
IN-SITU ENHANCED BIOREMEDIATION TO REDUCE LARGE TCE/PCE PLUMES AND GOVERNMENT'S LIFECYCLE COSTS

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PERFORMANCE GOAL AND APPROACH

PERFORMANCE GOAL

- ▶ Optimize remedies to reduce government's **life cycle costs**.

APPROACH

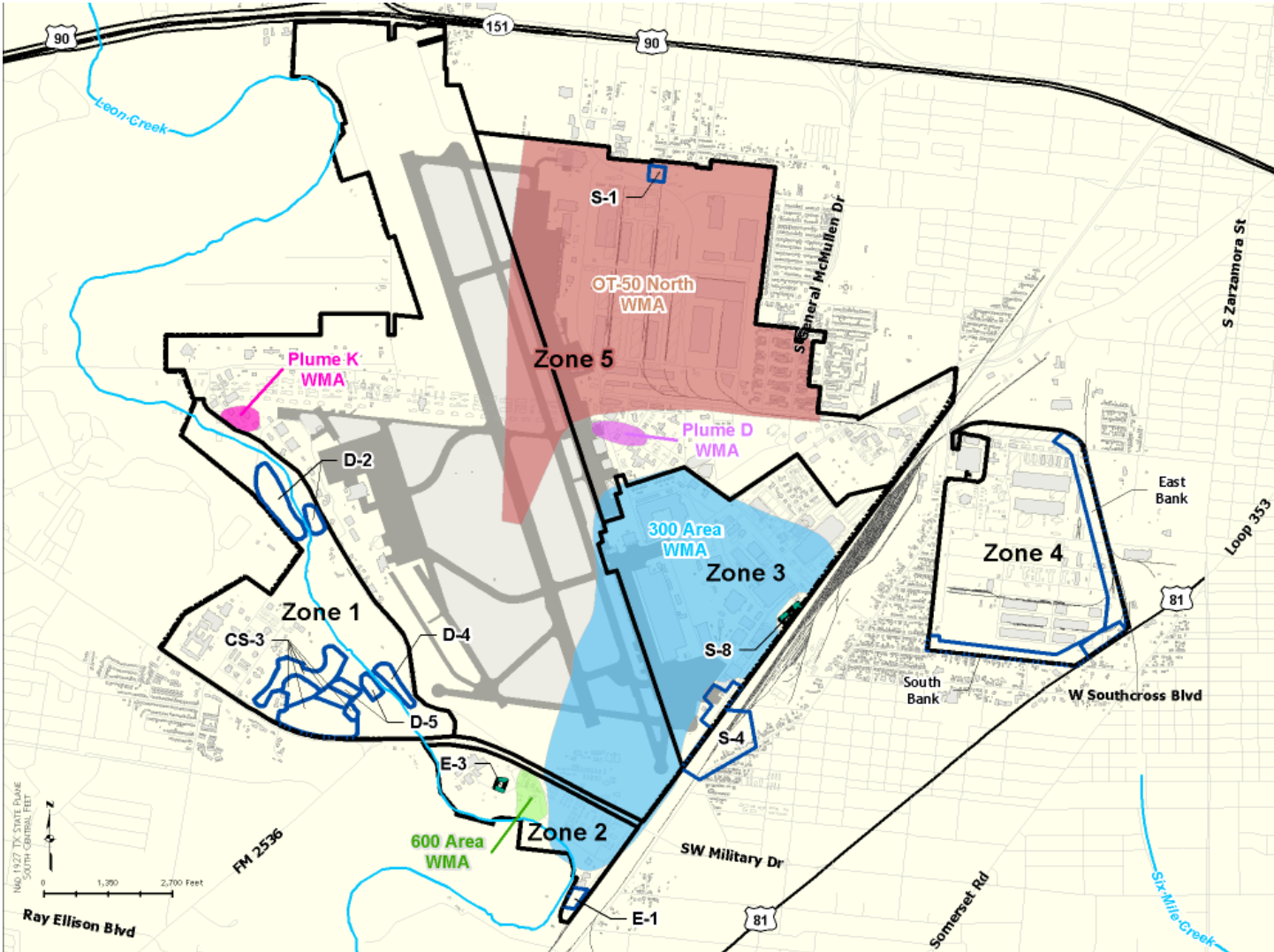
- ▶ In situ enhanced bioremediation (**ISEB**) to reduce plumes footprints.
- ▶ Reduce **groundwater monitoring**.
- ▶ Reduce **O&M** costs.

PRE-ISEB PLUMES

- ▶ At a former Air Force Base, **TCE and PCE plumes** up to 4 miles long were present in 2010.
- ▶ Plumes existed on-base and off-base under a **residential area**.
- ▶ **Multiple sources** existed from historical operations.
- ▶ Various remedies had been installed in the past to **remediate** sources.



INSTALLATION MAP



ZONE 3 GROUNDWATER PLUMES

▶ Three Units

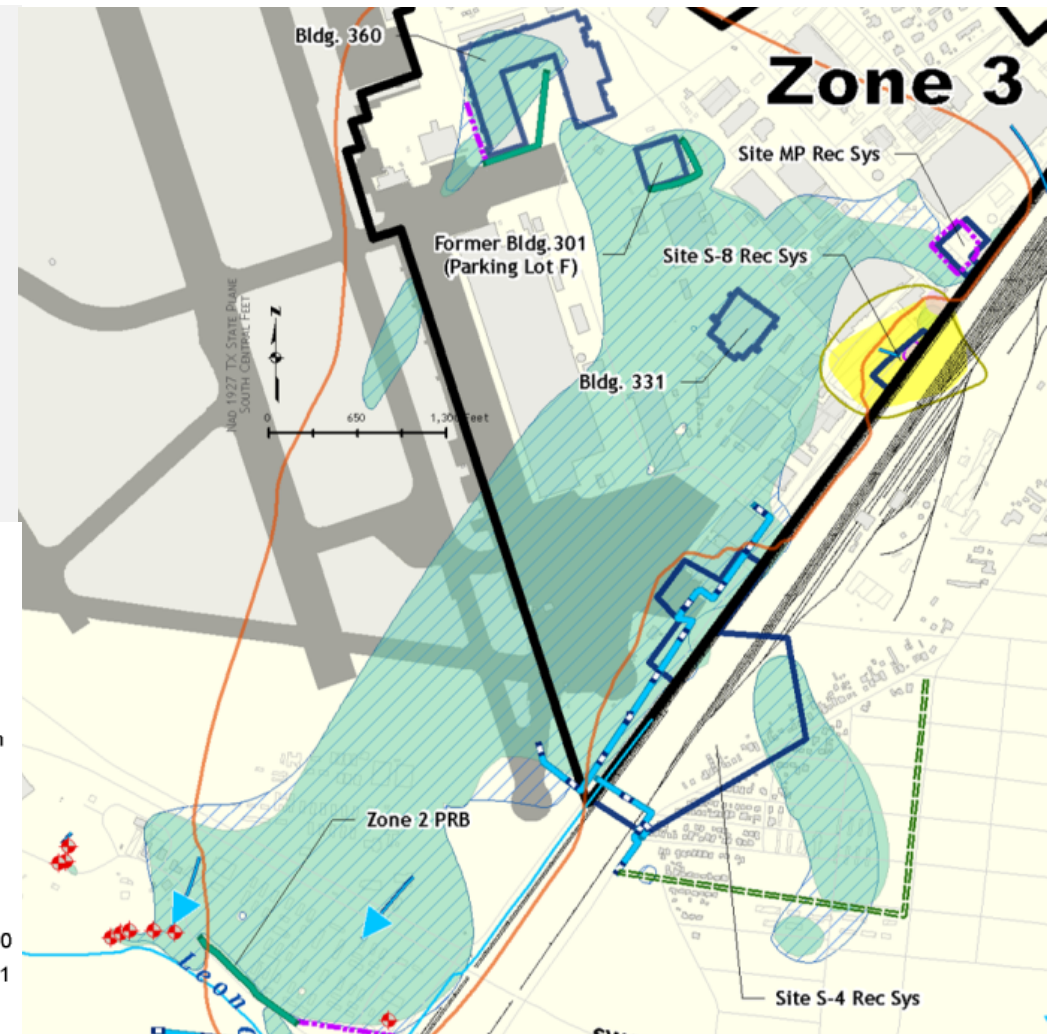
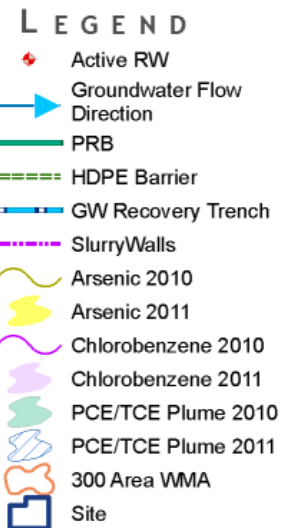
- ▶ 300 Area
- ▶ RCRA Site S-8
- ▶ Site S-4

▶ Remedies Installed

- ▶ Permeable Reactive Barrier (PRB)
- ▶ High-density Polyethylene Barrier
- ▶ Slurry Wall
- ▶ GW Recovery System/P&T
- ▶ ISEB Injections
- ▶ Soil Vapor Extraction (SVE)
- ▶ Electrical Resistance Heating (ERH)

▶ COCs > GWPS

- ▶ Benzene
- ▶ Chlorobenzene
- ▶ PCE
- ▶ TCE
- ▶ DCE
- ▶ Vinyl Chloride
- ▶ Arsenic



ZONE 3 EXISTING REMEDIES

Previous remedies were site-specific and did not address large overall plume.

