

Enhanced In Situ Reductive Bioremediation of Trichloroethene in an Aerobic, Fractured Bedrock Aquifer, MCB Camp Pendleton, San Diego, California

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*Bioremediation
Symposium*

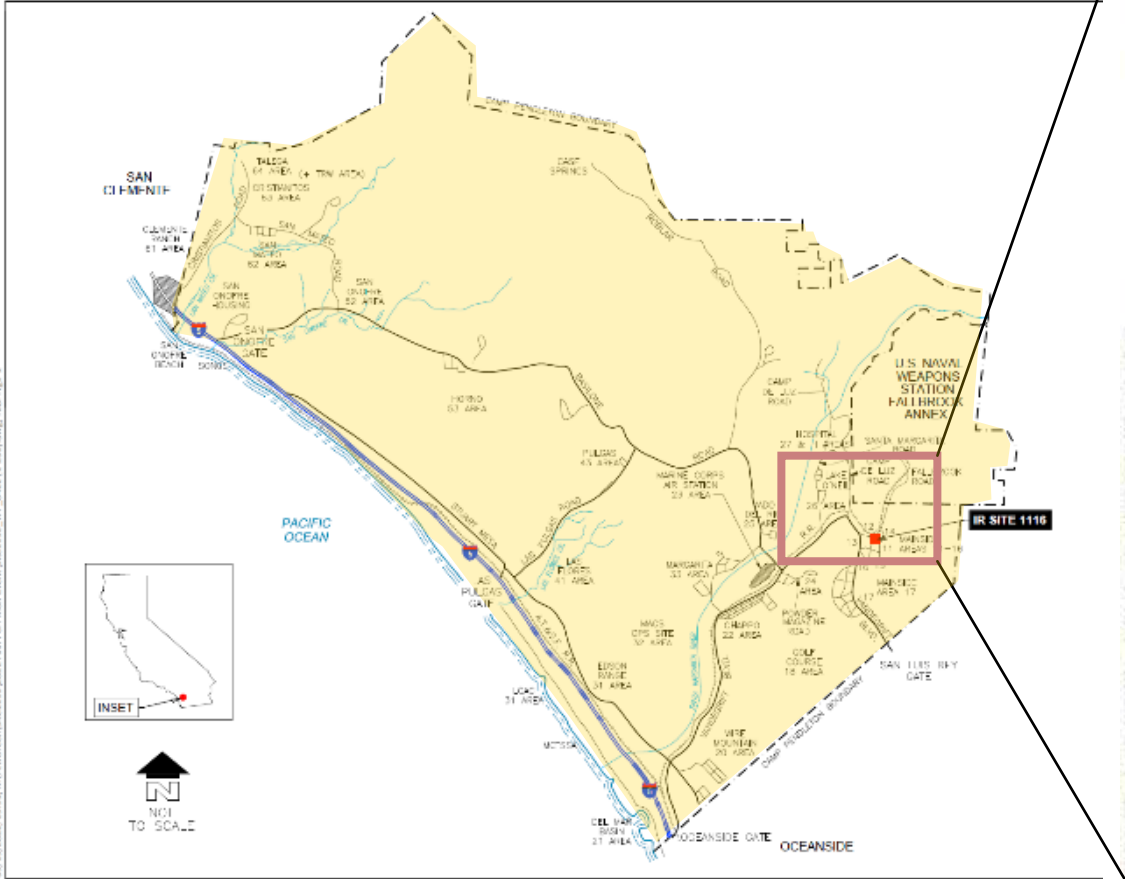


