

Project 1007 – SG1 Update

Rebecca Higgins, PG | East Metro Unit

Gary Krueger, PSS | East Metro Unit

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Project 1007 Update

Background	Settlement Language & Context
Investigation Phases	Source Assessment Progression
Results To-Date	Surface Water, Sediment, Foam & Groundwater/Drinking Water
Risk Assessment	Human & Ecological Health
Modeling	Combined Surface Water & Groundwater Model
Drinking Water Protection: Long-Term Remedies	Multi-Benefit Well Analysis & ASR Evaluation
Drinking Water Protection: Interim Corrective Actions	Surface Water & Sediment



Background: 3M Settlement Language

- Under Priority 1 of the 3M Settlement, the MPCA *"shall conduct a source assessment and feasibility study regarding the role of the Valley Branch Water District's project known as Project 1007 in the conveyance of PFCs in the environment."*
- Other than site specific remedy implementation and temporary measures, *"the 3M Grant shall fund future projects that would have been payable under the SACO."*

Background: Project 1007 Context

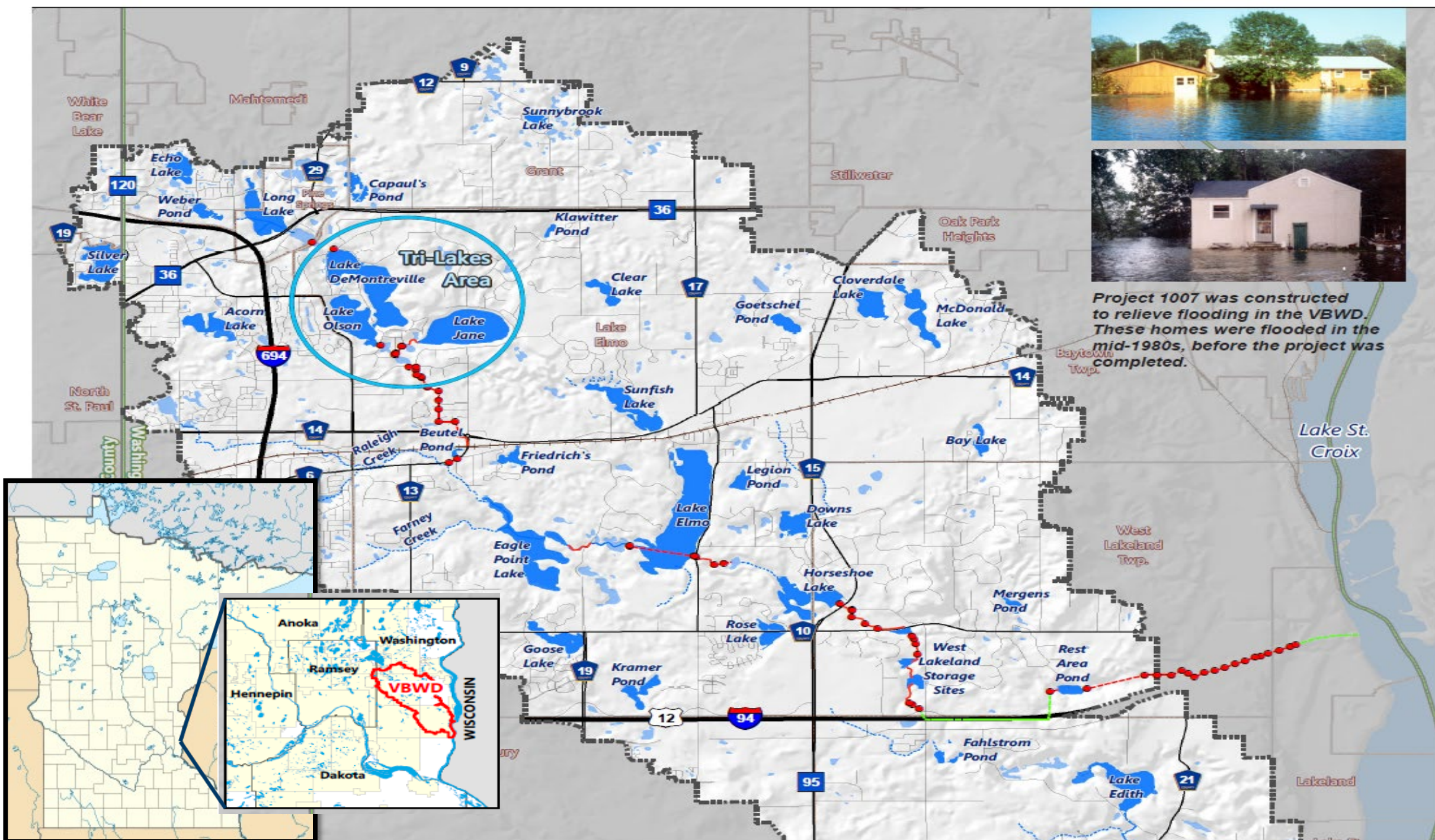
Known Facts: 3M Oakdale Site and Washington County Landfill are primary sources of PFAS that feed into the system. The full extent of the corridor may be impacted by secondary sources from PFAS-impacted sediment and surface water.

Why we are doing this work: to understand the complete picture of sources, pathways and risks to human and ecological health.

Goals: investigate the region for PFAS impacts to better understand how the contaminants move and what we can do about the multiple layers of complexities in this situation.

Key Goals

1. Determine nature of PFAS impacts to the varied media (i.e., ground water/drinking water sources, surface water, soil and sediment) across a very complex system. A robust evaluation is necessary given the variability of the system to help identify those "secondary" sources of PFAS.
2. Determine where Human Health and Ecological value exceedances are encountered across the system in surface water, sediment and groundwater/drinking water sources.
3. Create a combined surface water and groundwater model that fully evaluates that interaction, and which will be a useful tool for looking at long-term cleanup options.
4. Identify and evaluate reasonable cost-effective mitigation measures, both short and long term, to address PFAS impacts to the environment; including ground water/drinking water source control, surface water treatment and sediment removal.
5. Evaluate utilizing Multi-benefit wells as a regional groundwater option to provide safe water for drinking or other purposes, while aiding in addressing the long-term groundwater impacts.



Investigation Phases

Investigation Phases



Baseline Sampling Event

Fall 2019



Beta Phase Investigation

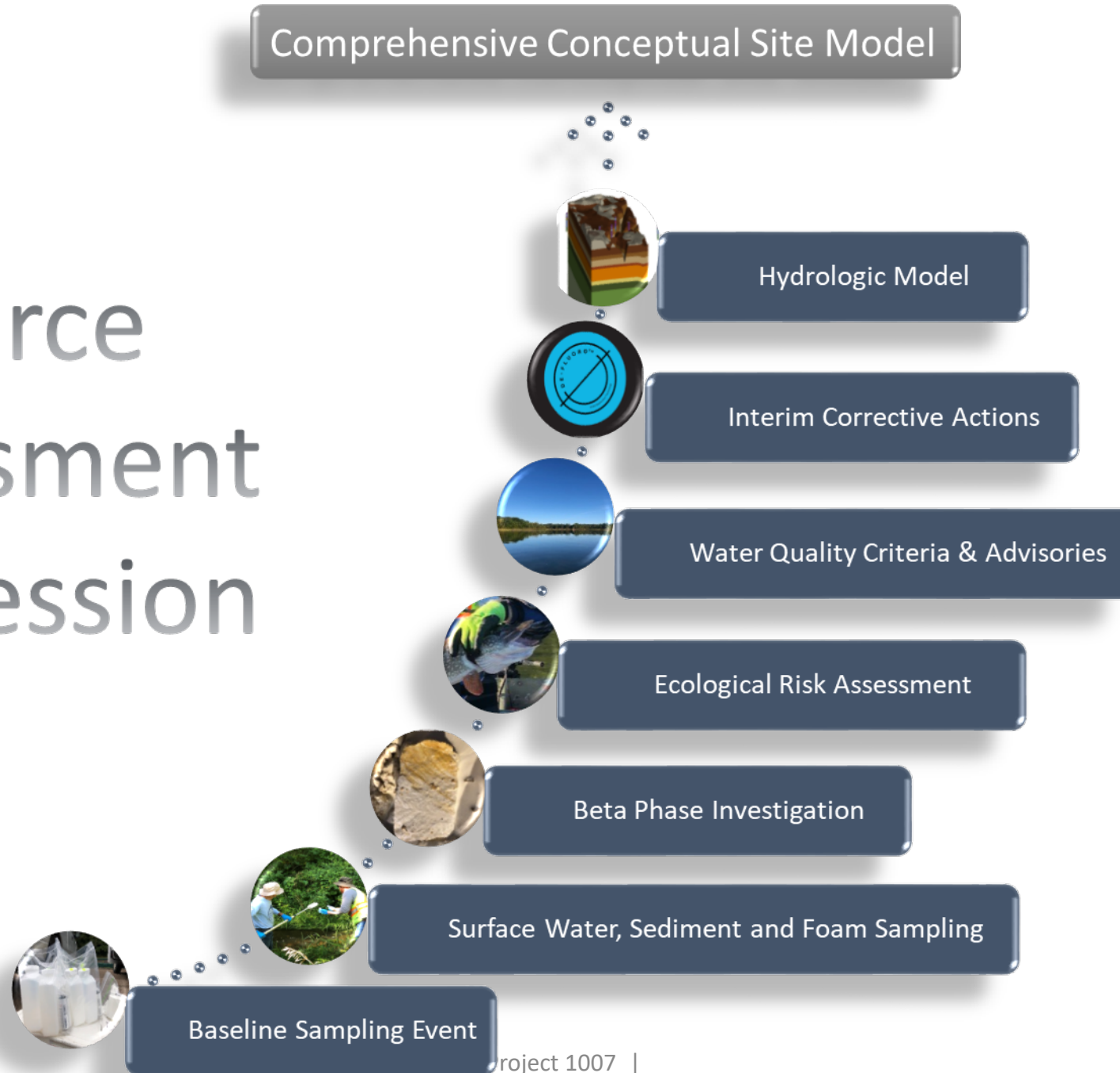
Fall 2019 – Summer 2020



Focused Investigation

Fall/Winter 2020 - 2021

Source Assessment Progression

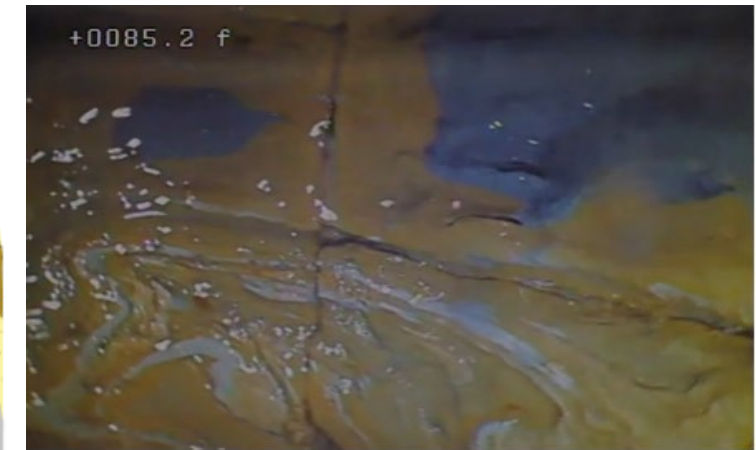
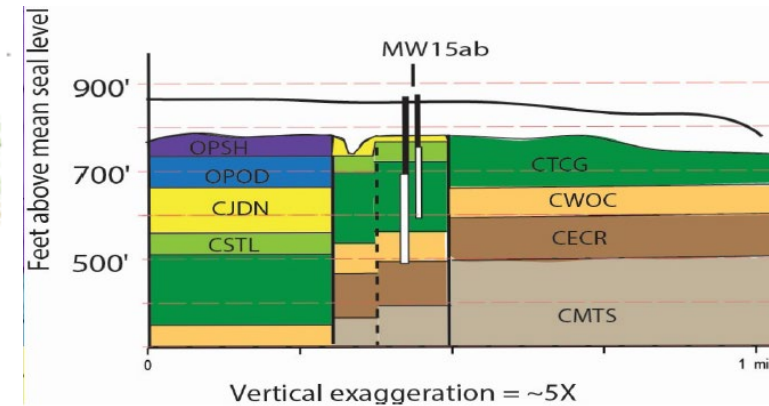
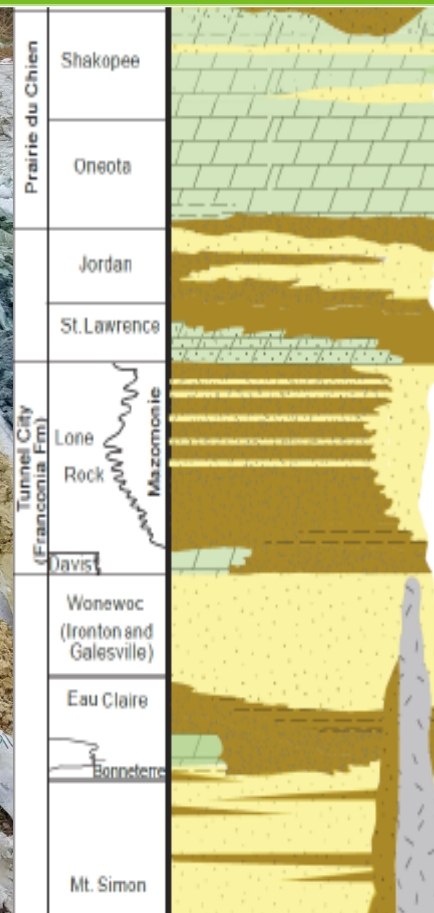
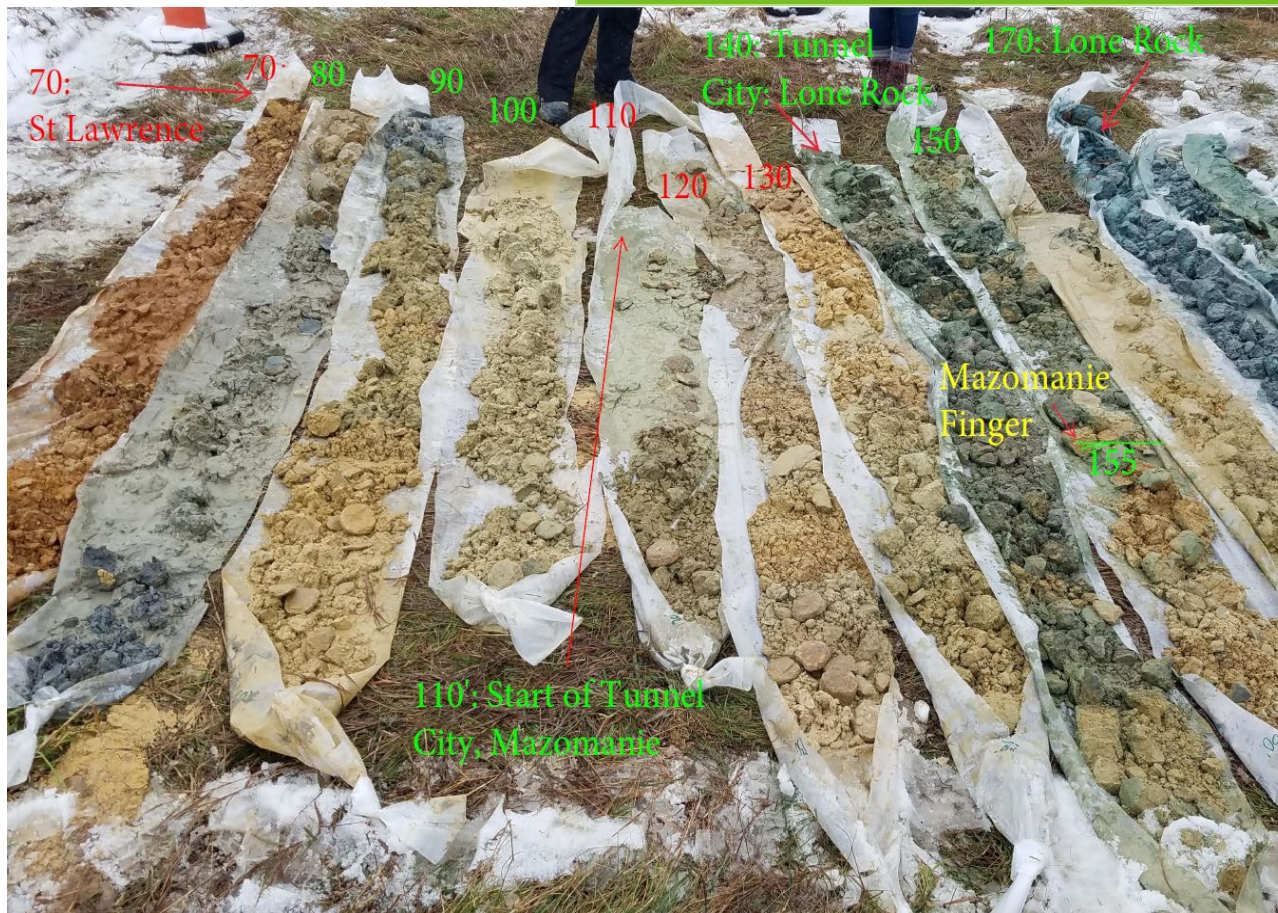


Beta Site Investigation – Bedrock Wells

Example of Rotosonic-Drilled Bedrock Well Core Characteristics

Brittle deformation and horizontal fractures

Near suspected cataclastic shear zone of Cottage Grove fault



Beta Site Investigation – Shallow Wells

Nested shallow wells installed at depth intervals with high PFAS concentrations from Vertical Aquifer Profiling (VAP) sampling.



