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Status of Cleanup at Twin Cities Army Ammunition Plant (TCAAP)

RAB Meeting

9-17-2024

AGENDA – September 17, 2024 at 7 P.M.

- Old Business
- Cleanup Status Update
  - Groundwater Remediation
  - Per- and polyfluoroalkyl substances (PFAS)
  - U.S. Geological Survey (USGS) (Groundwater Model and Site K)
  - Round Lake
- New Business
- Next Meeting Agenda
- Public Comments

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Old Business

- Vote to accept the minutes from previous meeting.
- Contract for Round Lake construction was awarded in August 2023. Date of next Round Lake Technical Working Group meeting to be determined.
- Army held groundwater stakeholder meeting on 17 September 2024.

What has the Army done since February 2024?

- Draft Final FY 2023 Annual Performance Report (APR) in regulatory review.
- Met with Groundwater Stakeholders on 17 September 2024.
- Next Round Lake Technical Working Group (TWG) meeting date to be determined.
- Hydraulic evaluation of the TCAAP Groundwater Recovery System (TGRS) in process.
- FY2024 Annual groundwater sampling and land use control inspections completed.

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TCAAP Cleanup Status Update

LEGEND:

- Operable Unit 1 (North Plume)
- Operable Unit 2 of the New Brighton/ Arden Hills Superfund Site (the same area occupied by the Twin Cities Army Ammunition Plant in 1983, when the Site was placed on the NPL.)
- Operable Unit 3 (South Plume)
- Municipal Boundaries

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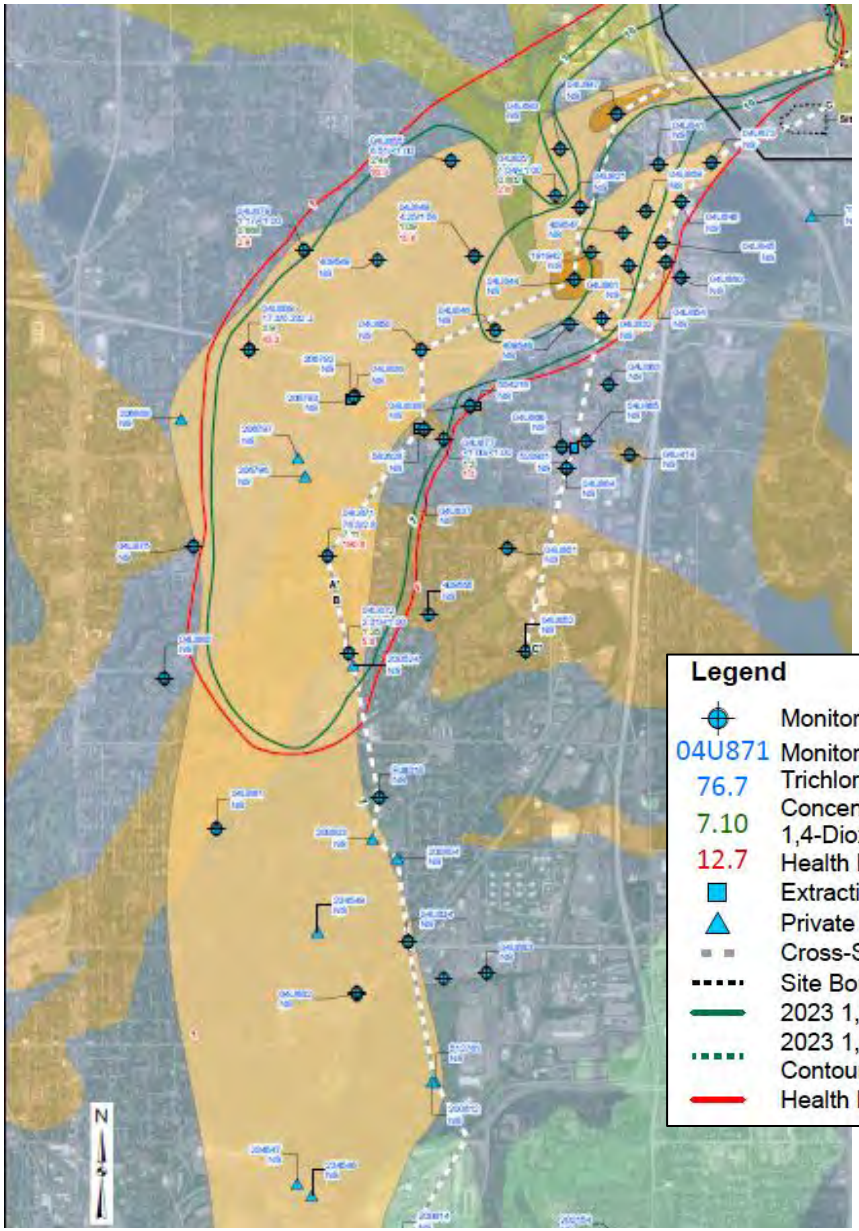
Groundwater Sampling Update

- Groundwater sampling allows the Army to monitor the plumes and update the maps.
- Groundwater sampling (major year) completed in Summer 2024.
- Groundwater data will be validated and incorporated into the FY 2024 APR.
- Annual plume maps are available in the respective APRs, most recently updated in the Draft Final FY 2023 APR.
- Statistical evaluation of monitoring well network in process.

POC Information (Thomas Toudouze, U.S. AEC, 210-466-1920, thomas.p.toudouze2.civ@army.mil)

FY 2023 – Prairie du Chien Plume Map



- Plume remains relatively stable compared to FY22 results.
- Some minor decreases spread throughout the plume.
- Higher concentration area (>100ug/L) remains as two distinct lobes (shown on next slide), consistent with FY22 results.

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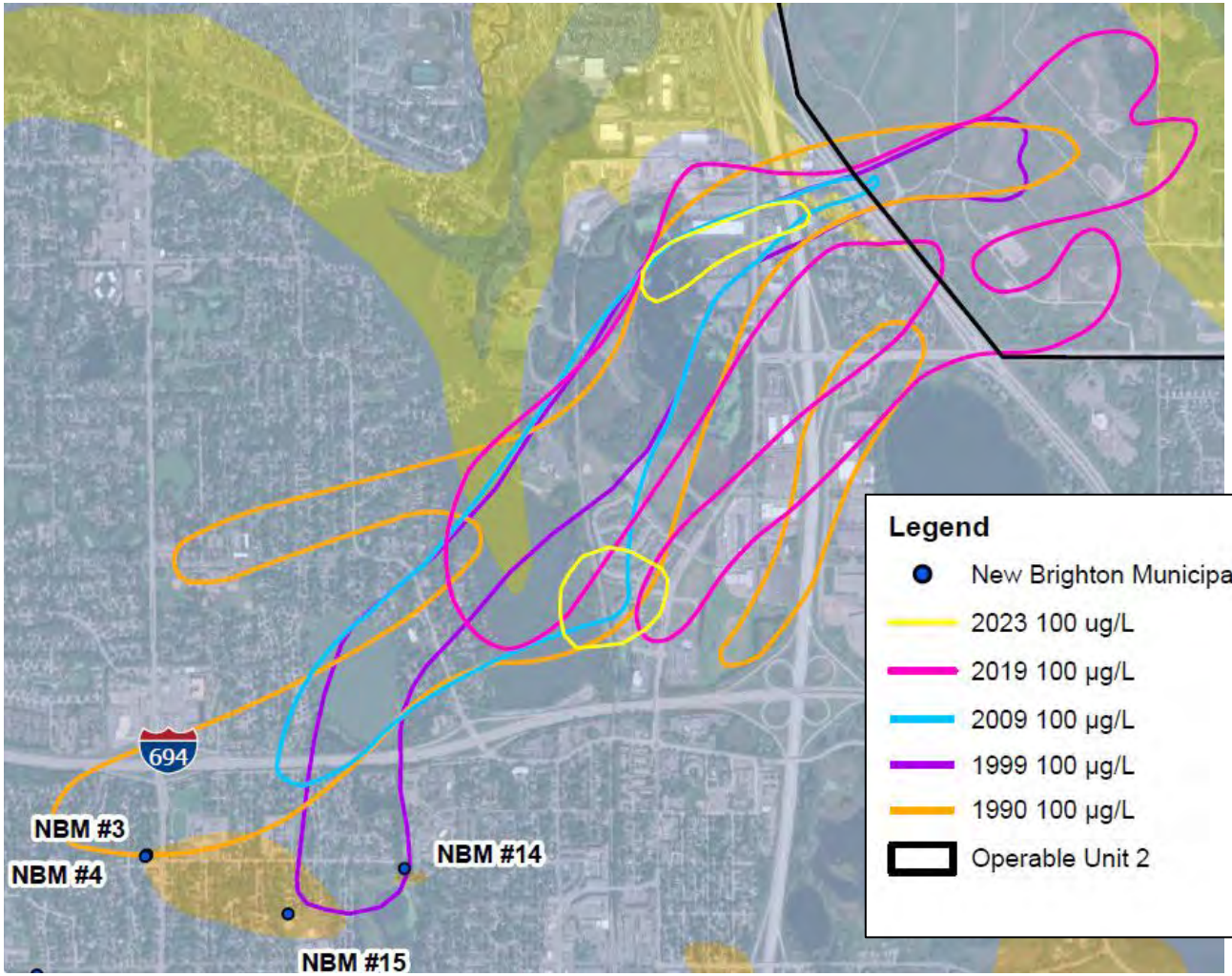
FY 2023 – Prairie du Chien Plume Map Over Time



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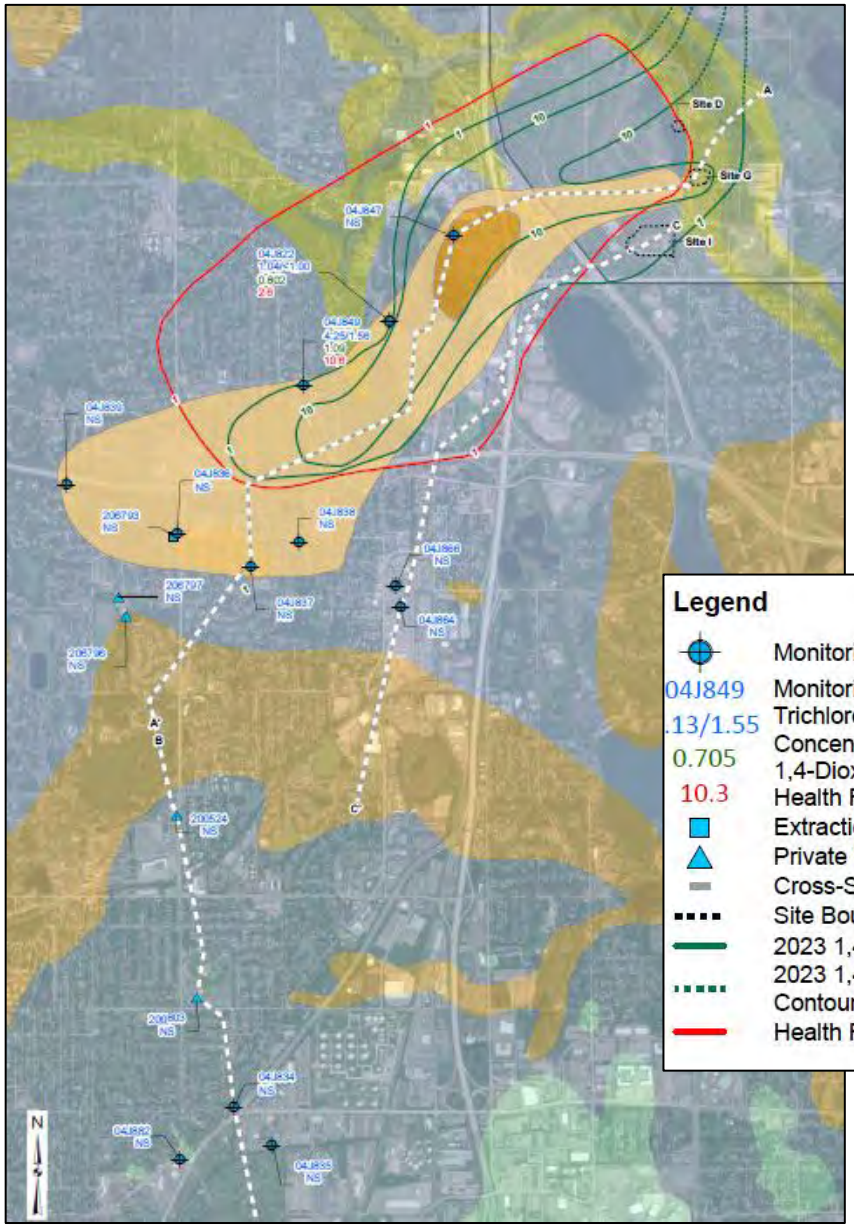
FY 2023 – Jordan Plume Map



- Main plume remains relatively stable compared to FY22 results.
- Downgradient wells non-detect in FY22 (most not sampled in FY23).
- Higher concentration area not sampled in FY23.

Legend

- Monitoring Well
- 04J849 — Monitoring Well ID
- .13/1.55 — Trichloroethene/1,1,1-Trichloroethane Concentration (µg/L)
- 0.705 — 1,4-Dioxane Concentration (µg/L)
- 10.3 — Health Risk Index
- Extraction Well
- Private Well
- Cross-Section Line
- Site Boundary
- 2023 1,4 Dioxane Concentration Contour (µg/L)
- 2023 1,4 Dioxane Concentration Inferred Contour (µg/L)
- Health Risk Index =1

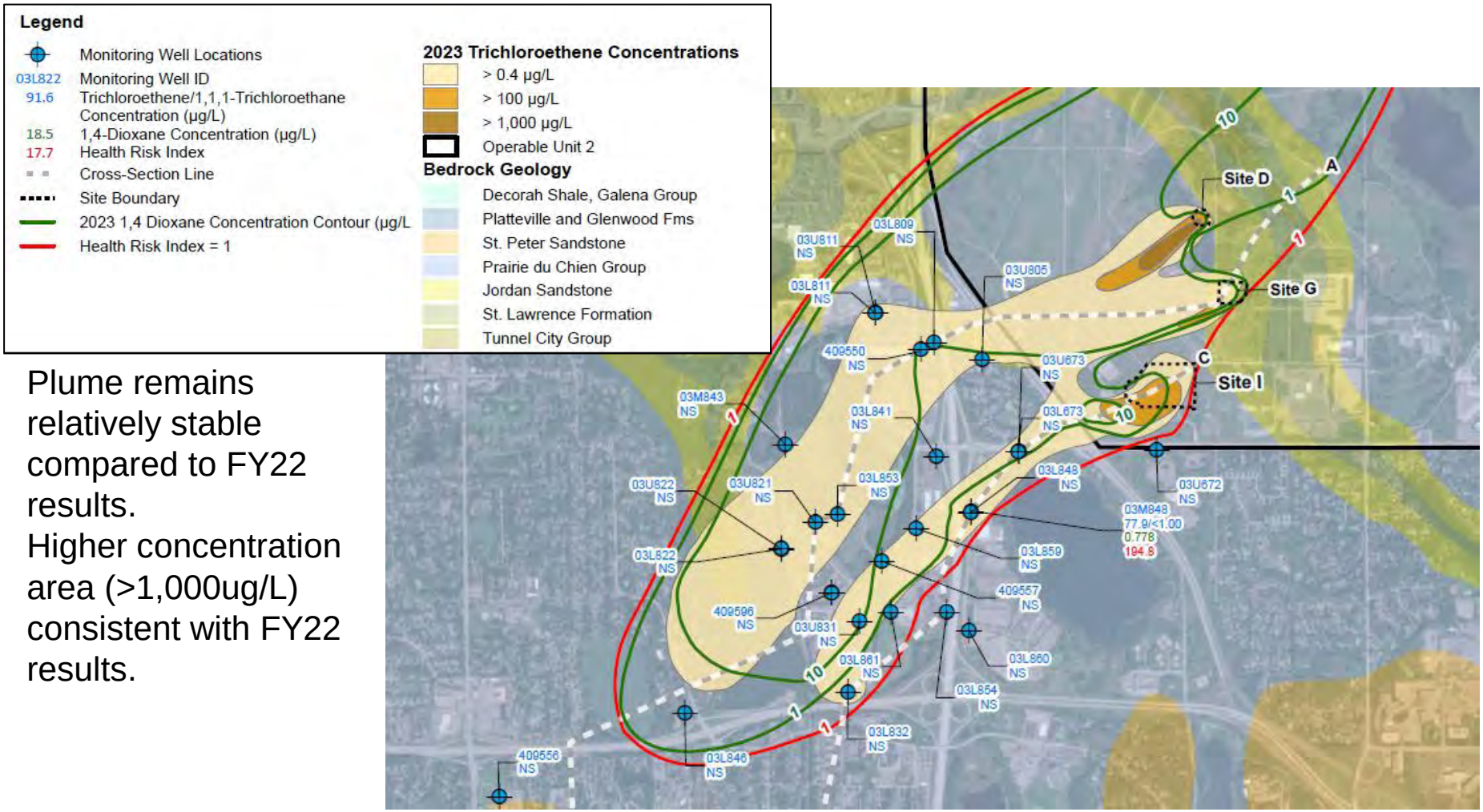
2023 Trichloroethene Concentrations (µg/L)

- > 0.4 µg/L
- > 100 µg/L
- Operable Unit 2

Bedrock Geology

- Decorah Shale, Galena Group
- Platteville and Glenwood Fms
- St. Peter Sandstone
- Prairie du Chien Group
- Jordan Sandstone
- St. Lawrence Formation
- Tunnel City Group

FY 2023 – OU2 Unconsolidated Sediments Plume Map



- Plume remains relatively stable compared to FY22 results.
- Higher concentration area (>1,000ug/L) consistent with FY22 results.

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Twin Cities Army Ammunition Plant Cleanup

LEGEND:

- Operable Unit 1 (North Plume)
- Operable Unit 2 of the New Brighton/ Arden Hills Superfund Site (the same area occupied by the Twin Cities Army Ammunition Plant in 1983, when the Site was placed on the NPL.)
- Operable Unit 3 (South Plume)
- Municipal Boundaries

POC Information (Thomas Toudouze, U.S. AEC, 210-466-1920, thomas.p.toudouze2.civ@army.mil)

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OU1 Optimization

- No change since last meeting.
- Goal: increase amount of contaminant removed by relocating well more central to plume.
- Optimization identified a need for a new well in New Brighton.
- Plan has been approved and funds have been sent to install new well.
- Meeting with New Brighton next week to discuss path forward.

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Twin Cities Army Ammunition Plant Cleanup

POC Information (Thomas Toudouze, U.S. AEC, 210-466-1920, thomas.p.toudouze2.civ@army.mil)

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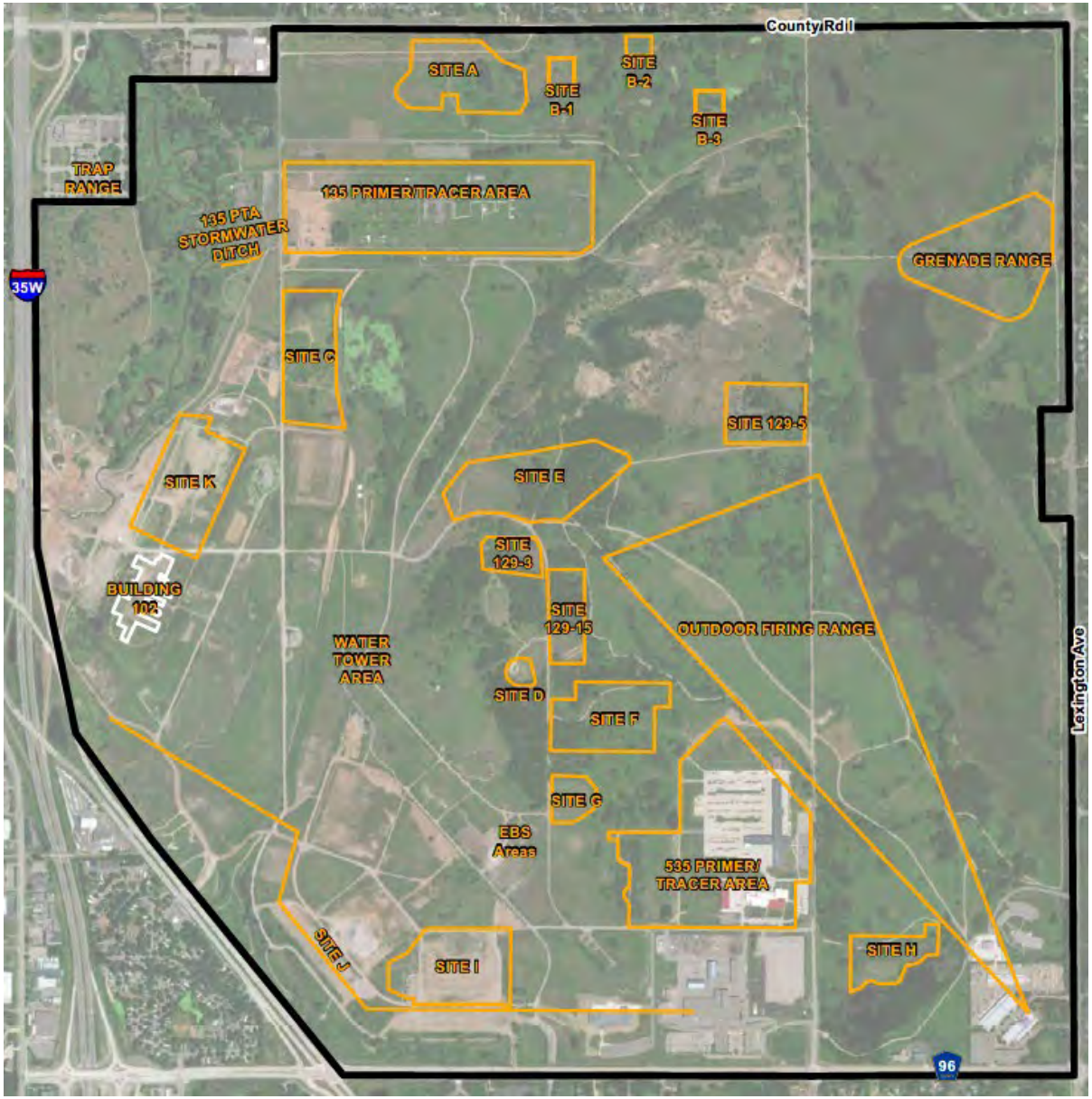
OU2


County Rd I
SITE A
SITE B-1
SITE B-2
SITE B-3
TRAP RANGE
135 PRIMER/TRACER AREA
135 PTA STORMWATER DITCH
GRENADE RANGE
35W
SITE C
SITE 129-5
SITE K
SITE E
SITE 129-3
BUILDING 102
SITE 129-15
OUTDOOR FIRING RANGE
WATER TOWER AREA
SITE D
SITE F
Lexington Ave
SITE G
EBS Areas
535 PRIMER/ TRACER AREA
SITE J
SITE I
SITE H
96

