NanoFe™

Supported Zero-Valent Nanoiron

Insitu Groundwater Treatment Using Nanoiron: A Case Study

PARS Environmental Inc.

Outline

- OVERVIEW OF PARS
- INTRODUCTION
- TECHNOLOGY OVERVIEW
- CASE STUDY
- SUMMARY
- RECENT PROJECT EXPERIENCE

OVERVIEW OF PARS

- Established in 1984
- PARS focus is innovative technologies
- PARS provides engineering, environmental, and health & safety services
- New Jersey Technology Council selected PARS as “Environmental Technology Company of the Year” in May 2004

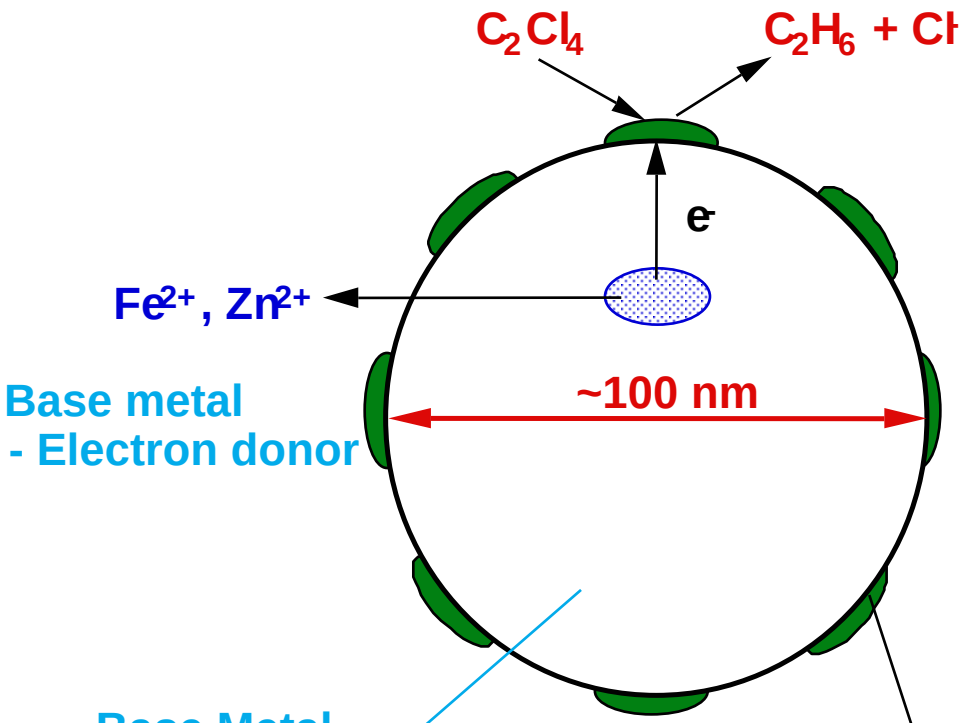
Introduction

- Nanoiron will remediate recalcitrant contaminants in soils and groundwater
- Sub-micron ($<10^{-6}$m) particles of Fe^0 with a noble metal catalyst
- Based on proven redox processes
- Very flexible and destroys contaminants rapidly *in-situ* or *ex-situ*

Treatable by Nanoiron Technology

- Contaminants:
  - Halogenated aliphatics (PCE, TCE, 1,1,1-TCA, 1,1,2,2-TeCA)
  - Halogenated aromatics
  - PCBs
  - Halogenated herbicides & pesticides
  - Nitroaromatics
  - Metals (e.g. $Cr^{+6,}$ As)
- Geologic Conditions:
  - Sand
  - Silt
  - Fractured rock
  - Landfills
  - Fill materials
  - Sediments

