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Quality Assurance Project Plan
For
HRC Injection Pilot Study
IR Program Site 16

Naval Construction Battalion Center Davisville
North Kingstown, Rhode Island

Contract No. N62472-92-D-1296
Task Order No. 0107

Prepared for

Department of the Navy
Engineering Field Activity Northeast
10 Industrial Highway, Mail Stop No. 82
Lester, Pennsylvania 19113-2090

Prepared by

EA Engineering, Science, and Technology
Southborough Technology Park
333 Turnpike Road (Route 9)
Southborough, Massachusetts 01772

July 2004
FINAL
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LIST OF REVISIONS

Section	Date	Revision	Description

2. TABLE OF CONTENTS, LIST OF ACRONYMS, AND INTRODUCTION

Page

1. TITLE AND APPROVAL PAGES ..... UN

2. TABLE OF CONTENTS, LIST OF ACRONYMS, AND INTRODUCTION 2-1

2.1 Introduction 2-8
2.2 Site Description and Background 2-9

2.2.1 NCBC Davisville Description and History 2-9
2.2.2 Site Description and History 2-10
2.2.3 Climate 2-12
2.2.4 Site Hydrogeology 2-13

2.2.4.1 Hydrogeologic Zones 2-13

3. DISTRIBUTION LIST 3-1

4. PROJECT ORGANIZATION 4-1

4.1 Project Organization Chart 4-1
4.2 Communication Pathways 4-1

4.2.1 Modification to Approved Quality Assurance Project Plan 4-1

4.3 Project Roles and Responsibilities 4-1
4.4 Special Training Requirements/Certification 4-2
4.5 Project Personnel Agreement 4-2

5. PROJECT PLANNING AND PROJECT DEFINITIONS 5-1

5.1 Project Planning Meetings 5-1
5.2 Summary of Potential CVOC Contaminant Source Areas 5-1
5.3 Tidal Impact on Ground Water 5-2
5.4 Salt Water Intrusion Assessment 5-2
5.5 Nature and Extent of Contamination in Soil 5-2
5.6 Summary of the Nature and Extent of CVOC in Ground Water 5-3
5.7 Site Conceptual Model – Site Summary of the CVOC Release and Migration 5-4
5.8 Assessment of the Viability of Subsurface Conditions to Support Natural Biodegradation of the CVOC Plume 5-5

6. PROJECT DESCRIPTION AND SCHEDULE 6-1

6.1 Project Overview 6-1

Page

6.1.1 Use of HRC® to Accelerate Anaerobic Bioremediation at CVOC Plume Cutoff 6-4
6.1.2 Pilot-Scale Testing 6-5

6.2 Project Schedule 6-6
6.3 Reports and Data Presentation 6-6

6.3.1 HRC® Injection Pilot Test Report 6-6

7. PROJECT QUALITY OBJECTIVES AND MEASUREMENT PERFORMANCE CRITERIA 7-1

7.1 Project Quality Objectives 7-1
7.2 Measurement Performance Criteria 7-1

8. SAMPLING PROCESS DESIGN 8-1

8.1 Sampling Design Rationale 8-1
8.2 Ground-Water Sampling from Monitoring Wells 8-2
8.3 Soil Sampling 8-3

9. SAMPLING PROCEDURES AND REQUIREMENTS 9-1

9.1 Sampling Procedures 9-1

9.1.1 Ground-Water Sampling 9-1
9.1.2 Soil Sampling 9-1

9.2 Investigative Derived Waste Management 9-1
9.3 Decontamination Procedures 9-1
9.4 Field Equipment Maintenance, Testing, Calibration, and Inspection 9-1

10. SAMPLE HANDLING, TRACKING, AND CUSTODY REQUIREMENTS 10-1

10.1 Sample Designation and Labeling 10-1
10.2 Handling, Custody, and Shipping 10-1
10.3 Sample Documentation 10-1

10.3.1 Field Notebook 10-1
10.3.2 Chain-of-Custody Forms 10-1
10.3.3 Field Sampling Form 10-1

11. FIELD ANALYTICAL METHOD REQUIREMENTS 11-1

Page

12. FIXED LABORATORY ANALYTICAL METHOD REQUIREMENTS 12-1

12.1 Laboratory Calibration Procedures 12-1

12.1.1 Calibration Procedures 12-1
12.1.2 Equipment Identification 12-1
12.1.3 Calibration Frequency 12-2
12.1.4 Calibration Reference Standards 12-2
12.1.5 Calibration Failure 12-2
12.1.6 Calibration Records 12-3
12.1.7 Operational Calibration 12-4

13. QUALITY CONTROL REQUIREMENTS 13-1

13.1 Method (Reagent) Blank 13-1
13.2 Fortified Method Blank Spike (Laboratory Control Sample) 13-1
13.3 Fortified Sample (Matrix Spike) 13-1
13.4 Surrogates 13-2

14. DATA ACQUISITION REQUIREMENTS 14-1

15. DOCUMENTATION, RECORDS, AND DATA MANAGEMENT 15-1

15.1 Project Documentation and Records 15-1
15.2 Field Data Reporting 15-1
15.3 Laboratory Reporting 15-2
15.4 Data Management 15-2

15.4.1 Geographic Information System Preparation 15-2
15.4.2 Electronic Data Deliverables 15-3

15.5 Reports 15-3

16. ASSESSMENTS AND RESPONSE ACTIONS 16-1

17. QUALITY ASSURANCE MANAGEMENT REPORTS 17-1

18. VERIFICATION AND VALIDATION REQUIREMENTS 18-1

19. VERIFICATION AND VALIDATION PROCEDURES 19-1

20. DATA USABILITY/RECONCILIATION WITH PROJECT QUALITY GOALS 20-1

Page

20.1 Precision 20-1
20.2 Accuracy 20-1
20.3 Representativeness 20-2
20.4 Comparability 20-2
20.5 Completeness 20-2

REFERENCES

LIST OF FIGURES

Figure 1 Site Locus Map
Figure 2 HRC Pilot Test Vicinity Deep Zone Total CVOC (μg/L) Detected in November/December 2002
Figure 3 Former Building 41 Floor Plan
Figure 4 Project Organization Chart
Figure 5 Site Map
Figure 6 HRC Injection Well Specifications

LIST OF TABLES

Table 2-1A Pre-Drilling Water Level Measurement Table for HRC Injection Pilot Study, Site 16, NCBC Davisville
Table 2-1B Water Level Measurement Table for HRC Injection Pilot Study, Site 16, NCBC Davisville
Table 4-1 Communication Pathways
Table 4-2 Project Personnel Sign-Off Sheet
Table 6-1 Project Schedule Timeline Table
Table 7-1 Summary of Target Compounds and Analytes Table (Reference Limit and Evaluation Table), HRC Injection Pilot Study – Ground Water
Table 7-2 Summary of Target Compounds and Analytes Table (Reference Limit and Evaluation Table), HRC Injection Pilot Study – Soil
Table 7-3 Quality Control Criteria for Precision and Accuracy for Matrix Spikes, Matrix Spike Duplicates, Surrogates, and Laboratory Control Samples for HRC Injection Pilot Study, NCBC Davisville
Table 7-4 Measurement Performance Criteria Table, HRC Injection Pilot Study, NCBC Davisville
Table 8-1 Analytical Program for HRC Injection Pilot Study, Site 16, NCBC Davisville
Table 9-1 Sampling Locations, Sampling and Analysis Method/Standard Operating Procedure Requirements Table
Table 9-2 Field Sampling Equipment Calibration Table
Table 10-1 Sample Handling System, HRC Injection Pilot Study for Site 16, NCBC Davisville
Table 12-1A Project Reporting Limits, Analytical Precision, Accuracy, and Bias for Aqueous Samples, HRC Injection Pilot Study at Site 16, NCBC Davisville

LIST OF TABLES (Cont.)

Table 12-1B Project Reporting Limits, Analytical Precision, Accuracy, and Bias for Soil Samples, HRC Injection Pilot Study at Site 16, NCBC Davisville
Table 12-2 Fixed Laboratory Analytical Method/Standard Operating Procedure Reference, HRC Injection Pilot Study at Site 16, NCBC Davisville
Table 12-3 Fixed Laboratory Instrument Maintenance and Calibration Table, HRC Injection Pilot Study at Site 16, NCBC Davisville
Table 13-1 Fixed Laboratory Analytical Quality Control Sample Table – Ceimic Corporation, HRC Injection Pilot Study at Site 16, NCBC Davisville
Table 16-1 Project Assessment Table
Table 17-1 Quality Assurance Management Reports Table
Table 20-1 Formulas for the Calculation of Data Quality Characteristics for Chemical Data

LIST OF ATTACHMENTS

Attachment 1 Additional Site Information
Attachment 2 Standard Operating Procedures for Field Sampling
Attachment 3 Resumes of Key Project Team Members
Attachment 4 Geophysical Applications' Standard Operating Procedures
Attachment 5 Data Structure
Attachment 6 U.S. Environmental Protection Agency Draft Calibration Procedures
Attachment 7 Laboratory Standard Operating Procedure Cover Pages

LIST OF APPENDIXES

Appendix A Safety, Health, and Emergency Response Plan
Appendix B Responses to EPA and RIDEM Comments to the QAPP, including BCT Meeting Notes for the Site 16 HRC® Pilot Test

LIST OF ACRONYMS

BCT	BRAC Closure Team
bgs	Below ground surface
BRAC	Base Realignment and Closure Act
CADD	Computer-aided design and drafting
CVOC	Chlorinated volatile organic compounds
DCE	Dichloroethene
DNAPL	Dense non-aqueous phase liquid
EA	EA Engineering, Science, and Technology
EBS	Environmental Baseline Survey
EDD	Electronic data deliverable
EFANE	Engineering Field Activity Northeast
EPA	(U.S.) Environmental Protection Agency
FFTA	Fire Fighting Training Area
FWENC	Foster Wheeler Environmental Corporation
GIS	Geographic Information System
HRC	Hydrogen Release Compound
LNAPL	Light non-aqueous phase liquid
NCBC	Naval Construction Battalion Center
NFA	No Further Action
PCE	Tetrachloroethene
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
RI	Remedial investigation
RIDEM	Rhode Island Department of Environmental Management
RIEDC	Rhode Island Economic Development Corporation
RPM	Remedial Project Manager
SOP	Standard operating procedure
TCE	Trichloroethene

TCL	Target Compound List
TO	Task Order
µg/L	Micrograms per liter
UST	Underground storage tank
VC	Vinyl chloride
VOC	Volatile organic compounds

2.1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) has been prepared for the U.S. Navy, Engineering Field Activity Northeast (EFANE) to describe the field and laboratory testing program that will be utilized for the collection and reporting of analytical data in support of the Hydrogen Release Compound (HRC®) injection pilot study near the northeast end of former Building 41 at the Installation Restoration Program Site 16 area at Former Naval Construction Battalion Center (NCBC) Davisville facility (hereafter designated Site 16), in North Kingstown, Rhode Island (Figures 1 and 2). This HRC® injection pilot study is being performed under the Base Realignment and Closure Act (BRAC) Contract No. N62472-92-D-1296, Task Order 0107.

Site 16 is located at former NCBC Davisville in North Kingstown, Rhode Island. The site, including the HRC® Pilot Study area, is shown on Figures 1 and 2. The Navy has obtained right-of-access with the Rhode Island Economic Development Corp (RIEDC) and the North Atlantic Distribution, Inc (NORAD; a regional car storage and distribution company) to install the HRC® pilot test wells. The well locations and designations, and the general Stage I and II drilling areas, are shown on Figure 5. The drilling/installation of the total of 61 monitoring wells and HRC® injection wells will occur in 2 stages that will be performed one after another as follows:

1) Stage I drilling will include the first 25 monitoring wells, which will serve a dual purpose for both this project and the ongoing Site 16 Supplemental Phase II Investigation (refer to "Site Map – Drilling-Stage I" included in Attachment 1).

2) Stage II drilling work will include the remaining 24 HRC® monitoring wells and the 12 injection wells, all located in a relatively small geographic area (refer to "Site Map – Drilling-Stage II" included in Attachment 1).

This QAPP presents the methods to be used for drilling, well installation, sampling, and HRC® pilot test injection activities at Site 16. The related Safety, Health, and Emergency Response Plan is included as Appendix A and all fieldwork will be performed in accordance with the Safety, Health, and Emergency Response Plan. The HRC® injection will be performed by an experienced subcontractor in accordance with the methodologies outlined by Regenesis (Attachment 2). Based upon the results of the "Preliminary Identification and Screening of Remedial Action Technologies IR Program Site 16, NCBC Davisville, North Kingstown, Rhode Island" prepared by EA for the Navy dated September 2003, the Navy selected a pilot test of HRC® injection to evaluate this technology for potential future remediation of the source area at the site. This pilot test (treatability study) seeks to test the general feasibility and overall applicability of *in situ* HRC® injection within a pilot scale field test located near the southwestern (upgradient) extent of the >1,000 µg/L portion of the detected chlorinated volatile organic compounds (CVOC) plume in the deep overburden (vicinity of former Building 41; Figure 2) to enhance biodegradation rate of the CVOC. This location would result in minimizing the amount of the detected >1,000 ug/L CVOC plume that would be located in the deep overburden immediately upgradient of the pilot test area, perhaps reducing the amount of CVOC rebound in the test area after the test. This QAPP presents the HRC® injection pilot study plan

and field procedures for the work. In accomplishing these objectives, the general scope of work will include:

- One round of water level measurements from selected monitoring wells at Site 16 prior to well installation (completed on 7 and 9 April 2004), as listed in Table 2-1A.
- Installation of 12 deep (D) overburden injection wells and 49 monitoring wells.
- Collection of 2 confirmatory soil samples from each of the 25 deep (D) well borings for laboratory analysis
- Borehole geophysical logging of the open hole in bedrock portion of the 11 wells to be completed in competent bedrock
- Slug testing of the 50 new monitoring wells (S, I, and D) to be screened in the overburden
- Injection of the HRC® into the 12 injection wells to be screened in the deep (D) overburden zone
- Baseline ground-water sampling event prior to injection of the HRC®
- 13 ground-water monitoring events over a period of 2 years after injection of the HRC®.

