

N61165.AR.003461
CNC CHARLESTON
5090.3a

PHASE II INTERIM MEASURE WORK PLAN SOLID WASTE MANAGEMENT UNIT 196
(SWMU 196) ZONE H CNC CHARLESTON SC
8/9/2001
CH2M HILL

PHASE II INTERIM MEASURE WORK PLAN

SWMU 196, Zone H



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

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

CH2M-Jones

August 2001

Contract N62467-99-C-0960



CH2MHILL

CH2M HILL
3011 S.W. Williston Road
Gainesville, FL
32608-3928
Mailing address:
P.O. Box 147009
Gainesville, FL
32614-7009
Tel 352.335.7991
Fax 352.335.2959

August 9, 2001

Mr. David Scaturo
Division of Hazardous and Infectious Wastes
South Carolina Department of Health and
Environmental Control
Bureau of Land and Waste Management
2600 Bull Street
Columbia, SC 29201

Re: Phase II Interim Measure Work Plan (Revision 0), – SWMU 196, Zone H

Dear Mr. Scaturo:

Enclosed please find four copies of the Phase II Interim Measure Work Plan (Revision 0), – SWMU 196, Zone H 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 Paul Favara. Please contact him at 352/335-5877, extension 2396 if you have any questions or comments.

Sincerely,

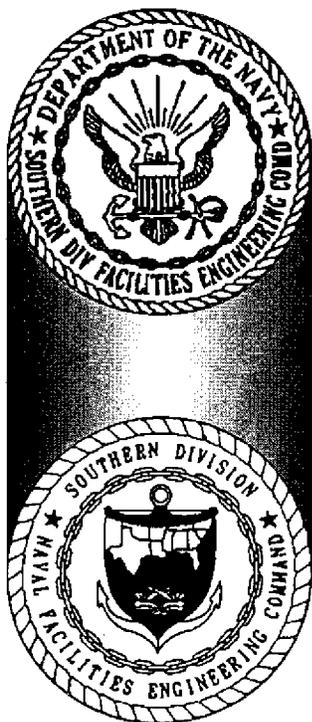
CH2M HILL

Dean Williamson, P.E.

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

PHASE II INTERIM MEASURE WORK PLAN

SWMU 196, Zone H



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

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

PREPARED BY
CH2M-Jones

August 2001

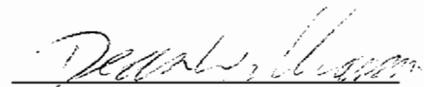
*Revision 0
Contract N62467-99-C-0960
158814.ZH.PR.16*

Certification Page for Phase II Interim Measure Work Plan (Revision 0) — SWMU 196, Zone H

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.

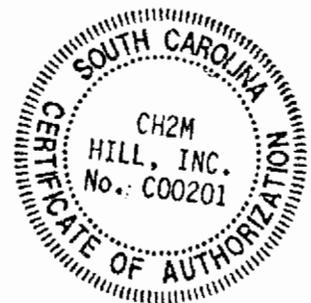
South Carolina

Temporary Permit No. T2000342



Dean Williamson, P.E.

8/7/2001
Date



1	3.8.3 Reagents	3-10
2	3.8.4 Process Monitoring Parameters	3-12
3	3.9 Reporting	3-15
4	3.10 Permitting	3-15
5	3.10.1 USACE Nationwide (Wetlands) Permits	3-15
6	3.10.2 SCDHEC Well Installation Request	3-17
7	3.10.3 SCDHEC Underground Injection Control Permit Application	3-17
8	Figure 3-1 Benzene Oxidation Pathway (GCI).....	3-18
9	Figure 3-2 Phase II-A Treatment Area (GCI)	3-19
10	Figure 3-3 Phase II-B Treatment Area and Injector Locations (GCI).....	3-20
11	Figure 3-4 Example Vent Well Construction (GCI).....	3-21
12	Figure 3-5 Geo-Cleanse Treatment Rig Schematic (GCI)	3-22
13	Figure 3-6 Geo-Cleanse® Patented Injector and Mixing Head Design Schematic (GCI)	3-23
14	Figure 3-7 Example Construction Detail for Shallow Injector (GCI).....	3-23
15	Figure 3-8 Example Construction Detail for Deep Injector (GCI).....	3-24
16	Figure 3-9 Example Construction Detail for Barrier Injector (GCI).....	3-25
17	Figure 3-10 Example Soil Boring and Well Construction Log (GCI).....	3-26
18	4.0 Investigation-Derived Waste	4-1
19	5.0 Project Schedule	5-1
20	Figure 5-1 Project Schedule.....	5-2
21	6.0 References.....	6-1
22	Appendix	
23	A Soil Boring Logs for Groundwater Samples at SWMU 196	

1 Acronyms and Abbreviations

2	1,2-DCB	1,2-dichlorobenzene
3	BMP	Best Management Practice
4	BRAC	Base Realignment and Closure Act
5	CA	Corrective Action
6	CB	chlorobenzene
7	CFR	<i>Code of Federal Regulations</i>
8	CMS	Corrective Measures Study
9	CNC	Charleston Naval Complex
10	CSAP	Comprehensive Sampling and Analysis Plan
11	DCB	dichlorobenzene
12	DMP	Data Management Plan
13	DNAPL	dense non-aqueous phase liquid
14	EnSafe	EnSafe Inc.
15	EPA	U.S. Environmental Protection Agency
16	ESDSOPQAM	Environmental Services Division <i>Standard Operating Procedures</i>
17		<i>and Quality Assurance Manual</i>
18	eV	electron volt
19	ft bls	feet below land surface
20	GCI	Geo-Cleanse International, Inc.
21	IDW	investigation-derived waste
22	IM	Interim Measure
23	IM WP	IM Work Plan
24	KOH	Potassium Hydroxide
25	µg/L	micrograms per liter
26	mg/L	milligrams per liter
27	NAVBASE	Naval Base
28	NWP	Nationwide Permit

1	PAH	polyaromatic hydrocarbon
2	PCB	polychlorinated biphenyl
3	PID	photoionization detector
4	PPE	personal protective equipment
5	ppm	part per million
6	PSI	pounds per square inch
7	QAP	Quality Assurance Plan
8	RCRA	Resource Conservation and Recovery Act
9	RFI	RCRA Facility Investigation
10	SCDHEC	South Carolina Department of Health and Environmental Control
11	SOP	standard operating procedure
12	SWMU	solid waste management unit
13	SVOC	semivolatile organic compound
14	USACE	U.S. Army Corps of Engineers
15	VOC	volatile organic compound

Section 1.0

1.0 Introduction

1.1 Purpose and Objectives of the Phase II IM WP

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 Act (BRAC), 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 has been prepared by CH2M-Jones to document the basis for a Phase II Interim Measure Work Plan (IM WP) at Solid Waste Management Unit (SWMU) 196 in Zone H of the CNC. The location of SWMU 196 within the CNC is presented in Figure 1-1.

The Phase I IM WP for SWMU 196 (Revision 1) was submitted in November 2000, with the field work completed in December 2000. The objective of the Phase I IM WP was to characterize the extent of chlorobenzene (CB) and dichlorobenzene (DCB) source areas in groundwater. The results of this effort are presented in Section 2.0 of this work plan.

The RCRA CA process allows for the implementation of an IM to control or minimize ongoing threats to human health or the environment (61 FR 19432 [1996]). The Phase II IM will involve the remediation of the CB/DCB source area at SWMU 196.

The remediation of the CB/DCB source area is not necessarily intended to be the final remedy for SWMU 196; however, the abatement of the source area is expected to be compatible with the final remedy selected for SWMU 196.

After completion of the Phase II IM at this site, the RCRA Corrective Measures Study (CMS) process will be followed to identify appropriate final remedial measures for SWMU 196, should additional corrective action be necessary after the IM is completed.

1 **1.2 Organization of the Phase II IM WP**

2 This IM WP consists of the following sections, including this introductory section:

3 **1.0 Introduction** —Presents the purpose of the report and background information
4 relating to the proposed investigation.

5 **2.0 Site Characterization** —Provides the results of the Phase I IM characterization.

6 **3.0 Technical Approach** — Describes the technical approach for completing the IM at
7 SWMU 196. The figures provided in this section were prepared by the subcontractor
8 responsible for the delivery of Fenton's reagent (Geo-Cleanse International, Inc. [GCI]).

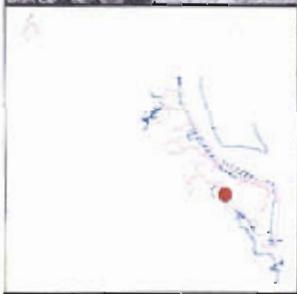
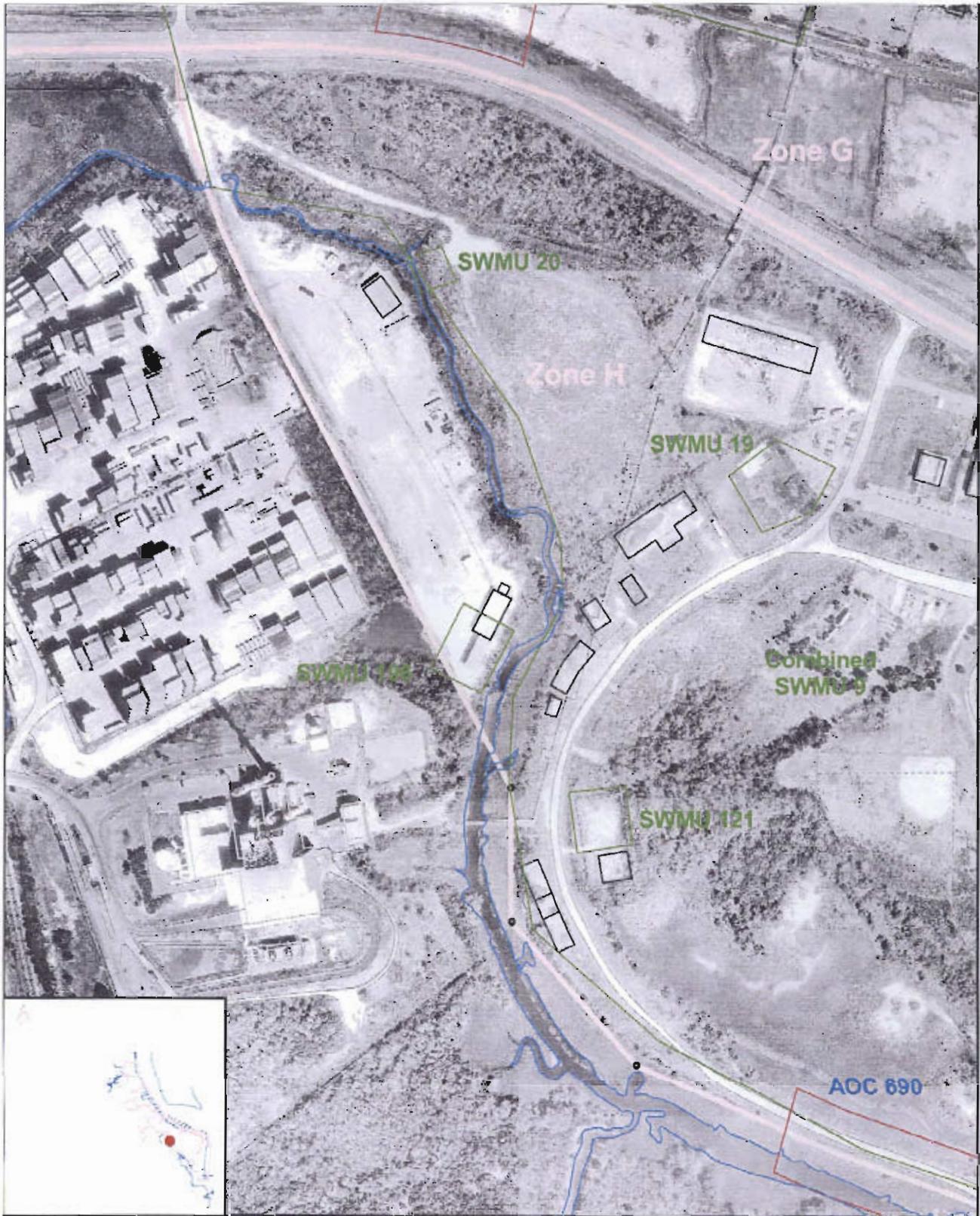
9 **4.0 Investigation-Derived Waste** — Describes the procedures to be implemented for
10 management of the investigation-derived waste (IDW).

11 **5.0 - Project Schedule** —Provides the detailed outline of the schedule to be
12 implemented during the Phase II IM.

13 **6.0 References** — Lists the references used in this document.

14 **Appendix A** contains the soil boring logs for groundwater sampling performed at
15 SWMU 196.

16 All tables and figures appear at the end of their respective sections.



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

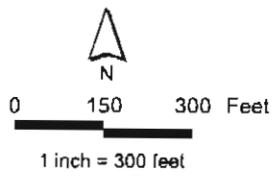


Figure 1-1
 Site Location Map
 SWMU 196
 Charleston Naval Complex

Section 2.0

2.0 Site Characterization (Phase I IM)

This section presents the results of the Phase I IM characterization effort and outlines the technical approach for the IM to be performed at SWMU 196.

2.1 Groundwater Characterization

2.1.1 Results of the Phase I IM WP

The RFI soil and groundwater investigations at SWMU 196 reported the presence of high concentrations of CB and DCB in shallow groundwater. Concentrations in several monitoring wells containing up to 15 milligrams per liter (mg/L) of CB and 13 mg/L of DCB were detected. These values are approximately 0.3 and 8 percent, respectively, of the maximum solubility of CB and 1,2-dichlorobenzene (1,2-DCB) in water, suggesting the possibility that CB or DCB may be present in the shallow aquifer in the form of a dense non-aqueous phase liquid (DNAPL).

The purpose of the Phase I IM WP was to better define the vertical and horizontal extent of CB and DCB source areas at SWMU 196. This field work was completed in December 2000.

Prior to collecting discrete groundwater samples, two soil borings were advanced to depths of approximately 15 feet below land surface (ft bls) to confirm the presence of the shallowest first aquitard/aquiclude below the water table. The locations of these borings are presented in Figure 2-1. Logs for these borings are presented in Appendix A.

The Geoprobe-type sampler was advanced to collect continuous soil samples in clear acetate sleeves. Sleeves were brought to the surface and visually classified by a field hydrogeologist. Both borings indicated the presence of the aquitard at approximately 15 ft bls. The completed soil boring and vertical profiler holes were filled to the ground surface with a bentonite grout, in accordance with Rule 61-71.10.B of the South Carolina Well Standards and Regulations. The soil brought to the surface was managed as IDW.

After the depths of the aquiclude were determined, the Waterloo™ profiler was used to collect groundwater from discrete sampling intervals at the 29 soil locations presented in Figure 2-1. Up to six different groundwater samples were collected from each location, ranging in depth from 5 to 15 ft bls, in approximate two-foot intervals. Table

1 2-1 summarizes the analytical results obtained utilizing the Waterloo™ Profiler for
2 groundwater sample collection.

3 The sum of each of the four chlorobenzene isomers, as reported in Table 2-1, represents
4 the "total chlorobenzene" results for each sample location and depth. Note that for the
5 purposes of this report, the term "total chlorobenzenes" refers to chlorobenzene and
6 dichlorobenzenes. Figures 2-2 through 2-7 show the total CB concentrations at different
7 depths.

8 Figure 2-2 shows the total CB concentrations at 5 ft bls. The highest total CB
9 concentration at this depth was found at sample 196GP010 with a concentration of
10 27,430 micrograms per liter ($\mu\text{g}/\text{L}$). Significant concentrations were also found in
11 196GP003 and 196GP002, also at 5 ft bls, with concentrations of 10,800 $\mu\text{g}/\text{L}$ and 8,005
12 $\mu\text{g}/\text{L}$, respectively.

13 Figure 2-3 shows the total CB concentrations at 7 ft bls. The highest total CB
14 concentration at this depth was found at sample 196GP010, with a concentration of
15 27,430 $\mu\text{g}/\text{L}$. Borings 196GP003, 196GP002, 196GP001, and 196GP022 also indicated
16 significant contamination at 7 ft bls, with concentrations of 9,675 $\mu\text{g}/\text{L}$, 10,250 $\mu\text{g}/\text{L}$,
17 23,866 $\mu\text{g}/\text{L}$, and 10,922 $\mu\text{g}/\text{L}$, respectively.

18 Figure 2-4 illustrates the total CB concentrations at 9 ft bls. The highest total CB
19 concentration at this depth was found at 196GP002, with a total concentration of 52,000
20 $\mu\text{g}/\text{L}$. Other borings with significant levels of contamination were 196GP010, 196GP003,
21 196GP001, and 196GP022 at 9 ft bls, with total CB concentrations of 3,740 $\mu\text{g}/\text{L}$, 31,590
22 $\mu\text{g}/\text{L}$, 48,460 $\mu\text{g}/\text{L}$, and 19,515 $\mu\text{g}/\text{L}$, respectively.

23 Figure 2-5 shows the total CB concentrations at a sampling depth of 11 ft bls. The
24 highest total CB concentration at this depth was found at 196GP001, with a
25 concentration of 33,595 $\mu\text{g}/\text{L}$. Significant concentrations were also found at 11 ft bls in
26 borings 196GP003, 196GP002, 196GP010, and 196GP022, with total CB concentrations of
27 6,940 $\mu\text{g}/\text{L}$, 14,970 $\mu\text{g}/\text{L}$, 2,430 $\mu\text{g}/\text{L}$, and 4,218 $\mu\text{g}/\text{L}$, respectively.

