Zero Valent Iron (ZVI) Powder Injection for In-situ Dechlorination of Chlorinated Organic Compounds at Hunters Point Shipyard, SF, CA.

Project Team

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ETS2003-Fe1

Presentation Outlines

- Introduction
- Location
- Primary Objectives
- Site Conditions
- Chemistry
- Data Summary
- Preliminary Results Discussions/Conclusions

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Introduction
ZVI Injection Project

Hunters Point Shipyard (HPS), located adjacent to San Francisco Bay, is currently undergoing remedial activities for decontamination of TCE/PCE in groundwater and soil, under the CERCLA and BRAC Processes

At site designated as RU - 4C in the HPS, there is a significant TCE/PCE contamination that must be remediated

Zero Valent Iron (ZVI) chemical reduction (for dehalogenation) process has been selected for its cost-effectiveness evaluation at this Hunters Point Shipyard site. ARS Technologies conducted a Ferox^{sm} test

ARS Technologies, which will follow this Navy's presentation would provide in details of their involvement in performing this technology demo work

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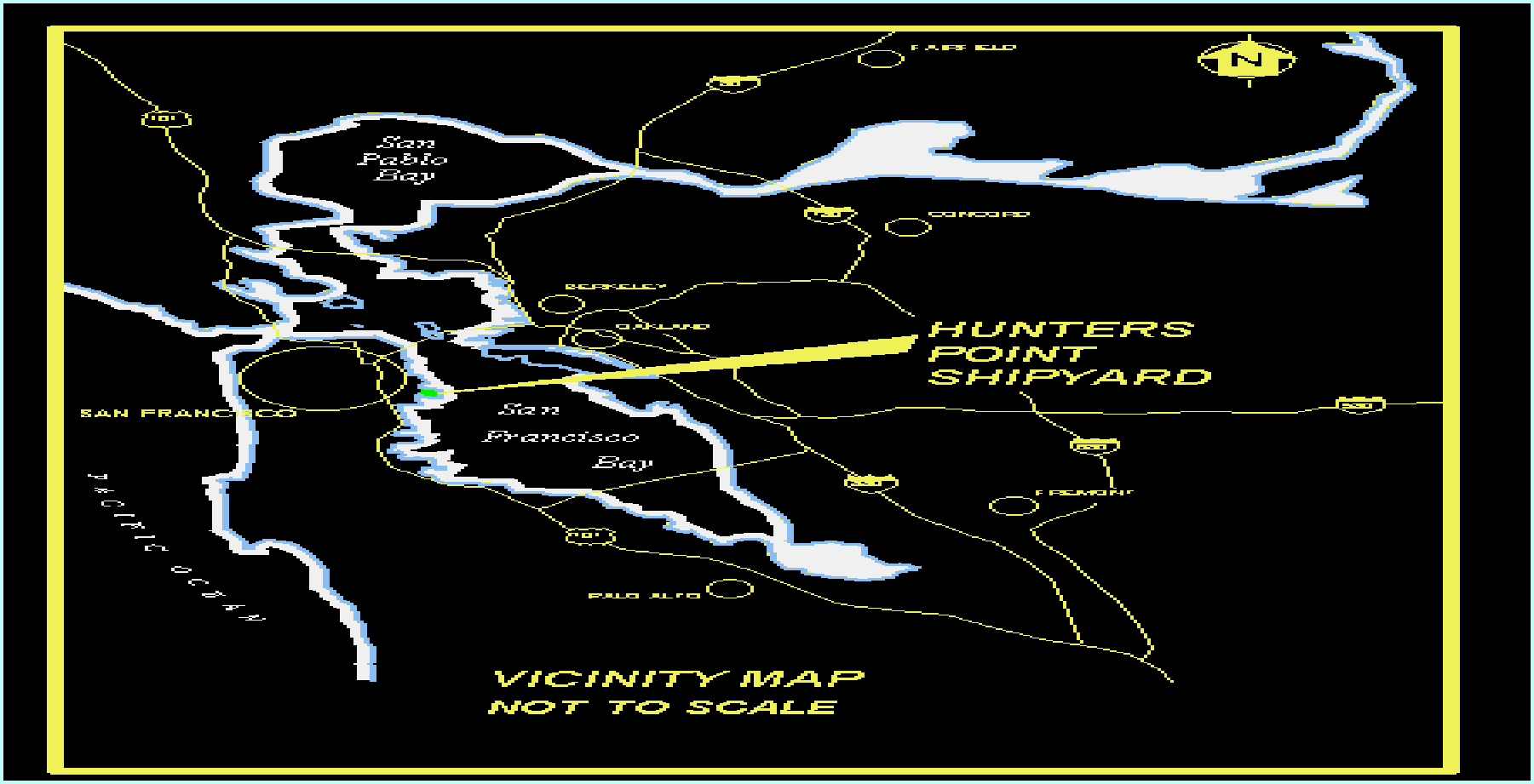
Hunters Point Shipyard
San Francisco, CA