Geoprobe Rig

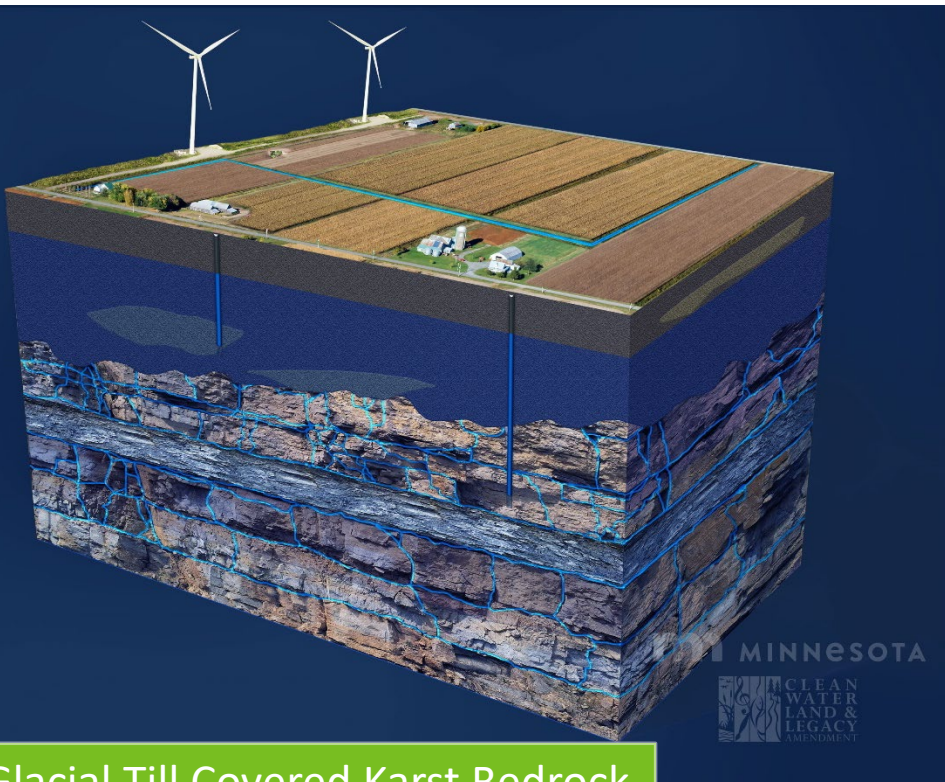
Shallow wells used to assess both seasonal variation in PFAS concentrations at-depth and hydrogeologic properties.



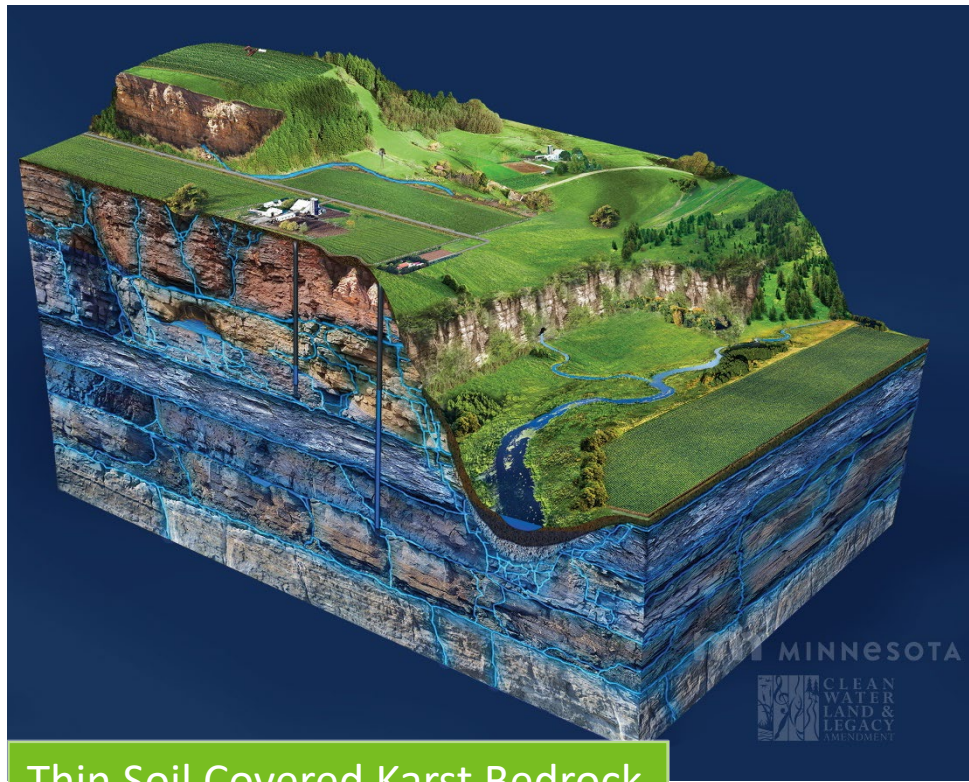
Mini Track-Mounted Sonic Rig
(for wells greater than 70' bgs)

Regional Hydrologic Connections - Drinking Water Risks

By understanding PFAS characteristics and the concentrations in foam, surface water, sediment and groundwater, we can incorporate the physical setting to better understand drinking water risks.



Glacial Till Covered Karst Bedrock



Thin Soil Covered Karst Bedrock

Understanding these physical and chemical relationships between foam, surface water, sediment and groundwater pathways is key to Project 1007 outcomes.

Vertical and horizontal movement across geologic features is a focus of the investigation.

Results To-Date

Overview of Results

33 PFAS compounds analyzed by AXYS and ALS laboratories

Methods MLA 110 or 537M by Liquid Chromatography-Tandem Mass Spectrometry using isotope dilution

Total Oxidizable Precursor Assay (TOP or TOPA) for forensic analysis of PFAS that may oxidize/weather

Additional chemistry:

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

Media Sampled

Surface water
Groundwater
Soil
Sediment
Foam
Aquatic Life Tissues

Units Refresher:

