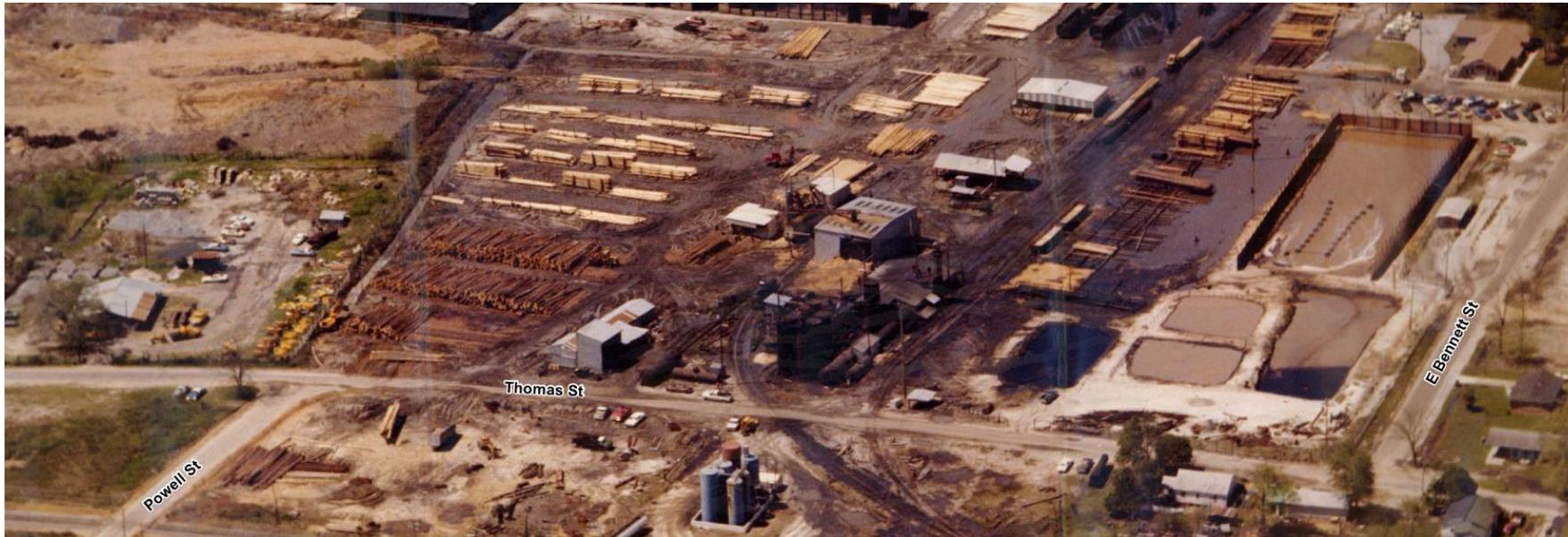


# Design and Implementation of In Situ Groundwater Remedy for SVOCs in a Karst Limestone Aquifer



Presented by Carrie McCoy, PE – Black & Veatch

With Support From:

Scott Miller, PE, USEPA Region 4

Shanna Thompson, PE, Geosyntec Consultants

Ed Hicks, PE, Black & Veatch

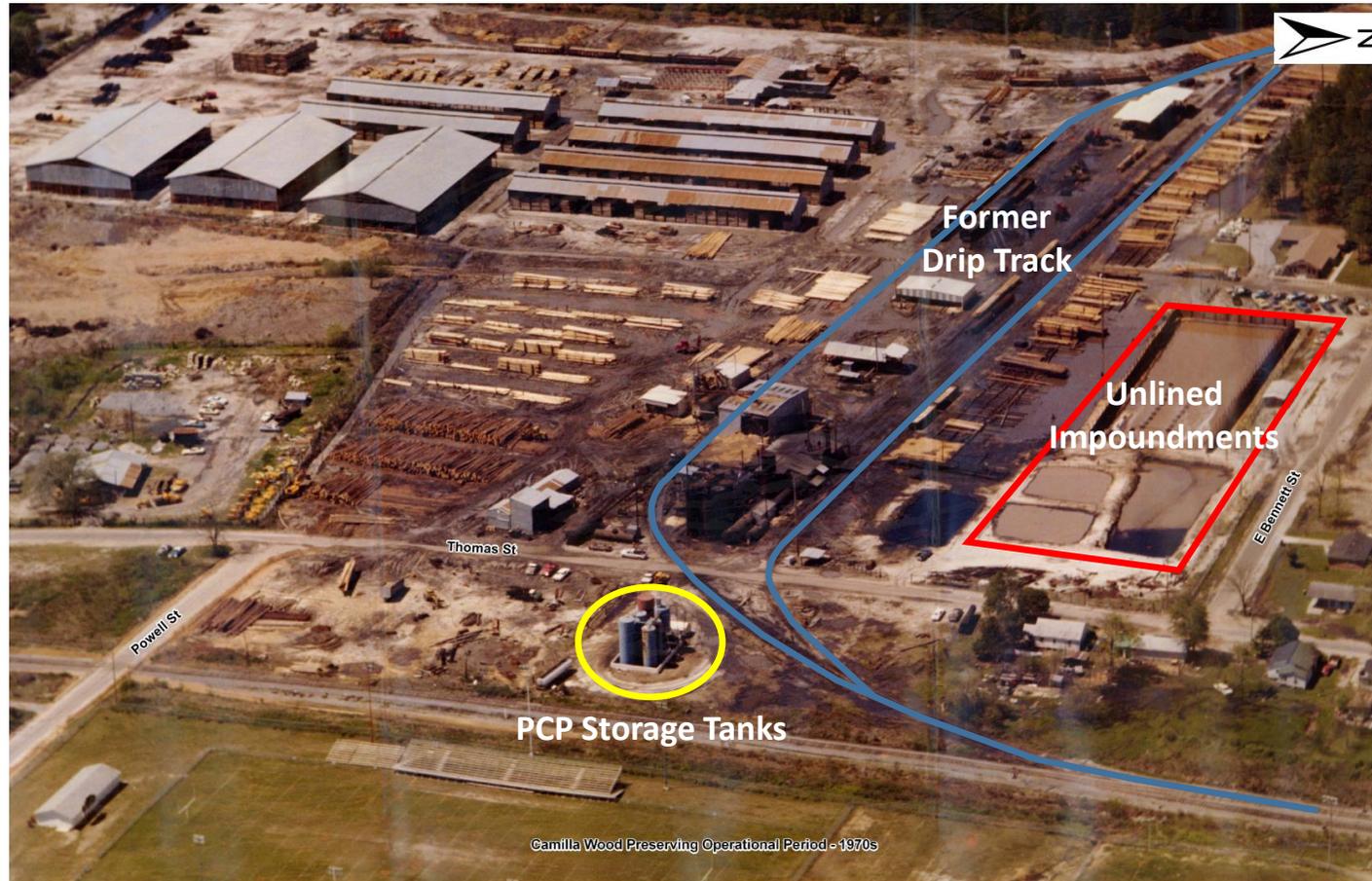
Joe Ivanowski, RG, Geosyntec Consultants