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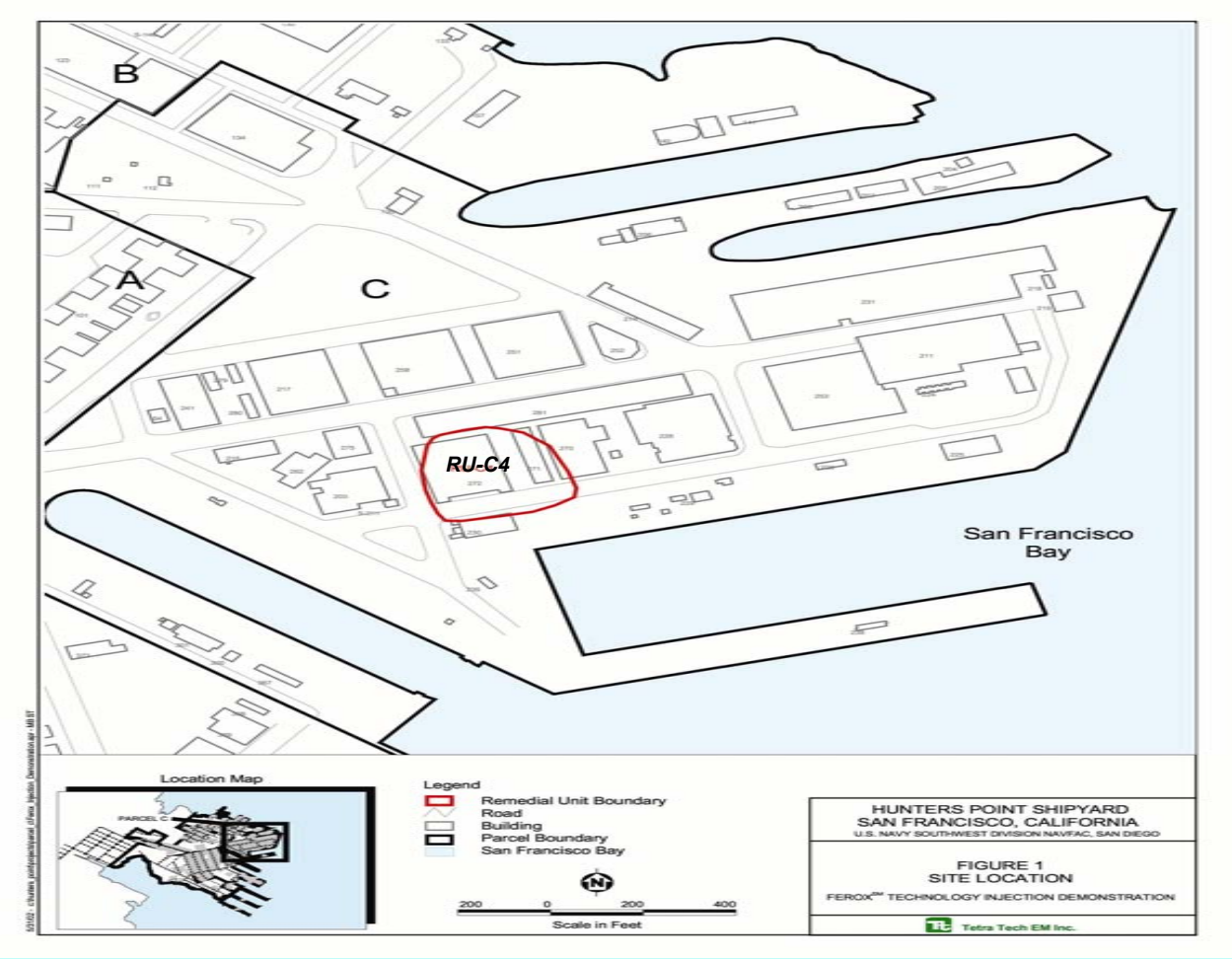
ZVI Technology Demonstration Site RU - C4



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Primary Objectives

- **Determine capability and cost-effectiveness for using ZVI powder injection to dechlorinate TCE/PCE in groundwater**