Nanoiron Dehalogenation Schematic



Noble Metals
- forms galvanic cells
- catalyze hydrogenation

NanoFe™

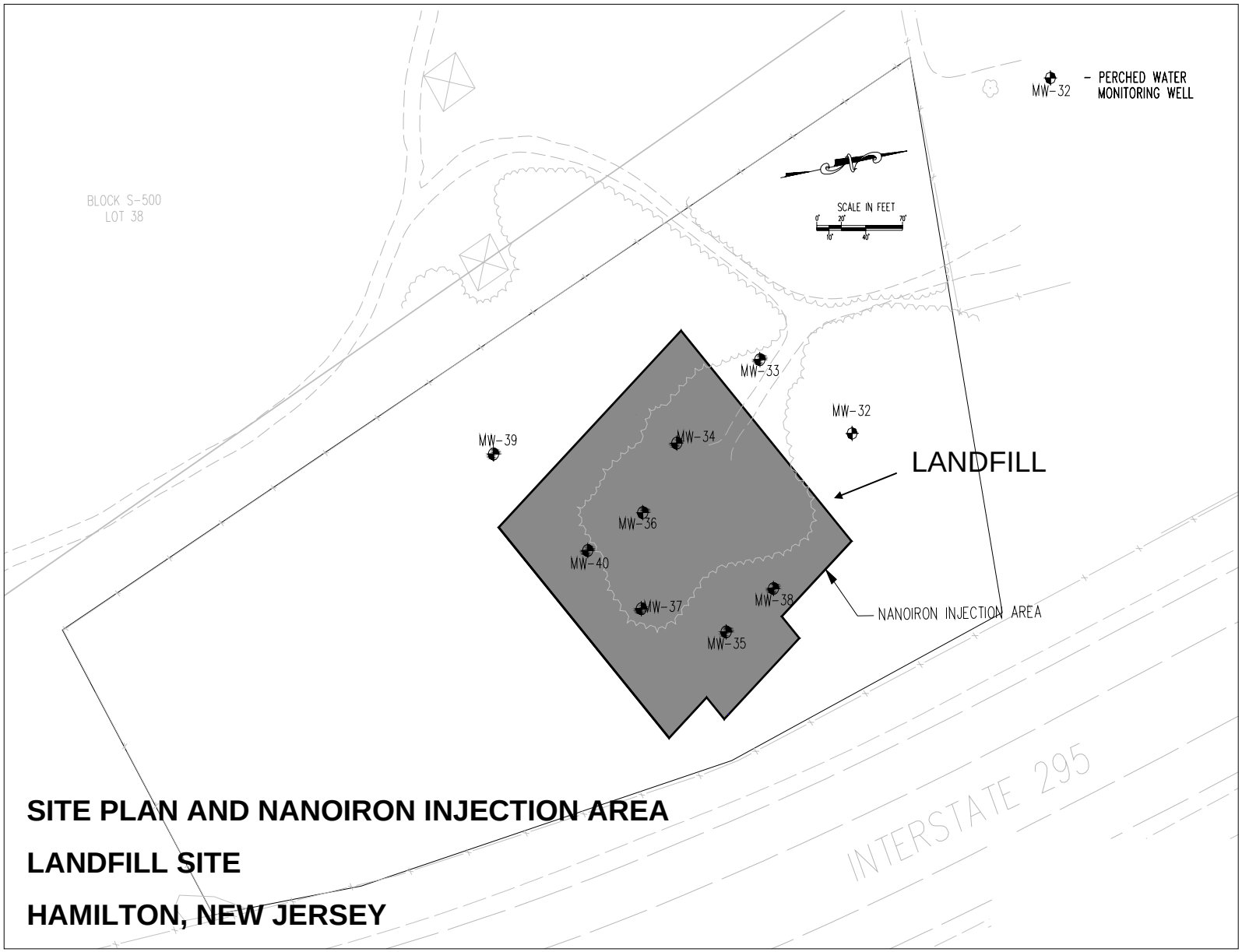
- Major process variables:
  - Fe^0 surface area
    - BET Surface Area 30 m^2/g
  - Presence of a noble metal catalyst
  - Nanoiron can be injected by gravity or under pressure

A Case Study

- Landfill site located adjacent to a Switchyard
- Soil and groundwater contaminated with chlorinated solvents (1,1,1-TCA, TCE, PCE, 1,1-DCE, 1,1-DCA) and metals (Al, Pb, Ni)
- >$1.0 million has been spent on natural attenuation
- Active remedy required
  - Excavate the Fill Area
  - Use Nanoiron technology to treat chlorinated solvent contaminants in ground water

Full-Scale Nanoiron Remediation

- The remedial goal - inject Nanoiron slurry into the most contaminated portion of the plume to significantly reduce the contaminant concentrations
- Nanoiron injection in two phases:
  - Phase 1 - 3,000 pounds of Nanoiron were injected over 20 days
  - Phase 2 – 1,500 pounds of Nanoiron were injected over 10 days
- Nanoiron was applied in an injection grid

