

Use of Zero-Valent Iron for Groundwater Remediation: Three Case Studies

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Nanoscale Particle Treatment of Groundwater

Naval Air Engineering Station
Lakehurst, NJ

Location and Site Conditions



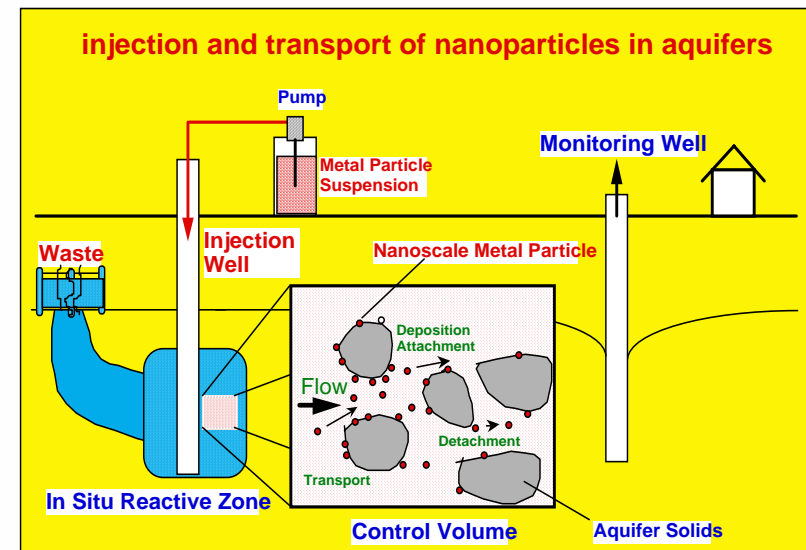
- Site of Hindenburg Crash in 1937
- Result from testing of aircraft launching activities
- Soil type = Coastal plain aquifer – mostly sand with some clay and gravel
- Targeted treatment depth was 50' – 70'
- Water table 15' BGS
- TCE present in GW up to 56 ug/L, avg. ~ 15 ug/L
- Two plumes treated with nanoscale iron with palladium catalyst
- Natural Attenuation was initially chosen, Regulators required more aggressive treatment
- >\$1M spent on MNA



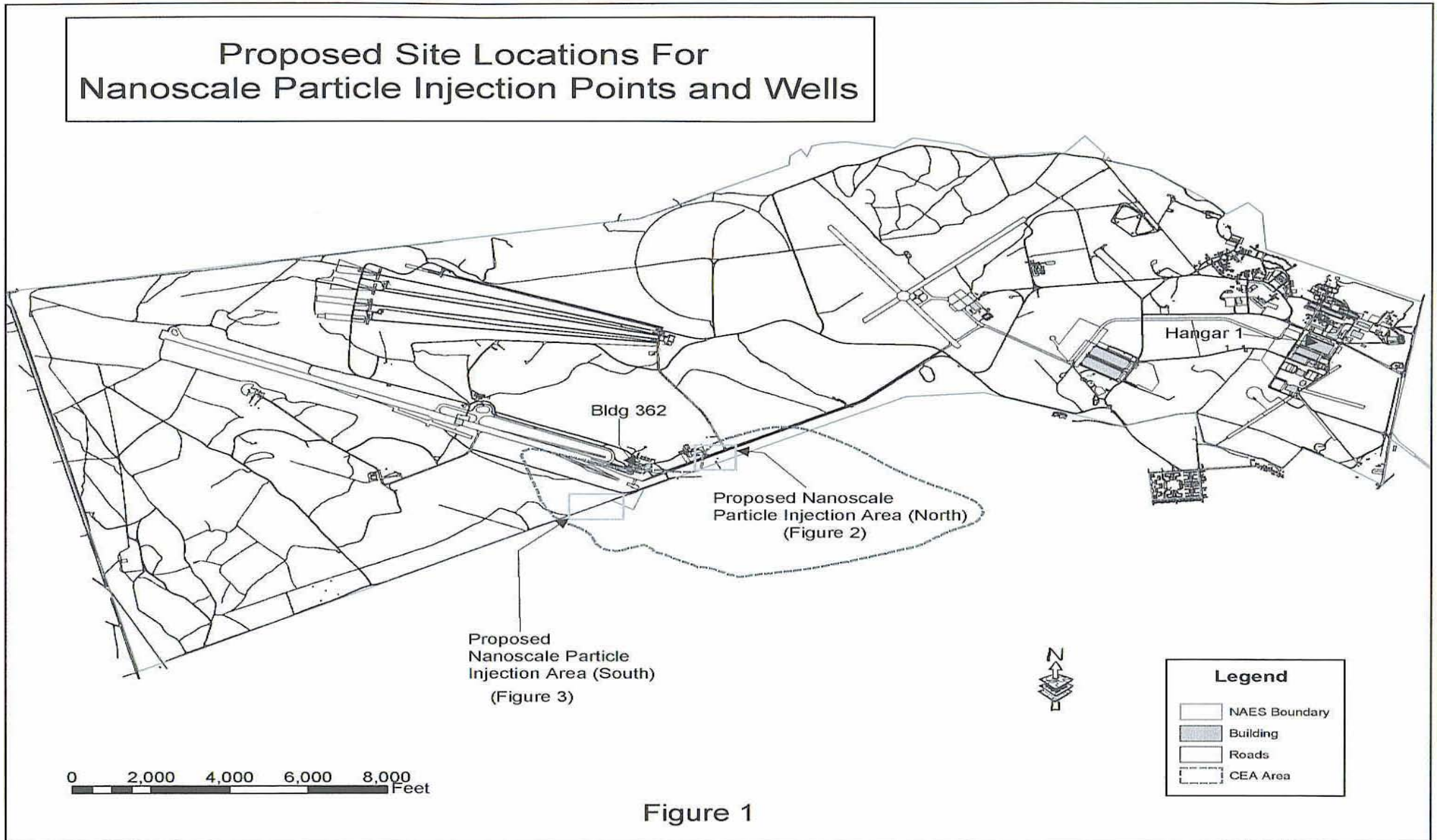
Treatment Details



- Used 20 lbs nanoFe/1200 gal water in each of 15 Geoprobe injection points
- Solution injected over a 20-foot interval (50'-70'), in equal 2-ft lifts
- Used GW from nearby extraction well
- A total of 300 lbs NanoFe injected
- TCE levels reduced up to 50% in single injection – additional injection anticipated
- NanoFe = nanoscale iron with a Pd⁰ coating (catalyst)
- 1.7 lbs Palladium used in Phase I; 3.75 lbs used in Phase II