2.2 SITE DESCRIPTION AND BACKGROUND

2.2.1 NCBC Davisville Description and History

The former NCBC Davisville facility is located in the Town of North Kingstown, Rhode Island, approximately 18 mi south of the state capital (Providence). NCBC Davisville (Figure 1) is composed of three areas: (1) the Main Center (Zones 1 through 4), (2) the West Davisville storage area, and (3) Camp Fogarty – a training facility located approximately 4 mi west of the Main Center. Camp Fogarty was transferred to the U.S. Department of the Army in December 1993 and is assigned to the Rhode Island National Guard. Adjoining the southern boundary of the Main Center is the decommissioned Naval Air Station Quonset Point, which was transferred by the Navy to the Rhode Island Port Authority (currently named the Rhode Island Economic Development Corporation [RIEDC]) and others between 1975 and 1980.

NCBC Davisville's mission was to provide mobilization support to the active Naval Construction Force; to act as a mobilization base for the rapid assembly, outfitting, and readying of Reserve Construction Battalions; to store, preserve, and ship advanced Base and mobilization stocks; and to procure, receive, pack, and ship collateral equipment for Atlantic, European, and Caribbean military construction projects. NCBC Davisville was comprised primarily of

warehouse space and freight yards, most of which are currently demolished, redeveloped, or empty.

In 1974, the Naval Air Station and a Naval Air Rework Facility at Quonset Point were decommissioned, and operations at the Base were greatly reduced pursuant to the Shore Establishment Realignment Act of 1973. In 1989, NCBC Davisville was placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List. In 1991, the closure of NCBC Davisville was announced, and operations were phased down to minimum staffing levels for public works, maintenance, security, and personnel. NCBC Davisville was decommissioned on 25 March 1994 and closed on 1 April 1994 under BRAC. A detailed description of the Base history can be found in the Final Basewide Environmental Baseline Survey (EBS) (EA 1995a). NCBC Davisville was transferred to Naval Facilities Engineering Command, EFANE (formerly Northern Division). EFANE is currently working closely with RIEDC toward lease or transfer of the portion of the Site 16 investigation area, including the HRC® injection pilot study area, that is located near the former Building 41 area. A more complete description of Site 16 and a summary of previous investigations at the entire Site is provided in the Phase I RI (EA 2001a).

2.2.2 Site Description and History

As stated in the Phase II EBS Report (EA 1998a), this building was a preservation and packing shop, and a construction equipment and automotive parts storage building were preservation and degreasing operations occurred. Because Building 41 was demolished and the area paved by RIEDC during October 2002, the following paragraphs are based on available information and observations prior to the demolition activity. Additionally during the period of building demolition and paving, a storm water detention pond was constructed in a portion of the area between the former Building 41 and Davisville Road. The approximate location of the storm water detention pond is shown on Figure 5. The bottom of this detention pond was designed to be at 25 ft. MSL. Based on past activities, it is likely that petroleum products and solvents were used and stored onsite at the former Building 41. The preservation tanks were addressed under the Navy's underground storage tank (UST) program. Stained asphalt floors in Building 41 were not considered to be of concern during the Phase II EBS, based on the limited extent of the staining, the absorptive ability of asphalt, and the lack of a direct pathway (e.g., spill runoff from the concrete to a foundation wall or soil). No floor drains were located in Building 41. The floor staining was considered to be consistent with the previous use of the building as an equipment preservation and packing shop, and parts storage. Recommendations for No Further Action (NFA) were made following review of available Phase II EBS information and site visits conducted by the BRAC Cleanup Team (BCT), the Town of North Kingstown, and RIEDC in September and October 1995. No field activities were conducted and no samples were collected for this Review Item based on the BCT recommendation for NFA (EA 1995a).

During the Phase I Remedial Investigation (RI), discussions occurred during November 2000 with a Seabee veteran, who worked in Building 41 from 1951 to 1953, to improve our understanding of the historical use of the building during that time. Additionally, there was a visit to the building in February 2001 with the same Seabee veteran. According to this veteran,

the rust removal (heated manganesed phosphoric acid), metal preservation (Cosmolene – particularly for Quonset Huts) and degreasing (chlorinated solvent, including a solvent recovery still) operations in Building 41 seemed to have begun and ended between 1951 and 1953. Waste solvent and sludge from the solvent recovery still were transported in drums to the Allen Harbor Landfill for disposal. After 1953, the preservation and degreasing operations were reportedly moved south to Building E-319.

Building 41 was divided into three sections as shown on Figure 3. Figure 3 illustrates the current understanding of the historical use of the building during 1951 to 1953, based on the above discussions during the Phase I RI, and from historical floor plan drawings obtained from RIEDC. The following summarizes the activities that reportedly occurred in the three sections of the building:

- The northeastern third (bay) of the building was reportedly used for packing and storage of parts for shipment. The area was observed on 15 February 2001 to be a large room with a high ceiling and generally empty, except for piles of salted sand stored by RIEDC in part of the southwestern portion.

- The middle third of the building was used for preservation of Quonset Huts by dipping in a large, partially in-ground tank(s) of Cosmolene (a grease used to prevent rusting of metallic surfaces). The Cosmolene dipping appears to have included a group of four tanks (Tanks 41-1 through 41-4). This portion of the building was observed in February 2001 to be a large room with a high ceiling and generally empty, except for the southwestern portion as stated below:

  — Historically, rust was stripped from metal parts in an aboveground tank of phospholene (manganesed phosphoric acid). This tank was reportedly above floor grade, and was apparently Tank 41-5 that was removed from the building in December 1994. Based upon a related Tank Closure Assessment Report by HRP Associates, Inc. (HRP 1995a), Tank 41-5 was a rectangular, open-top steel tank located along the east wall of the former restrooms area. An area of etching of the concrete floor surface, observed on 15 February 2001, may be evidence of their former location.

  — The southwest portion was insulated and has a lowered ceiling, apparently to retain heat for the workers in that area. This area was reportedly used for the packing of preserved small metal parts for vehicles.

- The southwestern third of the building was used for degreasing activity that included a vapor degreasing unit and a solvent recovery still. The area was also used for packing and shipping of parts. The vapor-degreasing tank (apparently Tank 41-6) and associated equipment were located in a pit (concrete vault) in the floor. Based upon a related Tank Closure Assessment Report by HRP Associates, Inc. (HRP 1995b), Tank 41-6 was a 500-gal rectangular steel tank and equipment that was removed in December 1994 as part of the Navy's UST program. According to the report, the tank "was dry and required no

cleaning prior to removal." The concrete vault in the floor of the building "was 5 ft wide, 6 ft long, and 7 ft deep." After removal of the tank, the pit (vault) was filled with common fill consisting of a sand and gravel mix, and then completed with an asphalt surface at floor grade that was visible during the building walkover. This area of Building 41 was observed on 15 February 2001 to be a large room with a high ceiling and generally empty, except for the northeastern portion where the old solvent recovery still equipment was still present. There was reportedly also a locked cage area where tools were stored in this portion of the building.

The Cosmolene dipping appears to have included a group of four tanks (Tanks 41-1 through 41-4). Based upon a related Tank Closure Assessment Report by HRP Associates, Inc. (HRP 1995c), the tanks were excavated in January 1995, cleaned, and disposed of as part of the Navy's UST program. A petroleum-based material was shoveled from the tanks before steam cleaning them. The metal tanks were reported to be in good condition (no rust or breaks) and there was no apparent leakage. It was reported that there was no petroleum odor or discernable staining in the excavation and TPH was not detected (less than 21 milligrams per kilogram [mg/kg]) in the final soil samples collected from the base of the excavation (about 6 ft below ground surface [bgs]. Tank 41-1 was a 6,500-gal rectangular, open-top steel tank within which there were three 900-gal square, open-top steel tanks (41-2, 41-3, and 41-4). Based on the presence of an old steam pipe that entered near the base of the west end of Tank 41-1, this tank appeared to have been used to heat the other three tanks. The excavation was backfilled to grade using the excavated soil and a common borrow fill consisting of a sand and gravel mix, and completed with an asphalt surface at floor grade that was visible during the building walkover.

Based on the Tank Closure Assessment Report by HRP Associates, Inc. (HRP 1995a), Tank 41-5, apparently the phospholene [manganesed phosphoric acid] tank was removed from the building in December 1994.

Based upon a Tank Closure Assessment Report by HRP Associates, Inc. (HRP 1995b), Tank 41-6 (vapor degreasing unit) and equipment was removed in December 1994 as part of the Navy's UST program. According to the report, the tank "was dry and required no cleaning prior to removal." The concrete vault in the floor of the building "was 5 ft wide, 6 ft long, and 7 ft deep." Because the tank was removed from a concrete vault, there was no excavation. Following removal from the vault, it was reported that "the tank appeared to be in generally good condition with some staining along the upper edge, around plumbing fixtures, and under small holes in the tank walls. The tank piping was constructed of steel and appeared to be in moderate condition. Pipe joints were secure with no visible signs of leakage. The floor and sidewalls of the vault were stained, especially in the east corner." The pit was filled with common fill consisting of a sand and gravel mix, and then completed with an asphalt surface at floor grade that was visible during the building walkover.

2.2.3 Climate

Given the coastal proximity of NCBC Davisville, weather patterns are continuously modified by the dynamic effects of Narragansett Bay and the Atlantic Ocean. The average annual wind speed

over the area is 10.6 mi per hour with a prevailing southwesterly direction. In the winter, the average temperature is 30°F and average daily minimum temperature is 20°F. In the summer, the average temperature is 70°F and average daily maximum is 80°F.

The average annual precipitation for the area is 45.32 in., as measured for the period of 1951-1980. Historically, June has been the driest month with an average of 2.79 in. of precipitation, whereas December, averaging 4.47 in., has been the wettest.

2.2.4 Site Hydrogeology

The Rhode Island Department of Environmental Management (RIDEM) has classified the ground water at this location as "GB" (assumed to require treatment prior to drinking).

2.2.4.1 Hydrogeologic Zones

The results of the Phase I RI and Phase II Hydrogeological Investigation (EA 2003) and previous investigations, show that the geology at Site 16 is characterized by anthropogenic fill and Quaternary (Pleistocene) glacial deposits mantling quartzite and phyllite bedrock of the Pennsylvanian age Rhode Island Formation (undifferentiated). Based upon the Phase I and Phase II Hydrogeological Investigation boring logs, the site is underlain by 6 main overburden/soil layers overlying fractured quartzite and phyllite bedrock. The following summarizes these overburden layers (from the ground surface to bedrock):

(1) Reworked soil and fill material - Generally a mix of silt, sand, and gravel with cobbles reworked from historical construction (around buildings, roads, and paved areas) and Seabee construction training activities; a mix of mostly sand, silty sand, and gravelly sand used to fill in the southern end of Allen Harbor and a related historical eastern waterway present prior to 1940; boulders that comprise the rip-rap along the Allen Harbor shoreline and fragments of wood, glass, metal, and charcoal.

(2) Relatively recent harbor and adjacent deposits - apparently deposited naturally near the floor and former southern edge of Allen Harbor and an eastern extension (prior to 1940) and include peat-like material, organic material, seagrass, peat moss, and silt and/or sand with organic material.

(3) Glacio-fluvial deposits - typically sand with varying amounts of silt and/or gravel.

(4) Glacio-lacustrine deposits - typically dark gray silt, sandy silt, very fine sand and silt, and clayey silt layers or lenses that are present as discontinuous layers and lenses beneath the site. Silt layers or lenses were not encountered in three general portions of the investigation area: the north central area (just north of the former Fire Fighting Training Area [FFTA]), the northeastern to southeastern edge, and the south central area. Where present, these silt deposits are comprised of 1-6 lenses typically separated by sand to silty sand.

(5) Lower sand deposits - typically sand with varying amounts of silt located between the deepest overlying silt lens and the underlying sandy silty gravel deposits. These deposits are present as discontinuous layers and lenses beneath the site throughout the investigation area.

(6) Weathered bedrock or sandy silty gravel to gravelly sand to sandy gravelly silt (possibly till) deposited as a discontinuous layer beneath the site investigation area.

The six Site 16 subsurface soil strata, plus bedrock, have been divided into the following four hydrogeological zones (beginning with the shallowest zone):

(1) Shallow ground-water zone ('S' wells)

The shallow ground-water zone is the saturated portion of the reworked soil/fill and/or glacio-fluvial sand unit overlying the glacio-lacustrine silt and very fine sand unit or directly overlying the silty gravelly sand to sandy gravelly silt (possibly till) where the glacio-lacustrine deposits are not present. This zone occurs under unconfined conditions. Beneath the EBS 28/FFTA, the ground water is interpreted to flow toward the east and north toward Allen Harbor. Beneath the former Building 41 area, ground water is interpreted to flow toward the east. Beneath the old railroad spur area, ground water is interpreted to flow toward the east and northeast in the portion north of MW16-35S and toward the southeast in the portion south of MW16-35S.

(2) Intermediate ground-water zone ('I' wells)

The intermediate ground-water zone consists of sand to silty sand and silt lenses just above and within the glacio-lacustrine unit. This layer overlies the silty gravelly sand to sandy gravelly silt (possibly till). This zone occurs under partially confined conditions. Ground-water flow is interpreted to be generally toward the northeast (with localized north and east directions) beneath the former Building 41/old railroad spur area and the EBS 28/FFTA area. An exception is present beneath the western portion of former Building 41 and between MW16-19I and MW16-39I where there appears to be a seasonal southeasterly flow direction.

