

EXPEDITED IMPLEMENTATION OF COMBINED IN-SITU TREATMENT TECHNOLOGIES TO ADDRESS DNAPL AT A MULTI-PARCEL FORMER MGP SITE



Ben Clement | June 4, 2024
Battelle Chlorinated Conference | Denver, CO

BURNS  MCDONNELL

Agenda

- 1** Background
- 2** Pilot Testing
- 3** Optimization
- 4** Implementation
- 5** Results/Lessons Learned
- 6** Conclusions

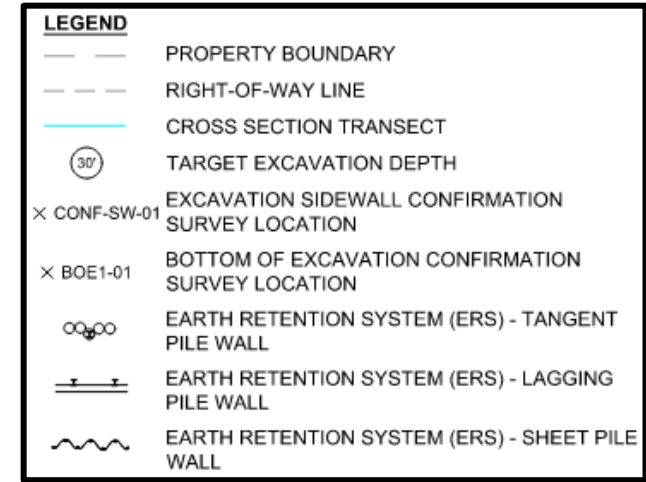


Litchfield MGP Background and Site Features



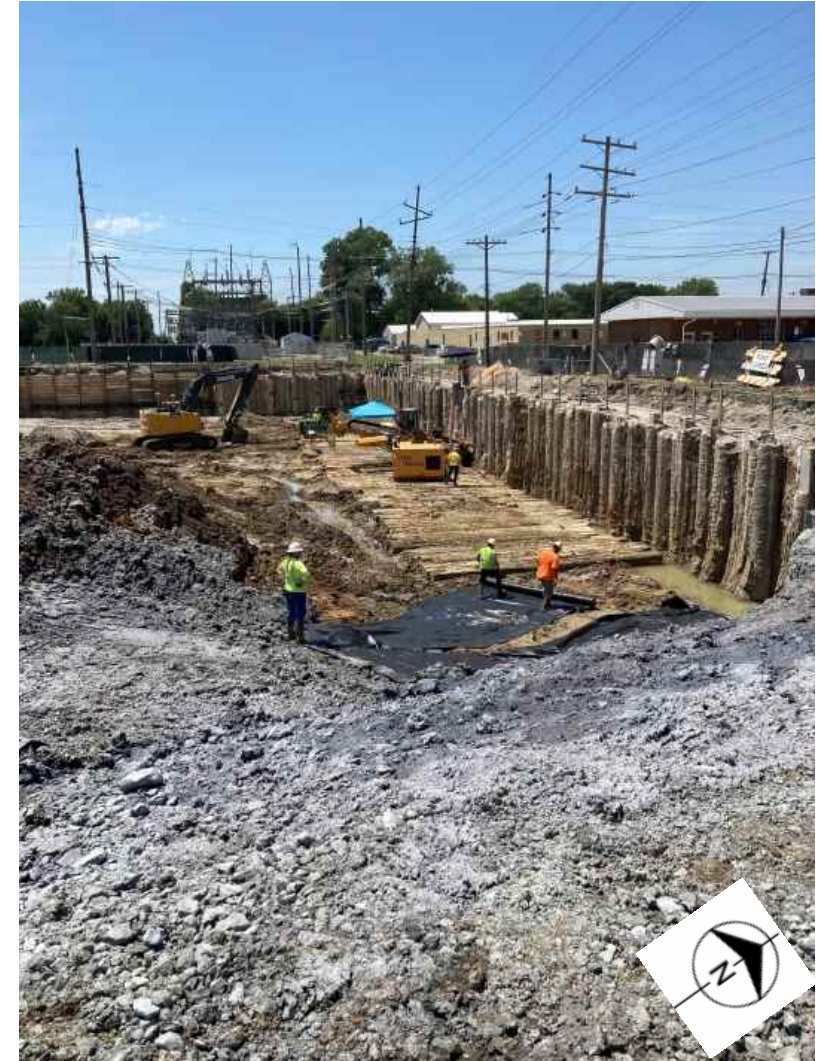
- ▶ MGP Operation
1892-1942
- ▶ Property Owned by Utility
Company (Electric and Natural
Gas Provider)
- ▶ Present Day Lay-Down Yard and
Gas Regulator Station
- ▶ Surrounding Property usage
commercial/ industrial



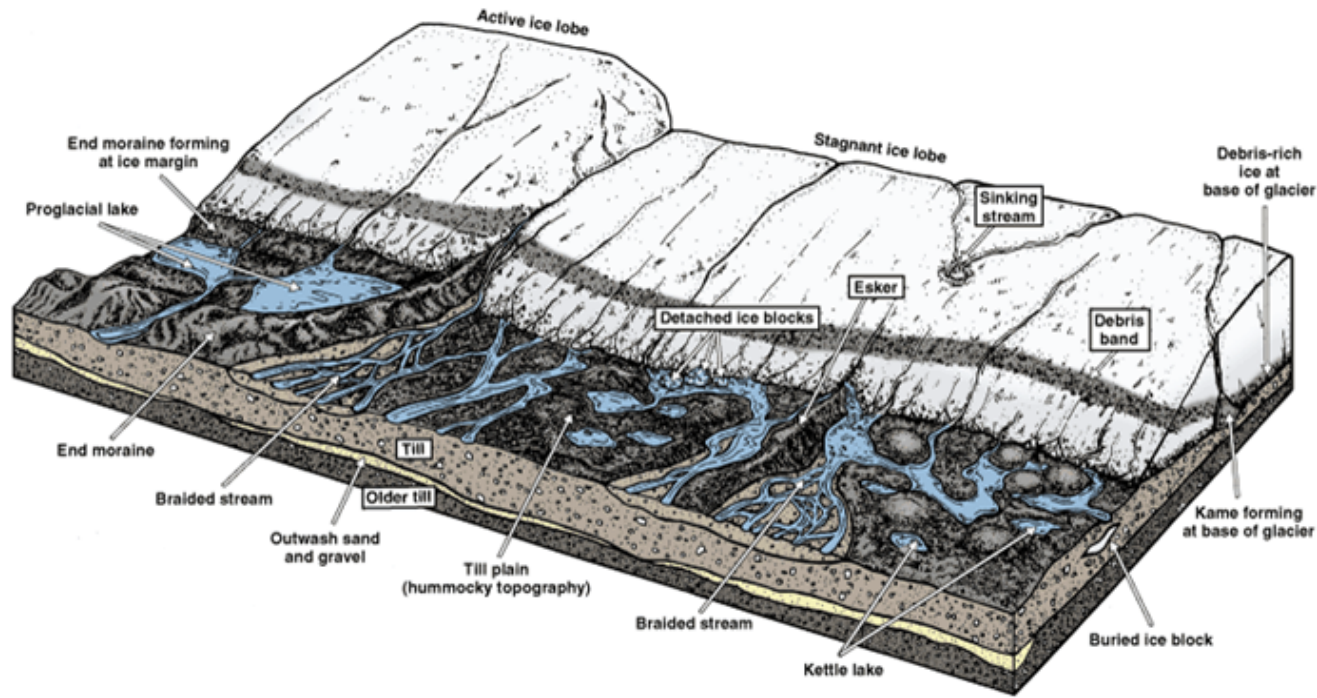


Maximum Depth (ft)	Minimum Depth (ft)	Color
-40.00	-35.01	
-35.00	-30.01	
-30.00	-25.01	
-25.00	-20.01	
-20.00	-15.01	
-15.00	-10.01	
-10.00	-5.01	
-5.00	0.00	

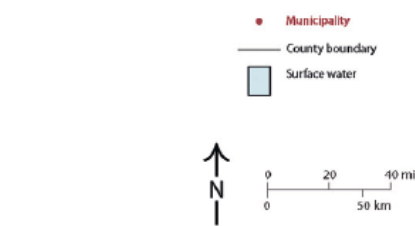
Background | Excavation On-site



Environmental Sequence Stratigraphy



- Depositional Setting
- Graphical Grain Size Logs
- Predictive Model Efficiently Tested



HUDSON EPISODE

alluvial sand, gravel, and silt

WISCONSIN EPISODE

Mason Group

Thickness of Wisconsin loess (5-ft contour interval)

silt and clay in lakes
sand and gravel in valleys, outwash fans, beaches, and dunes

Wedron Group

till and ice-marginal sediment

End moraine

Till plain

ILLINOIS EPISODE

silt and clay in ice marginal lakes

sand and gravel in valleys, outwash fans, and ice-contact ridges

Winnebago Fm; diamicton (till and ice-marginal sediment)

Till plain

Glasford Fm; diamicton (till and ice-marginal sediment)