NAES Lakehurst Site Locations



NAES Lakehurst Northern Plume



Proposed Nanoscale Particle Injection Wells, Northern Plume

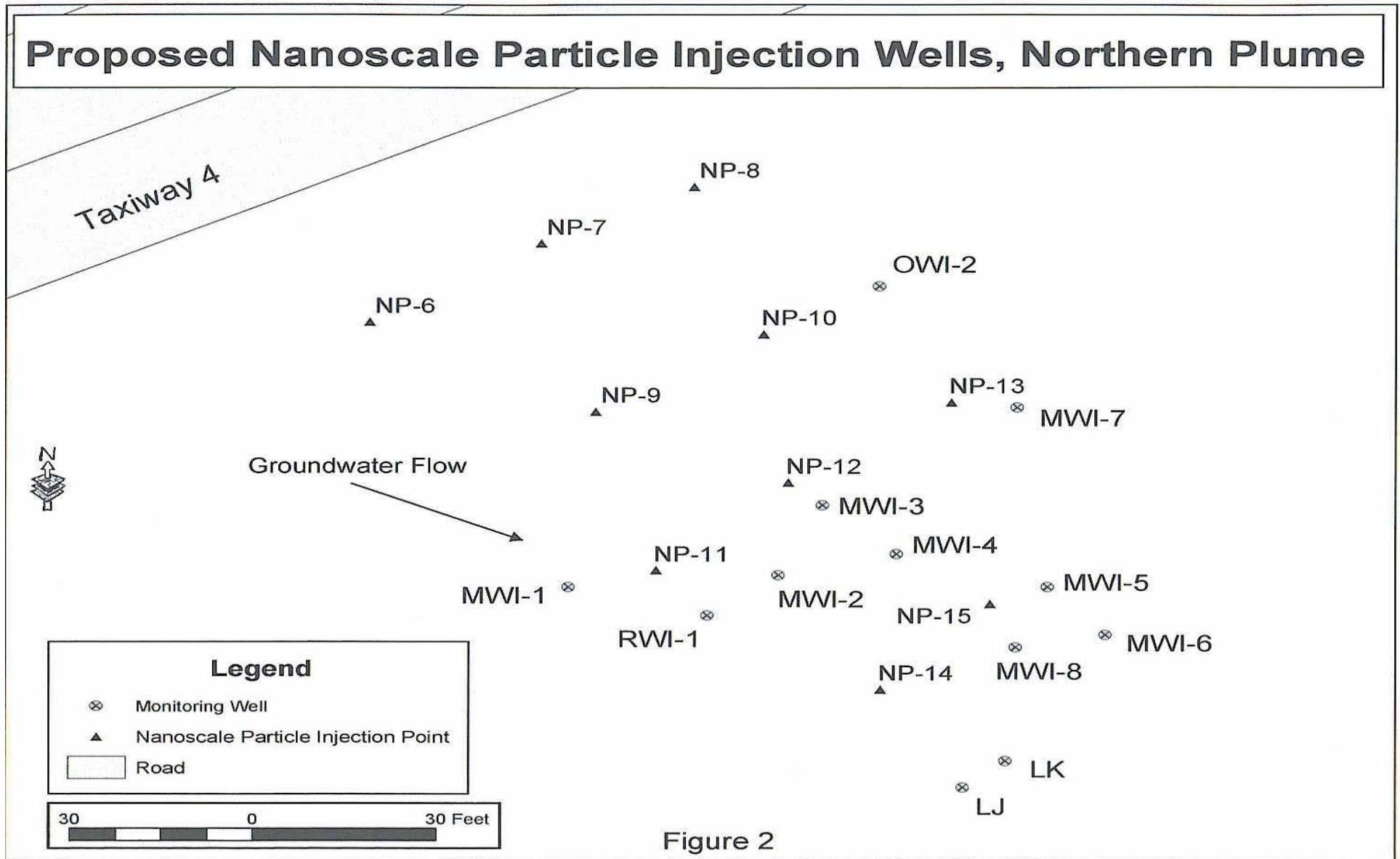


Figure 2

NAES Lakehurst Southern Plume

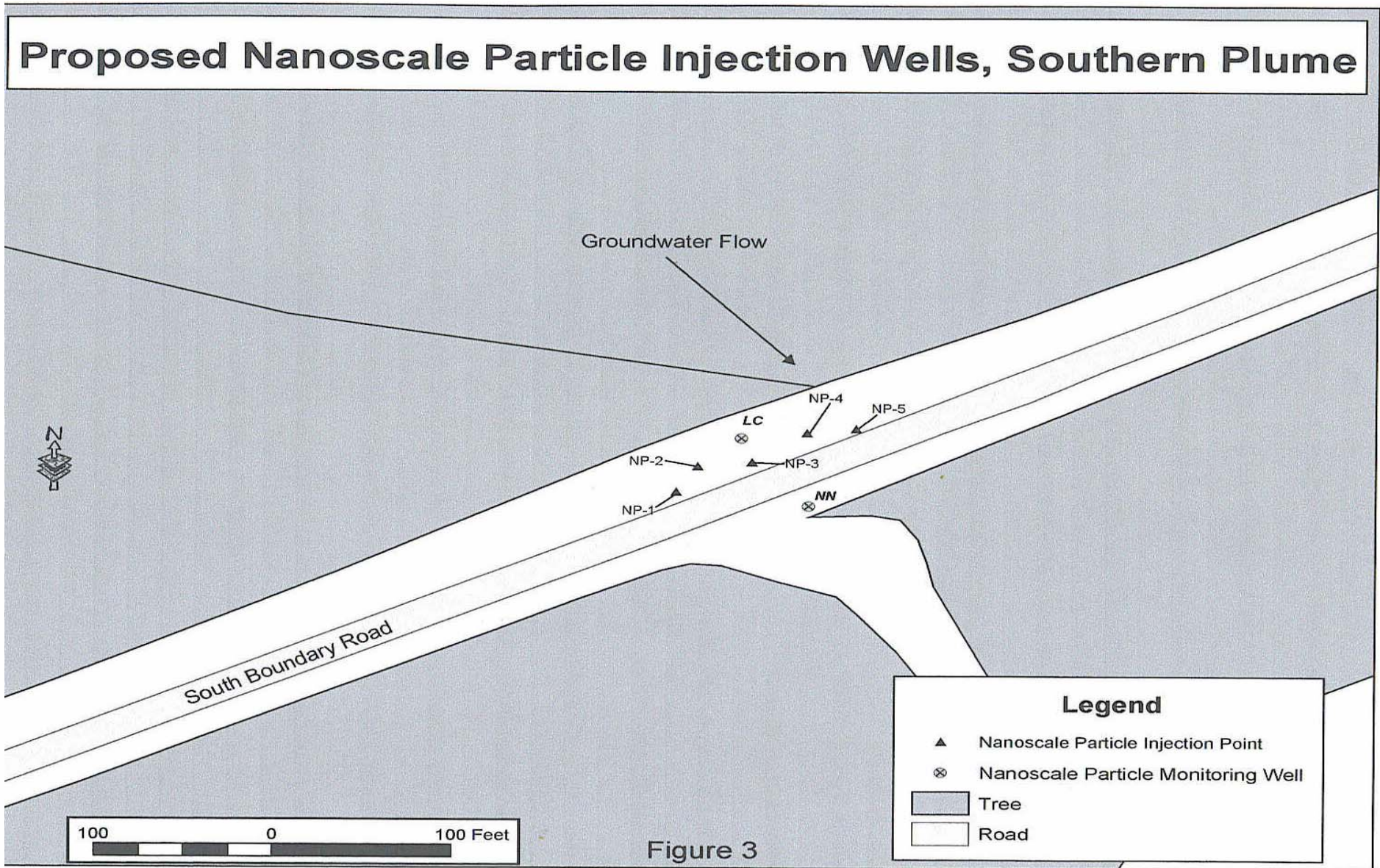
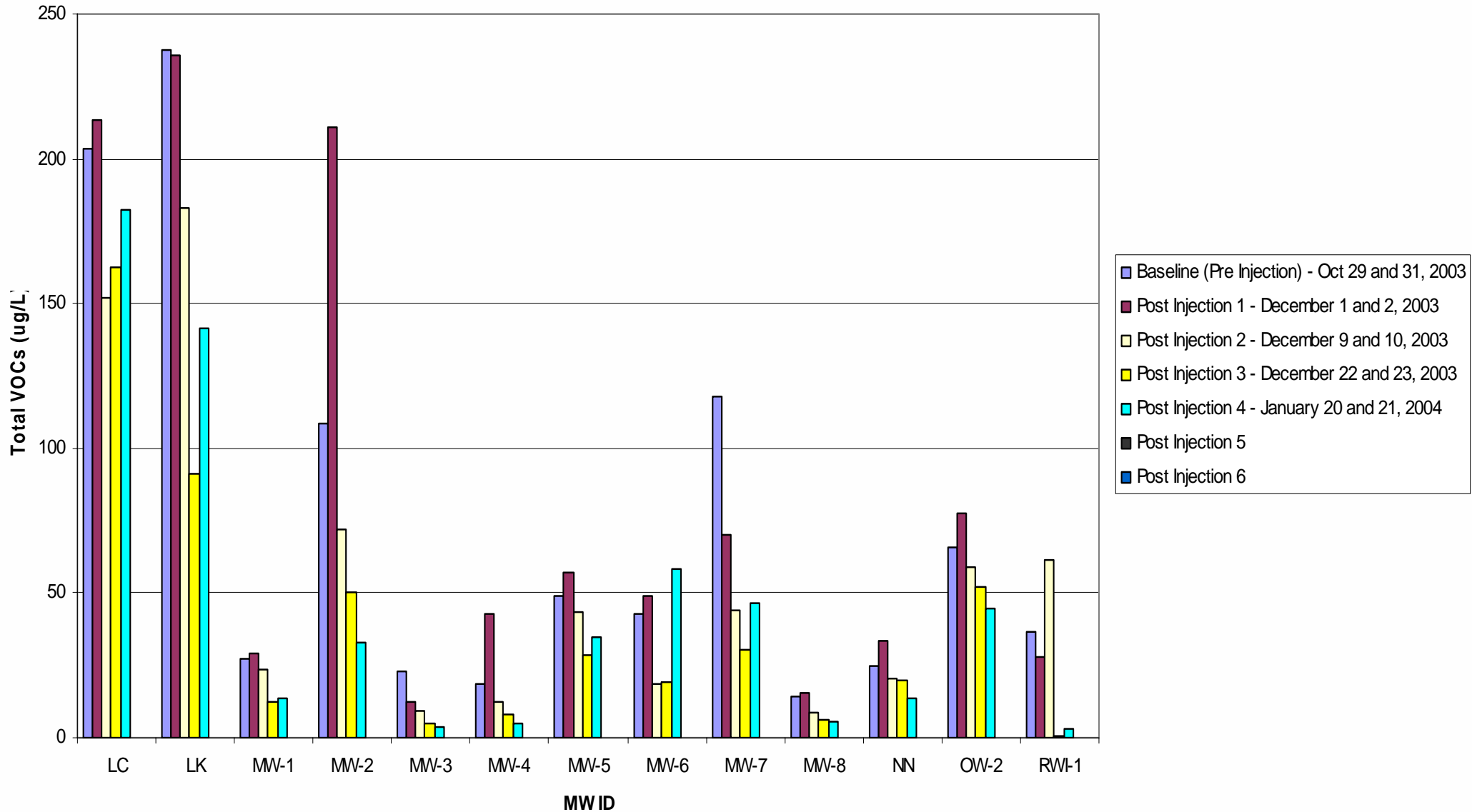