- **Evaluate potential plume displacement that may occur during ZVI injection**

- **Assess Radius of Influence at the project site**

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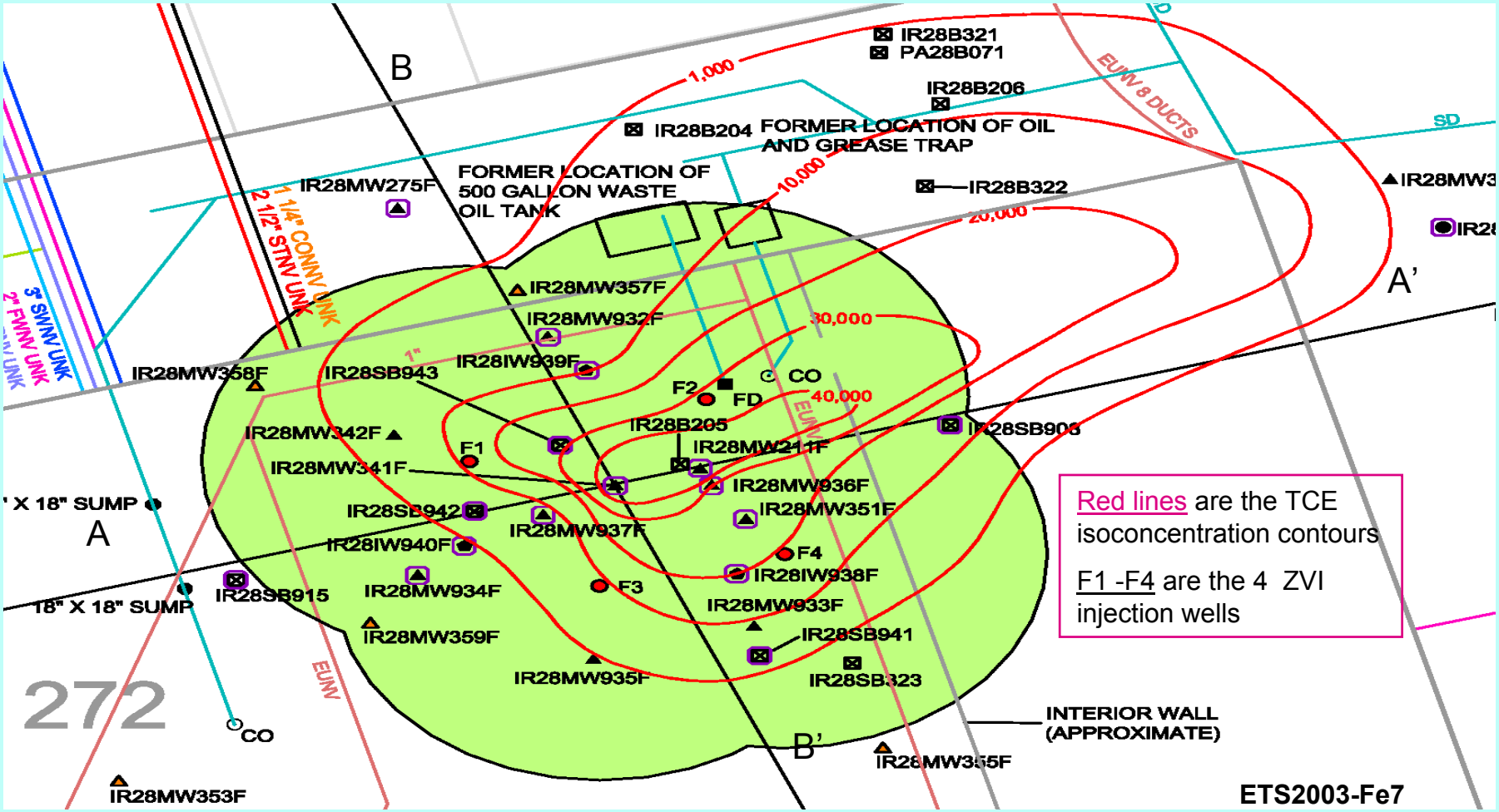
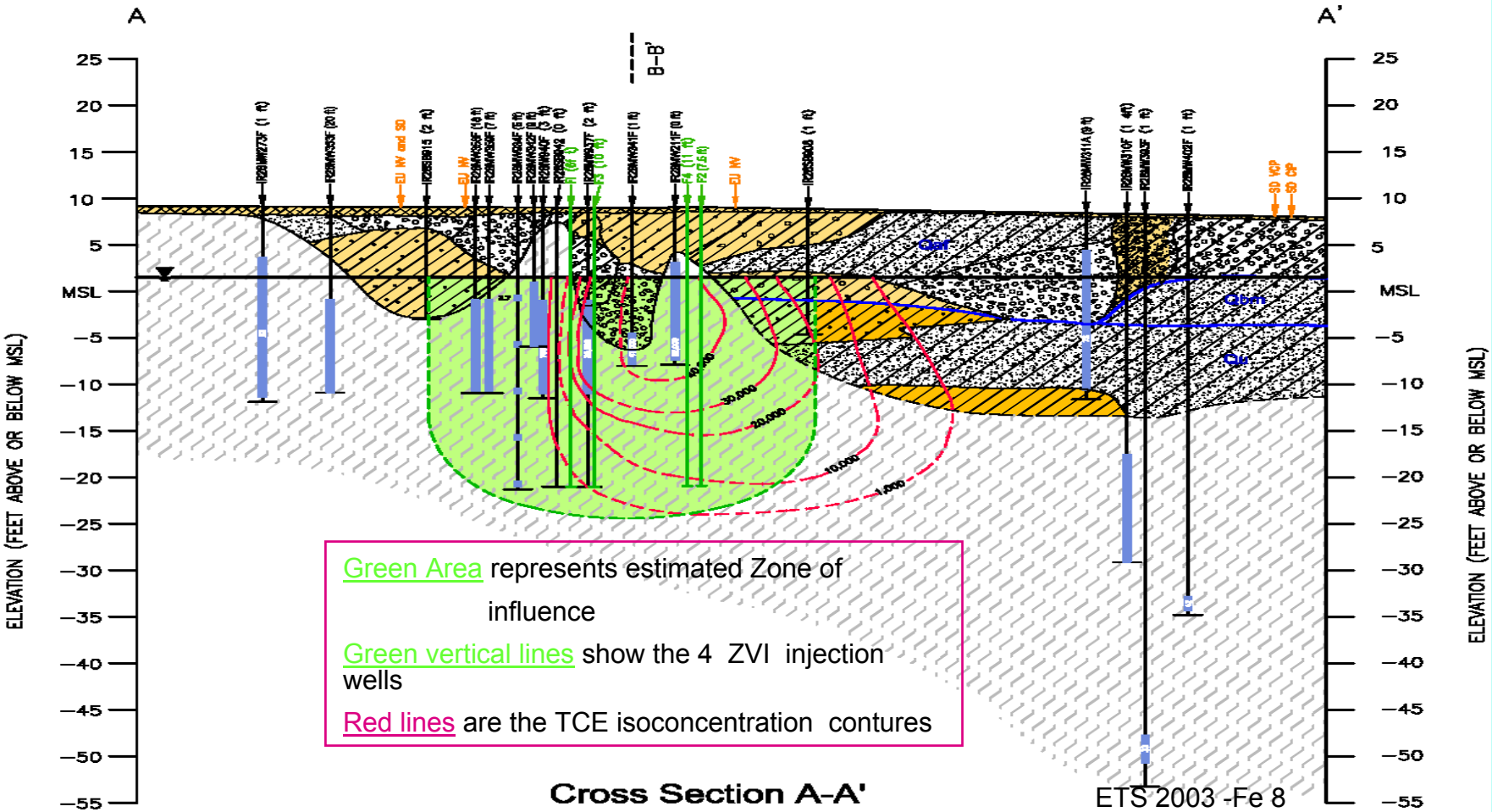
Estimated ZVI Treatment Zone at RU-C4