Site MP

- ▶ Previous Remedy: Slurry Wall, 1999/Recovery System P&T
 - ▶ Soil source material was excavated and emulsified vegetable oil (EVO) applied in 2010
 - ▶ Second in-situ EVO treatment applied inside slurry wall in 2012
 - ▶ Effective at capturing plume at source

Building 360

- ▶ Previous Remedy: PRB 2003/ERH 2008–2009
 - ▶ Contaminants bypassing PRB

Building 331 (300 Area WMA)

- ▶ Previous Remedy: EVO Injection, 2006 and 2009
 - ▶ Concentrations increasing prior to the 2009 reinjection
 - ▶ Concentrations decreasing after the 2009 injections

Zone 2 Permeable Reactive Barriers

- ▶ Previous Remedy: PRB & Slurry Wall, 2004/GW Recovery System/P&T
 - ▶ Effective at mitigating plume migration to the south towards Leon Creek

Site S-4

- ▶ Previous Remedy: GW Recovery System/P&T

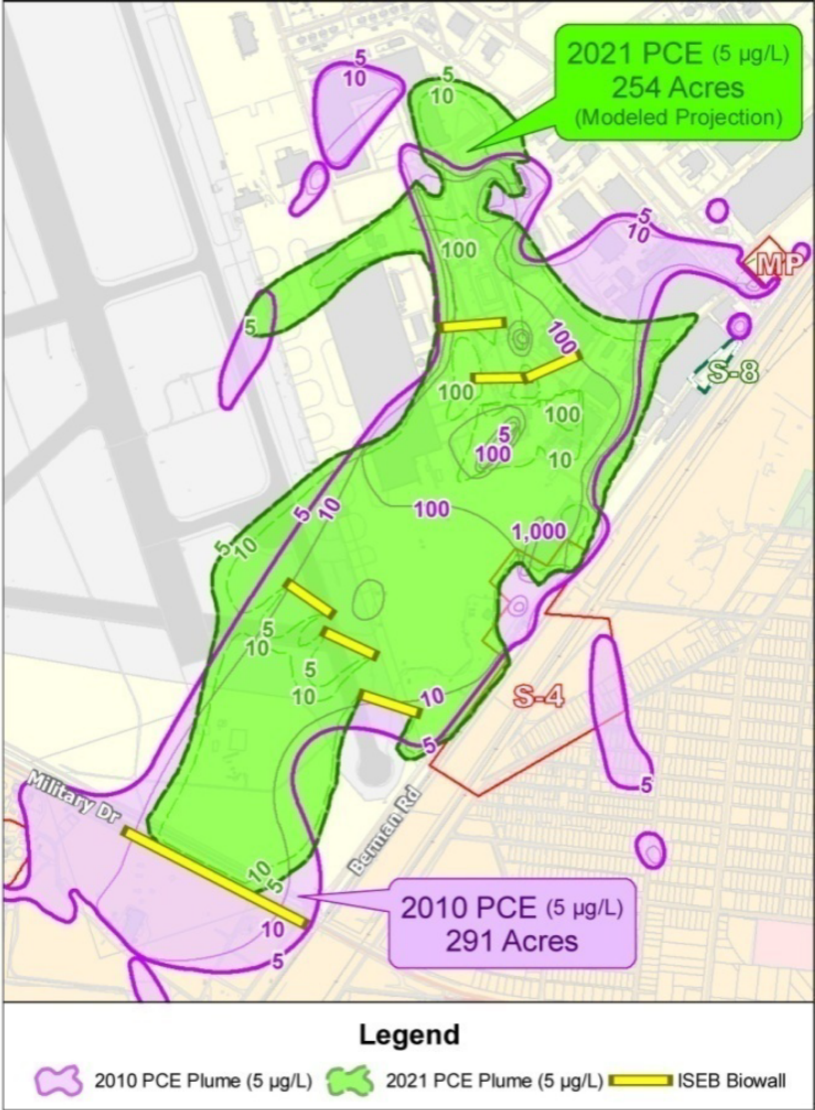
RCRA Site S-8

- ▶ Previous Remedy: GW P&T, SVE, & Bioventing, Optimized 2010
 - ▶ Effective at capturing/treating plume



ZONE 3 PERFORMANCE MODEL

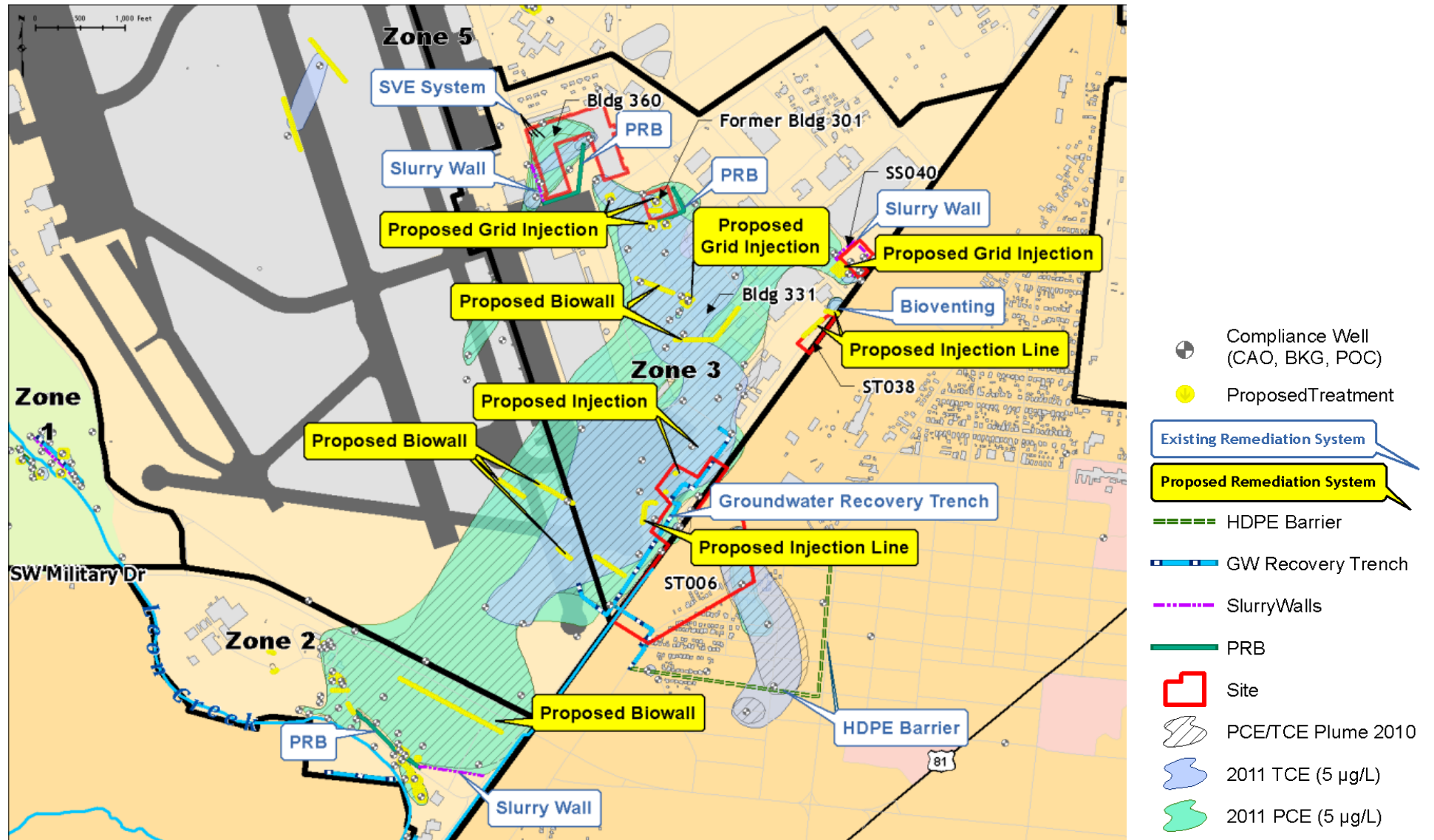
Exhibit 1-50. SS037 Groundwater Plume Reduction Comparison



