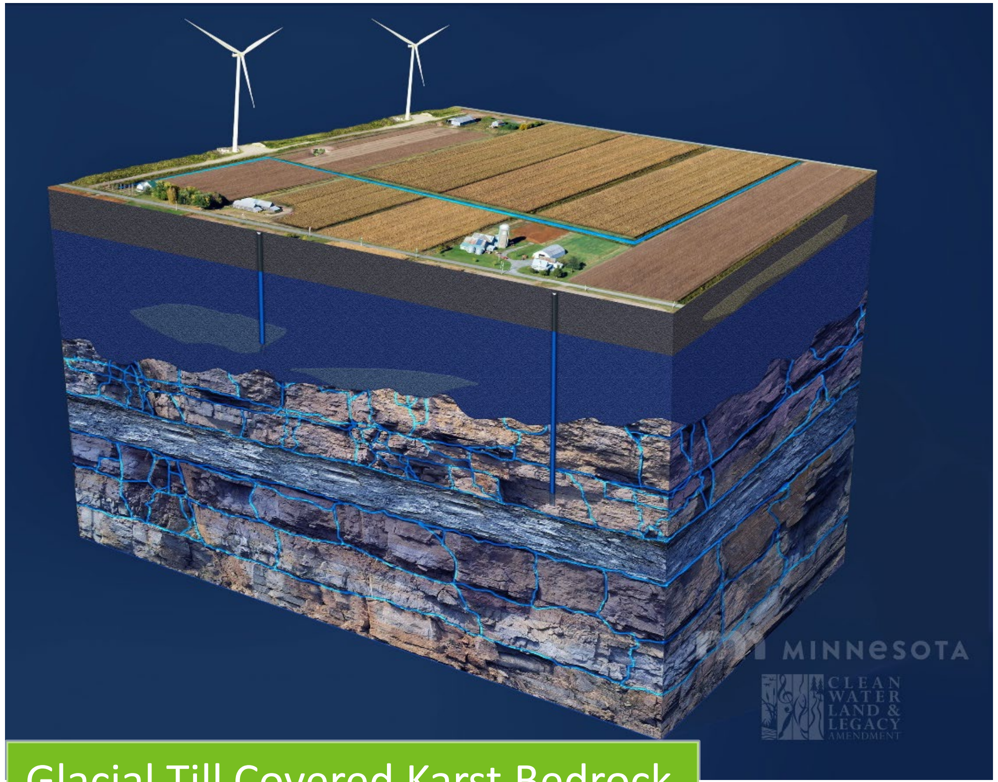
Drinking Water Protection: Near-Term and Long-Term Actions

Project 1007 High-Level Process

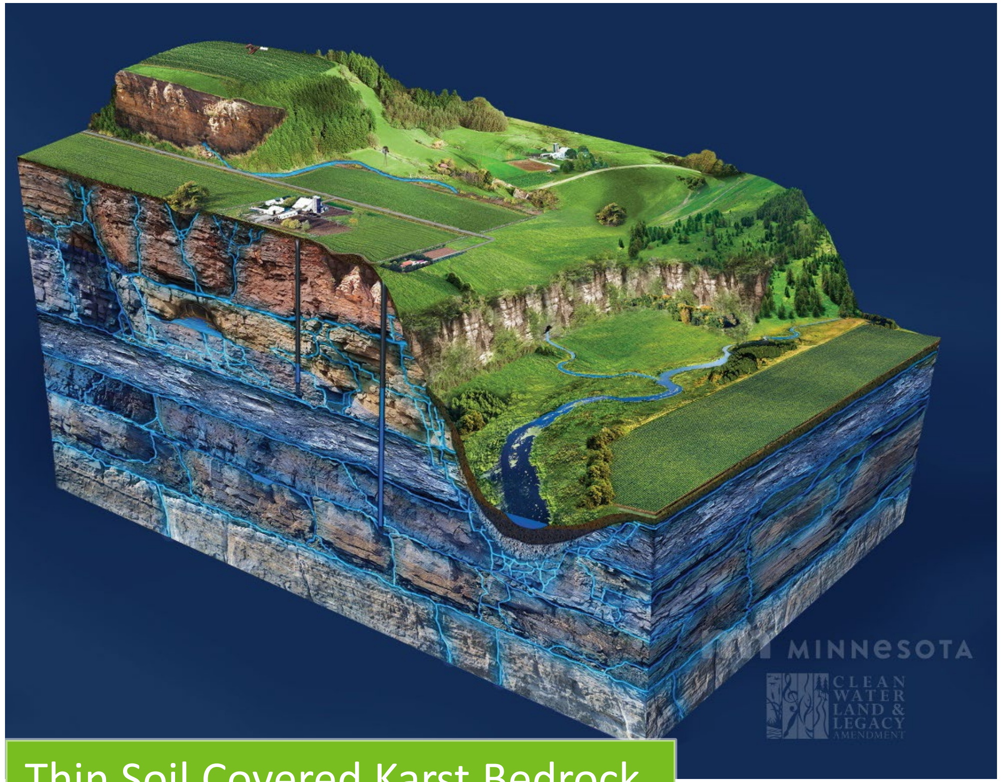


Regional Hydrologic Connections - Drinking Water Risks

Geologic Challenges: Glacial till and karst-burdened landscape with buried bedrock valleys and fault zone
Hydrogeologic Challenges: Extensively interwoven surface and groundwater communication
Chemical Challenges: Complex unknown historic PFAS mixtures