Site Location{ MARINE CORPS BASE CAMP PENDLETON

Los Angeles



Site Location



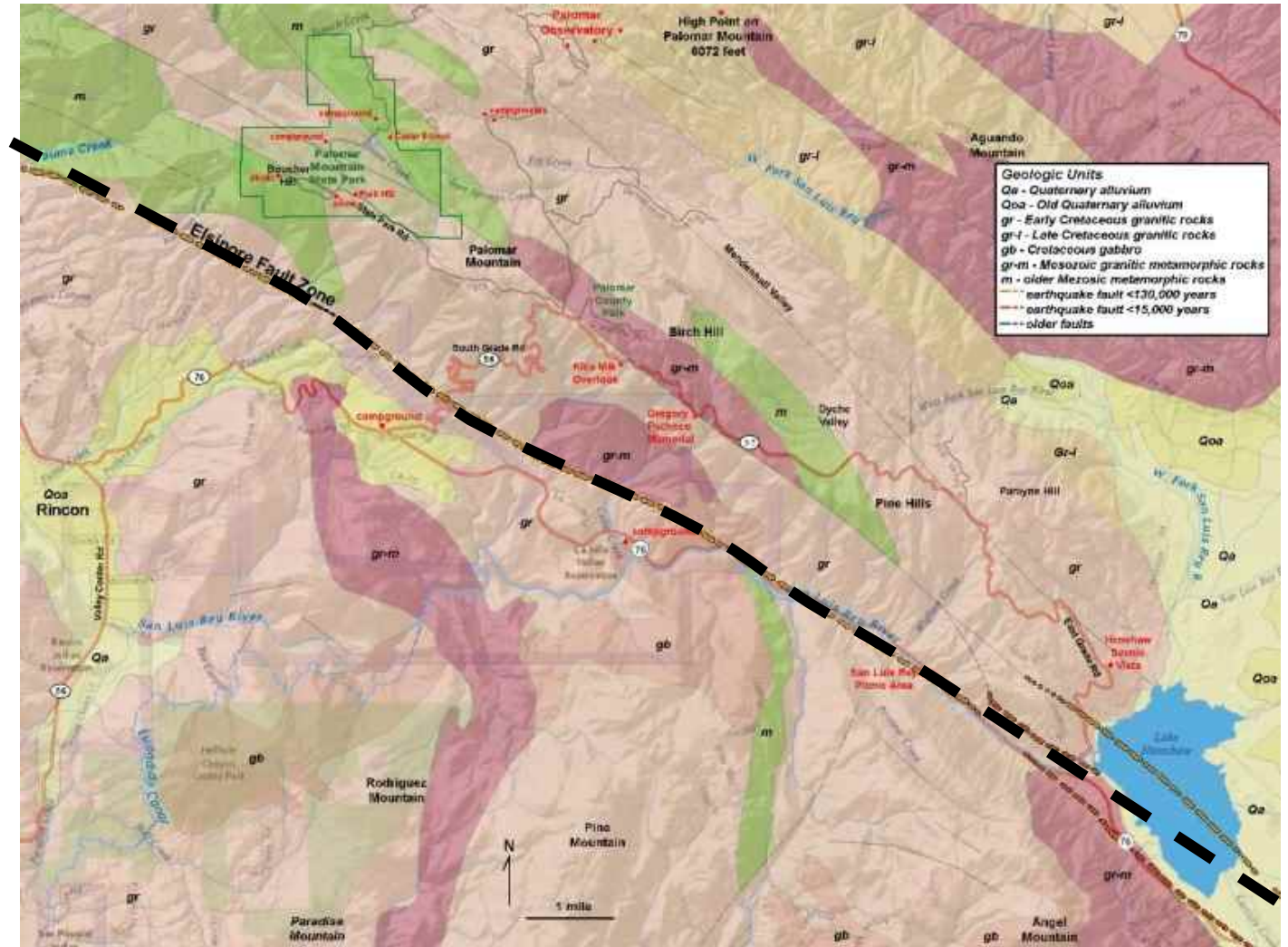
Regional Geology

Quaternary Sediments at surface

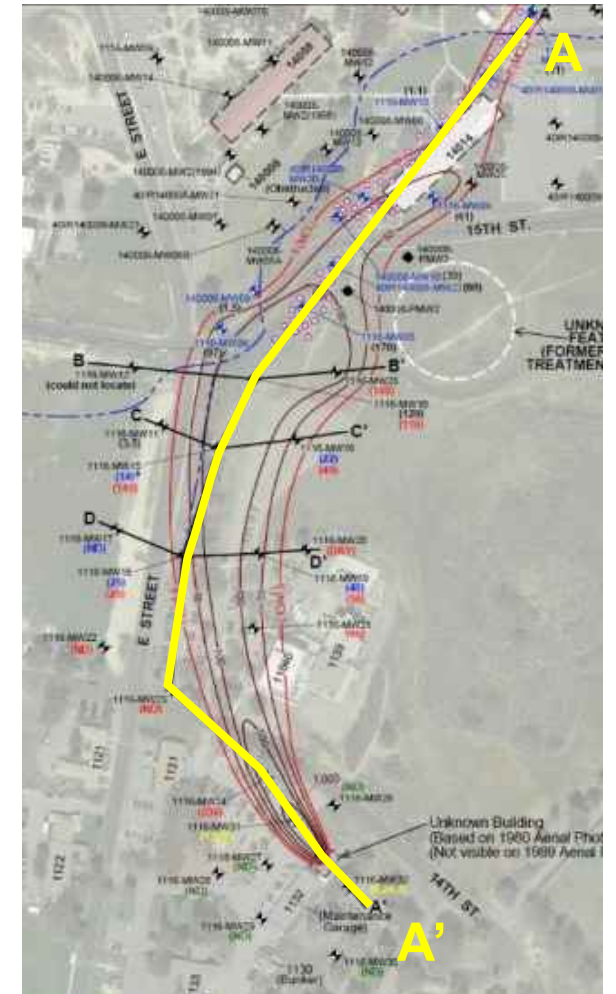
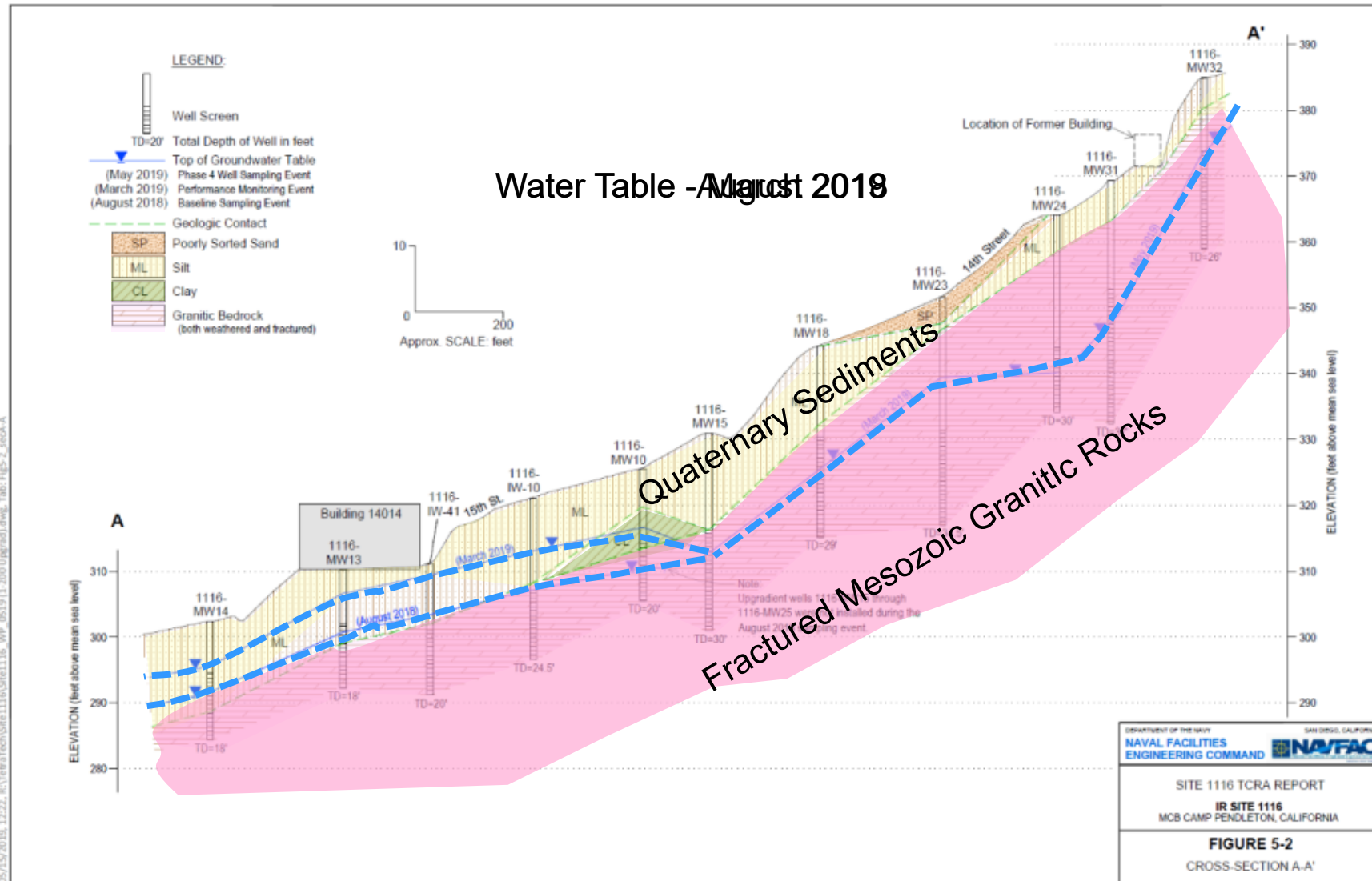
Primarily Cretaceous and other Mesozoic Granitic Rocks