KELLY_127_1



ZONE 3 PROPOSED REMEDIES

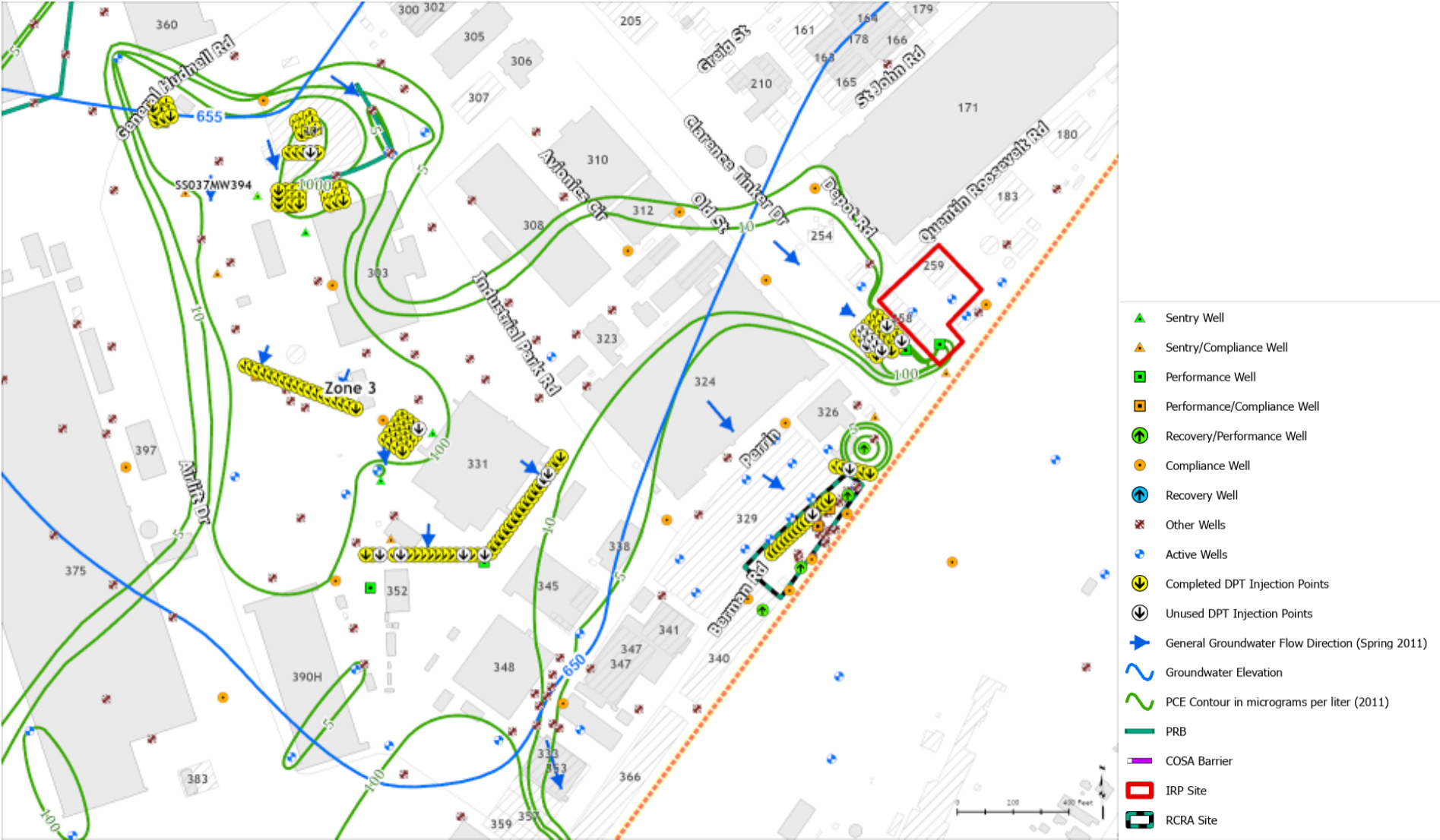


ZONE 3 PERFORMANCE MODEL

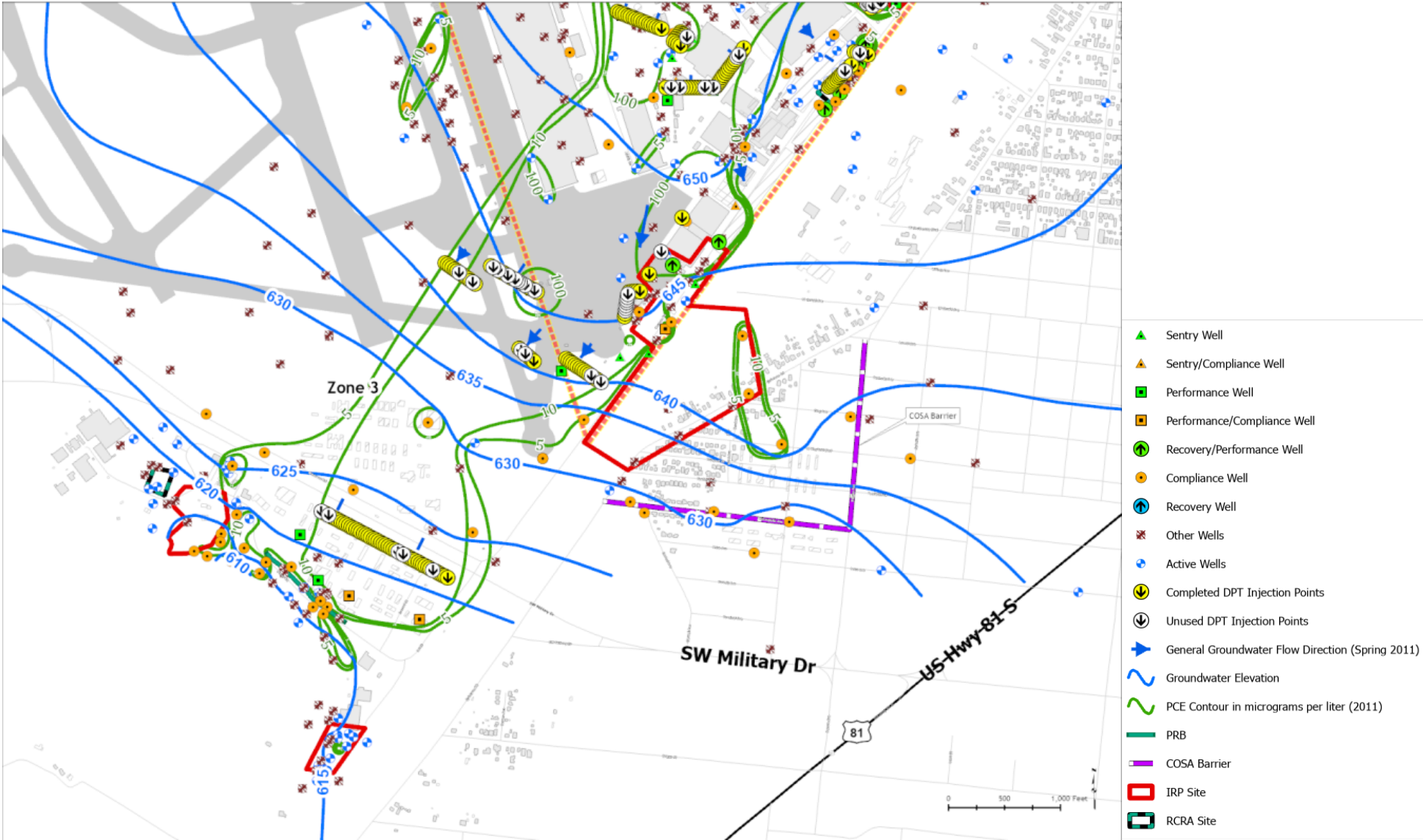
Zone 3 – SS037	
Year	Metric
1	1.5% Reduction in Plume size
2	3% Reduction in Plume size
3	4.5% Reduction in Plume size
4	6% Reduction in Plume size
5	7.5% Reduction in Plume size
6	9% Reduction in Plume size
7	10.5% Reduction in Plume size
8	12% Reduction in Plume size
9	13.5% Reduction in Plume size
10	15% Reduction in Plume size