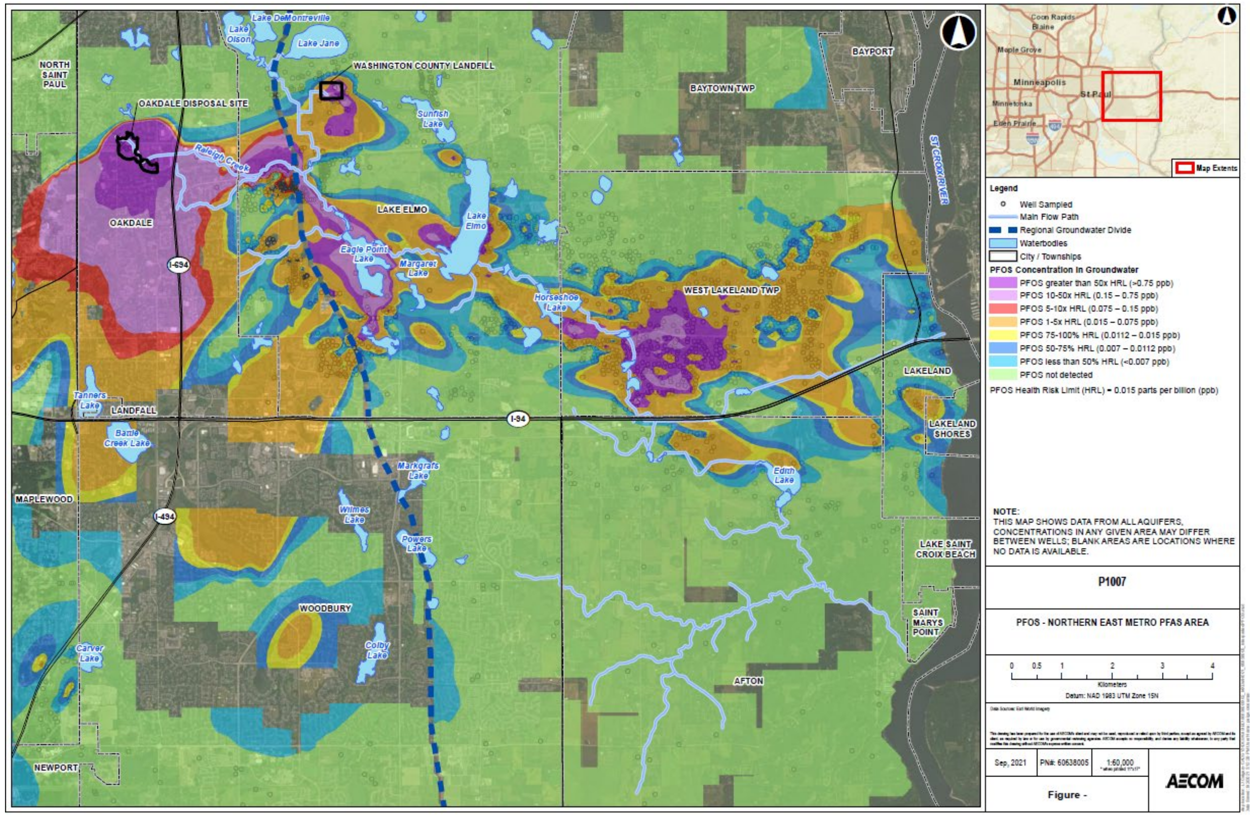


Glacial Till Covered Karst Bedrock

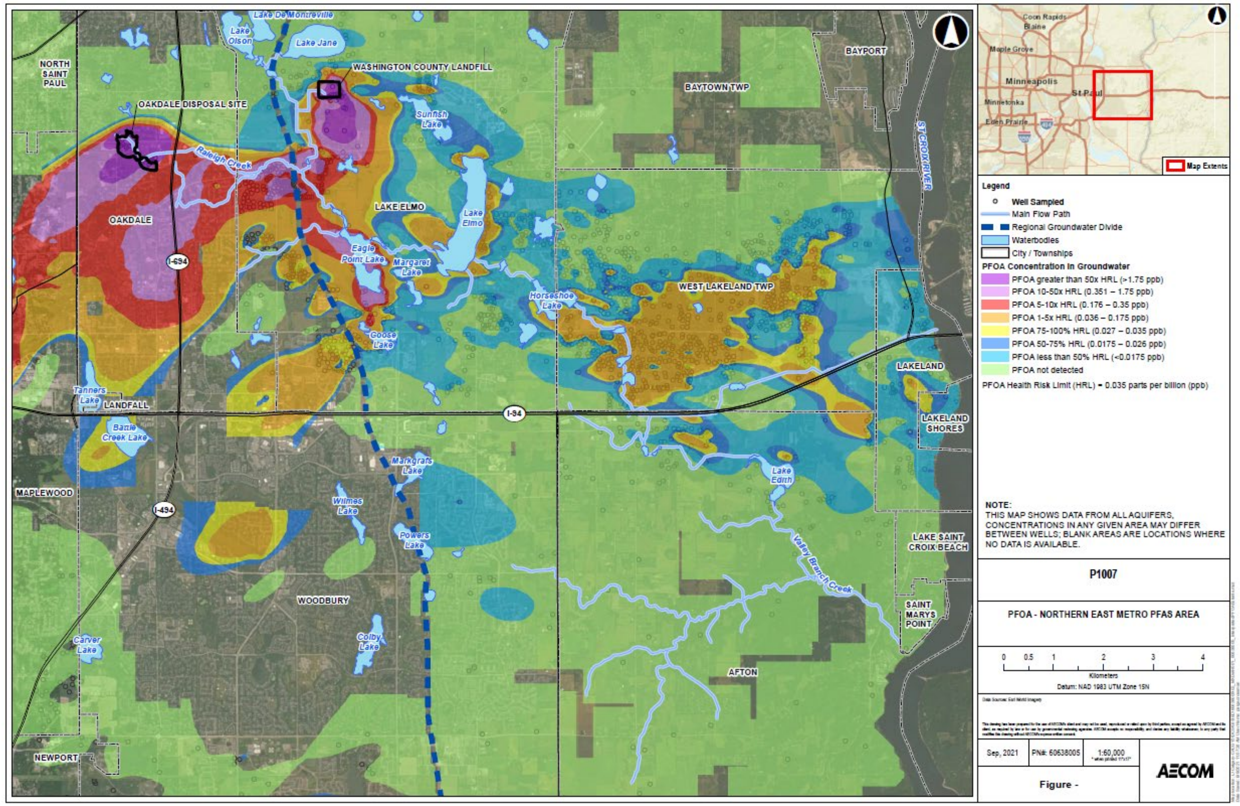


Thin Soil Covered Karst Bedrock

PFOS/PFOA Extents Known To-Date - 2021



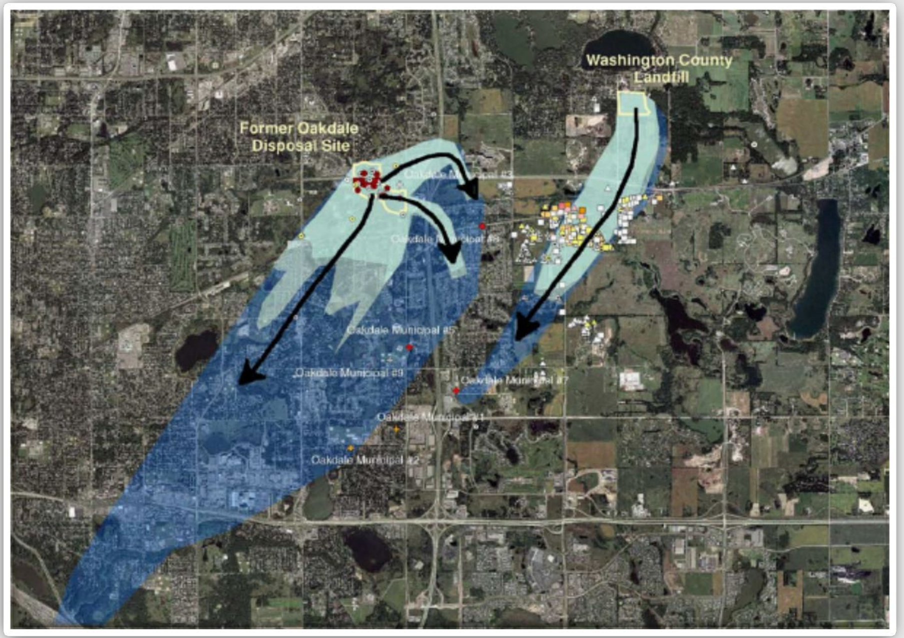
PFOS

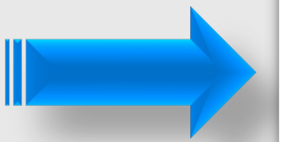


PFOA

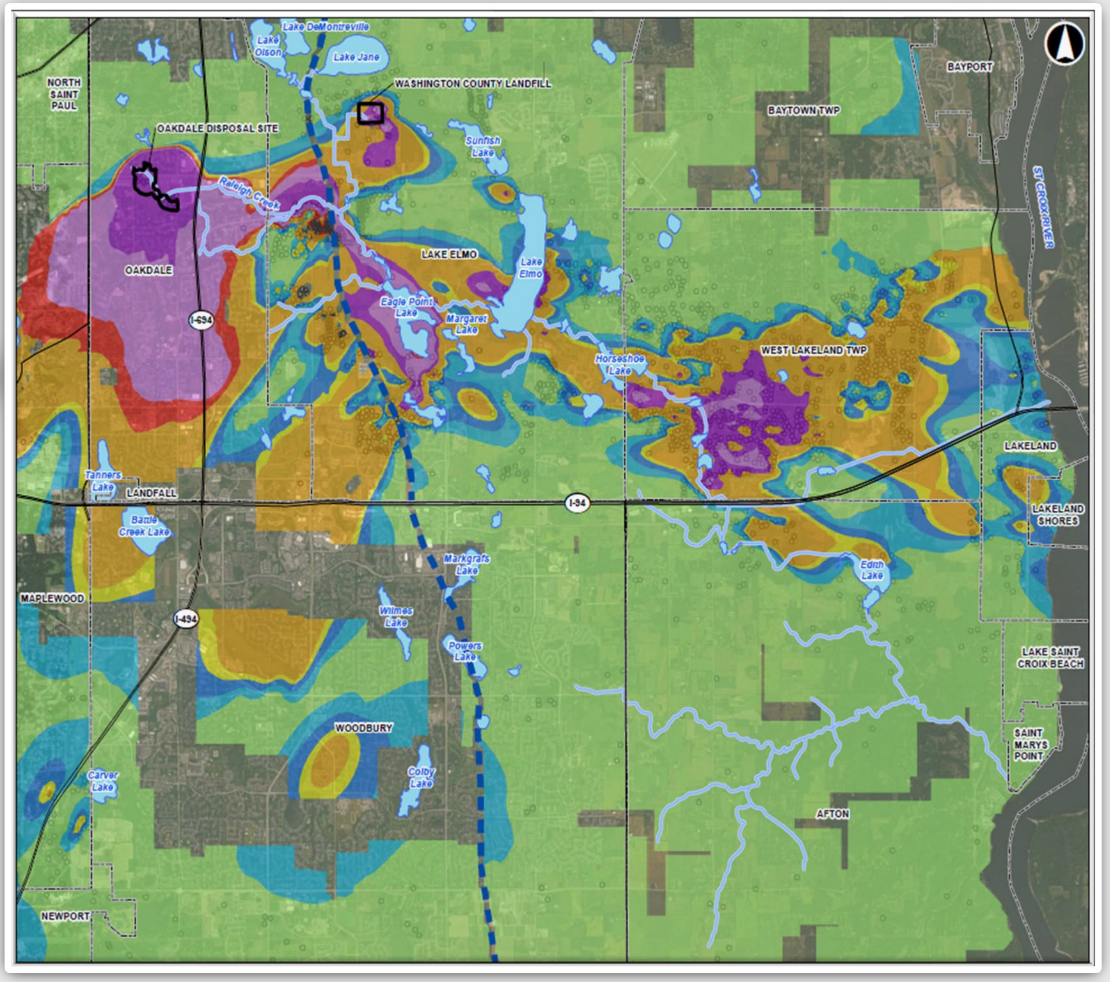
Evolving Groundwater Characterization

2005





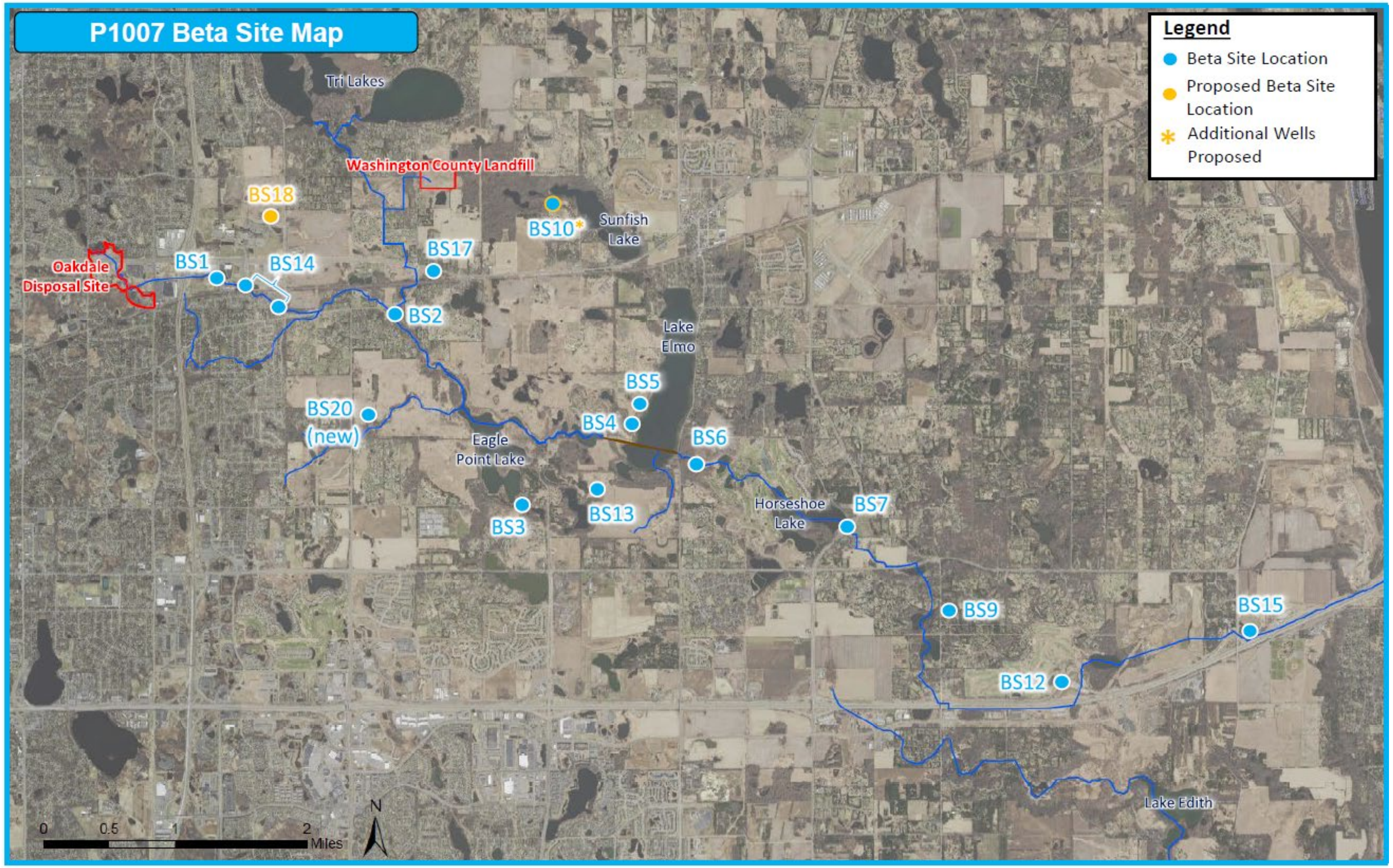
2021



Comprehensive data collection across multiple media is:

- Fundamental to improving numeric models; and
- integral to this regional-scale complex CSM.

Project 1007 FY22 Plans and Beyond



- Complete Monitoring Well installations
- Continued In-Field Monitoring
- Addendums to Ecological Risk Assessments
- Aquifer Pumping Tests
- Near-Term Actions – Pilot Testing
- Long-Term Treatment Evaluations
  - Groundwater
  - Surface Water
  - Sediment

Results To-Date

Project 1007 Analytical

40 PFAS compounds analyzed by AXYS laboratory

Methods MLA 110 by Liquid Chromatography-Tandem Mass Spectrometry using isotope dilution

Total Oxidizable Precursor Assay

Branched:Linear Isomer Analysis

Additional chemistry:

- Stable Isotope, $\delta^{18}O$, Tritium, anion/cations, TOC, TDS.

Media Sampled

Surface water
Groundwater
Soil
Sediment
Foam
Aquatic Life Tissue
Plant Tissue
Bird, Mammal Tissue

Complex Hydrogeology: Multiple Groundwater Divides

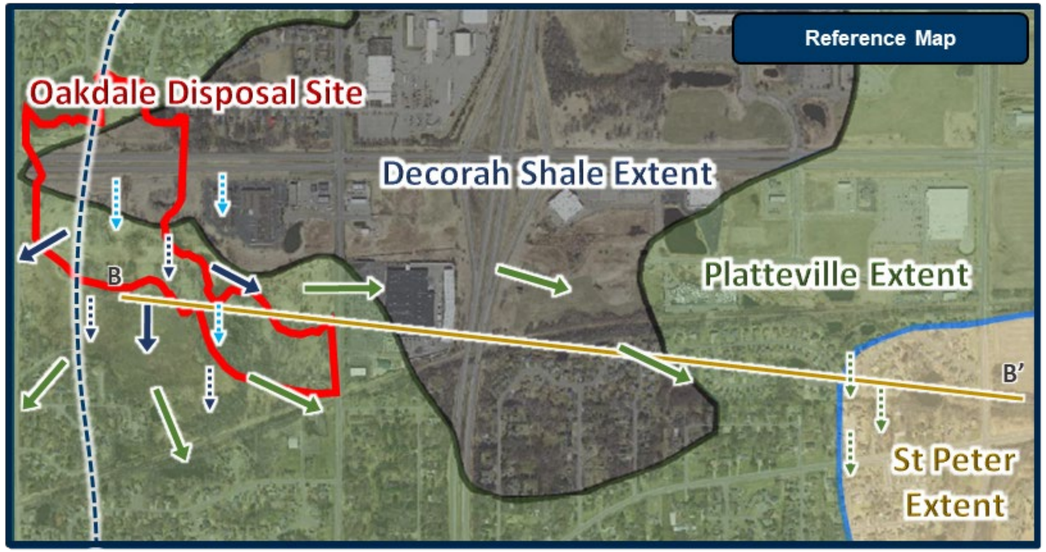
Legend

- Approximate Groundwater Flow Direction
- P1007 Flow Path
- Extent of Historic Source Areas

Notes

First Aquifer Divide:
Quaternary and Platteville Aquifers
Second Aquifer Divide:
St Peter Aquifer
Third Aquifer Divide:
Prairie du Chien and Jordan Aquifers