(3) Deep overburden ground-water zone ('D' wells)

The deep overburden ground-water zone consists of the silty gravelly sand to sandy gravelly silt (possibly till) unit and/or the weathered bedrock zone. These two types of geologic materials are considered as a similar ground-water zone because of the wide variability in composition of these materials. The weathered phyllite bedrock forms a thin zone (2–3 ft in thickness) that is hydrogeologically similar because of the apparent horizontal and vertical variation observed which would allow for horizontal and vertical flow (hydraulic communication) through it. In other words, ground water could flow more readily through the softer, fractured phyllite, but less could flow through the more very weathered phyllite with fractures filled by silt and clay. The deep overburden ground-water zone occurs primarily under partially confined conditions. Ground-water flow is interpreted to be generally toward the northeast beneath the EBS 28/FFTA, the eastern portion of the former Building 41, and the northern portion of the old railroad

spur area. Beneath the central portion of the old railroad spur area the ground water is interpreted to flow toward the east, but toward the southeast beneath the western portion of the former Building 41, the southern portion of the old railroad spur area, and Buildings 318 and E-319

(4) Competent bedrock ground-water zone ('R' and 'R2' wells)

The competent bedrock ground-water zone includes the upper approximately 25–30 ft of competent bedrock ('R' wells) and the bedrock ('R2') 25 ft below the termination of the 'R' wells which was investigated, but may extend deeper. This zone is typically in direct hydraulic connection with the overlying deep ground-water zone. The bedrock ground-water zone occurs primarily under partially confined conditions. The ground-water flow in the shallow bedrock ('R') is interpreted to be approximately toward the northeast. Also, the data suggest the presence of a southeast trending ground-water divide from approximately MW03-03R through MW16-55R to MW16-17R. The ground-water flow in the deeper bedrock ('R2') is interpreted to be approximately east northeast to northeast. However, this interpretation is biased by the small number (3) and position (nearly in a straight line) of these wells.

3. DISTRIBUTION LIST

The following is the list of organization and agency representatives to whom the QAPP will be distributed. The QAPP is a dynamic document and should be revised or updated to reflect changes in organization and procedures needed to meet the Quality Objectives identified herein. Whenever revisions are made or addenda added to the QAPP, those listed below will receive the revisions/addenda. This distribution system does not preclude making and using copies of the QAPP. However, those listed below are responsible for distributing the QAPP, and any additional material to update any copies within their organizations.

- Engineering Field Activity Northeast
  Fred Evans, Remedial Project Manager (610) 595-0557 X159

- EA Engineering, Science, and Technology
  Jim Shultz, Task Order (TO) Project Manager (508) 485-2982 X208

- U.S. Environmental Protection Agency, Region 1
  Christine Williams (617) 918-1384

- Rhode Island Department of Environmental Management
  Louis Maccarone (401) 222-2797 X7142

- U.S. Fish and Wildlife Service
  Andrew Major (603) 223-2541

- National Oceanic and Atmospheric Administration
  Ken Finkelstein (617) 918-1499

- Town of North Kingstown
  Marilyn Cohen (401) 294-3331 X233

- Rhode Island Economic Development Corporation
  Steven King (401) 295-0044

- CDW Consultants, Inc. (EPA Oversight Contractor)
  Kathleen Campbell (508) 875-2657

4. PROJECT ORGANIZATION

4.1 PROJECT ORGANIZATION CHART

The project organization chart is shown on Figure 4.

4.2 COMMUNICATION PATHWAYS

As issues arise during performance of this HRC® injection pilot study, the pathway for decision-making is summarized on Table 4-1. The overall project lines of communication are shown on Figure 4. All other communication lines will be considered shadow communication and will be non-binding and not official.

4.2.1 Modifications to Approved Quality Assurance Project Plan

Members of the BCT (Navy, EPA Region 1, and RIDEM) can request modification of the QAPP. Such requests should be submitted in writing to the Navy Remedial Project Manager (RPM) and can be discussed during a BCT meeting or telephone call, as needed, to achieve concurrence of the modification. Resulting changes to the QAPP will be as revised, and dated pages submitted to the "Distribution List" (Section 3) for insertion into their QAPP documents. The revisions will be documented on the "List of Revisions" page located in front of the Table of Contents.

4.3 PROJECT ROLES AND RESPONSIBILITIES

The individuals directly involved with the HRC® injection pilot study project and their specific responsibilities are outlined below. Refer to Attachment 3 for resumes of the following individuals.

Mr. Fred Evans, Navy Remedial Project Manager – Overall coordination of the project and decision-maker. Coordinates all activities within Engineering Field Activity Northeast for this site. Coordinate resolution of issues with regulatory case managers. Navy member of the BCT.

Mr. James Shultz, TO Project Manager – Coordination of the EA Project Work and is the EA decision-maker. Coordinates all project activities within EA for this Site and ensures quality of the project work. Regularly communicates project status with the Navy RPM.

Ms. Christine Williams, EPA Region 1, Remedial Project Manager – EPA Region 1 decision-maker and oversight of Navy investigation and remediation. Coordinates all activities within EPA for this site. EPA member of the BCT.

Mr. Richard Gottlieb, RIDEM, Remedial Project Manager – RIDEM decision-maker and oversight of Navy investigation and remediation. Coordinates all activities within RIDEM for this site. RIDEM member of the BCT.

Ms. Robin Clark, TO Task Manager – Coordination and scheduling of field activities, laboratory analysis, data review and data validation reports, and overall coordination of fieldwork.

Mr. Ken Finkelstein, National Oceanic and Atmospheric Administration – Reviews the investigation reports in relation to specific trustee responsibilities.

Mr. Andrew Major, U.S. Fish and Wildlife Service – Reviews the investigation reports in relation to specific trustee responsibilities.

Mr. Steven King (RIEDC) and Ms. Marilyn Cohen (Town of North Kingstown) – Reviews the investigation reports in consideration of future use of the site.

Dr. Henry Leibovitz, Ceimic Corporation, Laboratory Manager – Coordinates the analytical laboratory process and ensures the quality of the laboratory report of the sample analytical results.

4.4 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

No special training requirements or certifications are required for this project except for the 40-hour Hazardous Waste Operations class and 8-hour annual refreshers. At least one onsite worker will have First Aid and cardiopulmonary resuscitation training. The Site Manager will have Site Supervisor Training in addition to the 40-hour Hazardous Waste Operations training. The Safety, Health, and Emergency Response Plan (Appendix A) provides additional information.

4.5 PROJECT PERSONNEL AGREEMENT

Each person involved with implementation of the QAPP will sign Table 4-2 after reading the QAPP to indicate agreement to follow the QAPP as written.

5. PROJECT PLANNING AND PROJECT DEFINITIONS

5.1 PROJECT PLANNING MEETINGS

Project meetings of the BCT will begin after submittal of the QAPP. Project meetings will be as requested by the Navy RPM, the EPA RPM, or the RIDEM RPM. Typically project planning and updating discussions have occurred during the quarterly BCT meeting held at the RIEDC headquarters building at 30 Enterprise Drive, North Kingstown, Rhode Island. Notes of those meetings are prepared by Navy, or its designee, and submitted to the attendees. The list of the attendees is provided in the notes of each such meeting.

5.2 SUMMARY OF POTENTIAL CVOC CONTAMINANT SOURCE AREAS

The following summarizes the 5 apparent CVOC source areas located within or near 3 general areas as interpreted from the Phase II Hydrogeological Investigation results (EA 2003). These apparent source areas were interpreted in part based on the detection of elevated concentrations of CVOC in the shallow and intermediate ground-water zones suggesting an area where there may have been a release to ground surface. Additionally, the detected concentrations of CVOC were reflective of sorbed- and dissolved-phase CVOC.

EBS Review Item 28 – formerly used by the Navy for the purpose of training construction equipment operators (Figure 2). Historically, the following two primary uses occurred at this site:

(1) Creosote Dip Tank Area – Wood pilings were dipped into tanks containing creosote and staged in the area to dry before being loaded onto ships.

(2) Former Fire Fighting Training Area – Reportedly, structures were constructed, doused with flammable materials, set on fire, and extinguished as part of fire fighting training exercises during the late 1960s.

Based on the Phase I and II RI data, this historical site use activity appears to be a source for the localized polycyclic aromatic hydrocarbon (PAH) contamination in soil and appears to be a source for the detected petroleum VOC, CVOC, semivolatile organic compounds, and polycyclic aromatic hydrocarbons in ground water. The RI data suggest that CVOC releases may have been at three general locations within this area bounded by Westcott, Davisville, and Allens Harbor Roads; i.e., in the vicinity of MW16-05, MW16-40S, and MW16-45 (the alleged former FFTA) (Figures 4-3 and 4-6 in Attachment 1).

EBS Review Item 29 - Former Building 41 – This building was a preservation and packing shop, and a construction equipment and automotive parts storage building. Preservation and degreasing operations occurred at Former Building 41 during 1951–53. Based on past activities, it is likely that petroleum products and solvents were used and stored onsite. Although NFA was

determined for this review item during the EBS, the Phase I RI and Phase II Hydrogeological Investigation included further investigation of Building 41.

Based on the Phase I RI, an old solvent recovery still was one of the few pieces of the old operations that was still present in an otherwise empty building. It was thought that somewhere beneath the building may be a key source area for the CVOC detected in the Site 16 deep overburden and bedrock ground-water zones. However, the actual surface or subsurface CVOC release area(s) had not then been identified. During the Phase II Hydrogeological Investigation, three borings were installed through the floor of former Building 41 to assess if there had been release beneath the building. However, based on the Phase II Hydrogeological Investigation results, the highest detected total CVOC concentration was still in soil and water samples from the deep zones just outside the footprint of the building at MW16-14D and MW16-15D/R and beneath the northeast end of the building in samples from MW16-32D (Figure 4-9 in Attachment 2). This suggests that the CVOC release(s) was at another location, upgradient or nearby, and had flowed down to these wells screened in the deep overburden and bedrock zones

Old Railroad Spur Area – Based on the Phase II Hydrogeological Investigation results, there appear to be 2 CVOC release areas in the old railroad spur area in the vicinity of MW16-37S/I and MW16-38I (Figure 4-3 and 4-6 in Attachment 2).

5.3 TIDAL IMPACT ON GROUND WATER

A preliminary tidal study was performed on monitoring wells that are located in close proximity to the Allen Harbor shoreline to determine if the water level in these monitoring wells is affected by the tides. The affect of tide stages was observed as fluctuations (rise and decline) of the potentiometric water surface as measured in the monitoring wells. The Phase II Hydrogeological Investigation data indicate that largest tidal impact on ground water appears to be within 65 ft of the harbor shoreline (0.8–1.9 ft of cyclic water level fluctuation measured at MW16-04 and MW16-48). At distances greater than 105 ft from the shoreline, the tidal impact was observed to be minor; i.e., typically less than 0.5 ft. Beyond 320 ft from the shoreline, the tidal impact was observed to be negligible; i.e., typically less than 0.1 ft. Former Building 41 was located approximately 600 ft from the shoreline.

5.4 SALT WATER INTRUSION ASSESSMENT

The Phase II Hydrogeological Investigation sample results of salinity analyses indicate that a denser-than-fresh-water salt-wedge is not present beneath the Site 16 Phase II Hydrogeological Investigation area which is consistent with the data obtained previously for the Phase I RI. The eastern and northeastern areas are slightly brackish, up to approximately 6 ppth salinity.

5.5 NATURE AND EXTENT OF CONTAMINATION IN SOIL

During the Phase II Hydrogeological Investigation drilling activity, 12 soil samples were collected during the installation of MW16-30D, MW16-31D, MW16-32D located within the footprint of former Building 41 (Figure 3). Nine of these samples were analyzed for VOC and 4

were analyzed for oil and grease. These data were obtained to aid assessment of potential VOC release beneath the floor of former Building 41, and if additional soil borings and monitoring wells in the vicinity of former Building 41. Oil and grease was detected at MW16-31D (8-10 ft bgs). VOC (trichloroethene [TCE]) were detected in only the 56–58 ft bgs samples from MW16-31D (830 μg/kg) and MW16-32D (4,000 μg/kg). These data do not support the theory that a CVOC release occurred within or beneath the building. Although elevated total CVOC were detected in the soil and ground-water samples from the deep overburden, VOC were not detected in soil samples collected from shallower depths, indicating that the CVOC had been released elsewhere and had then migrated laterally to those deep wells.

5.6 SUMMARY OF THE NATURE AND EXTENT OF CVOC IN GROUND WATER

Based on the Phase II Hydrogeological Investigation samples results, 86 percent of the TCE mass detected in ground water at Site 16 appears to be present in deep overburden and bedrock zones, as opposed to shallow or intermediate overburden zones. No light non-aqueous phase liquid (LNAPL) or dense non-aqueous phase liquid (DNAPL) has been measured (observed as a separate phase liquid) in the monitoring wells in the Site 16 investigation area and no compounds were detected in excess of 1 percent of their solubility.

