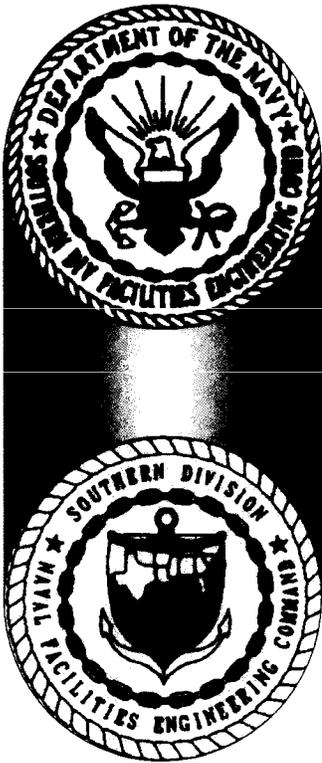


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CORRECTIVE MEASURES STUDY REPORTS SOLID WASTE MANAGEMENT UNIT 39
(SWMU 39) ZONE A CNC CHARLESTON SC
10/4/2002
CH2M HILL

CORRECTIVE MEASURES STUDY REPORT

SWMU 39. Zone A



***Charleston Naval Complex
North Charleston, South Carolina***

SUBMITTED TO
***U.S. Navy Southern Division
Naval Facilities Engineering Command***

CH2M Jones

October 2002

*Revision No. 0
Contract N62467-99-C-0960*

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October 4, 2002

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South Carolina Department of Health and
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Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Re: Corrective Measures Study Report (Revision 0) – SWMU 39, Zone A

Dear Mr. Scaturo:

Enclosed please find four copies of the Corrective Measures Study Report (Revision 0) for SWMU 39 in Zone A of the Charleston Naval Complex (CNC). This report has been prepared pursuant to agreements by the CNC BRAC Cleanup Team for completing the RCRA Corrective Action process.

The principal author of this document is Casey Hudson. Please do not hesitate to contact him at 407/423-0030, extension 251, should you have any questions or comments.

Sincerely,

CH2M HILL

Dean Williamson, P.E.

cc: Rob Harrell/Navy, w/att
Gary Foster/CH2M HILL, w/att

CORRECTIVE MEASURES STUDY REPORT

SWMU 39, Zone A



***Charleston Naval Complex
North Charleston, South Carolina***

SUBMITTED TO
***U.S. Navy Southern Division
Naval Facilities Engineering Command***

PREPARED BY
CH2M-Jones

October 2002

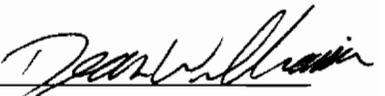
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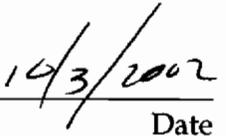
I, Dean Williamson, certify that this report has been prepared under my direct supervision. The data and information are, to the best of my knowledge, accurate and correct, and the report has been prepared in accordance with current standards of practice for engineering.

South Carolina

P.E. No. 21428



Dean Williamson, P.E.



Date

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1 Acronyms and Abbreviations

2	ARS	ARS Technologies
3	BRAC	Base Realignment and Closure
4	CA	Corrective Action
5	cfm	Cubic feet per minute
6	CMS	Corrective Measures Study
7	CNC	Charleston Naval Complex
8	COC	Chemical of concern
9	COPC	Chemical of potential concern
10	CPT	Cone penetrometer technology
11	CVOC	Chlorinated volatile organic compound
12	DAF	Dilution attenuation factor
13	DCE	Dichloroethene
14	DNAPL	Dense non-aqueous phase liquid
15	DPT	Direct-push technology
16	EnSafe	EnSafe Inc.
17	EPA	U.S. Environmental Protection Agency
18	ERT	Electrical resistance tomography
19	EVS	Environmental Visualization System
20	ft bls	Foot below land surface
21	HI	Hazard index
22	HRC	Hydrogen release compound
23	ILCR	Incremental lifetime cancer risk
24	LAI	Liquid atomized injection
25	MCL	Maximum contaminant level
26	MCS	Media cleanup standard
27	µg/L	Microgram per liter
28	mg/kg	Milligram per kilogram

1 **Acronyms and Abbreviations, Continued**

2	MNA	Monitored natural attenuation
3	NAVBASE	Naval Base
4	O&M	Operation and maintenance
5	ORP	Oxygen reduction potential
6	PCB	Polychlorinated biphenyl
7	PCE	Tetrachloroethene
8	PF	Pneumatic fracturing
9	POL	Petroleum, oil, and lubricant
10	PRB	Permeable reactive barrier
11	RAO	Remedial action objective
12	RBC	Risk-based concentration
13	RCRA	Resource Conservation and Recovery Act
14	RFI	RCRA Facility Investigation
15	RGO	Remedial goal option
16	RI	Remedial investigation
17	SAP	Sampling and Analysis Plan
18	SCDHEC	South Carolina Department of Health and Environmental Control
19	SSL	Soil screening level
20	SVOC	Semivolatile organic compound
21	SWMU	Solid Waste Management Unit
22	TCE	Trichloroethene
23	TPH	Total petroleum hydrocarbon
24	VOC	Volatile organic compound
25	yd ³	Cubic yards
26	ZVI	Zero-valent iron

Section 1.0

1.0 Introduction

In 1993, Naval Base (NAVBASE) Charleston was added to the list of bases scheduled for closure as part of the Defense Base Realignment and Closure (BRAC) Act, which regulates closure and transition of property to the community. The Charleston Naval Complex (CNC) was formed as a result of the dis-establishment of the Charleston Naval Shipyard and NAVBASE on April 1, 1996.

CNC Corrective Action (CA) activities are being conducted under the Resource Conservation and Recovery Act (RCRA); the South Carolina Department of Health and Environmental Control (SCDHEC) is the lead agency for CA activities at the site. All RCRA CA activities are performed in accordance with the Final Permit (Permit No. SC0 170 022 560).

In April 2000, CH2M-Jones was awarded a contract to provide environmental investigation and remediation services at the CNC. This submittal presents a Corrective Measures Study (CMS) Report for Solid Waste Management Unit (SWMU) 39 in Zone A at the CNC. Figure 1-1 presents the location of SWMU 39 within Zone A.

1.1 Corrective Measures Study Report Purpose and Scope

This CMS report evaluates CA alternatives for chlorinated solvents present in the shallow, intermediate, and deep portions of the surficial aquifer at SWMU 39, and develops the basis for selection of CA alternatives for source control, contaminant migration at the property boundary, and downgradient contaminant migration. In addition, this CMS report presents the results of the additional characterization of the chlorinated solvents in groundwater as identified in the *Sampling and Analysis Plan (SAP), SWMU 39, Zone A, Revision 0* (CH2M-Jones, 2002a); a summary of the chemicals of concern (COCs) that were identified at SWMU 39; and the proposed media cleanup standards (MCSs) for volatile organic compounds (VOCs) in groundwater. The *CMS Work Plan, SWMU 39, Zone A, Revision 0* (CH2M-Jones, 2002b), evaluated and refined the COCs identified at SWMU 39 as presented in the *Zone A RCRA Facility Investigation (RFI) Report, Revision 0* (EnSafe Inc. [EnSafe], 1998).

1.2 Background Information

1.2.1 Facility Description

SWMU 39 is the site of a former outdoor storage area for petroleum, oil, and lubricant (POL) drums along the north wall of Building 1604. Figure 1-2 presents the site layout at SWMU 39. Building 1604 is a large warehouse building located near the northern boundary of the CNC. SWMU 39 is bounded to the north by the Hess Oil tank farm, to the west by a road and railroad along the base boundary, to the south by railroad lines and buildings associated with SWMU 42, and to the east by buildings associated with SWMU 38.

A marine equipment company currently leases Building 1604 and stores boats and other marine equipment outdoors, north of the building. The original area on the north side of the building where drums were reportedly stored is now covered with asphalt pavement.

1.2.2 Site History

The SWMU 39 area was previously studied by EnSafe during the Zone A RFI, which was completed in 1998. A Monitored Natural Attenuation (MNA) study was completed in 1999. The results of the MNA study were reported in a CMS Technical Memorandum (EnSafe, 1999). The results of the RFI and the MNA study revealed a fairly widespread but diffuse occurrence of chlorinated VOCs (CVOCs) in the shallow, intermediate, and deep zones of the unconfined shallow (water table) aquifer. The studies did not identify any discrete areas of soil contamination, which could be acting as the source of the VOCs in groundwater. The extent of dissolved CVOCs in site groundwater was further refined in April/May and July/August 2002 with the advancement of 66 Geoprobe™ direct-push technology (DPT) points as outlined in the *Sampling and Analysis Plan (SAP), SWMU 39, Zone A, Revision 0* (CH2M-Jones, 2002a). The location of these Geoprobe™ points are depicted in Figure 1-3.

The MNA study (EnSafe, 1999) reported that aquifer conditions conducive to natural bioremediation of CVOCs by reductive dechlorination processes vary in Zone A. The MNA Study report indicated that the conditions required generally become more favorable moving southward in Zone A. The groundwater quality data support the conclusion that natural attenuation of CVOCs is occurring to some degree in all zones of the shallow aquifer system in this area.

In 2001, CH2M-Jones conducted a pilot test of enhanced in situ biodegradation by injection of Hydrogen Release Compound® (HRC®), using technology developed by Regenesis, Inc. The results of this study are provided in Appendix A.

1 **1.2.3 Site Hydrogeology**

2 The site hydrogeology consists of a series of Quaternary interbedded sands and clays,
3 varying in thickness from 21 to 56 ft in the SWMU 39 area. The sands and clays contain an
4 unconfined (water table) aquifer system that overlies the Tertiary Ashley Formation. The
5 Ashley Formation is comprised of silts and clays and acts as an aquiclude for the water table
6 aquifer. Figure 1-4 depicts the interpreted Ashley Formation elevation at SWMU 39 mapped
7 using the monitoring well logs and information obtained during the RFI. Figure 1-5 presents
8 a three-dimensional (3-D) visualization of the top of the Ashley Formation created using
9 Environmental Visualization System (EVS) software.

10 Monitoring wells were installed in shallow (10 to 15 feet below land surface [ft bls]),
11 intermediate (15 to 30 ft bls), and deep (30 to 50 ft bls) sandy zones of groundwater flow in
12 the water table aquifer. The three zones are vertically interconnected, and converge into one
13 hydrogeologic unit south of Building 1607. Typical groundwater elevation contours for the
14 shallow, intermediate, and deep aquifer zones are presented in Figures 1-6 through 1-8,
15 based upon measurements made in July 2001.

16 The Zone A shallow groundwater flow direction has been consistently determined to be in a
17 generally south-southeast direction, with a separate flow component to the southwest,
18 toward an offsite wetland area associated with Noisette Creek. There is minimal tidal
19 influence on groundwater levels, and flow velocities averaging 14 ft per year have been
20 calculated by EnSafe, based on aquifer test results.

21 A shallow groundwater divide and radial recharge area appear to exist in the vicinity of
22 Building 1648 (see Figure 1-6). The intermediate groundwater flow path is also generally to
23 the southeast across Zone A. Groundwater flow in the deep zone of the aquifer is also
24 generally to the southeast, but fewer data points exist south of Building 1648 to determine
25 the fate of groundwater flowing through this area.

26 Based on available historic site maps, Building 1604 and nearby buildings were built in the
27 1943-1947 time frame. Using a conservative assumption that POL storage and releases
28 occurred from the first day of operations, groundwater from SWMU 39 could have migrated
29 up to approximately 800 ft downgradient by the present date. This estimated distance
30 assumes no biodegradation or adsorption of VOCs in the aquifer, and does not assume a
31 preferential subsurface flow path.

1 1.2.4 Nature and Extent of Contamination

2 During the Zone A RFI, extensive soil and groundwater sampling was performed. Three
3 separate events of surface/subsurface soil boring installation were conducted, with a total of
4 43 borings installed. Three of the soil borings were installed through the floor of Building
5 1604, directly south of SWMU 39. During the first event soil samples were analyzed for
6 VOCs, semivolatile organic compounds (SVOCs), metals, pesticides, polychlorinated
7 biphenyls (PCBs), and total petroleum hydrocarbon (TPH). During the second sampling
8 event soils were analyzed for TPH, with selected samples also analyzed for pesticide/PCBs
9 and SVOCs. Samples from the third event were analyzed for VOCs. After the first soil
10 sampling event, 21 borings using Geoprobe™ technology were installed, with a subsurface
11 soil sample and a shallow groundwater sample collected from each Geoprobe boring for
12 VOC analysis (see Figure 10.4.1 in Appendix A of the *Zone A RFI Report, Revision 0*, for RFI
13 soil boring and Geoprobe locations). The Geoprobe samples were analyzed for VOCs.

14 No VOCs were detected above their respective risk-based concentrations (RBCs) in surface
15 soil samples collected at SWMU 39. Twenty-two SVOCs were detected in surface soils. Five
16 of the SVOCs exceeded their RBCs; all exceedances were in the same sample, 039SB00501.
17 This boring is located at the north edge of SWMU 39, in the area where subsurface free
18 product was detected from the adjacent Hess operations. Please refer to Figure 10.4.1 of the
19 RFI report for the boring location, and Appendix C for Liquid Phase Hydrocarbon maps
20 from the *Amerada Hess 2000 Semi-Annual Progress Report*. Copies of the above referenced
21 figures were also included in the *CMS Work Plan, SWMU 39, Zone A, Revision 0* (CH2M-
22 Jones, 2002b).

23 Benzene and ethylbenzene exceeded their soil screening levels (SSLs) in sample 039SB00802,
24 which is located north of SWMU 39 near the fence (see Figure 10.4.1 in Appendix A of the
25 RFI report for boring location). Naphthalene, fluorene, phenanthrene, and 2-
26 methylnaphthalene were each detected in at least one sample, but no SVOCs were detected
27 at concentrations exceeding their SSLs in subsurface soils. Mercury was detected in four
28 lower interval soil samples at concentrations from 1.4 to 2.0 milligrams per kilogram
29 (mg/kg), slightly exceeding the 1 mg/kg SSL (based on a dilution attenuation factor
30 [DAF]=10). Cobalt was detected in seven subsurface soil samples, with concentrations
31 ranging from 1.8 to 2.5 mg/kg.

32 Groundwater characterization events conducted during the RFI included the collection of 21
33 Geoprobe™ samples; installation of 15 shallow monitoring wells, five intermediate
34 monitoring wells, eight deep monitoring wells, and the completion of a cone penetrometer

1 technology (CPT) survey. Thirteen CPT boring installations were conducted in Zone A, and
2 16 borings were installed offbase along the neighborhood streets in the vicinity of the
3 Virginia Avenue entrance to the base. Shallow groundwater samples from the CPT borings
4 were collected and analyzed for VOCs. A total of 12 monitoring well sampling events were
5 conducted between October 1995 and October 1997. See Figure 10.4.3 of the *Zone A RFI*
6 *Report, Revision 0* for RFI monitoring well locations.

7 The most commonly occurring constituents in groundwater include tetrachloroethene
8 (PCE), trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene
9 (trans-1,2-DCE), and vinyl chloride. CVOC concentrations have been observed to be
10 somewhat variable and, in some cases, to have decreased during subsequent groundwater
11 monitoring events. This trend was confirmed during the groundwater monitoring event
12 conducted by CH2M-Jones in July 2000 for the facility-wide Groundwater Monitoring Plan.

13 During the RFI, maximum CVOC concentrations observed were in the 100 to 300 microgram
14 per liter ($\mu\text{g}/\text{L}$) range in monitoring well clusters A039GW012 and A039GW013. Well
15 cluster A039GW012 is located directly south of Building 1604; well cluster A039GW013 is
16 located approximately 400 ft to the south, on the south side of Building 1607. Groundwater
17 monitoring well locations are depicted in Figure 1-3.

18 The water quality data collected during CH2M-Jones's July 2000 groundwater monitoring
19 field effort included results from well cluster A039GW013, and from new monitoring well
20 cluster A039GW023, which was recently installed to fill a data gap along the western CNC
21 boundary. Analytical results are presented in Table 2-1 of the *CMS Work Plan, SWMU 39,*
22 *Zone A, Revision 0* (CH2M-Jones, 2002b). Well cluster A039GW023 is located approximately
23 600 ft southwest of Building 1604 (see Figure 1-3). The July 2000 data indicated CVOC
24 concentrations have decreased to less than 100 $\mu\text{g}/\text{L}$ at monitoring well cluster A039GW013,
25 and reductive dechlorination compounds such as cis-1,2-DCE and vinyl chloride are being
26 produced at this location. At well A039GW023D, CVOC compounds are being detected in
27 the 5 to 20 $\mu\text{g}/\text{L}$ range, indicating either a diffuse local source or the arrival of the leading
28 edge of a dissolved-phase VOC groundwater plume originating from the interior of the
29 SWMU 39 area.

30 To further evaluate the nature and extent of CVOCs in site groundwater, an additional 66
31 Geoprobe™ technology borings, identified as A039GP048 through A039GP088 and
32 A039GP090 through A039GP114, were advanced through the saturated zone during two
33 separate events completed in April/May and July/August 2002. The location of these
34 Geoprobe™ borings are provided in Figure 1-3. In most locations three samples, collected

1 from each Geoprobe™ point at approximate intervals of 6 to 10 ft bls, 23 to 27 ft bls, and 42
2 to 48 ft bls, were analyzed for VOCs. Detected concentrations of the VOCs are provided in
3 Appendix B. Contaminants detected above their maximum contaminant level (MCL), or for
4 those chemicals that have no MCL their respective U.S. Environmental Protection Agency
5 (EPA) Region III tap water RBC, included the following:

- 6 • **Acetone:** 3 samples – maximum concentration of 220 µg/L
- 7 • **1,3-Dichlorobenzene:** 1 sample – concentration of 0.64 J µg/L
- 8 • **1,1-DCE:** 7 samples – maximum concentration of 17 J µg/L
- 9 • **Benzene:** 2 samples – maximum concentration of 48 µg/L
- 10 • **cis-1,2-DCE:** 28 samples – maximum concentration of 860 µg/L
- 11 • **1,1,2,2-Tetrachloroethane:** 1 sample – concentration of 0.78 J µg/L
- 12 • **PCE:** 11 samples – maximum concentration of 130 µg/L
- 13 • **TCE:** 41 samples – maximum concentration of 340 µg/L
- 14 • **Vinyl Chloride:** 36 samples – maximum concentration of 420 µg/L

15 Contaminant concentrations of PCE, TCE, cis-1,2-DCE, and vinyl chloride from the samples
16 collected in the shallow, intermediate, and deep zones of the aquifer during this event are
17 depicted on Figures 1-9 through 1-20. These figures also show the analytical results from
18 the previous Geoprobe™ borings advanced at the site, as well as results from the latest
19 samples collected from each of the site groundwater monitoring wells. In addition, a 3-D
20 visualization of the dissolved CVOC groundwater plume was created using the EVS
21 software. Figures 1-21, 1-22, 1-23, and 1-24 present plan views of the PCE, TCE, cis-1,2 DCE,
22 and vinyl chloride plumes using this software.

23 Elevated contaminant concentrations in each of the three aquifer zones (i.e., shallow,
24 intermediate, and deep) are present in the immediate area north of Building 1607 and in the
25 area surrounding the western portion of Building 1605. Areas of elevated concentration
26 downgradient of this area include: south and southwest of Buildings 1606 and 1627;
27 surrounding Buildings 1608A and 1608B; northwest of Building 1639 and immediately west
28 of Avenue D; and the northern portion of the SWMU 42 boundary. The elevated
29 contaminant concentrations are primarily in the intermediate and deep zones of the surficial
30 aquifer except for the area northwest of Building 1639 and immediately west of Avenue D,
31 which has elevated concentrations in all three zones.

1 1.2.5 Summary of Risk Assessment

2 A risk assessment for SWMU 39 was performed and documented in the *Zone A RFI Report,*
3 *Revision 0* (Section 10.4.13) for chemicals of potential concern (COPCs) that had been
4 identified in the preliminary screening process. According to the RFI risk assessment,
5 environmental media at SWMU 39 that were impacted included surface soils and
6 groundwater. The RFI risk assessment evaluated exposure to surface soils onsite under both
7 the unrestricted (residential) and site worker (industrial) land use scenarios. For these
8 scenarios, the incidental and dermal contact exposure pathways were evaluated.

9 In the RFI report, any chemical contributing to a cumulative risk level of 1E-06 or greater
10 and/or a cumulative hazard index (HI) greater than 1.0, and whose incremental lifetime
11 cancer risk (ILCR) exceeds 1E-06 or whose hazard quotient exceeds 0.1, was considered a
12 COC. This is conservative for carcinogenic compounds, because a cumulative risk level of
13 1E-04 and individual ILCR of 1E-06 is recommended by the EPA as a trigger level for
14 establishing COCs.

15 The COCs that were identified for SWMU 39 and documented in the *Zone A RFI Report,*
16 *Revision 0* (EnSafe, 1998) as needing further evaluation through a CMS were evaluated in
17 Section 3.0 of the *CMS Work Plan, SWMU 39, Zone A, Revision 0* (CH2M-Jones, 2002b). The
18 COCs identified in the *Zone A RFI Report, Revision 0* were presented and re-evaluated to
19 select a final set of COCs to be addressed by this CMS.

20 As a result of the COC refinement, there were no surface or subsurface soil COCs identified
21 at SWMU 39. No remedial actions are required for surface or subsurface soil at SWMU 39.
22 The CVOCs PCE, TCE, 1,1-DCE, cis-1,2-DCE, and vinyl chloride were retained as
23 groundwater COCs for further evaluation and remedial alternative analysis in this CMS
24 report.

25 1.3 Report Organization

26 This CMS report consists of the following sections, including this introductory section:

27 **1.0 Introduction** —Presents the purpose and scope of the CMS, as well as relevant
28 background information including site history, site hydrogeology, nature and extent of
29 contamination, and summary of the risk assessment; most notably the COCs identified
30 at the site.

- 1 **2.0 RAOs, Proposed MCSs, and Alternative Evaluation Criteria** —Presents the remedial
2 action objectives (RAOs) of this CMS and presents proposed MCSs for VOCs in
3 groundwater.
- 4 **3.0 Description of Candidate Corrective Measure Alternatives** —Describes each of the
5 candidate corrective measure alternatives for source and plume control at SWMU 39.
- 6 **4.0 Detailed Analysis of Alternatives**—Presents the applicable treatment technologies
7 considered for groundwater remediation and a description of the technology screening
8 process. The section also summarizes the factors and methodology used to evaluate and
9 rank the corrective measure alternatives and the results of the evaluation.
- 10 **5.0 Recommended Corrective Measure Alternative**—Describes the preferred corrective
11 measure alternative to achieve the MCSs and RGOs for source and plume control at
12 SWMU 39 based on a comparison of the alternatives.
- 13 **6.0 References** — Lists the references used in this document.
- 14 **Appendix A** provides the results of the 2001 pilot study conducted at SWMU 39, using
15 Hydrogen Release Compound (HRC)® injection technology.
- 16 **Appendix B** contains a summary table presenting analytes detected in the groundwater at
17 SWMU 39 during the April/May and July/August 2002 investigation.
- 18 **Appendix C** provides the cost estimates for each corrective measure alternative evaluated in
19 this CMS.
- 20 All tables and figures appear at the end of their respective sections.

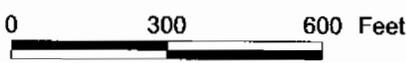
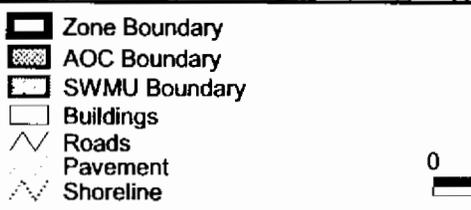
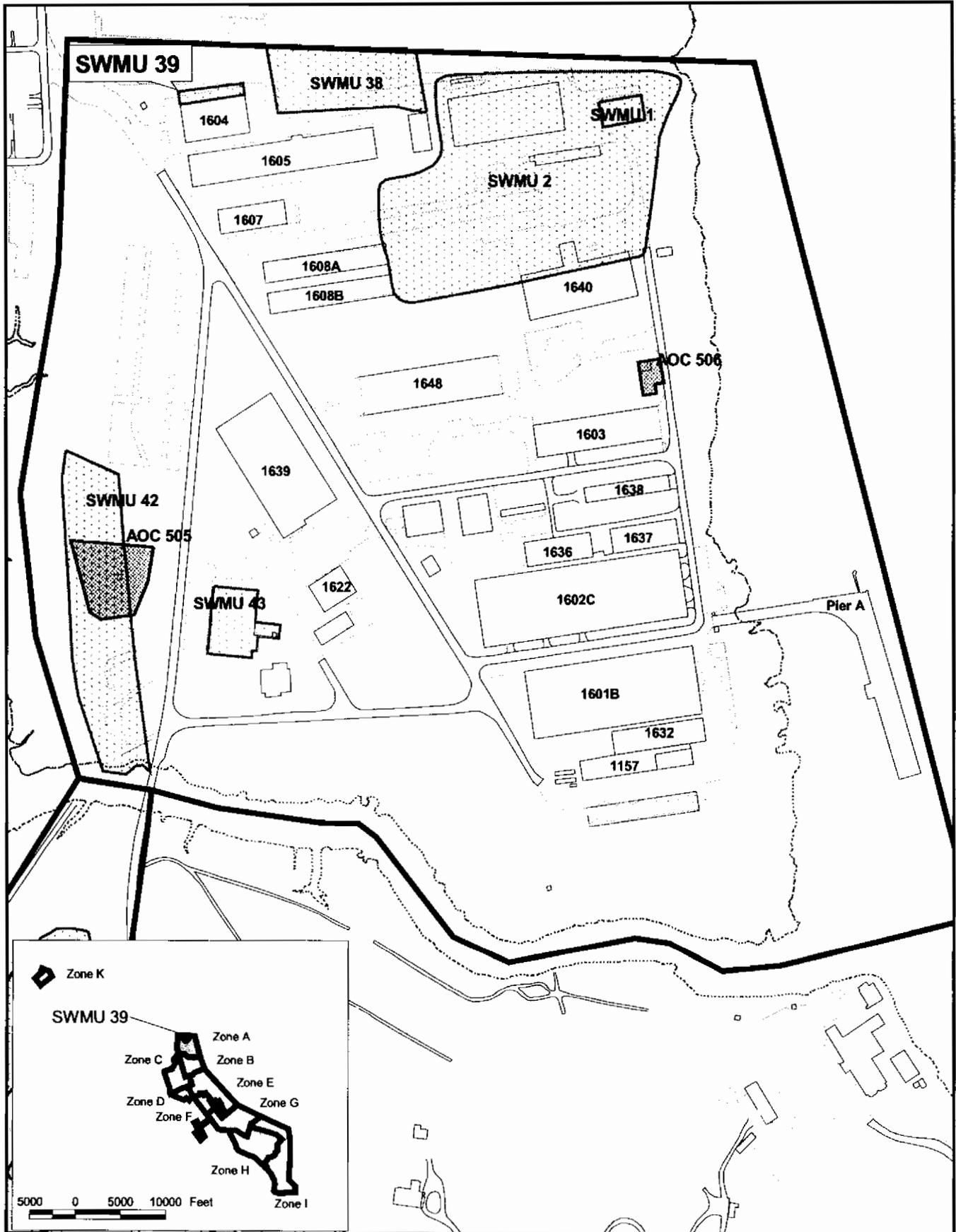


Figure 1-1
 Site Location
 SWMU 39, Zone A
 Charleston Naval Complex

NOTE: Aerial Photo Date is 1987



-  SWMU Boundary
-  Buildings
-  Zone Boundary
-  Fence
-  Railroads
-  Roads

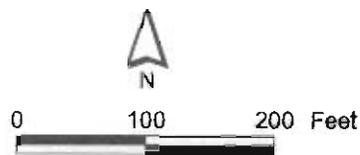
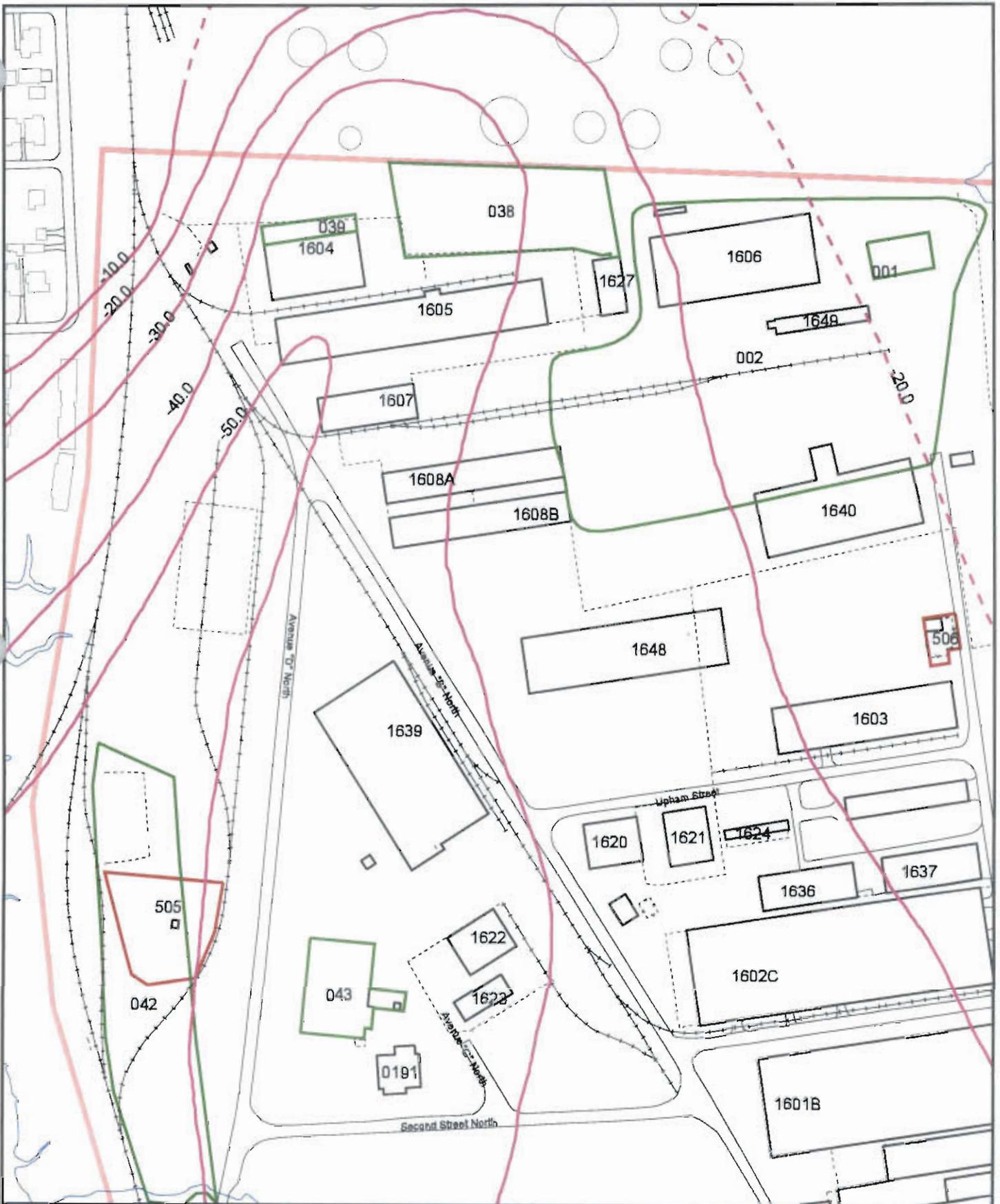


Figure 1-2
Site Layout
SWMU 39, Zone A
Charleston Naval Complex



- Inferred Top of Ashley Formation
- Known Top of Ashley Formation
- Fence
- Railroads
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

-10 - Feet Above Mean Sea Level

0 300 600 Feet

1 inch = 250 feet

Figure 1-4
 Interpreted Ashley Formation Elevation
 SWMU 39, Zone A
 Charleston Naval Complex

NOTE: Original figure created in color

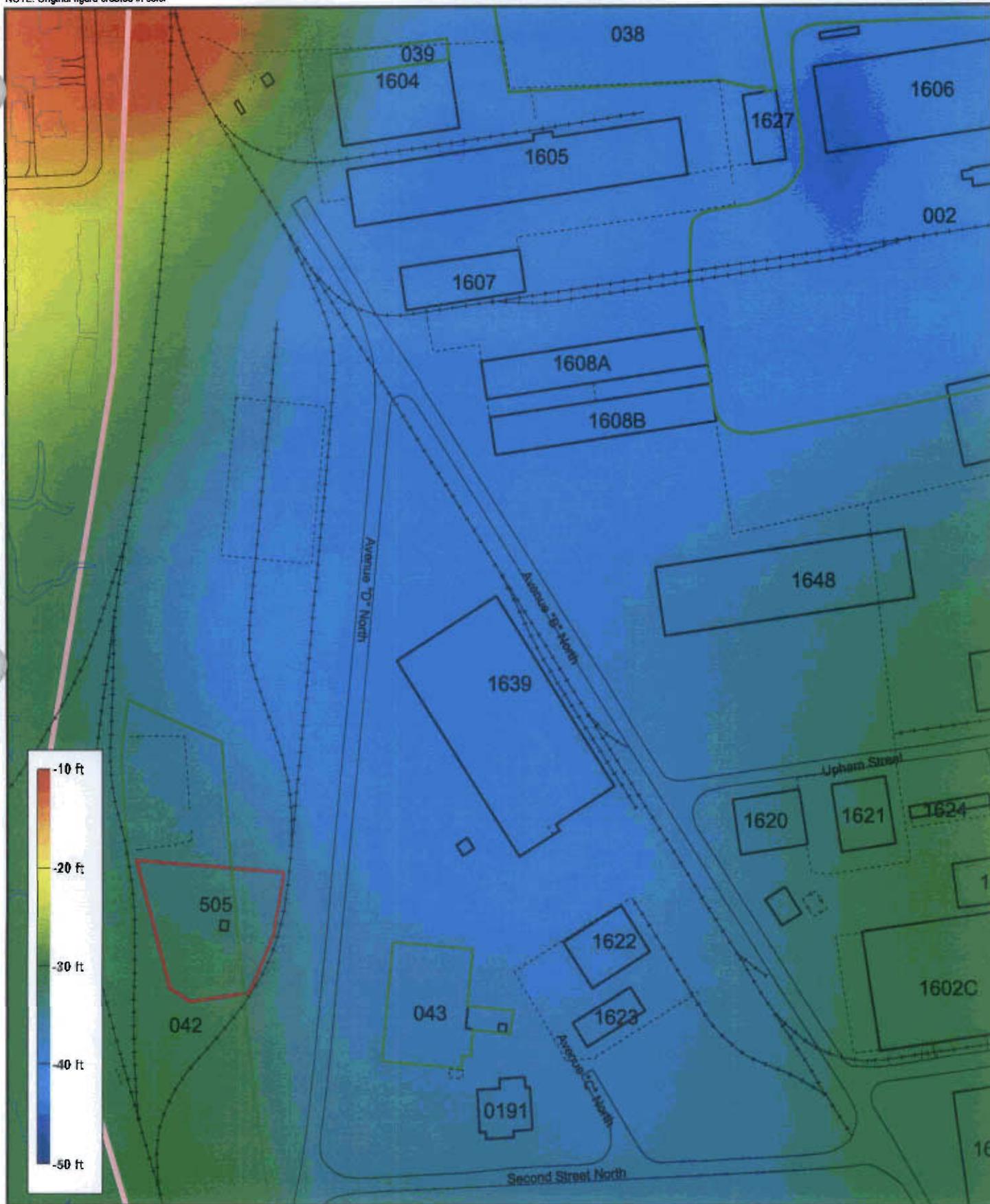


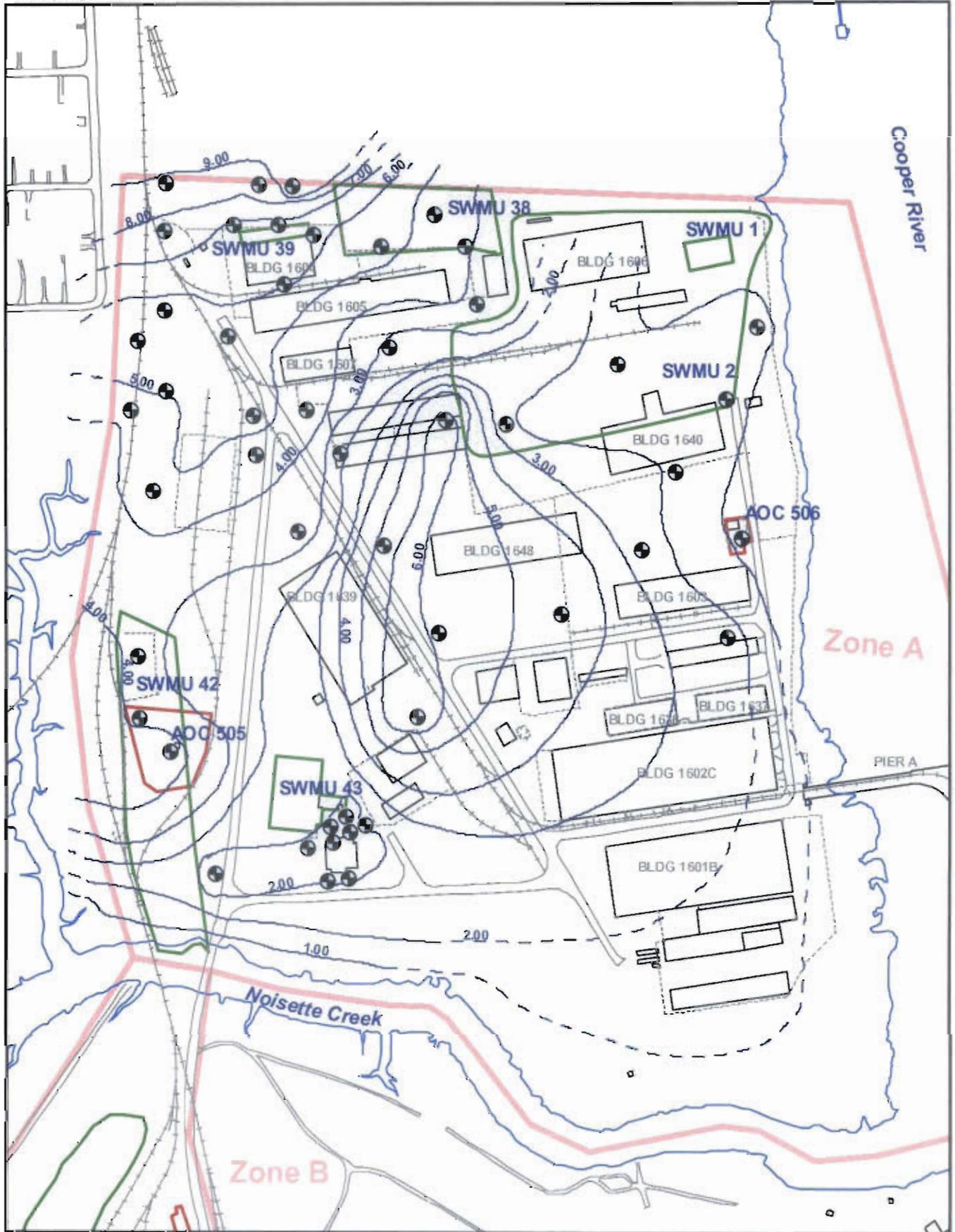
Figure 1-5
Ashley Formation Elevation - 3-D Plan View
SWMU 39, Zone A
Charleston Naval Complex

- Railroads
- Roads
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary



1 inch = 200 feet

NOTE: Original figure created in color



Shallow Groundwater Contours (07/13/01) (ft msl)

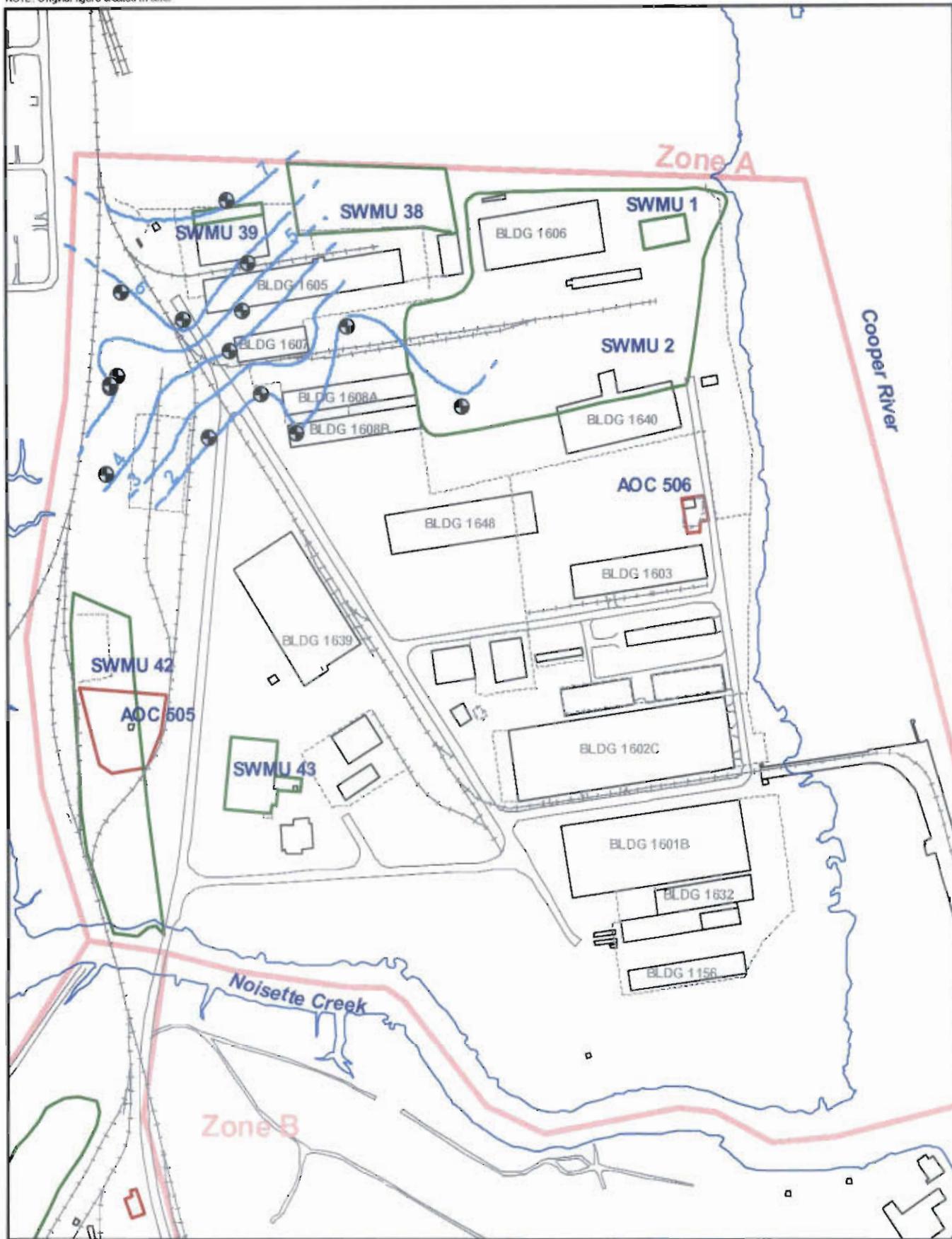
- | | |
|-----------|------------------|
| Known | Groundwater Well |
| Inferred | ACC Boundary |
| Fence | SWMU Boundary |
| Roads | Buildings |
| Shoreline | Zone Boundary |
| Railroads | |



0 300 600 Feet

Figure 1-6
Shallow Groundwater Contours
Zone A
Charleston Naval Complex

NOTE: Original figure created in color



Intermediate Groundwater Contours (07/13/01) (ft msl)

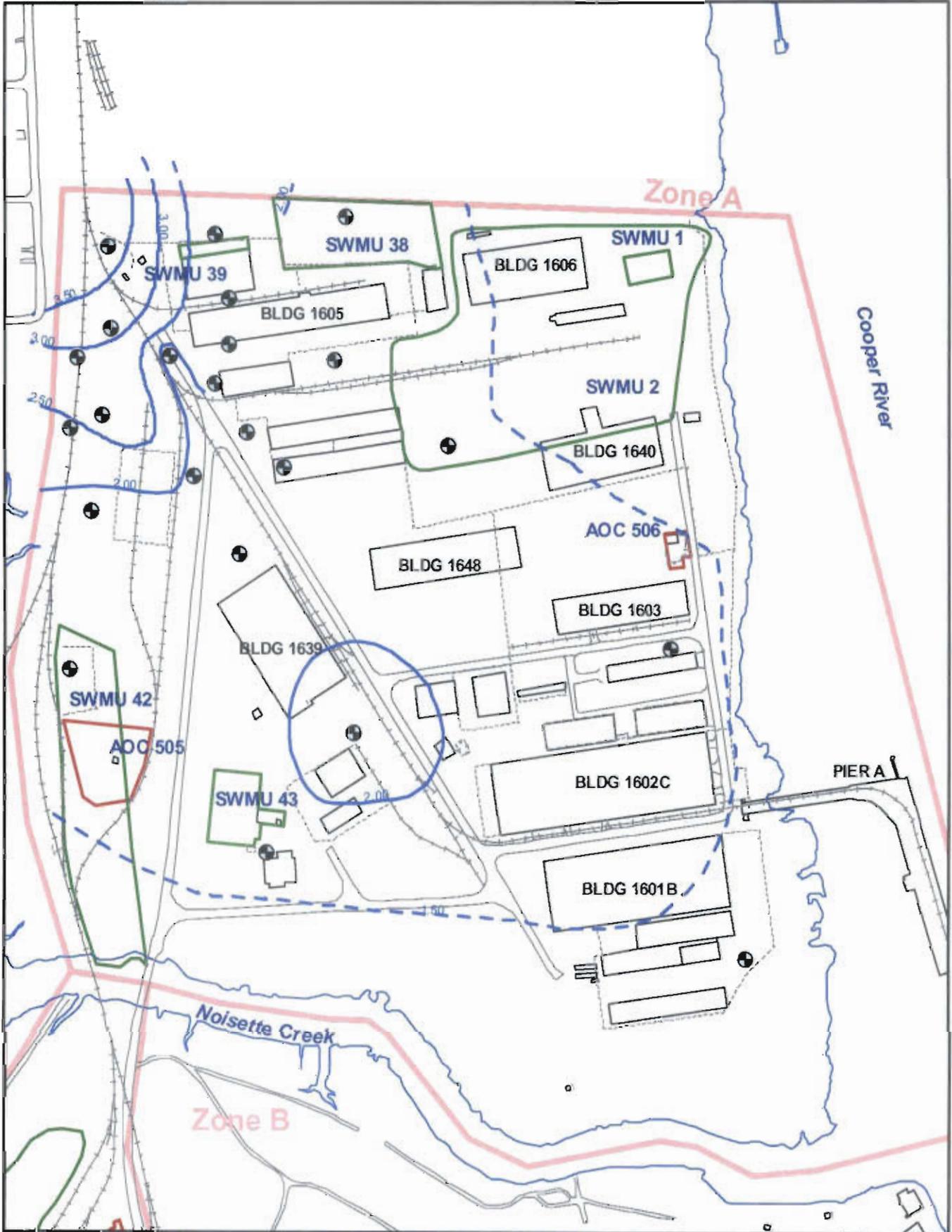
- | | |
|-----------|------------------|
| Known | Groundwater Well |
| Inferred | AOC Boundary |
| Fence | SWMU Boundary |
| Roads | Buildings |
| Shoreline | Zone Boundary |
| Railroads | |



0 300 600 Feet

Figure 1-7
Intermediate Groundwater Contours
Zone A
Charleston Naval Complex

NOTE: Original figure created in color



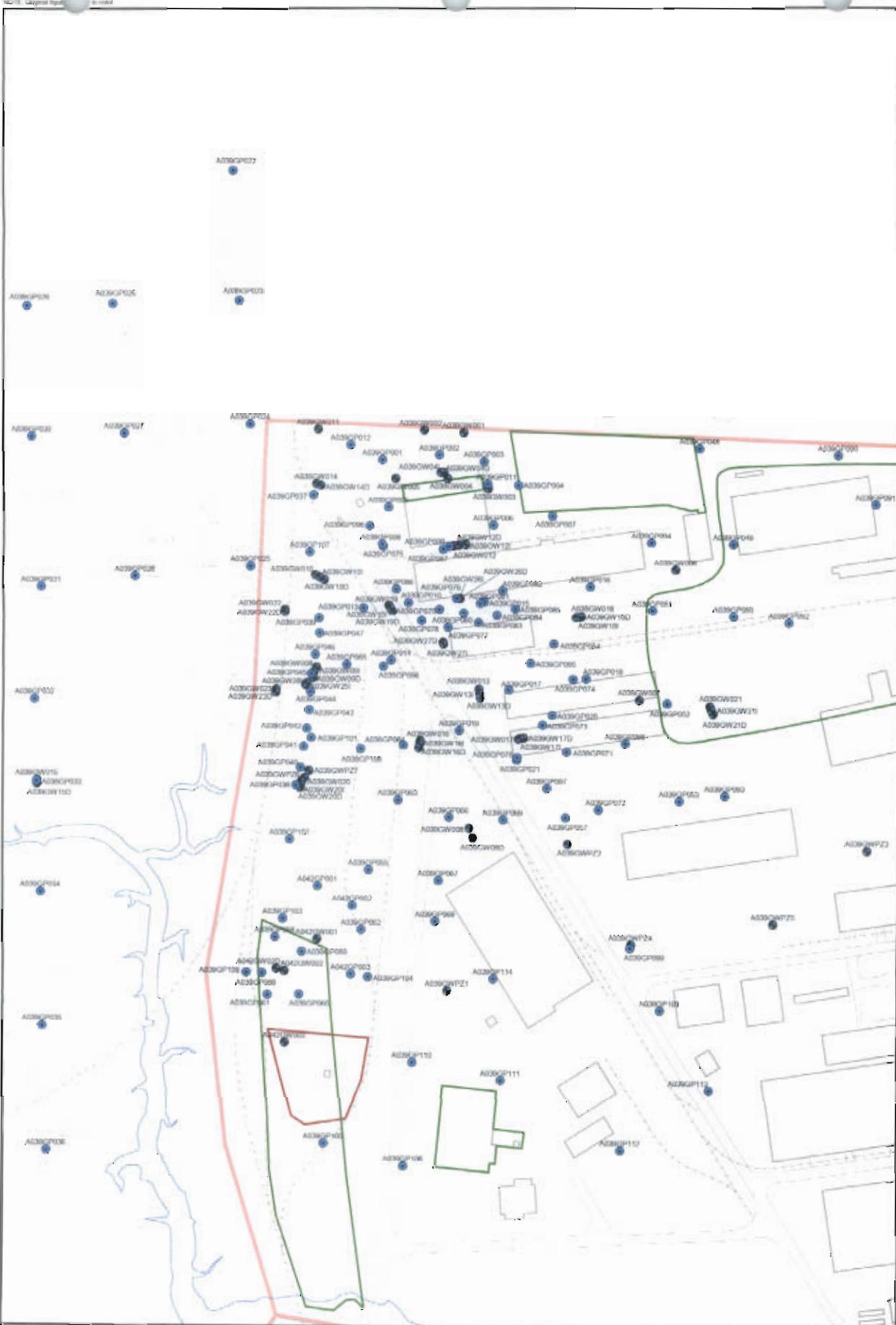
Deep Groundwater Contours (07/13/01) (ftmsl)

- | | |
|-----------|------------------|
| Known | Groundwater Well |
| Inferred | AOC Boundary |
| Fence | SWMU Boundary |
| Roads | Buildings |
| Shoreline | Zone Boundary |
| Railroads | |



0 300 600 Feet

Figure 1-8
 Deep Groundwater Contours
 Zone A
 Charleston Naval Complex



- Groundwater Probs
- Groundwater Well
- Railroads
- Roads - Lines
- ~ Shoreline
- Surrounding Area
- ACIC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

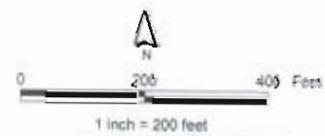
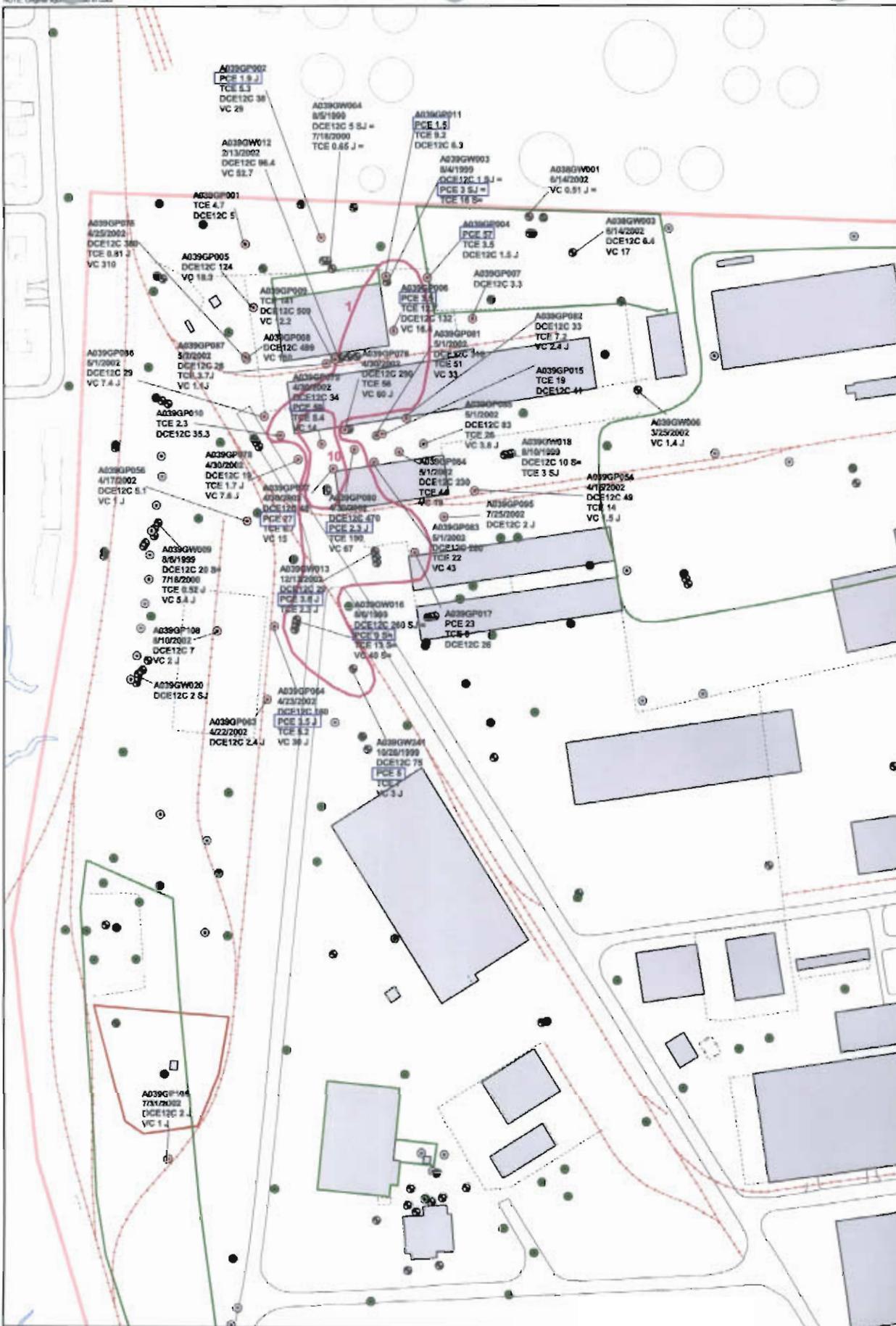


Figure 1-3
 Groundwater Sample Locations
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads

- PCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

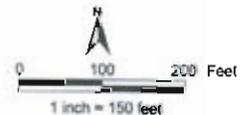
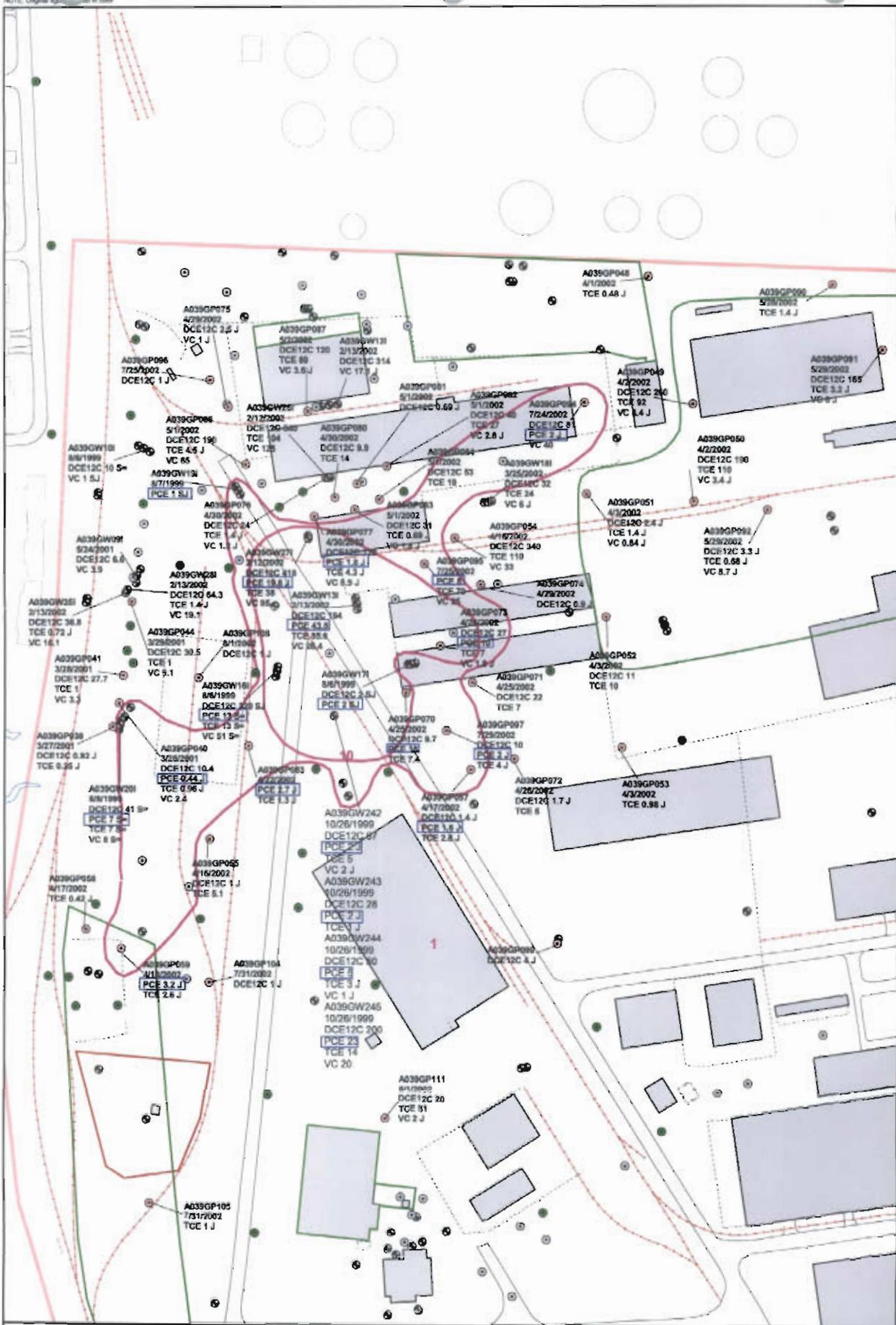


Figure 1-9
 PCE Distribution
 Surficial Aquifer - Shallow Zone
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- ⊙ Groundwater Well - Not Sampled
- ⊕ Groundwater Probe - Analyte Detected
- ⊖ Groundwater Probe No Analyte Detected
- ⊙ Groundwater Probe - Not Sampled
- Fence
- Railroads
- PCE isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

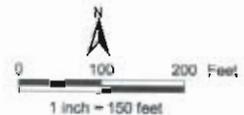
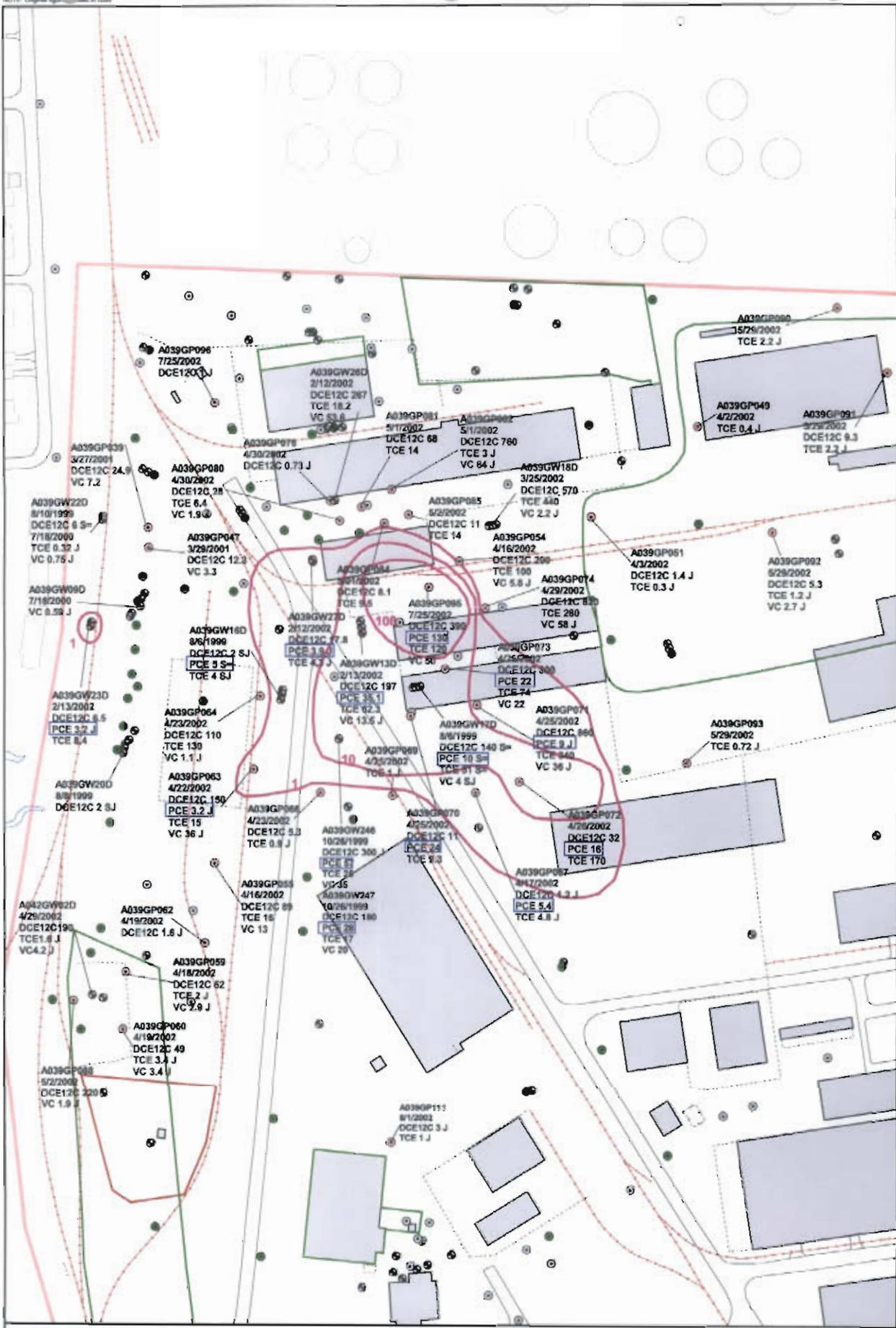