ng/L = ppt

μg/L = ppb

mg/L = ppm

μg/mL = ppm

Drinking Water

Surface Water

Wastewater &

Some Foams

pg/g = ppt

ng/g = ppb

μg/kg = ppb

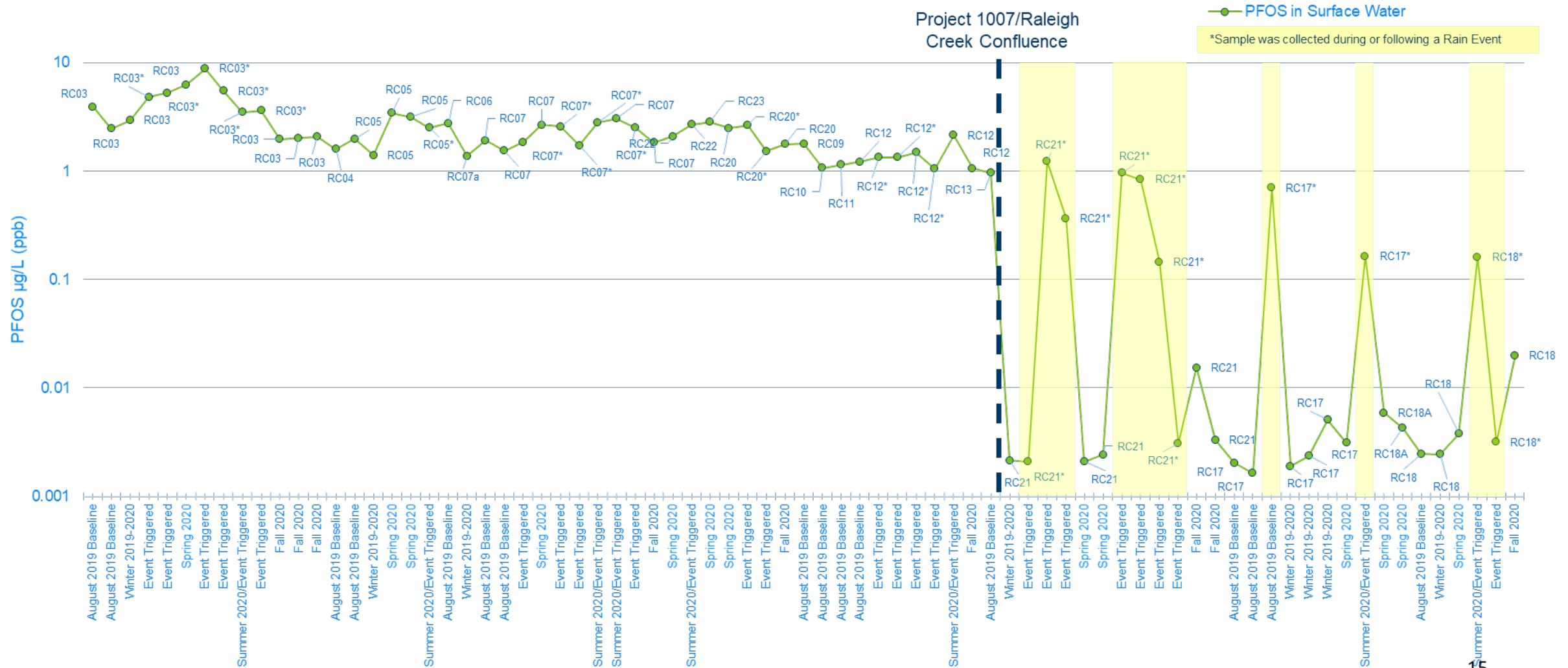
mg/kg = ppm

Not typical

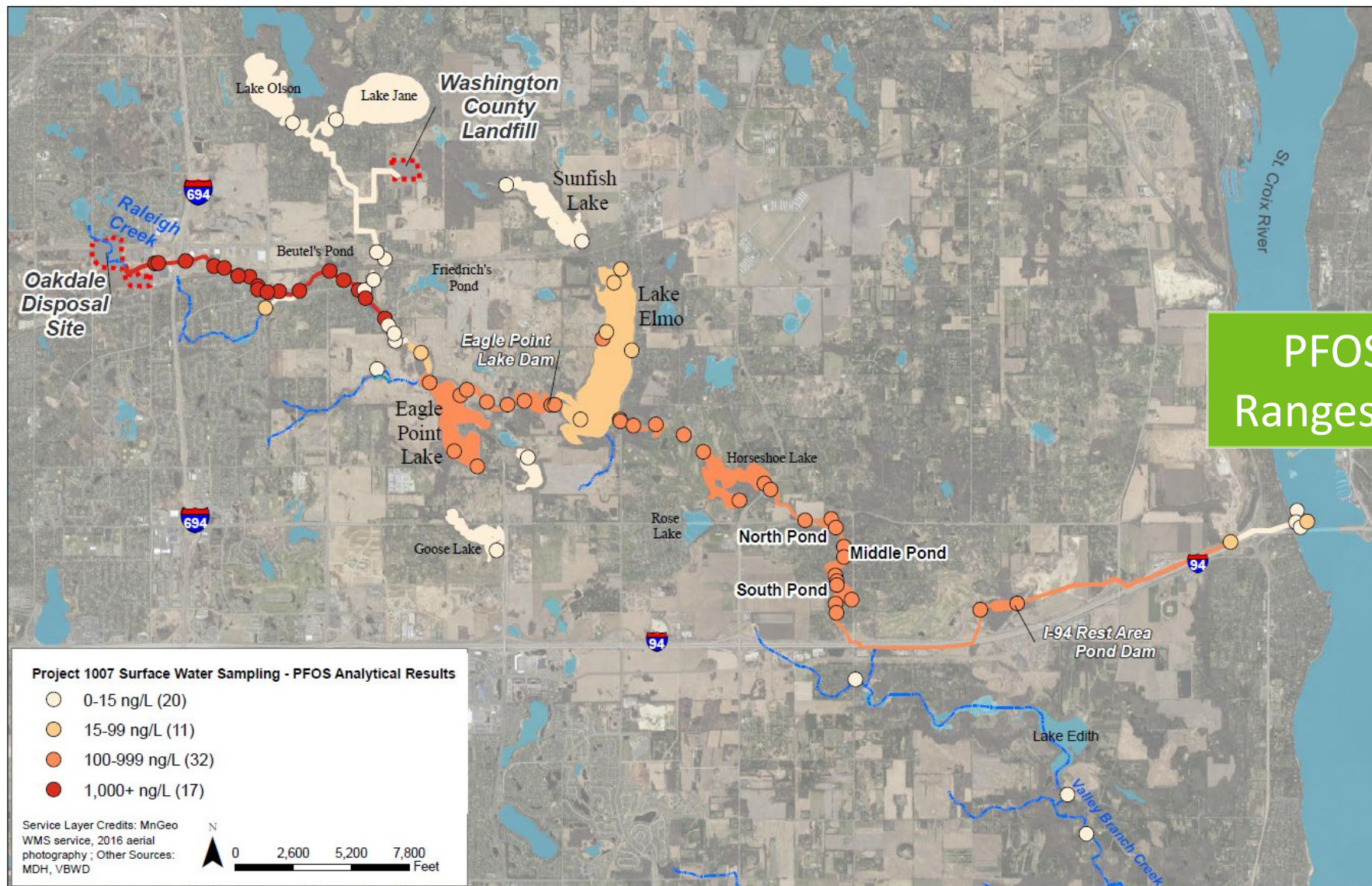
Tissues &
Sediment

Soil

Results To-Date: Surface Water Pulses of PFOS



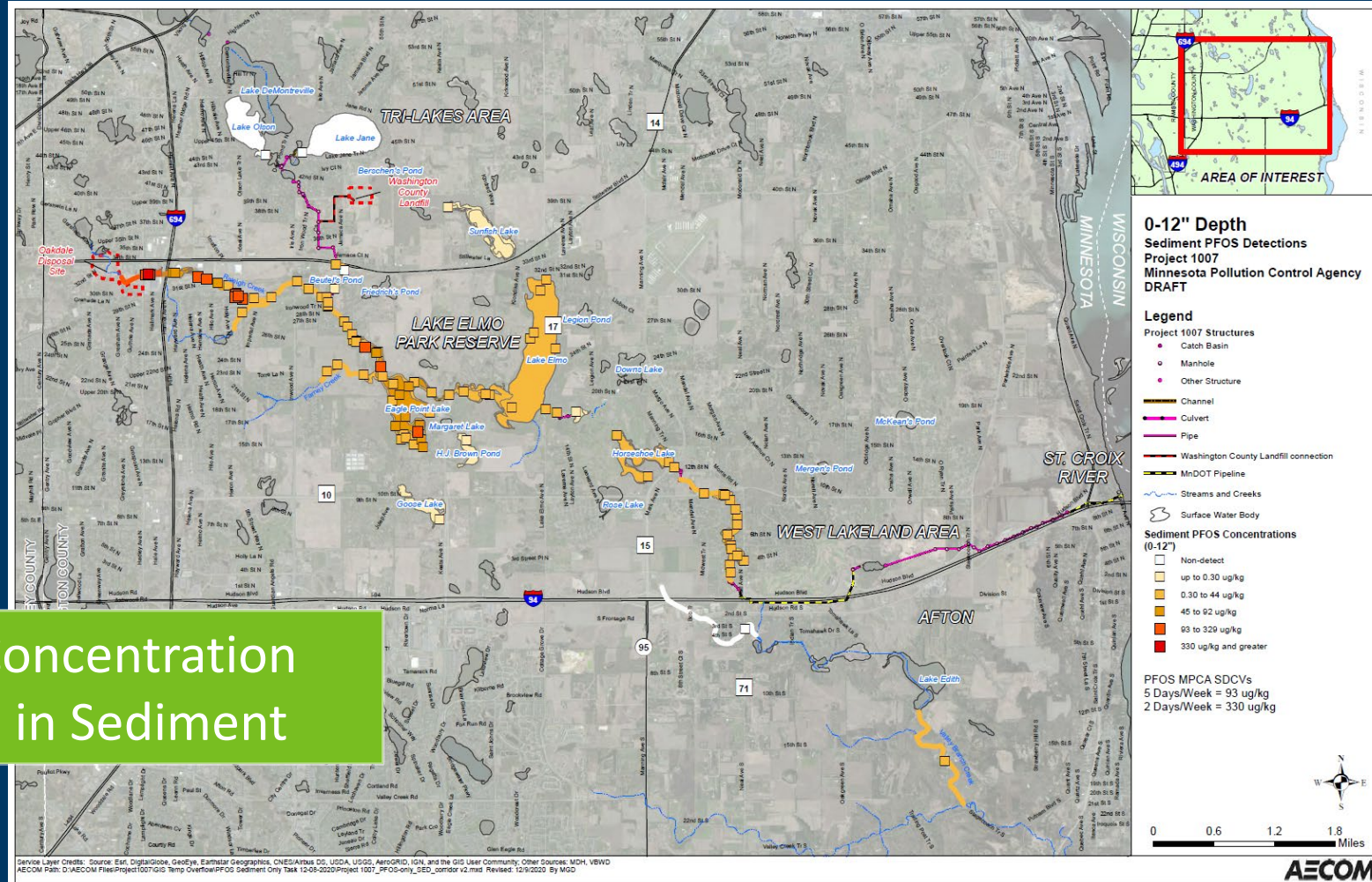
Results To-Date: Surface Water Impacts and New Surface Water Quality Criteria



PFOS Concentration
Ranges in Surface Water

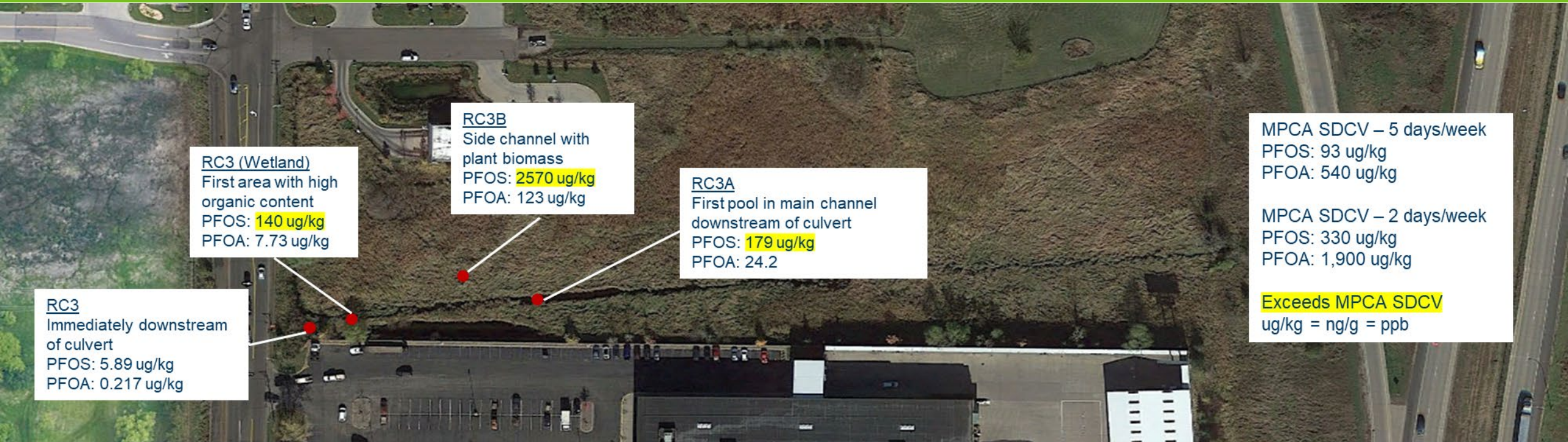
Site-Specific Water
Quality Criteria
0.05 ng/L (ppt)

Results To-Date: Sediment Impacts and Sediment Cleanup Values

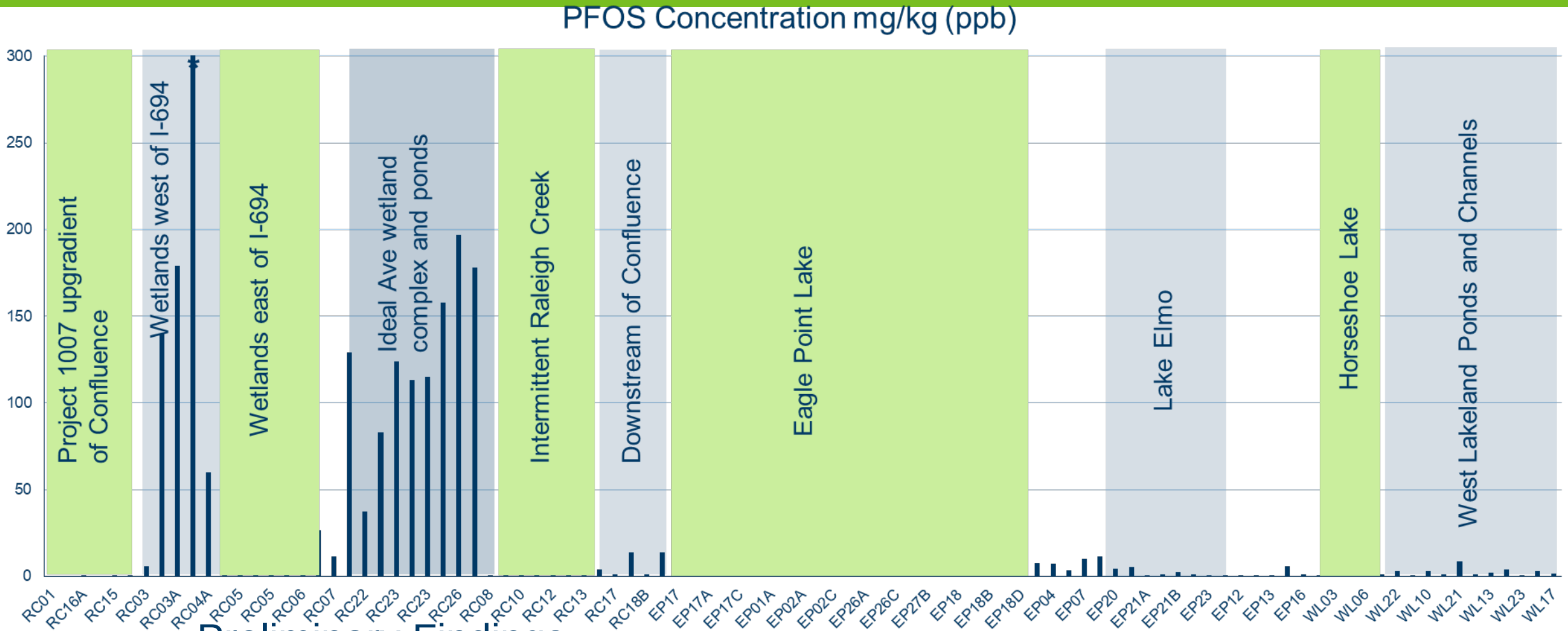


PFOS Concentration
Ranges in Sediment

Example of Sediment Sinks: Wetland Downgradient of Oakdale Disposal Site (West of I-694)



PFOS Concentrations in Sediment Across Corridor



Preliminary Findings

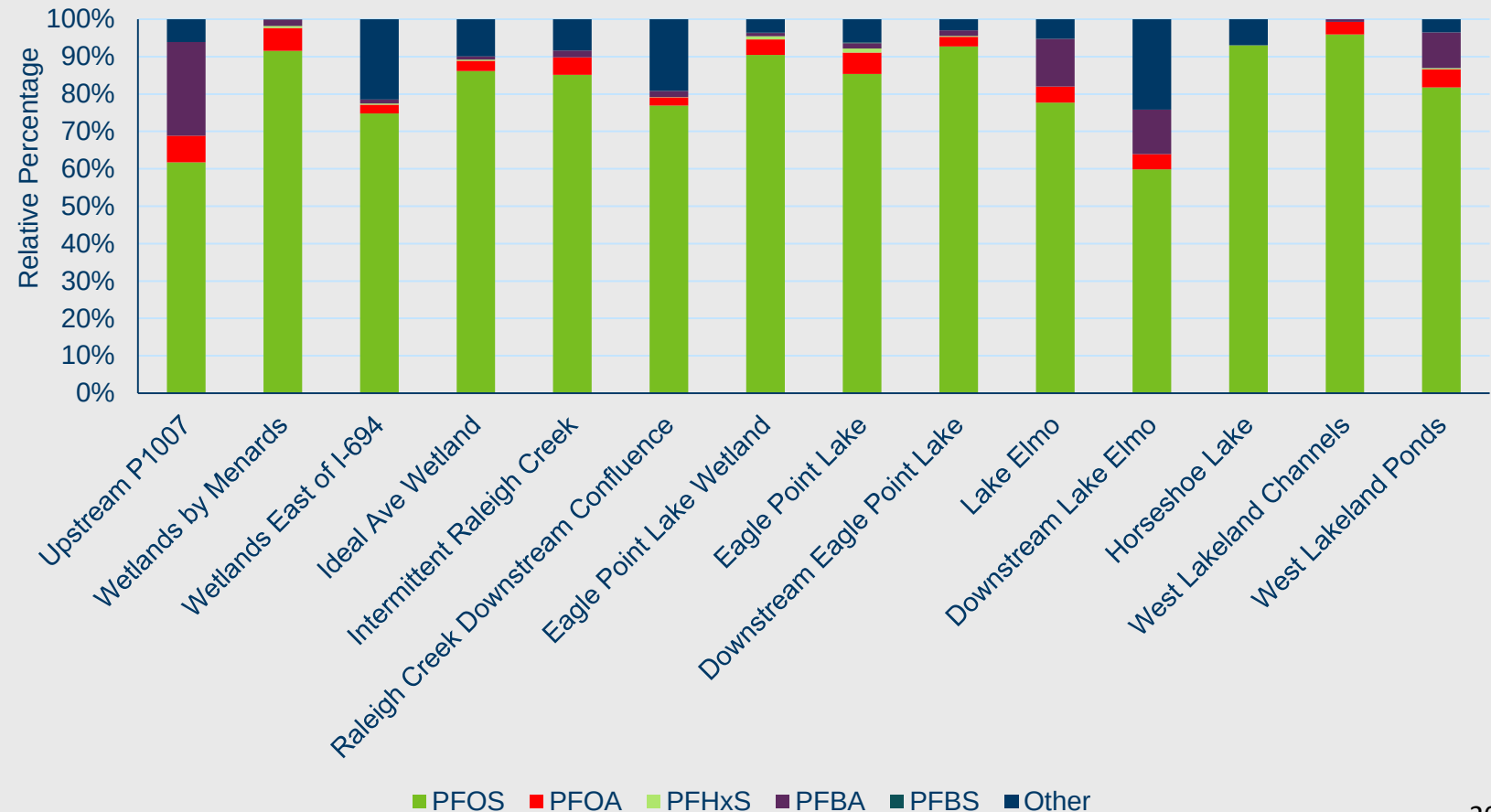
Highest concentrations in sediment observed in wetland areas directly downgradient of Oakdale Disposal Site and in Ideal Avenue wetland complex.