The CVOC plume (with total CVOC, at times, greater than 700 micrograms per liter [μg/L]) was identified beneath an area located approximately between the northeastern corner of the Former Building 41 and MW16-05D (Figure 4-9 in Attachment 2). For the deep overburden ground-water zone, the Phase I RI data (March 2001) indicate the presence of CVOC in the area between at least the northeastern corner of Former Building 41 (MW16-14D at 4,907 μg/L total CVOC and MW16-15D at 6,206 μg/L total CVOC) and MW16-05D (2,308 μg/L total CVOC) (Appendix A, Figure 4-31). For the Phase II, 23 deep overburden wells were added to the monitoring well network. The 6 highest total CVOC concentrations detected in samples from the deep overburden wells during the Phase II Hydrogeological Investigation (November-December 2002) include 5 of the wells sampled during the Phase I RI that also had high CVOC concentrations (MW16-14D at 3,004 μg/L, MW16-15D at 2,703 μg/L, and MW16-32D at 2,700 μg/L near former Building 41, and MW16-02D at 1,708 μg/L, MW16-29D at 1,269 μg/L, and MW16-05D at 1,509 μg/L in the EBS 28/FFTA) (Figure 4-9 in Attachment 2). In general, the CVOC extent detected during the Phase I RI is very similar to that detected by the Phase II Hydrogeological Investigation except for some refinement within the plume area by the additional wells. The CVOC concentrations detected within the deep overburden ground-water zone are not reflective of the nearby presence of DNAPL. Although chlorinated DNAPL may have historically migrated through this zone, current dissolved CVOC concentrations noted in the above investigations are not reflective of the presence of DNAPL and, therefore, are presumably a result of adsorbed and absorbed phase (hereafter referred to collectively as sorbed phase) CVOC that are associated with the aquifer matrix and resultant dissolved phase CVOC that are in chemical equilibrium with the sorbed phase CVOC mass.

Additionally, CVOC (specifically TCE) within the upper bedrock zone beneath the CVOC plume located in the deep overburden zone. In general, the highest total CVOC and TCE concentrations in the upper bedrock ground-water zone were detected in the sample collected

from MW16-15R (northeast end of former Building 41), followed in concentration by the sample collected from MW16-44R (Figure 4-12 in Attachment 2). These 2 samples are from wells that are constructed deeper than the related deep overburden (D) wells MW16-15D and MW16-44D, respectively, and are located directly beneath the CVOC (predominantly TCE) plume described for the overlying deep ground-water zone. These results indicate that the plume has migrated vertically downward from the deep ground-water zone through fractures into at least the upper 25–30 ft of competent bedrock and is at concentrations similar to those detected in the overlying deep overburden zone. Vertically, CVOC concentrations generally decrease from the deep overburden zone to the shallow bedrock zone, except for at location MW16-44D/R, where the concentration is slightly higher in the sample from the bedrock. Similar to the deep overburden zone, current dissolved CVOC concentrations in the rock zone noted in the above investigations are reflective of the presence of only aqueous phase and sorbed phase CVOC.

During the Phase II Hydrogeological Investigation, 3 wells were completed in the 25–30 ft of competent bedrock (R2) below where the adjacent bedrock (R) well was constructed. CVOC were detected in the samples collected from each of these 3 wells (Figure 4-15 in Attachment 2). The total CVOC concentrations detected in the samples from MW16-02R2 (125.97 μg/L) and MW16-15R2 (182.42 μg/L) are 6–7 times lower than the related samples collected from the overlying shallow competent bedrock zone (MW16-02R, 847.58 μg/L; and MW16-15R, 1,354.2 μg/L). TCE was not detected in the sample from MW16-55R2 and the total CVOC was only 0.2 μg/L.

5.7 SITE CONCEPTUAL MODEL – SITE SUMMARY OF THE CVOC RELEASE AND MIGRATION

The background, hydrogeological framework, and constituent extent have been presented in the previous sections of this chapter. The CVOC plume detected in the deep overburden and bedrock ground-water zones may have developed from contributions from five potential release areas: two in the former Building 41/old railroad spur area in the vicinity of MW16-37I and MW16-38I and three in the EBS 28/former FFTA in the vicinity of MW16-05I, MW16-40S, and MW16-45I. There may also have been a release in the vicinity of the northeast end of former Building 41 that has not yet been encountered by the previous soil boring and sampling activities. These releases then migrated downward into and through the silty gravelly sand and weathered bedrock deposits above competent bedrock, and then, into fractures in the underlying competent bedrock. Except for the MW16-37 vicinity, these potential release areas are generally located above the interpreted valley in the competent bedrock surface present between the northeastern end of the former Building 41 and well cluster MW16-05. Generally, the rock quality designation values calculated for the 5-ft length cores from the upper 5-8 ft of the competent bedrock are less than 50 percent within this same 'valley' area, indicative of a more fractured upper bedrock interval which may be of higher permeability, and thus, a preferential zone for lateral ground water and plume movement at this depth interval. In general, the CVOC extent detected in the deep overburden and shallow bedrock zones during the Phase I RI is very similar to that detected by the Phase II Hydrogeological Investigation except for some refinement within the plume area by the additional wells. Although CVOC have also been

detected in samples of the deep ground water beneath the Navy Site 03 and FUD site former Nike PR-58 site, located west-northwest and generally upgradient from Site 16, the available data indicate that CVOC contribution from these sites to Site 16, if any, is de minimis.

The CVOC detected in the ground-water samples is almost entirely TCE. The other detected CVOC may have been impurities in TCE used for degreasing and/or they may be degradation products. The CVOC release (mostly TCE), being denser than ground water, migrated downward to the gravelly sand deposits due in part to the discontinuous nature of the silt layers that do not provide a protective interval to slow/retard the downward migration, but rather sometimes could act as a series of alternating shelf-like features to flow down and around, and aiding in the distribution of the released CVOC in the overburden to the extent currently detected. At well cluster MW16-37S/I/D, an apparent CVOC release area, no silt layers were encountered. Based on the proximity of the MW16-37S/I apparent CVOC release area to MW16-14D and MW16-15D/R, it would seem to be a potential source for the CVOC detected in samples from those deep wells. However, based on the interpreted ground-water flow direction at MW16-37S/I source area, the absence of silt layers, an interpreted bedrock surface that slopes away from the MW16-14D and MW16-15R area, and a variable vertical gradient at MW16-15, the source for the elevated CVOC detected in MW16-14D and MW16-15D/R is not obviously from the MW16-37S/I vicinity. Although the historical storm drain system is typically located above the ground-water table, a historical release to a catch basin(s) along the north side of the former Building 41 followed by leakage from the system near the northeast end of the former building could provide a source for the CVOC in those two deep wells, albeit very hypothetical source. Elevated CVOC concentrations have not been detected in samples from the 2 wells located north of the building near that portion of the historical storm drain system.

No LNAPL or DNAPL has been measured (observed as a separate phase liquid) in the Phase II Hydrogeological Investigation monitoring wells. Based on indirect criteria, the presence of NAPL may be suspected (perhaps as residual NAPL as a coating on soil particles or as ganglia between soil particles or in bedrock fractures) in the vicinity of the Building 41 and FFTA source areas. However, no compounds were detected in excess of 1 percent of their solubility.

5.8 ASSESSMENT OF THE VIABILITY OF SUBSURFACE CONDITIONS TO SUPPORT NATURAL BIODEGRADATION OF THE CVOC PLUME

The data indicate that spatially limited areas of the site contain adequate to strong evidence of CVOC biodegradation. However, these areas are limited to subsurface reducing environments that contain petroleum constituents, which serve as electron donors in reductive dechlorination. In addition, the ratio of parent to daughter CVOC at these locations indicate inadequate rates of reductive dechlorination to lead to significant natural attenuation of parent CVOC. Although petroleum compounds that act as electron donors were detected at Site 16, the concentration of these compounds in ground water is not significant enough to promote a substantial reductive dechlorination of CVOC. Therefore, the site conditions are conducive to natural reductive dechlorination, but rate limitations have generally resulted as a function of electron donor absence.

6. PROJECT DESCRIPTION AND SCHEDULE

6.1 PROJECT OVERVIEW

The HRC® injection pilot study will utilize *in situ* injection of a reducing agent (i.e., HRC®) to enhance biodegradation rates for CVOC within a potential source area of Site 16.. The primary objective of the HRC® pilot test is to directly assess the overall site-specific efficacy, site-specific ability to deliver the HRC®, and the rate of performance of enhanced bioremediation as a ground-water plume area cutoff technique. In addition, as a by-produce of the pilot test, to significantly decrease the CVOC concentrations in the upgradient (southwestern) portion of the CVOC plume area. This QAPP presents the HRC® injection pilot study plan and field procedures for the work at the former Building 41 site. In accomplishing these objectives, the following activities will be performed during the HRC® injection pilot study:

- Water level measurements from 50 established monitoring wells at Site 16 prior to implantation of the drilling portion of the pilot study as agreed during the BCT Meeting of 30 March 2004 (Table 2-1A). This work was completed on 7 and 9 April 2004 following a significant rain event on 31 March and 1 April 2004 (approximately 3.4 in. of rain was measured at the Providence T F Green State AR station). The water level data is summarized in Table 2-1A and the interpretive contouring of the related water surface elevation data is shown on Figures 1-4 in Attachment 1. The contouring of these data is similar to that for data collected for the Site 16 Phase II Hydrogeological Investigation in November 2002 and March 2003 (EA 2003).

- Installation of 12 deep (D) overburden injection wells and 49 monitoring wells (13 screened in the shallow [S] overburden zone, 12 screened in the intermediate [I] overburden zone, 13 screened in the deep [D] overburden/weathered bedrock zone, and 11 completed as open boreholes in the upper competent bedrock [R] zone) at the locations shown on Figure 5. The general process for the installation of wells are included in Attachment 2 (Section 2.4 of Standard Operating Procedure [SOP] No. 2).

  Prior to initiating drilling of monitoring well clusters MW16-65S/I/D/R and MW16-66S/I/D/R, their locations must be finalized with the BCT, and possibly refined, based on the results of the recent seismic refraction survey work (fieldwork performed 12-13 July 2004) performed as part of the ongoing Site 16 Supplemental Phase II Investigation. Drilling of these 2 well clusters will not begin until approval is provided to the TO Task Manager by the TO Project Manager.

  The Navy has obtained right-of-access with the Rhode Island Economic Development Corp (RIEDC) and the North Atlantic Distribution, Inc (NORAD; a regional car storage and distribution company) to install the HRC® pilot test wells. The well locations and designations, and the general Stages I and II drilling areas, are shown on Figure 5. The drilling/installation of the total of 61 monitoring wells and HRC® injection wells will occur in 2 stages that will be performed one after another as follows:

3) Stage I drilling will include the first 25 monitoring wells, which will serve a dual purpose for both this project and the ongoing Site 16 Supplemental Phase II Investigation (refer to "Site Map – Drilling-Stage I" included in Attachment 1).

4) Stage II drilling work will include the remaining 24 HRC® monitoring wells and the 12 injection wells, all located in a relatively small geographic area (refer to "Site Map – Drilling-Stage II" included in Attachment 1).

The relationship of the approximate well locations to the car parking spaces is also shown on those two figures in Attachment 1, including a 50-ft radius around each well to be installed that will need to be open (no cars) during the well drilling and HRC® injection activities. Removal of the cars has been and will continue to be coordinated by the TO Project Manager and TO Task Manager with the RIEDC and NORAD.

- Collection of 2 confirmatory soil samples from each of the 25 deep (D) well borings (12 injection wells and 13 monitoring wells) for laboratory analysis of the Target Compound List (TCL) volatile organic compound (VOC) and total organic carbon (TOC) (refer to Section 8.3).

- Borehole geophysical logging of the open hole in bedrock portion of the 11 wells to be completed in competent bedrock (Geophysical Applications' SOP for Borehole logging is provided in Attachment 4). The logging will include the following 8 methods: caliper, single-point resistance, fluid temperature, natural gamma, fluid resistivity, heat-pulse flow meter (under both static/ambient and pumping conditions), acoustic televiewer (ATV) (ALT Model FAC40 ATV or similar) logging, and optical televiewer (OTV).

- Slug testing of the 25 deep wells to be screened in the overburden. The field procedures are provided in Attachment 2, SOP No. 4.

- Baseline ground-water sampling event prior to injection of the HRC® to include: 1) a synoptic round of depth to water level measurements from 111 monitoring and injection wells (Table 2-1B) and 2) ground-water sampling from each of 73 wells (shown on Figure 5).

  If the baseline sample results indicate the presence of a high concentration source area (DNAPL) at one or more of the new wells, the design and type of the pilot test would be reconsidered.

- Injection of the HRC® into the 12 deep injection wells. The field pilot test will generally consist of applying HRC® in an array of 12 injection deep wells near the northeast end of former Building 41. The procedures for the HRC® injection are provided in Attachment 2, SOP No. 5.

The field pilot test will consist of applying HRC® in 2 linear arrays of injection wells located across the CVOC plume and monitoring the ground-water quality upgradient, within, and downgradient of the pilot treatment zone over a 24-month period. As shown on Figure 5, the HRC® well array will consist of 6 evenly spaced deep injection wells over 2 parallel lengths of approximately 100 ft and oriented approximately perpendicular to the interpreted direction of ground-water flow. Injection wells will be installed for HRC® delivery because direct-push equipment is not effective and cannot be used for the deep overburden and weathered bedrock zones. Each HRC® deep injection well will consist of a well screened within the deep overburden sand/gravel and/or weathered bedrock (Figure 6).

HRC® will be injected into the wells via strategically positioned packers and a pump capable of processing the HRC® material with a viscosity of 20,000 centipoise at flow rates of 3-10 gal per minute at pressures ranging from 200 to 1,500 psig.

A calculated ground-water velocity of approximately 1 ft/day (overburden values) was used when considering the specified time of HRC®-release dosing requirements and injection well spacing. Current deep (D) overburden well ground-water geochemistry and natural attenuation conditions, which are assumed to be reducing (based on 2001 sample analytical data (*EA Phase I Remedial Investigation Report of IR Program Site 16 Volume I: Technical Report; October, 2001*), were also evaluated in order to assess competing electron acceptor demand (e.g., oxygen, manganese, ferric iron, or sulfate) for the HRC®-supplied electron donor. Higher competing electron acceptor-based demand governs the required amounts of HRC® to achieve remedial goals.