Figure 1-10
 PCE Distribution
 Surficial Aquifer - Intermediate Zone
 SWMU 39, Zone A
 Charleston Naval Complex

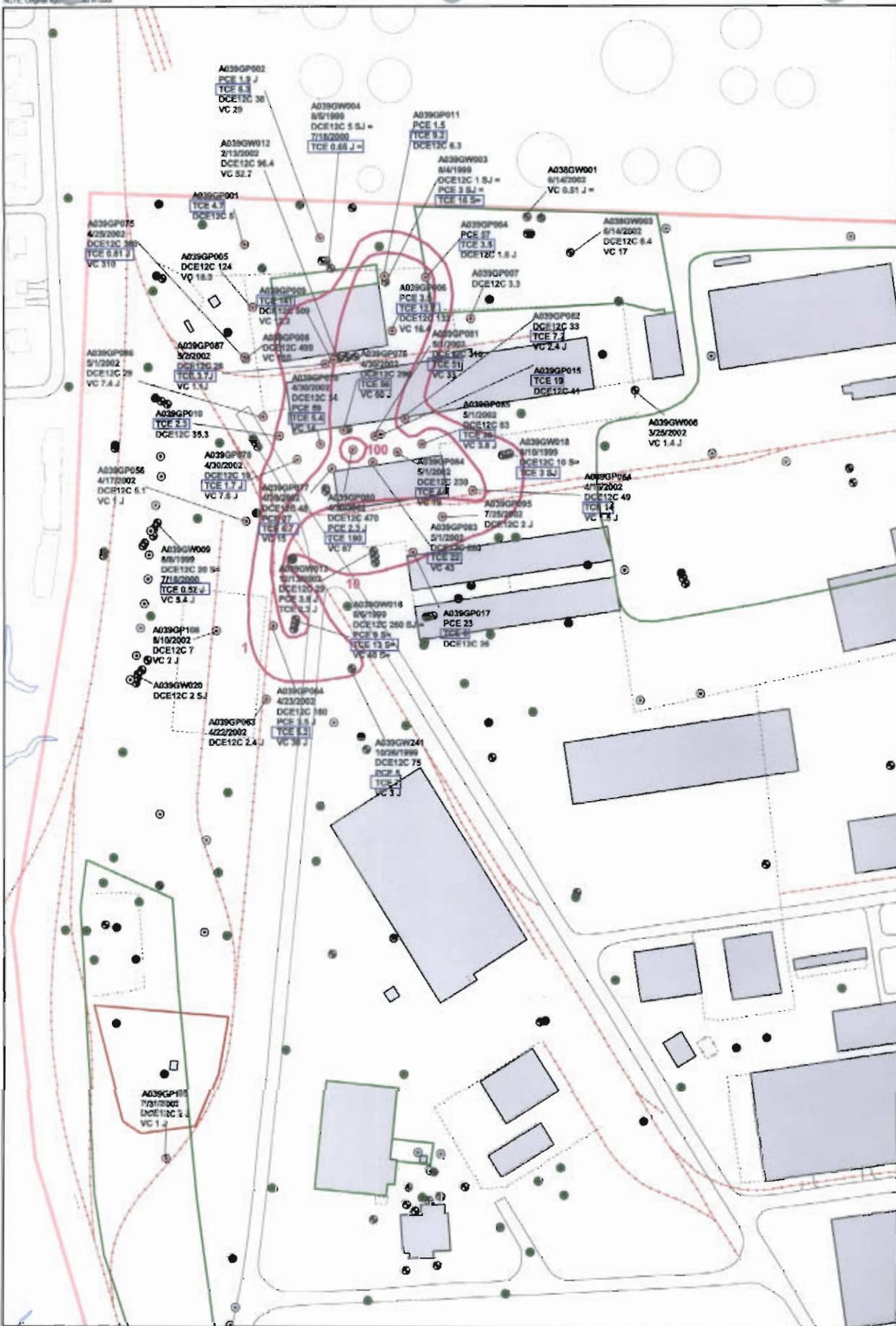


- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads

- PCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary



Figure 1-11
 PCE Distribution
 Surficial Aquifer - Deep Zone
 SWMU 39, Zone A
 Charleston Naval Complex

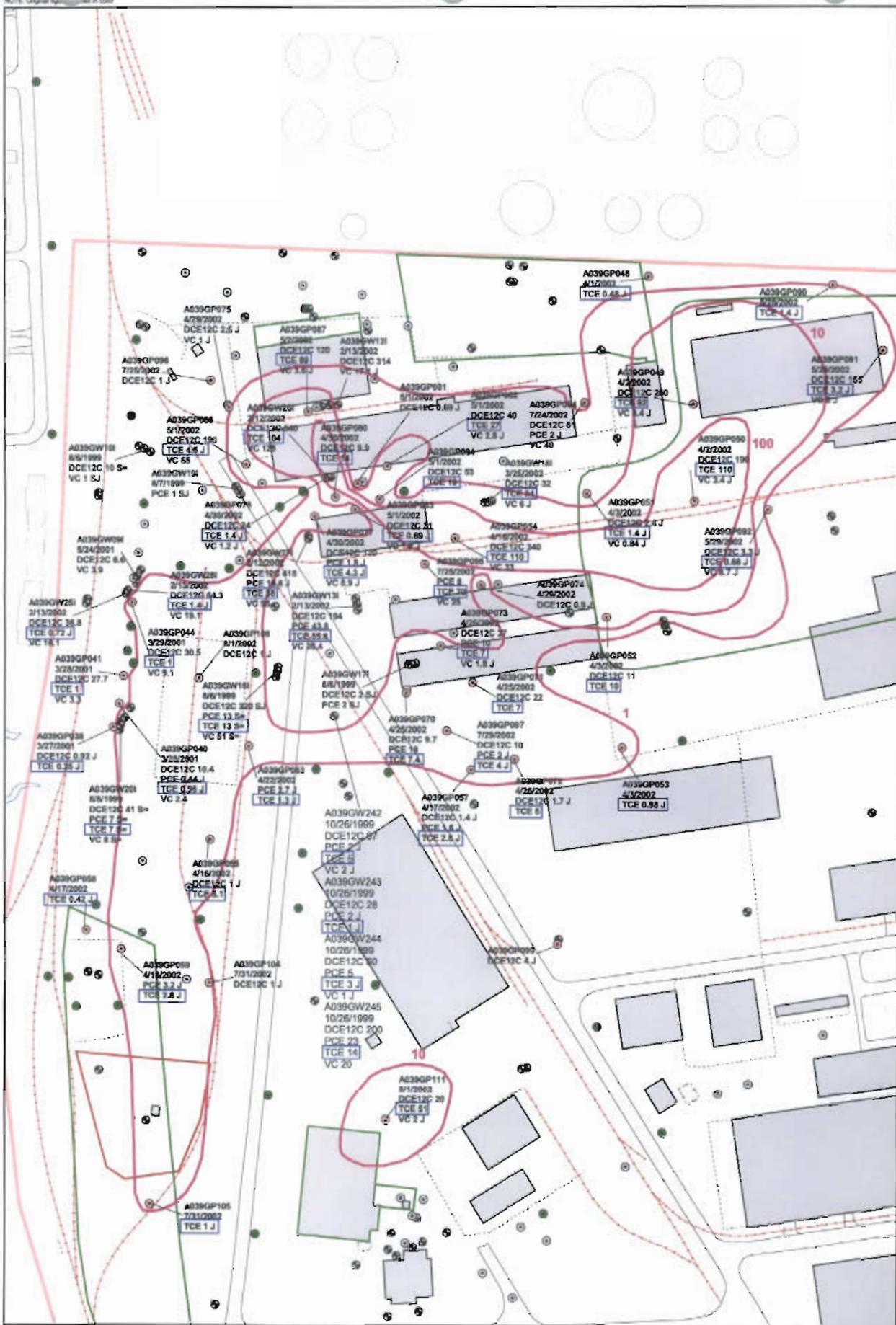


- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- - - Fence
- - - Railroads

- ~ TCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary



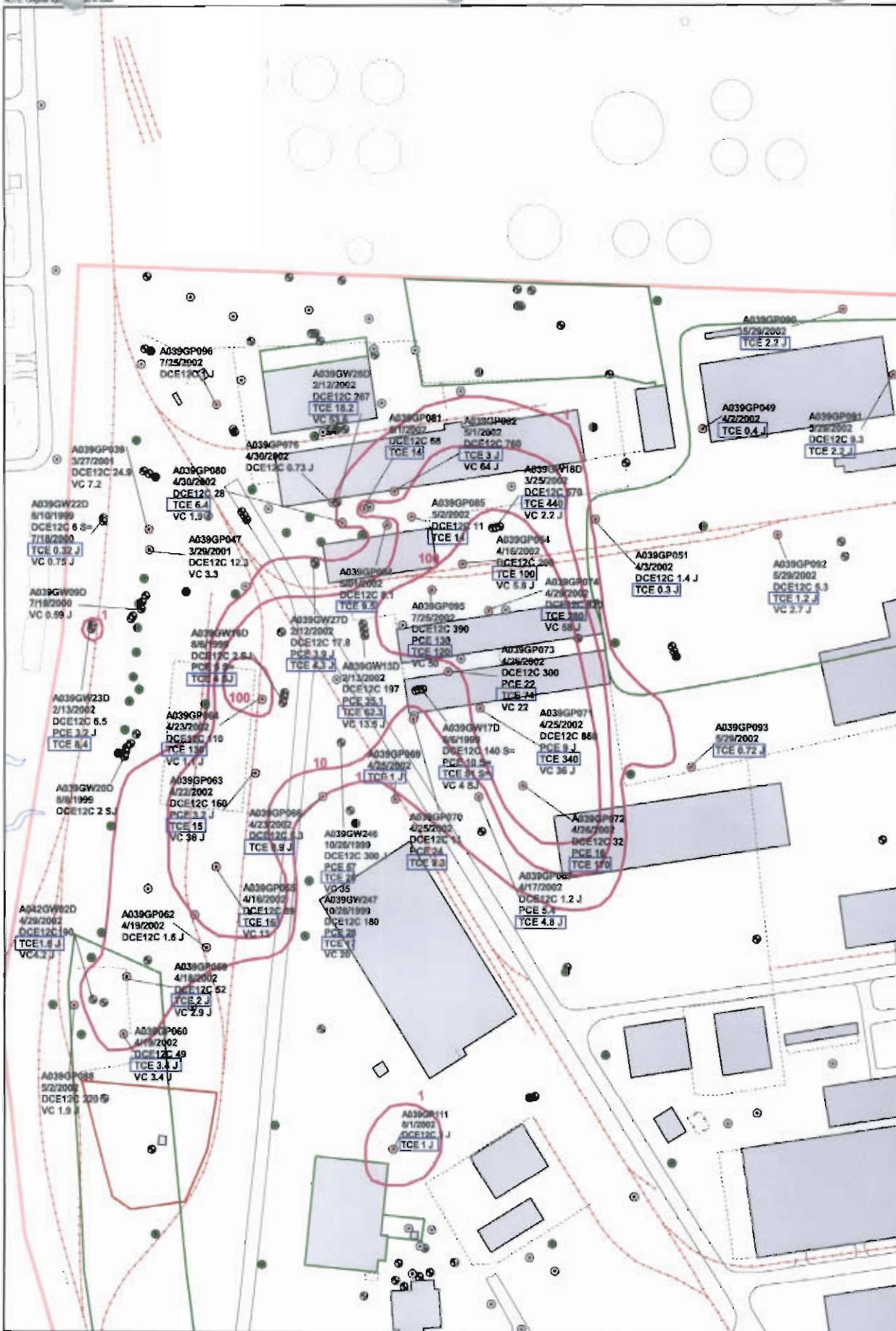
Figure 1-12
 TCE Distribution
 Surficial Aquifer - Shallow Zone
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads
- TCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary



Figure 1-13
 TCE Distribution
 Surficial Aquifer - Intermediate Zone
 SWMU 39, Zone A
 Charleston Naval Complex

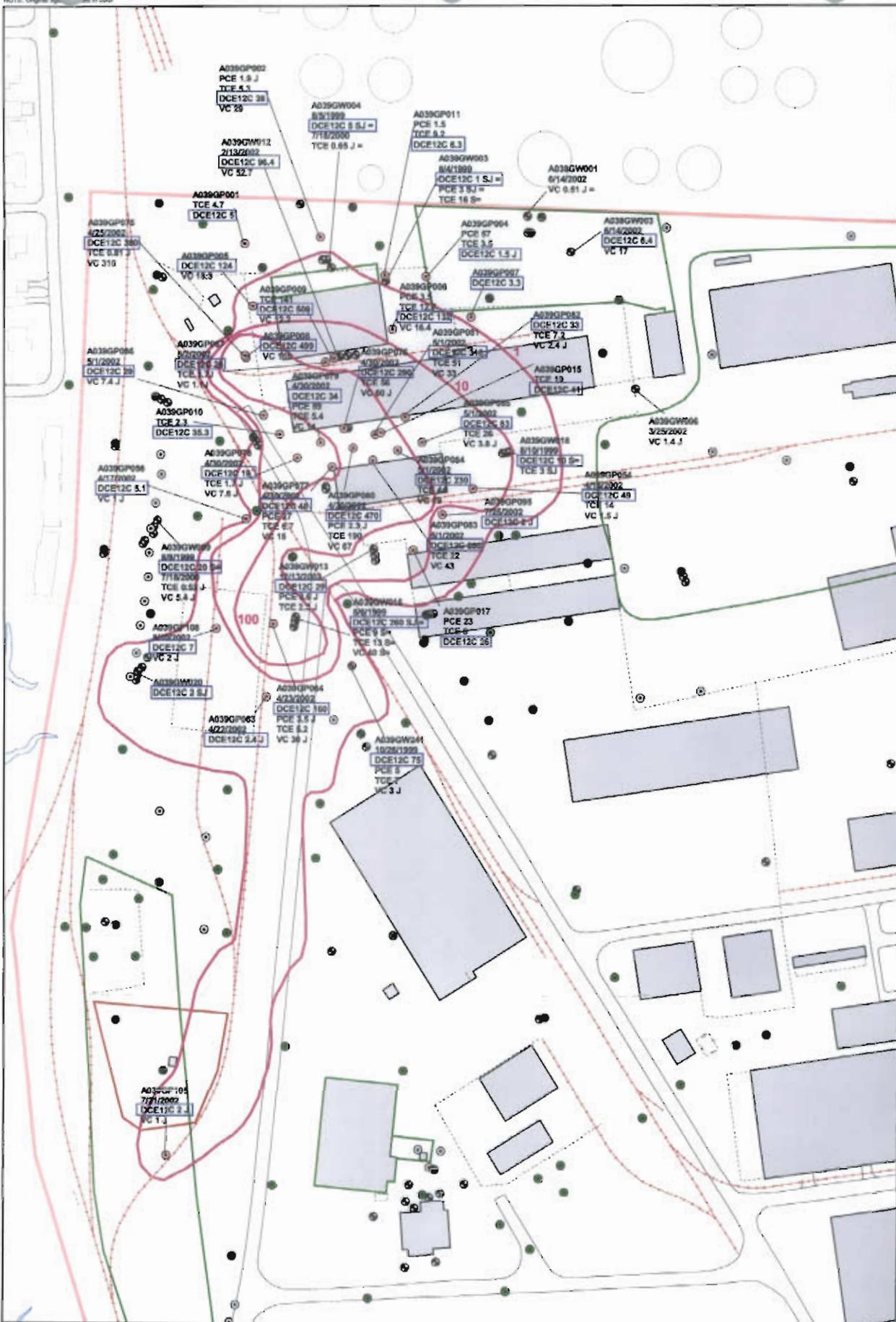


- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- - - Fence
- - - Railroads

- ~ TCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary



Figure 1-14
 TCE Distribution
 Surficial Aquifer - Deep Zone
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads
- cis-1,2-DCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

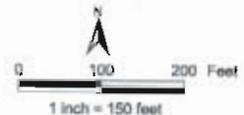
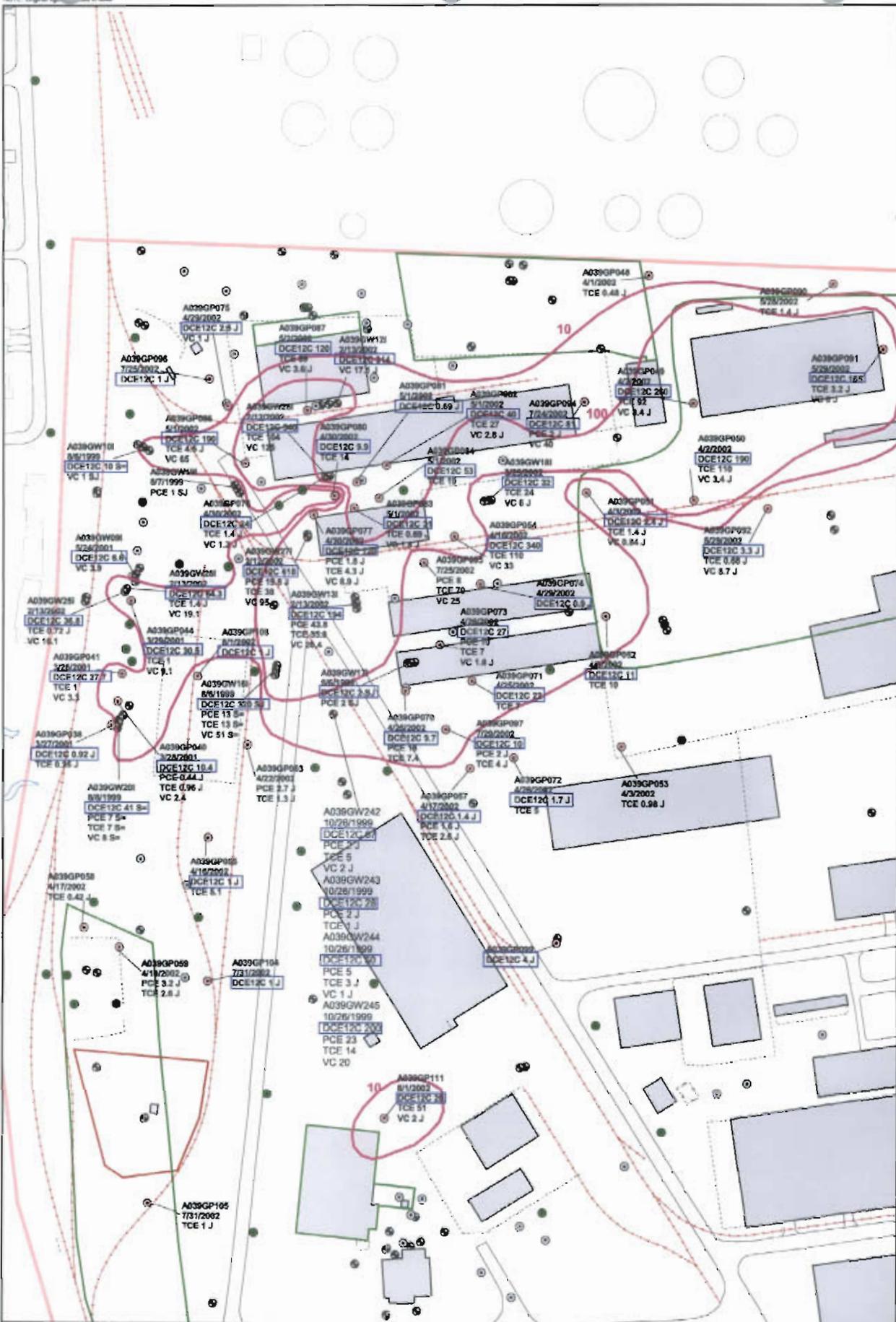


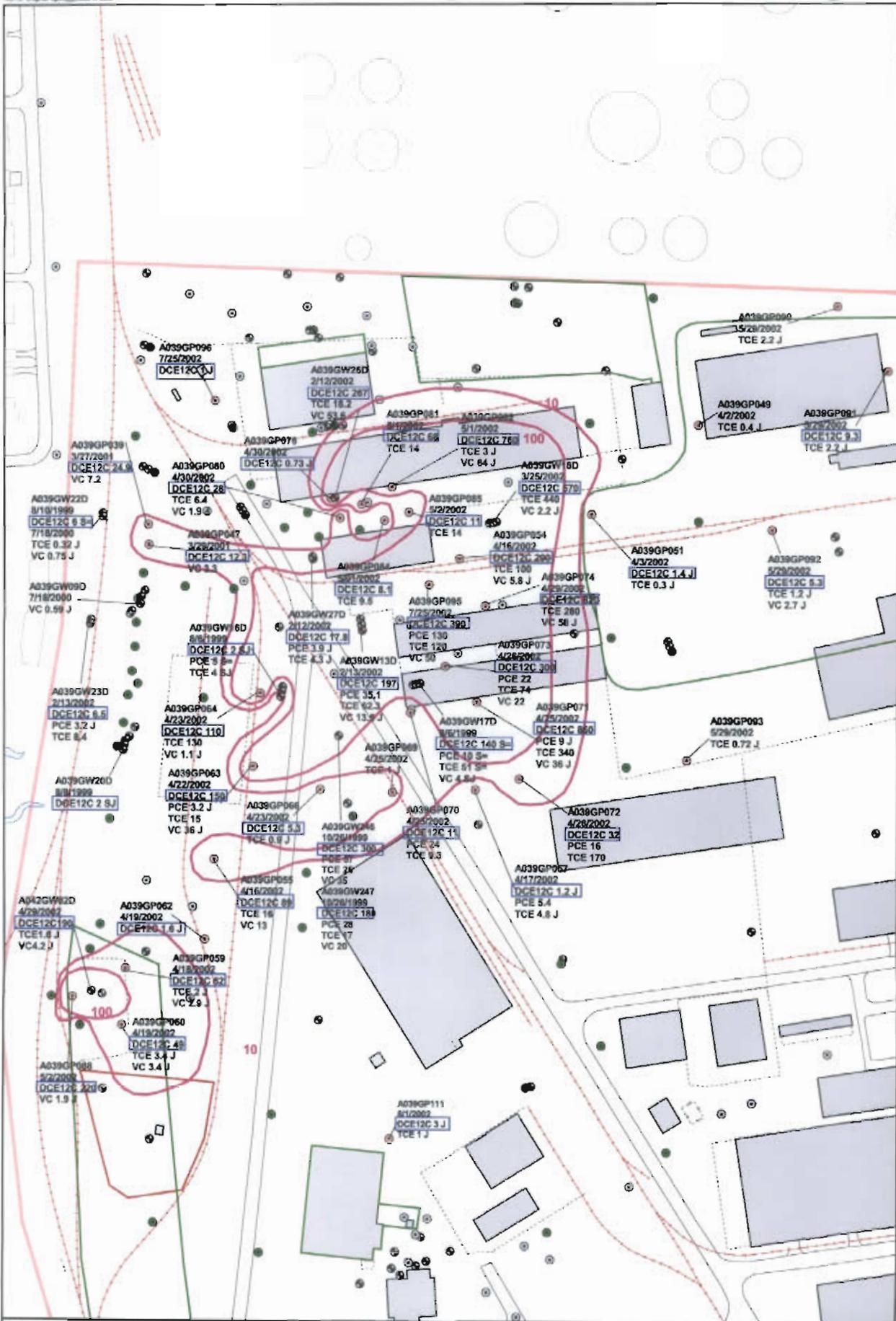
Figure 1-15
 cis-1,2-DCE Distribution
 Surficial Aquifer - Shallow Zone
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads
- cis-1,2-DCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary



Figure 1-16
 cis-1,2-DCE Distribution
 Surficial Aquifer - Intermediate Zone
 SWMU 39, Zone A
 Charleston Naval Complex

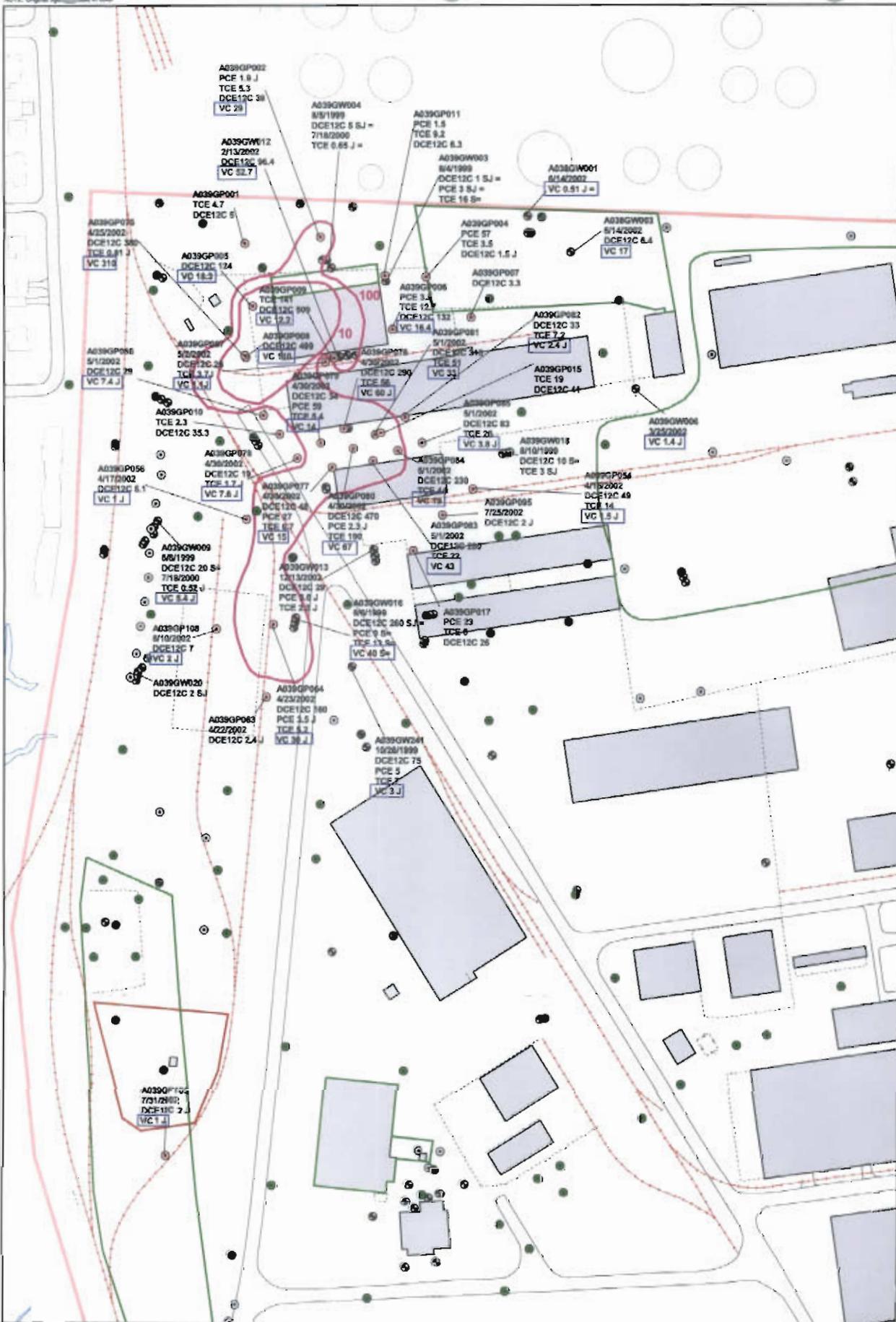


- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads

- cis-1,2-DCE Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary



Figure 1-17
 cis-1,2-DCE Distribution
 Surficial Aquifer - Deep Zone
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads

- Vinyl Chloride Isocentration Contour - ug/l
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

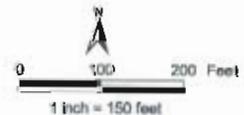
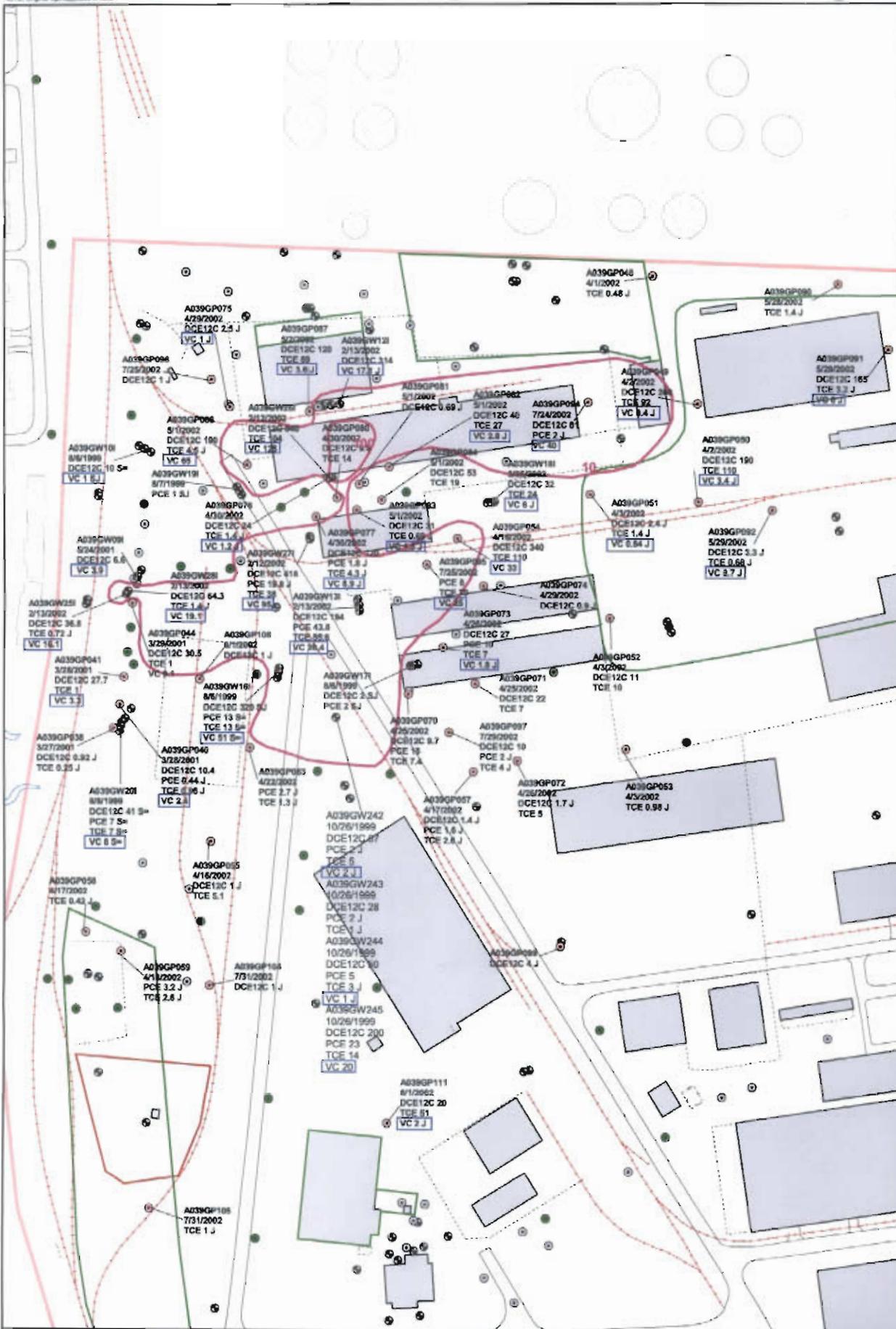


Figure 1-18
 Vinyl Chloride Distribution
 Surficial Aquifer - Shallow Zone
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe - No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads

- Vinyl Chloride Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

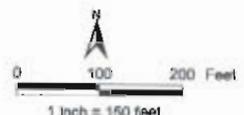
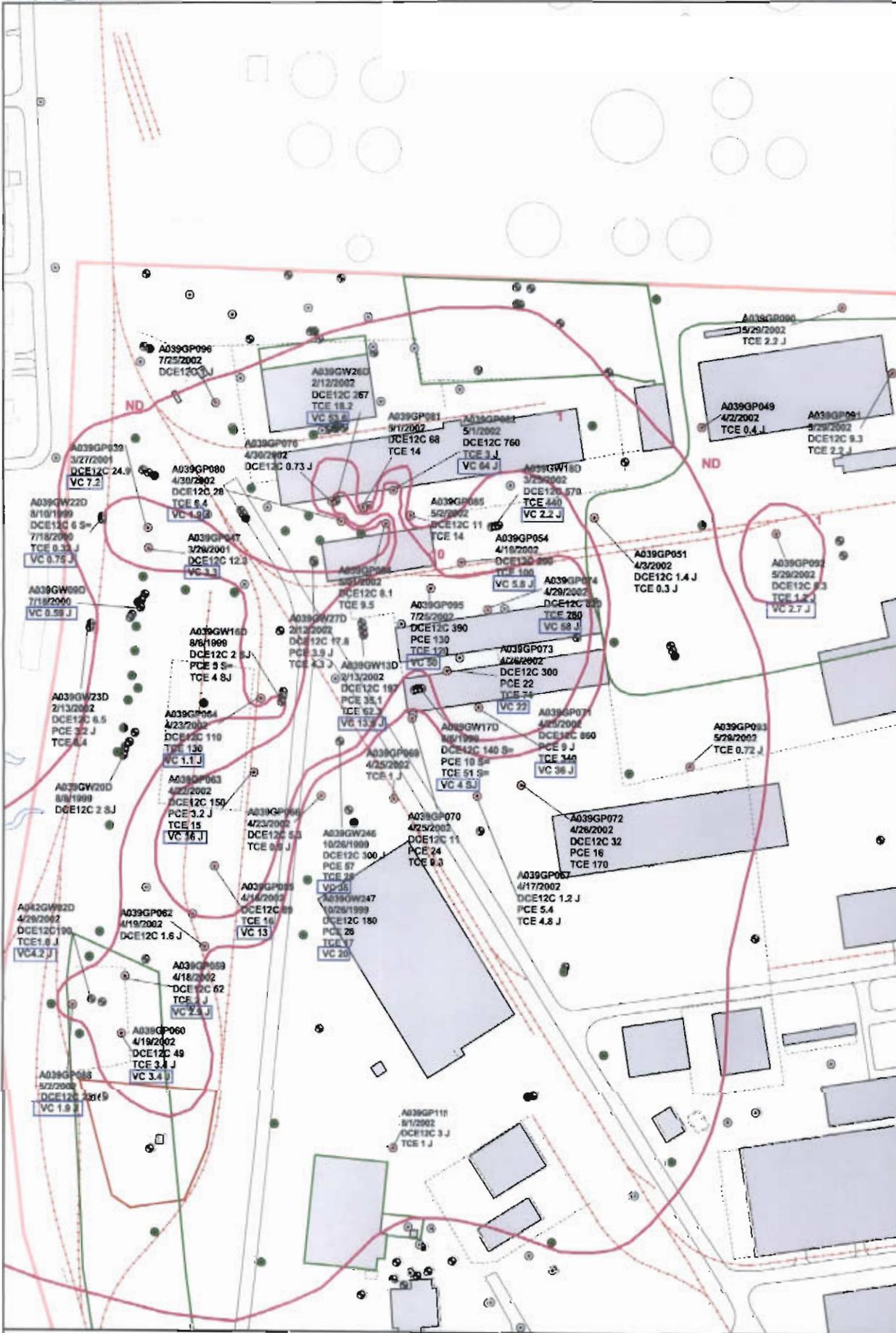


Figure 1-19
 Vinyl Chloride Distribution
 Surficial Aquifer - Intermediate Zone
 SWMU 39, Zone A
 Charleston Naval Complex



- Groundwater Well - Analyte Detected
- Groundwater Well - No Analyte Detected
- Groundwater Well - Not Sampled
- Groundwater Probe - Analyte Detected
- Groundwater Probe No Analyte Detected
- Groundwater Probe - Not Sampled
- Fence
- Railroads

- Vinyl Chloride Isoconcentration Contour - ug/L
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

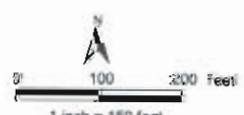


Figure 1-20
 Vinyl Chloride Distribution
 Surficial Aquifer - Deep Zone
 SWMU 39, Zone A
 Charleston Naval Complex

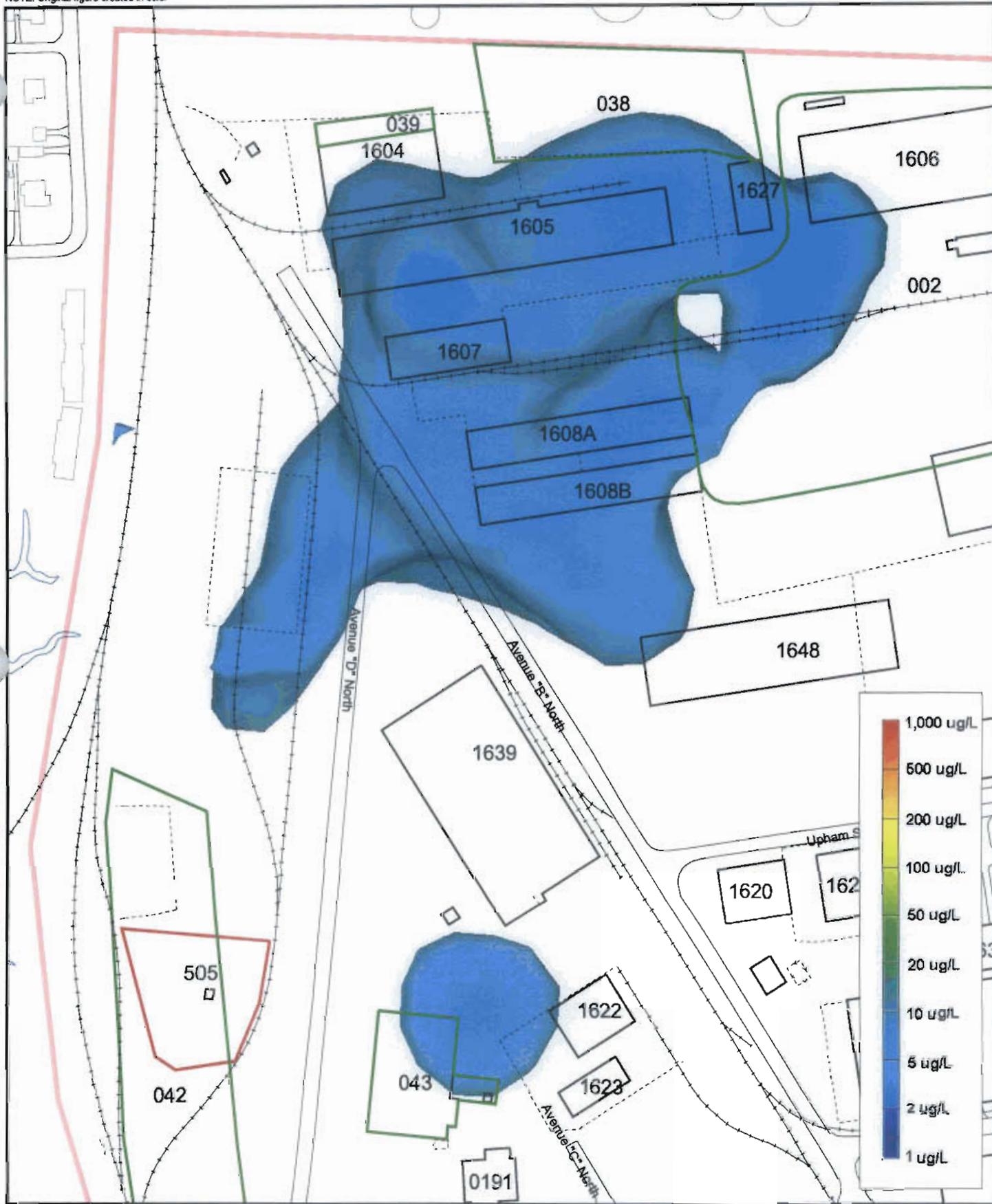
NOTE: Original figure created in color



Figure 1-21

PCE Distribution at 5 ug/L - 3-D Plan View
SWMU 39, Zone A
Charleston Naval Complex

NOTE: Original figure created in color



- Fence
- Railroads
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

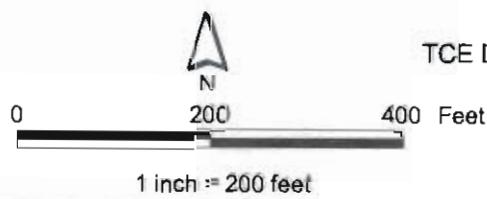
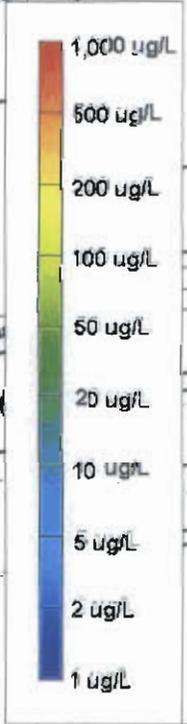


Figure 1-22
TCE Distribution at 5 ug/L - 3-D Plan View
SWMU 39, Zone A
Charleston Naval Complex

NOTE: Original figure created in color



- Fence
- Railroads
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

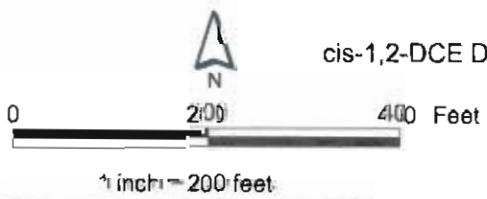
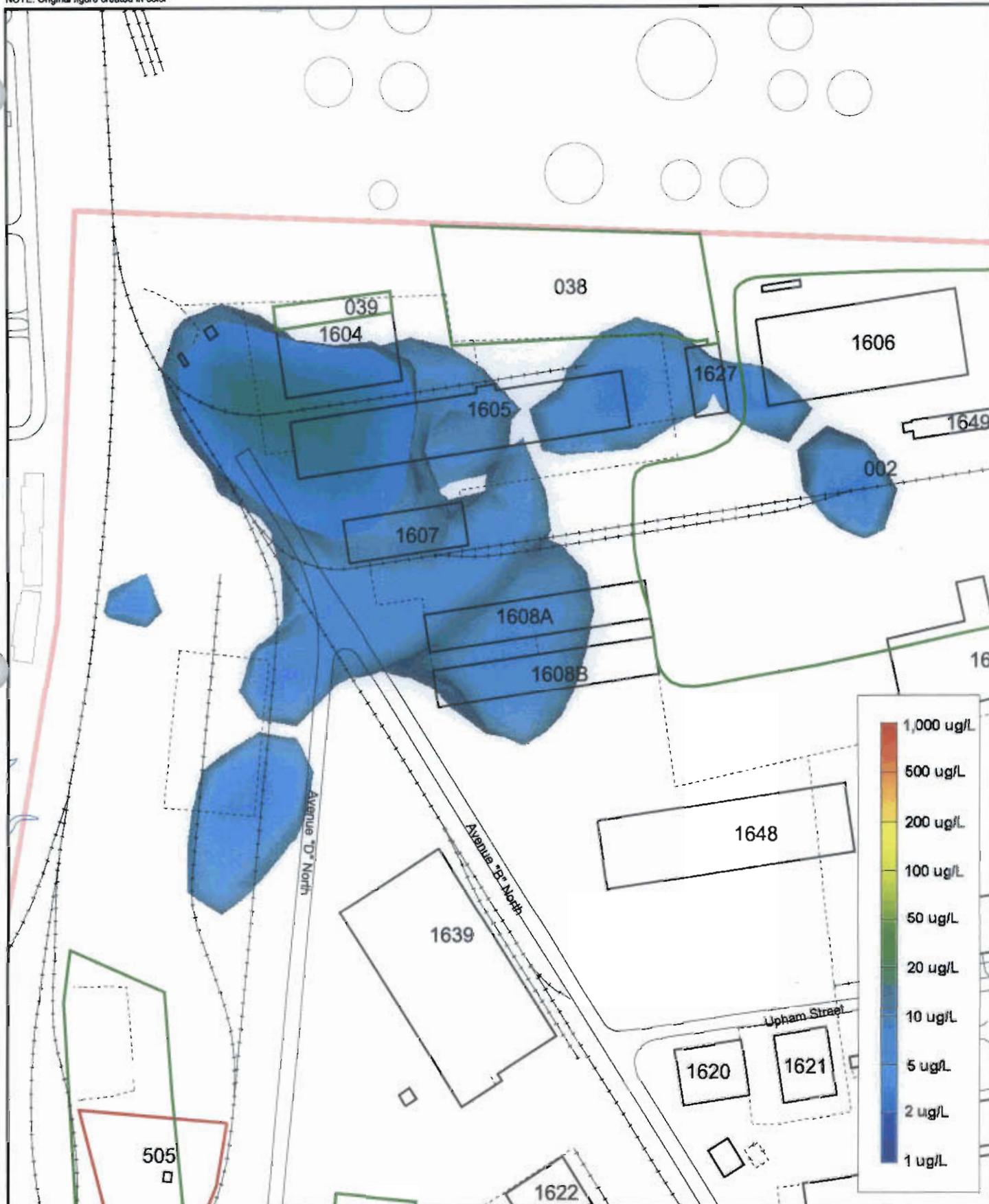


Figure 1-23
 cis-1,2-DCE Distribution at 70 ug/L - 3-D Plan view
 SWMU 39, Zone A
 Charleston Naval Complex

NOTE: Original figure created in color



- Fence
- Railroads
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

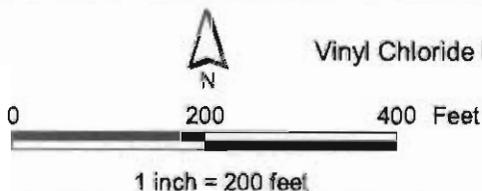


Figure 1-24
Vinyl Chloride Distribution at 5 ug/L - 3-D Plan View
SWMU 39, Zone A
Charleston Naval Complex

Section 2.0

1 2.0 RAOs, Proposed MCSs, and Alternative 2 Evaluation Criteria

3 This section discusses the Remedial Action Objectives (RAOs) of this CMS and presents
4 proposed Media Cleanup Standards (MCSs) for VOCs in groundwater. Once the RAOs and
5 MCSs are established, candidate remedial technologies and alternatives can be developed to
6 meet these objectives. This section also identifies the evaluation criteria used in comparing
7 the CMS alternatives.

8 2.1 Remedial Action Objectives

9 RAOs are environmental medium-specific goals that are created to protect human health
10 and the environment by preventing or reducing exposures under current and future land
11 use conditions. The RAOs identified for the groundwater at SWMU 39 are: 1) to prevent
12 ingestion and direct/dermal contact with groundwater having unacceptable carcinogenic or
13 non-carcinogenic risk, 2) to restore the aquifer to beneficial use, and 3) to control offsite
14 migration of the VOC plume in groundwater to the extent practical.

15 2.2 Remedial Goal Options and Proposed Media Cleanup 16 Standards

17 Throughout the process of remediating a hazardous waste site, a risk manager uses a
18 progression of increasingly acceptable site-specific media levels in considering remedial
19 alternatives. Remedial goal options (RGOs) and MCSs under RCRA are developed at the
20 end of the risk assessment in the RFI/Remedial Investigation (RI)/State programs.

21 RGOs can be based on a variety of criteria, such as specific ILCR levels (e.g., 1E-04, 1E-05, or
22 1E-06), HI levels (e.g., 0.1, 1.0, 3.0), or site background concentrations. For a particular RGO,
23 specific MCSs can be determined as target concentration values. Achieving these MCSs is
24 accepted as demonstrating that the RGOs and RAOs have been achieved. Achieving these
25 goals should promote the protection of human health and the environment, while achieving
26 compliance with applicable state and federal standards.

27 The exposure medium of concern for SWMU 39 is CVOC-contaminated groundwater. The
28 specific chemicals for which RGOs and MCSs are needed include PCE, TCE, cis-1,2-DCE,
29 1,1-DCE, and vinyl chloride. The proposed MCSs for each of these chemicals are the current

1 drinking water maximum contaminant levels (MCLs). These values are presented in Table
2 2-1.

3 **2.3 Evaluation Criteria**

4 According to the RCRA permit issued by SCDHEC (SCDHEC, 1998), the alternatives were
5 evaluated with the following five criteria:

- 6 1. Protect human health and the environment.
- 7 2. Attain MCSs, which will generally be the RGOs.
- 8 3. Control the source of releases to minimize future releases that may pose a threat to
9 human health and the environment.
- 10 4. Comply with applicable standards for the management of wastes generated by remedial
11 activities.
- 12 5. Other factors include (a) long-term reliability and effectiveness; (b) reduction in toxicity,
13 mobility, or volume of wastes; (c) short-term effectiveness; (d) implementability; and (e)
14 cost.

15 Each of the five criteria is defined in more detail below:

16 **2.3.1 Protect Human Health and the Environment**

17 The alternatives were evaluated on the basis of their ability to protect human health and the
18 environment. The ability of an alternative to achieve this criterion may or may not be
19 independent of its ability to achieve the other standards. For example, an alternative may be
20 protective of human health, but may not be able to attain the MCSs if the MCSs are not
21 directly tied to protecting human health.

22 **2.3.2 Attain MCSs**

23 The alternatives were evaluated on the basis of their ability to achieve the RGOs defined in
24 the CMS Work Plan for SWMU 39 (CH2M-Jones, 2002b). Another aspect of this criterion is
25 the time frame to achieve the RGOs.

1 **2.3.3 Control the Source of Releases**

2 This standard deals with the control of releases of contamination from the source (the area
3 in which the contamination originated).

4 **2.3.4 Comply with Applicable Standards for Management of Wastes**

5 This criterion deals with the management of wastes derived from implementing the
6 alternatives; for example, treatment or disposal of well cuttings, contaminated groundwater,
7 or excavated material from a source area.

8 **2.3.5 Other Factors**

9 Five other factors are to be considered if an alternative is found to meet the four criteria
10 described above. These other factors are as follows:

11 a. Long-term reliability and effectiveness

12 The various alternatives will be evaluated on the basis of their reliability, and the
13 potential impact should the alternative fail. In other words, a qualitative assessment
14 was made as to the chance of the alternative's failing and the consequences of that
15 failure.

16 b. Reduction in the toxicity, mobility, or volume of wastes

17 Alternatives with technologies that reduce the toxicity, mobility, or volume of the
18 contamination were generally favored over those that do not. Consequently, a
19 qualitative assessment of this factor was performed for each alternative.

20 c. Short-term effectiveness

21 Alternatives were evaluated on the basis of the risk they create during the
22 implementation of the remedy. Factors that may be considered include fire,
23 explosion, and exposure of workers to hazardous substances.

24 d. Implementability

25 The alternatives were evaluated for their implementability by considering any
26 difficulties associated with conducting the alternatives (such as the construction
27 disturbances they may create), operation of the alternatives, and the availability of
28 equipment and resources to implement the technologies comprising the alternatives.

29 e. Cost

30 A net present value of each alternative was developed. These cost estimates were
31 used for the relative evaluation of the alternatives, not to bid or budget the work.

1 The estimates were based on information available at the time of the CMS and on a
2 conceptual design of the alternative. They are "order-of-magnitude" estimates with a
3 generally expected accuracy of -30 percent to +50 percent for the scope of action
4 described for each alternative. The estimates were categorized into capital costs and
5 operations and maintenance costs for each alternative.

TABLE 2-1
Proposed MCSs for VOCs in Groundwater at SWMU 39
Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Chemical	Proposed MCS ($\mu\text{g/L}$)
Tetrachloroethene (PCE)	5
Trichloroethene (TCE)	5
Cis-1,2-Dichloroethene (cis-1,2-DCE)	70
1,1-Dichloroethene (1,1-DCE)	7
Vinyl Chloride	2

$\mu\text{g/L}$ Micrograms per liter

Section 3.0

3.0 Description of Candidate Corrective Measure Alternatives

This section presents the identification and description of candidate corrective measure alternatives for source and plume control at SWMU 39. For CVOC contamination areas, separate engineering alternatives for source and plume control are often appropriate and more effective than single remedy solutions. Source control alternatives are selected to reduce dense non-aqueous phase liquid (DNAPL) mass, or where DNAPLs are not present, higher concentrated groundwater contamination area(s) that are generally smaller in volume than the dissolved plume. Plume control alternatives typically address the dissolved plume that is usually less contaminated than the source area(s) in predetermined locations. Locations are selected to mitigate offsite and/or downgradient migration of dissolved contaminants. This CMS report outlines corrective measure alternatives for source control and offsite and downgradient plume control.

3.1 Evaluation Approach

Currently available groundwater remedial technologies were screened for applicability to contaminants and physical conditions present at SWMU 39; with only viable remedial technologies known for effective treatment of CVOCs selected for source control and plume control alternative analysis. Detailed analyses of these selected technologies, presented below, provide the rationale to support the selection of the recommended corrective measure alternatives. A detailed analysis of corrective measure alternatives for source control, contaminant migration control at the property boundary, and downgradient contaminant control are evaluated in Section 4.0 of this report. Each alternative was analyzed using the evaluation criteria outlined in Section 2.3.

3.2 Description of Alternatives

3.2.1 Source Control Corrective Measure Alternatives

A source control measure is intended to mitigate residual source areas of COCs that could continue to release dissolved-phased COCs to the groundwater. Previous investigations at SWMU 39 have not identified concentrations of CVOCs at, or greater than, 1 percent of their maximum solubility in water. The value of 1 percent or greater of the maximum solubility of

1 a solvent in groundwater is often used as an empirical indicator of the likely presence of a
2 DNAPL near the monitored location. Typically, this empirical value is used to identify
3 DNAPL source area(s) at a particular site. Though no DNAPL areas are identified at SWMU
4 39, areas of the site which will be considered as candidates for "source area" treatment are
5 defined as those having a total CVOC concentration of greater than 1,000 µg/L. The location
6 and approximate elevation of the source area is provided as follows:

- 7 • North Central Portion of Building 1608A - Deep interval of the surficial aquifer,
8 approximately 48 to 50 ft bls
- 9 • South Central Portion of Building 1608B - Deep interval of the surficial aquifer,
10 approximately 47 to 48 ft bls

11 Figures 3-1 and 3-2 present the 3-D plan and profile visualization, developed using EVS
12 software, of the dissolved CVOC source area. This treatment volume, consisting of
13 approximately 76 cubic yards (yd³), is identified on Figure 3-1. Currently, there are no
14 monitoring wells within the proposed source control treatment area. As part of the
15 proposed corrective measure for source control two additional monitoring wells will be
16 installed in the target treatment area.

17 These proposed monitoring wells, which are depicted on Figure 3-1, will be used to evaluate
18 the effectiveness and performance of the selected source control alternative.

19 The corrective measure alternatives developed for source control in the deep interval at
20 SWMU 39 include the following:

- 21 • Alternative 1 – In situ Chemical Oxidation (ISCO) Using Fenton's Reagent
- 22 • Alternative 2 – In situ Chemical Reduction (ISCR) Using Zero-Valent Iron

23 A comparison evaluation of these alternatives is provided in Section 4.1 and in Table 4-1. A
24 description of these alternatives is presented below.

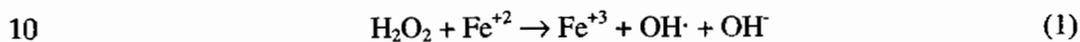
25 **Alternative 1 – In situ Chemical Oxidation Using Fenton's Reagent**

26 Oxidative treatment is advantageous as a remedial technology for chlorinated ethenes
27 because it is rapid and aggressive. In situ oxidation is achieved by delivering chemical
28 oxidants to contaminated media resulting in the contaminants being completely oxidized
29 into carbon dioxide (CO₂) or converted into innocuous compounds (such as chloride)
30 commonly found in the subsurface. The most widely used oxidants include hydrogen
31 peroxide (Fenton's reagent), potassium permanganate, and ozone.

1 Hydrogen peroxide was selected as the preferred oxidant due its successful application at
2 other CVOC sites and because of its pressure-delivery method. The chemistry involved is
3 based upon Fenton's reagent. Fenton's reagent oxidizes organic contaminants to CO₂ and
4 water, plus chloride (in the case of chlorinated compounds).

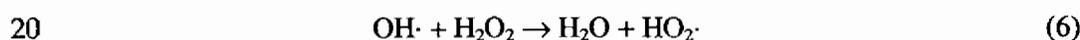
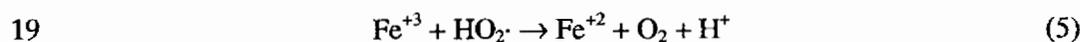
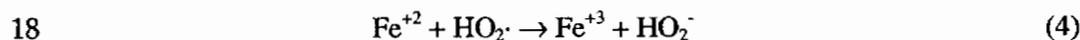
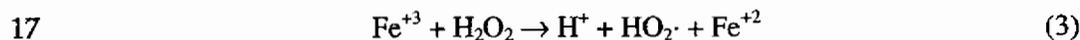
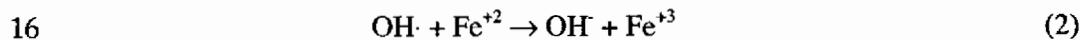
5 In 1894, H.J.H. Fenton reported that malic acid was rapidly oxidized by hydrogen peroxide
6 in the presence of iron salts. Haber and Weiss (1934) identified the oxidation mechanism
7 resulting from mixtures of hydrogen peroxide and ferrous iron (referred to as Fenton's
8 reagent) as a hydroxyl free radical (OH·) formed by the following reaction:

9



11

12 Where H₂O₂ is hydrogen peroxide, Fe⁺² is ferrous iron, Fe⁺³ is ferric iron, OH· is hydroxyl
13 free radical, and OH⁻ is hydroxyl ion. Fenton's reagent chemistry is complex, involving a
14 number of additional reactions producing both oxidants and reductants that contribute to
15 contaminant destruction (e.g., Watts et al., 1999):



21 Where HO₂· is hydroperoxyl radical, HO₂⁻ is hydroperoxyl anion, O₂ is molecular oxygen,
22 H⁺ is the hydrogen ion, and H₂O is water. Additional reactions occur with organic
23 compounds. The suite of reactions associated with Fenton's reagent is complex, but is very
24 effective in destroying many organic compounds dissolved in groundwater, sorbed to soil
25 particles, or existing as non-aqueous phase liquids in subsurface environments.

26 The hydroxyl free radical generated by Fenton's reagent is a powerful, non-selective
27 oxidant, therefore any organic compound may be oxidized including native organic
28 compounds and soil biota. Oxidation of an organic compound by Fenton's reagent is a rapid
29 and exothermic (heat-producing) reaction. Rate constants for reactions of hydroxyl free
30 radical with common environmental pollutants are typically in the range of 10⁷ to 10¹⁰ M⁻¹s⁻¹

1 (e.g., Buxton et al., 1988; Haag and Yao, 1992), and 100-percent mineralization is generally
2 completed in minutes. Intermediate compounds are primarily naturally occurring
3 carboxylic acids. The end products of oxidation are primarily carbon dioxide and water,
4 plus chloride (in the case of chlorinated compounds). None of the injected reagents poses an
5 environmental hazard. Unconsumed hydrogen peroxide naturally degrades to oxygen and
6 water within a few days of injection.

7 The recommended chemical oxidation delivery method uses the Geo-Cleanse® Process
8 which is a patented technology that simultaneously injects hydrogen peroxide and trace
9 quantities of metallic salts under pressure to the subsurface to destroy organic contaminants
10 in soil and groundwater. U.S. patents 5,525,008 and 5,611,642 protect the technology. The
11 Geo-Cleanse® Process delivers a calculated charge of hydrogen peroxide and catalyst to the
12 contaminated region via specially designed injection equipment consisting of mixing heads
13 and subsurface injectors. The injection methodology and equipment are the keys to the Geo-
14 Cleanse® Process.

15 **Alternative 2 – In situ Chemical Reduction Using Zero-Valent Iron**

16 In situ chemical reduction using zero-valent colloidal iron (ZVI) involves the subsurface
17 injection and dispersion of targeted quantities of ZVI. ZVI, a strong reductant, has
18 demonstrated effectiveness as a reactive medium for the in situ chemical reduction or
19 dehalogenation of chlorinated ethenes. The recommended delivery method for ZVI into the
20 aquifer is the FeroxSM technology process developed by ARS Technologies (ARS).