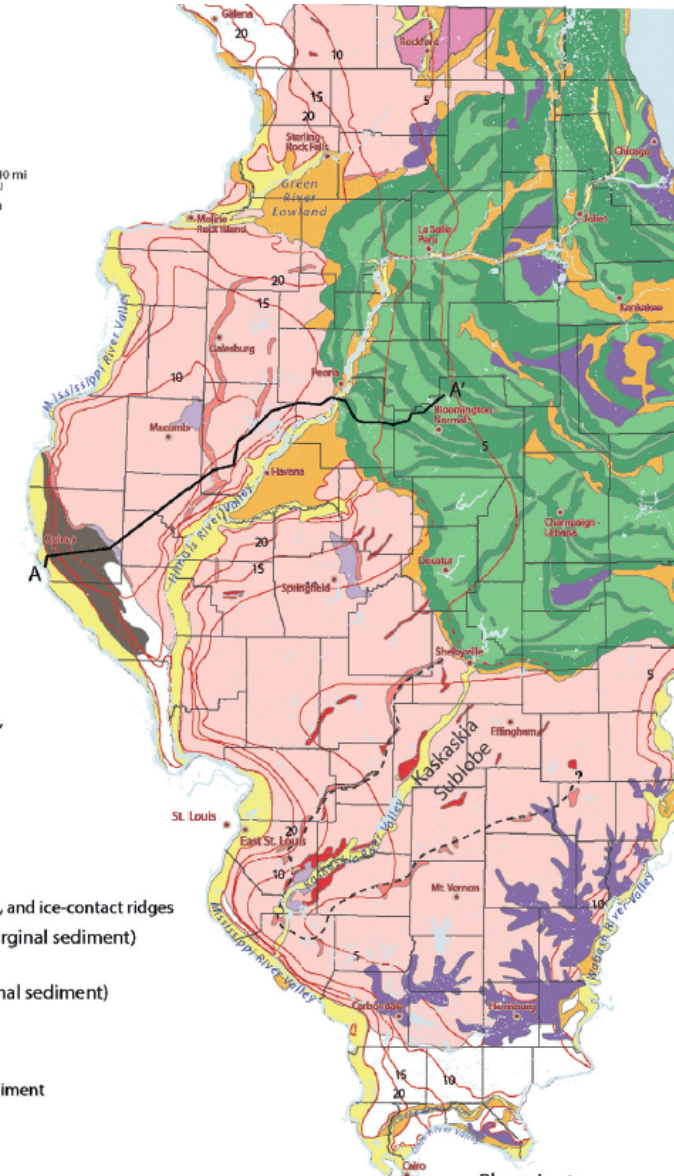
Morainal ridges

Till plain

PRE-ILLINOIS EPISODE

predominantly till and ice-marginal sediment

UNGLACIATED AREAS

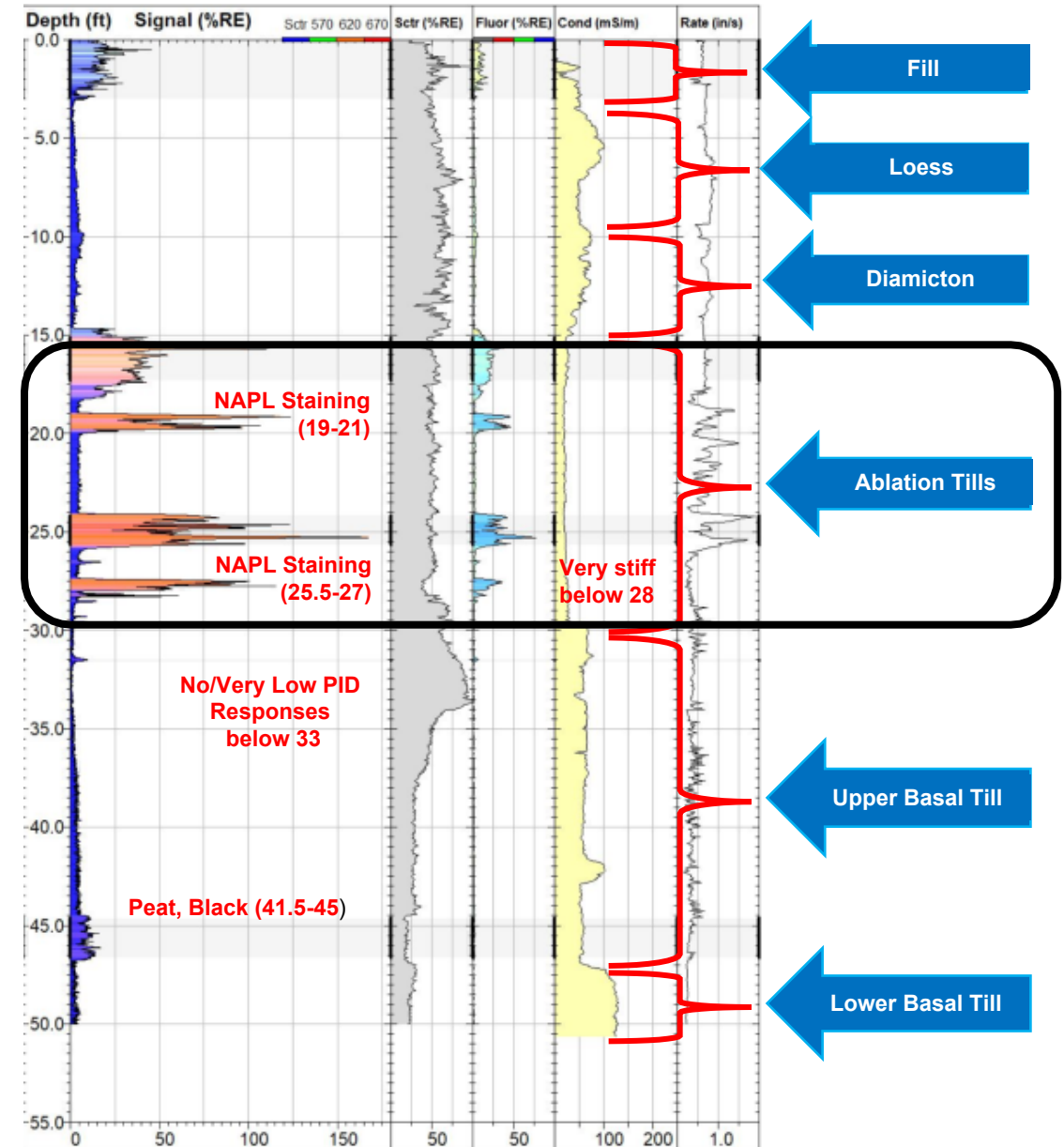


High-Resolution Data for Stratigraphic Correlation



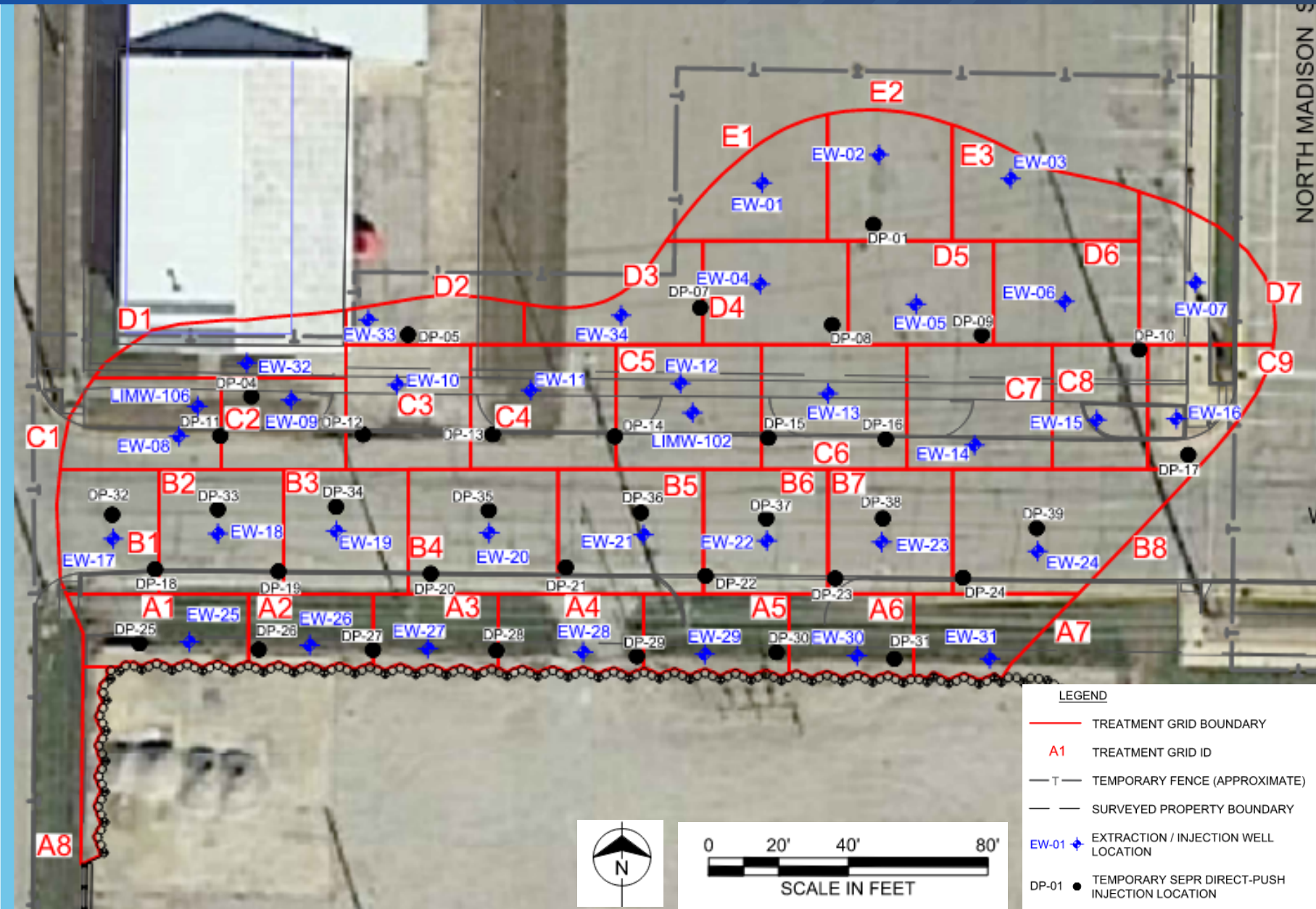
STRATIGRAPHIC KEY

-  ARTIFICIAL FILL
-  LOESS: LIGHT BROWN, ORANGE AND BLACK MOTTLED CLAYEY SILT TO SILTY CLAY; MEDIUM STIFF, LOW TO MEDIUM PLASTICITY.
-  SANGAMON GEOSOL: NOT WELL DESCRIBED IN SITE BORINGS, BUT INFERRED TO BE PRESENT BASED ON REGIONAL INFORMATION. THICKNESS UNCONSTRAINED BY SITE DATA.
-  ABLATION TILL: DIAMICTON. SILTY, SANDY CLAY WITH GRAVEL.
-  ABLATION TILL: ICE CONTACT AND STRATIFIED DRIFT FACIES; CLAYEY SILTS AND SANDS, WITH GRAVEL.
-  ABLATION TILL: ICE CONTACT AND STRATIFIED DRIFT FACIES; CONCENTRATED GRAVELS AND/OR SANDS INDICATED IN LITHOLOGIC BORINGS
-  BASAL TILL (UPPER): INCREASED GRAVEL AND WOODY DEBRIS. SOME ~TWO FEET THICK PEAT RICH ZONES.
-  BASAL TILL (LOWER): HIGHER CLAY CONTENT, LOWER GRAVEL CONTENT, SPARSE ORGANIC MATERIAL.