Figure 3

Total VOCs Sampling Results



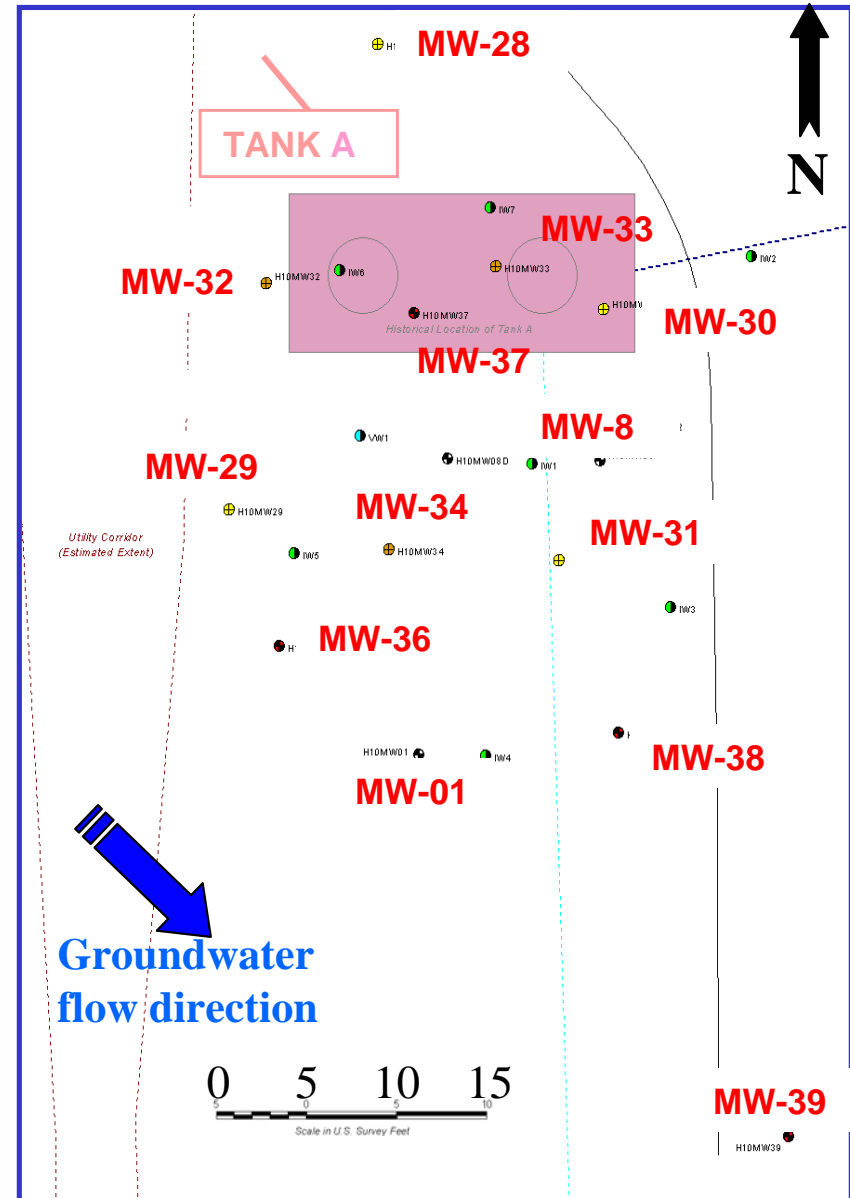
Source Area Treatment with Nanoscale Particles

Naval Air Station
Jacksonville, FL

Location and Site Conditions



- Hanger 1000
- Tank A removed in 1994
- Soil
 - Fine to medium sand, silty sand, and clayey sand from 0 to 24 feet bgs
 - Dense clay from 24 to 54 ft bgs
 - TCA = 337 mg/kg
 - TCE = 224 mg/kg
 - PCE = 139 mg/kg
- Groundwater
 - Flow toward southeast
 - Water table at 7 feet bgs
 - TVOCs => 50mg/l
- Engineering Control and MNA anticipated as next step



Treatment Details



- **Nanoscale Iron**
 - Food grade Polymer Supported w/Palladium Catalyst
 - Purchased from PARS Environmental
 - CVOC mass estimated: 40 to 125 lbs
 - 300 lbs of iron was injected
 - Prior to 2003, nanoscale iron was not commercially available
 - Costs for the nanoscale iron has dropped 2 times