Existing Underground Conditions : (A-A') Cross Section View



Green Area represents estimated Zone of influence

Green vertical lines show the 4 ZVI injection wells

Red lines are the TCE isoconcentration contures

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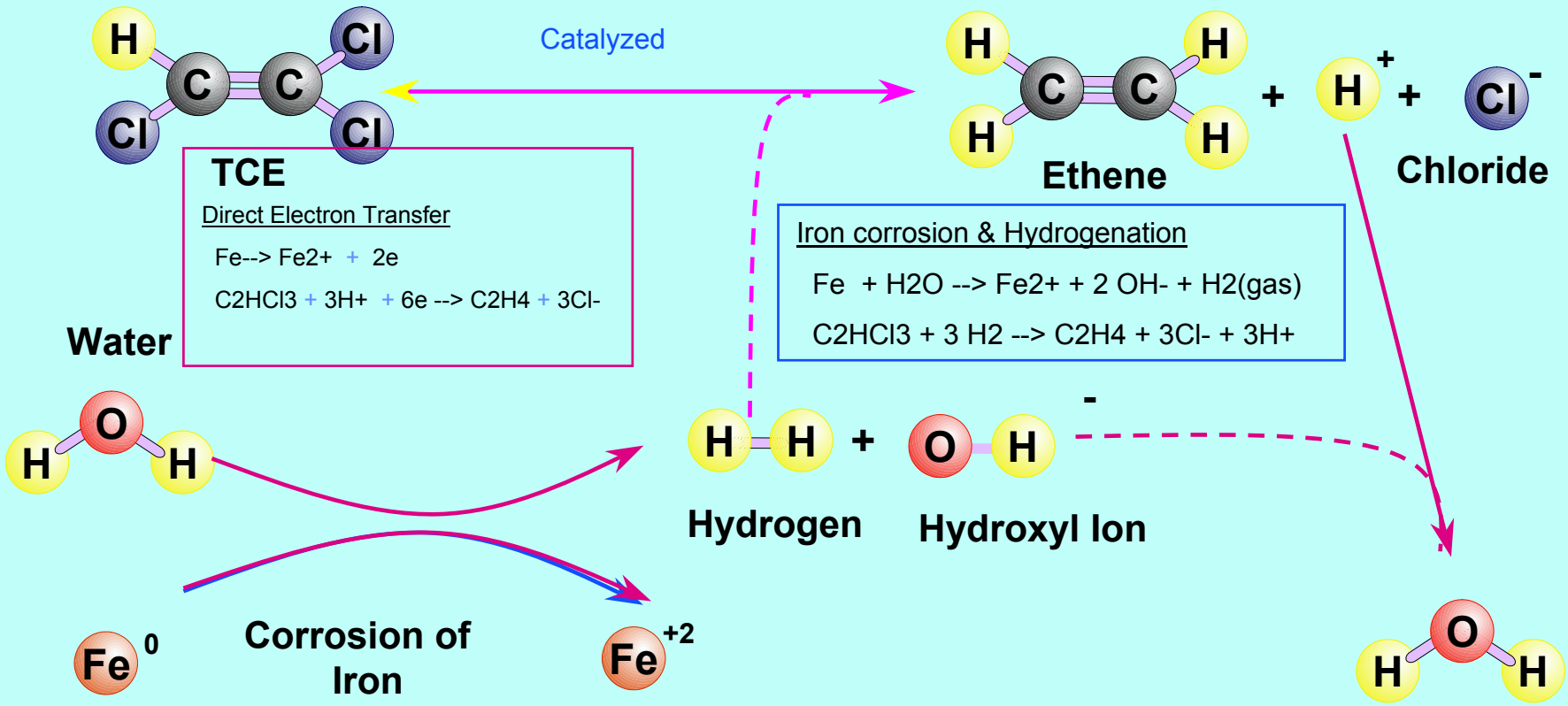
ZVI Technology Chemistry (direct electron transfer & hydrogenation)



Note: Equation not stoichiometrically balanced

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ZVI Particle Surface Area Comparison

(Chemical reactivities are in proportion to SA)

Iron type	Surface Area (SA) in m^2/g	Ratio to BNP
Iron turnings	0.019	x1,763
Electrolytic iron	0.057	x 587
Iron granules	0.287	x 116
Commercial iron powder	0.900	x 37
Synthesized BNPs (bi-metallic nanoparticles; generally coated with Pd/Pt)	33.500	x 1

Iron powder has about 47 times larger SA (exposure) than the iron turnings'