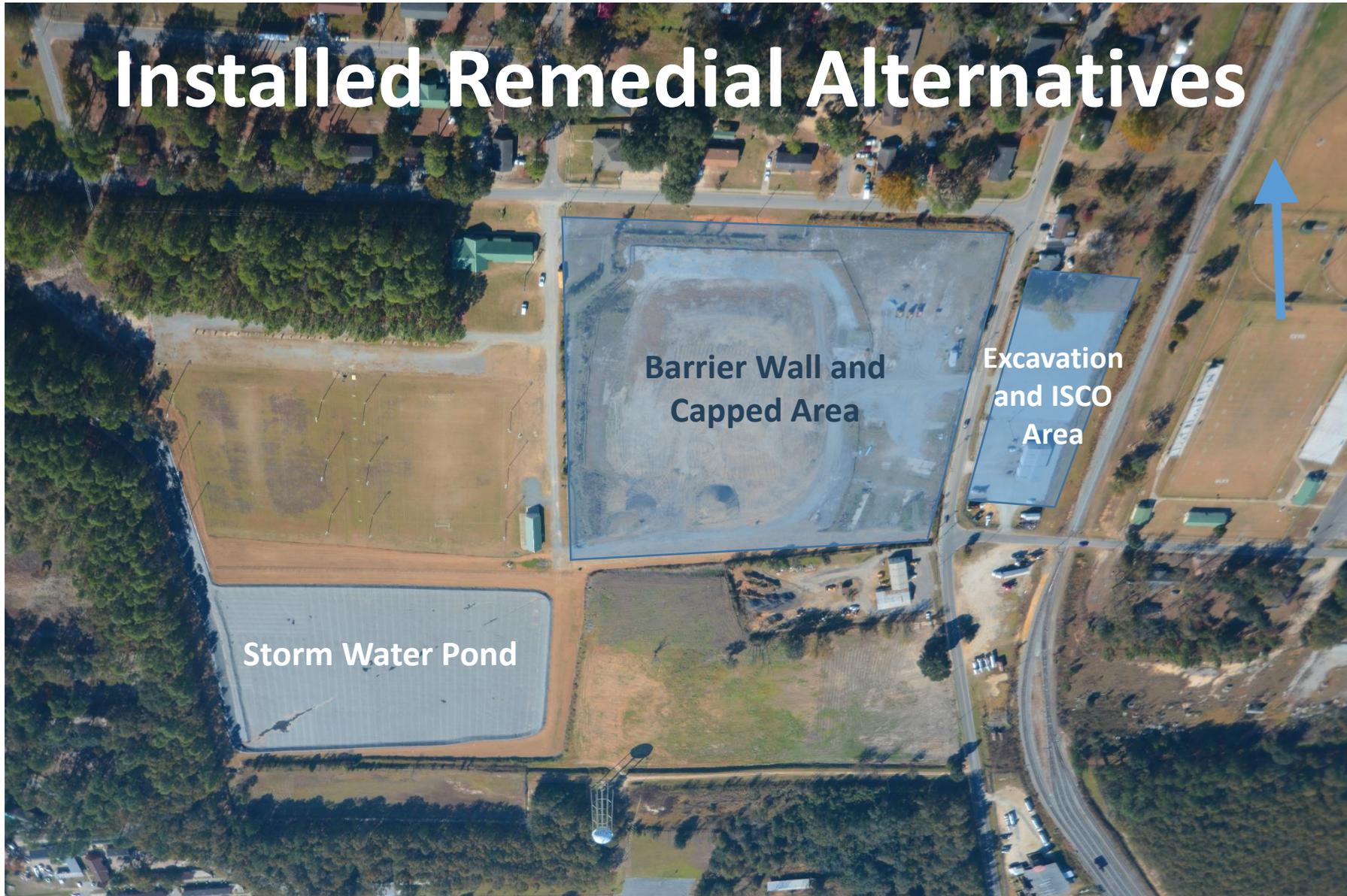
Geosyntec  
consultants

# CAMILLA WOOD PRESERVING SUPERFUND SITE

## CAMILLA, GEORGIA



# Installed Remedial Alternatives



# ISCO DATA GAPS AND DESIGN ASSUMPTIONS

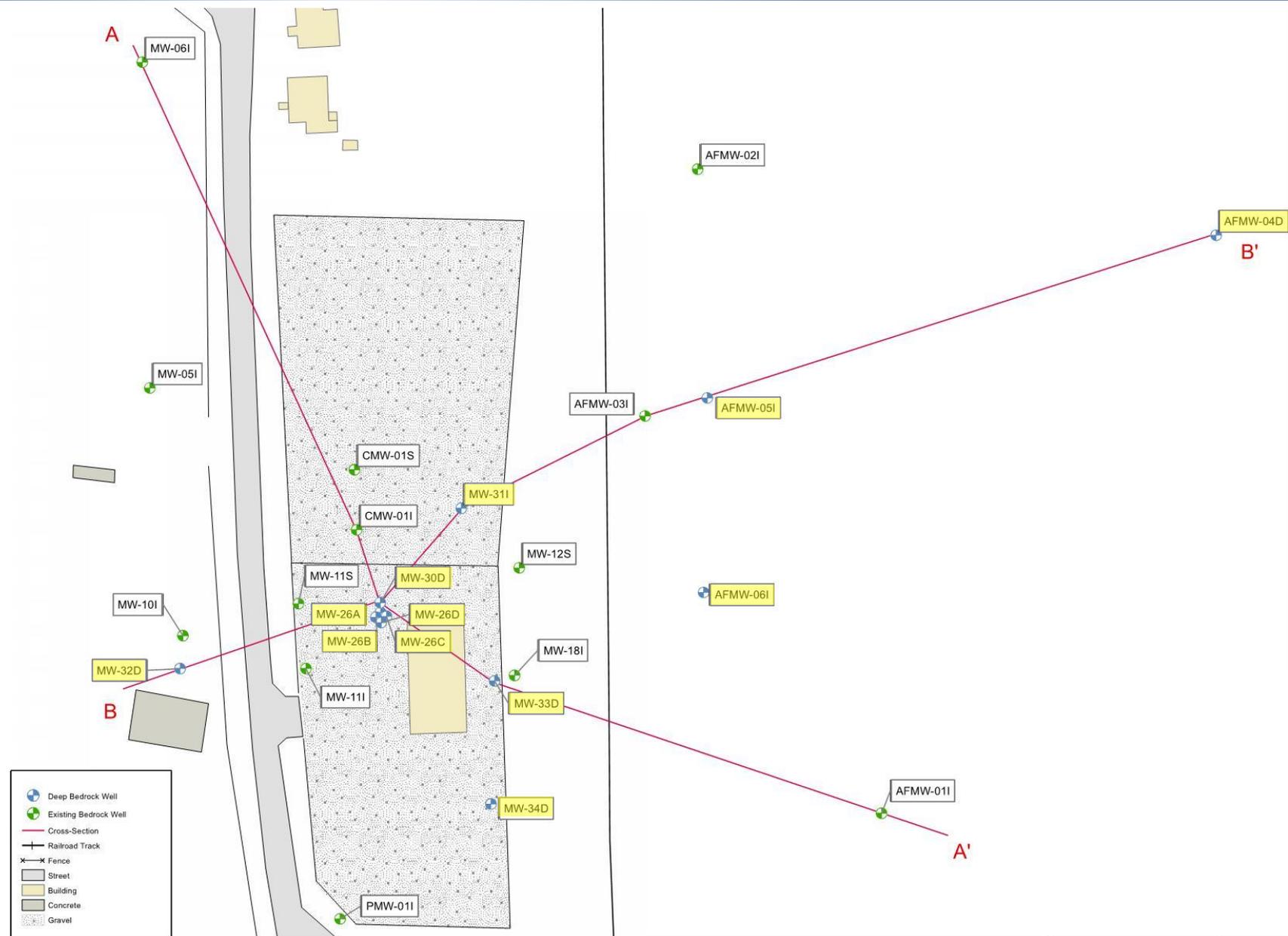
- Potential unknown sinkholes
- Lack of soil data above and below limestone interface
- Validation of assumption that aquifer would accept injected oxidants