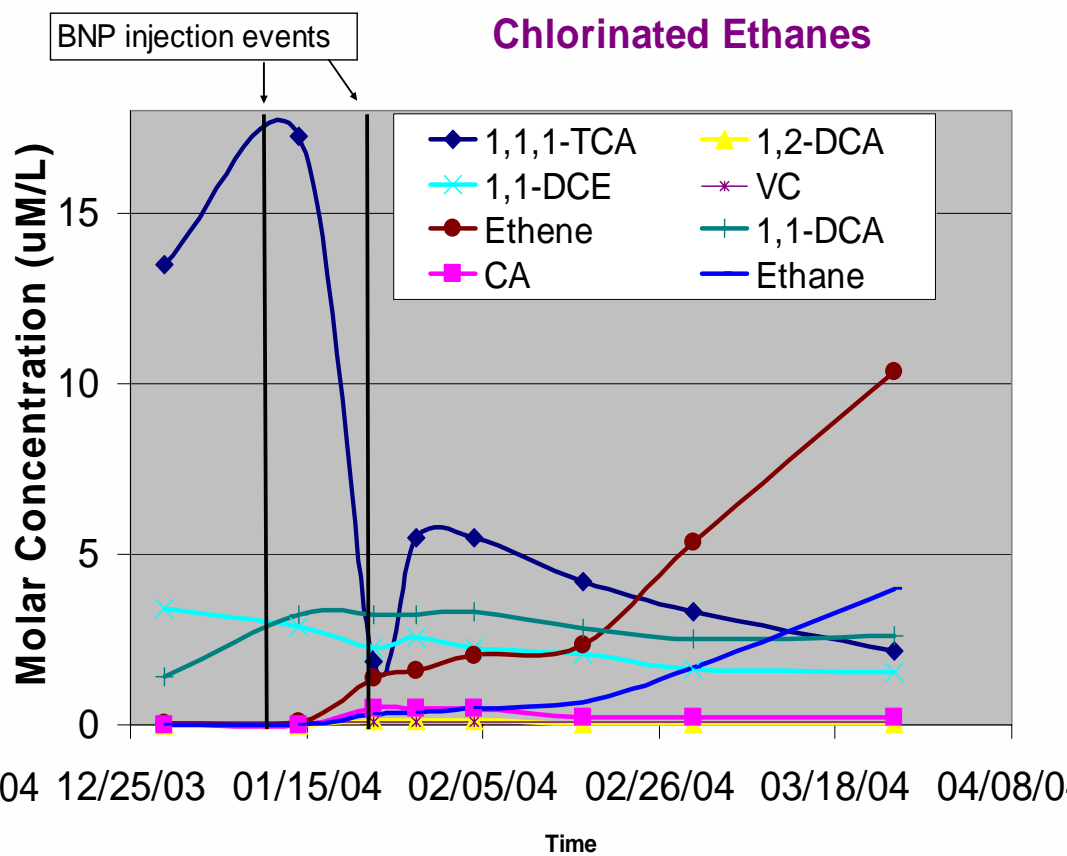
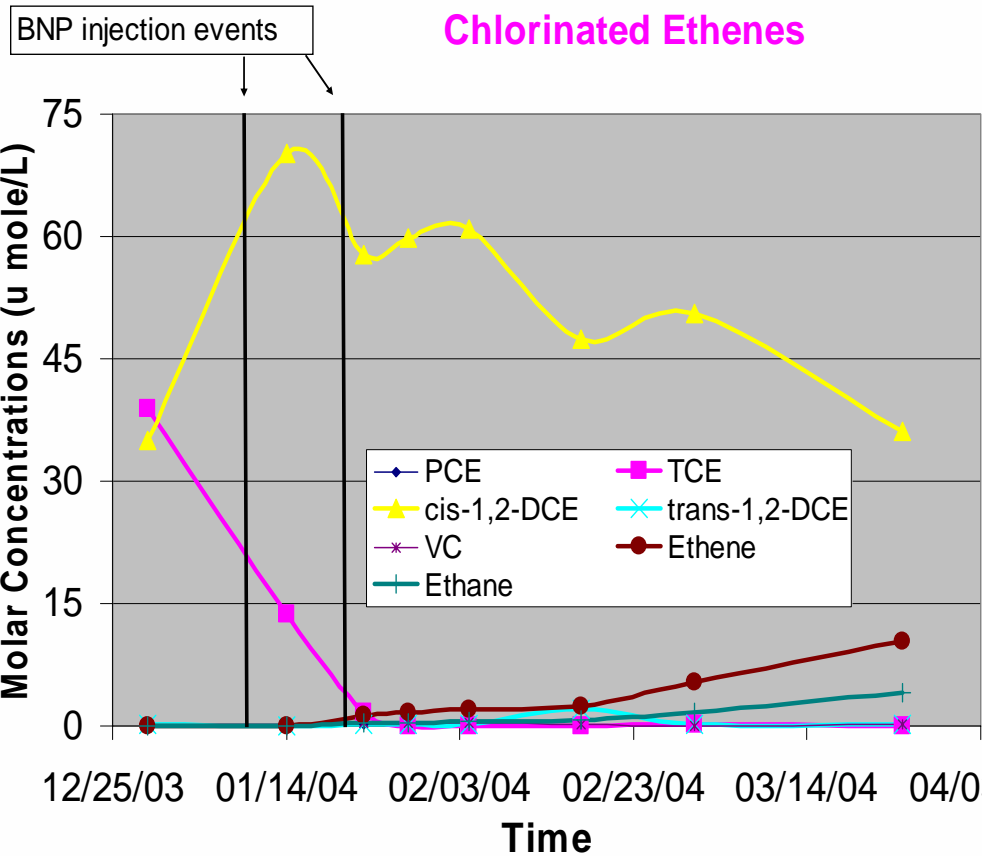
Treatment Details (con't)



- **Two injection methods:**
 - Strategic DPT injections
 - Recirculation Process
- **More work is yet to be done:**
 - Groundwater sampling for 3 remaining quarters
 - Confirmation soil sampling
- **Cost estimates**
 - Current is \$300-350/yd³
 - Excavation estimated to be \$400-500/yd³
 - Estimate with less sampling and lower iron costs is \$215-265/yd³



