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In-Situ Chemical Oxidation from Pilot Study to Full-Scale Implementation

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Presentation Overview

- Site Background
- Review of Pilot Study
- Full-Scale Ozone/Oxygen Sparging
  - Respiration Test
- Contingency Planning
  - SVE
- GW Parameters and Analytical Results
- Conclusions
- Lessons Learned

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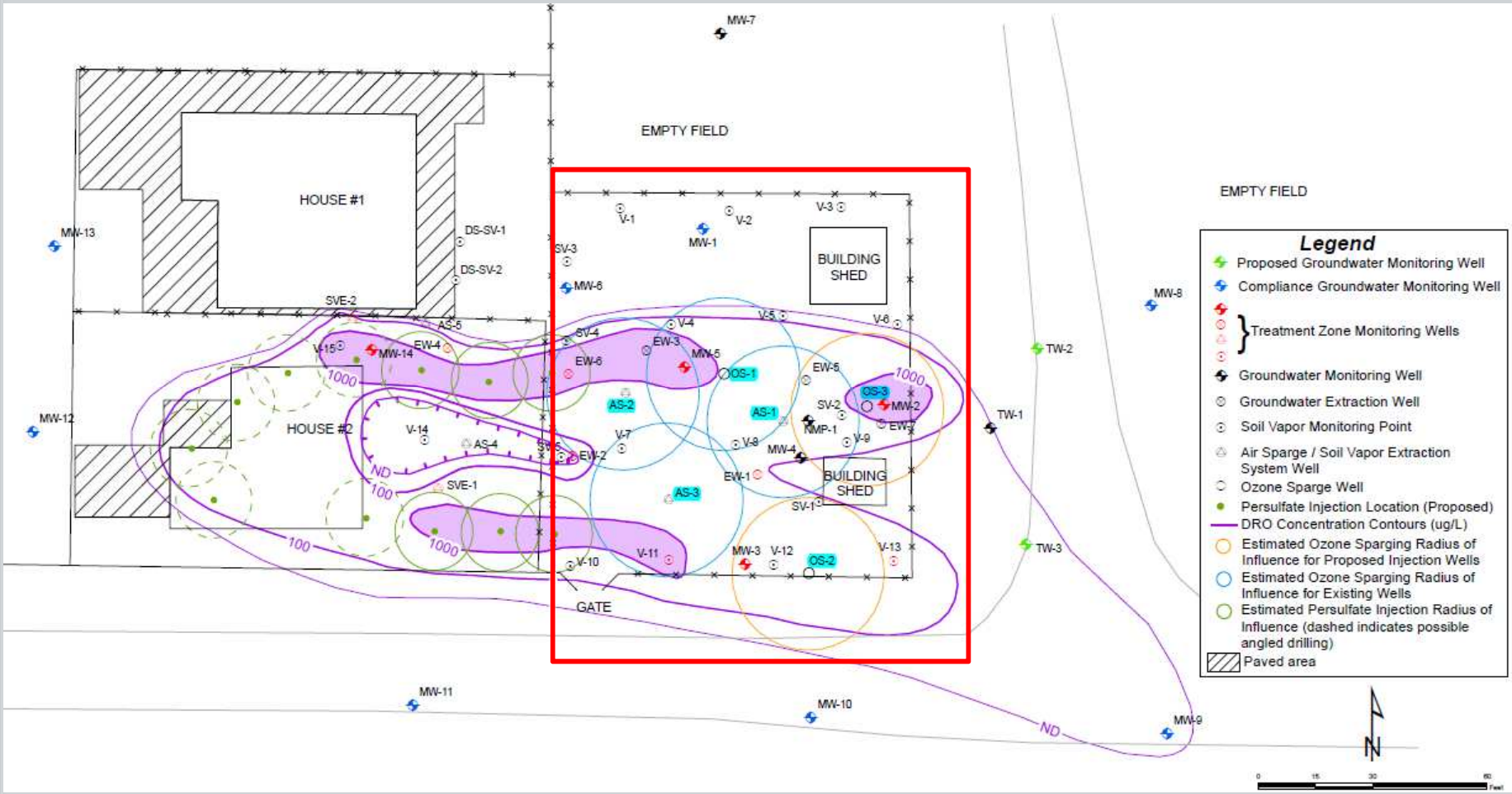
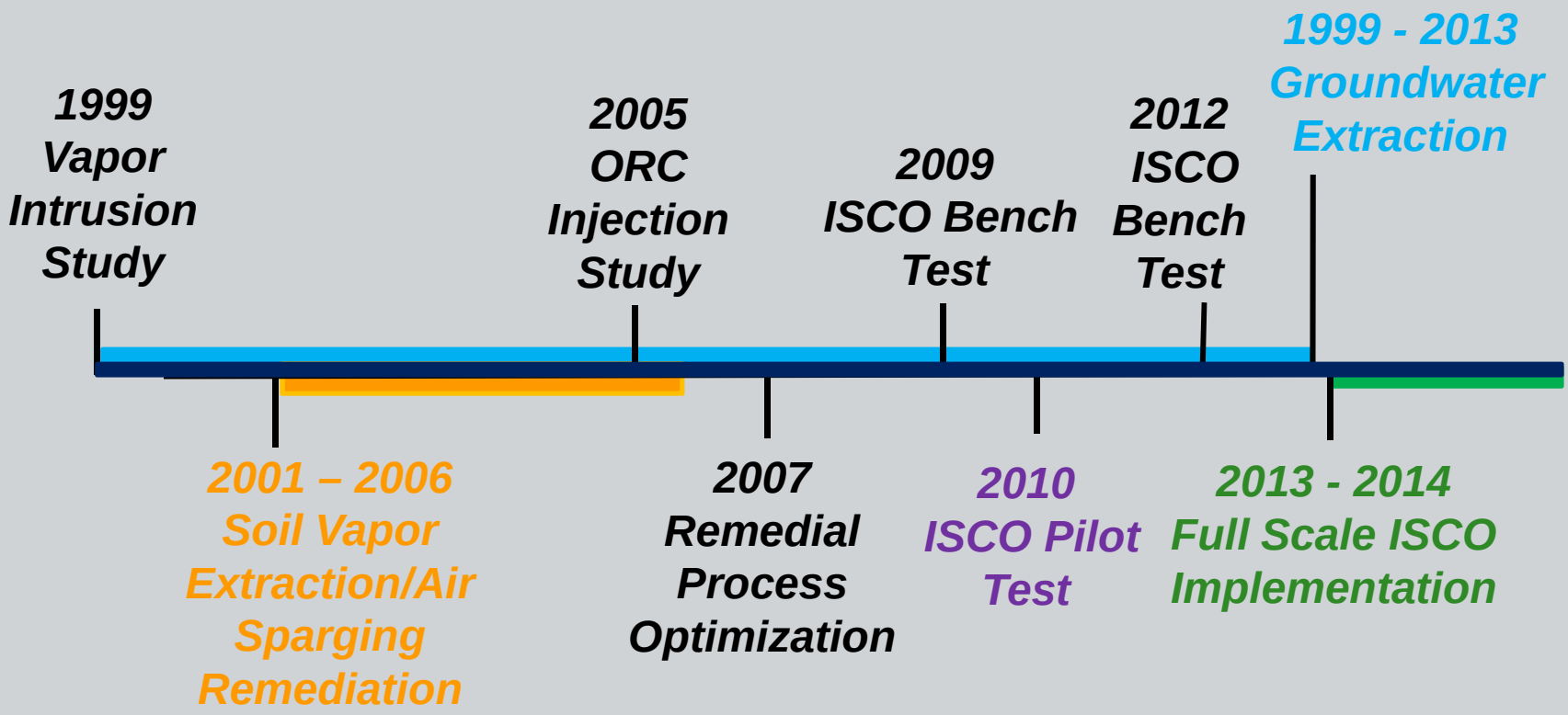
Off-Site versus On-Site Treatment



Chronology of Key Site Events

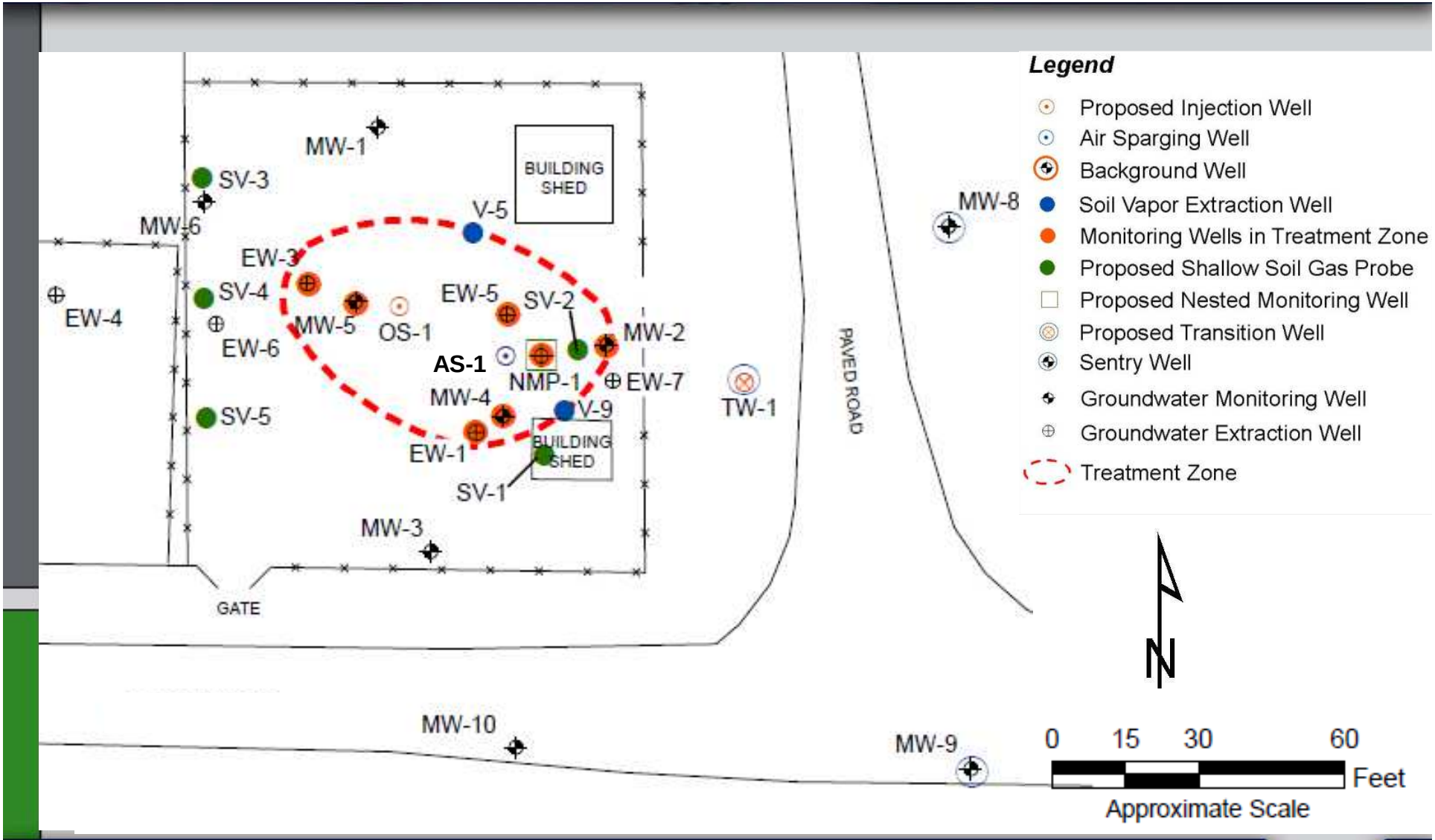


Site Background – Nature and Extent of Impacts

- Chemicals of Concern identified in **saturated zone:**
  - Gasoline Range Organics (GRO)
  - Diesel Range Organics (DRO)
  - Motor Oil Range Organics (ORO)