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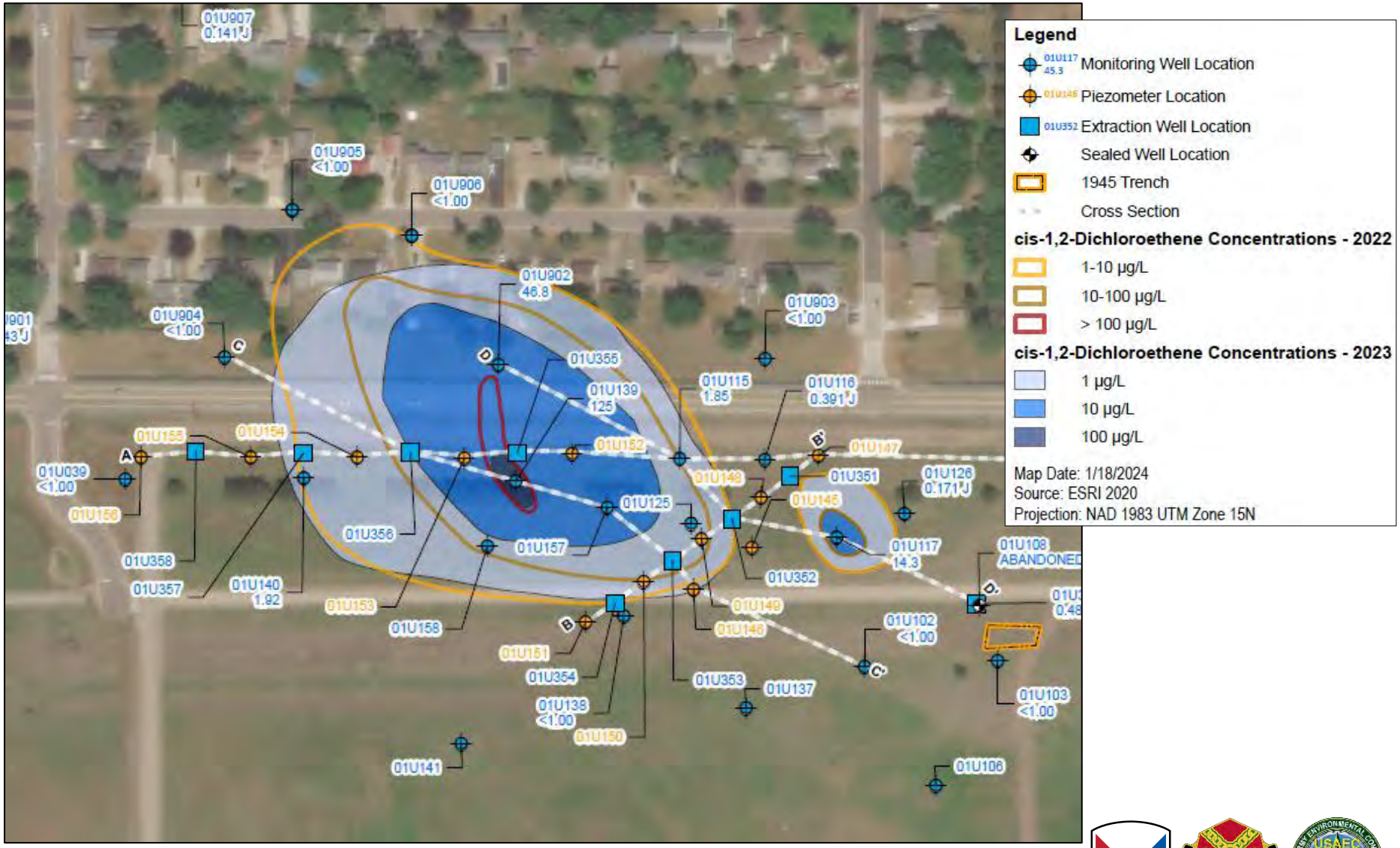
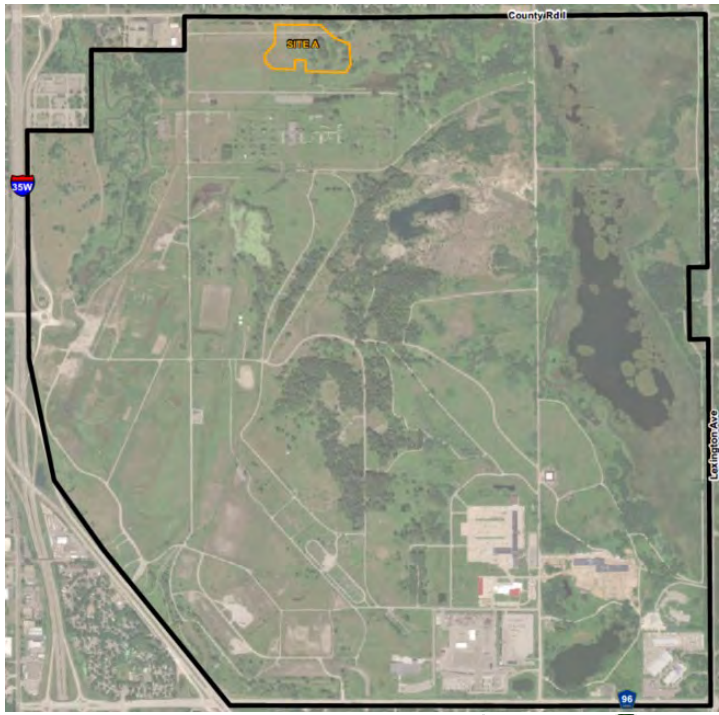
OU2 – Site A Monitored Natural Attenuation



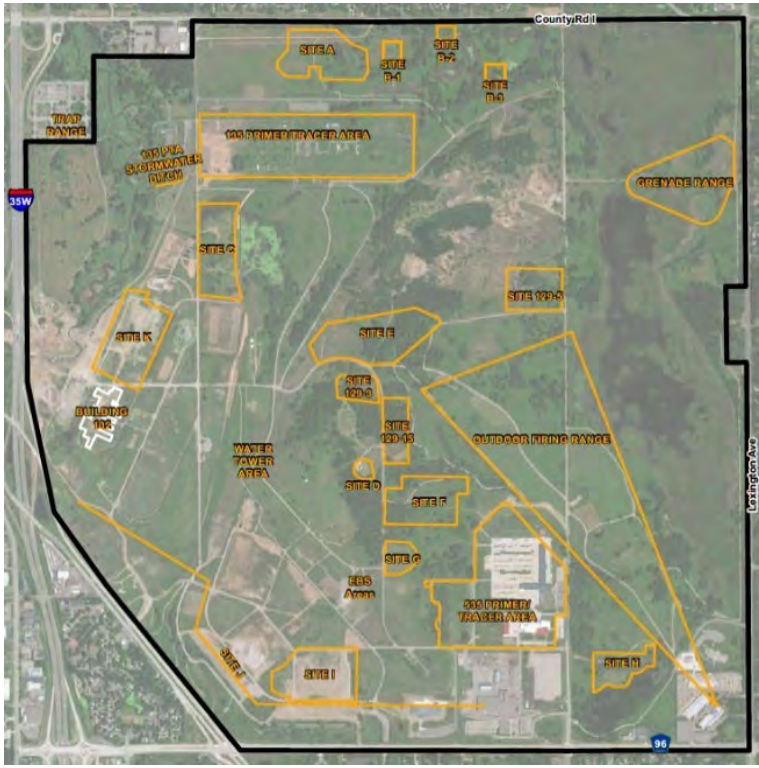
OU2 – Site A Monitored Natural Attenuation

- Main plume (FY 2023) relatively stable compared to FY 2022 – higher concentration area (> 100 µg/L) continues decreasing.
- Concentrations within the heart of the smaller plume have decreased from FY 2022.

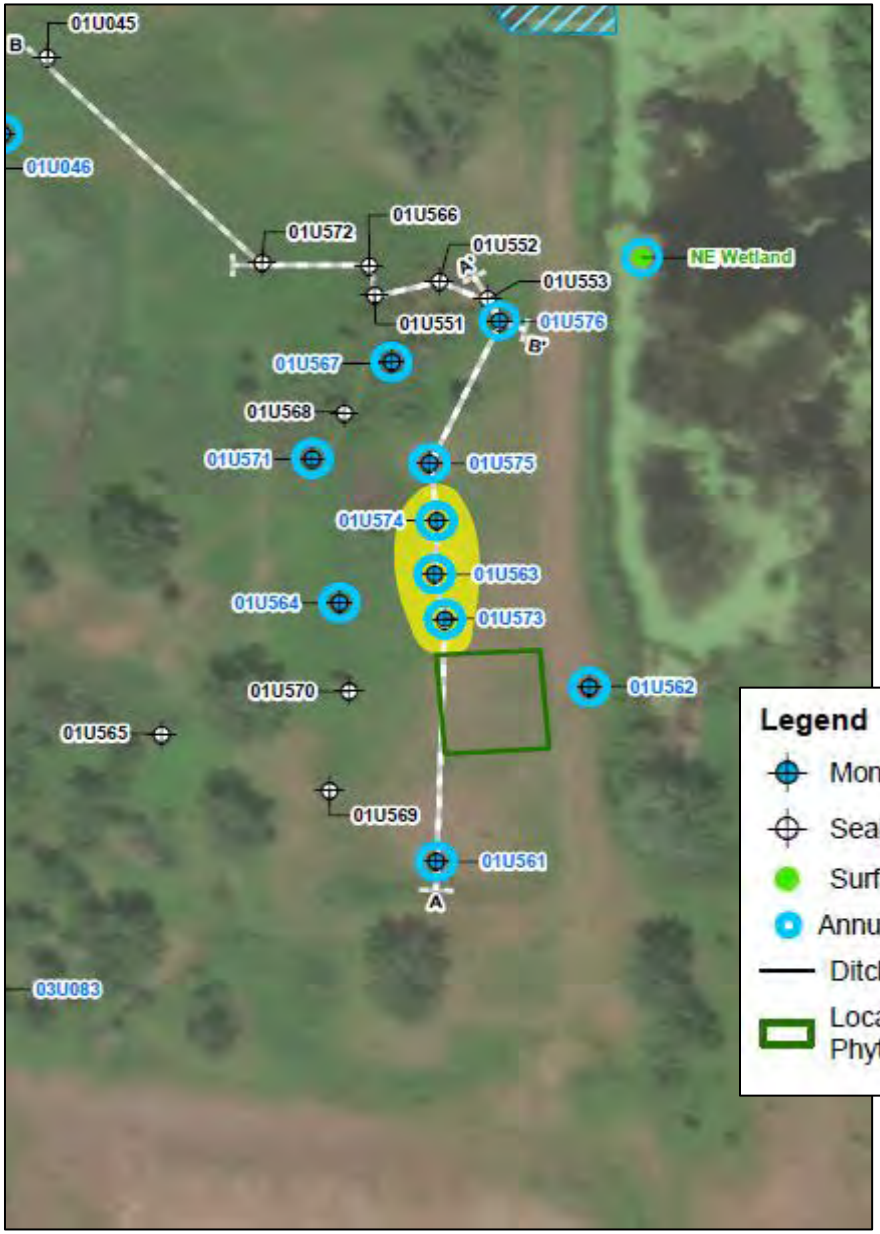


OU2 – Site C Monitored Natural Attenuation

- Three locations exceed cleanup level compared to one location in FY 2022.
- Plume rebounded compared to FY 2022; however, new exceedances are localized.
- Continue monitored natural attenuation.



OU2 – Site C Monitored Natural Attenuation

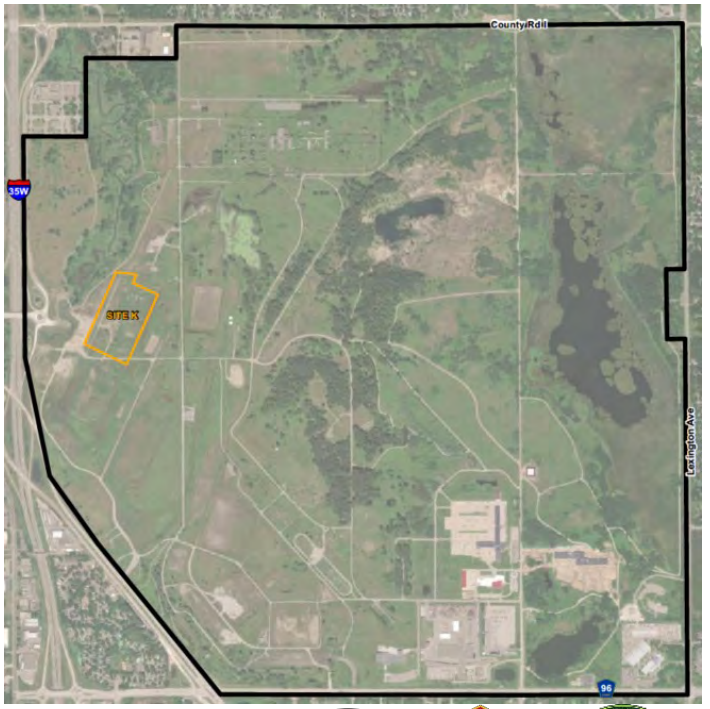


Legend

- Monitoring Well Location
- Sealed Well Location
- Surface Water Sampling Locations
- Annual Monitoring Locations
- Ditch
- Location of Plot for Phytoremediation Demonstration
- Approximate Boundary of Wetland Constructed in 2007
- Cross Section
- 15 µg/L Lead Contour (2023)

OU2 – Site K Pump and Treat

- Plume relatively stable compared to FY 2023.
- Annual groundwater sampling for FY2024 completed in June 2024.
- Groundwater collection system continues to provide containment of the horizontal and vertical extent of the trichloroethene (TCE) plume.
- Continue pump and treat operations.
- In May 2024, a telemetry system was added to the Site K treatment system resulting in faster response times to alarms, decreasing downtime.



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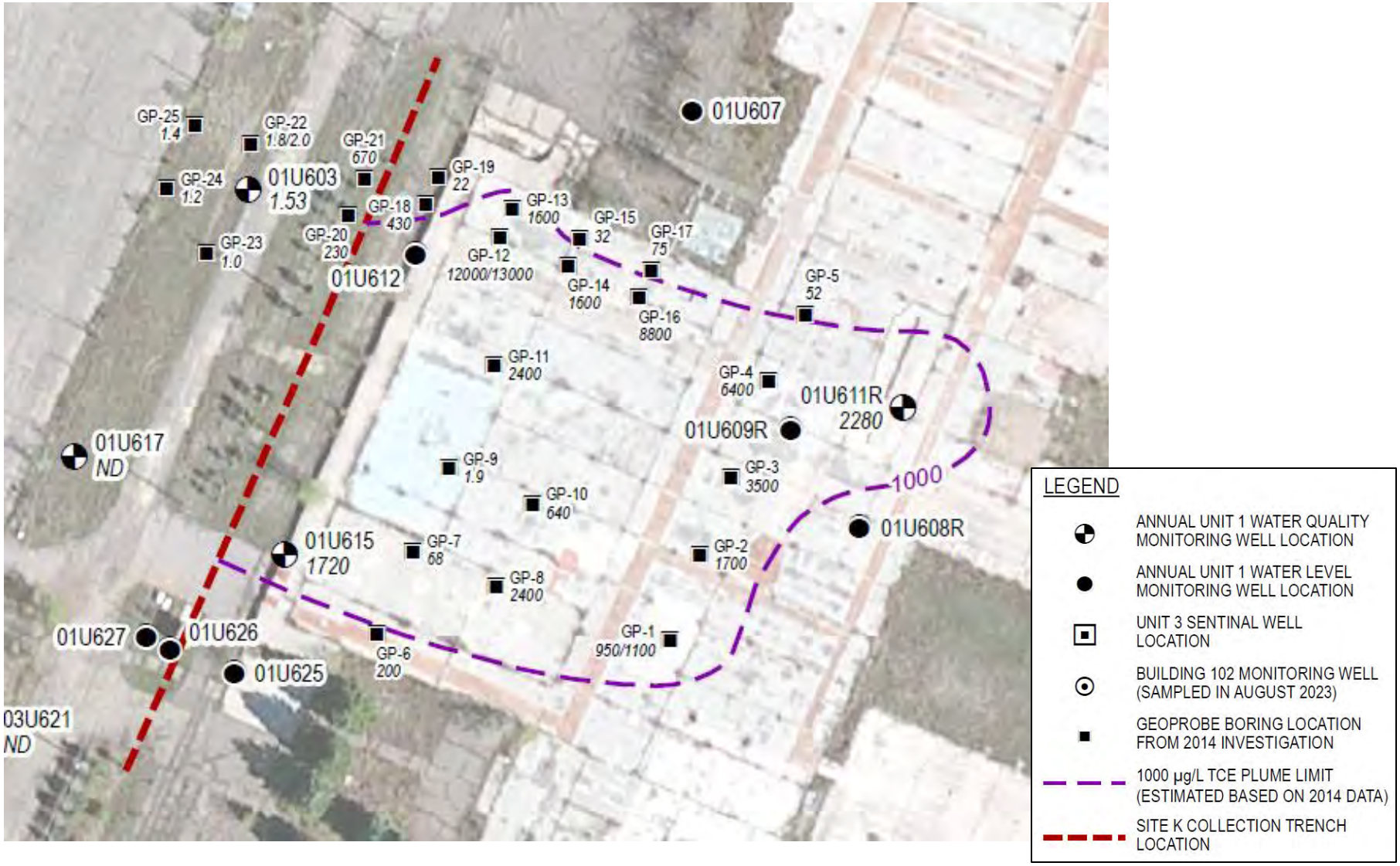
OU2 – Site K Pump and Treat



OU1/OU2 Well Abandonment and Reinstallation

- Abandonment of three industrial wells in OU1 and 42 monitoring wells in OU2.
- Reinstallation of four monitoring wells in OU1 and one monitoring well in OU2.
- Monitoring well reinstallation in OU1 pending successful right-of-entry negotiations.
- All activities planned for FY 2024.

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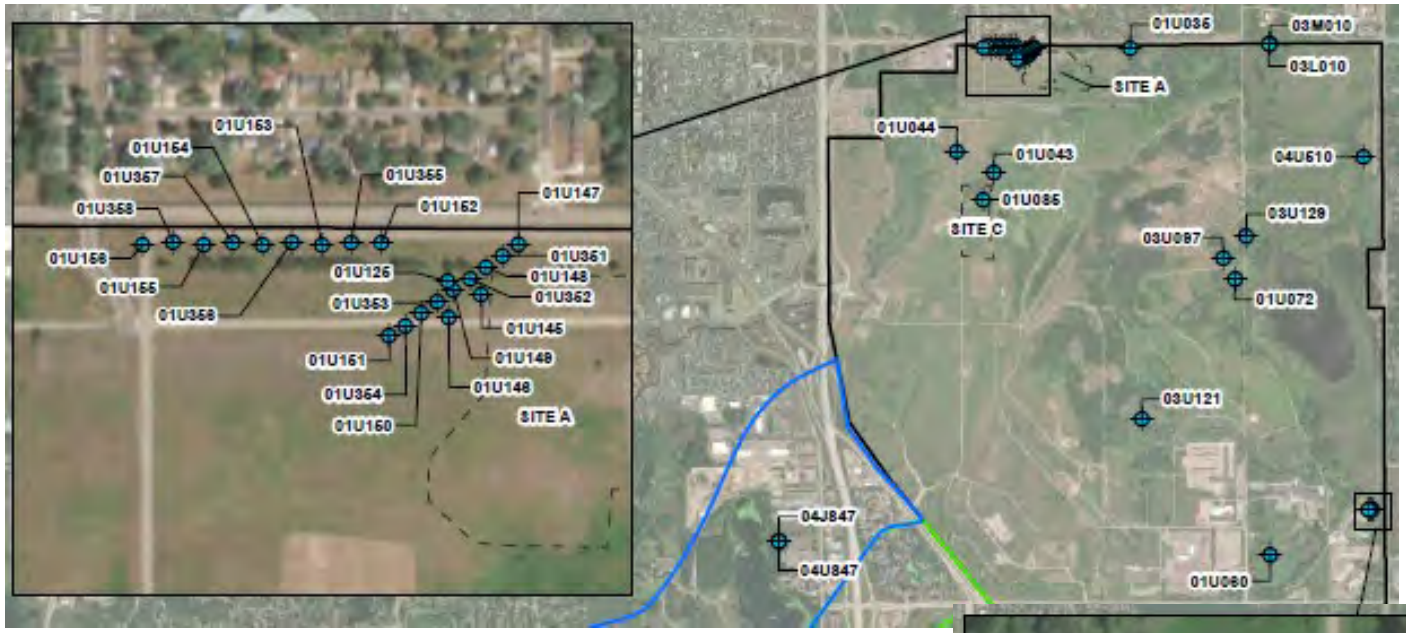
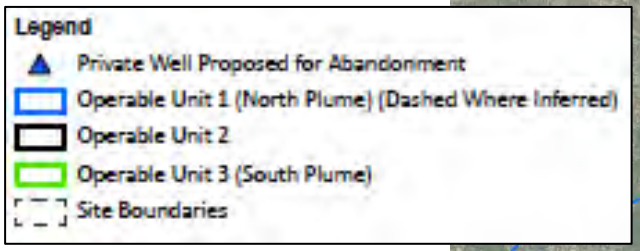
OU1/OU2 Well Abandonment and Reinstallation

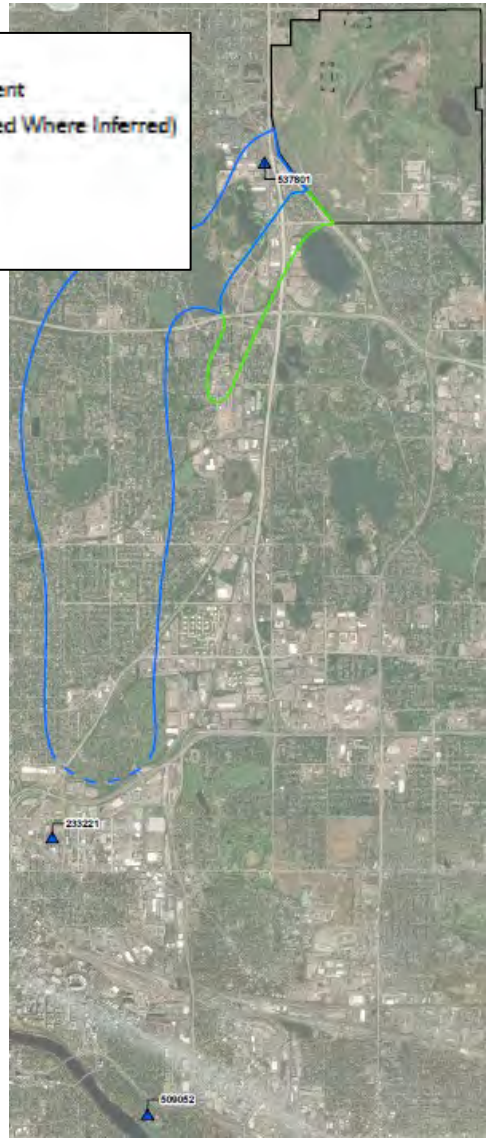


Legend

- Monitoring Well Proposed for Abandonment
- Operable Unit 2
- Operable Unit 3 (South Plume)
- Operable Unit 1 (North Plume)
- Site Boundaries

OU1/OU2 Well Abandonment and Reinstallation





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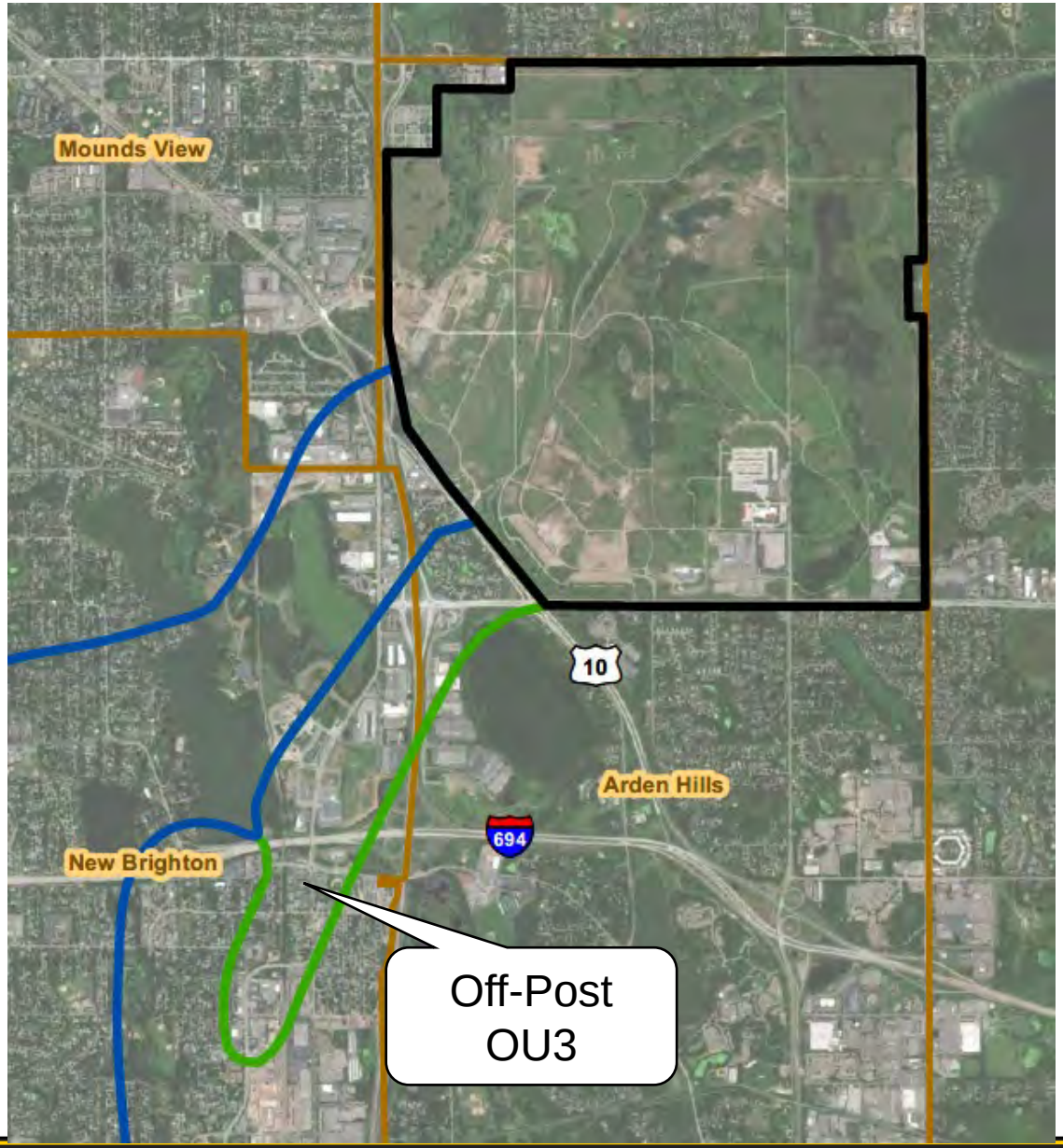
Twin Cities Army Ammunition Plant Cleanup



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POC Information (Thomas Toudouze, U.S. AEC, 210-466-1920, thomas.p.toudouze2.civ@army.mil)

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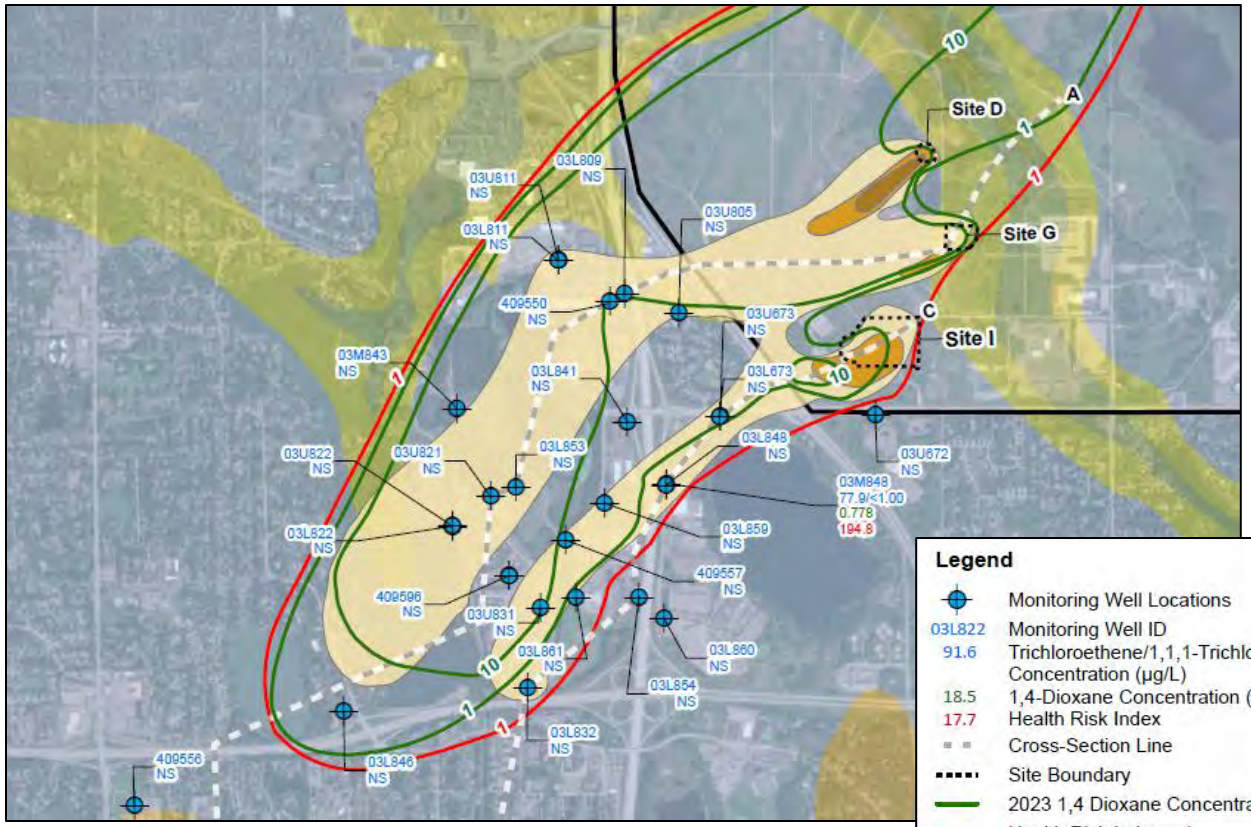
OU3 Plume

- OU3 plume remains relatively stable – results consistent with FY2023.
- Continued monitored natural attenuation.
- Annual groundwater sampling completed in June 2024.