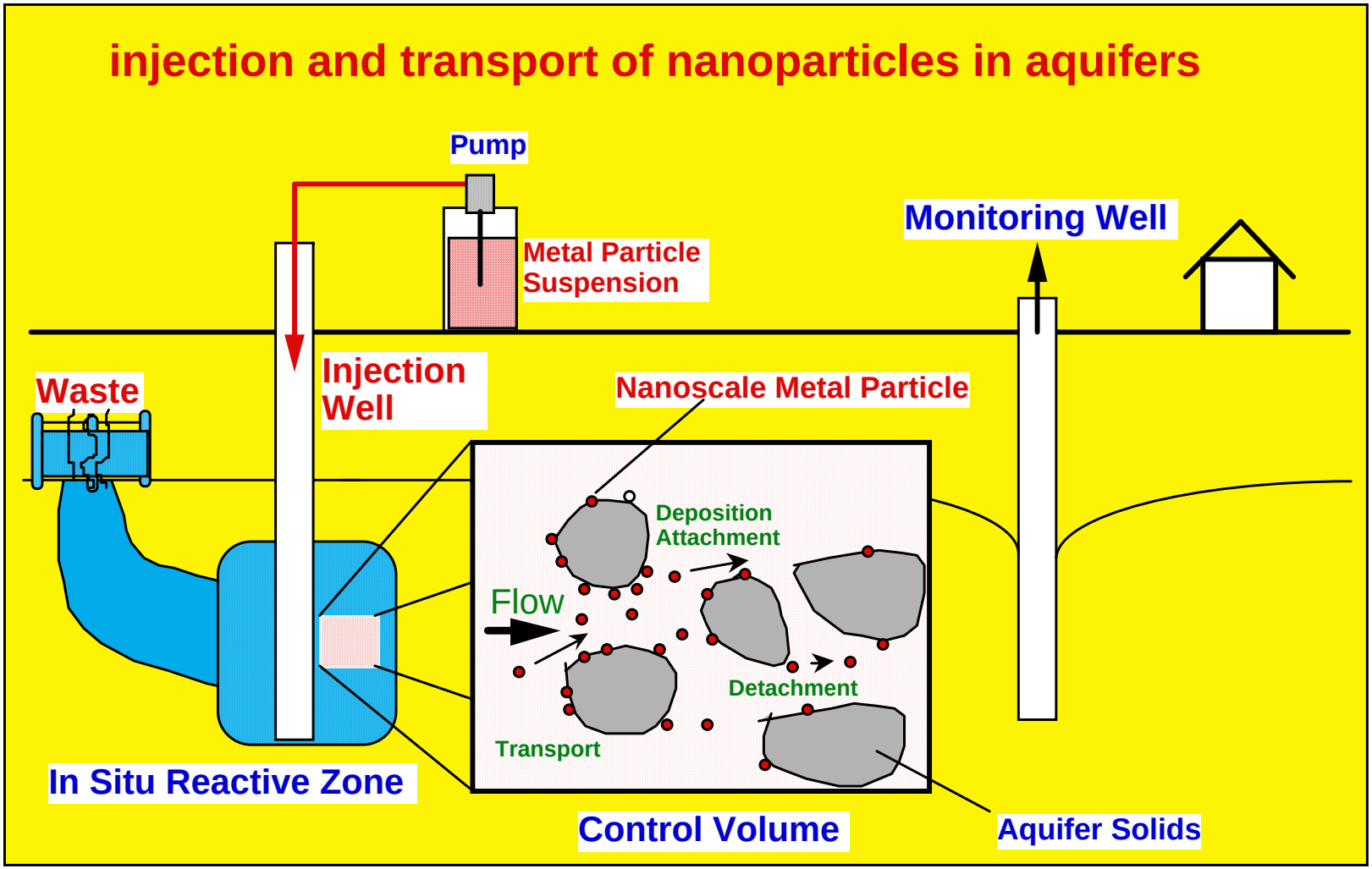


SITE PLAN AND NANOIRON INJECTION AREA

LANDFILL SITE

HAMILTON, NEW JERSEY

Schematic of Field Application Set-up



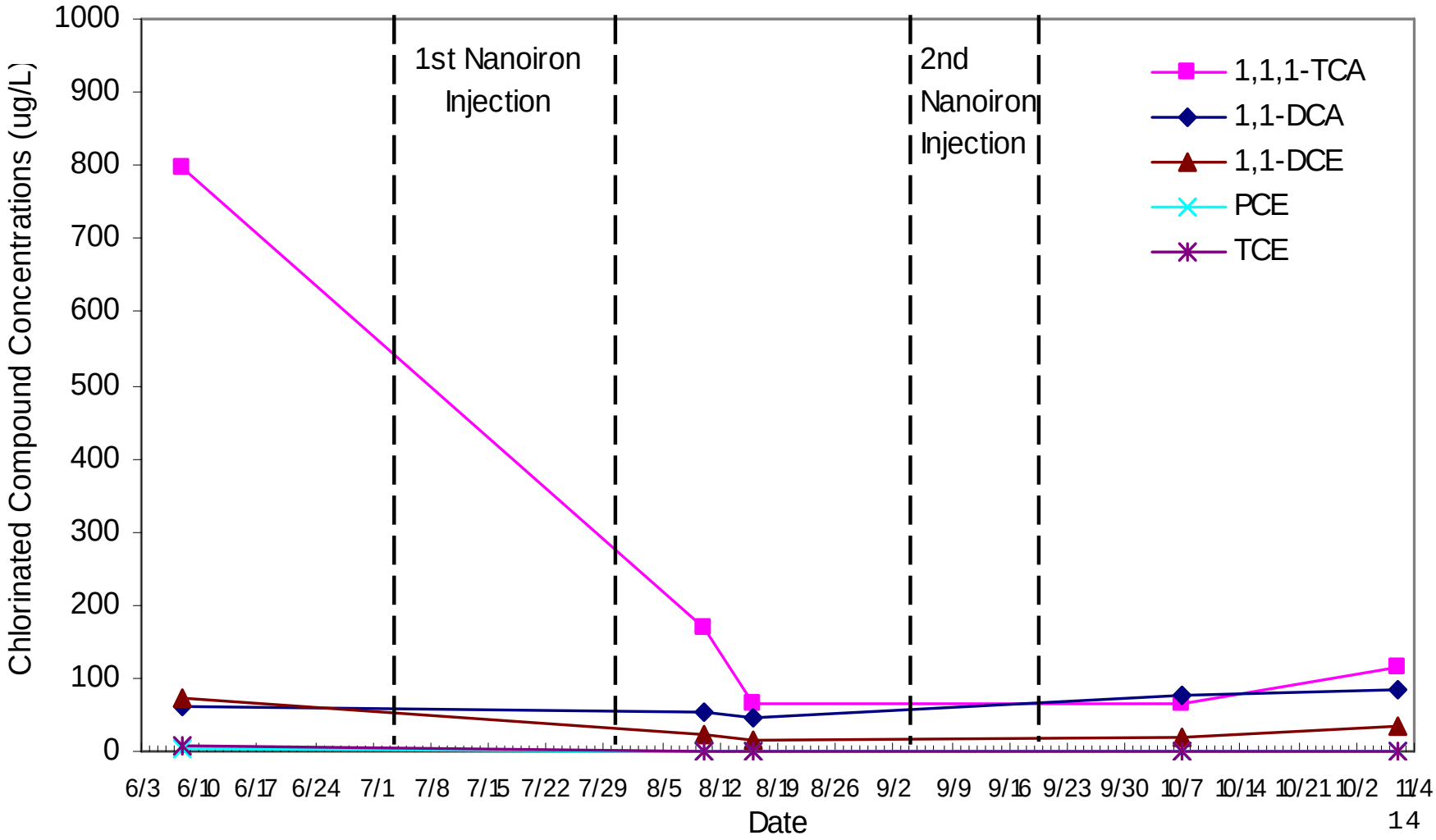
The Field Application Set Up

NanoFe™ Application

NanoFe™ = Fe^0 with Pd^0 (catalyst)