Matrix	GRO	DRO	ORO
Groundwater (µg/L)	3,500	5,600	520
Clean-up Levels (µg/L)	100	100	100

ISCO Ozone Pilot Test Site Layout

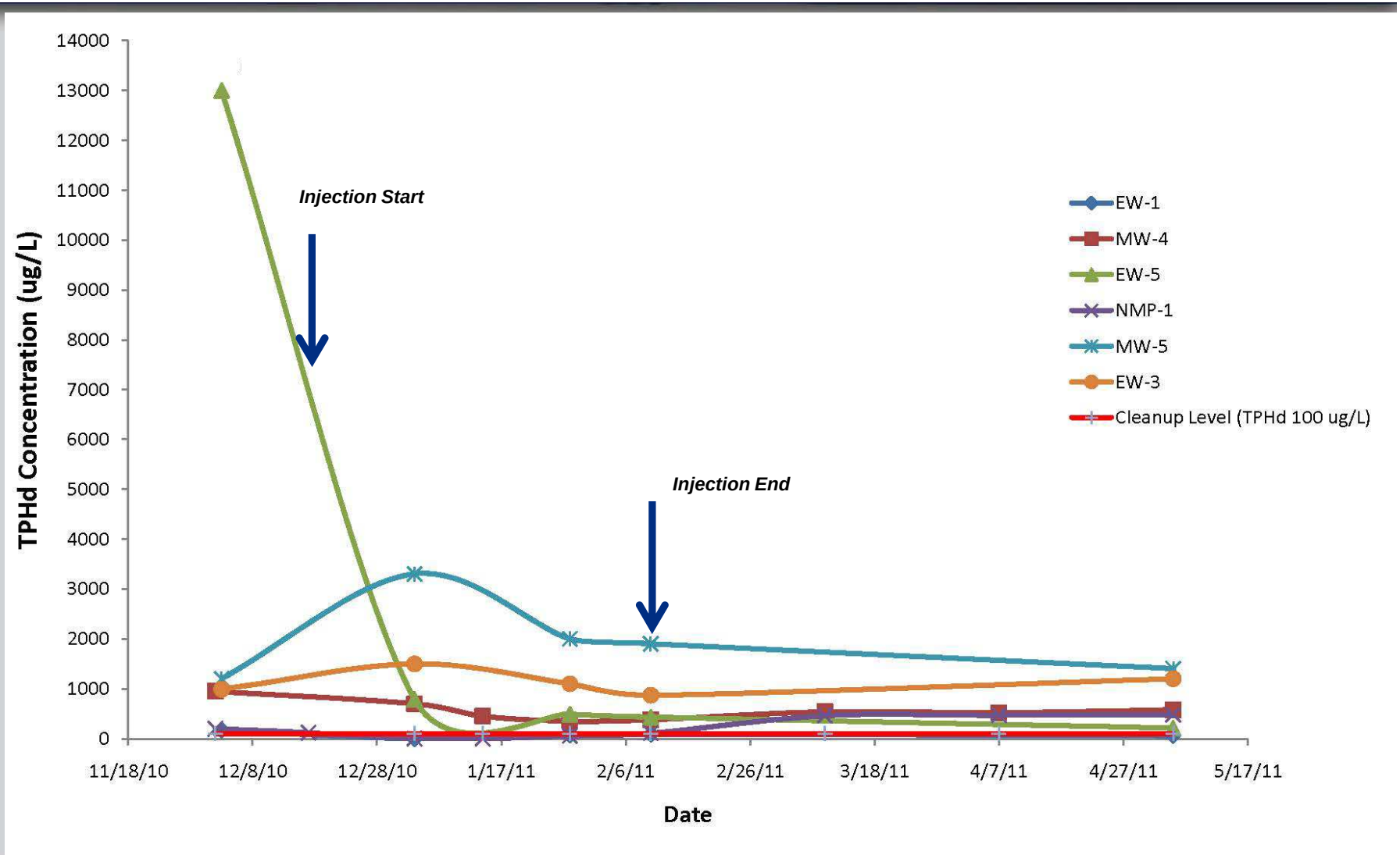


ISCO Pilot Test

Pilot Test Injection Specifications

- Injection pressure: 5.5 to 6.0 psi
- Sparge flow rate: 3.5 cfm per well
- Equivalent to ~ 4 lb O_3/day (2 lb O_3/day/well)
- ROI ~20 ft
- Alternating pulse period 60 minutes

Pilot Test Results - DRO Concentration



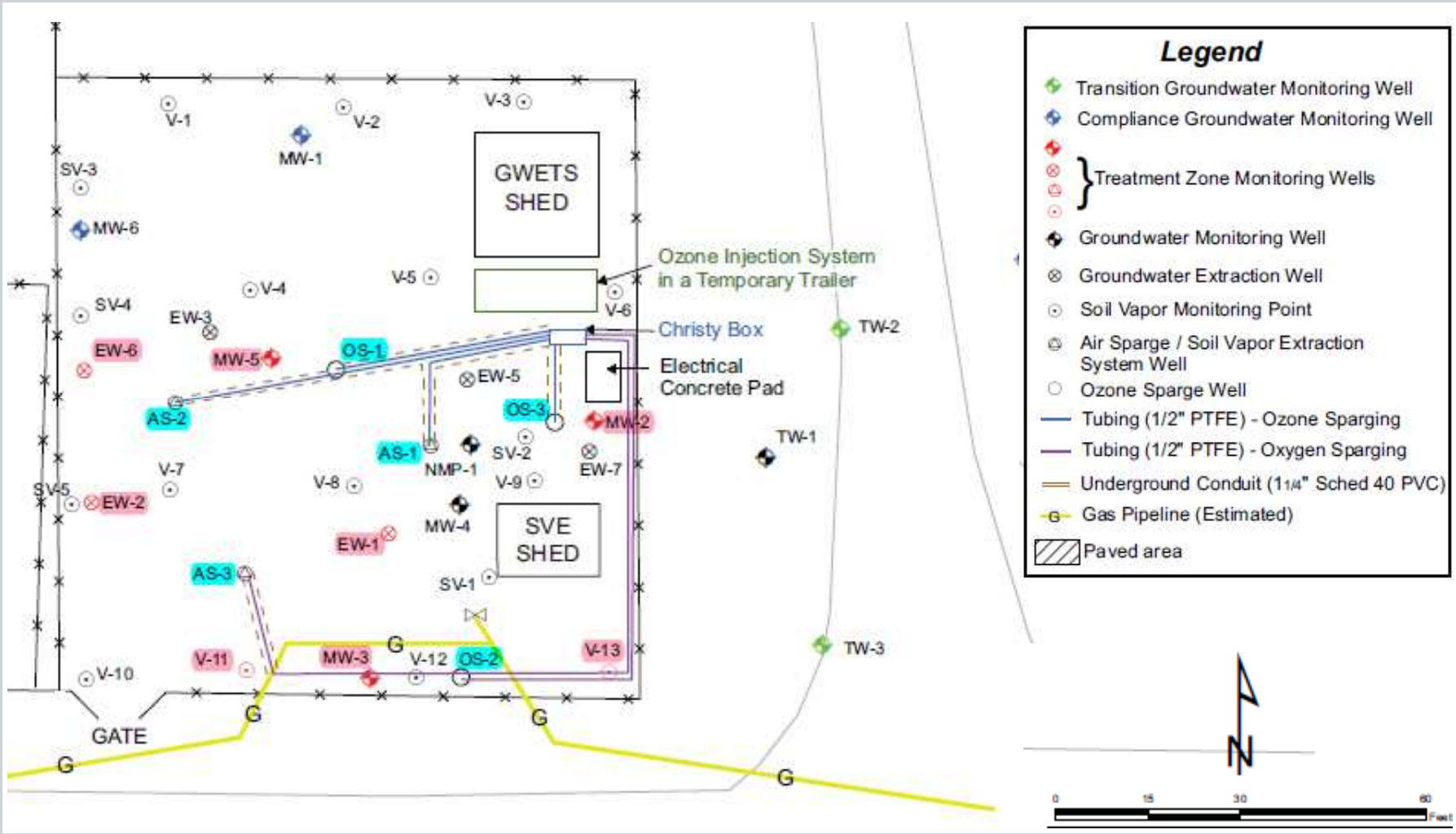
Ozone Injection Pilot Test Results

- ISCO using ozone successfully destroyed COCs in saturated zone
- Byproducts (hexavalent chromium and bromate) were detected in only NMP-1
  - Hexavalent Chromium (max 44 µg/L) decreased to baseline levels in three months
  - Bromate (max 110 µg/L) decreased to near baseline levels in one month
- Ozone/VOCs did not impact offsite residence and can be contained within treatment zone