Highly Fractured

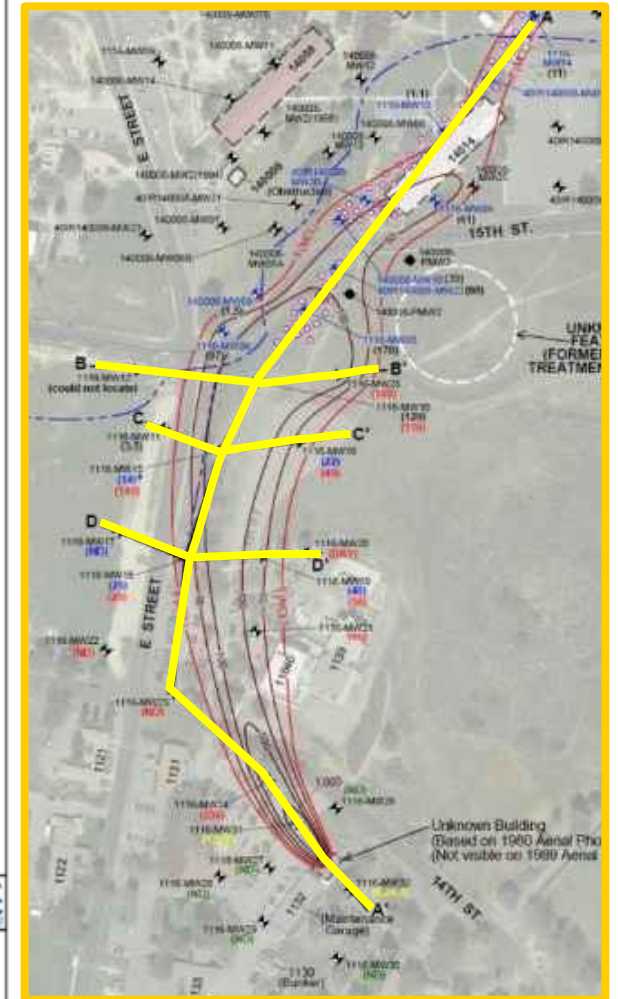
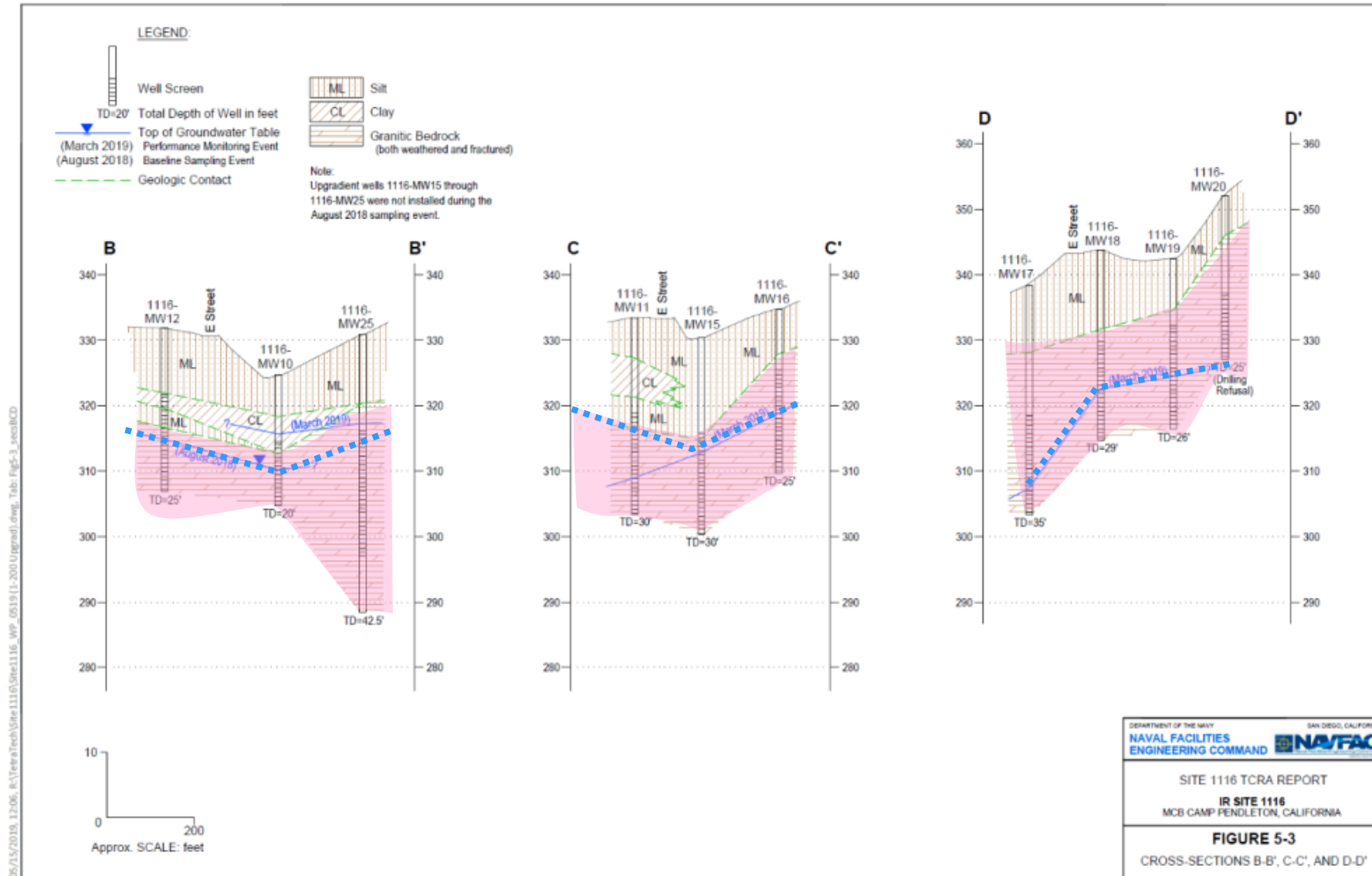
Relatively Recent ~2.5 Million Years strand faulting along Elsinore fault



Site Hydrogeology



Site Hydrogeology



Site Location

Groundwater Flow to NE

Groundwater 5 to 27 Ft BGS - SW

Groundwater 10 to 15' BGS -NE

In San Luis Rey Hydrologic Unit

Listed as beneficial use for
Industrial processes and domestic
agriculture

Not currently used for any of these
purposes



Time Critical Removal Action (TCRA)

Time-Critical Removal Action (TCRA) Phase 1

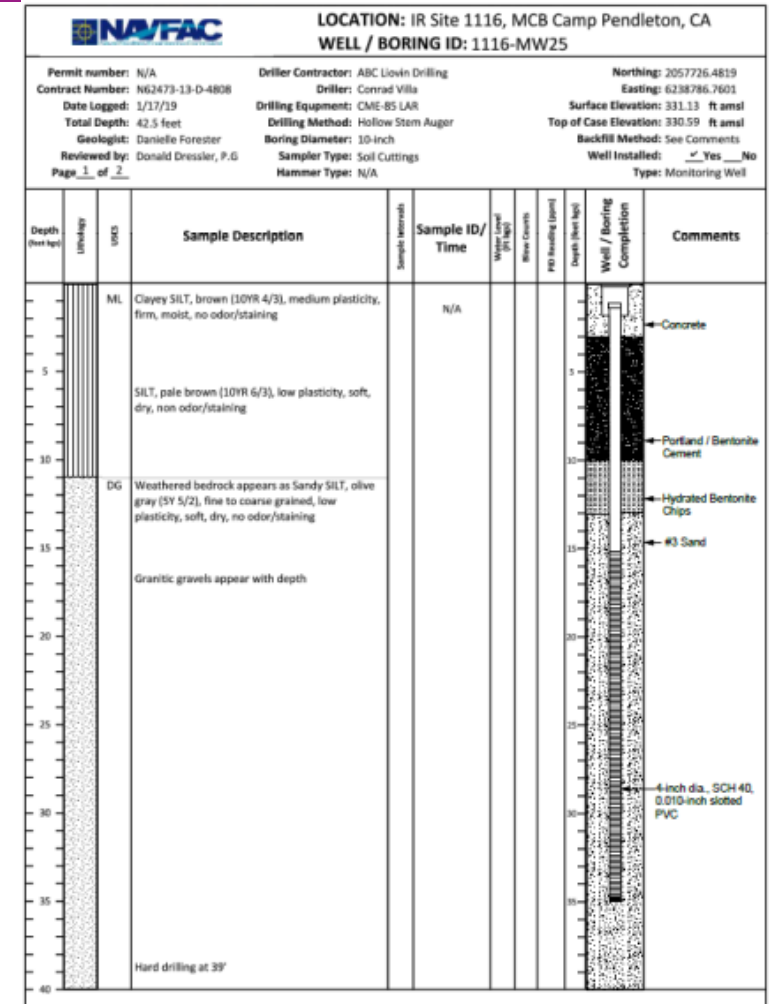
August to December 2018

Installed 100 Injection wells (August to September, 2018)