Distribution of Specific PFAS in Sediment

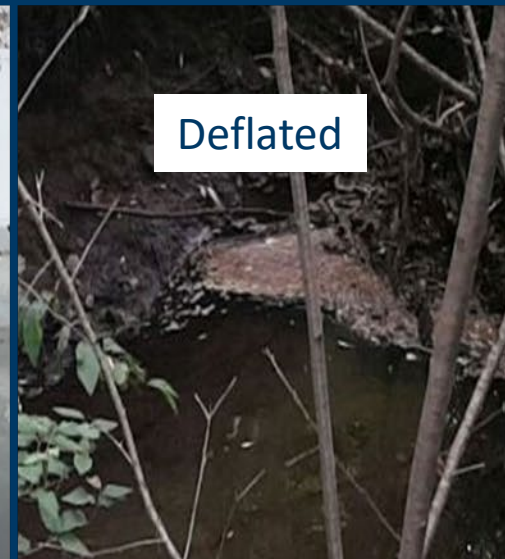
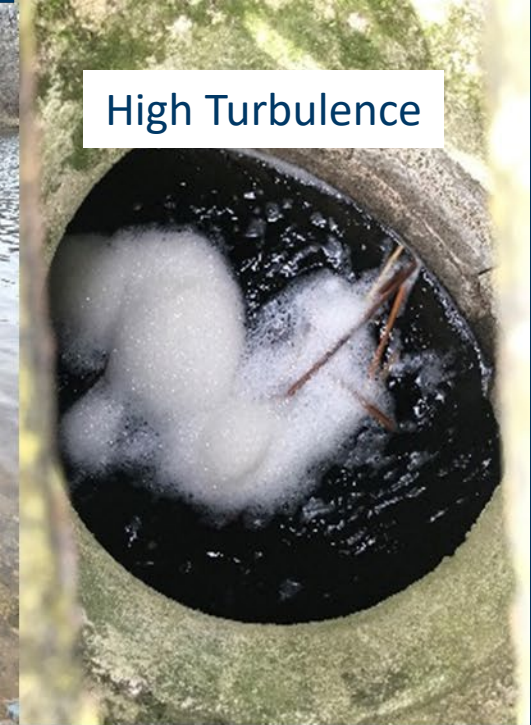
Preliminary Findings

- Sediment in locations upstream of the Confluence and Lake Elmo have a higher relative percentage of PFBA
- PFOS is consistently the highest PFAS compound concentration in sediment

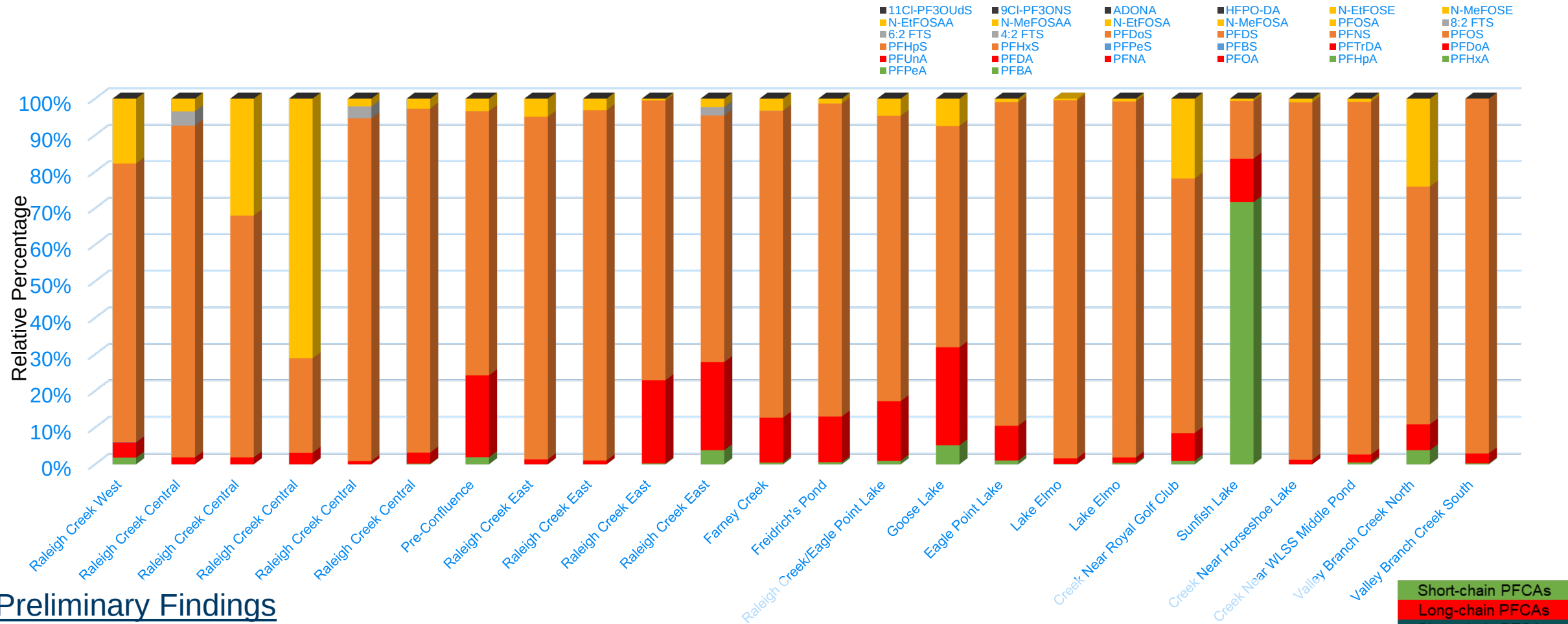
Average Relative Percentage of PFAS Compounds Across Project 1007 to West Lakeland Ponds



Results To-Date: Observed Foam Characteristics and Foam Concentrations

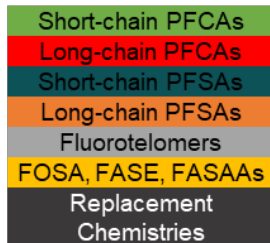


Project 1007 PFAS Compound Distribution in Foam



Preliminary Findings

- Foam samples are overwhelmingly comprised of long-chain PFASs (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





Risk Assessments

Risk Assessment Overview

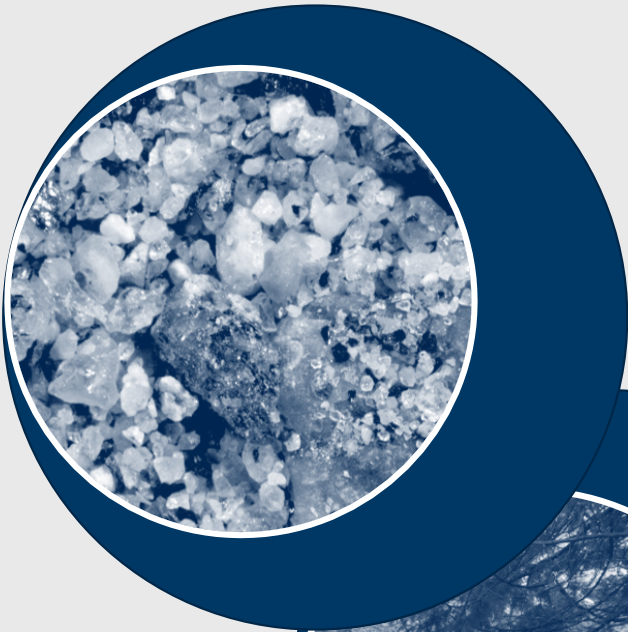
Human Health Exposure Routes –
Drinking Water, Incidental Ingestion,
Recreational, and Fish/Deer Consumption

Ecological Health Exposure Routes –
Surface Water, Incidental Ingestion, Food
Web/Consumption

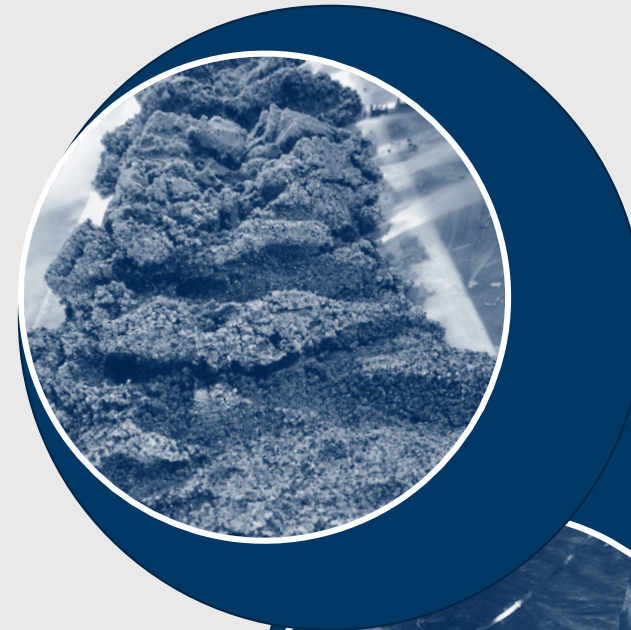


Non-Drinking Water Health Risk Values

Sediment



Soil



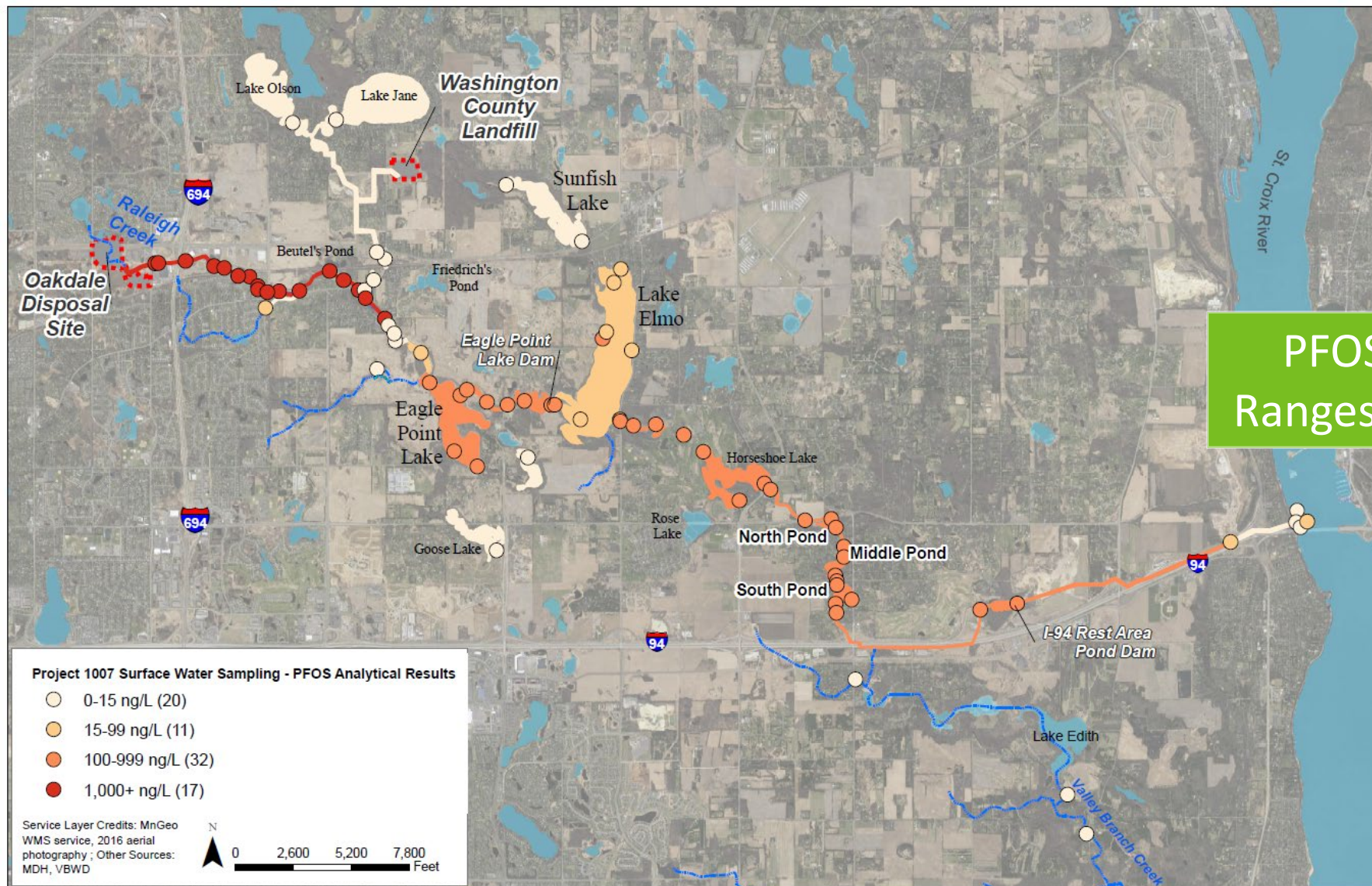
Surface Water



Foam



Risk Assessment: Surface Water Impacts and New Surface Water Quality Criteria



PFOS Concentration
Ranges in Surface Water

Site-Specific Water
Quality Criteria
0.05 ng/L (ppt)

Baseline Ecological Risk Assessment Field Collection

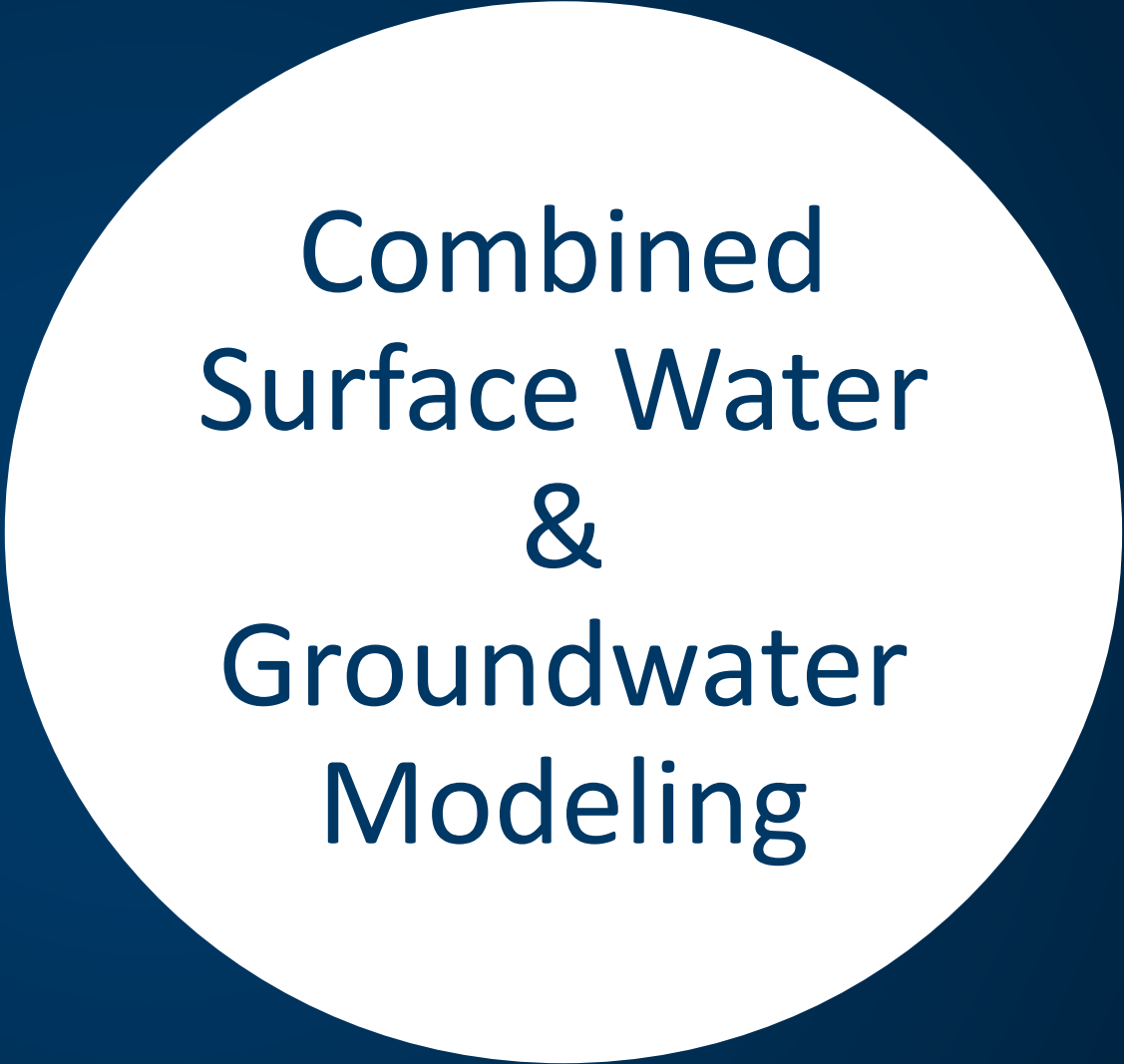
Assessment EndPoints

Protection and maintenance of ecological communities at levels similar to those of nearby populations not exposed to PFAS.

Measure of Effects (respectively)

Comparison of sediment, porewater, surface water and foam concentrations to direct toxicity screening levels.