Oakdale Disposal Site Hydrogeology Review: West to East

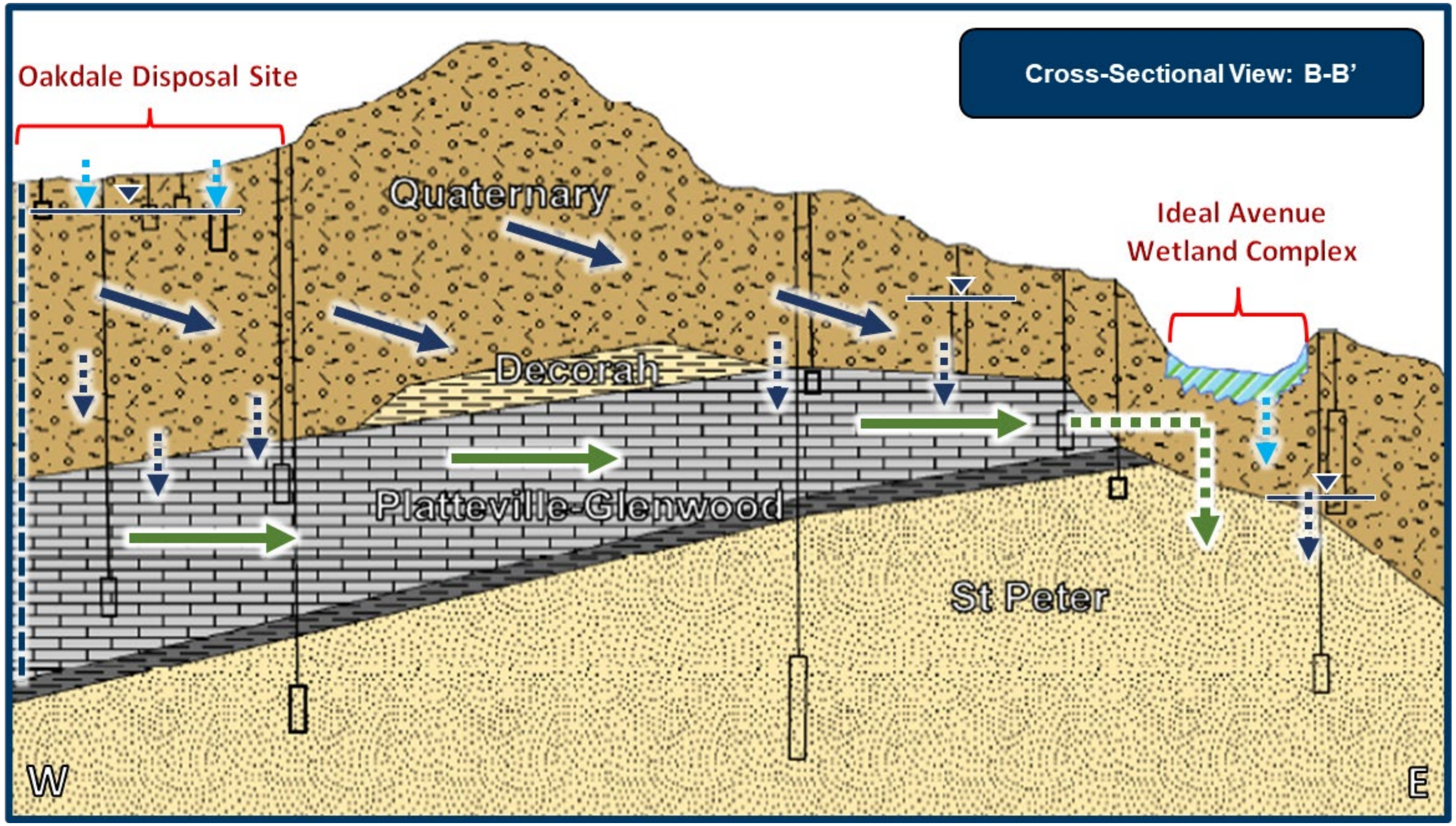


Legend

- Surface to Groundwater Infiltration
- Horizontal GW Flow: Quaternary
- Vertical GW Migration from Quaternary
- Horizontal GW Flow: Platteville
- Vertical GW Migration from Platteville
- First Approximate Groundwater Divide (Quaternary and Platteville)
- Approx. Water Table (Quaternary)

Notes

Vertical exaggeration is 24.5:1
Horizontal extent is approximately 1.4 miles



PFAS Preferential Pathway: Shallow GW and Surface Water Contributions

Legend

Horizontal Groundwater Flow

Vertical Groundwater Flow

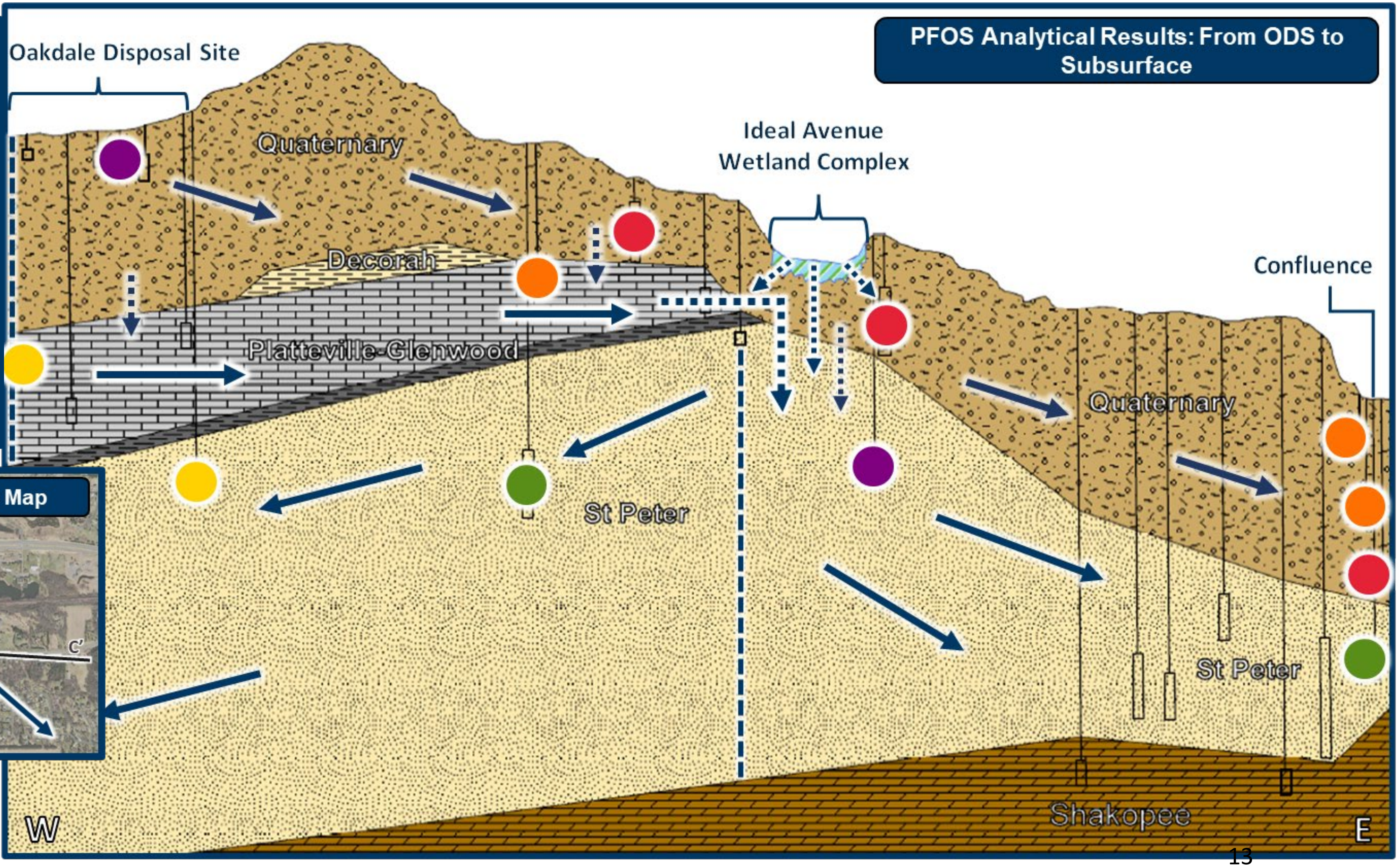
Approximate Groundwater Divides

PFOS (ppb)

- > 2.0
- 0.75 – 2.0
- 0.20 – 0.75
- 0.12 – 0.20
- < 0.12

Notes

Vertical exaggeration is 24.5:1.
Horizontal extent is approximately 2.1 miles.
All analytical data from wells sampled between 2019 and 2021.
Sample at ODS is 49.1 ppb.



Statistical Analysis of Contaminant Mixtures

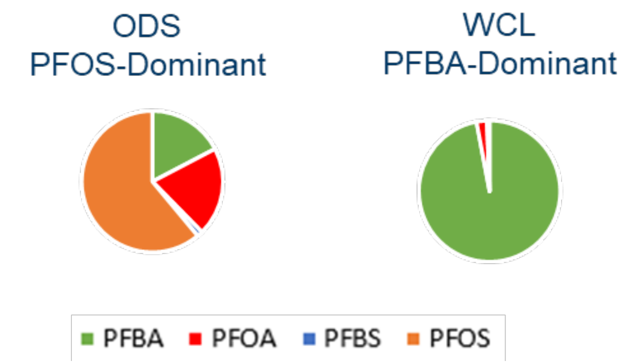
Methods

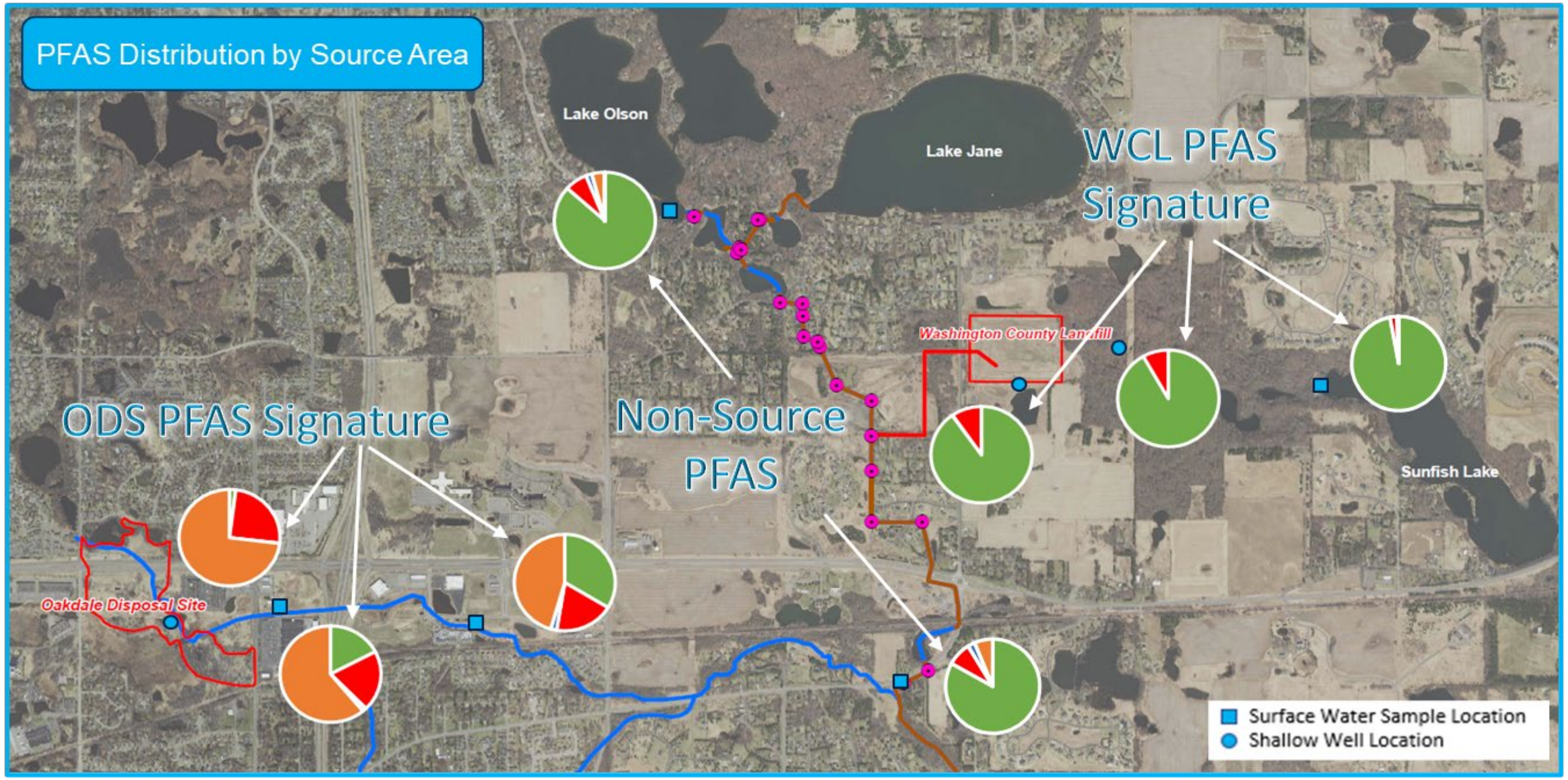
PFOS:PFBA Ratios or Relative % Distributions	High vs Low Flow % Hydrologic Conditions	Branched:Linear Isomer Ratios	Multi-Variate Statistics (Clustering)	TOP Assay Graphical Statistics (Euclidian and UMAP)

PFAS Mixture Comparison from 2 Source Areas

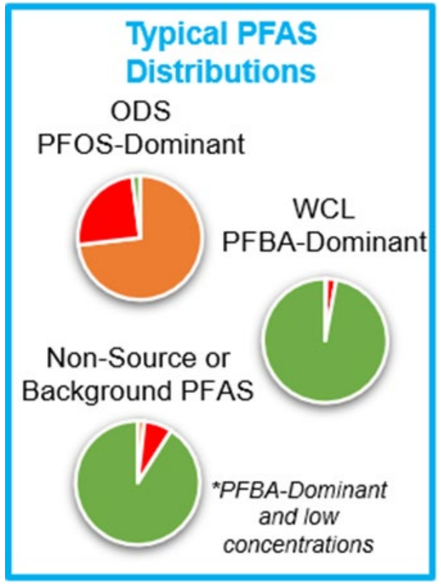
The PFAS signature associated with ODS is generally PFOS-dominant, while PFAS contamination from WCL is generally PFBA-dominant. As a result, analysis of the PFBA:PFOS ratio or the relative distribution of key compounds can be used to determine PFAS source contribution at different locations.