Full-Scale Ozone Injection Implementation

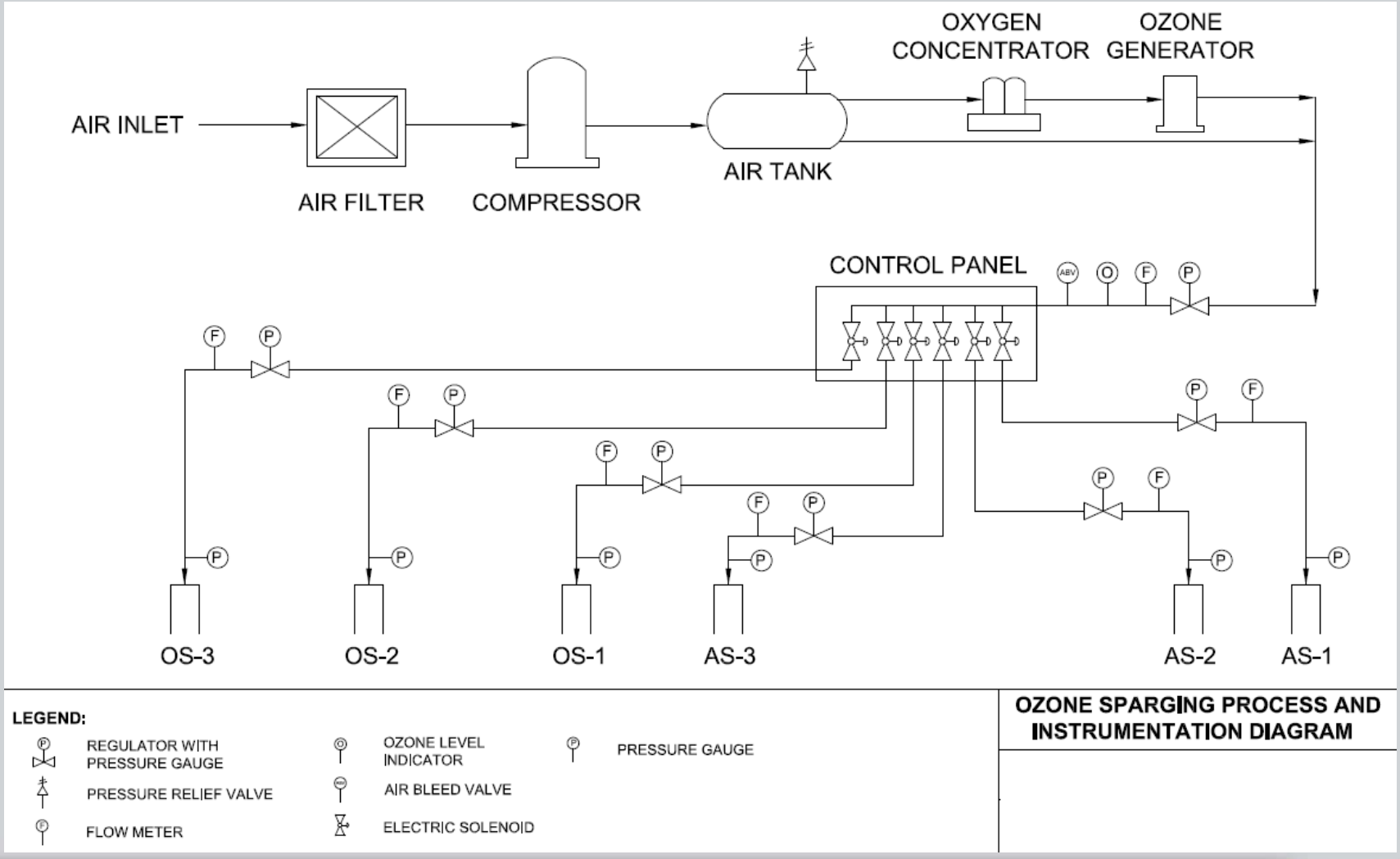
- Injection Wells = 6
- Treatment Monitoring Wells = 8
- Transition and Compliance Wells = 10
- Injection pressure: 12 to 25 psi
- Sparge flow rate: 6.8 cfm per well
- Ozone Capacity: 27 ppd
- ROI: 20 ft based on DO and ORP measurements

Actual Oxygen/Ozone Sparging Layout



Pre-Field Activities

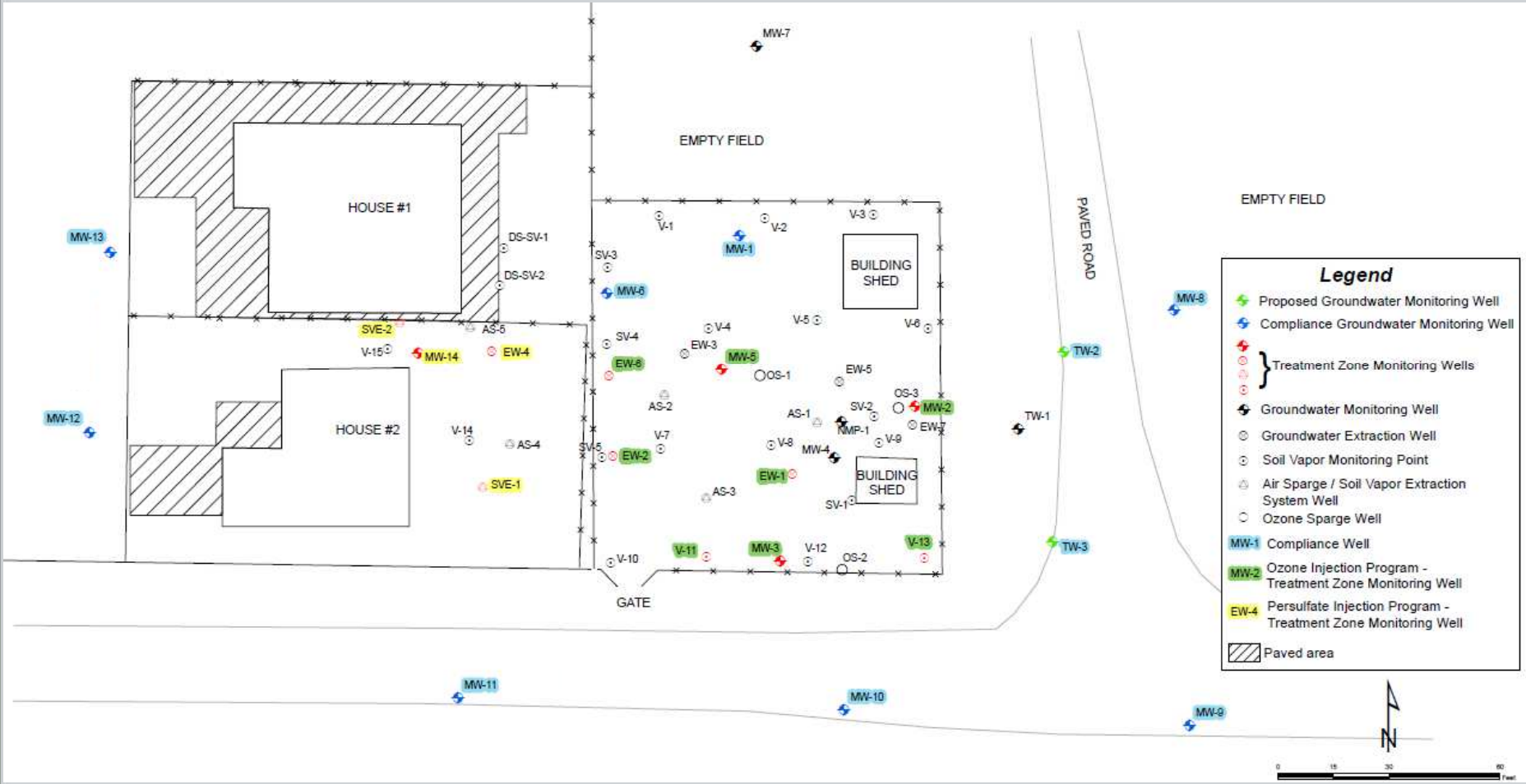
Ozone System Layout



Operation Optimization

- Standard Injection Interval per well: 60 minutes
- After four months of operation, focused ozone operation at hot spots
- Injection intervals were also adjusted based on concentrations and VOC off-gassing
  - Increased from 60 to 90 minutes in AS-2 and OS-3
  - Decreased from 60 to 30 minutes in AS-1 and AS-3

Soil Vapor and Groundwater Monitoring Wells



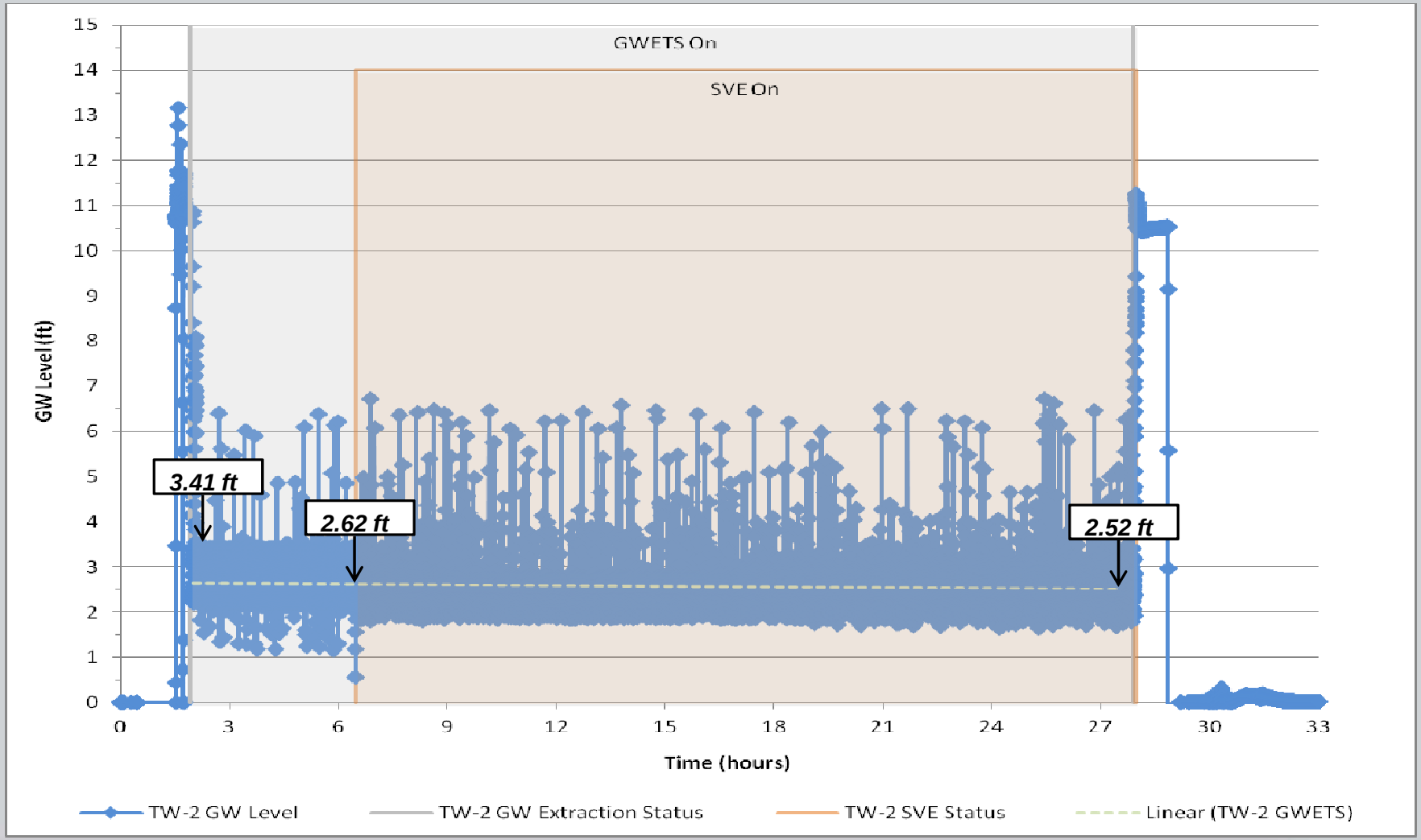
Soil Vapor Extraction

- Ozone offgassing was not detected in the ozone treatment wells
- Due to elevated PID concentration in the wellhead of MW-10 one month after operation, SVE was conducted at MW-10 for three weeks
- Dual phase extraction was conducted at TW-2, which had elevated PID readings
  - Initial PID were approximately 900 ppmv and decreased to 20 ppmv after 6 months of operation