Combined Surface Water & Groundwater Modeling

Regional Basis for 1007 Combined Model:

East Metro Conceptual Drinking Water Supply Plan Model

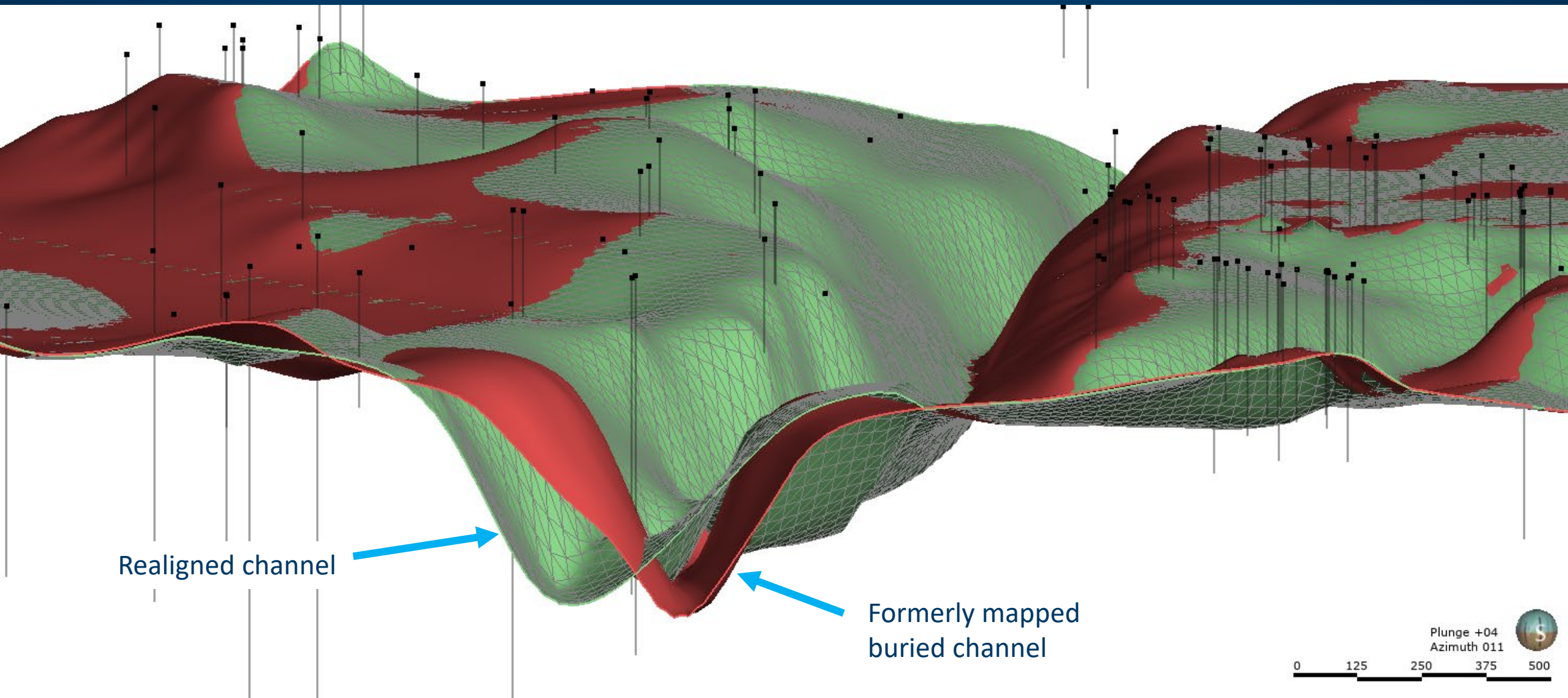
Steady-state
Non-Transient
Water Particle Flow Path Analysis
Built on Recent Models

Figure C.1. Location and extent of the model domain.

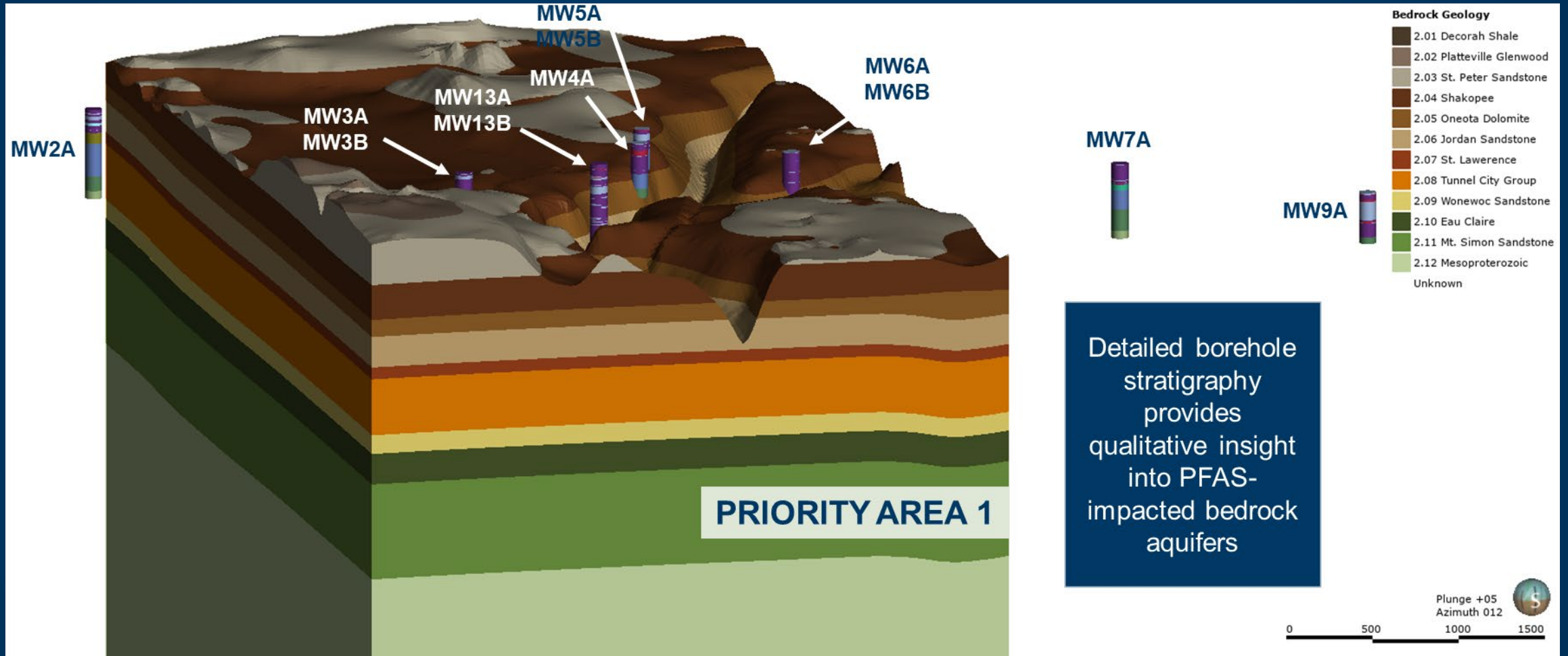


Background imagery service layer credits: Esri, Garmin, GEBCO, National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center (NGDC), and other contributors.

Leapfrog Visual Conceptual Site Model Build-Out by Sections



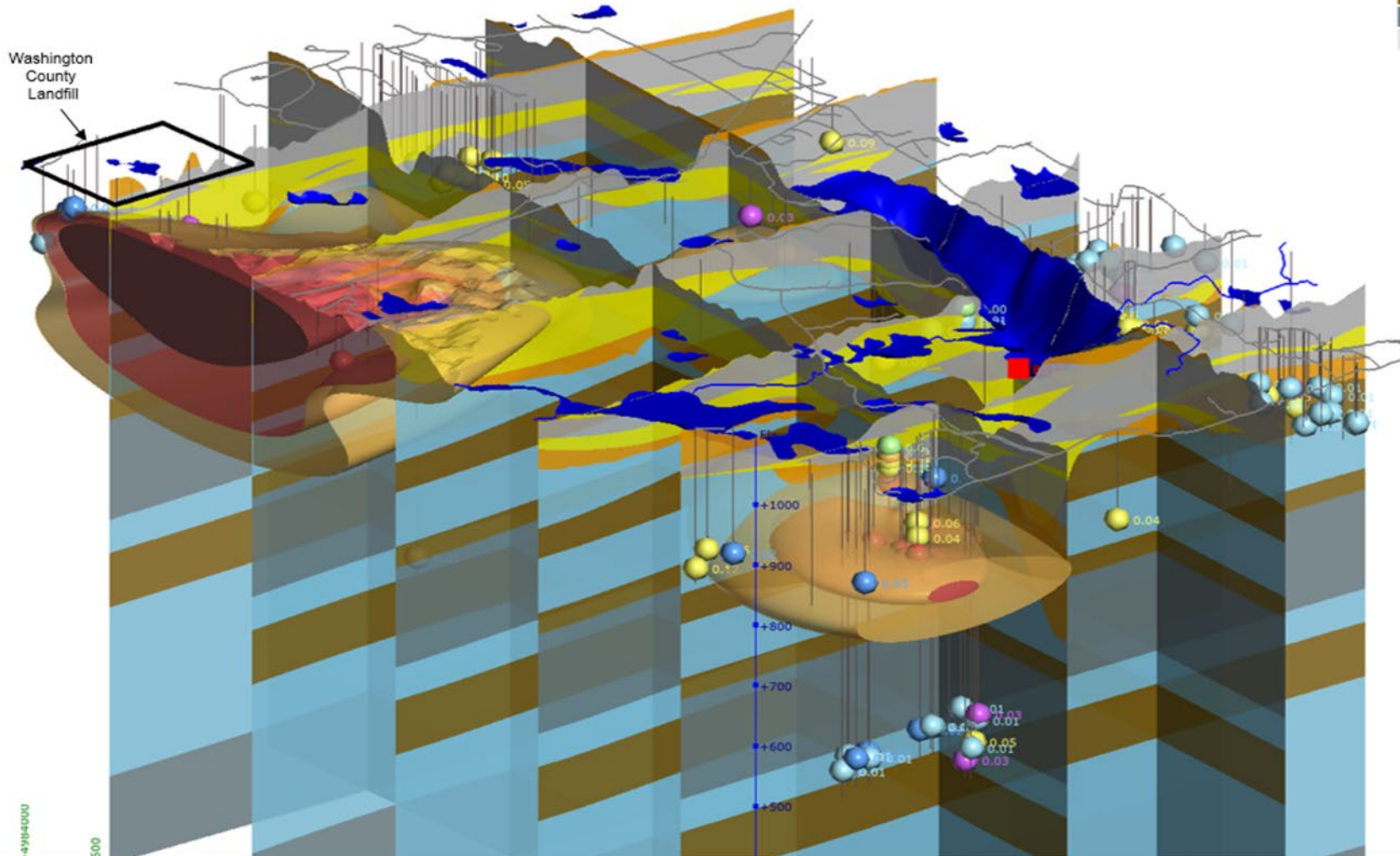
Leapfrog Visual Conceptual Site Model



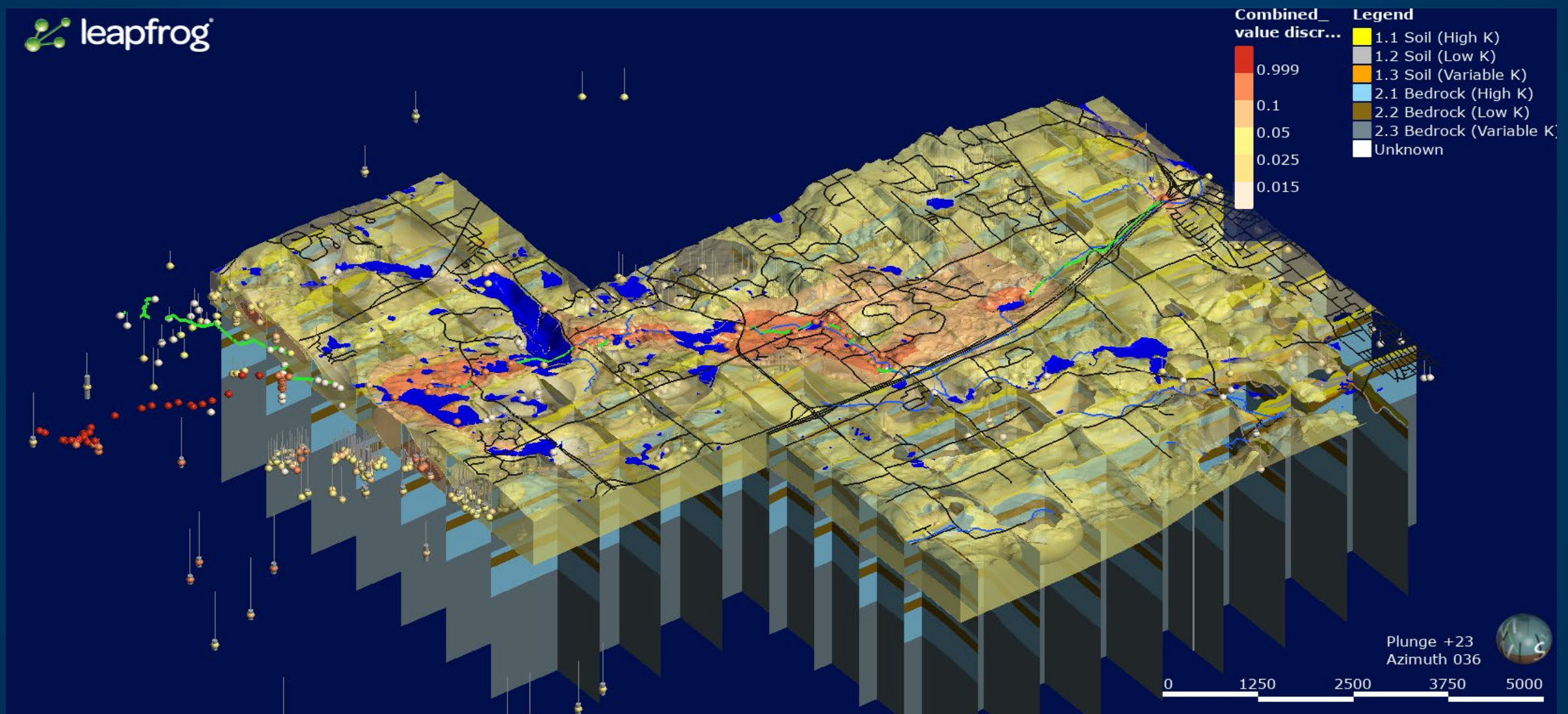
Groundwater Plume Interpolation

PRIORITY AREA 1

PFOA (Groundwater Data from 2013 to 2020)
Plumes 0.175 to 1.75 ug/L



Constructing Visual Conceptual Site Model



Multi-Benefit Well Considerations

Multi-benefit wells may be an option for consideration in the regional groundwater options to provide safe water while aiding in addressing long-term groundwater impacts.

Multi-benefit wells are bedrock wells that serve multiple functions and benefit both long-term municipal drinking water supply demands while controlling large, regional groundwater plumes, ultimately providing alternatives for demand and PFAS removals.