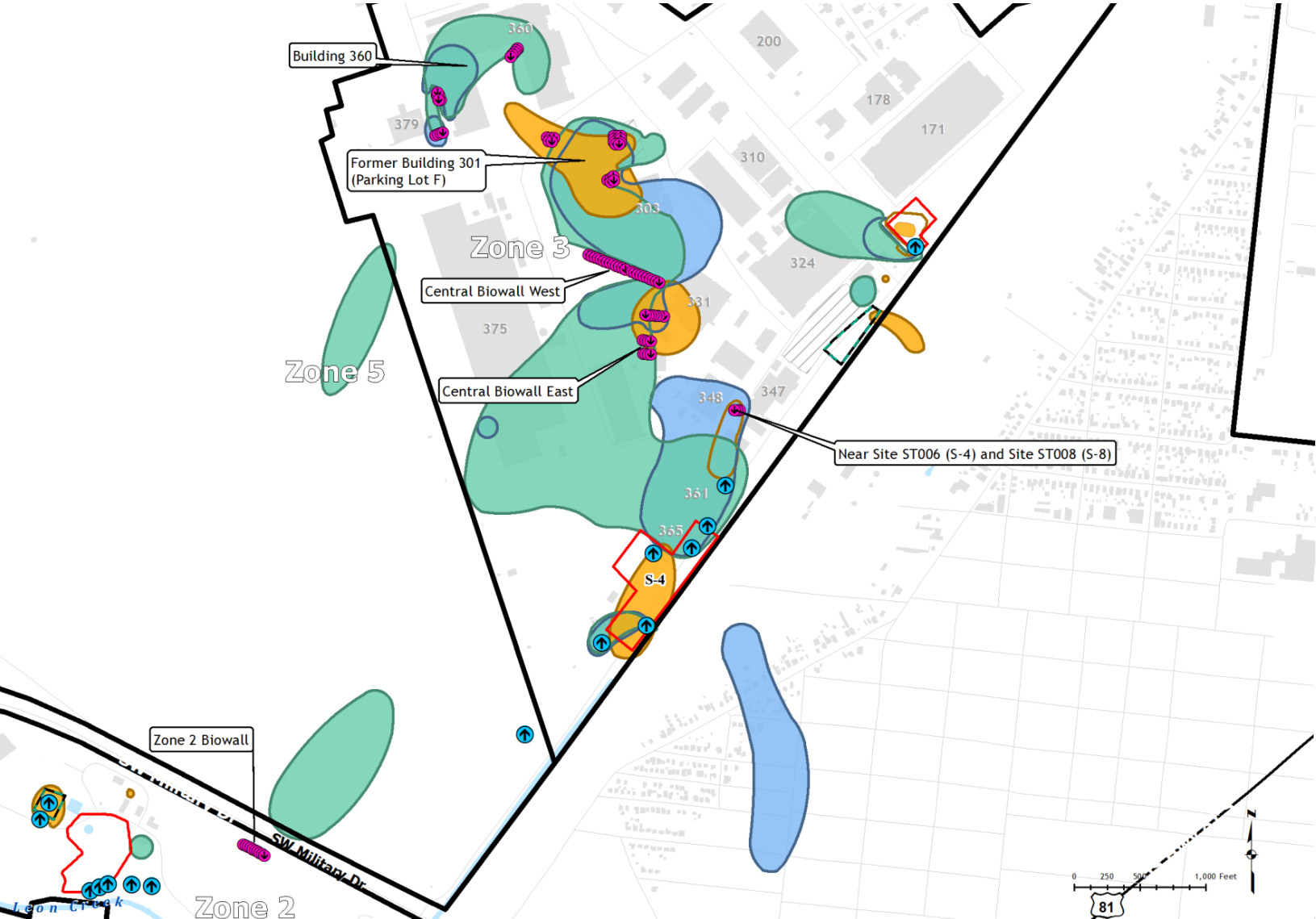
ZONE 3 ISEB APPROACH



ZONE 3 ISEB APPROACH



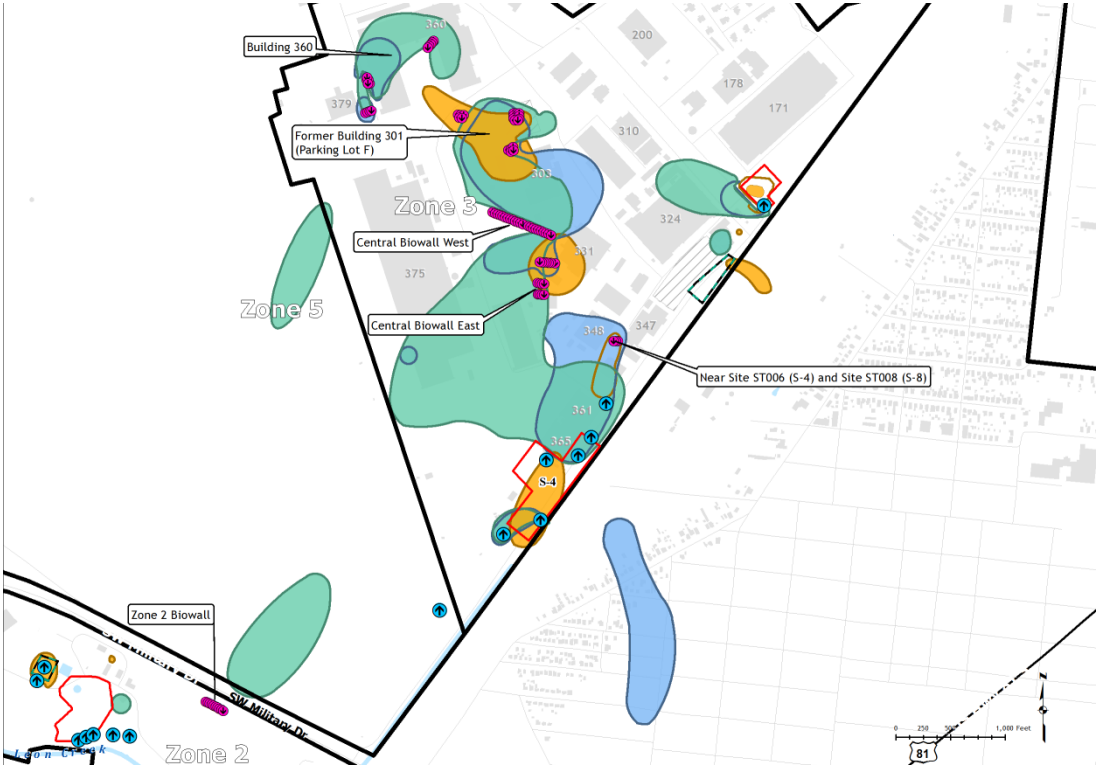
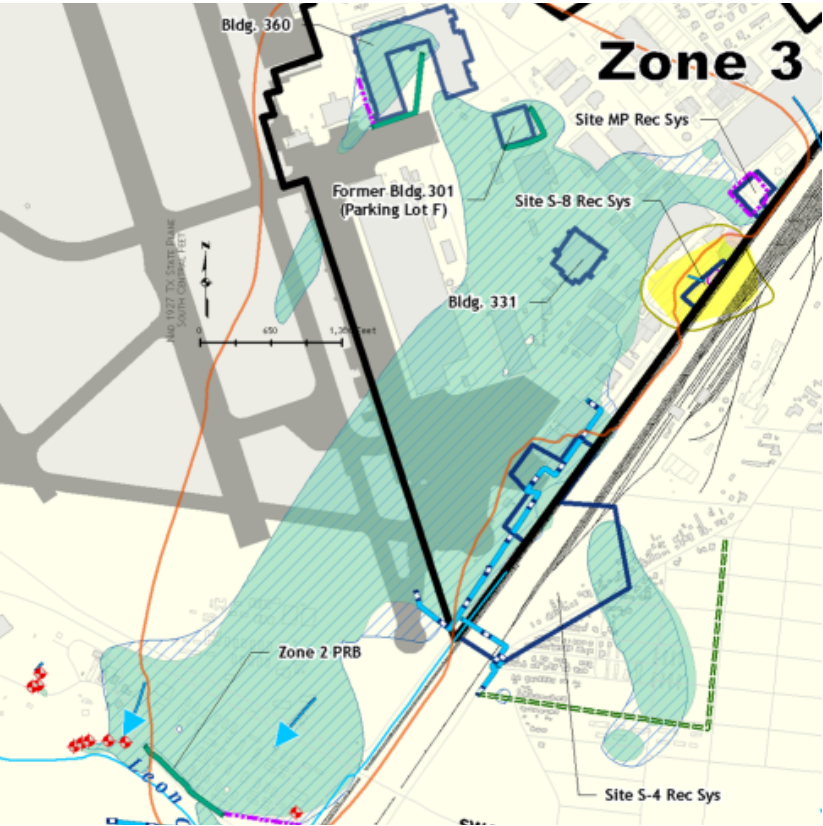
ZONE 3 POST-ISEB PLUMES



- ISEB Injection Location (2020)
- Recovery Well
- 2019 PCE (5 µg/L)
- 2019 TCE (5 µg/L)
- 2019 VC (2 µg/L)
- IRP Site
- RCRA Site
- Zone 3