- Validation of assumption that worst contamination present in top 10 feet of fractured limestone
- Validation of assumption that aquifer had sufficient conductivity to distribute oxidants

**ASSUMPTION #1: The intermediate aquifer will accept an injected solution.**

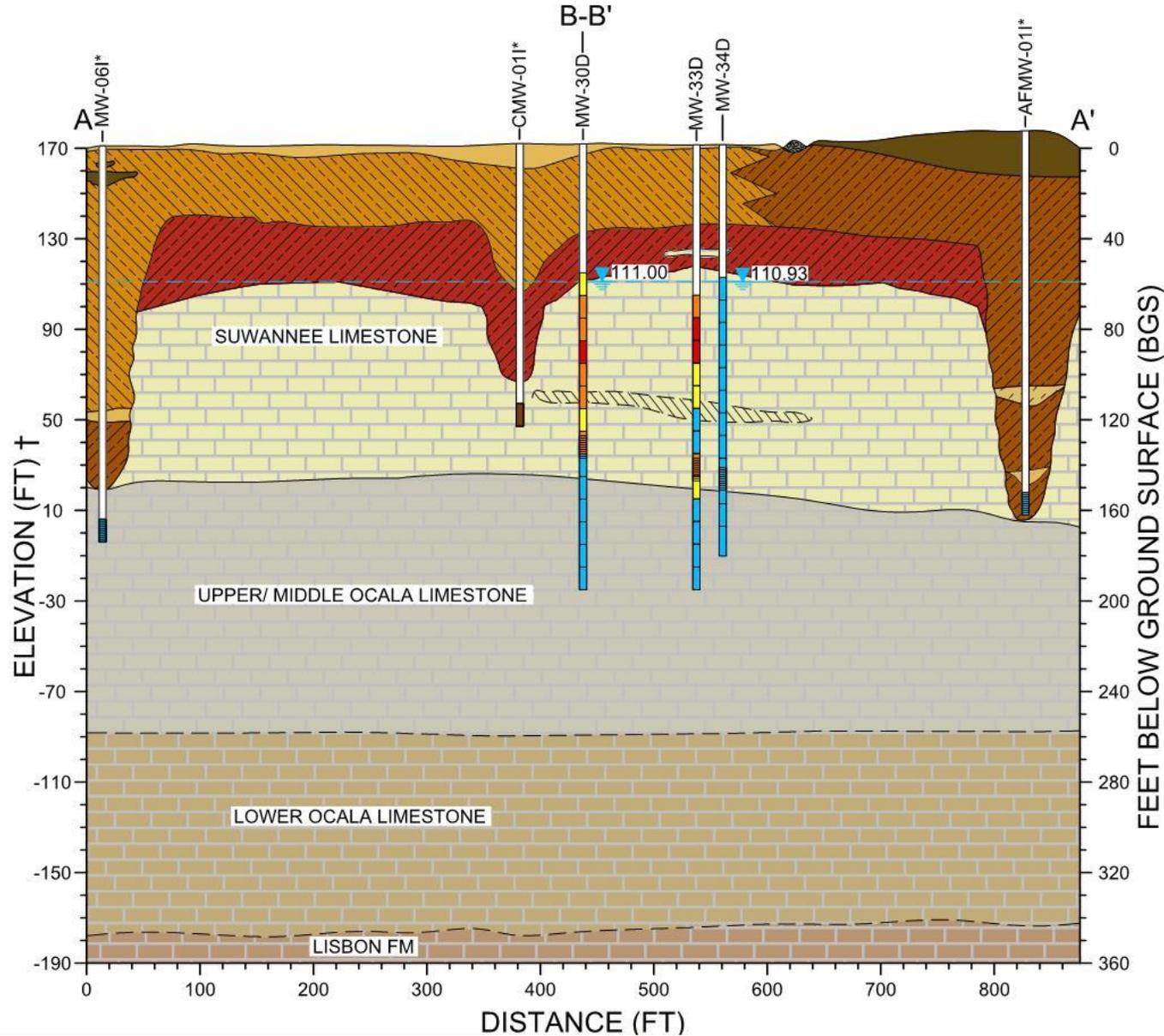
**ASSUMPTION #2: The gross contamination present in the intermediate aquifer is located in the top 10 feet of the fractured limestone.**