21 The FeroxSM technology is a patented in situ subsurface remediation process for the
22 treatment of chlorinated solvents and dissolved metals. The FeroxSM technology involves the
23 subsurface injection and dispersion of specific quantities of highly reactive ZVI powder into
24 saturated or unsaturated contamination zones. The FeroxSM technology has the ability to
25 inject the ZVI using DPT technology in areas of subsurface utilities and infrastructure. The
26 ZVI incorporated in the FeroxSM application is a 98+ percent pure, reduced iron powder
27 imported from Japan. The powder's particle size, shape, and carbon content result in a
28 highly reactive material. The small particle size of this ZVI powder, as compared to
29 domestic-grade iron powder, provides more surface area per unit weight, resulting in this
30 powder being more reactive in the subsurface.

31 The ZVI is delivered into the subsurface through ARS's patented Liquid Atomized Injection
32 (LAI) Technology. In conjunction with the LAI process, ARS can apply pneumatic fracturing
33 (PF) at each injection point, if necessary, prior to introducing the ZVI into the subsurface.

1 The use of LAI in conjunction with fracturing provides a unique method to apply the ZVI to
2 the subsurface and directly access and target contaminants within the subsurface.

3 Because the heterogeneous geology at SWMU 39 may present limitations for other
4 conventional hydraulic injection methods, ARS may use incorporate a gas-based delivery
5 approach for the emplacement of the ZVI into the subsurface. PF is a patented process in
6 which a gas is injected into the subsurface at pressures that exceed the combined
7 overburden pressure and cohesive soil strength of the geologic matrix, and at flow rates that
8 exceed the effective permeability of the undisturbed soil. The result is the propagation of
9 fractures outward from the injection well to distances of 20 to 25 ft. The use of PF will be
10 critical to the in situ treatment process since it will allow for effective permeability
11 enhancement of the clay lenses, sandy silts, and cohesive materials, resulting in a reduction
12 of geologic heterogeneities present within the subsurface. This occurs prior to and while
13 emplacing the reactive ZVI in the subsurface.

14 **3.2.2 Corrective Measure Alternatives at the Downgradient Property Boundary**

15 Plume control measures will be implemented as needed to prevent the offsite CVOC
16 migration beyond the western CNC property boundary. Groundwater COCs have not been
17 detected in any of the groundwater samples collected beyond the CNC boundary at
18 concentrations above their MCL. Although the groundwater gradients are not significant in
19 westward direction, the potential for offsite migration exists due to the close proximity of
20 contaminants to the CNC boundary. TCE and vinyl chloride were detected at concentrations
21 slightly greater than their MCL in samples collected from monitoring wells located 45 to 60
22 ft east of the property boundary and in samples collected from Geoprobe™ borings
23 advanced approximately 108 to 135 ft east of the property boundary. Based on the EVS
24 software, TCE and vinyl chloride have the potential to migrate off site. However, this is
25 based on the limited number of groundwater samples along the western boundary.

26 Currently, only two monitoring well pairs (i.e., A039GW022/22D and A039GW023/23D)
27 exist on the CNC property immediately west of the rail line, which is 55 to 70 ft east of the
28 property boundary. These two well pairs are separated by approximately 180 ft. As part of
29 the corrective measure for contaminant migration control at the property boundary, three
30 additional well pairs consisting of a intermediate and deep well will be installed
31 immediately west of the rail line on 90 to 100-ft centers, resulting in five well pairs covering
32 approximately 380 ft along the western boundary. These monitoring wells, which are
33 presented on Figure 3-3, will be sampled on a yearly basis. The results will be used to

1 evaluate the implementation of future active corrective measures to control the offsite
2 migration of the dissolved CVOC plume.

3 Because of the detected TCE concentration of 8.4 µg/L in the recent sample collected from
4 monitoring well A039GW23D on February 13, 2002 and the previous detection of vinyl
5 chloride at 4.9] µg/L in the sample collected on July 18, 2000, this CMS will address the
6 intermediate and deep intervals of the surficial aquifer (i.e., 27 to 37 ft bls) in the
7 surrounding area of monitoring well A039GW23D. A 555 yd³-treatment volume, which is
8 approximately 100 ft long, 15 ft wide, and centered approximately 40 ft north of monitoring
9 well A039GW23D, is also depicted on Figure 3-3 with the EVS-modeled total CVOC plume
10 at a concentration of greater than 50 µg/L. This proposed treatment volume is intended as a
11 contingency in the event contaminant migration is moving westward, as indicated in
12 samples collected from the existing and proposed monitoring wells west of the railroad lines
13 near the CNC property boundary.

14 The corrective measure alternatives developed for contaminant migration control at the
15 property boundary include the following:

- 16 • Alternative 1 – Monitoring/Natural Attenuation
- 17 • Alternative 2 – In situ Chemical Reduction Using ZVI
- 18 • Alternative 3 – Permeable Reactive Barrier
- 19 • Alternative 4 – In situ Air Sparging
- 20 • Alternative 5 - Enhanced In situ Anaerobic Biodegradation

21 A description of these alternatives is presented below.

22 **Alternative 1 – Monitoring/Natural Attenuation**

23 Natural attenuation is the reduction of CVOC concentration by the natural processes
24 present in the aquifer, including volatilization, hydrolysis, dilution, dispersion, adsorption,
25 and biotic and abiotic degradation. The collective effect of these processes is termed natural
26 attenuation. MNA is a careful evaluation of natural attenuation mechanisms using
27 monitoring. EPA has issued a Draft Final OSWER Directive on Monitored Natural
28 Attenuation (EPA, 1997), in which it recognizes that monitored natural attenuation is
29 appropriate as a remedial approach, “where it can be demonstrated capable of achieving a
30 site’s remedial objectives within a time frame that is reasonable compared to that offered by
31 other methods, and where it meets the applicable remedy selection criteria for that

1 particular OSWER program." EPA clearly states its expectation that "monitored natural
2 attenuation will be most appropriate when used in conjunction with active remediation
3 measures (e.g., source control) or as a follow-up to active remediation measures that already
4 have been implemented."

5 Under the natural attenuation alternative, the low-level CVOC plume in the non-source area
6 of the surficial aquifer would be evaluated using a monitoring system designed to track the
7 plume location and magnitude. Monitoring data would be compared to the predicted
8 transport and fate of the CVOCs to check predictions accuracy.

9 In general, the MNA alternative consists of three major features:

- 10 • A designed monitoring program
- 11 • A tracking and data evaluation program
- 12 • A contingency response plan in the event that the monitoring indicates downgradient
13 migration of dissolved CVOCs

14 A MNA study (EnSafe, 1999) reported that aquifer conditions conducive to natural
15 attenuation of CVOCs by reductive chlorination processes vary in Zone A. This report
16 indicated that conditions required generally become more favorable moving southward in
17 Zone A which include portions of the downgradient CVOC plume. The groundwater
18 quality data support the conclusion that the natural attenuation is occurring to some degree
19 in all zones of the shallow aquifer system in this area.

20 The MNA alternative would be implemented in conjunction with a long-term monitoring
21 plan. The purpose of the plan is to monitor plume migration over time, and to verify that
22 natural attenuation is occurring. The plan would specify new and existing wells located
23 within, upgradient to, crossgradient to, within and downgradient of the dissolved-phase
24 plume from both the immediate area of Buildings 1608A and 1608B and between Buildings
25 1605 and 1607.

26 The monitoring plan may include CVOCs, metals (at selected locations), dissolved oxygen,
27 nitrates, ferrous iron, sulfates, common cations and anions, and dissolved hydrocarbon
28 gases, ethene, ethane, and methane. The data would provide characterization of plume
29 extent, native groundwater quality, oxygen reduction potential (ORP) indicators, and
30 indicators of biological degradation products of the CVOCs.

31 However, recent developments in the study of MNA have made it easier to evaluate the
32 potential success of an MNA alternative. One of these developments include the analysis for

1 *Dehalococcoides ethenogenes*. A variety of halo-respiring bacteria have been shown to
2 dechlorinate PCE and TCE to cis-1,2-DCE, but only *Dehalococcoides ethenogenes* has been
3 documented to cause the complete dechlorination of PCE/TCE to ethene (Hendrickson,
4 2002). DNA molecular tools are used to provide semi-quantitative population density data
5 on this microorganism. The advantage of detecting *Dehalococcoides* is that its presence has
6 been correlated with complete dechlorination and a single round of groundwater samples
7 analyzed for the microorganism indicates if and where spatially the potential for complete
8 dechlorination may occur at SWMU 39.

9 Assuming that the source of the contamination is controlled or being treated, it is expected
10 that the CVOC plume would slowly decrease in concentration as a result of natural
11 attenuation. Because of the slow contaminant migration velocity, declines in concentrations
12 from the implemented source control areas may not be seen immediately. Additional
13 contingency remedies would be considered if natural attenuation indicates low performance
14 as evidenced by one of the following conditions:

- 15 • Increasing trends for total CVOC concentrations at offsite and/or downgradient edge of
16 plume that significantly increase potential exposures or related risks.
- 17 • Near-source wells exhibit large concentration increases indicative of a new or renewed
18 release related to former Navy operations.

19 **Alternative 2 – In situ Chemical Reduction Using Zero-Valent Iron**

20 A brief technical description of in situ chemical reduction technology involving colloidal
21 ZVI with the patented FeroxSM technology injection process is presented in the previous
22 section which describes in situ chemical reduction using ZVI.

23 **Alternative 3 – Permeable Reactive Barrier**

24 The permeable reactive barrier (PRB) involves the placement of reactive treatment medium
25 in in situ permeable zones in the target treatment area or across the flow path of
26 contaminated groundwater. Like the patented FeroxSM technology injection process, the PRB
27 uses ZVI as an in situ chemical reduction technology. The reducing conditions cause the
28 CVOCs to abiotically reductively dehalogenate to by-products such as ethene. However, the
29 process is a passive operation that relies on the natural flow of groundwater to bring
30 dissolved contaminants in contact with the ZVI. As in the case of PRB, the ZVI is not a
31 powder but added as a blend of grindings and an inert agent such as sand. A PRB, which is
32 approximately 30 inches wide, is constructed in a horizontal manner perpendicular to the
33 direction of groundwater flow. The implementability of PRB is evaluated by the presence of

1 subsurface utilities and obstructions, and the termination depth of the barrier. In addition,
2 the barrier width can be reduced by constructing low-permeability wings or funnels on the
3 sides of the PRB to direct groundwater flow through the reactive media. The actual
4 dimensions of a PRB are governed by the residence time needed for reaction (i.e., treatment
5 of the CVOCs).

6 **Alternative 4 – In situ Air Sparging**

7 In situ air sparging involves the sparging or injecting compressed air at controlled pressures
8 and volumes into the aquifer to cause the transfer of CVOCs from groundwater into the air.
9 Because of natural heterogeneity, most aquifers do not allow air to distribute evenly, and as
10 a result, the effectiveness of in situ air sparging is dependent on air distribution through the
11 aquifer. Injected air usually moves upward through a few preferred flow paths or channels.
12 The airflow paths will be influenced by pressure and flow rate of the injected air and depth
13 of injection. Contaminant mass removal processes that occur during the operation of air
14 sparging systems include: in situ air stripping of dissolved VOCs, volatilization of trapped
15 and adsorbed phase contamination present below the water table and in the capillary fringe,
16 and aerobic biodegradation of both dissolved and adsorbed phase contaminants. For
17 CVOCs the primary mass removal processes include in situ air stripping and direct
18 volatilization. A pilot study would be required to evaluate design parameters such as air
19 injection rate and pressure, and sparge well spacing.

20 In situ air sparging can be applied to a series of vertical air sparge wells or a sparge trench
21 constructed with coarse backfill. A vertical well system was selected as an engineering
22 alternative for SWMU 39 because it is less expensive and the installation is less disruptive
23 than a horizontal trench-based air sparging system. Air sparge well spacing would be
24 evaluated through a pilot study by estimating the "zone of influence." This zone of
25 influence is an approximate indication of the average distance traveled by air channels from
26 the sparge point in the radial directions, under controlled conditions. The preferred
27 measuring technique of the zone of influence is: measurement of head space pressure with
28 sealed saturated zone monitoring probes (i.e., piezometers). For cost estimation purposes
29 provided in this CMS, it was assumed that the air sparge wells will be installed on 15-ft
30 centers. Effectiveness may be limited due to the stiff marsh clay located west of Avenue D at
31 an approximate elevation of 30 to 50 ft bls.

32 **Alternative 5 – Enhanced Anaerobic Biodegradation**

33 The main CVOc biodegradation mechanism in anaerobic-reducing environments is
34 reductive dechlorination, which involves the sequential replacement of chlorine atoms on

1 the alkene molecule by hydrogen atoms. The chlorinated ethenes serve as electron acceptors
2 in these degradation reactions. Carbon compounds such as sugars, alcohols, fatty acids
3 serve as electron donors. This natural process is to some extent occurring at SWMU 39. This
4 alternative would include more active measures in areas of the downgradient dissolved
5 plume to accelerate the naturally occurring process. In anaerobic reductive dechlorination, a
6 carbon atom in the chlorinated solvent accepts an electron from an electron donor
7 (reduction), causing the release of a chlorine atom (dechlorination). The more chlorine
8 atoms a compound has, the more oxidized its carbon is, and therefore the more susceptible
9 it is to reductive dechlorination. This results in sequential dechlorination of a contaminant.
10 The general reductive dechlorination process results in the formation of breakdown
11 products as detailed below:

12 $\text{PCE} \Rightarrow \text{TCE} \Rightarrow \text{DCE} \Rightarrow \text{vinyl chloride} \Rightarrow \text{ethene}$

13 The dechlorination process is effective for dissolved-phase CVOCs and has some success
14 with DNAPL-level concentrations of chlorinated solvents where *Dehalococcoides ethenogenes*
15 has been shown to be active at the DNAPL-water interface.

16 For anaerobic biodegradation to be successful, adequate quantities of electron donor,
17 carbon, and nutrients must come in contact with the active microbial consortia and the
18 target contaminants. The dehalogenation process involves the replacement of a halogen,
19 such as chloride, with hydrogen. In natural anaerobic systems, hydrogen is the most
20 common electron donor, released by the anaerobic fermentation of organic carbon.
21 Anaerobic processes can be enhanced by the addition of hydrogen gas or chemicals that
22 stimulate release of hydrogen gas to the target zone of treatment.

23 An alternative approach for in situ hydrogen addition is to provide a fermentable substance
24 such as HRC® into the groundwater. HRCs® release readily biodegradable materials, such
25 as lactate or similar materials, which are metabolized by indigenous anaerobic
26 microorganisms, resulting in the release of hydrogen. The hydrogen can then be used by
27 organisms capable of dechlorinating CVOCs.

28 Addition of a substrate or other enhancements can be achieved through injection in closely
29 spaced wells located in a line perpendicular or parallel to groundwater flow or by insertion
30 of the material(s) directly into the aquifer using direct push technologies. Effectiveness of
31 any enhancement or anaerobic reductive dechlorination is dependent on the ability to
32 supply the rate-limiting reagent directly to the microorganisms.

1 During 2001, HRC® was injected in three distinct locations at SWMU 39 with limited
2 success. The rate of dissolved-phase CVOC degradation was generally slow. Results of the
3 2001 pilot study are provided in Appendix A of this report.

4 At some sites, the activity of the naturally occurring microorganisms is significantly reduced
5 or potentially inhibited because of site geochemical conditions. Bioaugmentation may also be
6 applicable at SWMU 39 if incomplete dechlorination of TCE occurs regardless of the
7 electron donors that are used if the appropriate bacteria are not present. Bioaugmentation
8 involves the injection of a known microbia consortia of chlorinated solvent-degrading
9 bacteria. At some sites, conversion of TCE to cis-1,2-DCE occurs, but further degradation
10 does not occur, even after addition of electron donors and nutrients. Implementation of
11 bioaugmentation with selected known chlorinated solvent-degrading consortia are known
12 to be capable of complete dechlorination to ethene (Major et al., 2001). Complete
13 dechlorination has occurred at these site when bioaugmentation with microbial cultures
14 known to be capable of complete dechlorination has been employed. Bioaugmentation is
15 considered potentially applicable in these special cases and can be evaluated through
16 laboratory microcosm study or pilot testing.

17 **3.2.3 Downgradient Contaminant Migration Control Corrective Measure** 18 **Alternatives**

19 A second component to plume control measures will be implemented to mitigate the
20 downgradient migration of dissolved CVOCs in a manner that creates unacceptable risk.
21 The dissolved CVOC plume has migrated radially in an eastern to southwestern direction
22 from apparent source area in the immediate area of Buildings 1608A and 1608B. Localized
23 areas of the site east of Avenue D and across the northern portion of SWMU 42 were
24 selected for potential corrective measures based on current plume concentrations and the
25 potential for downgradient migration. Each of these selected site regions is aligned
26 perpendicular to the flow path of contaminated groundwater. The locations and
27 approximate elevations of the individual downgradient areas are provided as follows:

- 28 • Between Buildings 1627 and 1606 and encompassing the rail line approximately 120 feet
29 southwest of Building 1649 – Intermediate interval of the surficial aquifer, 25 to 40 ft bls
- 30 • Approximately 30 ft northwest of the northwest corner of Building 1648 – Deep interval
31 of the surficial aquifer, approximately 30 to 46 ft bls
- 32 • Across the northern portion of the SWMU 42 boundary – Intermediate and deep
33 intervals of the surficial aquifer, approximately 15 to 46 ft bls

1 Figure 3-4 presents these proposed downgradient contaminant migration control areas with
2 the EVS-modeled total CVOC plume at a concentration greater than 50 µg/L. These areas
3 may be changed based on the results of the additional characterization of CVOCs in
4 groundwater.

5 Currently, only three monitoring wells (i.e., A042GW002, A042GW02D, and A042GW001)
6 exist in these proposed downgradient contaminant treatment areas. As part of the corrective
7 measure for downgradient contaminant migration control, ten additional monitoring wells
8 will be installed in these downgradient plume areas. These monitoring wells with their
9 screen intervals, as shown on Figure 3-4, will be sampled on a yearly basis. The results will
10 be used to evaluate the implementation of future active corrective measures to control the
11 downgradient migration of the dissolved CVOC plume.

12 The corrective measure alternatives developed for downgradient contaminant migration
13 control at SWMU 39 include the following:

- 14 • Alternative 1 - Monitoring/Natural Attenuation
- 15 • Alternative 2 - In situ Air Sparging/Biosparging
- 16 • Alternative 3 - Enhanced In situ Anaerobic Biodegradation

17 A description of these alternatives is presented below.

18 **Alternative 1 – Monitoring/Natural Attenuation**

19 A brief technical description of MNA is presented in the previous section describing the
20 MNA process. However, due to differences in subsurface lithology, contingent remedies
21 selected for these downgradient contaminant migration control areas may be different than
22 the contingent remedies recommended for the area proposed for contaminant migration
23 control at the property boundary.

24 **Alternative 2 – In situ Air Sparging/Biosparging**

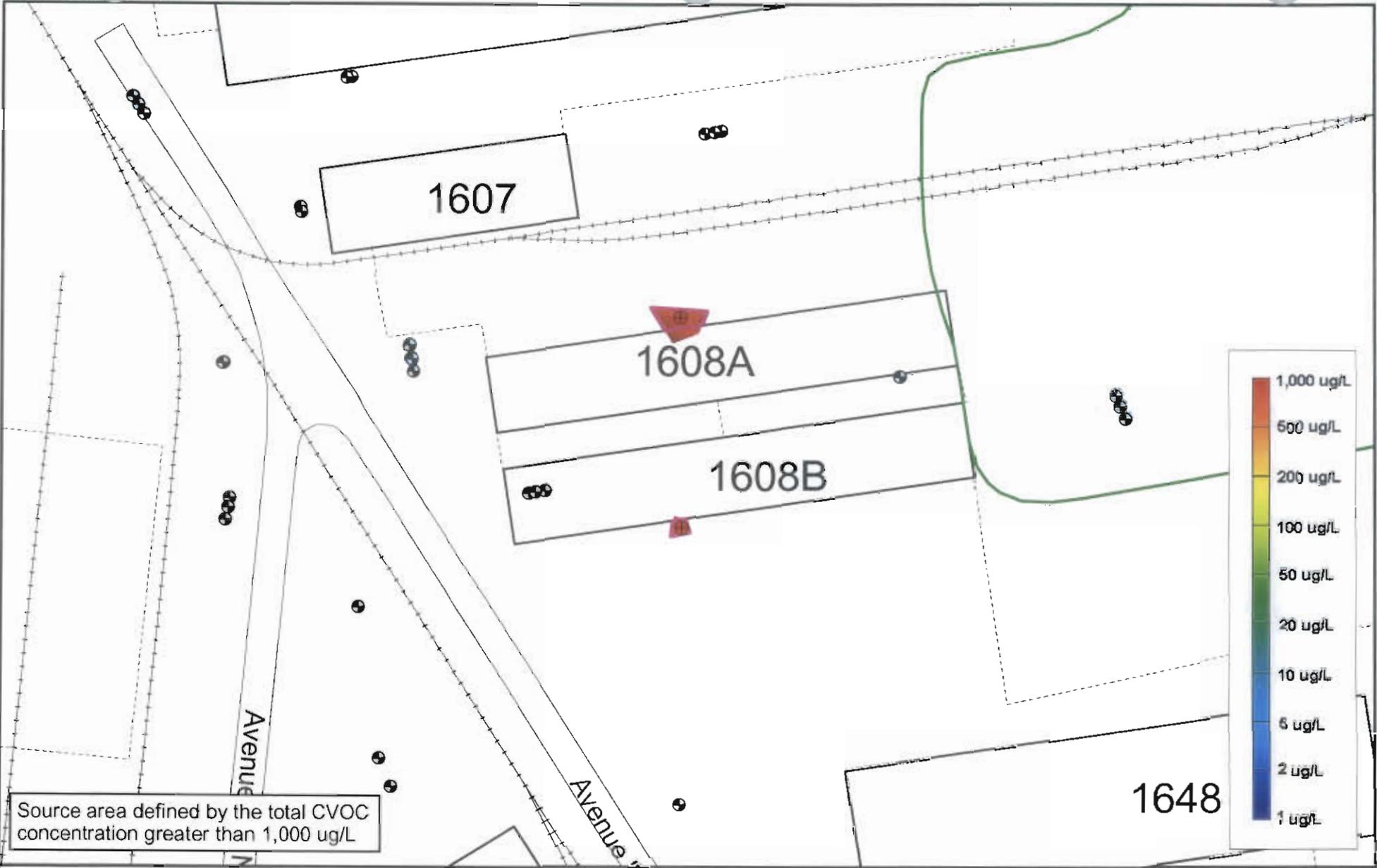
25 A brief technical description of in situ air sparging is presented in the previous section.
26 Biosparging is the injection of air at low flow rates (i.e., 0.5 cubic feet per minute (cfm) to 2
27 to 3 cfm per injection point) into the saturated formation to enhance biodegradation. With
28 biosparging delivery of adequate oxygen to support biodegradation is the primary objective
29 of air injection, and as a result, the volume of injected air is less than what is required for the
30 stripping and volatilization processes seen in air stripping. The application of biosparging
31 would be appropriate for aerobically biodegradable compounds such as cis-1,2-DCE and
32 vinyl chloride. Because the geology in the proposed target treatment areas consists of sand

1 at deeper elevations, it was assumed for cost estimation purposes that the sparge wells will
2 be installed on 25-ft centers. However, and in addition to the other required design
3 parameters, this will be evaluated from the pilot test results.

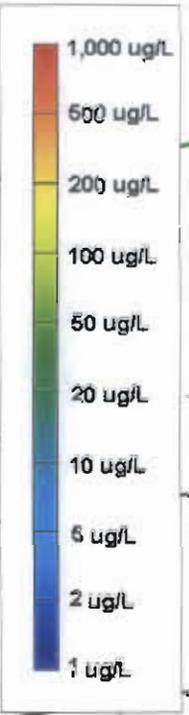
4 **Alternative 3 – Enhanced Anaerobic Biodegradation**

5 A brief technical description of enhanced anaerobic biodegradation with bioaugmentation is
6 presented in the previous section. Like the contingency remedy, in situ air
7 sparging/biosparging injector well spacing may be greater than that which was designed
8 for a contingent remedy at the western property boundary.

NOTE: Original figure was in color



Source area defined by the total CVOC concentration greater than 1,000 ug/L



- Proposed Deep Monitoring Well
- Monitoring Well
- Target Treatment Area
- Fence
- Railroads

- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

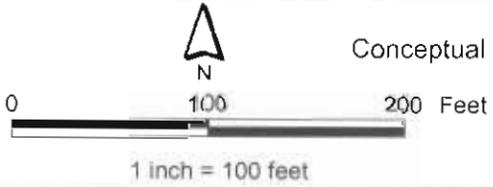
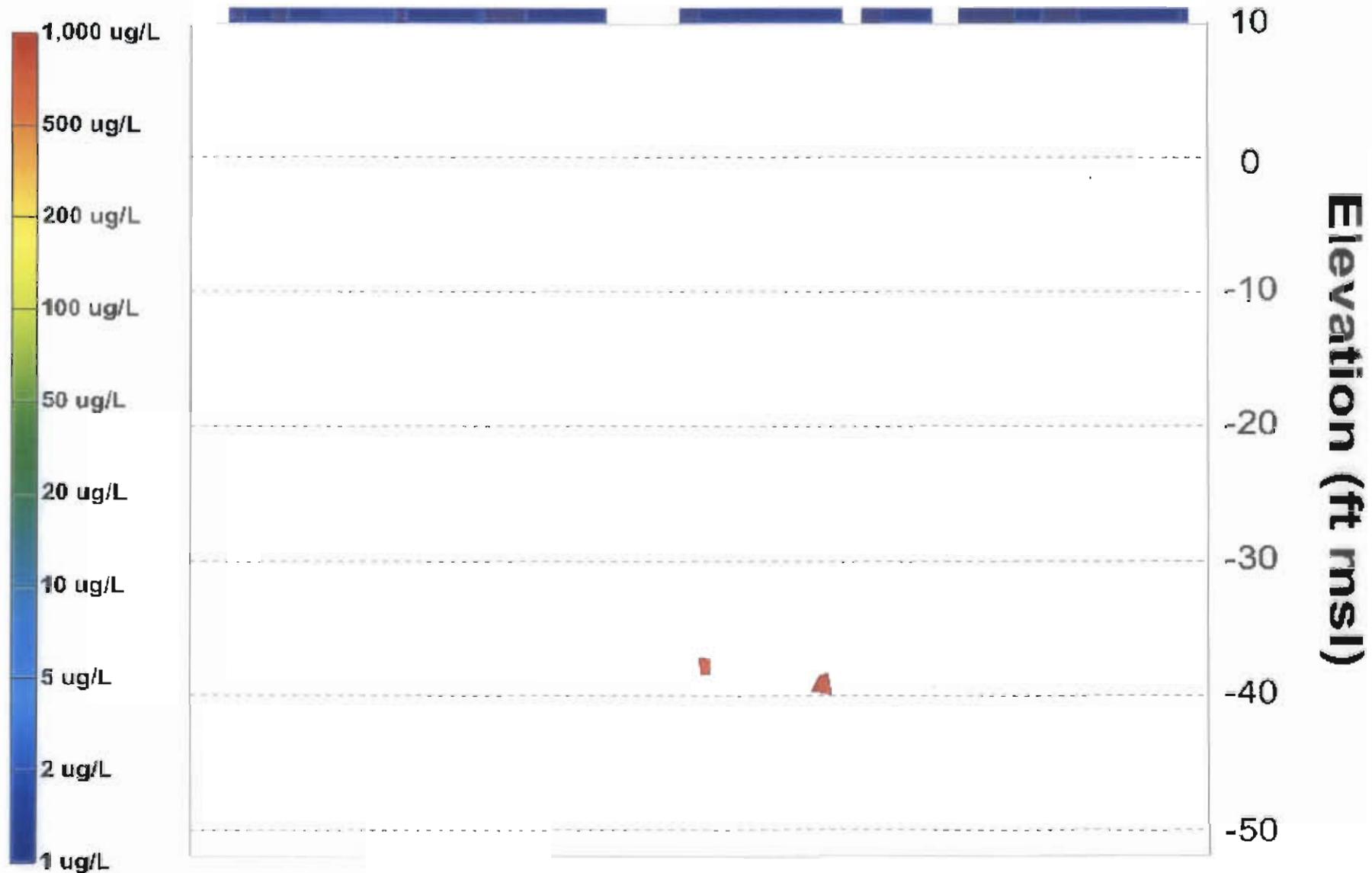


Figure 3-1
 Conceptual Source Control Target Treatment Areas - 3-D Plan View
 SWMU 39, Zone A
 Charleston Naval Complex

NOTE: Original figure in color



Source area defined by the total CVOC concentration greater than 1,000 ug/L

Figure 3-2
Conceptual Source Control Target Treatment Areas - 3-D Profile (West View)
SWMU 39, Zone A
Charleston Naval Complex

3-D Plan View is Depiction of Total CVOC Distribution at 50 ug/L



- Proposed Intermediate Monitoring Well
- Proposed Deep Monitoring Well
- Monitoring Well
- Target Treatment Area
- Fence
- Railroads
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

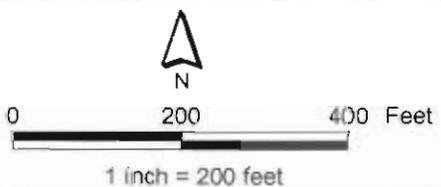
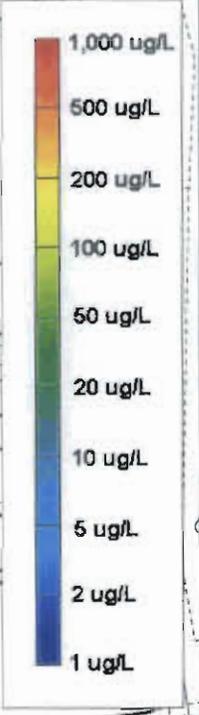
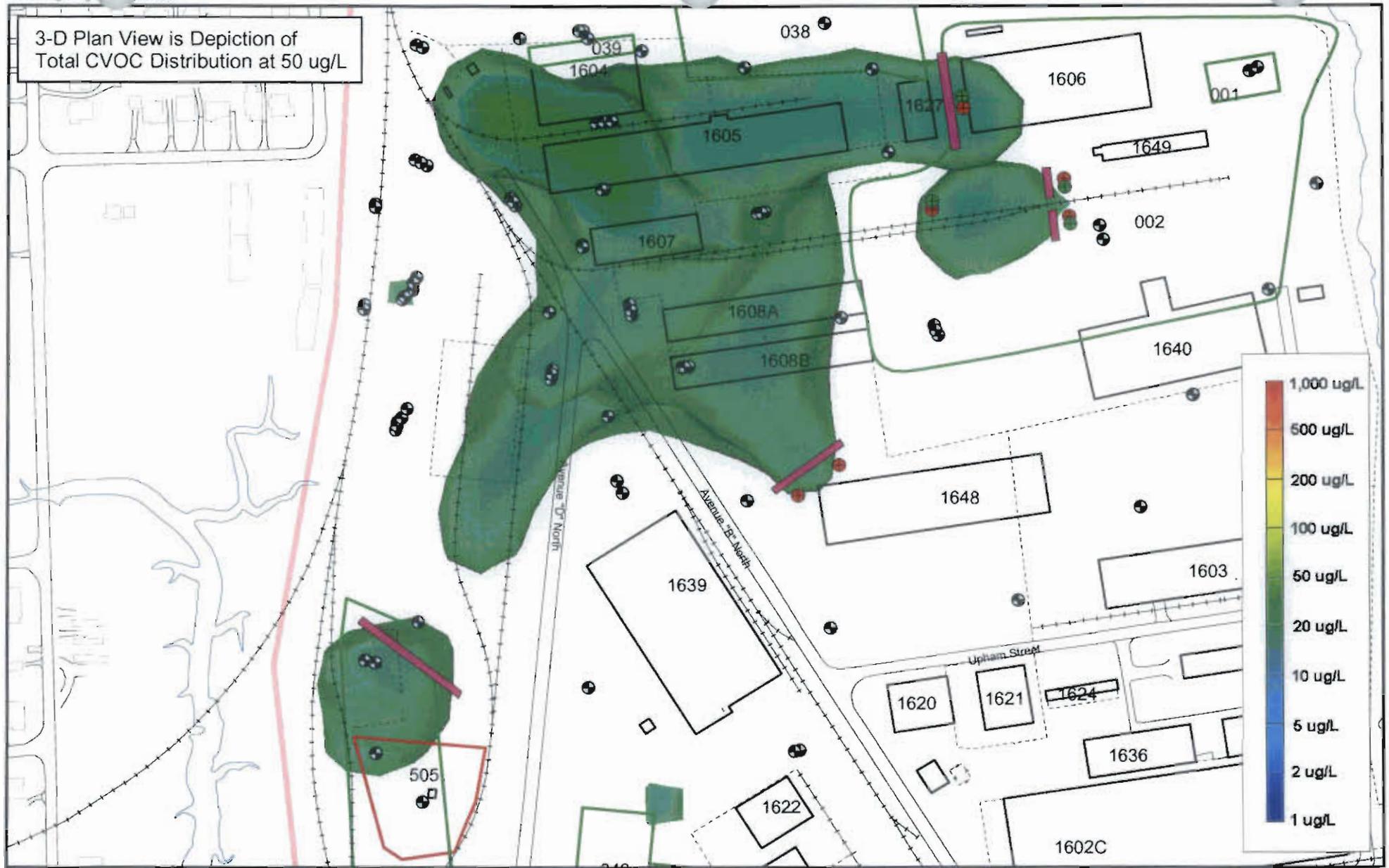


Figure 3-3
Conceptual Property Boundary Contaminant Migration Control Target Treatment Area
SWMU 39, Zone A
Charleston Naval Complex

NOTE: Original figure is in color

3-D Plan View is Depiction of Total CVOC Distribution at 50 ug/L



- Proposed Intermediate Monitoring Well
- Proposed Deep Monitoring Well
- Monitoring Well
- Target Treatment Area
- Fence
- Railroads
- Roads
- Shoreline
- AOC Boundary
- SWMU Boundary
- Buildings
- Zone Boundary

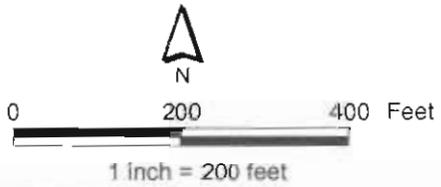


Figure 3-4
 Conceptual Downgradient Contaminant Migration Control Target Treatment Areas
 SWMU 39, Zone A
 Charleston Naval Complex

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1 **4.0 Detailed Analysis of Alternatives**

2 This section presents the detailed analysis of corrective measure alternatives for
3 groundwater at SWMU 39.

4 **4.1 Analysis of Source Control Alternatives**

5 Corrective measure alternatives for source control in the deep interval of the surficial
6 aquifer at SWMU 39 include ISCO and ISCR. These corrective measure alternatives were
7 evaluated in detail using the evaluation criteria described in Section 2.3. Results of the
8 detailed evaluations for source control alternatives are presented in Table 4-1.

9 **4.1.1 Alternative 1 – In situ Chemical Oxidation Using Fenton’s Reagent**

10 Application of ISCO for the designated source area would involve injection of Fenton’s
11 reagent into approximately 76 ft³, as previously discussed in Section 3.2.1. A conceptual
12 design of a ISCO system would include 3 injection points within the proposed source
13 control area. This assumes an injector radius of influence of 20 feet. Approximately 300
14 gallons would be injected per location with an anticipated duration of injection of 2 days.
15 ISCO with its rapid reaction has a short residence time within the environment creating a
16 potential for auxiliary “polish” treatments. Typically, the oxidant remains in the
17 environment for only a few hours once injected. As a result, the entire target treatment area
18 defined by the total CVOC concentration of 1,000 µg/L including the region under
19 Buildings 1608A and 1608B would be addressed as part of the ISCO treatment. The cost
20 estimate has assumed that two “polish” treatments will be required within a year following
21 the initial injection.

22 **4.1.2 Alternative 2 – In situ Chemical Reduction Using Zero-Valent Iron**

23 A conceptual design of a ISCR system would include injection points within the proposed
24 source control area to create in situ reactive zones. The reactive zones would be placed in
25 the groundwater flow paths within the target treatment zones. As a result, because of its
26 interpreted location under existing structures, the target treatment area in the immediate
27 vicinity of Buildings 1608A and 1608B would be designed in two separate areas outside the
28 existing buildings. This design of the target treatment area surrounding Buildings 1608A
29 and 1608B reduces the volume to approximately 60 ft³, or 21 percent, when compared to the

1 target treatment volume proposed by the ISCO alternative. These proposed target treatment
2 areas are depicted in Figure 3-1.

3 Groundwater in the designated source area that is upgradient of the in situ reactive zone
4 would subsequently pass through the reactive zone, thus treating the CVOCs in that
5 groundwater. Injectors are placed on 12 to 15-foot centers for the more shallow intervals of
6 less than 20 feet but increases to 20 to 30 feet at the deeper intervals greater than 30 feet as
7 would be appropriate for the two source control areas. While ISCR using the FeroxSM
8 technology process is a new technology, ARS has conservatively estimated that in situ
9 chemical reduction or dehalogenation of chlorinated ethenes can occur up to five years after
10 injection of the reactive medium. This limits the number of "polish" treatments when
11 comparing ISCR to ISCO.

12 **4.2 Analysis of Property Boundary Contaminant Migration** 13 **Control Alternatives**

14 Corrective measure alternatives for property boundary contaminant migration control in the
15 intermediate and deep intervals of the surficial aquifer at SWMU 39 include MNA, ISCR,
16 PRB, air sparging, and enhanced anaerobic biodegradation. These corrective measure
17 alternatives were evaluated in detail using the evaluation criteria described in Section 2.3.
18 Results of the detailed evaluations for property boundary contaminant migration control
19 alternatives are presented in Table 4-2.

20 **4.2.1 Alternative 1 – Monitoring/Natural Attenuation**

21 MNA would consist of the annual monitoring of key monitoring wells near the boundary at
22 SWMU 39 for VOCs and selected MNA parameters. The MNA alternative would be
23 implemented in conjunction with a long-term monitoring plan and source control
24 alternative. The purpose of the plan is to monitor plume migration over time, and to verify
25 that natural attenuation is occurring. Assuming that the source of the contamination is
26 controlled or being treated, it is expected that the CVOC plume would slowly decrease in
27 concentration as a result of natural attenuation. An internal part of plan would include the
28 selection of contingency remedies if natural attenuation indicates low performance. MNA is
29 the easiest alternative to implement at the property boundary and also the least expensive.

30 **4.2.2 Alternative 2 – In situ Chemical Reduction Using Zero-Valent Iron**

31 ISCR, if required, would be conceptually implemented over a 555-yd³ treatment volume at
32 the western property boundary as depicted in Figure 3-3. Five injection points on 20-foot

1 centers would be used for the 100-foot long target treatment area. This volume was
2 preliminarily selected as the conceptual basis of design using the dissolved CVOC plume at
3 a total concentration of 50 µg/L from the EVS software. However, this design volume may
4 be modified based on the results of the groundwater samples collected annually from the
5 existing and proposed monitoring wells at the western property boundary. ISCR is
6 moderately expensive, easy to implement, effective in treating chlorinated ethenes, and has
7 a longer resistance time in the environment when compared to other alternative such as
8 ISCO and enhanced biodegradation.

9 **4.2.3 Alternative 3 – Permeable Reactive Barrier**

10 A 30-inch wide, 100-foot long PRB was selected as the preliminary conceptual design at the
11 western property boundary. Like the ISCR alternative, this conceptual design may be
12 modified based on the results of the groundwater samples collected annually from the
13 existing and proposed monitoring wells at the western property boundary. The passive
14 process that relies on the natural flow of groundwater to bring dissolved contaminants in
15 contact with the ZVI may be appropriate at SWMU 39 because of the slow site groundwater
16 velocity. However, there are concerns of iron fouling, the presence of subsurface utilities
17 and obstructions, and expense of implementation.

18 **4.2.4 Alternative 4 – In situ Air Sparging**

19 Because of the geologic conditions the conceptual air sparge design would consist of eight
20 air injection points on 15-foot centers covering the 100-foot long target treatment area. A
21 pilot study would be required to evaluate design parameters such as air injection rate and
22 pressure and injection well spacing. The application of air sparging would be appropriate
23 for aerobically biodegradable compounds such as cis-1,2-DCE and vinyl chloride, but may
24 have little or no effectiveness on anaerobic biodegradable compounds such as TCE and PCE.
25 Air sparging has been successfully implemented at other sites with aerobically
26 biodegradable compounds because the capital costs are relatively low and it is easy to
27 implement. Air sparging concerns include uniform distribution of compressed air in
28 heterogeneous systems, especially at elevations of stiff marsh clay at the property boundary,
29 and the added costs associated with operation and maintenance (O&M).

30 **4.2.5 Alternative 5 – Enhanced In situ Anaerobic Biodegradation**

31 A conceptual design of an enhanced in situ anaerobic biodegradation treatment alternative
32 would include 26 injection points on 8-foot centers within the proposed target treatment

1 area at the property boundary. However, the location and size of the target treatment area
2 may be modified and substantially reduced depending on future groundwater conditions.

3 During 2001, HRC® was injected in three distinct locations at SWMU 39 with limited
4 success and slow rate of dissolved-phase CVOC degradation. The HRC® material is
5 expensive and additional "polishing" treatments would be required on a yearly basis since
6 the HRC® material remains in the environment for only a few weeks once injected.

7 As a result, alternative viable electron donors such as lactate, chitin, ethanol may be used in
8 a pilot study application to evaluate its effectiveness. In addition, enhanced anaerobic
9 biodegradation with bioaugmentation may also be applicable since incomplete
10 dechlorination of TCE can occur regardless of the electron donors used if the appropriate
11 bacteria are not present.

12 **4.3 Analysis of Downgradient Contaminant Migration Control** 13 **Alternatives**

14 Selected corrective measure alternatives for downgradient contaminant migration control in
15 the intermediate and deep intervals of the surficial aquifer at SWMU 39 include MNA, air
16 sparging, and enhanced anaerobic biodegradation. As outlined in Section 3.2.3, three
17 contingency target treatment areas were identified that comprise approximately 650 linear
18 feet. These contingency target treatment areas selected perpendicular to groundwater flow
19 and to preclude excessive downgradient migration will be modified and further designed if
20 required based on future groundwater data. The downgradient corrective measure
21 alternatives were evaluated in detail using the evaluation criteria described in Section 2.1.
22 Results of the detailed evaluations for downgradient contaminant migration control
23 alternatives are presented in Table 4-3.

24 **4.3.1 Alternative 1 - Monitoring/Natural Attenuation**

25 The MNA alternative, as summarized in Section 4.2.1, would be implemented for
26 downgradient contamination migration control concurrently with the proposed MNA at the
27 western property boundary, and would consist of annual monitoring of key monitoring
28 wells at the downgradient areas.

29 **4.3.2 Alternative 2 – In situ Air Sparging/Biosparging**

30 The application of biosparging, as described in Section 4.2.4, would be appropriate for
31 aerobically biodegradable compounds such as cis-1,2-DCE and vinyl chloride, which are
32 present in downgradient areas of the dissolved plume. The conceptual air sparge design

1 would consist of 31 air injection points on 25-foot centers covering the three target treatment
2 areas of up to approximately 650 feet. Because of the separation of the target treatment area
3 located across the northern portion of the SWMU 42 boundary from the other two areas,
4 two air sparge systems would be required to treat the entire three areas. However, the
5 location and size of the target treatment area(s) may be modified and substantially reduced
6 depending on future groundwater conditions. A pilot study would be required to evaluate
7 the design parameters such as air injection rate and pressure and sparge well spacing. As
8 outlined in the previous section, air sparging concerns include uniform distribution of
9 compressed air in heterogeneous systems, added costs associated with O&M, and limited
10 effectiveness on anaerobic biodegradable compounds.

11 **4.3.3 Alternative 3 – Enhanced In situ Anaerobic Biodegradation**

12 A conceptual design of an enhanced in situ anaerobic biodegradation treatment alternative
13 would consist of approximately 58 injection points on 13-foot centers within the proposed
14 three downgradient migration control areas. However, the location and size of the target
15 treatment area may be modified and substantially reduced depending on future
16 groundwater conditions.

17 Substrate or other enhancement material is expensive and additional “polishing” treatments
18 would be required on a yearly basis since some substrate material for instance HRC®
19 remains in the environment for only a few weeks once injected.

20 As a result, alternative viable electron donors such as lactate, chitin, and ethanol may be
21 used in a pilot study application to evaluate its effectiveness. In addition, enhanced
22 anaerobic biodegradation with bioaugmentation may also be applicable since incomplete
23 dechlorination of TCE can occur regardless of the electron donors used if the appropriate
24 bacteria are not present.

25 **4.4 Comparative Analysis of Alternatives**

26 This section presents the comparative analysis of the corrective measure alternatives for
27 source control and the plume control alternatives. In this process, the alternatives were
28 compared in terms of the evaluation criteria to identify relative differences as advantages
29 and disadvantages that may influence the selection of one alternative.

1 **4.4.1 Source Control Alternatives**

2 **Protect Human Health and the Environment**

3 Both source control alternatives are considered protective of human health and the
4 environment, provided no one uses the site groundwater for potable uses. As part of the
5 corrective measures implementation, land use controls (LUCs) will be evaluated for the
6 potential impact at SWMU 39 based on future land use at the site.

7 **Attainment of MCSs**

8 It is unlikely that, even under the best conditions, nearly complete treatment of the
9 dissolved-phase CVOCs to below MCLs will be achieved quickly in the source area. Under
10 optimal conditions, an effective remedial action for the source area may possibly result in up
11 to a 80-percent reduction (one order of magnitude) of contaminant concentration. However,
12 at SWMU 39 reduction of CVOCs in localized regions within the source area would require
13 greater than 95-percent reduction in concentration to meet their respective MCLs.

14 Both source control alternatives, coupled with the appropriate plume control alternatives,
15 are expected to achieve MCSs at the western property boundary and at areas of potential
16 downgradient CVOC migration. Also, by treating the designated source area, downgradient
17 plume concentrations will significantly decrease overtime.

18 **Control of the Source of Releases**

19 The historical sources of CVOCs no longer exist at SWMU 39. No DNAPL areas have been
20 identified at the site. Each of the source control alternatives provides an aggressive
21 approach for the treatment of dissolved CVOCs.

22 **Compliance with Applicable Waste Management Standards**

23 Each source control alternative will accumulate minimal waste during implementation,
24 limited to solid waste associated with well drilling or direct push applications. Vapor or
25 liquid discharge is not expected and as a result, permitting will not be required.

26 **Long-Term Reliability and Effectiveness**

27 If effectively applied, each source control alternative has the potential for achieving long-
28 term effectiveness. Residence time within the aquifer using ZVI is expected to be greater
29 than with the rate of reactions associated with the hydrogen peroxide injection during in
30 situ chemical oxidation. Because each of the source control alternatives were developed and
31 implemented over the last decade, the long-term reliability and effectiveness are not proven.

1 **Reduction of Toxicity, Mobility, or Volume of Wastes**

2 Each of the source control alternatives provides an aggressive reduction potential in
3 contaminant concentration of up to 80 percent.

4 **Short-Term Effectiveness**

5 Each source control alternative provides immediate contaminant reduction observed within
6 the first year of implementation. Both alternatives do not adversely impact the environment
7 with minimal waste accumulation during field application.

8 **Implementability**

9 Source control alternatives involve a relatively low level of site disruption. Each alternative
10 uses pressure or pneumatic injection methods of reactive materials which have been
11 implemented at dozens of other project sites with relative ease and with few incidents.

12 **Estimated Cost**

13 A summary of the estimated cost for each source control corrective measure alternative is
14 provided in Table 4-1. The summary table presents the estimated capital and O&M costs,
15 and the calculated present worth for each alternative. Detailed cost estimate tables are
16 provided in Appendix C. The order-of-magnitude level cost estimates are based on
17 conceptual descriptions of the alternatives, not detailed design information. These estimates
18 have an expected accuracy of -30 percent to +50 percent.

19 **4.4.2 Property Boundary Contaminant Migration Control Alternatives**

20 **Protect Human Health and the Environment**

21 All property boundary contaminant migration control alternatives are considered protective
22 of human health and the environment.

23 **Attainment of MCSs**

24 Each property boundary contaminant migration control alternative, coupled with the
25 appropriate source control alternative, is expected to achieve MCSs at the western CNC
26 property boundary.

27 **Control of the Source of Releases**

28 This criterion is addressed during evaluation of the source control component of the overall
29 remedial strategy, and is not applicable for plume control alternatives.

1 **Compliance with Applicable Waste Management Standards**

2 Each alternative will accumulate small quantities of soil and liquid waste during
3 implementation, limited to solid waste associated with well drilling. In the case of the PRB a
4 larger volume of waste would be accumulated during the trenching activities.

5 **Long-Term Reliability and Effectiveness**

6 Each property boundary contaminant migration control alternative is considered effective
7 and reliable in the long term.

8 **Reduction of Toxicity, Mobility, or Volume of Wastes**

9 Each property boundary contaminant migration control alternative is expected to reduce all
10 dissolved-phase CVOCs migrating offsite to below MCSs. The MNA alternative however
11 will gradually reduce the dissolved-phase CVOCs to the MCSs through biodegradation via
12 reductive dechlorination.

13 **Short-Term Effectiveness**

14 Each property boundary contaminant migration control alternative does not adversely
15 impact the environment, has minimal waste accumulation, and has no or minimal risk to
16 on-site workers and the surrounding community during construction and implementation.

17 **Implementability**

18 Construction of the PRB, when compared to the in situ chemical reduction and in situ air
19 sparging, will have the highest level of site disruption. In situ chemical reduction and
20 enhanced in situ anaerobic biodegradation use injection wells and PF with little required
21 O&M when compared to the other alternatives. Air sparging, which uses a rotary vane or
22 rotary screw air compressor, has been implemented at hundreds of other project sites with
23 relative ease and without incident. MNA involves a minimal degree of site construction
24 activity and is considered the easiest alternative to technically and administratively
25 implement.

26 **Estimated Cost**

27 A summary of the estimated costs for each property boundary contaminant migration
28 control corrective measure alternative is provided in Table 4-2. The summary table presents
29 the estimated capital and O&M costs, as well as the calculated present worth for each
30 alternative. Detailed cost estimate tables are provided in Appendix C. The order-of-
31 magnitude level cost estimates are based on conceptual descriptions of the alternatives, not

1 detailed design information. These estimates have an expected accuracy of -30 percent to
2 +50 percent.

3 **4.4.3 Downgradient Contaminant Migration Control Alternatives**

4 **Protect Human Health and the Environment**

5 All downgradient contaminant migration control alternatives are considered protective of
6 human health and the environment.

7 **Attainment of MCSs**

8 Each downgradient contaminant migration control alternative, coupled with the
9 appropriate source control alternative, is expected to achieve MCSs at areas of potential
10 downgradient CVOC migration.

11 **Control of the Source of Releases**

12 This criterion is addressed during evaluation of the source control component of the overall
13 remedial strategy, and is not applicable for plume control alternatives.

14 **Compliance with Applicable Waste Management Standards**

15 Each alternative will accumulate small quantities of soil and liquid waste during
16 implementation, limited to solid waste associated with monitoring well drilling and
17 installation of injection wells in the case of the in situ air sparging/biosparging and
18 enhanced in situ anaerobic biodegradation alternatives.

19 **Long-Term Reliability and Effectiveness**

20 Each downgradient contaminant migration control alternative is considered effective and
21 reliable in the long term.

22 **Reduction of Toxicity, Mobility, or Volume of Wastes**

23 MNA will gradually reduce the dissolved-phase CVOCs to the MCSs at areas of potential
24 downgradient migration through biodegradation via reductive dechlorination. In situ air
25 sparging/biosparging and enhanced in situ anaerobic biodegradation provide more of an
26 aggressive reduction in contaminant concentration at the areas of potential CVOC
27 downgradient migration. Each downgradient contaminant migration control alternative is
28 expected to reduce all dissolved-phase CVOCs migrating downgradient to below MCSs.

1 **Short-Term Effectiveness**

2 Each alternative does not adversely impact the environment, has minimal waste
3 accumulation, and has no or minimal risk to onsite workers and the surrounding
4 community during construction and implementation.

5 **Implementability**

6 MNA involves the minimal degree of site construction activity and is considered the easiest
7 alternative to technically and administratively implement. In situ air sparging and enhanced
8 in situ anaerobic biodegradation involves the installation of injection wells which results in
9 a low degree of site disruption. Because of the mechanical equipment involved the air
10 sparging/biosparging alternative will involve minimal O&M when compared to the other
11 alternatives.

12 **Estimated Cost**

13 A summary of the estimated costs for each downgradient contaminant migration control
14 corrective measure alternative is provided in Table 4-3. The summary table presents the
15 estimated capital and O&M costs, as well as the calculated present worth for each
16 alternative. Detailed cost estimate tables are provided in Appendix C. The order-of-
17 magnitude level cost estimates are based on conceptual descriptions of the alternatives, not
18 detailed design information. These estimates have an expected accuracy of -30 percent to
19 +50 percent.

TABLE 4-1
 Detailed Analysis of Source Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	In situ Chemical Oxidation Using Fenton's Reagent	In situ Chemical Reduction Using Zero-Valent Iron
Protection Of Human Health and the Environment	Process will be protective of human health and the environment.	Process will be protective of human health and the environment.
Attainment of Media Cleanup Standards	Potential for 80 percent of the source area to achieve MCSs within six months of implementation.	Potential for 80 percent of the source area to achieve MCSs within one year of implementation.
Control of the Source of Releases	Original source of the release is no longer present. Process will gradually reduce contaminant mass in the source area.	Original source of the release is no longer present. Process will gradually reduce contaminant mass in the source area.
Compliance with Applicable Waste Management Standards	Not expected to accumulate significant quantities of waste requiring management.	Not expected to accumulate significant quantities of waste requiring management.
Long-Term Reliability and Effectiveness		
Magnitude of Residual Risk	Extensive reduction of residual risk within the source area.	Extensive reduction of residual risk within the source area.
Adequacy of Reliability of Controls	Expected to provide adequate control over the long term. Application is short due to rapid reactions associated with the technology.	Expected to provide adequate control over the long term.
Reduction of Toxicity, Mobility, or Volume of Wastes		
Amount of Hazardous Materials Anticipated to be Destroyed/Treated	If properly implemented, the process is expected to result in an approximate 80-percent reduction of source area CVOCs.	If properly implemented, the process is expected to result in an approximate 80-percent reduction of source area CVOCs.
Degree and Quantity of Reduction	High. Process is expected to remove most of the source area CVOCs.	High. Process is expected to remove most of the source area CVOCs.
Irreversibility of Reduction	High. Reactions associated with Fenton's reagent are irreversible.	High. Chemical reductive dechlorination is irreversible.
Type and Quantity of Treatment Residuals	Carbon dioxide, water, and chloride.	Minimal treatment residuals (Ferrous Iron).

TABLE 4-1
 Detailed Analysis of Source Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	In situ Chemical Oxidation Using Fenton's Reagent	In situ Chemical Reduction Using Zero-Valent Iron
(Reduction of Toxicity, Mobility, or Volume of Wastes)		
Preference for Treatment as a Principal Element	Treatment is the principal component of this alternative.	Treatment is the principal component of this alternative.
Short-Term Effectiveness		
Protection of Workers During Remedial Action Construction	Implementation poses a moderate degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.	Implementation poses a moderate degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.
Protection of Community During Remedial Action	Implementation poses a minimal degree of safety or health hazards to the CNC community.	Implementation poses a minimal degree of safety or health hazards to the CNC community.
Environmental Impacts of Remedial Action	Process should not create adverse impacts on the environment.	Process should not create adverse impacts on the environment.
Implementability		
Technical Feasibility	High. Process uses industry proven and readily available technology.	High. Process uses industry proven and readily available technology.
Administrative Feasibility	High. Will require UIC permit. Pilot test may be required to evaluate site effectiveness.	High. Will require UIC permit. Pilot test may be required to evaluate site effectiveness.
Estimated Costs^a		
Capital Cost	\$108,200	\$109,600
Annual O&M Cost	\$11,000	\$12,000
Present Value 20-Year O&M Cost ^b	\$160,700	\$175,300
Total Cost	\$269,000	\$285,000

^a Order-of-magnitude level cost estimates with expected accuracy of plus 50 to minus 30 percent.

^b Assumes percent interest and a 20-year operation period.

TABLE 4-2
 Detailed Analysis of Property Boundary Contaminant Migration Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	Monitoring/Natural Attenuation	In situ Chemical Reduction Using Zero-Valent Iron	Permeable Reactive Barrier	In situ Air Sparging	Enhanced In situ Anaerobic Biodegradation
Protection Of Human Health and the Environment	Process will be protective of human health and the environment.	Process will be protective of human health and the environment.	Process will be protective of human health and the environment.	Process will be protective of human health and the environment.	Process will be protective of human health and the environment.
Attainment of Media Cleanup Standards	Alternative can potentially maintain MCSs at the target treatment area.	Alternative should meet MCSs at the target treatment area.	It is expected that the alternative will meet MCSs at the target treatment area.	Alternative may not meet MCSs at the target treatment area based on limited effectiveness in low permeability lithology.	Alternative can potentially meet MCSs at the target treatment area.
Control of the Source of Release	Not applicable. Addressed in the source control component of the overall site remediation strategy.	Not applicable. Addressed in the source control component of the overall site remediation strategy.	Not applicable. Addressed in the source control component of the overall site remediation strategy.	Not applicable. Addressed in the source control component of the overall site remediation strategy.	Not applicable. Addressed in the source control component of the overall site remediation strategy.
Compliance with Applicable Waste Management Standards	Not expected to accumulate significant quantities of waste requiring management.	Not expected to accumulate significant quantities of waste requiring management.	Not expected to accumulate significant quantities of waste requiring management.	Alternative not expected to accumulate significant quantities of waste requiring management.	Not expected to accumulate significant quantities of waste requiring management.
Long-Term Reliability and Effectiveness					
Magnitude of Residual Risk	Gradual reduction of residual risk within dissolved-phase plume, resulting in adequate reduction in residual risk at the target treatment areas.	Residual risk with exposure at the CNC property boundary reduced to minimal levels.	Residual risk with exposure at the CNC property boundary reduced to minimal levels.	Residual risk with exposure at the CNC property boundary reduced to minimal levels.	Residual risk with exposure at the CNC property boundary reduced to minimal levels.

TABLE 4-2
 Detailed Analysis of Property Boundary Contaminant Migration Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	Monitoring/Natural Attenuation	In situ Chemical Reduction Using Zero-Valent Iron	Permeable Reactive Barrier	In situ Air Sparging	Enhanced In situ Anaerobic Biodegradation
(Long-Term Reliability and Effectiveness)					
Adequacy of Reliability of Controls	Monitoring and contingency measures would be adequate to manage exposure at the contingent target treatment area.	Process would adequately and reliably control exposure at the contingent target treatment area.	Process would adequately and reliably control exposure at the contingent target treatment area.	Process has the potential to adequately and reliably control exposure at the contingent target treatment area.	Process would adequately and reliably control exposure at the contingent target treatment area.
Reduction of Toxicity, Mobility, or Volume of Wastes					
Amount of Hazardous Materials Anticipated to be Destroyed/Treated	Variable. In conjunction with source control, process is expected to reduce dissolved-phase CVOCs to their respective MCSs before reaching the contingent target treatment area.	Contingent on CVOC migration west of Avenue D. Expected to treat any CVOCs reaching the contingent target treatment area.	Contingent on CVOC migration west of Avenue D. Expected to treat any CVOCs reaching the contingent target treatment area.	Contingent on CVOC migration west of Avenue D. Potential for limited success based on presence of stiff marsh clay at the elevation of contingent treatment.	Contingent on CVOC migration west of Avenue D. In conjunction with source control, expected to treat any CVOCs reaching the contingent target treatment area.
Degree and Quantity of Reduction	Coupled with a source control alternative is expected to reduce dissolved-phase CVOCs to MCSs at the target treatment area near the western property boundary.	Because of the expected low levels of CVOCs, greater than 80 percent reduction of any dissolved-phase CVOC reaching the contingent target treatment area.	Because of the expected low levels of CVOCs, greater than 80 percent reduction of any dissolved-phase CVOC reaching the contingent target treatment area.	Because of the expected low levels of CVOCs, greater than 80 percent reduction of any dissolved-phase CVOC reaching the contingent target treatment area.	Because of the expected low levels of CVOCs, 50 to 75 percent reduction of any dissolved-phase CVOC reaching the proposed contingent target treatment area.
Irreversibility of Reduction	High. Biodegradation of CVOCs via reductive dechlorination is irreversible.	High. Chemical reductive dechlorination is irreversible.	High. Chemical reductive dechlorination is irreversible.	High. Physical removal of CVOCs from the groundwater is irreversible.	High. Chemical reductive dechlorination is irreversible.
Type and Quantity of Treatment Residuals	Minimal treatment residuals is anticipated.	Minimal treatment residuals is anticipated.	Minimal treatment residuals is anticipated.	Minimal treatment residuals is anticipated.	Minimal treatment residuals is anticipated.

TABLE 4-2
 Detailed Analysis of Property Boundary Contaminant Migration Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	Monitoring/Natural Attenuation	In situ Chemical Reduction Using Zero-Valent Iron	Permeable Reactive Barrier	In situ Air Sparging	Enhanced In situ Anaerobic Biodegradation
Reduction of Toxicity, Mobility, or Volume of Wastes					
Preference for Treatment as a Principal Element	Active treatment is not a component of this alternative.	Treatment is the principal component of this alternative.	Treatment is the principal component of this alternative.	Treatment is the principal component of this alternative.	Treatment is the principal component of this alternative.
Short-Term Effectiveness					
Protection of Workers During Remedial Action Construction	Implementation poses a minimal degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.	Implementation poses a low degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.	Implementation poses a low degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.	Implementation poses a low degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.	Implementation poses a low degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.
Protection of Community During Remedial Action	Implementation poses a minimal degree of safety or health hazards to the CNC community.	Implementation poses a minimal degree of safety or health hazards to the CNC community.	Implementation poses a minimal degree of safety or health hazards to the CNC community.	Implementation poses a minimal degree of safety or health hazards to the CNC community.	Implementation poses a minimal degree of safety or health hazards to the CNC community.
Environmental Impacts of Remedial Action	Process should not create adverse impacts on the environment.	Process should not create adverse impacts on the environment.	Process should not create adverse impacts on the environment.	Process should not create adverse impacts on the environment.	Process should not create adverse impacts on the environment.
Implementability					
Technical Feasibility	High. Except for the new innovative analytical techniques process uses conventional and readily available technology.	High. Process uses industry proven and readily available technology.	High. Process uses conventional and readily available technology.	High. Process uses conventional and readily available technology.	High. Process uses industry proven and readily available technology.
Administrative Feasibility	High. Few major administrative issues are expected.	High. Will require UIC permit. Pilot test may be required to evaluate site effectiveness.	High. Few major administrative issues are expected.	High. Pilot test may be required as part of the design process.	High. Will require UIC permit.