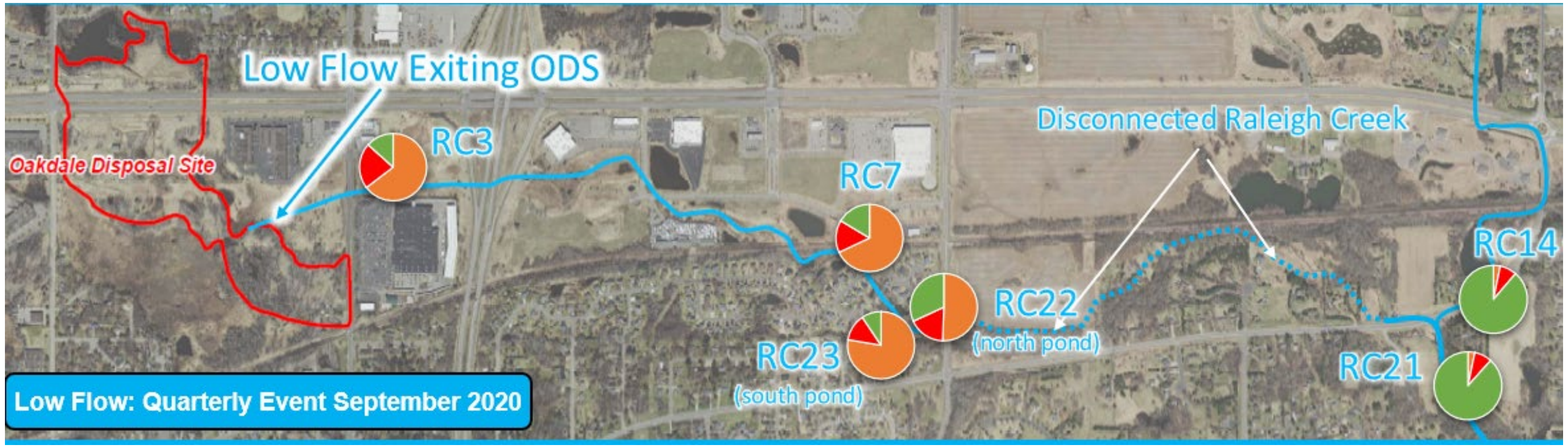
Typical PFAS Distribution: ODS v.s. WCL

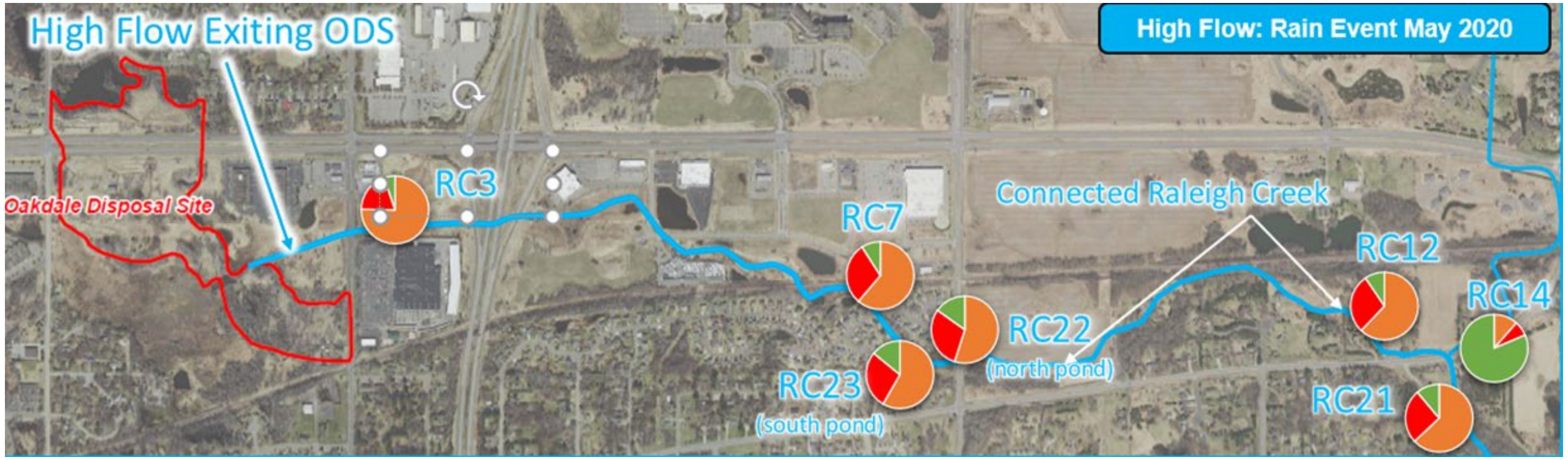




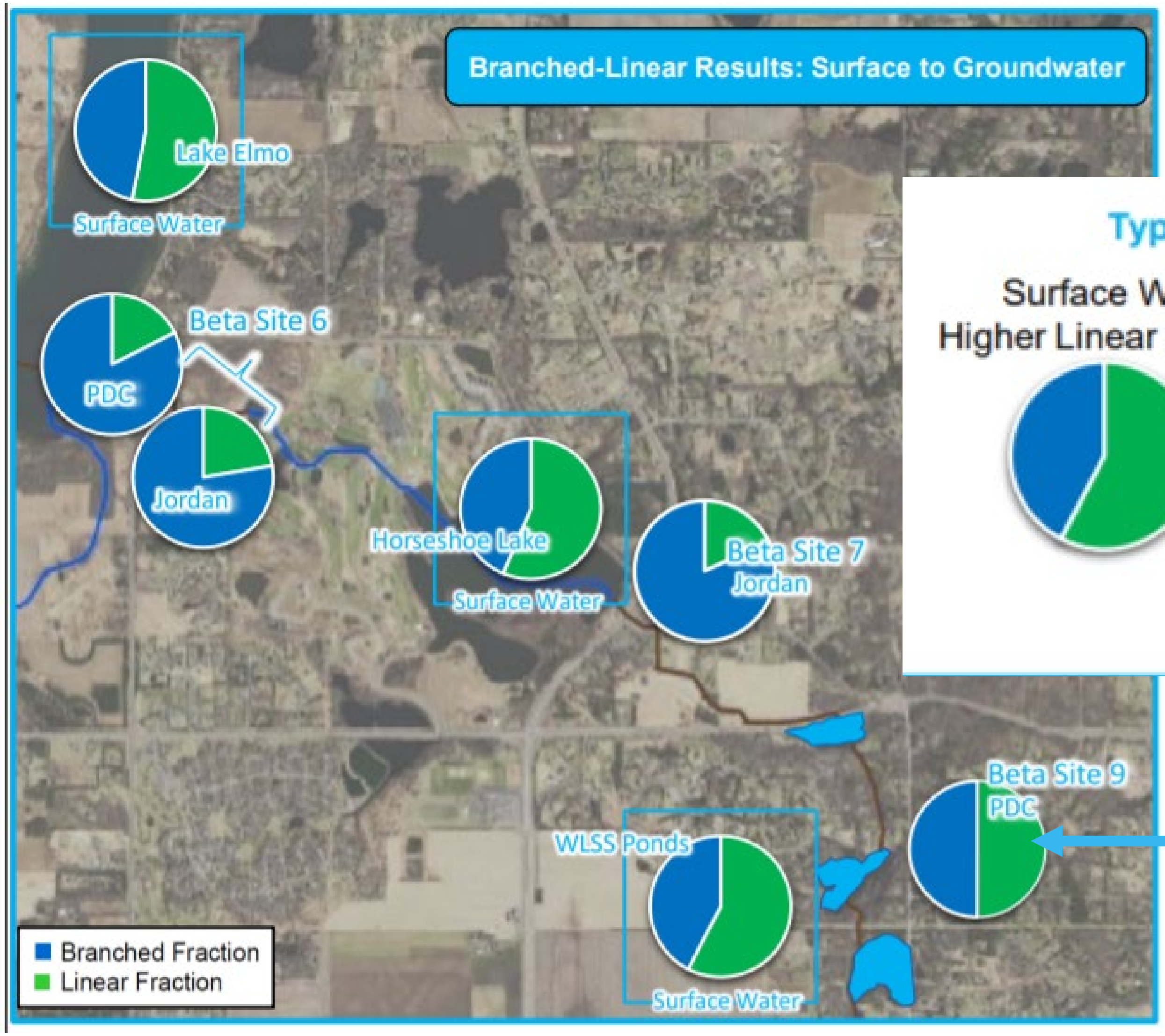
Lines of Evidence: High Flow vs. Low Flow Conditions