28 Figure 2-6 shows the total CB concentrations at 13 ft bls. The highest total CB
29 concentration at this depth was found at 196GP023, with a concentration of 284,110
30 $\mu\text{g}/\text{L}$. Other borings with significant levels of contamination are 196GP005, 196GP001,
31 196GP002, 196GP011, 196GP010, and 196GP003, with corresponding concentrations of
32 32,720 $\mu\text{g}/\text{L}$, 35,340 $\mu\text{g}/\text{L}$, 10,939 $\mu\text{g}/\text{L}$, 3,900 $\mu\text{g}/\text{L}$, 2,750 $\mu\text{g}/\text{L}$, and 3,110 $\mu\text{g}/\text{L}$.

1 Figure 2-7 shows the total CB concentrations at 15 ft bls. At this depth, the highest level
2 of contamination was found at 196GP022, with a concentration of 50,850 µg/L.
3 Locations 196GP010, 196GP011, 196GP001, and 196GP005 presented contaminant
4 concentrations at 2,120 µg/L, 1,220 µg/L, 3,542 µg/L, and 2,961 µg/L, respectively.
5 Overall, the highest total CB concentration (284,110 µg/L) was found at 13 ft bls.
6 Chlorobenzene represented the greatest concentration as 282,000 µg/L; this
7 concentration exceeds 1 percent of the solubility of chlorobenzene in water, indicating
8 the potential presence of DNAPL.

1 Contents

2 Section	Page
3 Acronyms and Abbreviations.....	vi
4 1.0 Introduction.....	1-1
5 1.1 Purpose and Objectives of the Phase II IM WP	1-1
6 1.2 Organization of the Phase II IM WP.....	1-2
7 Figure 1-1 SWMU 196 Site Location Map.....	1-3
8 2.0 Site Characterization (Phase I IM).....	2-1
9 2.1 Groundwater Characterization	2-1
10 2.1.1 Results of the Phase I IM WP.....	2-1
11 Table 2-1 Groundwater Profile Results	2-4
12 Figure 2-1 Groundwater Sample Locations without Aerial View	2-9
13 Figure 2-2 Total CB Concentrations at 5 Feet Below Land Surface.....	2-10
14 Figure 2-3 Total CB Concentrations at 7 Feet Below Land Surface.....	2-11
15 Figure 2-4 Total CB Concentrations at 9 Feet Below Land Surface.....	2-12
16 Figure 2-5 Total CB Concentrations at 11 Feet Below Land Surface.....	2-13
17 Figure 2-6 Total CB Concentrations at 13 Feet Below Land Surface.....	2-14
18 Figure 2-7 Total CB Concentrations at 15 Feet Below Land Surface.....	2-15
19 3.0 Technical Approach.....	3-1
20 3.1 Geo-Cleanse® Process	3-1
21 3.2 Fenton’s Reagent and CB/DCB Treatment	3-3
22 3.3 Treatment Goals	3-4
23 3.4 Target Treatment Area for the Phase II-A and Phase II-B IMs.....	3-5
24 3.4.1 Treatment Depth Interval.....	3-6
25 3.5 Geo-Cleanse Injection Equipment	3-6
26 3.6 Injector Installation	3-7
27 3.6.1 Utility Clearance.....	3-7
28 3.6.2 Injector Construction	3-7
29 3.7 Performance and Process Monitoring	3-8
30 3.8 Treatment Program Procedures	3-9
31 3.8.1 Sequence of Events.....	3-9
32 3.8.2 Duration of Treatment	3-10

TABLE 2-1

Table 1. Groundwater Profile Results

Samples Collected:	12/11/00 - 12/16/00	Collected by:	R. Brand	Client:	CH2MHill
Samples Received:	12/11/00 - 12/16/00	Received by:	D. McInnes	Client Address:	1766 Sea Lark Lane
Samples Analyzed:	12/11/00 - 12/16/00	Analyzed by:	D. McInnes		Navarre, FL 32566
Samples Reported:	12/16/2000	Reported by:	Doug McInnes		
Project Identification:	CHAS SWMU-196	Report Revision:	0.0	Client Contact:	Darryl Gates
Columbia Job Code:	CHM12110	Method Deviations:	Project Specific QA/QC	Client Phone:	850-939-8300 X 23
Purchase Order:	P.O. 2389	Sampling Method:	Direct Push	Client Fax:	850-939-0035

USEPA Method 8260 Water Sample Analysis Results in ug/L

Compound	PQL ¹	196GP001	196GP001	196GP001	196GP001	196GP001	196GP001	196GP001	196GP002	196GP002	196GP002	196GP002
		5	7	9	11	13	15	5	7	9	11	
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Chlorobenzene	10	150	23100 D	42800 D	13800 D	7680 D	920	7870 D	9570 D	1600	1440	
1,3-Dichlorobenzene	10	10 U	86	320	9 J	1410	62	100 U	100 U	350	100 U	
1,4-Dichlorobenzene	10	10 U	290 D	1080	86	1850 D	160	100 U	180	850	380	
1,2-Dichlorobenzene	10	9 J	390 D	4250 D	19700 D	24400 D	2400	65 J	400	49200 D	13100 D	
40	179 0	23866 0	48460 0	33595 0	35340 0	3542 0	8135 0	10250 0	52000 0	15020		
Dilution Factor:	100,1,10	10, 1, 100, 500	1, 10, 100, 500	1, 10, 100	1, 10, 100, 500	1, 10	10, 100	10, 100	10, 100, 500	10, 100		

Compound	PQL ¹	196GP002	196GP002	196GP003	196GP003	196GP003	196GP003	196GP003	196GP003	196GP004	196GP004
		13	15	5	7	9	11	13	15	5	7
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Chlorobenzene	10	78 J	52 J	10500 D	9400 D	750	880	220	100	70	27
1,3-Dichlorobenzene	10	100 U	100 U	100 U	100 U	100 U	100 U	100 U	100 U	10 U	10 U
1,4-Dichlorobenzene	10	1450	170	200	50 J	390	100 U	100 U	180	10 U	10 U
1,2-Dichlorobenzene	10	9400 D	290	100 U	200	30400 D	6160 D	2790 D	280	180	63
40	11028 0	612 0	10900 0	9750 0	31640 0	7040 0	3210 0	660 0	270 0	110	
Dilution Factor:	10, 100	10	10, 100	10, 100	10, 100, 500	10, 100	10, 100	10	10, 1	10, 1	

Compound	PQL ¹	196HP004	196GP004	196GP004	196GP004	196GP004	196GP005	196GP005	196GP005	196GP005	196GP005
		7	9	11	13	15	5	7	9	11	13
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Chlorobenzene	10	18	38	100 U	100 U	13	950 D	220	3960	1150	13400
1,3-Dichlorobenzene	10	10 U	10 U	100 U	100 U	10 U	10 U	100 U	1000 U	100 U	560 J
1,4-Dichlorobenzene	10	10 U	10 U	100 U	170	10 U	15	100 U	1000 U	100 U	2040
1,2-Dichlorobenzene	10	48	150	1360	270	93	14	100 U	1000 U	100 U	17000
40	86 0	208 0	1660 0	640 0	126 0	989 0	520 0	6960 0	1450 0	33000	
Dilution Factor:	10, 1	10, 1	10, 50	10	10, 1	100, 1, 10	100, 10	100	100, 10, 50	100	

U: Non-detect result J: Estimated value - less than PQL D: Dilute result E: Estimated value - greater than upper limit of calibration curve
 B: Compound found in associated method blank

¹ PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

SAMPLE NARRATIVE:

This report will not be reproduced without the expressed written permission of the client

TABLE 2-1 (CONTINUED)

Samples Collected:	12/11/00 - 12/16/00	Collected by:	R. Brand	Client:	CH2MHill
Samples Received:	12/11/00 - 12/16/00	Received by:	D. McInnes	Client Address:	1766 Sea Lark Lane
Samples Analyzed:	12/11/00 - 12/16/00	Analyzed by:	D. McInnes		Navarre, FL 32566
Samples Reported:	12/16/2000	Reported by:	Doug McInnes		
Project Identification:	CHAS SWMU-196	Report Revision:	0.0	Client Contact:	Darryl Gates
Columbia Job Code:	CHM12110	Method Deviations:	Project Specific QA/QC	Client Phone:	850-939-8300 X 23
Purchase Order:	P.O. 2369	Sampling Method:	Direct Push	Client Fax:	850-939-0035

USEPA Method 8260 Water Sample Analysis Results in ug/L

Quality Control Analyst: _____

Compound	PQL ¹	196GP005	196GP006	196GP007	196GP008	196GP008										
		15	5	7	9	11	13	15	13	7	9					
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)				
Chlorobenzene	10	1320	1440	1920	2240	D 1300	270	64	10	U 150	180					
1,3-Dichlorobenzene	10	42	J 100	U 100	U 170	100	U 100	U 10	U 10	U 10	U 10	U				
1,4-Dichlorobenzene	10	170	100	U 100	U 430	32	J 100	U 10	U 10	U 8	J 9	J				
1,2-Dichlorobenzene	10	1450	270	240	1900	380	550	46	10	U 75	88					
		2982	0	1910	0	2360	0	4740	0	130	0	40	0	243	0	267
Dilution Factor:	10	10	10	10	10, 100	10	10	10, 1	10, 1	1	1	1				

Compound	PQL ¹	196GP008	196GP008	196GP008	196GP009	196GP009	196GP009	196GP010	196GP010	196GP010	196HP010									
		11	13	15	9	11	13	7	9	11	11									
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)									
Chlorobenzene	10	140	130	23	10	U 10	U 100	U 17400	D 8840	900	260	J								
1,3-Dichlorobenzene	10	10	U 10	U 10	U 10	U 10	U 100	U 450	1000	U 500	U 500	U								
1,4-Dichlorobenzene	10	6	J 7	J 10	U 10	U 10	U 100	U 1380	770	J 500	U 500	U								
1,2-Dichlorobenzene	10	72	77	17	10	93	690	8200	D 19600	2340	1800									
		228	0	224	0	60	0	40	0	123	0	990	0	27430	0	30210	0	4240	0	3060
Dilution Factor:	10, 1	10, 1	1	10, 1	10, 1	10, 1	10	10, 200	100	500, 50	50									

Compound	PQL ¹	196GP010	196GP010	196GP011	196GP011	196GP011	196GP011	196GP011	196GP011	196GP013	196GP12									
		13	15	5	7	9	11	13	15	3	7									
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)									
Chlorobenzene	10	470	260	J 540	490	450	120	1000	U 56	J 130	370									
1,3-Dichlorobenzene	10	500	U 500	U 100	U 100	100	U 100	U 1000	U 100	U 10	U 100	U								
1,4-Dichlorobenzene	10	500	U 500	U 100	U 100	100	U 100	U 1000	U 100	U 10	U 100	U								
1,2-Dichlorobenzene	10	1780	1490	840	710	2510	E 2000	2400	1090	10	U 100	U								
		3250	0	2750	0	1580	0	1400	0	3160	0	2320	0	5400	0	1346	0	160	0	670
Dilution Factor:	500, 50	100, 50	100, 10	100, 10	100, 10	100, 10	100, 10	100	100, 10	10, 1	10									

U: Non-detect result J: Estimated value - less than PQL D: Dilute result E: Estimated value - greater than upper limit of calibration curve
 B: Compound found in associated method blank

1 PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

SAMPLE NARRATIVE:

This report will not be reproduced without the expressed written permission of the client

TABLE 2-1 (CONTINUED)

Samples Collected:	12/11/00 - 12/16/00	Collected by:	R. Brand	Client:	CH2MHill
Samples Received:	12/11/00 - 12/16/00	Received by:	D. McInnes	Client Address:	1766 Sea Lark Lane
Samples Analyzed:	12/11/00 - 12/16/00	Analyzed by:	D. McInnes		Navarre, FL 32566
Samples Reported:	12/19/2000	Reported by:	Doug McInnes		
Project Identification:	CHAS SWMU-196	Report Revision:	0.0	Client Contact:	Darryl Gates
Columbia Job Code:	CHM12110	Method Deviations:	Project Specific QA/QC	Client Phone:	850-939-8300 X 23
Purchase Order:	P.O. 2389	Sampling Method:	Direct Push	Client Fax:	850-939-0035

USEPA Method 8260 Water Sample Analysis Results in ug/L

Quality Control Analyst: _____

Compound	PQL ¹	196GP12	196GP12	196GP12	196GP14	196GP15							
		11	13	15	5	7	9	11	13	15	7		
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	
Chlorobenzene	10	70	15	8	J	10	U	10	U	10	U	10	U
1,3-Dichlorobenzene	10	10	U	10	U								
1,4-Dichlorobenzene	10	10	U	10	U								
1,2-Dichlorobenzene	10	54	7	26	10	U	10	U	10	U	10	U	U
Dilution Factor:		144	0	42	0	54	0	40	0	40	0	40	0

Compound	PQL ¹	196GP15	196GP15	196GP15	196GP15	196GP16	196GP16	196GP16	196GP16	196GP16	196GP16	196GP17	
		9	11	13	15	5	7	9	11	13	7		
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	
Chlorobenzene	10	10	U	10	U								
1,3-Dichlorobenzene	10	10	U	10	U								
1,4-Dichlorobenzene	10	10	U	10	U								
1,2-Dichlorobenzene	10	10	U	10	U								
Dilution Factor:		40	0	40	0	40	0	40	0	40	0	40	0

Compound	PQL ¹	196GP17	196GP17	196GP17	196GP17	196GP17	196GP18	196GP18	196GP18	196GP18	196GP18	196GP18	
		9	9 DUP	11	13	15	7	9	11	13	15		
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	
Chlorobenzene	10	10	U	10	U								
1,3-Dichlorobenzene	10	10	U	10	U								
1,4-Dichlorobenzene	10	10	U	10	U								
1,2-Dichlorobenzene	10	10	U	10	U								
Dilution Factor:		40	0	40	0	40	0	40	0	40	0	40	0

U: Non-detect result J: Estimated value - less than PQL D: Dilute result E: Estimated value - greater than upper limit of calibration curve
 B: Compound found in associated method blank

¹ PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

SAMPLE NARRATIVE:

This report will not be reproduced without the expressed written permission of the client

Samples Collected:	12/11/00 - 12/16/00	Collected by:	R. Brand	Client:	CH2MHill
Samples Received:	12/11/00 - 12/16/00	Received by:	D. McInnes	Client Address:	1766 Sea Lark Lane
Samples Analyzed:	12/11/00 - 12/16/00	Analyzed by:	D. McInnes		Navarre, FL 32566
Samples Reported:	12/16/2000	Reported by:	Doug McInnes		
Project Identification:	CHAS SWMU-196	Report Revision:	00	Client Contact:	Darryl Gates
Columbia Job Code:	CHM12110	Method Deviations:	Project Specific QA/QC	Client Phone:	850-939-8300 X 23
Purchase Order:	P.O. 2389	Sampling Method:	Direct Push	Client Fax:	850-939-0035

USEPA Method 8260 Water Sample Analysis Results in ug/L

Quality Control Analyst _____

Compound	PQL ¹	196GP19	196GP19	196GP19	196GP19	196GP20	196GP20	196GP20	196GP20	196GP21	196GP21
	(ug/L)	7	9	11	15	7	9	11	13	7	9
Chlorobenzene	10	10 U	10 U	10 U	10 U	43	8 J	10 U	10 U	190	120
1,3-Dichlorobenzene	10	10 U									
1,4-Dichlorobenzene	10	10 U									
1,2-Dichlorobenzene	10	10 U	10 U	10 U	4 J	10 U	19 U	6 J	10 U	10 U	17
		40 0	40 0	40 0	34 0	73 0	47 0	36 0	40 0	220 0	157
Dilution Factor:		1	1	1	1	1	1	1	1	10,1	1

Compound	PQL ¹	196GP21	196GP21	196GP21	196GP22	196GP22	196GP22	196GP22	196GP22	196GP22	196GP23	196GP24
	(ug/L)	11	13	15	7	9	11	13	15	4	4	
Chlorobenzene	10	40	50	21	10900 D	19500 D	4080 D	3760 D	31000 D	282000 D	1060 D	D
1,3-Dichlorobenzene	10	10 U	12	51	590 E	150	4	J				
1,4-Dichlorobenzene	10	10 U	10 U	5 J	10 U	10 U	64	190	860 E	620 D	21	
1,2-Dichlorobenzene	10	15	7 J	150	12	10 U	62	110	18400 D	1340 D	140	
		75 0	77 0	186 0	10932 0	19530 0	4218 0	4111 0	50850 0	284110 0	1225	
Dilution Factor:		1	1	1	1,100	1,100	1,100	1,200	1,500	1,10,500	1	

Compound	PQL ¹	196GP25	196GP26	196GP27	196GP28	196GP29
	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)	(ug/L)
Chlorobenzene	10	300	260 D	300 D	10 U	10 U
1,3-Dichlorobenzene	10	10	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	10	9	12 J	12	10 U	10 U
1,2-Dichlorobenzene	10	79	93	94	10 U	10 U
		398 0	375 0	416 0	40 0	40 0
Dilution Factor:		1	1	1	1	1

U: Non-detected result J: Estimated value - less than PQL D: Dilute result E: Estimated value - greater than upper limit of calibration curve
 B: Compound found in associated method blank

¹ PQL: Practical quantitation limit using the initial calibration curve low point and dilution factors where applicable

SAMPLE NARRATIVE:

This report will not be reproduced without the expressed written permission of the client

TABLE 2-1 (CONTINUED)

Samples Collected:	12/11/00 - 12/16/00	Collected by:	R. Brand	Client:	CH2MHill
Samples Received:	12/11/00 - 12/16/00	Received by:	D. McInnes	Client Address:	1766 Sea Lark Lane
Samples Analyzed:	12/11/00 - 12/16/00	Analyzed by:	D. McInnes		Navarre, FL 32566
Samples Reported:	12/19/2000	Reported by:	Doug McInnes	Client Contact:	Darryl Gates
Project Identification:	CHAS SWMU-196	Report Revision:	0.0	Client Phone:	850-939-8300 X 23
Columbia Job Code:	CHM12110	Method Deviations:	Project Specific QA/QC	Client Fax:	850-939-0035
Purchase Order:	P O 2389	Sampling Method:	Direct Push		