Installed 21 Upgradient Monitoring wells (August to September, 2018)

Injection and Monitoring Well Construction

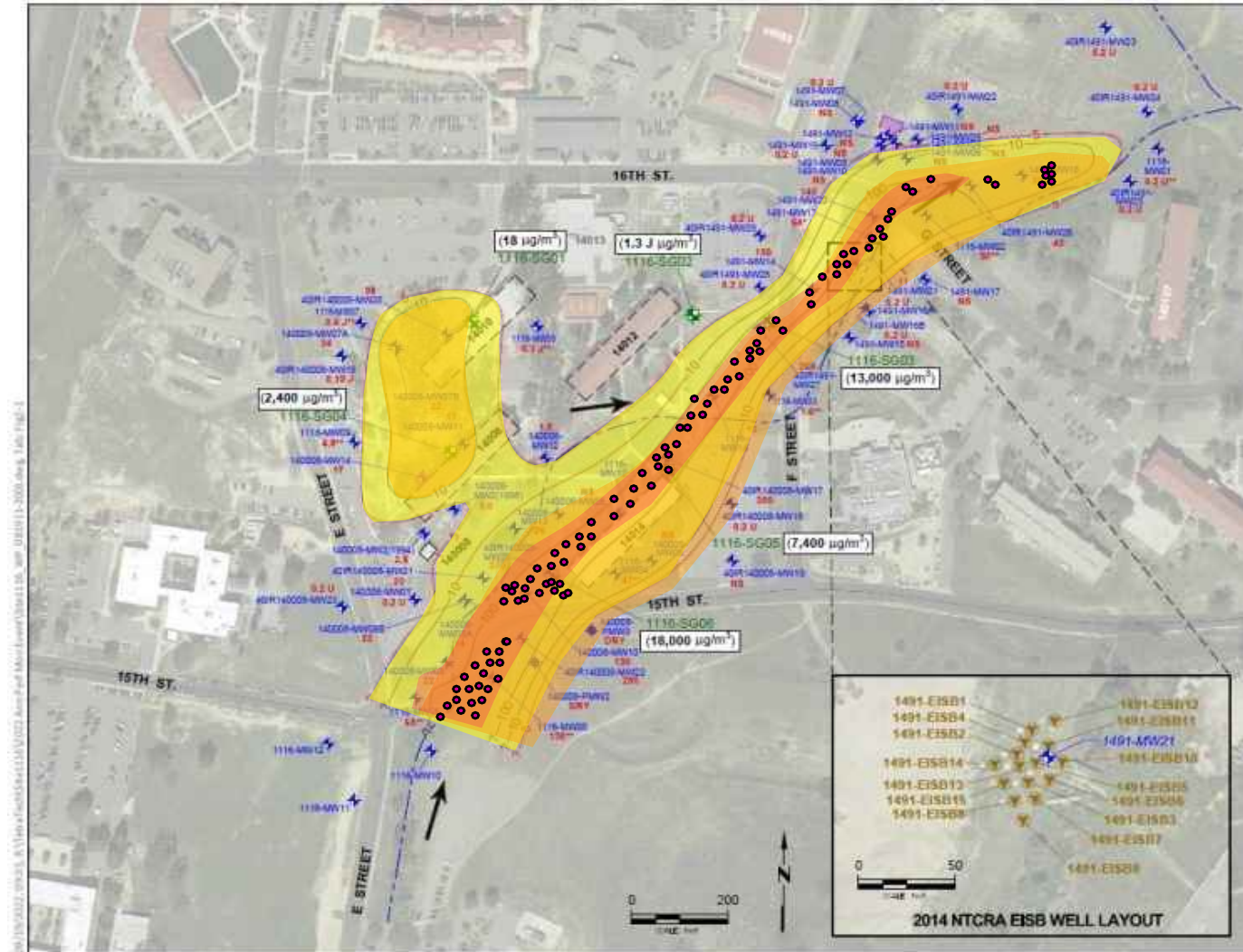
- Injection and Monitoring Wells Construction
- Hollow Stem Auger
- 10-inch diameter borings
- 4-inch diameter 0.010 inch PVC



TCRA Downgradient Plume 2018

Injected 40,462 gallons of substrate
(avg 405 gallons per well)

Injected 173 Liters of Dhc



ELS™ is a microemulsion of food-grade carbon that supports the treatment of a wide range of groundwater contaminants. ELS creates reducing conditions and promotes enhanced reductive dechlorination reactions. ELS is specially designed for easy on-site handling and addition to the subsurface via existing wells, hydraulic injection networks, or direct push technology.



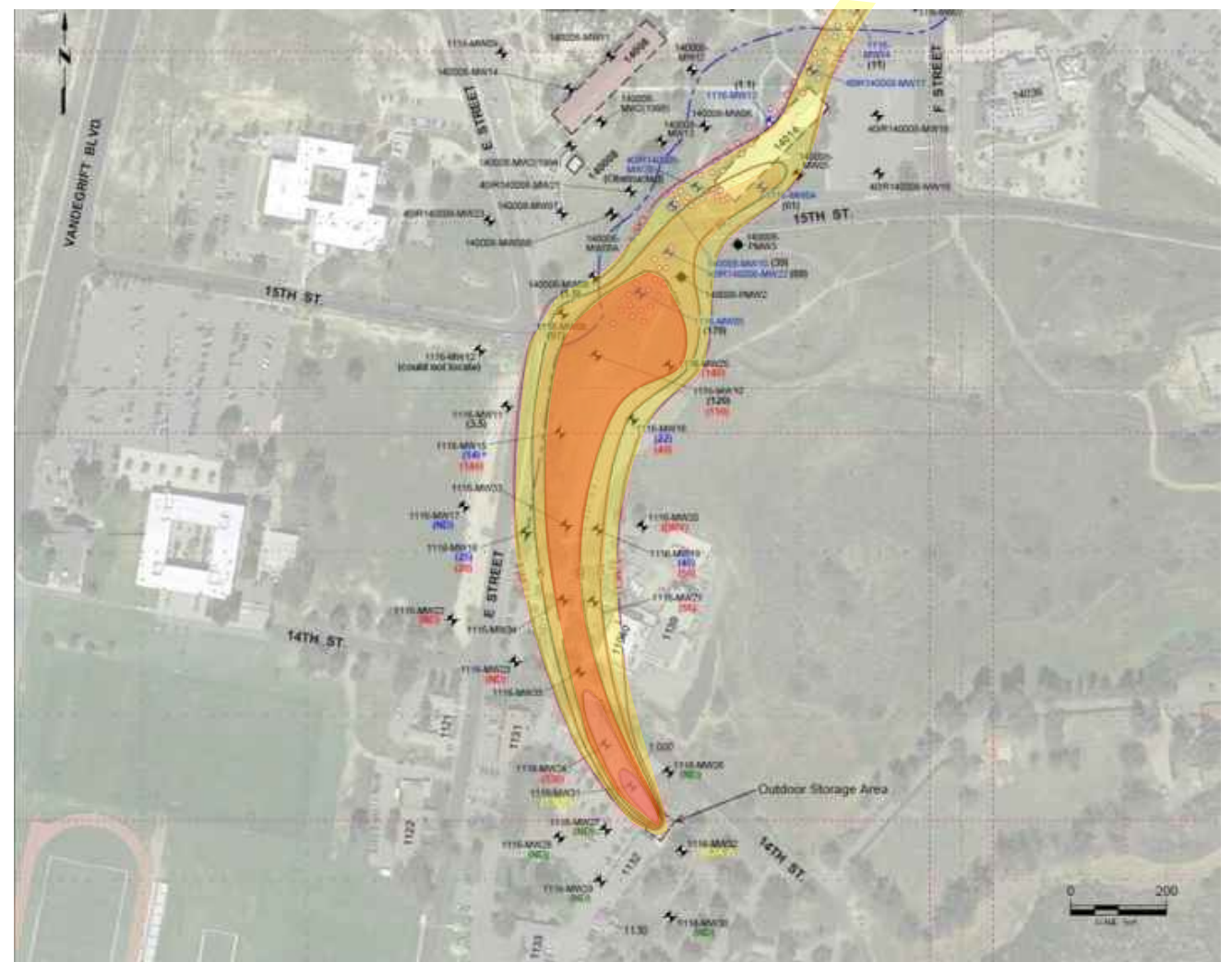
- **Composition**
 - Food-grade lecithin, including:
 - ✓ Polysaccharides & sugars to support rapid creation of reducing conditions
 - ✓ Phospholipids for long-term release of organic carbon
 - ✓ Slow-release nitrogen & phosphorus
- **Availability**
 - 25% emulsion and 100% concentrate
- **Packaging:**
 - 5-gal. pail, 55-gal. drum, 275-gal. tote (25% emulsion only)