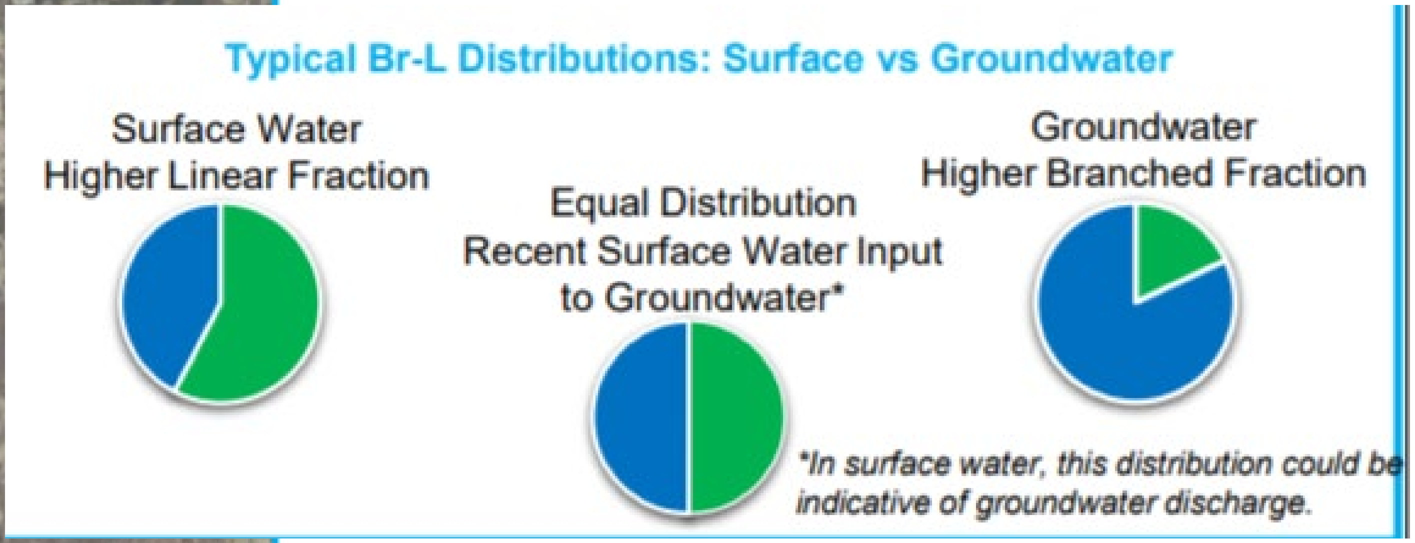






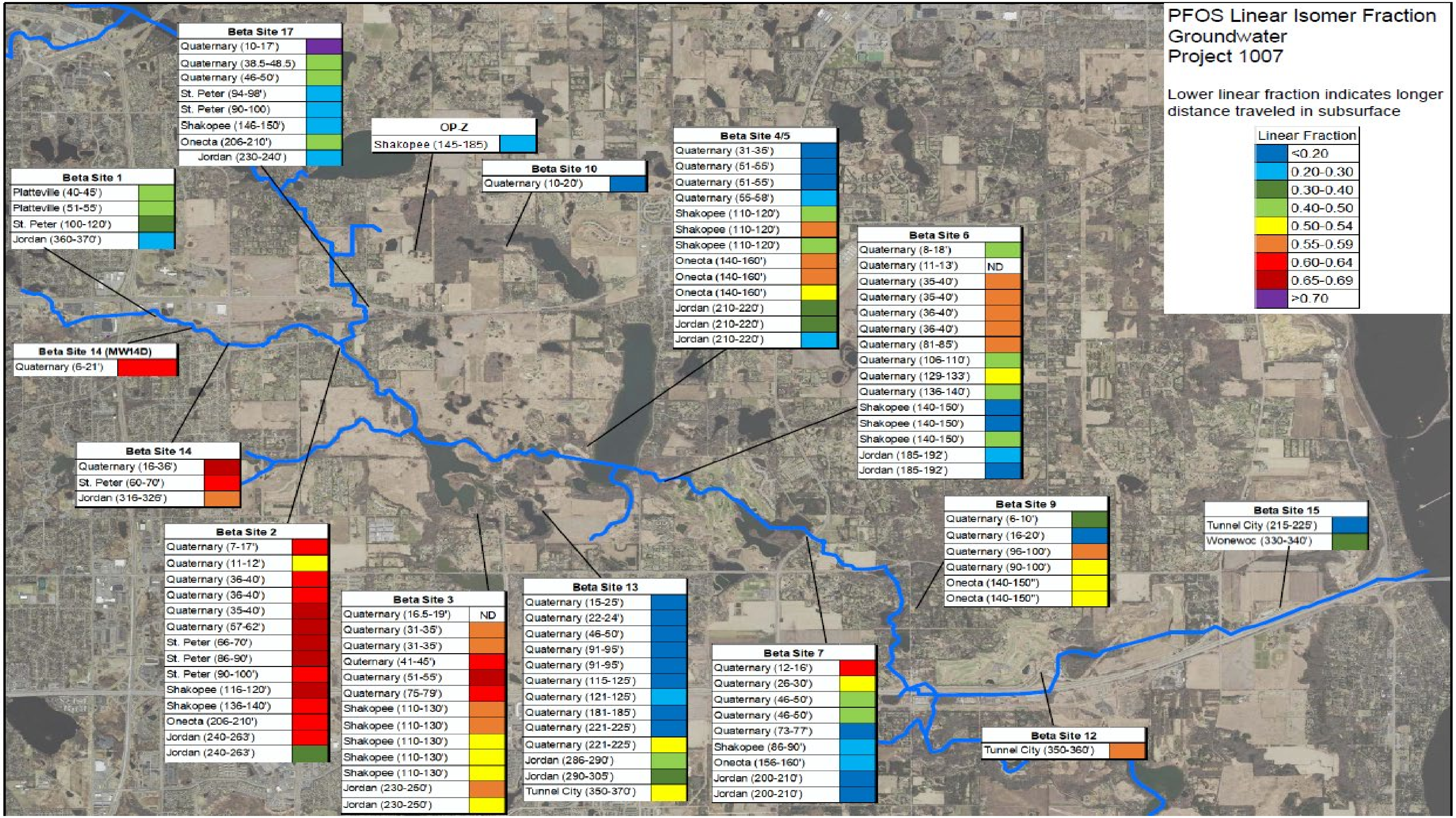
Branched:Linear Isomer Ratios





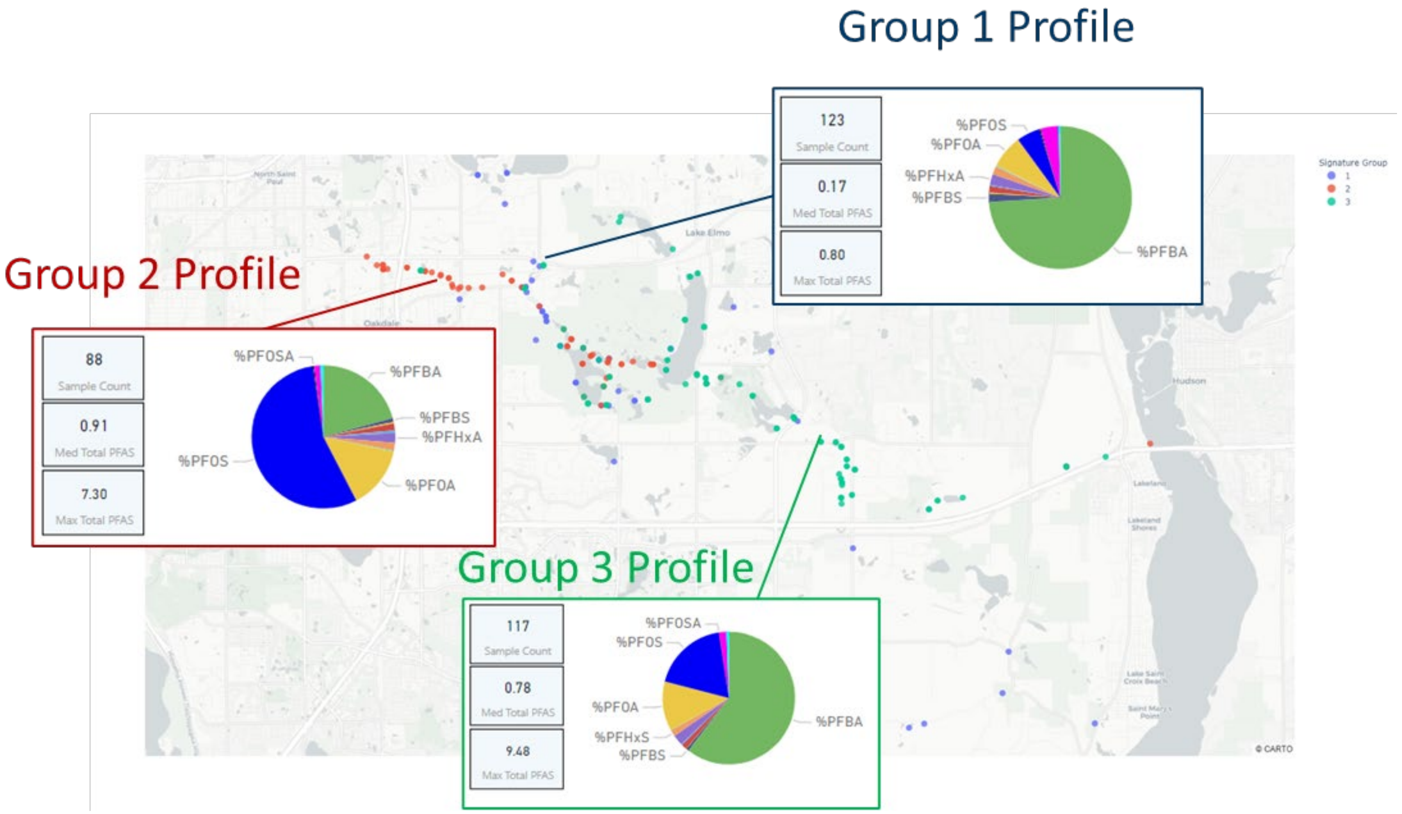
This increase in linear fraction in downgradient bedrock aquifer indicates surface water infiltration

Branched:Linear Isomer Analysis



Multivariate Statistical Analysis

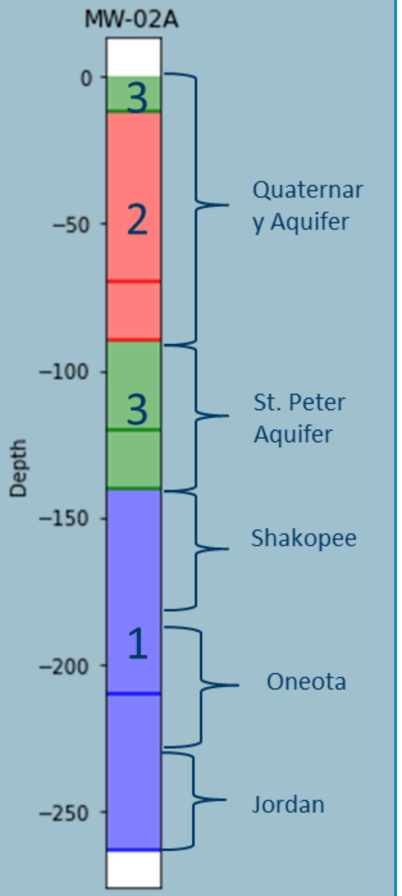
Multivariate statistical clustering showed three dominant PFAS profiles



Identifying PFAS Signature Changes at Individual Well Nests

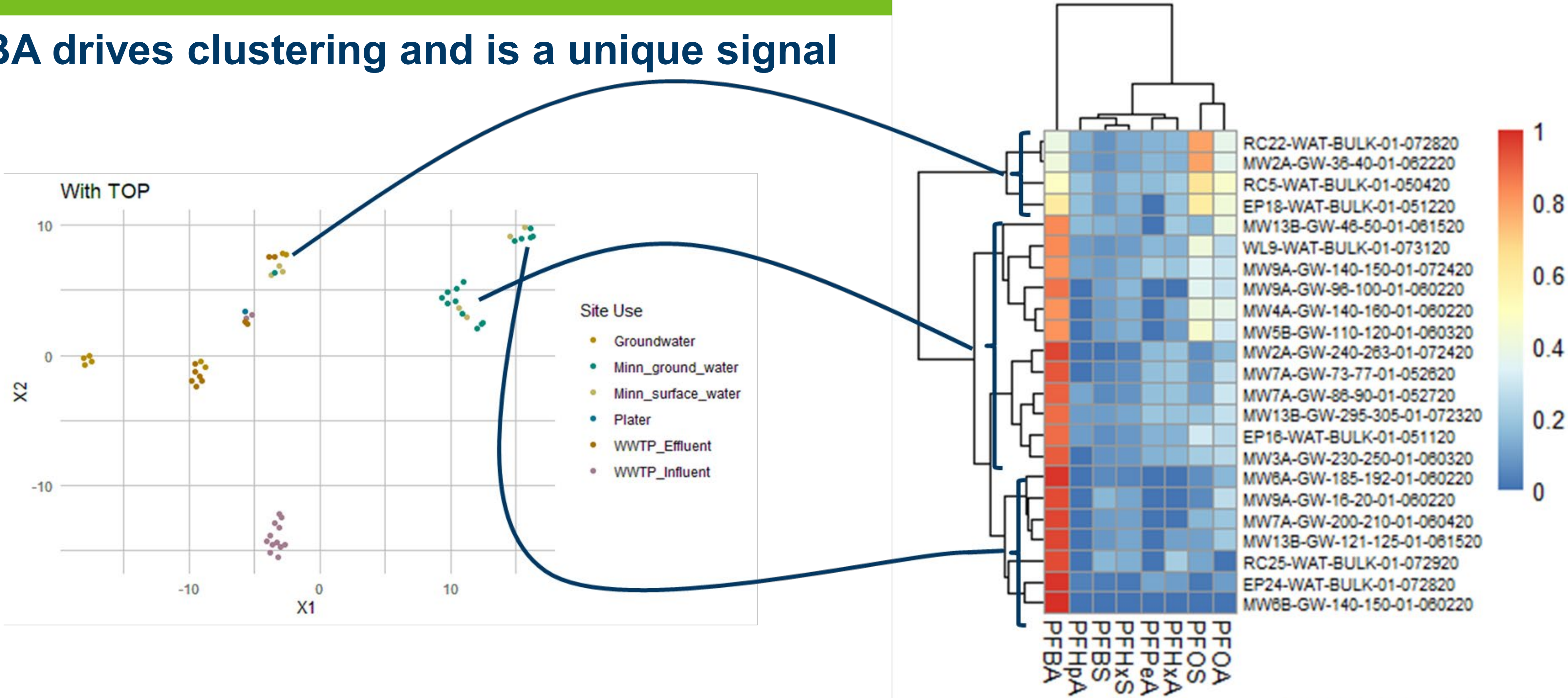
Group 2 PFOS / Group 3 PFBA+PFOS

Group 1 PFBA



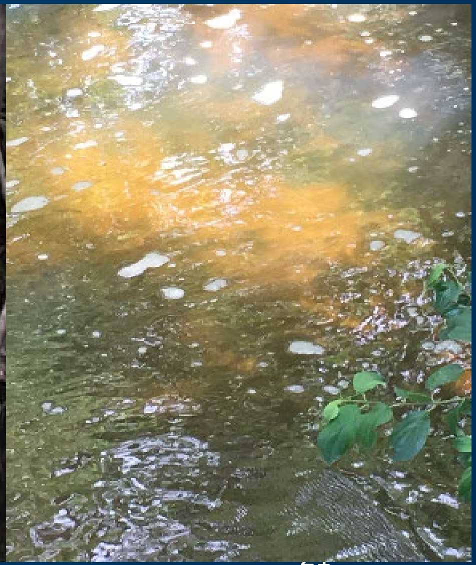
University of California at Berkeley
Total Oxidizable Precurser Analysis – Statistical Evaluation