## Additional Investigation Included:

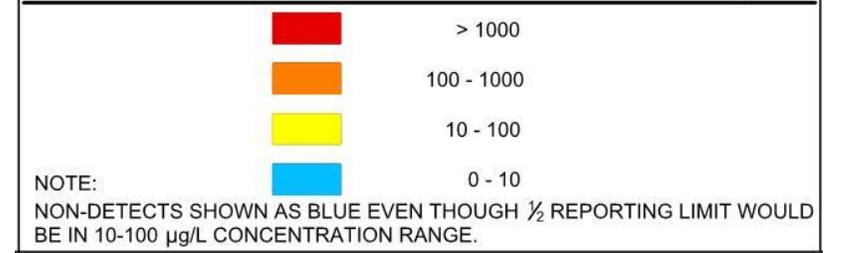
- 9 new deep wells
- 3 sentinel wells
- Iso-Flow sampling in fractured limestone
- SVOC analysis in onsite mobile lab



# GEOLOGIC CROSS-SECTION A-A'



## PCP CONCENTRATIONS FROM ISO-FLOW SAMPLING AND MONITORING WELL SAMPLES (µg/L)

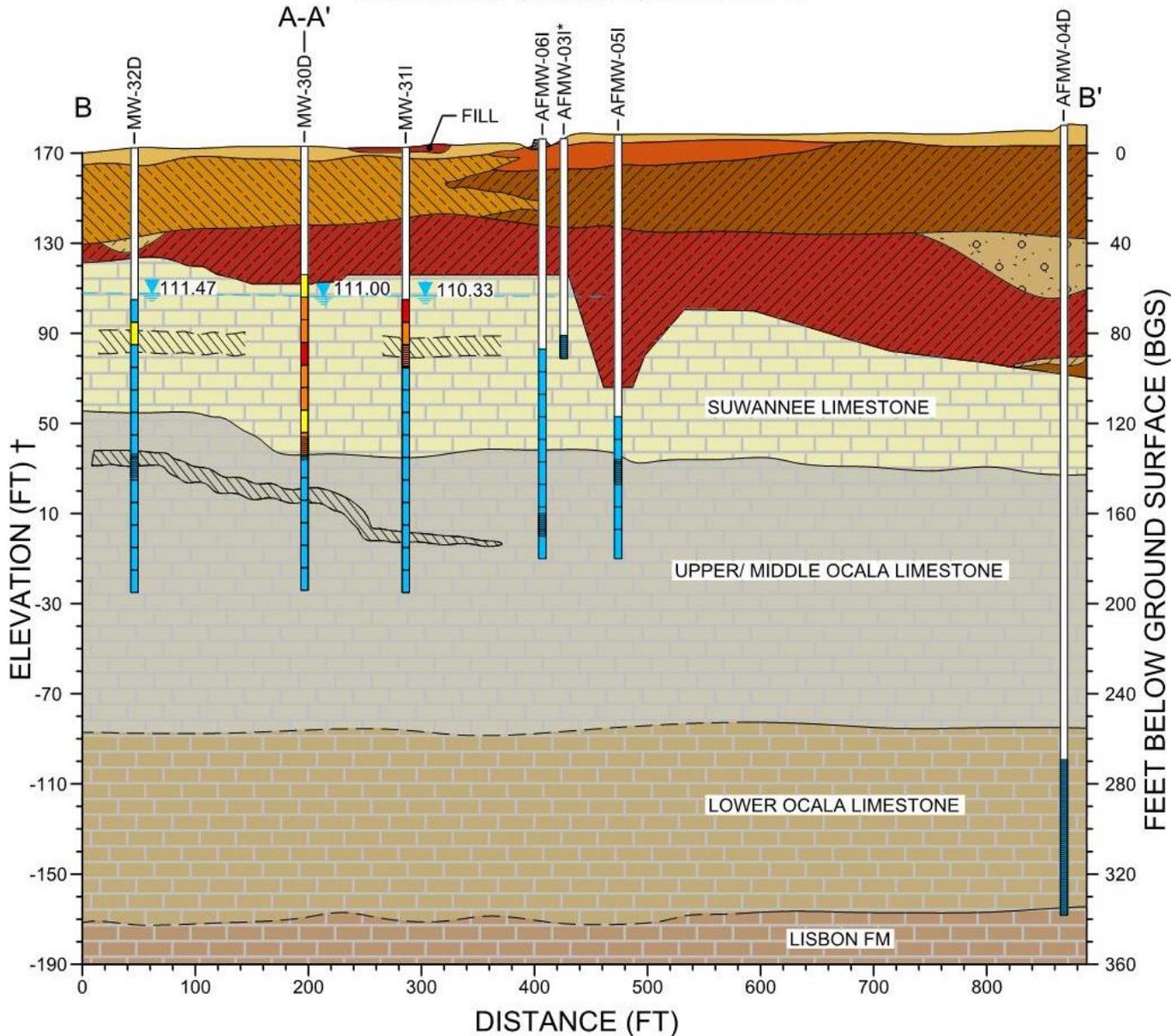


### LEGEND

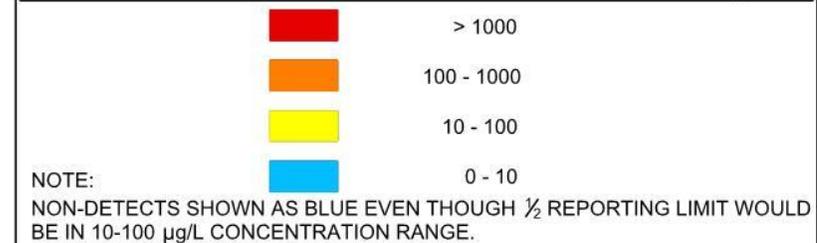
- LIGHT BROWN TO GRAY FINE SAND; OCCASIONAL SILTY LENSES
- REDDISH-BROWN TO ORANGE CLAYEY SILT AND SILTY CLAY; OCCASIONAL FINE SAND LENSES
- REDDISH-BROWN TO LIGHT BROWN MOTTLED CLAY; LOW TO MODERATE PLASTICITY
- MOTTLED YELLOW, RED, TAN, WHITE AND PURPLE CLAY; MODERATE TO HIGH PLASTICITY; STIFF; WEATHERED LIMESTONE FRAGMENTS AND MINERAL CONCRETIONS THROUGHOUT
- TAN TO BROWN CLAYEY SAND TO VERY SANDY CLAY
- BROWN SILTY SAND
- MOTTLED RED, BROWN, AND TAN VERY CLAYEY SAND
- LIGHT BROWN MEDIUM SAND AND CLAY WITH ABUNDANT GRAVEL TO BOULDER-SIZE CHERT NODULES)
- SUWANNEE LIMESTONE
- UPPER/ MIDDLE OCALA LIMESTONE
- LOWER OCALA LIMESTONE
- LISBON FM
- RAILROAD BALLAST
- CONTACT
- CRYSTALLIZED LIMESTONE ZONE
- SCREEN
- POTENTIOMETRIC SURFACE (2/2/13)
- INFERRED CONTACT