Emulsification of ELS[®] On Site



TCRA Upgradient Plume 2019

Monitoring During downgradient TCRA indicated the plume was 1,100 feet further upgradient than thought

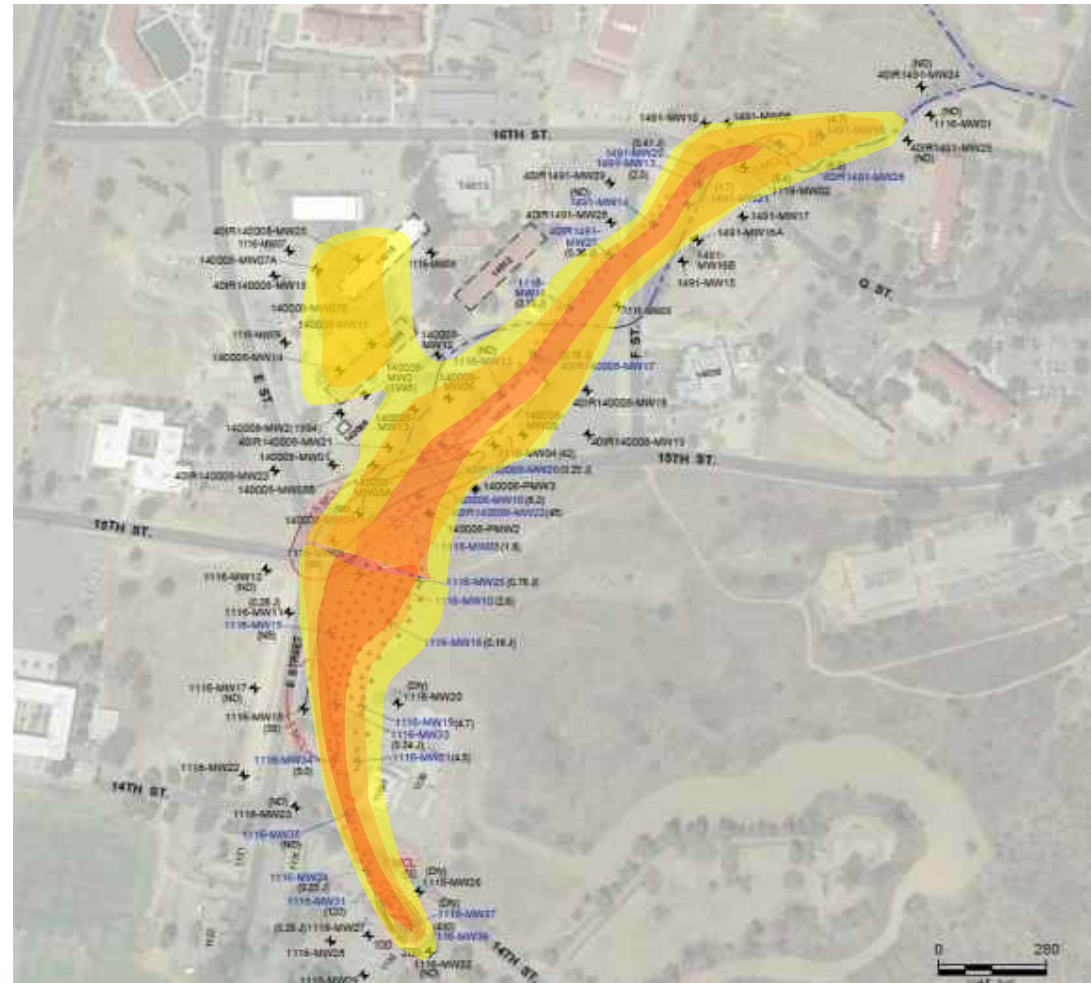


TCRA Site Characterization 2018 - 2019

TCRA Plume 2018

TCRA Plume 2019

Max TCE 1,700 $\mu\text{g/L}$



TCRA Upgradient Plume 2019

September to November 2019
installed 76 injection wells.

Injected 42,000 gallons of
ELS emulsion

Injected 197 Liters
of Dhc.