In-Situ Remediation Treatment Area

- ▶ Surfactant Enhanced Product Recovery (SEPR®) + In-Situ Chemical Oxidation (ISCO)
- ▶ 28,045 square feet
- ▶ Treatment zone ranging from 10-16 feet thick
 - Minimum treatment depth = 14 ft
 - Maximum treatment depth = 34 ft
- ▶ Treatment area divided into well-centric cells
 - A1 through E3

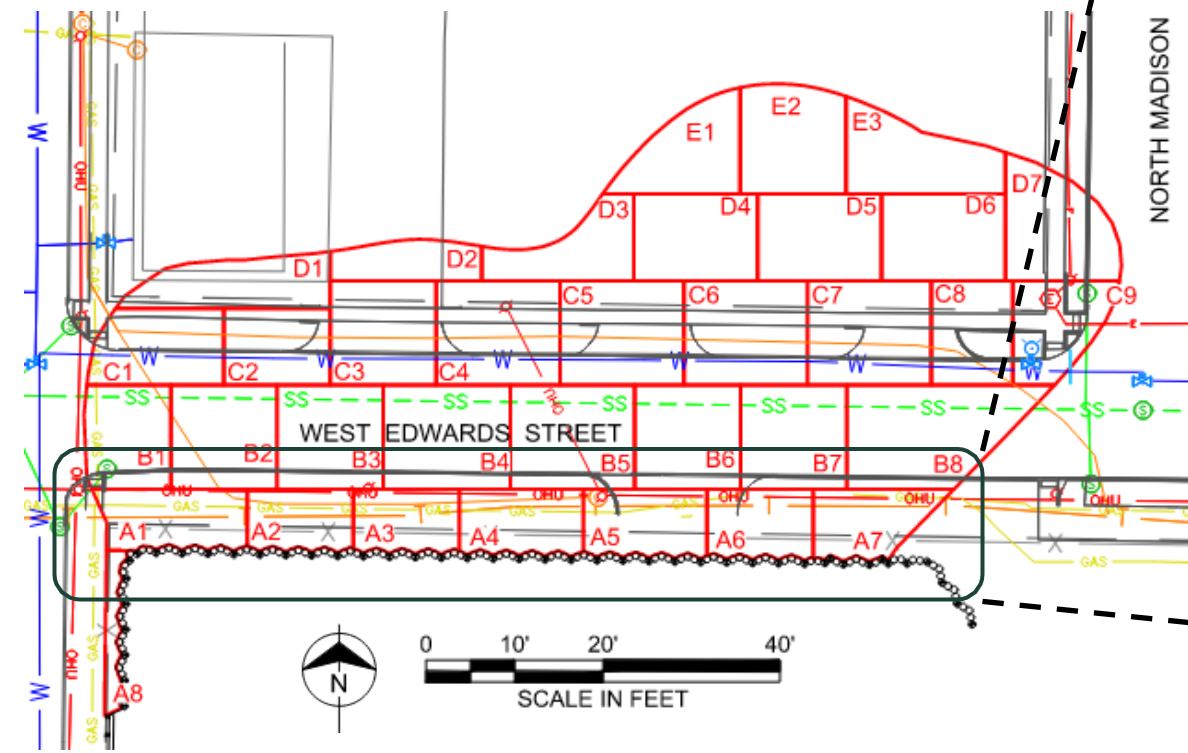


Remediation Treatment Area



Presence of Utilities

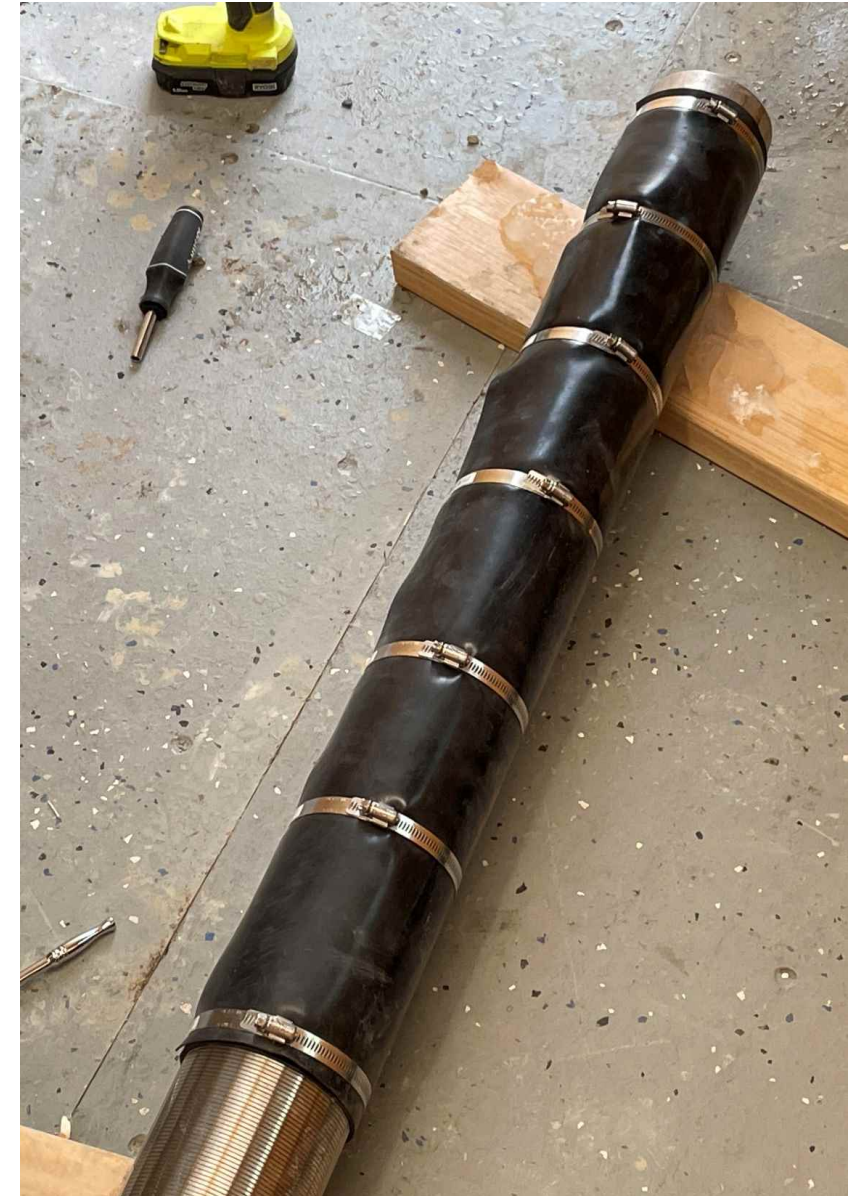
- ▶ Overhead power
- ▶ Utility poles service substation
- ▶ Subsurface gas, fiber, sewer, and water



Optimization Measures



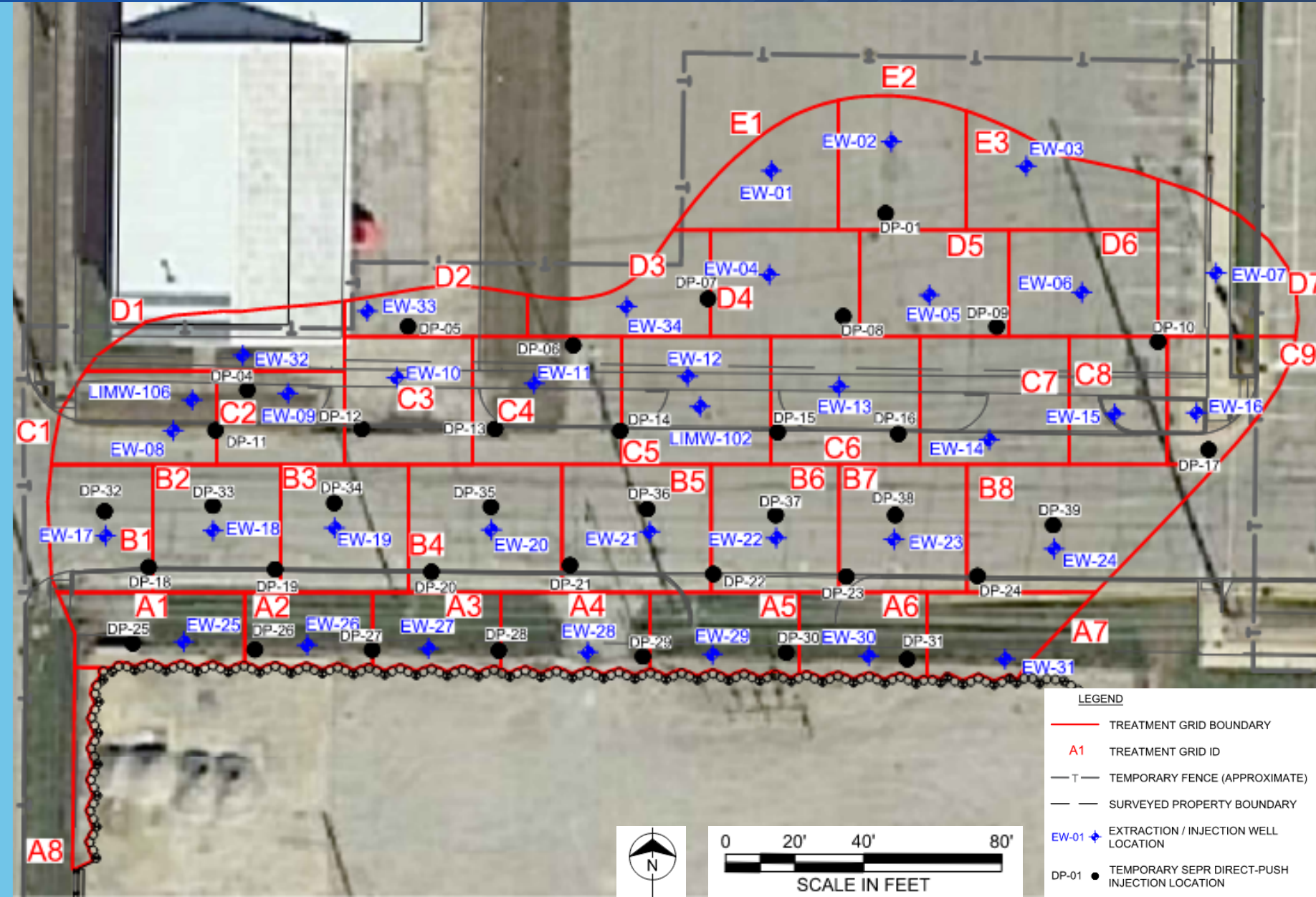
- ▶ Increased number of recovery wells
- ▶ Well design/installation
 - Site wells targeting deepest basal till depths
 - Use of stainless-steel screens with greater % open area
 - Larger borehole diameters
 - Customization of screen intervals
- ▶ Delivery approach variability
 - Push-pull
 - Triangulate Around Recovery Wells
 - Upgradient => Downgradient
- ▶ Vacuum extraction between shifts
- ▶ Dashboard creation and mass removal criteria established to support expedited timeline