Legend

- Monitoring Well Locations
- 03L822 — Monitoring Well ID
- 91.6 — Trichloroethene/1,1,1-Trichloroethane Concentration (µg/L)
- 18.5 — 1,4-Dioxane Concentration (µg/L)
- 17.7 — Health Risk Index
- Cross-Section Line
- Site Boundary
- 2023 1,4 Dioxane Concentration Contour (µg/L
- Health Risk Index = 1

2023 Trichloroethene Concentrations

- > 0.4 µg/L
- > 100 µg/L
- > 1,000 µg/L
- Operable Unit 2

Bedrock Geology

- Decorah Shale, Galena Group
- Platteville and Glenwood Fms
- St. Peter Sandstone
- Prairie du Chien Group
- Jordan Sandstone
- St. Lawrence Formation
- Tunnel City Group

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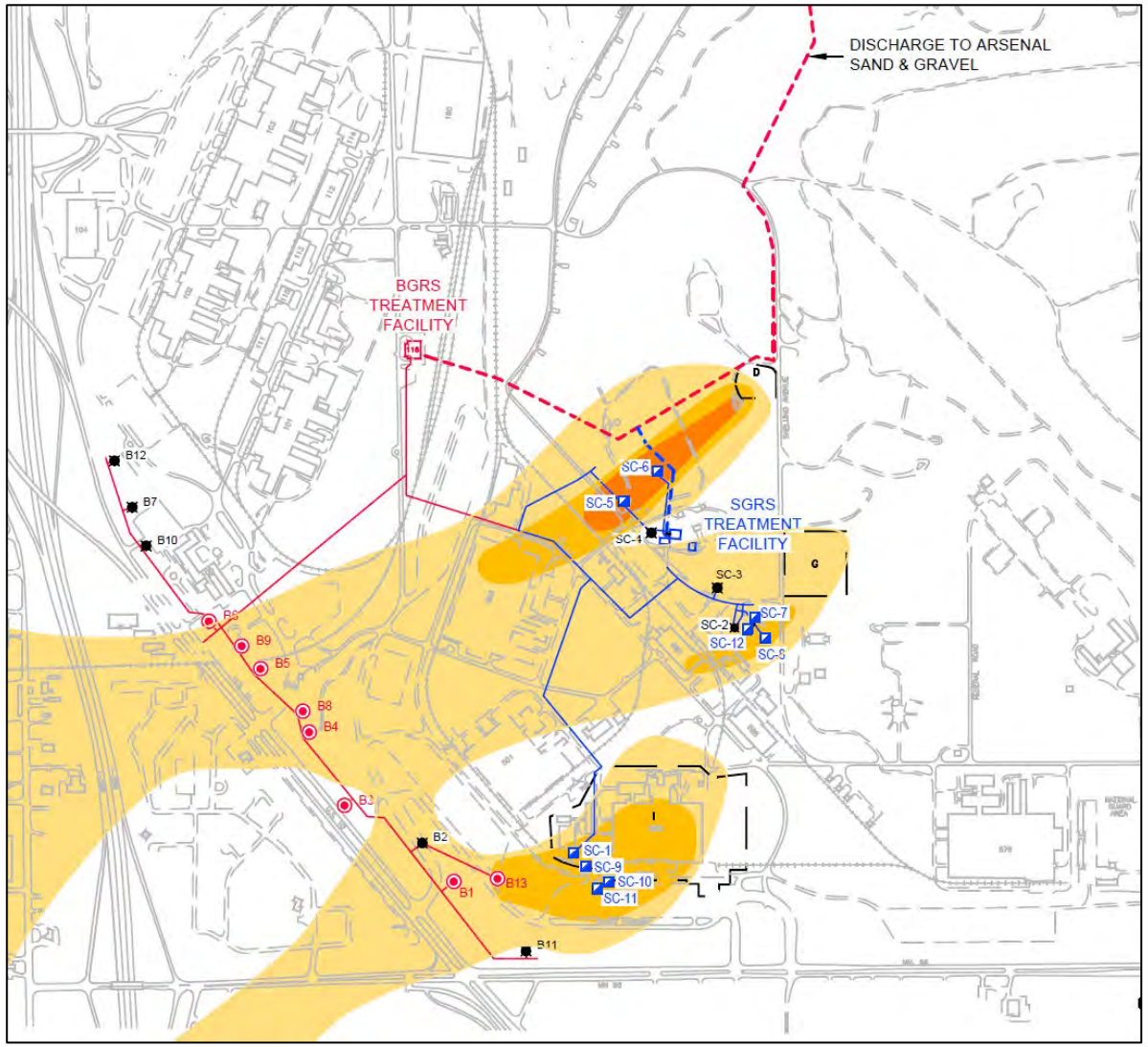
Update on the Deep Groundwater TCAAP Groundwater Recovery System (TGRS)

OU2 Optimization – TGRS Layout – TCE

Boundary Groundwater Recovery System (BGRS)

Source Area Groundwater Recovery System (SGRS)

BGRS + SGRS = TGRS

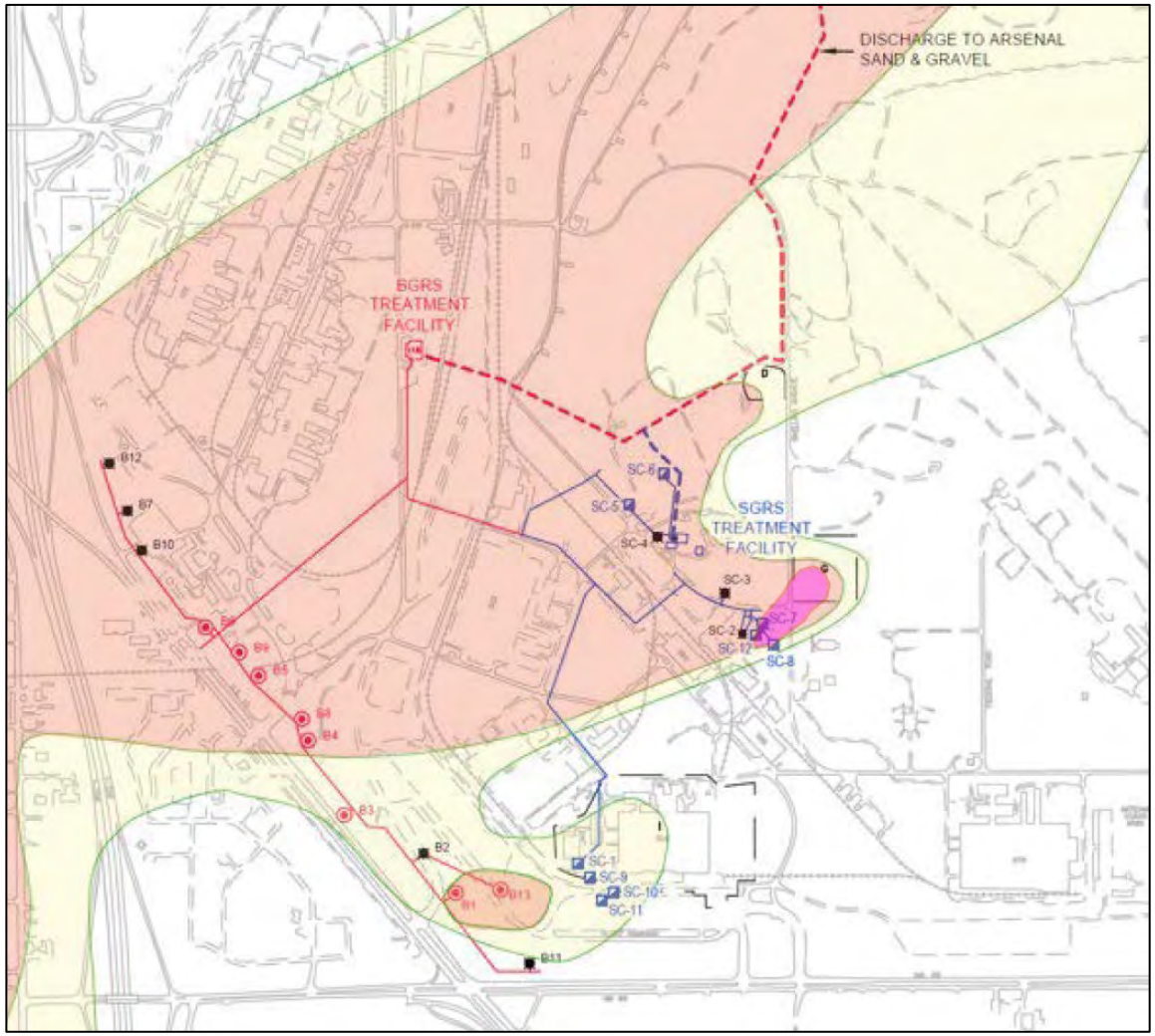


OU2 Optimization – TGRS Layout – 1,4-Dioxane

Boundary Groundwater Recovery System (BGRS)

Source Area Groundwater Recovery System (SGRS)

BGRS + SGRS = TGRS



SGRS Update

System Operation

- 380 to 400 gpm water flow under steady state conditions
- System is operating and meeting all discharge criteria (1,4-Dioxane, TCE, 1,1,1-TCA, bromate) from monthly sampling since start up.

SGRS Discharge Criteria	
1,4-Dioxane	1.0 µg/L
TCE	5 µg/L
1,1,1-TCA	200 µg/L
Bromate	10 µg/L

- Full treatment to criteria of 1,4-dioxane and TCE in AO reactor; air stripper only needed for chlorinated alkanes

Advanced Oxidation (AO) Reactor

TGRS Update

Sampling

- Discharge Criteria: Discharged water from both Building 116 (BGRS) and SGRS are sampled monthly and analyzed in accordance with the ROD to ensure discharge standards are met.
- Since the SGRS has been in operation the influent TCE and 1,4-Dioxane concentrations have decreased by over 60% for both TCE and 1,4-Dioxane.
- The TCE and 1,4-Dioxane concentrations in the individual source area extraction wells have also decreased over the course of SGRS's operation.
- Air sampling and modeling will be completed for Building 116 emissions once new TGRS operational flow rates are established following agency approval of the Source Area Hydraulic Evaluation Report for the SGRS.

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OU2 Deep Groundwater Remediation – FY2024 Operation to Date

- The Fiscal Year 2024 annual average extraction rate (BGRS + SGRS) through July 2024 is approximately 1,907 gal per minute (gpm), **well above** the Global Operating Strategy (GOS) Operational Minimum of 1,745 gpm.
- The removal rates observed during FY2023 for VOCs and 1,4-dioxane have not been achieved since FY 2004.
- Through July 2024, the BGRS has pumped 686,752,038 gallons and removed 250 lbs of VOCs; and the SGRS has pumped 151,022,202 gallons and removed 1,209 lbs of VOCs.
- The Source Area Hydraulic Evaluation Report has been provided to the EPA and MPCA for review and agency comments have been incorporated. At the time of this presentation the report has not been finalized.

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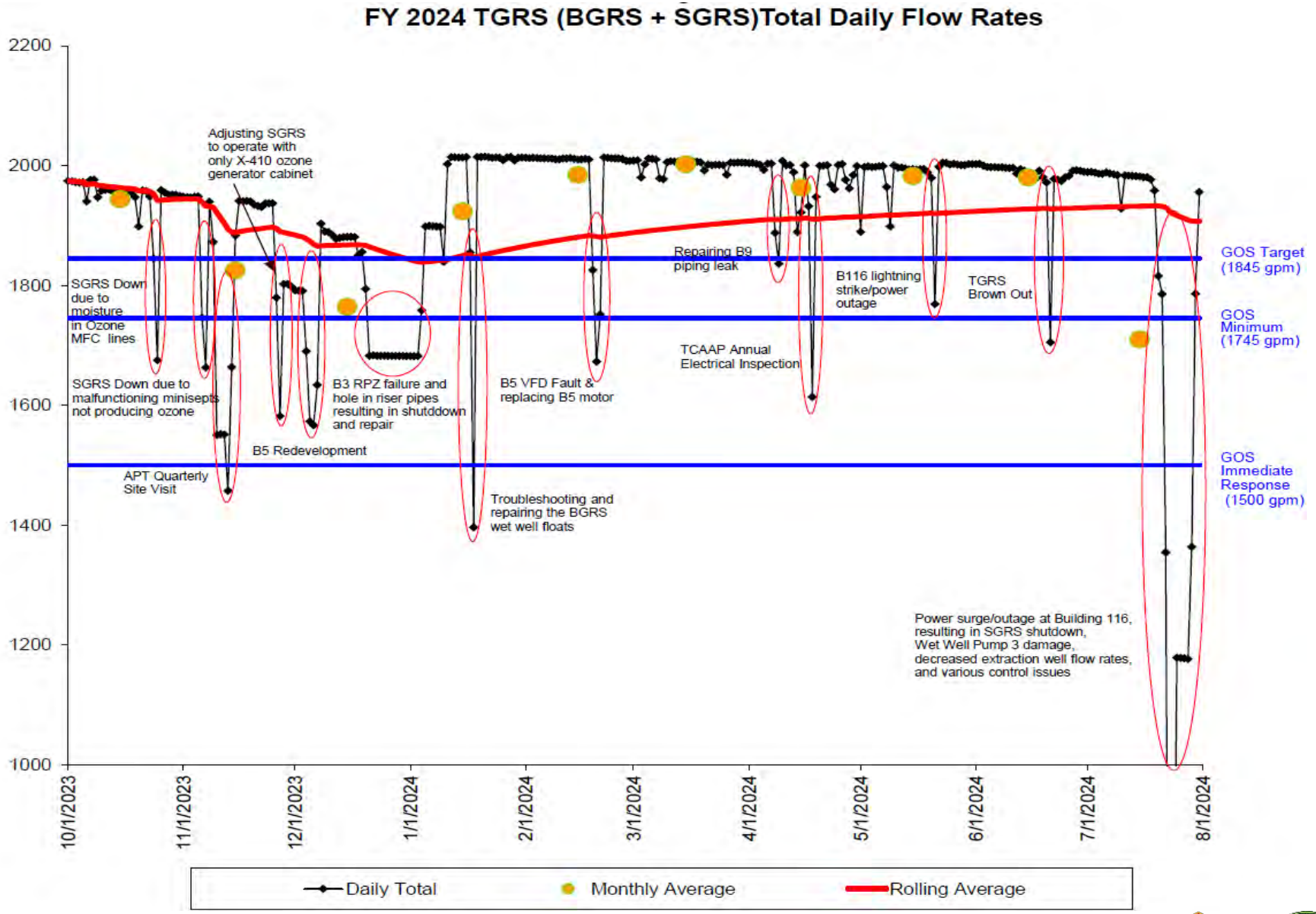
FY 2024 Daily Flow Rates



POC Information (Thomas Toudouze, U.S. AEC, 210-466-1920, thomas.p.toudouze2.civ@army.mil)

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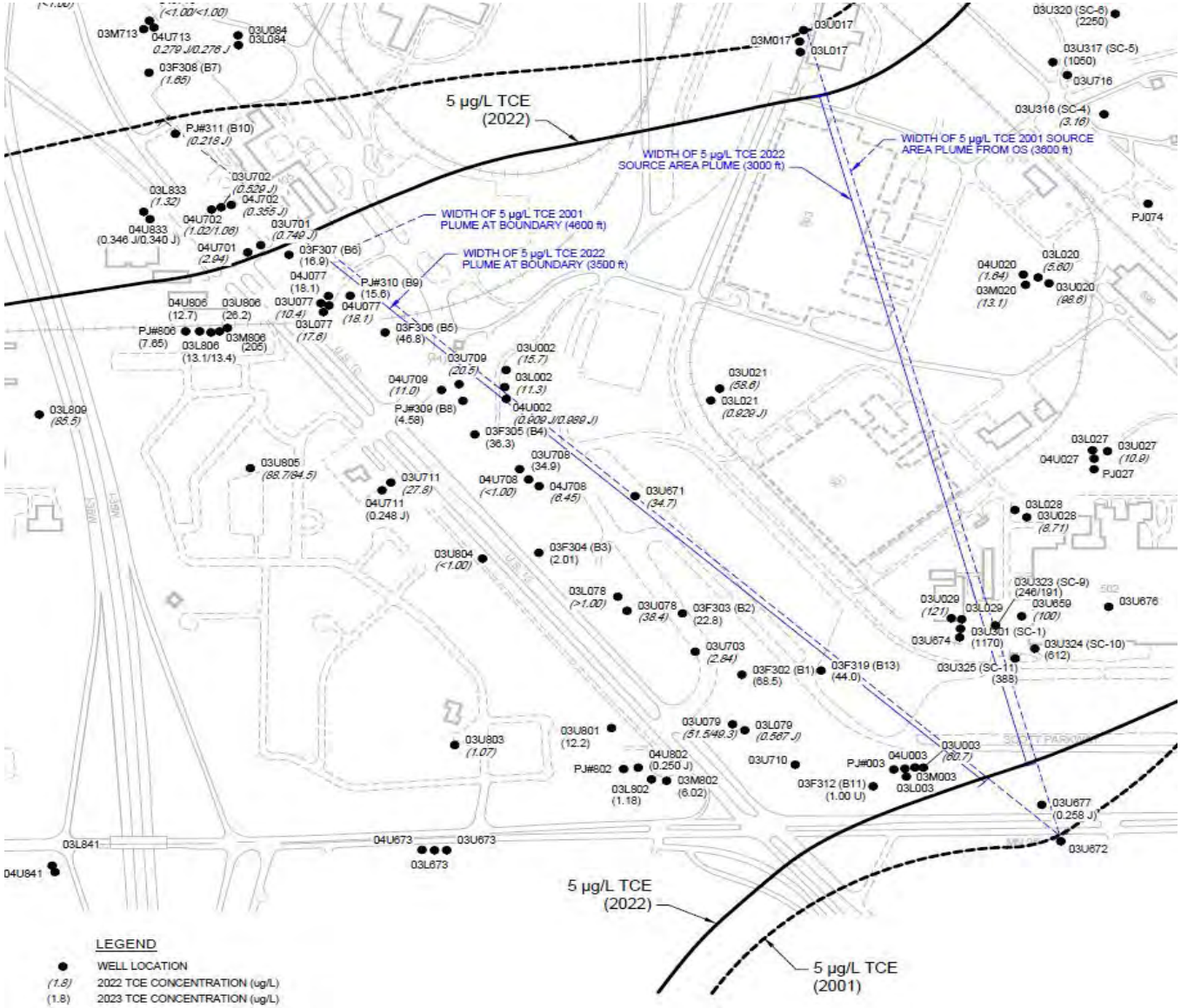
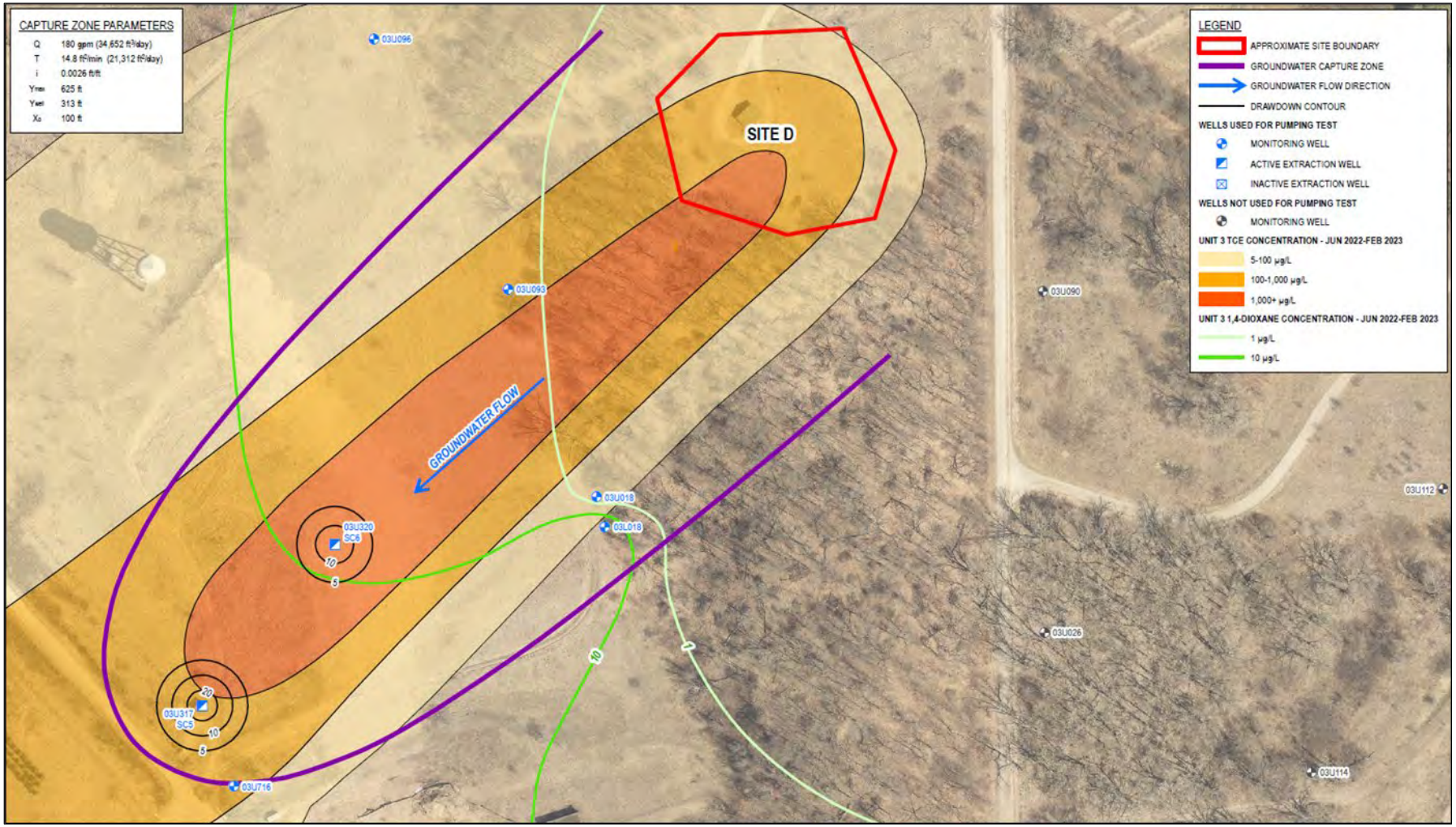
2023 TCE Plume (3,000 feet wide)