VC forms at the site under natural conditions as indicated by the available site data. The production of VC is expected as a result of accelerated anaerobic biodegradation with HRC® compound. However, Regenesis' experience has been that this occurs several months after the injection of the HRC® and continues over a relatively short time (a few months). It is important to note that the elevated VC concentrations are only temporary and short-lived. Currently, the ground surface of the pilot test area is mostly paved and contains no buildings. VC is included in the TCL VOC analytical program for the ground-water samples to be collected during the monitoring events following injection of the HRC®. If VC is found to be migrating upward so as to result in an unacceptable release to the atmosphere, it could be addressed, for example, by the injection of ORC® to accelerate the degradation of the VC.

- 13 ground-water monitoring events over a period of 2 years after injection of the HRC® to include: 1) a synoptic round of depth to water level measurements from 111 monitoring and injection wells (Table 2-1B) and 2) ground-water sampling from each of 73 wells (shown on Figure 5) during each event (refer to Section 8.2).

6.1.1 Use of HRC® to Accelerate Anaerobic Bioremediation at CVOC Plume Cutoff

HRC® is a reducing agent used to enhance *in situ* biodegradation rates of dissolved CVOC by supporting anaerobic reductive dechlorination processes. Reductive dechlorination is now recognized as one of the primary attenuation mechanisms by which chlorinated solvent ground-water plumes can be contained and/or remediated. HRC® is a proprietary polylactate ester that, upon being inserted into the subsurface, slowly releases lactate. Lactate is metabolized by naturally occurring microorganisms, resulting in the creation of anaerobic aquifer conditions and the production of hydrogen. Naturally occurring microorganisms capable of reductive dechlorination then use the hydrogen to progressively remove chlorine atoms from chlorinated hydrocarbon contaminants (e.g., converting tetrachloroethene [PCE] to TCE to dichloroethene [DCE] to VC to ethene).

HRC® is manufactured as a viscous gel that is injected into the saturated zone in a grid or cutoff barrier configuration for either localized area or cutoff-based treatment approaches. The use of HRC® for ground-water remediation offers a comparatively simple and cost-effective remediation alternative for sites that would otherwise require unacceptably long periods of time for natural attenuation, or the high levels of capital investment and operating expense associated with active remediation technologies. Alternatively, HRC® is used as a plume management technology in tandem with other active technologies that address source zone remediation. Unlike many other *in situ* reducing and oxidizing agents, HRC® applications are designed for only one particular round of injection per year for most sites. The slow time-release activation of lactate and slow rates of biodegradation effectively lead to few necessary rounds of application, even for full-scale treatment. Toward that end, the proposed HRC® pilot test at Site 16 is scoped to include only a single round of injection.

All of the chlorinated hydrocarbons present at the site are amenable to HRC® anaerobic reductive dechlorination processes, although the rates of accelerated biodegradation tend to be faster for more chlorinated (e.g., PCE and TCE) rather than less chlorinated (e.g., DCE and VC) contaminants. Accelerated aerobic biodegradation using Oxygen Release Compound® can also be effective at degrading certain CVOC; however PCE and TCE are not generally amenable to *in situ* oxidative biodegradation processes. Because TCE is prevalent at the site and since subsurface redox conditions currently favor anaerobic biodegradation, an HRC® technique for a dissolved-phase plume is heavily favored over an Oxygen Release Compound® technique.

It should be noted that HRC® would cause accelerated generation of daughter products that proceed by reaction all the way to VC. However, VC is generated as a daughter product under natural conditions as well (just not quite as fast a rate as under HRC® conditions). It would not be expected that VC would show up during the pilot test as vadose gas since it would probably take many years (if not decades) to diffuse upward through the saturated zone to vadose elevations (unless there is a strong upward vertical gradient in the area). However, air emissions should not be a problem considering that VC will be generated within the deep saturated zone and would have to disperse and diffuse through a significant portion of the overlying saturated zone to create a problem within the vadose zone as an air emission at the site. Currently, the ground surface of the pilot test area is mostly paved and contains no buildings. VC is included in

the TCL VOC analytical program for the ground-water samples to be collected during the monitoring events following injection of the HRC®. If VC is found to be migrating upward so as to result in an unacceptable release to the atmosphere, it could be addressed, for example, by the injection of ORC® to accelerate the degradation of the VC.

The following information about HRC®, including Technical Bulletins (from Regenesis) is included in Attachment 2:

- HRC® Overview
- HRC® How it works
- HRC® Installation Instructions

  — Application in cold weather settings
  — Detailed installation procedures
  — Installation Instructions
  — Pump information

    – Equipment Pumps

- Enhanced Bioremediation of TCE at Department of Defense Landfill Site
- Biological Reductive Dechlorination of chlorinated aliphatic hydrocarbons (CAH)
- Environmentally Safe
- The formation of Vinyl Chloride using HRC®
- HRC® Performance Characteristics, Longevity
- Distribution of HRC® in the Aquifer
- Bedrock Application of HRC®
- How does Hydrogen in HRC® finally get to the chlorinated hydrocarbons?
- Competition for Hydrogen between Reductive Dechlorinators and other Microorganisms.

6.1.2 Pilot-Scale Testing

As stated previously, this pilot study (treatability study) seeks to directly assess the overall site-specific efficacy, site-specific ability to deliver the HRC®, and the rate of performance of enhanced bioremediation as a ground-water plume area cutoff technique by utilizing *in situ* injection of a reducing agent (i.e., HRC®) to enhance biodegradation rates for CVOC within a pilot-scale field test located near the southwestern (upgradient) extent of the >1,000 µg/L portion of the detected CVOC plume area in the deep overburden zone (vicinity of former Building 41; Figure 2). Additionally, design parameters will be evaluated to potentially scale up pilot scale parameters to full-scale operations for a potential plume cutoff remedial scenario. The effectiveness of the pilot test will be evaluated within the deep overburden/weathered bedrock subsurface zone that currently appears to contain a large portion of the CVOC mass. Post-injection ground-water data will be compared with pre-injection baseline data within the test area to evaluate whether significant CVOC mass reduction can be accomplished downgradient of HRC® application. An additional objective, as a by-produce of the pilot test, is to significantly

decrease the CVOC concentrations in the upgradient (southwestern) portion of the CVOC plume area.

6.2 PROJECT SCHEDULE

Refer to Table 6-1 for the Project Schedule.

6.3 REPORTS AND DATA PRESENTATION

The HRC® injection pilot study report schedule is included in Table 6-1. As available, field findings will be presented during BCT meetings.

6.3.1 HRC® Injection Pilot Test Report

The HRC® injection pilot test report will present the project data in tabular format and on figures (tag maps). Preparation and submittal of a HRC® injection pilot study report will include:

- Site background information, a summary of field and laboratory procedures, the hydrogeological findings, and results and interpretation of chemical analysis.
- Assessment of the overall site-specific efficacy, site-specific ability to deliver the HRC®, and the rate of performance of enhanced bioremediation.
- Assessment of the potential for scale up of the pilot scale parameters to full-scale operations for a potential plume cutoff remediation scenario.

The HRC® injection pilot study report will be submitted as a Draft, Responses to Comments, and Final to the BCT. The Final will incorporate the agency review comments.

7. PROJECT QUALITY OBJECTIVES AND MEASUREMENT PERFORMANCE CRITERIA

7.1 PROJECT QUALITY OBJECTIVES

The project data quality objective is to provide data of known and documented quality to determine if each sample can be compared to its associated screening level. The screening levels are provided in this QAPP. The data quality indicators to be measured are described below.

7.2 MEASUREMENT PERFORMANCE CRITERIA

Analytical results will be needed from at least 90 percent of the planned ground-water samples from monitoring wells for the sampling event. For duplicate samples, the Relative Percent Difference (RPD) will need to be no more than 30 percent for ground-water samples and no more than 50 percent for soil samples. Ground-water and soil sample results will be compared to the project action limits included in Tables 7-1 and 7-2. Acceptance criteria are provided in Table 7-3 for quality control (QC) samples, i.e., Laboratory Control Samples and matrix spike/matrix spike duplicates. Measurement performance criteria for ground-water samples are included in Table 7-4. Analytical precision and accuracy/bias are presented in Chapter 12.

This pilot study (treatability study) seeks to directly assess the overall site-specific efficacy, site-specific ability to deliver the HRC®, and the rate of performance of enhanced bioremediation as a ground-water plume area cutoff technique by utilizing *in situ* injection of a reducing agent (i.e., HRC®) to enhance biodegradation rates for CVOC within a pilot-scale field test located near the southwestern (upgradient) extent of the >1,000 µg/L portion of the detected CVOC plume area in the deep overburden zone (vicinity of former Building 41; Figure 2). The pilot study will be deemed successful if significant depletion (at least 50 percent and preferably one order of magnitude) of TCE is observed within the pilot test area by the conclusion of the 24-month study. Pre- and post-injection samples of ground water will be collected from 73 monitoring wells (depth intervals) for analysis of the TCL VOC and natural attenuation parameters to document the baseline concentrations for comparison with the post-injection concentrations in the immediate vicinity of the test plot to assess the amount of CVOC concentration decrease. The HRC® injection wells will not be used to obtain ground-water samples for laboratory chemical analysis.

The performance measures for the planned 24-month test duration are as follows:

1. Successful injection of the HRC® material via the 12 injection wells.

2. Establishment of the strongly reducing conditions generally appropriate for the accelerated natural attenuation by use of HRC®.

3. At least a 50 percent, and preferably a one order of magnitude, decline of dissolved parent CVOC (TCE) within the pilot study area by the conclusion of the 24-month study.

8. SAMPLING PROCESS DESIGN

8.1 SAMPLING DESIGN RATIONALE

This chapter describes the HRC® injection pilot study sampling rationale and the analytical program and methods. The QC and quality assurance (QA) requirements are provided in Chapters 13 and 17. Safety and health procedures to be followed during sampling are described in the Safety, Health, and Emergency Response Plan (Appendix A). The Analytical Program is provided in Table 8-1. A summary of analytical parameters is included in Tables 7-1 and 7-2.

Objectives – The objectives of this HRC® injection pilot study is to utilize *in situ* injection of a reducing agent (i.e., HRC®) to enhance biodegradation rate for CVOC within an area located near the southwestern extent of the >1,000 µg/L portion of the CVOC plume (vicinity of former Building 41) to enhance biodegradation rate of the CVOC.

Appropriate Data and Coverage – Based on the Phase II Hydrogeological Investigation samples results, 86 percent of the TCE mass detected in ground water at Site 16 appears to be present in deep overburden and bedrock zones, as opposed to shallow or intermediate overburden zones. Based on the results of the Phase I RI and the results of the Phase II Hydrogeological Investigation, the HRC® injection pilot study monitoring and injection well locations and screened intervals have been selected to assess the effects of the HRC® injection at the area of Former Building 41, vicinity of a potential source area within Site 16 investigation area. The area is near the southwestern (upgradient) extent of the >1,000 µg/L portion of the CVOC plume area within the deep overburden and upper bedrock ground-water zones. Therefore, it is anticipated that this location would result in minimizing the amount of the detected >1,000 ug/L CVOC plume area that would be located in the deep overburden immediately upgradient of the pilot test area, perhaps reducing the amount of CVOC rebound in the study area after the test.

The design of the pilot study is based on the use of "HRC® Design Software for Barrier Treatment" by Regenesis. All available design information and software from Regenesis was accessed and utilized to design the HRC® pilot test for Site 16. In addition, several direct conversations with Regenesis technical support were conducted to evaluate site-specific factors and study objectives. The pilot test design information for the deep overburden ground-water zone is included at the end of Attachment 1. The available Site 16 Phase I and II investigation slug test data, particularly that for existing wells located in the proposed pilot test area (MW16-14D, MW16-15D, and MW16-32D), were used to estimate the range of potential transport velocities of ground water and to assess test design criteria for emplacement and transport of HRC® reagent within the deep ground-water zone. The range of potential ground-water linear velocities (approximately 0.3 to 1 ft/day) was established based on review of this data. The study design criteria including injection well locations (two rows of 6 well pairs), monitoring well locations, and well spacing were developed based on this potential range of velocities. Although the HRC injection wells in a given injection well row are proposed on 20-ft centers (Figure 5), the offset location of the injection wells in the adjacent downgradient row allows for an effective transverse spacing between injection wells of 10 ft. Two rows of injection wells

were designed to optimize ground-water contact with emplaced HRC® reagent. The radius of influence for each injection well, therefore, was designed for approximately 5 ft. This radius of influence was determined based on site-specific information and the experience of Regenesis with HRC® injection. The location of the injection well array also allows for the use of 4 exiting monitoring wells.

Monitoring well locations were selected along and transverse to the interpreted direction of ground-water flow (generally toward the northeast in the vicinity of the injection wells) at varying distances from the injection array to observe the results from the injection event, ranging from locations between the 2 rows of injection wells to a maximum of approximately 340 ft downgradient (northeast) from the injection wells. The interpreted direction of ground-water flow is generally toward the northeast in the vicinity of the injection wells (Figures 1-4 in Attachment 1). There are 4 lines of monitoring wells oriented transverse to the interpreted direction of ground-water flow as shown of Figure 5. Line 1 is located upgradient of the injection well array (Figure 5). Line 2 is locate very close to the injection well array. Lines 2 and 3 are located downgradient of the injection well array. Both the overburden (S, I, and D) and upper bedrock (R) ground-water zones are included in the ground-water monitoring program to provide data to assess both the lateral and vertical impacts of the HRC® injection. Because the production of VC is expected as a daughter product from the accelerated biodegradation of the TCE, monitoring wells screened in the intermediate (I) and shallow (S) overburden zones have been included in the monitoring well clusters located nearest the injection well array (i.e., those located between and just northeast of the injection well rows) to monitor for the formation and potential upward migration of VC as a degradation product.

The general process for selection of the screened intervals of deep wells to be completed in the overburden is included in Attachment 1 (Section 2.4 of SOP No. 2). Geophysical logging of the open rock portions of the planned "R" monitoring wells will be performed to aid in the assessment of bedrock fractures and areas of ground-water flow.