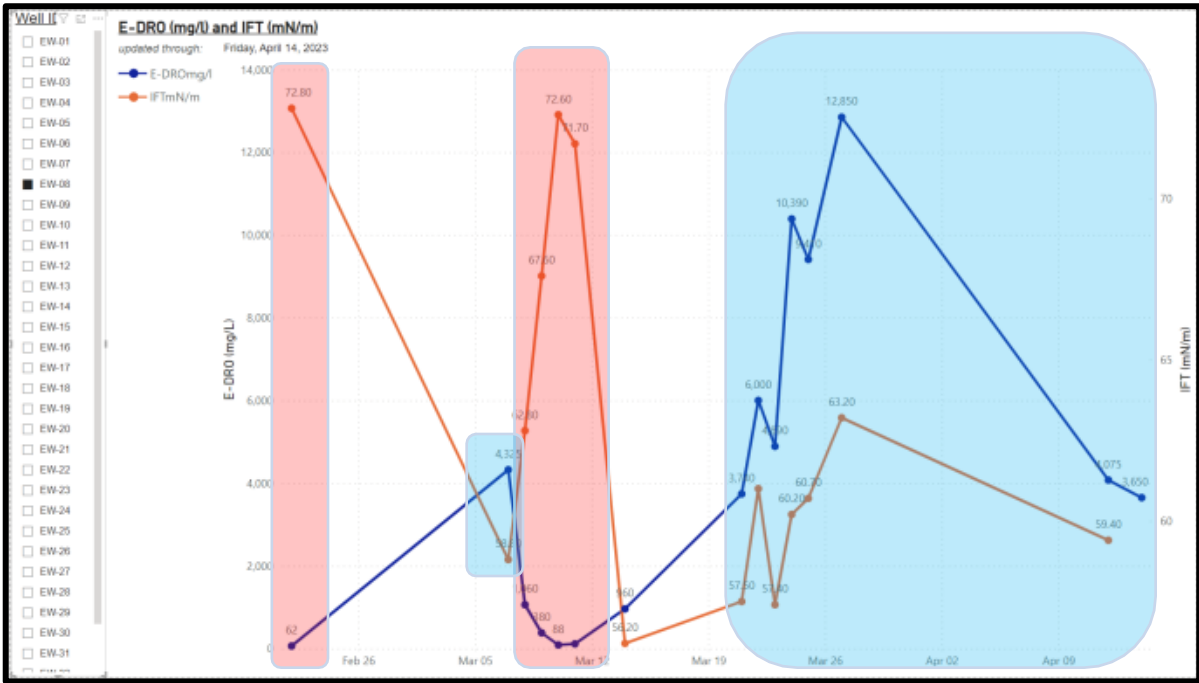
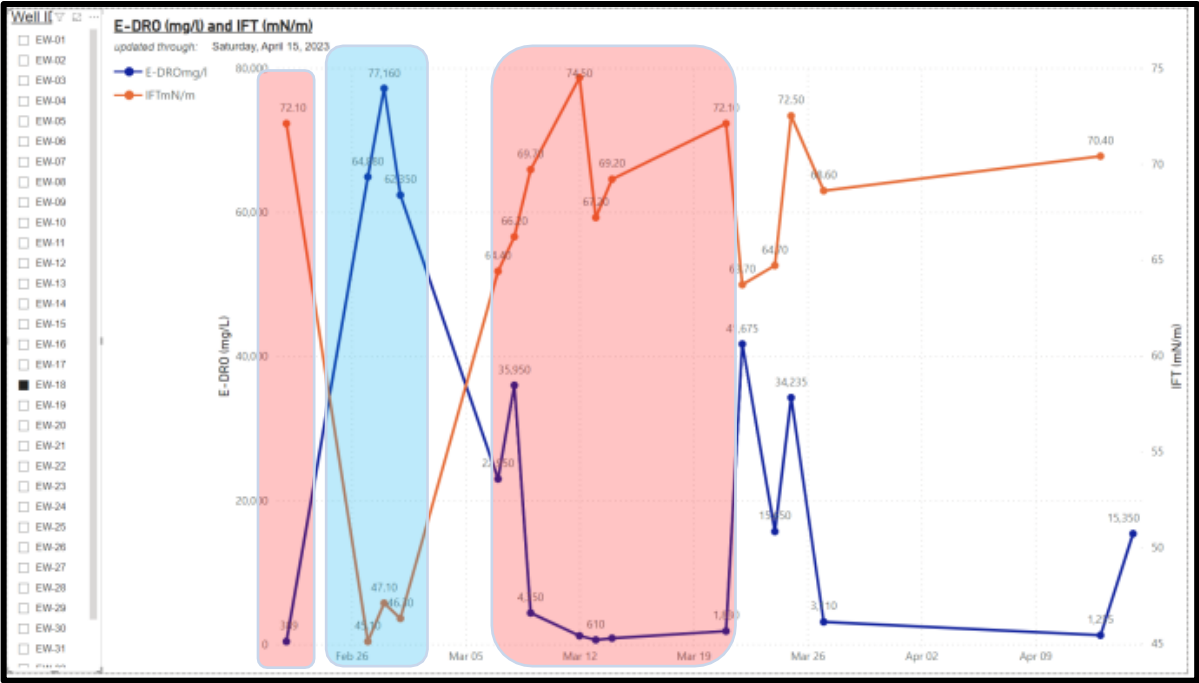
SEPR® Phase - 25 g/L Emulse 10



- ▶ 83,415 gallons + 30,700-gallon water flush.
- ▶ Injection through wells
- ▶ 37 direct-push points
- ▶ 34 extraction wells
- ▶ 2 monitoring wells
- ▶ Recovery up to 23 wells at at time – 165,500 gallons.
- ▶ Performance Monitoring of IFT and TPH-E-DRO.
- ▶ February 25, 2023 - July 11, 2024



Power BI Dashboard



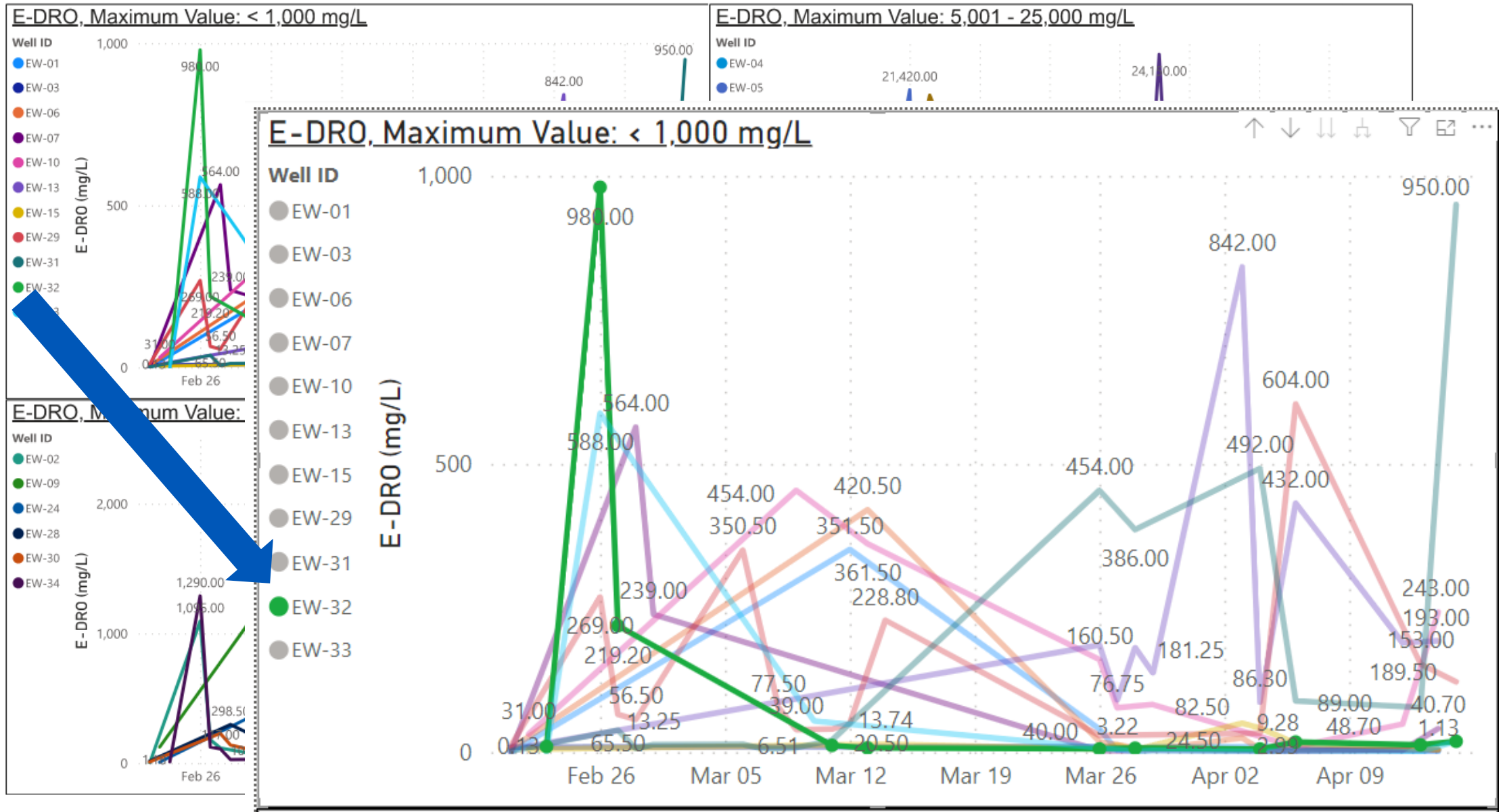
Interfacial Tension (IFT)
E-DRO Concentrations