TABLE 4-2
 Detailed Analysis of Property Boundary Contaminant Migration Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	Monitoring/Natural Attenuation	In situ Chemical Reduction Using Zero-Valent Iron	Permeable Reactive Barrier	In situ Air Sparging	Enhanced In situ Anaerobic Biodegradation
Estimated Costs^a					
Capital Cost	\$27,900	\$164,400	\$679,100	\$135,100	\$79,300
Annual O&M Cost	\$16,000	\$15,000	\$13,000	\$31,000 (Yrs. 1-5) \$12,800 (Yrs. 6-20)	\$55,000
Present Value 20-Year O&M Cost ^b	\$233,700	\$219,100	\$189,900	\$269,900	\$803,300
Total Cost	\$262,000	\$383,000	\$869,000	\$405,000	\$883,000

^a Order-of-magnitude level cost estimates with expected accuracy of plus 50 to minus 30 percent.

^b Assumes percent interest and a 20-year operation period.

TABLE 4-3
 Detailed Analysis of Downgradient Contaminant Migration Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	Monitoring/Natural Attenuation	In situ Air Sparging/Biosparging	Enhanced In situ Anaerobic Biodegradation
Protection Of Human Health and the Environment	Process will be protective of human health and the environment.	Process will be protective of human health and the environment.	Process will be protective of human health and the environment.
Attainment of Media Cleanup Standards	Alternative can potentially eventually meet MCSs at the downgradient treatment zones.	It is expected that the alternative will meet MCSs at the downgradient treatment zones.	Alternative can potentially meet MCSs at the downgradient treatment zones.
Control of the Source of Release	Not applicable. Addressed in the source control component of the overall site remediation strategy.	Not applicable. Addressed in the source control component of the overall site remediation strategy.	Not applicable. Addressed in the source control component of the overall site remediation strategy.
Compliance with Applicable Waste Management Standards	Not expected to accumulate significant quantities of waste requiring management.	Because vapor recovery will not be part of the alternative it is not expected to accumulate significant quantities of waste requiring management.	Not expected to accumulate significant quantities of waste requiring management.
Long-Term Reliability and Effectiveness			
Magnitude of Residual Risk	Gradual reduction of residual risk within dissolved-phase plume, resulting in adequate reduction in residual risk at areas of potential downgradient migration.	Residual risk with exposure at areas of potential downgradient CVOC migration reduced to minimal levels.	Residual risk with exposure at areas of potential downgradient CVOC migration reduced to minimal levels.
Adequacy of Reliability of Controls	Monitoring and contingency measures would be adequate to manage exposure at potential areas of downgradient CVOC migration.	Process would adequately and reliably control exposure at potential areas of downgradient CVOC migration.	Process would adequately and reliably control exposure at potential areas of downgradient CVOC migration.

TABLE 4-3
 Detailed Analysis of Downgradient Contaminant Migration Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	Monitoring/Natural Attenuation	In situ Air Sparging/Biosparging	Enhanced In situ Anaerobic Biodegradation
Reduction of Toxicity, Mobility, or Volume of Wastes			
Amount of Hazardous Materials Anticipated to be Destroyed/Treated	Variable. In conjunction with source control, process is expected to reduce dissolved-phase CVOCs to their respective MCSs before reaching areas of potential downgradient migration.	Contingent on downgradient CVOC migration. In conjunction with source control, expected to treat any CVOCs reaching the proposed areas of downgradient migration treatment.	Contingent on downgradient CVOC migration. In conjunction with source control, expected to treat any CVOCs reaching the proposed areas of downgradient migration treatment.
Degree and Quantity of Reduction	Process is expected to reduce dissolved-phase CVOCs to MCSs on the CNC property.	Because of the expected low levels of CVOCs, greater than 80 percent reduction of any dissolved-phase CVOC reaching the proposed areas of downgradient migration treatment.	Because of the expected low levels of CVOCs, 50 to 75 percent reduction of any dissolved-phase CVOC reaching the proposed areas of downgradient migration treatment.
Irreversibility of Reduction	High. Biodegradation of CVOCs via reductive dechlorination is irreversible.	High. Biodegradation of CVOCs from groundwater is irreversible.	High. Chemical reductive dechlorination is irreversible.
Type and Quantity of Treatment Residuals	Minimal treatment residuals is anticipated.	Minimal treatment residuals is anticipated.	Minimal treatment residuals is anticipated.
Preference for Treatment as a Principal Element	Natural treatment is a component of this alternative.	Treatment is the principal component of this alternative.	Treatment is the principal component of this alternative.
Short-Term Effectiveness			
Protection of Workers During Remedial Action Construction	Implementation poses a minimal degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.	Implementation poses a low degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.	Implementation poses a low degree of safety and health hazards to workers. Requires a Site Health and Safety Plan.
Protection of Community During Remedial Action	Implementation poses a minimal degree of safety or health hazards to the CNC community.	Implementation poses a minimal degree of safety or health hazards to the CNC community.	Implementation poses a minimal degree of safety or health hazards to the CNC community.

TABLE 4-3
 Detailed Analysis of Downgradient Contaminant Migration Control Corrective Measure Alternatives
 Corrective Measures Study Report, SWMU 39, Zone A, Charleston Naval Complex

Evaluation Criteria	Monitoring/Natural Attenuation	In situ Air Sparging/Biosparging	Enhanced In situ Anaerobic Biodegradation
(Short-Term Effectiveness)			
Environmental Impacts of Remedial Action	Process should not create adverse impacts on the environment.	Process should not create adverse impacts on the environment.	Process should not create adverse impacts on the environment.
Implementability			
Technical Feasibility	High. Except for the new innovative analytical techniques process uses conventional and readily available technology.	High. Process uses conventional and readily available technology.	High. Process uses industry proven and readily available technology.
Administrative Feasibility	High. Few major administrative issues are expected.	High. Pilot test may be required as part of the design process.	High. Will require UIC permit.
Estimated Costs^a			
Capital Cost	\$28,100	\$437,700	\$141,600
Annual O&M Cost	\$16,000	\$35,000 (Yrs. 1-5) \$16,800 (Yrs. 6-20)	\$87,000
Present Value 20-Year O&M Cost ^b	\$233,700	\$328,300	\$1,270,700
Total Cost	\$262,000	\$766,000	\$1,412,000

^a Order-of-magnitude level cost estimates with expected accuracy of plus 50 to minus 30 percent.

^b Assumes percent interest and a 20-year operation period.

5.0 Recommended Corrective Measure Alternative

Based on the preceding evaluation of available viable technologies and conditions at SWMU 39, a corrective measure approach employing ZVI using the FeroxSM technology as the source control measure combined with MNA is considered by CH2M-Jones as the preferred alternative. In addition, enhanced anaerobic degradation, air sparging, ZVI or a combination thereof are identified as contingent remedies for plume control. Because the subsurface lithology varies with depth and location throughout SWMU 39, the contingent remedy if required will be selected based on site-specific conditions.

Groundwater conditions at SWMU 39 indicate ongoing reductive dechlorination processes, which when coupled with a source control alternative are potentially effective in controlling property boundary and downgradient migration of CVOCs. In situ chemical reduction using ZVI is recommended as the source control alternative for SWMU 39. The ZVI will be injected into the subsurface as a reactive medium for the in situ chemical reduction of chlorinated solvents. A pilot study may be required to evaluate its effectiveness and to determine the optimal ZVI addition rate in a full-scale operation if the pilot study is deemed successful.

A MNA program, as generally described in Section 3.2.2, will be implemented to monitor the attenuation of the CVOC plume at SWMU 39. An initial step of the MNA program will include the analysis for *Dehalococcoides ethenogenes*. In addition, the program will be structured based on the findings presented in the *Zone A SWMU 39 Corrective Measures Study Technical Memorandum on Monitored Natural Attenuation Feasibility* (EnSafe, 1999). As previously discussed, a contingent remedy will be selected based on site-specific conditions. In the case of in situ air sparging/biosparging, a pilot study may be required since TCE may only be susceptible to aerobic degradation under highly reducing conditions associated with methanogenic reactions. Enhanced anaerobic biodegradation, coupled with bioaugmentation to treat cis-1,2-DCE and vinyl chloride, may be considered if required. This alternative will evaluate viable electron donors in a pilot study application to evaluate their effectiveness. Bioaugmentation will also be considered as part of the alternative since incomplete dechlorination of TCE can occur regardless of the electron donors used if the appropriate bacteria are not present.

Because of the subsurface geology, in situ chemical reduction using ZVI may also be a viable contingent remedy for property boundary contaminant migration control.

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Appendix A

HRC Injection Pilot Study Summary

SWMU 39, Zone A

Charleston Naval Complex

Introduction

The chlorinated volatile organic compounds (CVOCs) in groundwater can be biologically degraded by naturally occurring microorganisms. When CVOCs are naturally degraded under anaerobic conditions, the process is termed "reductive dechlorination." The microbes substitute a hydrogen atom for a chlorine atom on the CVOC molecule, thereby reducing the chlorination state of the compound. The addition of a suitable organic substrate such as hydrogen-release compound® (HRC®) to the aquifer can increase the rate of dechlorination by one order of magnitude or more, ultimately producing a non-toxic ethene end-product (Regenesis, 2000).

Purpose

CH2M-Jones conducted pilot-scale testing of HRC as a remedial alternative in 2001. The purpose of the test was to attempt to enhance the natural reductive dechlorination (bioremediation) of groundwater by injecting HRC into the subsurface. Using a direct-push technology (DPT) system, HRC was introduced into three subsurface test grids surrounding monitor wells known to have previously detected CVOCs.

Pre-Injection Baseline and Geochemical Monitoring

Approximately two weeks prior to HRC injection activities, a baseline geochemical groundwater monitoring event was conducted on selected existing monitor wells. Natural attenuation parameters including: dissolved gases; organic acids; dissolved iron and manganese; water quality parameters including chloride, nitrate/nitrite, sulfate/sulfide, pH, dissolved oxygen, and oxidation-reduction potential. Wells sampled were the monitor well clusters around which the HRC injection grids were installed; wells A039GW012, 12I and 12D; A039GW013, 13I, and 13D; A039GW25I and A039GW28I.

Approximately 2 months after the HRC was injected, the wells were sampled again and the geochemical parameters were compared to the baseline values to determine whether HRC was creating the changes in aquifer reducing conditions necessary to induce and enhance reductive dechlorination of VOCs.

New Monitor Well Installation and Sampling

Monitor wells A039GW25I and A039GW28I were installed along the western Zone A boundary between existing wells A039GW09D and A039GW23D, to assist in evaluating HRC behavior at the leading edge of the VOC plume.

In August and November, 2001, and February 2002, the existing and new wells were sampled and analyzed for VOCs to determine if the presence of HRC in the aquifer was creating any changes in the concentrations and ratios of dissolved VOCs in groundwater. During the last event in February 2002, monitor well A039GW23D was also sampled, as it is slightly farther downgradient of the injection grid.

Two additional well pairs, A039GW26I/26D and A039GW27I/27D were installed to monitor the dissolved VOC plume interior, away from the HRC injection test locations. These wells were also sampled at the same time as the other wells, and the results were used to fill in data gaps in plume interior delineation.

Well boring logs and monitor wells construction details are presented in the attached figures and tables.

HRC Injection Methodology

The HRC injection work started on May 15, 2001 at the well cluster 039GW013 area grid, by installing an intermediate and deep boring at each of 9 locations with the Geoprobe as described in the approved HRC Pilot Test Work Plan (CH2M-Jones, January 2001). HRC was then injected through the Geoprobe rods, using a grout pump specially modified to meet Regensis' specifications, at a rate of 2 pounds per vertical foot. The approximate injection depth intervals were 10 to 30 feet bls for intermediate borings, and 30 to 50 feet bls for the deep borings, as lithology permitted. A total of approximately 720 gallons of HRC were injected at this grid, as planned. Small amounts of drinking water were used as a primer and chaser during the pumping of HRC to prevent pumping air into the formation.

The geochemical baseline groundwater monitoring was accomplished as planned prior to starting HRC injections, with the addition of monitor well A039GW009I as an additional monitoring point.

The second injection grid is located around the monitor well 039GW012 cluster, located between buildings 1604 and 1605. This grid also consisted of nine injection locations, with injection occurring in the shallow (5-15 feet bls), intermediate (10-30 feet bls), and deep (30-50 feet bls) aquifer zones. The HRC was injected at a rate of 4 pounds per vertical foot for this potential VOC source area, with a total HRC injection volume of approximately 1,080 pounds. The injections went as planned at this grid.

The third grid is located by monitor well clusters 039GW023 and 039GW009, and was injected with approximately 720 pounds of HRC. The injection strategy differed slightly from the test design specifications at this grid. Because the deep zone (greater than 30 feet bls) was found to consist mainly of tight clays, HRC was injected in the intermediate and shallow zones, but not into the deep zone. The grid geometry was adjusted slightly, dictated by site conditions. The injection rate was also increased from the design rate of 2 pounds per vertical foot to 3 pounds per vertical foot, to compensate for the reduced vertical injection interval thickness in this area.

HRC injections were completed on May 29, 2001. Each boring at all injection grids was abandoned upon removal of tools by tremie pipe grouting to the land surface with Portland cement grout. All boring locations were surveyed for position by a registered land surveyor using GPS equipment.

Exact injection intervals in each boring varied based on lithology, and were determined using pumping pressures to indicate permeable zones into which to inject HRC. Injections occurred in 1 foot vertical increments in each interval. HRC was pre-heated to approximately 100 degrees F prior to injection using a water bath, to liquefy it and to enhance pumping characteristics. During injection, no surface emergence of HRC was observed away from any borehole, and very little HRC returned to the surface at any boreholes during pumping, indicating successful injections.

The second round of geochemical groundwater monitoring was performed in July, 2001. The VOC bioremediation performance verification sampling events were conducted in August and November 2001, and in February 2002 as planned.

Results and Data Interpretation

Analytical results for the geochemical and VOC groundwater monitoring are presented in the attached Excel spreadsheets, organized by well number. Data are also presented for each well in histogram graph format for geochemical and VOC parameters. The graphs show concentration variances in color, and each graph has a comment box that indicates the trends expected for that parameter after injection.

Conclusions

Based on the results of the pilot test, HRC is not likely to be selected as the final full scale groundwater remedy.

Although the HRC was observed to affect the site groundwater geochemistry at several locations, HRC did not significantly enhance the existing rate of natural attenuation during the 9 month test period.

Natural attenuation of VOCs in groundwater by reductive dechlorination is still feasible and is occurring, but aquifer concentrations of VOCs may not be high enough at this site for HRC to display a distinct advantage over natural attenuation.

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
VOA	1,1-Dichloroethene	A039GW012	039GW012L2	5/14/01	2.4	J	ug/L
VOA	1,1-Dichloroethene	A039GW012	039GW012L4	8/16/01	1.9	J	ug/L
	1,1-Dichloroethene	A039GW012	039GW012M1	2/13/02	10	U	ug/L
	1,1-Dichloroethene	A039GW12D	039GW12DM1	2/13/02	5	U	ug/L
VOA	1,1-Dichloroethene	A039GW12I	039GW121L2	5/14/01	2.6	J	ug/L
VOA	1,1-Dichloroethene	A039GW12I	039GW121L4	8/16/01	6.6	J	ug/L
	1,1-Dichloroethene	A039GW12I	039GW121M1	2/13/02	3	J	ug/L
GENCHEM	Acetic Acid	A039GW012	039GW012L3	7/19/01	8.6	=	mg/l
GENCHEM	Acetic Acid	A039GW012	039GW012L4	8/16/01	13.6	=	mg/l
GENCHEM	Acetic Acid	A039GW012	039GW012M1	2/13/02	32.1	=	MG/L
GENCHEM	Acetic Acid	A039GW12D	039GW12DL3	7/19/01	2.5	=	mg/l
GENCHEM	Acetic Acid	A039GW12D	039GW12DL4	8/16/01	21.7	=	mg/l
GENCHEM	Acetic Acid	A039GW12D	039GW12DL5	10/29/01	26.1	=	mg/l
GENCHEM	Acetic Acid	A039GW12D	039GW12DM1	2/13/02	41.4	=	MG/L
GENCHEM	Acetic Acid	A039GW12I	039GW12IL3	7/19/01	126	=	mg/l
GENCHEM	Acetic Acid	A039GW12I	039GW12IL4	8/16/01	203	=	mg/l
GENCHEM	Acetic Acid	A039GW12I	039GW12IM1	2/13/02	204	=	MG/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW012	039GW012L2	5/14/01	175	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW012	039GW012L4	8/16/01	178	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW12D	039GW12DL2	5/14/01	129	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW12D	039GW12DL4	8/16/01	186	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW12I	039GW121L2	5/14/01	198	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW12I	039GW121L4	8/16/01	583	=	mg/L
GENCHEM	Butyric Acid	A039GW012	039GW012L3	7/19/01	6	=	mg/l
GENCHEM	Butyric Acid	A039GW012	039GW012L4	8/16/01	3.5	=	mg/l
	Butyric Acid	A039GW012	039GW012M1	2/13/02	1	U	MG/L
GENCHEM	Butyric Acid	A039GW12D	039GW12DL3	7/19/01	4.9	=	mg/l
GENCHEM	Butyric Acid	A039GW12D	039GW12DL4	8/16/01	6.8	=	mg/l
GENCHEM	Butyric Acid	A039GW12D	039GW12DL5	10/29/01	2.1	=	mg/l
	Butyric Acid	A039GW12D	039GW12DM1	2/13/02	5.7	=	MG/L
GENCHEM	Butyric Acid	A039GW12I	039GW12IL3	7/19/01	73.9	=	mg/l
GENCHEM	Butyric Acid	A039GW12I	039GW12IL4	8/16/01	221	=	mg/l
	Butyric Acid	A039GW12I	039GW12IM1	2/13/02	37.9	=	MG/L
CH4 / CO2	Carbon Dioxide	A039GW012	039GW012L2	5/14/01	37	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW012	039GW012L3	7/19/01	26	=	mg/l

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
CH4 / CO2	Carbon Dioxide	A039GW012	039GW012L4	8/16/01	69	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW012	039GW012M1	2/13/02	59	=	mg/L
CH4 / CO2	Carbon Dioxide	A039GW12D	039GW12DL2	5/14/01	8.4	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW12D	039GW12DL3	7/19/01	7.7	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW12D	039GW12DL4	8/16/01	19	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW12D	039GW12DM1	2/13/02	15	=	mg/L
CH4 / CO2	Carbon Dioxide	A039GW12I	039GW12IL2	5/14/01	22	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW12I	039GW12IL3	7/19/01	100	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW12I	039GW12IL4	8/16/01	240	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW12I	039GW12IM1	2/13/02	87	=	mg/L
GENCHEM	Chloride	A039GW012	039GW012L2	5/14/01	8.58	=	mg/L
GENCHEM	Chloride	A039GW012	039GW012L3	7/19/01	9.34	=	mg/L
GENCHEM	Chloride	A039GW12D	039GW12DL2	5/14/01	27.3	=	mg/L
GENCHEM	Chloride	A039GW12D	039GW12DL3	7/19/01	24.8	=	mg/L
GENCHEM	Chloride	A039GW12I	039GW12IL2	5/14/01	11.7	=	mg/L
GENCHEM	Chloride	A039GW12I	039GW12IL3	7/19/01	12.8	=	mg/L
VOA	cis-1,2-Dichloroethylene	A039GW012	039GW012L2	5/14/01	159	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW012	039GW012L4LR	8/16/01	116	J	ug/L
	cis-1,2-Dichloroethylene	A039GW012	039GW012M1	2/13/02	96.4	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW12D	039GW12DL4	8/16/01	0.37	J	ug/L
	cis-1,2-Dichloroethylene	A039GW12D	039GW12DM1	2/13/02	5	U	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW12I	039GW12IL2	5/14/01	310	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW12I	039GW12IL4LR	8/16/01	599	J	ug/L
	cis-1,2-Dichloroethylene	A039GW12I	039GW12IM1L				
	cis-1,2-Dichloroethylene	A039GW12I	R	2/13/02	314	=	ug/L
CH4 / CO2	Ethane	A039GW012	039GW012L2	5/14/01	500	=	ng/L
CH4 / CO2	Ethane	A039GW012	039GW012L3	7/19/01	360	=	ng/L
CH4 / CO2	Ethane	A039GW012	039GW012L4	8/16/01	830	=	ng/L
CH4 / CO2	Ethane	A039GW012	039GW012M1	2/13/02	5	U	ng/L
CH4 / CO2	Ethane	A039GW12D	039GW12DL2	5/14/01	50	=	ng/L
CH4 / CO2	Ethane	A039GW12D	039GW12DL3	7/19/01	160	=	ng/L
CH4 / CO2	Ethane	A039GW12D	039GW12DL5	10/29/01	59	=	ng/L
CH4 / CO2	Ethane	A039GW12D	039GW12DM1	2/13/02	100	=	ng/L
CH4 / CO2	Ethane	A039GW12I	039GW12IL2	5/14/01	490	=	ng/L
CH4 / CO2	Ethane	A039GW12I	039GW12IL3	7/19/01	420	=	ng/L

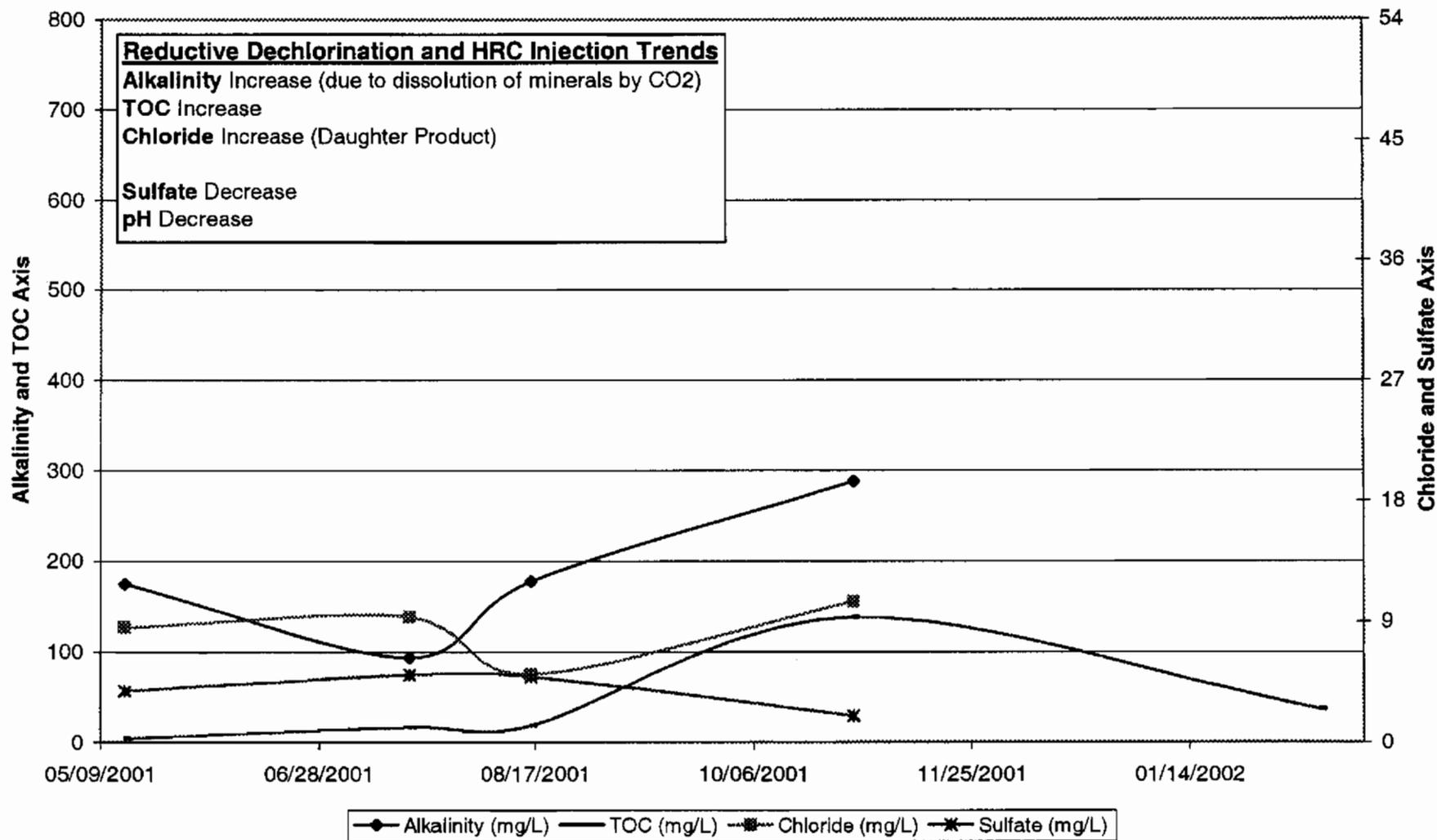
ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
CH4 / CO2	Ethane	A039GW12I	039GW12IL4	8/16/01	580	=	ng/L
CH4 / CO2	Ethane	A039GW12I	039GW12IM1	2/13/02	100	=	ng/L
CH4 / CO2	Ethene	A039GW012	039GW012L2	5/14/01	760	=	ng/L
CH4 / CO2	Ethene	A039GW012	039GW012L3	7/19/01	550	=	ng/L
CH4 / CO2	Ethene	A039GW012	039GW012L4	8/16/01	1300	=	ng/L
CH4 / CO2	Ethene	A039GW012	039GW012M1	2/13/02	6600	=	ng/L
CH4 / CO2	Ethene	A039GW12D	039GW12DL2	5/14/01	9	=	ng/L
CH4 / CO2	Ethene	A039GW12D	039GW12DL3	7/19/01	16	=	ng/L
CH4 / CO2	Ethene	A039GW12D	039GW12DL5	10/29/01	250	=	ng/L
CH4 / CO2	Ethene	A039GW12D	039GW12DM1	2/13/02	8.2	=	ng/L
CH4 / CO2	Ethene	A039GW12I	039GW12IL2	5/14/01	810	=	ng/L
CH4 / CO2	Ethene	A039GW12I	039GW12IL3	7/19/01	1000	=	ng/L
CH4 / CO2	Ethene	A039GW12I	039GW12IL4	8/16/01	2000	=	ng/L
CH4 / CO2	Ethene	A039GW12I	039GW12IM1	2/13/02	9800	=	ng/L
CH4 / CO2	Hydrogen	A039GW012	039GW012L2	5/14/01	4.3	=	nM
CH4 / CO2	Hydrogen	A039GW012	039GW012L4	8/16/01	8.8	=	nM
CH4 / CO2	Hydrogen	A039GW012	039GW012M1	2/13/02	2.6	=	nM
CH4 / CO2	Hydrogen	A039GW12D	039GW12DL2	5/14/01	3.6	=	nM
CH4 / CO2	Hydrogen	A039GW12D	039GW12DL3	7/19/01	840	=	nM
CH4 / CO2	Hydrogen	A039GW12D	039GW12DL4	8/16/01	910	=	nM
CH4 / CO2	Hydrogen	A039GW12D	039GW12DL5	10/29/01	1.1	=	nM
CH4 / CO2	Hydrogen	A039GW12D	039GW12DM1	2/13/02	1300	=	nM
CH4 / CO2	Hydrogen	A039GW12I	039GW12IL2	5/14/01	1.2	=	nM
CH4 / CO2	Hydrogen	A039GW12I	039GW12IL3	7/19/01	570	=	nM
CH4 / CO2	Hydrogen	A039GW12I	039GW12IL4	8/16/01	310	=	nM
CH4 / CO2	Hydrogen	A039GW12I	039GW12IM1	2/13/02	8.4	=	nM
METAL	Iron	A039GW012	039GW012L2	5/14/01	86.7	J	ug/L
METAL	Iron (Ferrous)	A039GW012	039GW012L2	5/14/01	1.49	J	mg/L
	Iron (Ferrous)	A039GW012	039GW012M1	2/13/02	8.04	J	mg/L
	Iron (Ferrous)	A039GW12D	039GW12DM1	2/13/02	0.236	UJ	mg/L
	Iron (Ferrous)	A039GW12I	039GW12IM1	2/13/02	1.21	J	mg/L
FLTMET	Iron (Ferrous), Dissolved	A039GW012	039GW012L3	7/19/01	4.74	J	mg/L
FLTMET	Iron (Ferrous), Dissolved	A039GW12I	039GW12IL3	7/19/01	5.02	J	mg/L
FLTMET	Iron, Dissolved	A039GW012	039GW012L3	7/19/01	167	=	ug/L
FLTMET	Iron, Dissolved	A039GW12I	039GW12IL3	7/19/01	3280	=	ug/L

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
FLTMET	Iron, Dissolved	A039GW12I	039GW121L4	8/16/01	14700	=	ug/L
	Iron, Dissolved, Dissolved	A039GW012	039GW012M1	2/13/02	510	=	ug/L
	Iron, Dissolved, Dissolved	A039GW12D	039GW12DM1	2/13/02	49	U	ug/L
	Iron, Dissolved, Dissolved	A039GW12I	039GW12IM1	2/13/02	283	=	ug/L
	Lactic Acid	A039GW012	039GW012M1	2/13/02	1	U	MG/L
GENCHEM	Lactic Acid	A039GW12D	039GW12DL3	7/19/01	3.3	=	mg/l
GENCHEM	Lactic Acid	A039GW12D	039GW12DL4	8/16/01	30.1	=	mg/l
	Lactic Acid	A039GW12D	039GW12DM1	2/13/02	1	U	MG/L
GENCHEM	Lactic Acid	A039GW12I	039GW12IL3	7/19/01	114	=	mg/l
GENCHEM	Lactic Acid	A039GW12I	039GW12IL4	8/16/01	174	=	mg/l
	Lactic Acid	A039GW12I	039GW12IM1	2/13/02	1	U	MG/L
METAL	Manganese	A039GW012	039GW012L2	5/14/01	2940	=	ug/L
METAL	Manganese	A039GW12D	039GW12DL2	5/14/01	12	J	ug/L
METAL	Manganese	A039GW12I	039GW121L2	5/14/01	582	=	ug/L
FLTMET	Manganese, Dissolved	A039GW012	039GW012L3	7/19/01	2150	=	ug/L
FLTMET	Manganese, Dissolved	A039GW012	039GW012L4	8/16/01	2760	=	ug/L
	Manganese, Dissolved	A039GW012	039GW012M1	2/13/02	5510	J	ug/L
FLTMET	Manganese, Dissolved	A039GW12D	039GW12DL3	7/19/01	28.2	=	ug/L
FLTMET	Manganese, Dissolved	A039GW12D	039GW12DL4	8/16/01	71.4	=	ug/L
	Manganese, Dissolved	A039GW12D	039GW12DM1	2/13/02	66.7	J	ug/L
FLTMET	Manganese, Dissolved	A039GW12I	039GW12IL3	7/19/01	3070	=	ug/L
FLTMET	Manganese, Dissolved	A039GW12I	039GW121L4	8/16/01	6570	=	ug/L
	Manganese, Dissolved	A039GW12I	039GW12IM1	2/13/02	2770	J	ug/L
CH4 / CO2	Methane	A039GW012	039GW012L2	5/14/01	430	=	ug/L
CH4 / CO2	Methane	A039GW012	039GW012L3	7/19/01	290	=	ug/L
CH4 / CO2	Methane	A039GW012	039GW012L4	8/16/01	1700	=	ug/L
CH4 / CO2	Methane	A039GW012	039GW012M1	2/13/02	8400	=	ug/L
CH4 / CO2	Methane	A039GW12D	039GW12DL2	5/14/01	19	=	ug/L
CH4 / CO2	Methane	A039GW12D	039GW12DL3	7/19/01	76	=	ug/L
CH4 / CO2	Methane	A039GW12D	039GW12DL4	8/16/01	220	=	ug/L
CH4 / CO2	Methane	A039GW12D	039GW12DL5	10/29/01	42	=	ug/L
CH4 / CO2	Methane	A039GW12D	039GW12DM1	2/13/02	1600	=	ug/L
CH4 / CO2	Methane	A039GW12I	039GW12IL2	5/14/01	530	=	ug/L
CH4 / CO2	Methane	A039GW12I	039GW12IL3	7/19/01	380	=	ug/L
CH4 / CO2	Methane	A039GW12I	039GW12IL4	8/16/01	2500	=	ug/L

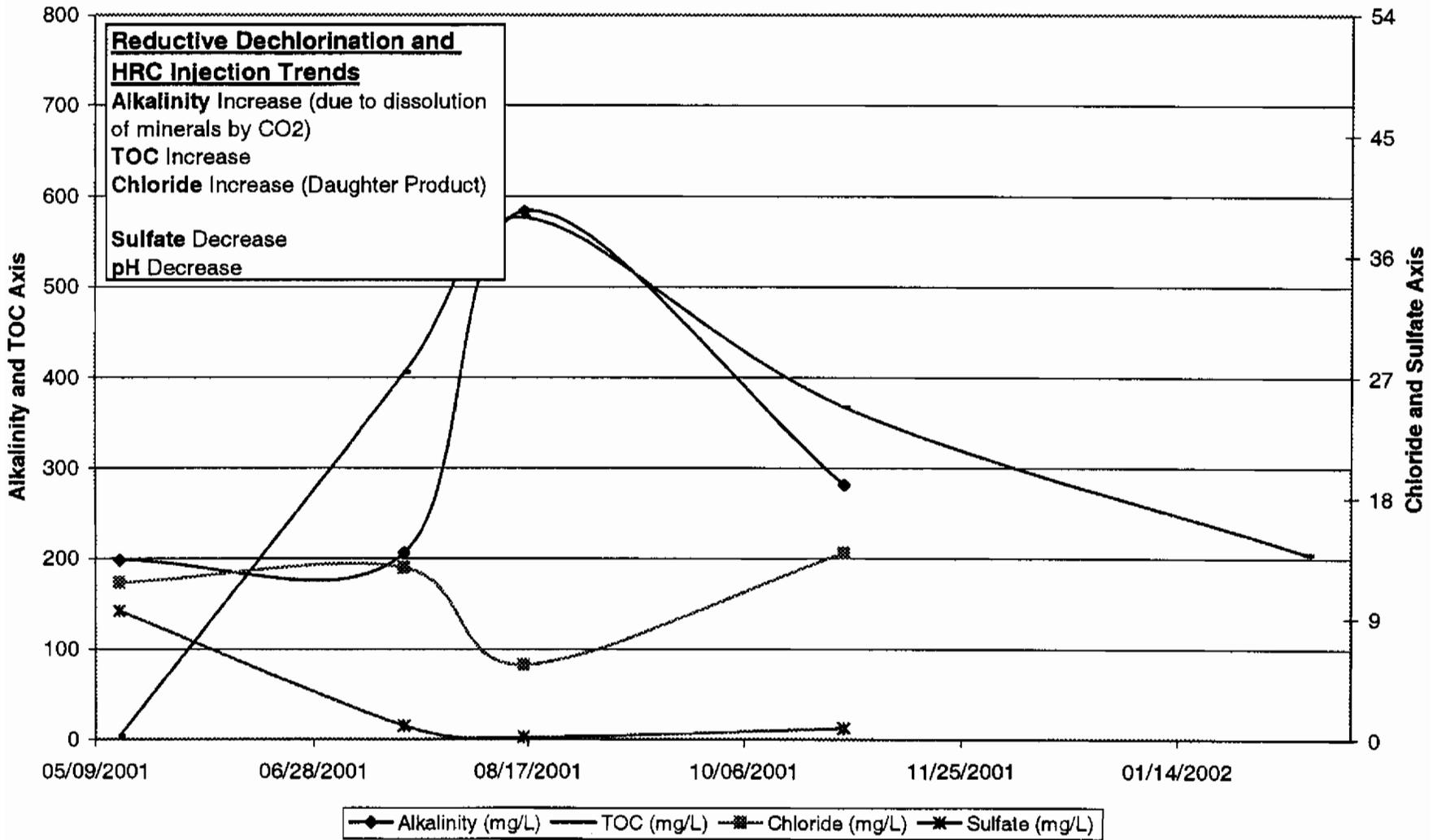
ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
CH4 / CO2	Methane	A039GW12I	039GW12IM1	2/13/02	11000	=	ug/L
GENCHEM	Propionic Acid	A039GW012	039GW012L3	7/19/01	19.3	=	mg/l
GENCHEM	Propionic Acid	A039GW012	039GW012L4	8/16/01	16.2	=	mg/l
	Propionic Acid	A039GW012	039GW012M1	2/13/02	28.8	=	MG/L
GENCHEM	Propionic Acid	A039GW12D	039GW12DL3	7/19/01	20.2	=	mg/l
GENCHEM	Propionic Acid	A039GW12D	039GW12DL4	8/16/01	43.8	=	mg/l
GENCHEM	Propionic Acid	A039GW12D	039GW12DL5	10/29/01	34.3	=	mg/l
	Propionic Acid	A039GW12D	039GW12DM1	2/13/02	41	=	MG/L
GENCHEM	Propionic Acid	A039GW12I	039GW12IL3	7/19/01	256	=	mg/l
GENCHEM	Propionic Acid	A039GW12I	039GW12IL4	8/16/01	412	=	mg/l
	Propionic Acid	A039GW12I	039GW12IM1	2/13/02	248	=	MG/L
GENCHEM	Pyruvic Acid	A039GW012	039GW012L2	5/14/01	0.4	=	mg/l
GENCHEM	Pyruvic Acid	A039GW012	039GW012L3	7/19/01	0.1	=	mg/l
GENCHEM	Pyruvic Acid	A039GW012	039GW012L4	8/16/01	0.2	=	mg/l
	Pyruvic Acid	A039GW012	039GW012M1	2/13/02	0.1	U	MG/L
GENCHEM	Pyruvic Acid	A039GW12D	039GW12DL5	10/29/01	0.2	=	mg/l
	Pyruvic Acid	A039GW12D	039GW12DM1	2/13/02	0.1	U	MG/L
GENCHEM	Pyruvic Acid	A039GW12I	039GW12IL2	5/14/01	0.1	=	mg/l
GENCHEM	Pyruvic Acid	A039GW12I	039GW12IL3	7/19/01	0.5	=	mg/l
GENCHEM	Pyruvic Acid	A039GW12I	039GW12IL4	8/16/01	0.2	=	mg/l
	Pyruvic Acid	A039GW12I	039GW12IM1	2/13/02	0.1	U	MG/L
GENCHEM	Sulfate (as SO4)	A039GW012	039GW012L2	5/14/01	3.79	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW012	039GW012L3	7/19/01	5.03	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW12D	039GW12DL2	5/14/01	13	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW12D	039GW12DL3	7/19/01	10.5	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW12I	039GW12IL2	5/14/01	9.57	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW12I	039GW12IL3	7/19/01	1.01	=	mg/L
GENCHEM	Sulfide	A039GW12D	039GW12DL2	5/14/01	0.026	J	mg/L
GENCHEM	Sulfide	A039GW12D	039GW12DL3	7/19/01	0.536	=	mg/L
GENCHEM	Sulfide	A039GW12D	039GW12DL4	8/16/01	0.328	=	mg/L
GENCHEM	Sulfide	A039GW12I	039GW12IL4	8/16/01	0.0667	=	mg/L
	Tetrachloroethylene (PCE)	A039GW012	039GW012M1	2/13/02	10	UJ	ug/L
	Tetrachloroethylene (PCE)	A039GW12D	039GW12DM1	2/13/02	5	UJ	ug/L
	Tetrachloroethylene (PCE)	A039GW12I	039GW12IM1	2/13/02	12.5	U	ug/L
GENCHEM	Total Organic Carbon	A039GW012	039GW012L2	5/14/01	4.03	=	mg/L

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
GENCHEM	Total Organic Carbon	A039GW012	039GW012L3	7/19/01	16.9	J	mg/L
GENCHEM	Total Organic Carbon	A039GW012	039GW012L4	8/16/01	18.2	=	mg/L
GENCHEM	Total Organic Carbon	A039GW012	039GW012M1	2/13/02	36.4	=	mg/L
GENCHEM	Total Organic Carbon	A039GW12D	039GW12DL2	5/14/01	1.79	=	mg/L
GENCHEM	Total Organic Carbon	A039GW12D	039GW12DL3	7/19/01	43.8	J	mg/L
GENCHEM	Total Organic Carbon	A039GW12D	039GW12DL4	8/16/01	52.9	J	mg/L
GENCHEM	Total Organic Carbon	A039GW12D	039GW12DM1	2/13/02	47.5	=	mg/L
GENCHEM	Total Organic Carbon	A039GW12I	039GW12I1L2	5/14/01	2.95	=	mg/L
GENCHEM	Total Organic Carbon	A039GW12I	039GW12I1L3	7/19/01	405	J	mg/L
GENCHEM	Total Organic Carbon	A039GW12I	039GW12I1L4	8/16/01	576	J	mg/L
GENCHEM	Total Organic Carbon	A039GW12I	039GW12I1M1	2/13/02	204	=	mg/L
VOA	trans-1,2-Dichloroethene	A039GW012	039GW012L2	5/14/01	3.4	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW012	039GW012L4	8/16/01	1.8	J	ug/L
	trans-1,2-Dichloroethene	A039GW012	039GW012M1	2/13/02	1.8	J	ug/L
	trans-1,2-Dichloroethene	A039GW12D	039GW12DM1	2/13/02	5	U	ug/L
VOA	trans-1,2-Dichloroethene	A039GW12I	039GW12I1L2	5/14/01	2.2	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW12I	039GW12I1L4	8/16/01	3.2	J	ug/L
	trans-1,2-Dichloroethene	A039GW12I	039GW12I1M1	2/13/02	1.2	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW012	039GW012L2	5/14/01	33.5	=	ug/L
VOA	Trichloroethylene (TCE)	A039GW012	039GW012L4	8/16/01	19.4	J	ug/L
	Trichloroethylene (TCE)	A039GW012	039GW012M1	2/13/02	10	U	ug/L
	Trichloroethylene (TCE)	A039GW12D	039GW12DM1	2/13/02	5	U	ug/L
VOA	Trichloroethylene (TCE)	A039GW12I	039GW12I1L2	5/14/01	49.3	=	ug/L
VOA	Trichloroethylene (TCE)	A039GW12I	039GW12I1L4	8/16/01	8.6	J	ug/L
	Trichloroethylene (TCE)	A039GW12I	039GW12I1M1	2/13/02	12.5	U	ug/L
VOA	Vinyl chloride	A039GW012	039GW012L2	5/14/01	9.6	J	ug/L
VOA	Vinyl chloride	A039GW012	039GW012L4	8/16/01	6.1	J	ug/L
	Vinyl chloride	A039GW012	039GW012M1	2/13/02	52.7	=	ug/L
	Vinyl chloride	A039GW12D	039GW12DM1	2/13/02	10	U	ug/L
VOA	Vinyl chloride	A039GW12I	039GW12I1L4	8/16/01	3.3	J	ug/L
	Vinyl chloride	A039GW12I	039GW12I1M1	2/13/02	17.1	J	ug/L