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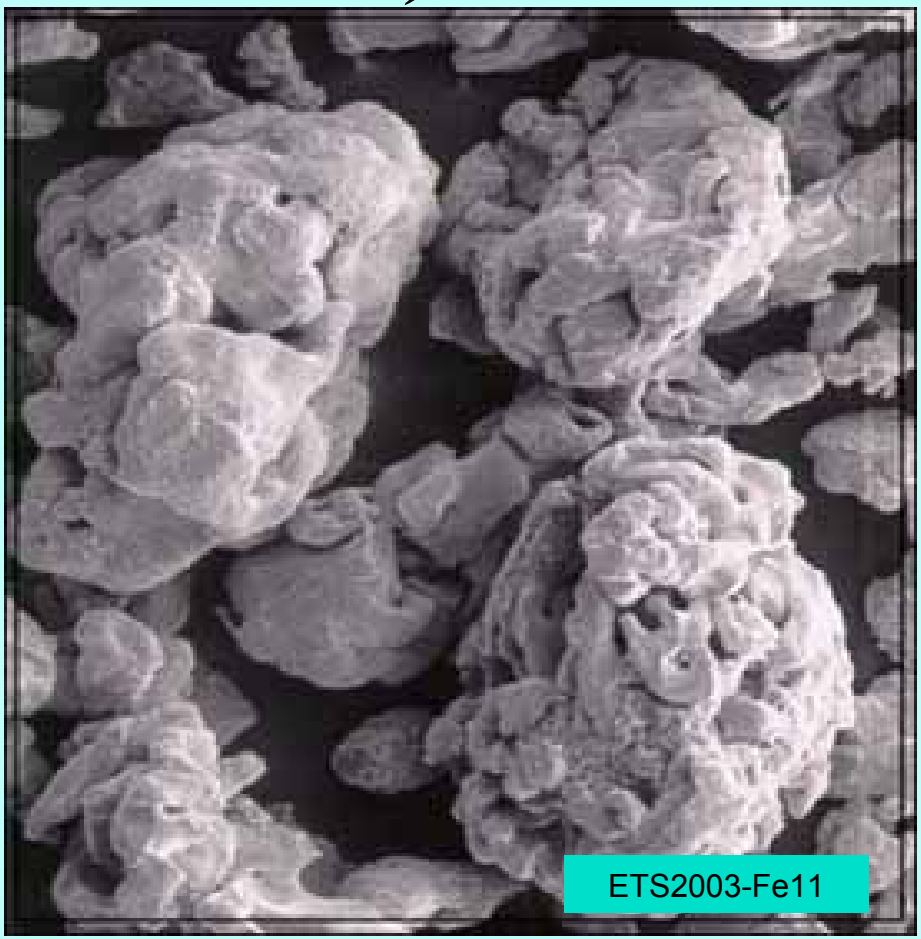
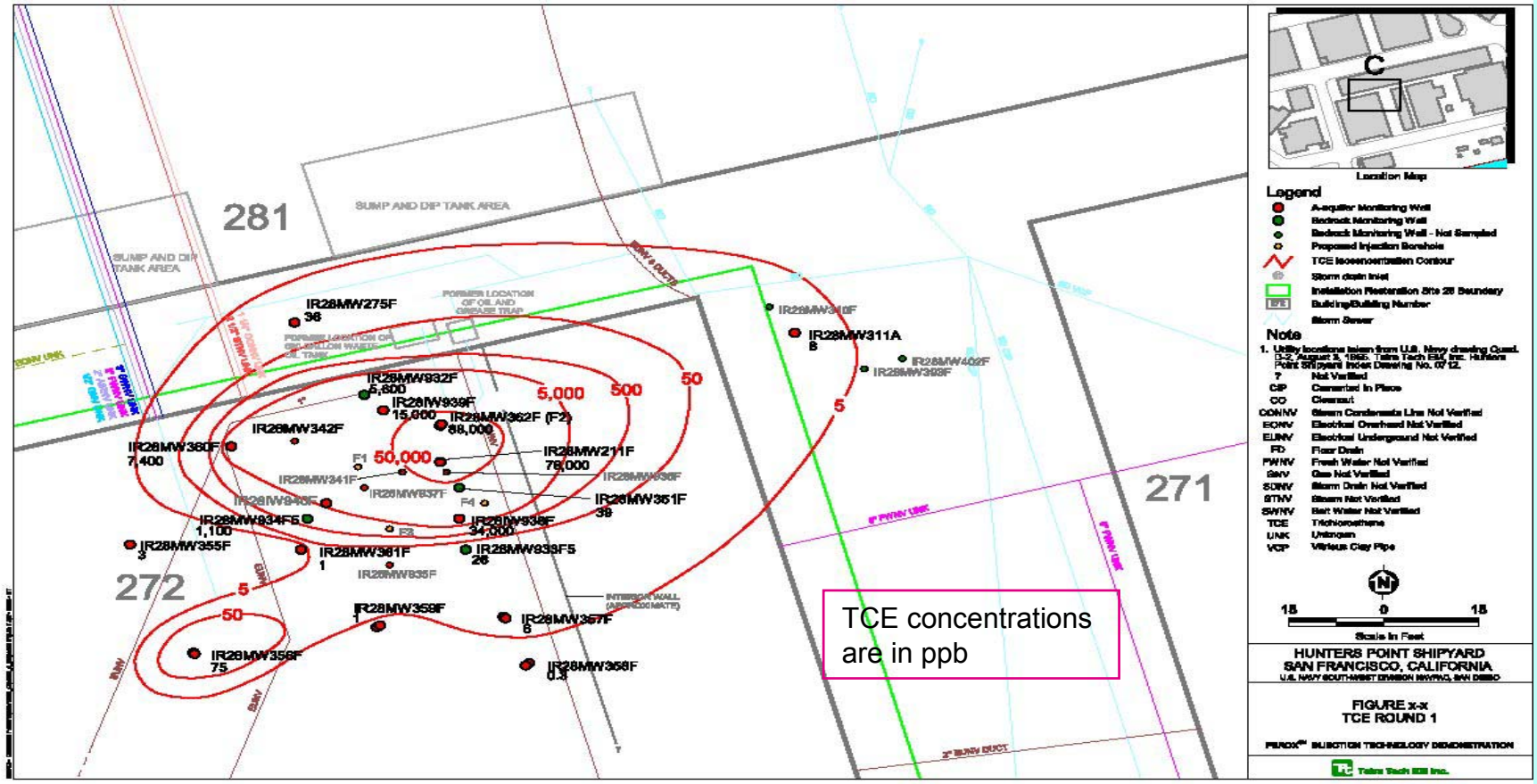
High Reactivity of ZVI Powder (Influential Factors)