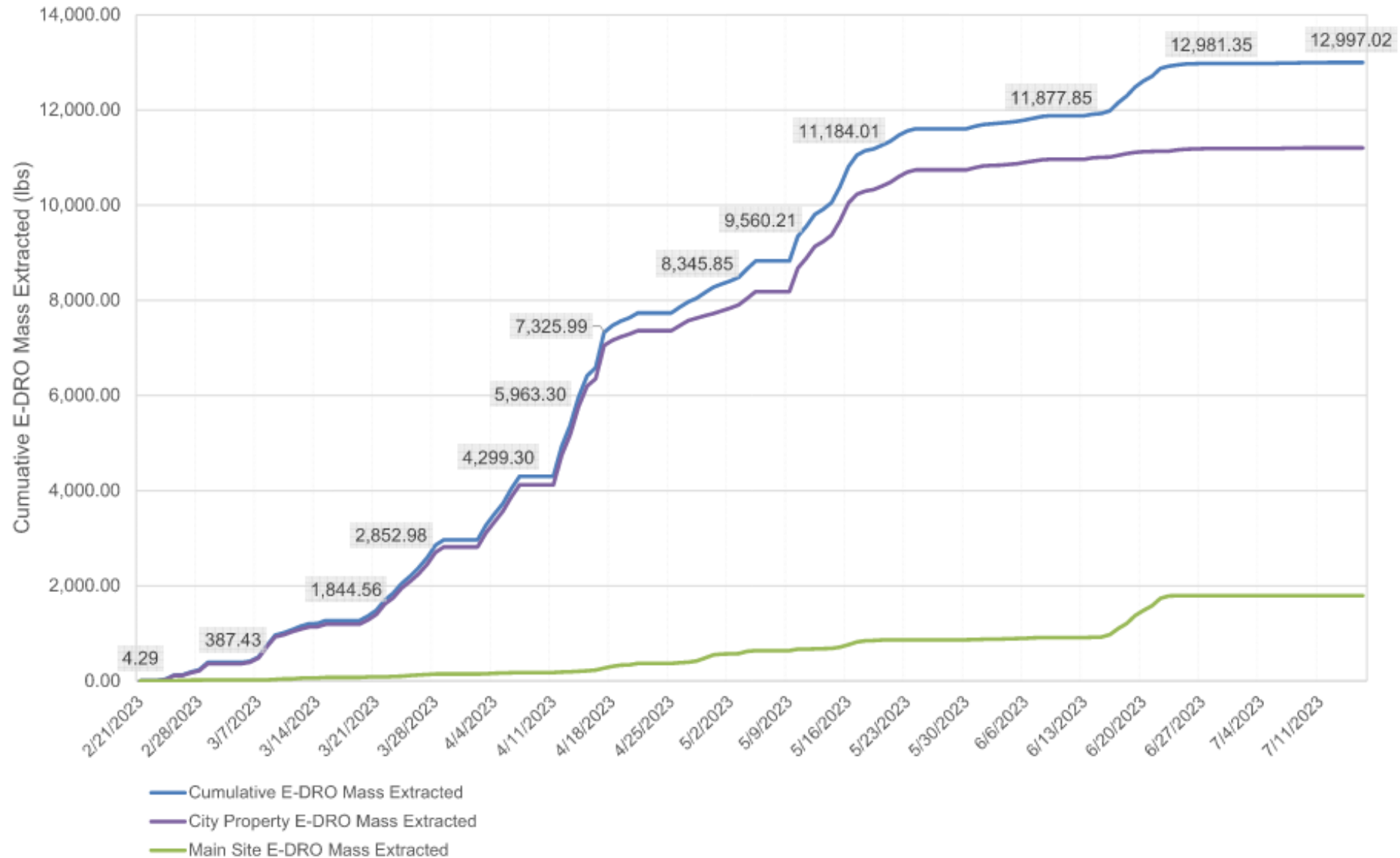
Interfacial Tension (IFT)
E-DRO Concentrations



Litchfield | Power BI Dashboard



Results: TPH-E-DRO Mass Recovered



Mass Recovery-Based Criteria Matrix



Well ID	Asymptotic Conditions Observed in E-DRO?	E-DRO Concentrations Below 1,000 mg/L over last week? ¹	Target Recovery Volume % Complete ²	Average Daily Extracted E-DRO over last week (lb/gal)	Average Daily Gallons Recovered over last week (gallons)	Average Daily Mass Recovered over last week (lbs)	Rank for Starting ISCO by Concentration	Rank for Starting ISCO By Mass Recovery	Grid ID	Property
EW-01	X	Yes	37	2.88E-05	27	1.09E-03	2	1	E1	City
EW-02	X	Yes	670	4.37E-03	405	1.80E+00	19	30	E2	City
EW-03	X	Yes	21	5.00E-05	21	1.52E-03	3	2	E3	City
EW-04	X	Yes	37	2.04E-04	2	2.45E-03	6	3	D4	City
EW-05	X	Yes	29	1.41E-04	27	6.57E-03	4	7	D5	City
EW-06	X	Yes	28	6.10E-04	9	1.71E-02	9	7	D6	City
EW-07	X	Yes	132	2.23E-05	135	3.09E-03	1	4	D7	City
EW-08		No	72	4.15E-02	29	1.21E+00	30	29	C1	Edwards Street
EW-09	X	Yes	54	1.20E-02	20	2.57E-01	28	22	C2	Schneider
EW-10		Yes	58	8.89E-03	30	2.80E-01	24	24	C3	Schneider
EW-11		No	87	9.44E-03	49	4.33E-01	26	25	C4	Schneider
EW-12		No	79	5.97E-03	49	2.73E-01	21	23	C5	City
EW-13		Yes	31	1.21E-03	68	8.32E-02	12	12	C6	City
EW-14	X	Yes	74	2.22E-02	49	1.07E+00	29	28	C7	Edwards Street
EW-15	X	Yes	26	2.37E-01	176	2.57E+01	33	34	C8	City
EW-16	X	No	88	1.24E-01	44	5.90E+00	32	32	C9	City
EW-17		No	92	1.92E-03	49	8.77E-02	14	13	B1	Edwards Street
EW-18		No	93	2.34E-03	49	1.08E-01	17	15	B2	Edwards Street
EW-19		No	71	1.97E-03	49	9.09E-02	15	14	B3	Edwards Street
EW-20		No	59	3.60E-01	23	9.51E+00	34	33	B4	Edwards Street
EW-21		Yes	46	9.74E-03	49	4.53E-01	27	26	B5	Edwards Street
EW-22	X	No	73	8.94E-03	45	4.75E-01	25	27	B6	Edwards Street
EW-23	X	Yes	70	3.72E-03	49	1.97E-01	18	19	B7	Edwards Street
EW-24		Yes	51	4.59E-03	49	2.25E-01	20	20	B8	Edwards Street
EW-25		No	36	6.22E-02	95	5.51E+00	31	31	A1	Ameren
EW-26		No	116	6.95E-03	15	1.09E-01	22	17	A2	Ameren
EW-27	X	Yes	84	2.01E-03	54	1.09E-01	16	18	A3	Ameren
EW-28		Yes	52	1.01E-03	9	8.98E-03	10	9	A4	Ameren
EW-29		Yes							A5	Ameren
EW-30	X	Yes							A6	Ameren
EW-31	X	Yes							A7	Ameren
EW-32	X	Yes							D1	Schneider
EW-33	X	Yes							D2	Schneider
EW-34		Yes							D3	City

Locations most recommended to begin ISCO treatment on basis of ranking of corresponding data.