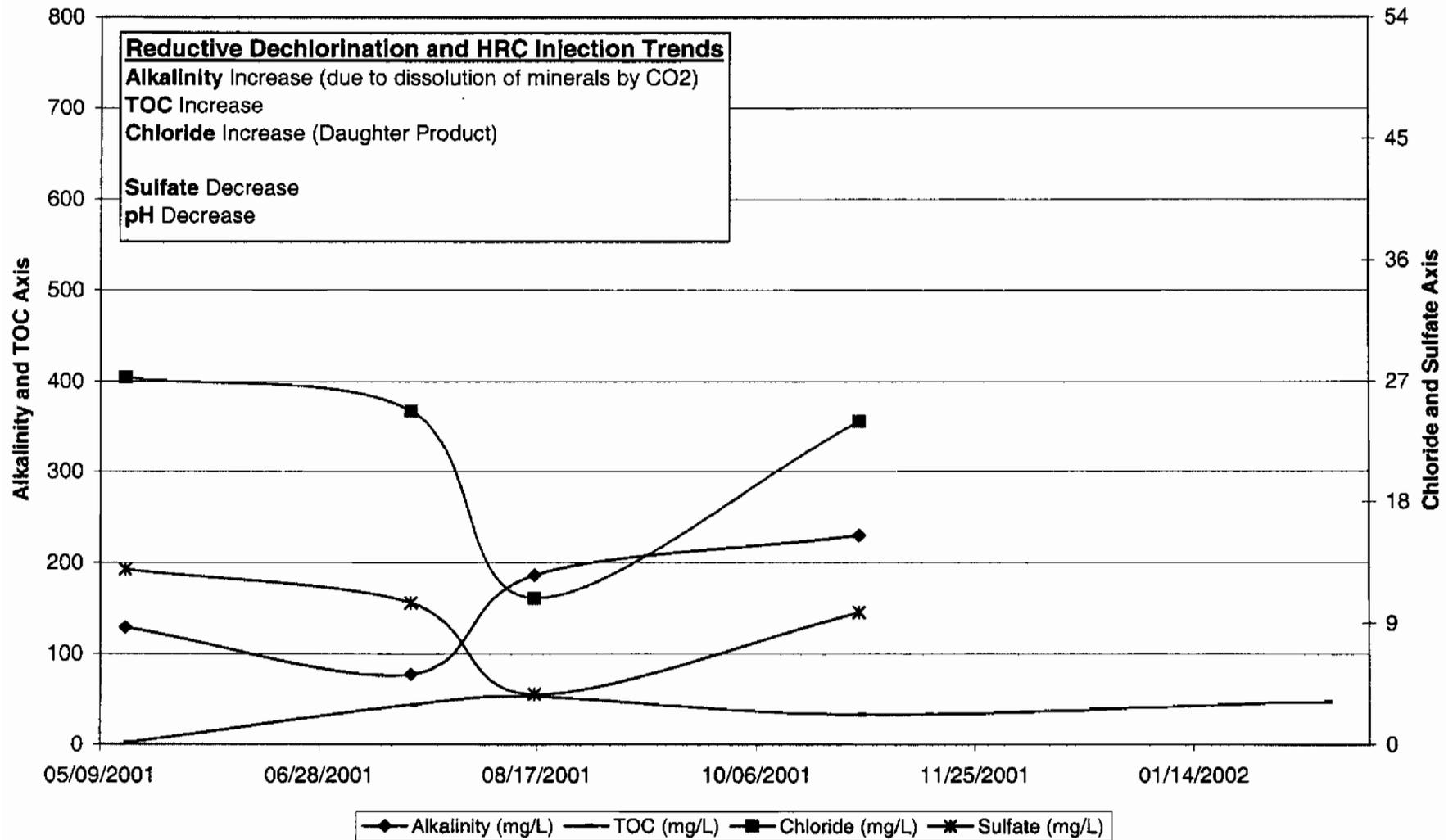
A039GW012 Geochemical Indicators



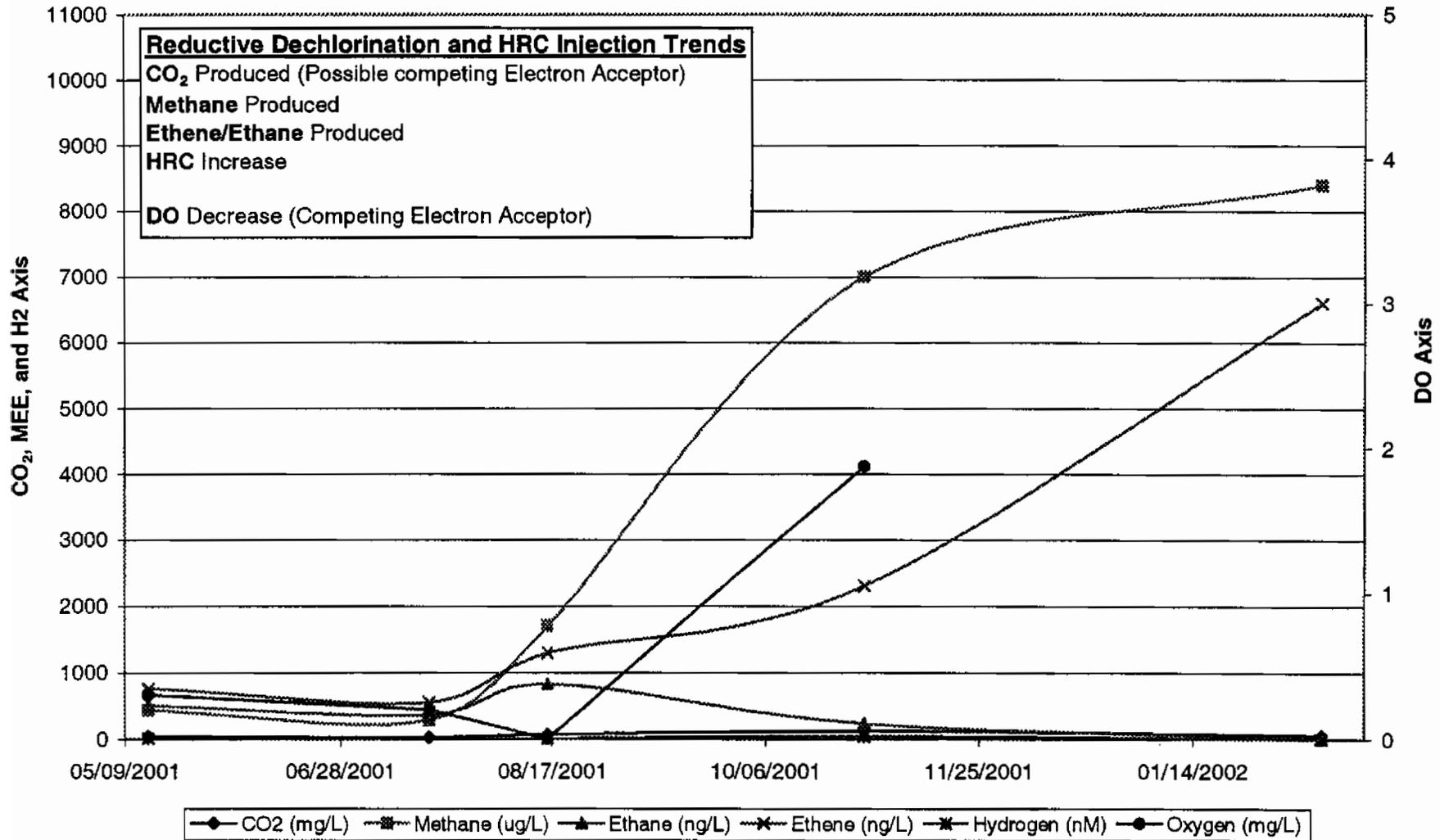
A039GW012I Geochemical Indicators



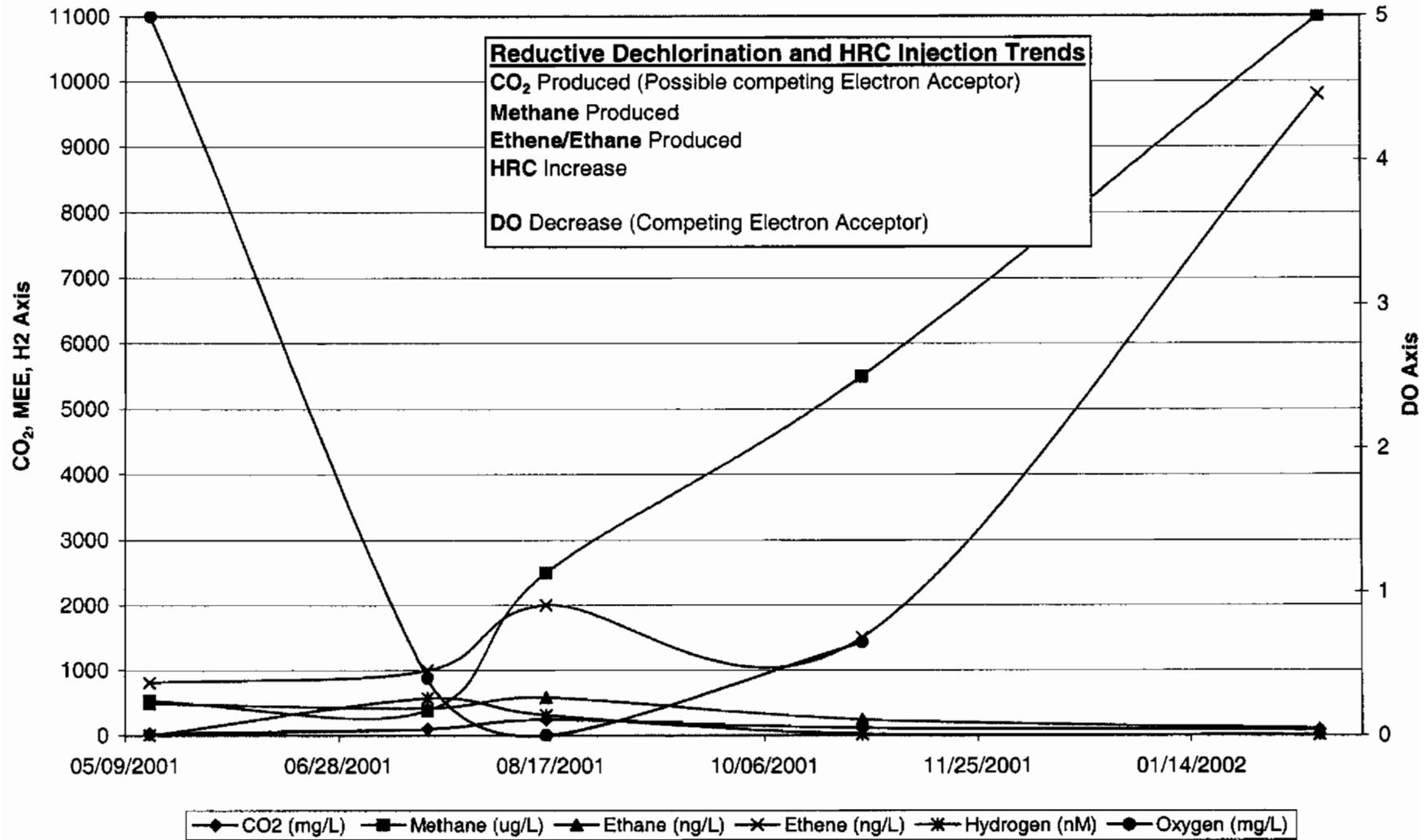
A039GW012D Geochemical Indicators



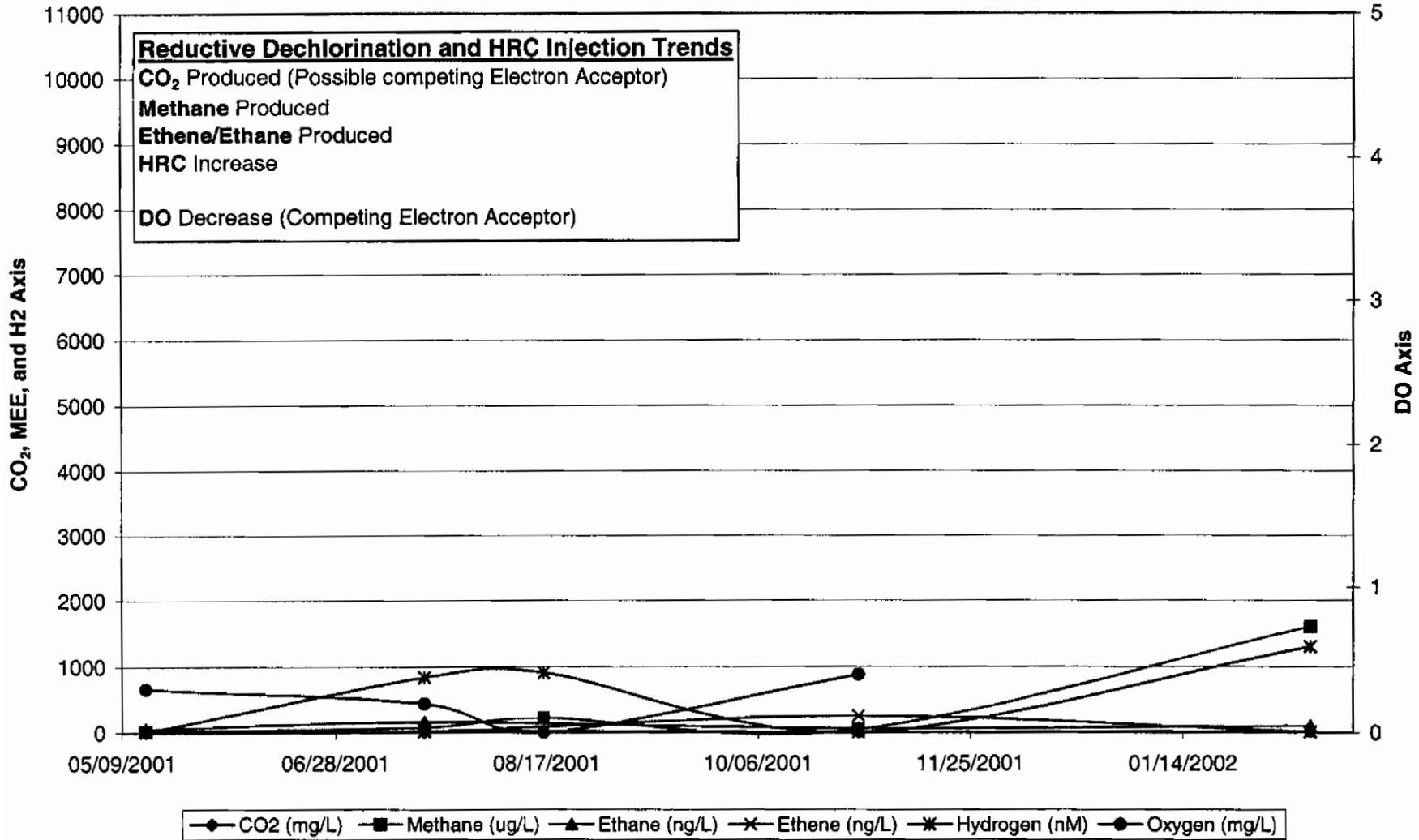
A039GW012 Dissolved Gasses



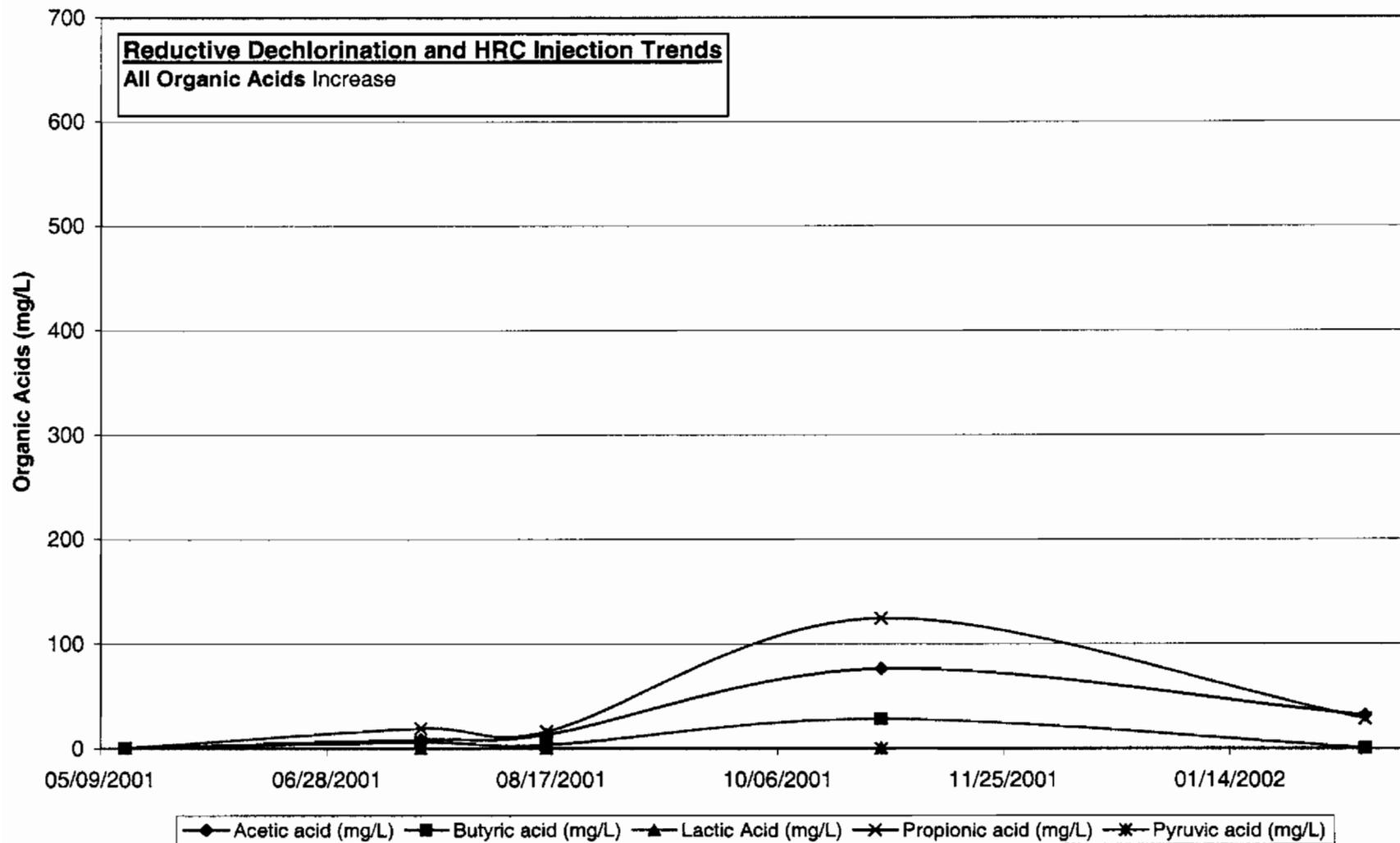
A039GW012I Dissolved Gasses



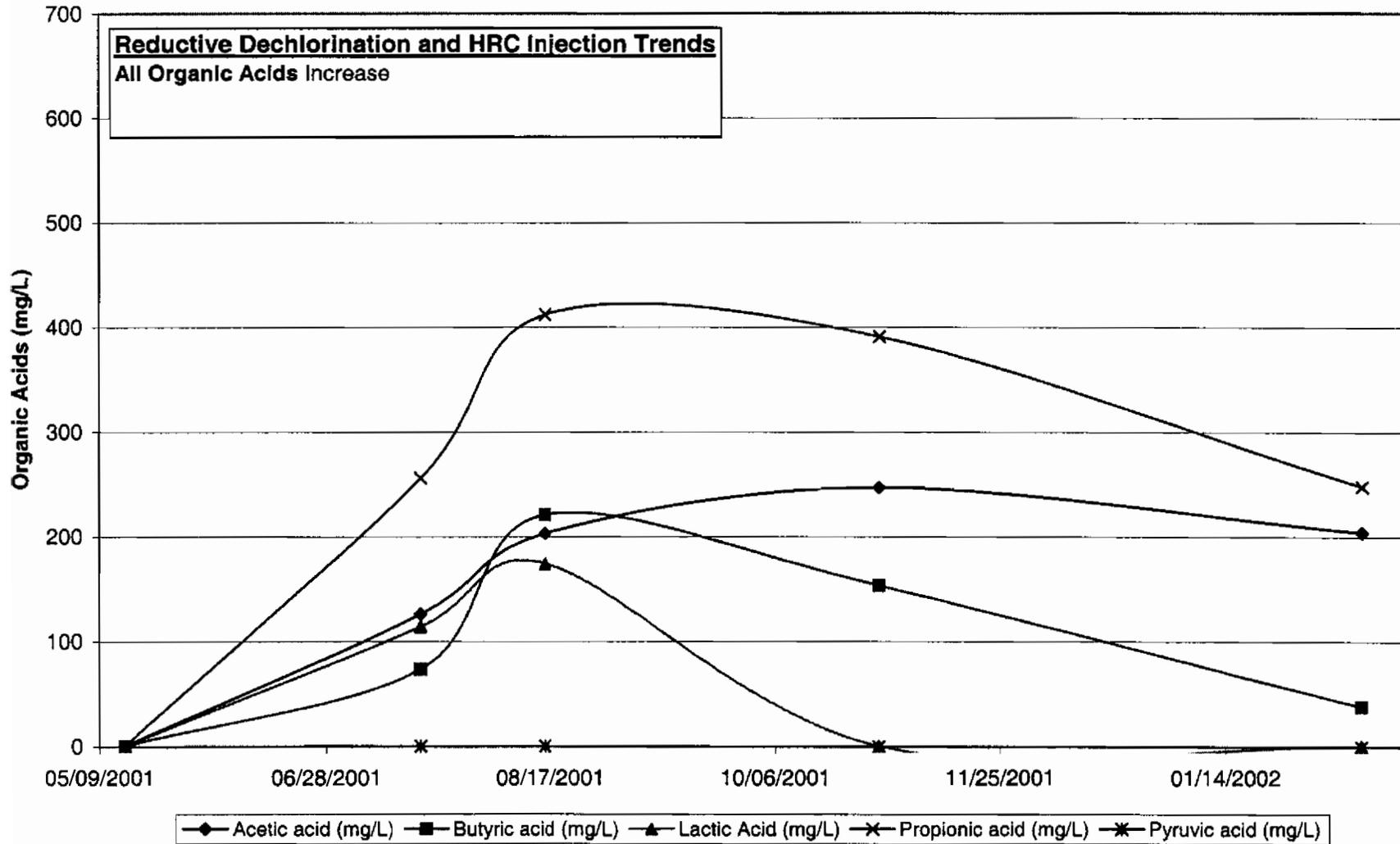
A039GW012D Dissolved Gasses



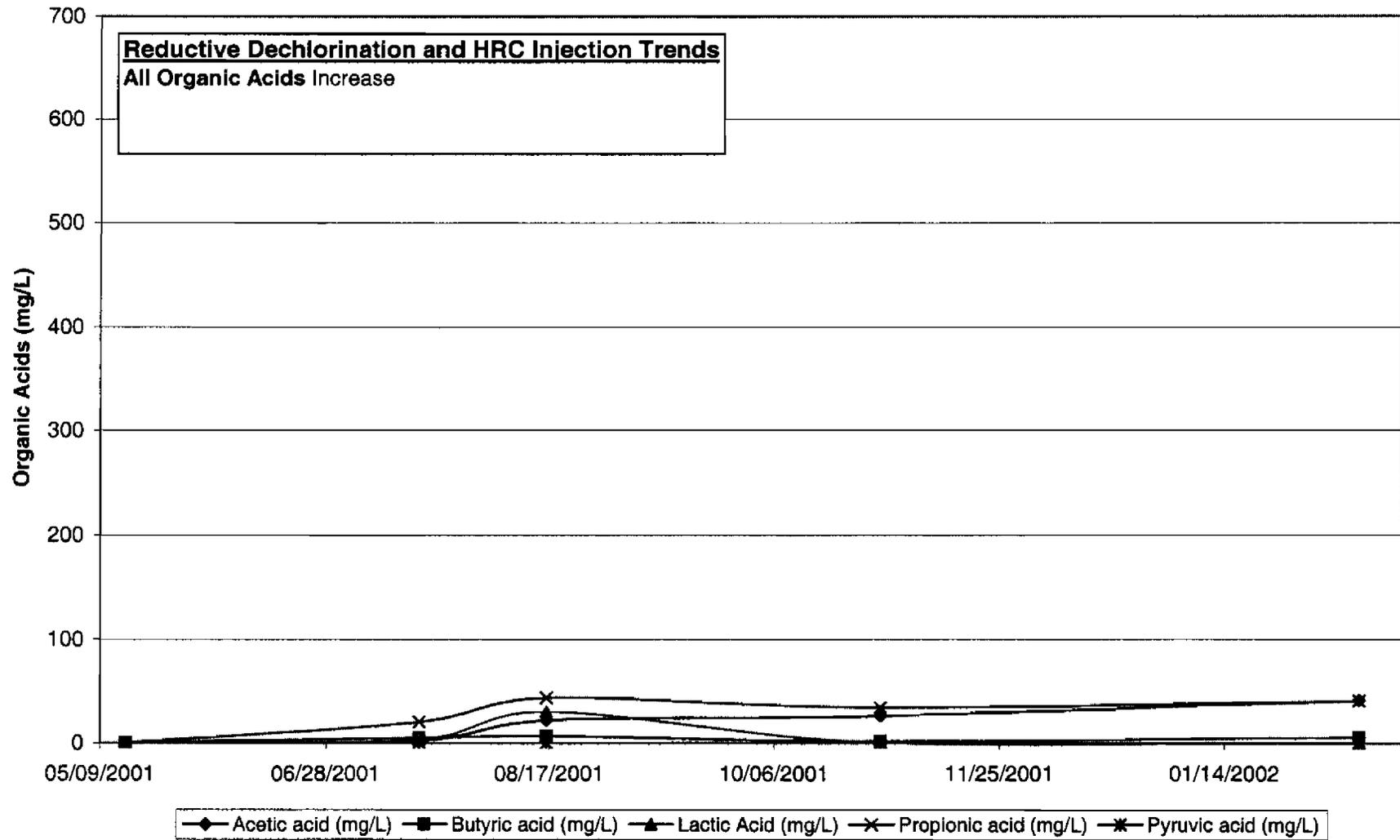
A039GW012 Organic Acids



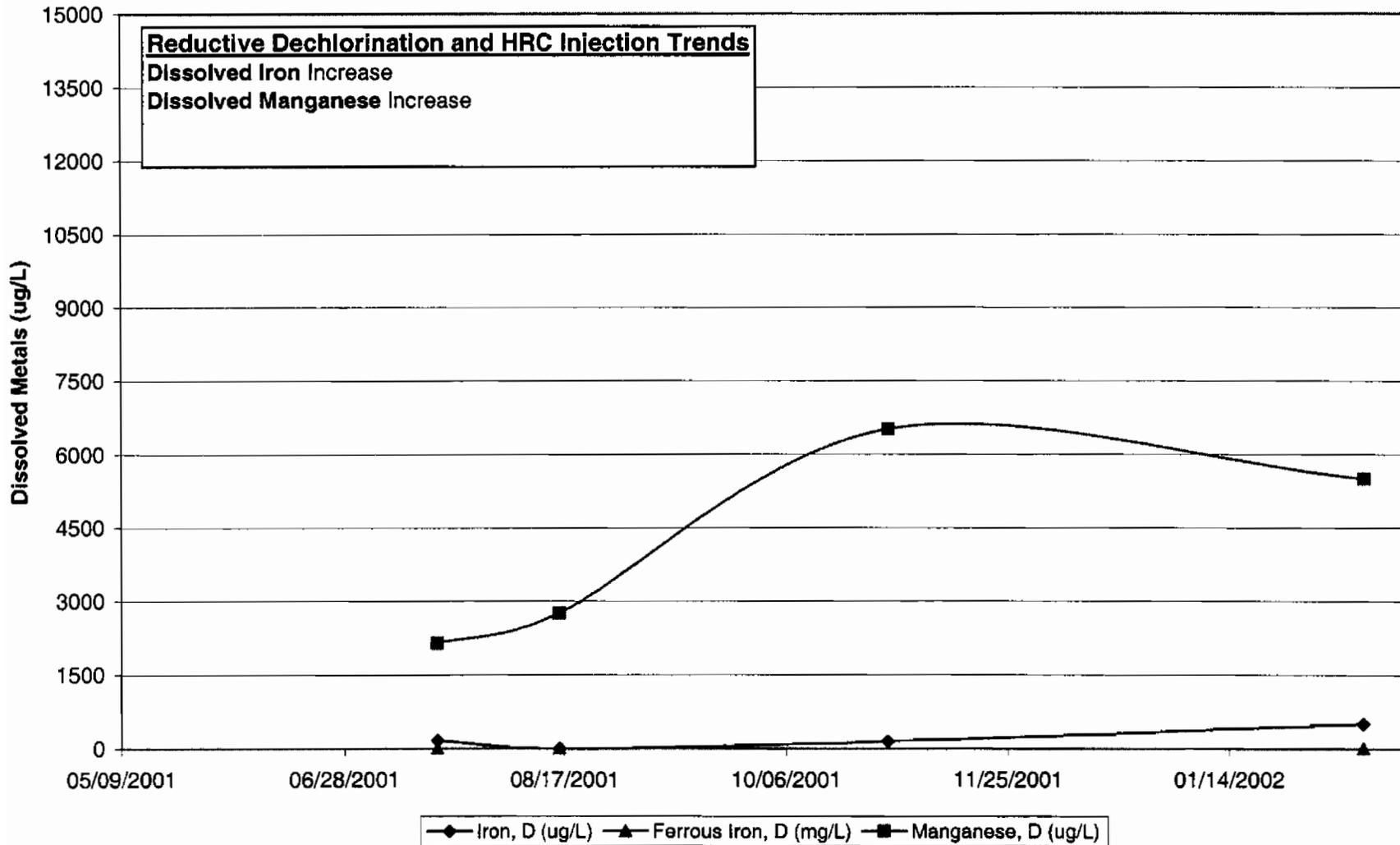
A039GW012I Organic Acids



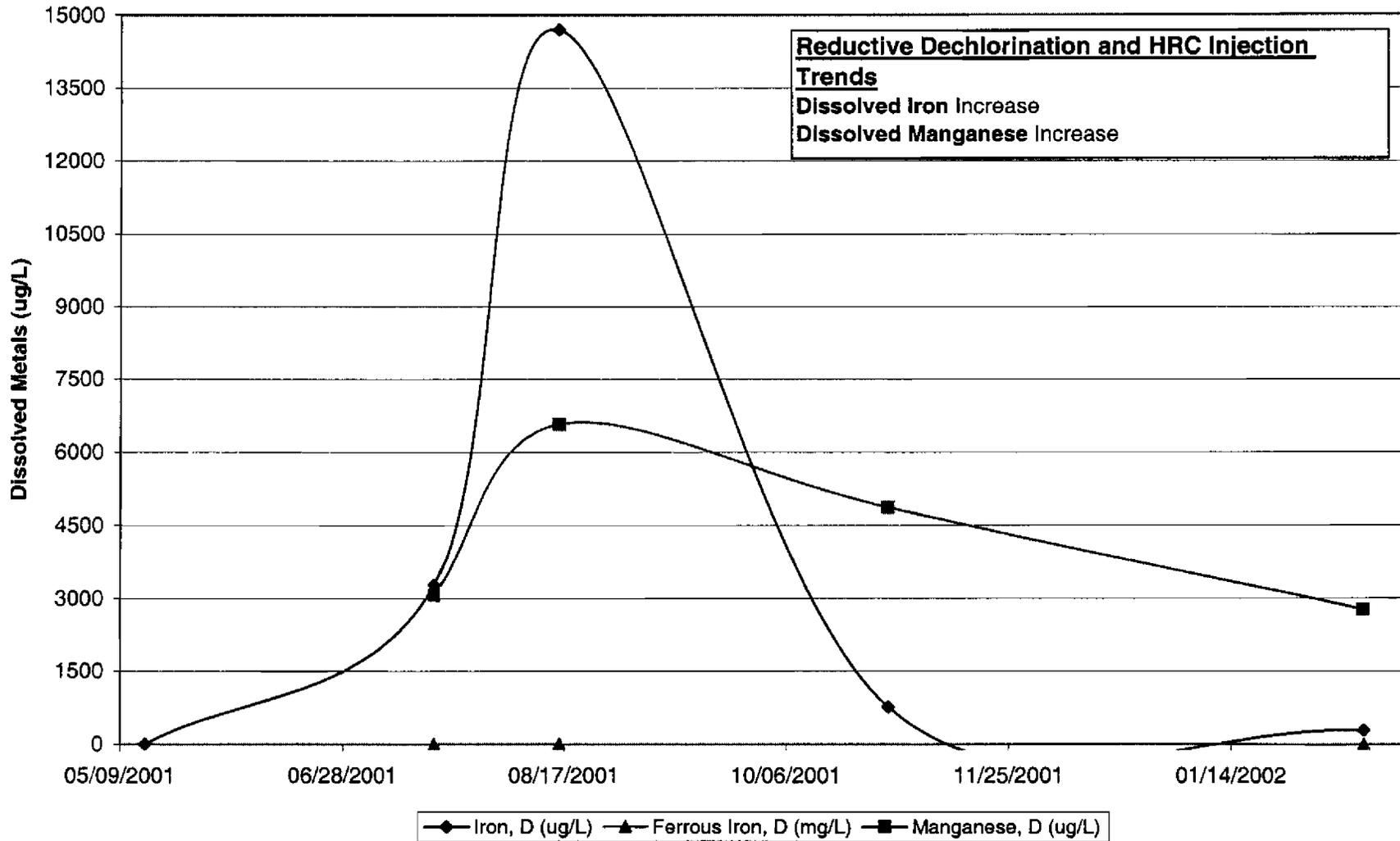
A039GW012D Organic Acids



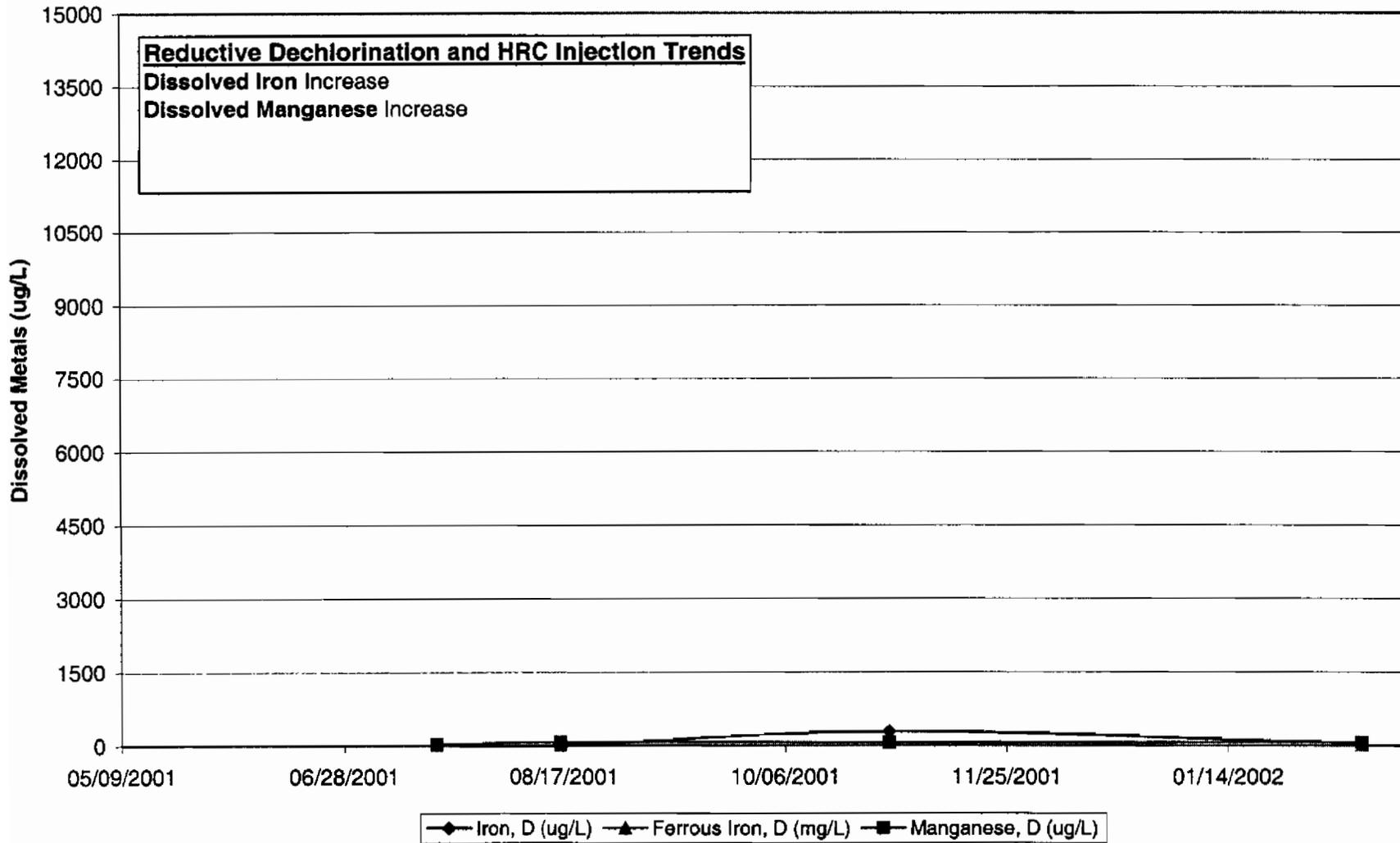
A039GW012 Dissolved Metals



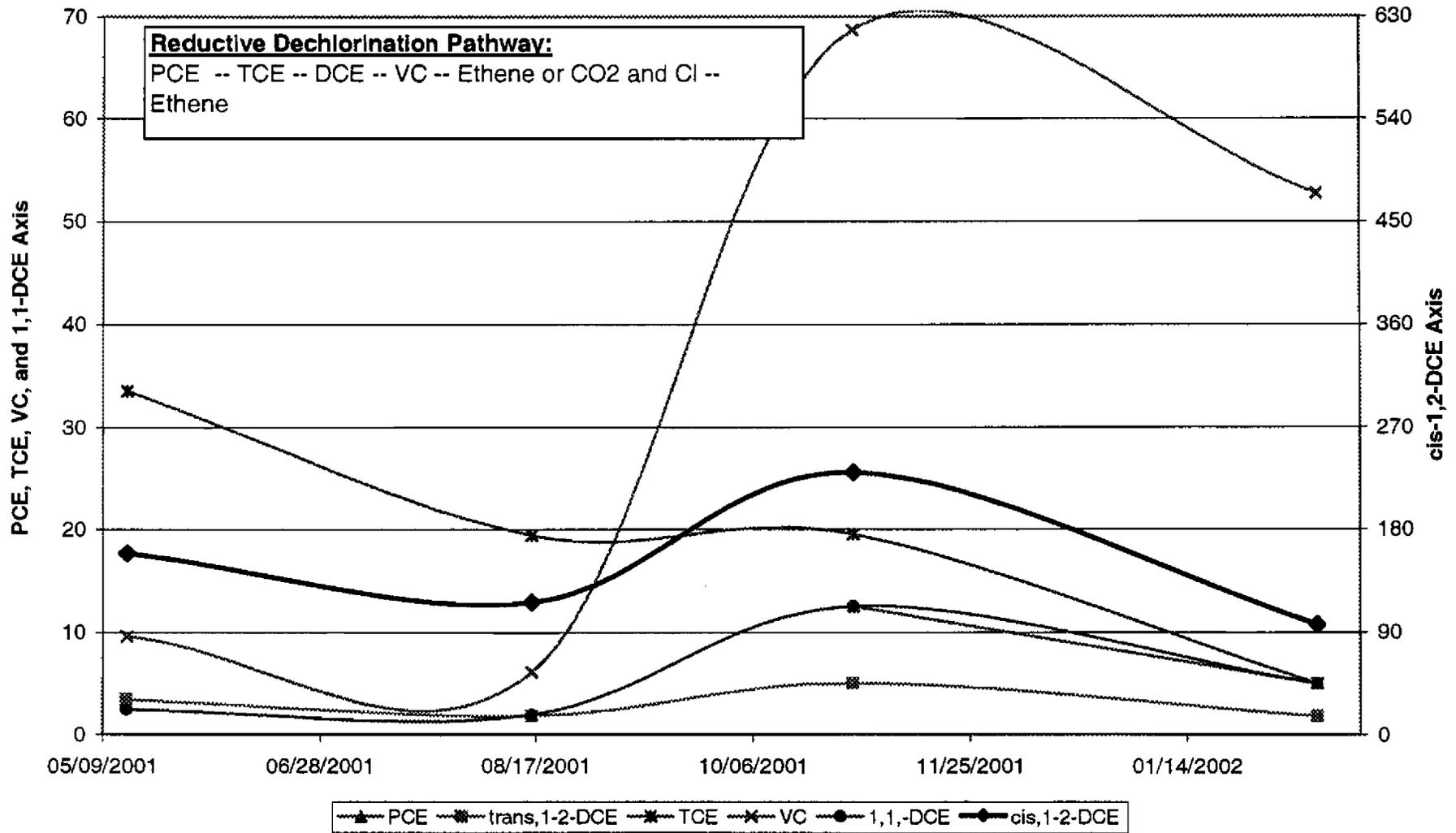
A039GW012I Dissolved Metals



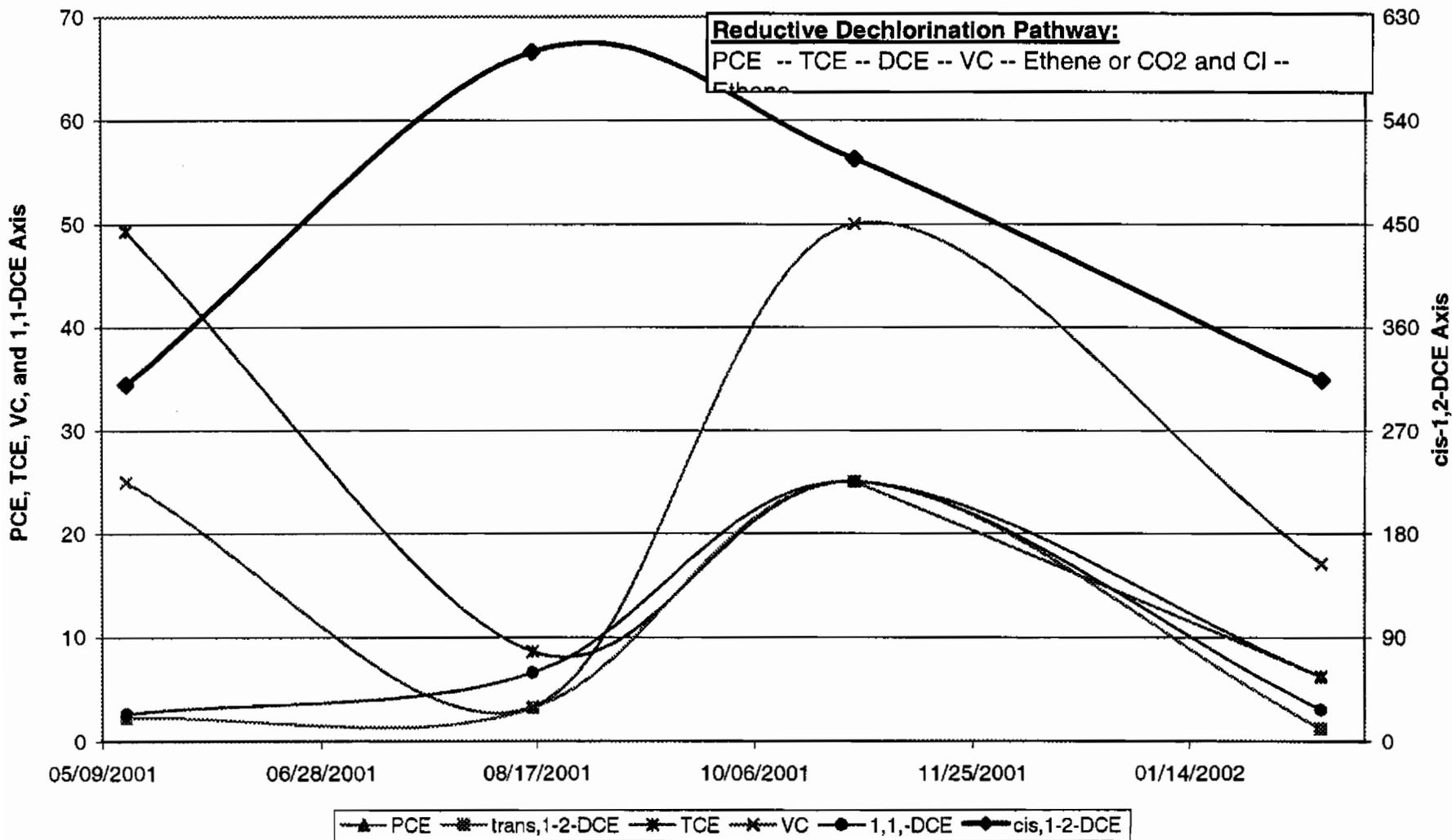
A039GW012D Dissolved Metals



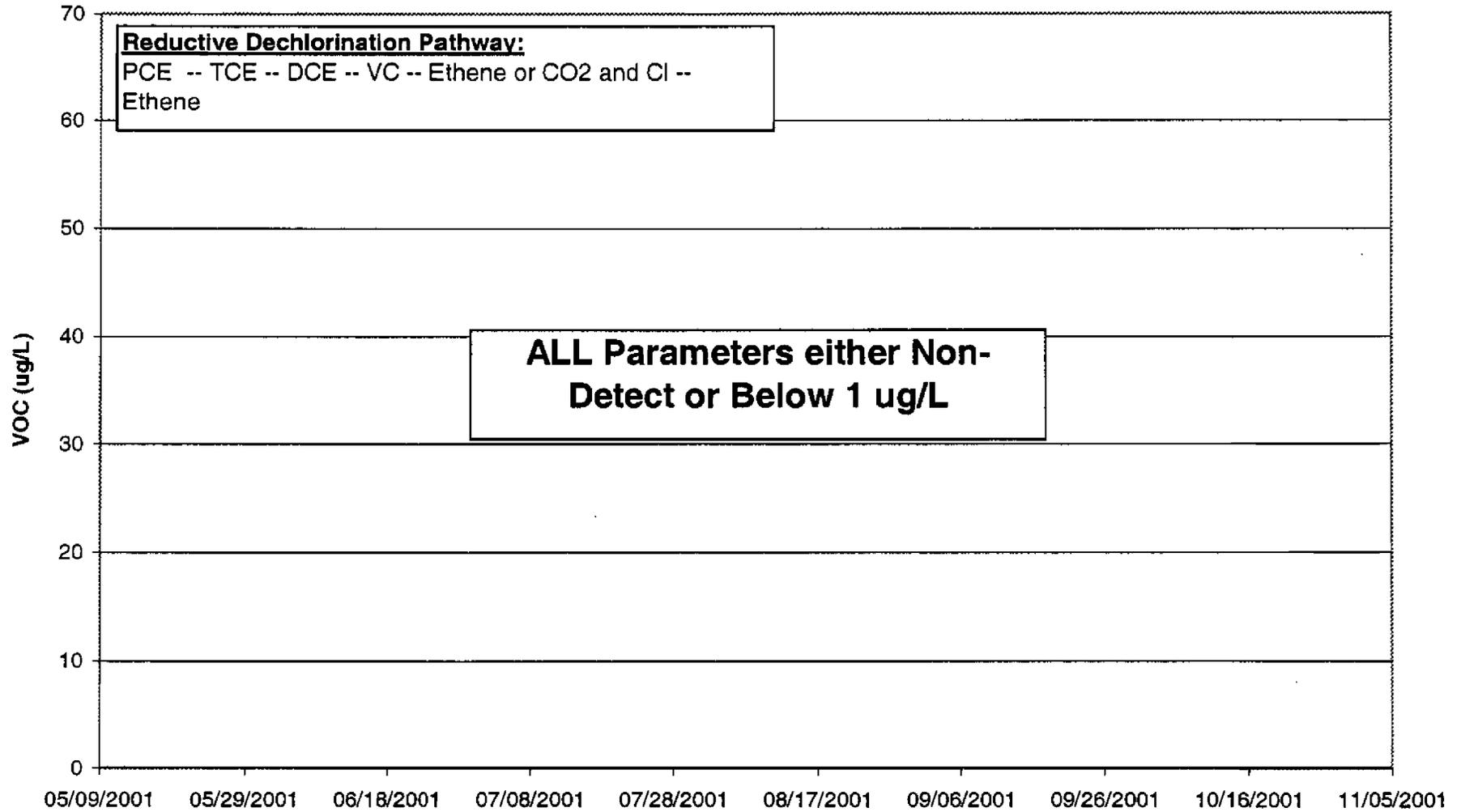
A039GW012 Volatile Organic Compounds



A039GW12I Volatile Organic Compounds



A039GW012D
Volatile Organic Compounds



ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
CH4 / CO2	Carbon Dioxide	A039GW013	039GW013L4	8/15/01	99	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW013	039GW013L3	7/18/01	72	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW013	039GW013L2	5/11/01	84	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW013	039HW013L2	5/11/01	91	=	mg/l
CH4 / CO2	Ethene	A039GW013	039GW013L4	8/15/01	9	=	ng/L
CH4 / CO2	Ethene	A039GW013	039GW013L3	7/18/01	13	=	ng/L
CH4 / CO2	Ethene	A039GW013	039HW013L2	5/11/01	8	=	ng/L
CH4 / CO2	Ethene	A039GW013	039GW013L2	5/11/01	7	=	ng/L
CH4 / CO2	Hydrogen	A039GW013	039GW013L2	5/11/01	0.6	=	nM
CH4 / CO2	Hydrogen	A039GW013	039GW013L4	8/15/01	1.1	=	nM
CH4 / CO2	Hydrogen	A039GW013	039HW013L2	5/11/01	0.94	=	nM
CH4 / CO2	Methane	A039GW013	039GW013L2	5/11/01	0.33	=	ug/L
CH4 / CO2	Methane	A039GW013	039HW013L2	5/11/01	0.03	=	ug/L
FLTMET	Iron, Dissolved	A039GW013	039GW013L4	8/15/01	79.6	J	ug/L
FLTMET	Iron, Dissolved	A039GW013	039GW013L3	7/18/01	4.36	J	ug/L
FLTMET	Manganese, Dissolved	A039GW013	039GW013L3	7/18/01	12.9	J	ug/L
FLTMET	Manganese, Dissolved	A039GW013	039GW013L4	8/15/01	17.7	=	ug/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW013	039GW013L2	5/11/01	30.2	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW013	039GW013L3	7/18/01	22	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW013	039HW013L2	5/11/01	25.1	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW013	039GW013L4	8/15/01	21	J	mg/L
GENCHEM	Chloride	A039GW013	039GW013L3	7/18/01	6.75	=	mg/L
GENCHEM	Chloride	A039GW013	039GW013L2	5/11/01	6.5	=	mg/L
GENCHEM	Chloride	A039GW013	039HW013L2	5/11/01	6.55	=	mg/L
GENCHEM	Chloride	A039GW013	039GW013L4	8/15/01	5.35	J	mg/L
GENCHEM	Nitrate-Nitrite-N	A039GW013	039GW013L3	7/18/01	0.43	=	mg/L
GENCHEM	Nitrate-Nitrite-N	A039GW013	039GW013L4	8/15/01	0.34	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW013	039GW013L4	8/15/01	24.9	J	mg/L
GENCHEM	Sulfate (as SO4)	A039GW013	039HW013L2	5/11/01	25.7	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW013	039GW013L2	5/11/01	26.5	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW013	039GW013L3	7/18/01	27.9	=	mg/L
GENCHEM	Sulfide	A039GW013	039GW013L3	7/18/01	0.032	J	mg/L
GENCHEM	Total Organic Carbon	A039GW013	039GW013L3	7/18/01	1.23	J	mg/L
METAL	Manganese	A039GW013	039HW013L2	5/11/01	3.93	J	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW013	039GW013L2	5/11/01	23.8	=	ug/L

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
VOA	cis-1,2-Dichloroethylene	A039GW013	039HW013L2	5/11/01	12.7	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW013	039GW013L4	8/15/01	12.6	J	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW013	039GW013L2	5/11/01	4.1	J	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW013	039HW013L2	5/11/01	2.3	J	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW013	039GW013L4	8/15/01	2.1	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW013	039GW013L2	5/11/01	0.4	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW013	039HW013L2	5/11/01	1	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW013	039GW013L4	8/15/01	0.86	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW013	039GW013L2	5/11/01	2	J	ug/L
CH4 / CO2	Carbon Dioxide	A039GW13D	039GW13DL4	8/15/01	110	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW13D	039GW13DL3	7/18/01	32	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW13D	039GW13DL2	5/14/01	81	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW13D	039GW13DL5	10/29/01	110	=	mg/l
CH4 / CO2	Ethane	A039GW13D	039GW13DL3	7/18/01	69	=	ng/L
CH4 / CO2	Ethane	A039GW13D	039GW13DL5	10/29/01	230	=	ng/L
CH4 / CO2	Ethane	A039GW13D	039GW13DL2	5/14/01	150	=	ng/L
CH4 / CO2	Ethene	A039GW13D	039GW13DL4	8/15/01	310	=	ng/L
CH4 / CO2	Ethene	A039GW13D	039GW13DL3	7/18/01	85	=	ng/L
CH4 / CO2	Ethene	A039GW13D	039GW13DL2	5/14/01	200	=	ng/L
CH4 / CO2	Ethene	A039GW13D	039GW13DL5	10/29/01	400	=	ng/L
CH4 / CO2	Hydrogen	A039GW13D	039GW13DL5	10/29/01	26	=	nM
CH4 / CO2	Hydrogen	A039GW13D	039GW13DL2	5/14/01	1.3	=	nM
CH4 / CO2	Hydrogen	A039GW13D	039GW13DL3	7/18/01	320	=	nM
CH4 / CO2	Hydrogen	A039GW13D	039GW13DL4	8/15/01	330	=	nM
CH4 / CO2	Methane	A039GW13D	039GW13DL4	8/15/01	340	=	ug/L
CH4 / CO2	Methane	A039GW13D	039GW13DL3	7/18/01	42	=	ug/L
CH4 / CO2	Methane	A039GW13D	039GW13DL5	10/29/01	210	=	ug/L
CH4 / CO2	Methane	A039GW13D	039GW13DL2	5/14/01	100	=	ug/L
FLTMET	Iron (Ferrous), Dissolved	A039GW13D	039GW13DL4	8/15/01	1.59	=	mg/L
FLTMET	Iron, Dissolved	A039GW13D	039GW13DL3	7/18/01	91.3	J	ug/L
FLTMET	Iron, Dissolved	A039GW13D	039GW13DL4	8/15/01	496	=	ug/L
FLTMET	Manganese, Dissolved	A039GW13D	039GW13DL3	7/18/01	40.5	=	ug/L
FLTMET	Manganese, Dissolved	A039GW13D	039GW13DL4	8/15/01	80.4	=	ug/L
GENCHEM	Acetic Acid	A039GW13D	039GW13DL5	10/29/01	28.5	=	mg/l
GENCHEM	Acetic Acid	A039GW13D	039GW13DL3	7/18/01	8.8	=	mg/l

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
GENCHEM	Acetic Acid	A039GW13D	039GW13DL4	8/15/01	32.6	=	mg/l
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13D	039GW13DL2	5/14/01	119	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13D	039GW13DL3	7/18/01	15	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13D	039GW13DL4	8/15/01	158	J	mg/L
GENCHEM	Butyric Acid	A039GW13D	039GW13DL5	10/29/01	4.6	=	mg/l
GENCHEM	Chloride	A039GW13D	039GW13DL4	8/15/01	12.2	J	mg/L
GENCHEM	Chloride	A039GW13D	039GW13DL3	7/18/01	12.3	=	mg/L
GENCHEM	Chloride	A039GW13D	039GW13DL2	5/14/01	12.7	=	mg/L
GENCHEM	Lactic Acid	A039GW13D	039GW13DL4	8/15/01	14.5	=	mg/l
GENCHEM	Lactic Acid	A039GW13D	039GW13DL3	7/18/01	10.7	=	mg/l
GENCHEM	Propionic Acid	A039GW13D	039GW13DL5	10/29/01	49.2	=	mg/l
GENCHEM	Propionic Acid	A039GW13D	039GW13DL3	7/18/01	13.3	=	mg/l
GENCHEM	Propionic Acid	A039GW13D	039GW13DL4	8/15/01	42.1	=	mg/l
GENCHEM	Pyruvic Acid	A039GW13D	039GW13DL4	8/15/01	0.2	=	mg/l
GENCHEM	Pyruvic Acid	A039GW13D	039GW13DL2	5/14/01	0.1	=	mg/l
GENCHEM	Sulfate (as SO4)	A039GW13D	039GW13DL2	5/14/01	28.5	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW13D	039GW13DL4	8/15/01	12.9	J	mg/L
GENCHEM	Sulfate (as SO4)	A039GW13D	039GW13DL3	7/18/01	25.5	=	mg/L
GENCHEM	Sulfide	A039GW13D	039GW13DL4	8/15/01	0.538	=	mg/L
GENCHEM	Sulfide	A039GW13D	039GW13DL3	7/18/01	0.192	J	mg/L
GENCHEM	Total Organic Carbon	A039GW13D	039GW13DL4	8/15/01	58.6	J	mg/L
GENCHEM	Total Organic Carbon	A039GW13D	039GW13DL3	7/18/01	47.7	J	mg/L
GENCHEM	Total Organic Carbon	A039GW13D	039GW13DL2	5/14/01	2.5	=	mg/L
METAL	Manganese	A039GW13D	039GW13DL2	5/14/01	31.2	=	ug/L
VOA	1,1-Dichloroethene	A039GW13D	039GW13DL4	8/15/01	2.7	J	ug/L
VOA	1,1-Dichloroethene	A039GW13D	039GW13DL2	5/14/01	2.8	J	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW13D	039GW13DL2	5/14/01	130	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW13D	039GW13DL4LF	8/15/01	120	J	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW13D	039GW13DL4	8/15/01	45.6	J	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW13D	039GW13DL2	5/14/01	57.6	=	ug/L
VOA	trans-1,2-Dichloroethene	A039GW13D	039GW13DL4	8/15/01	0.83	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW13D	039GW13DL2	5/14/01	0.78	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW13D	039GW13DL2	5/14/01	62.6	=	ug/L
VOA	Trichloroethylene (TCE)	A039GW13D	039GW13DL4	8/15/01	42.2	J	ug/L
VOA	Vinyl chloride	A039GW13D	039GW13DL4	8/15/01	3.3	J	ug/L

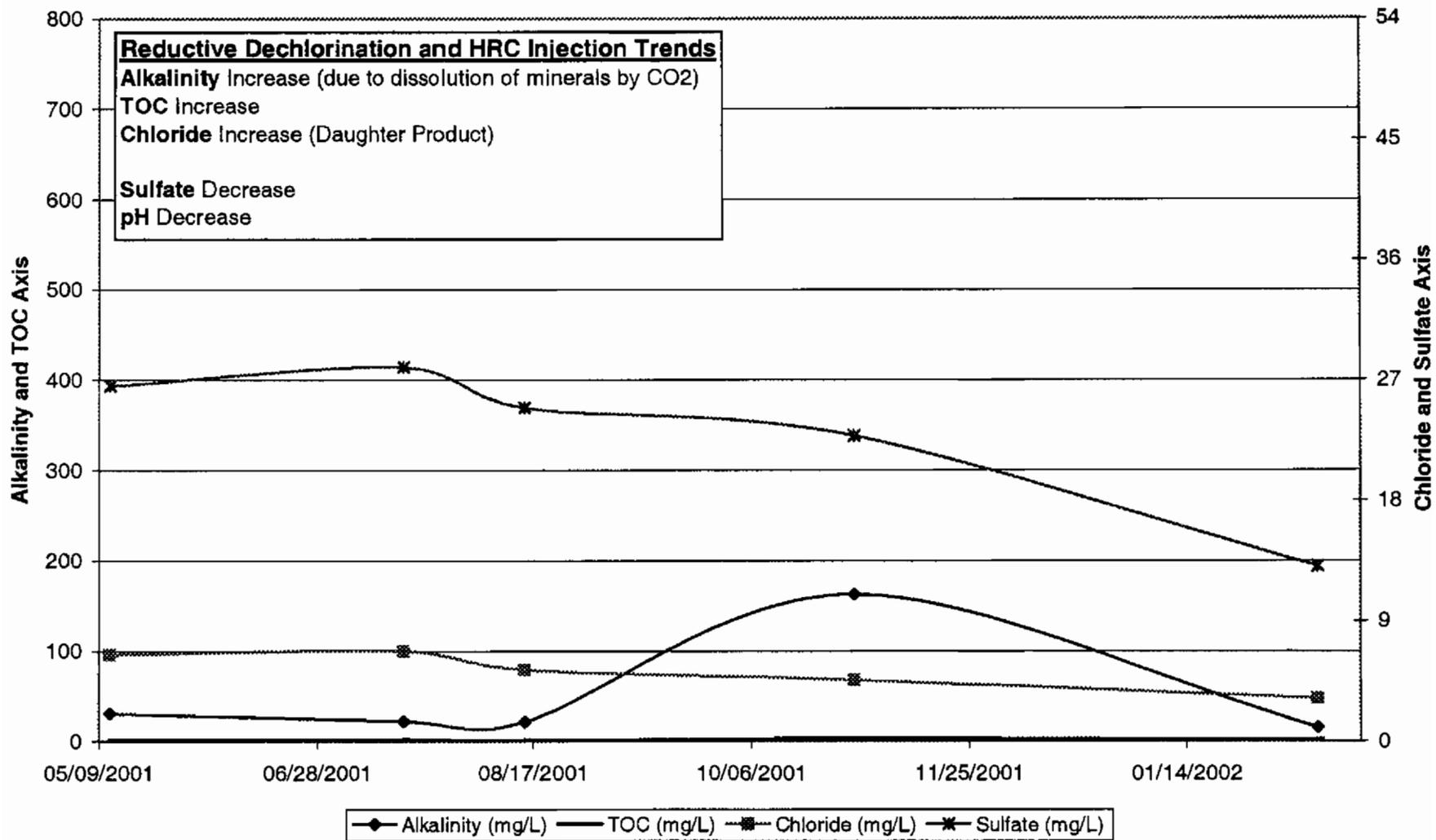
ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
VOA	Vinyl chloride	A039GW13D	039GW13DL2	5/14/01	7.8	J	ug/L
CH4 / CO2	Carbon Dioxide	A039GW13I	039GW13IL3	7/18/01	37	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW13I	039GW13IL4	8/15/01	110	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW13I	039HW13IL3	7/18/01	51	=	mg/l
CH4 / CO2	Ethane	A039GW13I	039GW13IL3	7/18/01	74	=	ng/L
CH4 / CO2	Ethane	A039GW13I	039HW13IL3	7/18/01	100	=	ng/L
CH4 / CO2	Ethene	A039GW13I	039GW13IL3	7/18/01	220	=	ng/L
CH4 / CO2	Ethene	A039GW13I	039HW13IL3	7/18/01	310	=	ng/L
CH4 / CO2	Ethene	A039GW13I	039GW13IL4	8/15/01	720	=	ng/L
CH4 / CO2	Hydrogen	A039GW13I	039GW13IL4	8/15/01	1.2	=	nM
CH4 / CO2	Methane	A039GW13I	039HW13IL3	7/18/01	140	=	ug/L
CH4 / CO2	Methane	A039GW13I	039GW13IL3	7/18/01	100	=	ug/L
CH4 / CO2	Methane	A039GW13I	039GW13IL4	8/15/01	310	=	ug/L
FLTMET	Iron (Ferrous), Dissolved	A039GW13I	039HW13IL4	8/15/01	1.02	=	mg/L
FLTMET	Iron, Dissolved	A039GW13I	039HW13IL3	7/18/01	37.8	J	ug/L
FLTMET	Iron, Dissolved	A039GW13I	039GW13IL3	7/18/01	28.7	J	ug/L
FLTMET	Manganese, Dissolved	A039GW13I	039HW13IL4	8/15/01	243	=	ug/L
FLTMET	Manganese, Dissolved	A039GW13I	039GW13IL3	7/18/01	242	=	ug/L
FLTMET	Manganese, Dissolved	A039GW13I	039HW13IL3	7/18/01	222	=	ug/L
FLTMET	Manganese, Dissolved	A039GW13I	039GW13IL4	8/15/01	227	=	ug/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13I	039HW13IL3	7/18/01	95	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13I	039HW13IL4	8/15/01	94.5	J	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13I	039GW13IL3	7/18/01	92.5	=	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13I	039GW13IL4	8/15/01	94.5	J	mg/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13I	039GW13IL2	5/11/01	90.5	=	mg/L
GENCHEM	Chloride	A039GW13I	039HW13IL4	8/15/01	6.12	J	mg/L
GENCHEM	Chloride	A039GW13I	039GW13IL4	8/15/01	6.16	J	mg/L
GENCHEM	Chloride	A039GW13I	039HW13IL3	7/18/01	7.47	=	mg/L
GENCHEM	Chloride	A039GW13I	039GW13IL2	5/11/01	7.39	=	mg/L
GENCHEM	Chloride	A039GW13I	039GW13IL3	7/18/01	7.32	=	mg/L
GENCHEM	Pyruvic Acid	A039GW13I	039GW013IL2	5/11/01	0.2	=	mg/l
GENCHEM	Sulfate (as SO4)	A039GW13I	039GW13IL4	8/15/01	17.6	J	mg/L
GENCHEM	Sulfate (as SO4)	A039GW13I	039HW13IL4	8/15/01	17.6	J	mg/L
GENCHEM	Sulfate (as SO4)	A039GW13I	039GW13IL2	5/11/01	19	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW13I	039HW13IL3	7/18/01	20	=	mg/L

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
GENCHEM	Sulfate (as SO4)	A039GW13I	039GW13IL3	7/18/01	19.7	=	mg/L
GENCHEM	Total Organic Carbon	A039GW13I	039GW13IL4	8/15/01	3.31	=	mg/L
GENCHEM	Total Organic Carbon	A039GW13I	039GW13IL3	7/18/01	4.38	J	mg/L
GENCHEM	Total Organic Carbon	A039GW13I	039HW131L4	8/15/01	3.05	=	mg/L
GENCHEM	Total Organic Carbon	A039GW13I	039HW131L3	7/18/01	4.22	J	mg/L
GENCHEM	Total Organic Carbon	A039GW13I	039GW131L2	5/11/01	2.84	=	mg/L
METAL	Iron (Ferrous)	A039GW13I	039GW131L2	5/11/01	0.025	J	mg/L
METAL	Manganese	A039GW13I	039GW131L2	5/11/01	129	=	ug/L
VOA	1,1-Dichloroethene	A039GW13I	039HW131L4	8/15/01	3.6	J	ug/L
VOA	1,1-Dichloroethene	A039GW13I	039GW131L4	8/15/01	4.1	J	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW13I	039GW131L2	5/11/01	152	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW13I	039HW131L4LR	8/15/01	188	J	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW13I	039GW131L4LR	8/15/01	136	=	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW13I	039HW131L4	8/15/01	49.5	J	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW13I	039GW131L4	8/15/01	57.8	J	ug/L
VOA	Tetrachloroethylene (PCE)	A039GW13I	039GW131L2	5/11/01	55.4	=	ug/L
VOA	trans-1,2-Dichloroethene	A039GW13I	039GW131L4	8/15/01	3.6	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW13I	039GW131L2	5/11/01	2.6	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW13I	039HW131L4	8/15/01	3	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW13I	039GW131L4	8/15/01	35.5	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW13I	039GW131L2	5/11/01	38.8	=	ug/L
VOA	Trichloroethylene (TCE)	A039GW13I	039HW131L4	8/15/01	32.2	J	ug/L
VOA	Vinyl chloride	A039GW13I	039HW131L4	8/15/01	16.6	J	ug/L
VOA	Vinyl chloride	A039GW13I	039GW131L4	8/15/01	23.3	J	ug/L
VOA	Vinyl chloride	A039GW13I	039GW131L2	5/11/01	14.5	J	ug/L
CH4 / CO2	Carbon Dioxide	A039GW013	039GW013M1	2/13/02	70	=	mg/L
CH4 / CO2	Ethane	A039GW013	039GW013M1	2/13/02	2	J	ng/L
CH4 / CO2	Ethene	A039GW013	039GW013M1	2/13/02	6.9	=	ng/L
CH4 / CO2	Hydrogen	A039GW013	039GW013M1	2/13/02	0.79	=	nM
CH4 / CO2	Methane	A039GW013	039GW013M1	2/13/02	0.16	=	ug/L
CH4 / CO2	Carbon Dioxide	A039GW13D	039GW13DM1	2/13/02	100	=	mg/L
CH4 / CO2	Ethane	A039GW13D	039GW13DM1	2/13/02	35	=	ng/L
CH4 / CO2	Ethene	A039GW13D	039GW13DM1	2/13/02	360	=	ng/L
CH4 / CO2	Hydrogen	A039GW13D	039GW13DM1	2/13/02	4.6	=	nM
CH4 / CO2	Methane	A039GW13D	039GW13DM1	2/13/02	5300	=	ug/L

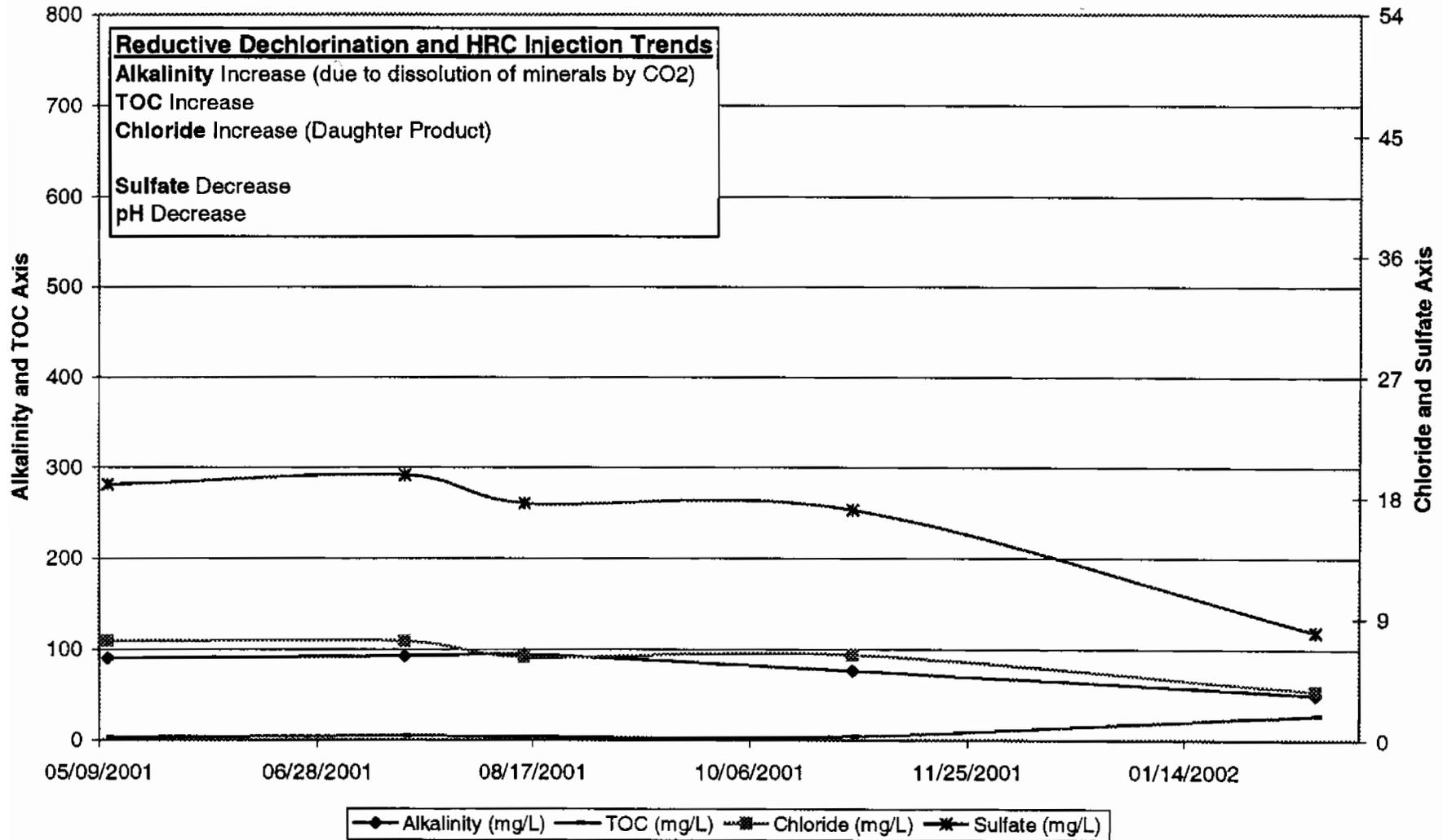
ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
CH4 / CO2	Carbon Dioxide	A039GW13I	039GW13IM1	2/13/02	77	=	mg/L
CH4 / CO2	Ethane	A039GW13I	039GW13IM1	2/13/02	120	=	ng/L
CH4 / CO2	Ethene	A039GW13I	039GW13IM1	2/13/02	370	=	ng/L
CH4 / CO2	Hydrogen	A039GW13I	039GW13IM1	2/13/02	7.9	=	nM
CH4 / CO2	Methane	A039GW13I	039GW13IM1	2/13/02	220	=	ug/L
VOA	1,1-Dichloroethene	A039GW013	039GW013M1	2/13/02	5	U	ug/L
acid	Acetic Acid	A039GW013	039GW013M1	2/13/02	1	U	MG/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW013	039GW013M1	2/13/02	29.6	U	mg/L
acid	Butyric Acid	A039GW013	039GW013M1	2/13/02	1	U	MG/L
GENCHEM	Chloride	A039GW013	039GW013M1	2/13/02	6.35	U	mg/L
VOA	cis-1,2-Dichloroethylene	A039GW013	039GW013M1	2/13/02	29	=	ug/L
METAL	Iron (Ferrous)	A039GW013	039GW013M1	2/13/02	0.066	UJ	mg/L
FLTMET	Iron, Dissolved, Dissolved	A039GW013	039GW013M1	2/13/02	43.5	U	ug/L
acid	Lactic Acid	A039GW013	039GW013M1	2/13/02	1	U	MG/L
FLTMET	Manganese, Dissolved	A039GW013	039GW013M1	2/13/02	8.05	U	ug/L
GENCHEM	Nitrate-Nitrite-N	A039GW013	039GW013M1	2/13/02	0.28	U	mg/L
acid	Propionic Acid	A039GW013	039GW013M1	2/13/02	1	U	MG/L
acid	Pyruvic Acid	A039GW013	039GW013M1	2/13/02	0.1	U	MG/L
GENCHEM	Sulfate (as SO4)	A039GW013	039GW013M1	2/13/02	26.2	U	mg/L
GENCHEM	Sulfide	A039GW013	039GW013M1	2/13/02	0.023	U	mg/L
VOA	Tetrachloroethylene (PCE)	A039GW013	039GW013M1	2/13/02	3.6	J	ug/L
GENCHEM	Total Organic Carbon	A039GW013	039GW013M1	2/13/02	1.25	=	mg/L
VOA	trans-1,2-Dichloroethene	A039GW013	039GW013M1	2/13/02	0.44	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW013	039GW013M1	2/13/02	2.3	J	ug/L
VOA	Vinyl chloride	A039GW013	039GW013M1	2/13/02	10	U	ug/L
VOA	1,1-Dichloroethene	A039GW13D	039GW13DM1	2/13/02	4.3	J	ug/L
acid	Acetic Acid	A039GW13D	039GW13DM1	2/13/02	46.8	=	MG/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13D	039GW13DM1	2/13/02	167	=	mg/L
acid	Butyric Acid	A039GW13D	039GW13DM1	2/13/02	24.3	=	MG/L
GENCHEM	Chloride	A039GW13D	039GW13DM1	2/13/02	12.3	U	mg/L
VOA	cis-1,2-Dichloroethylene	A039GW13D	039GW13DM1	2/13/02	197	=	ug/L
METAL	Iron (Ferrous)	A039GW13D	039GW13DM1	2/13/02	3.09	J	mg/L
FLTMET	Iron, Dissolved, Dissolved	A039GW13D	039GW13DM1	2/13/02	1890	=	ug/L
acid	Lactic Acid	A039GW13D	039GW13DM1	2/13/02	1	U	MG/L
FLTMET	Manganese, Dissolved	A039GW13D	039GW13DM1	2/13/02	127	J	ug/L

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
GENCHEM	Nitrate-Nitrite-N	A039GW13D	039GW13DM1	2/13/02	0.0069	U	mg/L
acid	Propionic Acid	A039GW13D	039GW13DM1	2/13/02	46.6	=	MG/L
acid	Pyruvic Acid	A039GW13D	039GW13DM1	2/13/02	0.1	U	MG/L
GENCHEM	Sulfate (as SO4)	A039GW13D	039GW13DM1	2/13/02	15.5	U	mg/L
GENCHEM	Sulfide	A039GW13D	039GW13DM1	2/13/02	0.056	=	mg/L
VOA	Tetrachloroethylene (PCE)	A039GW13D	039GW13DM1	2/13/02	35.1	=	ug/L
GENCHEM	Total Organic Carbon	A039GW13D	039GW13DM1	2/13/02	76	=	mg/L
VOA	trans-1,2-Dichloroethene	A039GW13D	039GW13DM1	2/13/02	1.1	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW13D	039GW13DM1	2/13/02	62.3	=	ug/L
VOA	Vinyl chloride	A039GW13D	039GW13DM1	2/13/02	13.5	J	ug/L
VOA	1,1-Dichloroethene	A039GW13I	039GW13IM1	2/13/02	3.8	J	ug/L
acid	Acetic Acid	A039GW13I	039GW13IM1	2/13/02	8.8	=	MG/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW13I	039GW13IM1	2/13/02	98.5	U	mg/L
acid	Butyric Acid	A039GW13I	039GW13IM1	2/13/02	1	U	MG/L
GENCHEM	Chloride	A039GW13I	039GW13IM1	2/13/02	7.24	U	mg/L
VOA	cis-1,2-Dichloroethylene	A039GW13I	039GW13IM1	2/13/02	194	=	ug/L
METAL	Iron (Ferrous)	A039GW13I	039GW13IM1	2/13/02	1.1	J	mg/L
FLTMET	Iron, Dissolved, Dissolved	A039GW13I	039GW13IM1	2/13/02	1210	=	ug/L
acid	Lactic Acid	A039GW13I	039GW13IM1	2/13/02	10.6	=	MG/L
FLTMET	Manganese, Dissolved	A039GW13I	039GW13IM1	2/13/02	609	J	ug/L
GENCHEM	Nitrate-Nitrite-N	A039GW13I	039GW13IM1	2/13/02	0.0069	U	mg/L
acid	Propionic Acid	A039GW13I	039GW13IM1	2/13/02	19.8	=	MG/L
acid	Pyruvic Acid	A039GW13I	039GW13IM1	2/13/02	0.1	U	MG/L
GENCHEM	Sulfate (as SO4)	A039GW13I	039GW13IM1	2/13/02	16	U	mg/L
GENCHEM	Sulfide	A039GW13I	039GW13IM1	2/13/02	0.023	U	mg/L
VOA	Tetrachloroethylene (PCE)	A039GW13I	039GW13IM1	2/13/02	43.8	=	ug/L
GENCHEM	Total Organic Carbon	A039GW13I	039GW13IM1	2/13/02	27.1	=	mg/L
VOA	trans-1,2-Dichloroethene	A039GW13I	039GW13IM1	2/13/02	2.8	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW13I	039GW13IM1	2/13/02	35.8	=	ug/L
VOA	Vinyl chloride	A039GW13I	039GW13IM1	2/13/02	26.4	=	ug/L