Site D Hydraulic Capture – TCE and 1,4-Dioxane



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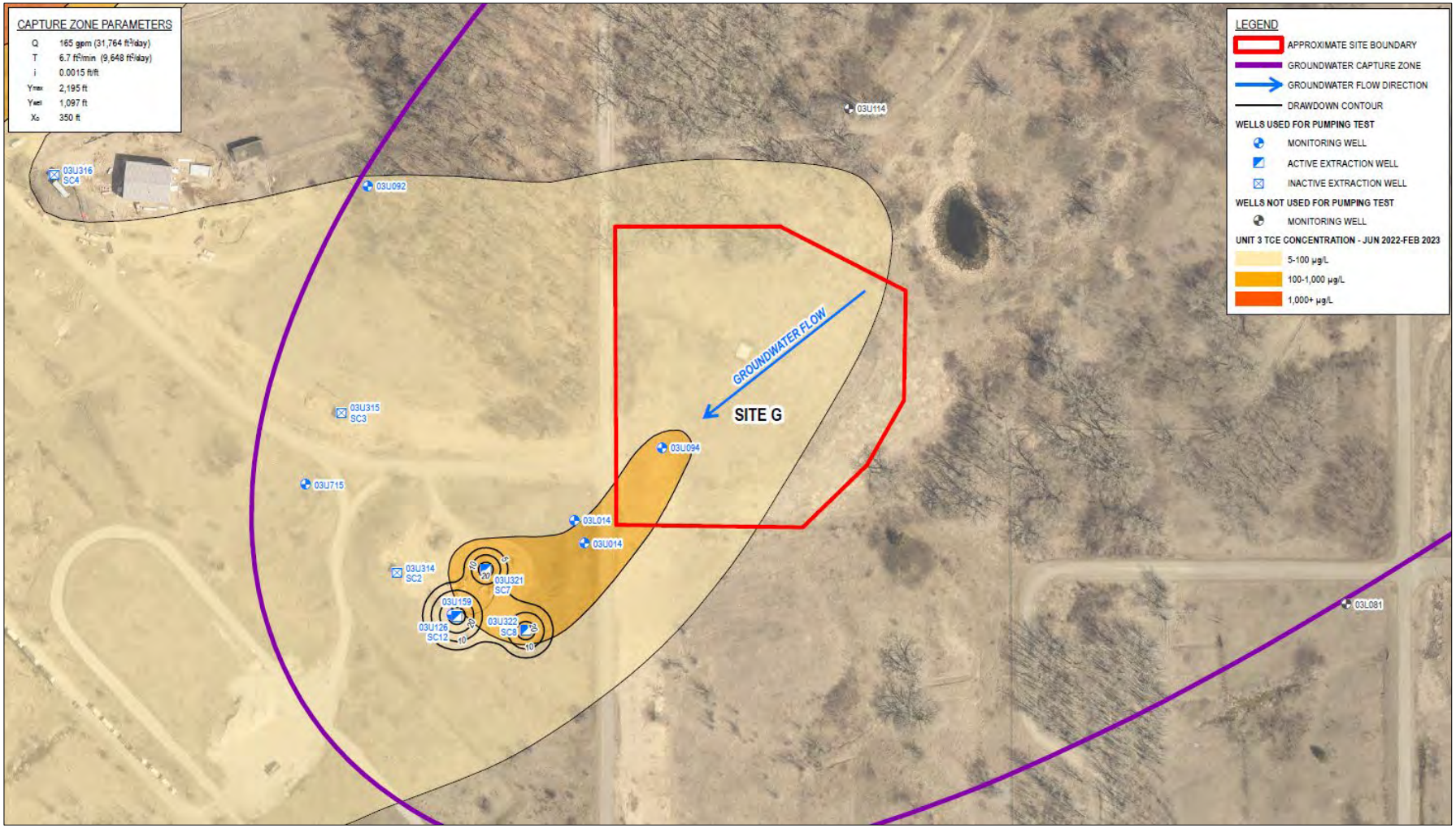
Site G Hydraulic Capture – TCE



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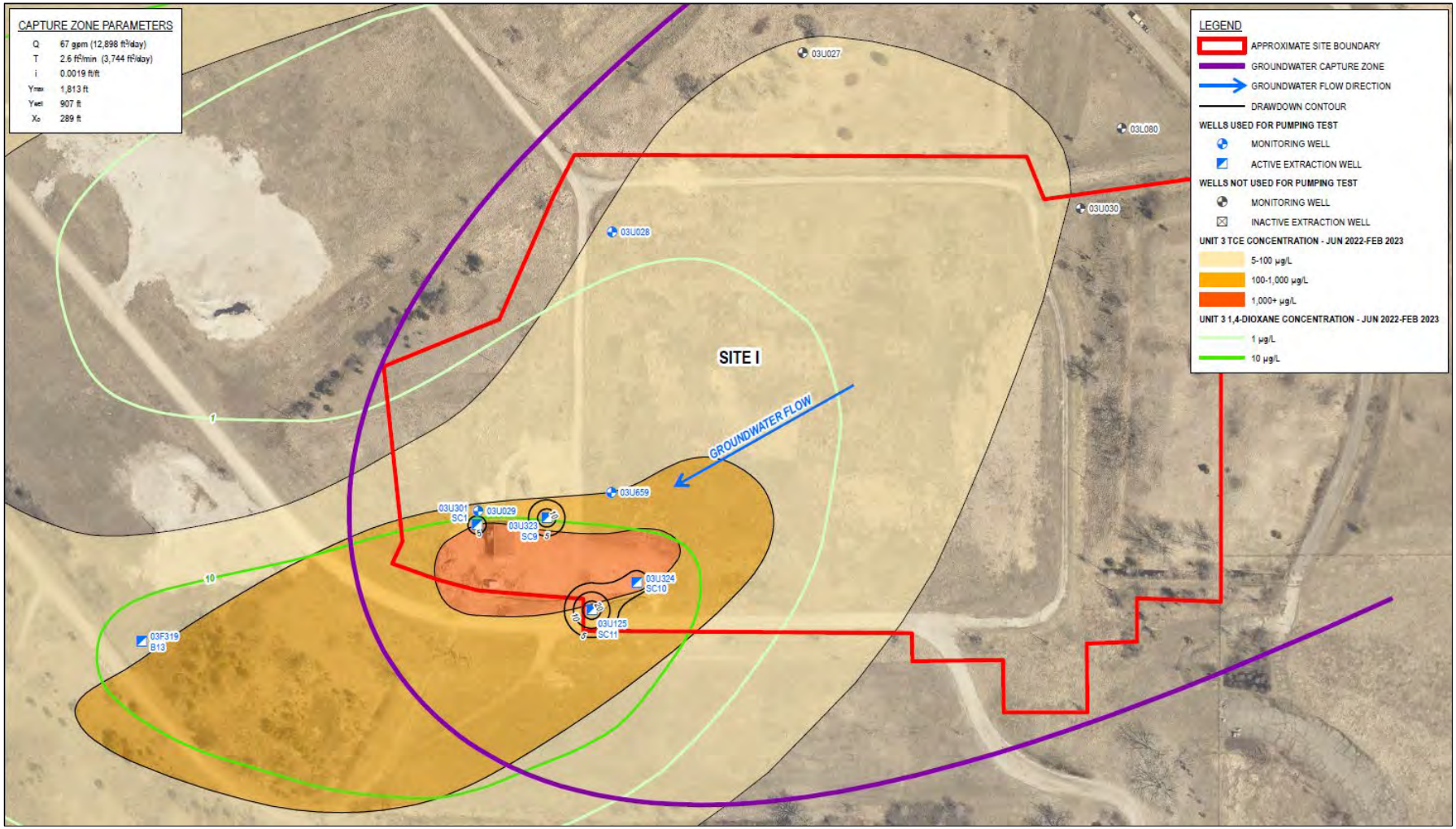
Site G Hydraulic Capture – 1,4-Dioxane

Site I Hydraulic Capture – TCE and 1,4-Dioxane



BGRS (Building 116) Air Emissions

- Since SC-5 and SC-1 have been removed from BGRS influent and re-routed to SGRS influent, TCE concentrations have reduced from 201 µg/L in 2020 (when modelled/sampled) to less than 40 µg/L (80% reduction) while operating the full boundary well system (greater than 1,600 gpm).
- Once new operating strategy is approved (with likely lower BGRS flow and TCE emission rates), an air sampling work plan will be prepared and submitted for Regulator (EPA and MPCA) review.

PFAS

- A Preliminary Assessment and Site Inspection (PA/SI) was finalized by the Army in September of 2023.
- In July of 2024, the Army received a joint letter from EPA and MPCA requesting additional Areas of Potential Interest (AOPIs) be added to the upcoming Remedial Investigation and Feasibility Study (RI/FS).
- The Army has agreed to discuss the inclusion of additional AOPIs with EPA and MPCA, discussion is expected to take place in October.
- A RI/FS contract is currently being built with an expected award during 3rd quarter FY25 pending funds availability.

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Additional Presentations

- USGS Groundwater Model Update
- USGS Site K Update
- Round Lake Design

What's Next

- OU1
  - Optimization identified a need for a new well in New Brighton.
  - Begin industrial well abandonment (3 wells).
  - Begin installation of 4 monitoring wells.
- OU2
  - Begin abandonment of 42 monitoring wells.
  - Begin installation of 1 monitoring well including optimization of the monitoring well network.
  - Begin Risk Assessment for unrestricted land use.
  - 135 Primer Tracer Area – sold.
- OU3
  - Continue groundwater monitoring.
- Round Lake
  - Continue remedial design.
- Administrative Record/Information Repository
  - Army working with Arden Hills Army Training Site (AHATS) to enlarge space.

New Business

- Recommend next RAB meetings 18 February and 16 September 2025.
- Topics for future RAB meetings?
- Additional administrative requirements for RAB?
- Suggestions for improvement of RAB?

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Next Meeting Agenda

- Review/Approve minutes of last meeting
- Old Business
- Cleanup Status Update
- New Business
- Next Meeting Agenda
- Public Comments

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Public Comments

- Does anyone have any comments, concerns or suggestions

Questions

- You can ask questions now or at anytime using the email listed on the website.

TCAAP Groundwater Flow and Transport Model Update

September 2024 RAB and
Stakeholder Meetings

This information is preliminary and is subject to revision. It is being provided to meet the need for timely best science. The information is provided on the condition that neither the U.S. Geological Survey nor the U.S. Government may be held liable for any damages resulting from the authorized or unauthorized use of the information.

USGS Upper Midwest Groundwater Modeling Team
Andy Leaf
Laura Schachter
Howard Reeves
Meg Haserodt

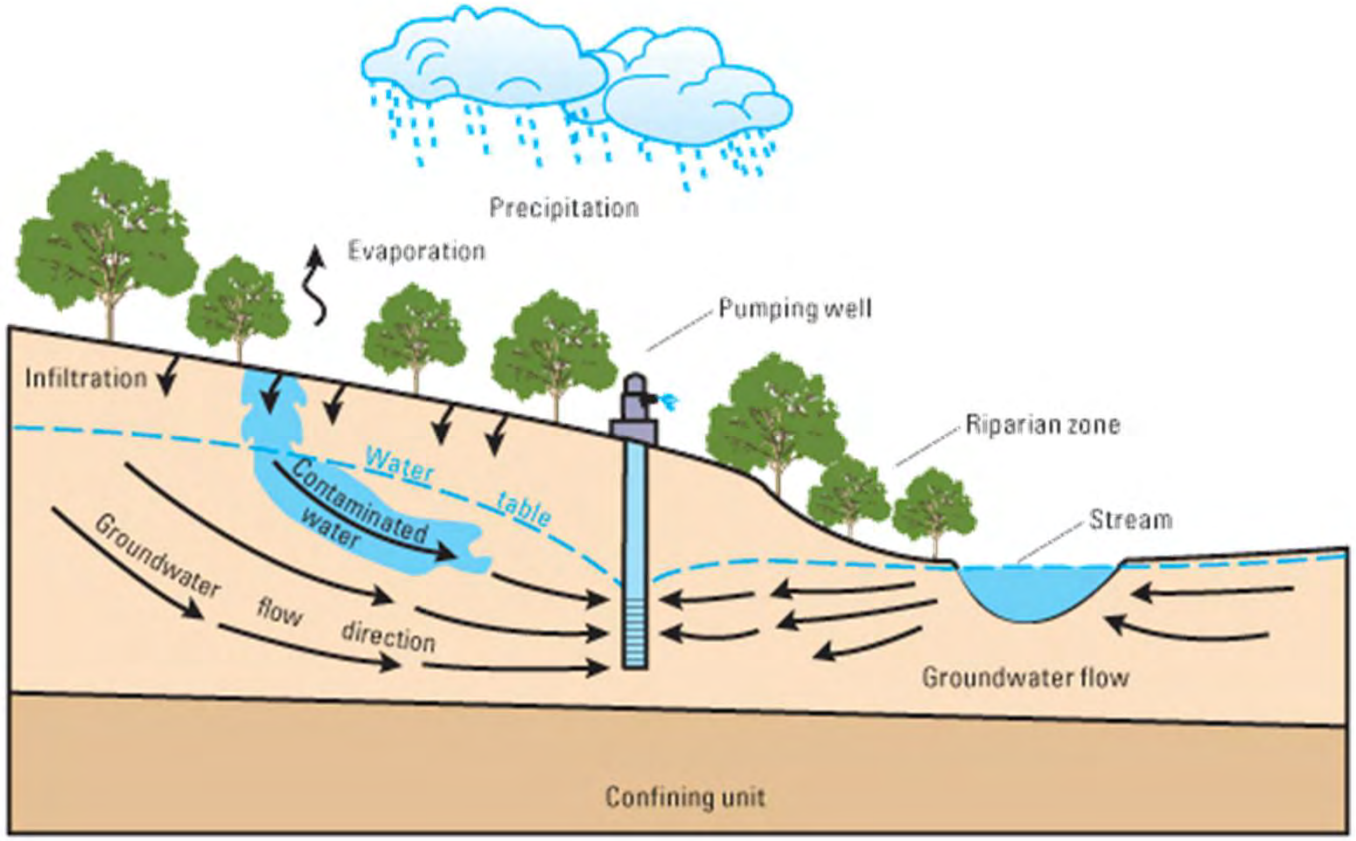
Project Overview

- Build a groundwater flow and transport model to simulate the deeper groundwater system near TCAAP
  - The purpose of this effort is to estimate the expected plume capture from the pumping remediation systems.
- Focus on the OU1, OU2, & OU3 groundwater plumes
- Contaminants
  - 1,4-dioxane
  - Trichloroethene (TCE)

Figure modified from Figure 2-1 in the Fiscal Year 2020 *Annual Performance Report*.

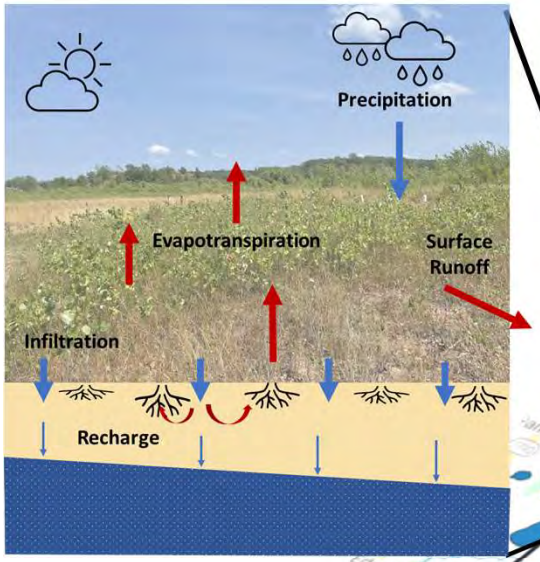
What is a groundwater flow + transport model?

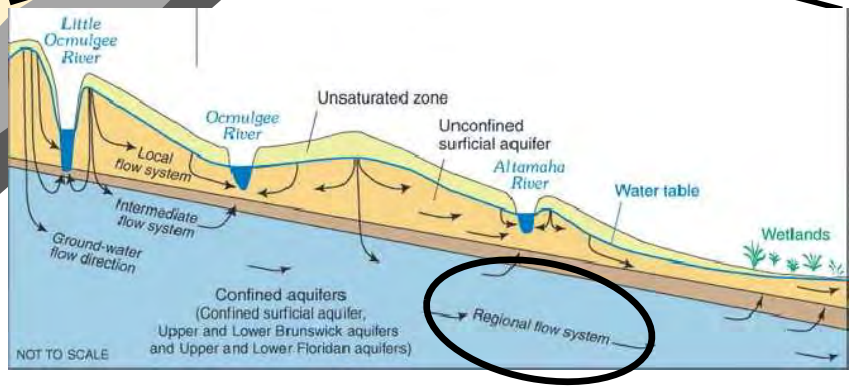
- Groundwater flow: the path water takes from where it enters the ground to where it exits the ground.
- Groundwater transport: how a chemical moves and interacts with the groundwater system.



https://pubs.usgs.gov/fs/2012/3004/

Groundwater Flow Model





Recharge

Pumping

TCAAP

Exchanges with lakes and rivers

Regional Groundwater

Regional Groundwater

(From Metro Model 3)

Regional Groundwater

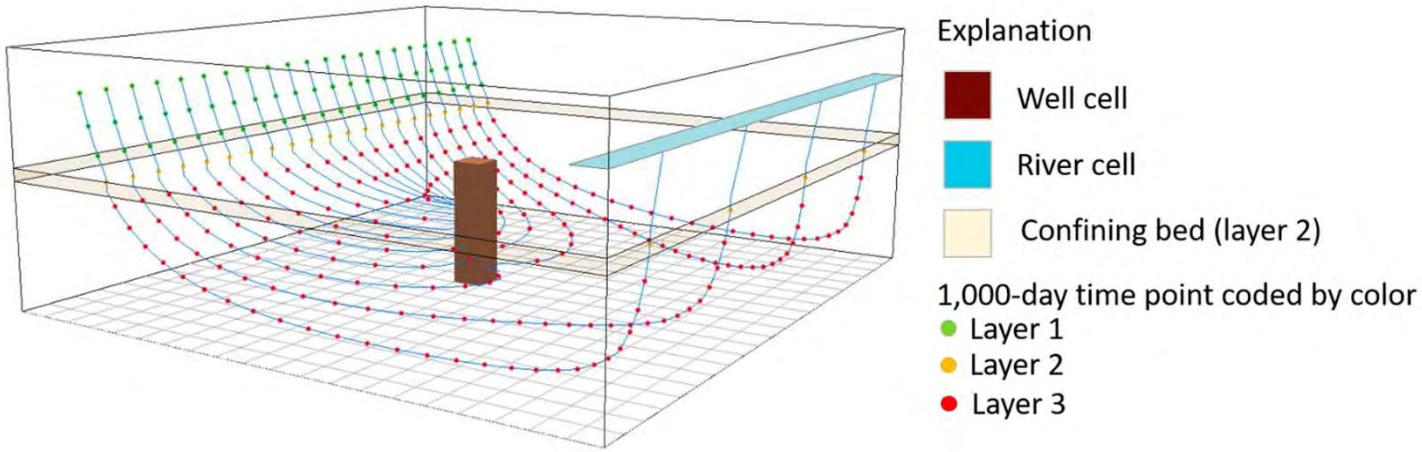
Regional Groundwater

Geology

Metro Model 3: https://metrocouncil.org/Wastewater-Water/Planning/Water-Supply-Planning/Planners/Metro-Model-3.aspx
Regional flow photo from http://ponce.sdsu.edu/groundwater_utilization_and_sustainability.html; site photo in recharge diagram from Mary Lee, USAEC; river photo from: https://www.visitsaintpaul.com/blog/mississippi-river/; and pump photo from: https://www.watereducation.org/aquapedia/groundwater.

Simulating advective transport with particle tracking

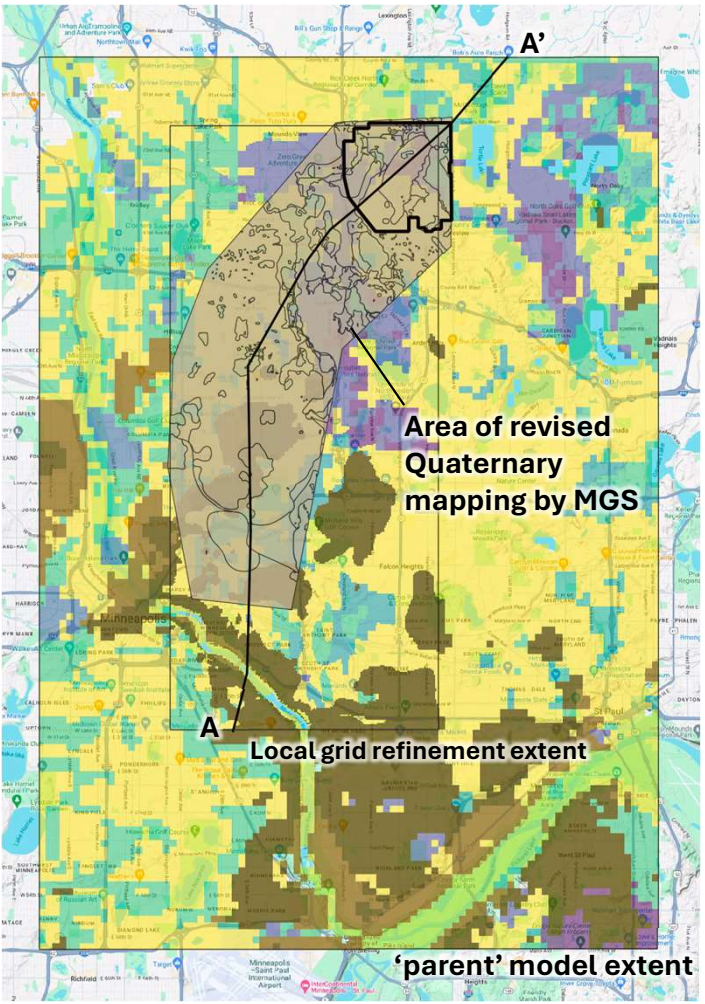
- **Advective transport** describes the movement of water through the groundwater flow system
- Can use a groundwater flow model and particle tracking software such as MODPATH, to simulate advective transport by tracing hypothetical "particles" through a groundwater flow solution.
- Does not consider other contaminant transport processes like decay, sorption, etc.

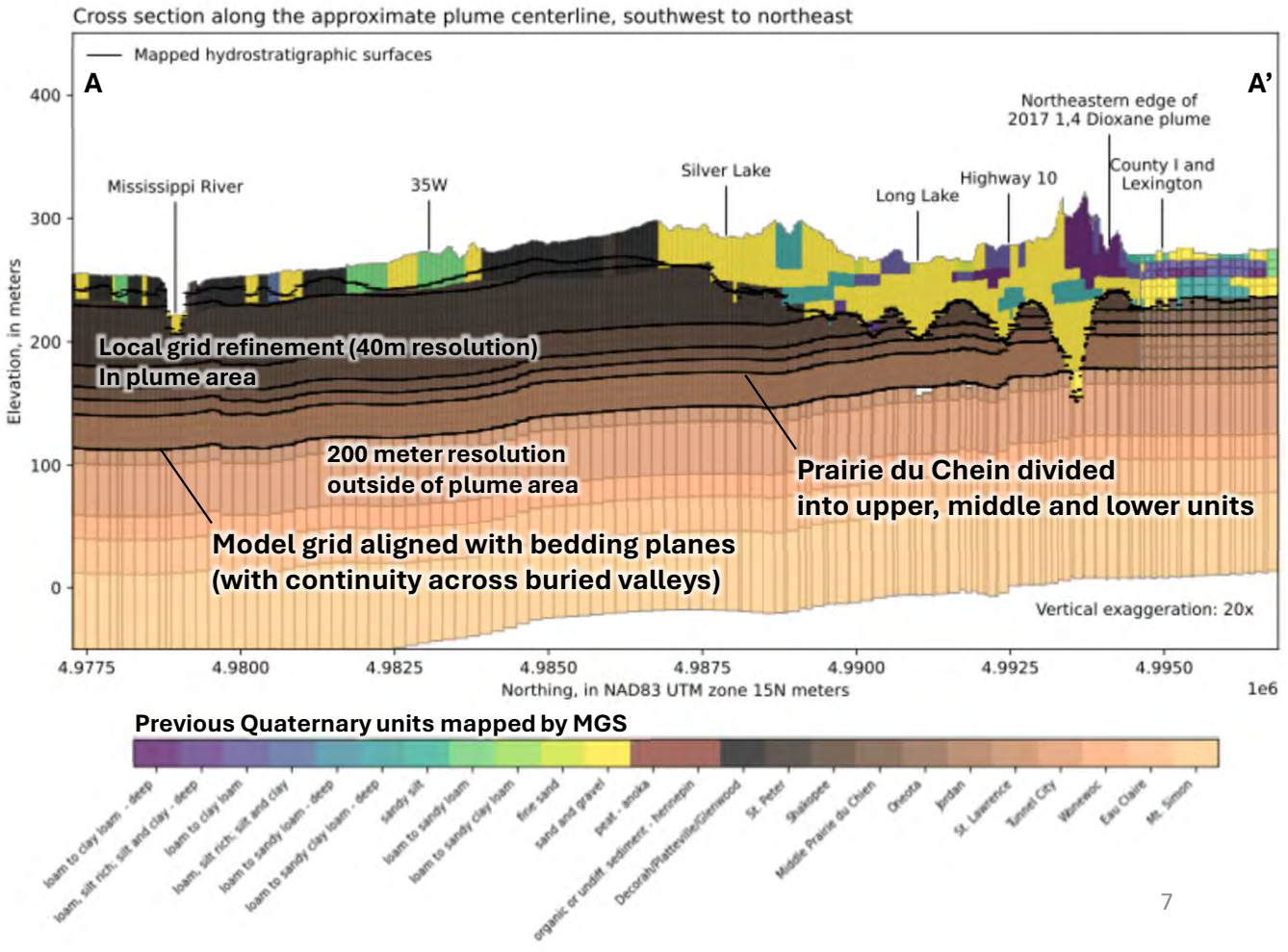


Pollock, D.W., 2016, User guide for MODPATH Version 7—A particle-tracking model for MODFLOW: U.S. Geological Survey Open-File Report 2016–1086, 35 p., http://dx.doi.org/10.3133/ofr20161086.