Source Well MW-37 Results



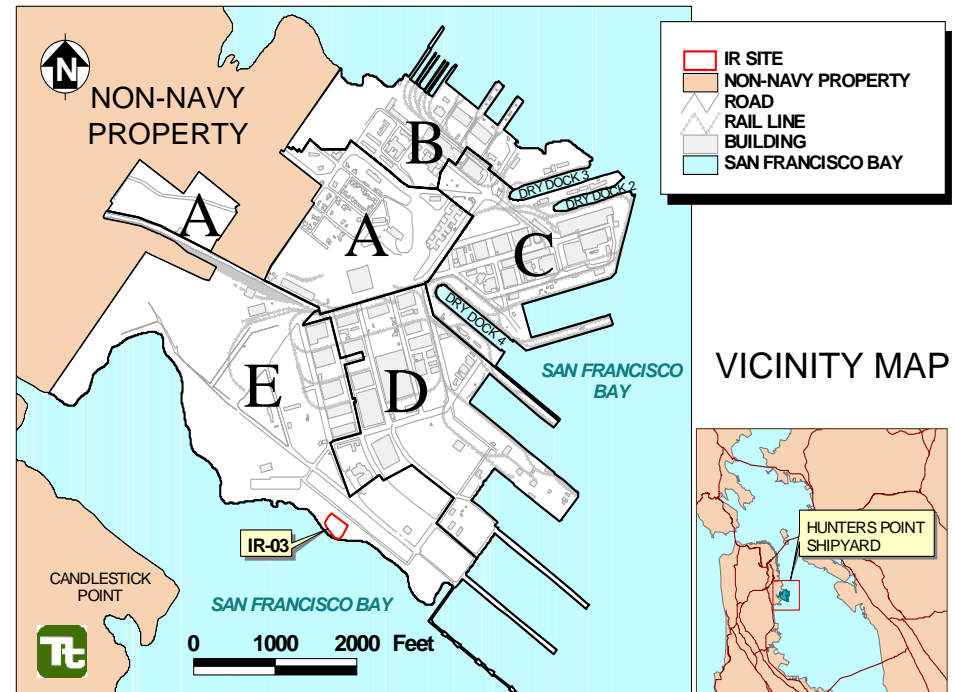
Micro-Scale ZVI Treatment of Groundwater

Hunter's Point Shipyard
San Francisco, CA

Location and Site Conditions



- Remedial Unit C4
- Pneumatic fracturing to inject micro-scale ZVI
- Soil type = 10ft layer of artificial fill over fractured bedrock
- Targeted depth is 7ft bgs to 32 ft bgs
- Water table is 7 ft bgs
- TCE present in GW up to 88 mg/l
- Removed 99.1% of total chlorinated solvents
- Project cost estimate was \$117/yd³