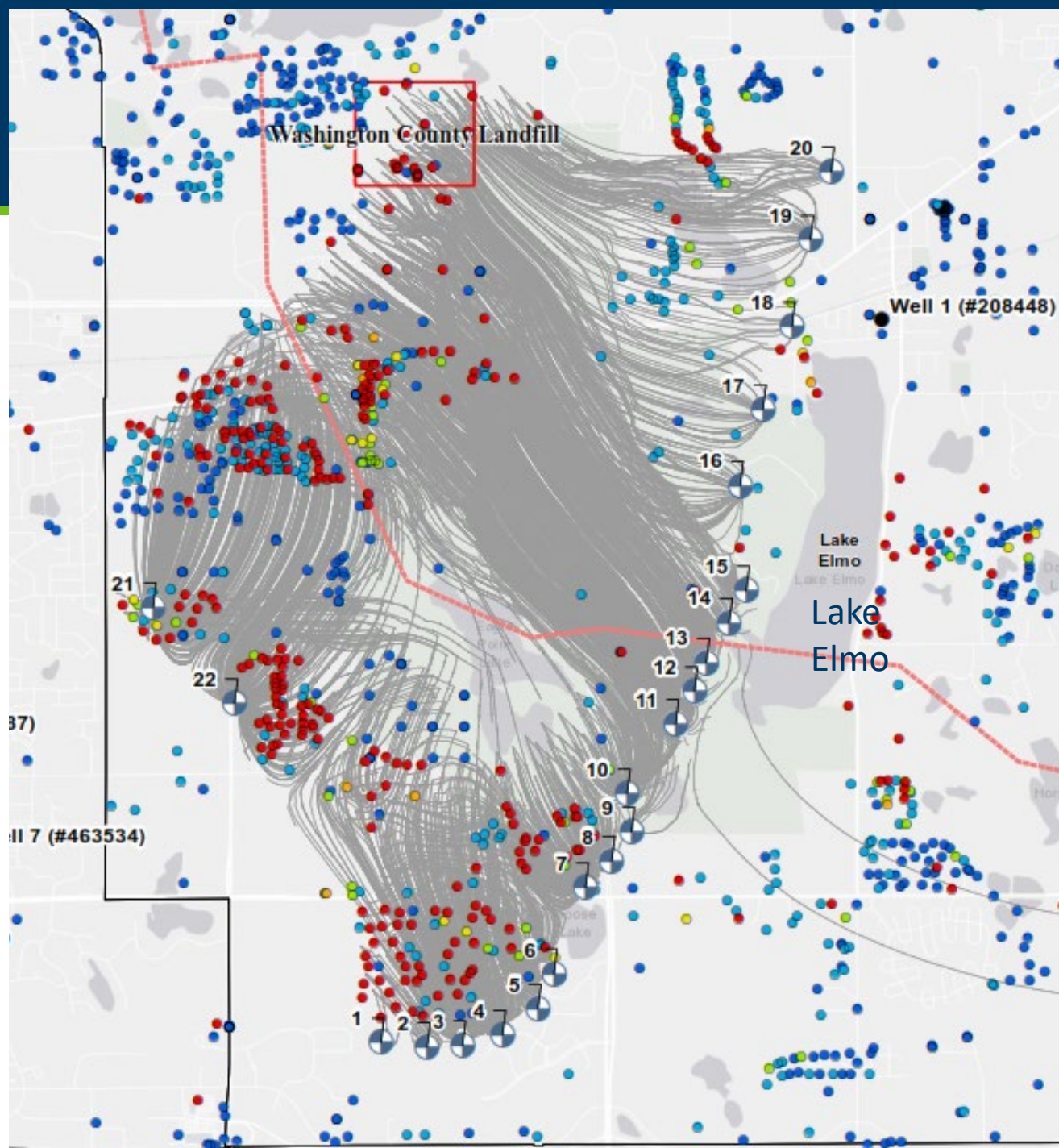
Multi-Benefit Well Simulation Objective

Model a groundwater management concept using multi-benefit wells to offset PFAS contamination by simulating the following:

- Multi-benefit extraction wells for PFAS capture and treatment, and subsequent drinking water or other reuse water supply
- Injection wells to support PFAS capture, dispose of treated water, and mitigate impacts to groundwater and lake levels

Community	2040 ADD (gpm)
Woodbury	7,528
Oakdale	2,125
Lake Elmo	1,411
Cottage Grove	3,264
Newport	261
Lakeland	250
St Paul Park	576
West Lakeland	292
Total Combined	15,707

Particle Tracking and Capture



- Particles placed in areas where $HI > 1$
- Multi-benefit wells located for capture of particles

Multi-Benefit and Injection Wells

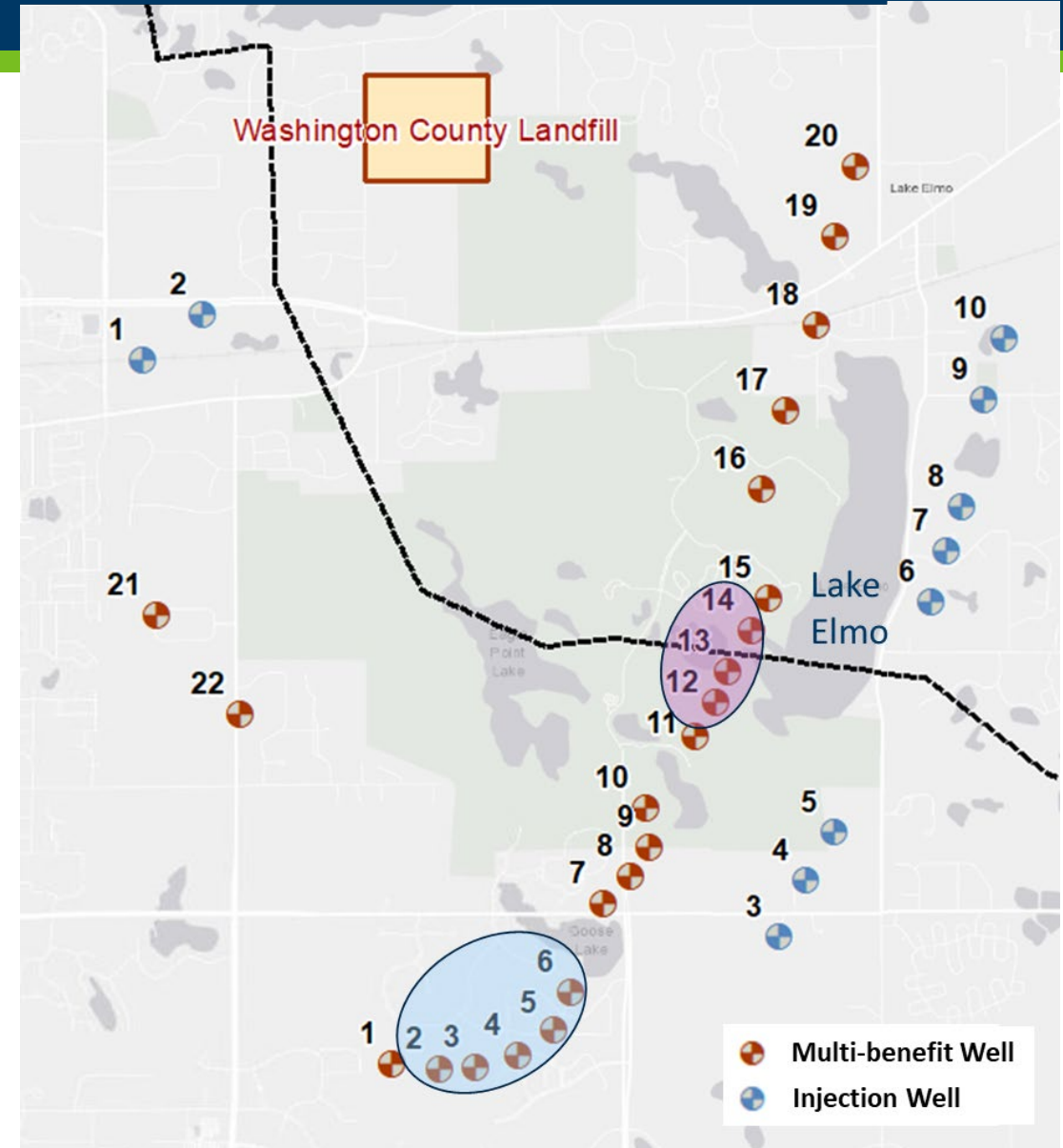
Combined Extraction Rate: 10,550 gpm (67% total ADD)

Total Extraction (gpm)	2040 ADD (gpm)		Total Injection (gpm)
	Oakdale	Lake Elmo	
10,550	2,125	1,411	7,014

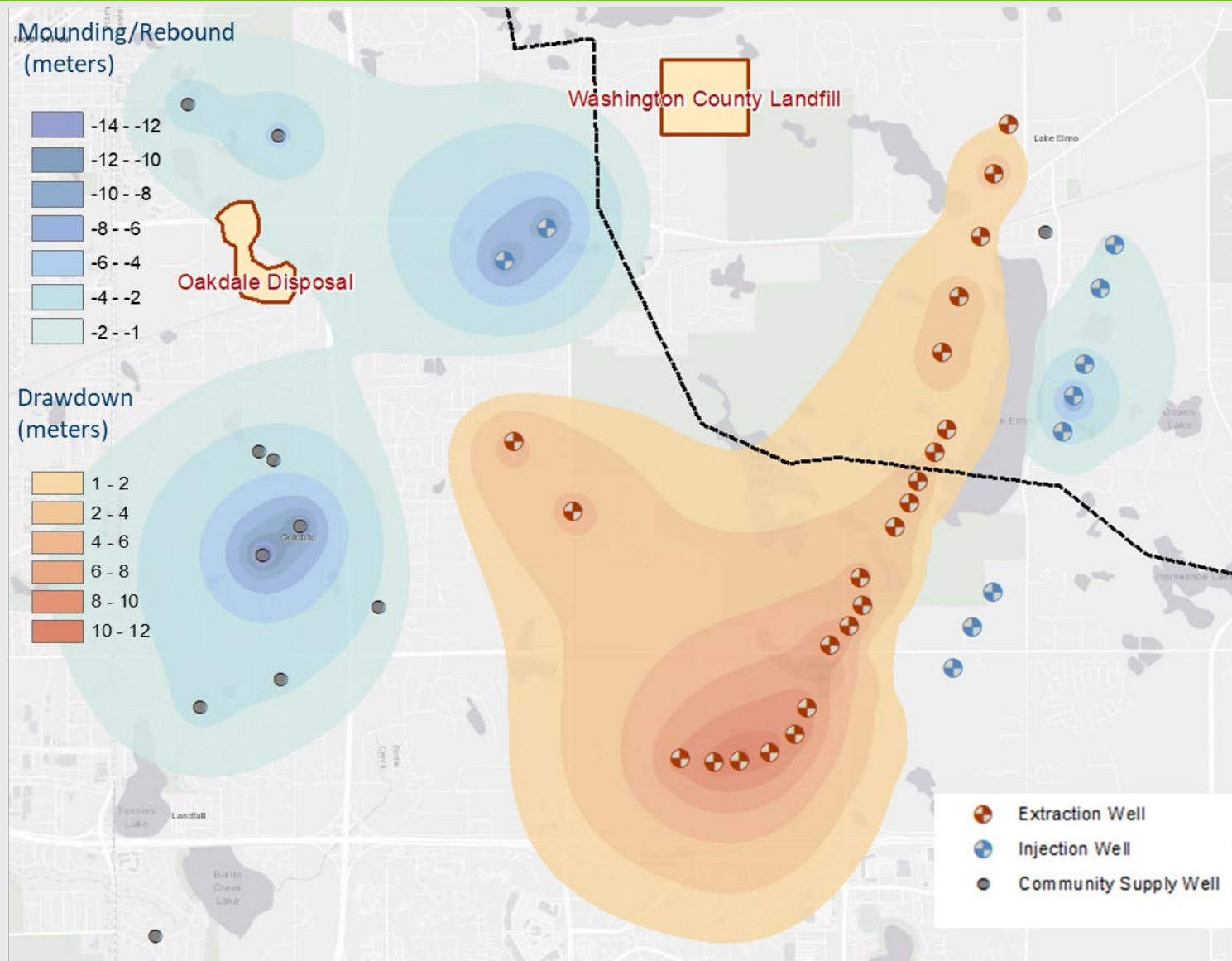
Well ID	Rate (gpm)	Drawdown (m)		Available Head (m)		Percent of Available Head	
		Prairie Du Chien	Jordan Sandstone	Prairie Du Chien	Jordan Sandstone	Prairie Du Chien	Jordan Sandstone
1	400	9	9	22	67	41	13
2	400	11	11	20	66	57	17
3	400	12	12	19	65	62	18
4	400	12	12	18	65	65	18
5	400	10	10	17	65	58	16
6	550	10	10	17	64	57	15
7	550	8	8	17	64	46	13
8	400	6	7	33	64	19	10
9	400	4	5	44	63	9	7
10	500	4	5	19	62	24	8
11	500	2	3	25	58	10	4
12	500	2	3	0	57	0	5
13	550	2	2	0	57	0	4
14	600	2	2	0	57	0	4
15	500	2	2	19	57	10	4
16	400	3	3	11	57	26	6
17	500	3	3	11	57	27	6
18	600	1	2	27	57	5	3
19	550	3	4	18	58	17	7
20	550	1	1	13	48	6	2
21	500	6	6	37	75	16	8
22	400	6	6	33	72	19	8

Exceeds 50% available head (Prairie Du Chien)

Prairie Du Chien not present



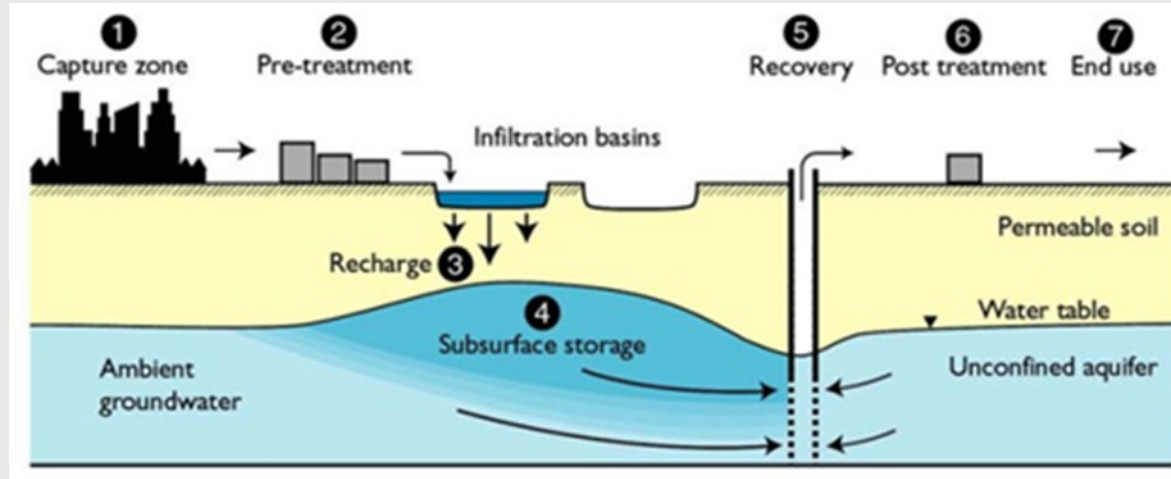
Drawdown/Mounding & Rebound in Jordan Sandstone



- Evaluate multi-benefit extraction wells for PFAS capture, treatment, and drinking water supply at a high, initial level of modeling
- Offset cumulative impacts to groundwater and lake levels from pumping
- PFAS capture volume could account for more than half the 2040 groundwater demand
- PFAS removal from groundwater is active and accelerated