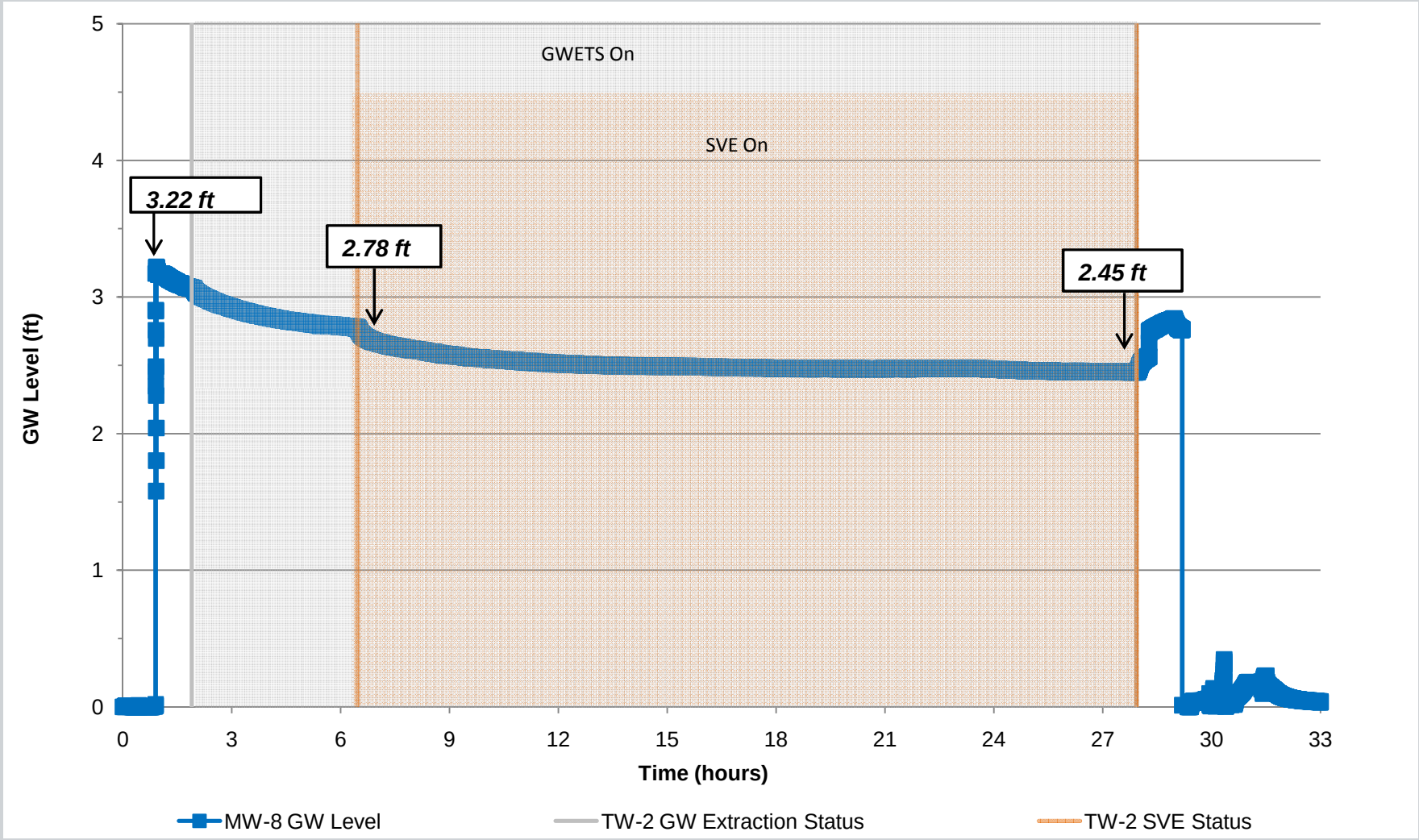
Pump Test at TW-2

- Placed pressure transducers within TW-2 and two downgradient wells (MW-8 and MW-2)
- Tested three cases over 33 hours
  - No remediation system (Control)
  - GWE only
  - GWE and SVE
- In all cases, GW elevation decreased with GWE and SVE operation