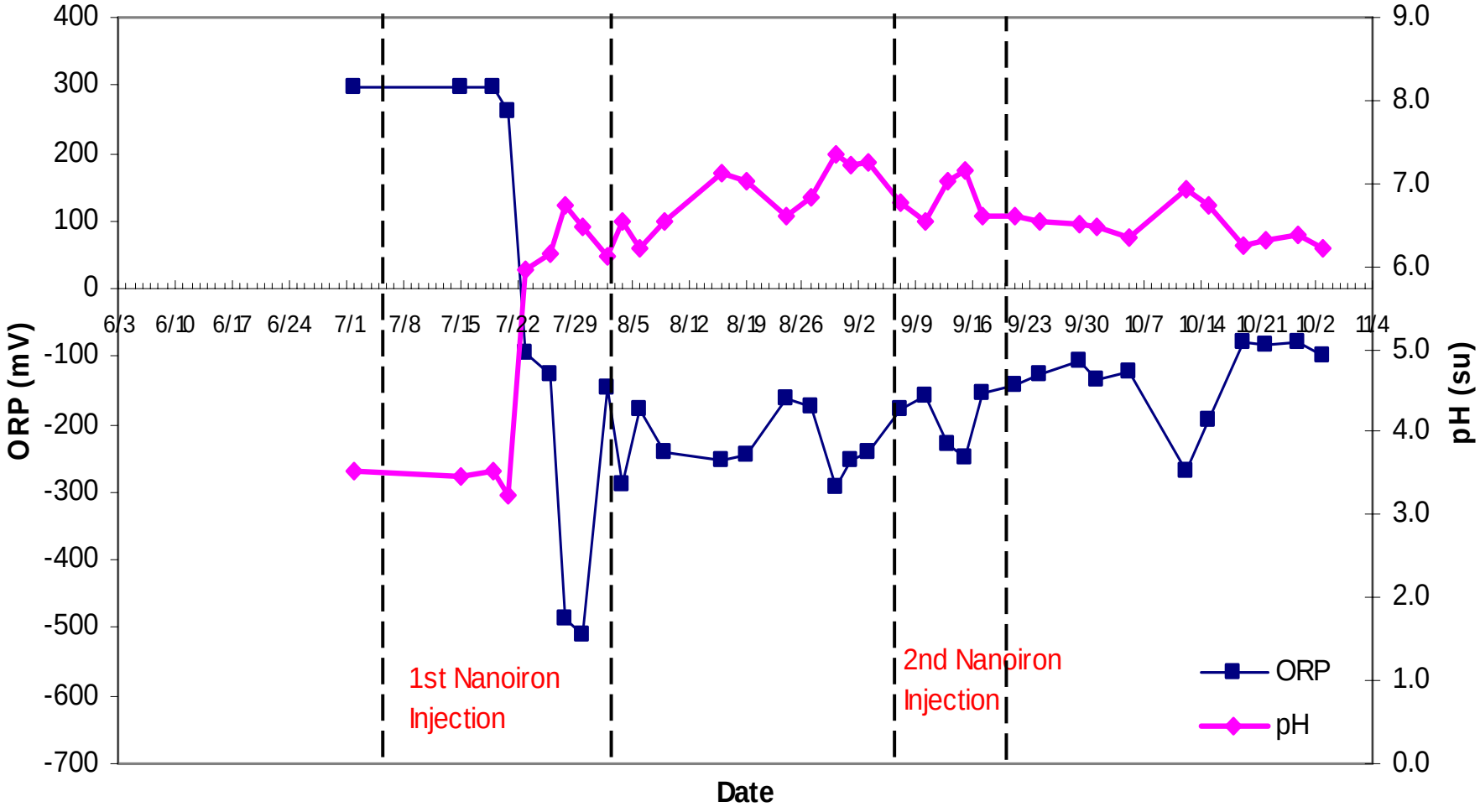
Nanoiron Field Application

(Landfill Site, New Jersey) – CVOCs Trends