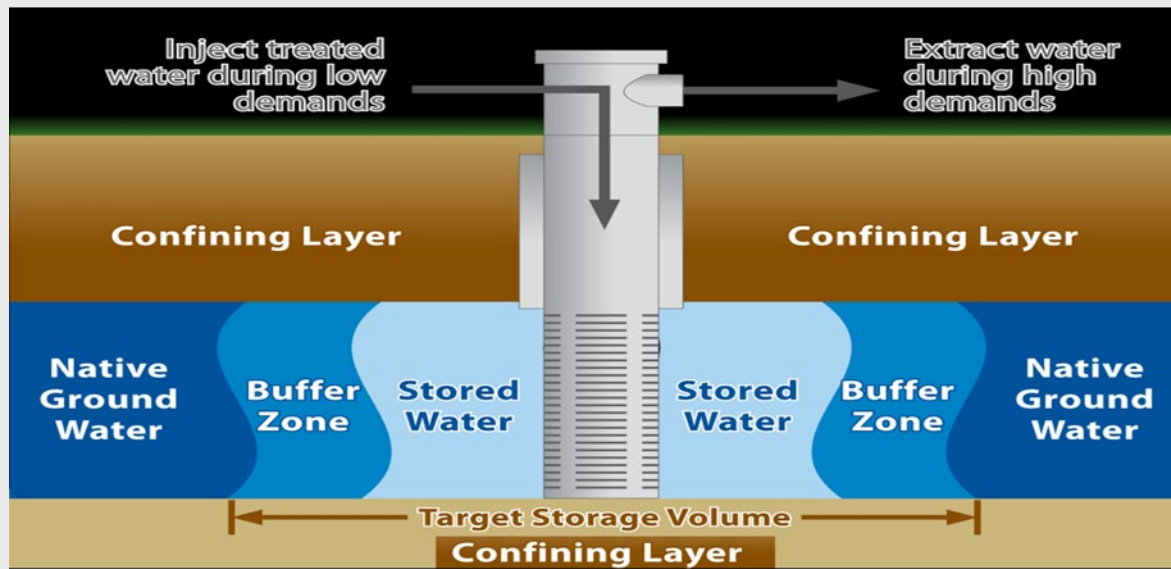
Managed Aquifer Recharge

Passive aquifer recharge



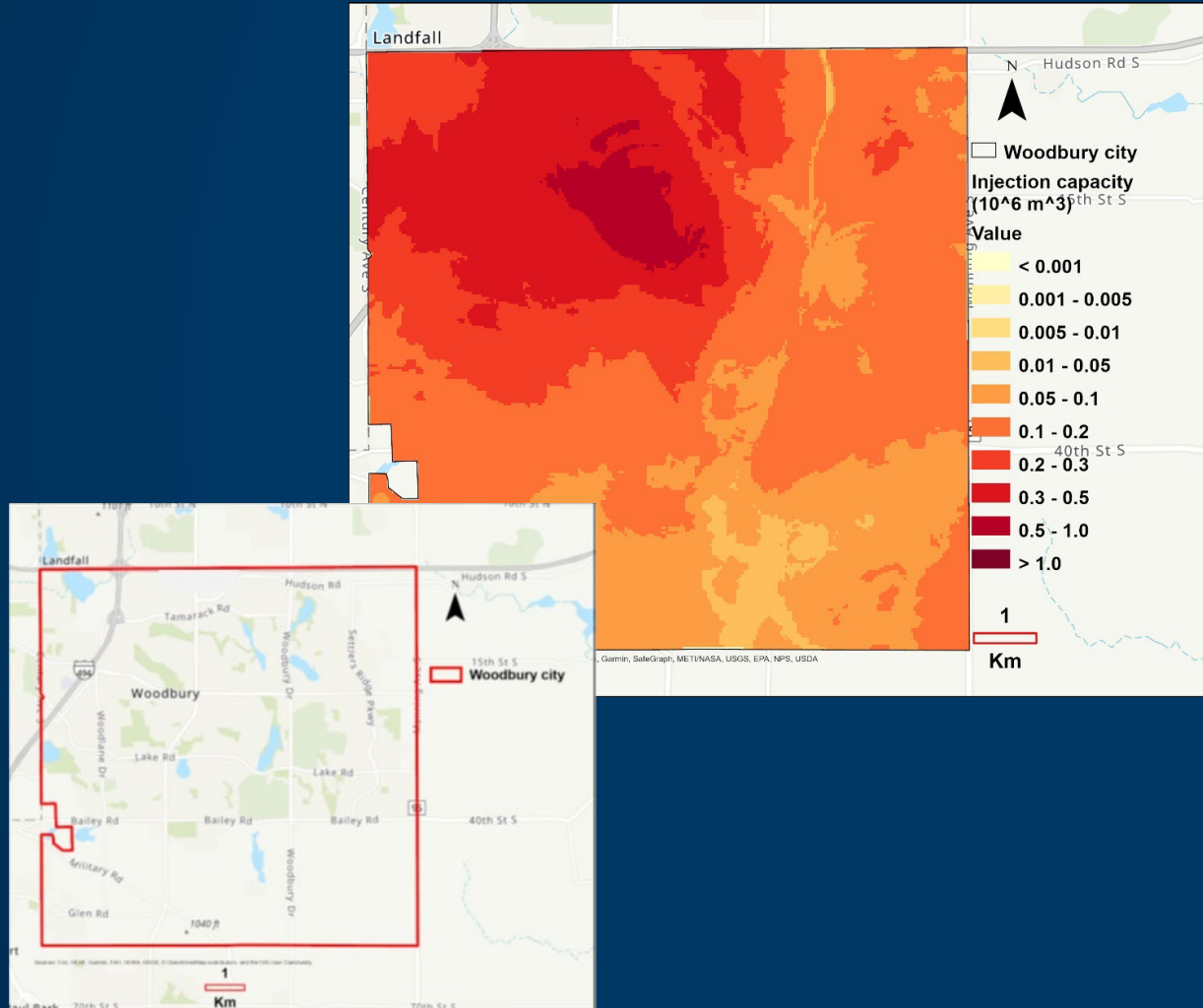
- Recharge through infiltration
- Common in Minnesota

Active – aquifer storage and recovery (ASR)



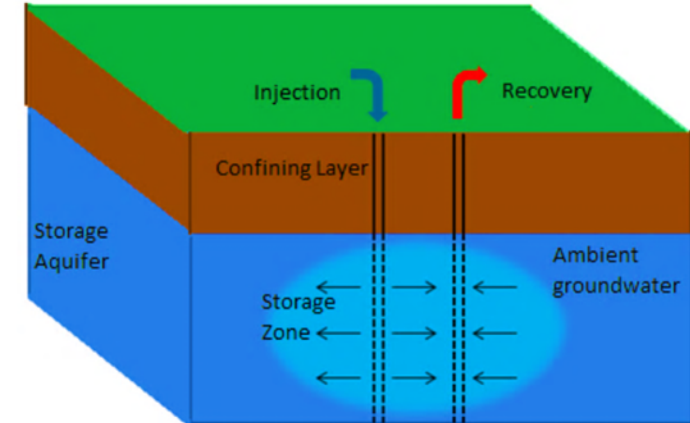
- Recharge via direct injection
- Inject during periods of surplus
- Withdraw when needed
- Only one system in Minnesota
- Common elsewhere

Woodbury Managed Aquifer Recharge - ASR Example



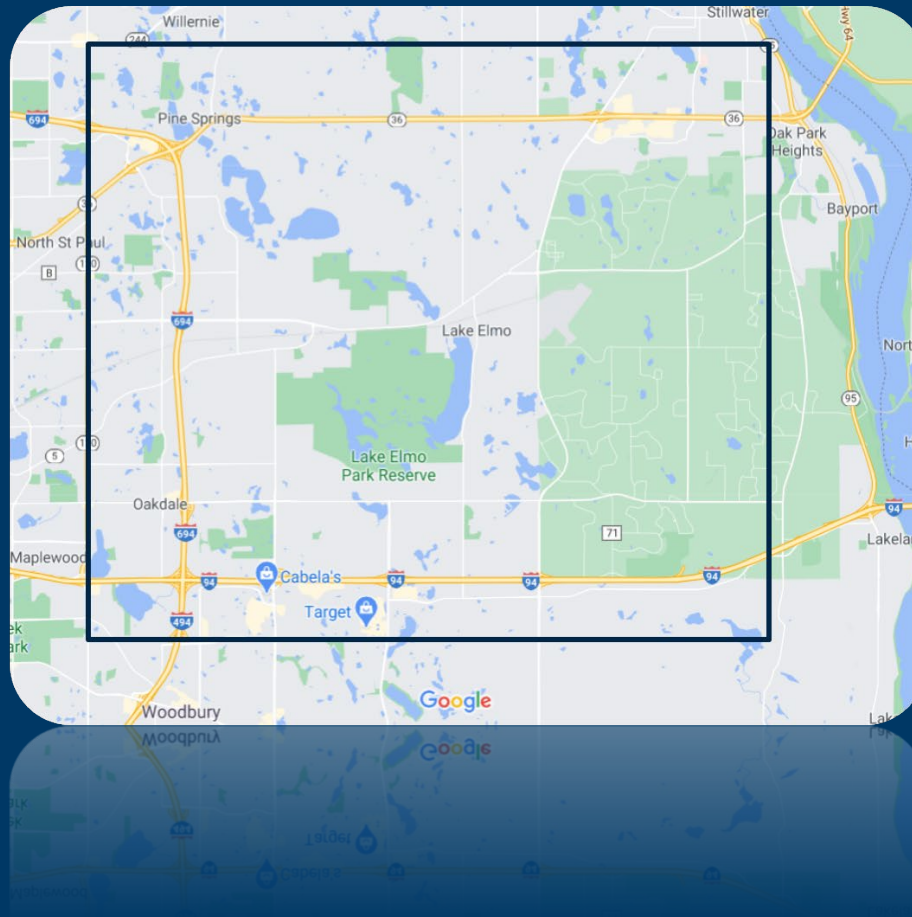
Why do we need to estimate injection capacity?

Aquifer storage and recovery (ASR)



- ASR is one type of MAR. It is a process of water banking via wells during periods of excess availability and later use in the period of scarcity.
- To consider ASR, we first need to understand how much we can inject.

Managed Aquifer Recharge - ASR

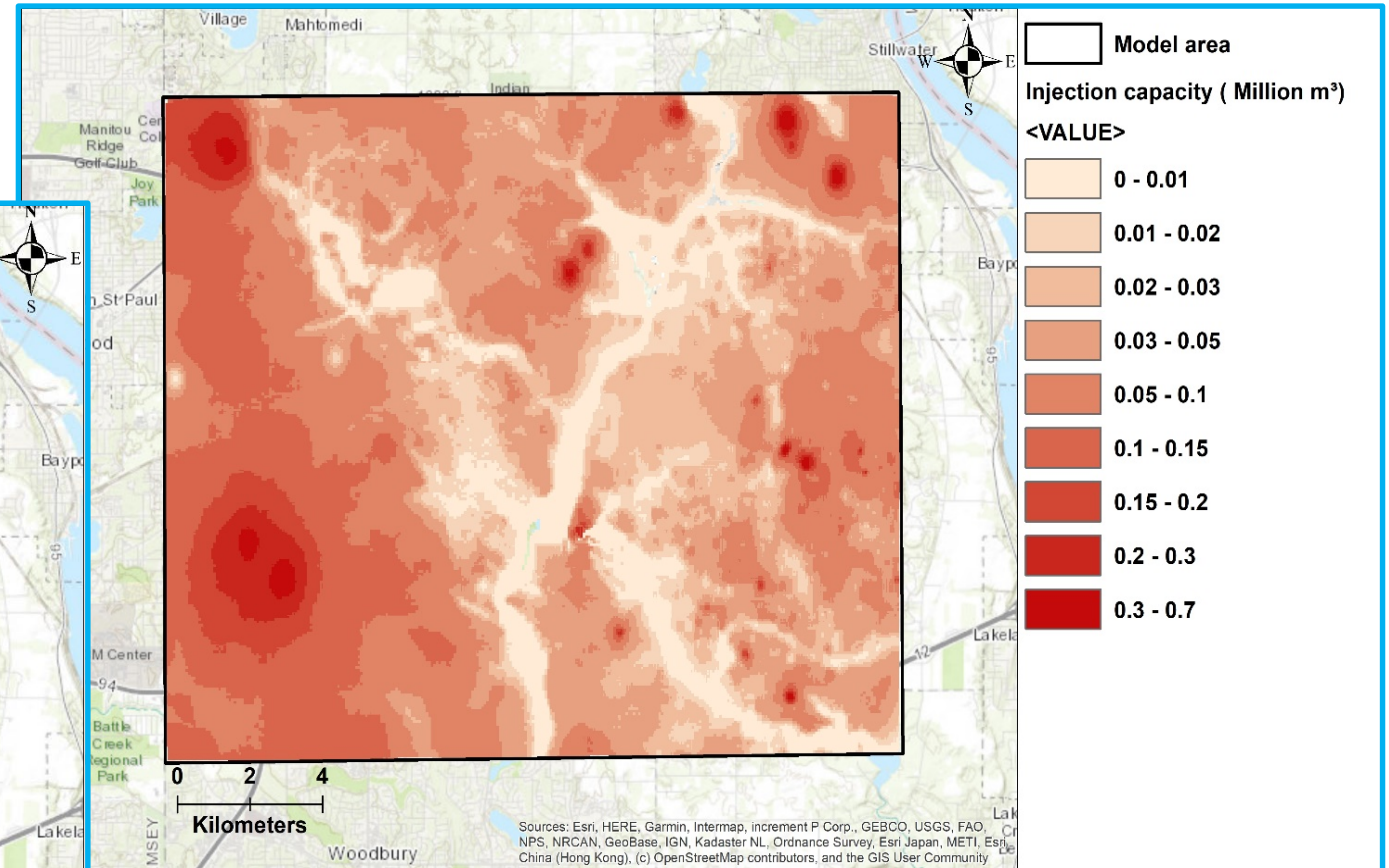
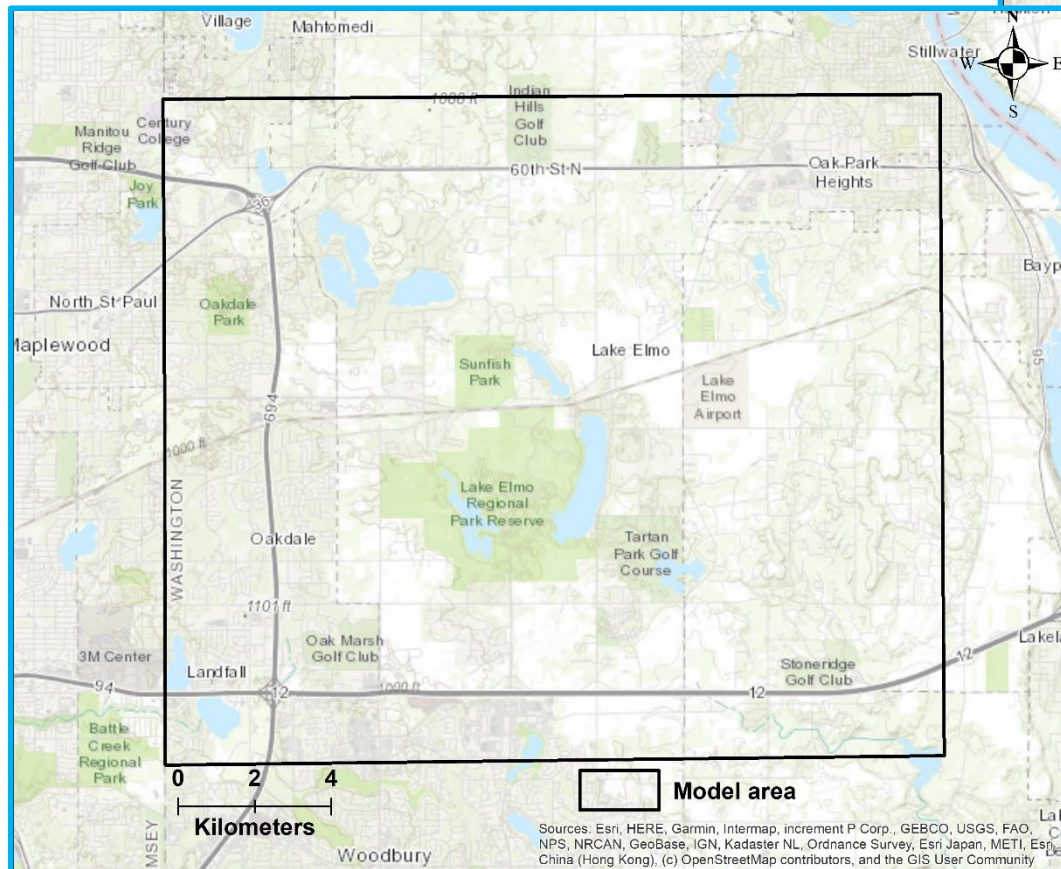


Project 1007
Aquifer Storage and
Recovery Boundary

Injection Capacity
Desktop Evaluation
Underway – Report
coming January from
UofM/MGS

1007 Aquifer Storage and Recovery – Injection Capacity

We extended and applied the methodology to the Lake Elmo area





Interim Corrective Actions

Interim Corrective Actions

Surface water cleanup options are being pursued.