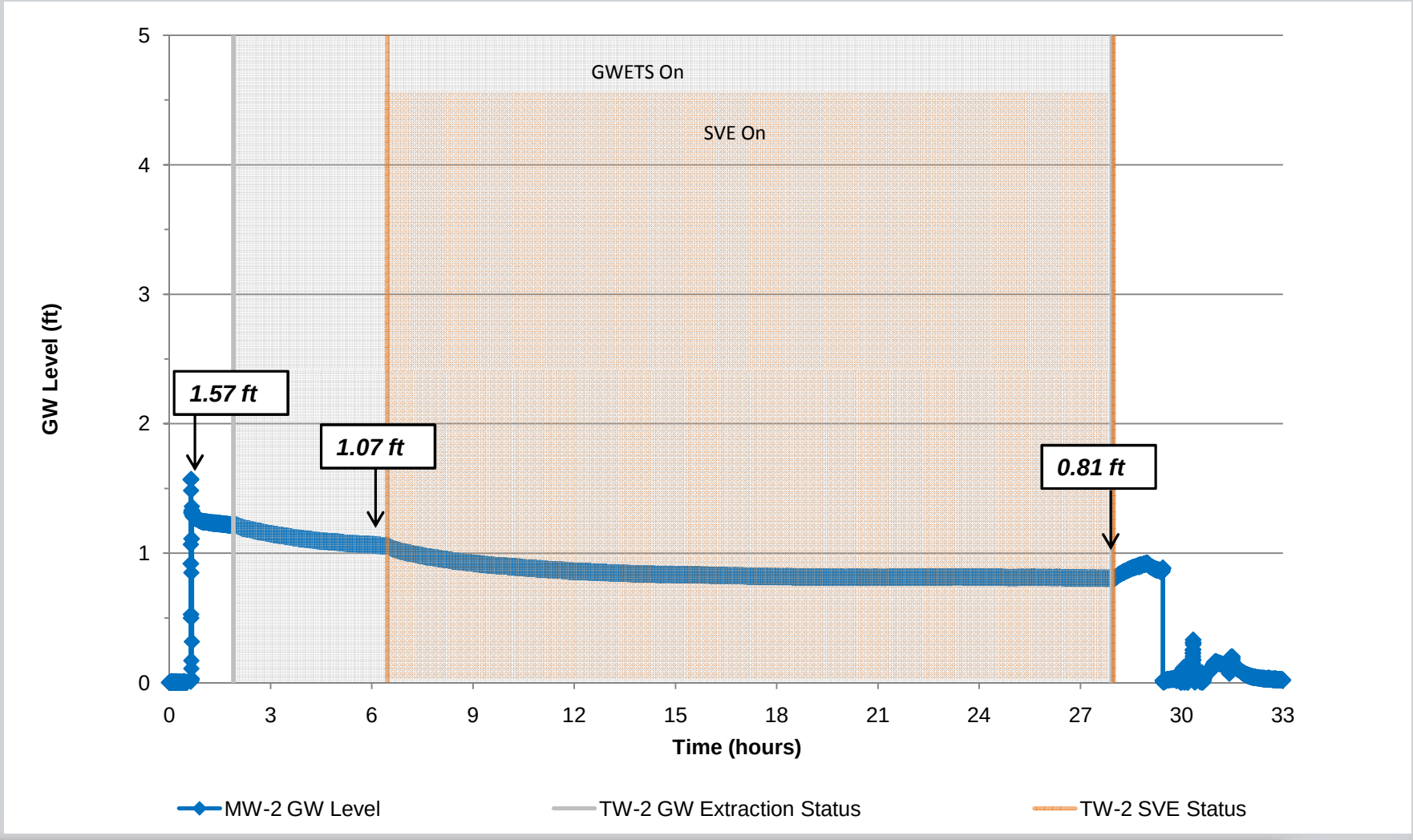
Pump Test at TW-2



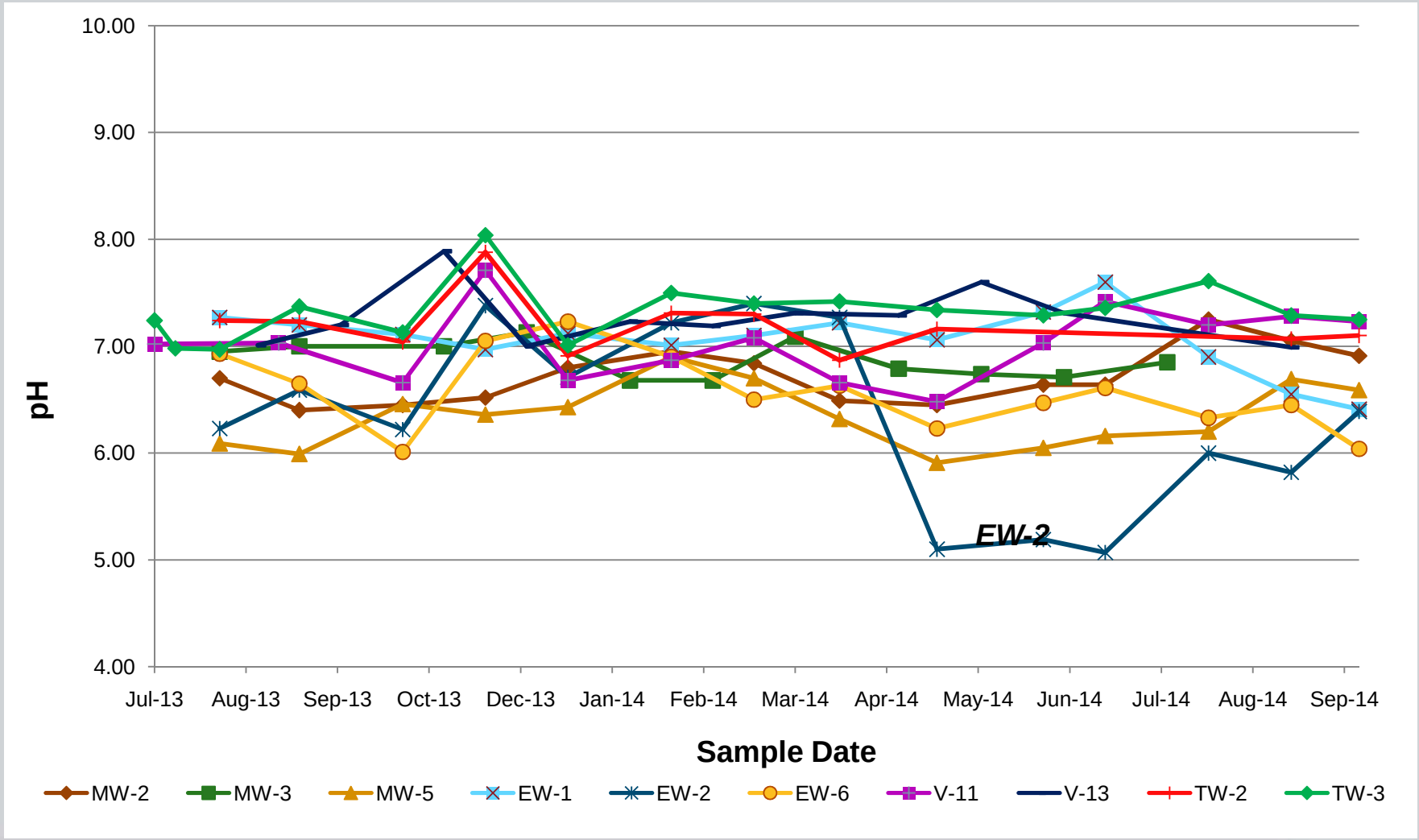
Pump Test at MW-8 (35 Foot From TW-2)



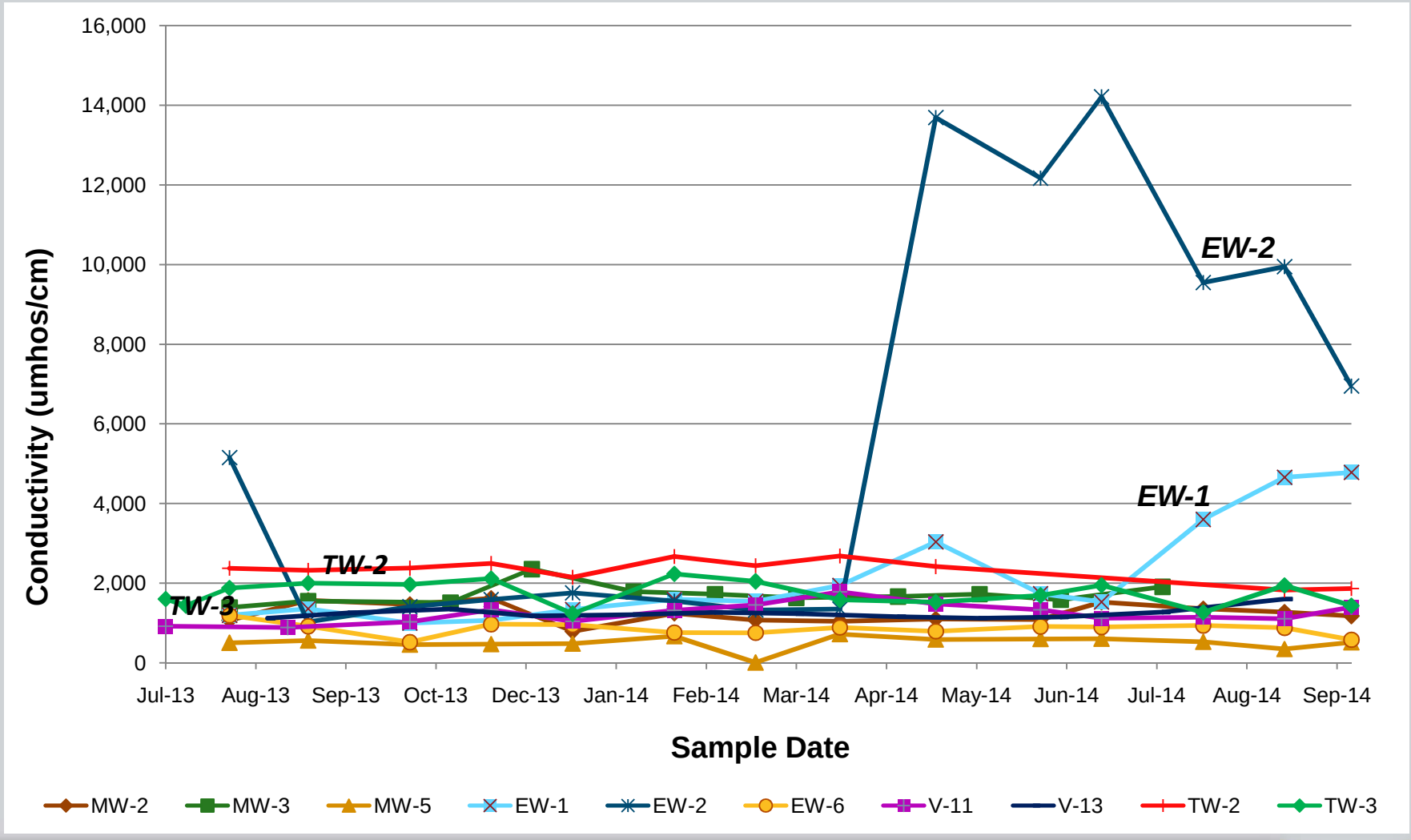
Pump Test at MW-2 (40 Foot From TW-2)