Groundwater Flow and Advective Transport Model Updates

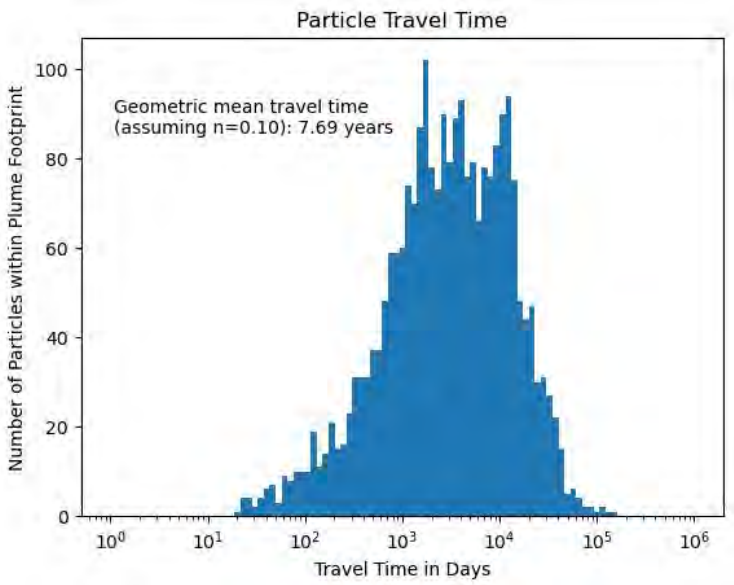
Model Layering (see supplemental slides for model details)

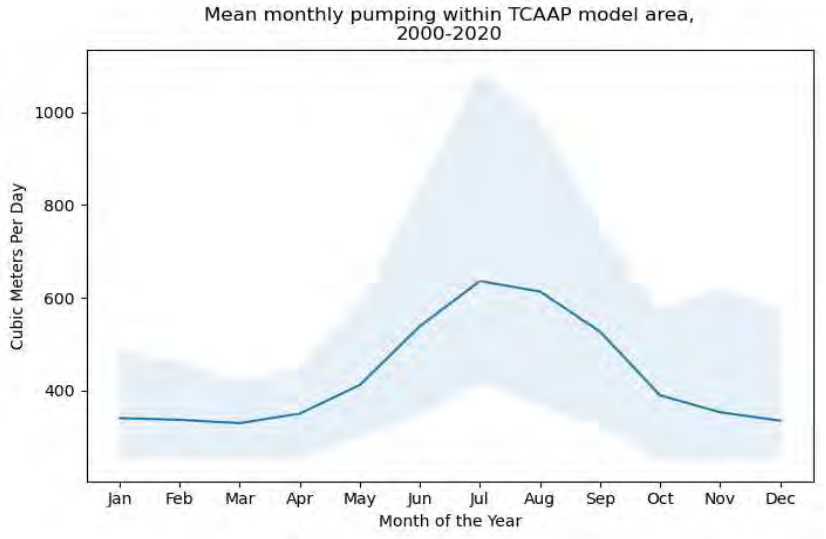




Do transient conditions matter?

- Transient simulations consider changes in the hydrologic system through time
- In the area around TCAAP:
  - Water use varies seasonally by ~30%
  - Wells exhibit a multi-decadal trend of rising water levels
  - Nearby lake levels are remarkably stable, within +/- 1 ft over the last few decades
  - 9 months of water level monitoring in the TCAAP gravel pit indicate about a 2 ft range in pit water levels



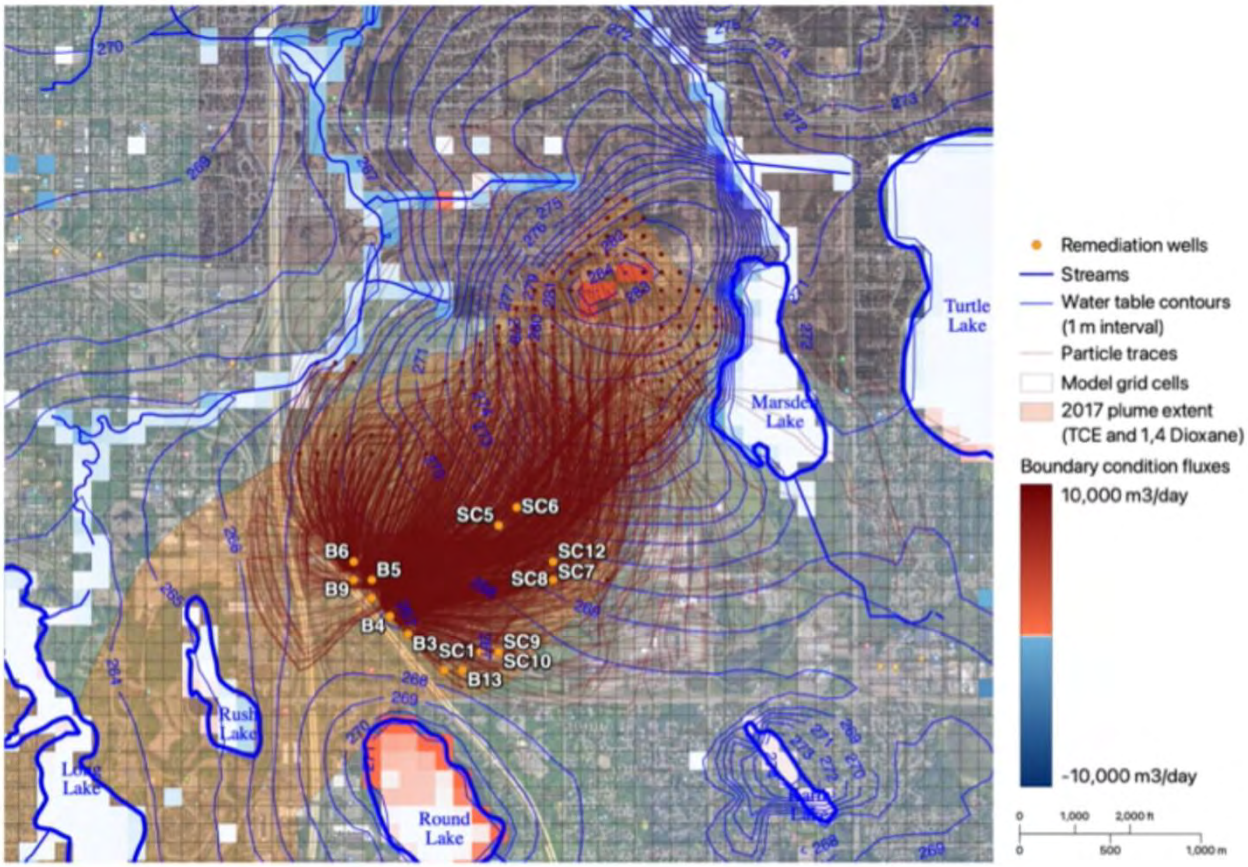


Relevance to model predictions:

- Does flow transience meaningfully affect flow paths and ultimately, **plume capture percentage**, **plume width**, or **plume extent in x years?**
- The time it takes for hydrologic changes to propagate through the aquifer are similar to simulated travel times to the remediation wells

Plume capture analysis – preliminary results

- Particle tracking (advective transport) can be used to delineate the areas contributing water to wells (capture zones)
- This slide shows an example of plume capture results. These will be updated in the final version of the model.



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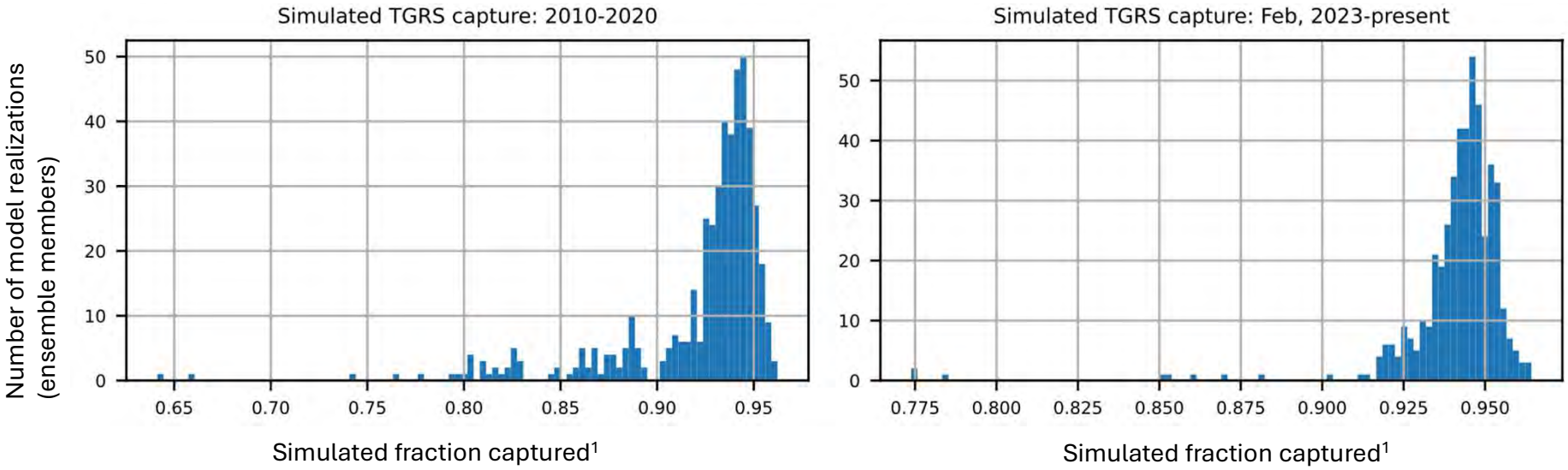
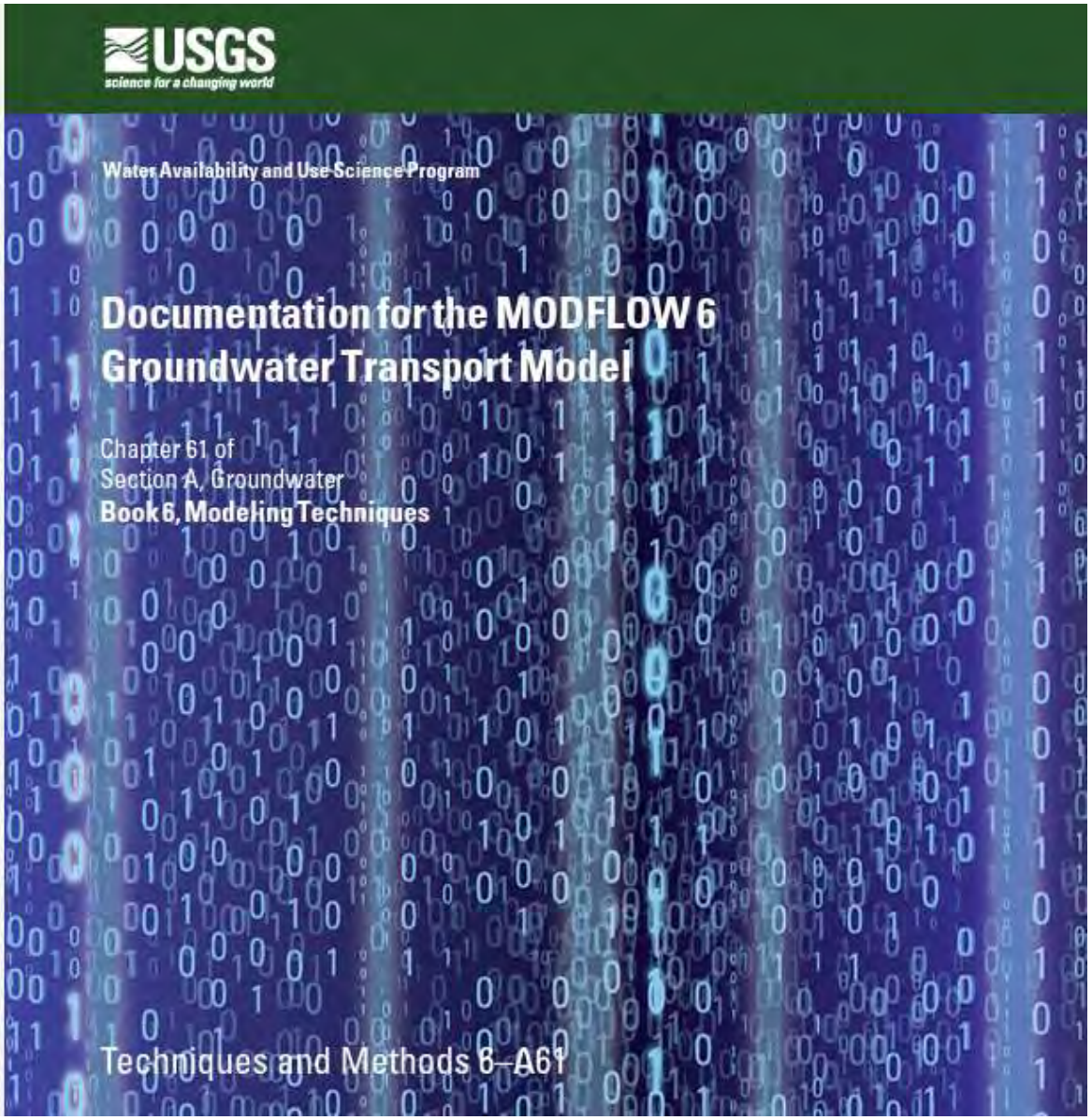
Plume capture analysis – preliminary results

- Preliminary calibration of the steady-state flow model indicates ~94% (+/- 2 %) capture of the on-site part of the contamination plumes.[1]
- This model prediction may change somewhat as the model continues to be refined.



[1]Defined as the volume of water originating within the combined 2017 TCE and 1,4 Dioxane plume footprint on the TCAAP property, extending from the water table to the base of the Jordan sandstone. This is likely a conservative estimate of the actual mass capture, because it equally weights all water within this volume. In reality, the plume extent varies with depth, and the highest concentrations of contamination are near the center of this volume (highest probability of capture); many areas near the edges of this volume (less certain capture) are uncontaminated.

Groundwater Contaminant Transport Model



Contaminant Transport Processes

- Groundwater flow (**advection**[1])
- Attachment (**sorption**[1]) of contaminants to soil and rock particles
- Breakdown (**degradation**[1]) of contaminants
- Local-scale variability in subsurface causes spreading of plume (**dispersion**[1])
- Input of contaminant from the source area (**source loading**) and existing contaminant in the aquifer (**starting conditions**)
- Physical removal of contaminant by exiting the aquifer through pumping wells or natural groundwater discharge into streams and lakes

[1]See supplemental information slides for illustrations of these processes.

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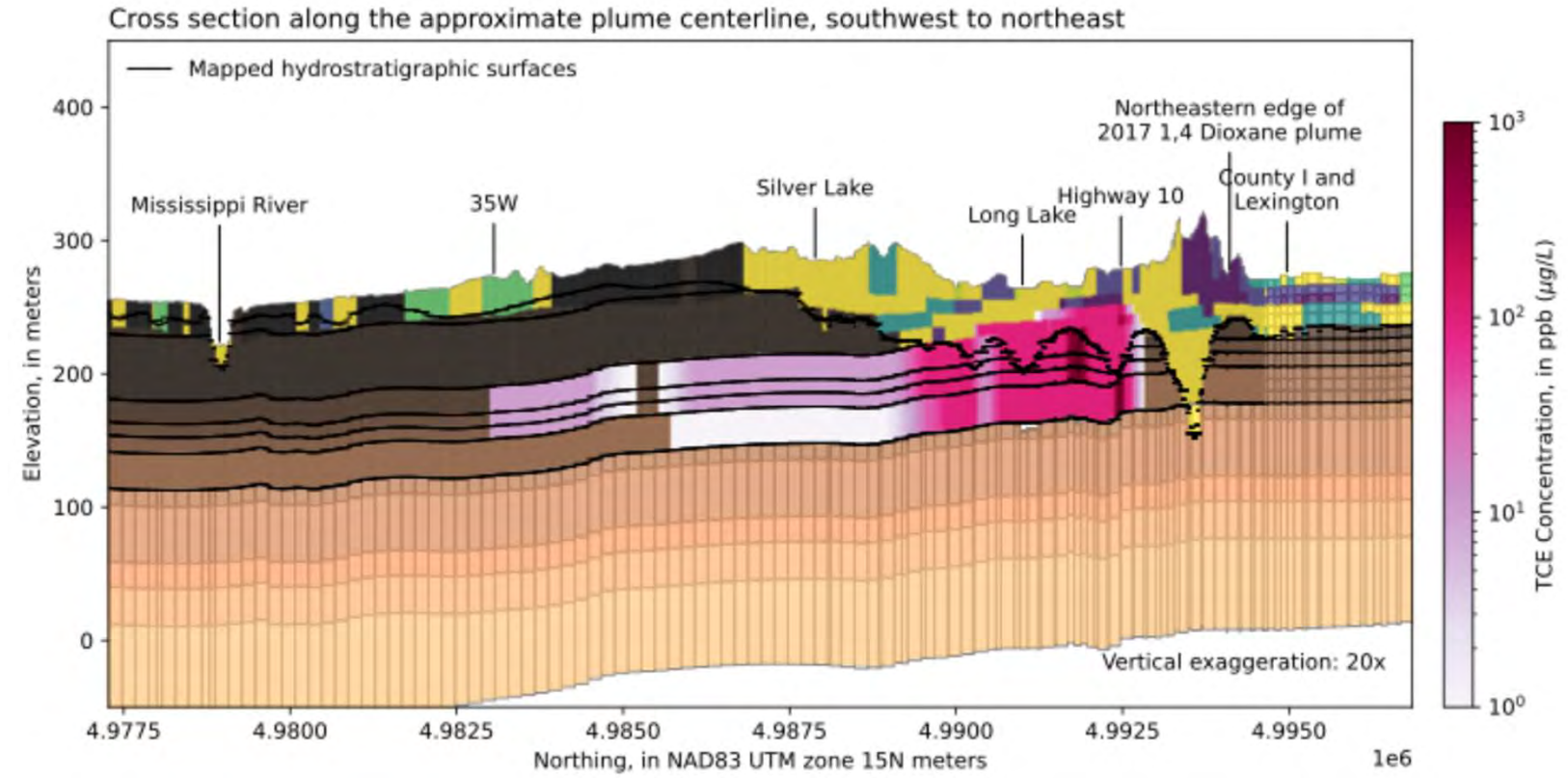
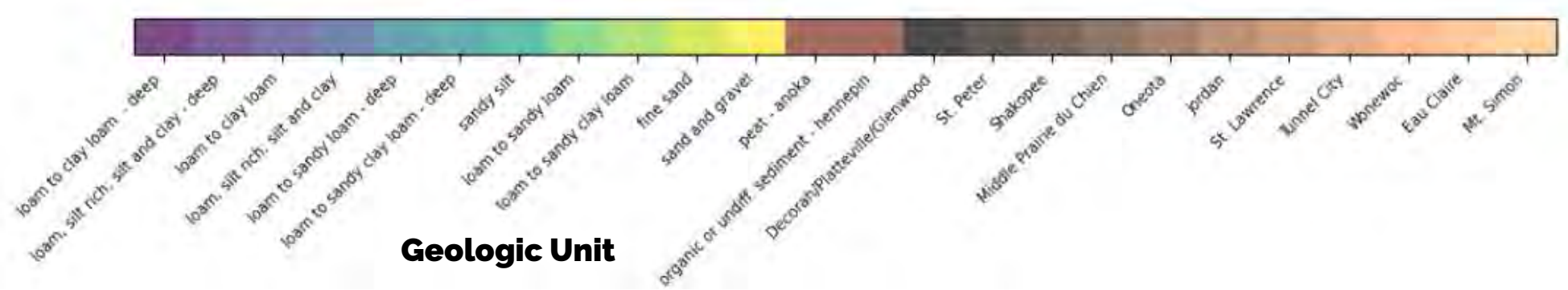
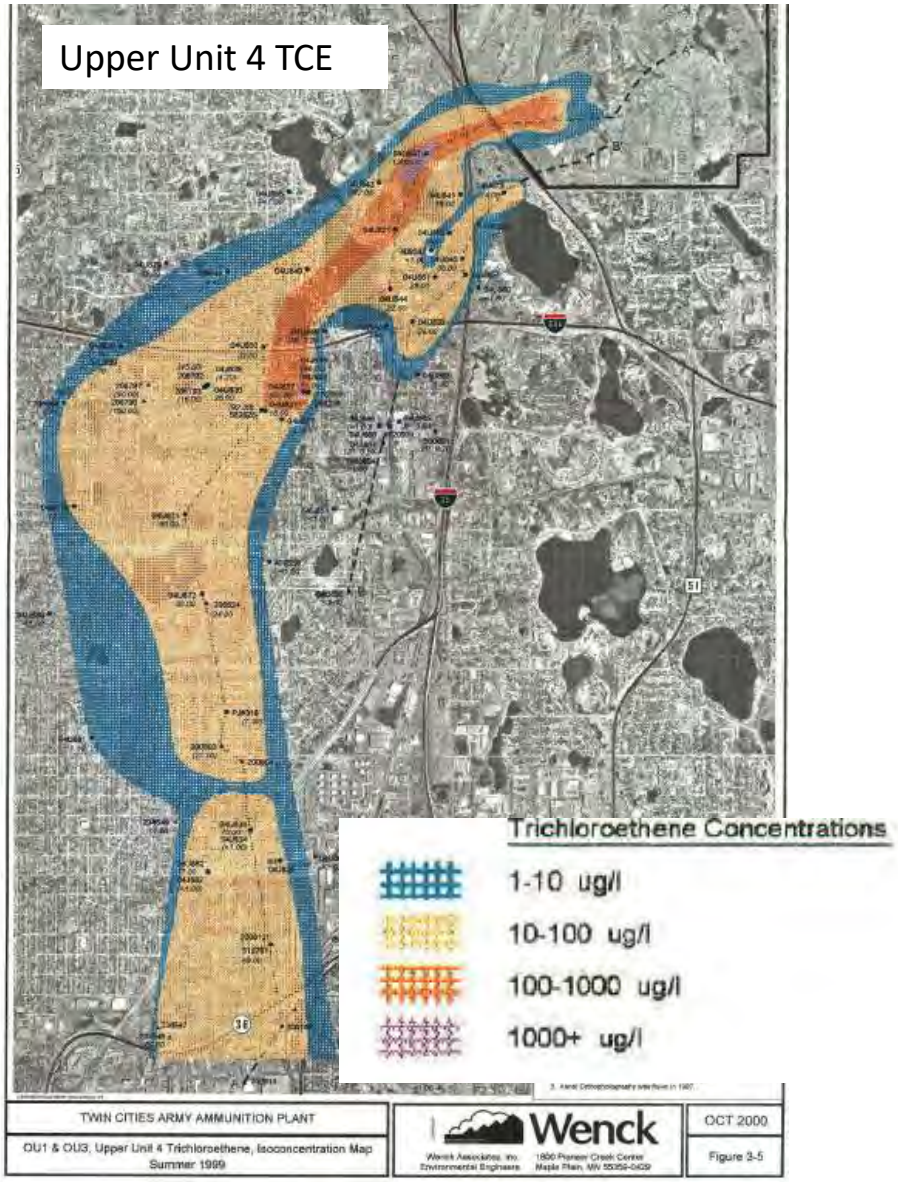




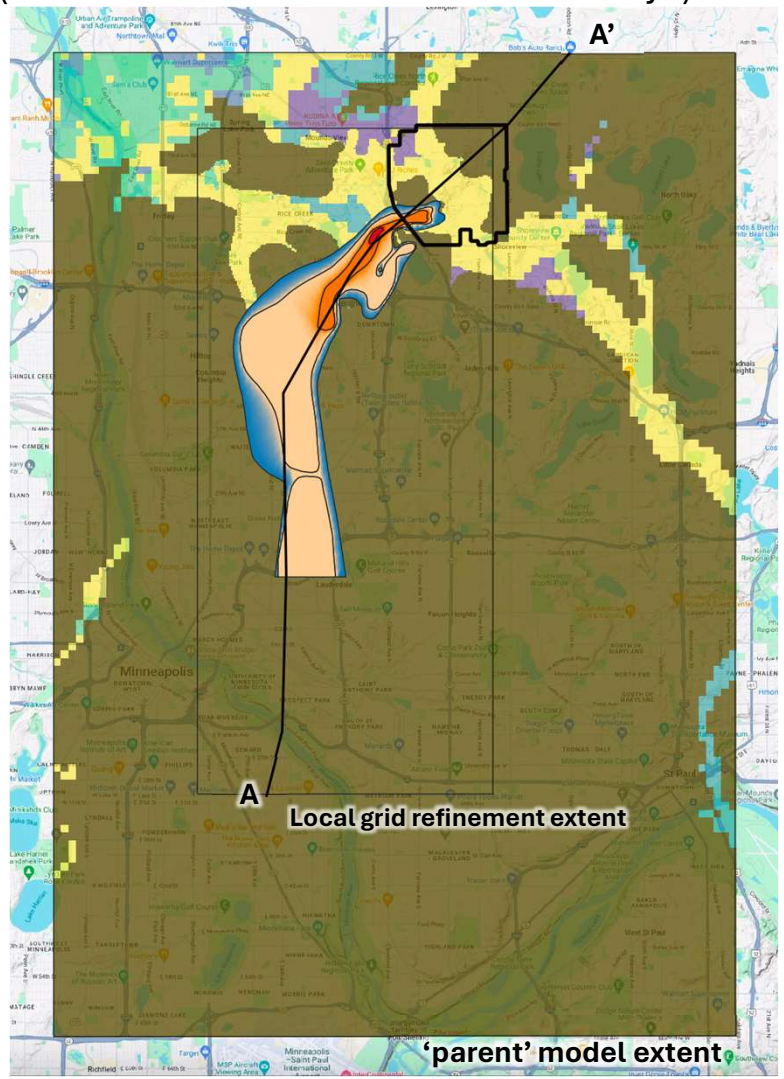
Geologic Unit

TCE Starting Conditions

- Initiate the plume in the model using the 1999 Annual Performance Report TCE plumes
- No lower unit 4 (Jordan) plume extent mapped in 1999 so estimated from well TCE data.