- Irregular Shape Provides High Reactive Surface Area
- Particle sizes are ~40 µm (avg. dia.), easy in dispersion to all spaces avail. and can also treat adsorbed contaminants bond to soil
- High Purity Iron (95%+, reactive ingredients) with trace carbon within the particle structure
- Use of Ferox's PFLAI technique to force ZVI powder broad distribution



Pre-ZVI Injection - TCE concentration in Groundwater



TCE concentrations are in ppb

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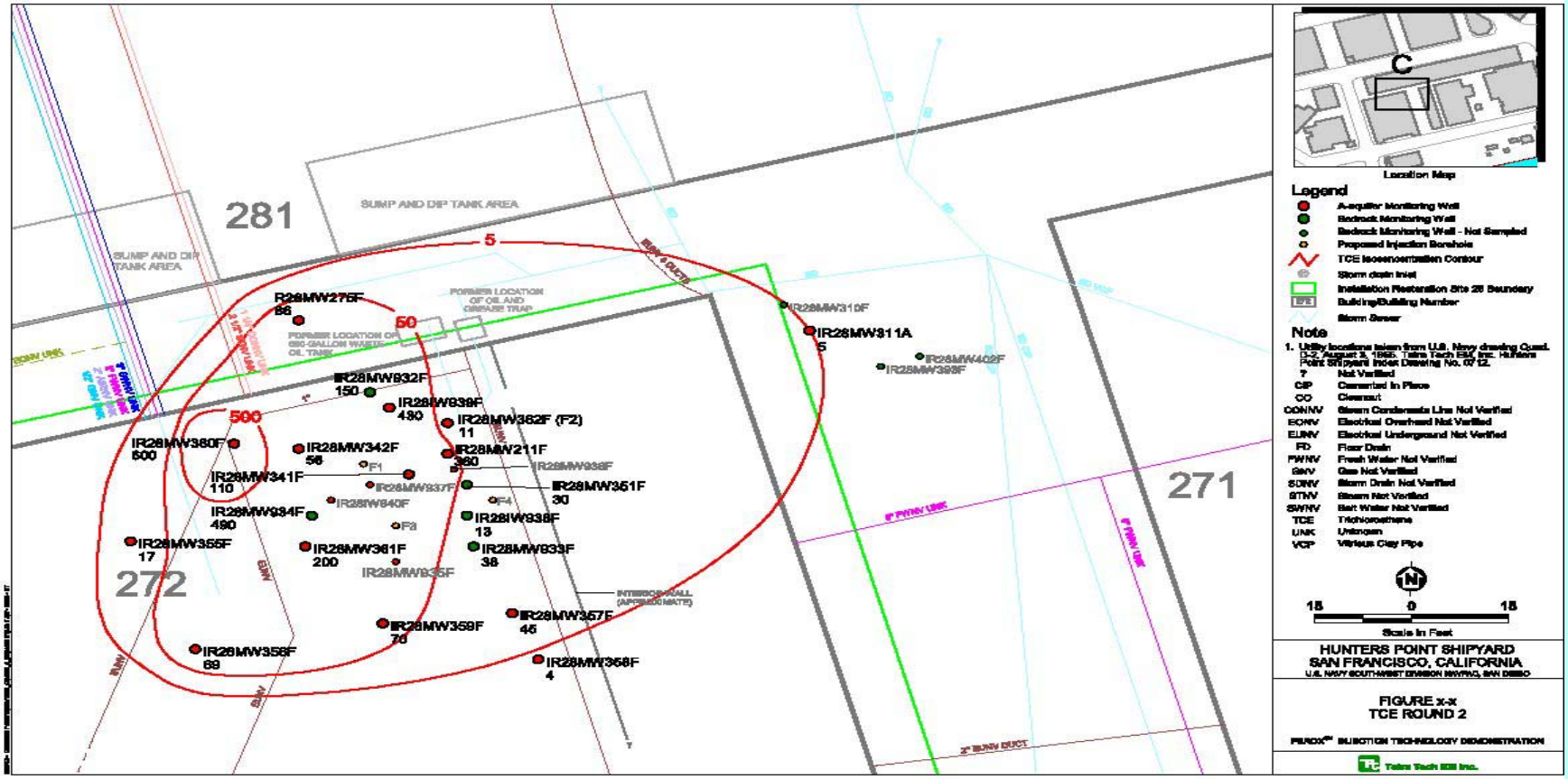
Post - ZVI Injection
TCE in Groundwater
(after 3 weeks of treatment)