USEPA Method 8260 Water Sample Analysis Results in ug/L

Quality Control Analyst: _____

This report will not be reproduced without the expressed written permission of the client

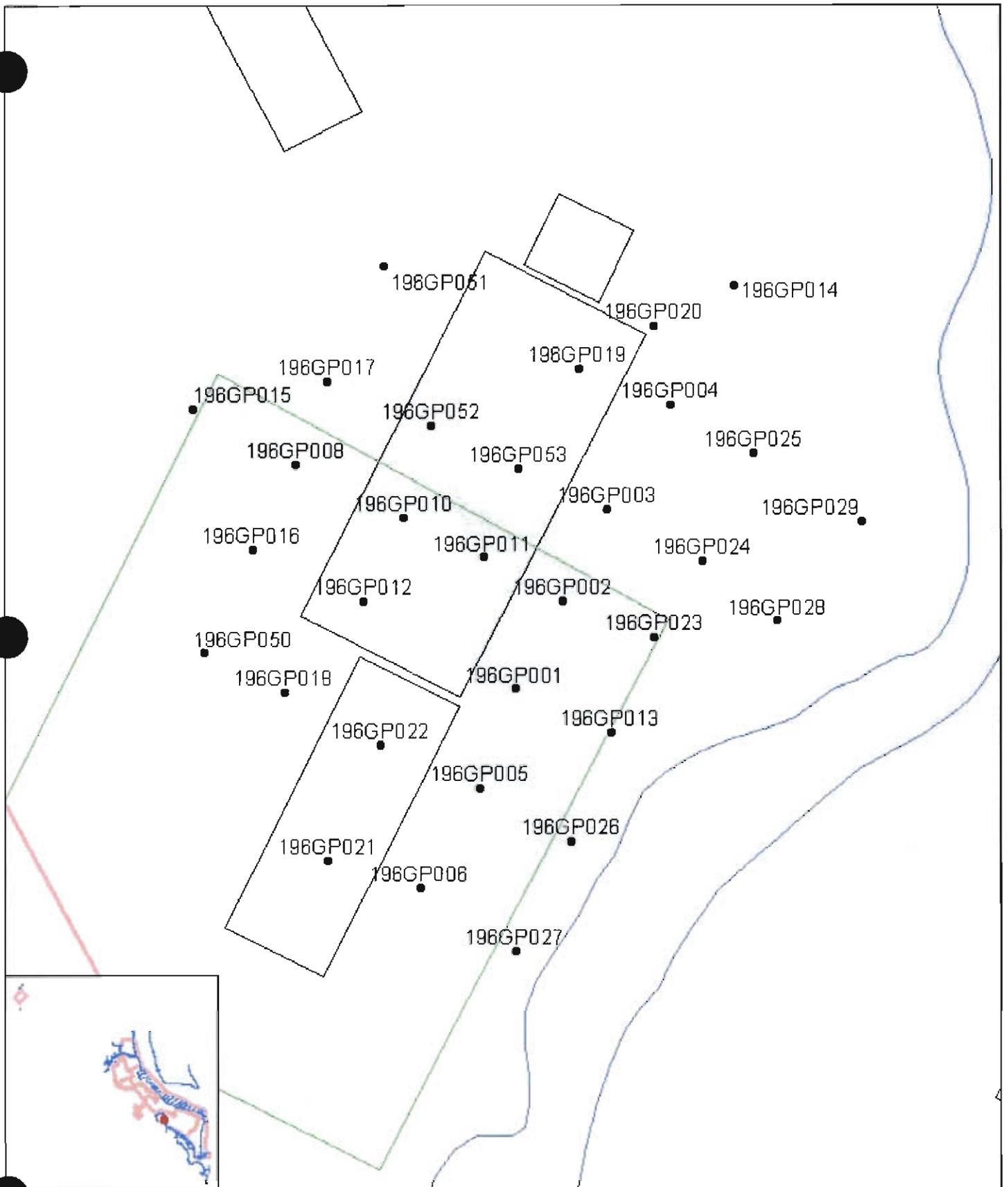


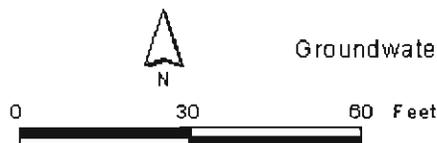
Figure 2-1

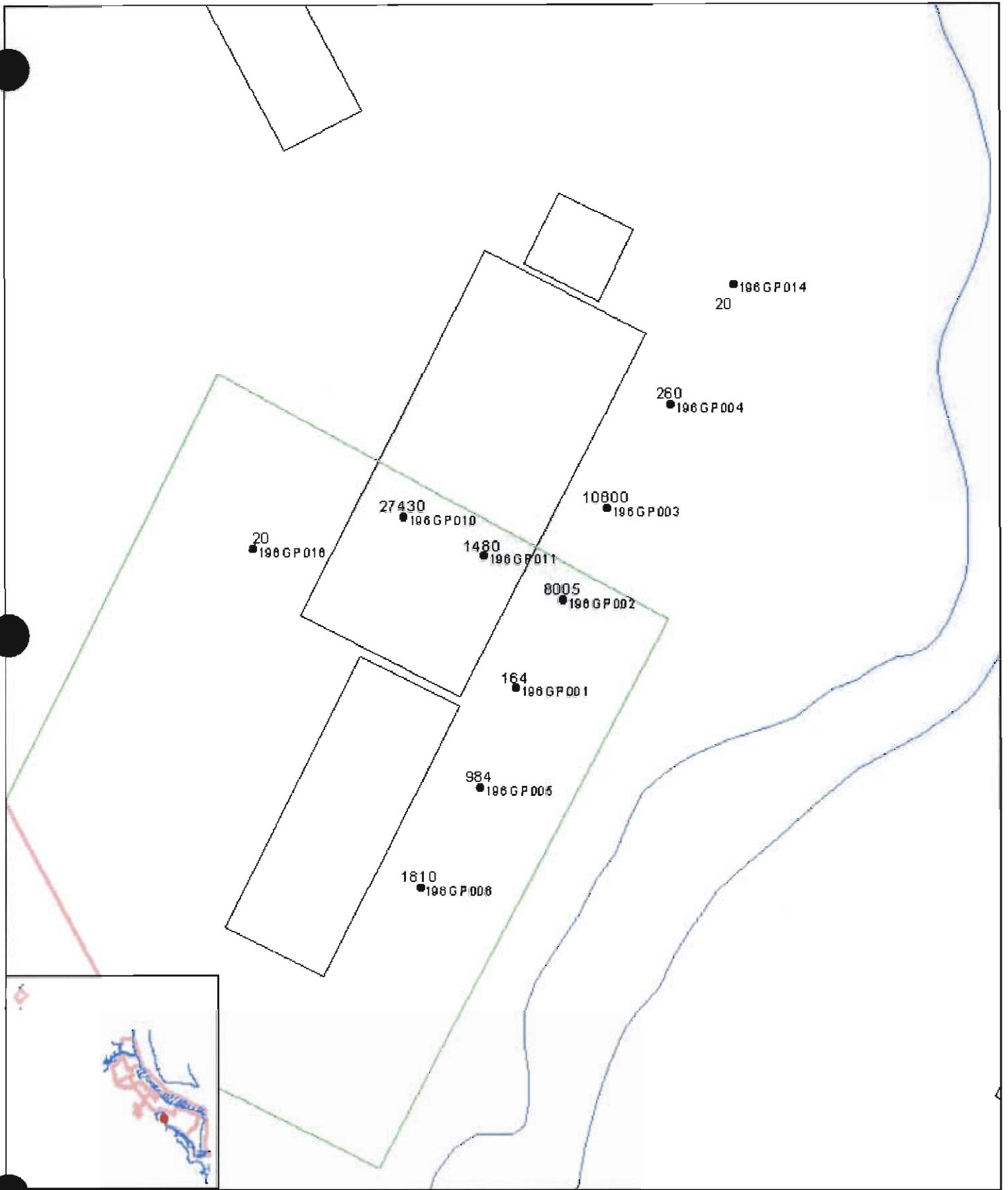
Groundwater Sample Locations w/out Aerial View

SW MU 196

Charleston Naval Complex

- Boring Locations
- ∩ Shoreline
- ▭ AOC Boundary
- ▭ SW MU Boundary
- ▭ Buildings

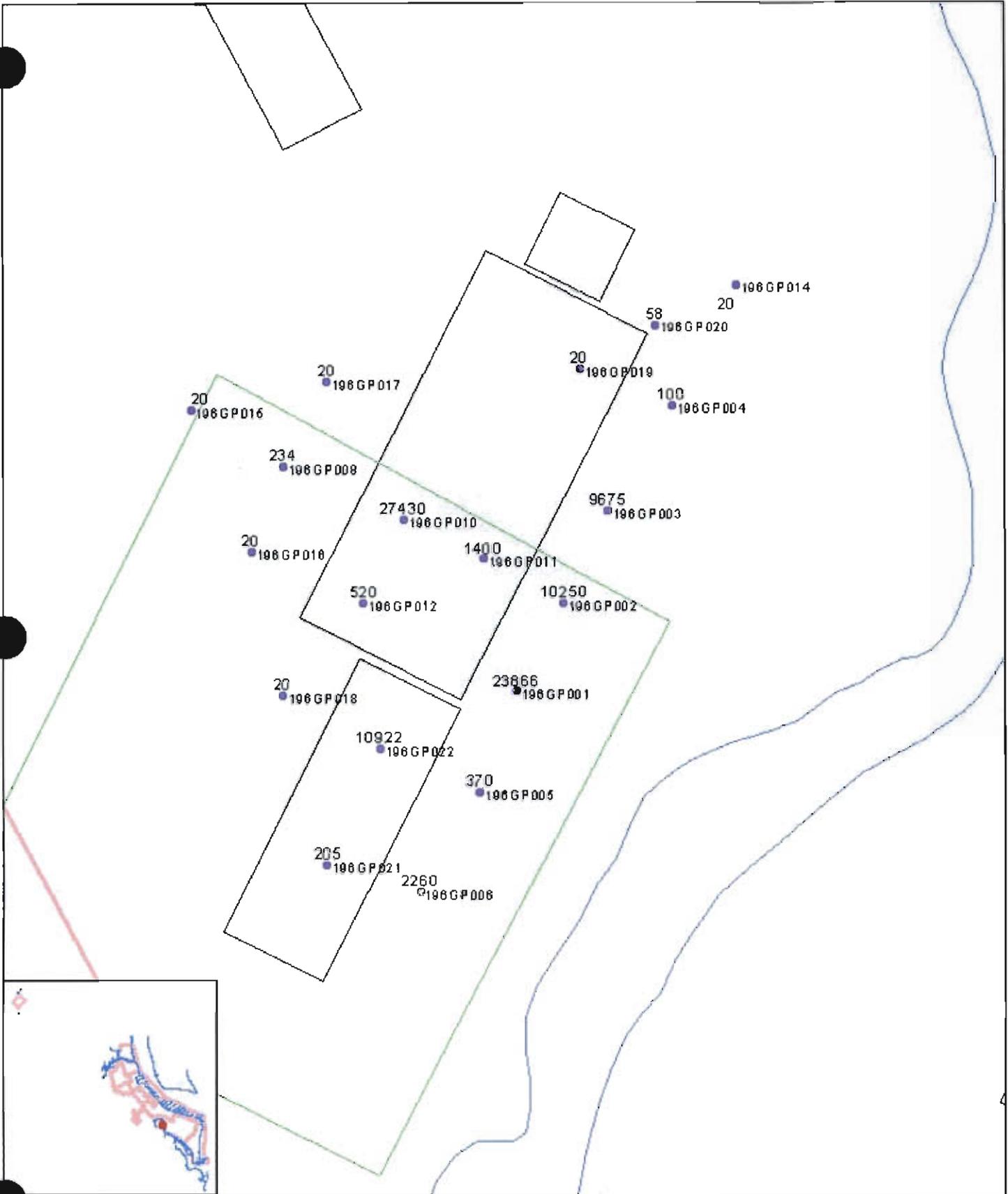




● Total CB's w/S ample ID at 5 ft bgs



Figure 2-2
 Total CB's at 5 ft bgs
 SWMU 196
 Charleston Naval Complex

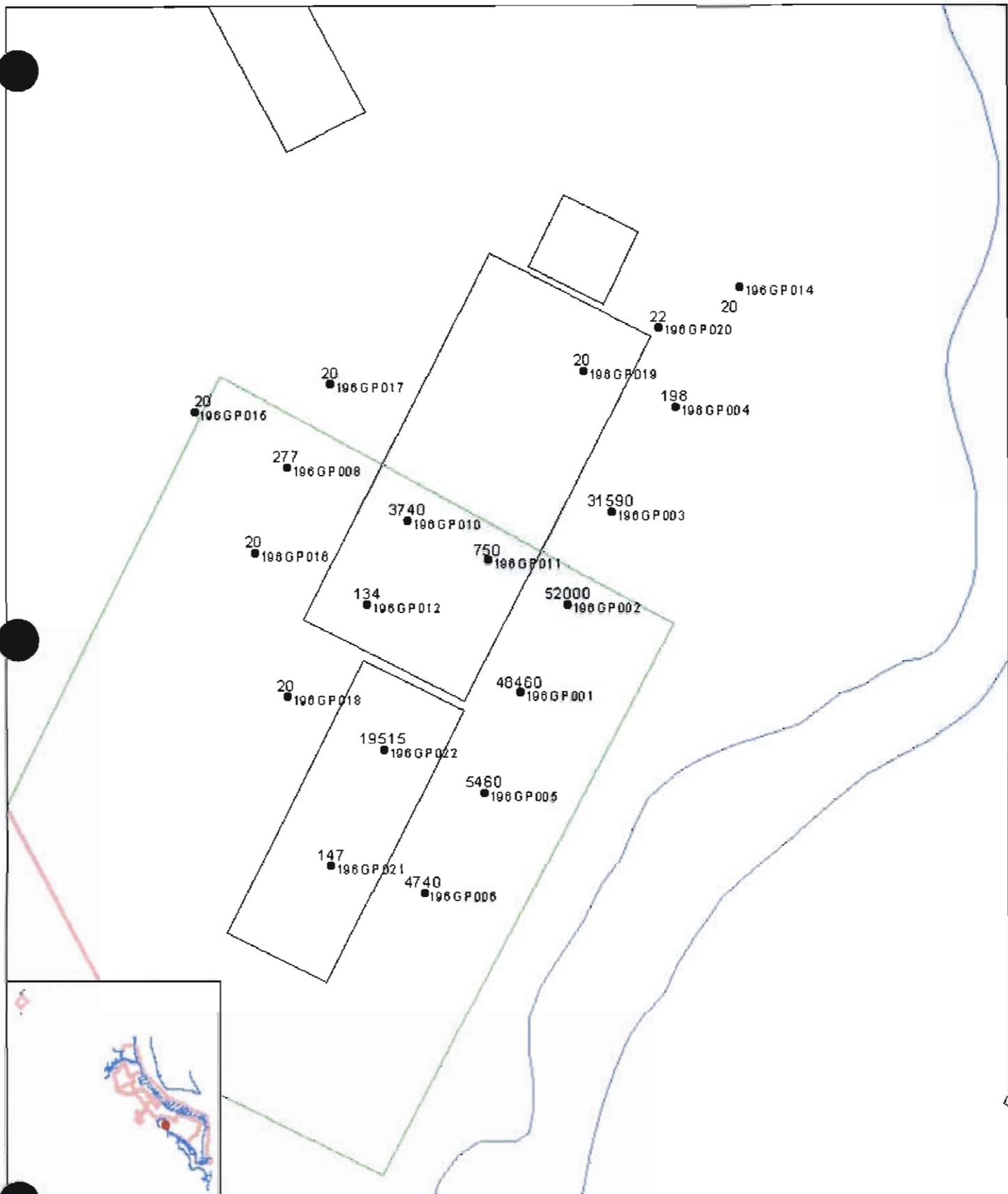


● Total CB's (ppb) w/Sample ID at 7 ft bgs



0 30 60 Feet

Figure 2-3
 Total CB's at 7 ft bgs
 SWMU 196
 Charleston Naval Complex



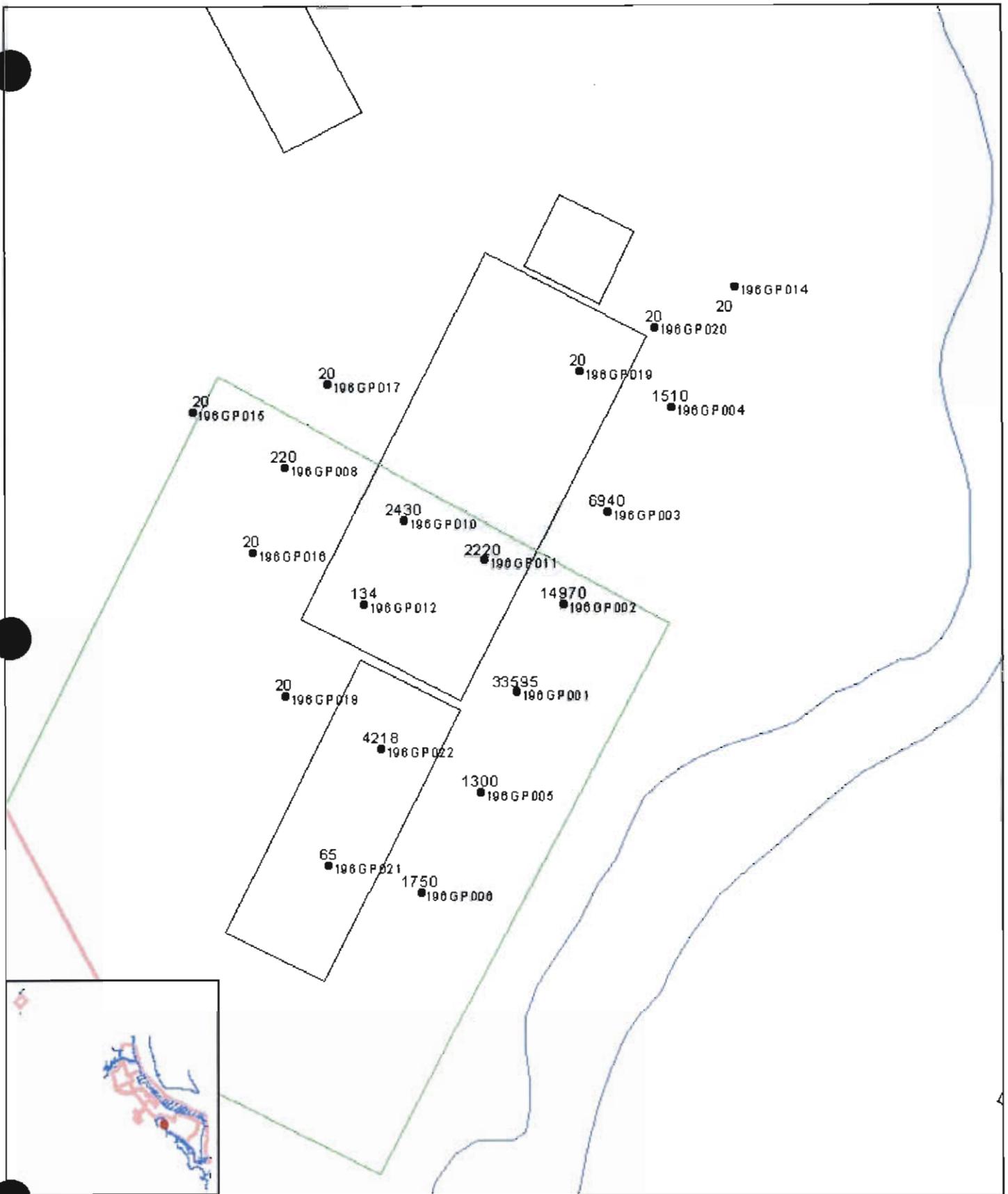
Total CB's (ppb) w/Sample ID at 9 ft bgs