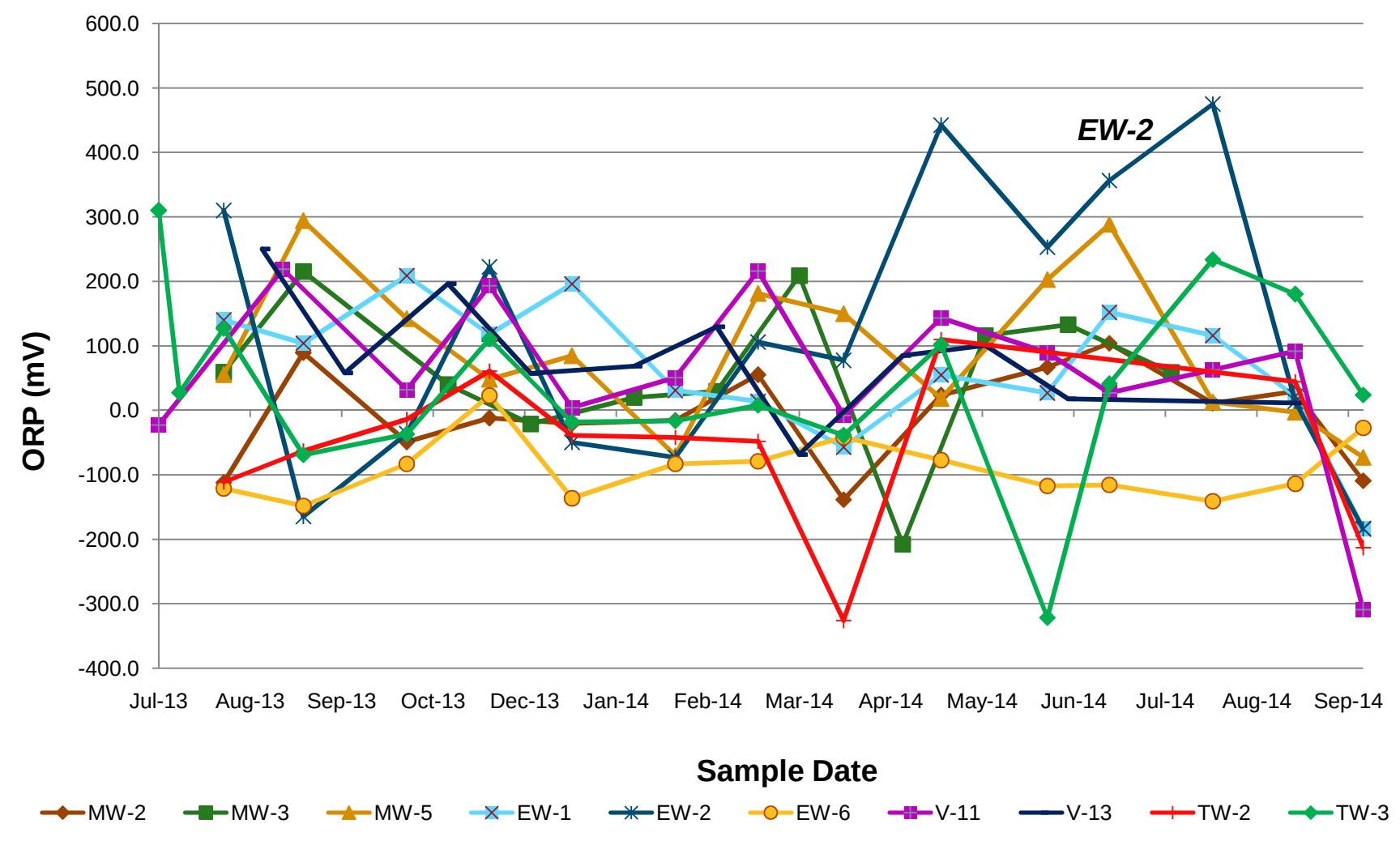
Ozone Treatment Wells - pH



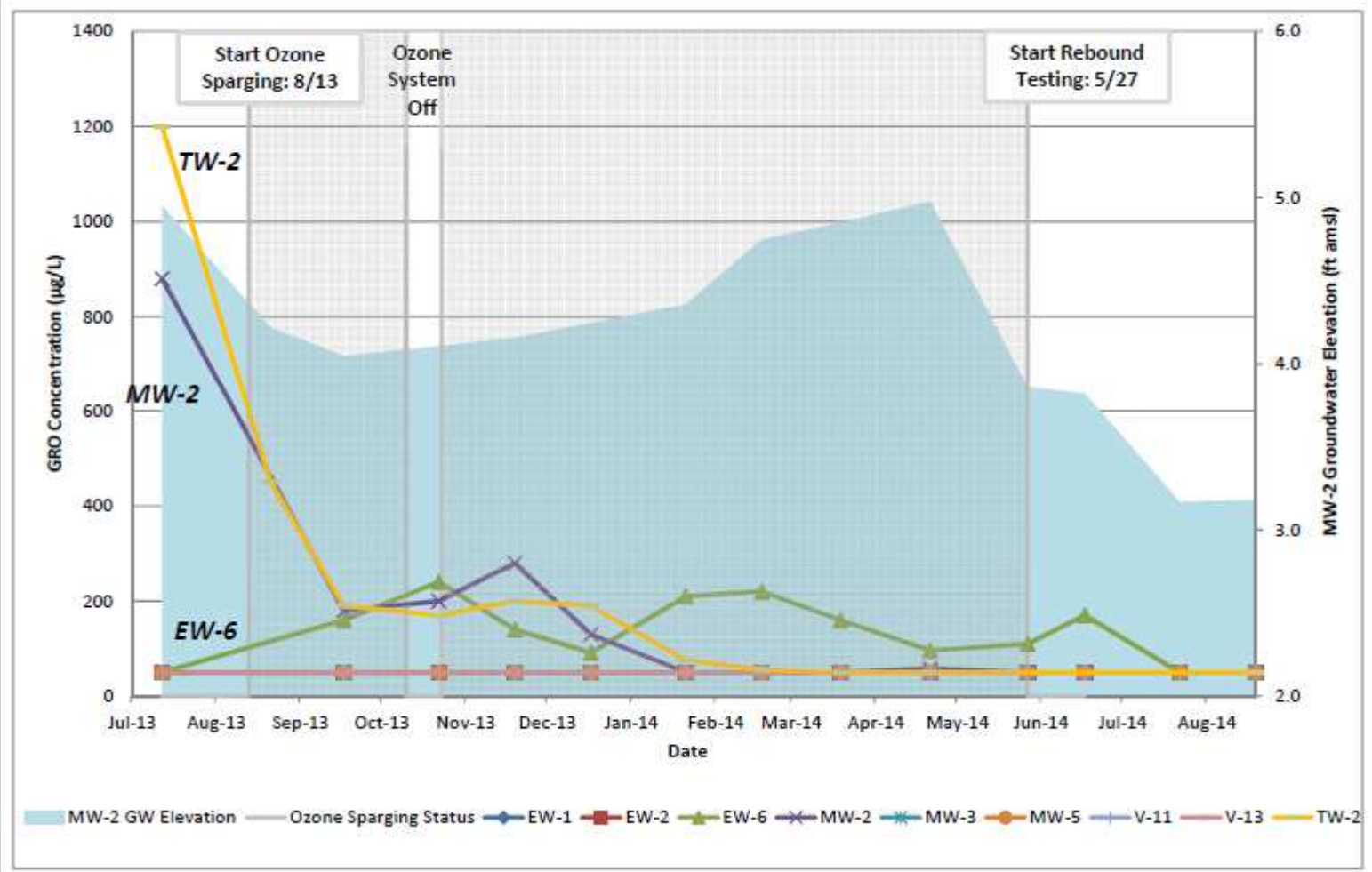
Ozone Treatment Wells - Conductivity



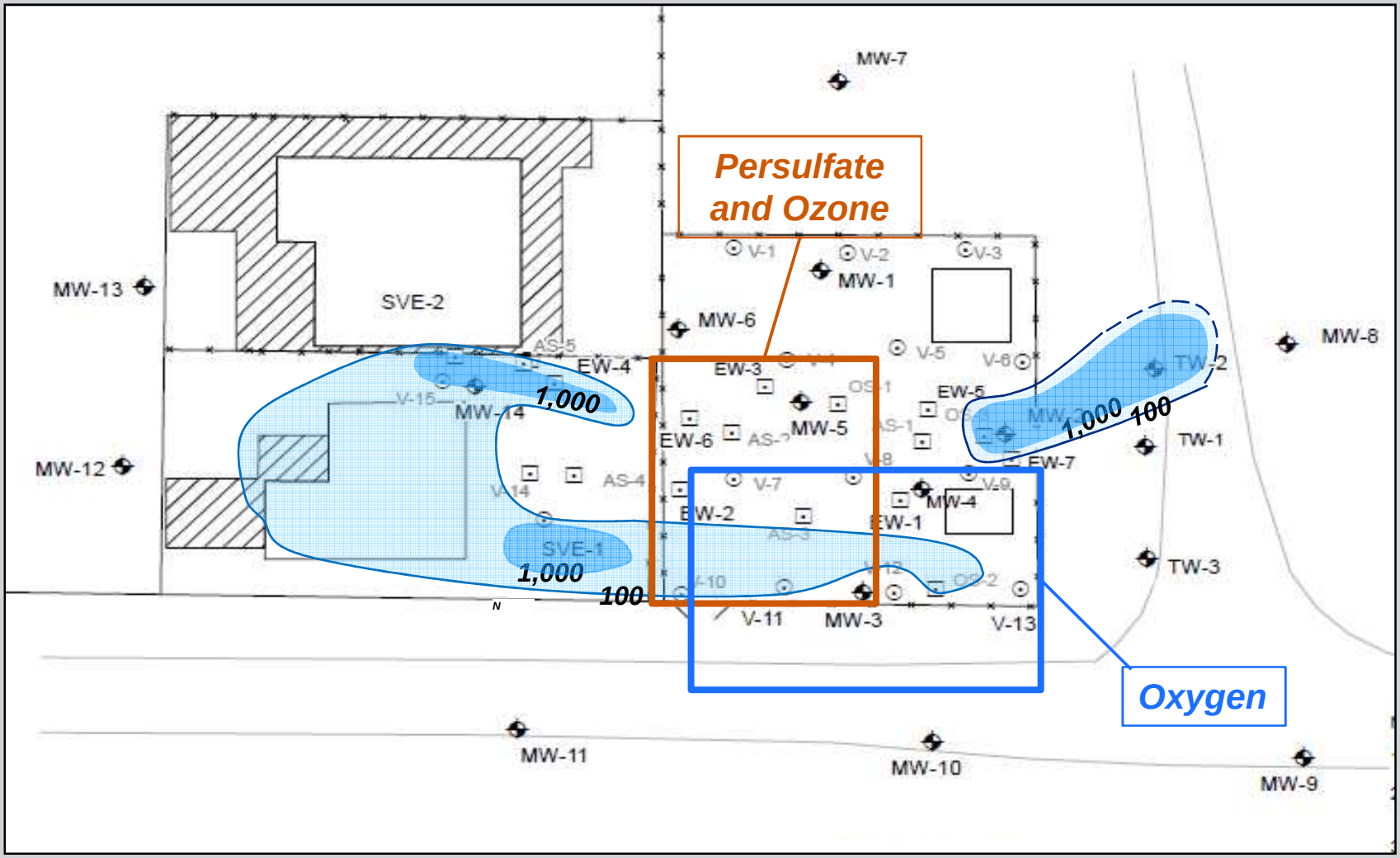
Ozone Treatment Wells - ORP