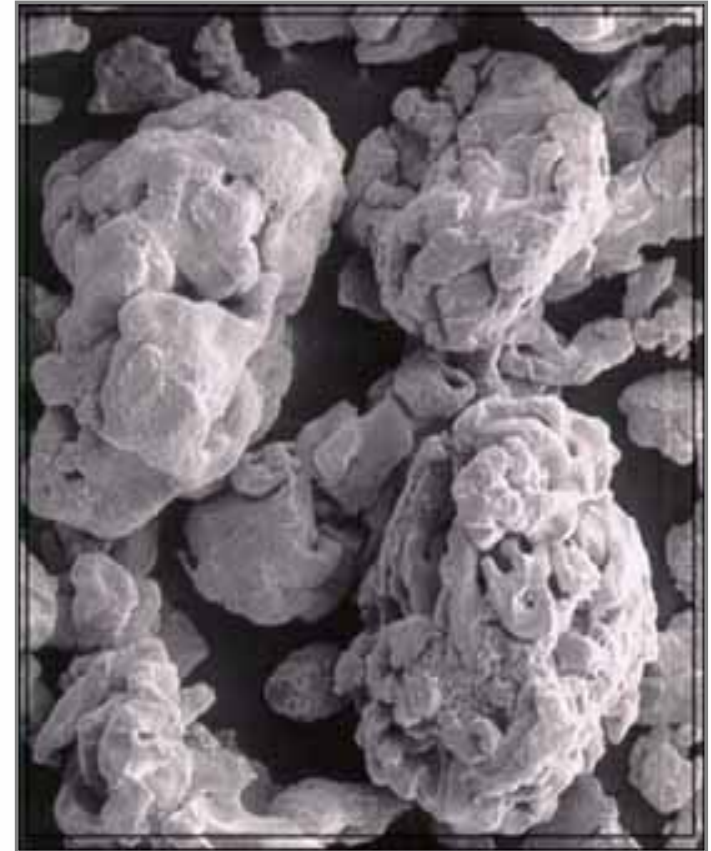
Hunter's Point Shipyard

ZVI

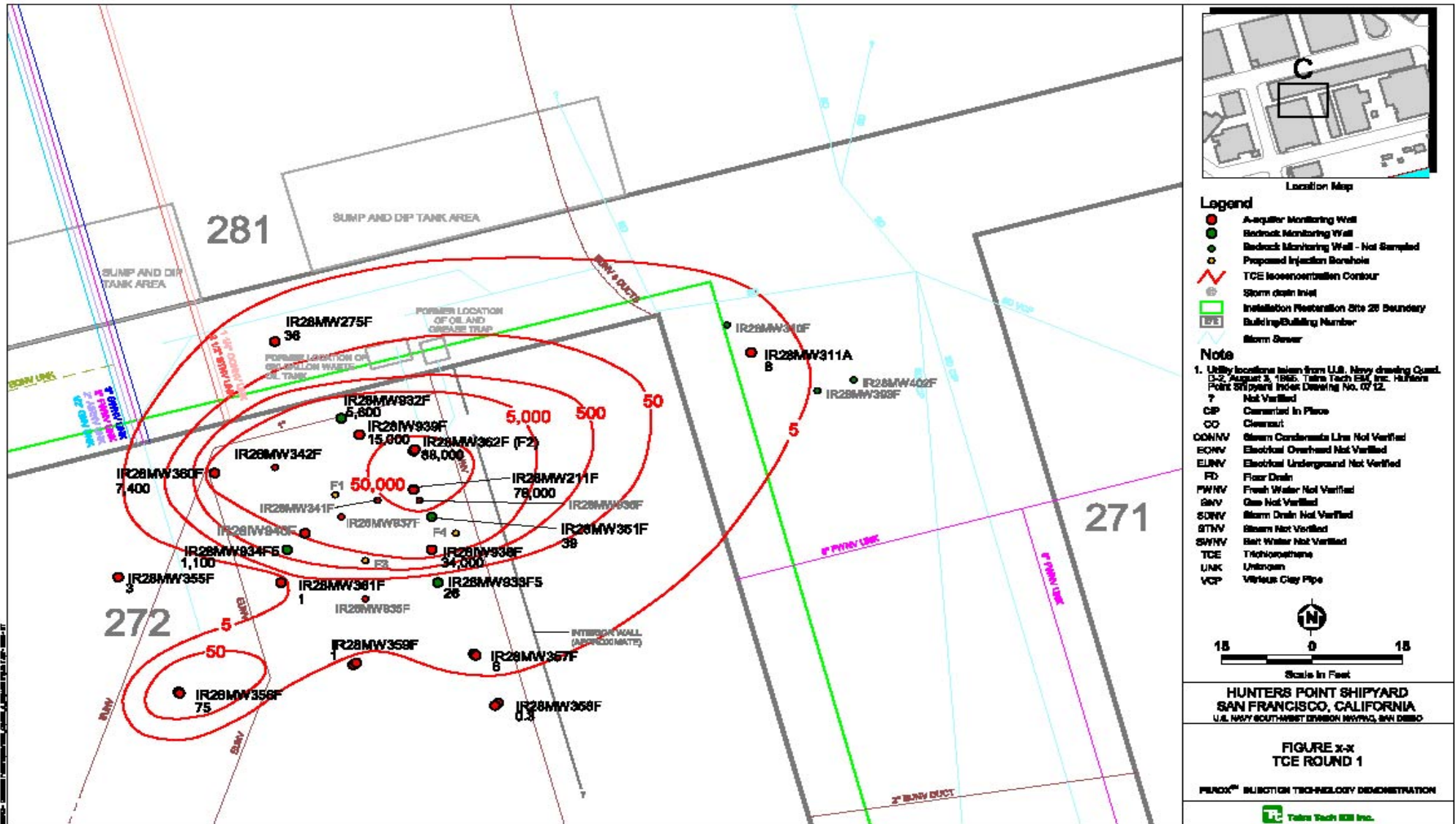
- ~40 um particles
- High Purity Iron (95%+) with trace carbon within the particle structure

Pneumatic Fracturing

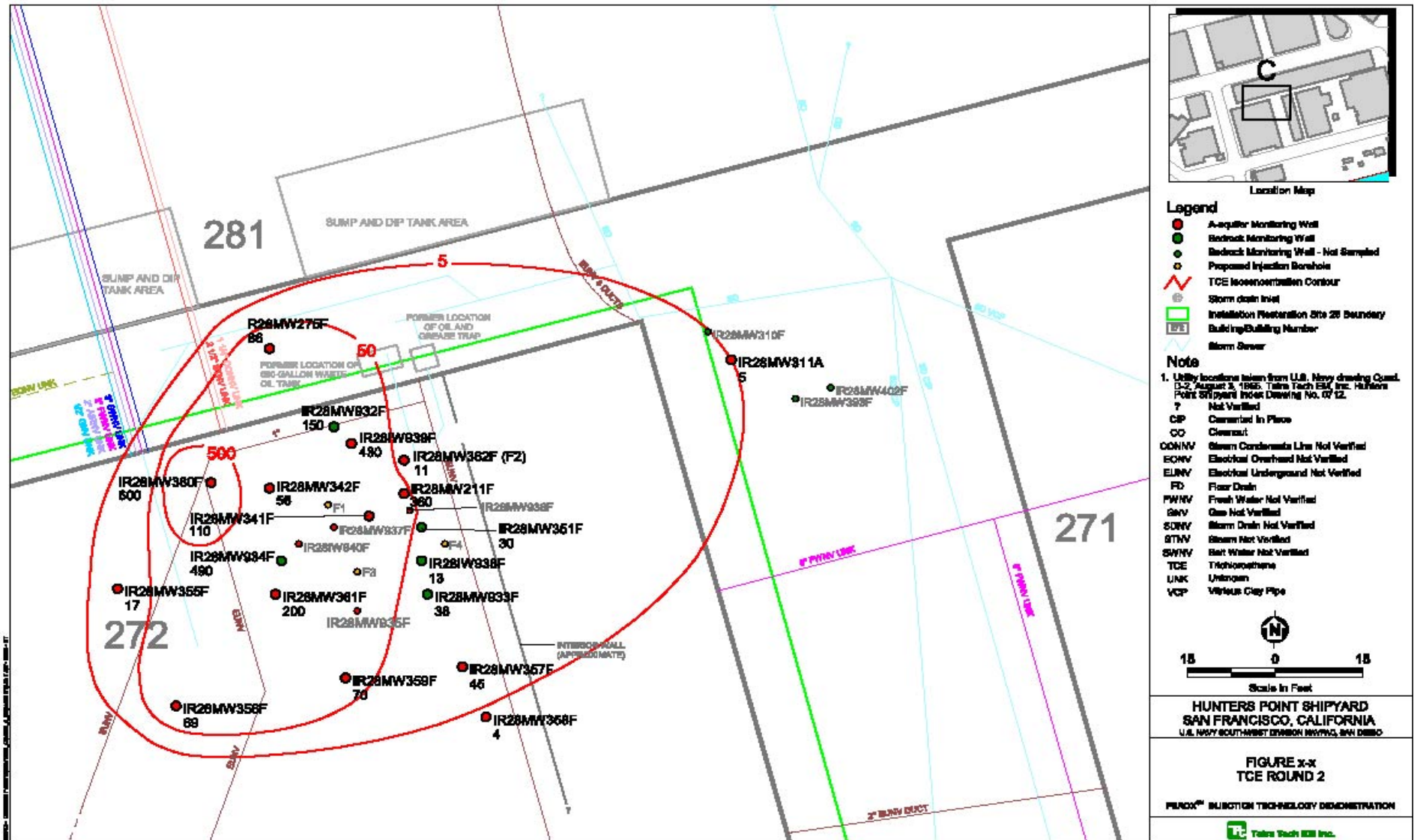
- Inject nitrogen gas for 10 – 15 seconds to fill pore spaces (and open new pore spaces)
- Following initial nitrogen injection, ZVI-water slurry is introduced to the gas stream
- Nitrogen acts as carrier fluid to atomize and disperse slurry into the formation
- Liquid atomized injection of ZVI slurry increases contact with contaminants
- 4 injection boreholes with 15 ft radius