0 30 60 Feet



Figure 2-4
Total CB's at 9 ft bgs
SWMU 196
Charleston Naval Complex



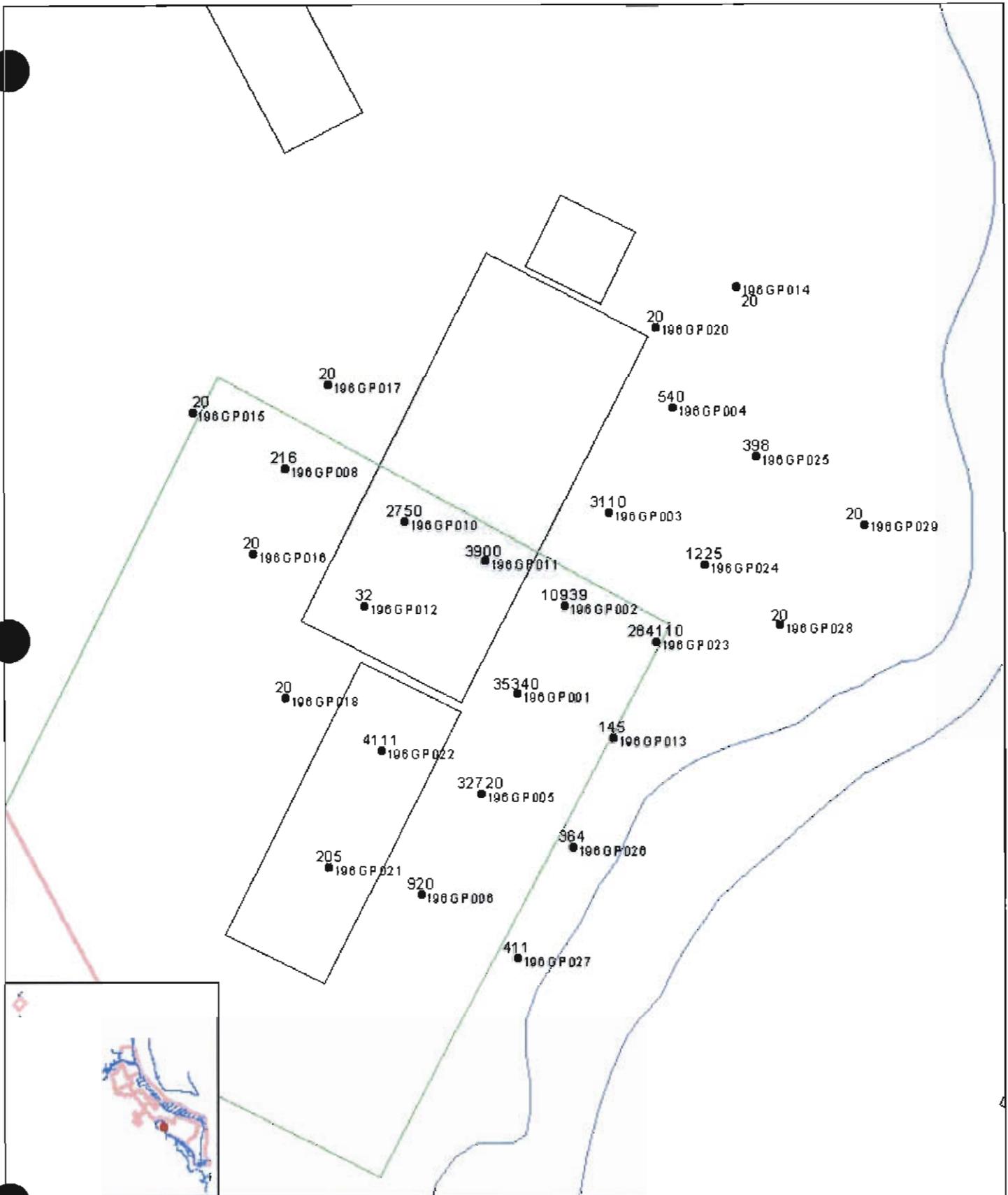
● Total CB's (ppb) w/Sample ID at 11 ft bgs



0 30 60 Feet



Figure 2-5
Total CB's at 11 ft bgs
SW MU 196
Charleston Naval Complex

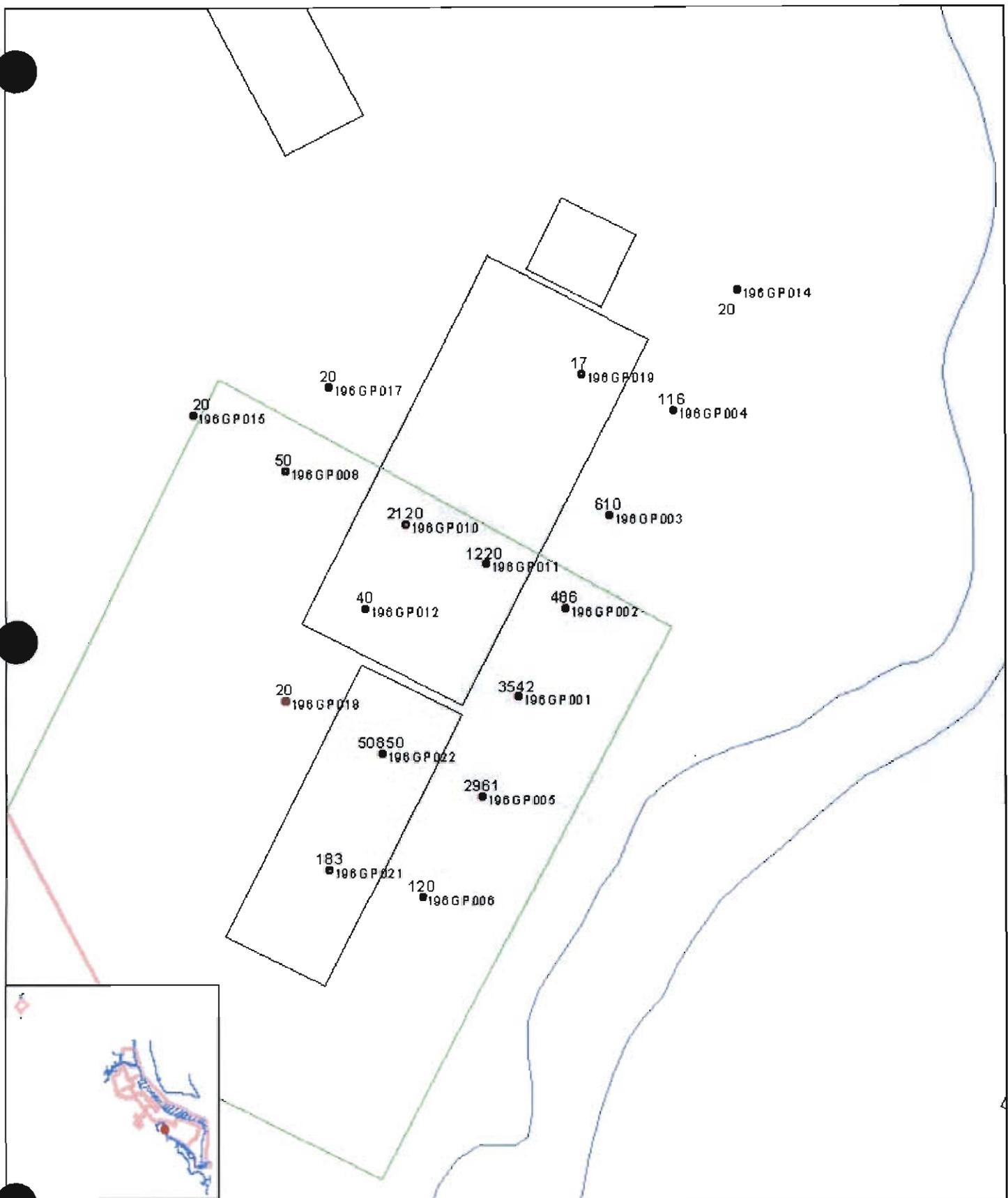


Total CB's (ppb) w/Sample ID at 13 ft bgs



0 30 60 Feet

Figure 2-6
 Total CB's 13 ft bgs
 SWMU 196
 Charleston Naval Complex



Total CB's (ppb) at 15 ft bgs



0 30 60 Feet



Figure 2-7
 Total CB's at 15 ft bgs
 SW MU 196
 Charleston Naval Complex

Section 3.0

3.0 Technical Approach

This Phase II IM will involve the remediation of contaminated groundwater at SWMU 196 using in-situ chemical oxidation. GCI is the remediation contractor that will implement the IM at SWMU 196. The Phase II IM will be completed in two sub-phases: Phase II-A will be a focused application in the area of the highest contamination, and Phase II-B will be address the remainder of the target treatment area.

The sections below address the following issues:

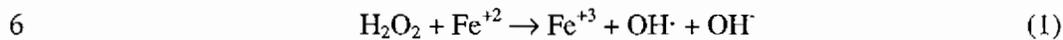
- The Geo-Cleanse® process
- Applicability of Fenton's reagent to CB and DCB
- Treatment goals
- Areas to be treated during the Phase II-A IM (focused area) and the Phase II-B (IM treatment of other areas)
- Injection equipment
- Injector installation
- Performance and process monitoring
- Treatment program procedures
- Reporting
- Permitting

3.1 Geo-Cleanse® Process

The Geo-Cleanse® Process is a patented technology that simultaneously injects hydrogen peroxide and trace quantities of metallic salts under pressure to the subsurface in order to destroy organic contaminants in soil and groundwater. U.S. patents 5,525,008 and 5,611,642 protect the technology. The Geo-Cleanse® Process delivers a calculated charge of hydrogen peroxide and catalyst to the contaminated region via specially designed injection equipment consisting of mixing heads and subsurface injectors. The injection methodology and equipment are the keys to the Geo-Cleanse® Process. The chemistry involved is based upon Fenton's reagent. Fenton's reagent oxidizes organic contaminants to carbon dioxide and water, plus chloride (in the case of chlorinated compounds).

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

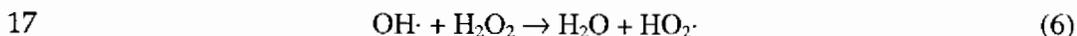
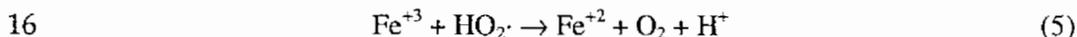
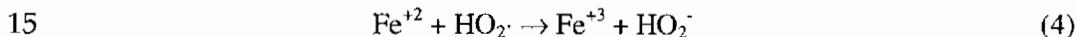
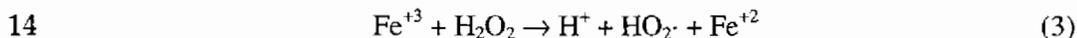
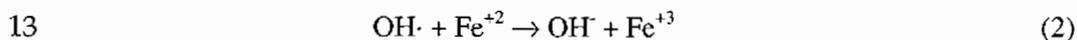
5



7

8 Where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, Fe^{+3} is ferric iron, $\text{OH}\cdot$ is
9 hydroxyl free radical, and OH^- is hydroxyl ion. Fenton's reagent chemistry is complex,
10 involving a number of additional reactions producing both oxidants and reductants that
11 contribute to contaminant destruction (e.g., Watts et al., 1999):

12



18

19 Where $\text{HO}_2\cdot$ is hydroperoxyl radical, HO_2^- is hydroperoxyl anion, O_2 is molecular
20 oxygen, H^+ is the hydrogen ion, and H_2O is water. Additional reactions occur with
21 organic compounds. The suite of reactions associated with Fenton's reagent is complex,
22 but is very effective in destroying many organic compounds dissolved in groundwater,
23 sorbed to soil particles, or existing as non-aqueous phase liquids in subsurface
24 environments.

25 The hydroxyl free radical generated by Fenton's reagent is a powerful, non-selective
26 oxidant. Oxidation of an organic compound by Fenton's reagent is a rapid and
27 exothermic (heat-producing) reaction. Rate constants for reactions of hydroxyl free
28 radical with common environmental pollutants are typically in the range of 10^7 to 10^{10}
29 $\text{M}^{-1}\text{s}^{-1}$ (e.g., Buxton et al., 1988; Haag and Yao, 1992), and 100-percent mineralization is

1 generally completed in minutes. Intermediate compounds are primarily naturally
2 occurring carboxylic acids. The end products of oxidation are primarily carbon dioxide
3 and water, plus chloride (in the case of chlorinated compounds). None of the injected
4 reagents poses an environmental hazard. Unconsumed hydrogen peroxide naturally
5 degrades to oxygen and water within a few days of injection.

6 **3.2 Fenton's Reagent and CB/DCB Treatment**

7 Fenton's reagent oxidizes chlorinated monoaromatic compounds such as
8 chlorobenzenes to substituent carbon dioxide, water, and chloride, via an oxidation
9 pathway that involves carboxylic acids. The oxidation pathway of benzene is well
10 known and provides a model for the oxidation pathway of other monoaromatic
11 compounds (Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling and
12 Johnson, 1975; Edwards and Curci, 1992 [full reference to be provided]; Scheck and
13 Frimmel, 1995). The rate constant for oxidation of benzene by hydroxyl free radicals is
14 reported as $7.8 \times 10^9 \text{ M}^{-1}\text{s}^{-1}$ (Buxton et al., 1988). Reaction of benzene with hydroxyl free
15 radicals produces short-lived and highly reactive aromatic intermediates. The initial
16 attack is hydroxylation to phenol and subsequent oxidation to orthobenzoquinone. The
17 benzene oxidation pathway is presented as Figure 3-1.

18 Once orthobenzoquinone is formed, ring tension and oxidizing agents rapidly force
19 fission of the aromatic ring to produce muconic acid, a linear carboxylic acid. The
20 pathway then proceeds through a series of intermediate carboxylic acids to carbon
21 dioxide. Hydroxyl radicals do not readily oxidize certain carboxylic acids produced as
22 intermediate oxidation products from organic compounds, thus mineralization may be
23 incomplete although no hazardous intermediate compounds are formed. For example,
24 oxalic acid produced as an intermediate product of Fenton's reagent oxidation of
25 benzene is not readily oxidized in the absence of light (e.g., Karpel vel Leitner, 1997).

26 A similar series of intermediate products, possibly including benzoic acid, is also
27 reported for toluene (Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling
28 and Johnson, 1975). Although the oxidation pathways for other compounds, particularly
29 polycyclic aromatic hydrocarbon (PAH) compounds, are not as well known as for
30 benzene, the susceptibility of the remaining aromatic compounds to Fenton's reagent
31 oxidation is well demonstrated (e.g., Martens and Frankenberger, 1995; Chen and
32 Pignatello, 1997; Lindsey and Tarr, 2000).

1 Haag and Yao (1992) report a rate constant of $4 \times 10^9 \text{ M}^{-1}\text{s}^{-1}$ for the reaction of 1,2,4-
2 trichlorobenzene with hydroxyl free radical, indicating that Fenton's reagent oxidation
3 of 1,2,4-trichlorobenzene is very rapid. Additionally, Watts et al. (1997 [full reference to
4 be provided]) report that Fenton's reagent effectively and rapidly oxidizes
5 trichlorobenzene sorbed to soil mineral surfaces. Thus, available laboratory data
6 indicate that Fenton's reagent can treat all forms of trichlorobenzene, including
7 nonaqueous phase liquid product, dissolved and sorbed phases. In addition to 1,2,4-
8 trichlorobenzene, site characterization data also indicate the presence of additional
9 organic constituents including other isomers of trichlorobenzene, and isomers of
10 dichlorobenzene, all of which are also rapidly oxidized by Fenton's reagent (e.g., Haag
11 and Yao, 1992).