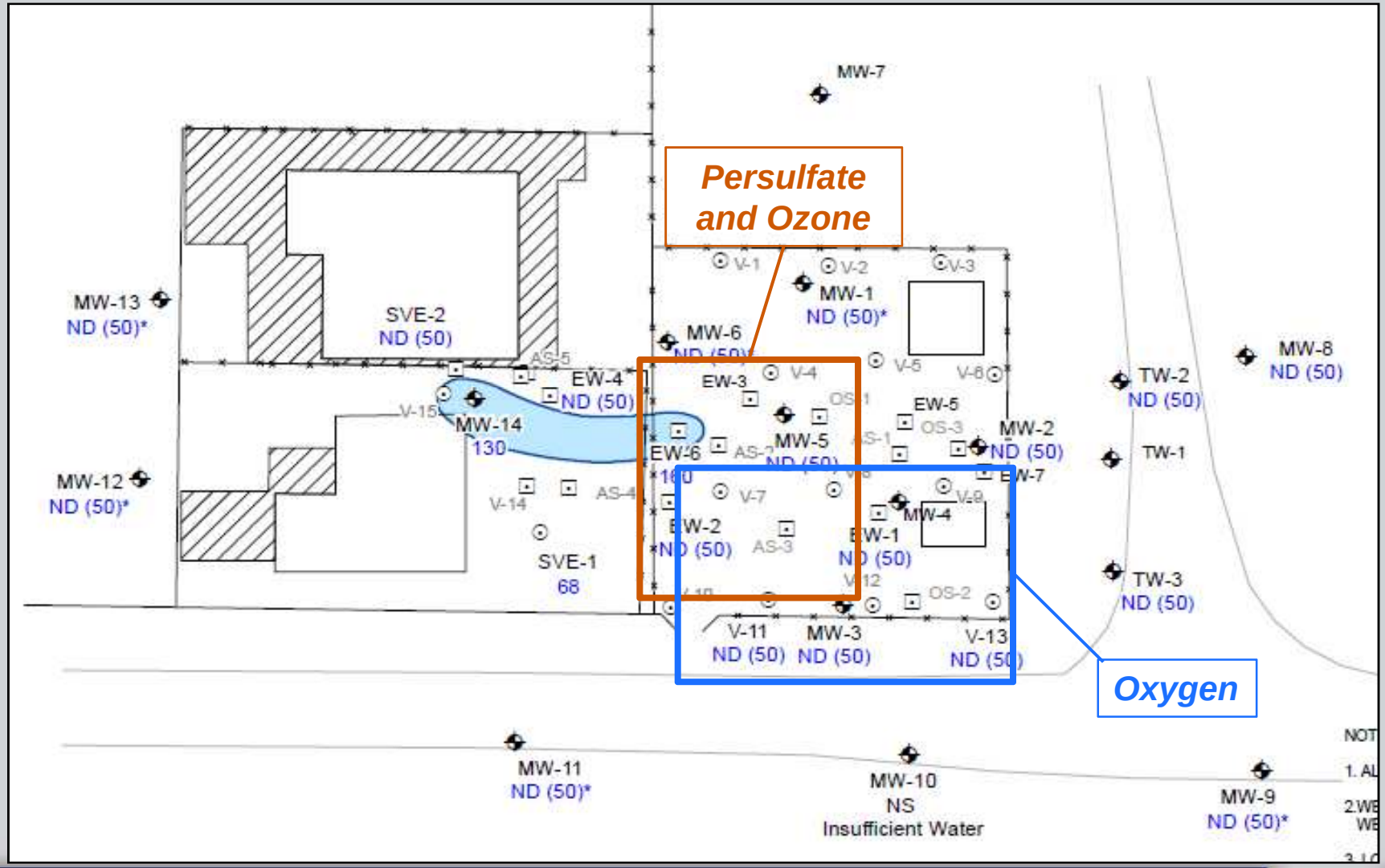
GRO Concentration Trends



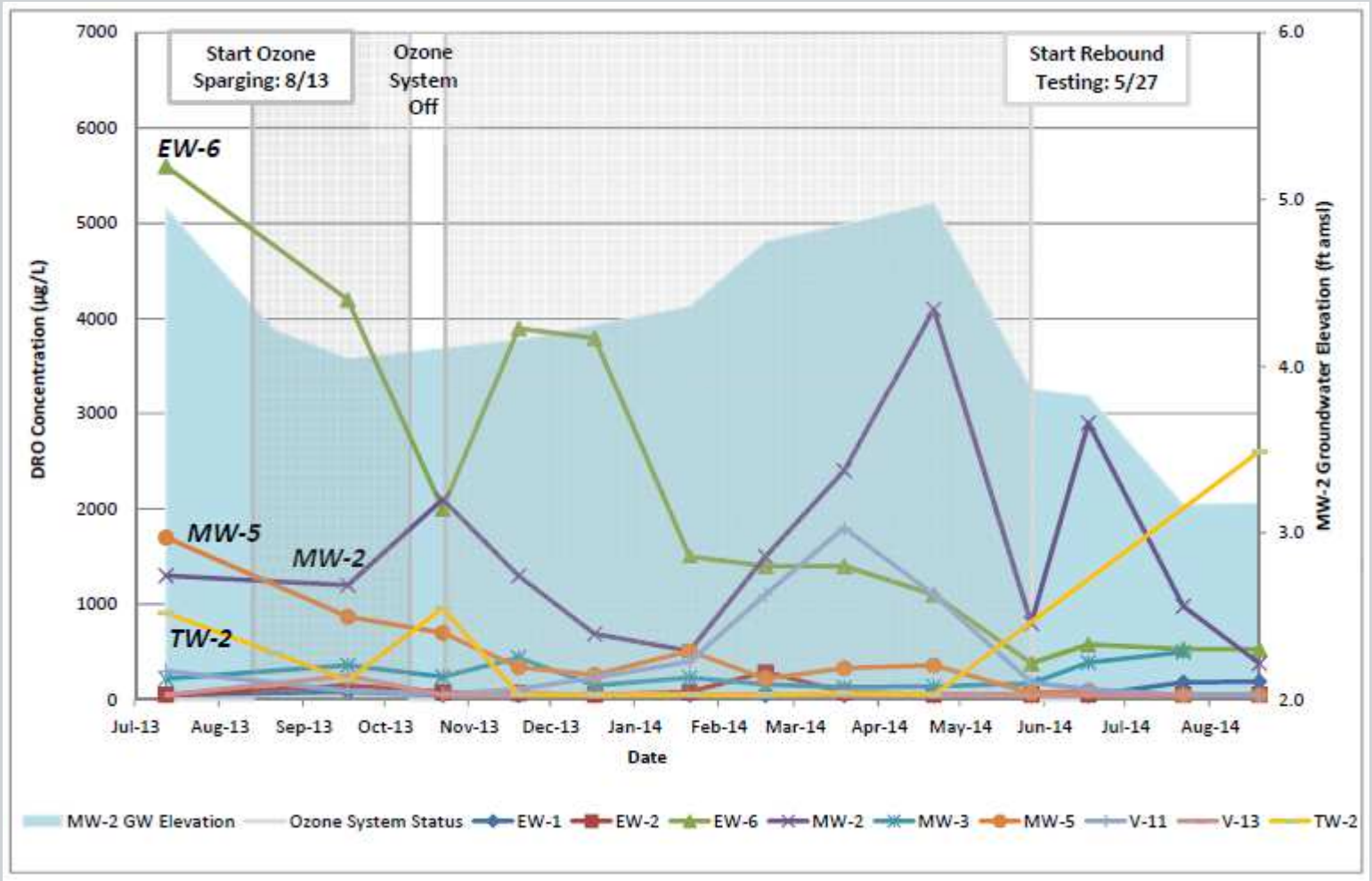
GRO Contour Prior to Remediation



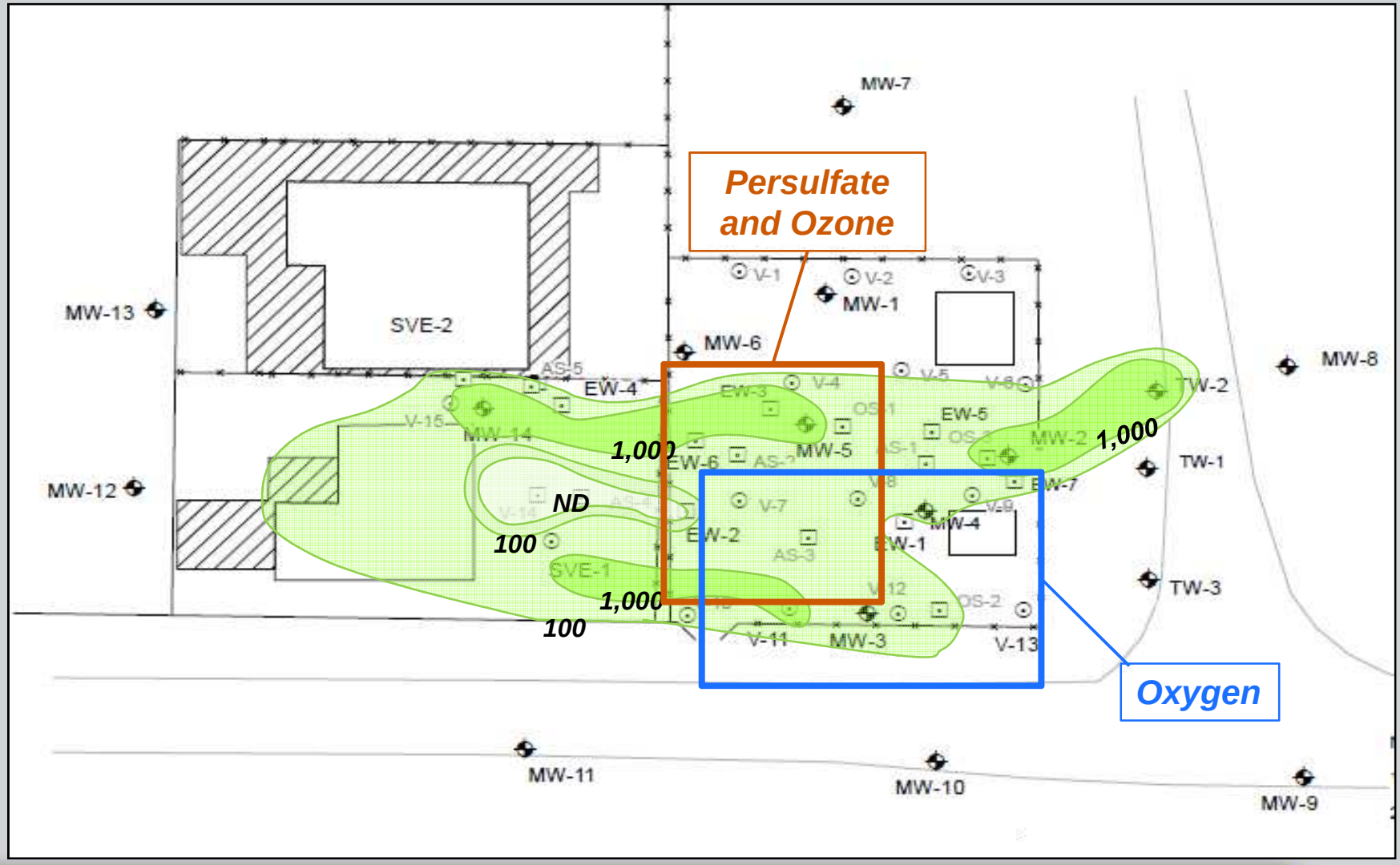
GRO Contour After One Year of Remediation