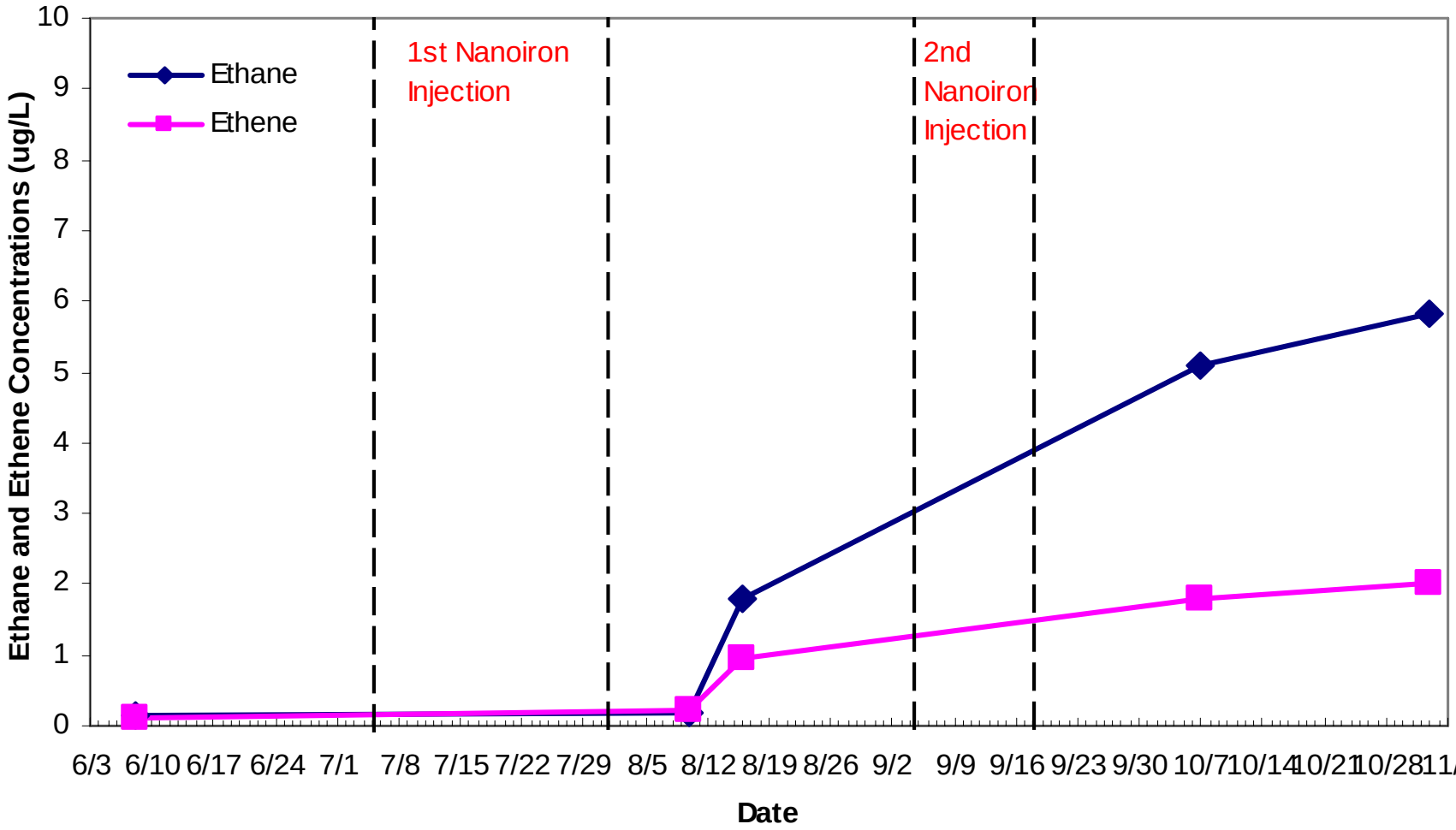
Nanoiron Field Application

(Landfill Site, New Jersey) – ORP and pH Trends

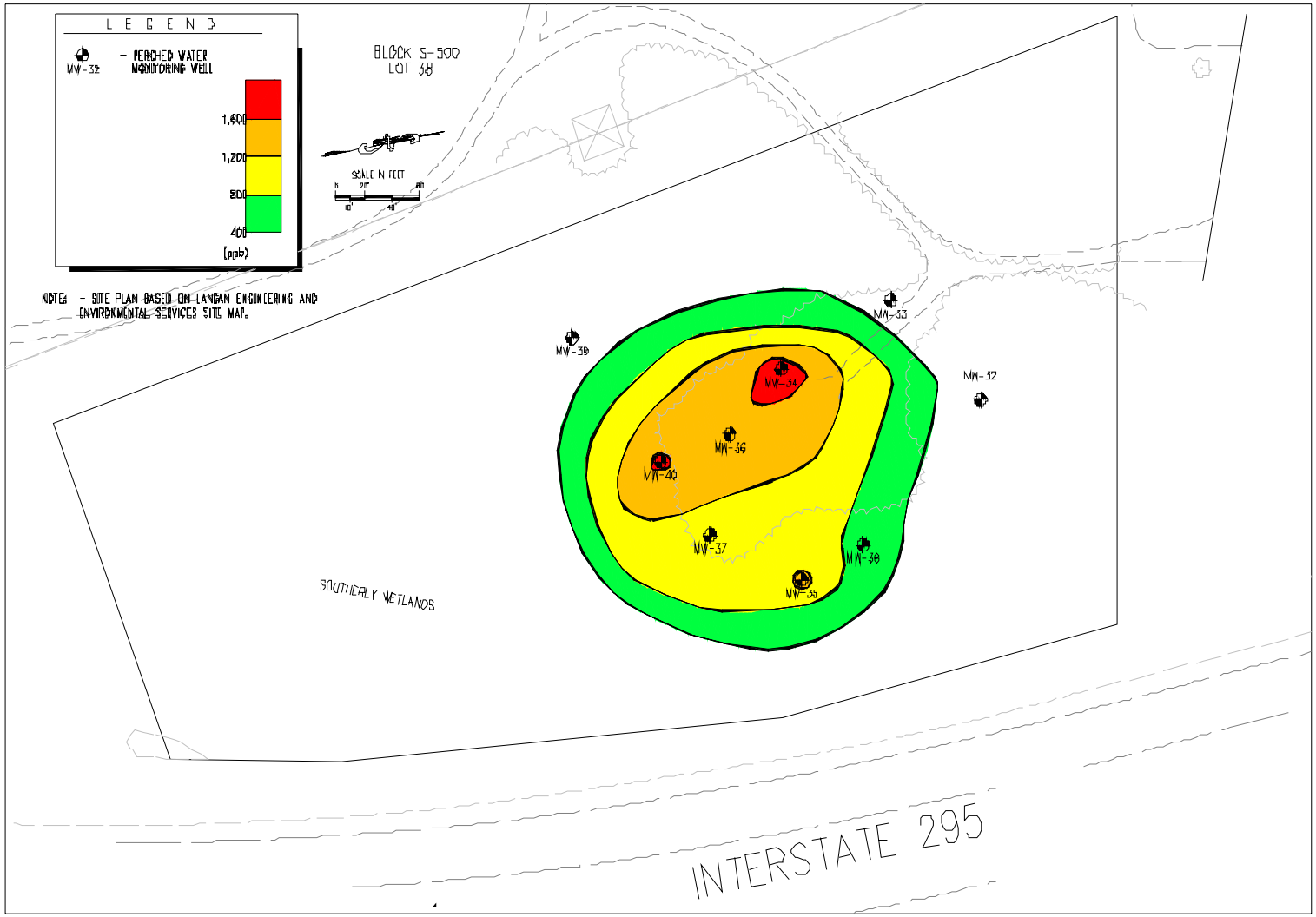