12 The Fenton's reagent oxidation pathway of chlorobenzene is very similar to that of
13 benzene, producing chlorophenol and chlorobenzoquinone prior to ring fission (Sedlak
14 and Andren, 1991). Isomers of dichlorobenzene and trichlorobenzene are also reported
15 from the Sharon Transformer Plant site or detected in the tested samples. The oxidation
16 pathway for these compounds is not well known, but is anticipated to be very similar to
17 that of benzene and chlorobenzene. This is because hydroxyl radicals preferentially
18 attack aromatic ring structures (dechlorination occurs by other mechanisms) and rate
19 constants are not strongly affected by the degree of chlorination (Sedlak and Andren,
20 1991). Watts et al. (1994 [full reference to be provided], 1997) report rapid oxidation of
21 polychlorinated benzenes (including trichlorobenzene isomers) sorbed to several
22 different soil matrices. Previous GCI field experience has included one site impacted by
23 1,2,4-trichlorobenzene, including free product accumulations (Bryant and Wilson, 1999).
24 Treatment of this site with the Geo-Cleanse® Process resulted in the complete
25 destruction of the free product within the treatment area, without formation of any
26 hazardous intermediate compounds.

27 **3.3 Treatment Goals**

28 The IM for SWMU 196 will consist of several phases. Phase II-A will focus on a limited
29 area of high concentrations. Phase II-B will address the entire target treatment area.
30 Finally, a polishing phase will be completed if additional treatment is warranted.

31 The primary objective for the in-situ chemical oxidation is the destruction of 90 percent
32 of the CB detected in groundwater at the site within the treatment area. Satisfying this
33 objective requires the collection of a sufficient quantity of accurate data during the
34 Phase II-A treatment phase to assess treatment factors for the full-scale treatment.

1 Factors that will be evaluated include effective radius of influence, sustainable injection
2 rate, oxidation efficiency, and the effect of site-specific geological and hydrogeological
3 conditions on the overall treatment. These factors will determine the best injector design
4 and optimum chemical formulation necessary to achieve at least 90 percent reduction in
5 the full-scale program. The approximate extent of the Phase II-A and Phase II-B
6 treatment areas are presented in Figures 3-2 and 3-3.

7 **3.4 Target Treatment Area for the Phase II-A and Phase II-B** 8 **IMs**

9 The Phase II-A IM will be conducted in a focused area of SWMU 196. The purpose of
10 conducting the focused application of chemical oxidation is to collect operational data
11 (e.g., injector well radius of influence; chemical feed rate) that can be used to better
12 design and construct the Phase II-B IM, which will address a much larger area. The
13 Phase II-A target treatment area is approximately 75 ft x 40 ft, and encompasses the
14 locations of 196GP010, 196GP011, 196GP002, 196GP003, 196GP023, and 196GP024,
15 which are the locations with the highest total CB contamination at the site.

16 For the Phase II-A IM, five injectors will be installed through the floor of Building 1838.
17 Additional injectors will be installed in the building as part of Phase II-B. When
18 injection is considered beneath structures, subsidence is an issue that will be considered.
19 Subsidence may occur in the following circumstances: in a clay lithology, where the clay
20 matrix can change in physical properties, (i.e., loading factors), especially in clay fill
21 areas with macro void spaces; and in fill areas with high organic content, where the
22 peroxide may digest some of the matrix. Based on the information available for the site,
23 these conditions do not appear to exist.

24 In order to monitor potential degassing (i.e., CO₂ and O₂) beneath the floor of Building
25 1838, ports will be installed through the floor of Building 1838. If pressure accumulates
26 beneath the floor in excess of five pounds per square inch (PSI), the vent flow balance
27 system will be activated to reduce any gas pressure. The vent flow balance system is a
28 series of vent wells in the vadose zone that can be opened to the atmosphere to allow
29 pressure to be released. The vent well locations are presented in Figures 3-2 and 3-3. A
30 construction diagram for the vent well is presented as Figure 3-4.

31 Upon completion of the Phase II-A treatment program, additional refinements will be
32 made for the full-scale injection program. The full-scale injection program anticipates

1 approximately 33 injectors (including wells used for the Phase II-A injection) across the
2 target treatment area (see Figure 3-3) with approximate dimensions of 90 ft x 210 ft.

3 **3.4.1 Treatment Depth Interval**

4 For the Phase II-A work, a total of seven injectors will be installed at two vertical levels.
5 One level consisting of three injectors will be installed and screened approximately 3 to
6 6 ft above the aquitard and will be referred to as shallow injectors. The second level,
7 consisting of four injectors, will be installed and screened from approximately 0 to 3 ft
8 from the top of the aquitard. These will be referred to as deep injectors. Two barrier
9 injectors will be installed along the eastern edge of the treatment area to protect the
10 wetlands and the stream from any reagents.

11 The barrier injectors are installed as injection wells. However, their primary function is
12 to monitor gases at the barrier well location. The vapor in the barrier injectors will be
13 monitored for increased photo ionization detector (PID) levels which may indicate the
14 increased presence of contaminants at that location. Note that elevated PID levels in this
15 area do not necessarily indicate the migration of a contaminant. The reaction of Fenton's
16 reagent with contaminants is an exothermic reaction, causing a higher contaminant
17 solubility. This may cause higher PID levels in groundwater due to increased solubility,
18 or increased PID levels in the vapor due to simply increased groundwater temperature.
19 In the event that the PID levels in the barrier well vapors significantly increase to a level
20 which would potentially indicate the transport of contaminants in water, the wells will
21 receive a charge of oxidant. The oxidant charge will degrade mobilized contaminant in
22 the area and prevent further migration. Additional charges of oxidant can be applied as
23 warranted.

24 The additional injector wells and barrier wells installed during Phase II-B will also be
25 located approximately 0 and 6 ft above the aquitard (approximately equal numbers at
26 each elevation). Both of the Phase II-A and Phase II-B IMs will be restricted to the
27 saturated zone in the depth interval of 5 to 15 ft bls, corresponding to the upper site soils
28 above the marsh clay layer aquiclude.

29 **3.5 Geo-Cleanse Injection Equipment**

30 GCI will stage a mobile treatment unit at the site. A schematic of a typical mobile
31 treatment unit is provided in Figure 3-5. Hydrogen peroxide is staged at the site in a
32 tanker. Additional support services at the site include water and power.

1 The GCI mobile treatment unit includes tanks, pumps, gauges, and flow control valves
2 to deliver reagents safely and effectively to mixing heads installed on the injectors.
3 Safety features include redundant check valves to control reagent flow, construction
4 materials to withstand the reagents and pressures encountered, and eyewashes and
5 safety. Reagent injection to the subsurface is conducted via specially designed mixing
6 heads that are attached to the riser pipe of the injector (see Figure 3-6). The mixing
7 heads are designed with redundant safety features including check valves, pressure
8 gauges, and flow-control ball valves. They are constructed of stainless steel to withstand
9 the reagents.

10 The entire system, from the peroxide tanker to the mobile treatment unit, as well as
11 from the mobile treatment unit to the injector head, is entirely closed and there is no
12 exposure to the hydrogen peroxide. The entire system is leak-checked prior to operation.
13 Procedures to address spills are provided in the Site-Specific Health and Safety Plan. In
14 summary, in the event of a small spill (tens of gallons or less), the spill is addressed by
15 spraying the area with water until the hydrogen peroxide is diluted. In the event of a
16 catastrophic spill (such as from a tank truck failure), the area must be evacuated, local
17 fire department authorities notified, and a 24-hour GCI Emergency Hotline is available
18 at (609) 924-6677 through the manufacturer of the hydrogen peroxide, FMC.

19 **3.6 Injector Installation**

20 **3.6.1 Utility Clearance**

21 The location of known utilities will be identified by CH2M -Jones before the injectors
22 are installed. Injector locations that are near the identified underground utilities will be
23 initially dug with a posthole digger to a depth of at least 4 ft below grade to ensure that
24 the drilling location is clear. Injection wells installed inside of Building 1838 will require
25 the removal of concrete.

26 **3.6.2 Injector Construction**

27 Example construction details for shallow, deep, and barrier injectors are provided in
28 Figures 3-7, 3-8, and 3-9, respectively. Injectors are constructed of materials intended to
29 withstand elevated temperatures and pressures, as well as exposure to the reagents
30 utilized during the Geo-Cleanse® Process. The injectors are constructed with 0.010-slot
31 stainless steel screens and Schedule 80 steel riser pipe and couplings. The pipe and
32 screen diameters are 1.25 inches. The injectors will be installed with a 3-ft screen. The
33 relatively short screen length is intended to provide greater hydraulic control over

1 reagent injection depths and to prevent formation of preferred reagent pathways
2 through the formation.

3 The injectors are built and placed into the soil borings through the hollow stem auger.
4 The augers will be systematically extracted as completion materials are added to ensure
5 that materials do not bridge within the auger. The borehole with the injector will be
6 backfilled with filter pack sand to a level approximately one foot above the top of the
7 screen. If necessary, sand may be added by tremie pipe with approved water for
8 adequate settling. Next, a 1-ft thick layer of bentonite (medium pellets or 3/8-inch chips)
9 will be added and allowed 15 minutes to hydrate. Hydration water for the bentonite
10 should not be necessary because the targeted intervals are all within the saturated zone.
11 However, four gallons of approved water will be added to hydrate the bentonite if no
12 water is present within the augers. The injectors will then be sealed to grade with a
13 cement/bentonite grout mix. A cement/bentonite mix was selected to provide a more
14 competent seal (important for injection) than high-solids bentonite slurry. The grout mix
15 will be added by tremie pipe with side discharge to ensure the complete displacement
16 of water within the augers and competent distribution. The grout is a non-shrinking mix
17 consisting of Portland Type I cement, bentonite powder, and water in the ratio of 94
18 pounds Portland Type I cement (five pounds of bentonite powder and seven gallons of
19 water). The target mixture weighs approximately 15 pounds per gallon. The grout will
20 be allowed to settle after completion and additional grout will be added as necessary to
21 fill the borehole. The injectors will be completed with flush mounts; however, injectors
22 located in the marsh area will be completed with stick-up construction. Construction
23 details will be recorded on the soil boring log maintained for each boring (see Figure
24 3-10).

25 **3.7 Performance and Process Monitoring**

26 Performance monitoring is defined as groundwater samples collected to characterize
27 groundwater for base-line sampling, as well as monitoring after treatment phases.
28 Performance groundwater samples will be collected after seven and 30 days, each,
29 during both Phase II-A and Phase II-B. Should an additional polishing phase be
30 required, performance sampling will also be performed at the same time intervals. All
31 performance monitoring will be completed by CH2M-Jones.

32 Field procedures and groundwater analyses will follow standard procedures found in
33 the approved Comprehensive Sampling and Analysis Plan (CSAP) portion of the RFI
34 Work Plan (EnSafe Inc. [Ensafe]/Allen & Hoshall, 1994). The CSAP outlines all

1 monitoring procedures to be performed during the investigation in order to characterize
2 the environmental setting, source, and releases of hazardous constituents. In addition,
3 the CSAP includes the Quality Assurance Plan (QAP) and Data Management Plan
4 (DMP) to verify that all information and data are valid and properly documented.
5 Unless otherwise noted, the sampling strategy and procedures will be performed in
6 accordance with the U.S. Environmental Protection Agency (EPA) Environmental
7 Services Division *Standard Operating Procedures and Quality Assurance*
8 *Manual* (ESDSOPQAM) (1996).

9 The groundwater samples will be sampled in accordance with the CSAP for volatile
10 organic compounds (VOCs). VOCs will be analyzed in accordance with the EPA's SW-
11 846 Method 8260.

12 Process monitoring, which will be performed by GCI, refers to analyses of groundwater
13 and offgas samples collected within and adjacent to the treatment area, during
14 implementation of the in-situ chemical oxidation treatment for purposes of determining
15 if appropriate geochemical conditions are established in the aquifer, whether reagents
16 are distributed effectively, and if an efficient oxidation reaction is occurring. The types
17 of analyses conducted during process monitoring are groundwater quality
18 measurements and are described Section 3.8.4 of this work plan.

19 **3.8 Treatment Program Procedures**

20 **3.8.1 Sequence of Events**

21 The treatment program phases include mobilization, treatment, and demobilization.
22 Mobilization normally requires one day of onsite activities. Tasks required for
23 mobilization include positioning the GCI mobile treatment unit, hydrogen peroxide
24 tanker and generator; establishing an exclusion zone; constructing the safety shower
25 and hydrogen peroxide transfer station; connecting the treatment unit to the water
26 source and power generator; and leak- and safety-checking all hosing and fittings. A
27 health and safety meeting with all personnel is normally conducted on the first day.

28 Each day of injection typically begins with a tailgate health and safety meeting. Injection
29 of catalyst and hydrogen peroxide solutions is then performed during the course of the
30 day, with monitoring as is described in Section 3.8.4. of this work plan. Normal
31 workdays range from 8 to 10 hours, or during available daylight (whichever is shorter).
32 At the end of each day, the mixing heads and lines will be returned to the mobile
33 treatment unit and ancillary equipment secured, the hydrogen peroxide tanker will be

1 locked, the generator or power supply will be turned off, and the site will be secured for
2 the night.

3 Demobilization activities include clearing the site of any fluids or debris resulting from
4 injection activities, dismantling the hydrogen peroxide transfer station and safety
5 shower, disconnecting from water and power supplies, and securing the mobile
6 treatment unit, hydrogen peroxide tanker, and generator. Demobilization activities
7 typically require a half-day of onsite activities.

8 **3.8.2 Duration of Treatment**

9 Phase II-A of the treatment program at SWMU 196 is anticipated to require nine days of
10 onsite activities, including mobilization, injection, and demobilization activities. Injector
11 installation is anticipated to require three days of drilling activities. An estimated 35,000
12 pounds (lbs) (3,500 gallons) of 50-percent concentration hydrogen peroxide are
13 anticipated for injection (50-percent concentration hydrogen peroxide is staged at the
14 site for economic reasons, maximum injected concentration is 25 percent). The volume
15 of catalyst solution is anticipated to be from 2 to 4 times the peroxide volume during the
16 injection phase.

17 The conceptual locations of the injectors for Phase II-B are provided in Figure 3-3. The
18 actual spacing and placement of the full-scale injectors will be determined at the
19 completion of the Phase II-A test program. A total of 74,000 lbs (7,400 gallons) of 50-
20 percent hydrogen peroxide is allotted for the full-scale program, along with
21 approximately 2 to 4 times that amount of catalyst solution. Injector installation is
22 anticipated to take 6 to 8 days, and the injection program is anticipated to take 12 to 14
23 days. Full-scale design is anticipated within two weeks of the completion and receipt of
24 performance results for Phase II-A.

25 The implementation of a polishing phase may be required if additional treatment, in
26 excess of that accomplished in Phases II-A and II-B, is warranted to achieve the objective
27 of removing 90-percent of the total CB concentration. The polishing injection design can
28 be completed within two weeks of the completion and receipt of the post full-scale
29 treatment analytical data. The polishing phase includes the possible installation of up to
30 five additional injectors. The polish injector installation will take approximately two
31 days, depending on the number of additional injectors required. The polish phase field
32 injection may take up to four days, and can include up to 12,000 lbs (1,200 gallons) of 50-
33 percent hydrogen peroxide.

3.8.3 Reagents

The reagents used in the Geo-Cleanse® Process, as well as their purpose, injected concentrations and fate, are summarized as follows:

Hydrogen Peroxide

50-percent technical grade, used as oxidizing agent. Injected into groundwater and soils with a maximum 25-percent concentration, with resultant concentrations to groundwater of less than 1 percent. This concentration quickly falls to less than 25 parts per million (ppm) within several hours following injection, and is typically completely consumed within 2 to 3 days.

Ferrous Sulfate

100-ppm aqueous solution of food grade reagent, used as a catalyst. This concentration is typically diluted in groundwater to less than 10 ppm. The ferrous iron is oxidized in the subsurface to ferric iron and precipitates as an iron oxide or iron hydroxide. Ferrous sulfate may not be used if sufficient natural iron (greater than 25 mg/L) is present in groundwater.

Sulfuric Acid

66° (98-percent) technical grade, diluted prior to injection in water to a pH of approximately 4. This is used in the catalyst solution to inhibit oxidation of ferrous iron to ferric iron in the catalyst solution prior to injection, and to adjust pH of the groundwater to the optimal range for Fenton's reagent (<6). Groundwater pH will return to ambient background conditions within a few days of injection. This reagent may not be utilized depending upon site-specific conditions. Sulfuric acid may not be used if either the groundwater pH is already acidic (<6), or if a more stabilizing catalyst solution is desired (in which case phosphoric acid may be used). At one week and again at 30 days after the Phase II-A injection is completed, the groundwater pH will be evaluated. Based on the results of this evaluation, a neutralization phase, after the full-scale program using potassium hydroxide (KOH), may be considered to return the groundwater to ambient conditions.

Phosphoric Acid

85-percent technical grade, diluted prior to injection in water to a pH of approximately 4. This is used in the catalyst solution to inhibit oxidation of ferrous iron to ferric iron in the catalyst solution prior to injection, and to adjust the pH of the groundwater to the optimal range for Fenton's reagent (<6). Groundwater pH will return to ambient

1 background conditions within a few days of injection. This reagent may not be utilized
2 depending upon site-specific conditions. Phosphoric acid may not be used if either the
3 groundwater pH is already acidic (<6), or if a more reactive catalyst solution is desired
4 (in which case sulfuric acid may be used). At one week and again at 30 days after the
5 Phase II-A injection is completed, the groundwater pH will be evaluated. Based on the
6 results of this evaluation, a neutralization phase, after the full-scale program using
7 KOH, may be considered to return the groundwater to ambient conditions.

8 **Calcium Phosphate**

9 10-ppm aqueous solution of food grade reagent, used to stabilize the Fenton's reagent.
10 This concentration is diluted in groundwater to less than 1 ppm. The calcium remains
11 dissolved in the solution and the phosphate is either precipitated or is utilized as a
12 nutrient in biological reactions. This reagent may not be utilized depending upon site-
13 specific conditions. Calcium phosphate may be used if additional phosphate is desired
14 for stabilization, without additional acidity.