TCE Starting Conditions in model layer 6
(middle Prairie du Chien & buried valleys)



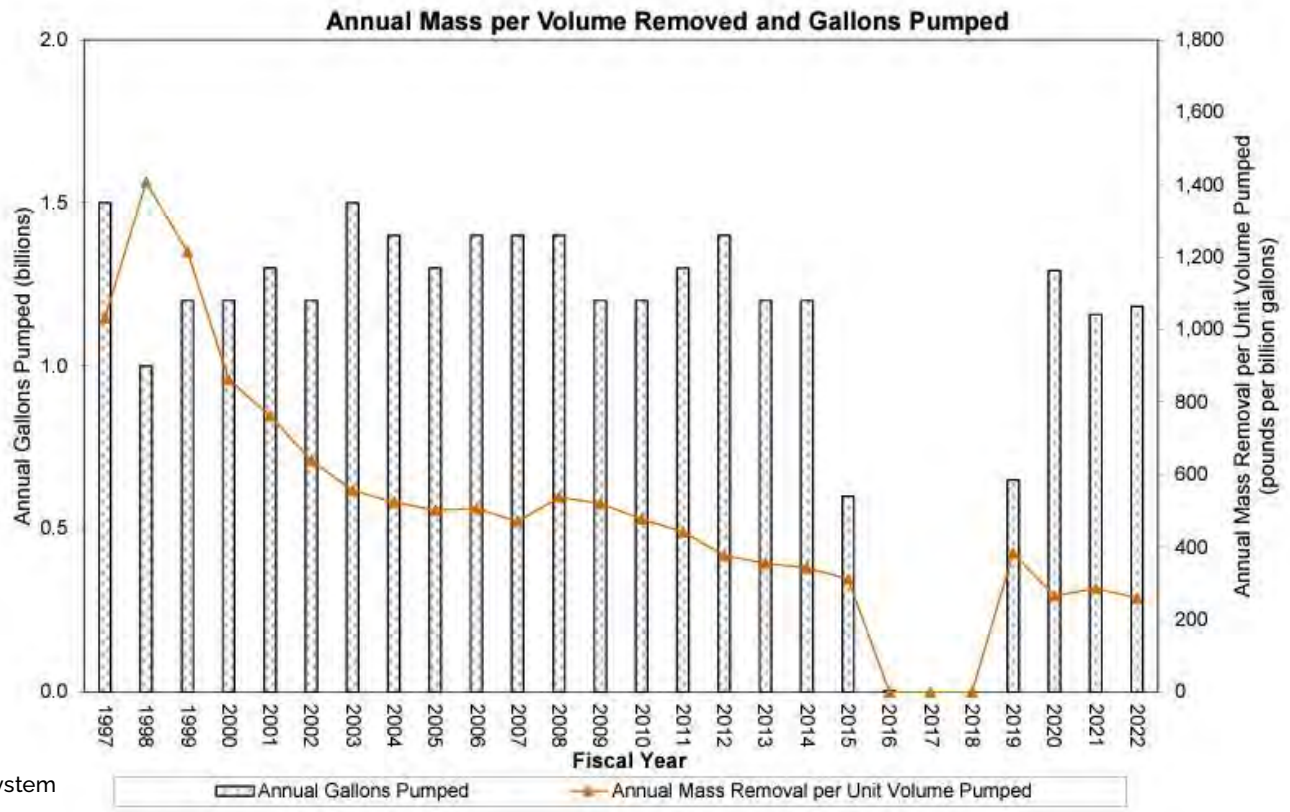
Initial TCE concentrations (µg/L)
- 1
- 10
- 100
- > 1000

Pumping

- Pumping from TGRS and NBCGRS is the main way contaminant is being removed from the aquifer.
- Good site data for pumping rates and concentrations.
  - We will compare the modeled contaminant coming out of the pumping system over time to this site data.

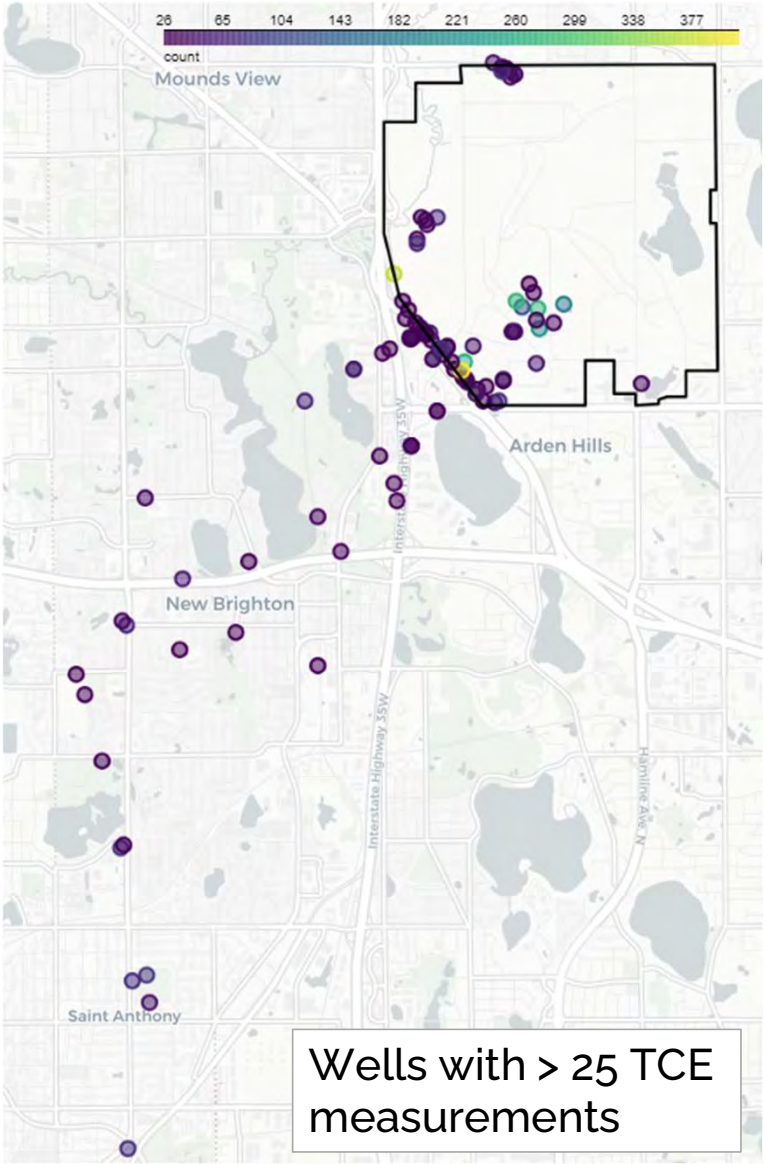
FIGURE 2-11
OU1, NBCGRS MASS REMOVAL HISTORY

FY 2022 Annual Performance Report



TGRS = TCAAP Groundwater Recovery System
NBCGRS = New Brighton Contaminated Groundwater Recovery System

Figure from 2022 APR estimating the total VOC mass removal over time.



Wells with > 25 TCE measurements

Transport Model History Matching

- Simulate transport processes using parameters in the model.
- Many of these model parameters are uncertain and have a range of reasonable values.
- Tune the model parameter values to best match field data, for example:
  - Concentrations in wells
  - Remediation system effluent concentrations
  - Interpreted plume characteristics (width, center of mass, overlap between simulated and interpreted plumes, etc.)

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Project Timeline

FY 2025

- Refine history matching to get groundwater flow and TCE transport model that reasonably reproduces measured site data
- Build 1,4-Dioxane transport model
- Draft online map for users to interactively explore model results

FY 2026

- Final model adjustments & estimates of plume capture by pumping system
- Publication of model & results in USGS Series Report
- Archive model files in publicly available data release
- Publish interactive online map of model results

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Questions?

Questions for the USGS Modeling Team that were not asked during the live presentation can be emailed to:

Meg Haserodt, mhaserodt@usgs.gov

Supplemental Modeling Information

Summary of Current Model Status

MODFLOW 6 steady-state groundwater flow and advective transport model (MODPATH 7)

- **Two periods representing 2010-2020 and February 2023 to present** remediation system pumping
- **Initial version with uniform 100-meter discretization**
  - Suitable for particle tracking (advective transport or simulation of flow paths)
- **In-progress version with 40-meter resolution in area of plume (local grid refinement)**
  - 200-meter resolution elsewhere
  - Suitable for mass transport (simulation of concentrations)
- **Both versions have continuous layers based on bedrock hydrostratigraphic units**, which also include the portions of the Quaternary deposits that intersect the units in buried valleys (see cross section figures and layering details below):
  - **The current layering reflects the most recent (2024) bedrock surfaces mapped by the Minnesota Geological Survey (MGS)**
  - The current Quaternary units reflect previous Twin Cities-wide Quaternary mapping efforts by MGS; obtained from them in 2021. **Currently, we are working to incorporate more recent (2024) mapping efforts that describe the TCAAP site in greater detail.**
  - **Layering details:**
    - A single upper layer containing the water table; represents upper bedrock units where present; Quaternary deposits elsewhere
    - St. Peter sandstone (3 layers): at the site, where the St. Peter is eroded away, the lower two of these three layers represent the Quaternary materials in Upper and Lower Unit 3, respectively
    - Prairie du Chien (Upper Unit 4; 3 layers):
      - Shakopee dolomite
      - A more conductive middle zone representing the bedding plane fracture between the Shakopee and Oneota, and other fractures and associated dissolution features in the upper Oneota
      - The Oneota dolomite (thought to be a confining unit in some areas but heterogenous)
    - Jordan Sandstone (Lower Unit 4; 3 layers)
    - Each hydrostratigraphic unit below the Jordan is represented with a single layer

Summary of Current Model Status

- **MODFLOW 6 steady-state groundwater flow model (continued)**
  - **Preliminary history matching results for uniform 100-meter, including ensemble estimates of remediation system capture**
    - Using head targets from the site and the MN Well Database
    - Horizontal hydraulic conductivity fields modified from the Twin Cities Metro Model
    - Vertical hydraulic conductivities based on ranges provided by MGS
  - **In-progress:**
    - **Finish testing and debugging 40-meter (local grid refinement) version of model**
    - **Improved history matching**
      - Focus on conditions within the plume area, including matching vertical head gradients and observed water levels in the gravel pit
      - Account for uncertainty in porosity (travel times of water captured by remediation system)
      - Include revised Quaternary mapping
      - Incorporate flow surveys from Rice Creek
      - Incorporate ongoing improvements to the Soil Water Balance (groundwater recharge) model
    - **Transient version of uniform 100-meter flow model**
      - Goal is to test effects of transience on particle paths and estimates of plume capture
      - If the results are similar to steady-state, we can probably proceed with a steady-state flow model for mass transport simulation

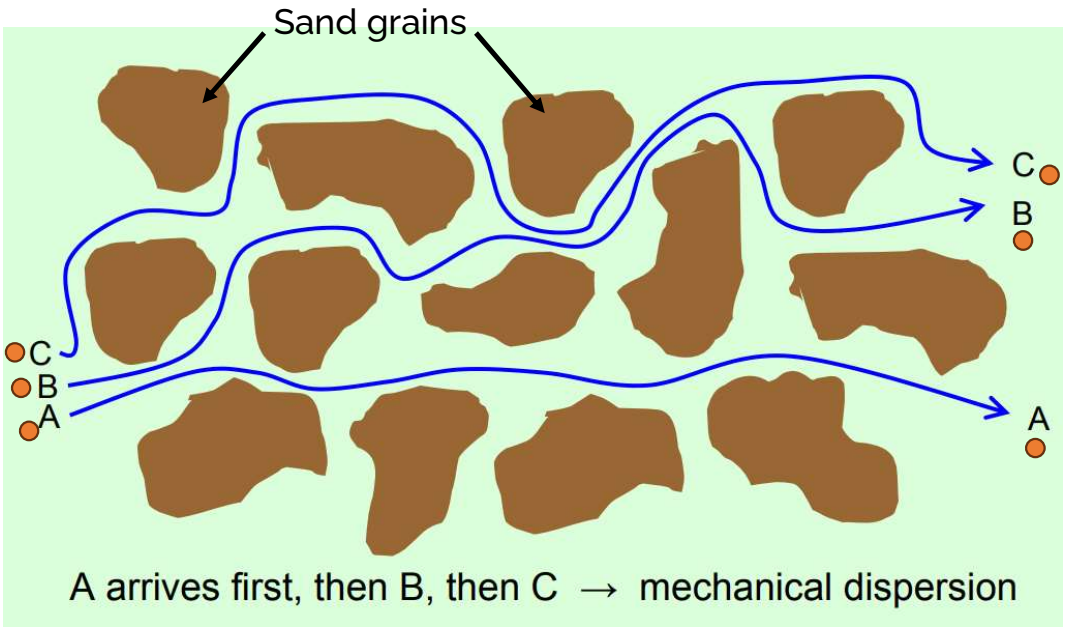
- **MODFLOW 6 transport model**
  - Completed automated workflow to set up model for TCE plume
  - Model currently starts with 1999 interpreted plumes as initial concentrations
  - Working on incorporating field observations and forecasts
  - **Next steps:**
    - History matching and uncertainty analysis
    - 1, 4 Dioxane model following same methods

Other model details

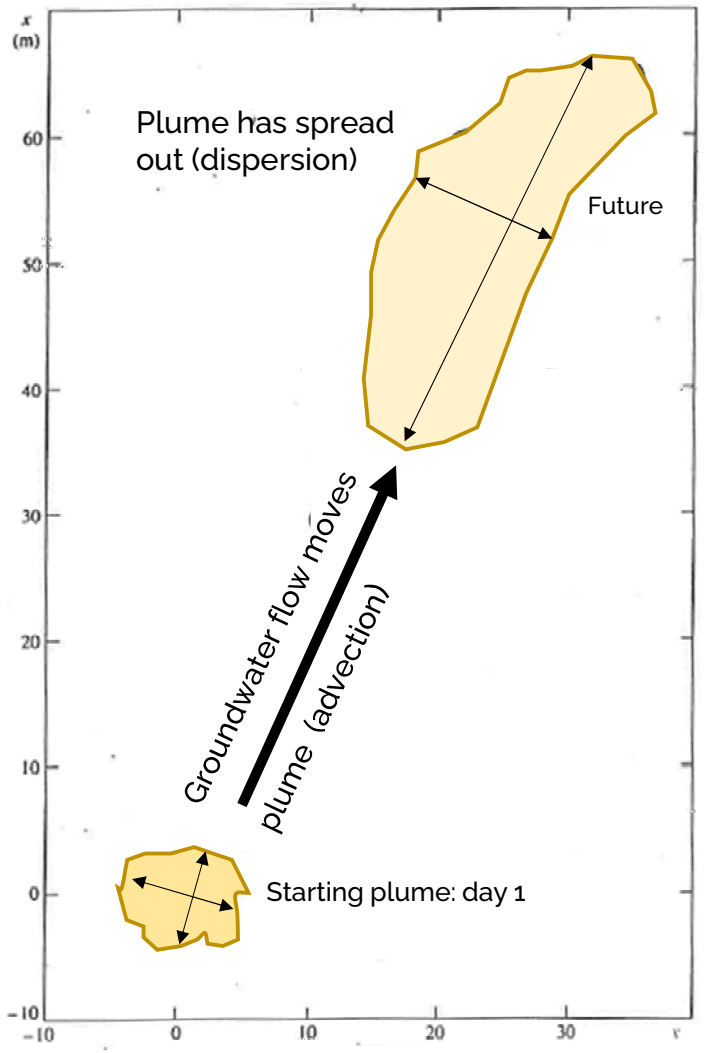
- **Model Boundary Conditions (all versions)**
  - Streams and lakes based on NHDPlus High Resolution and 3-meter lidar DEM
  - Rice Creek simulated with the MODFLOW SFR Package
  - Lakes and the Mississippi River simulated with the MODFLOW RIV Package
  - Groundwater recharge based on net infiltration results from Soil Water Balance code simulation (pending revision)
  - Specified heads along the model perimeter from the steady-state Metro Model (version 3) flow solution
  - Water use from MN Well Database and site pumping data (MODFLOW 6 Multi-Aquifer Well Package)
- **Evaluating past and present remediation systems (all versions)**
  - Remediation wells simulated with the MODFLOW 6 Multi-Aquifer Well Package
  - Discharge to the gravel pit simulated with the Recharge Package

Advection and Dispersion

Advection: Contaminant moves with the groundwater
Dispersion: Molecules take different length paths through the rock or soil resulting in spreading of the plume.



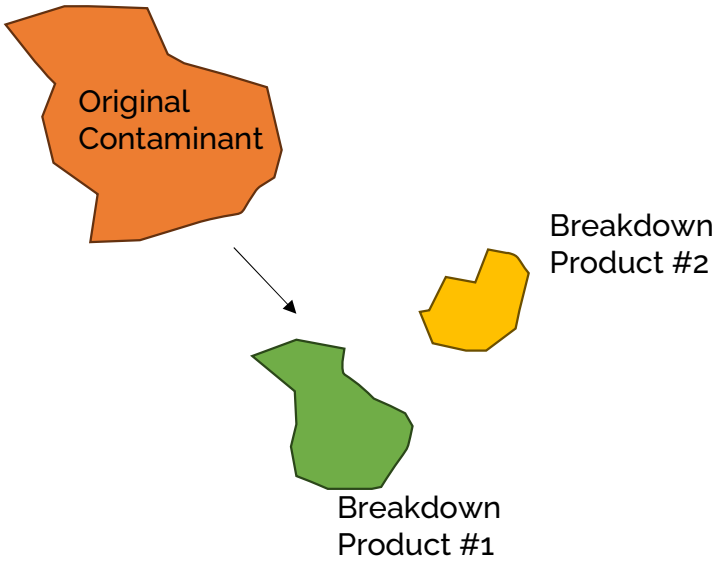
Dispersion Image: https://ocw.mit.edu/courses/civil-and-environmental-engineering/1-34-waste-containment-and-remediation-technology-spring-2004/lecture-notes/lecture03.pdf



Hypothetical Plume Example

Decay

- Some contaminants naturally decay over time
- Rate of decay influenced by
    - aquifer properties
    - contaminant properties
    - contaminant concentration
    - microorganisms
- Can enhance decay by making conditions more favorable for microbes (e.g. bioremediation at Site K).



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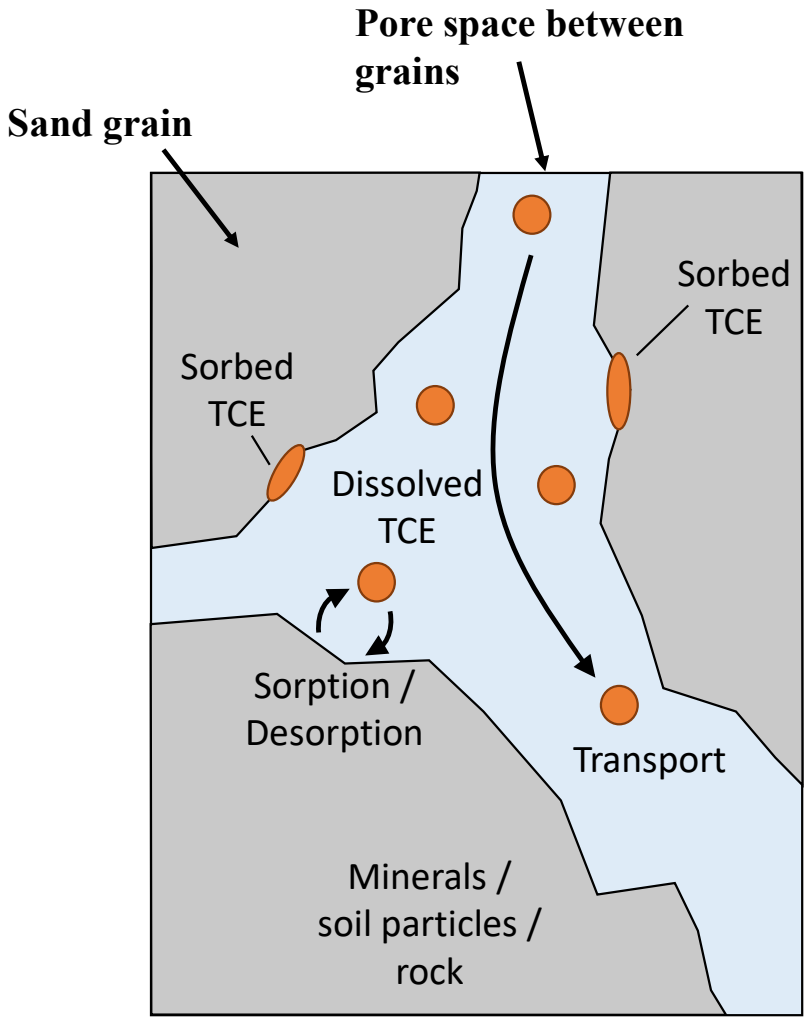
Sorption

- Sorption is when a contaminant sticks onto the soil particles or rock surface instead of flowing with the groundwater.
- Amount and rate of sorption is influenced by
  - Aquifer material properties
  - Water chemistry
  - Contaminant chemical properties



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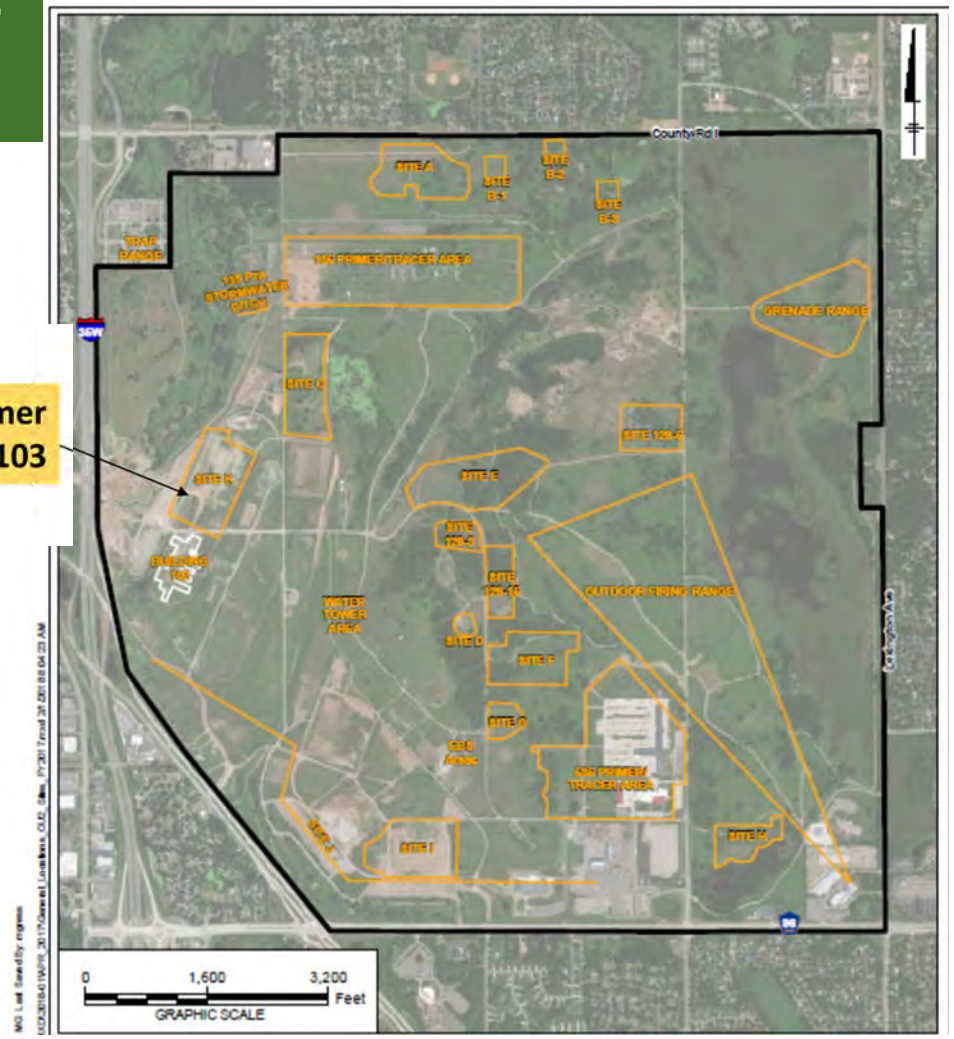
OU2- Site K USGS Treatability Test