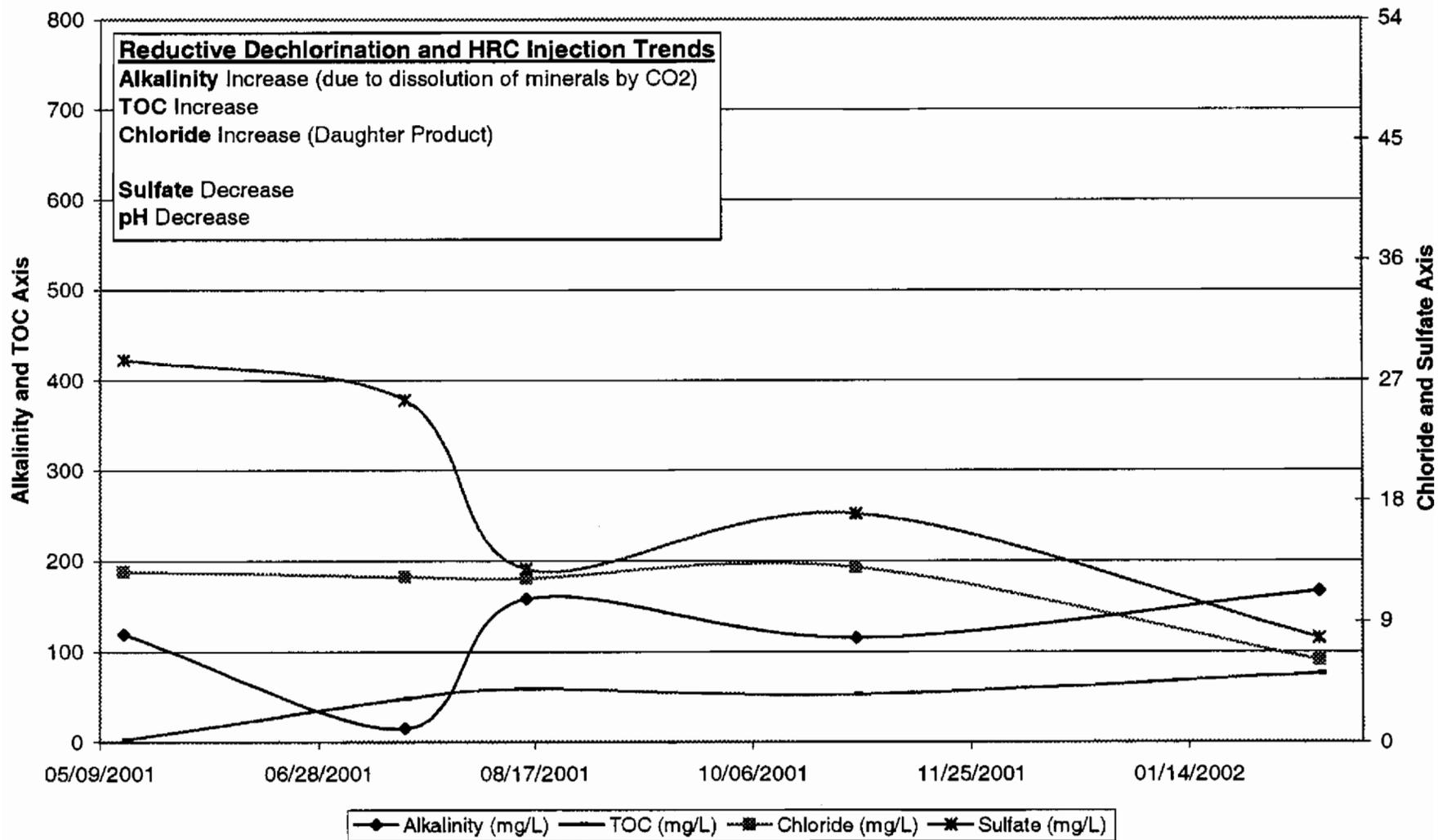
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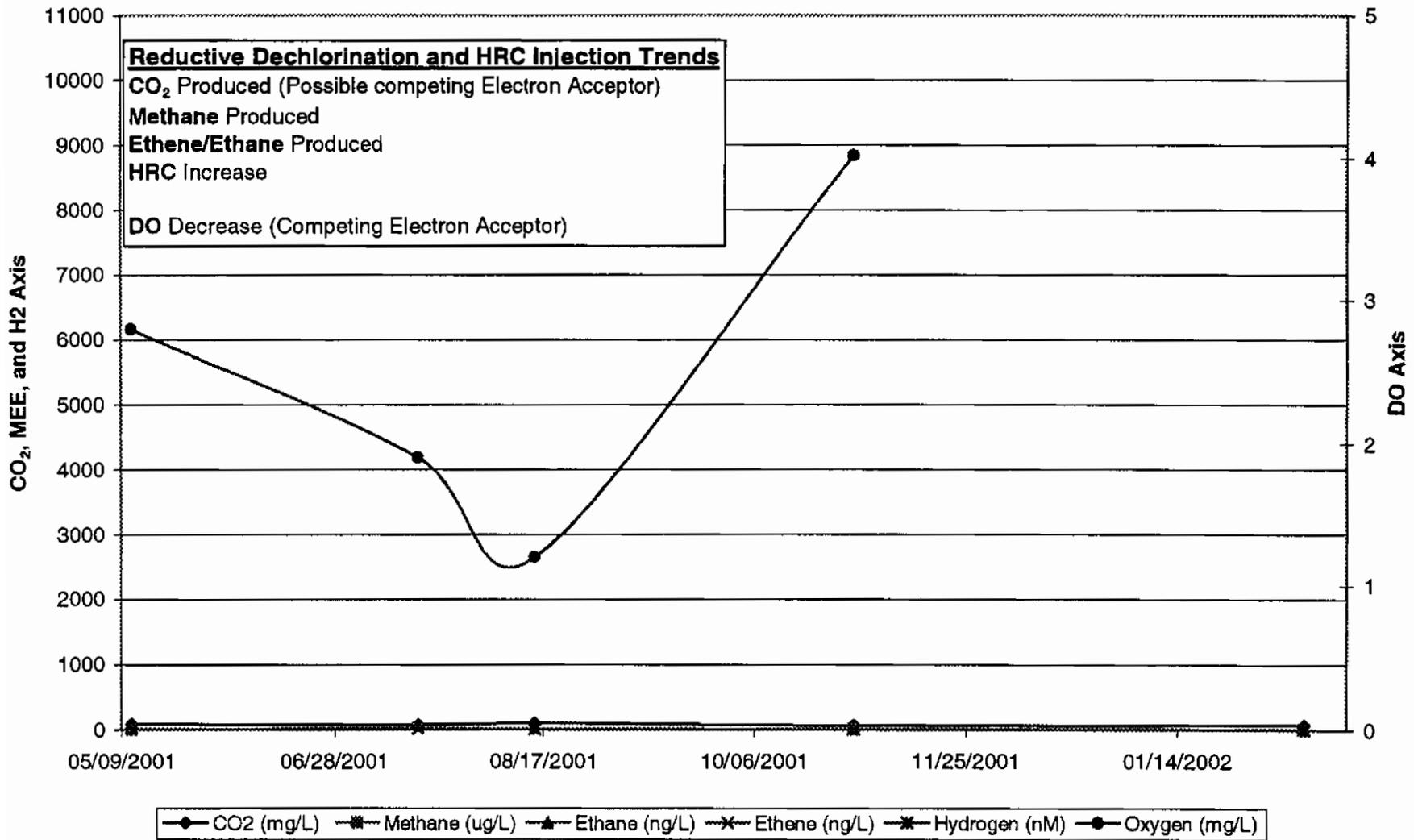
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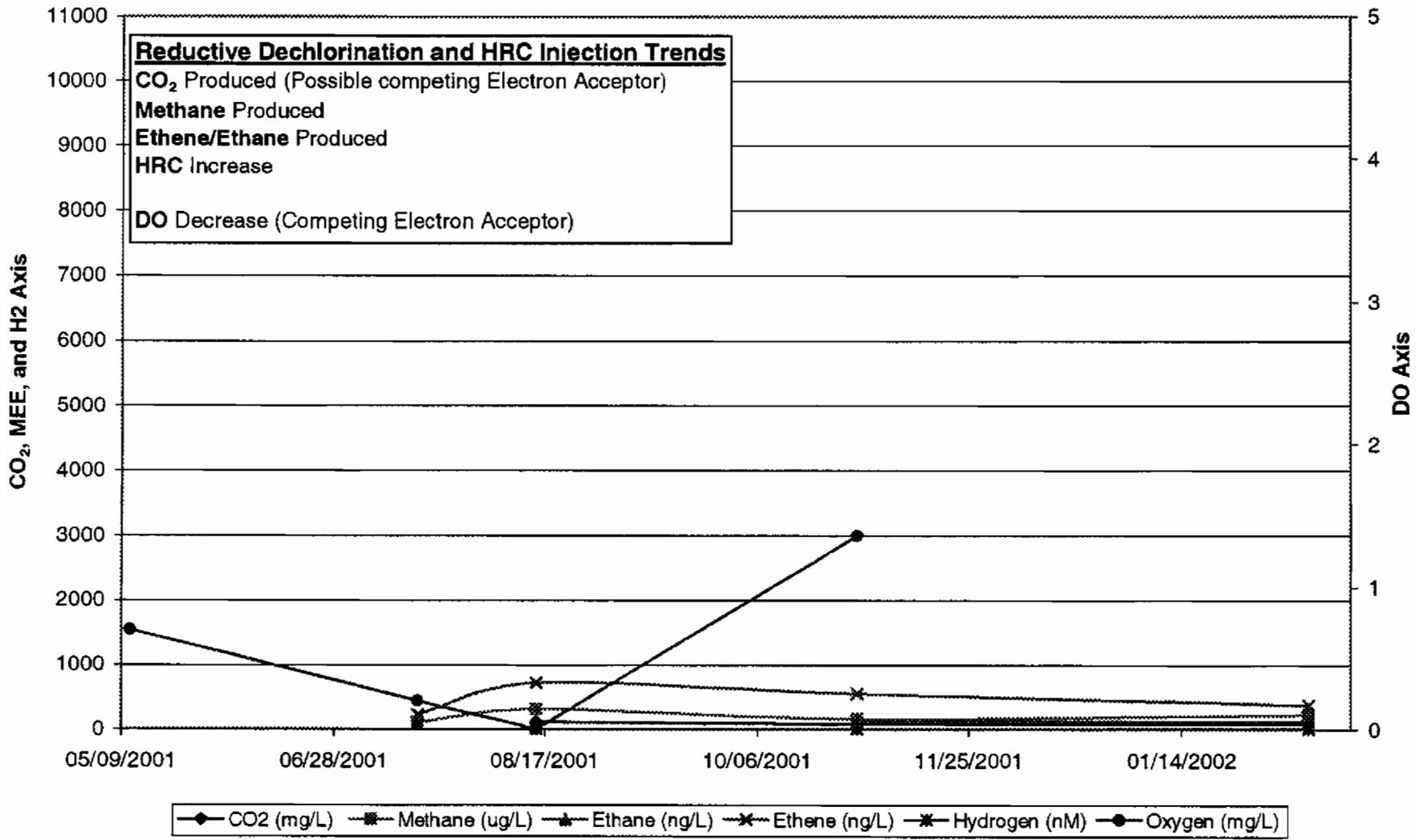
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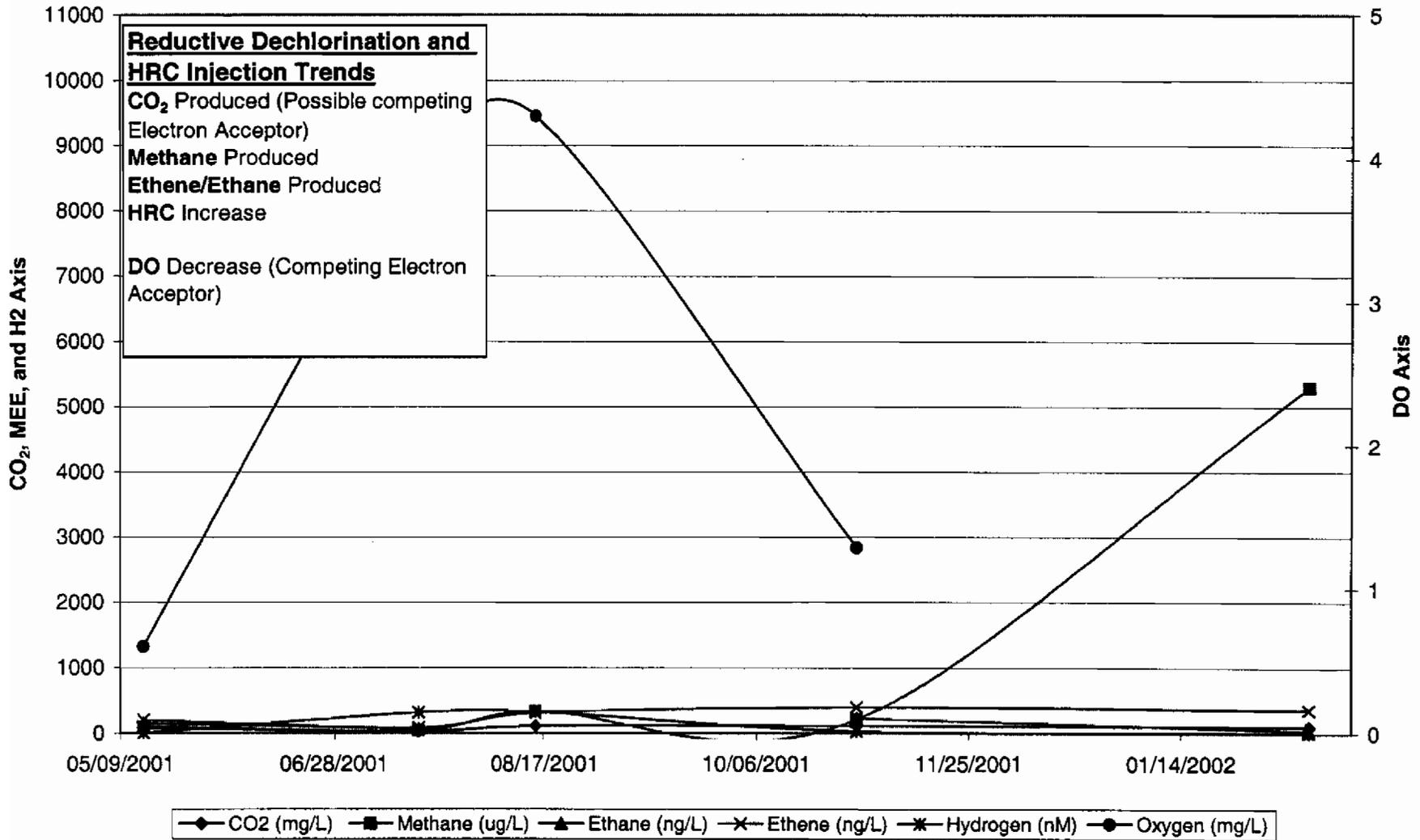
A039GW013 Dissolved Gasses



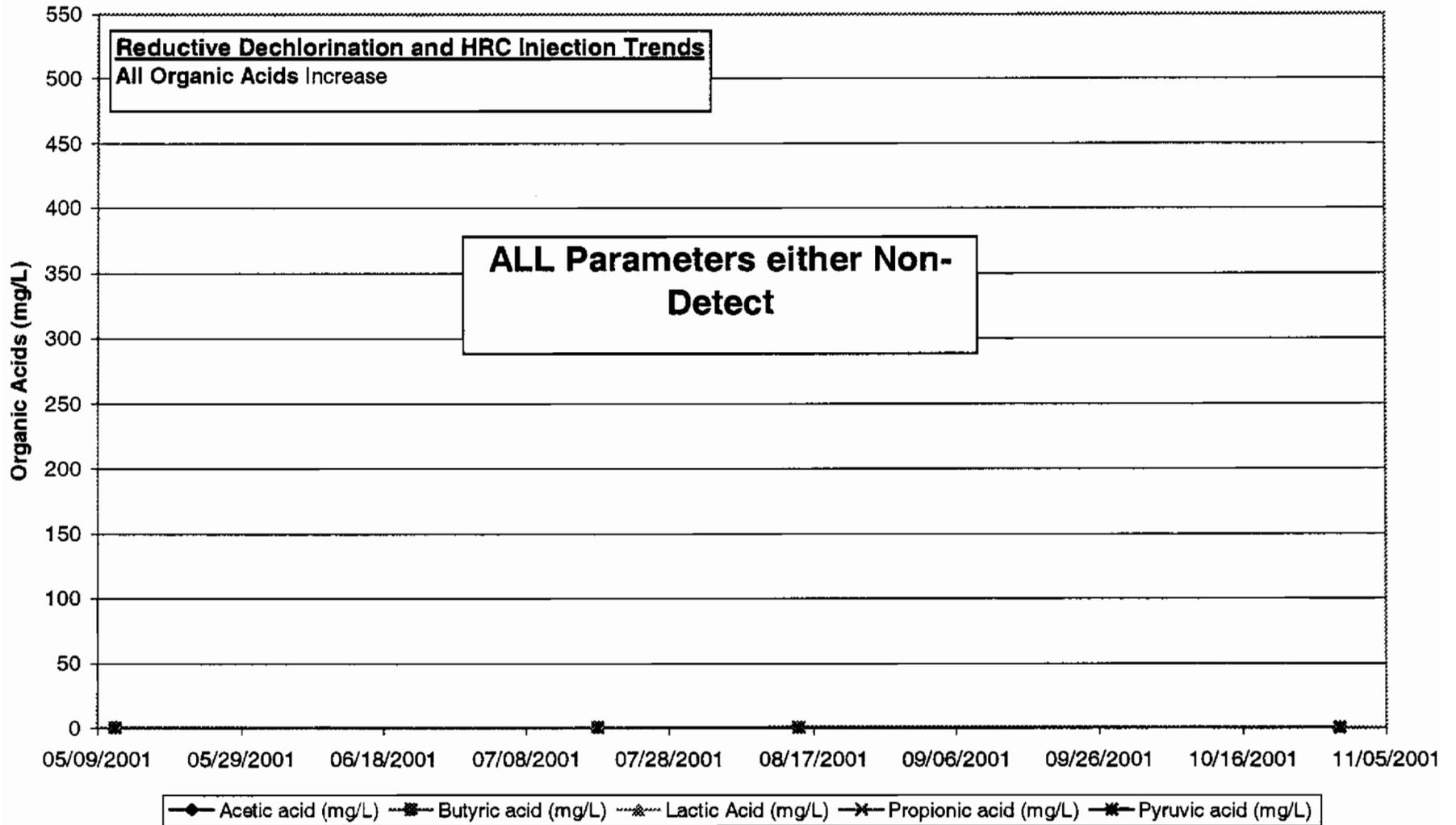
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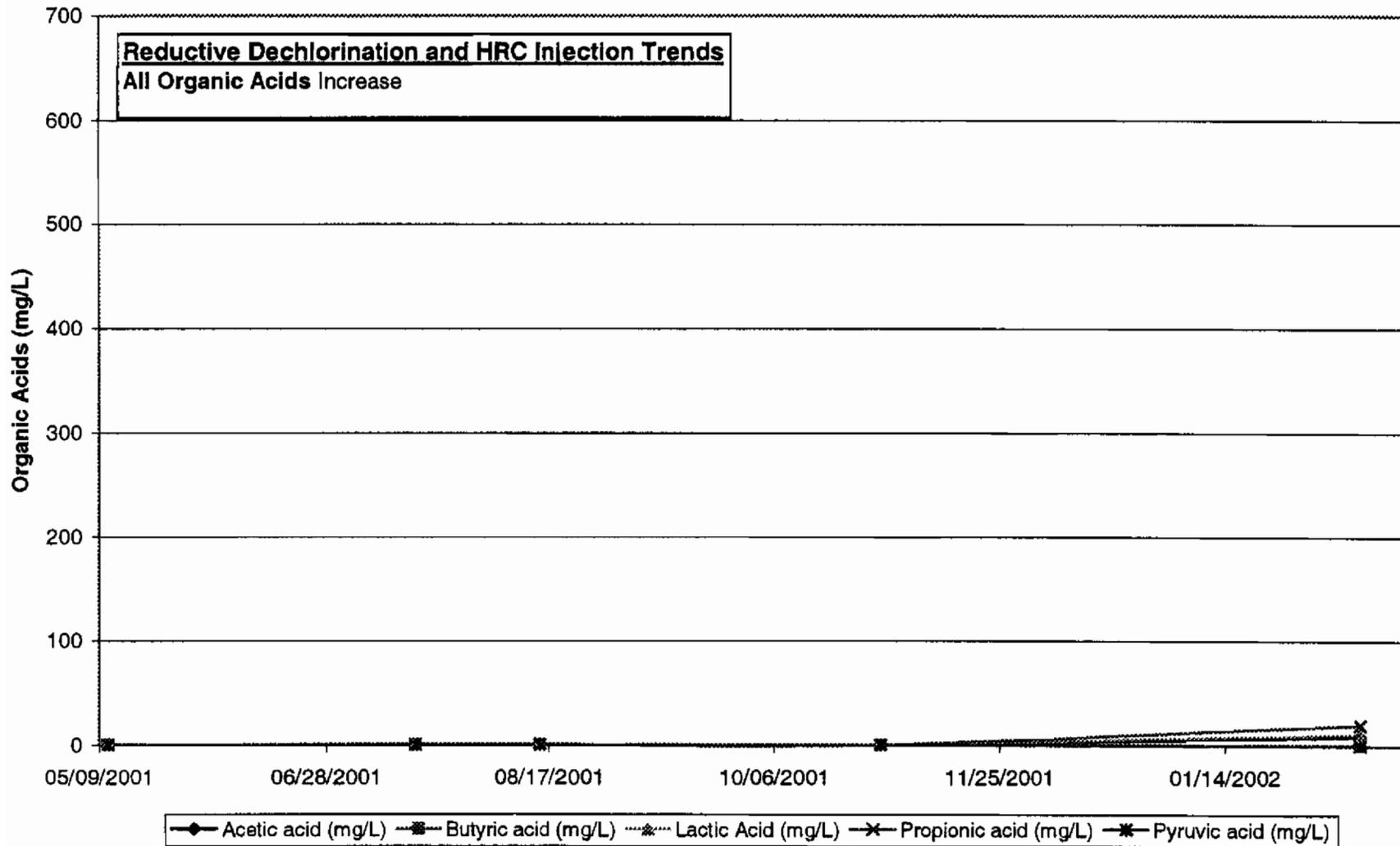
A039GW013D Dissolved Gasses



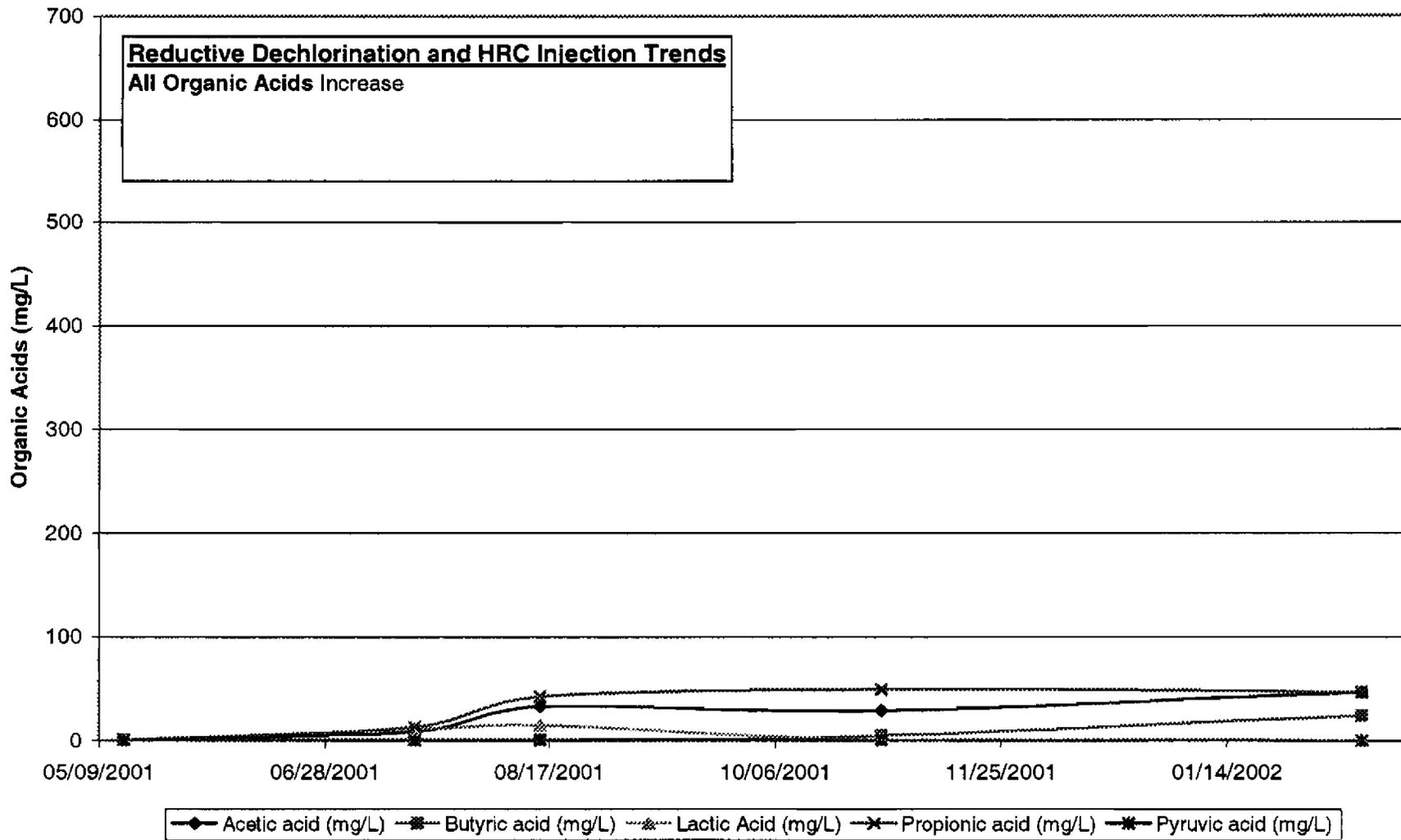
**A039GW013
Organic Acids**



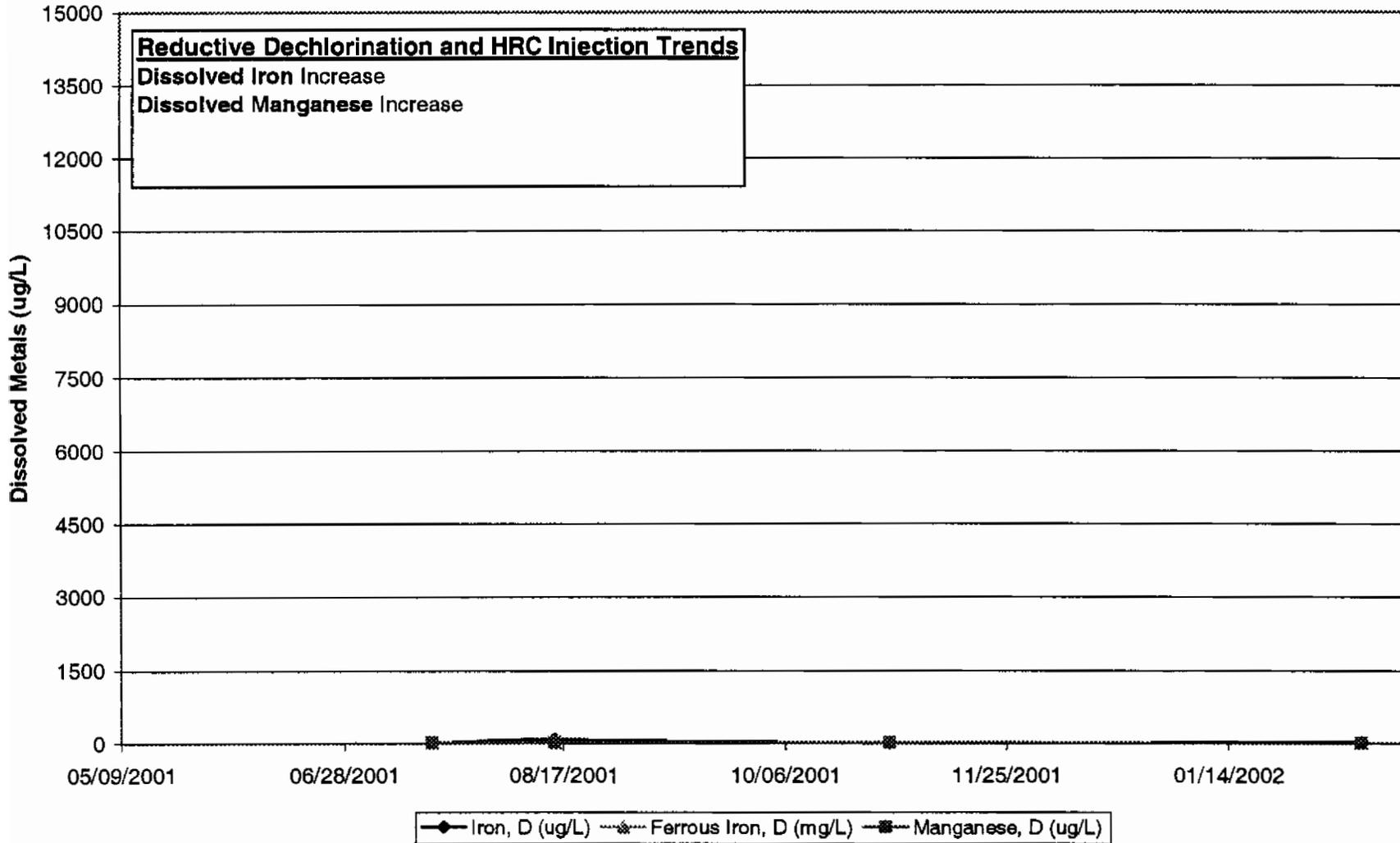
A039GW013I Organic Acids



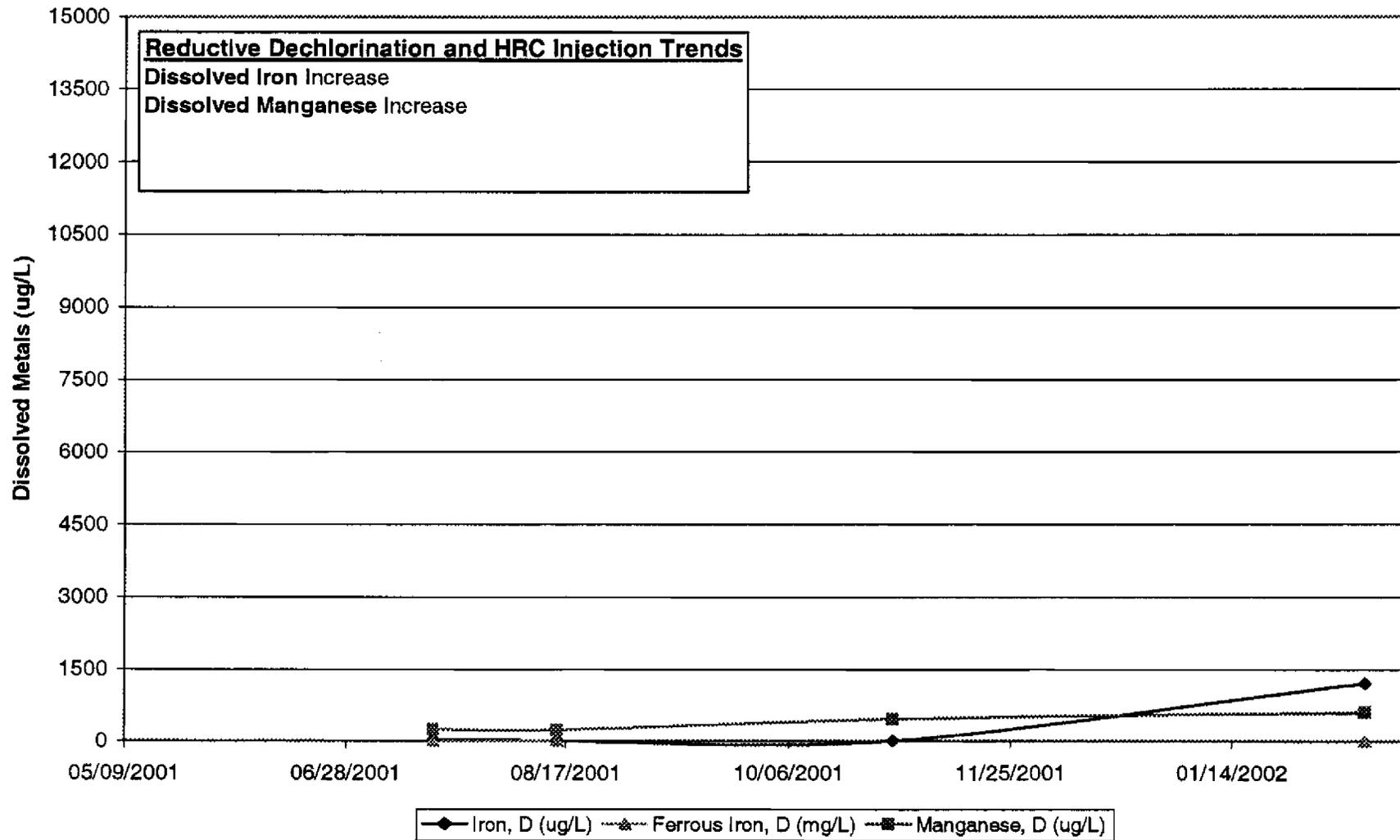
A039GW013D Organic Acids



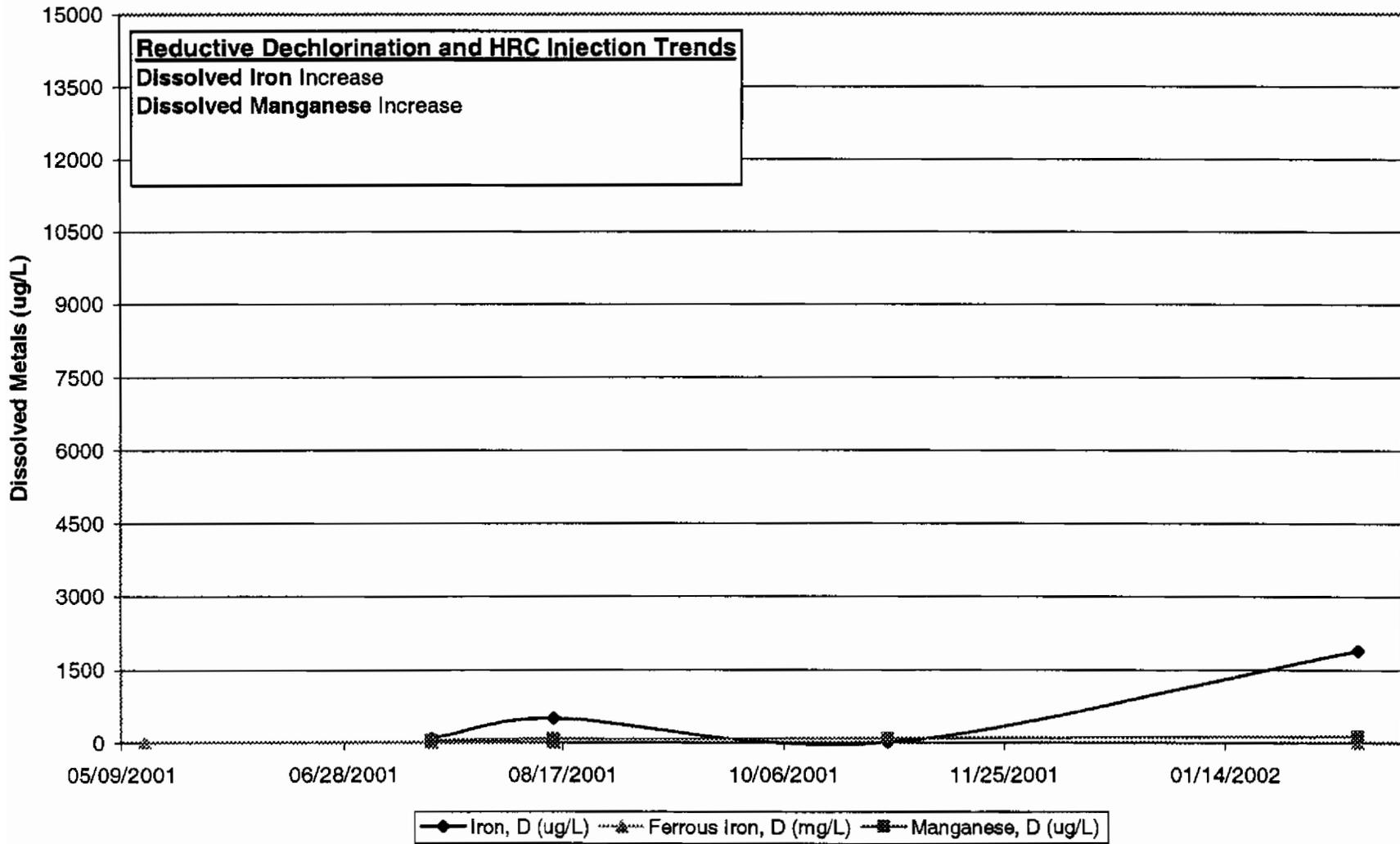
A039GW013 Dissolved Metals



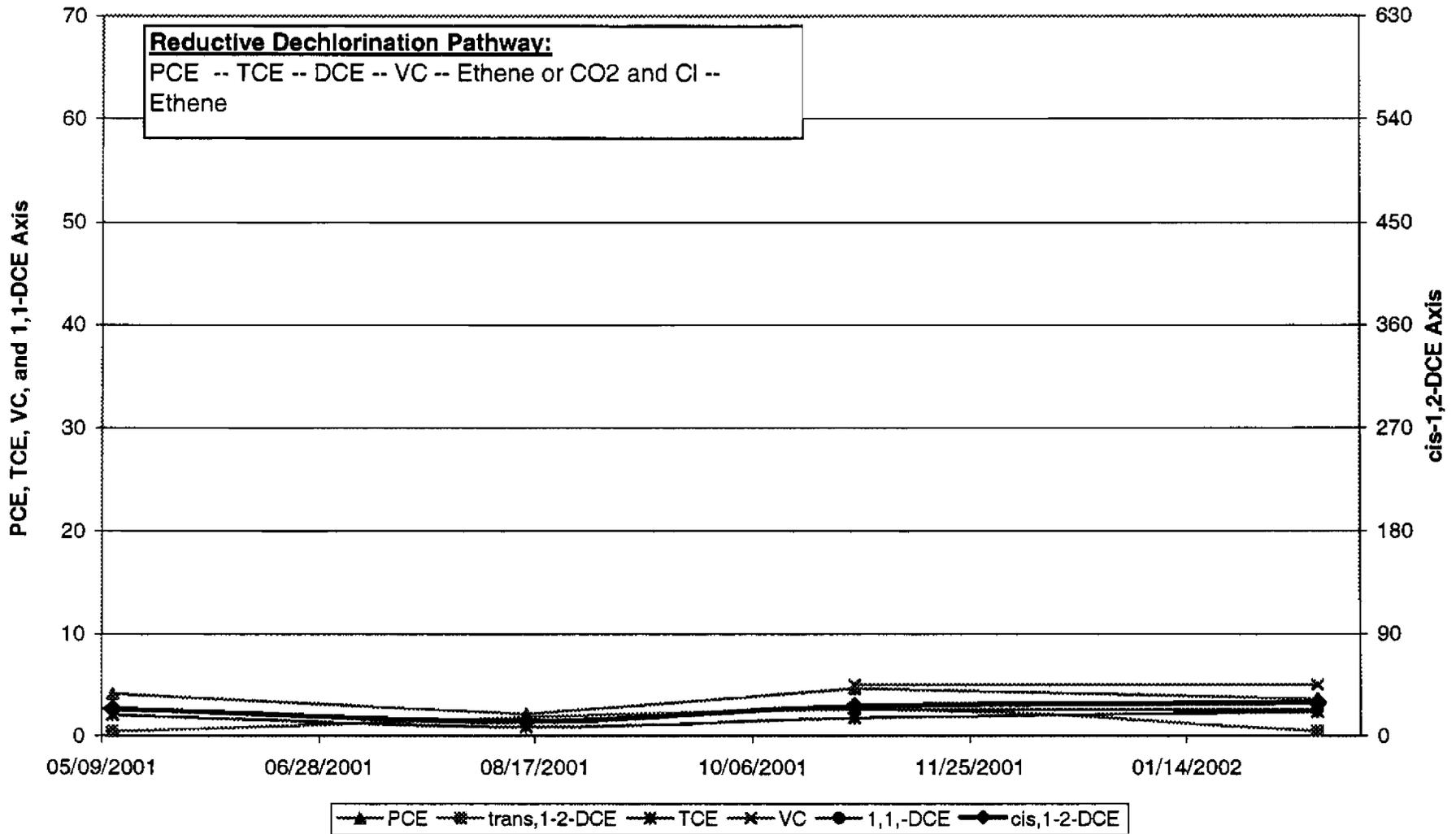
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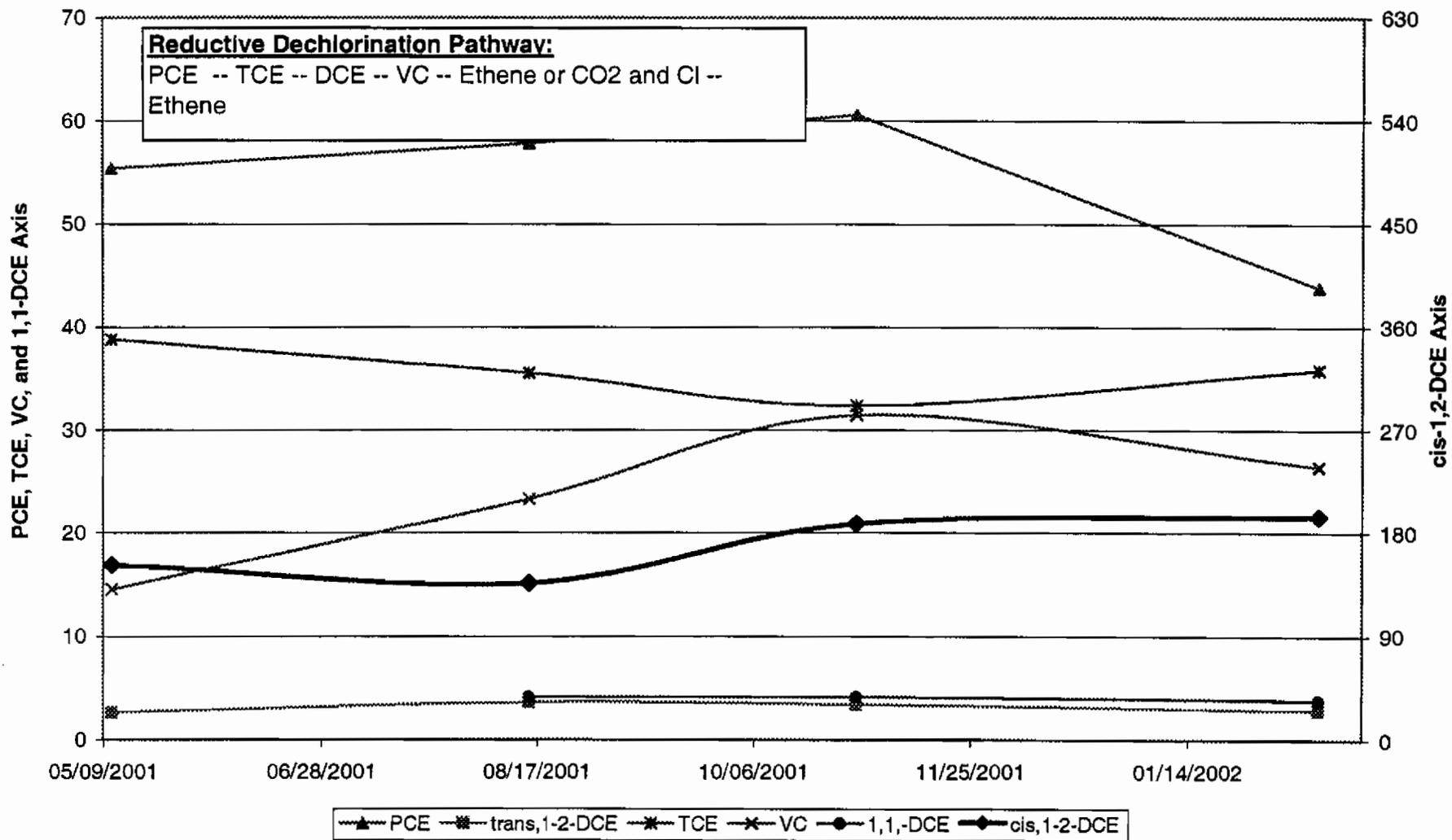
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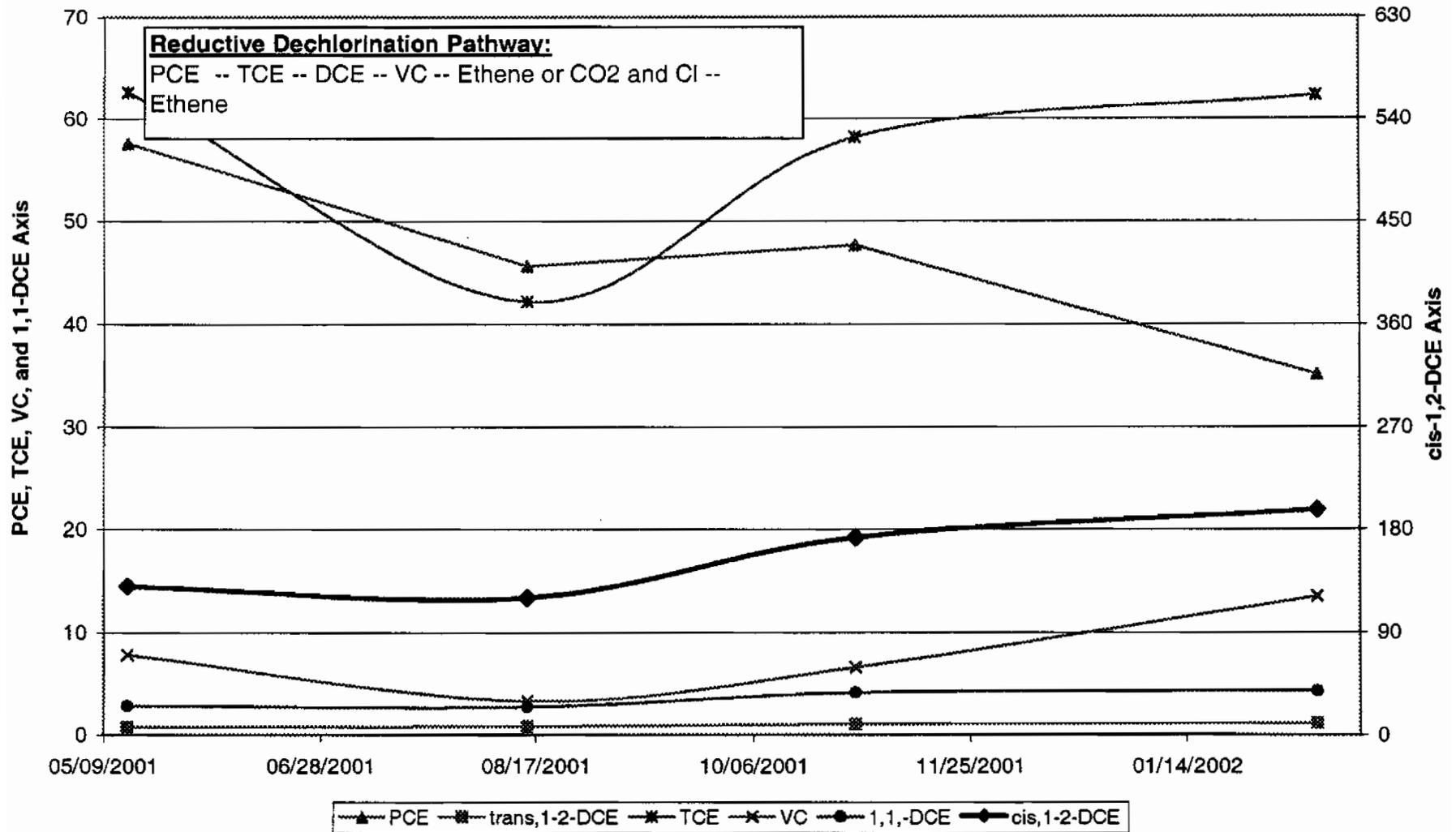
A039GW013 Volatile Organic Compounds



A039GW13I Volatile Organic Compounds



A039GW13D Volatile Organic Compounds



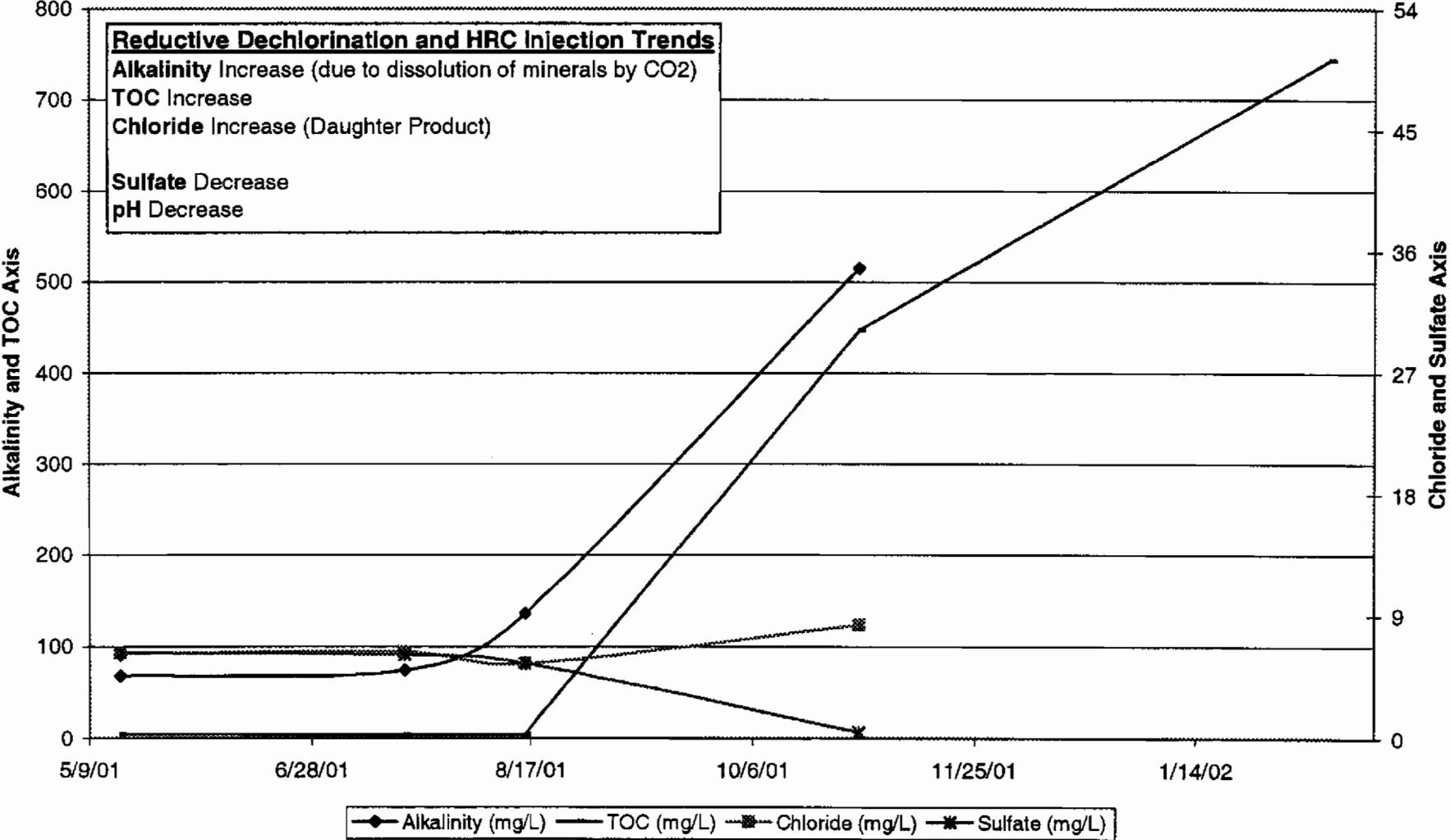
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CH4 / CO2	Carbon Dioxide	A039GW25I	039GW25IL2	5/16/01	87	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW25I	039GW25IL3	7/19/01	50	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW25I	039GW25IL4	8/15/01	99	=	mg/l
CH4 / CO2	Ethane	A039GW25I	039GW25IL2	5/16/01	430	=	ng/L
CH4 / CO2	Ethane	A039GW25I	039GW25IL3	7/19/01	280	=	ng/L
CH4 / CO2	Ethene	A039GW25I	039GW25IL2	5/16/01	3700	=	ng/L
CH4 / CO2	Ethene	A039GW25I	039GW25IL3	7/19/01	2100	=	ng/L
CH4 / CO2	Ethene	A039GW25I	039GW25IL4	8/15/01	4000	=	ng/L
CH4 / CO2	Hydrogen	A039GW25I	039GW25IL2	5/16/01	2.2	=	nM
CH4 / CO2	Hydrogen	A039GW25I	039GW25IL4	8/15/01	1.2	=	nM
CH4 / CO2	Methane	A039GW25I	039GW25IL2	5/16/01	530	=	ug/L
CH4 / CO2	Methane	A039GW25I	039GW25IL3	7/19/01	340	=	ug/L
CH4 / CO2	Methane	A039GW25I	039GW25IL4	8/15/01	690	=	ug/L
FLTMET	Iron (Ferrous), Dissolved	A039GW25I	039GW25IL3	7/19/01	1.55	J	mg/L
FLTMET	Iron (Ferrous), Dissolved	A039GW25I	039GW25IL4	8/15/01	4	=	mg/L
FLTMET	Iron, Dissolved	A039GW25I	039GW25IL3	7/19/01	1630	=	ug/L
FLTMET	Manganese, Dissolved	A039GW25I	039GW25IL3	7/19/01	284	=	ug/L
FLTMET	Manganese, Dissolved	A039GW25I	039GW25IL4	8/15/01	296	=	ug/L
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW25I	039GW25IL4	8/15/01	136	J	mg/L
GENCHEM	Chloride	A039GW25I	039GW25IL2	5/16/01	6.24	=	mg/L
GENCHEM	Chloride	A039GW25I	039GW25IL3	7/19/01	6.38	=	mg/L
GENCHEM	Chloride	A039GW25I	039GW25IL4	8/15/01	5.46	J	mg/L
GENCHEM	Sulfate (as SO4)	A039GW25I	039GW25IL2	5/16/01	6.28	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW25I	039GW25IL3	7/19/01	6.12	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW25I	039GW25IL4	8/15/01	5.52	J	mg/L
GENCHEM	Total Organic Carbon	A039GW25I	039GW25IL2	5/16/01	3.83	=	mg/L
GENCHEM	Total Organic Carbon	A039GW25I	039GW25IL3	7/19/01	3.7	J	mg/L
GENCHEM	Total Organic Carbon	A039GW25I	039GW25IL4	8/15/01	3.72	=	mg/L
METAL	Iron	A039GW25I	039GW25IL2	5/16/01	7.76	J	ug/L
METAL	Iron (Ferrous)	A039GW25I	039GW25IL2	5/16/01	5.53	J	mg/L
METAL	Manganese	A039GW25I	039GW25IL2	5/16/01	275	=	ug/L
VOA	1,1-Dichloroethene	A039GW25I	039GW25IL2	5/16/01	0.82	J	ug/L
VOA	1,1-Dichloroethene	A039GW25I	039GW25IL4	8/15/01	1	J	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW25I	039GW25IL2	5/16/01	69.2	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW25I	039GW25IL4	8/15/01	72.6	J	ug/L

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
VOA	trans-1,2-Dichloroethene	A039GW25I	039GW25IL2	5/16/01	1.4	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW25I	039GW25IL4	8/15/01	1.8	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW25I	039GW25IL2	5/16/01	1.9	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW25I	039GW25IL4	8/15/01	2.1	J	ug/L
VOA	Vinyl chloride	A039GW25I	039GW25IL2	5/16/01	21.5	=	ug/L
VOA	Vinyl chloride	A039GW25I	039GW25IL4	8/15/01	17.6	J	ug/L
CH4 / CO2	Carbon Dioxide	A039GW28I	039GW28IL2	5/16/01	90	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW28I	039GW28IL3	7/19/01	52	=	mg/l
CH4 / CO2	Carbon Dioxide	A039GW28I	039GW28IL4	8/15/01	81	=	mg/l
CH4 / CO2	Ethane	A039GW28I	039GW28IL2	5/16/01	280	=	ng/L
CH4 / CO2	Ethane	A039GW28I	039GW28IL3	7/19/01	200	=	ng/L
CH4 / CO2	Ethene	A039GW28I	039GW28IL2	5/16/01	1600	=	ng/L
CH4 / CO2	Ethene	A039GW28I	039GW28IL3	7/19/01	1200	=	ng/L
CH4 / CO2	Ethene	A039GW28I	039GW28IL4	8/15/01	2100	=	ng/L
CH4 / CO2	Hydrogen	A039GW28I	039GW28IL2	5/16/01	1.9	=	nM
CH4 / CO2	Hydrogen	A039GW28I	039GW28IL4	8/15/01	31	=	nM
CH4 / CO2	Methane	A039GW28I	039GW28IL2	5/16/01	340	=	ug/L
CH4 / CO2	Methane	A039GW28I	039GW28IL3	7/19/01	270	=	ug/L
CH4 / CO2	Methane	A039GW28I	039GW28IL4	8/15/01	490	=	ug/L
FLTMET	Iron, Dissolved	A039GW28I	039GW28IL3	7/19/01	1690	=	ug/L
FLTMET	Iron, Dissolved	A039GW28I	039GW28IL4	8/15/01	715	=	ug/L
FLTMET	Manganese, Dissolved	A039GW28I	039GW28IL3	7/19/01	406	=	ug/L
FLTMET	Manganese, Dissolved	A039GW28I	039GW28IL4	8/15/01	548	=	ug/L
GENCHEM	Acetic Acid	A039GW28I	039GW28IL3	7/19/01	13.8	=	mg/l
GENCHEM	Acetic Acid	A039GW28I	039GW28IL4	8/15/01	41.8	=	mg/l
GENCHEM	Alkalinity, Total (as CaCO3)	A039GW28I	039GW28IL4	8/15/01	211	J	mg/L
GENCHEM	Butyric Acid	A039GW28I	039GW28IL4	8/15/01	5.7	=	mg/l
GENCHEM	Chloride	A039GW28I	039GW28IL2	5/16/01	51.1	=	mg/L
GENCHEM	Chloride	A039GW28I	039GW28IL3	7/19/01	39.1	=	mg/L
GENCHEM	Chloride	A039GW28I	039GW28IL4	8/15/01	30.3	J	mg/L
GENCHEM	Lactic Acid	A039GW28I	039GW28IL3	7/19/01	18.7	=	mg/l
GENCHEM	Lactic Acid	A039GW28I	039GW28IL4	8/15/01	24.2	=	mg/l
GENCHEM	Propionic Acid	A039GW28I	039GW28IL3	7/19/01	22.9	=	mg/l
GENCHEM	Propionic Acid	A039GW28I	039GW28IL4	8/15/01	70.4	=	mg/l
GENCHEM	Pyruvic Acid	A039GW28I	039GW28IL3	7/19/01	0.1	=	mg/l