ZONE 3 POST-ISEB PLUMES



ZONE 4 GROUNDWATER PLUMES

One Unit

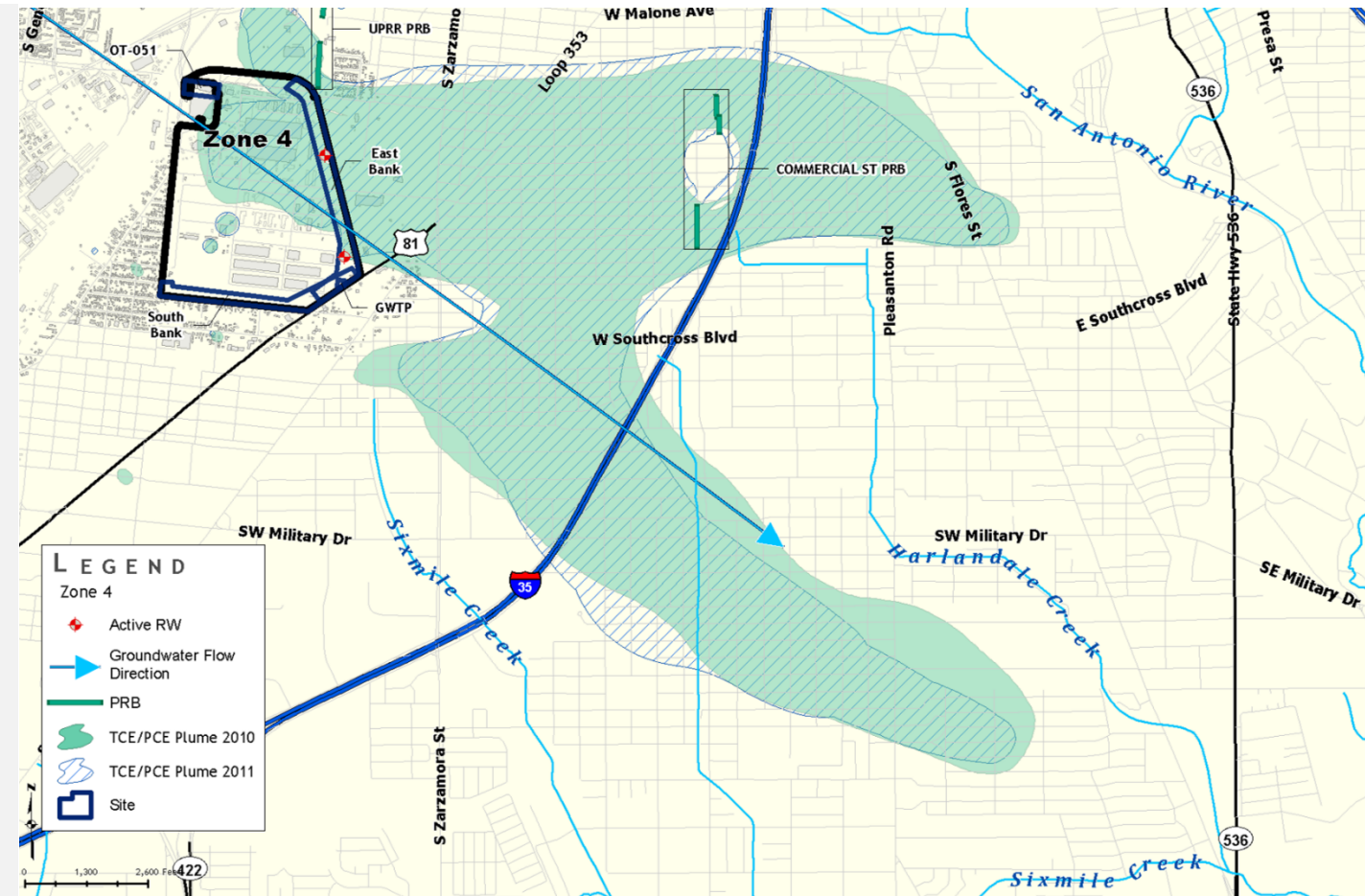
- ▶ East Kelly WMA

COCs > GWPS

- ▶ PCE
- ▶ TCE
- ▶ 1,2-DCE
- ▶ Vinyl Chloride

Remedies Installed

- ▶ PRB
- ▶ Recovery Systems/P&T
- ▶ Groundwater Treatment Plant



ZONE 4 EXISTING REMEDIES

Site OT-051

- ▶ Previous Remedy: EVO Injections, October 2002
 - ▶ Natural degradation was occurring

East and South Bank

- ▶ Previous Remedy: Recovery System/P&T
 - ▶ Effective at capturing plume

Union Pacific Railroad PRB

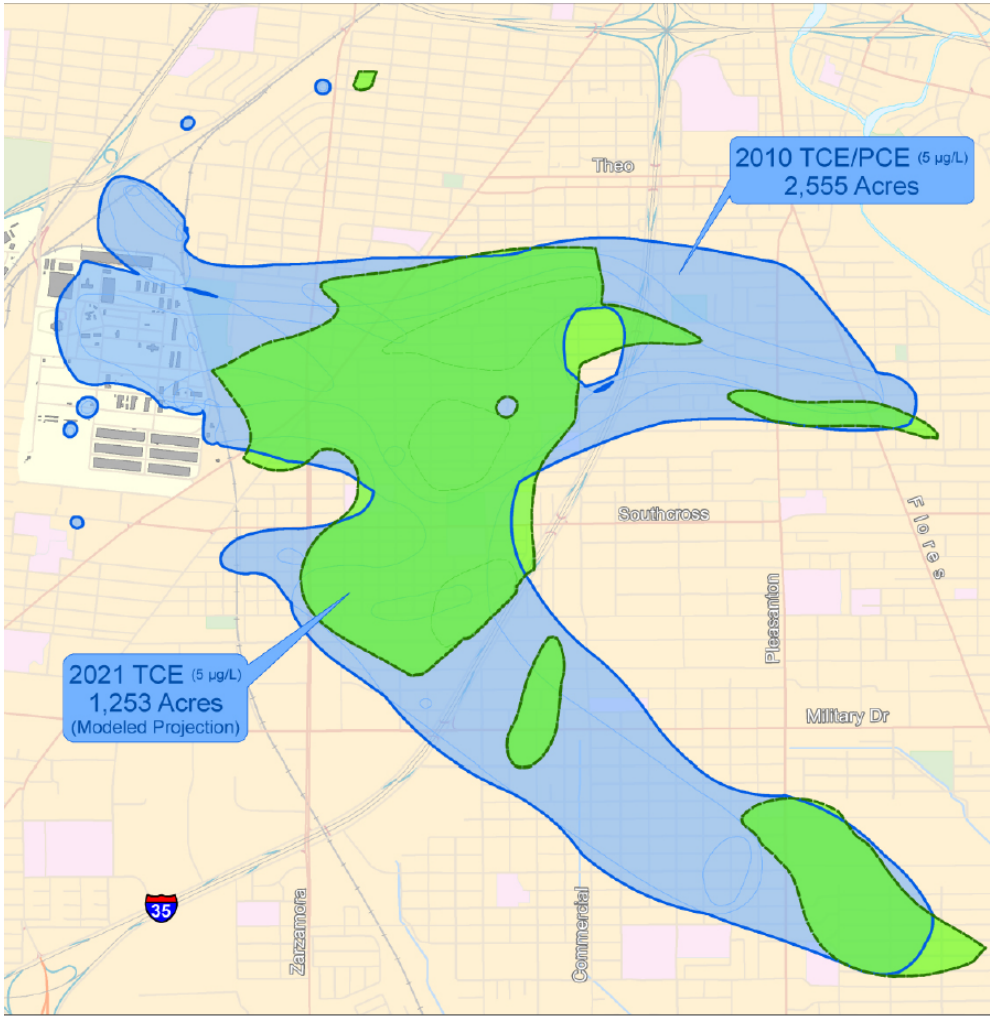
- ▶ Previous Remedy: PRB
 - ▶ Effective at treating plume

Commercial Street PRB

- ▶ Previous Remedy: PRB
 - ▶ Effective at treating plume
 - ▶ Plume may be flowing over a portion of the wall