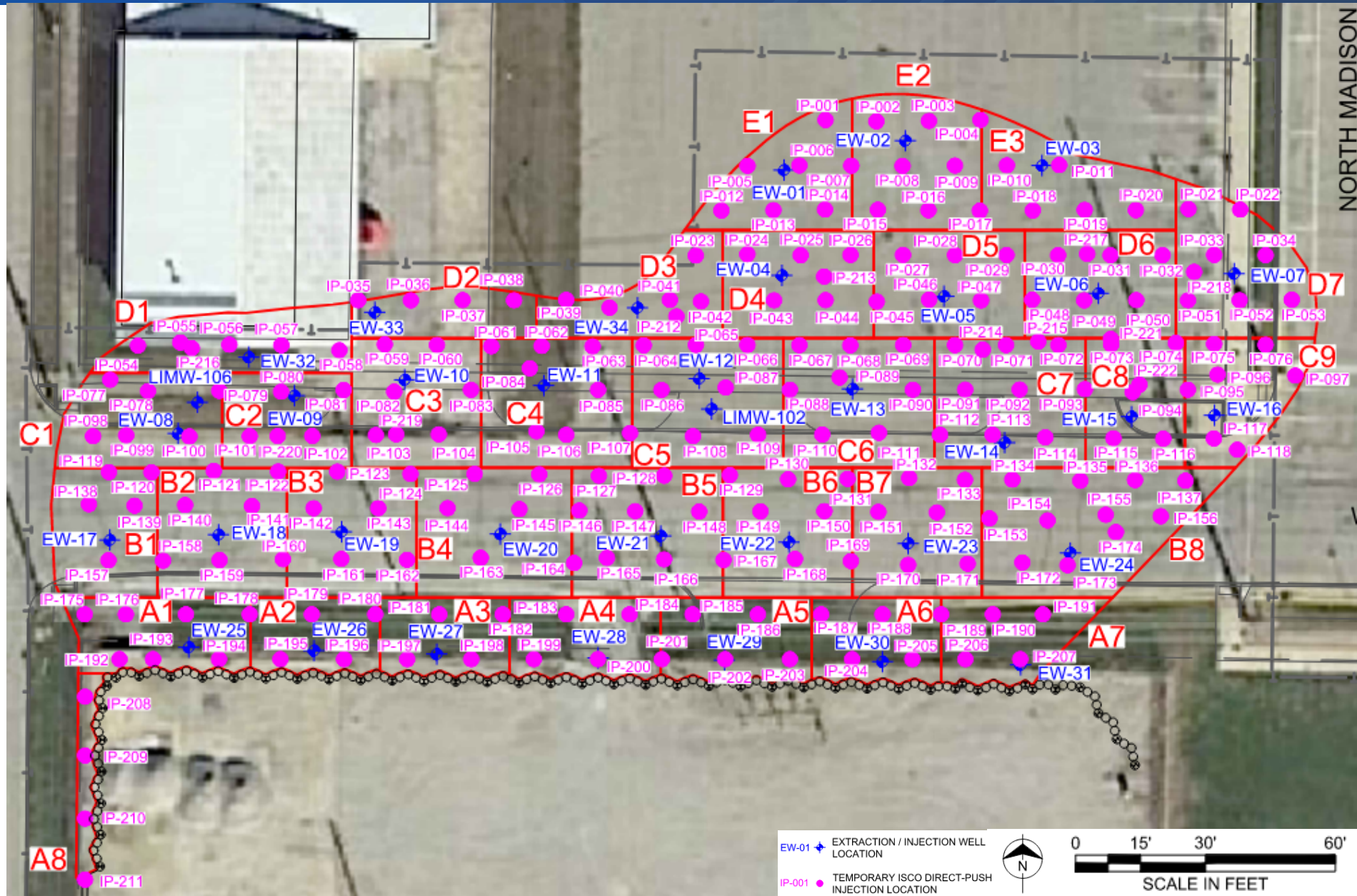
Locations least recommended to begin ISCO treatment on basis of ranking of corresponding data.

Bolded Well and Grid IDs recommended as the next ones to begin ISCO treatment.

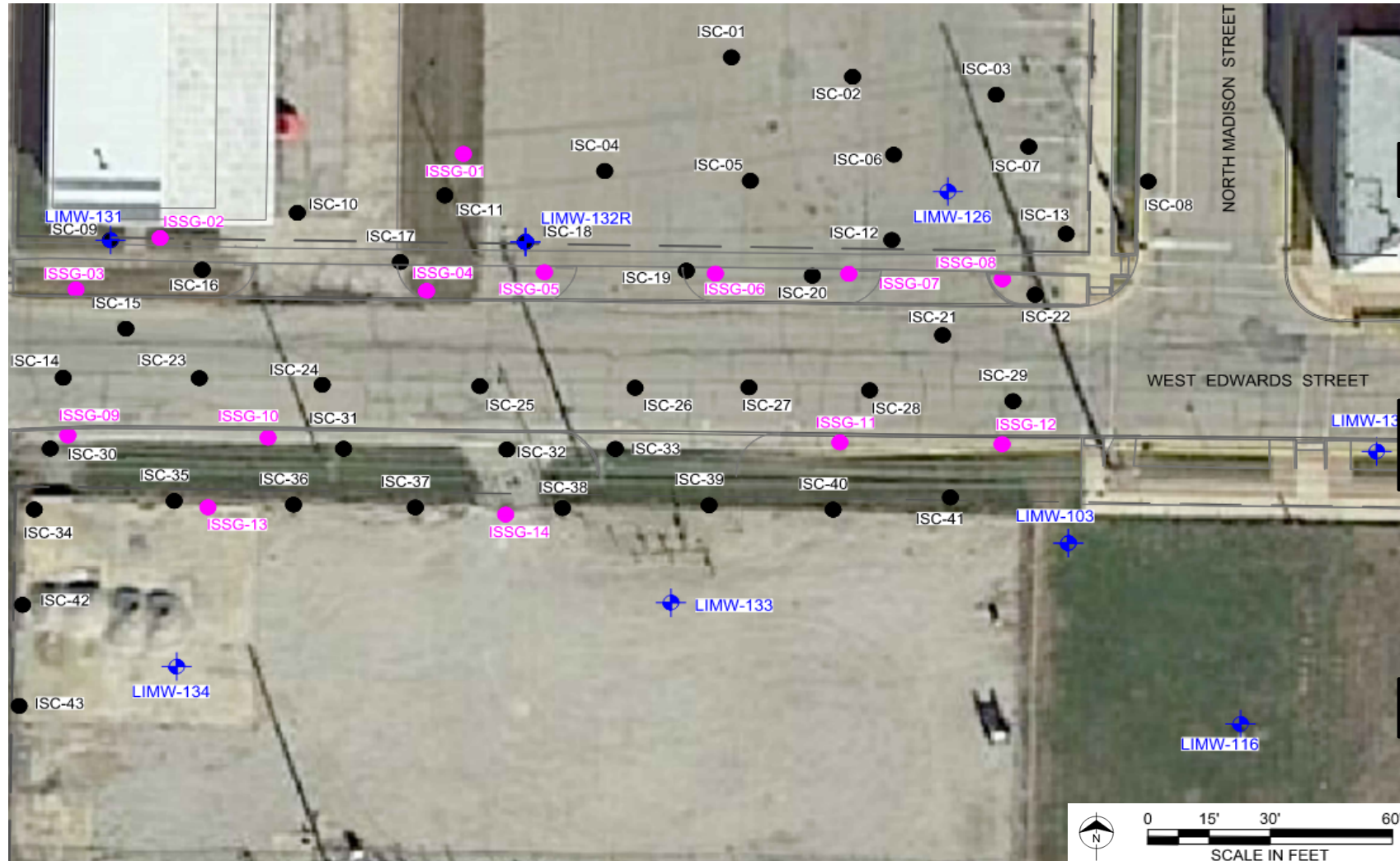
ISCO Phase | 30 mg/L Provect-OX



- ▶ 67,375 gallons
- ▶ 211 direct-push injection locations
- ▶ Injection in 5-foot screen increments to enhance distribution
- ▶ Performance monitoring:
 - Persulfate, pH, ORP
- ▶ May 13, 2023 through July 11, 2023



Results: Post-Remediation Confirmation Samples



► 43 soil sample locations

ISC-01 ● SOIL CONFIRMATION SAMPLE LOCATION

► 14 soil gas sampling locations

ISSG-01 ● SOIL GAS CONFIRMATION SAMPLE LOCATION

► 3 monitoring wells within the treatment zone

LIMW-103 ● SHALLOW MONITORING WELL LOCATION

Results: Post-Remediation Confirmation Soil Samples



34 of 43 soil sample locations met site-specific ROs

- Locations that did not generally confined to center of road

SUM OF ORGANICS		
Pre-Remediation (SB-49)	Post-Remediation (ISC-09)	% Reduction
570 mg/kg	49.2 mg/kg	91%

ISC-09

SB-49

SB-11

ISC-16

ISC-19

SB-38

SUM OF ORGANICS		
Pre-Remediation (SB-11)	Post-Remediation (ISC-16)	% Reduction
6,890 mg/kg	367 mg/kg	95%

SUM OF TOTAL PETROLEUM HYDROCARBONS (TPH)		
Pre-Remediation (SB-38)	Post-Remediation (ISC-19)	% Reduction
23,000 mg/kg	5,960 mg/kg	74%