Dr. Michelle M. Lorah
Research Hydrologist
U.S. Geological Survey
Baltimore, Maryland
mmlorah@usgs.gov

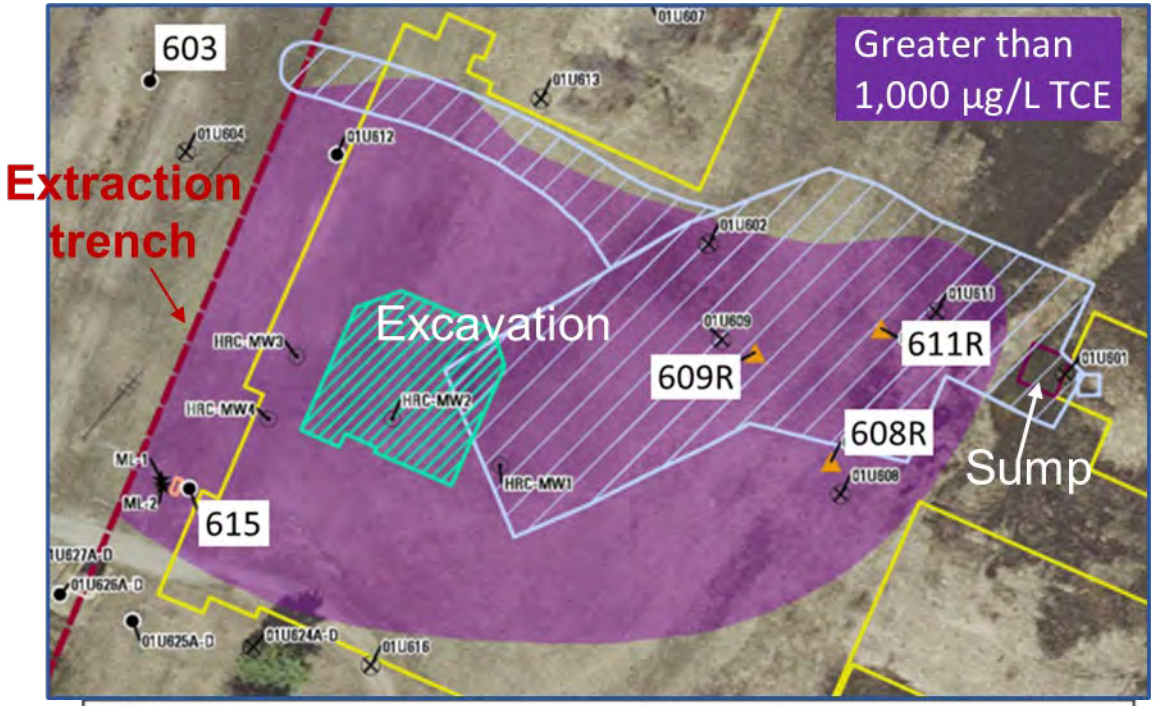
Restoration Advisory Board Meeting,
TCAAP, MN, September 17, 2024

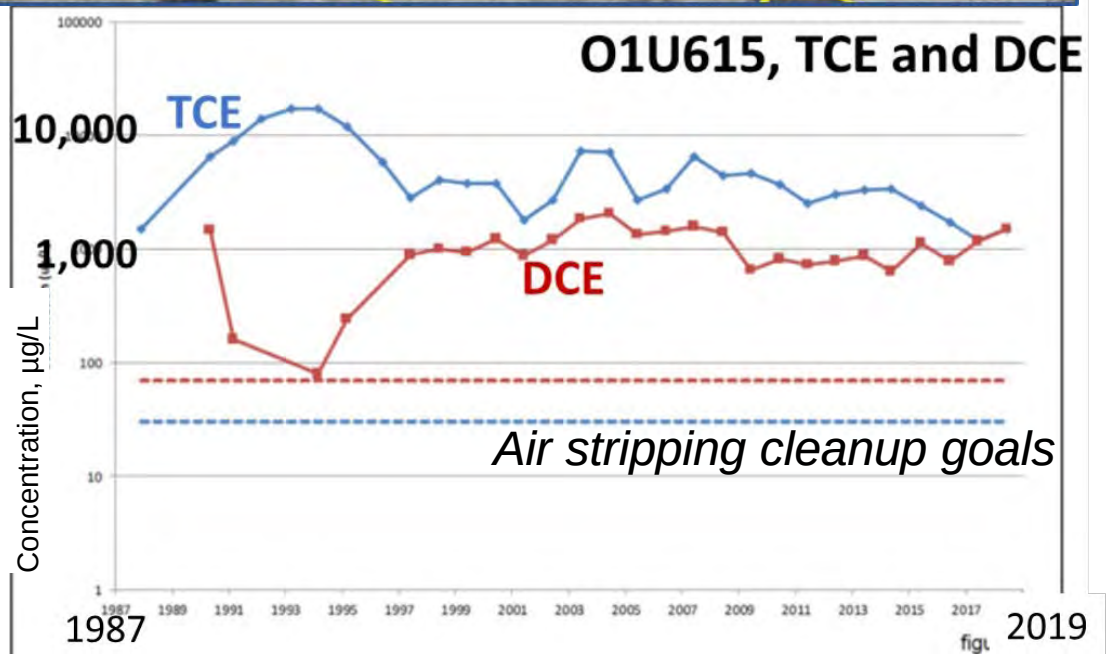


Purpose

Groundwater extraction and air stripping controlling plume but not decreasing concentrations.

- Improve remediation of trichloroethylene (TCE) and dichloroethylene (DCE) using bioremediation in shallow groundwater.
- Potential complicating factors:
  - Fluctuating water table and flow directions in shallow groundwater
  - likely residual sorbed or separate solvent phase at base of groundwater unit

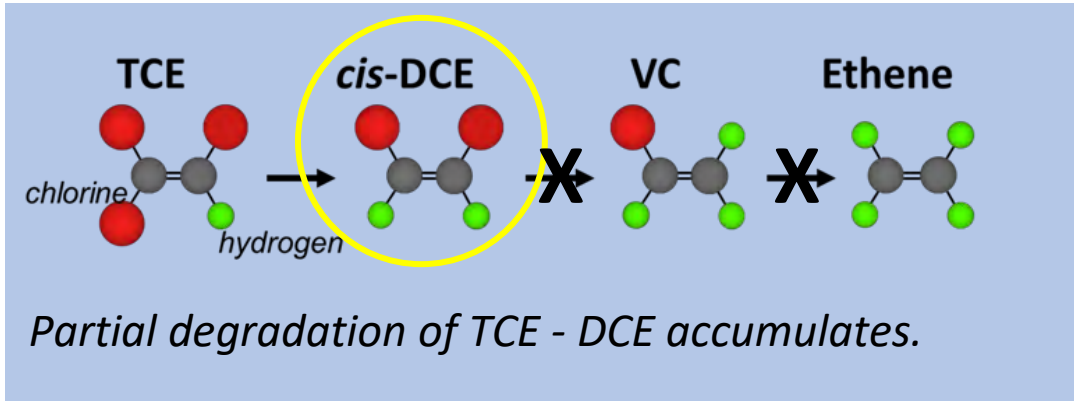




From FY 2019 Annual Performance Report, PIKA ARCADIS U.S., INC.

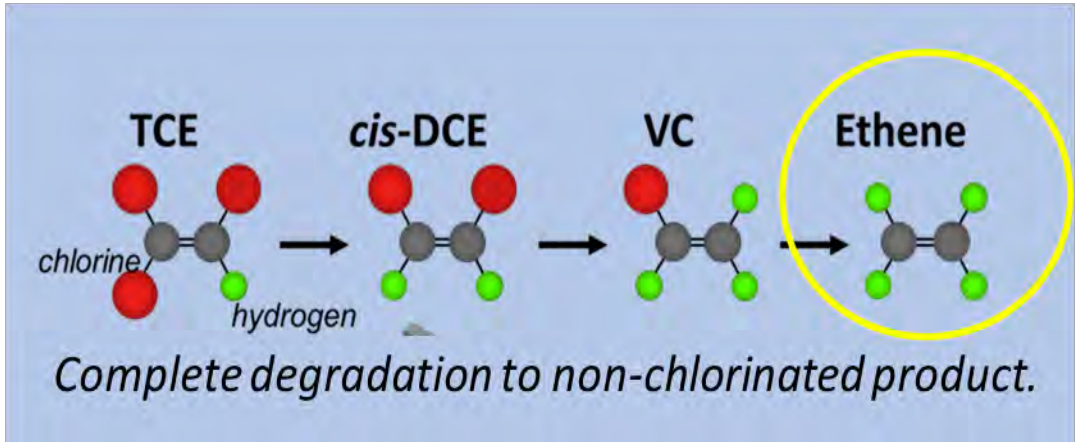
Biodegradation by reductive dechlorination

Site K Untreated Groundwater



Partial degradation of TCE - DCE accumulates.

- Native bacteria capable of complete biodegradation may not be present or have low population density.
- Dissolution/desorption of DNAPL can cause daughter product accumulation and inhibit complete degradation.



Need to achieve complete degradation for bioremediation. Ethene detections are a clear indication of complete degradation.

Bioremediation

Biostimulation: add donor (carbon) and nutrients to enhance native microbial population

Bioaugmentation: add microbes known to degrade contaminants, along with donor and nutrients

Site Evaluation

- Site history evaluation
- Phase 1 and 2 drilling, sampling, water levels, slug tests
- Site microbial community and matrices for lab tests

Natural Degradation

- Natural biotic rates
- Natural abiotic rates

Lab Treatability Tests

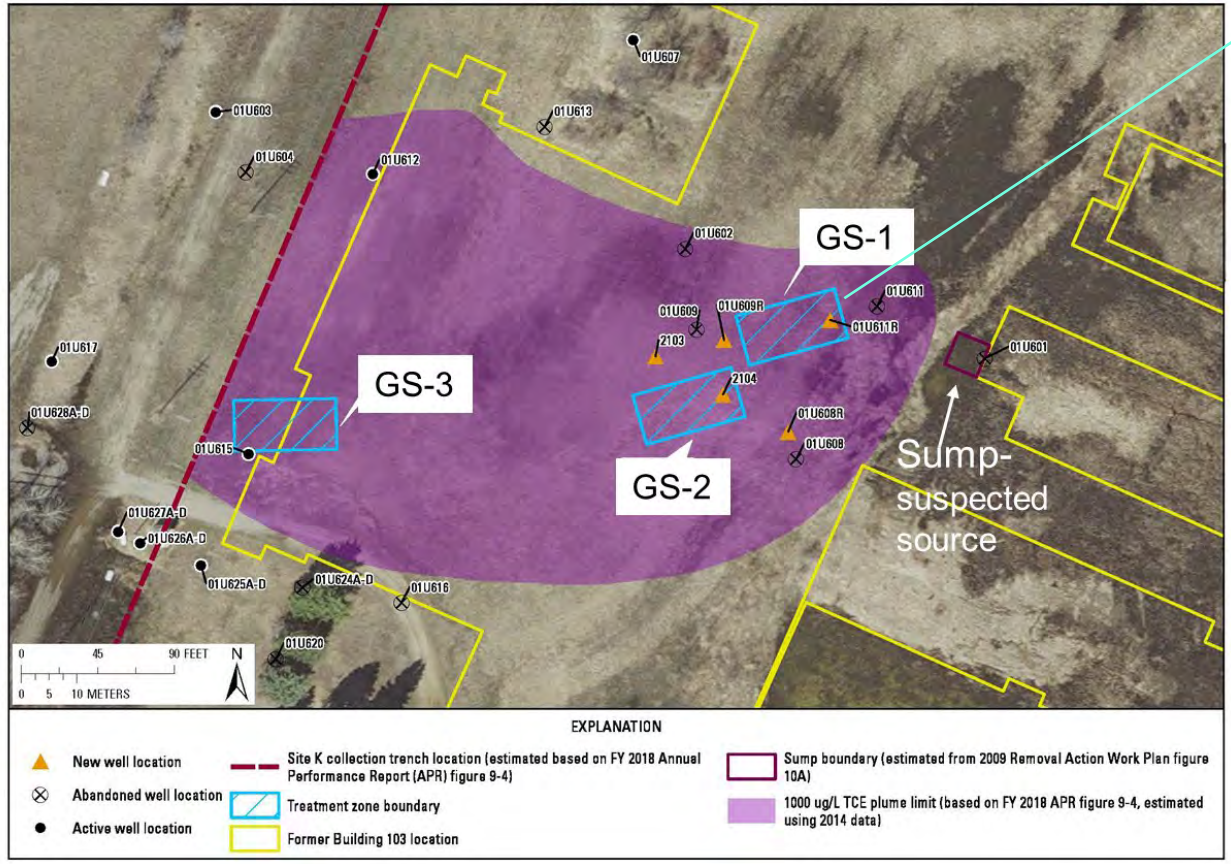
- Evaluate bioaugmentation
- Select effective electron donor
- Evaluate temperature effect

Field Treatability Test – Year One

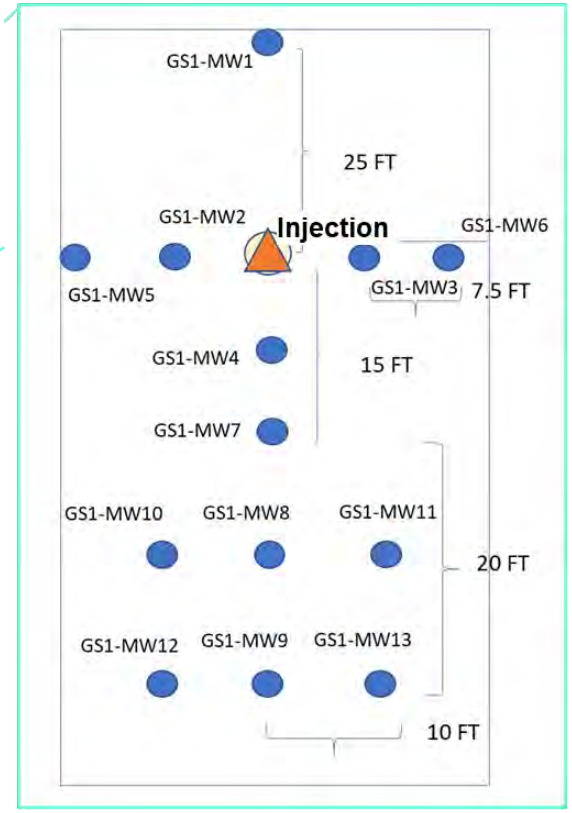
- Installation of injection and monitoring wells
- Baseline sampling and analysis; hydrologic data
- Biostimulation injection
- Bioaugmentation injection
- Performance monitoring

- Initial site evaluation, lab tests, injections, and Year One performance monitoring of the field treatability test completed between and October 2020 to December 2022.
- Completed data report; in review for on-line publication.
- Draft interpretative report to be completed by end of September 2024.

Year One Field Test



Three treatment plots, two in suspected source area (GS-1, GS-2) and one downgradient near trench (GS-3).



Treatment Plot Design

Each plot ~ 30 x 60 ft
1 injection well
13 monitoring wells

Biostimulation (October 18–20, 2021)

- SRS®-SD EVO (Terra Systems)— combination of lactate and emulsified vegetable oil.
- Mixed with Site K treatment effluent (1:5) and bromide tracer added.

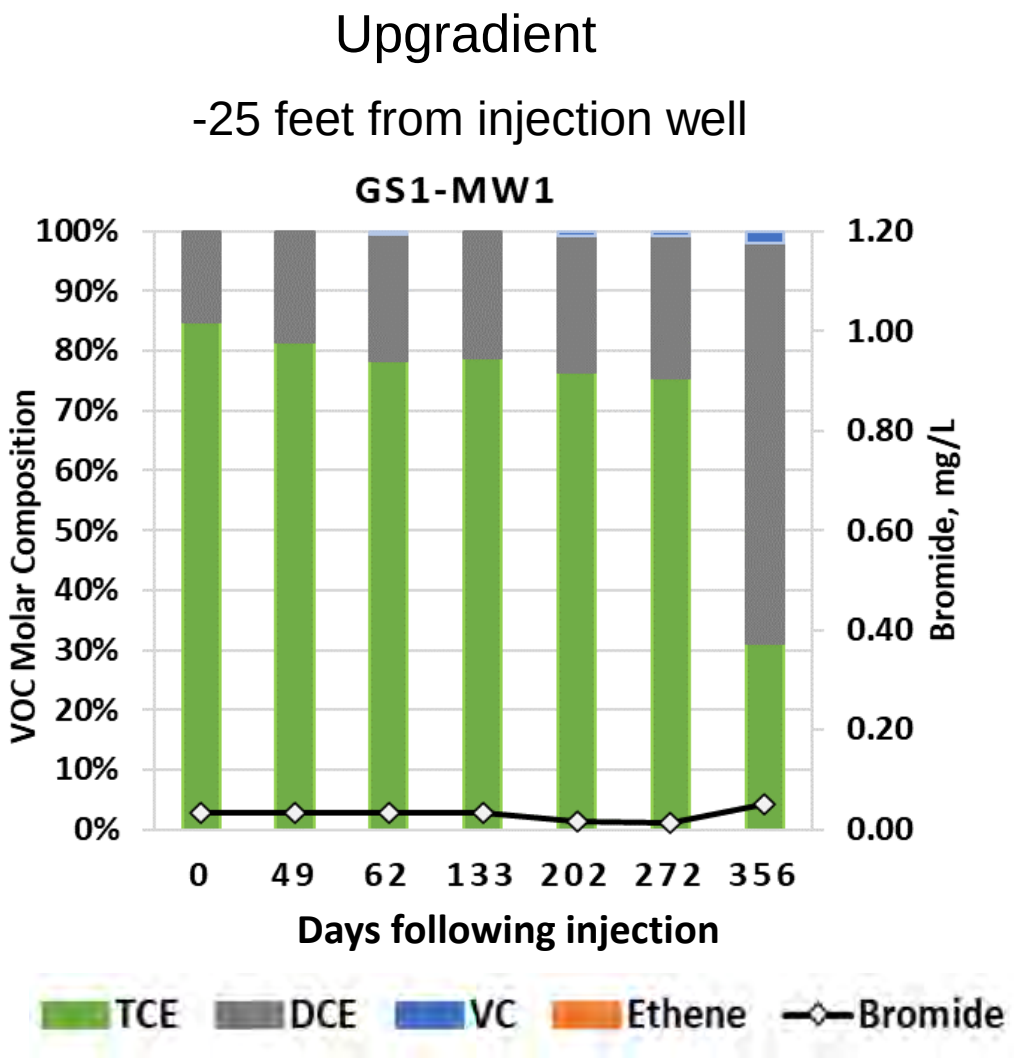
Bioaugmentation (November 29–30, 2021)

- Injected known dechlorinating culture, WBC-2.

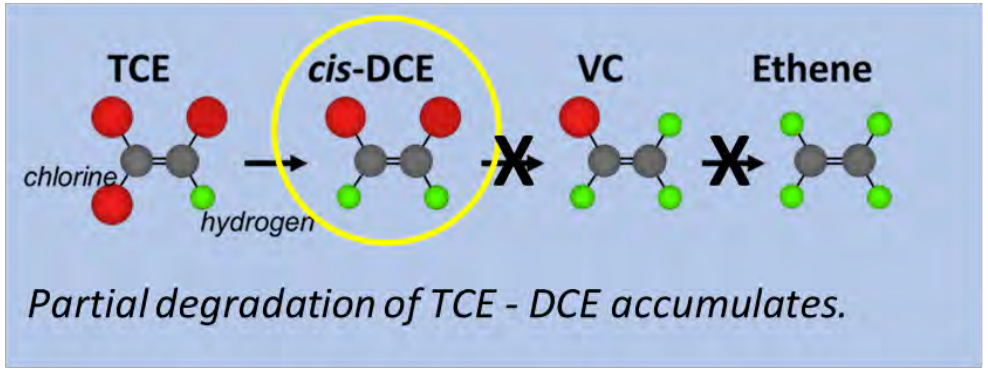
Water level depth in feet below land surface (01U609R), October 2021-August 2022, and injection and sampling events for Site K bioremediation pilot test.

- Purple arrows: injections of donors and WBC-2
- Yellow arrows: full sampling events (baseline and Q1, Q2, Q3, quarterly events). Q4 conducted October 2022 (not shown).
- Black arrows: other sampling events in select wells and limited constituents.

GS-1, Upgradient Well, Oct. 2021—Oct. 2022



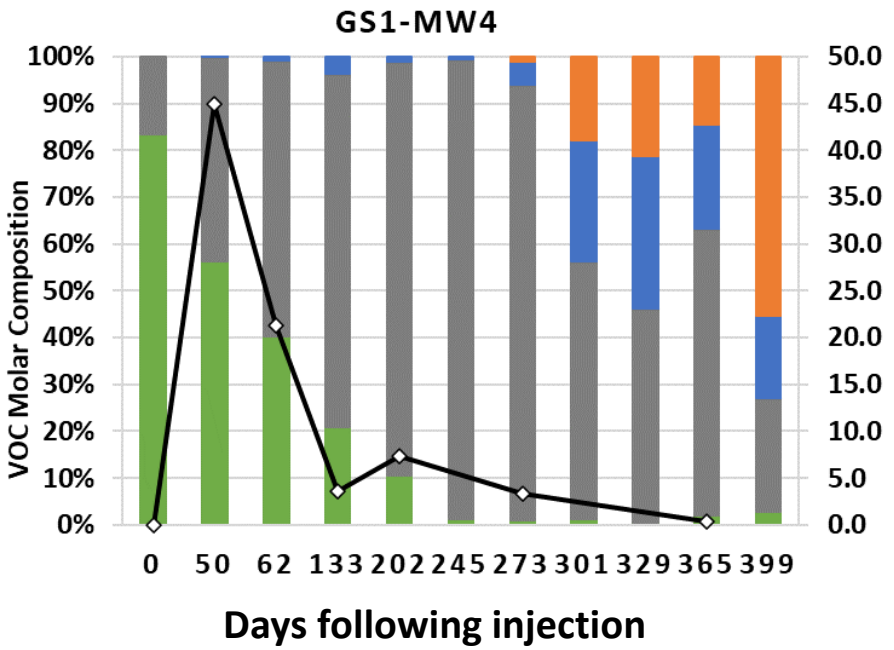
- VOC composition indicates that **degradation of TCE was not enhanced in the upgradient well** following injection.
- Low, consistent bromide concentrations indicate tracer in donor injection did not reach upgradient well until possibly at day 356.