TCRA Upgradient Plume 2019

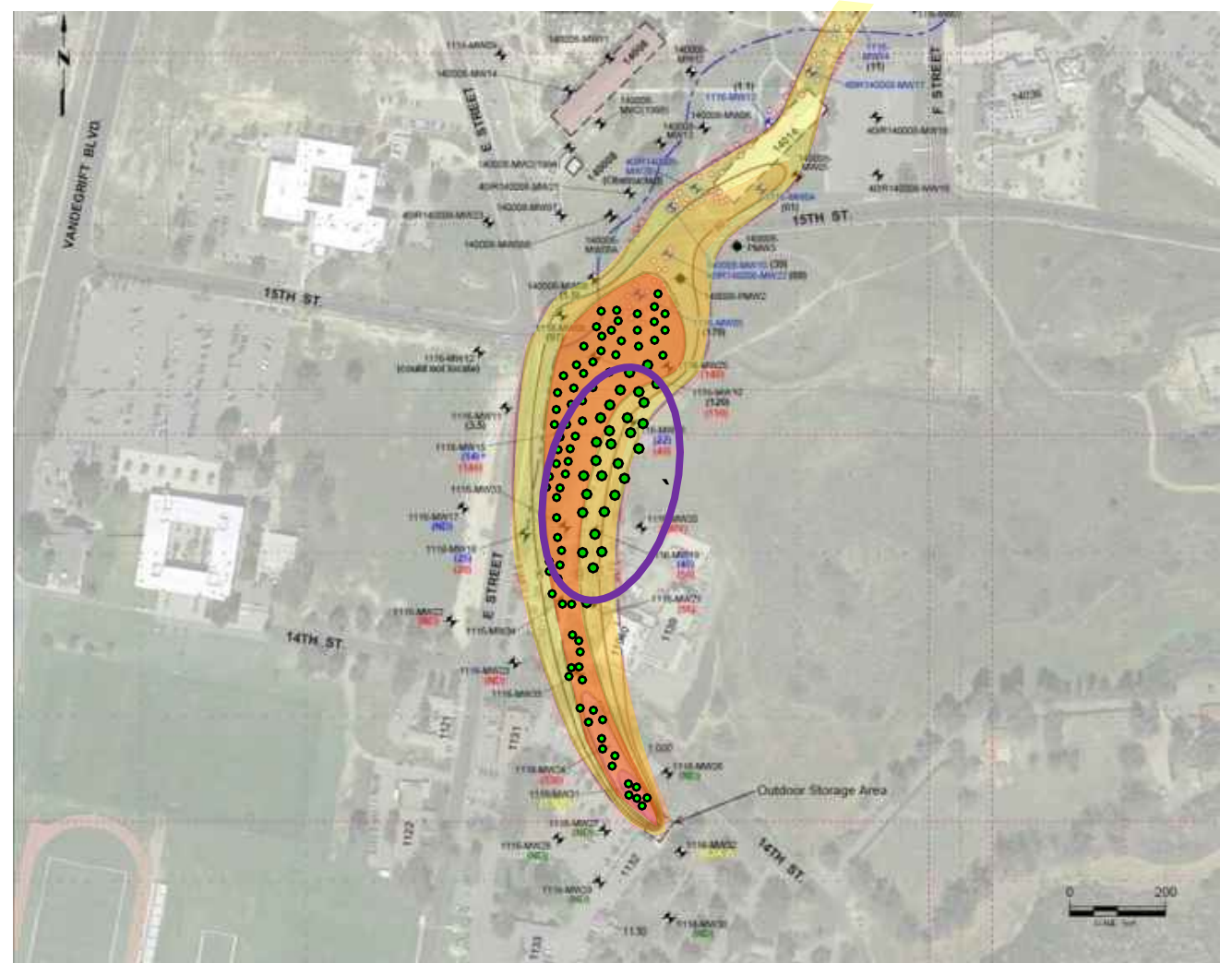
February to March 2021

Installed 30 New wells.

Injected 10,689 gallons of ELS

Injected 72.7 Liters of SDC-9.

Injection volumes ranged from 18 to 2,188 gallons per well.

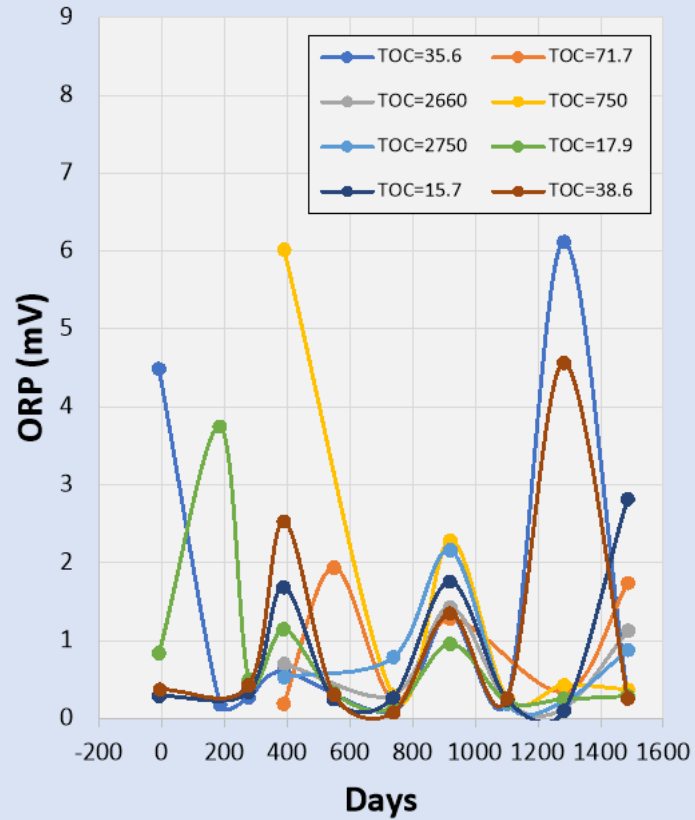


TCRA Injection Summary

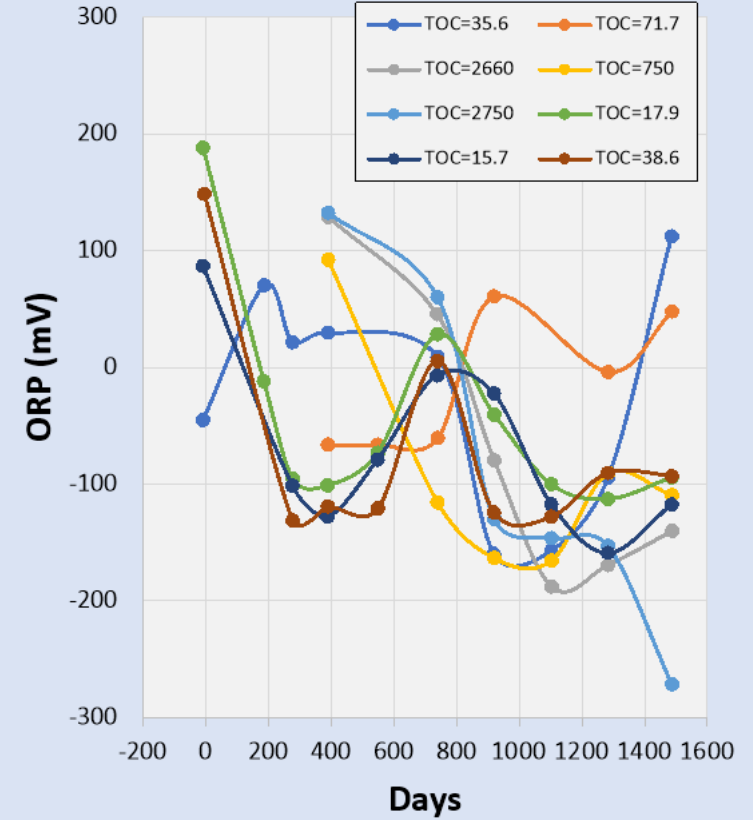
TCRA Injection Summary - ELS Emulsion				
Injection Area	Maximum Gallons	Minimum Gallons	Average Gallons	Total Gallons
Downgradient	2246	14	405	40462
Upgradient	3616	21	504	42000
Additional	2188	18	342	10689
Source	1341	21	217	3686
Summary	3616	14	367	96837