Nanoiron Field Application

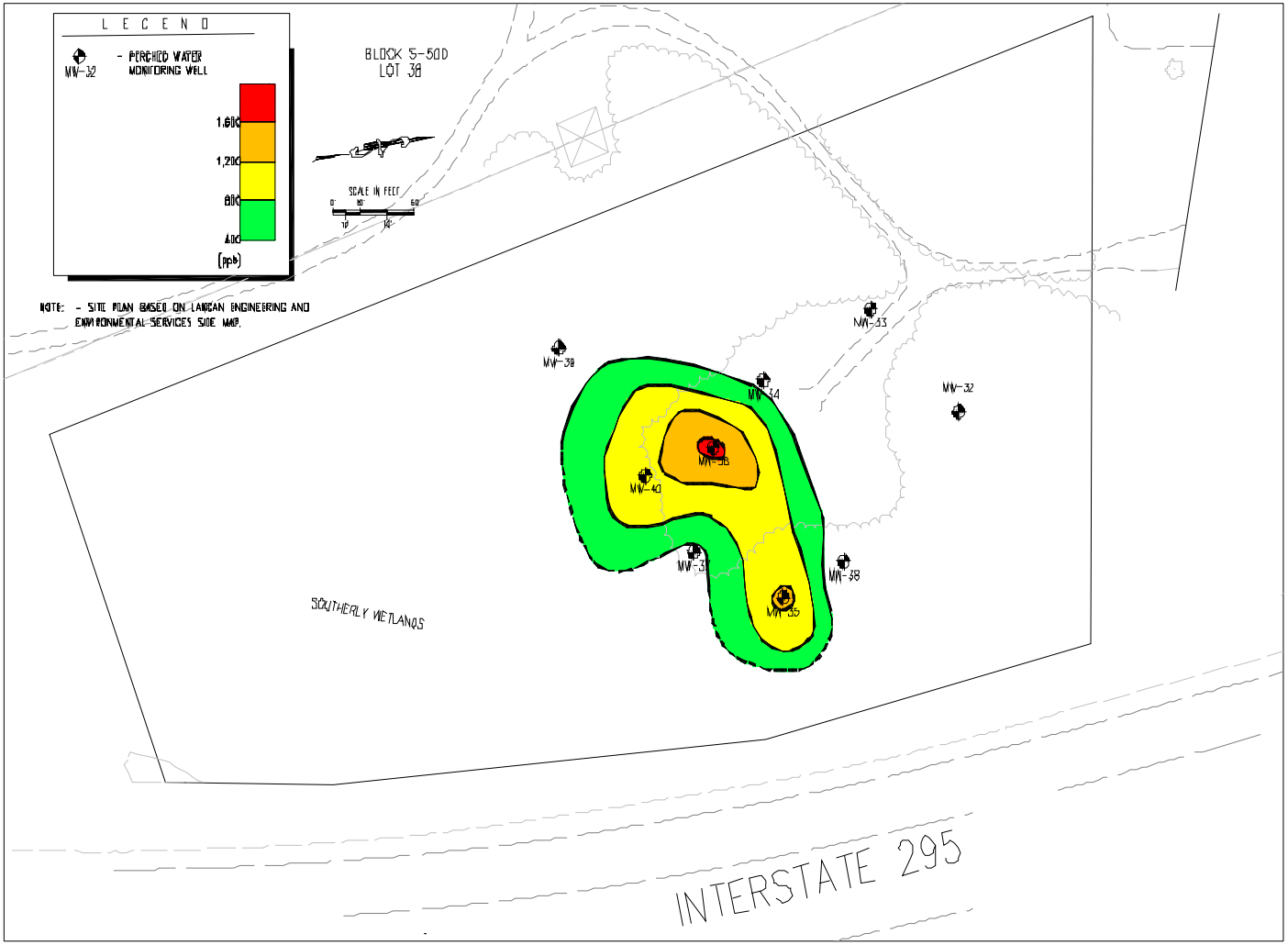
(Landfill Site, New Jersey) – Ethane and Ethene Trends