SB-11 ● HISTORICAL SAMPLE LOCATION

ISC-01 ● IN-SITU REMEDIATION CONFIRMATION
SAMPLE LOCATION

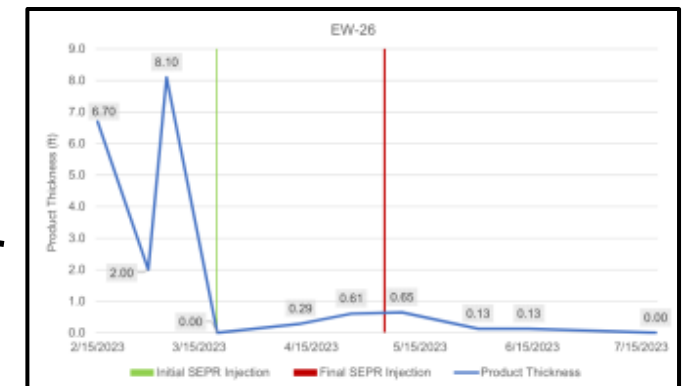
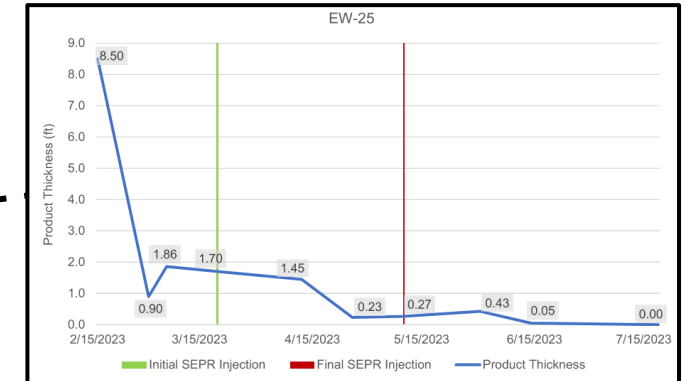
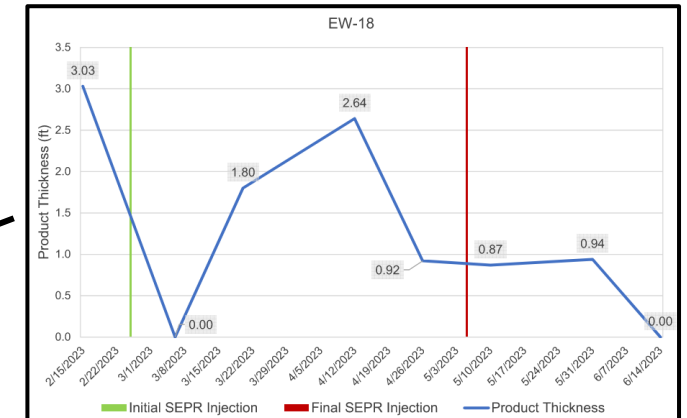
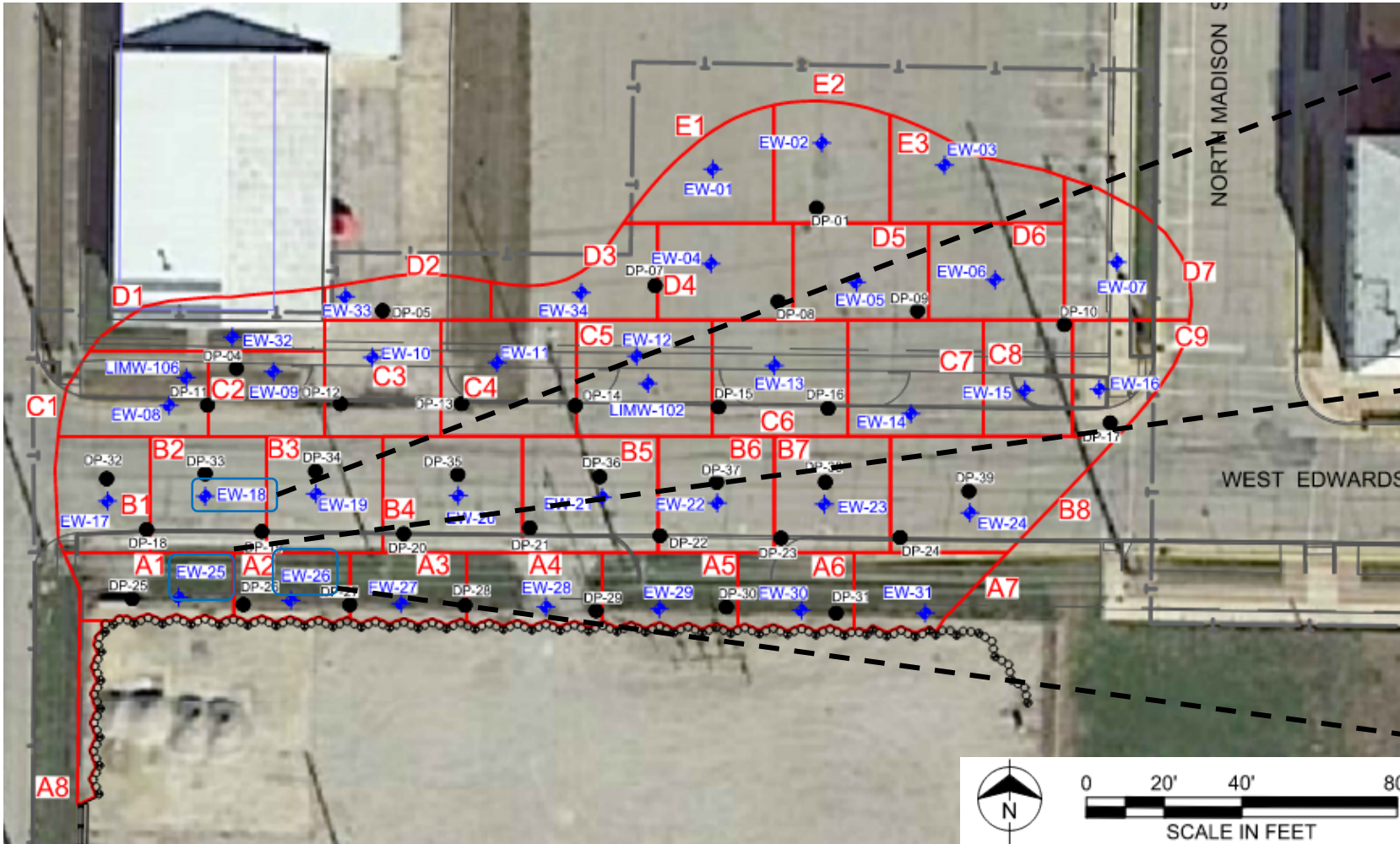


0 15' 30' 60'
SCALE IN FEET

Post-Remediation Groundwater Data



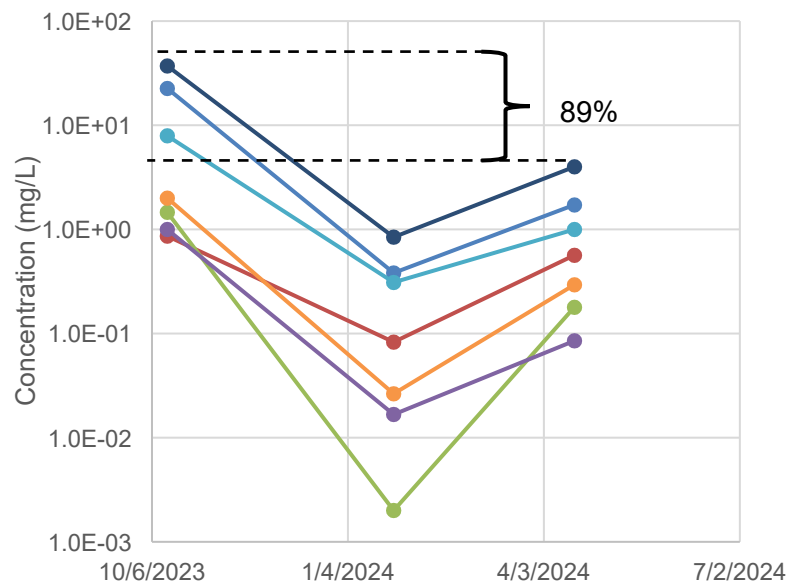
No measurable DNAPL in extraction wells



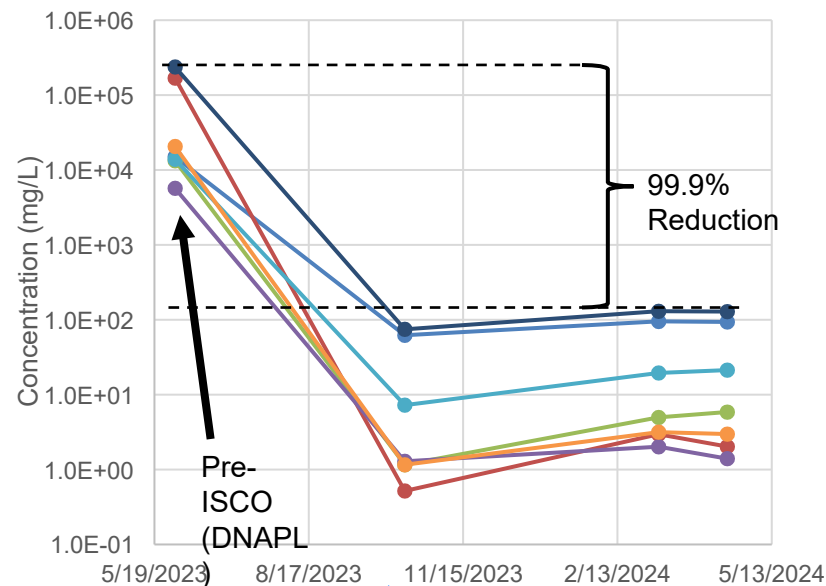
Post-Remediation Groundwater Data



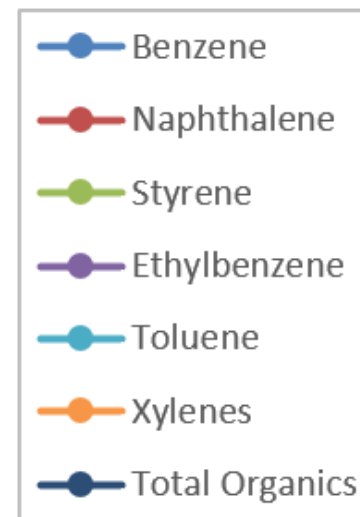
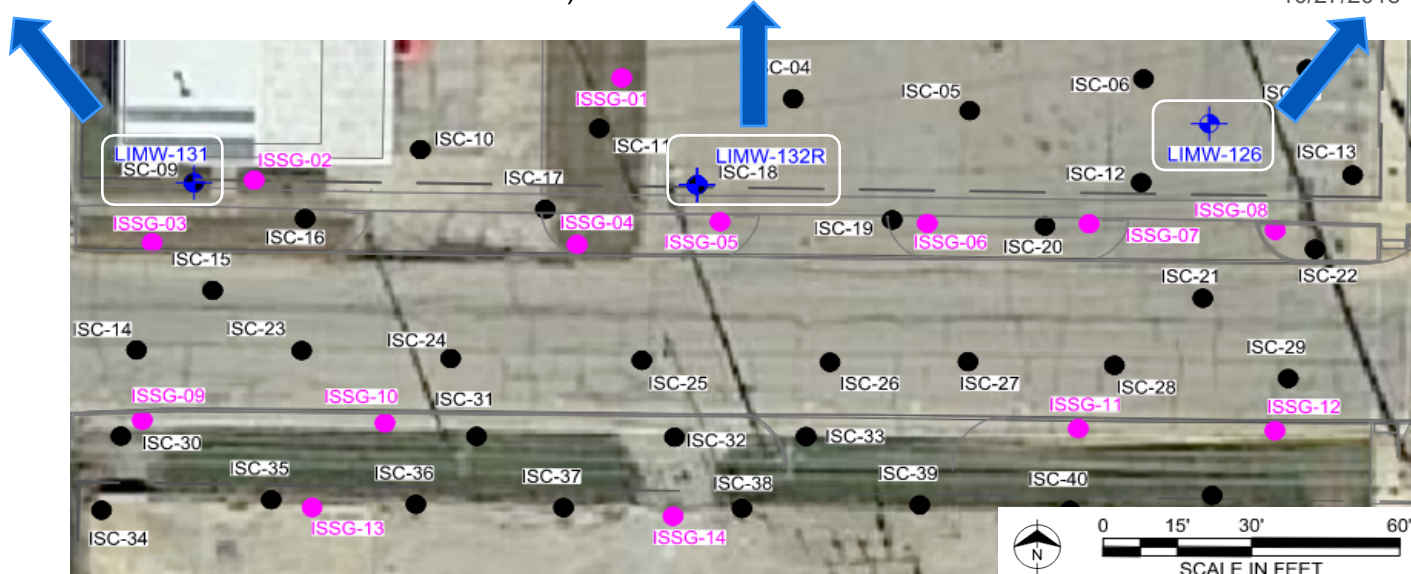
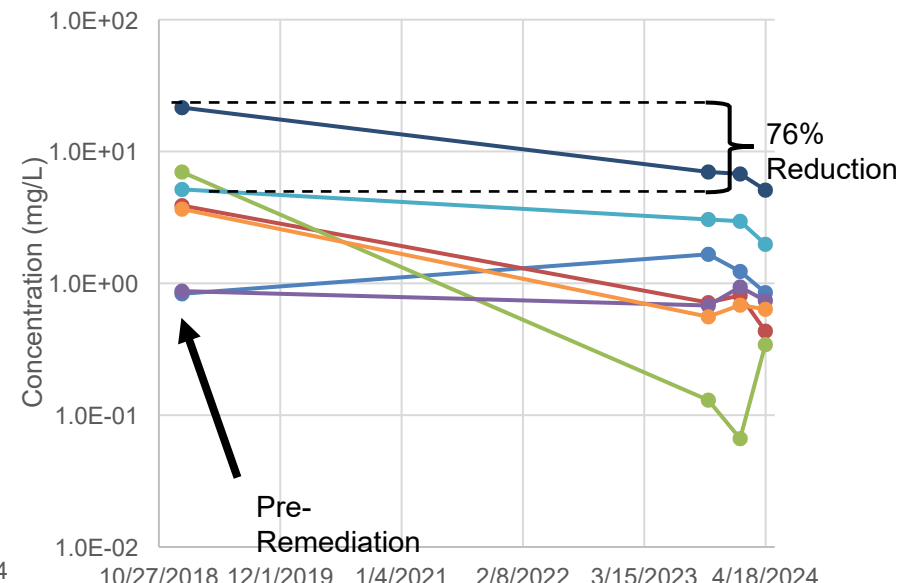
LIMW-131