† ALL VERTICAL ELEVATIONS REFERENCED TO NAVD 88 DATUM

# GEOLOGIC CROSS-SECTION B-B'



## PCP CONCENTRATIONS FROM ISO-FLOW SAMPLING AND MONITORING WELL SAMPLES (µg/L)



### LEGEND

- LIGHT BROWN TO GRAY FINE SAND; OCCASIONAL SILTY LENSES
- REDDISH-BROWN TO ORANGE CLAYEY SILT AND SILTY CLAY; OCCASIONAL FINE SAND LENSES
- REDDISH-BROWN TO LIGHT BROWN MOTTLED CLAY; LOW TO MODERATE PLASTICITY
- MOTTLED YELLOW, RED, TAN, WHITE AND PURPLE CLAY; MODERATE TO HIGH PLASTICITY; STIFF; WEATHERED LIMESTONE FRAGMENTS AND MINERAL CONCRETIONS THROUGHOUT
- TAN TO BROWN CLAYEY SAND TO VERY SANDY CLAY
- BROWN SILTY SAND
- MOTTLED RED, BROWN, AND TAN VERY CLAYEY SAND
- LIGHT BROWN MEDIUM SAND AND CLAY WITH ABUNDANT GRAVEL TO BOULDER-SIZE CHERT NODULES)
- SUWANNEE LIMESTONE
- UPPER/ MIDDLE OCALA LIMESTONE
- LOWER OCALA LIMESTONE
- LISBON FM
- RAILROAD BALLAST
- CONTACT
- CRYSTALLIZED LIMESTONE ZONE
- SCREEN
- POTENTIOMETRIC SURFACE (2/2/13)
- INFERRED CONTACT

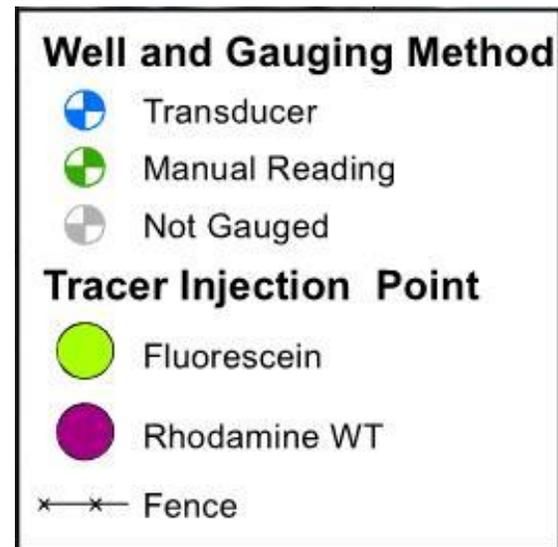
† ALL VERTICAL ELEVATIONS REFERENCED TO NAVD 88 DATUM

**ASSUMPTION #3: The intermediate aquifer has sufficient conductivity to distribute oxidants, either naturally or with augmentation.**