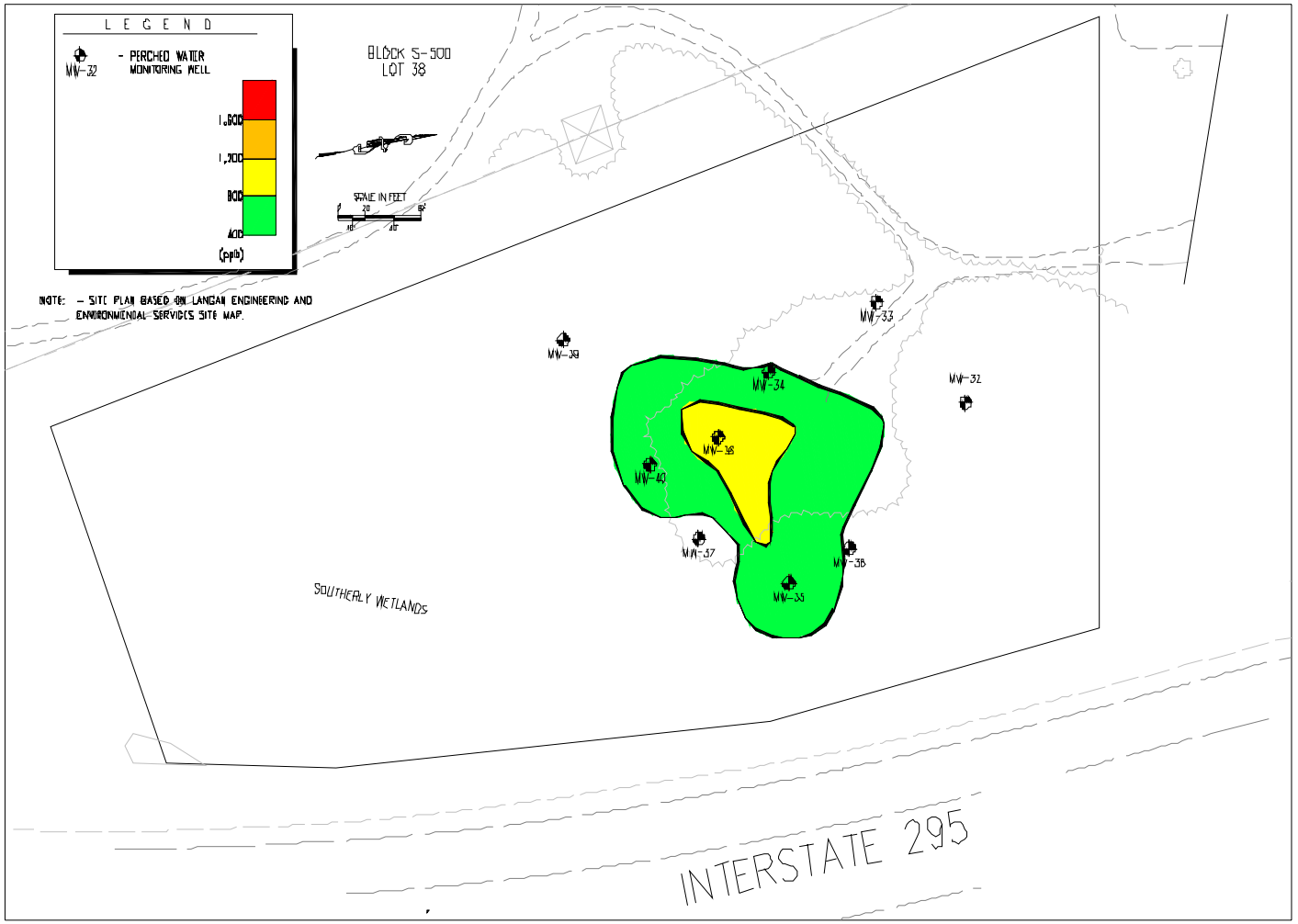
Total VOCs Plume - Baseline



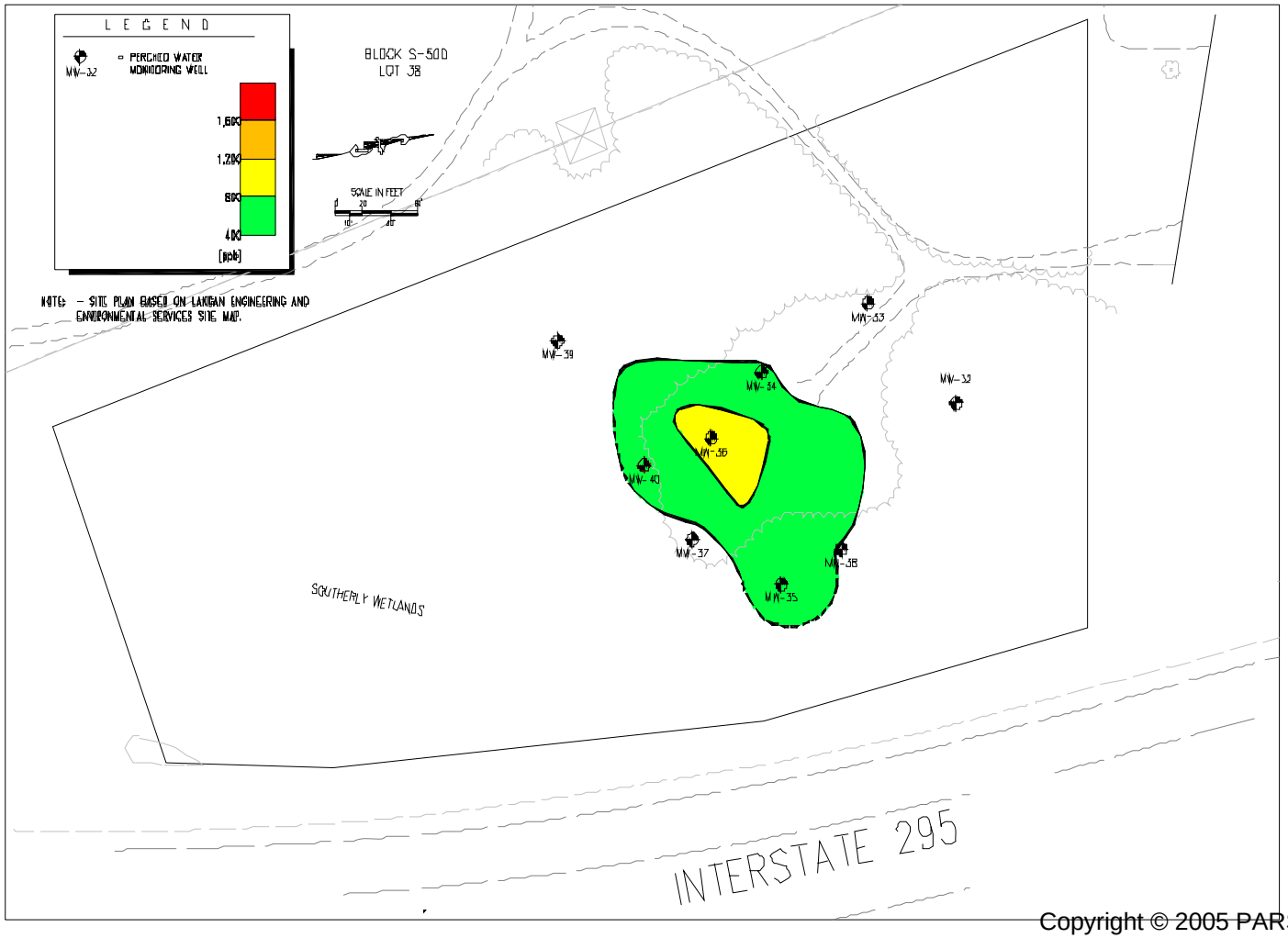
Total VOCs Plume – After First Nanoiron Application