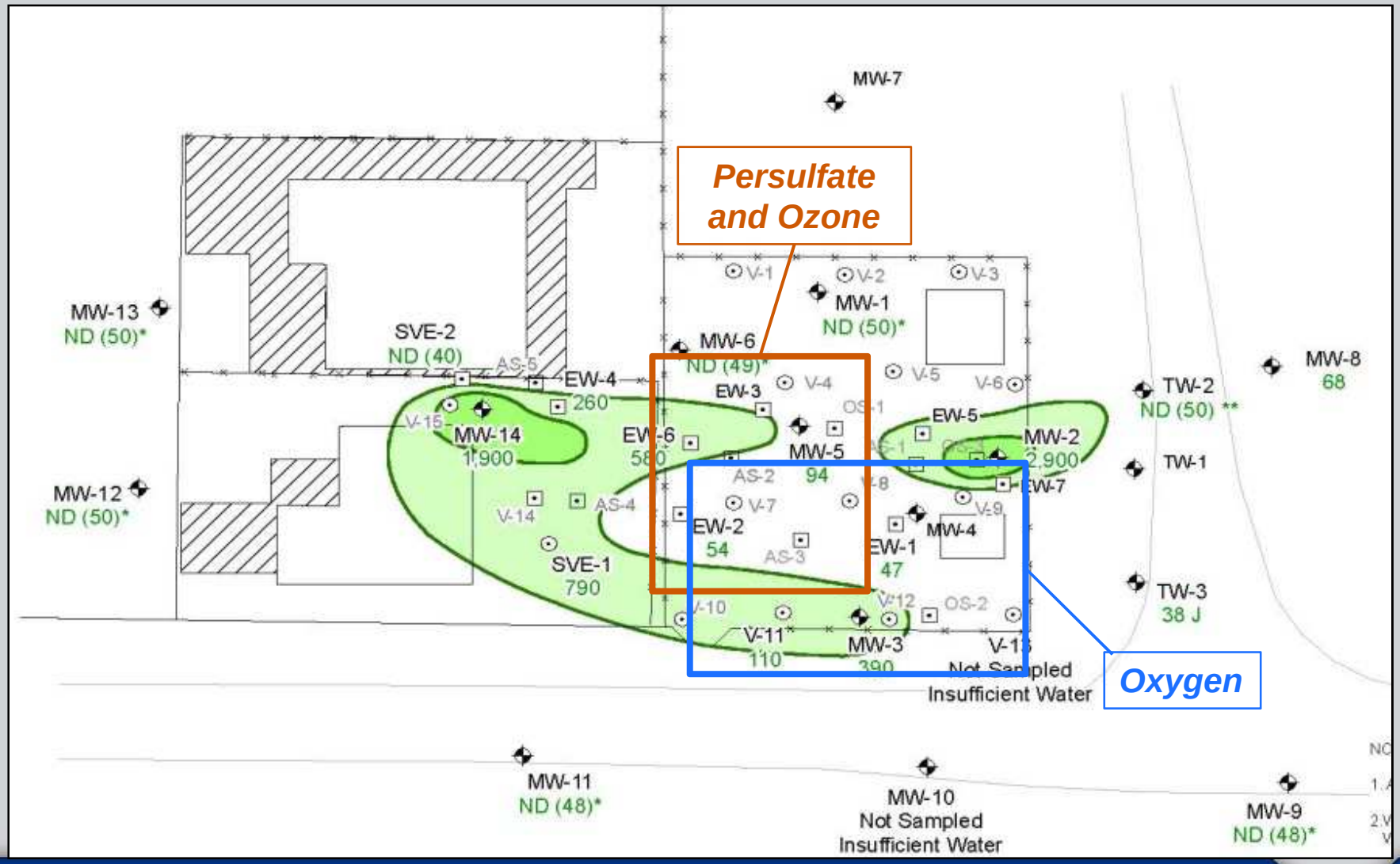
DRO Concentration Trends



DRO Contour Prior to Remediation



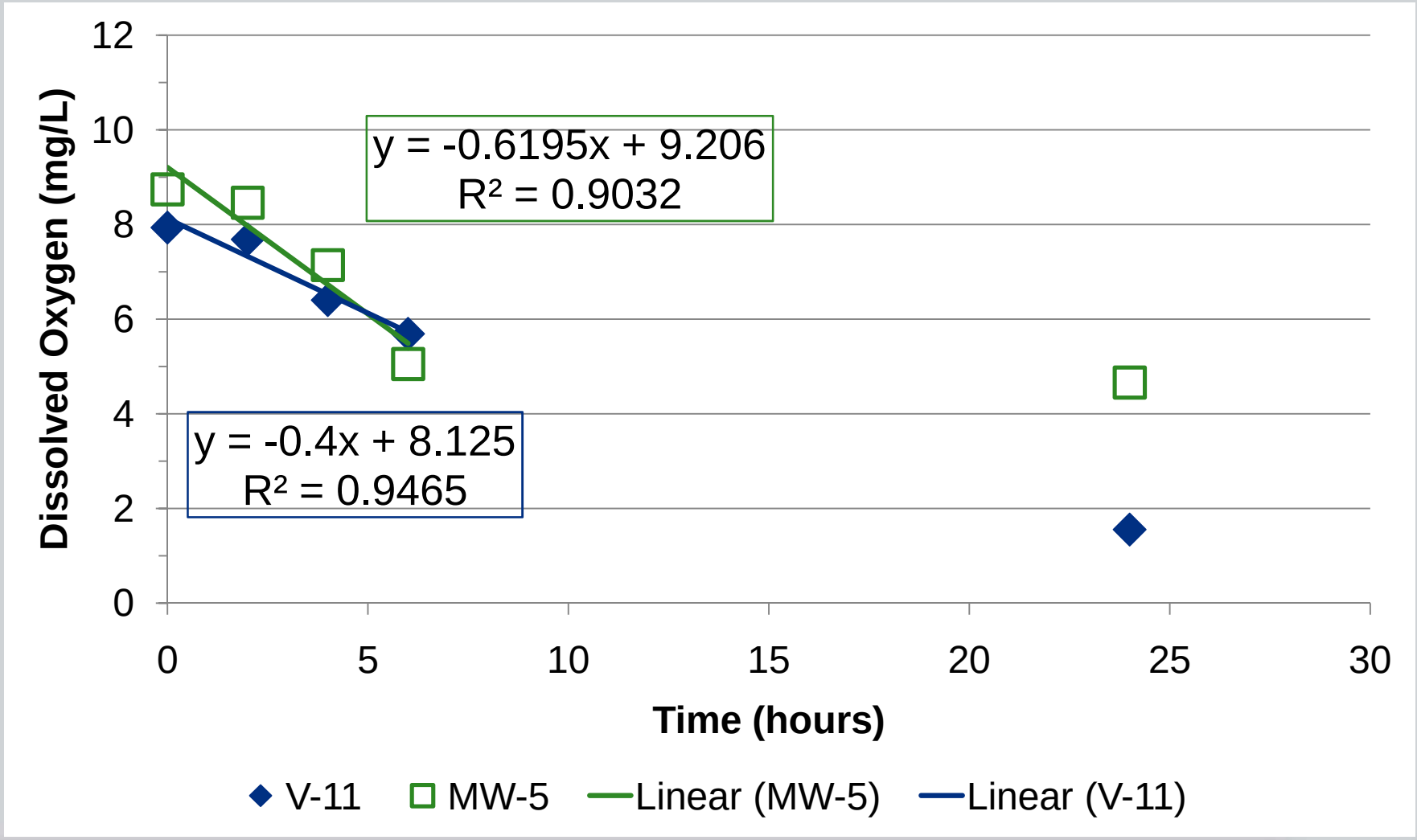
DRO Contour After One Year of Remediation



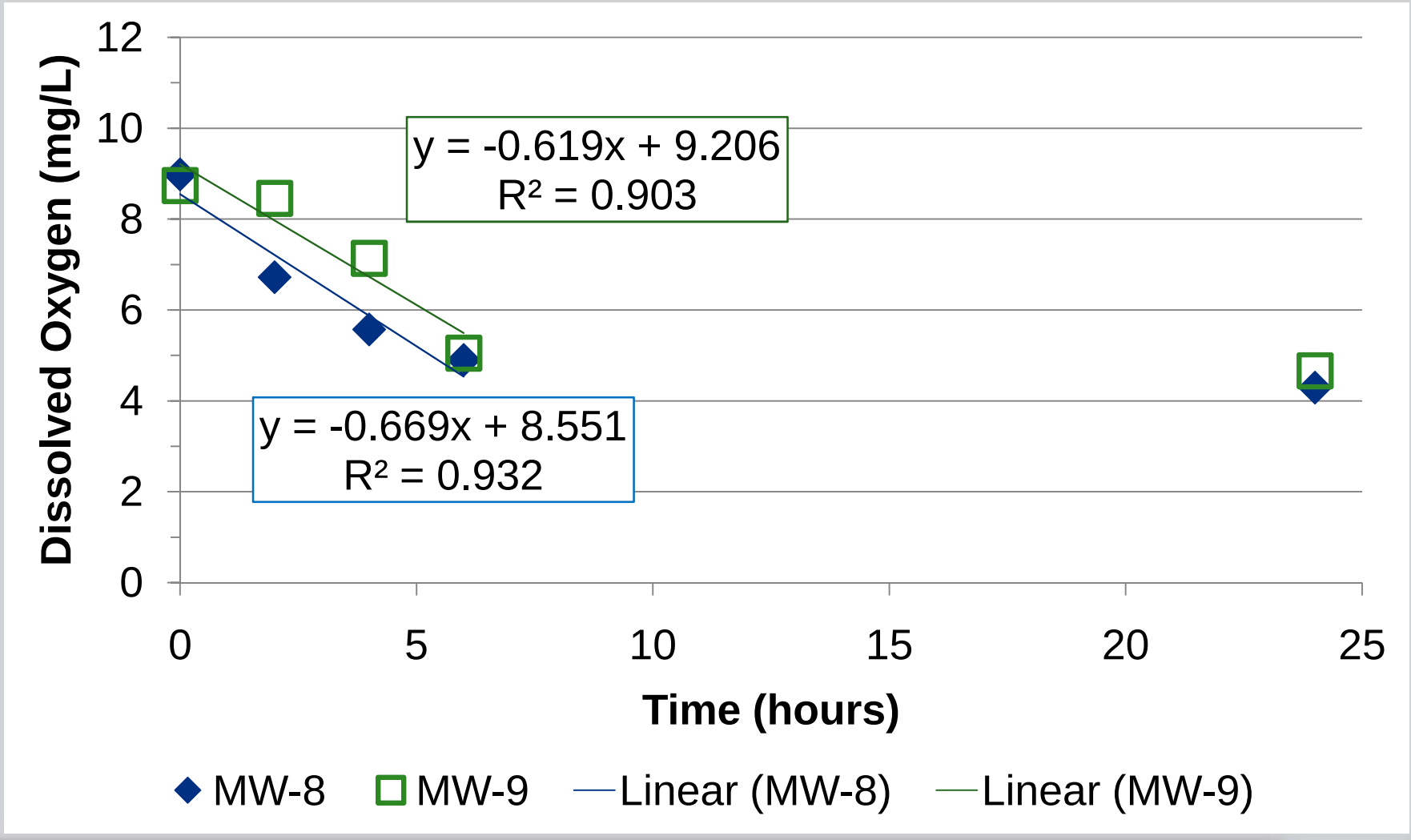
Oxygen Respiration Test

- Conducted oxygen respiration at AS-2 and AS-3
  - Sparged for 24 hours
- Monitored DO at V-11 and MW-5
  - 0, 2, 4, 6, 24 hours
- Determined dissolved oxygen utilization rate (DOUR) by measuring DO decrease over time
- Oxygen Sparging DOUR = 12 mg DO/L/day
- Air Sparging DOUR = 15 mg DO/L/day

Oxygen Sparging Respiration Test Results



Air Sparging Respiration Test Results



Full-Scale Design Based on Pilot Study Test

Parameter	Pilot Study	Full-Scale (Design)	Full-Scale (Actual)
Number of Injection Wells	2 ozone wells	6 ozone wells	4 ozone wells; 2 oxygen wells
Flow Rate per Well	3.5 cfm	6.8 cfm	6.8 cfm
Radius of Influence	20 feet	20 feet	20 feet
Injection Capacity	4 ppd	10 ppd	27 ppd
Injection Pressure	5.5 - 6.0 psi	15 psi	12 - 25 psi
Injection Interval per Well	60 minutes	60 minutes	60 minutes

Conclusions

- GRO and DRO were reduced significantly at ozone treatment wells
- No byproducts (bromate or hexavalent chromium) were detected in transition and compliance wells
- SVE was utilized for VOC offgassing at MW-10
- Dual phase extraction at TW-2 was successful
- Interaction between persulfate and ozone along the western fence boundary may yield better results
- Based on the DOUR, oxygen sparging is similar to air sparging

Questions

- Thank You

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Extra Slides

Site Background - Site Specific Information

- Former natural gas processing station (1960 - 1980s)
- Interbedded layers of sand and silty sand (0 - 30 ft bgs)
- Three hydrostratigraphic layers:
  - **Shallow unconfined zone (15 - 30 ft bgs)**
  - Confining layer (30 – 70 ft bgs)
  - Deep zone (70 – 90 ft bgs)
- Shallow unconfined zone
  - Groundwater velocity: 0.4 ft/day
  - Flow direction: southeast and northeast

ISCO Ozone Pilot Test Site Layout