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DATA SUMMARY
(1)

IR28MW211F – Hot Spot Well
ORP and TCE vs. Time
(This Monitoring Well is 6 ft from F2 Injection well)

	12/01/02	01/06/03	02/03/03
TCE concentration: (unit in ppb)	76,000	420	730
ORP (in mv) :	+ 166.3	- 555.7	- 447.2
pH	6.90	8.52	7.91

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DATA SUMMARY
(2)

IR28MW341F – Hot Spot Well
ORP and TCE vs. Time

(This Monitoring Well is 8 ft from F1 Injection well)

	12/01/02	01/06/03	02/03/03
TCE concentration: (unit in ppb)	41,000	100	160
ORP (in mv) : (estimated)	+ 170.1	- 351.1	- 471.3
pH	6.92	7.87	8.51

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DATA SUMMARY
(3)

IR28MW342F – Mid Plume Well
ORP and TCE vs. Time

(This Monitoring Well is 10 ft from F1 Injection well)

TCE concentration: : 12/01/02	01/06/03	02/03/03	
(unit in ppb)			
	5,100	47	79
ORP (in mv) :	+ 159.7	- 323.9	- 569
pH	6.77	8.18	8.61

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DATA SUMMARY
(4)

IR28MW362F – F2 Injection Well
ORP and TCE vs. Time

(This Monitoring Well is 0 ft from F2 Injection well)

	12/01/02	01/06/03	02/03/03
TCE concentration: (unit in ppb)	88,000	11	78
ORP (in mv) : (estimated)	+ 88.5	- 555.2	- 436
pH	7.32	8.24	8.27

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DATA SUMMARY
(5)

IR28MW360F – Mid Plume Well
ORP and TCE vs. Time

(This Monitoring Well is 20 ft from F1 Injection well)

TCE concentration: :	12/01/02	01/06/03	02/03/03
(unit in ppb)	7,400	690	610
ORP (in mv) : (estimated)	+ 90.6	+12.3	+253.3
pH	6.91	7.08	7.17

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Preliminary Results Discussions/Conclusions (1)

- As shown in Data Summary Tables 1-5, it indicates that

  (1) the injected ZVI powder is capable of quickly altering oxidation-reduction potential (ORP) from a positive value (oxidation conditions) to a negative value in a reductive mode which demonstrated an active dechlorination reaction of TCE/PCE had taken place

  (2) every sample showed increase in pH value which was a good indication of continued generation of hydroxyl irons due to active iron corrosion reaction

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Preliminary Results Discussions/Conclusions (2)

- TCE concentrations in groundwater sample, collected from different monitoring wells, showed significant reduction in only 3 weeks after ZVI injection treatment. We also measured PCE, DCE, and VC concentrations (not shown in the tables) in all those corresponding samples collected for TCE, ORP measurement. The data have also shown that the same characteristics/trend as TCEs', that there were significant dechlorination reactions taken place
- Plume displacement has been found not significant, as they are shown by comparing the Pre- and Post ZVI injection figures

Preliminary Results Discussions/Conclusions (3)

- Typical Radius of Influence (ROI) (from ZVI injection wells) has been found to be about 15-20 feet. (from ZVI Injection Point). All data collected for proof is available but not shown here

It appears that implementation of the ZVI powder injection technology to dehalogenate TCE/PCE in groundwater and soils is a simple, safe and cost-effective method. Employing a pneumatic fraction liquid atomization injection technique would further assure the benefit of extending in distributing the ZVI powder in the subsurface

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