15 **3.8.4 Process Monitoring Parameters**

16 As part of the process monitoring, GCI will collect field measurements during the
17 injection to ensure that the appropriate subsurface conditions exist for Fenton's reagent,
18 that an efficient reaction is occurring, and to monitor the reaction progress. Parameters
19 that are monitored include both groundwater quality and liberated gas measurements
20 (i.e., carbon dioxide and oxygen). At least one groundwater sampling event will be
21 conducted each day, including one in the morning prior to beginning the injection and
22 one in the afternoon prior to concluding the injection. Gas measurements will be
23 conducted at approximately two-hour intervals throughout the day using appropriate
24 calibrated field meters described below. Monitoring will be performed only in the active
25 treatment area and in the breathing zone as part of the Health and Safety Plan (i.e., the
26 entire site is not monitored during every sampling event). Additional analyses may be
27 performed as dictated by site conditions, but not at prescribed time intervals.

28 Parameters that are monitored, their purpose, method, resolution, and range are as
29 follows:

30 **pH**

31 Groundwater pH is monitored to ensure that appropriate pH conditions (pH <6) are
32 established. A Hach test kit model 17-F is used. The test is a colorimetric method using
33 bromothymol blue as an indicator. The range is 5.5 to 8.5 with resolution of ±0.1 units.
34 The pH measurements may be supplemented with test strips (0 to 6 with resolution of

1 ±0.5 units) if necessary. A pH meter is not used because the electrodes are damaged by
2 hydrogen peroxide.

3 **Alkalinity**

4 Alkalinity affects Fenton's reagent treatment because dissolved bicarbonate (the
5 predominant component of groundwater alkalinity) is an efficient hydroxyl free radical
6 scavenger. A target value of <100 mg/L is desired. Alkalinity is also related to pH,
7 because groundwater pH controls bicarbonate equilibrium and the capacity of the
8 groundwater to contain bicarbonate. A Hach test kit model AL-AP/MG-L is used. The
9 test is a titration method using a sulfuric acid reagent. The range is 0 to 100 mg/L (as
10 CaCO₃) with resolution of ±5 mg/L, or 20 to 400 mg/L with resolution of ±20 mg/L.
11 This is typically collected at the beginning and end of the program.

12 **Dissolved Chloride**

13 Chloride is produced as an oxidation product of chlorinated hydrocarbons (see Section
14 2.2 of this work plan). A Hach test kit model 8-P is used. The test is a titration method
15 using a silver nitrate indicator. The range is 5 to 100 mg/L (as Cl⁻) with ±5 mg/L
16 resolution, or 20 to 400 mg/L (as Cl⁻) with ±20 mg/L resolution. Chloride concentration,
17 as a result of contaminant oxidation at this site, is anticipated to be high based upon the
18 suspected presence of DNAPL.

19 **Dissolved Iron**

20 Dissolved iron (either as ferrous or ferric forms) is a catalyst for Fenton's reagent. A
21 minimum of 10 mg/L is desired in groundwater, and dissolved iron monitoring
22 determines if ferrous sulfate is used in the catalyst blend. A Hach test kit model IR-18B
23 is used to measure both forms of iron. The test is a colorimetric method using
24 phenanthroline reagent. The range is 0 to 10 mg/L with resolution of ±0.2 mg/L.

25 **Hydrogen Peroxide**

26 Hydrogen peroxide is monitored to ensure that reagents are distributed throughout the
27 treatment area. Hydrogen peroxide is measured with Merckoquant colorimetric test
28 strips (E.M. Science, Gibbstown, NJ) with a measurable range of 0 to 100 mg/L. The test
29 strips have indicators labeled at 0, 1, 3, 10, 30, and 100 mg/L peroxide, and intermediate
30 concentrations can be interpolated.

31 **Carbon Dioxide**

32 The oxidation of organic compounds yields carbon dioxide, which is liberated from the
33 subsurface through adjacent injectors and monitoring wells. Carbon dioxide production

1 is a sensitive measure of the efficiency and progress of the treatment. At sites impacted
2 by chlorinated aliphatics such as chlorobenzene and dichlorobenzenes, carbon dioxide
3 production typically reaches maximum levels of approximately 7 to 10 percent in the
4 early stages (during the first 2 to 4 days) of injection, then decreases asymptotically to
5 zero during the course of the treatment as the subsurface organic contaminants are
6 destroyed. Carbon dioxide concentration is measured in headspaces of injectors and
7 monitoring wells within and adjacent to the treatment area. The measurement is
8 performed with a GasTech GT series carbon dioxide/oxygen meter. The meter uses a
9 non-dispersive infrared absorbance detection method. Resolution is ± 0.1 percent and
10 range is 0 to 20 percent.

11 **Oxygen**

12 Reaction of hydroxyl free radicals with hydrogen peroxide, other radicals, or other non-
13 organic compounds produces oxygen. Oxygen is liberated from the subsurface through
14 adjacent injectors and monitoring wells. At sites impacted by chlorinated compounds
15 such as chlorobenzenes, oxygen production is typically low during the first few days of
16 injection (approximately 10 to 15 percent) then increases to >30 percent over the course
17 of the treatment as the subsurface organic contaminants are destroyed. Oxygen
18 concentration is measured in headspaces of injectors and monitoring wells within and
19 adjacent to the treatment area. The measurement is performed with a GasTech GT series
20 carbon dioxide/oxygen meter. The meter uses an electrochemical detection method.
21 Resolution is ± 0.1 percent and range is 0 to 30 percent

22 **VOCs**

23 Fenton's reagent produces offgases, which pass through potentially contaminated water
24 prior to liberation via adjacent wells. Gases passing through contaminated groundwater
25 may entrain relatively low concentrations of VOCs. Henry's Law predicts the maximum
26 concentration of a VOC in a gas that has passed through a contaminated water sample.
27 As a rule of thumb (supported by GCI field experience), the maximum concentration of
28 a VOC in the offgas is approximately the same order of magnitude as the concentration
29 of the VOC in groundwater. Thus, the concentration of VOCs in offgases is typically at
30 the maximum level during the initial of injection stages (1 to 2 days), and then decreases
31 over the course of the treatment.

32 VOCs are monitored with a PID meter. The PID meter reads a concentration in ppm by
33 volume, however that reading does not correspond exactly to a concentration of VOCs
34 in the air sample. The PID response varies among organic compounds, and the PID also

1 responds to water vapor (resulting in a PID reading that is much higher than the actual
2 VOC concentration in the offgas). PID readings are measured in headspaces of injectors
3 and monitoring wells within and adjacent to the treatment area. The measurement is
4 performed with a ThermoEnvironmental 580B PID meter with a 10.6 eV (electron volt)
5 lamp. The ionization potentials of chlorobenzene and dichlorobenze are 9.06 eV and
6 9.07eV, respectively. Resolution is ± 0.1 ppm and range is 0 to 2,500 ppm.

7 Following the Phase II-A treatment program, groundwater within the target treatment
8 area will be collected at approximately 7 and 30 days after treatment to determine the
9 removal of CB in Phase II-A, and to finalize the design, if necessary, for Phase II-B.

10 **3.9 Reporting**

11 A Phase II IM report will be provided 30 days after the final performance samples are
12 reported from the laboratory.

13 **3.10 Permitting**

14 **3.10.1 U.S. Army Corps of Engineers (USACE) Nationwide (Wetlands) Permits**

15 The installation of temporary wells in wetlands is permissible per the USACE
16 Nationwide Permit (NWP) Program (USACE, 2000). The NWP Program requirements
17 are included in the *Code of Federal Regulations* (CFR), and are summarized below.

18 An NWP is issued to encompass survey activities including core sampling, seismic
19 exploratory operations, plugging of seismic shot holes, and other exploratory-type bore
20 holes, soil survey and sampling, as well as historic resources surveys. Discharges and
21 structures associated with the recovery of historic resources are not authorized by this
22 NWP.

23 The drilling and discharge of excavated material from test wells for oil and gas
24 exploration is not authorized by this NWP; however, the plugging of such wells is
25 authorized. Fill placed for roads, pads, and other similar activities is not authorized by
26 this NWP. Nor does the NWP authorize any permanent structures. The discharge of
27 drilling muds and cuttings may require a permit under section 402 of the Clean Water
28 Act (Sections 10 and 404).

29 The following subsections present the general conditions that must be followed to allow
30 for validity of authorizations by a NWP.

1 **Navigation**

2 No activity may cause more than a minimal adverse effect on navigation.

3 **Soil Erosion and Sediment Controls**

4 Appropriate soil erosion and sediment controls must be used and maintained in
5 effective operating conditions during construction. All exposed soil and other fills, as
6 well as any work below the ordinary high water mark or high tide line, must be
7 permanently stabilized at the earliest practicable date.

8 **Aquatic Life Movements**

9 No activity may substantially disrupt the movement of those species of aquatic life
10 indigenous to the water body, including those species that typically migrate through the
11 area, unless the activity's primary purpose is to impound water. Culverts placed in
12 streams must be installed to maintain low flow conditions.

13 **Equipment**

14 Heavy equipment working in wetlands must be placed on mats. Otherwise other
15 measures must be taken to minimize soil disturbance.

16 **Regional and Case-by-Case Conditions**

17 The activity must comply with regional conditions that may have been added by the
18 division engineer (see 33 CFR 330.4[e]), as well as with any case-specific conditions
19 added by the USACE or by the State or tribe in its Section 401 water quality certification
20 and Coastal Zone Management Act consistency determination.

21 **Endangered Species**

22 No activity is authorized under any NWP that likely jeopardizes the continued existence
23 of a threatened or endangered species, or a species proposed for such designation, as
24 identified under the Federal Endangered Species Act, or which will destroy or adversely
25 modify the critical habitat of such species. Non-federal permittees must notify the
26 District Engineer if any listed species or designated critical habitat might be affected or
27 is in the vicinity of the project, or is located in the designated critical habitat. Activities
28 must not begin until notified by the District Engineer that the requirements of the
29 Endangered Species Act have been satisfied and that the activity is authorized.

30 For activities that may affect Federally-listed endangered or threatened species or
31 designated critical habitat, the notification must include the name(s) of the endangered
32 or threatened species that may be affected by the proposed work or that use the

1 designated critical habitat that may be affected by the proposed work. As a result of
2 formal or informal consultation with the Fish and Wildlife Service or National Fisheries
3 Marine Services, the District Engineer may add species-specific regional endangered
4 species conditions to the NWP.

5 Activities under this permit must use Best Management Practices (BMPs) to minimize
6 disturbance to the wetlands and inhabitants. These BMPs include:

- 7 • Avoidance of discharge
- 8 • Placement of heavy equipment working in wetlands on mats
- 9 • Removal of temporary fills
- 10 • Minimization of disturbance to vegetation

11 Notification to the District USACE may be made after the fact within 30 days of the
12 activity, and must include a description of the activities and location shown on a plat
13 (USACE, 2000).

14 **3.10.2 SCDHEC Well Installation Request**

15 In accordance with R.61-79.265 Subpart F of the South Carolina Hazardous Waste
16 Management Regulations, and R.61-71 of the South Carolina Well Standards and
17 Regulations, a request for the advancement of the vertical profiler locations is required
18 to be submitted to SCDHEC two weeks prior to the scheduled activity. The written
19 request provides the purpose of the vertical profiler activity and consists of well
20 construction details, if required, as well as a map depicting the proposed vertical
21 profiler locations. In addition, because the vertical profiler locations are considered
22 temporary, the request will provide the method used for abandonment.

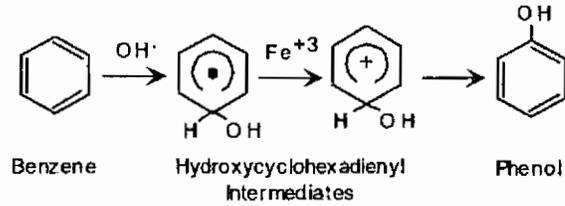
23 Once the project is completed and access to the injection wells is no longer necessary,
24 the monitoring wells will be abandoned in accordance with Rule 61-71.10.B of the South
25 Carolina Well Standards and Regulations.

26 **3.10.3 SCDHEC Underground Injection Control Permit Application**

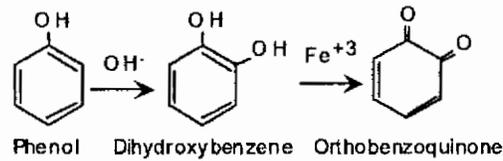
27 An approved Underground Injection Control Permit will be approved prior to the
28 initiation of field work.

Benzene Oxidation Pathway

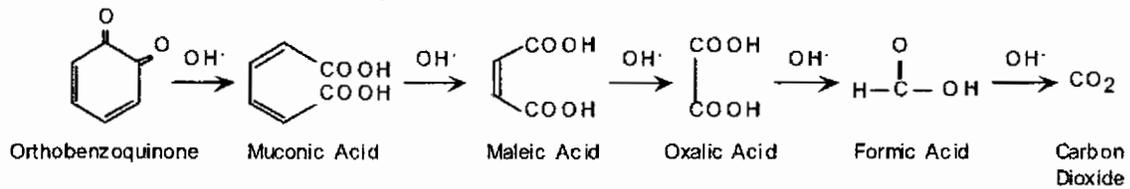
Step 1. Benzene Hydroxylation to Phenol



Step 2. Phenol Oxidation to Benzoquinone



Step 3. Carboxylic Acid Formation and Oxidation to Carbon Dioxide

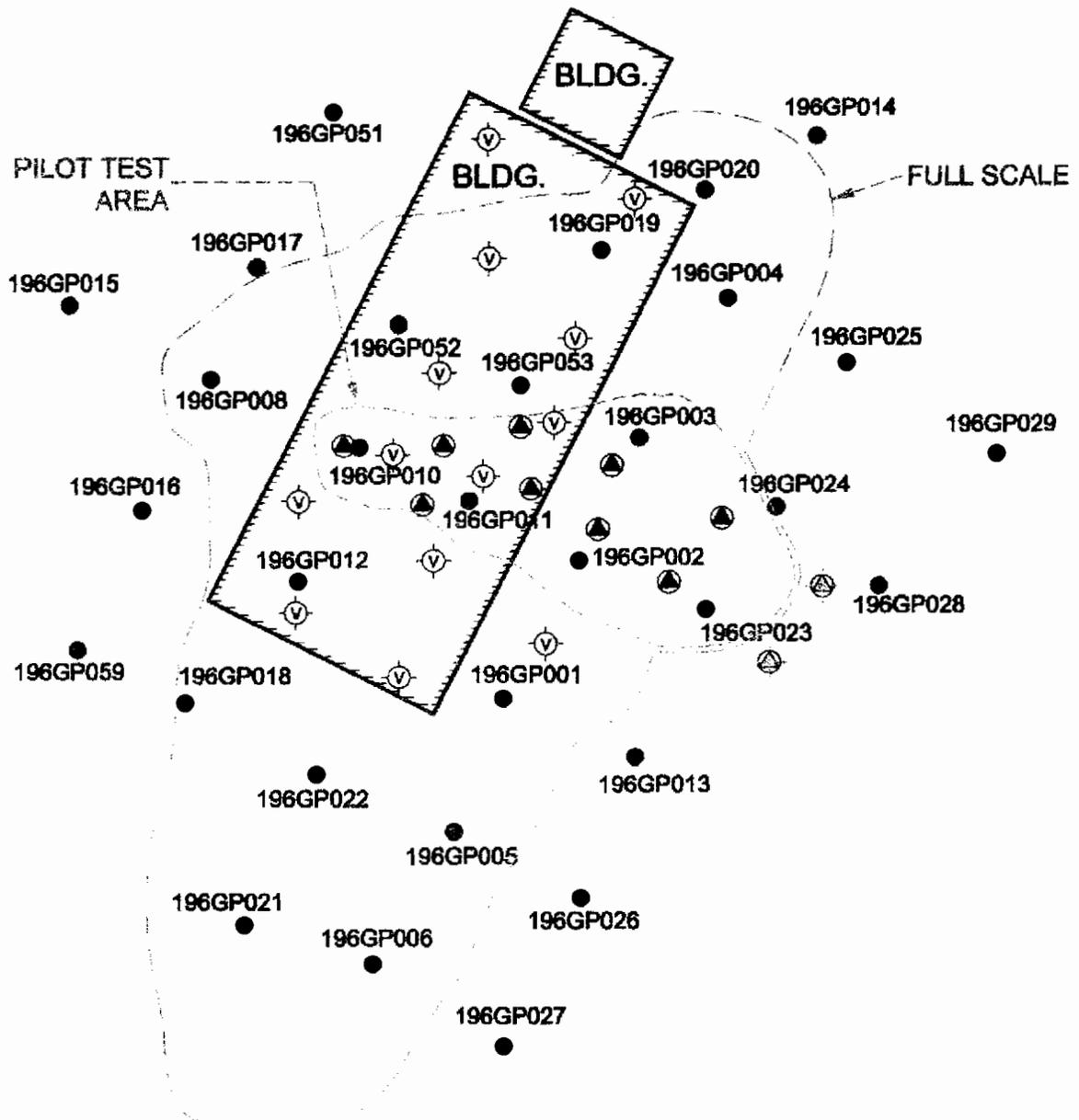


References: Walling, 1975; Edwards and Curci 1992; Scheck and Frimmel 1995.