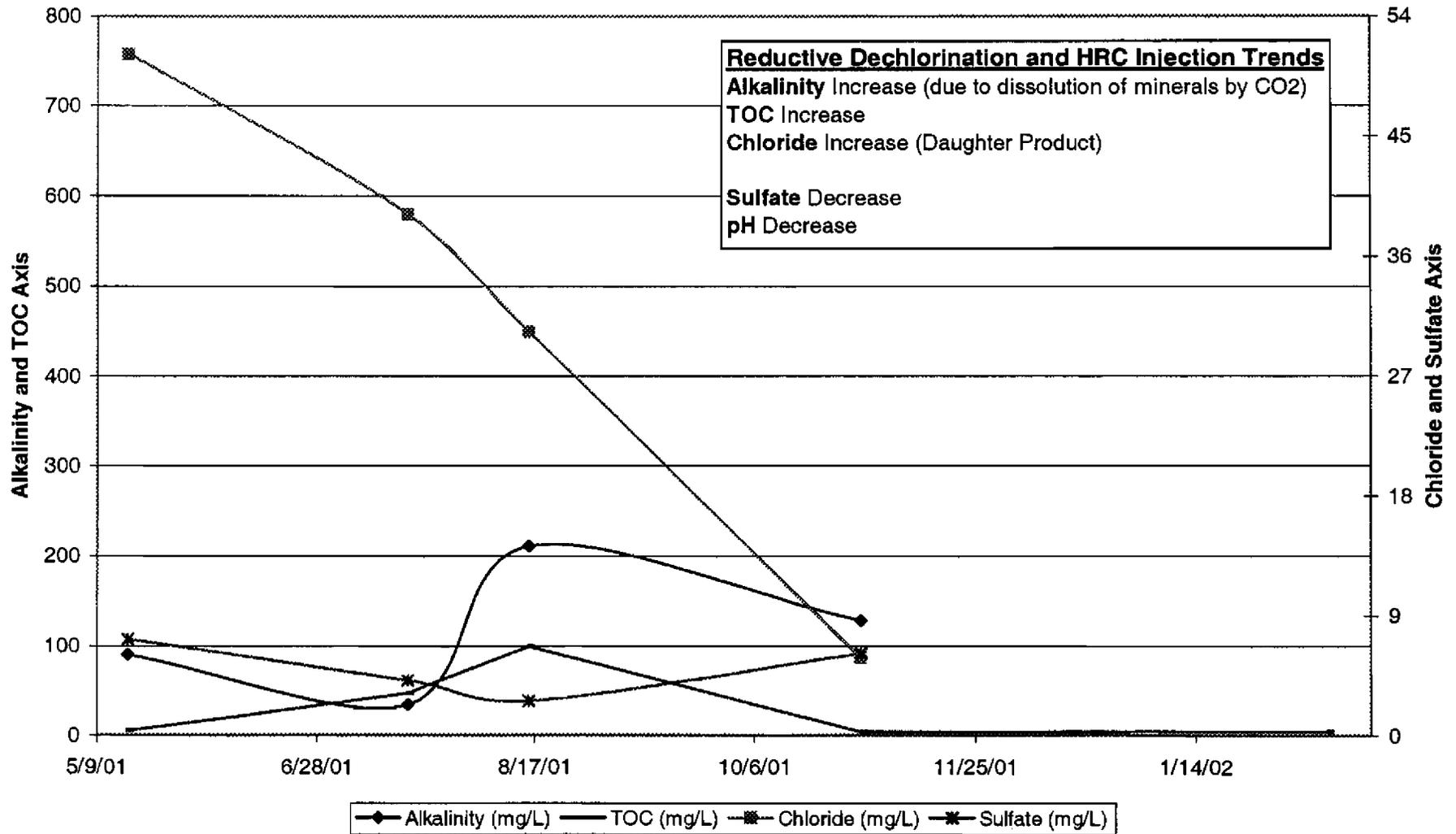
ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualfier	Units
GENCHEM	Pyruvic Acid	A039GW28I	039GW28IL4	8/15/01	0.1	=	mg/l
GENCHEM	Sulfate (as SO4)	A039GW28I	039GW28IL2	5/16/01	7.25	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW28I	039GW28IL3	7/19/01	4.11	=	mg/L
GENCHEM	Sulfate (as SO4)	A039GW28I	039GW281L4	8/15/01	2.57	J	mg/L
GENCHEM	Sulfide	A039GW28I	039GW28IL3	7/19/01	0.023	J	mg/L
GENCHEM	Total Organic Carbon	A039GW28I	039GW28IL2	5/16/01	4.51	=	mg/L
GENCHEM	Total Organic Carbon	A039GW28I	039GW28IL3	7/19/01	46.8	J	mg/L
GENCHEM	Total Organic Carbon	A039GW28I	039GW281L4	8/15/01	99.4	J	mg/L
METAL	Iron (Ferrous)	A039GW28I	039GW28IL2	5/16/01	9.41	J	mg/L
METAL	Manganese	A039GW28I	039GW28IL2	5/16/01	323	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW28I	039GW28IL2	5/16/01	25.4	=	ug/L
VOA	cis-1,2-Dichloroethylene	A039GW28I	039GW281L4	8/15/01	33.7	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW28I	039GW28IL2	5/16/01	0.46	J	ug/L
VOA	trans-1,2-Dichloroethene	A039GW28I	039GW281L4	8/15/01	0.75	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW28I	039GW28IL2	5/16/01	0.57	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW28I	039GW281L4	8/15/01	0.82	J	ug/L
VOA	Vinyl chloride	A039GW28I	039GW28IL2	5/16/01	8.8	J	ug/L
VOA	Vinyl chloride	A039GW28I	039GW281L4	8/15/01	9.3	J	ug/L
VOA	1,1-Dichloroethene	A039GW25I	039GW25IM1	2/13/02	5	U	ug/L
GENCHEM	Acetic Acid	A039GW25I	039GW25IM1	2/13/02	657	=	MG/L
GENCHEM	Butyric Acid	A039GW25I	039GW25IM1	2/13/02	235	=	MG/L
VOA	cis-1,2-Dichloroethylene	A039GW25I	039GW25IM1	2/13/02	36.8	=	ug/L
METAL	Iron (Ferrous)	A039GW25I	039GW25IM1	2/13/02	16	J	mg/L
FLTMET	Iron, Dissolved, Dissolved	A039GW25I	039GW25IM1	2/13/02	177000	=	ug/L
GENCHEM	Lactic Acid	A039GW25I	039GW25IM1	2/13/02	1	U	MG/L
FLTMET	Manganese, Dissolved	A039GW25I	039GW25IM1	2/13/02	3760	J	ug/L
GENCHEM	Propionic Acid	A039GW25I	039GW25IM1	2/13/02	688	=	MG/L
GENCHEM	Pyruvic Acid	A039GW25I	039GW25IM1	2/13/02	0.5	=	MG/L
VOA	Tetrachloroethylene (PCE)	A039GW25I	039GW25IM1	2/13/02	5	UJ	ug/L
GENCHEM	Total Organic Carbon	A039GW25I	039GW25IM1	2/13/02	743	=	mg/L
VOA	trans-1,2-Dichloroethene	A039GW25I	039GW25IM1	2/13/02	0.88	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW25I	039GW25IM1	2/13/02	0.72	J	ug/L
VOA	Vinyl chloride	A039GW25I	039GW25IM1	2/13/02	16.1	=	ug/L
VOA	1,1-Dichloroethene	A039GW28I	039GW28IM1	2/13/02	0.76	J	ug/L
GENCHEM	Acetic Acid	A039GW28I	039GW28IM1	2/13/02	1	U	MG/L

ParamClass	ParamName	StationID	SampleID	Date Collected	Concentration	Qualifier	Units
GENCHEM	Butyric Acid	A039GW28I	039GW28IM1	2/13/02	1	U	MG/L
VOA	cis-1,2-Dichloroethylene	A039GW28I	039GW28IM1	2/13/02	64.3	=	ug/L
METAL	Iron (Ferrous)	A039GW28I	039GW28IM1	2/13/02	0.115	UJ	mg/L
FLTMET	Iron, Dissoived, Dissolved	A039GW28I	039GW28IM1	2/13/02	34	U	ug/L
GENCHEM	Lactic Acid	A039GW28I	039GW28IM1	2/13/02	1	U	MG/L
FLTMET	Manganese, Dissolved	A039GW28I	039GW28IM1	2/13/02	299	J	ug/L
GENCHEM	Propionic Acid	A039GW28I	039GW28IM1	2/13/02	1	U	MG/L
GENCHEM	Pyruvic Acid	A039GW28I	039GW28IM1	2/13/02	0.3	=	MG/L
VOA	Tetrachloroethylene (PCE)	A039GW28I	039GW28IM1	2/13/02	5	UJ	ug/L
GENCHEM	Total Organic Carbon	A039GW28I	039GW28IM1	2/13/02	4.06	=	mg/L
VOA	trans-1,2-Dichloroethene	A039GW28I	039GW28IM1	2/13/02	1.4	J	ug/L
VOA	Trichloroethylene (TCE)	A039GW28I	039GW28IM1	2/13/02	1.4	J	ug/L
VOA	Vinyl chloride	A039GW28I	039GW28IM1	2/13/02	19.1	=	ug/L
CH4 / CO2	Carbon Dioxide	A039GW25I	039GW25IM1	2/13/02	250	=	mg/L
CH4 / CO2	Ethane	A039GW25I	039GW25IM1	2/13/02	5	U	ng/L
CH4 / CO2	Ethene	A039GW25I	039GW25IM1	2/13/02	920	=	ng/L
CH4 / CO2	Hydrogen	A039GW25I	039GW25IM1	2/13/02	3.3	=	nM
CH4 / CO2	Methane	A039GW25I	039GW25IM1	2/13/02	8500	=	ug/L
CH4 / CO2	Carbon Dioxide	A039GW28I	039GW28IM1	2/13/02	74	=	mg/L
CH4 / CO2	Ethane	A039GW28I	039GW28IM1	2/13/02	360	=	ng/L
CH4 / CO2	Ethene	A039GW28I	039GW28IM1	2/13/02	2600	=	ng/L
CH4 / CO2	Hydrogen	A039GW28I	039GW28IM1	2/13/02	0.81	=	nM
CH4 / CO2	Methane	A039GW28I	039GW28IM1	2/13/02	480	=	ug/L

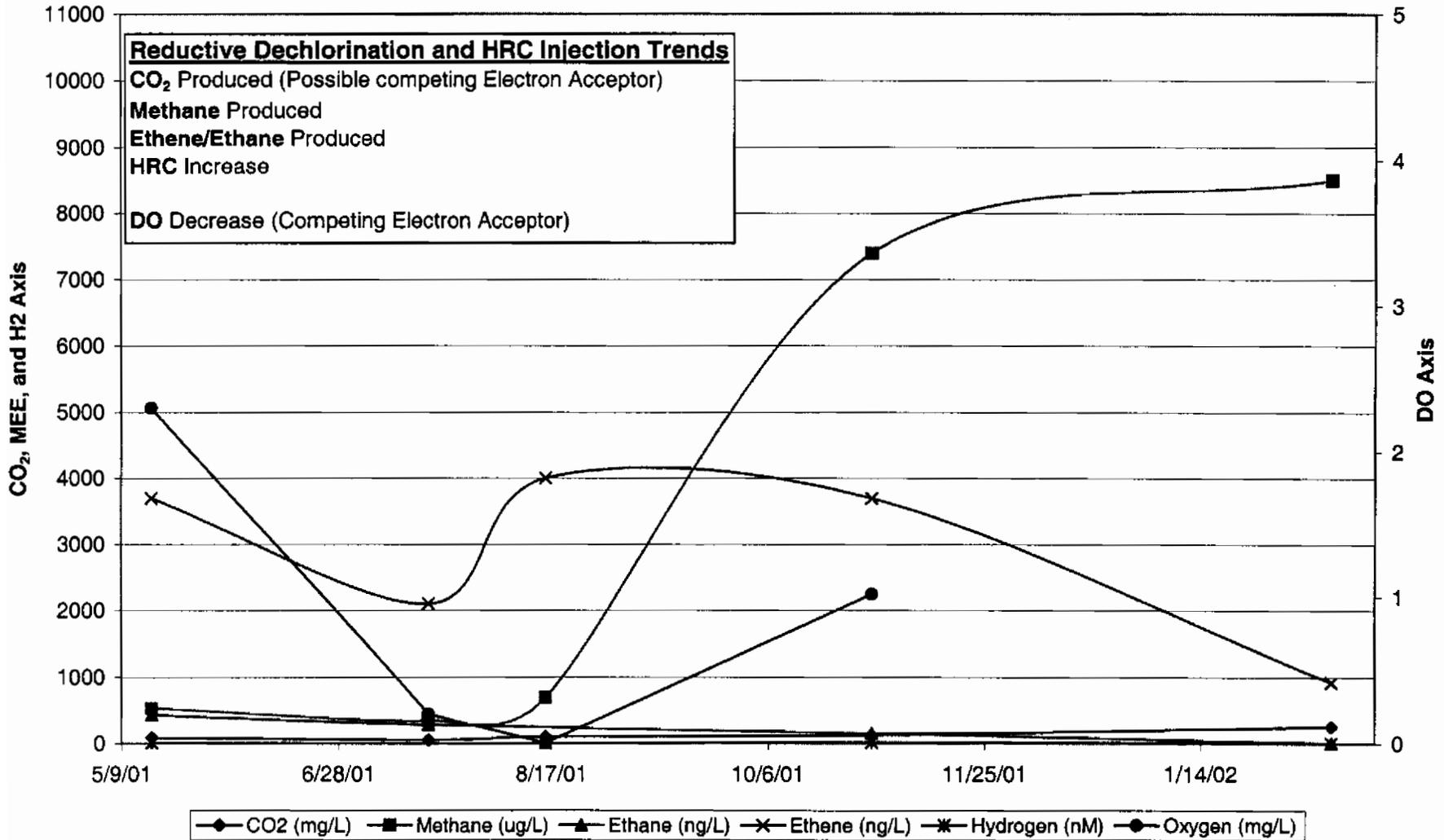
A039GW25i Geochemical Indicators



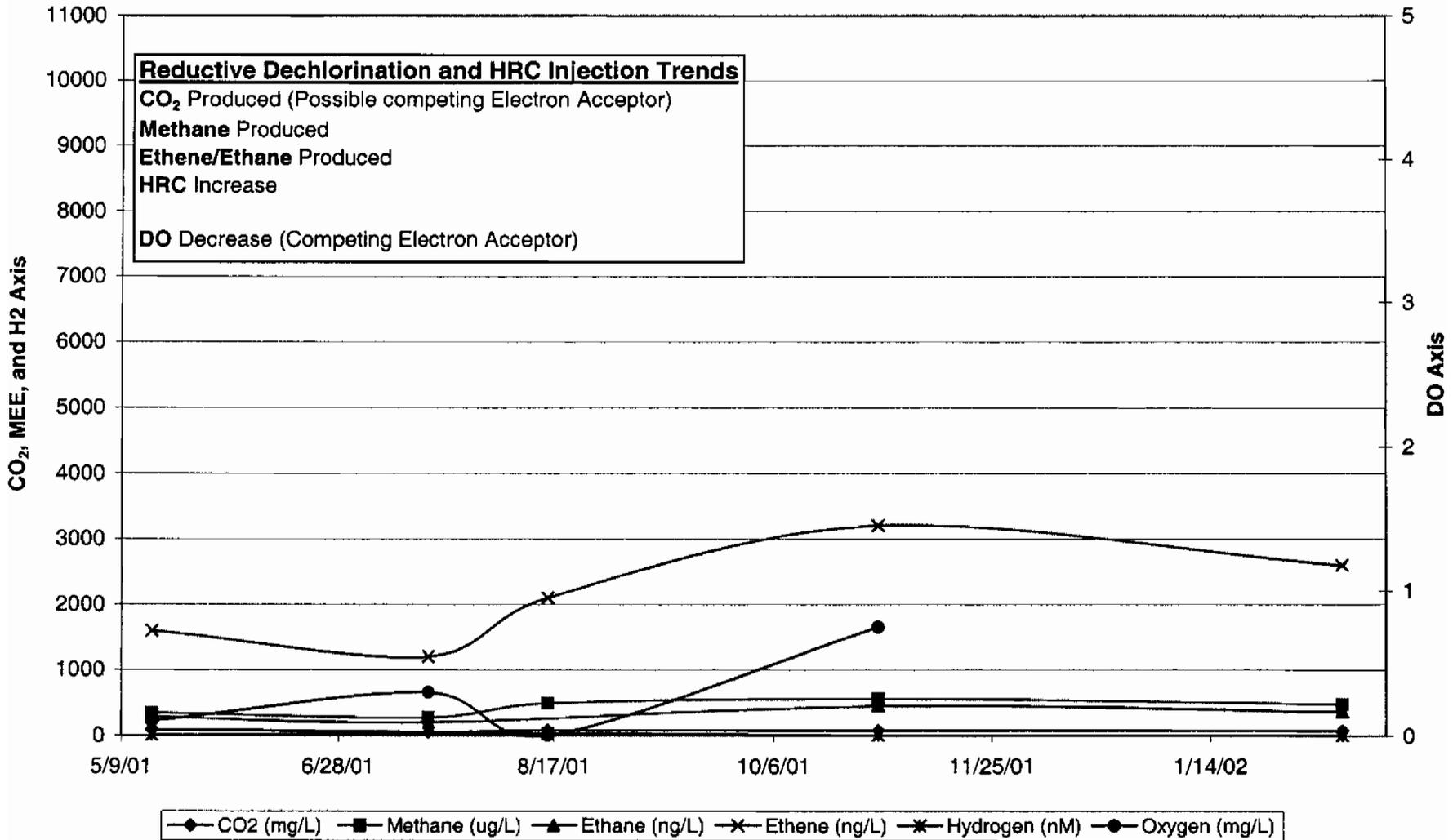
A039GW28I Geochemical Indicators



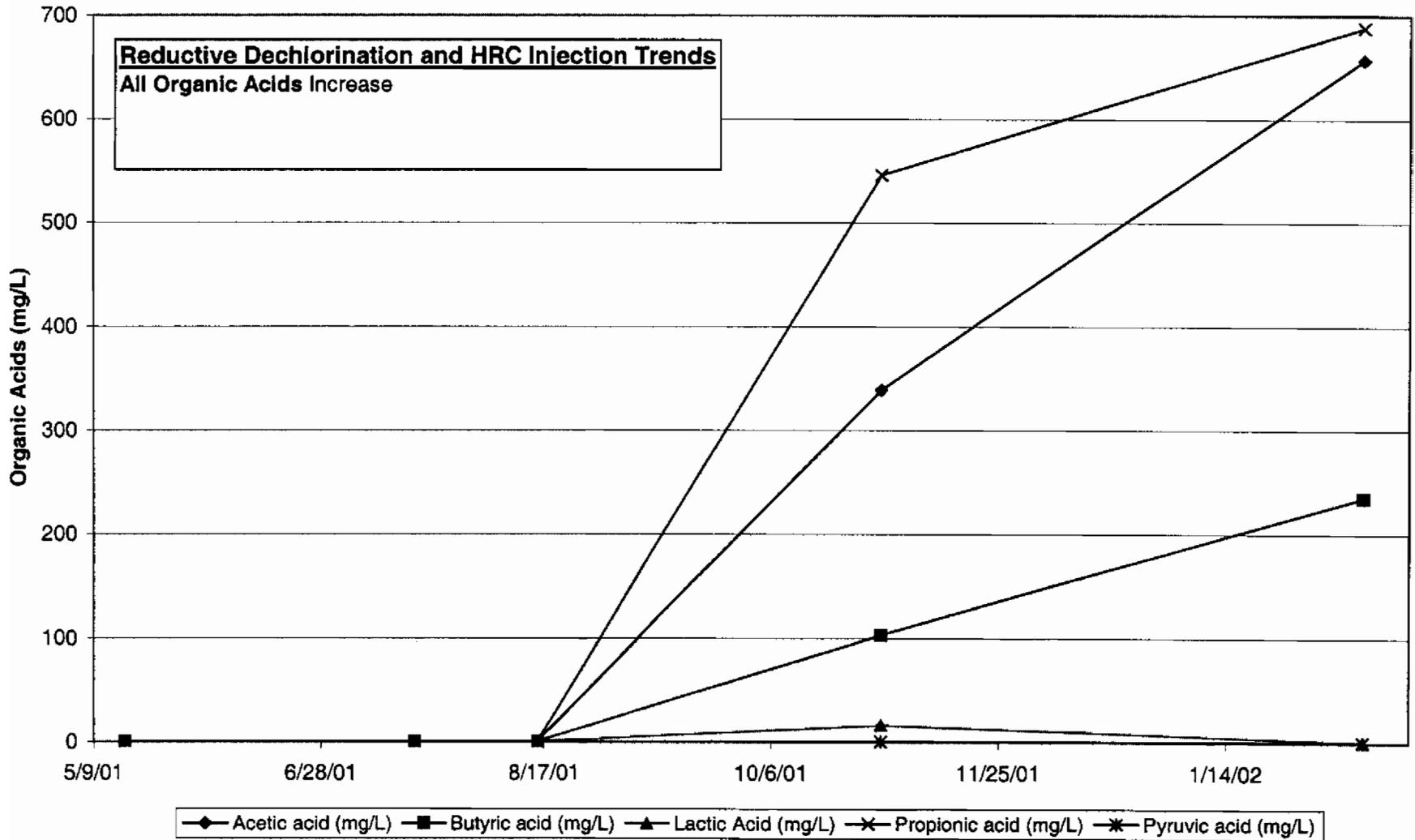
A039GW025I Dissolved Gasses



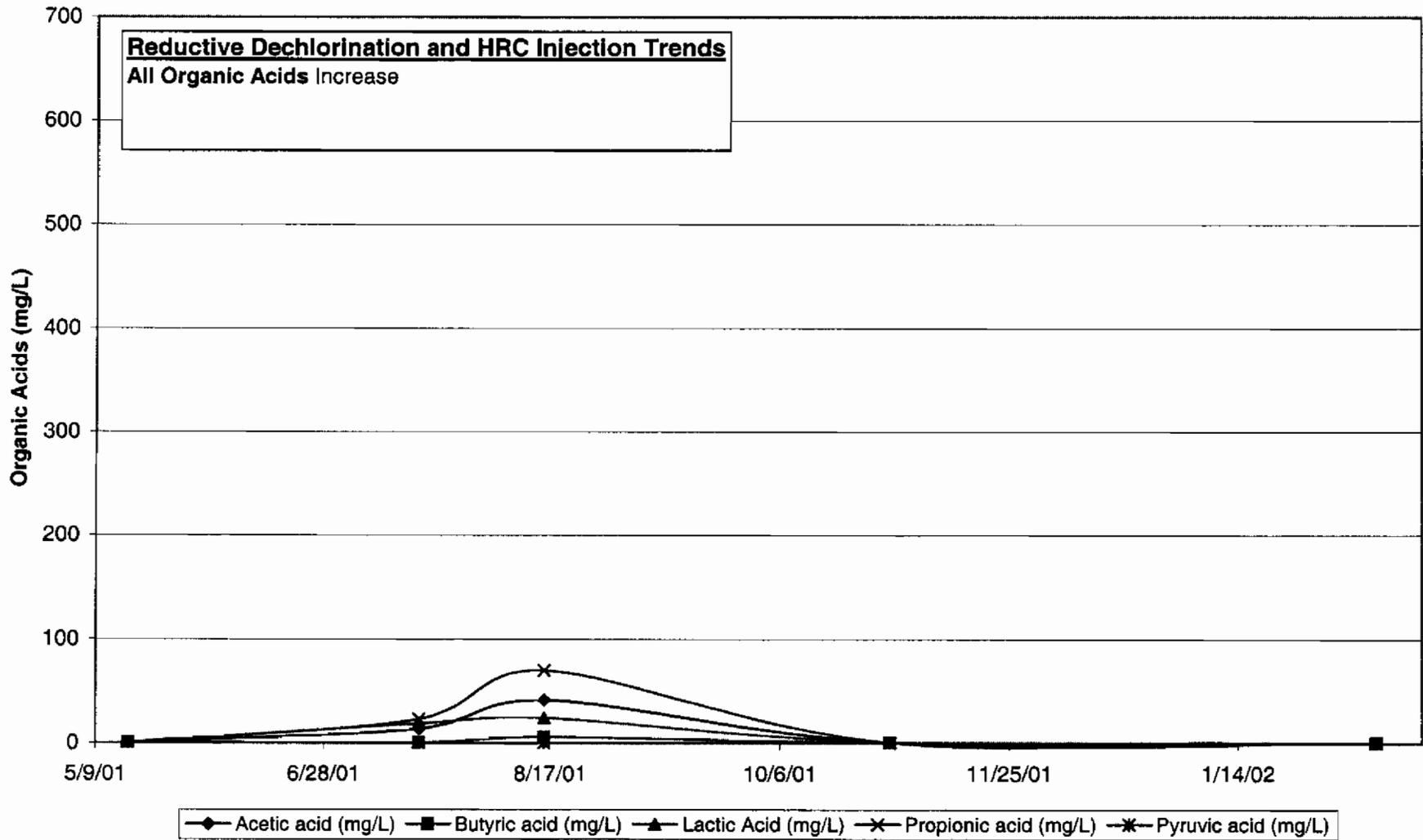
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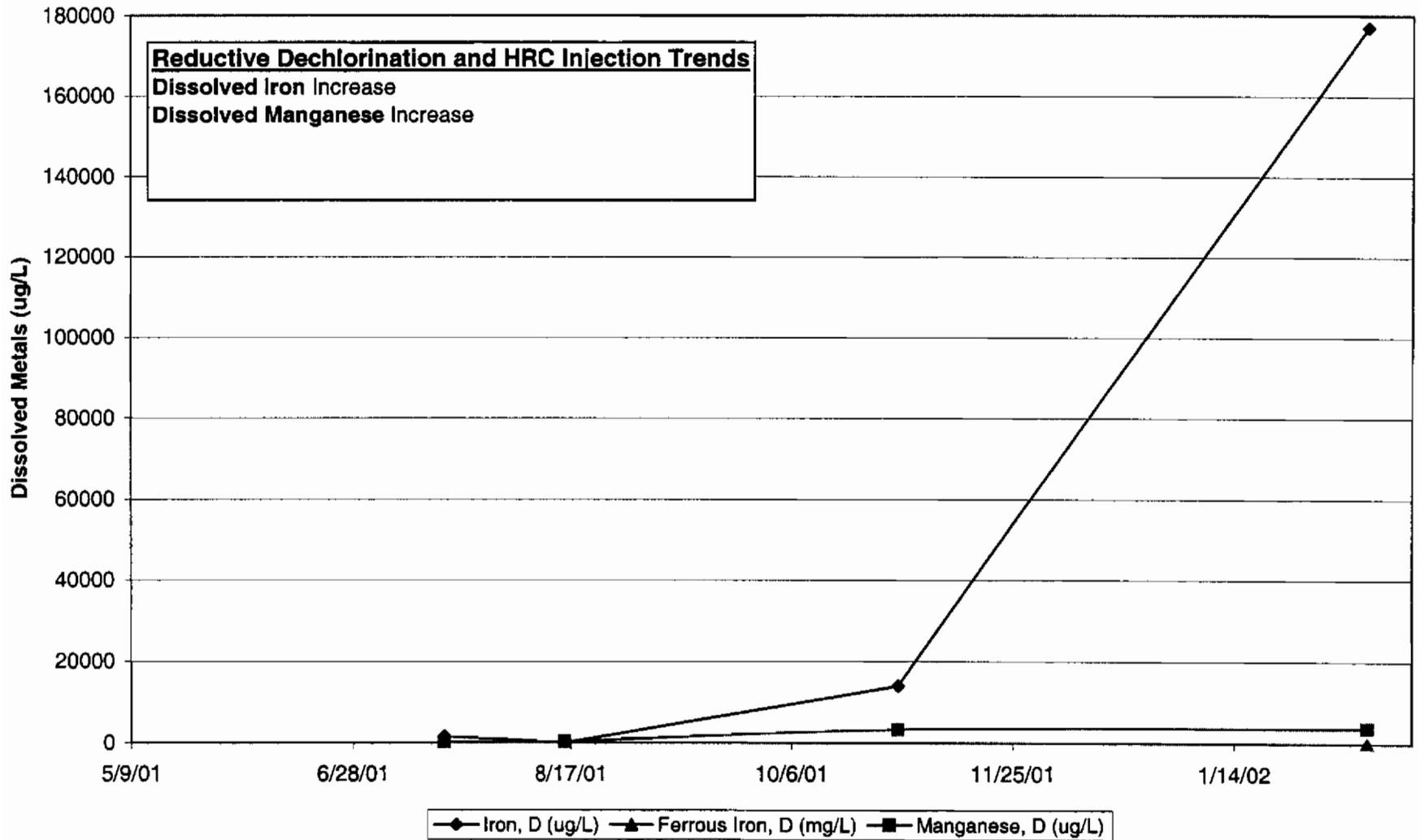
A039GW025I Organic Acids



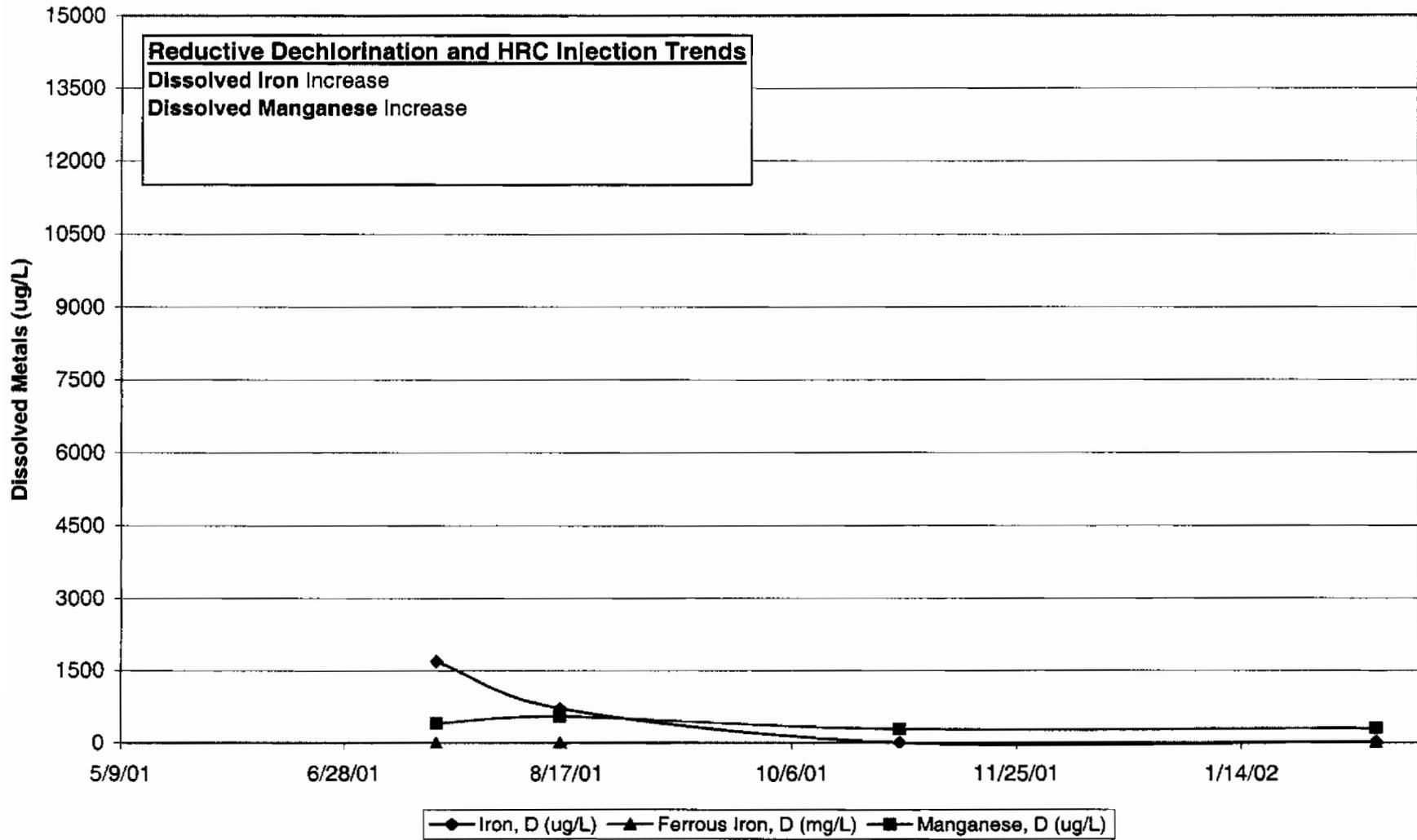
A039GW028I Organic Acids



A039GW025I Dissolved Metals

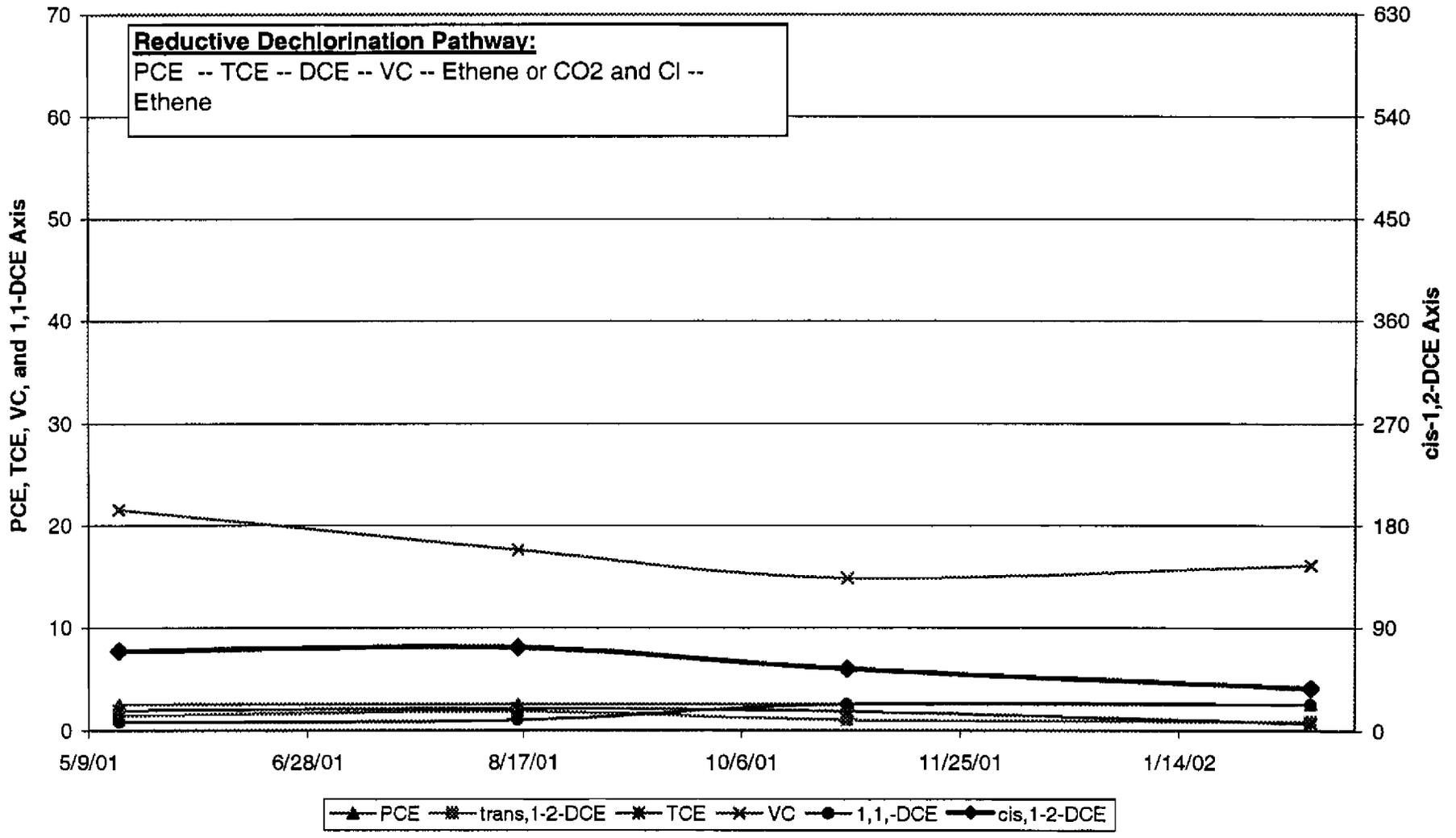


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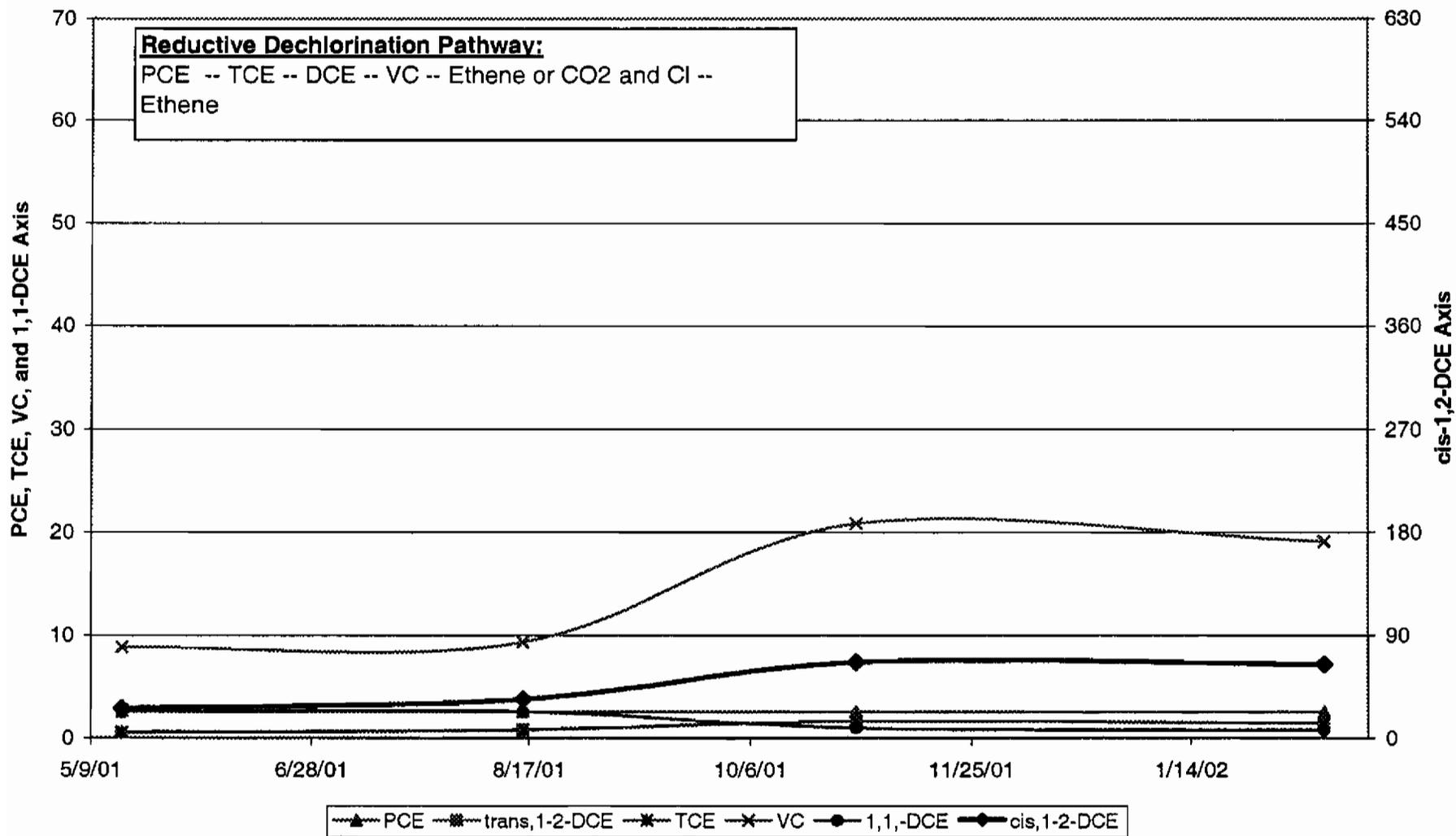


A039GW25I

Volatile Organic Compounds



A039GW28I Volatile Organic Compounds





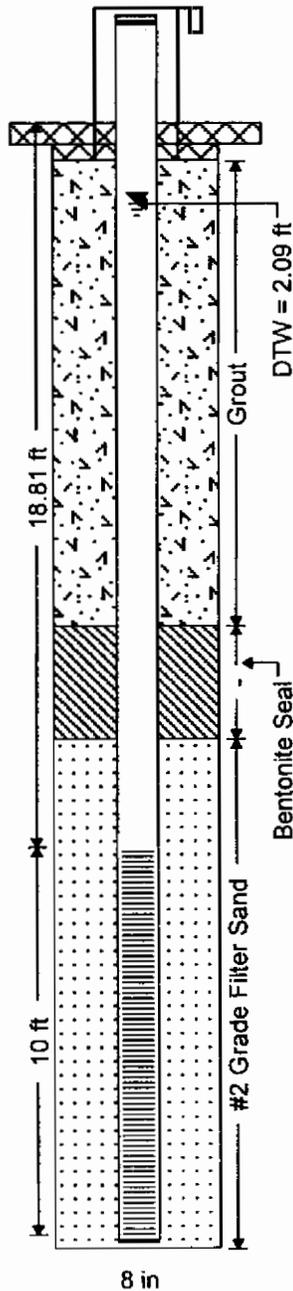
Well Number: A039GW25I

Sheet: 1 of 1

Client: Naval Facilities Engineering Command
Project: Charelston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A
Logged by: Kim-Lee Murphy
Start/Finish Date: 05/03/01 - 05/04/01

Depth Below Surface(ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
-3		Ground Surface			
0		Surface Conditions: Grass and topsoil	0		
2		Dark, grayish brown, silty fine SAND			
5		Very dark brown, "Marsh Clay", sticky, plastic, organic odor	5		
7		<i>Logged from Drill Cuttings</i>			
12					
13		Dark brown, silty medium to fine SAND with some clay, saturated, poorly sorted, no odor, still organic (mucky)	13		
17		Brownish gray, silty CLAY with some sand, dense	17		
21		Gray, silty SAND, loose, saturated	21		
25		Green-gray CLAY, dense, plastic	25		
27					
29		End of Log	29		
32					



Wellhead Protection Cover Type:
 8" Manhole Cover
 2' by 2' Concrete Pad

Diameter/Type of Well Casing:
 2" Diameter, Schedule 40 PVC
Type/slot size of screen:
 2" Diameter, Schedule 40 PVC,
 0.010 slot

Type Screen Filter:
 #2 Filter Sand
 (7.7 50-lb bags)

Type of Seal:
 3/8" Bentonite Pellets
 (2 5-gallon buckets)

Grout:
 Portland Type 1 Cement

Method of Placement:
 Trimie



Well Number: A039GW26D

Sheet: 1 of 2

Client: Naval Facilities Engineering Command
Project: Charleston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A
Logged by: Kim-Lee Murphy
Start/Finish Date: 05/03/01 - 05/04/01

Depth Below Surface(ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
0		Ground Surface Surface Conditions: Asphalt	0	<p>The well diagram shows a vertical casing of 2" diameter Schedule 40 PVC. At the top, there is an 8" manhole cover on a 2' by 2' concrete pad. Below the casing, there is a grout section. A screen is located at a depth of 6.74 ft from the top of the casing. Below the screen is a Bentonite Seal. At the bottom of the casing is a #2 Grade Filter Sand Pack. The total depth of the casing is 32.5 ft.</p>	<p>Wellhead Protection Cover Type: 8" Manhole Cover 2' by 2' Concrete Pad</p>
5		Orange, fine to medium SAND, trace silt, fairly well-sorted <i>Logged from Drill Cuttings</i>	5		<p>Diameter/Type of Well Casing: 2" Diameter, Schedule 40 PVC</p> <p>Type/slot size of screen: 2" Diameter, Schedule 40 PVC, 0.010 slot</p>
10		Very Loose material Medium brown, silty fine SAND	10		<p>Type Screen Filter: #2 Filter Sand (3.5 50-lb bags)</p>
15					<p>Type of Seal: 3/8" Bentonite Pellets (2 5-gallon buckets)</p>
20		Green-gray silty CLAY, dense, wet	20		<p>Grout: Portland Type 1 Cement</p> <p>Method of Placement: Trimie</p>
30			30		

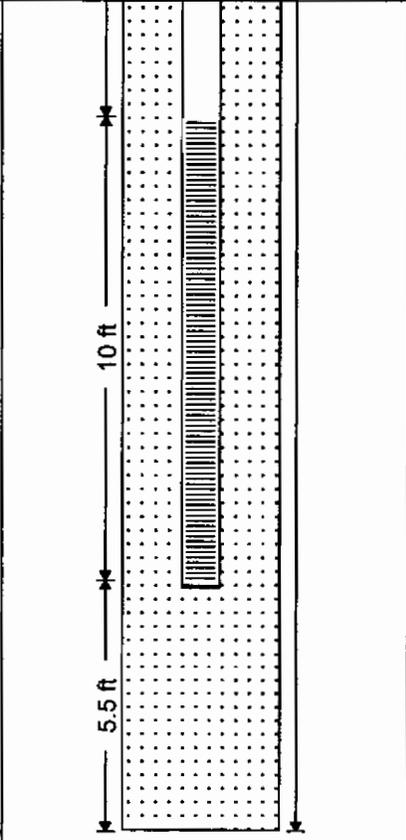


Well Number: A039GW26D

Sheet: 2 of 2

Client: Naval Facilities Engineering Command
Project: Charleston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A
Logged by: Kim-Lee Murphy
Start/Finish Date: 05/03/01 - 05/04/01

Depth Below Surface(ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
35 40 45		Brown, Silty fine sand, very loose			<p>Note: Flowing sands occurred during installation. Complicated installation of sand pack. Only able to place 3.5 bags of filter sand; rest of sand pack is filled with native flowing sands and collapsed material. Well seal placed high above top of screen.</p>
50 55 60		End of Log	48		



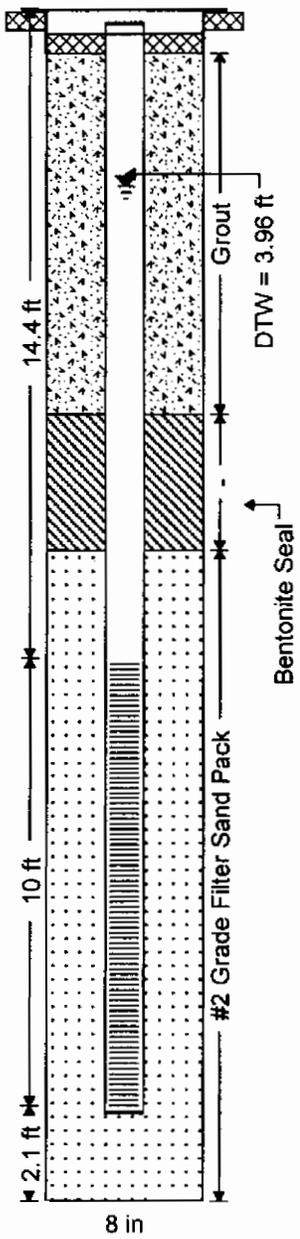
Well Number: A039GW261

Sheet: 2 of 1

Client: Naval Facilities Engineering Command
Project: Charleston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A
Logged by: Kim-Lee Murphy
Start/Finish Date: 05/02/01 - 05/04/01

Depth Below Surface (ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
0		Ground Surface	0		
		Surface Conditions: Asphalt			<p>Wellhead Protection Cover Type: 8" Manhole Cover 2' by 2' Concrete Pad</p>
5		Orange, fine to medium SAND, trace silt, fairly well-sorted	5		<p>Diameter/Type of Well Casing: 2" Diameter, Schedule 40 PVC</p> <p>Type/slot size of screen: 2" Diameter, Schedule 40 PVC, 0.010 slot</p>
		<i>Logged from Drill Cuttings</i>			
10		Medium brown, silty fine SAND, liquified	10		<p>Type Screen Filter: #2 Filter Sand (6 50-lb bags)</p> <p>Type of Seal: 3/8" Bentonite Pellets (2 5-gallon buckets)</p>
15					<p>Grout: Portland Type 1 Cement</p> <p>Method of Placement: Trimie</p>
20		Green-gray silty CLAY, plastic, wet	20		
25					<p>Note: Flowing sands during installation.</p>
30		End of Log	27		





Well Number: A039GW27D

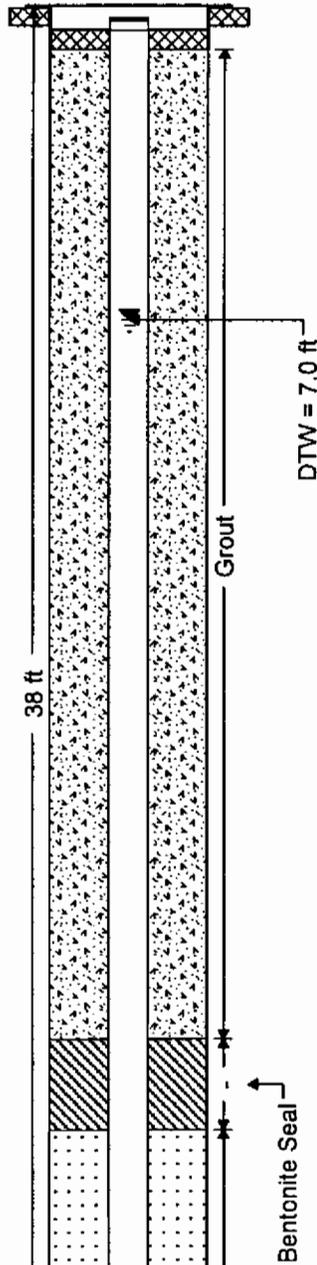
Sheet: 1 of 2

Client: Naval Facilities Engineering Command
Project: Charleston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A

Logged by: Kim-Lee Murphy
Start/Finish Date: 05/01/01 - 05/02/01

Depth Below Surface (ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
0		Ground Surface	0		
0		Surface Conditions: Asphalt	0		Wellhead Protection Cover Type: 8" Manhole Cover 2' by 2' Concrete Pad
5		Tan SAND, some silt, with occasional gray clay.	5		Diameter/Type of Well Casing: 2" Diameter, Schedule 40 PVC
5		Water content increasing greatly with depth.			Type/slot size of screen: 2" Diameter, Schedule 40 PVC, 0.010 slot
10		Logged from Drill Cuttings			Type Screen Filter: #2 Filter Sand (3 50-lb bags)
15					Type of Seal: 3/8" Bentonite Pellets (1.5 5-gallon buckets)
20					Grout: Portland Type 1 Cement
25		Green-gray silty CLAY, dense, wet	25		Method of Placement: Trimie
30					





Well Number: A039GW27D

Client: Naval Facilities Engineering Command
Project: Charleston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A

Logged by: Kim-Lee Murphy
Start/Finish Date: 05/01/01 - 05/02/01

Depth Below Surface(ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
35		Brown, Silty fine sand, very loose	35		Note: Flowing sands occurred during installation. Complicated installation of sand pack. Only able to place 3 bags of filter sand; rest of sand pack is filled with native flowing sands and collapsed material. Well seal placed high above top of screen.
50	End of Log	End of Log	49		
55					
60					

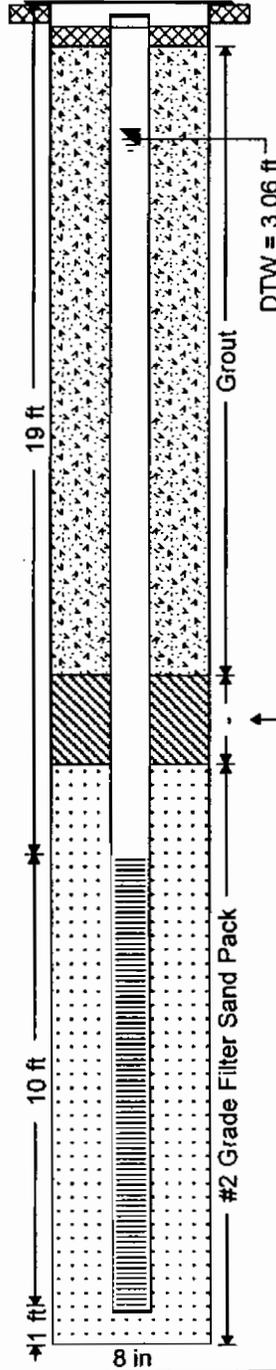


Well Number: A039GW271

Sheet: 1 of 1

Client: Naval Facilities Engineering Command
Project: Charleston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A
Logged by: Kim-Lee Murphy
Start/Finish Date: 04/30/01 - 05/02/01

Depth Below Surface(ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
0		Ground Surface	0		
		Surface Conditions: Asphalt			<p>Wellhead Protection Cover Type: 8" Manhole Cover 2' by 2' Concrete Pad</p>
5		Tan SAND, some silt, with occasional gray clay. Water content increasing greatly with depth. Logged from Drill Cuttings	5	 <p>The diagram shows a vertical well casing with a diameter of 8 inches. The casing is surrounded by grout. A screen is located at a depth of 19 feet from the surface. Below the screen is a 10-foot thick sand pack. A bentonite seal is located at a depth of 15 feet from the surface. The diagram also indicates a depth to water table (DTW) of 3.06 feet.</p>	<p>Diameter/Type of Well Casing: 2" Diameter, Schedule 40 PVC</p> <p>Type/slot size of screen: 2" Diameter, Schedule 40 PVC, 0.010 slot</p> <p>Type Screen Filter: #2 Filter Sand (7 50-lb bags)</p> <p>Type of Seal: 3/8" Bentonite Pellets (1.5 5-gallon buckets)</p> <p>Grout: Portland Type 1 Cement</p> <p>Method of Placement: Trimie</p>
25		Green-gray CLAY, dense, plastic, wet	25		<p>Note: Flowing sands during installation.</p>
30			30		



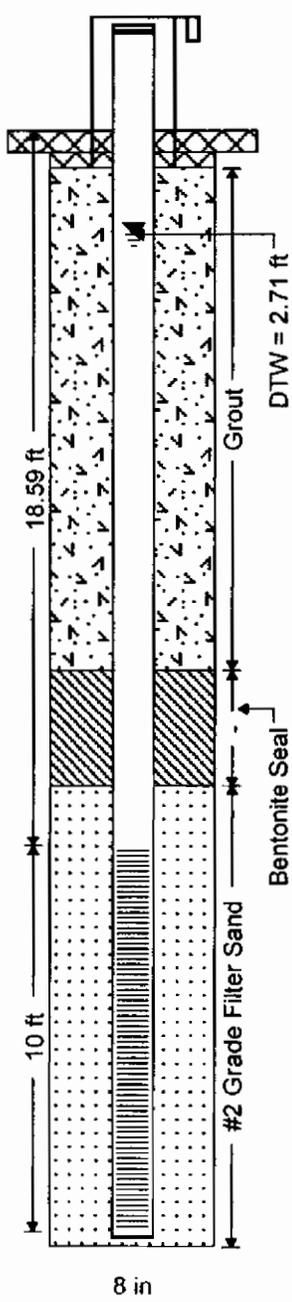
Well Number: A039GW28I

Sheet: 1 of 1

Client: Naval Facilities Engineering Command
Project: Charelston Naval Complex
Location: SWMU 39
Project Number: 158814.ZA.PR.01

Driller: Environmental Enterprise Group (EEG)
Drilling Method: Simco trailer-mounted HSA rig
Sampling Method: N/A
Logged by: Kim-Lee Murphy
Start/Finish Date: 05/04/01 - 05/07/01

Depth Below Surface(ft)	Soil Log	Soil Description	Depth / Elev	Well Diagram	Well Construction Notes
-3					
		Ground Surface			
0		Surface Conditions: Grass and topsoil	0		
2		Dark, grayish brown, silty fine SAND			
7		<i>Logged from Drill Cuttings</i>			
8		Very dark brown, "Marsh Clay", sticky, plastic, organic odor	8		
12					
13		Dark brown, silty medium to fine SAND with some clay, saturated, poorly sorted, no odor, still organic (mucky)	13		
17		Brownish gray, silty CLAY with some sand, dense	17		
20		Gray, silty SAND, loose, saturated	20		
22					
25		Green-gray CLAY, dense, plastic	25		
27					
29		End of Log	29		
32					



Wellhead Protection Cover Type:
 8" Manhole Cover
 2' by 2' Concrete Pad

Diameter/Type of Well Casing:
 2" Diameter, Schedule 40 PVC

Type/slot size of screen:
 2" Diameter, Schedule 40 PVC,
 0.010 slot

Type Screen Filter:
 #2 Filter Sand
 (7.5 50-lb bags)

Type of Seal:
 3/8" Bentonite Pellets
 (2 5-gallon buckets)

Grout:
 Portland Type 1 Cement

Method of Placement:
 Trimie

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1)
		Depth (ft bls)					(µg/L)
1,1-Dichloroethane	A039GP054	27	04/16/02	9.3	=	NA	80
	A039GP055	46	04/16/02	3.3	J		
	A039GP059	46	04/18/02	1.7	J		
	A039GP060	40	04/19/02	1.4	J		
	A039GP063	40	04/22/02	4.7	J		
	A039GP064	10	04/23/02	3.3	J		
	A039GP064	46	04/23/02	1	J		
	A039GP064	46	04/23/02	1	J		
	A039GP071	46	04/25/02	15	J		
	A039GP073	27	04/26/02	0.81	J		
	A039GP073	48	04/26/02	5.8	J		
	A039GP074	48	04/29/02	9.4	J		
	A039GP074	48	04/29/02	12	J		
	A039GP075	10	04/29/02	7.8	J		
	A039GP076	10	04/30/02	10	=		
	A039GP076	27	04/30/02	0.71	J		
	A039GP077	10	04/30/02	1.5	J		
	A039GP077	27	04/30/02	3.3	J		
	A039GP079	10	04/30/02	1	J		
	A039GP080	10	04/30/02	8.8	=		
	A039GP081	10	05/01/02	8.3	=		
	A039GP082	27	05/01/02	0.74	J		
	A039GP082	48	05/01/02	14	=		
	A039GP083	10	05/01/02	8.9	J		
	A039GP084	10	05/01/02	6.2	=		
	A039GP085	10	05/01/02	1.4	J		
	A039GP086	27	05/01/02	3	J		
	A039GP087	10	05/02/02	0.66	J		
	A039GP087	27	05/02/02	1.3	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
1,1-Dichloroethane	A039GP088	48	05/02/02	1.3	J	NA	80
	A039GP095	27	07/25/02	8.7	J		
	A039GP095	48	07/25/02	19	J		
	A039GP096	10	07/25/02	47	J		
	A039GP098	44	07/29/02	3.3	J		
	A039GP108	10	08/01/02	3.5	J		
	A039GP108	44	08/01/02	3.2	J		
1,1-Dichloroethene	A039GP049	32	04/02/02	1.6	J	7	0.044
	A039GP050	32	04/02/02	2.9	J		
	A039GP054	27	04/16/02	7.2	J		
	A039GP054	46	04/16/02	4.2	J		
	A039GP055	46	04/16/02	1.6	J		
	A039GP063	40	04/22/02	2.1	J		
	A039GP064	10	04/23/02	1.8	J		
	A039GP064	46	04/23/02	2.3	J		
	A039GP064	46	04/23/02	2.2	J		
	A039GP071	46	04/25/02	17	J		
	A039GP072	27	04/26/02	0.7	J		
	A039GP072	46	04/26/02	1.8	J		
	A039GP073	27	04/26/02	0.88	J		
	A039GP073	48	04/26/02	8	J		
	A039GP074	48	04/29/02	21	=		
	A039GP074	48	04/29/02	24	J		
	A039GP075	10	04/29/02	3.2	J		
	A039GP076	10	04/30/02	7.3	J		
	A039GP077	10	04/30/02	0.91	J		
	A039GP079	10	04/30/02	0.98	J		
A039GP080	10	04/30/02	9.6	=			

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
1,1-Dichloroethene	A039GP080	27	04/30/02	0.79	J	7	0.044
	A039GP081	10	05/01/02	4.3	J		
	A039GP082	27	05/01/02	1.1	J		
	A039GP082	48	05/01/02	10	=		
	A039GP083	10	05/01/02	4.7	J		
	A039GP084	10	05/01/02	3.6	J		
	A039GP084	48	05/01/02	0.89	J		
	A039GP085	10	05/01/02	1.2	J		
	A039GP086	27	05/01/02	2.7	J		
	A039GP087	27	05/02/02	2.1	J		
	A039GP088	48	05/02/02	2.2	J		
	A039GP091	32	05/29/02	1	J		
	A039GP094	27	07/24/02	4.9	J		
	A039GP095	27	07/25/02	3.9	J		
	A039GP095	48	07/25/02	6.3	J		
	A039GP096	10	07/25/02	4.3	J		
	A039GP098	44	07/29/02	0.6	J		
	A039GP108	10	08/01/02	0.65	J		
	A039GP111	27	08/01/02	0.81	J		
1,1,1-Trichloroethane	A039GP108	10	08/01/02	1.4	J	200	320
1,1,2,2-Tetrachloroethane	A039GP107	10	07/31/02	0.78	J		0.053
1,2,3-Trichlorobenzene	A039GP054	10	04/16/02	1.6	J	NA	NA
	A039GP106	44	07/31/02	0.9	J	NA	NA
	A039GP107	10	07/31/02	2.4	J		
1,2-Dichlorobenzene	A039GP107	44	07/31/02	0.48	J	600	55
1,2-Dichloroethane	A039GP049	32	04/02/02	1.3	J	5	0.12

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
		Depth (ft bls)					
1,2-Dichloroethane	A039GP081	48	05/01/02	0.57	J	5	0.12
	A039GP084	48	05/01/02	0.87	J		
	A039GP085	48	05/02/02	1.1	J		
	A039GP085	48	05/02/02	0.98	J		
	A039GP096	10	07/25/02	1.6	J		
1,2-Dichloroethene (total)	A039GP049	32	04/02/02	280	=	NA	5.5
	A039GP050	32	04/02/02	220	=		
	A039GP051	32	04/03/02	2.6	J		
	A039GP051	56	04/03/02	1.4	J		
	A039GP052	32	04/03/02	12	=		
	A039GP054	10	04/16/02	54	=		
	A039GP054	27DL	04/16/02	380	=		
	A039GP054	46	04/16/02	220	=		
	A039GP055	27	04/16/02	1.1	J		
	A039GP055	46	04/16/02	99	=		
	A039GP056	10	04/17/02	5.6	=		
	A039GP057	27	04/17/02	1.6	J		
	A039GP057	46	04/17/02	1.3	J		
	A039GP059	46	04/18/02	57	=		
	A039GP060	40	04/19/02	49	=		
	A039GP062	40	04/19/02	1.6	J		
	A039GP063	10	04/22/02	2.4	J		
	A039GP063	40	04/22/02	160	=		
	A039GP064	10	04/23/02	160	=		
	A039GP064	46	04/23/02	120	=		
A039GP064	46	04/23/02	120	=			
A039GP066	48	04/23/02	5.3	=			
A039GP070	27	04/25/02	9.7	=			