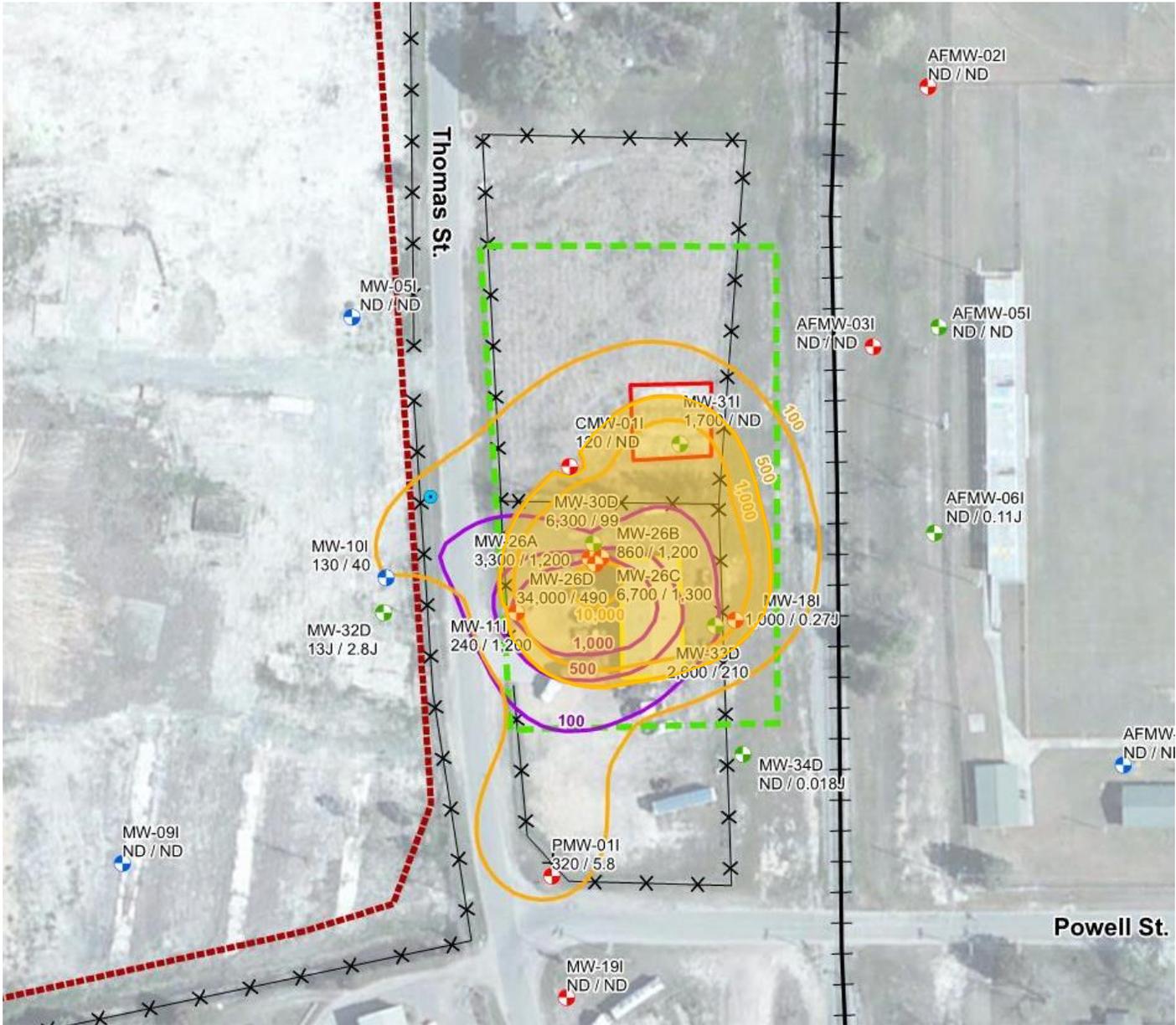


## Hydrogeologic Testing Included:

- Well Installation
- Pneumatic Slug Testing
- Step Draw-Down Testing
- Pumping with Dye Tracer Test



# Modeled PCP and Naphthalene Groundwater Distribution in the Intermediate Aquifer



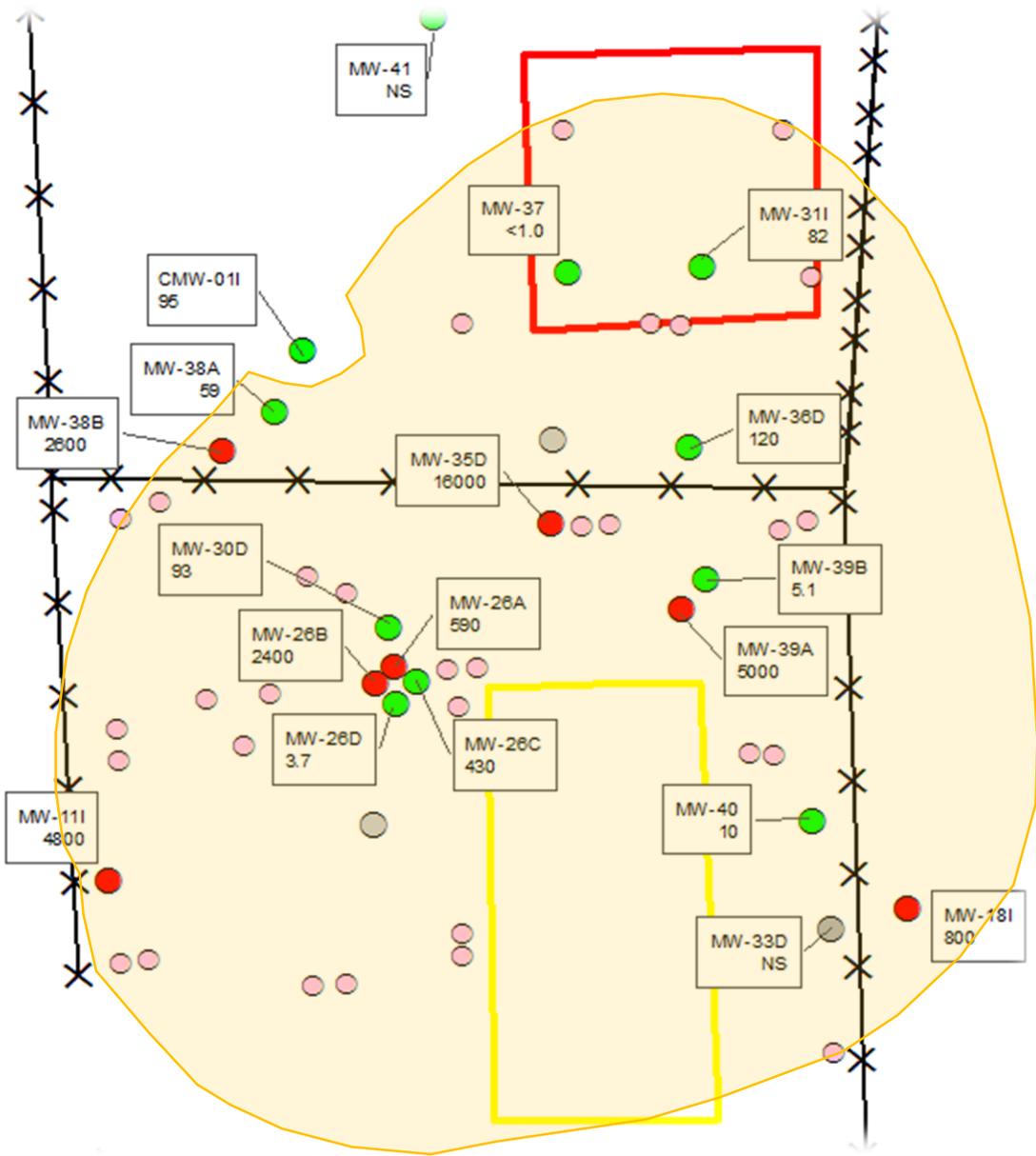
**Groundwater Data Event**

- Boring Iso-Flow Data (Feb, Sept 2013)
- June 2013 Monitoring Well Data
- Feb 2014 Monitoring Well Data
- PCP Modeled Iso-Concentration Contour (ug/L)
- Naphthalene Modeled Iso-Concentration Contour (ug/L)
- Municipal Fire Hydrant
- Approximate ISCO Treatment & Staging Area Boundary
- Former Chemical Storage Area
- Truck/Automotive Repair Shop
- Approximate Barrier Wall Alignment
- Fence
- Railroad Tracks

**Notes:**

1. ND = Constituent not detected at or above the method detection limit.  
J = Constituent was detected below the calibration range and is estimated.
2. Maximum PCP and naphthalene concentrations presented per well or boring location in ug/L (i.e., PCP/naphthalene).