Site Geochemistry

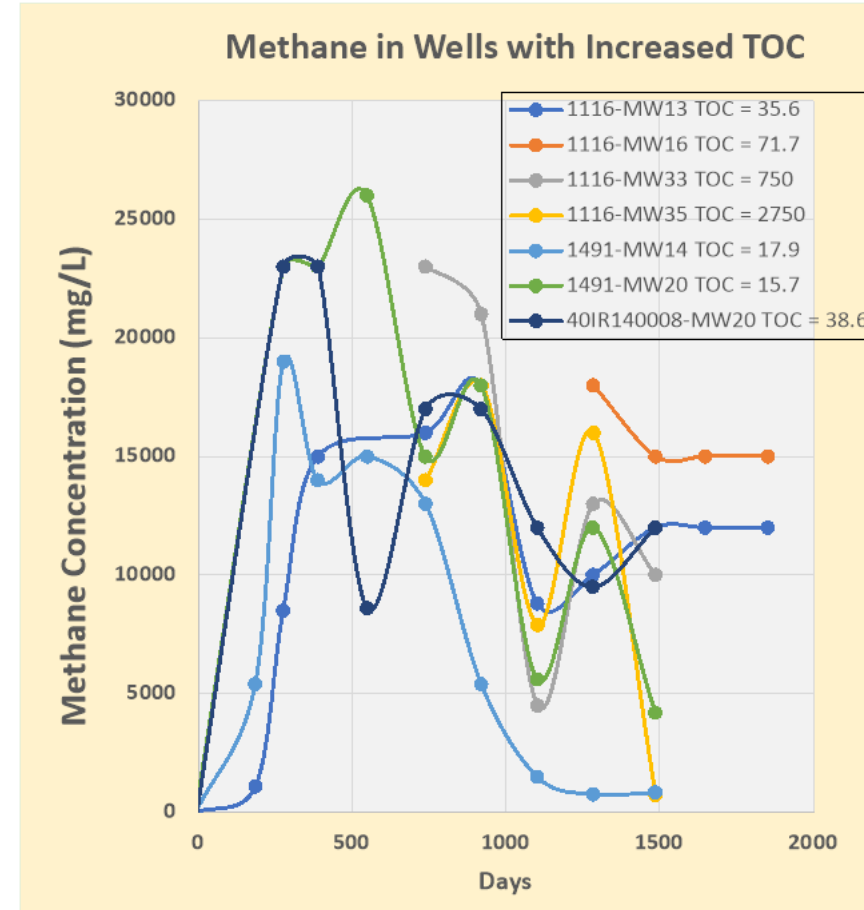
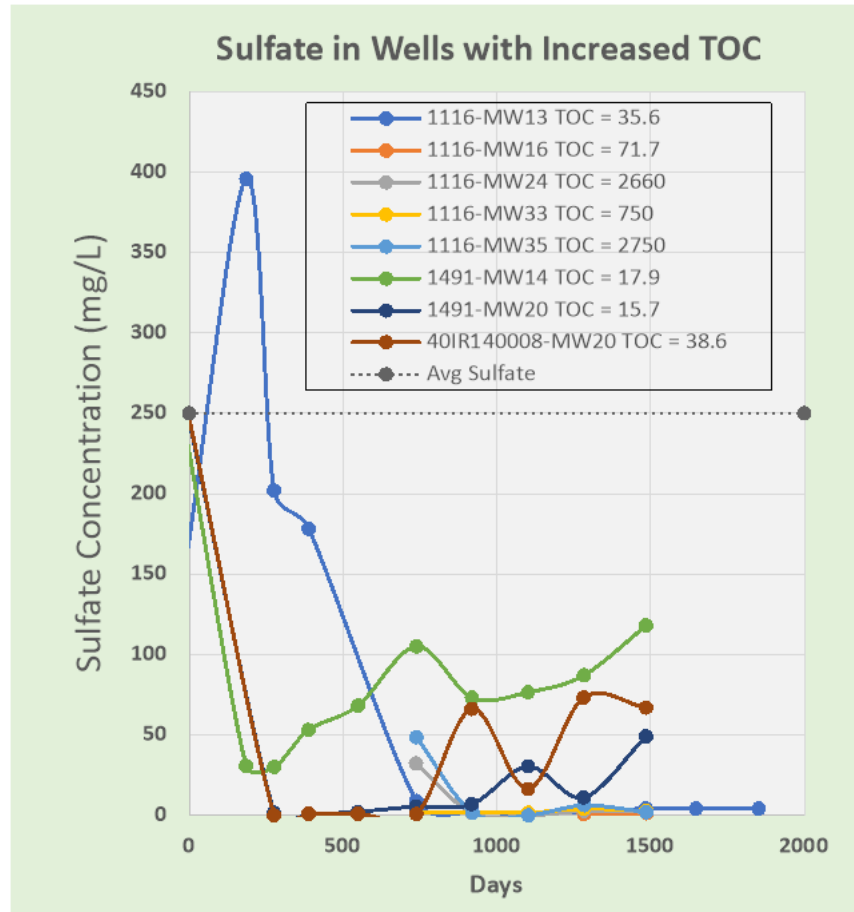
DO in Wells With Increased TOC