PFBA drives clustering and is a unique signal

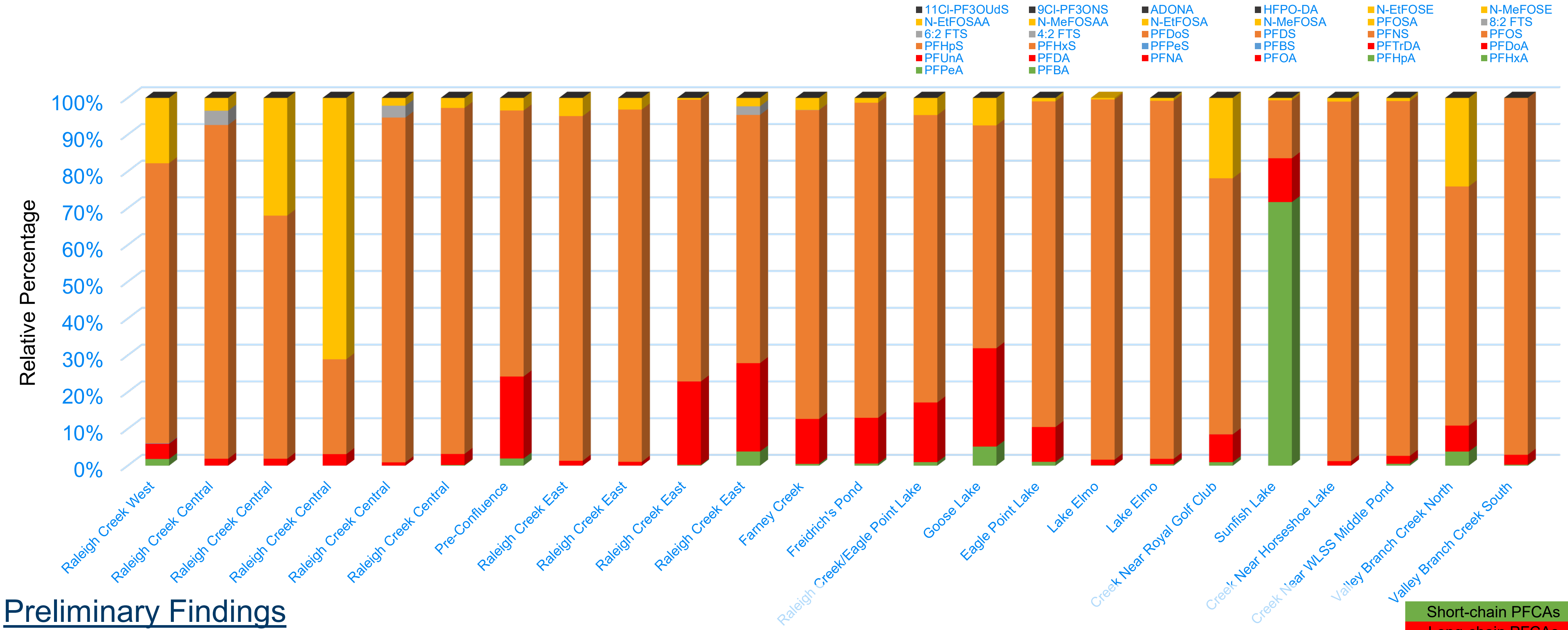


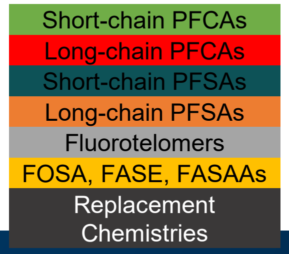
Courtesy of N. Antell, UCB

Results To-Date: Observed PFAS-Containing Foam Characteristics



Project 1007 PFAS Compound Distribution in Foam

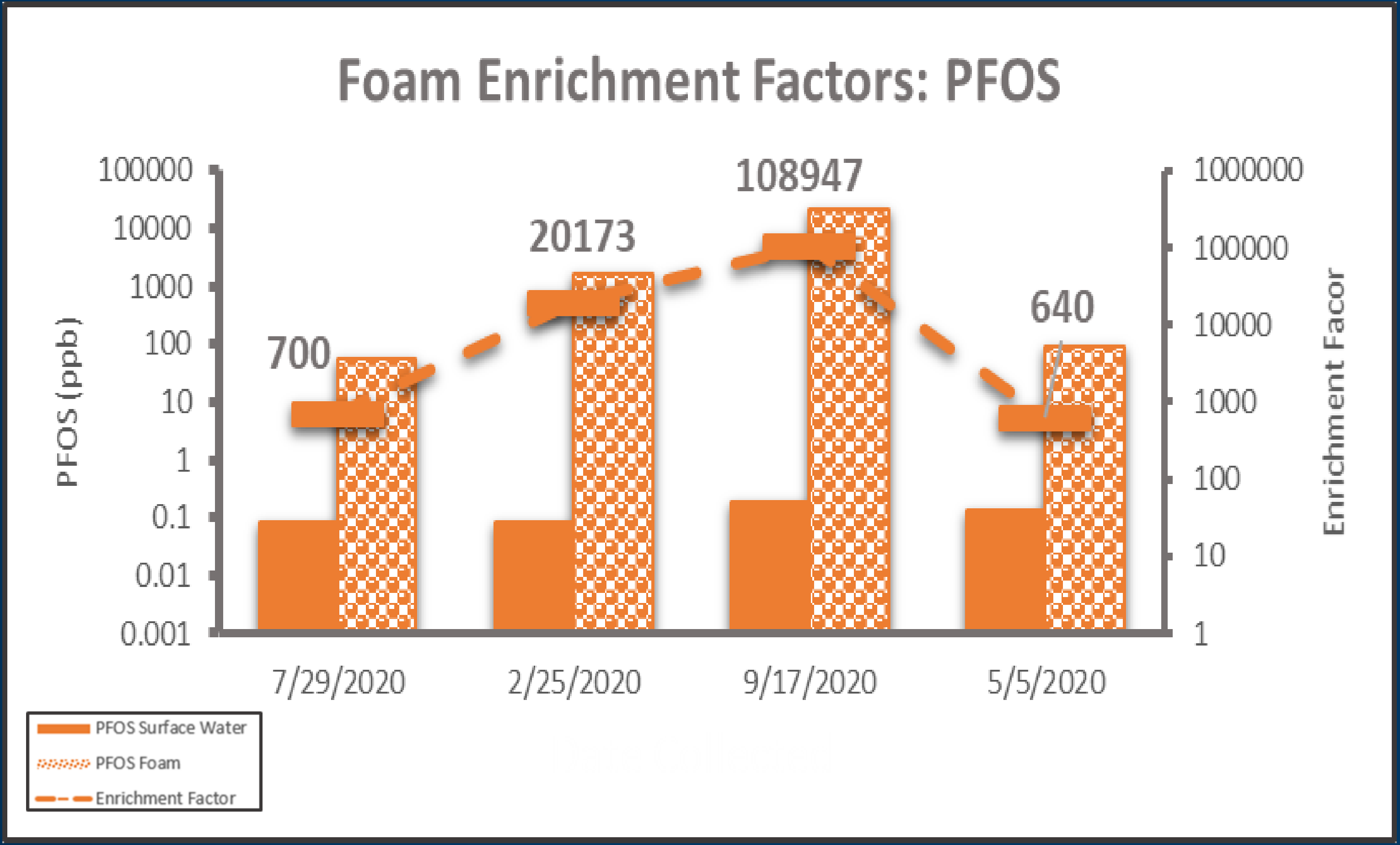




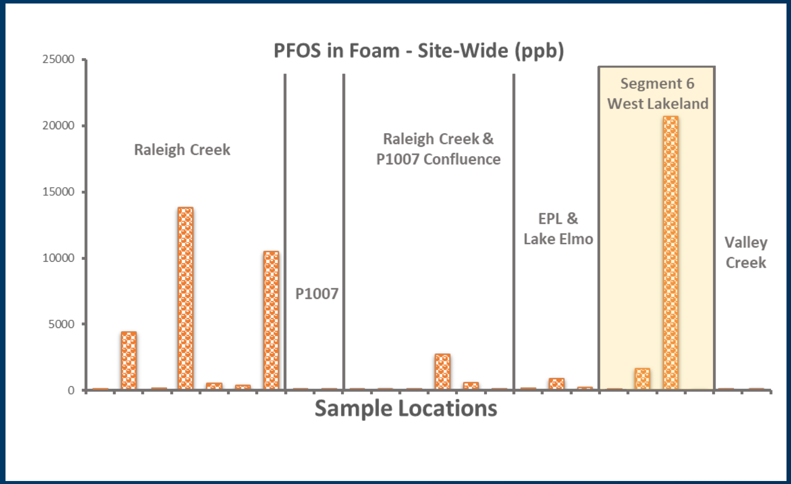
Preliminary Findings

- Foam samples are overwhelmingly comprised of long-chain PFSAs (up to 97% of total PFAS)
- Greater than 20% of foam consists of PFSA precursors in areas near ODS, downgradient of Lake Elmo, and Valley Branch Creek

PFAS-Containing Foam
Enrichment Factors and Source Proximity



~8Miles



Risk Assessments

Baseline Ecological Risk Assessment Results
Individual-level and Population-level risks

Population-level risks due to PFOS exposure were identified for ***great blue heron, muskrat and mink*** - key receptors to consider in remedial decisions.

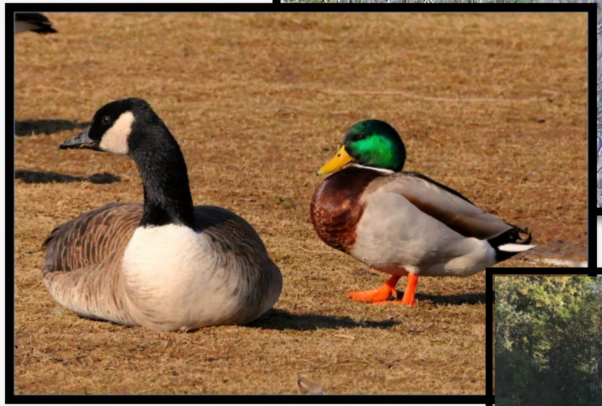
Individual-level risks due to PFOS exposure were identified for ***tree swallow, spotted sandpiper, great blue heron, muskrat, little brown bat and mink*** – key receptors to consider if T&E species may be represented by one of these particular species and feeding guilds.

Updates to Baseline Ecological Risk Assessment

- DNR has **60 deer liver** results - PFAS levels in livers from deer harvested in Lake Elmo Park Reserve (LEPR) appear *preliminarily* to be *lower* than levels seen in Maine, Michigan, and Wisconsin that prompted deer meat consumption advisories. Report expected mid-2022.

- DNR will collect **25 mallards this winter and 25 Canadian geese** this summer (2022) from the LEPR and report expected by end of the calendar year.

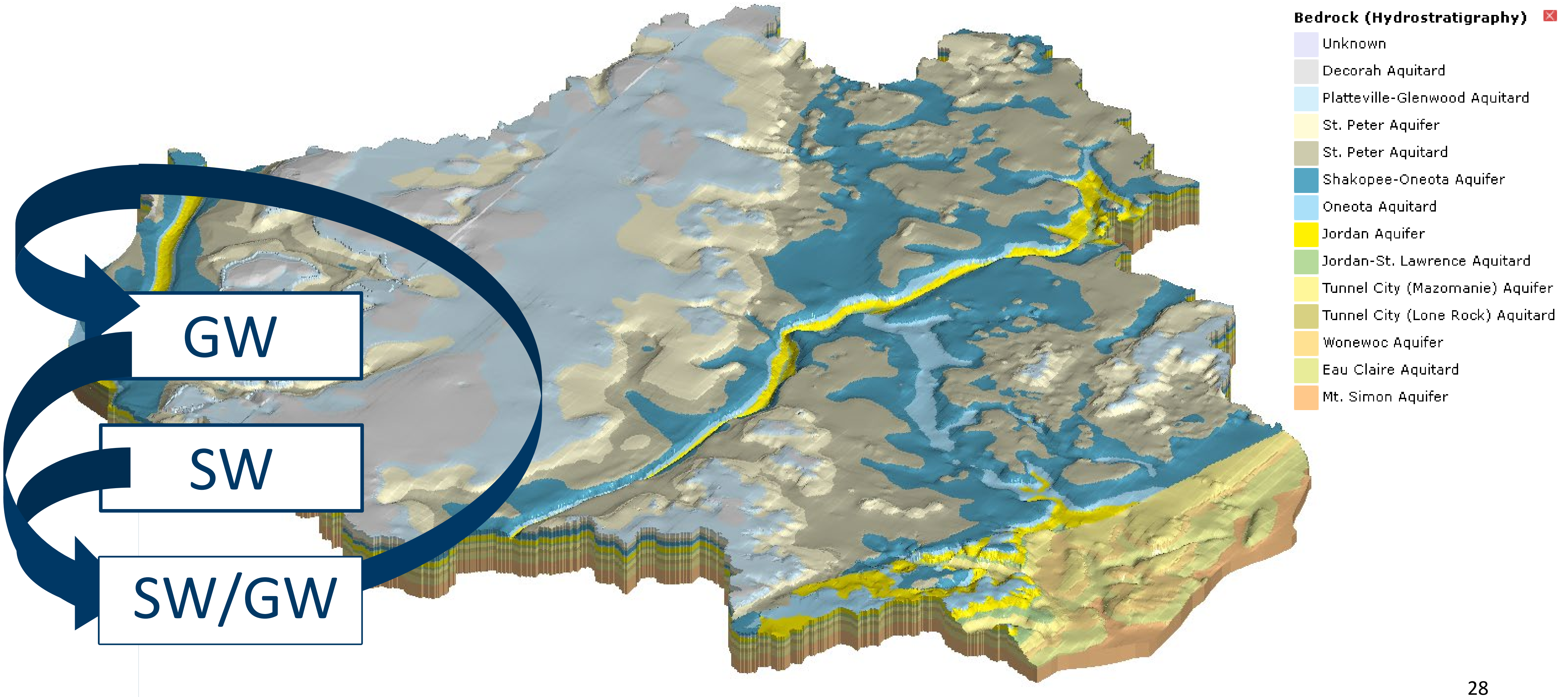
- **Plant tissue** sample results from Project 1007 areas are in and under evaluation now by AECOM risk assessors, addendum expected in March.