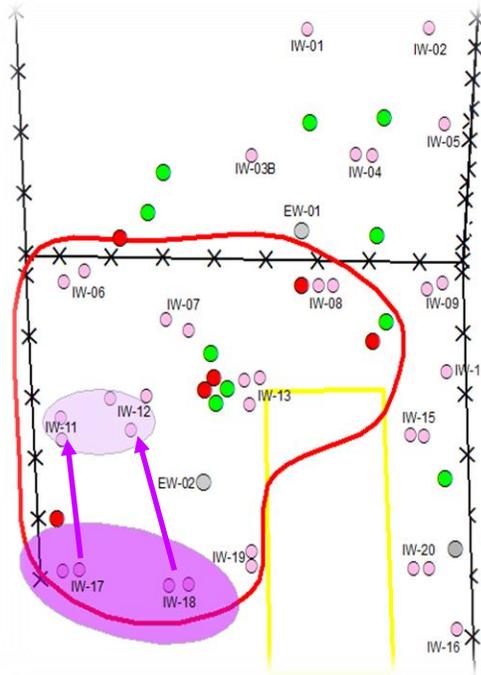
## ISCO Injection Event #1

- Event 1 in Summer 2014
  - 188,363 gallons of  $\text{KMnO}_4$  injected (74,000 pounds)
  - 4,000-6,000 gallons per well
  - Flow rate of 6-8 gpm at <10 psi
- Monthly check of field parameters for 6 months
- Performance monitoring quarterly
  - Three events between January and July 2015
  - Results for Q3 shown to the left

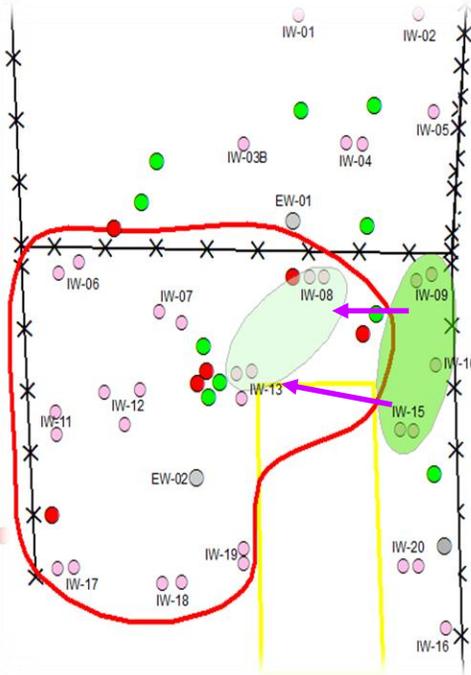
- PCP < 500 ug/L
- PCP > 500 ug/L
- Extraction Well
- Injection Well
- Monitoring Well - not sampled

# Design of ISCO Injection #2

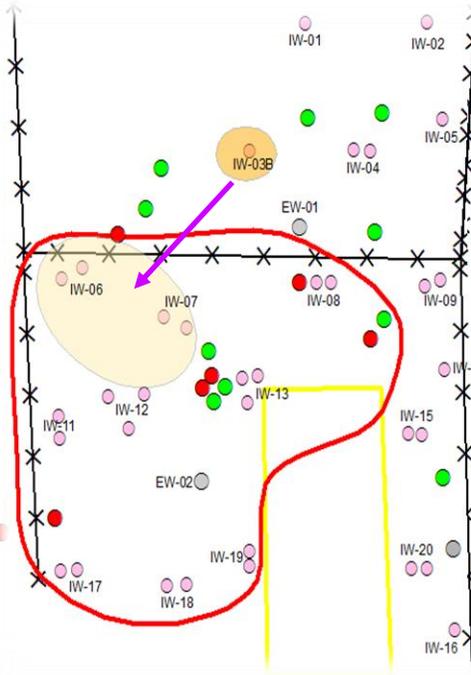
## Focus on moving oxidant



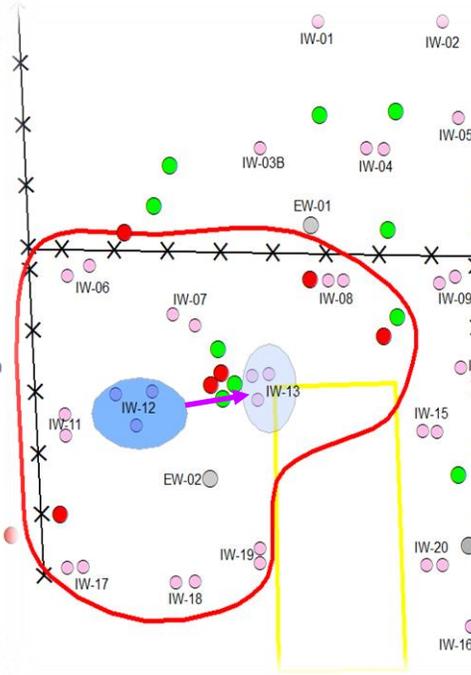
- Group 1**
- 2,000 gallon extraction target per well
  - 8,000 gallon 3%  $\text{KMnO}_4$  injection target per well