ZONE 4 PERFORMANCE MODEL



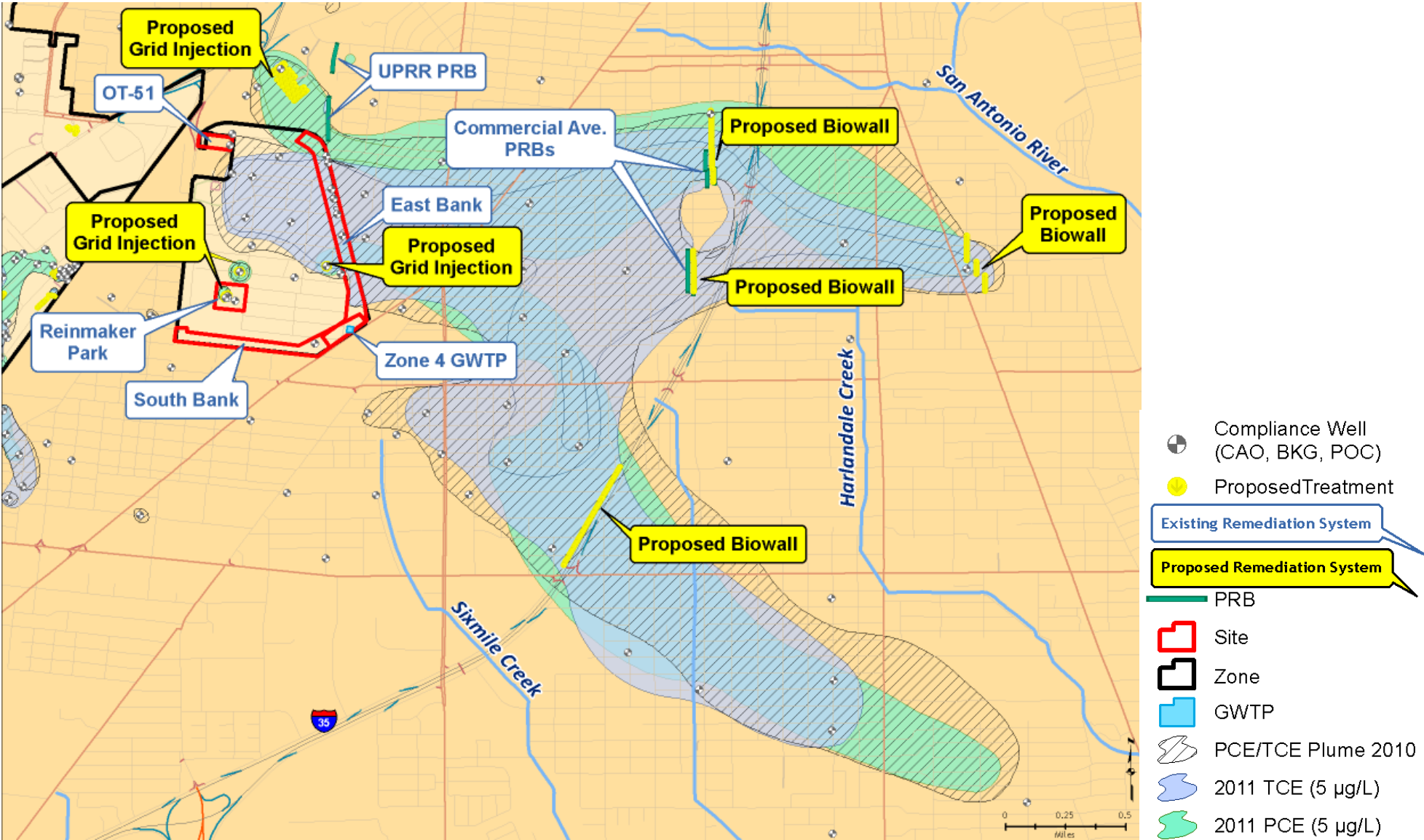
Legend

-  2021 TCE Plume (5 µg/L) (Modeled Projection)
-  2010 TCE/PCE Combined Plume (5 µg/L)

RELEV_115.1
Exhibit 1-65. Model Results for TCE/PCE Plume in 2021 for Zone 4



ZONE 4 PROPOSED REMEDIATION

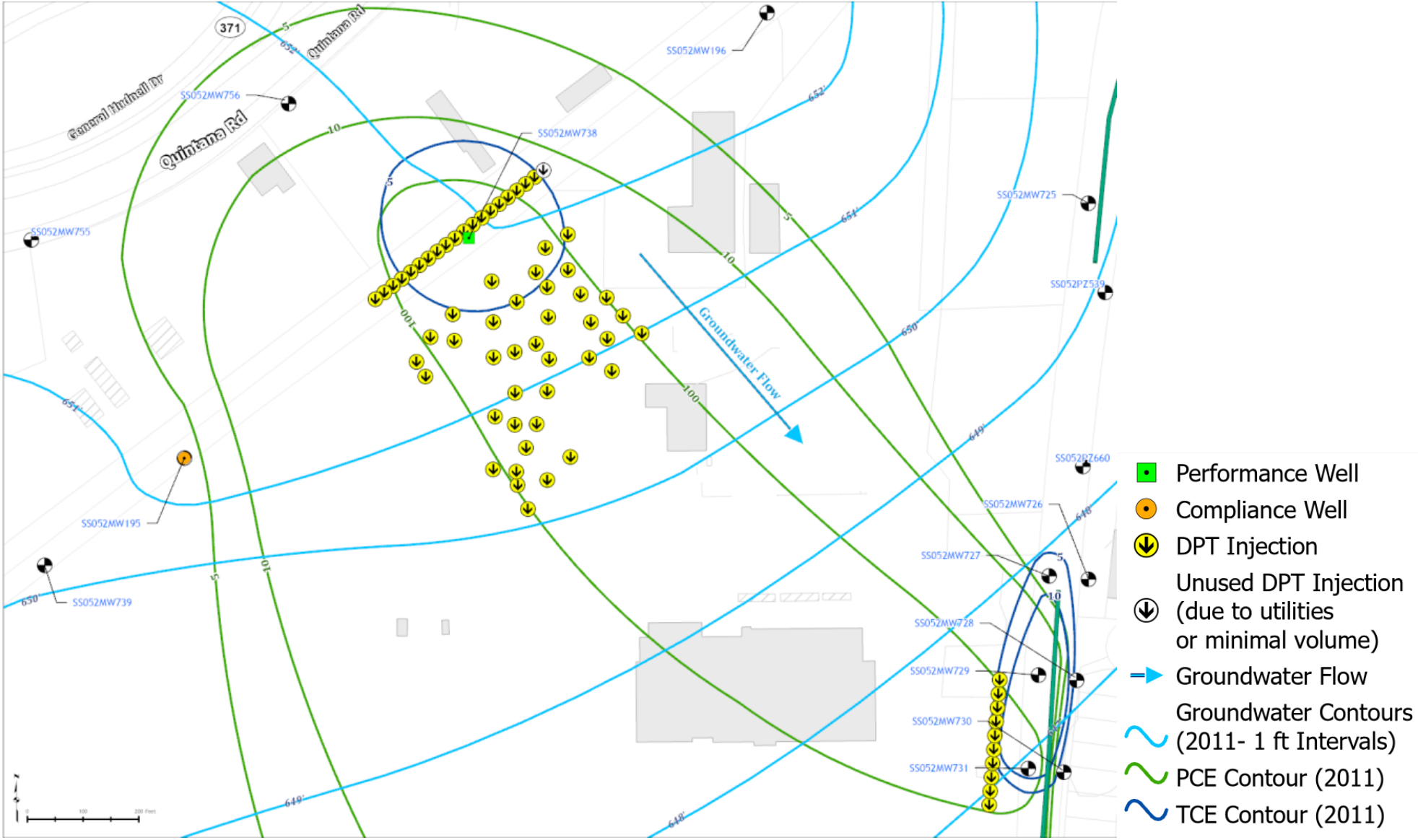


ZONE 4 PERFORMANCE MODEL

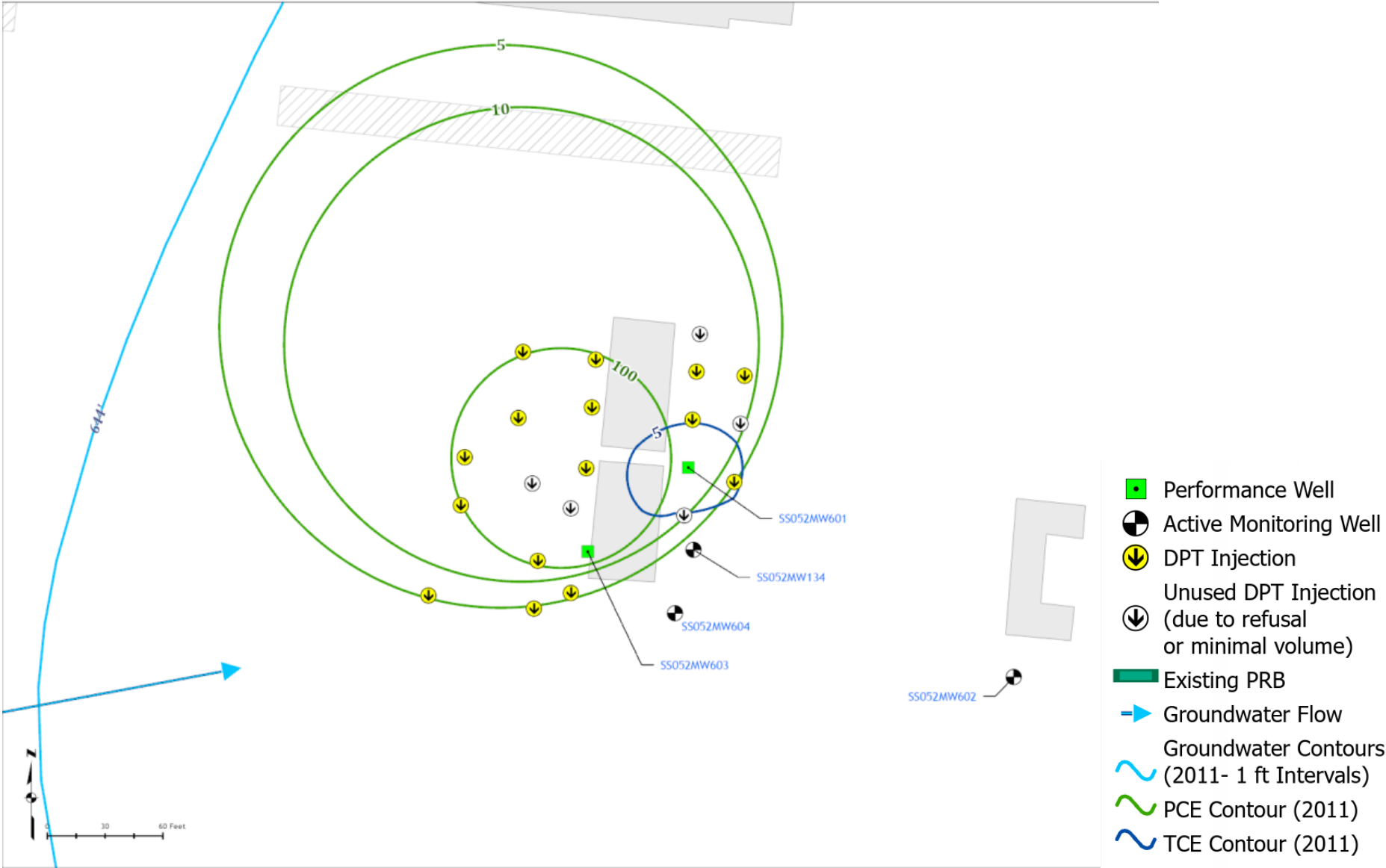
Year	Metric
1	5% Reduction in Plume size
2	11% Reduction in Plume size
3	16% Reduction in Plume size
4	22% Reduction in Plume size
5	25% Reduction in Plume size
6	30% Reduction in Plume size
7	35% Reduction in Plume size
8	40% Reduction in Plume size
9	45% Reduction in Plume size
10	49% Reduction in Plume size