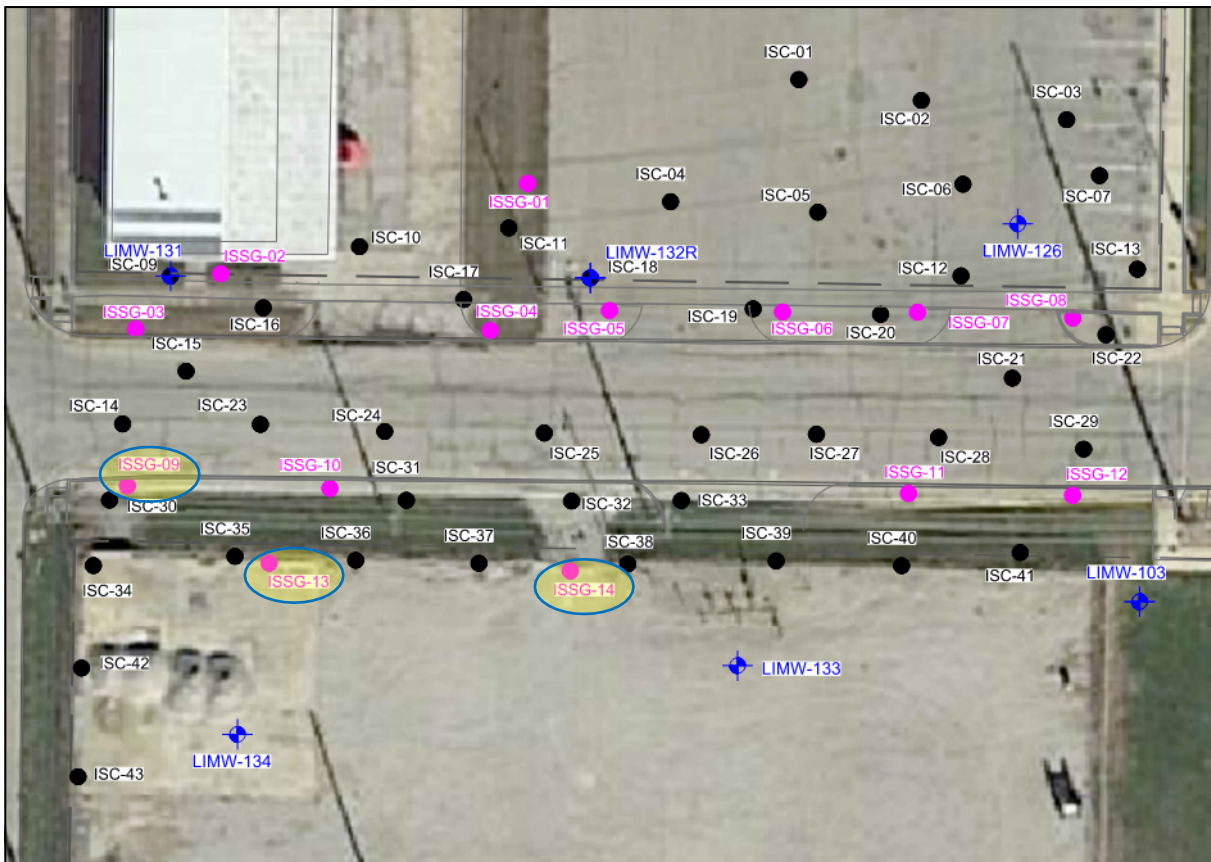
EW-12/LIMW-132/132R



LIMW-126

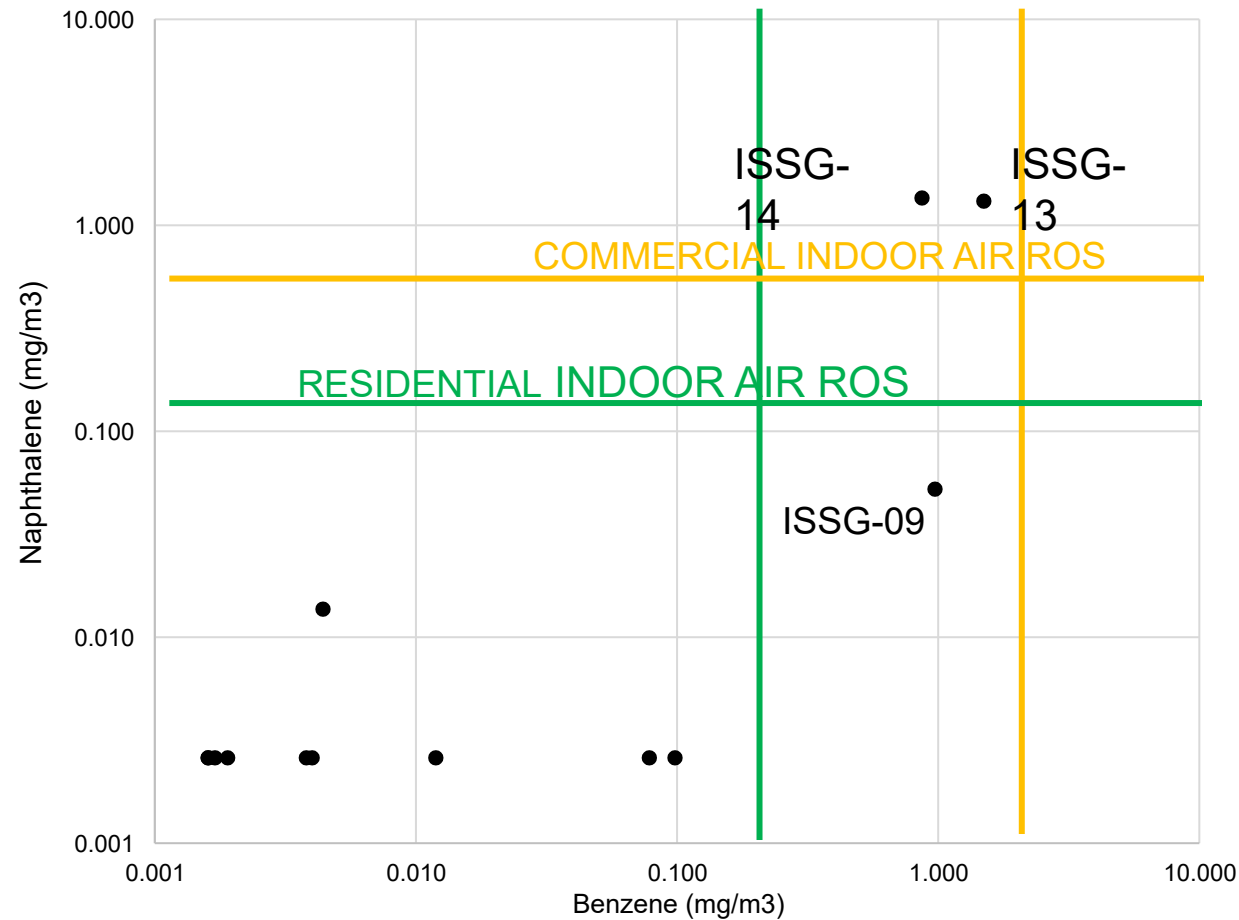


Post-Remediation Soil Gas Data



ISSG-01 ● SOIL GAS CONFIRMATION SAMPLE LOCATION

Benzene vs. Naphthalene in Post-Remediation Soil Gas



Challenges/Lessons Learned



- ▶ Timeframe
- ▶ Historic brick 36-inch combined sewer exhibited “red water” i.e. persulfate detections
 - Additional monitoring and extraction protocols employed
 - 3.64-inch precipitation event near end of project caused sewer backup
- ▶ Scope creep on restoration activities



Persulfate – 35 ppm, pH – 6.42 s.u.

Rationing Rational RestoRation Rationale



Circa 1886



December 2022



August 2023



August 2023



October 2023



November 2023



May 2024



Conclusions

- ▶ Lots of moving parts – communication was key
- ▶ Pilot study provided actionable data for full-scale design refinement, however, more significant pilot study effort may have informed team of additional challenges prior to full-scale
 - NAPL separation more challenging than pilot
- ▶ Mass removal approach provided justification criteria for decision making
- ▶ Estimated savings of minimum **\$4M** versus alternatives
- ▶ External stakeholders ultimately appreciated final product delivered



Thank You!



Ameren



SEPR® is patented technology from EthicalChem

Let's Connect



Email

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LinkedIn