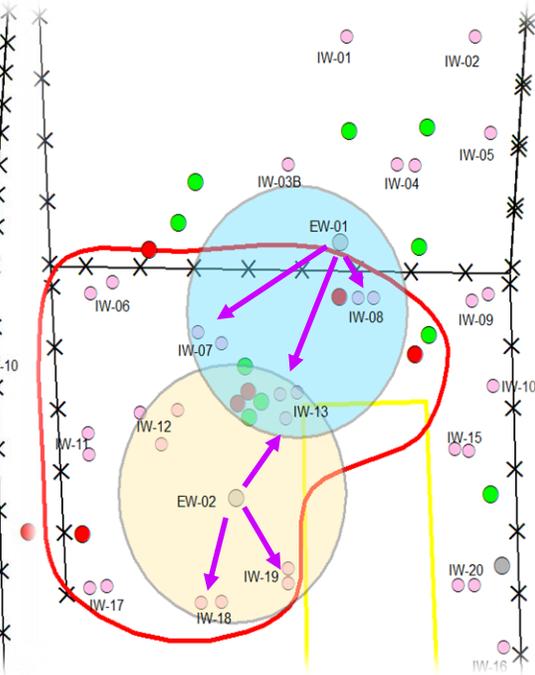
- Group 2**
- 2,000 gallon extraction target per well
  - 8,000 gallon 3%  $\text{KMnO}_4$  injection target per well



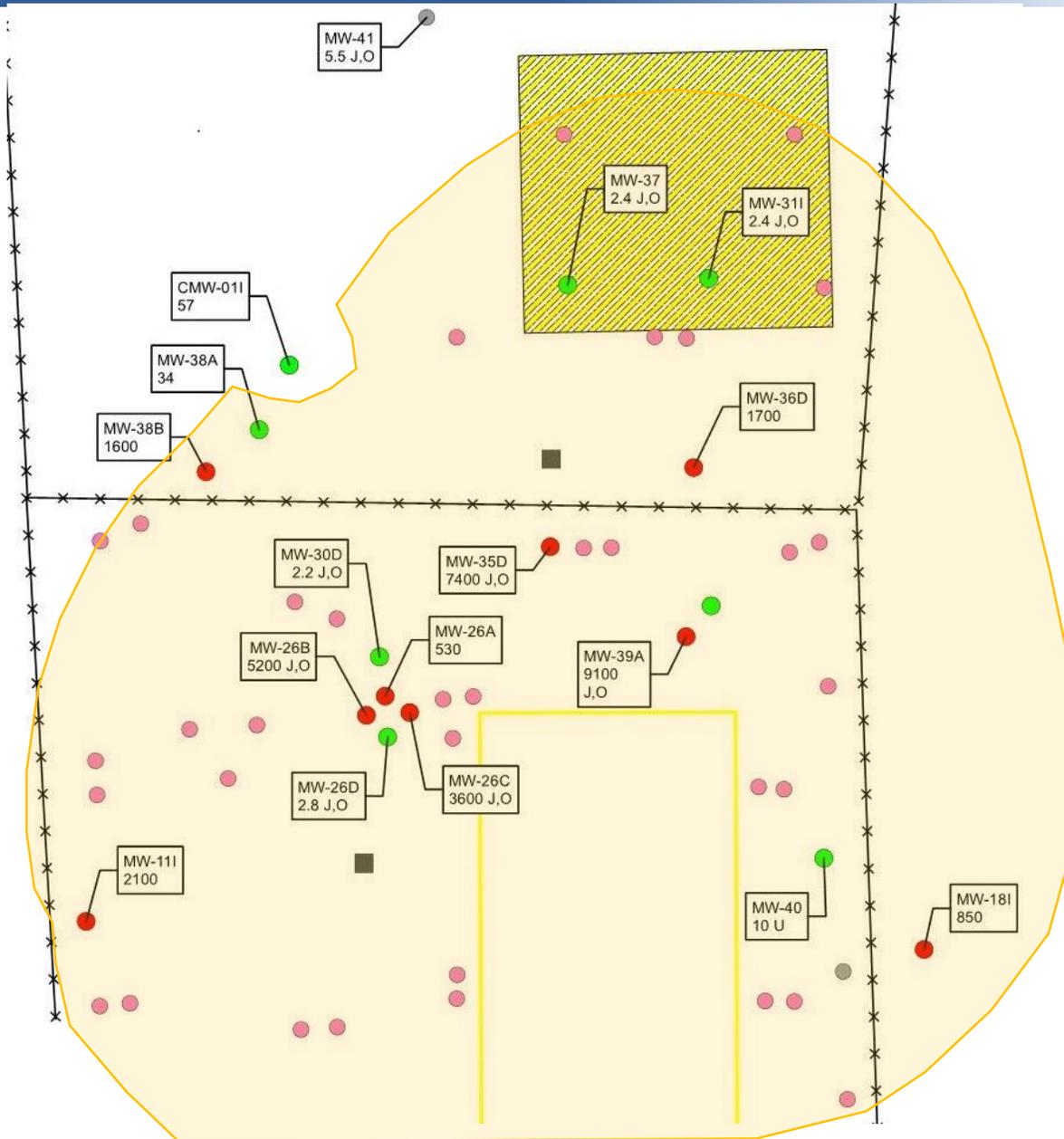
- Group 3**
- 2,000 gallon extraction target from IW-03B
  - 16,000 gallon 3%  $\text{KMnO}_4$  injection target per well



- Group 4**
- 2,000 gallon extraction target per well
  - 4,000 gallon 3%  $\text{KMnO}_4$  injection target per well



- Groups 5 and 6**
- 15,000 gallon extraction target per well
  - 3,000 gallon 3%  $\text{KMnO}_4$  injection target per well



## ISCO Injection Event #2

- Pre-event baseline groundwater sampling in February 2016
- Event 2 in Spring 2016
  - 92,431 gallons of  $\text{KMnO}_4$  injected
  - 2,000-8,000 gallons per well
  - Flow rate of 2-5 gpm at <40 psi
- Monthly check of field parameters for 6 months
- Performance monitoring quarterly
  - Three events between July 2016 and January 2017
  - Results for Q3 shown to the left

- PCP < 500 ug/L
- PCP > 500 ug/L
- Extraction Well
- Injection Well
- Monitoring Well - not sampled

# SUMMARY OF ISCO ACTIVITIES

- 46 permanent wells installed
- Two injections with a total of 280,794 gallons of  $\text{KMnO}_4$  solution injected
- Following Injection #1, 42% reduction in PCP, 61% reduction in naphthalene and 10 of 18 wells below 500 ppb PCP
- Following injection #2, further reductions in plume with 13 of 18 wells below 500 ppb PCP
- Groundwater monitoring program to continue

# LESSONS LEARNED

- Challenge assumptions and seek out blind spots
- More data points in the right places deliver better results
- Small, local phenomenon can have a big impact on success
- Never stop refining your CSM

# QUESTIONS?