**EXAMPLE AROMATIC COMPOUND (BENZENE)
FENTON'S REAGENT OXIDATION PATHWAY**

Geo-Cleanse International, Inc.
4 Mark Road, Suite C
Kenilworth, NJ 07033

FIGURE 3-1



LEGEND	
196GP027	BORING LOCATIONS
	INJECTOR LOCATION
	BARRIER INJECTOR LOCATION
	VENT WELL LOCATION

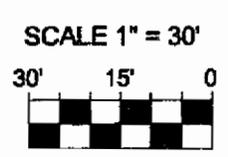
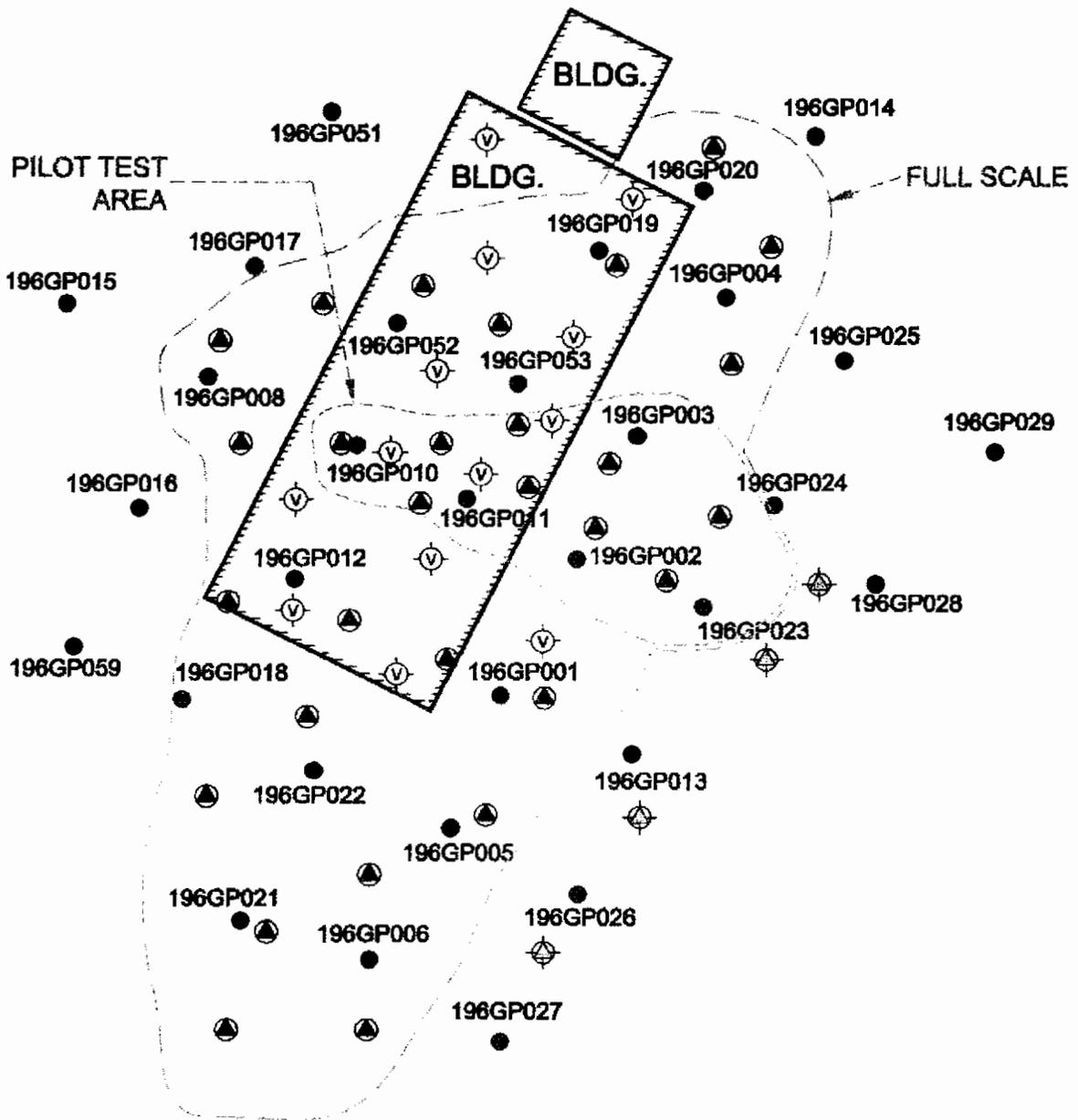


FIGURE 3-2	PHASE II-A	
SWMU 198 CHARLESTON NAVAL COMPLEX NORTH CHARLESTON, SOUTH CAROLINA		DATE:08/02/01
		DESIGNED:
		CHECKED:
		APPROVED:
		DRAWN:AP
REF.:CH2M-JONES, CONTRACT N62467-89-C-0960		



LEGEND	
196GP027	BORING LOCATIONS
	INJECTOR LOCATION
	BARRIER INJECTOR LOCATION
	VENT WELL LOCATION

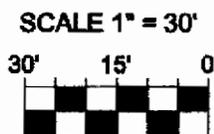
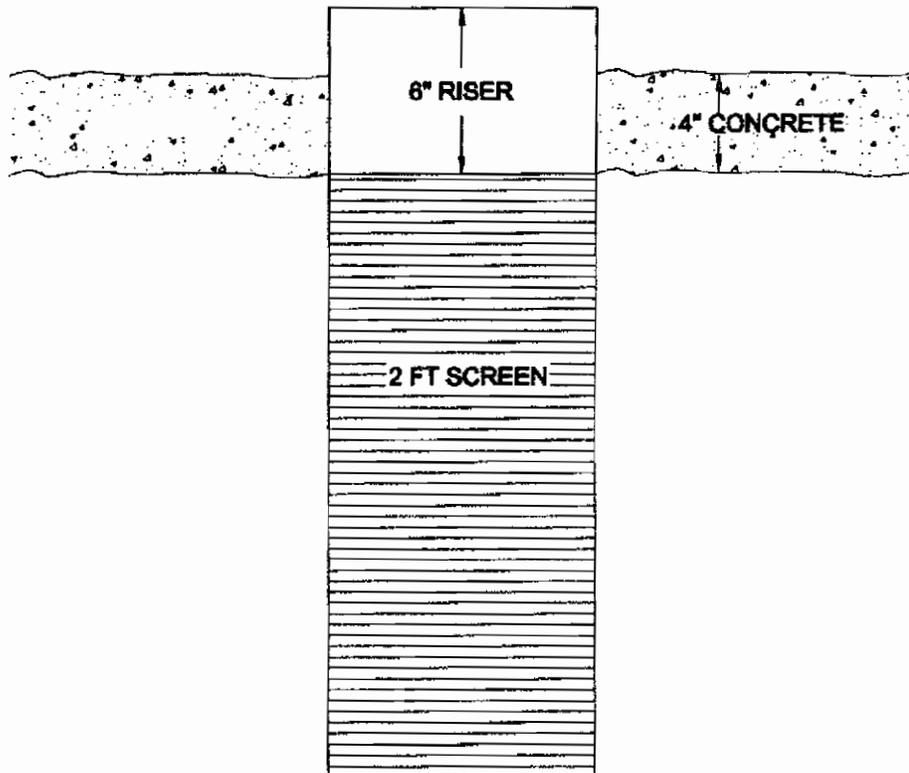


FIGURE 3-3		PHASE II-B INJECTOR LOCATIONS	
SWMU 196		DATE:08/02/01	
CHARLESTON NAVAL COMPLEX		DESIGNED:	
NORTH CHARLESTON, SOUTH CAROLINA		CHECKED:	
		APPROVED:	
		DRAWN:AP	
		REF.:CH2M-JONES, CONTRACT N62467-99-C-0960	

**VENT WELL CONSTRUCTION
(ASSUMING 4" CONCRETE FLOOR SLAB)**



NOT TO SCALE

FIGURE 3-4	EXAMPLE VENT WELL CONSTRUCTION	
	SWMU 198 CHARLESTON NAVAL COMPLEX NORTH CHARLESTON, SOUTH CAROLINA	DATE:08/22/01
 Geo-Cleanse INTERNATIONAL, INC.	DESIGNED:	
	CHECKED:	
	APPROVED:	
	DRAWN/APP:	

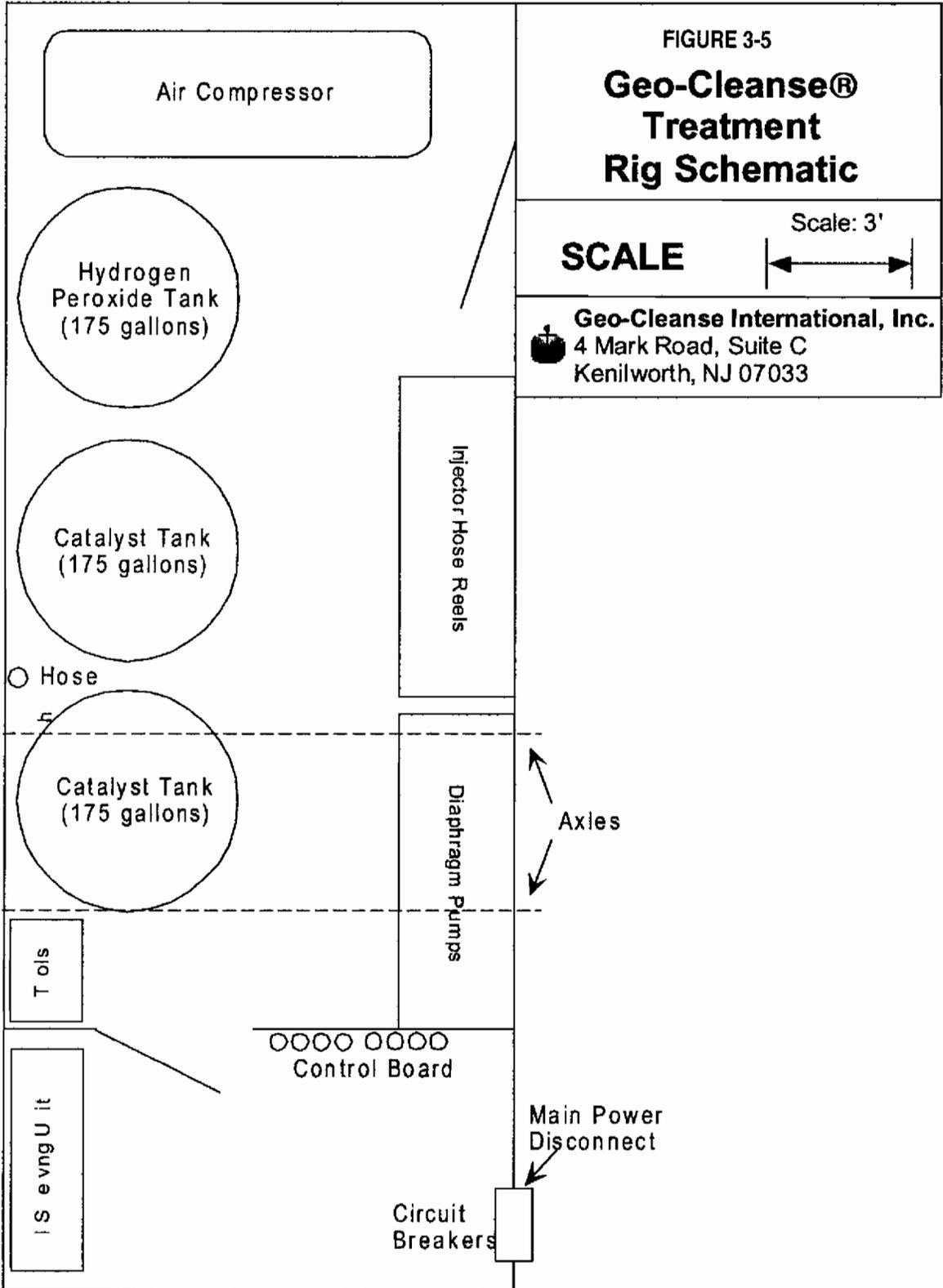


FIGURE 3-5

**Geo-Cleanse®
Treatment
Rig Schematic**

SCALE Scale: 3'
 ←————→

Geo-Cleanse International, Inc.
 4 Mark Road, Suite C
 Kenilworth, NJ 07033

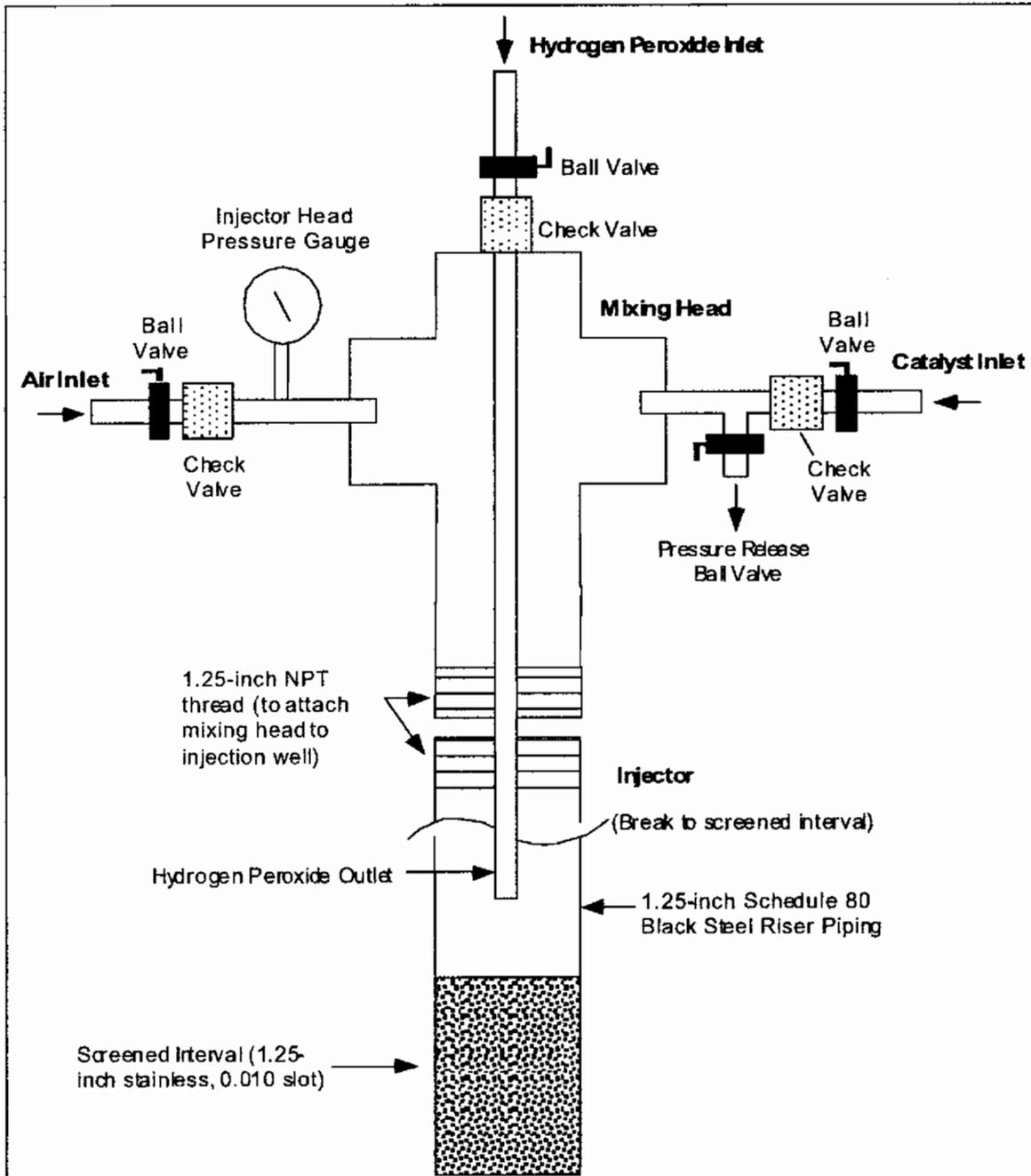


FIGURE 3-6 . Geo-Cleanse® Patented Injector and Mixing Head Design Schematic (U.S. Patents 5,525,008 and 5,611,642)