Combined Surface Water & Groundwater Modeling

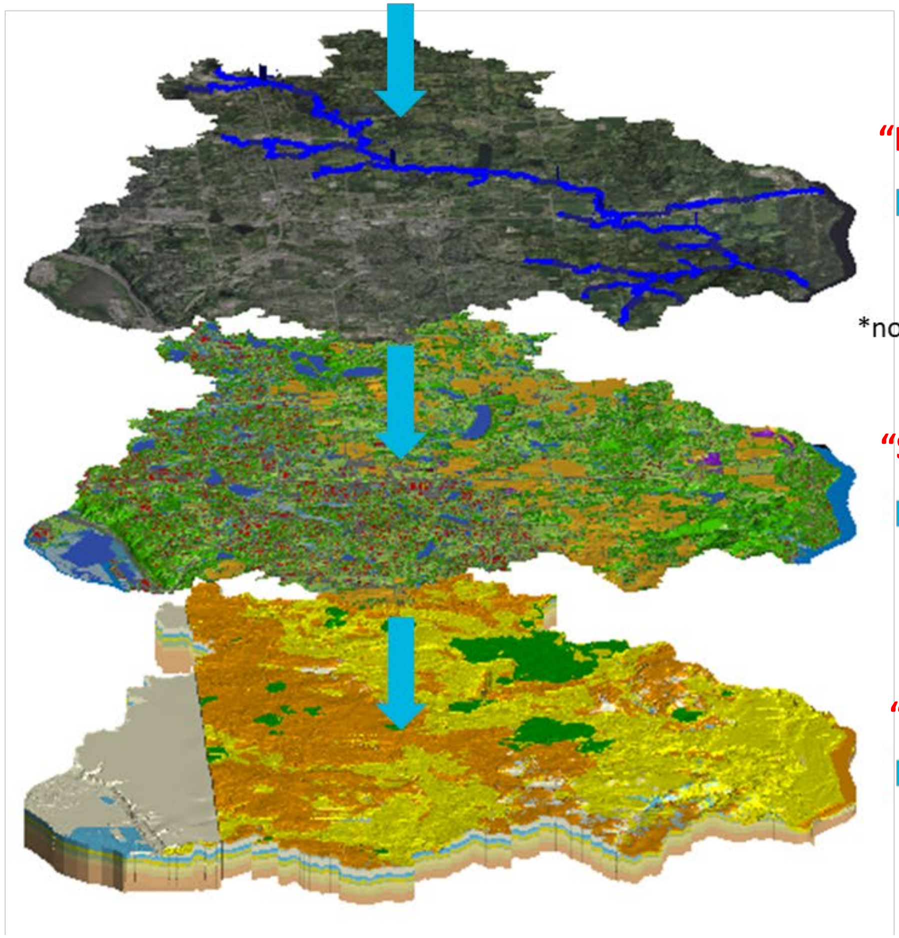
Surface Water / Groundwater Study Areas

Forward progress toward integrated model



Integrated SW/GW Model

Precipitation and Snowmelt



Hydrology

"Rainfall-Runoff Models"

Streamflow

*not all streams shown

Land Cover / Physiography

"Soil Water Balance Models"

Evapotranspiration

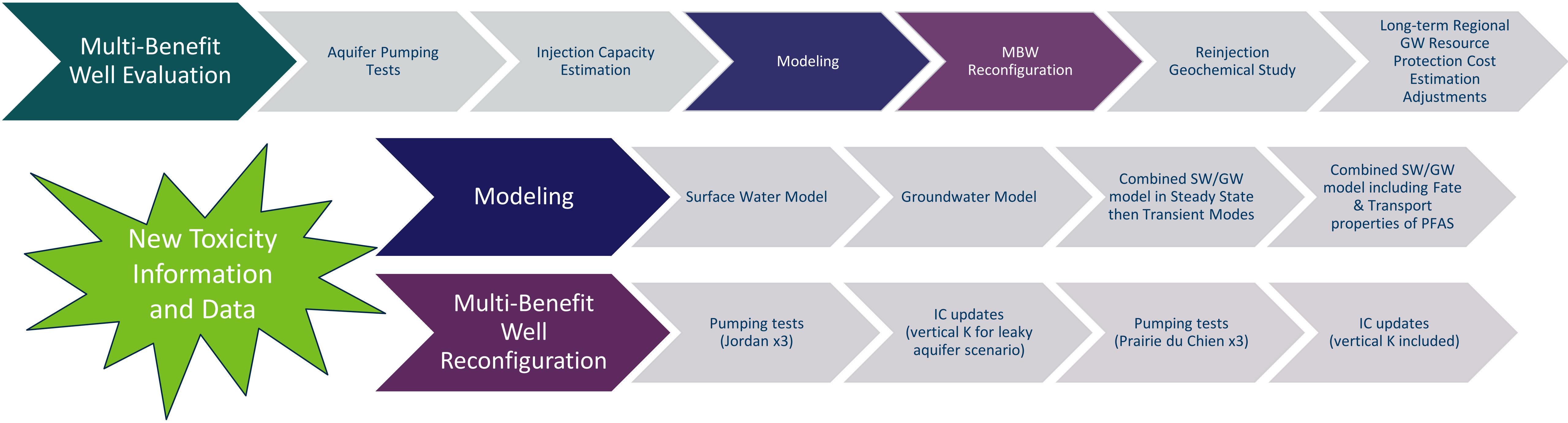
Hydrogeology and Geology

"Groundwater Models"

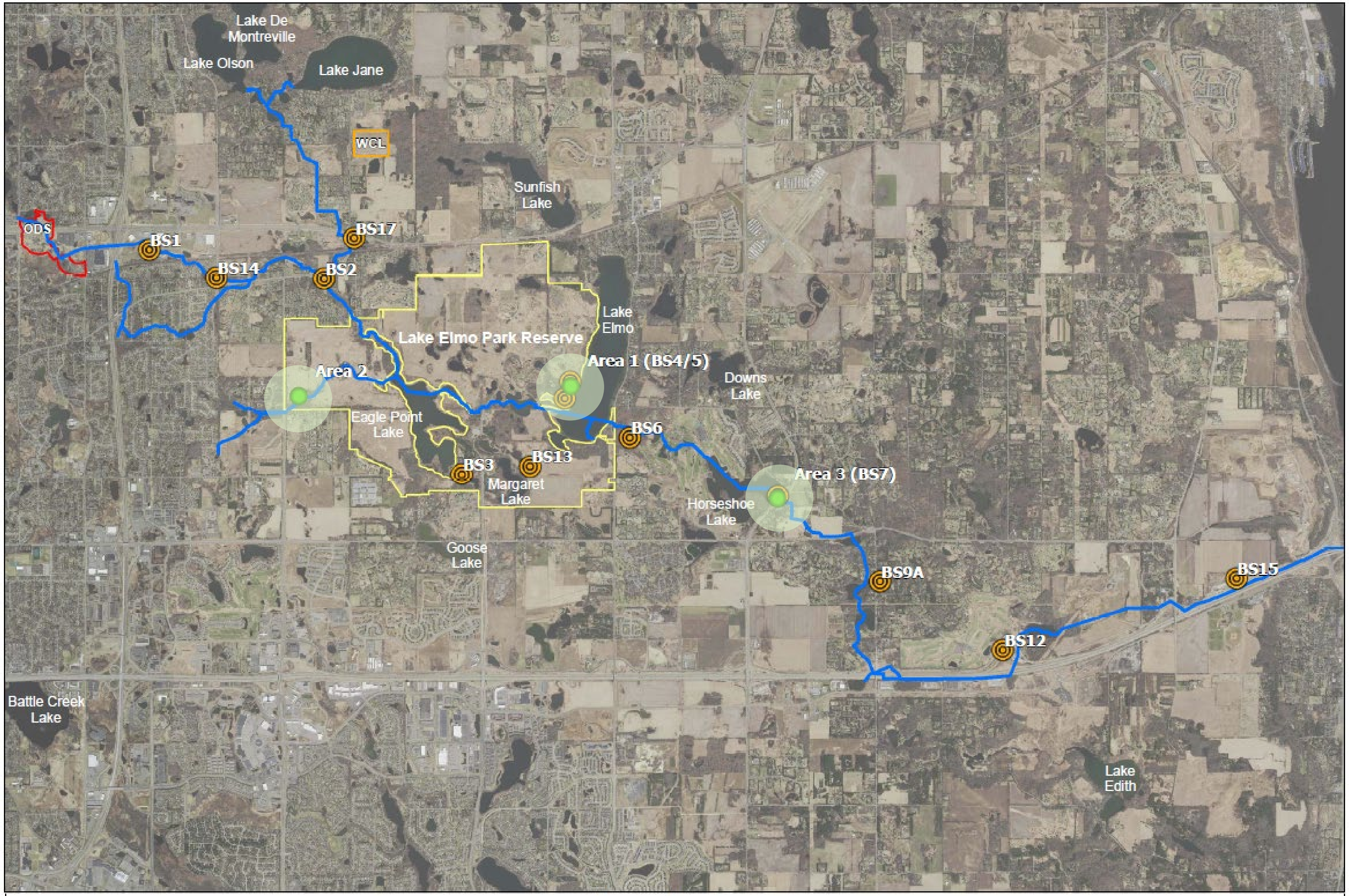
Groundwater Flow

Drinking Water Protection: Multi-Benefit Well Conceptual Design Framework

Multi-Benefit Wells (MBWs) are wells designed to obtain remedial objectives while providing municipal supply to achieve long-term regional groundwater resource protection goals.



Project 1007 - Aquifer Pumping Test Locations

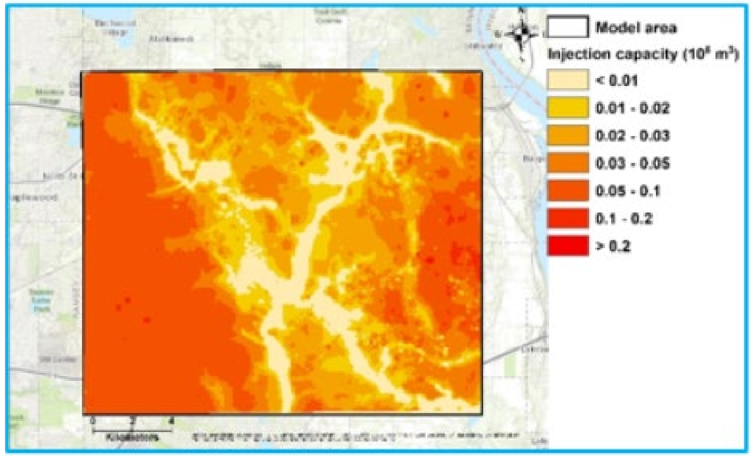


3 Aquifer Pumping Tests
- #1 Done
- #2 Done
- #3 Spring 2022

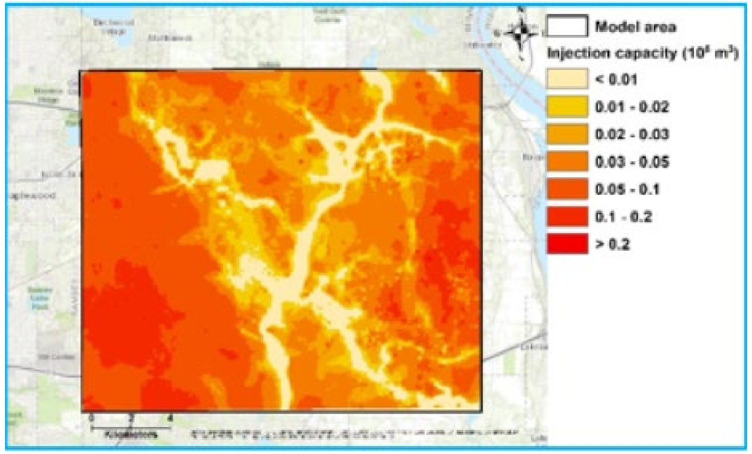
Results integrated into combined surface water and groundwater model.