Consistent Data Management – To ensure the consistency and long-term usability of the collected data, all gathered information will be compiled according to pre-defined data structures and formats, i.e., the *EQUIS* Data Structure (Attachment 4). Details of sampling procedures and data compilations are provided in Attachment 1 and Chapter 15, respectively.

8.2 GROUND-WATER SAMPLING FROM MONITORING WELLS

During the HRC® injection pilot study, one pre-injection (baseline monitoring event) and 13 post-injection monitoring events are planned over a period of 2 years. Each monitoring event will include:

1) A synoptic round of depth to water level measurements from 111 monitoring and injection wells (Table 2-1B), and

2) Ground-water sampling from each of 73 monitoring wells (shown on Figure 5). These events would be monthly during the first 6 months, bi-monthly for the next 6 months, and

quarterly for the remaining12 months (Table 6-1), except when the vinyl chloride formation begins, at which point, monitoring would be monthly until the vinyl chloride concentrations return to those detected prior to HRC® injection or to the end of the pilot study. The ground-water samples will be submitted for laboratory analysis of TCL VOC and natural attenuation parameters to assess the extent of CVOC remediation by the HRC® and to assess the viability of the subsurface conditions for enhanced natural biodegradation of the CVOC.

The analytical program for HRC® injection pilot study ground-water samples is included in Table 8-1.

8.3 SOIL SAMPLING

A total of 2 soil samples will be collected from within the screened interval each of the 25 deep (D) well borings (12 injection wells and 13 monitoring wells) and submitted for laboratory analysis of the TCL VOC and total organic carbon (TOC). These soil samples will be selected from the highest soil sample headspace vapor measurements using a flame ionization detector (FID) and/or the samples exhibiting visual and olfactory signs.

The analytical program for the soil samples to be collected for the HRC® injection pilot study is included in Table 8-1.

9. SAMPLING PROCEDURES AND REQUIREMENTS

Sampling, decontamination, equipment calibration, and maintenance procedures are provided in this section.

9.1 SAMPLING PROCEDURES

9.1.1 Ground-Water Sampling

The procedures for the sampling of ground water are described in Attachment 2 (SOP No. 1). Table 9-1 includes sampling locations, sampling and analysis method, sample container, volume, preservation, holding time requirements, and SOP requirements.

9.1.2 Soil Sampling

The procedures for the sampling of soil (SOP No. 2) are described in Attachment 2. Table 9-1 includes sampling locations, sampling and analysis method, sample container, volume, preservation, holding time requirements, and SOP requirements.

9.2 INVESTIGATIVE DERIVED WASTE MANAGEMENT

This section addresses the procedures for handling, collection, and storage of investigative derived waste generated during sampling activities which are detailed within each of the SOPs in Attachment 2.

9.3 DECONTAMINATION PROCEDURES

Decontamination procedures are described within each of the SOPs in Attachment 2.

Pre-cleaned sample containers will be provided by the laboratory and, therefore, will not require cleaning or decontamination during the HRC® injection pilot study.

9.4 FIELD EQUIPMENT MAINTENANCE, TESTING, CALIBRATION, AND INSPECTION

Field measurement equipment will be rented. Each piece of equipment will be inspected by the Navy's contractor to be in proper working order and calibrated before its use (Table 9-2). Each morning and at the end of a day of a sampling event, each piece of field measurement equipment will be checked to determine that the unit is within 10 percent of each calibration standard. Each probe that is above 10 percent of its calibration standard will be recalibrated. Prior to use each day and after each use during a day, field analytical equipment probe(s) will be decontaminated in accordance with Attachment 2. When not in use, the instrument will be stored in an area shielded from weather conditions. Field sampling equipment calibration and checking results will be recorded in calibration log. Equipment that does not calibrate, or does not function

properly, will not be used and will be replaced as soon as possible. A copy of the EPA Draft Calibration Procedures is included in Attachment 6.

10. SAMPLE HANDLING, TRACKING, AND CUSTODY REQUIREMENTS

Sample labeling, handling, tracking, and custody requirements are provided in this chapter of the QAPP, along with the field notes and documentation requirements. The Sample Handling System is described in Table 10-1.

10.1 SAMPLE DESIGNATION AND LABELING

See Attachment 2.

10.2 HANDLING, CUSTODY, AND SHIPPING

See Attachment 2.

10.3 SAMPLE DOCUMENTATION

The documentation necessary for this investigation includes the following:

- Field notebook
- Chain-of-custody form
- Field sampling form.

10.3.1 Field Notebook

See Attachment 2.

10.3.2 Chain-of-Custody Forms

See Attachment 2.

10.3.3 Field Sampling Form

This form will be used by the person sampling to record the physical measurements of the sample information, and also as a reference. Sampling forms are provided at the end of Attachment 2.

11. FIELD ANALYTICAL METHOD REQUIREMENTS

The field analyses planned for this work include the use of a water quality unit (for pH, Eh, dissolved oxygen, temperature, and conductivity) and turbidity meter for measurements during well purging and sampling activities. Water quality indicator parameters will be measured in the field in accordance with EPA's *Methods for Chemical Analysis of Water and Wastes* (EPA-600/4-79-020 [1983]) using the following methods: temperature (Method 170.1), pH (Method 150.1), turbidity (Method 180.1), specific conductance (Method 120.1), and dissolved oxygen (Method 360.1).

Hach kits will be used for the field measurement of ferrous iron (HACH DR/890 Colorimeter, or similar) and CO_2 (HACH Digital Titrator, or similar) in ground-water samples collected from the monitoring wells. They will be used in accordance with the associated manual for each type of kit. A copy of the Hach kit procedures is included in Attachment 2.

Instruments will be checked and/or calibrated as stated previously in Section 9.4. Equipment that does not calibrate, or does not function properly, will not be used and will be replaced as soon as possible.

After each use, the instrument will be decontaminated, checked, and stored in an area shielded from weather conditions. Prior to each use, field analytical equipment probe(s) will be decontaminated in accordance with Chapter 9.

12. FIXED LABORATORY ANALYTICAL METHOD REQUIREMENTS

The water samples will be analyzed by the selected laboratory using the analytical methods and reporting limits shown in Tables 12-1A and 12-1B. The analytical methods SOPs are on file at Ceimic Corporation. Cover sheets from the SOPs are included as Attachment 7.

For the analytical instrumentation, the testing, inspection, and maintenance will be performed in accordance with the procedures to be provided by the selected laboratory and manufacturer's recommendations (Tables 12-2 and 12-3). The following provides typical procedures that will be fine-tuned and finalized by the selected laboratory.

12.1 LABORATORY CALIBRATION PROCEDURES

The analytical systems, including instrumentation, equipment, and reference standards, used at the Contract Laboratory Protocol laboratory will be controlled by a formal calibration program. The program verifies that equipment is of the proper type, range, accuracy, and precision to provide data compatible with specified requirements. All instruments and equipment that measure a quantity, or whose performance is expected at a stated level, are subject to calibration. Calibration is performed by laboratory personnel using reference standards or externally by calibration agencies or equipment manufacturers.

12.1.1 Calibration Procedures

Written procedures will be used by the laboratory for all instruments and equipment subject to calibration. Whenever possible, recognized procedures, such as those published by the American Society of Testing and Materials or EPA or procedures provided by manufacturers, are adopted. If established procedures are not available, a procedure is developed considering the type of equipment, stability characteristics of the equipment, required accuracy, and the effect of operational error on the quantities measured. As a minimum, the procedures include:

- Equipment to be calibrated
- Reference standards used for calibration
- Calibration technique and sequential actions
- Acceptable performance tolerances
- Frequency of calibration
- Calibration documentation format.

12.1.2 Equipment Identification

Equipment that is subject to calibration will be identified by a unique number assigned by the laboratory, and calibration records will reference the specific instrument identification.

12.1.3 Calibration Frequency

Instruments and equipment are calibrated at prescribed intervals and/or as part of the operational use of the equipment. Calibration frequency is based on the type of equipment, inherent stability, manufacturer's recommendations, values provided in recognized standards, intended data use, specified analytical methods, effect of error upon the measurement process, and prior experience.

12.1.4 Calibration Reference Standards

Two types of reference standards are used within the laboratory for calibration:

- *Physical standards*, such as weights for calibrating balances and certified thermometers for calibrating working thermometers, refrigerators and ovens, are generally used for periodic calibration. Whenever possible, physical reference standards have known relationships to nationally recognized standards (e.g., National Institute of Standards and Technology) or accepted values of natural physical constants. If national standards do not exist, the basis for the reference is documented. Physical reference standards are used only for calibration and are stored separately from equipment used in analyses. In general, physical reference standards are at least 4-10 times as accurate as the requirements for the equipment which they are used to calibrate. In general, physical standards are recalibrated annually by a certified external agency, and the QA staff maintains documentation.

- *Chemical standards*, such as Standard Reference Materials provided by the National Institute of Standards and Technology or EPA. Whenever possible, chemical reference standards are directly traceable to National Institute of Standards and Technology Standard Reference Materials. If Standard Reference Materials are not available, compounds of vendor-certified high purity are used to prepare calibration standards. These are primarily used for operational calibration. Documentation (e.g., certificates of analysis) of traceability is required for all chemical standards used for calibration and QC. Chemical standards are verified prior to use.

12.1.5 Calibration Failure

Equipment or analytical systems that cannot be calibrated must be repaired and satisfactorily recalibrated before reuse. Analysis will not proceed until appropriate corrective action is taken and an acceptable calibration is achieved. This activity is documented in a Non-Conformation Record.

Scheduled calibration of equipment does not relieve the laboratory staff of the responsibility for using properly functioning equipment. If an equipment malfunction is suspected, the equipment is tagged and removed from service and recalibrated. If it fails recalibration, the above process

will apply. A contingency plan will be developed and implemented for major equipment failure. The plan includes guidelines on waiting for repairs, use of other instrumentation, subcontracting analyses, and evaluating scheduled priorities.

12.1.6 Calibration Records

Records are prepared and maintained for each piece of equipment subject to calibration. Records demonstrating accuracy of preparation, stability, and proof of continuity of reference standards are also maintained. Records for periodically calibrated equipment will include, as appropriate:

- Unique identification number of equipment and type of equipment
- Calibration frequency and acceptable tolerances
- Identification of calibration procedure used
- Date calibration was performed
- Identity of laboratory personnel and/or external agencies performing calibration
- Reference standards used for calibration
- Calibration data
- Certificates or statements of calibration provided by manufacturers and external agencies and traceability to national standards
- Information regarding calibration acceptance or failure and any repair of failed equipment.

Records for periodically calibrated equipment are maintained in the instrument logbooks, or in the equipment file maintained by the QA Officer. Physical reference standards are kept in a separate folder.

For instruments and equipment that are calibrated on an operational basis, calibration generally consists of determining instrumental response against compounds of known composition and concentration or the preparation of a standard response curve of the same compound at different concentrations. Records of these calibrations are maintained in the instrument logbook, which provide an ongoing record of the calibration undertaken for a specific instrument. Logbook entries will be signed and dated by the chemist. Copies are placed in data packages as required, and reviewed by the technical reviewer. Logbook entries are reviewed during internal audits by the Quality Services staff.

In addition to the instrument logbook, copies of the raw calibration data are kept with the analytical sample data. In this way, results can be readily processed and verified because the raw data package is complete as a unit. If samples from several projects are processed together, the calibration data are copied and included with each group of data.

12.1.7 Operational Calibration

Operational calibration is generally performed as part of the analytical procedure and refers to those operations in which instrument response (in its broadest interpretation) is related to analyte concentration. Included are the preparation of a standard response (calibration) curve and often the analysis of blanks.

Preparation of a standard calibration curve is accomplished by using calibration standards. The process is summarized as:

- Preparation of a standard calibration curve is accomplished by the analysis of calibration standards that are prepared by adding the analyte(s) of interest to the solvent that is introduced into the instrument.
- The concentrations of the calibration standards are chosen to cover the working range of the instrument or method.
- All sample measurements are made within this working range.
- The calibration curve is prepared by plotting or regressing the instrument responses versus the analyte concentrations, or by calculating a calibration/response factor for chromatographic methods.
- The concentrations of the analyzed samples are calculated from system response using the calibration curve.

13. QUALITY CONTROL REQUIREMENTS

Field duplicates of each sample type (i.e., ground water and soil) will be collected at the rate of 1 per every 10 samples. The field duplicate samples will be analyzed for the same parameters as the duplicated samples.

One rinsate blank will be collected from a decontaminated split-barrel soil sampler and analyzed for the same parameters as the soil samples. This sample will be collected and analyzed to evaluate the effectiveness of the decontamination procedure on samples sent for laboratory analysis.

One temperature blank will be included per shipping cooler containing ground-water and/or soil samples.

One trip blank will be included with each cooler containing ground-water or soil samples submitted for VOC analysis.

Fixed laboratory analytical QC is provided in Table 13-1. Fixed laboratory method and SOP precision and accuracy are provided in Tables 12-1A and 12-1B.

13.1 METHOD (REAGENT) BLANK

Method (reagent) blanks are used to monitor laboratory contamination. This is usually a sample of laboratory reagent water or soil matrix treated with all the reagents and in the same manner as the sample (i.e., digested, extracted, and distilled). One method blank will be prepared and analyzed every day that samples are prepared.

13.2 FORTIFIED METHOD BLANK SPIKE (LABORATORY CONTROL SAMPLE)

Fortified method blank samples are analyzed with each batch of 20 or fewer samples. These samples generally consist of laboratory reagent-grade water or solid matrix fortified with the analytes of interest for single-analyte methods and selected analytes for multi-analyte methods according to the appropriate analytical method. They are prepared and analyzed with the associated sample batch. The analyte recovery from each is used to monitor analytical accuracy.