We expect to consider sediment cleanup in targeted areas in the coming year.



SAFF®: Surface-Active Foam Fractionation

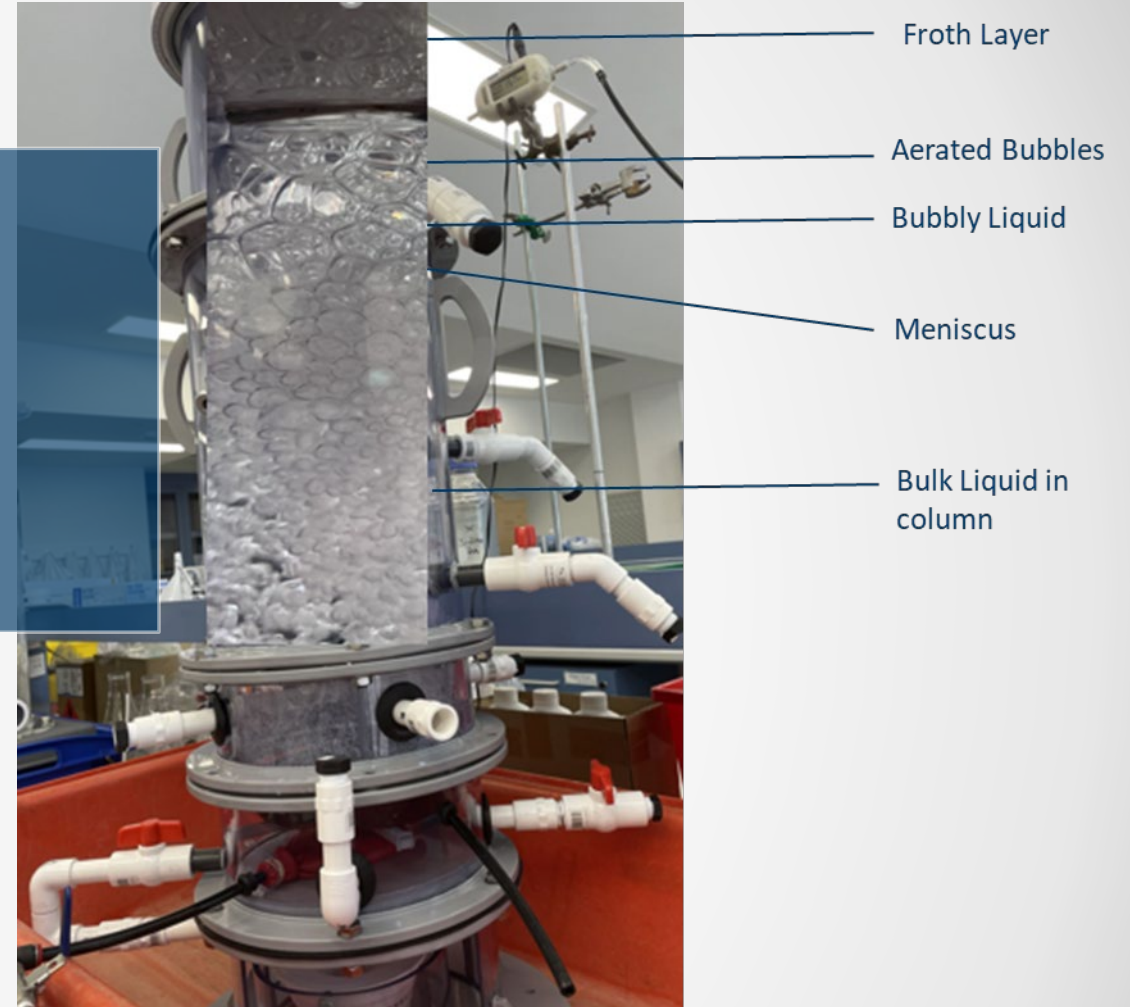


Bench-Scale Lab Testing In-Progress Surface Activated Foam Fractionation

Preliminary SAFF bench-scale results from 7 batches of 15L surface water samples:

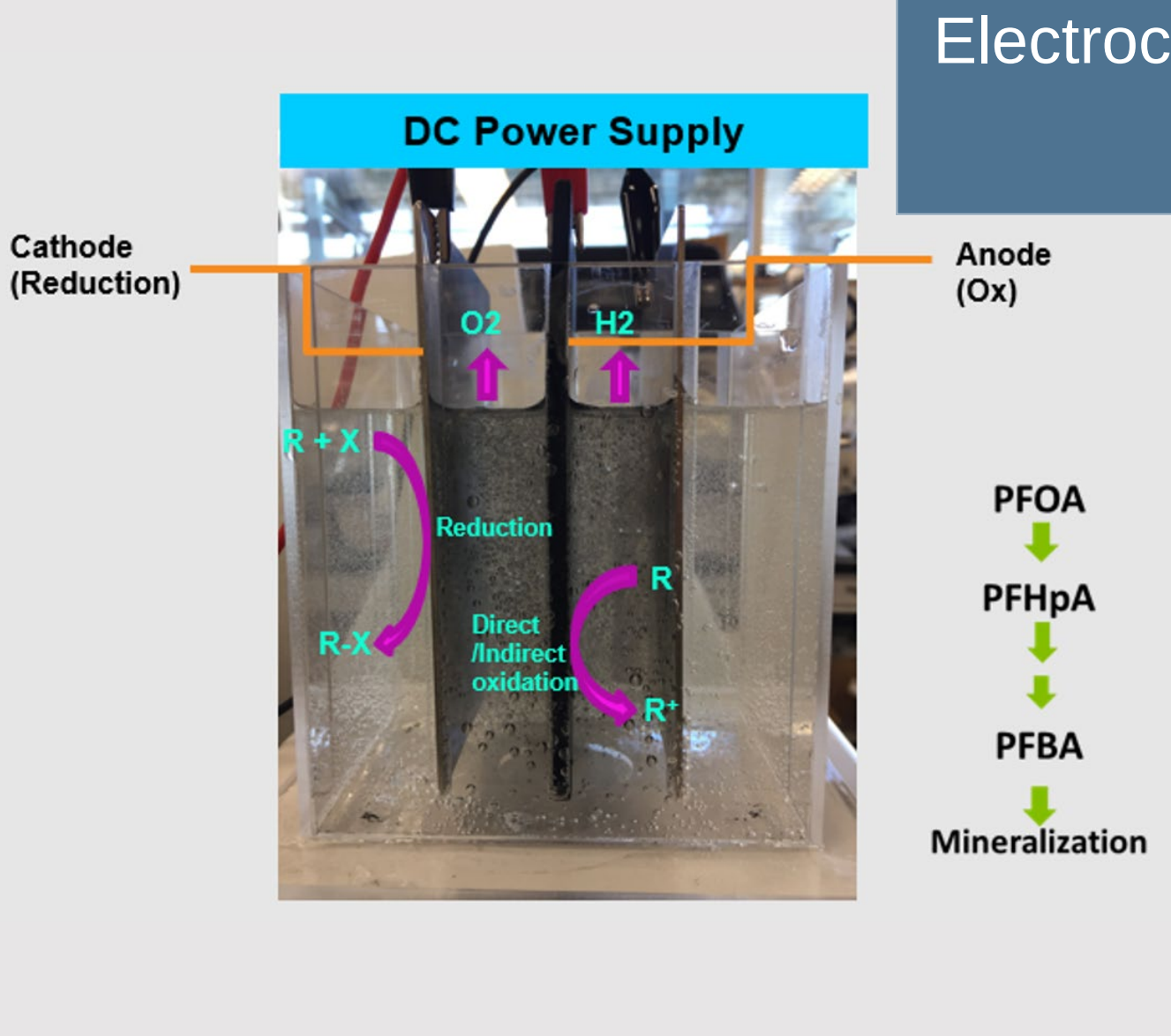
Total Bulk PFAS Removal: 79-85% in primary treatment

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



High-Performance SAFF Apparatus showing aeration & bubbly Liquid zone.

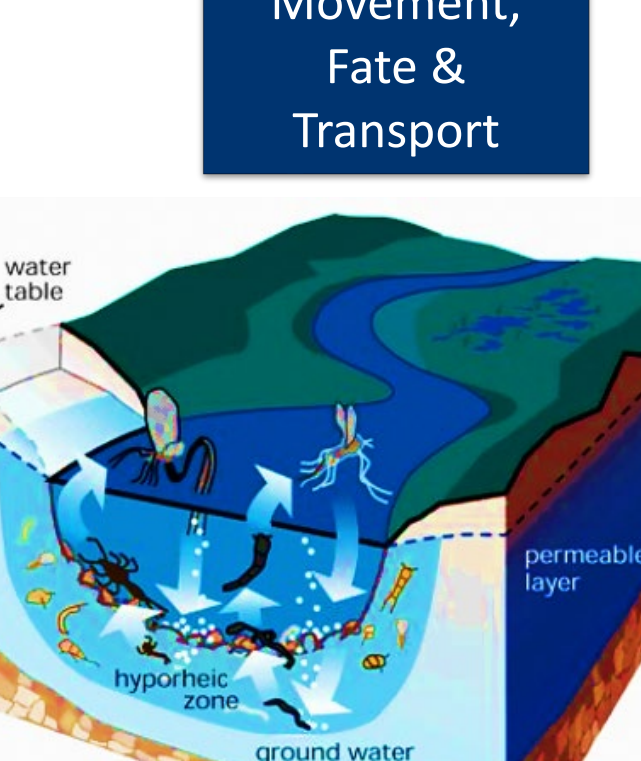
Bench-Scale Lab Testing In-Progress
Electrochemical Oxidation – DE-FLUORO™



Hyper-concentrate from SAFF system at Oakey Air Force Base in Oakey, Australia, with similar PFAS signature is on its way to AECOM DE-FLUORO™ lab in Texas for this test.

The diagram illustrates the photocatalytic degradation of PFOA. The top part shows a magnified view of a photocatalytic material (blue sphere) generating reactive species (red dots) that attack PFOA molecules (yellow and black spheres). The chemical structures of PFOA and PFO are shown. The bottom part shows a cross-section of a photocatalytic material (blue) under light irradiation, with reactive species (red dots) generated and attacking PFOA molecules (yellow and black spheres) in the water.

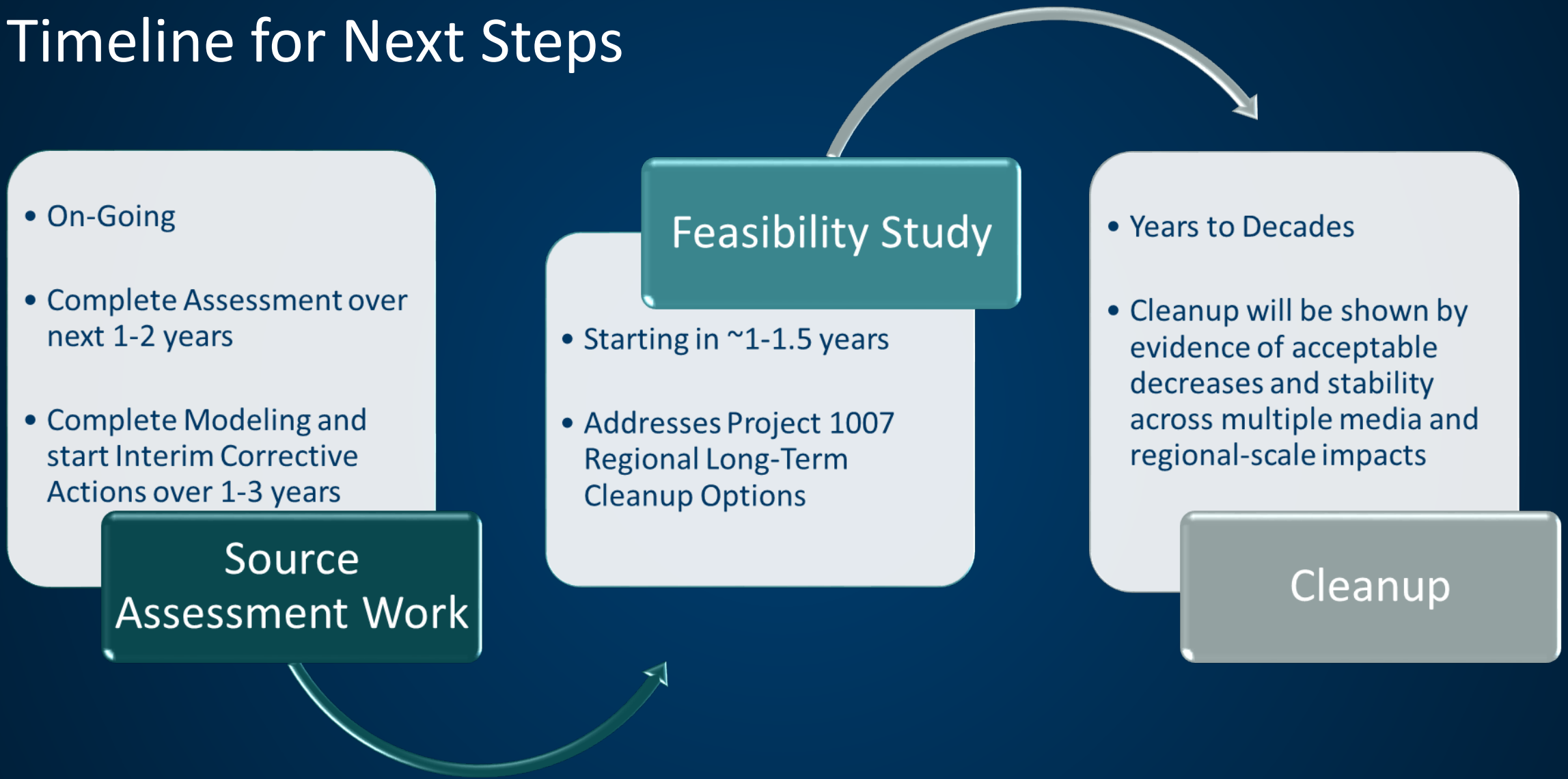
PFAS Movement, Fate & Transport



The diagram illustrates the movement, fate, and transport of PFAS in the environment. It shows a cross-section of the ground with a river, a water table, a hyporheic zone, and an impermeable layer. Arrows indicate the flow of water and PFAS (represented by red dots) from the river into the hyporheic zone and then into the groundwater. The hyporheic zone is labeled 'hyporheic zone' and the groundwater is labeled 'ground water'. The impermeable layer is labeled 'impermeable layer'.

47

Timeline for Next Steps



1 Key Goals

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Thank you

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Rebecca.Higgins@state.mn.us

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Gary.Krueger@state.mn.us