Graphical Injection Capacity Estimations

Non-leaky scenario



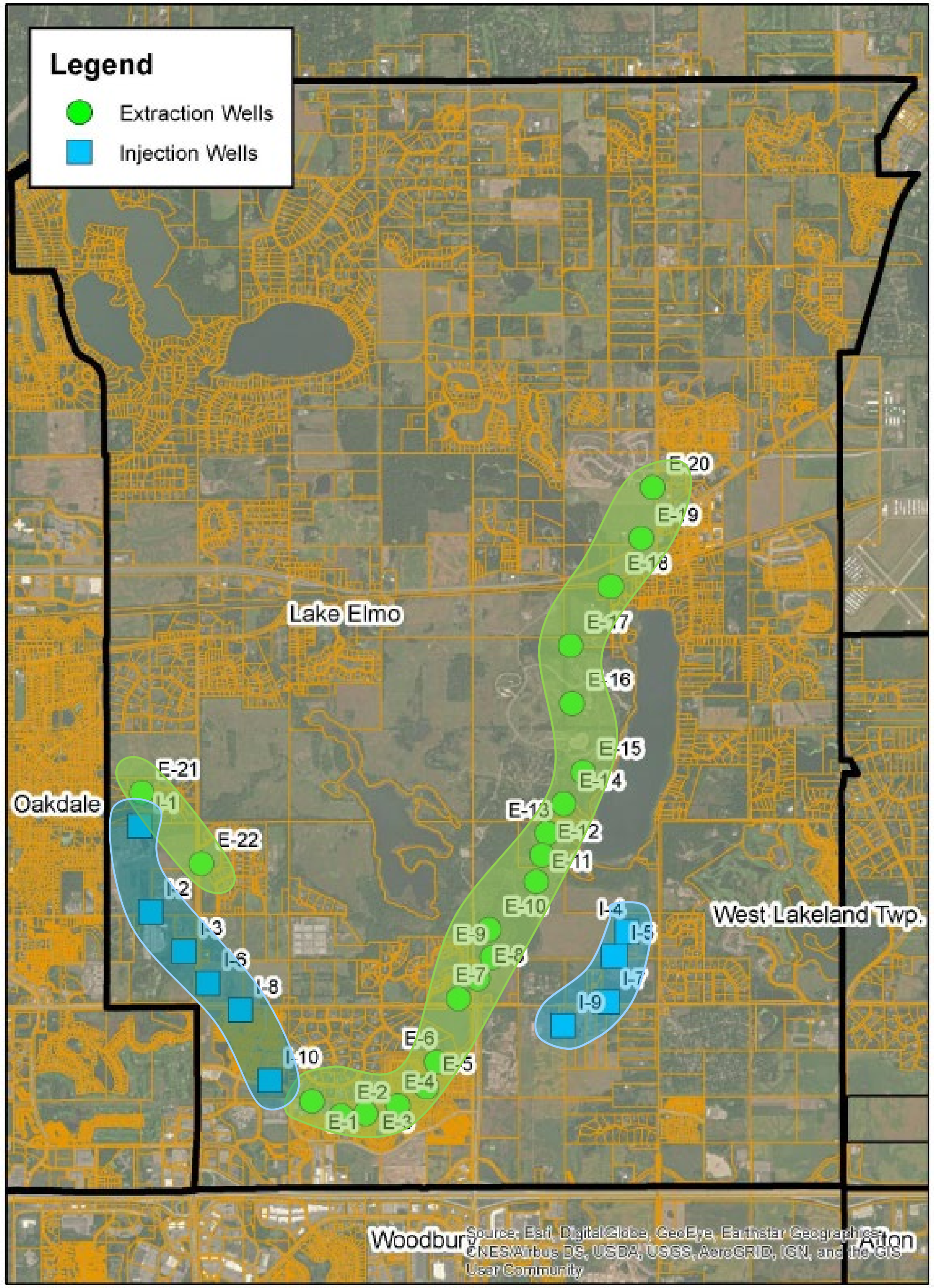
Leaky scenario



Project 1007 Injection Capacity Early Estimations

1) Developed a solution for well pumping capacity with inter-aquifer leakage based on the Hantush - Jacob solution.
2) Developed a practical mapping methodology that estimates injection capacity in areas where inter-aquifer leakage can be important.
3) Observed an average **increase in the injection capacity of about 26 percent** as compared to the nonleaky scenario (further analyses needed).
4) The developed tool can be easily applied to other leaky aquifers.

Multi-Benefit Well Array Continuous Reconfiguration



Next Step

Additional Pumping Test Data Goes into Model

Improve injection capacity estimation

Reconfigure Multi-Benefit Well Array

Near-Term Actions

Near-Term Surface Water Actions

- Drinking Water Protection Activities
  - Surface Water Actions
  - Groundwater Actions
  - Sediment Actions

How Near-Term **Surface Water Actions** Work: From Predictability to Field Pilot

Predictability test (desktop)

Bench-Scale test (lab)

WE ARE HERE

Pilot test (in-field)

Surface Water Treatment

Bench-Scale Lab Tested
Foam Fractionation

Total Bulk PFAS Removal: 79-85% in primary treatment

93-99% PFOS/PFOA removal overall

High-performance tertiary stage treatment removed down to C5 sulfonates and C6 carboxylates

Treated down to 1-10ppt PFOA, 5-10ppt PFOS

Liquid was concentrated 132x from 102L of surface water to 0.77L of hyperconcentrate

Next Steps: Procurement and Pilot-Testing

Bench-scale test – 2 stages of fractionation

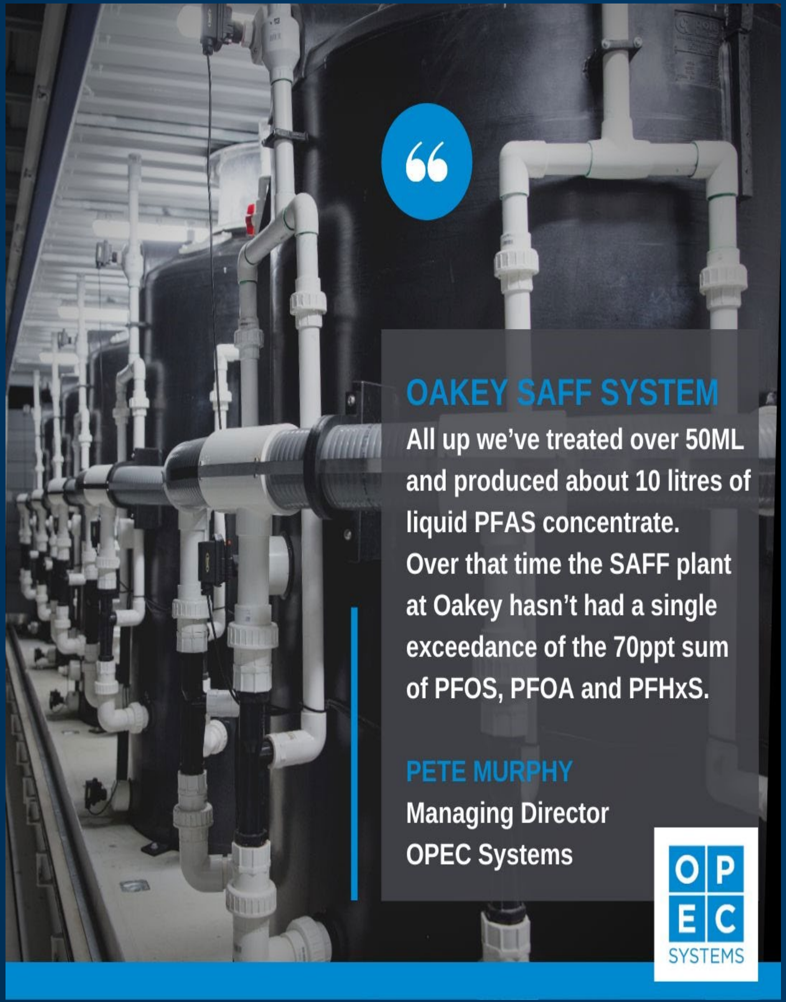
100L Raleigh Creek Water

Primary Foamate 5.73L

Secondary Foamate .77L

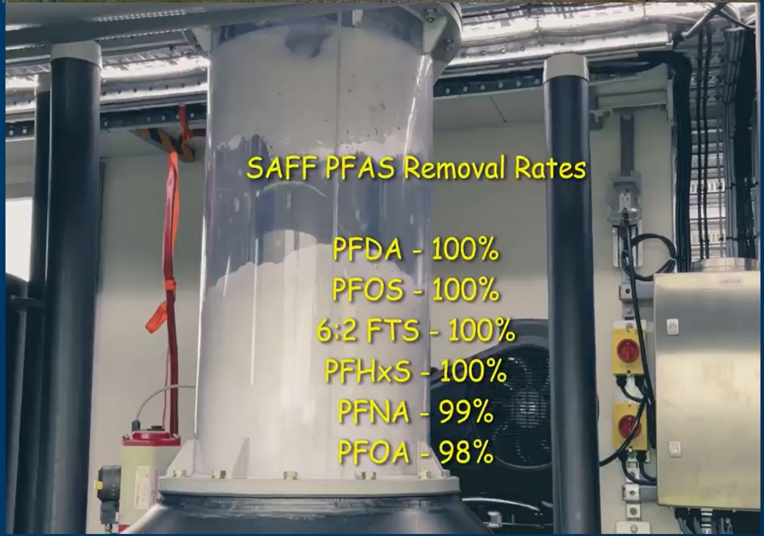
SAFF Case Studies

Australia



Sweden

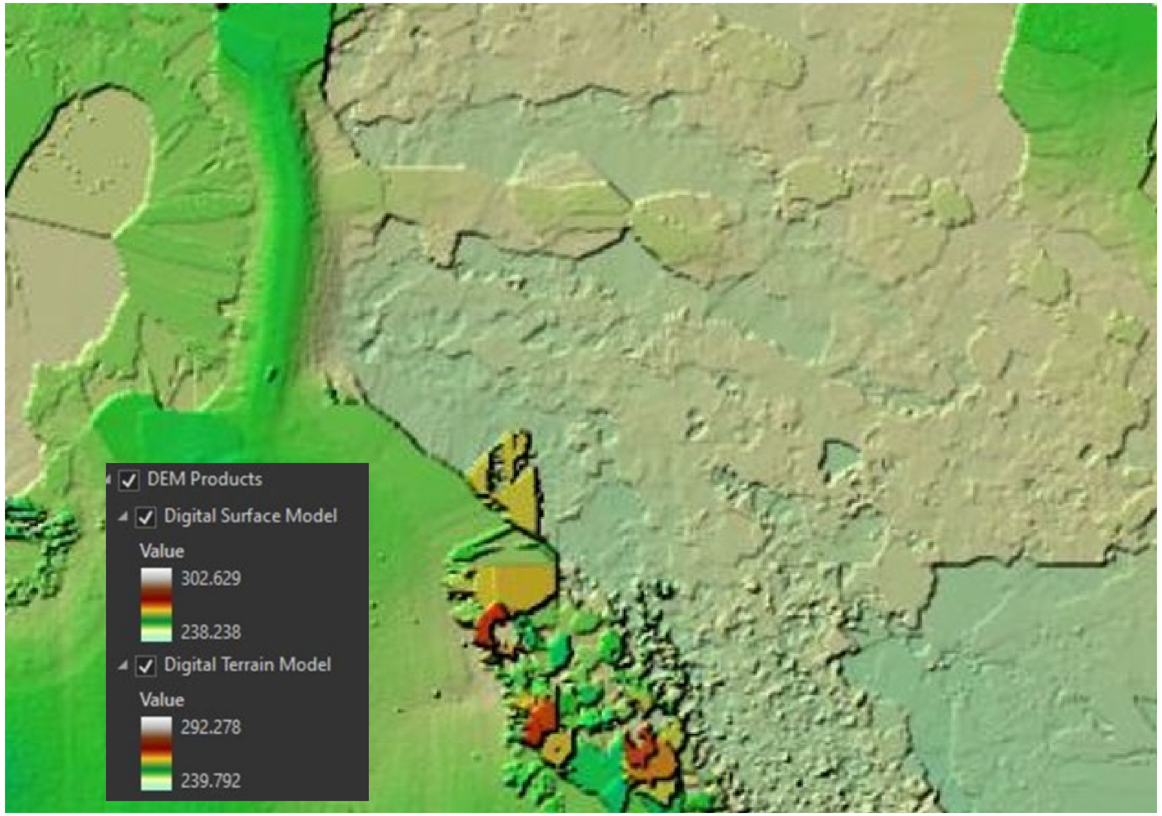
New York



Field-Implementation of SAFF Pilot Study

Potential testing locations for mobile SAFF unit

Drone Aerials and DSM/DTM Imagery



Drone coverage improves digital data and real-world considerations for corrective action considerations.

Near-Term and Long-Term High-Level Task Projections

2022

- Expanded Boundary Investigation
- Pumping Tests
- MBW Continuous Evaluation
- Foam Fractionation Pilot Study
- Monitoring
- Eco Risk Addendums

2023

- Surface Water, Groundwater, and Sediment FS Options Evaluated
- Monitoring
- MBW Continuous Evaluation
- Estimated Feasibility Study Potential Completion

2027

- Sediment and surface water actions started
- MBW Array Gradual Installation
- Iterative Evaluation of MBW array
- Local Drinking Water Connections & Installations
- O&M

2032

- Sediment and surface water actions completed
- Full MBW array functioning
- Continuous protective measures for monitoring and modeling
- O&M

2052

- Estimated pump and treat minimum timeframe for MBW array

Near-Term and Long-Term High-Level Cost Projections

FY22
- $6.3M

FY23
- $5-9M

FY27
- ~$100-223M

FY32
- $4.3M Annual O&M Costs

FY52
- Estimated Pump & Treat Minimum

Thank you

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