13.3 FORTIFIED SAMPLE (MATRIX SPIKE)

A fortified sample (matrix spike) is an aliquot of a field sample that is fortified with the analyte(s) of interest and analyzed to monitor matrix effects associated with a particular batch of samples. Matrix spike and matrix spike duplicate samples will be performed for every batch of 20 or fewer samples for organic analyses.

13.4 SURROGATES

Surrogates are organic compounds that are similar to analytes of interest in chemical composition, extraction, and chromatography, but are not normally found in environmental samples. These compounds are spiked into all blank, standards, samples, and spiked samples prior to analysis for organic parameters. Generally, surrogates are not used for inorganic analyses. Percent recoveries are calculated for each surrogate. Surrogates will be spiked into samples according to the appropriate analytical method (Section 12). Surrogate spike recoveries will fall within the control limits set in accordance with procedures specified in the method. Surrogate recoveries will not be calculated if sample dilution causes the surrogate concentration to fall below the quantitation limit.

14. DATA ACQUISITION REQUIREMENTS

During this HRC® injection pilot study, environmental samples will be submitted to Ceimic Corporation as outlined in Table 9-1. Ground-water sample data accumulated during the HRC® injection pilot study will be added to the site database for comparison of before and after HRC® injection pilot test. Soil data will be added to the database for additional characterization of the nature and extent of CVOC in deep soil in the specific area of the HRC® pilot test.

15. DOCUMENTATION, RECORDS, AND DATA MANAGEMENT

15.1 PROJECT DOCUMENTATION AND RECORDS

The following Project Documentation will be retained and maintained by the Navy and/or its designee until the end of the project or the end of the contract with the Navy, which ever comes first, at which time the field records will be transferred to the Navy:

- Field notebooks
- Sample chain-of-custody forms
- Waste manifest records
- Analytical laboratory reports
- Originals of submitted reports (including field sampling forms)
- Data validation reports
- Corrective action reports.

15.2 FIELD DATA REPORTING

Field records are evaluated by the TO Project Manager, or designee, for the following:

- Completeness
- Identification of valid samples
- Identification of anomalous field test data
- Accuracy and precision of field data and measurement.

The review of field record completeness checks that requirements for field activities in the work plan have been fulfilled, that complete records exist for each field activity, and that the procedures specified in the Work Plan have been implemented. Field documentation must ensure sample integrity and provide sufficient information to characterize each field event. The results of the completeness check are documented by the Site Manager, and any data affected by incomplete records are identified at this time.

The identification of valid samples involves interpreting and evaluating the field records to detect problems affecting representativeness of field samples. Field audits are another source of data for review. The TO Project Manager will perform periodic site visits during the field activities to check that the work is being performed in accordance with the QAPP and to resolve observed deviations. The judgements for data validity will be documented in the technical report, and field data associated with incorrect fieldwork will be identified. Anomalous field data will be identified and explained to the extent possible in the technical report.

15.3 LABORATORY REPORTING

The analytical data report will include the following items: all sample identification numbers, date(s) collected, date(s) analyzed, analytical results, detection limits, units, methods identification, project name/location, laboratory identification (name/address/phone number), laboratory QC sample results, initial calibration curves, calibration results, continuing calibration checks, and approval signature(s). The report is prepared and reviewed by someone other than the preparer for compliance with report deliverables requirements.

Throughout the HRC® Injection Pilot Study, when the resulting data are obtained, a reviewer designated by Ceimic's Project Manager will examine the final laboratory data for consistency with previous data. Compliance with QAPP requirements is also reviewed. Final assessment is the responsibility of Ceimic's QA Officer or designated quality reviewers. The report is then reviewed by the Laboratory Project Coordinator, who signs the report narrative to certify that the report meets the Data Quality Objectives for precision, accuracy, and completeness specified for this project. After completion of the review of the data report, the report is forwarded to the TO Project Manager who incorporates the results into the project report. The laboratory copy of the report is filed in the appropriate laboratory Central Project File.

15.4 DATA MANAGEMENT

Ground-water level elevation data; soil sampling locations; and fixed laboratory results of low-flow collected ground water will be added to the Geographic Information System (GIS) database.

15.4.1 Geographic Information System Preparation

Software – ARCVIEW Version 3.x.

Base Maps – The basis of the ARCVIEW project will be existing base maps which may include U.S. Geological Survey Digital Raster Graphs, Computer-Aided Design and Drafting (CADD) Base maps, Digital Orthophoto Quadrangles, and/or scanned and geo-rectified aerial photographs. All CADD files should be produced as to be compatible with a GIS (i.e., closed polygons for polygonal features [e.g., buildings], polylines instead of lines, blocks with attributes, elevations assigned to features when appropriate, and a distinct and clear layering system).

GIS Data Integration – Upon completion of the database, sample location themes are produced within the ARCVIEW Project. A separate SAMPLE LOCATION theme per media shall be provided (i.e.; ground water, soil). From these themes, layouts are created that can be printed to support reports as necessary.

Figure Preparation – The GIS will be used as applicable to generate site location maps, sample location maps, contaminant ISO-contour maps, potentiometric surface maps, bedrock contour maps and contaminant tag maps. Any figures or drawings prepared in CADD software packages or EQUIS, will be included in the ARCVIEW project deliverable as a theme with attribute tables

or layout as appropriate. All site plan view figures generated in a CADD software will utilize the specified coordinate system and will not be rotated (i.e., north is north).

15.4.2 Electronic Data Deliverables

The Navy or its designee will perform the tabulation, organization, and reduction of the results of the laboratory analyses. The EQUIS or NEDDS data structures will be utilized. The HRC® Injection Pilot Study analytical data will be incorporated into the existing NCBC Davisville database.

Database Format and Structure – The Navy or its designee evaluates the electronic data deliverables (EDDs) generated by the laboratories for completion and accuracy. If errors are found, the laboratory is notified by EA and the laboratory will resubmit the corrected EDD. If no errors are found, the laboratory EDD is migrated into an EQuIS database import format (Attachment 4) or a NEDDS database import format currently under development.

Data Validation – Data validation in accordance with the EPA Region I Laboratory data Validation, Functional Guidelines for Evaluation Organic and Inorganic Analysis (July 1996, Revised December 1996) is not anticipated for data obtained during from the pilot test.

Survey Data – The files will contain a minimum of location, northing, easting, ground surface elevation, and elevation of top of casing; North American Datum 1983 and the North American Vertical Datum 1988 and North American Datum 27 and NGVD 29 are to be provided as necessary.

Deliverable – Electronic data to be delivered to the Navy on CD-ROM(s).

15.5 REPORTS

The contents of the HRC® Injection Pilot Test and the schedule for submittals are presented in Section 6.3.

16. ASSESSMENTS AND RESPONSE ACTIONS

The TO Project Manager (or his designee) will have the authority to stop work upon finding a significant condition that would adversely affect the quality and usability of the data. The TO Project Manager will have the responsibility, through the TO Task Manager, for initiating and implementing response actions associated with findings identified during these onsite audits. Once the response actions have been implemented, the auditor will perform a follow-up audit to verify and document that the response actions were implemented effectively.

RIDEM or EPA RPMs (or their designee) may, at their discretion, conduct an audit of the field activities for this project. Upon finding a significant condition that would adversely affect the quality and usability of the data, these RPMs (or their designee) will immediately contact the Navy RPM.

Table 16-1 summarizes other types of assessments to be performed during performance of the HRC® Injection Pilot Test to ensure quality of the data for assessment of the site investigation, including daily internal assessments of field operations, weekly internal assessments during laboratory analysis of the samples collected, and an external assessment of the data validation procedures at the completion of that work to confirm that the work has been completed in accordance with this QAPP. The daily internal assessments of field operations will be performed by the TO Task Manager (or designee) including: review of the daily sample collection forms for completeness of the data required, field measurement equipment checking (and calibration, as necessary) has been completed, and proper temporary storage of collected samples pending transfer to the laboratory. Discrepancies will be resolved before the beginning of the next day's work, except for those related to sample storage that will be corrected immediately. The weekly internal assessments during laboratory analysis of the samples collected will be performed by the TO Task Manager (or designee) through telephone communication regarding the status of schedule to deliver the results to the Navy or its designee, sampling holding times, sample container breakage, temperature blanks, or other potential problems that could compromise the integrity of a sample aliquot(s) such that it would not be usable for the project. Problems identified that would compromise the integrity of a sample aliquot(s) will be reported to the TO Project Manager who with consultation of the Navy RPM decide if resampling is necessary and to what extent.

The TO Project Manager will have the responsibility for initiating and implementing response actions associated with findings identified during onsite audits. Once the response actions have been implemented, the auditor will perform a follow-up audit to verify and document that the response actions were implemented effectively. See Table 16-1 for project assessment.

17. QUALITY ASSURANCE MANAGEMENT REPORTS

Monthly project status reports are prepared by the TO Project Manager and submitted to the Navy by the 20th of the following month. The QA Management Reports Table is provided as Table 17-1.

18. VERIFICATION AND VALIDATION REQUIREMENTS

Data validation in accordance with the EPA Region 1 Laboratory Data Validation, Functional Guidelines for Evaluating Organic and Inorganic Analyses (July 1996, Revised December 1996) is not anticipated for data obtained from the pilot test.

An evaluation will be performed by the Navy or its designee, to include:

- Check to insure that holding times are met
- Confirm that the planned analytical methods have been used
- Check for potential cross contamination or the introduction of contamination to samples by assessing the results of the trip blanks, rinsate blanks, and laboratory method blanks
- Comparison of duplicate sample results with the related original sample results to see that they are within 30 percent for aqueous sample and 50 percent for soil samples

The TO Project Manager and the Navy Remedial Project Manager will be responsible for overall verification and final approval of the data in accordance with project purpose and use of the data.

19. VERIFICATION AND VALIDATION PROCEDURES

The analytical data from Ceimic Laboratory will be verified in accordance with the procedures outlined in Chapter 18. The TO Project Manager (or his/her designee) will also compare the sample descriptions with the field sheets for consistency and will ensure that related anomalies in the data are appropriately documented.

20. DATA USABILITY/RECONCILIATION WITH PROJECT QUALITY GOALS

Once the data results are compiled, the TO Project Manager or designee will review the field and laboratory QA/QC sample duplicates to determine if they fall within the acceptance limits as defined in this QAPP. Completeness will also be evaluated to determine if the completeness goal for this project has been met. If data quality indicators do not meet the project's requirements as outlined in this QAPP (including the accuracy for laboratory spikes), the data may be discarded and re-sampling may occur. The TO Project Manager will evaluate the cause of the failure and evaluate with the Navy RPM and make the decision to discard the data and re-sample. If the failure is tied to the analysis, calibration and maintenance techniques will be reassessed as identified by the appropriate laboratory personnel. If the failure is associated with the sample collection and re-sampling is needed, the samplers will be retrained.

The project quality goals are considered to have been met if the data quality indicators meet the project requirements as outlined in Sections 2.1 and 7 of the QAPP (e.g., if the project quality goals are met, then the sampling event has been successful).

20.1 PRECISION

Precision measures the reproducibility of measurements. It is strictly defined as the degree of mutual agreement among independent measurements as the result of repeated application of the same process under similar conditions. *Analytical* precision is the measurement of the variability associated with duplicate (two) or replicate (more than two) analyses. The Laboratory Control Sample is used to determine the precision of the analytical method. If the recoveries of analytes in the Laboratory Control Samples are within established control limits, then precision is within limits. In this case, the comparison is not between a sample and a duplicate sample analyzed in the same batch, rather the comparison is between the sample and samples analyzed in previous batches. *Total* precision is the measurement of the variability associated with the entire sampling and analysis process. It is determined by analysis of duplicate or replicate field samples and measures variability introduced by both the laboratory and field operations. Field duplicate samples and matrix duplicate spiked samples will be analyzed to assess field and analytical precision, and the precision measurement is determined using the relative percent difference between the duplicate sample results.

Precision is to be expressed as relative percent difference and calculated using the equations in Table 20-1.

20.2 ACCURACY

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systemic error and, therefore, reflects the total error associated with a measurement. A measurement is accurate when the value reported does not differ from the true value or known concentration of the spike or standard. Analytical accuracy is measured by comparing the percent recovery of analytes spiked into a Laboratory Control

Sample to a control limit. Matrix spikes will be used to assess analytical accuracy. For VOC, surrogate compound recoveries are also used to assess accuracy and method performance for each sample analyzed.

Both accuracy and precision are calculated for each analytical batch, and the associated sample results are interpreted by considering these specific measurements. Accuracy is to be expressed as percent recovery and calculated using the equation in Table 20-1.

20.3 REPRESENTATIVENESS

Objectives for representativeness are defined for each sampling and analysis task and are a function of the investigative objectives. Representativeness will be achieved through use of the standard field, sampling, and analytical procedures. Representativeness is also determined by appropriate program design, with consideration of elements such as proper well locations and sampling locations.

Chapters 9 and 10 of this QAPP contain the sampling and field handling protocols (e.g., storage, handling, and shipping) designed to ensure that the collected samples are representative of the media. Proper field documentation is to be used to show that the designated protocols have been followed and that sample identification and integrity have been maintained during the sampling event.

20.4 COMPARABILITY

Comparability is the confidence with which one data set can be compared to another data set. The objective for this QA/QC program is to produce data with the greatest possible degree of comparability. The number of matrices that are sampled and the range of field conditions encountered are considered in determining comparability. Comparability is achieved by using standard methods for sampling and analysis, reporting data in standard units, normalizing results to standard conditions and using standard and comprehensive reporting formats. Complete field documentation using standardized data collection forms will support the assessment of comparability. Historical comparability will be achieved through consistent use of methods and documentation procedures throughout the project.

With regard to field and laboratory analyses and measurements, similar methods with similar reporting limits will be used to the extent possible to ensure comparability of data collected during the planned fieldwork and the future work at the site.

20.5 COMPLETENESS

Completeness is calculated using the equation in Table 20-1 for the aggregation of data for each analyte measured for any particular sampling event or other defined set of samples. Completeness is calculated and reported for each method, matrix and analyte combination.