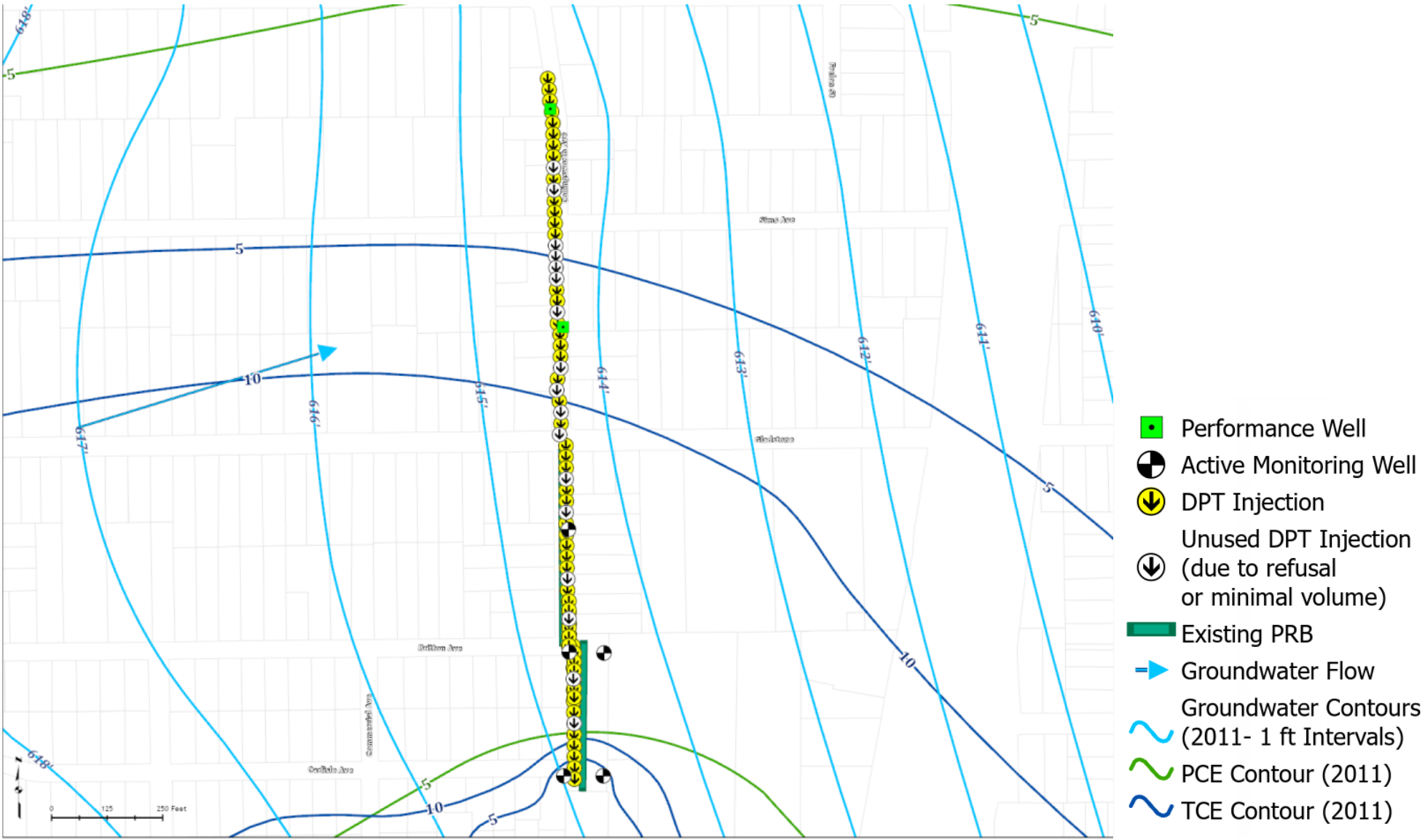
ZONE 4 PROPOSED REMEDIATION



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ZONE 4 PROPOSED REMEDIATION



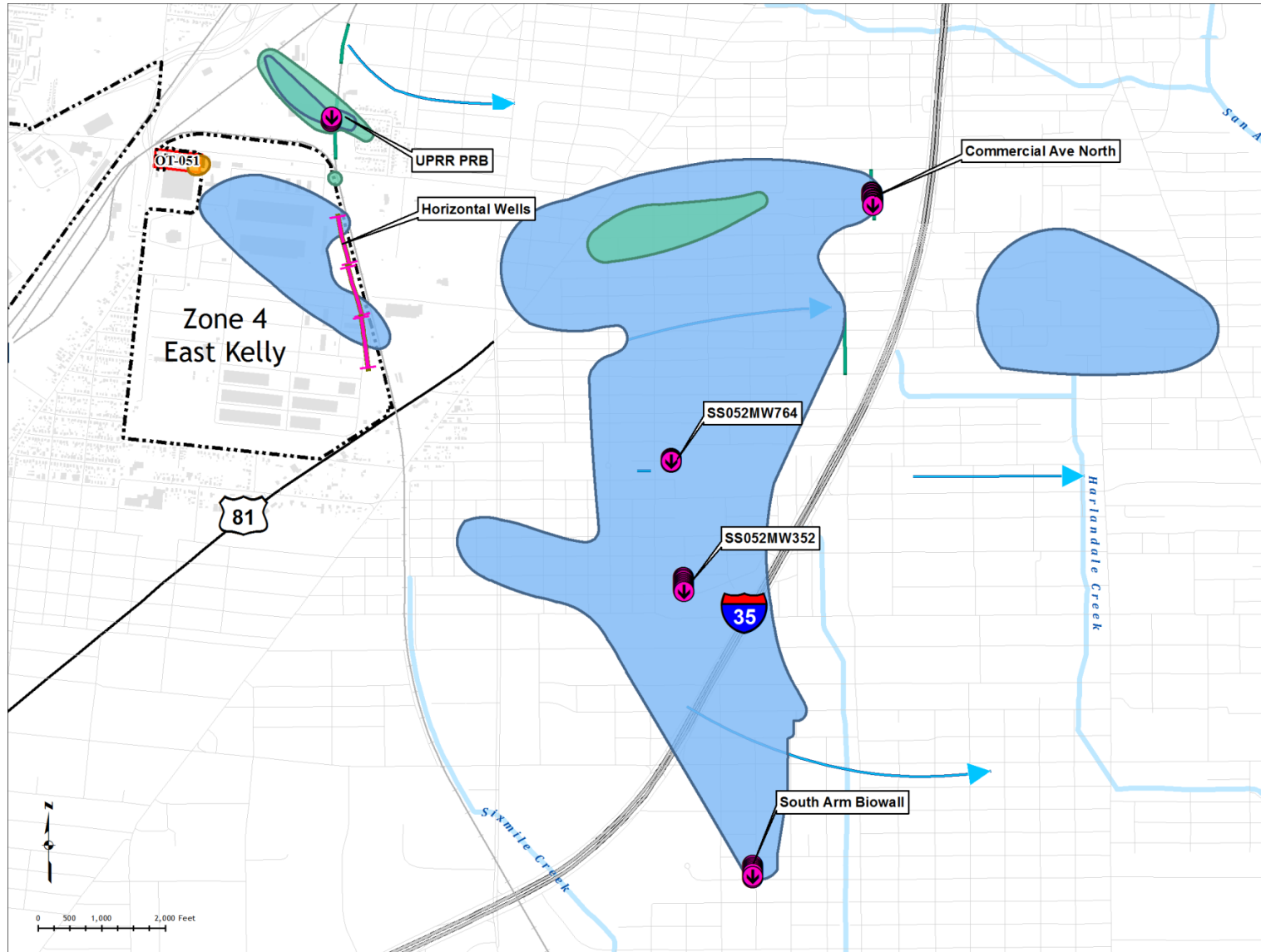
- Performance Well
- Active Monitoring Well
- DPT Injection
- Unused DPT Injection (due to refusal or minimal volume)
- Existing PRB
- ➔ Groundwater Flow
- ~ Groundwater Contours (2011- 1 ft Intervals)
- ~ PCE Contour (2011)
- ~ TCE Contour (2011)