Geo-Cleanse International, Inc.
 4 Mark Road, Suite C
 Kenilworth, NJ 07033

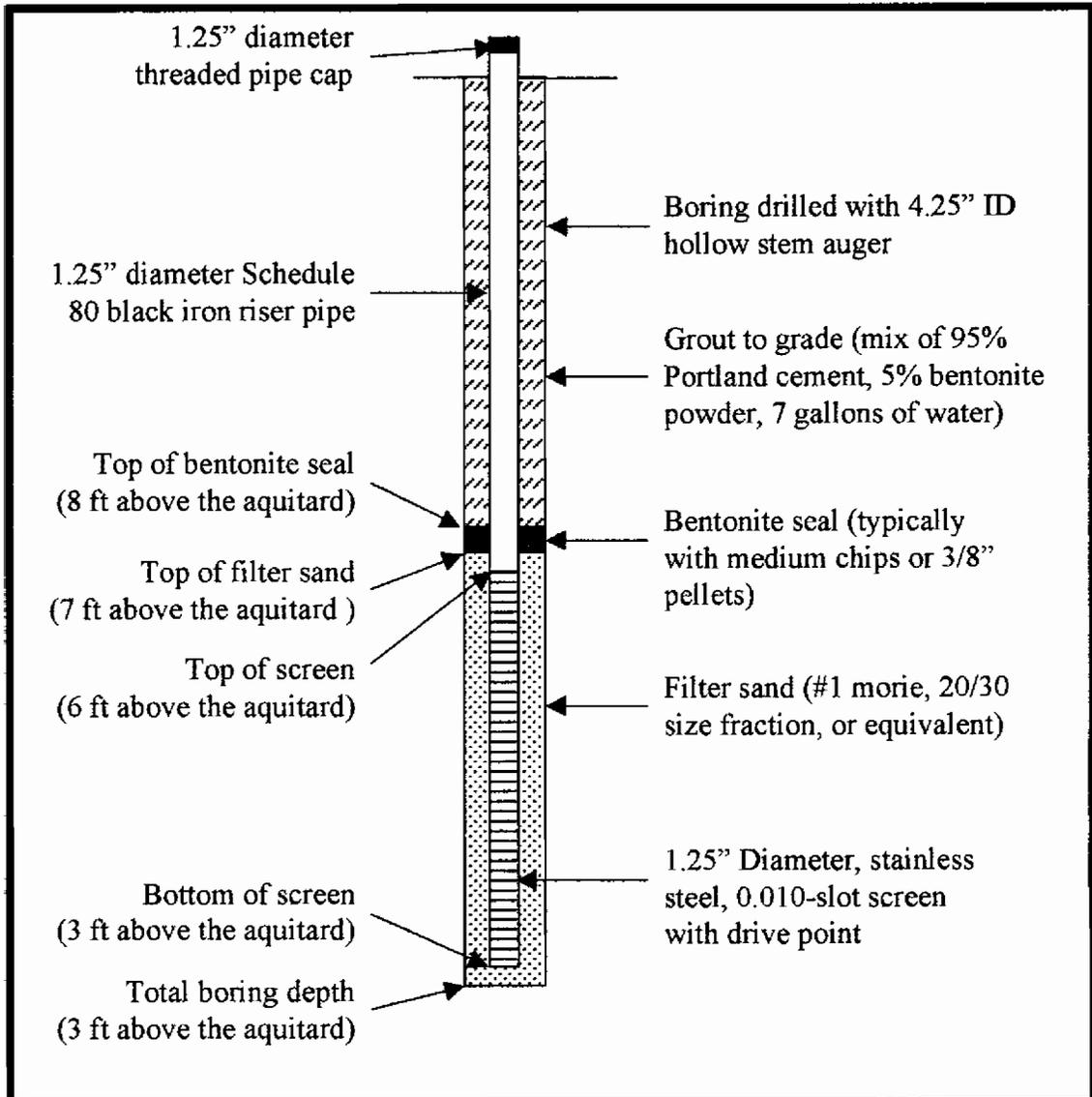


FIGURE 3-7 Example Construction Detail for Shallow Injector



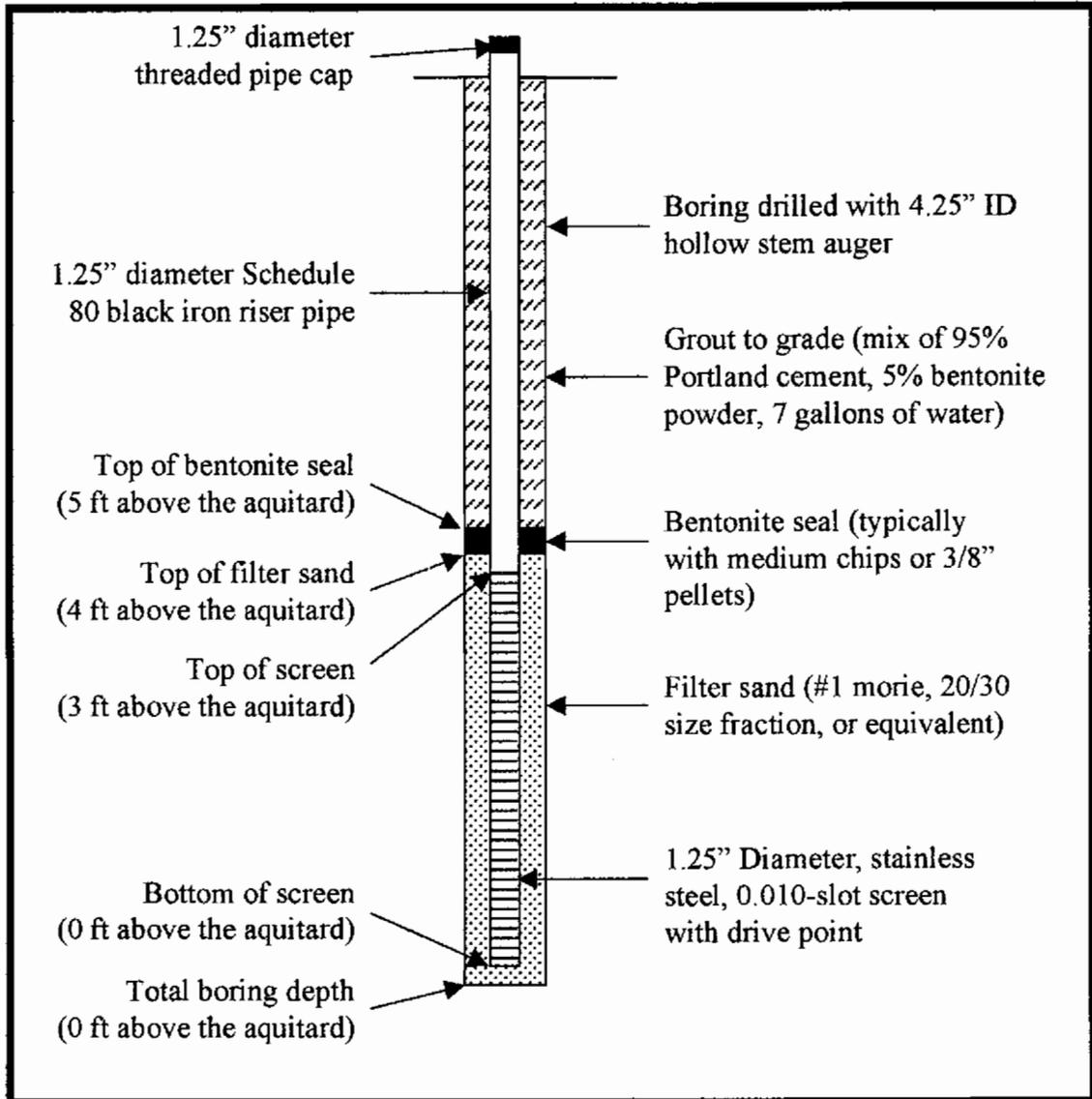
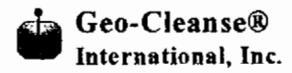


FIGURE 3-8 Example Construction Detail for Deep Injector



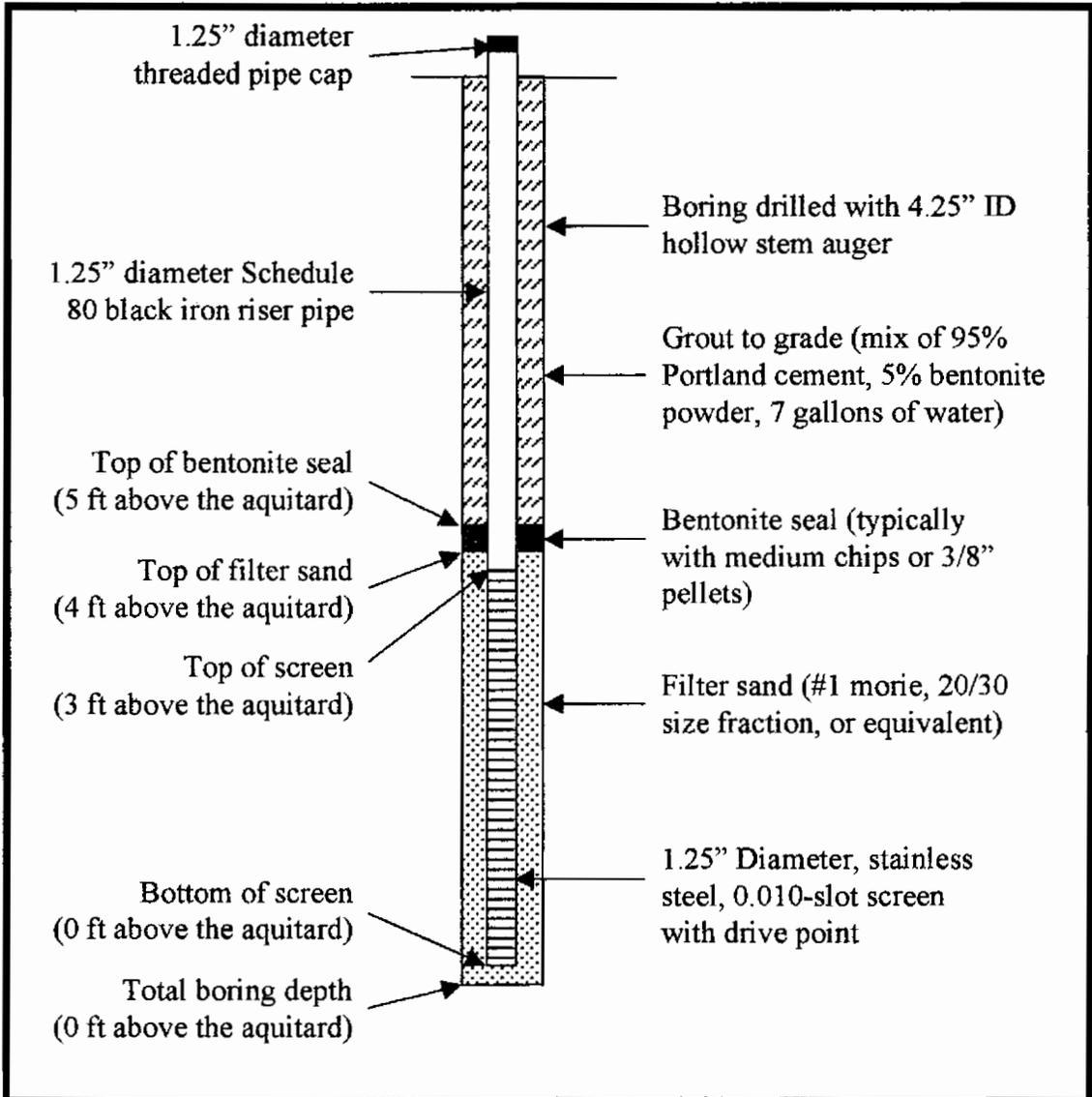


FIGURE 3-9 Example Construction Detail for Barrier Injector



Geo-Cleanse® International, Inc.

1 **4.0 Investigation-Derived Waste**

2 IDW that is generated during this effort will include purge water from the groundwater
3 sampling activities and well installation, soil cuttings from well installation, and
4 personal protective equipment (PPE). IDW will be collected in labeled 55-gallon drums
5 or portable tank for proper handling. Contained IDW will remain on site temporarily
6 until transported to the less than 90-day storage facility located at Building 1824. Once
7 the analytical results have been reviewed, the 55-gallon drums or portable tank
8 containing the groundwater contents will be transported, as required, to a permitted
9 and licensed facility for treatment or disposal.

Section 5.0

1 **5.0 Project Schedule**

2 Figure 5-1, shown on the following page, presents the project schedule.

Phase II IM at SWMU 196

ID	Task Name	Duration	Finish	Predecessors	3rd Quarter			4th Quarter			1st Quarter			2nd Quarter			3rd Quar
					Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
1	Submit Rev 0 Phase II IM WP	0 days	Fri 08/03/01			◆ 08/03											
2	Submit UIC Permit	0 days	Fri 08/03/01			◆ 08/03											
3	SCDHEC Review of Phase II IM WP	22 days	Mon 09/03/01	1			■										
4	SCDHEC Comments on Rev 0 WP	0 days	Mon 09/03/01	3													
5	Comments Resolved, Rev 1 submitted (if warranted)	0 days	Fri 09/14/01	4FS+9 days			◆ 09/03										
6	Phase II-A Injector Installation	5 days	Fri 10/05/01	5FS+10 days			◆ 09/14										
7	Phase II-A Baseline Sampling	2 days	Tue 10/16/01	6FS+5 days				■									
8	Phase II-A Injection	15 days	Fri 11/09/01	6FS+10 days					■								
9	Phase II-A Performance (7) Sampling	2 days	Mon 11/19/01	8FS+4 days						■							
10	Phase II-A Performance (30) Sampling	2 days	Tue 12/04/01	8FS+15 days							■						
11	Phase II-B Design Finalization	5 days	Thu 01/10/02	10FS+22 days								■					
12	Phase II-B Injector Installation	10 days	Fri 02/08/02	11FS+11 days									■				
13	Phase II-B Baseline Sampling	3 days	Fri 02/22/02	12FS+7 days										■			
14	Phase II-B Injection	15 days	Fri 03/15/02	12FS+10 days											■		
15	Phase II-B Performance (7) Monitoring	3 days	Wed 03/27/02	14FS+5 days												■	
16	Phase II-B Performance (30) Sampling	3 days	Wed 04/10/02	14FS+15 days												■	
17	Phase II Polishing Design	0 days	Fri 05/10/02	16FS+22 days												◆ 05/10	
18	Phase II Injector Installation	3 days	Tue 05/21/02	17FS+4 days												■	
19	Phase II Polishing Baseline Sampling	3 days	Thu 05/30/02	18FS+4 days												■	
20	Phase II Polishing Injection	5 days	Thu 06/06/02	19												■	
21	Phase II Polishing Performance (7) Sampling	3 days	Mon 06/17/02	20FS+4 days												■	
22	Phase II Polishing Performance (30) Sampling	3 days	Tue 07/02/02	20FS+15 days												■	
23	Phase II IM Report	0 days	Tue 07/16/02	22FS+10 days												◆ 0	

Project: IM Sked
Date: Tue 08/07/01

Task	■	Milestone	◆	Rolled Up Split	External Tasks	■
Split	Summary	■	Rolled Up Milestone	◇	Project Summary	■
Progress	■	Rolled Up Task	■	Rolled Up Progress	■		

1 6.0 References

- 2 Bryant, J.D., and Wilson, J.T. Rapid delivery system completes oxidation picture. *Soil &*
3 *Groundwater Cleanup*, August-September 1998, p.6-11. 1998.
- 4 Buxton, G. V., Greenstock, C. L., Helman, W. P., and Ross, A. B. Critical review of rate
5 constants for reactions of hydrated electrons, hydrogen atoms and hydroxyl radicals
6 ($\cdot\text{OH}/\cdot\text{O}$) in aqueous solution. *Journal of Physical and Chemical Reference Data*, v. 17, pp.
7 513-886. 1988.
- 8 Chen, R. and Pignatello, J.J. Role of Quinone Intermediates as Electron Shuttles in
9 Fenton Shuttles in Fenton and Photoassisted Fenton Oxidations of Aromatic
10 Compounds. *Environmental Science & Technology*, v. 31, pp.2399-2406. 1997.
- 11 EnSafe, Inc. *Zone H RCRA Facility Investigation Report, RFI Addendum. Volume I of V,*
12 *Section 2.4.* May 5, 2000.
- 13 EnSafe, Inc./ Allen & Hoshall. *Final Comprehensive Corrective Action Management Plan.*
14 August 30, 1994.
- 15 EnSafe/ Allen & Hoshall. *Final Comprehensive Sampling and Analysis Plan. RCRA Facility*
16 *Investigation.* July 30, 1996.
- 17 EnSafe/ Allen & Hoshall, Inc. *Zone H Final RFI Report. Volume I, Section 3.* July 5, 1996.
- 18 Haag, W. W. R., Yao, C. C. D. Rate constants for reaction of hydroxyl radicals with
19 several drinking water contaminants. *Environmental Science and Technology*, v. 26, pp.
20 1005-1013. 1992.
- 21 Karpel vel Leitner, N., and Doré, M. Mecanisme d'action des radicaux $\text{OH}\cdot$ sur les
22 acides glycolique, glyoxylique, acetique et oxalique en solution aqueuse: Incidence sur
23 la consommation de peroxyde d'hydrogene dans les systemes $\text{H}_2\text{O}_2/\text{UV}$ et $\text{O}_3/\text{H}_2\text{O}_2$.
24 *Water Research*, v. 31, pp. 1383-1397. 1997.
- 25 Lindsay Smith, J. R., and Norman, R. O. C. Hydroxylation. Part I. The oxidation of
26 benzene and toluene by Fenton's reagent. *Journal of the Chemical Society*, v. 1963, pp.
27 2897-2905. 1963.

- 1 Lindsey, M. E., and Tarr, M. A. Inhibition of hydroxyl radical reaction with aromatics by
2 dissolved natural organic matter. *Environmental Science & Technology*, v. 34, pp. 444-449.
3 2000.
- 4 Martens, D.A., and Frankenburger, W.T. Enhanced Degradation of Polycyclic Aromatic
5 Hydrocarbons in Soil Treated with an Advanced Oxidative Process – Fenton’s Reagent.
6 *Journal of Soil Contamination*. v. 4, pp 175-190. 1995.
- 7 Merz, J. H., and Waters, W. A. The oxidation of aromatic compounds by means of the
8 free hydroxyl radical. *Journal of the Chemical Society*, v. 1949, pp. 2427-2433. 1949.
- 9 Scheck, C. K., and Frimmel, F. H. Degradation of phenol and salicylic acid by ultraviolet
10 radiation/hydrogen peroxide/oxygen. *Water Research*, v. 29, pp. 2346-2352. 1995.
- 11 Sedlak, D. L., and Andren, A. W. Oxidation of chlorobenzene with Fenton’s reagent.
12 *Environmental Science & Technology*, v. 25, p. 777-782. 1991.
- 13 U.S. Environmental Protection Agency (EPA). Advance Notice of Proposed Rulemaking
14 (61 CFR 19432, May 1).
- 15 U.S. Environmental Protection Agency (EPA). *Environmental Investigations Standard*
16 *Operating Procedures and Quality Assurance Manual*. Region IV, Environmental Services
17 Division. 1996.
- 18 U.S. Army Corps of Engineers (USACE). Personal correspondence between David
19 Lane/CH2M HILL and Debbie King/USACE, Charleston District. September 14, 2000.
- 20 Walling, C., and Johnson, R. A. Fenton’s reagent. V. Hydroxylation and side-chain
21 cleavage of aromatics. *Journal of the American Chemical Society*, v. 97, pp. 363-367. 1975.
- 22 Watts, R. J., Bottenberg, B. C., Hess, T. F., Jensen, M. D., and Teel, A. L. Role of
23 reductants in the enhanced desorption and transformation of chloroaliphatic
24 compounds by modified Fenton’s reactions. *Environmental Science and Technology*, v. 33,
25 pp. 3432-3437. 1999.

Appendix A