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
1,2-Dichloroethene (total)	A039GP070	46	04/25/02	11	=	NA	5.5
	A039GP071	27	04/25/02	22	=		
	A039GP071	46	04/25/02	870	=		
	A039GP071	27	04/25/02	22	=		
	A039GP072	27	04/26/02	1.7	J		
	A039GP072	46	04/26/02	32	=		
	A039GP073	27	04/26/02	28	=		
	A039GP073	48	04/26/02	300	=		
	A039GP074	27	04/29/02	0.9	J		
	A039GP074	48DL	04/29/02	840	=		
	A039GP074	48	04/29/02	900	=		
	A039GP075	10	04/29/02	420	=		
	A039GP075	27	04/29/02	2.5	J		
	A039GP076	10	04/30/02	300	=		
	A039GP076	27	04/30/02	25	=		
	A039GP076	48	04/30/02	0.73	J		
	A039GP077	10	04/30/02	50	=		
	A039GP077	27	04/30/02	120	=		
	A039GP078	10	04/30/02	20	=		
	A039GP079	10	04/30/02	36	=		
	A039GP080	10DL	04/30/02	470	=		
	A039GP080	27	04/30/02	9.9	=		
	A039GP080	48	04/30/02	29	=		
	A039GP081	10	05/01/02	330	=		
	A039GP081	27	05/01/02	0.69	J		
	A039GP081	48	05/01/02	69	=		
	A039GP082	10	05/01/02	29	=		
	A039GP082	27	05/01/02	42	=		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
1,2-Dichloroethene (total)	A039GP082	48DL	05/01/02	780	=	NA	5.5
	A039GP082	10	05/01/02	33	=		
	A039GP083	10	05/01/02	280	=		
	A039GP083	27	05/01/02	31	=		
	A039GP084	10	05/01/02	240	=		
	A039GP084	27	05/01/02	54	=		
	A039GP084	48	05/01/02	8.6	=		
	A039GP085	10	05/01/02	85	=		
	A039GP085	48	05/02/02	12	=		
	A039GP085	48	05/02/02	12	=		
	A039GP086	10	05/01/02	30	=		
	A039GP086	27	05/01/02	200	=		
	A039GP087	10	05/02/02	26	=		
	A039GP087	27	05/02/02	120	=		
	A039GP088	48	05/02/02	220	=		
	A039GP091	32	05/29/02	180	=		
	A039GP091	46	05/29/02	9.9	=		
	A039GP092	32	05/29/02	4.8	J		
	A039GP092	42	05/29/02	5.9	=		
	A039GP094	27	07/24/02	120	=		
	A039GP095	27	07/25/02	220	=		
	A039GP095	10	07/25/02	2	J		
	A039GP095	48	07/25/02	400	=		
	A039GP096	10	07/25/02	580	=		
	A039GP096	27	07/25/02	0.96	J		
	A039GP096	46	07/25/02	0.78	J		
	A039GP097	27	07/29/02	10	=		
	A039GP097	27	07/29/02	11	=		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1)
		Depth (ft bls)					(µg/L)
1,2-Dichloroethene (total)	A039GP098	44	07/29/02	8.1	=	NA	5.5
	A039GP099	27	07/30/02	4.2	J		
	A039GP101	10	07/30/02	0.69	J		
	A039GP104	27	07/31/02	0.75	J		
	A039GP105	10	07/31/02	2	J		
	A039GP108	10	08/01/02	6.8	=		
	A039GP108	27	08/01/02	1.2	J		
	A039GP111	27	08/01/02	22	=		
1,2-Dichloropropane	A039GP111	44	08/01/02	3.3	J		
	A039GP092	32	05/29/02	0.51	J	5	0.16
	A039GP092	42	05/29/02	0.45	J		
1,3-Dichlorobenzene	A039GP094	27	07/24/02	0.64	J	NA	0.55
1,4-Dichlorobenzene	A039GP091	32	05/29/02	0.54	J	75	0.47
	A039GP092	32	05/29/02	0.32	J		
	A039GP094	27	07/24/02	0.7	J		
2-Hexanone	A039GP073	48	04/26/02	9.3	J	NA	NA
Acetone	A039GP051	10	04/03/02	21	=	NA	61
	A039GP051	56	04/03/02	14	=		
	A039GP053	56	04/03/02	15	=		
	A039GP058	27	04/17/02	12	=		
	A039GP058	46	04/17/02	13	=		
	A039GP059	46	04/18/02	23	=		
	A039GP073	48	04/26/02	36	J		
	A039GP074	27	04/29/02	10	J		
	A039GP076	27	04/30/02	30	J		
	A039GP077	27	04/30/02	18	J		
	A039GP078	27	04/30/02	27	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
Acetone	A039GP078	27	04/30/02	18	J	NA	61
	A039GP079	27	04/30/02	18	J		
	A039GP081	27	05/01/02	16	=		
	A039GP085	48	05/02/02	20	=		
	A039GP086	27	05/01/02	13	=		
	A039GP094	44	07/24/02	140	=		
	A039GP098	10	07/29/02	14	J		
	A039GP099	27	07/30/02	31	=		
	A039GP099	46	07/30/02	80	=		
	A039GP100	46	07/30/02	220	=		
	A039GP101	27	07/30/02	14	J		
	A039GP102	44	07/30/02	59	J		
	A039GP105	44	07/31/02	11	J		
	A039GP106	44	07/31/02	41	J		
	A039GP107	44	07/31/02	34	J		
	A039GP108	27	08/01/02	12	J		
	A039GP111	44	08/01/02	25	J		
	A039GP112	44	08/01/02	15	=		
Benzene	A039GP050	32	04/02/02	0.52	J	5	0.32
	A039GP051	56	04/03/02	0.33	J		
	A039GP054	27	04/16/02	1.5	J		
	A039GP055	46	04/16/02	0.63	J		
	A039GP059	46	04/18/02	0.45	J		
	A039GP063	40	04/22/02	0.82	J		
	A039GP064	10	04/23/02	0.53	J		
	A039GP064	46	04/23/02	0.75	J		
	A039GP064	46	04/23/02	0.79	J		
	A039GP071	46	04/25/02	3.8	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
Benzene	A039GP072	46	04/26/02	0.34	J	5	0.32
	A039GP073	48	04/26/02	0.97	J		
	A039GP074	48	04/29/02	1.2	J		
	A039GP075	10	04/29/02	5.7	J		
	A039GP076	10	04/30/02	0.99	J		
	A039GP077	27	04/30/02	0.32	J		
	A039GP080	10	04/30/02	1.2	J		
	A039GP081	10	05/01/02	1.1	J		
	A039GP081	48	05/01/02	0.74	J		
	A039GP082	27	05/01/02	0.34	J		
	A039GP082	48	05/01/02	4.8	J		
	A039GP083	10	05/01/02	0.76	J		
	A039GP084	10	05/01/02	0.64	J		
	A039GP084	27	05/01/02	0.32	J		
	A039GP084	48	05/01/02	0.44	J		
	A039GP085	10	05/01/02	0.65	J		
	A039GP085	48	05/02/02	0.31	J		
	A039GP086	27	05/01/02	2.6	J		
	A039GP087	27	05/02/02	0.62	J		
	A039GP088	48	05/02/02	0.8	J		
	A039GP091	32	05/29/02	2.3	J		
	A039GP092	32	05/29/02	6.5	=		
	A039GP092	42	05/29/02	2.9	J		
	A039GP094	27	07/24/02	0.66	J		
	A039GP094	44	07/24/02	0.43	J		
	A039GP096	10	07/25/02	48	=		
	A039GP099	46	07/30/02	0.3	J		
	A039GP100	46	07/30/02	0.48	J		
	A039GP105	44	07/31/02	0.38	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
Benzene	A039GP107	10	07/31/02	0.3	J	5	0.32
	A039GP107	44	07/31/02	0.6	J		
	A039GP108	10	08/01/02	0.38	J		
	A039GP108	27	08/01/02	0.54	J		
	A039GP108	44	08/01/02	0.4	J		
	A039GP110	44	08/01/02	0.27	J		
	A039GP111	27	08/01/02	0.66	J		
	A039GP111	44	08/01/02	0.53	J		
	A039GP112	44	08/01/02	0.57	J		
	A039GP113	44	08/02/02	0.35	J		
Carbon Disulfide	A039GP058	46	04/17/02	1.7	J	NA	100
	A039GP076	48	04/30/02	2.3	J		
	A039GP078	27	04/30/02	1.5	J		
	A039GP082	27	05/01/02	1.5	J		
	A039GP094	44	07/24/02	1.5	J		
	A039GP096	27	07/25/02	1.8	J		
	A039GP096	46	07/25/02	2.4	J		
	A039GP098	10	07/29/02	2.2	J		
	A039GP099	10	07/30/02	1.9	J		
	A039GP100	10	07/30/02	5	=		
	A039GP100	27	07/30/02	1.8	J		
	A039GP104	10	07/31/02	9.4	J		
	A039GP107	44	07/31/02	1.6	J		
	A039GP111	27	08/01/02	1.7	J		
Chloroethane	A039GP108	10	08/01/02	3.9	J	80 ^a	3.6
Chloroform	A039GP053	56	04/03/02	2.2	J	NA	0.15
Chloromethane	A039GP095	48	07/25/02	4.2	J	80 ^a	2.1
	A039GP105	44	07/31/02	3.2	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
cis-1,2-Dichloroethene	A039GP049	932	04/02/02	260	=	70	6.1
	A039GP050	32DL	04/02/02	190	=		
	A039GP051	32	04/03/02	2.4	J		
	A039GP051	56	04/03/02	1.4	J		
	A039GP052	32	04/03/02	11	=		
	A039GP054	10	04/16/02	49	=		
	A039GP054	27DL	04/16/02	340	=		
	A039GP054	46	04/16/02	200	=		
	A039GP055	27	04/16/02	1	J		
	A039GP055	46	04/16/02	89	=		
	A039GP056	10	04/17/02	5.1	=		
	A039GP057	27	04/17/02	1.4	J		
	A039GP057	46	04/17/02	1.2	J		
	A039GP059	46	04/18/02	52	=		
	A039GP060	40	04/19/02	49	=		
	A039GP062	40	04/19/02	1.6	J		
	A039GP063	10	04/22/02	2.4	J		
	A039GP063	40	04/22/02	150	=		
	A039GP064	10	04/23/02	160	=		
	A039GP064	46	04/23/02	110	=		
	A039GP064	46	04/23/02	110	=		
	A039GP066	48	04/23/02	5.3	=		
	A039GP070	27	04/25/02	9.7	=		
	A039GP070	46	04/25/02	11	=		
	A039GP071	27	04/25/02	22	=		
	A039GP071	46	04/25/02	860	=		
	A039GP071	27	04/25/02	22	=		
	A039GP072	27	04/26/02	1.7	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
cis-1,2-Dichloroethene	A039GP072	46	04/26/02	32	=	70	6.1
	A039GP073	27	04/26/02	27	=		
	A039GP073	48	04/26/02	300	=		
	A039GP074	27	04/29/02	0.9	J		
	A039GP074	48DL	04/29/02	820	=		
	A039GP074	48	04/29/02	890	=		
	A039GP075	10	04/29/02	380	=		
	A039GP075	27	04/29/02	2.5	J		
	A039GP076	10	04/30/02	290	=		
	A039GP076	27	04/30/02	24	=		
	A039GP076	48	04/30/02	0.73	J		
	A039GP077	10	04/30/02	48	=		
	A039GP077	27	04/30/02	120	=		
	A039GP078	10	04/30/02	19	=		
	A039GP079	10	04/30/02	34	=		
	A039GP080	10DL	04/30/02	470	=		
	A039GP080	27	04/30/02	9.9	=		
	A039GP080	48	04/30/02	28	=		
	A039GP081	10DL	05/01/02	310	=		
	A039GP081	27	05/01/02	0.69	J		
	A039GP081	48	05/01/02	68	=		
	A039GP082	10	05/01/02	29	=		
	A039GP082	27	05/01/02	40	=		
	A039GP082	48DL	05/01/02	760	=		
	A039GP082	10	05/01/02	33	=		
	A039GP083	10	05/01/02	280	=		
	A039GP083	27	05/01/02	31	=		
	A039GP084	10DL	05/01/02	230	=		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
cis-1,2-Dichloroethene	A039GP084	27	05/01/02	53	=	70	6.1
	A039GP084	48	05/01/02	8.1	=		
	A039GP085	10	05/01/02	83	=		
	A039GP085	48	05/02/02	12	=		
	A039GP085	48	05/02/02	11	=		
	A039GP086	10	05/01/02	29	=		
	A039GP086	27	05/01/02	190	=		
	A039GP087	10	05/02/02	26	=		
	A039GP087	27	05/02/02	120	=		
	A039GP088	48	05/02/02	220	=		
	A039GP091	32	05/29/02	165	=		
	A039GP091	46	05/29/02	9.3	=		
	A039GP092	32	05/29/02	3.3	J		
	A039GP092	42	05/29/02	5.3	=		
	A039GP094	27	07/24/02	81	=		
	A039GP095	27	07/25/02	220	=		
	A039GP095	10	07/25/02	2	J		
	A039GP095	48	07/25/02	390	=		
	A039GP096	10	07/25/02	580	=		
	A039GP096	27	07/25/02	0.96	J		
	A039GP096	46	07/25/02	0.78	J		
	A039GP097	27	07/29/02	10	=		
	A039GP097	27	07/29/02	11	=		
	A039GP098	44	07/29/02	8.1	=		
	A039GP099	27	07/30/02	4.2	J		
	A039GP101	10	07/30/02	0.69	J		
	A039GP104	27	07/31/02	0.75	J		
	A039GP105	10	07/31/02	2	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
cis-1,2-Dichloroethene	A039GP108	10	08/01/02	6.8	=	70	6.1
	A039GP108	27	08/01/02	1.2	J		
	A039GP111	27	08/01/02	20	=		
	A039GP111	44	08/01/02	3.3	J		
Ethylbenzene	A039GP091	32	05/29/02	0.93	J	700	130
	A039GP106	44	07/31/02	1	J		
	A039GP112	44	08/01/02	1.1	J		
m+p Xylene	A039GP091	32	05/29/02	1.7	J	NA	1,200
	A039GP112	44	08/01/02	2.2	J		
Methyl ethyl ketone (2-Butanone)	A039GP078	27	04/30/02	34	=	NA	190
	A039GP094	44	07/24/02	14	=		
	A039GP102	44	07/30/02	13	J		
Methylene Chloride	A039GP053	56	04/03/02	0.71	J	NA	4.1
o-Xylene	A039GP091	32	05/29/02	1.8	J	NA	1,200
	A039GP092	32	05/29/02	0.51	J		
	A039GP096	10	07/25/02	2.4	J		
PCE	A039GP057	27	04/17/02	1.6	J	5	1.1
	A039GP057	46	04/17/02	5.4	=		
	A039GP059	27	04/18/02	3.2	J		
	A039GP063	27	04/22/02	2.7	J		
	A039GP063	40	04/22/02	3.2	J		
	A039GP064	10	04/23/02	3.5	J		
	A039GP070	27	04/25/02	18	=		
	A039GP070	46	04/25/02	24	=		
	A039GP071	46	04/25/02	9	J		
	A039GP072	46	04/26/02	16	=		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (Hi=0.1) (µg/L)
PCE	A039GP073	27	04/26/02	10	=	5	1.1
	A039GP073	48	04/26/02	22	=		
	A039GP077	10	04/30/02	27	=		
	A039GP077	27	04/30/02	1.8	J		
	A039GP079	10	04/30/02	59	=		
	A039GP080	10	04/30/02	2.3	J		
	A039GP094	27	07/24/02	1.8	J		
	A039GP095	27	07/25/02	8.4	=		
	A039GP095	48	07/25/02	130	=		
	A039GP097	27	07/29/02	2.4	J		
	A039GP097	27	07/29/02	2.6	J		
Toluene	A039GP054	27	04/16/02	0.59	J	1,000	75
	A039GP073	27	04/26/02	0.53	J		
	A039GP076	27	04/30/02	1.8	J		
	A039GP076	48	04/30/02	0.92	J		
	A039GP085	27	05/02/02	0.62	J		
	A039GP091	32	05/29/02	3.9	J		
	A039GP092	32	05/29/02	0.43	J		
	A039GP093	42	05/29/02	0.46	J		
	A039GP100	46	07/30/02	0.59	J		
	A039GP105	44	07/31/02	0.54	J		
	A039GP106	27	07/31/02	0.57	J		
	A039GP106	44	07/31/02	1.7	J		
	A039GP107	27	07/31/02	1.1	J		
	A039GP107	44	07/31/02	1.2	J		
trans-1,2-Dichloroethene	A039GP049	32	04/02/02	11	=	100	12
	A039GP050	32	04/02/02	6.1	=		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1)
		Depth (ft bls)					(µg/L)
trans-1,2-Dichloroethene	A039GP054	10	04/16/02	0.91	J	100	12
	A039GP054	27	04/16/02	8.9	=		
	A039GP054	46	04/16/02	3.2	J		
	A039GP055	46	04/16/02	1.1	J		
	A039GP060	40	04/19/02	0.49	J		
	A039GP063	40	04/22/02	4.6	J		
	A039GP064	10	04/23/02	4.7	J		
	A039GP064	46	04/23/02	2.4	J		
	A039GP064	46	04/23/02	2.5	J		
	A039GP071	46	04/25/02	13	J		
	A039GP072	46	04/26/02	0.68	J		
	A039GP073	27	04/26/02	0.82	J		
	A039GP073	48	04/26/02	5.1	J		
	A039GP074	48	04/29/02	13	=		
	A039GP074	48	04/29/02	12	J		
	A039GP075	10	04/29/02	36	=		
	A039GP076	10	04/30/02	6	J		
	A039GP076	27	04/30/02	0.46	J		
	A039GP077	10	04/30/02	1.9	J		
	A039GP078	10	04/30/02	0.5	J		
	A039GP079	10	04/30/02	2.1	J		
	A039GP080	10	04/30/02	24	=		
	A039GP080	48	04/30/02	0.58	J		
	A039GP081	10	05/01/02	8.3	=		
	A039GP081	48	05/01/02	1	J		
	A039GP082	10	05/01/02	0.75	J		
	A039GP082	27	05/01/02	1.8	J		
	A039GP082	48	05/01/02	23	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
trans-1,2-Dichloroethene	A039GP082	10	05/01/02	0.6	J	100	12
	A039GP083	10	05/01/02	4.6	J		
	A039GP084	10	05/01/02	6.7	=		
	A039GP084	27	05/01/02	0.74	J		
	A039GP084	48	05/01/02	0.47	J		
	A039GP085	10	05/01/02	2	J		
	A039GP085	48	05/02/02	0.5	J		
	A039GP086	10	05/01/02	0.85	J		
	A039GP086	27	05/01/02	6.8	=		
	A039GP087	27	05/02/02	5	=		
	A039GP088	48	05/02/02	3.4	J		
	A039GP091	32	05/29/02	14.8	=		
	A039GP091	46	05/29/02	0.63	J		
	A039GP092	32	05/29/02	1.5	J		
	A039GP092	42	05/29/02	0.59	J		
	A039GP094	27	07/24/02	36	=		
	A039GP095	27	07/25/02	4.7	J		
	A039GP095	48	07/25/02	8.7	J		
	A039GP096	10	07/25/02	36	=		
	A039GP111	27	08/01/02	2.3	J		
TCE	A039GP048	34	04/01/02	0.48	J	5	1.6
	A039GP049	32	04/02/02	92	=		
	A039GP049	57	04/02/02	0.4	J		
	A039GP050	32	04/02/02	110	=		
	A039GP051	32	04/03/02	1.4	J		
	A039GP051	56	04/03/02	0.3	J		
	A039GP052	32	04/03/02	10	=		
	A039GP053	32	04/03/02	0.98	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
TCE	A039GP054	10	04/16/02	14	=	5	1.6
	A039GP054	27	04/16/02	110	=		
	A039GP054	46	04/16/02	100	=		
	A039GP055	27	04/16/02	5.1	=		
	A039GP055	46	04/16/02	16	=		
	A039GP057	27	04/17/02	2.6	J		
	A039GP057	46	04/17/02	4.8	J		
	A039GP058	27	04/17/02	0.42	J		
	A039GP059	27	04/18/02	2.6	J		
	A039GP059	46	04/18/02	2	J		
	A039GP060	40	04/19/02	3.4	J		
	A039GP063	27	04/22/02	1.3	J		
	A039GP063	40	04/22/02	15	=		
	A039GP064	10	04/23/02	5.2	=		
	A039GP064	46	04/23/02	130	=		
	A039GP064	46	04/23/02	130	=		
	A039GP066	48	04/23/02	0.9	J		
	A039GP069	46	04/25/02	1	J		
	A039GP070	27	04/25/02	7.4	=		
	A039GP070	46	04/25/02	9.3	=		
	A039GP071	27	04/25/02	7	=		
	A039GP071	46	04/25/02	340	=		
	A039GP071	27	04/25/02	7	=		
	A039GP072	27	04/26/02	5	=		
	A039GP072	46	04/26/02	170	=		
	A039GP073	27	04/26/02	7	=		
	A039GP073	48	04/26/02	74	=		
	A039GP074	48	04/29/02	280	=		
	A039GP074	48	04/29/02	280	=		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
 CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
TCE	A039GP075	10	04/29/02	0.81	J	5	1.6
	A039GP076	10	04/30/02	56	=		
	A039GP076	27	04/30/02	1.4	J		
	A039GP077	10	04/30/02	6.7	=		
	A039GP077	27	04/30/02	4.3	J		
	A039GP078	10	04/30/02	1.7	J		
	A039GP079	10	04/30/02	5.4	=		
	A039GP080	10	04/30/02	190	=		
	A039GP080	27	04/30/02	14	=		
	A039GP080	48	04/30/02	6.4	=		
	A039GP081	10	05/01/02	51	=		
	A039GP081	48	05/01/02	14	=		
	A039GP082	10	05/01/02	5.4	=		
	A039GP082	27	05/01/02	27	=		
	A039GP082	48	05/01/02	3	J		
	A039GP082	10	05/01/02	7.2	=		
	A039GP083	10	05/01/02	22	=		
	A039GP083	27	05/01/02	0.69	J		
	A039GP084	10	05/01/02	44	=		
	A039GP084	27	05/01/02	19	=		
	A039GP084	48	05/01/02	9.5	=		
	A039GP085	10	05/01/02	26	=		
	A039GP085	48	05/02/02	14	=		
	A039GP085	48	05/02/02	12	=		
	A039GP086	27	05/01/02	4.5	J		
	A039GP087	10	05/02/02	3.7	J		
	A039GP087	27	05/02/02	89	=		
	A039GP090	32	05/28/02	1.4	J		
	A039GP090	46	05/29/02	2.2	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
		Depth (ft bls)					
TCE	A039GP091	32	05/29/02	3.2	J	5	1.6
	A039GP091	46	05/29/02	2.2	J		
	A039GP092	32	05/29/02	0.68	J		
	A039GP092	42	05/29/02	1.2	J		
	A039GP093	42	05/29/02	0.72	J		
	A039GP094	27	07/24/02	220	=		
	A039GP095	27	07/25/02	70	=		
	A039GP095	48	07/25/02	120	=		
	A039GP097	27	07/29/02	4.1	J		
	A039GP097	27	07/29/02	4.2	J		
	A039GP098	44	07/29/02	5.5	=		
	A039GP105	27	07/31/02	1.1	J		
	A039GP111	27	08/01/02	51	=		
	A039GP111	44	08/01/02	0.71	J		
	Vinyl chloride	A039GP049	32	04/02/02	8.4		
A039GP050		32	04/02/02	3.4	J		
A039GP051		32	04/03/02	0.84	J		
A039GP054		10	04/16/02	1.5	J		
A039GP054		27	04/16/02	33	=		
A039GP054		46	04/16/02	5.8	J		
A039GP055		46	04/16/02	13	=		
A039GP056		10	04/17/02	1	J		
A039GP059		46	04/18/02	2.9	J		
A039GP060		40	04/19/02	3.4	J		
A039GP063		40	04/22/02	36	J		
A039GP064		10	04/23/02	30	J		
A039GP064		46	04/23/02	1.1	J		
A039GP064		46	04/23/02	1	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations
CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
Vinyl chloride	A039GP071	46	04/25/02	36	J	2	0.04
	A039GP073	27	04/26/02	1.8	J		
	A039GP073	48	04/26/02	22	=		
	A039GP074	48	04/29/02	53	=		
	A039GP074	48	04/29/02	58	J		
	A039GP075	10	04/29/02	310	=		
	A039GP075	27	04/29/02	1	J		
	A039GP076	10	04/30/02	60	J		
	A039GP076	27	04/30/02	1.2	J		
	A039GP077	10	04/30/02	15	=		
	A039GP077	27	04/30/02	8.9	J		
	A039GP078	10	04/30/02	7.6	J		
	A039GP079	10	04/30/02	14	=		
	A039GP080	10	04/30/02	67	=		
	A039GP080	48	04/30/02	1.9	J		
	A039GP081	10	05/01/02	33	=		
	A039GP082	10	05/01/02	1.2	J		
	A039GP082	27	05/01/02	2.8	J		
	A039GP082	48	05/01/02	64	J		
	A039GP082	10	05/01/02	2.4	J		
	A039GP083	10	05/01/02	43	=		
	A039GP083	27	05/01/02	1.8	J		
	A039GP084	10	05/01/02	19	=		
	A039GP085	10	05/01/02	3.8	J		
	A039GP086	10	05/01/02	7.4	J		
	A039GP086	27	05/01/02	65	=		
	A039GP087	10	05/02/02	1.1	J		
	A039GP087	27	05/02/02	3.6	J		
	A039GP088	48	05/02/02	1.9	J		

APPENDIX B

Analytes Detected in Groundwater – April/May and July/August 2002 Investigations

CMS Report, SWMU 39, Zone A, Charleston Naval Complex

Analyte	Sample Location	Sample Collection Termination Depth (ft bls)	Date Collected	Concentration (µg/L)	Qualifier	MCL (µg/L)	EPA Region III Tap Water RBC (HI=0.1) (µg/L)
Vinyl chloride	A039GP091	32	05/29/02	6	J	2	0.04
	A039GP092	32	05/29/02	8.7	J		
	A039GP092	42	05/29/02	2.7	J		
	A039GP094	27	07/24/02	40	=		
	A039GP095	27	07/25/02	25	=		
	A039GP095	48	07/25/02	50	=		
	A039GP096	10	07/25/02	420	=		
	A039GP098	44	07/29/02	0.63	J		
	A039GP105	10	07/31/02	0.69	J		
	A039GP108	10	08/01/02	1.7	J		
	A039GP111	27	08/01/02	1.5	J		
Xylenes, Total	A039GP091	32	05/29/02	3.4	J	10,000	1,200
	A039GP092	32	05/29/02	0.51	J		
	A039GP096	10	07/25/02	2.4	J		
	A039GP112	44	08/01/02	2.2	J		

^a MCL for total trihalomethanes (TTHMs) is 80 µg/L.

MCL - Maximum Contaminant Level

HI - Hazard Index

µg/L - micrograms per liter

= - The analyte was detected at the concentration shown.

J - Indicates an estimated value. A "J" qualifier may signify that the concentration is below the PQL, or that the "J" has been applied as a result of data validation.

NA - Screening criteria not available for the referenced compound.

COMPARISON OF TOTAL COST OF REMEDIAL SOLUTIONS
Source Control Alternatives

Site:	Charleston Naval Complex	Base Year:	2002
Location:	SWMU 39	Date:	09/01/02
Phase:	Corrective Measures Study		

	Alternative Number 1 In-Situ Chemical Oxidation Using Fenton's Reagent	Alternative Number 2 In-Situ Chemical Reduction Using Zero Valent Iron
Total Project Duration (Years)	20	20
Capital Cost	\$108,200	\$109,600
Annual O&M Cost (Years 1 through 20)	\$11,000	\$12,000
Total Present Worth of Solution	\$269,000	\$285,000

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This is an order-of-magnitude cost estimate that is expected to be within -30 to +50 percent of the actual project costs.

Alternative 1: In-Situ Chemical Oxidation Using Fenton's Reagent		COST ESTIMATE SUMMARY				
Site:	Charleston Naval Complex	Description:	In-situ chemical oxidation using Fenton's reagent in the source control area in the deep interval of the surficial aquifer.			
Location:	SWMU 39					
Phase:	Corrective Measures Study					
Base Year:	2002					
Date:	09/01/02					
CAPITAL COSTS						
	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
	Baseline Groundwater Sample Collection Event	1	EA	\$4,400	\$4,400	Sample 4 Existing and 2 Proposed Monitoring Wells for VOCs Two Deep Monitoring Wells @ 50 ft deep
	Monitoring Well Installation	1	EA	\$7,300	\$7,300	
	SUBTOTAL				\$11,700	
	In-Situ Chemical Oxidation Subcontractor Costs					
	Project Design	1	EA	\$9,000	\$9,000	
	Injector Fabrication / Installation	3	EA	\$800	\$2,400	Assume 20 ft radius @ depth of 55 ft Assume 10-Hour Work Days - Labor and Materials and Injection of 500 gals/day
	On Site Reagent Injection	2	Day	\$6,250	\$12,500	
	Reagents	9,000	LB	\$0.5	\$4,500	Assume 300 gals/injection point @ 10 lbs./gal.
	Project Documentation	1	EA	\$8,000	\$8,000	
	Mobilization / Demobilization	1	EA	\$15,000	\$15,000	
	SUBCONTRACTOR SUBTOTAL				\$51,400	
	Polish Treatment	2	EA	\$12,850	\$25,700	Assumed two polish treatments within one year following initial injection @ 25% of total Subcontractor Subtotal
	SUBTOTAL				\$88,800	
	Project Management	1%	of	\$88,800	\$888	
	Technical Support	2%	of	\$88,800	\$1,776	
	Construction Management	2%	of	\$88,800	\$1,776	
	Subcontractor General Requirements	1%	of	\$88,800	\$888	
	SUBTOTAL				\$94,128	
	Contingency	15%	of	\$94,128	\$14,119	
	TOTAL CAPITAL COST				\$108,200	
OPERATIONS AND MAINTENANCE COST						
	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
	Annual Groundwater Sample Collection Event	1	EA	\$4,400	\$4,400	
	Annual Report					
	Labor - Project Manager	12	HR	\$125	\$1,500	
	Labor - Engineer/Hydrogeologist	32	HR	\$90	\$2,880	
	Labor - Editor	12	HR	\$65	\$780	
	Labor - CAD Technician	24	HR	\$65	\$1,560	
	SUBTOTAL				\$11,120	
	TOTAL ANNUAL O&M COST				\$11,000	
PRESENT VALUE ANALYSIS						
				Discount Rate =	3.2%	
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT WORTH	NOTES	
1	FIRST YEAR CAPITAL COST	\$108,200	\$108,200	\$108,200		
1-20	ANNUAL O&M COST (Year 1 through 20)	\$11,000	\$11,000	\$160,667	Annual Sampling Event	
				\$268,867		
	TOTAL PRESENT WORTH OF ALTERNATIVE			\$269,000		
SOURCE INFORMATION						
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).						

Alternative 2: In-Situ Chemical Reduction Using Zero Valent Iron		COST ESTIMATE SUMMARY				
Site:	Charleston Naval Complex	Description: In-situ chemical reduction using zero valent iron in the source control area in the deep interval of the surficial aquifer.				
Location:	SWMU 39					
Phase:	Corrective Measures Study					
Base Year:	2002					
Date:	09/01/02					
CAPITAL COSTS						
	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
	Baseline Groundwater Sample Collection Event	1	EA	\$4,400	\$4,400	Sample 4 Existing and 2 Proposed Monitoring Wells for VOCs
	Baseline Groundwater Sample Collection Event - Hydrogen Analysis	6	EA	\$100	\$600	
	Monitoring Well Installation	1	EA	\$7,300	\$7,300	Two Deep Monitoring Wells @ 50 ft deep
	SUBTOTAL				\$12,300	
	In-Situ Chemical Reduction Subcontractor Costs					Estimate Provided by ARS Technologies, Inc.
	Project Planning and Design, Injection Implementation Plan, Health and Safety Plan Addendum	1	EA	\$9,000	\$9,000	
	Structural Analysis and Modeling of Buildings Within the Target Treatment Area	1	EA	\$15,000	\$15,000	
	Mobilization / Demobilization	1	EA	\$10,500	\$10,500	Includes Freight for ZVI
	Field Implementation	1	EA	\$21,150	\$21,150	3 Injection Points
	Material Costs - Zero Valent Iron	4,500	LB	\$1.7	\$7,650	Injector Installation
	Material Costs - Nitrogen	1	EA	\$6,120	\$6,120	Subcontractor, Equipment and Labor
	NIJT Royalty - Injection Technology	1	EA	\$1,200	\$1,200	\$100/injection
	Injection Summary Report	1	EA	\$7,000	\$7,000	
	SUBCONTRACTOR SUBTOTAL				\$77,620	
	SUBTOTAL				\$89,820	
	Project Management	1%	of	\$89,820	\$899	
	Technical Support	2%	of	\$89,820	\$1,798	
	Construction Management	2%	of	\$89,820	\$1,798	
	Subcontractor General Requirements	1%	of	\$89,820	\$899	
	SUBTOTAL				\$95,315	
	Contingency	15%	of	\$95,315	\$14,297	
	TOTAL CAPITAL COST				\$109,600	
OPERATIONS AND MAINTENANCE COST						
	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
	Annual Groundwater Sample Collection Event	1	EA	\$4,400	\$4,400	
	Annual Groundwater Sample Collection Event Additional Analysis - Hydrogen	6	EA	\$100	\$600	
	Annual Report	12	HR	\$125	\$1,500	
	Labor - Project Manager	32	HR	\$90	\$2,880	
	Labor - Engineer/Hydrogeologist	12	HR	\$65	\$780	
	Labor - Editor	24	HR	\$65	\$1,560	
	Labor - CAD Technician					
	SUBTOTAL				\$11,720	
	TOTAL ANNUAL O&M COST				\$12,000	
PRESENT VALUE ANALYSIS						
			Discount Rate =	3.2%		
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT WORTH	NOTES	
1	FIRST YEAR CAPITAL COST	\$109,600	\$109,600	\$109,600		
1-20	ANNUAL O&M COST (Year 1 through 20)	\$12,000	\$12,000	\$175,273	Annual Sampling Event	
				\$284,873		
	TOTAL PRESENT WORTH OF ALTERNATIVE			\$285,000		
SOURCE INFORMATION						
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).						

**COMPARISON OF TOTAL COST OF REMEDIAL SOLUTIONS
Downgradient Contaminant Migration Control Alternatives**

Site:	Charleston Naval Complex	Base Year:	2002
Location:	SWMU 39	Date:	09/01/02
Phase:	Corrective Measures Study		

	Alternative Number 1 Monitoring/ Natural Attenuation	Alternative Number 2 In-Situ Air Sparging/ Biosparging	Alternative Number 3 Enhanced Anaerobic Bioremediation using HRC[®]
Total Project Duration (Years)	20	20	20
Capital Cost	\$28,100	\$437,700	\$141,600
Annual O&M Cost	\$16,000 (Year 1 - 20)	\$35,000 (Year 1 - 5) \$16,800 (Year 6 - 20)	\$87,000 (Year 1 - 20)
Total Present Worth of Solution	\$262,000	\$766,000	\$1,412,000

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This is an order-of-magnitude cost estimate that is expected to be within -30 to +50 percent of the actual project costs.

Alternative 1: Monitoring/Natural Attenuation		COST ESTIMATE SUMMARY				
Site:	Charleston Naval Complex	Description: Monitoring/natural attenuation of the surficial aquifer.				
Location:	SWMU 39					
Phase:	Corrective Measures Study					
Base Year:	2002					
Date:	09/01/02					
CAPITAL COSTS						
	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
	Monitoring Well Installation	1	EA	\$0	\$0	No Monitoring Well Installation - Use Existing Network
	Monitoring/Natural Attenuation Work Plan					
	Groundwater Contingency Plan					
	Labor - Project Manager	12	HR	\$125	\$1,500	
	Labor - Engineer/Hydrogeologist	40	HR	\$90	\$3,600	
	Labor - Editor	16	HR	\$65	\$1,040	
	Labor - CAD Technician	16	HR	\$65	\$1,040	
	Monitoring/Natural Attenuation Groundwater Sample Collection Event	1	EA	\$14,100	\$14,100	Sample 8 Existing and 10 Proposed Monitoring Wells
	SUBTOTAL				\$21,280	
	Project Management	5%	of	\$21,280	\$1,064	
	Technical Support	5%	of	\$21,280	\$1,064	
	Construction Management	0%	of	\$21,280	\$0	
	Subcontractor General Requirements	5%	of	\$21,280	\$1,064	
	SUBTOTAL				\$24,472	
	Contingency	15%	of	\$24,472	\$3,671	
	TOTAL CAPITAL COST				\$28,100	
OPERATIONS AND MAINTENANCE COST						
	DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
	Annual Groundwater Sample Collection Event	1	EA	\$9,100	\$9,100	Sample cost without Dehalococcoides Ethenogenes analysis
	Annual Report					
	Labor - Project Manager	12	HR	\$125	\$1,500	
	Labor - Engineer/Hydrogeologist	32	HR	\$90	\$2,880	
	Labor - Editor	12	HR	\$65	\$780	
	Labor - CAD Technician	24	HR	\$65	\$1,560	
	SUBTOTAL				\$15,820	
	TOTAL ANNUAL O&M COST				\$16,000	
PRESENT VALUE ANALYSIS						
		Discount Rate =		3.2%		
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT WORTH	NOTES	
1	FIRST YEAR CAPITAL COST	\$28,100	\$28,100	\$28,100		
1 - 20	ANNUAL O&M COST (Year 1 - 20)	\$16,000	\$16,000	\$233,697	Annual Sampling	
	TOTAL PRESENT WORTH OF ALTERNATIVE			\$261,797		
				\$282,000		
SOURCE INFORMATION						
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).						

Alternative 2: In-Situ Air Sparging/Biosparging		COST ESTIMATE SUMMARY				
Site:	Charleston Naval Complex	Description:				
Location:	SWMU 39	Air sparging in three downgradient contaminant migration control areas in the intermediate and deep intervals of the surficial aquifer				
Phase:	Corrective Measures Study					
Base Year:	2002					
Date:	08/01/02					
CAPITAL COSTS						
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES	
Baseline Groundwater Sample Collection Event	1	EA	\$10,500	\$10,500	Sample 8 Existing and 10 Proposed Monitoring Wells	
Monitoring Well Installation	1	EA	\$25,600	\$25,600	Four Intermediate Wells @ 30 ft Deep and Six Deep Wells @ 50 ft deep	
SUBTOTAL				\$36,100		
Installation of Air Sparge System						
Installation of Air Sparge Wells	31	EA	\$2,750	\$85,250	Assume 55 ft Deep @ \$50/ft on 25-foot Centers	
Excavate/Fill for Air Sparge Pipe Trenching Areas (1,800 ft x 2 ft x 3 ft) (Includes Backfill Material, Compaction, and other Materials)	13	Day	\$1,500	\$19,500	Assume 130 ft/day. Four Person Crew with Excavator, Pickup Truck, and Compactor	
Air Sparge Pipe (HDPE - Air Pro)	1,800	FT	\$5	\$9,000		
Air Sparge Pipe Fittings and Valves (90, Tee, 45, Ball Valves, Reducers)	1	EA	\$21,800	\$21,800	Assume 65 ft/day. Three Person Crew with Misc. Hand Tools	
Install Air Sparge Pipe	24	Day	\$850	\$15,600	Assume Non-Hazardous Waste	
Transportation and Disposal of Well Cuttings (Air Sparge Wells and Pipe Trenching)	550	Ton	\$35	\$19,250	Assume Two Air Sparge Systems	
Air Sparge System (Includes Building)	2	EA	\$25,000	\$50,000		
Air Sparge System Instrumentation (Includes Flow Meters, Regulators, Gauges)	2	EA	\$1,000	\$2,000		
Air Sparge Well Manways	31	EA	\$500	\$15,500		
Install Air Sparge System, Instrumentation, and Manways	39	Day	\$800	\$35,100	Assume 40 Days for Manway Installation. Four Person Crew with Misc. Hand Tools and Concrete Vibrator	
Site Restoration	1	EA	\$2,500	\$2,500	Includes Labor and Materials	
Install Concrete Pad for Air Sparge System	2	EA	\$1,500	\$3,000	Includes Labor and Materials	
Install Control Panel	2	EA	\$19,500	\$39,000	Install Control Panel, Conduit, Wiring, and System Connections	
SUBCONTRACTOR SUBTOTAL				\$318,300		
SUBTOTAL				\$352,400		
Project Management	2%	of	\$352,400	\$7,048		
Remedial Design	2%	of	\$352,400	\$7,048		
Construction Management	2%	of	\$352,400	\$7,048		
Subcontractor General Requirements	2%	of	\$352,400	\$7,048		
SUBTOTAL				\$380,592		
Contingency	15%	of	\$380,592	\$57,089		
TOTAL CAPITAL COST				\$437,700		
OPERATIONS AND MAINTENANCE COST						
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES	
Annual Groundwater Sample Collection Event	1	EA	\$10,500	\$10,500	Sample 8 Existing and 8 Proposed Monitoring Wells	
Electrical	1	EA	\$2,800	\$2,800	Electricity Costs	
Labor - O&M Technician	240	HR	\$65	\$15,600	Assume 20 hrs/month	
Annual Report						
Labor - Project Manager	12	HR	\$125	\$1,500		
Labor - Engineer/Hydrogeologist	32	HR	\$80	\$2,560		
Labor - Editor	12	HR	\$65	\$780		
Labor - CAD Technician	24	HR	\$66	\$1,584		
SUBTOTAL - Annual Report				\$38,424		
TOTAL ANNUAL O&M COST				\$38,900		
PRESENT VALUE ANALYSIS						
			Discount Rate =	3.2%		
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT VALUE	NOTES	
1	FIRST YEAR CAPITAL COST	\$437,700	\$437,700	\$437,700		
1-5	ANNUAL O&M COST (Year 1 - 5)	\$38,900	\$38,900	\$328,258	Annual Sampling Yrs 1-20	
6-20	ANNUAL O&M COST (Year 6 - 20)	\$18,800	\$18,800	\$76,599	Assume 5 Yr System Operation	
TOTAL PRESENT WORTH OF ALTERNATIVE				\$786,000		
SOURCE INFORMATION						
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000)						

Alternative 3: Enhanced Anaerobic Bioremediation using HRC®		COST ESTIMATE SUMMARY			
Site:	Charleston Naval Complex	Description: Enhanced anaerobic biodegradation using HRC® in three downgradient control areas in the intermediate and deep intervals of the surficial aquifer.			
Location:	SWMU 39				
Phase:	Corrective Measure Study				
Base Year:	2002				
Date:	09/01/02				
CAPITAL COSTS					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Baseline Groundwater Sample Collection Event	1	EA	\$10,500	\$10,500	Sample 8 Existing and 10 Proposed Monitoring Wells
Baseline Groundwater Sample Collection Event - Methane, Ethane, and Ethane Analysis	18	EA	\$135	\$2,430	
Baseline Groundwater Sample Collection Event - Hydrogen Analysis	18	EA	\$100	\$1,800	
Monitoring Well Installation	1	EA	\$25,600	\$25,600	Four Intermediate Wells @ 30 ft Deep and Six Deep Wells @ 50 ft deep
SUBTOTAL				\$40,330	
Enhanced Bioremediation Subcontractor Costs	1	EA	\$0	\$0	Provided with purchase of HRC Assume 58 Injection Points on 13-ft Centers Assume Injection of 3 lbs/vertical foot, with HRC Injection from 25 to 50 ft bte Assume 32 lbs/5 gallon Bucket for Total of 258 Buckets
HRC Material Costs	4,350	LB	\$7	\$30,450	
HRC Shipping Costs	136	EA	\$11	\$1,496	
Injection Grout Pump	15	Day	\$150	\$2,250	
Injection Subcontractor Costs	1	EA	\$2,000	\$2,000	
Mobilization / Demobilization	1	EA	\$2,000	\$2,000	
On Site Injection	15	Day	\$2,500	\$37,500	Direct Push Technology: 10-Hour Work Days - Labor and Materials
SUBCONTRACTOR SUBTOTAL				\$73,696	
SUBTOTAL				\$114,026	
Project Management	2%	of	\$114,026	\$2,281	
Technical Support	2%	of	\$114,026	\$2,281	
Construction Management	2%	of	\$114,026	\$2,281	
Subcontractor General Requirements	2%	of	\$114,026	\$2,281	
SUBTOTAL				\$123,148	
Contingency	15%	of	\$123,148	\$18,472	
TOTAL CAPITAL COST				\$141,600	
OPERATIONS AND MAINTENANCE COST					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual Groundwater Sample Collection Event	1	EA	\$10,500	\$10,500	Sample 8 Existing and 10 Proposed Monitoring Wells
Annual Groundwater Sample Collection Event - Methane, Ethane, and Ethane Analysis	18	EA	\$135	\$2,430	
Annual Groundwater Sample Collection Event - Hydrogen Analysis	18	EA	\$100	\$1,800	
Annual Report	22	HR	\$125	\$2,750	
Labor - Project Manager	96	HR	\$30	\$2,880	
Labor - Engineer/Hydrogeologist	22	HR	\$65	\$1,430	
Labor - CAD Technician	42	HR	\$65	\$2,730	
SUBTOTAL				\$27,580	
Polish Treatment	80%	of	\$73,696	\$58,957	Yearly ReInjection
TOTAL ANNUAL O&M COST				\$87,000	
PRESENT VALUE ANALYSIS					
			Discount Rate =	3.2%	
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT WORTH	NOTES
1	FIRST YEAR CAPITAL COST	\$141,600	\$141,600	\$141,600	
1 - 20	ANNUAL O&M COST (Year 1 - 20)	\$87,000	\$87,000	\$1,270,727	Annual Sampling Yrs. 1 - 20 Yearly ReInjection
				\$1,412,327	
TOTAL PRESENT VALUE OF ALTERNATIVE				\$1,412,000	
SOURCE INFORMATION					
1 United States Environmental Protection Agency July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002 (USEPA, 2000)					

COMPARISON OF TOTAL COST OF REMEDIAL SOLUTIONS					
Property Boundary Contaminant Migration Control Alternatives					
Site:	Charleston Naval Complex	Base Year:	2002		
Location:	SWMU 39	Date:	09/01/02		
Phase:	Corrective Measures Study				
	Alternative Number 1	Alternative Number 2	Alternative Number 3	Alternative Number 4	Alternative Number 5
	Monitoring/ Natural Attenuation	In-Situ Chemical Reduction Using Zero Valent Iron	Permeable Reactive Barrier Wall	In-Situ Air Sparging	Enhanced Anaerobic Bioremediation using HRC®
Total Project Duration (Years)	20	20	20	20	20
Capital Cost	\$27,900	\$164,400	\$679,100	\$135,100	\$79,300
Annual O&M Cost	\$16,000 (Year 1 - 20)	\$15,000 (Year 1 - 20)	\$13,000 (Year 1 - 20)	\$31,000 (Year 1 - 5) \$12,800 (Year 6 - 20)	\$55,000 (Year 1 - 20)
Total Present Worth of Solution	\$262,000	\$383,000	\$869,000	\$405,000	\$883,000
<p><small>Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternative. This is an order of magnitude cost estimate that is expected to be within -30 to +50 percent of the actual project costs.</small></p>					

Alternative 1: Monitoring/Natural Attenuation		COST ESTIMATE SUMMARY				
Site:	Charleston Naval Complex	Description: Monitoring/natural attenuation of the surficial aquifer.				
Location:	SWMU 39					
Phase:	Corrective Measures Study					
Base Year:	2002					
Date:	09/01/02					
CAPITAL COSTS						
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES	
Monitoring Well Installation	1	EA	\$0	\$0	No Monitoring Well Installation - Use Existing Network	
Monitoring/Natural Attenuation Work Plan						
Groundwater Contingency Plan						
Labor - Project Manager	12	HR	\$125	\$1,500		
Labor - Engineer/Hydrogeologist	40	HR	\$90	\$3,600		
Labor - Editor	16	HR	\$65	\$1,040		
Labor - CAD Technician	16	HR	\$65	\$1,040		
Initial Monitoring/Natural Attenuation Groundwater Sample Collection Event	1	EA	\$13,900	\$13,900	Sample 8 Existing and 6 Proposed Monitoring Wells	
SUBTOTAL				\$21,080		
Project Management	5%	of	\$21,080	\$1,054		
Technical Support	5%	of	\$21,080	\$1,054		
Construction Management	0%	of	\$21,080	\$0		
Subcontractor General Requirements	5%	of	\$21,080	\$1,054		
SUBTOTAL				\$24,242		
Contingency	15%	of	\$24,242	\$3,636		
TOTAL CAPITAL COST				\$27,900		
OPERATIONS AND MAINTENANCE COST						
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES	
Annual Groundwater Sample Collection Event	1	EA	\$8,900	\$8,900	Sample cost without <i>Dehalococcoides</i> <i>Ethenogenes</i> analysis	
Annual Report						
Labor - Project Manager	12	HR	\$125	\$1,500		
Labor - Engineer/Hydrogeologist	32	HR	\$90	\$2,880		
Labor - Editor	12	HR	\$65	\$780		
Labor - CAD Technician	24	HR	\$65	\$1,560		
SUBTOTAL				\$15,620		
TOTAL ANNUAL O&M COST				\$16,000		
PRESENT VALUE ANALYSIS						
			Discount Rate =	3.2%		
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT WORTH	NOTES	
1	FIRST YEAR CAPITAL COST	\$27,900	\$27,900	\$27,900		
1 - 20	ANNUAL O&M COST (Year 1 - 20)	\$16,000	\$16,000	\$233,697	Annual Sampling Event	
				\$261,597		
TOTAL PRESENT WORTH OF ALTERNATIVE				\$262,000		
SOURCE INFORMATION						
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).						

Alternative 2: In-Situ Chemical Reduction Using Zero Valent Iron		COST ESTIMATE SUMMARY			
Site:	Charleston Naval Complex	Description: In-situ chemical reduction using zero valent iron at the property boundary in the intermediate and deep intervals of the surficial aquifer.			
Location:	SWMU 39				
Phase:	Corrective Measures Study				
Base Year:	2002				
Date:	09/01/02				
CAPITAL COSTS					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Baseline Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample 8 Existing and 6 Proposed Monitoring Wells
Baseline Groundwater Sample Collection Event - Hydrogen Analysis	14	EA	\$100	\$1,400	
Monitoring Well Installation	1	EA	\$15,000	\$15,000	Three Intermediate Wells @ 30 ft Deep and Three Deep Wells @ 50 ft deep
SUBTOTAL				\$22,800	
In-Situ Chemical Reduction Subcontractor Costs Estimate Provided by ARS Technologies, Inc.					
Project Planning and Design, Injection Implementation Plan, Health and Safety Plan Addendum	1	EA	\$13,000	\$13,000	
Mobilization / Demobilization	1	EA	\$14,500	\$14,500	
Field Implementation	1	EA	\$44,100	\$44,100	5 Injection Points on 20 ft Centers, Injector Installation Subcontractor, Equipment and Labor
Material Costs - Zero Valent Iron	8,700	LB	\$1.7	\$14,790	
Material Costs - Nitrogen	1	EA	\$11,900	\$11,900	
NJIT Royalty - Injection Technology	1	EA	\$1,800	\$1,800	
Injection Summary Report	1	EA	\$12,000	\$12,000	
SUBCONTRACTOR SUBTOTAL				\$112,090	
SUBTOTAL				\$134,890	
Project Management	1%	of	\$134,890	\$1,349	
Technical Support	2%	of	\$134,890	\$2,698	
Construction Management	2%	of	\$134,890	\$2,698	
Subcontractor General Requirements	1%	of	\$134,890	\$1,349	
SUBTOTAL				\$142,883	
Contingency	15%	of	\$142,983	\$21,448	
TOTAL CAPITAL COST				\$164,400	
OPERATIONS AND MAINTENANCE COST					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample 8 Existing and 6 Proposed Monitoring Wells
Annual Groundwater Sample Collection Event Additional Analysis - Hydrogen	14	EA	\$100	\$1,400	
Annual Report					
Labor - Project Manager	12	HR	\$125	\$1,500	
Labor - Engineer/Hydrogeologist	32	HR	\$90	\$2,880	
Labor - Editor	12	HR	\$65	\$780	
Labor - CAD Technician	24	HR	\$65	\$1,560	
SUBTOTAL				\$14,520	
TOTAL ANNUAL O&M COST				\$15,000	
PRESENT VALUE ANALYSIS					
			Discount Rate =	3.2%	
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT WORTH	NOTES
1	FIRST YEAR CAPITAL COST	\$164,400	\$164,400	\$164,400	
1 - 20	ANNUAL O&M COST (Year 1 - 20)	\$15,000	\$15,000	\$219,091	Annual Sampling Event
TOTAL PRESENT WORTH OF ALTERNATIVE				\$383,491	
SOURCE INFORMATION					
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000)					

Alternative 3: Permeable Reactive Barrier Wall		COST ESTIMATE SUMMARY			
Site:	Charleston Naval Complex	Description: Installation of a permeable reactive barrier wall at the property boundary in the intermediate and deep intervals of the surficial aquifer.			
Location:	SWMU 39				
Phase:	Corrective Measures Study				
Base Year:	2002				
Date:	09/01/02				
CAPITAL COSTS					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Baseline Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample 8 Existing and 6 Proposed Monitoring Wells Three Intermediate Wells @ 30 ft Deep and Three Deep Wells @ 50 ft deep
Monitoring Well Installation	1	EA	\$15,000	\$15,000	
SUBTOTAL				\$21,400	
Installation of Permeable Reactive Barrier Continuous Reactive Cell Configuration					
Pre-design - Bench Scale Column Test	1	EA	\$70,000	\$70,000	
Pre-design - Groundwater Flow Modeling	1	EA	\$50,000	\$50,000	
Mobilization / Demobilization	1	EA	\$20,000	\$20,000	
Emplacement Technique - Biopolymer Slurry (100 ft x 50 ft x 2.5 ft)	1	EA	\$63,650	\$63,650	Source Information No. 2
Transportation and Disposal of Soil Excavated from Continuous Reactive Cell	625	Ton	\$35	\$21,875	Assumes Non-Hazardous Waste
Granular Iron (100 ft x 47 ft x 2.5 ft x 140 lbs/cf / 2,000 lbs/ton)	825	Ton	\$350	\$288,750	Source Information No. 3 (Granular Iron Will Be Placed from 3 to 50 ft bls)
Pea Gravel (100 ft x 1 ft x 2.5 ft)	10	CY	\$65	\$650	12-inch Layer Between Granular Iron and Backfill
Backfill Site Soil (100 ft x 2 ft x 2.5 ft)	19	CY	\$10	\$190	
Grading and Restoration	0.02	Ac	\$15,000	\$300	
SUBCONTRACTOR SUBTOTAL				\$515,415	
SUBTOTAL				\$536,815	
Project Management	2%	of	\$536,815	\$10,736	
Remedial Design	4%	of	\$536,815	\$21,473	
Construction Management	2%	of	\$536,815	\$10,736	
Subcontractor General Requirements	2%	of	\$536,815	\$10,736	
SUBTOTAL				\$590,497	
Contingency	15%	of	\$590,497	\$88,574	
TOTAL CAPITAL COST				\$679,100	
OPERATIONS AND MAINTENANCE COST					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample 8 Existing and 6 Proposed Monitoring Wells
Annual Report					
Labor - Project Manager	12	HR	\$125	\$1,500	
Labor - Engineer/Hydrogeologist	32	HR	\$90	\$2,880	
Labor - Editor	12	HR	\$65	\$780	
Labor - CAD Technician	24	HR	\$85	\$1,560	
SUBTOTAL				\$13,120	
TOTAL ANNUAL O&M COST				\$13,120	
PRESENT VALUE ANALYSIS					
			Discount Rate =	3.2%	
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT VALUE	NOTES
1	FIRST YEAR CAPITAL COST	\$679,100	\$679,100	\$679,100	
1 - 20	ANNUAL O&M COST (Year 1 - 20)	\$13,000	\$13,000	\$189,879	Annual Sampling Event
				\$868,979	
TOTAL PRESENT WORTH OF ALTERNATIVE				\$868,000	
SOURCE INFORMATION					
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).					
2. Cost Estimate from Marzone Superfund Site Modified Based on SWMU 39 Site Conditions.					
3. Gavaskar, Arun R., et al. Permeable Barriers for Groundwater Remediation. Design, Construction, and Monitoring. Battelle Press, Columbus, Ohio. 1998.					

Alternative 4: In-Situ Air Sparging		COST ESTIMATE SUMMARY			
Site:	Charleston Naval Complex	Description: Air sparging at the property boundary in the intermediate and deep intervals of the surficial aquifer			
Location:	SWMU 39				
Phase:	Corrective Measures Study				
Base Year:	2002				
Date:	08/01/02				
CAPITAL COSTS					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Baseline Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample 8 Existing and 6 Proposed Monitoring Wells Three Intermediate Wells @ 30 ft Deep and Three Deep Wells @ 50 ft deep
Monitoring Well Installation	1	EA	\$15,000	\$15,000	
SUBTOTAL				\$21,400	
Installation of Air Sparge System					
Installation of Air Sparge Wells	8	EA	\$2,750	\$22,000	Assume 45 ft Deep @ 550ft on 15 ft Centers Assume 130 ft/day Four Person Crew with Excavator, Pickup Truck, and Compactor
Excavate/Fill for Air Sparge Pipe Trenching Area (200 ft x 2 ft x 3 ft) (Includes Bedding Material, Compaction, and other Materials)	2	Day	\$1,500	\$3,000	
Air Sparge Pipe (HDPE - Air Pro)	200	FT	\$5	\$1,000	
Air Sparge Pipe Fittings and Valves (90, Tee, 45, Ball Valves, Reducers)	1	EA	\$2,000	\$2,000	Assume 68 ft/day Three Person Crew with Misc. Hand Tools Assume Non-Hazardous Waste
Install Air Sparge Pipe	3	Day	\$650	\$1,950	
Transportation and Disposal of Well Cuttings (Air Sparge Wells and Pipe Trench)	55	Ton	\$35	\$1,925	
Air Sparge System (Includes Bunking)	1	EA	\$20,000	\$20,000	
Air Sparge System Instrumentation (Includes Flow Meters, Regulators, Gauges)	1	EA	\$1,000	\$1,000	
Air Sparge Well Manways	8	EA	\$500	\$4,000	
Install Air Sparge System, Instrumentation, and Manways	10	Day	\$900	\$9,000	Assume 10 Days for Manway Installation, Four Person Crew with Misc. Hand Tools and Concrete Vibrator
Site Restoration	1	EA	\$500	\$500	Includes Labor and Materials
Install Concrete Pad for Air Sparge System	1	EA	\$1,500	\$1,500	Includes Labor and Materials Install Control Panel, Conduit, Wiring, and System Connections
Install Control Panel	1	EA	\$19,500	\$19,500	
SUBCONTRACTOR SUBTOTAL				\$87,375	
SUBTOTAL				\$108,775	
Project Management	2%	of	\$108,775	\$2,176	
Remedial Design	2%	of	\$108,775	\$2,176	
Construction Management	2%	of	\$108,775	\$2,176	
Subcontractor General Requirements	2%	of	\$108,775	\$2,176	
SUBTOTAL				\$117,477	
Contingency	15%	of	\$117,477	\$17,822	
TOTAL CAPITAL COST				\$135,100	
OPERATIONS AND MAINTENANCE COST					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample 8 Existing and 6 Proposed Monitoring Wells Electricity Costs Assume 20 hrs/month
Electrical	1	EA	\$2,600	\$2,600	
Labor - O&M Technician	240	HR	\$65	\$15,600	
Annual Report					
Labor - Project Manager	12	HR	\$125	\$1,500	
Labor - Engineer/Hydrogeologist	32	HR	\$90	\$2,880	
Labor - Editor	12	HR	\$65	\$780	
Labor - CAD Technician	24	HR	\$65	\$1,560	
SUBTOTAL - Annual Report				\$31,320	
TOTAL ANNUAL O&M COST				\$31,000	
PRESENT VALUE ANALYSIS					
		Discount Rate =		3.2%	
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT VALUE	NOTES
1	FIRST YEAR CAPITAL COST	\$135,100	\$135,100	\$135,100	
1-5	ANNUAL O&M COST (Year 1 - 5)	\$31,000	\$31,000	\$289,834	Annual Sampling Yrs 1-20 Assume 5 Yr System Operation
6-20	ANNUAL O&M COST (Year 6 - 20)	\$12,800	\$12,800	\$404,834	
TOTAL PRESENT WORTH OF ALTERNATIVE				\$405,000	
SOURCE INFORMATION					
1 United States Environmental Protection Agency July 2000 A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study EPA 540-R-00-002 (USEPA, 2000).					

Alternative 3: Enhanced Anaerobic Bioremediation using HRC [®]		COST ESTIMATE SUMMARY			
Site:	Charleston Naval Complex	Description: Enhanced anaerobic biodegradation using HRC [®] at the property boundary in the intermediate and deep intervals of the surficial aquifer.			
Location:	SWMJ 39				
Phase:	Corrective Measures Study				
Base Year:	2002				
Date:	08/01/02				
CAPITAL COSTS					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Baseline Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample # Existing and 5 Proposed Monitoring Wells
Baseline Groundwater Sample Collection Event - Methane, Ethane, and Ethane Analysis	14	EA	\$135	\$1,890	
Baseline Groundwater Sample Collection Event - Hydrogen Analysis	14	EA	\$100	\$1,400	
Monitoring Well Installation	1	EA	\$15,000	\$15,000	Three Intermediate Wells @ 30 ft Deep and Three Deep Wells @ 50 ft deep
SUBTOTAL				\$24,690	
Enhanced Bioremediation Subcontractor Costs					
Project Planning and Design	1	EA	\$0	\$0	Provided with purchase of HRC Assume 26 Injection Points on 8-ft Centers. Assume Injection of 3 lbs/Aerial foot, with HRC Injection from 20 to 50 ft bis Assume 32 lbs/5 gallon Bucket for Total of 61 Buckets
HRC Material Costs	2,340	LB	\$7	\$18,380	
HRC Shipping Costs	74	EA	\$11	\$814	
Injection Grout Pump	8	Day	\$150	\$1,200	
Injection Subcontractor Costs					
Mobilization / Demobilization	1	EA	\$2,000	\$2,000	
On Site Injection	8	Day	\$2,500	\$20,000	Direct Push Technology: 10-Hour Work Days - Labor and Materials
SUBCONTRACTOR SUBTOTAL				\$40,394	
SUBTOTAL				\$65,084	
Project Management	1%	of	\$65,084	\$651	
Technical Support	2%	of	\$65,084	\$1,302	
Construction Management	2%	of	\$65,084	\$1,302	
Subcontractor General Requirements	1%	of	\$65,084	\$651	
SUBTOTAL				\$68,589	
Contingency	15%	of	\$68,589	\$10,348	
TOTAL CAPITAL COST				\$78,937	
OPERATIONS AND MAINTENANCE COST					
DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Annual Groundwater Sample Collection Event	1	EA	\$6,400	\$6,400	Sample # Existing and 6 Proposed Monitoring Wells
Annual Groundwater Sample Collection Event - Methane, Ethane, and Ethane Analysis	14	EA	\$135	\$1,890	
Annual Groundwater Sample Collection Event - Hydrogen Analysis	14	EA	\$100	\$1,400	
Annual Report					
Labor - Project Manager	22	HR	\$125	\$2,750	
Labor - Engineer/Hydrogeologist	68	HR	\$90	\$6,120	
Labor - Editor	22	HR	\$65	\$1,430	
Labor - CAD Technician	42	HR	\$65	\$2,730	
SUBTOTAL				\$22,540	
Polish Treatment	80%	of	\$40,394	\$32,300	Yearly Reinjection
TOTAL ANNUAL O&M COST				\$55,000	
PRESENT VALUE ANALYSIS					
			Discount Rate =	3.2%	
End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	TOTAL PRESENT WORTH	NOTES
1	FIRST YEAR CAPITAL COST	\$78,937	\$78,937	\$78,937	
1 - 20	ANNUAL O&M COST (Year 1 - 20)	\$55,000	\$55,000	\$803,333	Annual Sampling Yearly Reinjection
TOTAL PRESENT VALUE OF ALTERNATIVE				\$882,270	
SOURCE INFORMATION					
1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000)					