ZONE 4 PROPOSED REMEDIATION



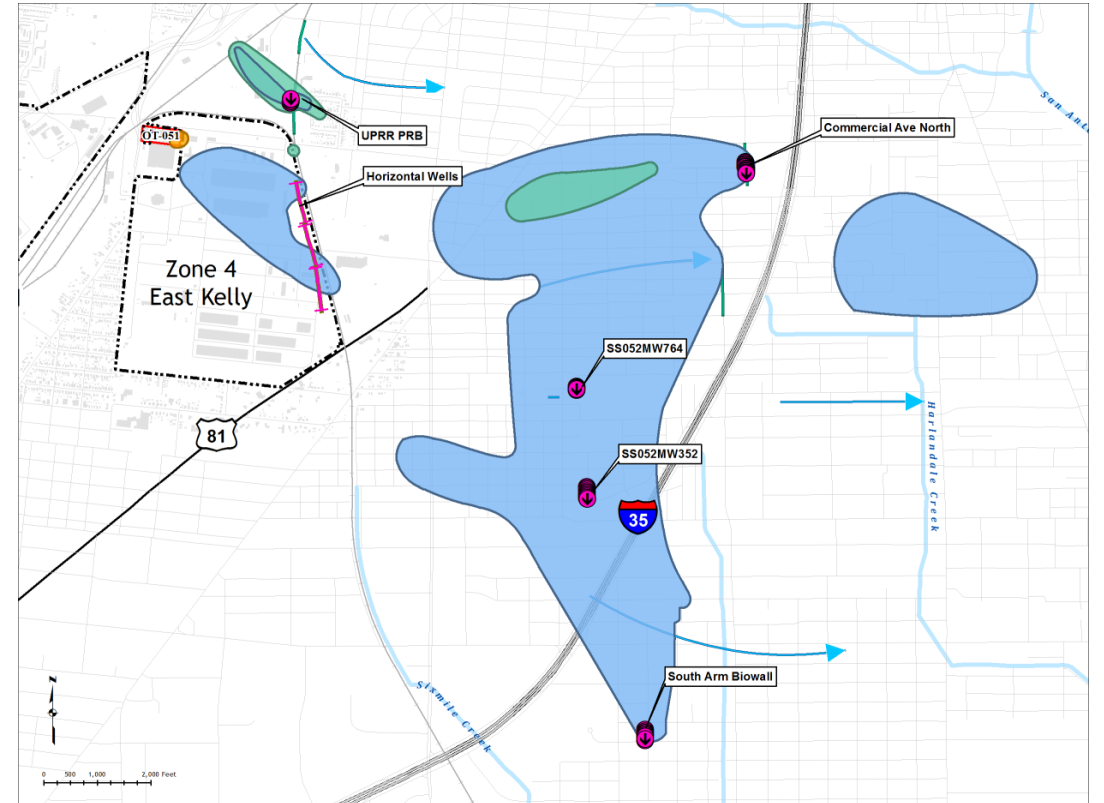
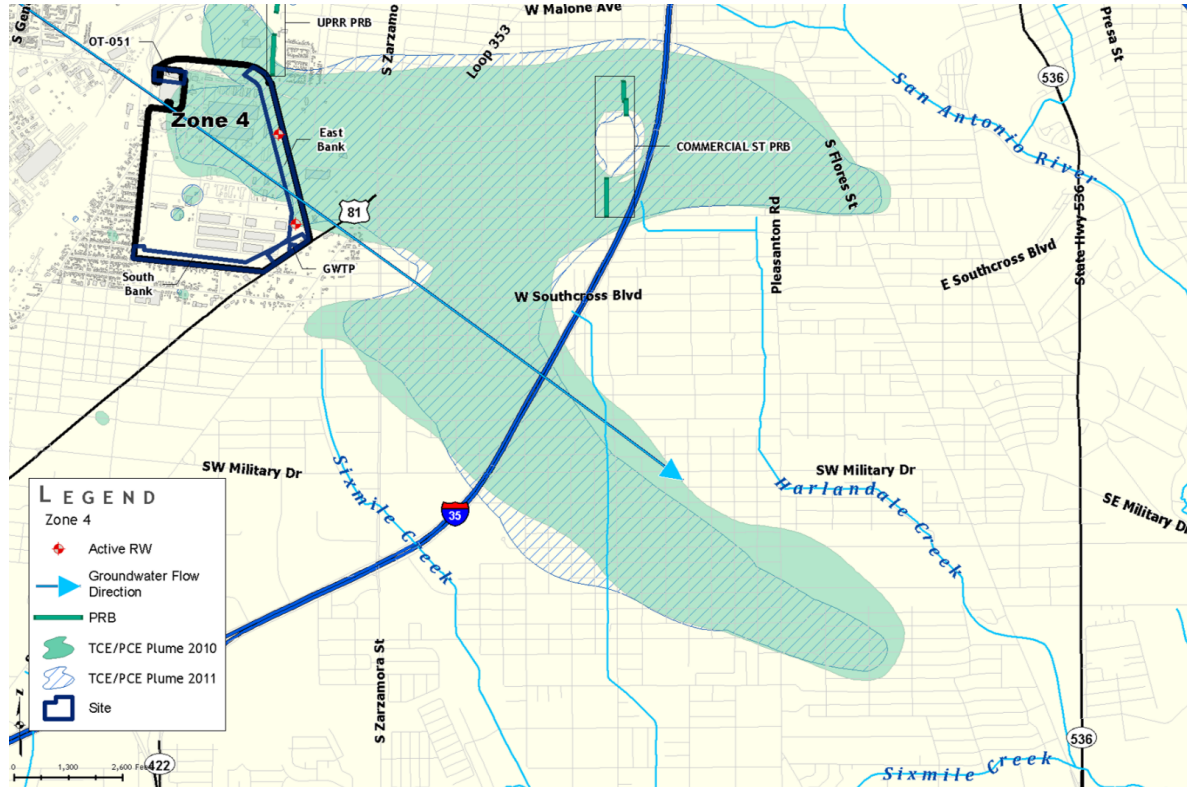
ZONE 4 POST-ISEB PLUME



- ISEB Injection Location (2020)
- 2020 Injection via Horizontal Well Screen
- 2019 PCE (5 µg/L)
- 2019 TCE (5 µg/L)
- 2019 VC (2 µg/L)
- Groundwater Flow Direction (2019)
- Permeable Reactive Barrier (PRB)
- Railroads
- Installation Restoration Program Site (IRP)
- Stream
- Buildings
- Former Base Boundary



ZONE 4 POST-ISEB PLUME



CHANGE IN REMEDY

Change in Remedy

- ▶ Petitioned regulators to change remedy from **P&T to MNA**.
- ▶ RCRA Permit Modification.

Groundwater Treatment Plant

- ▶ Decommissioned and dismantled GWTP.
- ▶ Reduction in O&M costs.



ZONE 4 POST-ISEB PLUME



ZONE 4 POST-ISEB PLUME



SUMMARY AND CONCLUSIONS

- ▶ Zone 3 plume reduction between 2010 and 2019 was **23% (target 12%)**.
- ▶ Zone 4 plume reduction between 2010 and 2019 was **57% (target 40%)**.
- ▶ Groundwater monitoring was reduced from over 228 wells to **130 wells**.
- ▶ Wells not being sampled were **abandoned**.
- ▶ Zone 4 Groundwater Treatment Plant was **decommissioned and dismantled**.
- ▶ Reduced government's lifecycle costs by **reducing sampling and O&M costs**.



QUESTIONS

Thank you to our co-authors:

- ▶ William Foss, APTIM, Houston, TX
- ▶ Robert Mayer, APTIM, Knoxville, TN

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Expect the Extraordinary.