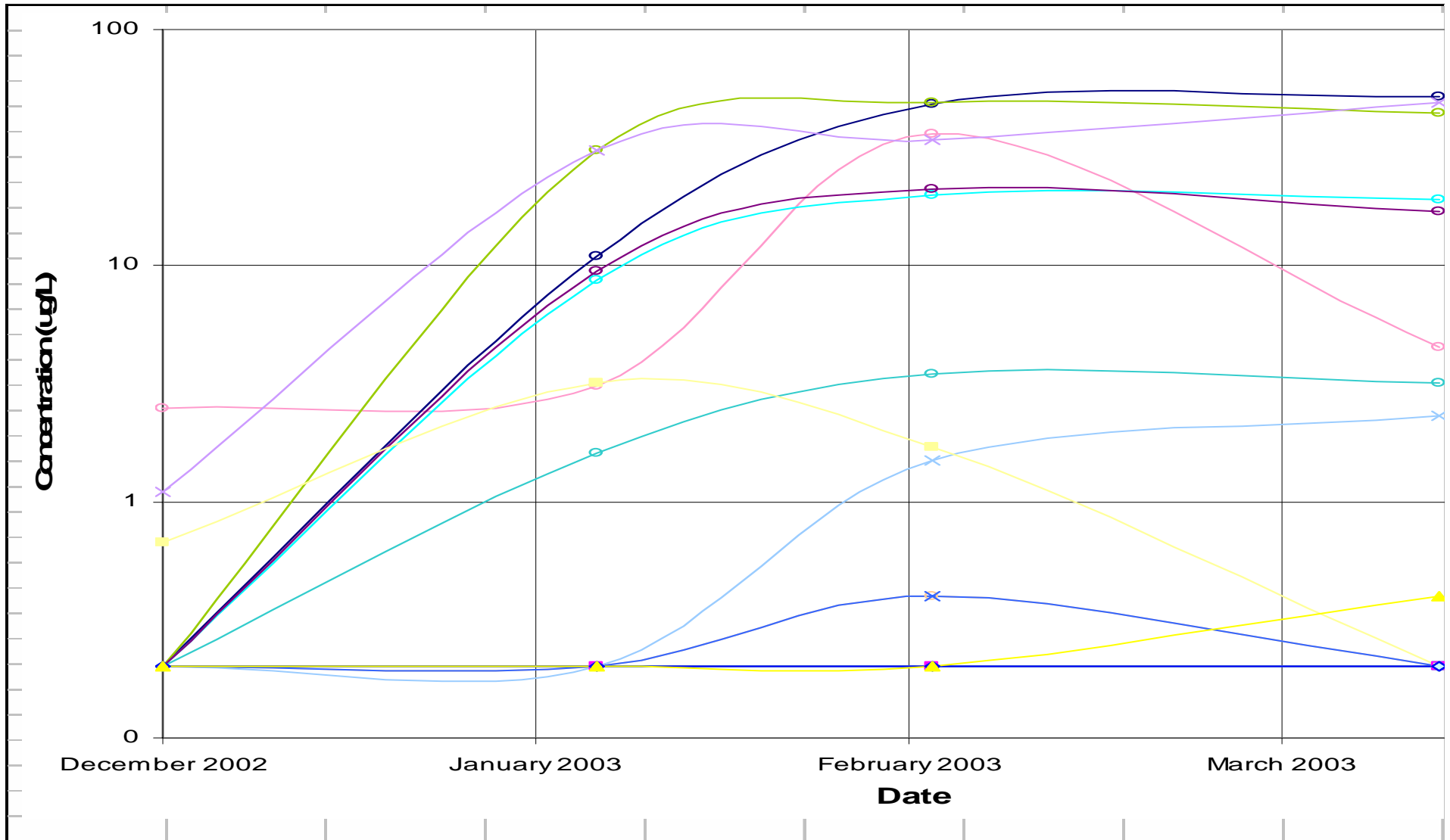
Hunter's Point Pre-ZVI Injection



Hunter's Point Post-ZVI Injection



Hunter's Point Ethene in Groundwater vs. Time



Hunter's Point Conclusions

- TCE in groundwater was reduced 99.2% in 3 weeks
- Project cost estimate was \$117/yd³
- Plume displacement not significant
- Radius of influence ranges from about 15 to 20 feet
- Applied to additional sites
- Evaluating applicability to another site with concentrations close to MCLs