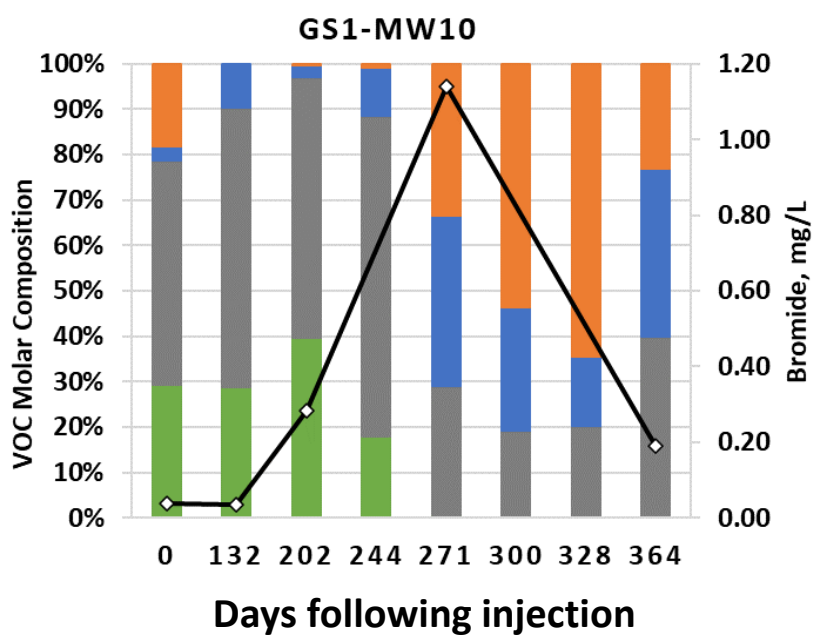
GS-1, Downgradient Wells, Oct. 2021—Oct. 2022

Downgradient →

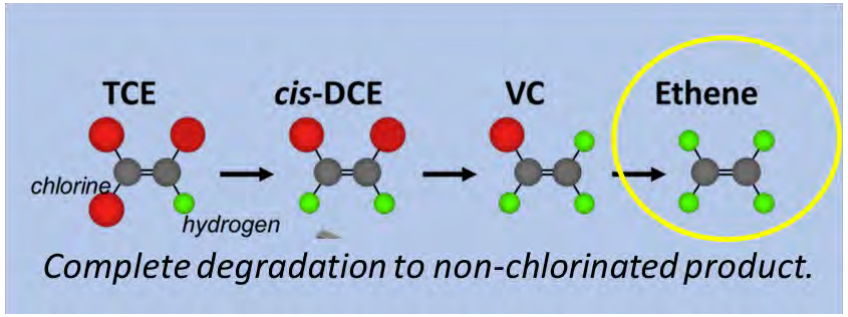
8 feet from injection well



20 feet from MW4

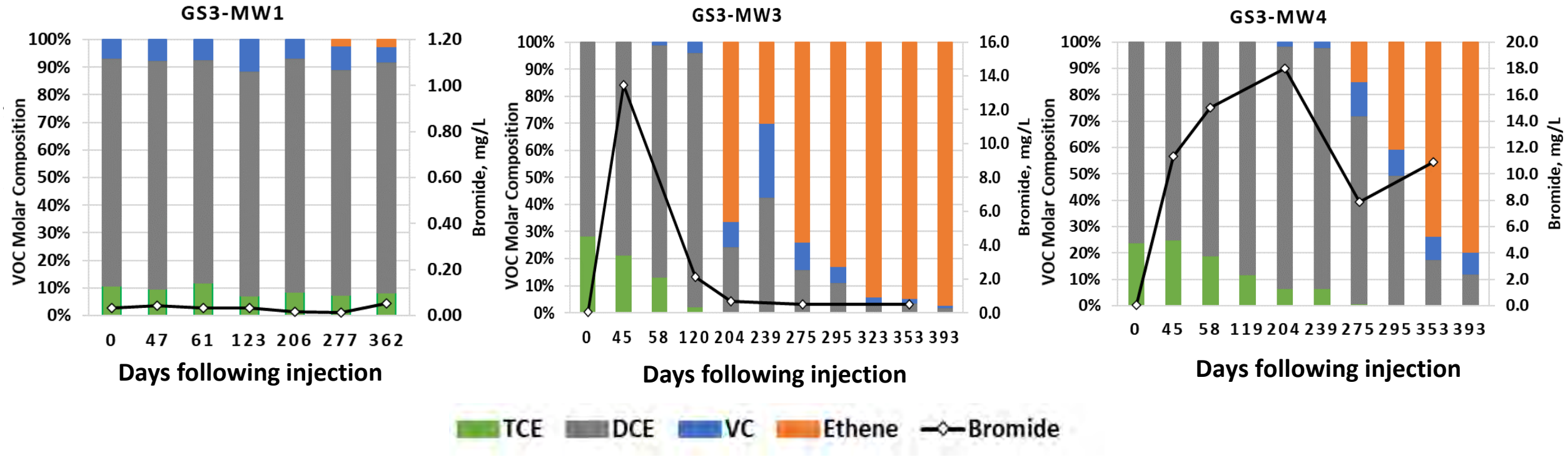


- VOC composition indicates that **degradation of TCE was enhanced in downgradient wells** following injection.
- Increases in bromide indicate that the tracer injected with the donor reached downgradient wells.

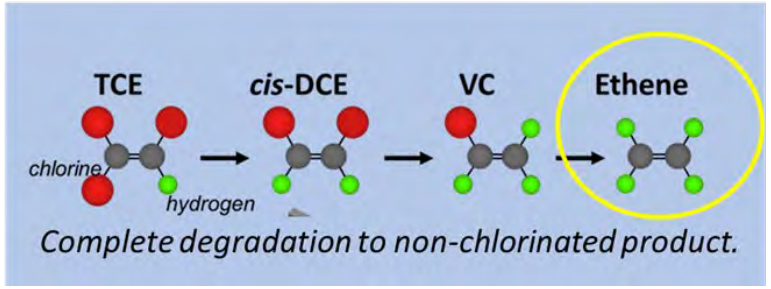


GS-3, Oct. 2021—Oct. 2022

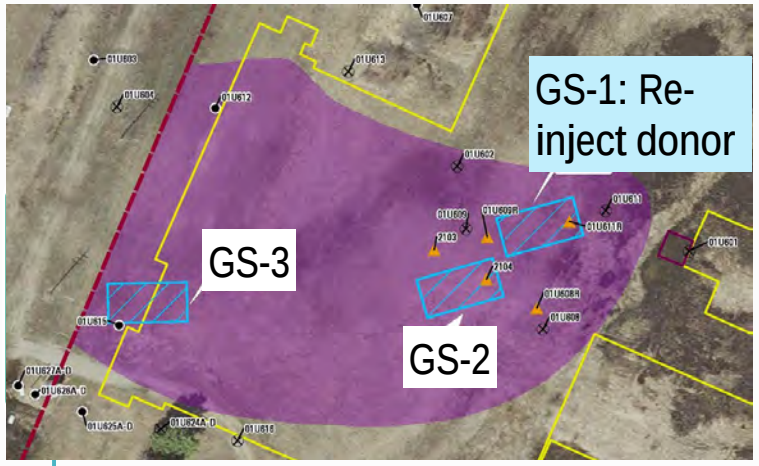
Upgradient →



- Patterns in VOC composition and bromide concentrations in the GS-3 treatment plot also indicate that **degradation of TCE was enhanced in the downgradient wells** following injection.



Expanded Pilot Treatability Test



Re-inject carbon donor in one plot (GS-1) in the spring. No additional WBC-2.

Analyze soil cores in GS-1 for VOCs before and after second injection.

Monitor GS-2 and GS-3 wells, along with GS-1, for another year.

Efficiency of bioremediation ultimately depends on how often injections are needed and the ability to remove mass of residual solvent sorbed to the soil in the aquifer.

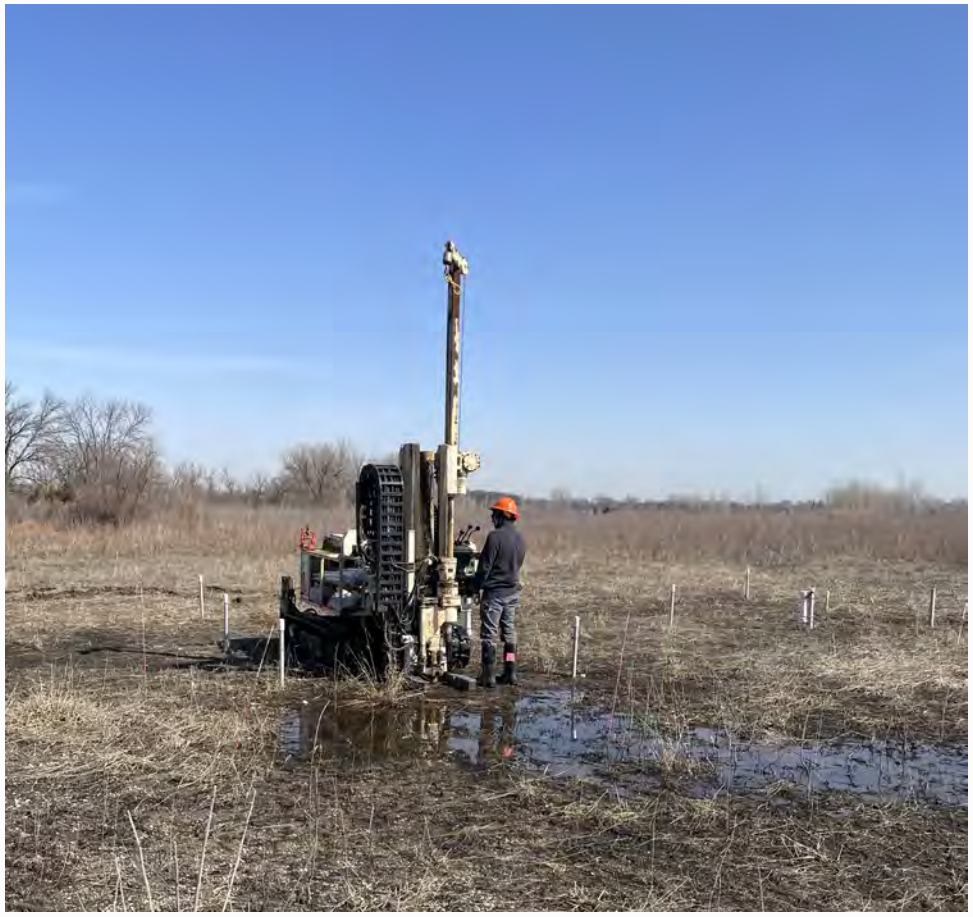
- How long does the initial donor amendment continue to enhance degradation without re-injection?
- Does donor injection when water levels are high result in faster distribution of amendments and improved degradation.
- Does the culture need to be re-injected to maintain efficient degradation rates?
- Does the complete biodegradation of TCE to ethene observed in the groundwater measurably reduce the sorbed or residual solvent in the soil?

Gain additional year of data for this shallow groundwater site that shows variable water level and flow conditions.

USGS

Field Treatability Test – Year Two

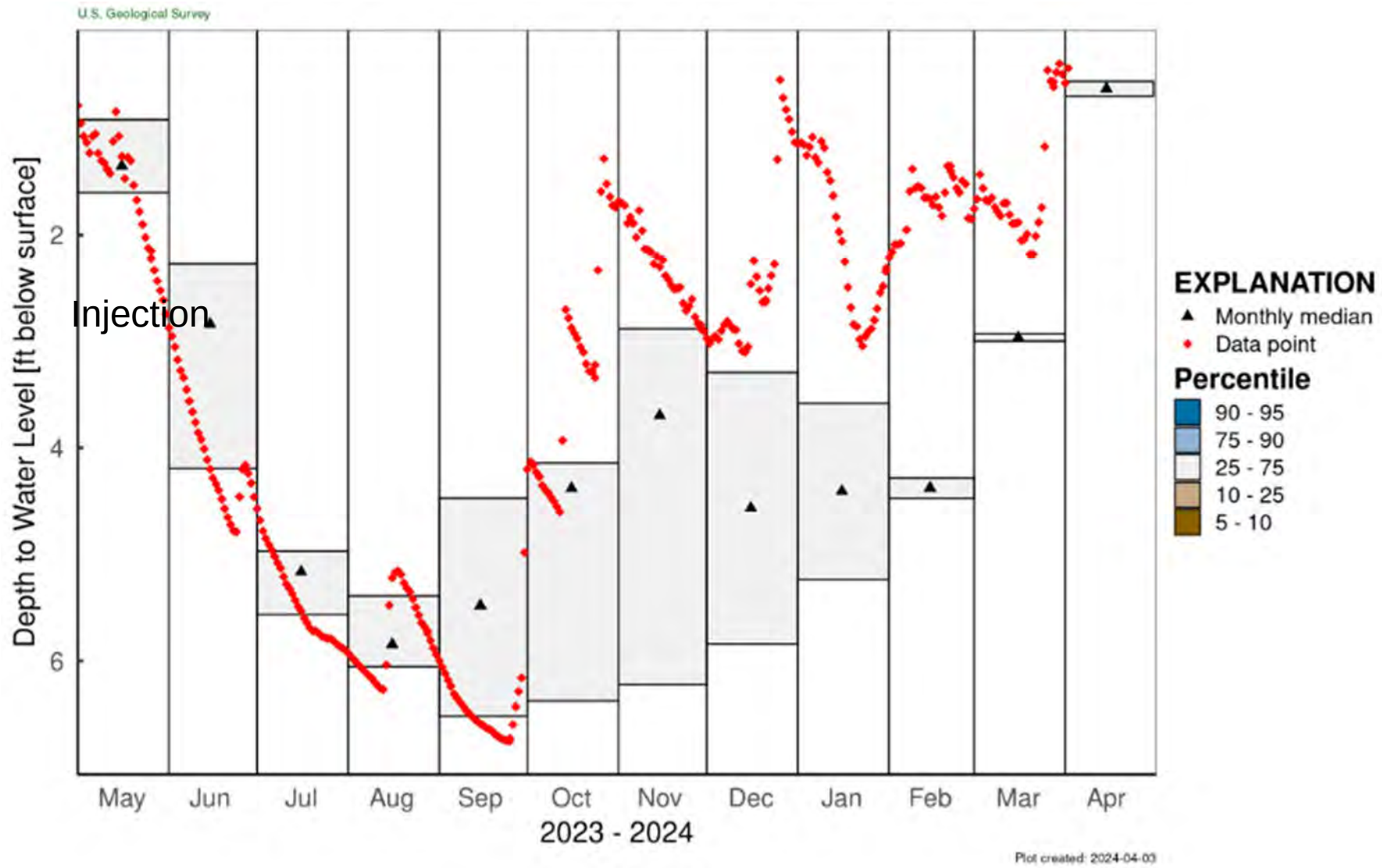
- Baseline soil core sampling completed in April 2023.
- Baseline groundwater sampling and immediately followed by the donor injection in GS-1 completed in May 2023.
- Three quarterly sampling events completed of all monitoring wells in GS-1, GS-2, and GS-3: September 2023, January 2024, May 2024.
- Monthly sampling throughout Year Two of select wells for VOCs, ethene, methane, and TOC.
- Continued hydrologic monitoring (continuous and synoptic) and slug tests in injection well in GS-1.
- Final soil core sampling completed in early July 2024.



Soil core collection, GS-1, April 2023

Water Level Depth, Well 608R, May 2023 – April 2024

- Water level elevations were higher in late October 2023 through March 2024 compared to Year One.
- The change in hydrologic conditions appears to have affected donor distribution and biodegradation. Data analysis of complete monitoring results ongoing.



from the USGS National Groundwater Conditions https://rconnect.usgs.gov/gwapp/

Planned tasks and schedule

- Complete draft of final report for initial pilot treatability test in September 2024.
- Complete microbial community analyses for Year Two sampling.
- Complete data analysis of Year Two monitoring results and combined interpretations from complete treatability test.
- Complete draft of final report of expanded pilot test in December 2024.

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USGS

U.S. ARMY

Round Lake
Remedial Design / Remedial Action Update

Twin Cities Army Ammunition Plant: Round Lake

Arden Hills, Minnesota

Contract No. W9128F22D0002

U.S. ARMY

Agenda

- Round Lake Remedial Action Overview Map
- Preliminary Design Investigation Results
- Project Schedule and Status

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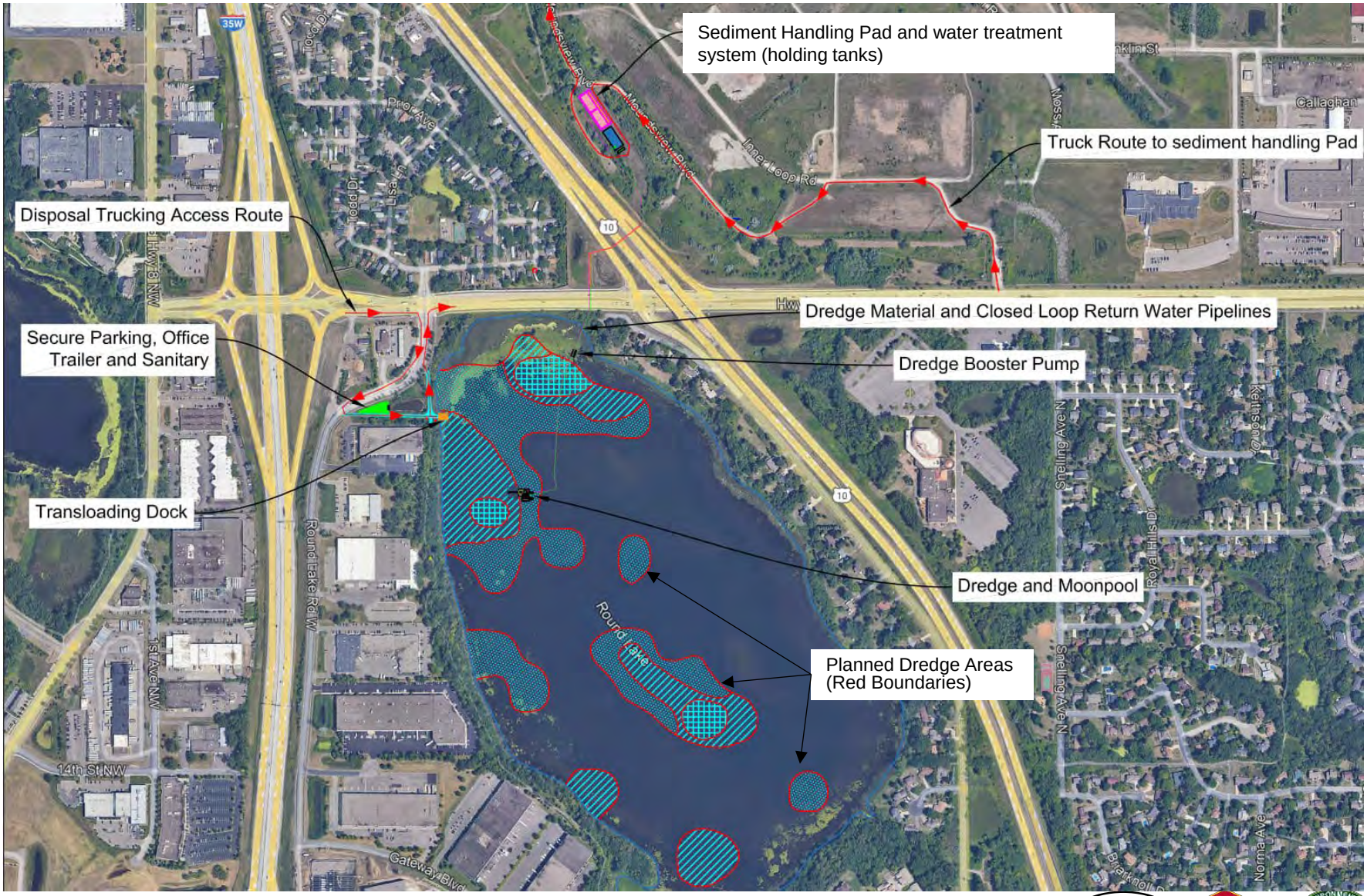
Round Lake Remedial Action



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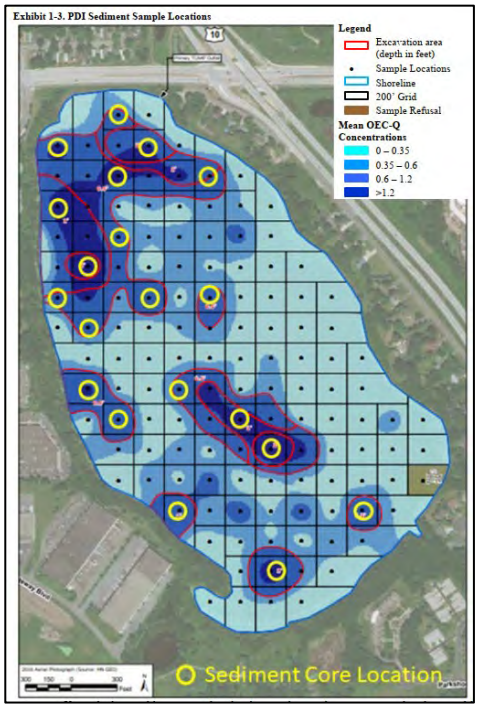
Preliminary Design Investigation (May 2024)

Objective: Collect data / information to support remedial design



- Evaluate sediment deposition in Round Lake since the last sampling in 2011
  - Bathymetric survey
  - Sediment coring and sampling
- Collect retainage pond sediment samples to determine need for remediation
- Inspect sewer system to confirm conditions are suitable to support cleanup activities

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Sediment Deposition in Round Lake

- Previous Sampling Conducted in 2011

  Basis for selected remedy in the ROD and associated sediment removal volume of 82,000 cubic yards

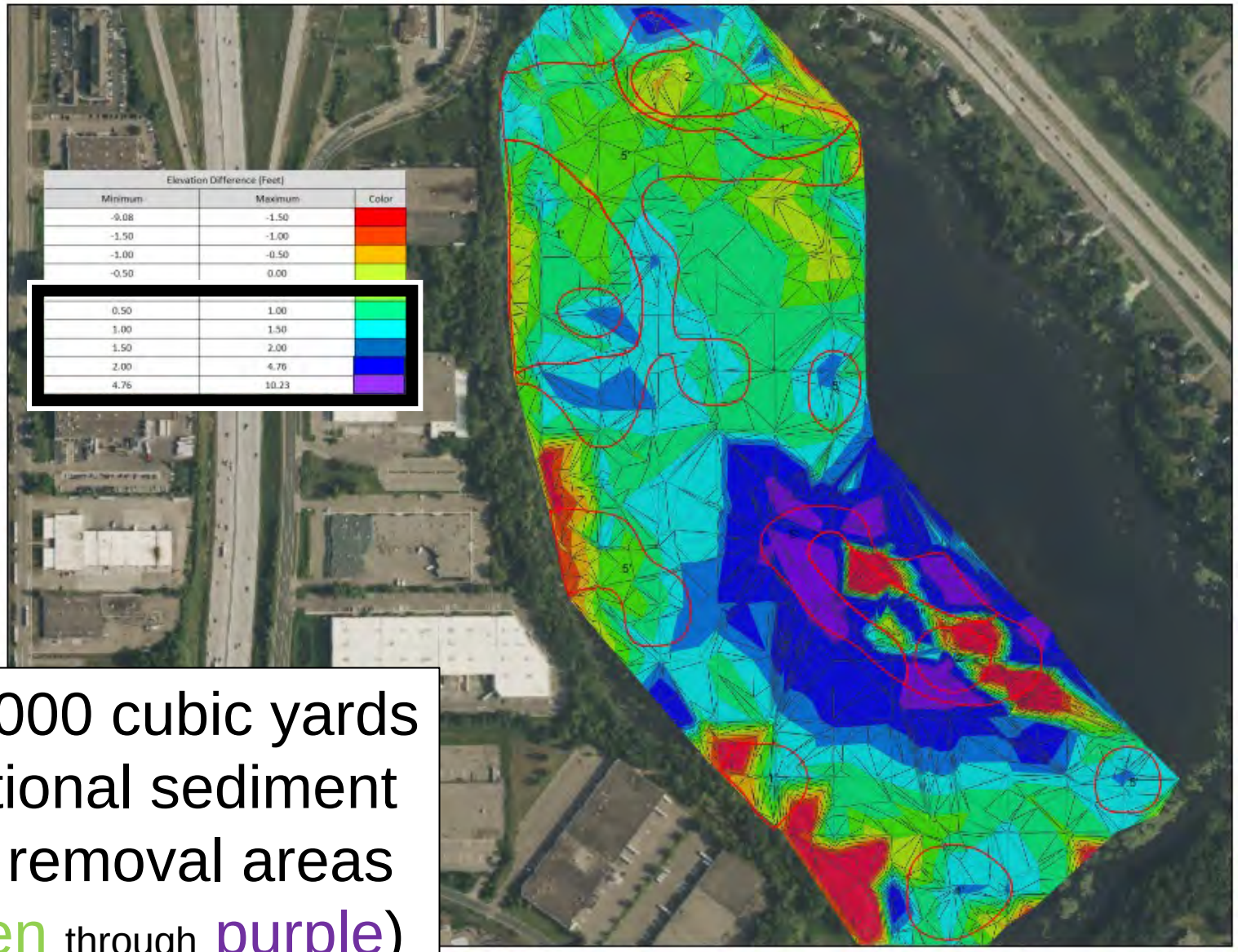
- Reported Round Lake Sedimentation Rate Greater than 1.5 centimeters (cm) per year

- Estimated Deposition from 2011 to 2026

  2026 – 2011 = 15 years x 1.5 cm/year

  Greater than 22.5 cm (9 inches)

U.S. ARMY Lake Bottom Elevation Change, 2011 - 2024



~60,000 cubic yards additional sediment over removal areas (green through purple)

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Retainage Pond Sampling

- Retainage pond sediment not previously sampled
- 3 sediment cores collected and sampled to 2 feet
- All 11 samples below cleanup level of 0.6 mPEC-Q* (established for metals)

*mPEC-Q = mean probable effect concentration quotient

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Storm Sewer Orientation

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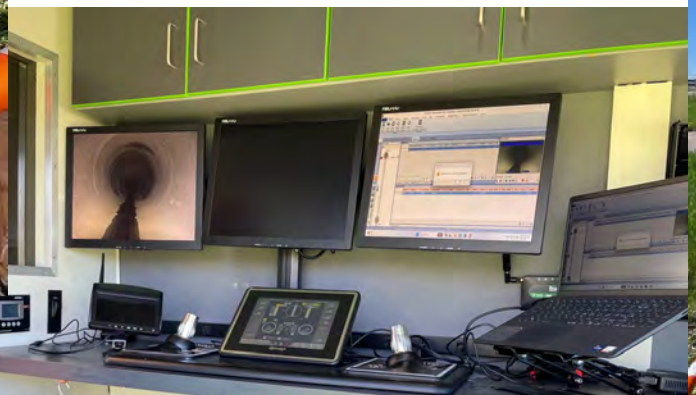
Storm Sewer Survey

Video footage confirms that the storm sewer is in good condition



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Round Lake Cleanup Schedule

- Preliminary Design Investigation: May 2024

- Remedial Design: 2024 - 2025
  - 30% Design (August 2024)
  - 60% Design (February 2025)
  - 90% Design (October 2025)
  - Final Design (February 2026)

- Remedial Action: 2025 - 2027
  - Vegetation Clearing (Nov 2025)
  - Sediment Removal Activities (Apr 2026 – 2027)