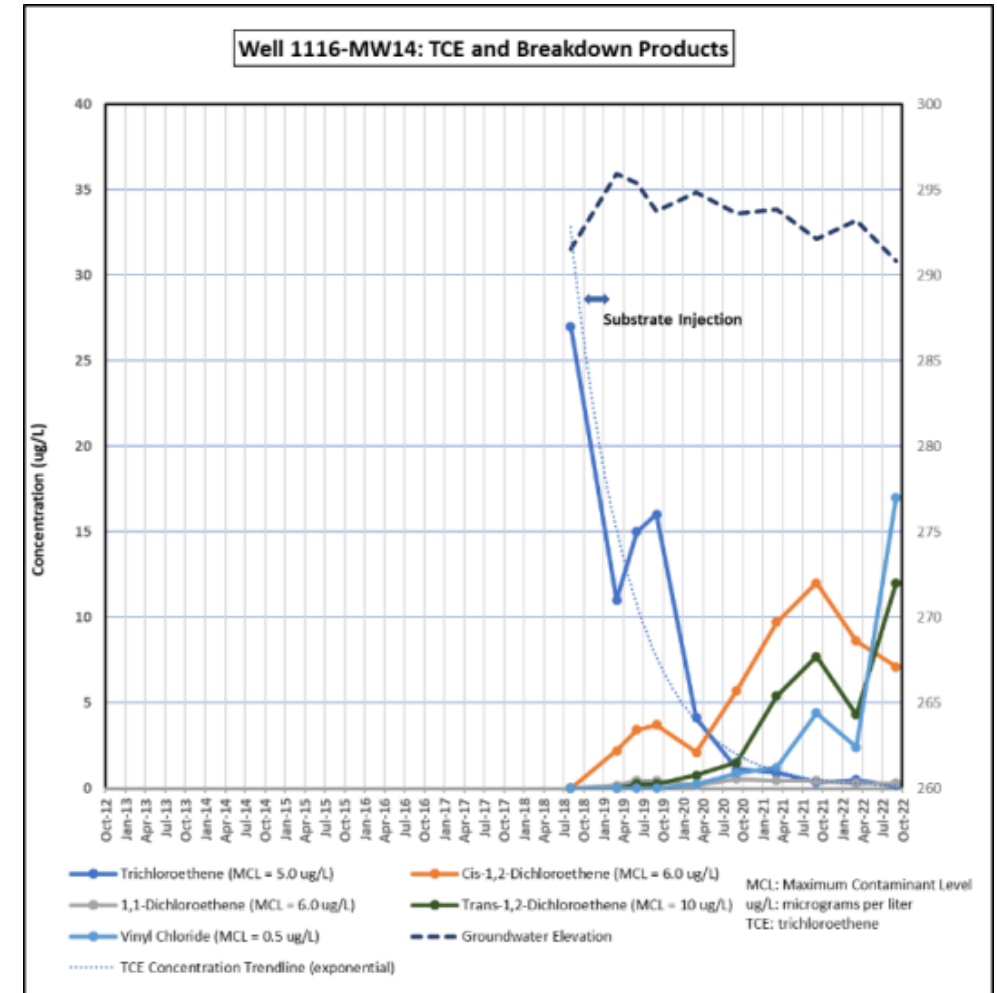
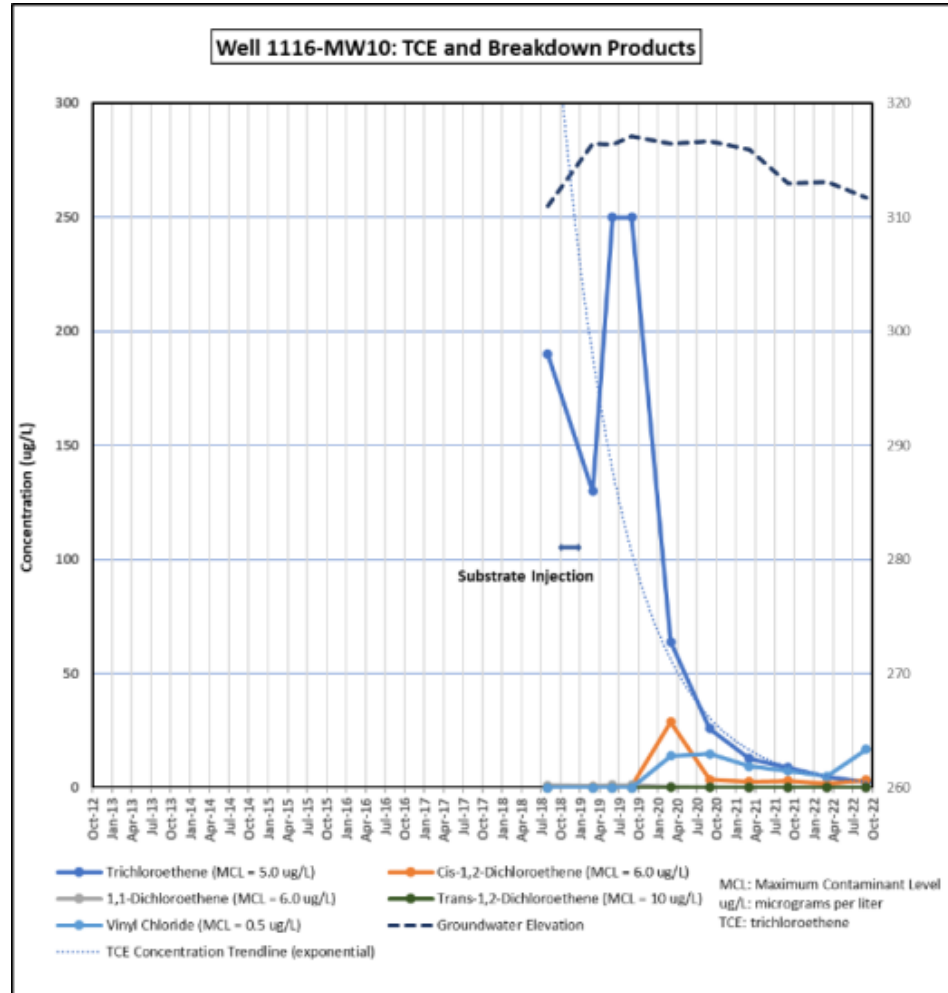
ORP in Wells With Increased TOC



Site Geochemistry

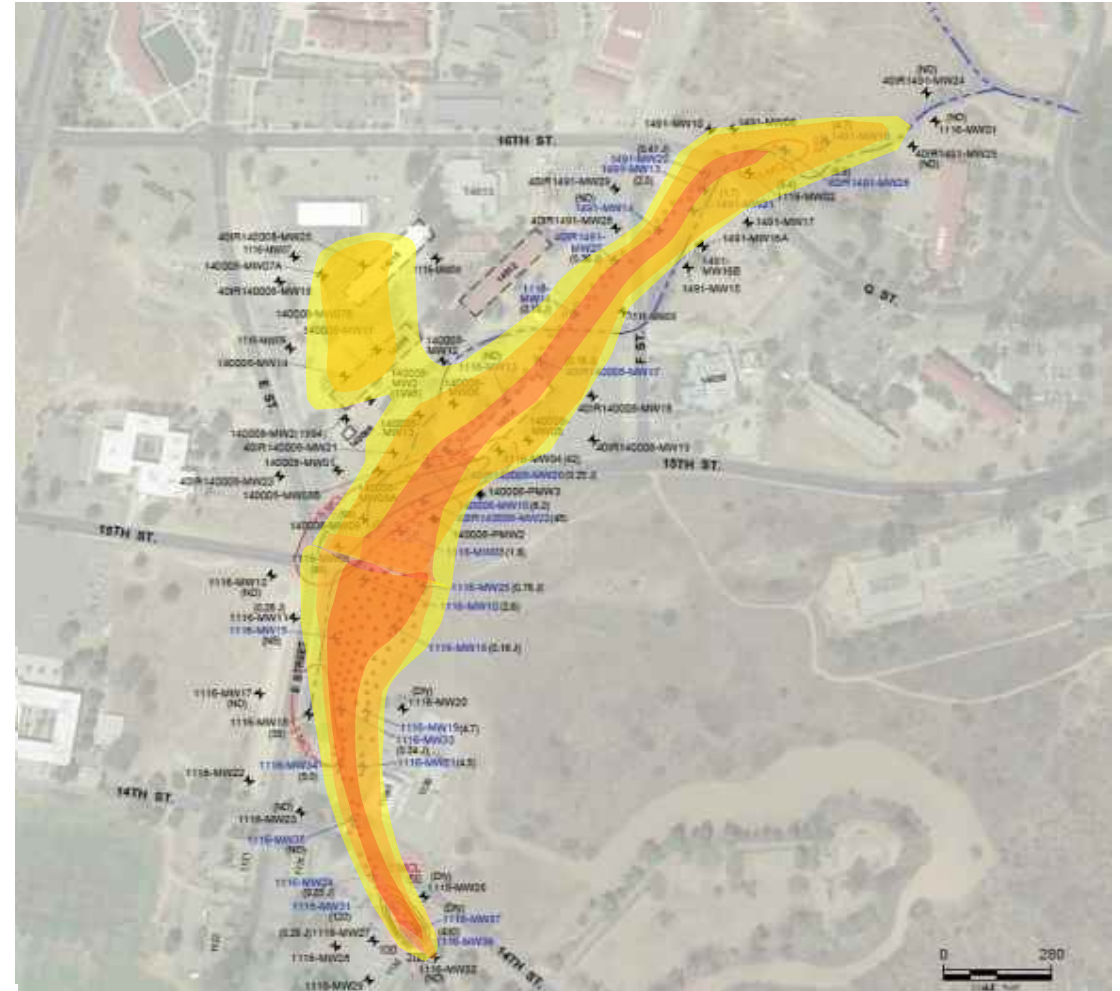


Reductive Dechlorination



Treatment Groundwater TCE Results

Extent of TCE in groundwater Plotted to CTRA



Presentation Summary

Emulsified Organic Substrate (ELS) easily distributed in fractured granitic aquifer

Following distribution oxidizing aerobic conditions are rapidly converted to anaerobic highly reducing (methanogenic) conditions.

Biologically mediated reductive dechlorination of TCE occurs rapidly

Some degradation may be FeS mediated biogeochemical reduction

Potential risk of TCE to indoor air removed

Questions?