Total VOCs Plume - After Second Nanoiron Application



Total VOCs Plume - Third Post-Injection Monitoring



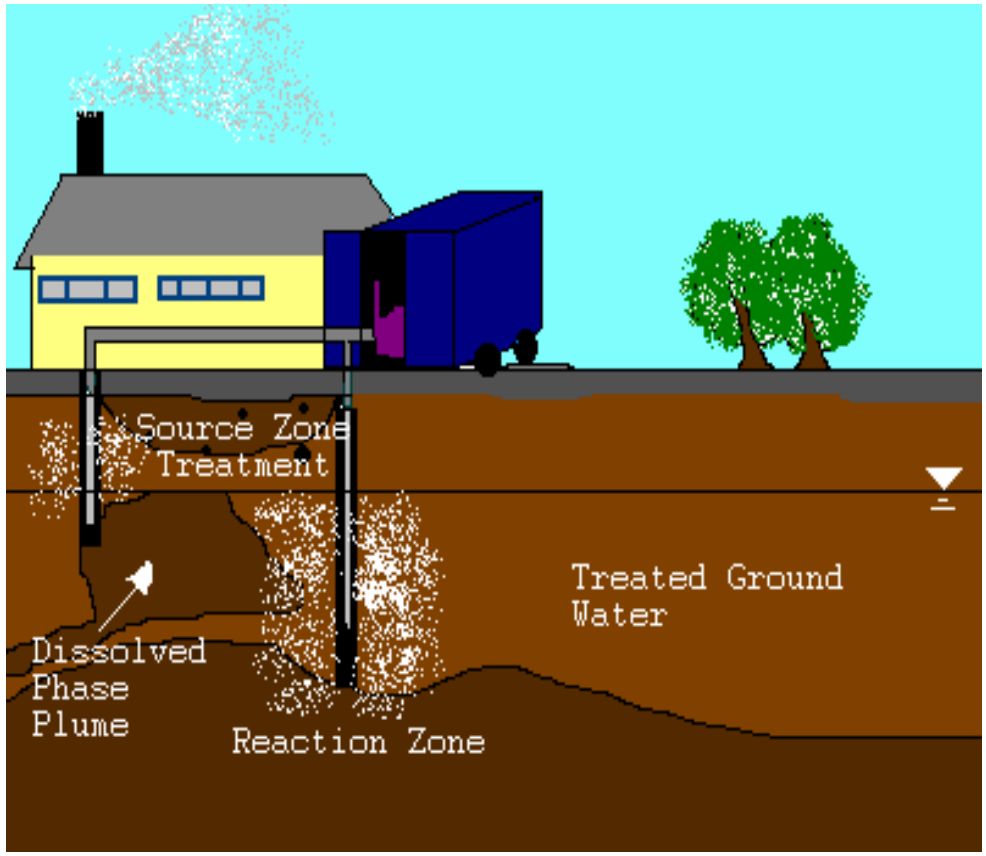
Summary

- Dissolved chlorinated groundwater contaminants degraded significantly

- Positive remedial effects of the Nanoiron injection activities are still occurring throughout the Perched Water zone

Summary - Nanoiron Technology

- Treats dissolved plume and source area(s)
- No depth limitations
- Highly reactive – rapid degradation & no toxic intermediates
- Portable – low capital + O&M costs
- Easily injected, Nanoiron flows with groundwater
- Low Nanoiron /contaminant ratios required



Recent Project Experience

Site	Location	Principal Contaminants
Manufacturing Plant	Trenton, New Jersey	TCE, cis-DCE, Vinyl Chloride
Former Electronics Manufacturing Plant	Titusville, Pennsylvania	PCE, TCE, cis-DCE
Plating Facility / Superfund Site	Franklin Square, New York	PCE, TCE, 1,1,1-TCA, Cr (VI)
DOD Facility	Lakehurst - 1, New Jersey	TCE, cis-DCE, Vinyl Chloride
DOD Facility	Lakehurst- 2&3, New Jersey	TCE, cis-DCE, Vinyl Chloride
Former Electrical Distribution Facility	New Brunswick, New Jersey	TCE, 1,1,1-TCA, 1,1-DCA, 1,1-DCE
Manufacturing Plant	Newfield, New Jersey	TCE, cis-DCE, Cr (VI)
Landfill Site	Hamilton, New Jersey	1,1,1-TCA, 1,1-DCA, 1,1-DCE, Pb, Ni
Chromium Ore Landfill	Kearny, New Jersey	Cr (VI)
Former Chemical Manufacturing Plant	Salem, Ohio	TCE, cis-DCE, Vinyl Chloride
DOD Facility	Dover, New Jersey	CT, CF, TCE, PCE, 1,1-DCE
DOD Facility	Aberdeen, Maryland	1,1,2,2-TeCA, 1,1,1-TCA, TCE
Chromium Ore Landfill	Jersey City, New Jersey	Cr (VI)
DOD Facility	Jacksonville - 1&2, Florida	TCE, cis-DCE, Vinyl Chloride

For further information, please contact:

PARS Environmental, Inc.

TEL: 609-890-7277

FAX: 609-890-9116

Web: www.parsenviro.com

- Harch Gill, hgill@parsenviro.com