The number of valid results divided by the number of possible individual analyte results, expressed as a percentage, determines the completeness of the data set. For completeness requirements, valid results are all results not qualified as unusable. The goal for completeness is at least 90 percent for the soil and ground-water samples to be collected from the soil boring and monitoring wells, respectively. For any instances of samples that could not be analyzed for any reason (holding time violations in which resampling and analysis were not possible, samples spilled or broken, etc.), the numerator of this calculation becomes the number of valid results minus the number of possible results not reported.

REFERENCES

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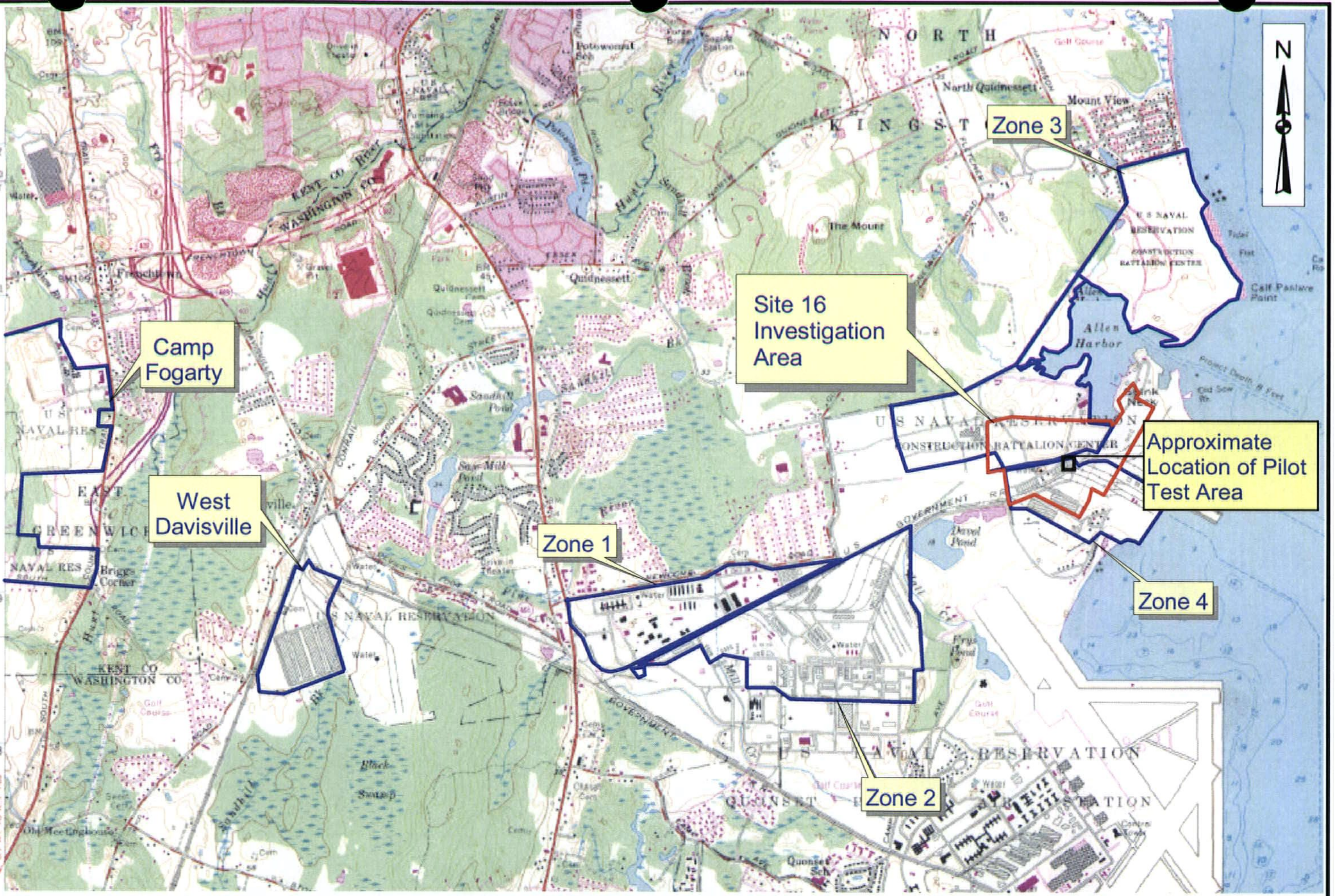
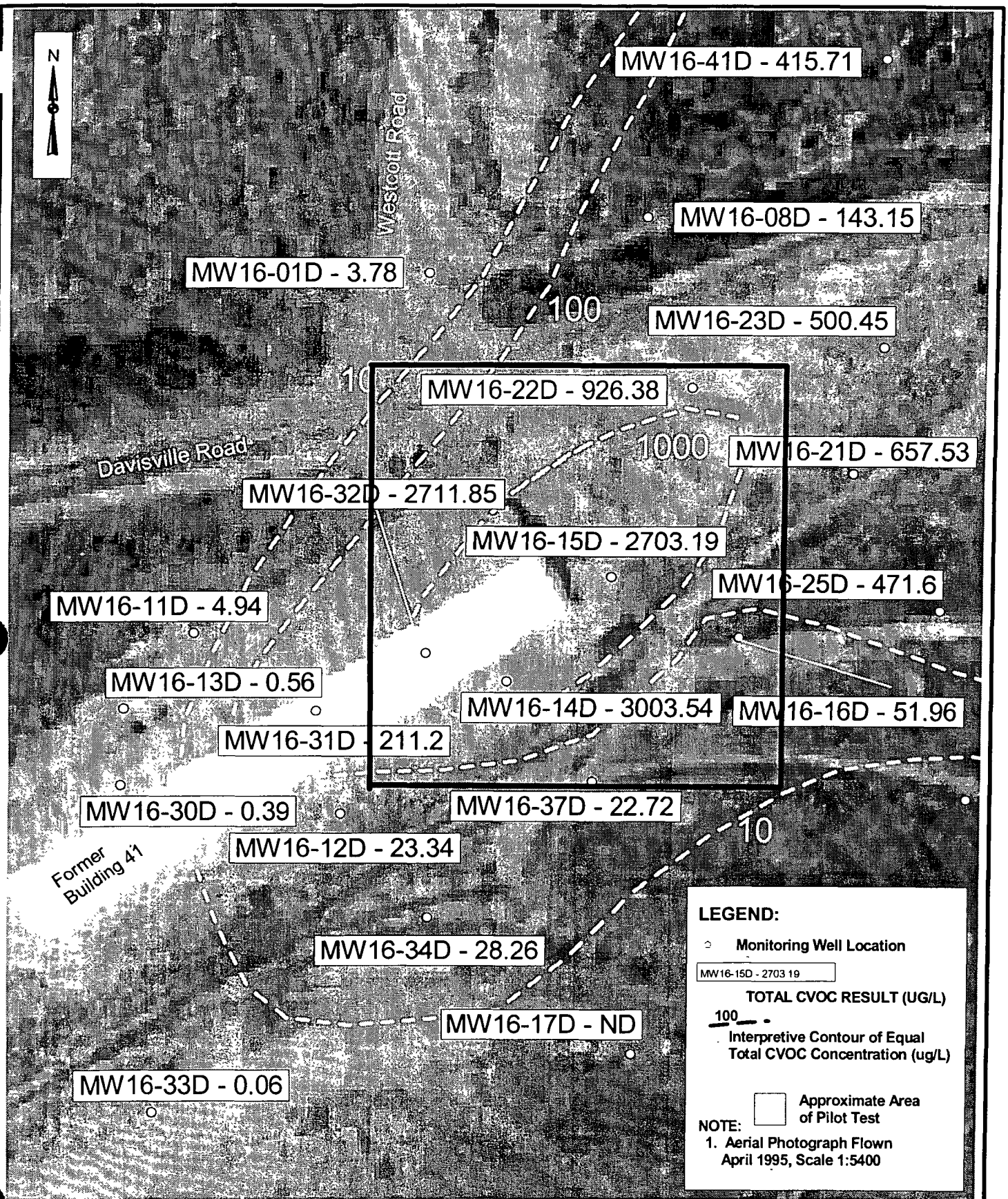
HRP Associates, Inc. 1995b. *Tank 41-6 Under Ground Storage Tank Closure Assessment Report, Removal of Storage Tanks at the Naval Construction Battalion Center, Davisville, Rhode Island.* April.

HRP Associates, Inc. 1995c. *41-1 Tank System Under Ground Storage Tank Closure Assessment Report, Removal of Storage Tanks at the Naval Construction Battalion Center, Davisville, Rhode Island.* June.



EA ENGINEERING, SCIENCE AND TECHNOLOGY, INC.	EFANE SITE 16 HRC INJECTION PILOT TEST FORMER NCBC DAVISVILLE FACILITY, NORTH KINGSTOWN, RHODE ISLAND	SITE LOCUS MAP FIGURE 1



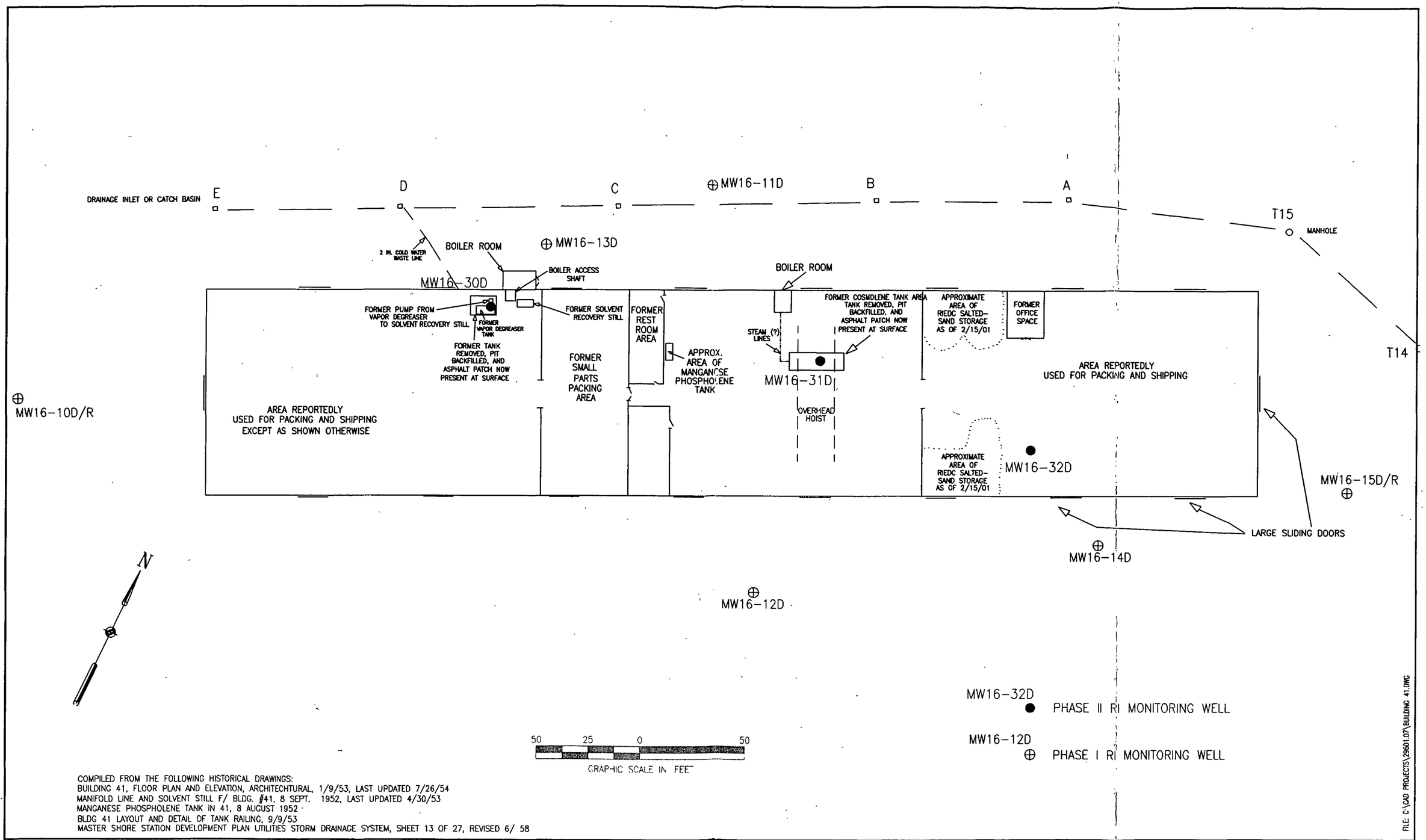
EA ENGINEERING, SCIENCE, AND TECHNOLOGY

40 0 40 80 Feet

EFANE
HRC INJECTION PILOT STUDY
SITE 16 NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

HRC PILOT TEST VICINITY
DEEP ZONE TOTAL CVOC (UG/L)
DETECTED IN NOVEMBER / DECEMBER 2002

FIGURE 2



COMPILED FROM THE FOLLOWING HISTORICAL DRAWINGS:
BUILDING 41, FLOOR PLAN AND ELEVATION, ARCHITECHTURAL, 1/9/53, LAST UPDATED 7/26/54
MANIFOLD LINE AND SOLVENT STILL F/ BLDG. #41, 8 SEPT. 1952, LAST UPDATED 4/30/53
MANGANESE PHOSPHOLENE TANK IN 41, 8 AUGUST 1952
BLDG 41 LAYOUT AND DETAIL OF TANK RAILING, 9/9/53
MASTER SHORE STATION DEVELOPMENT PLAN UTILITIES STORM DRAINAGE SYSTEM, SHEET 13 OF 27, REVISED 6/ 58

FILE: C:\CAD PROJECTS\29601.07\BUILDING 41.DWG

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

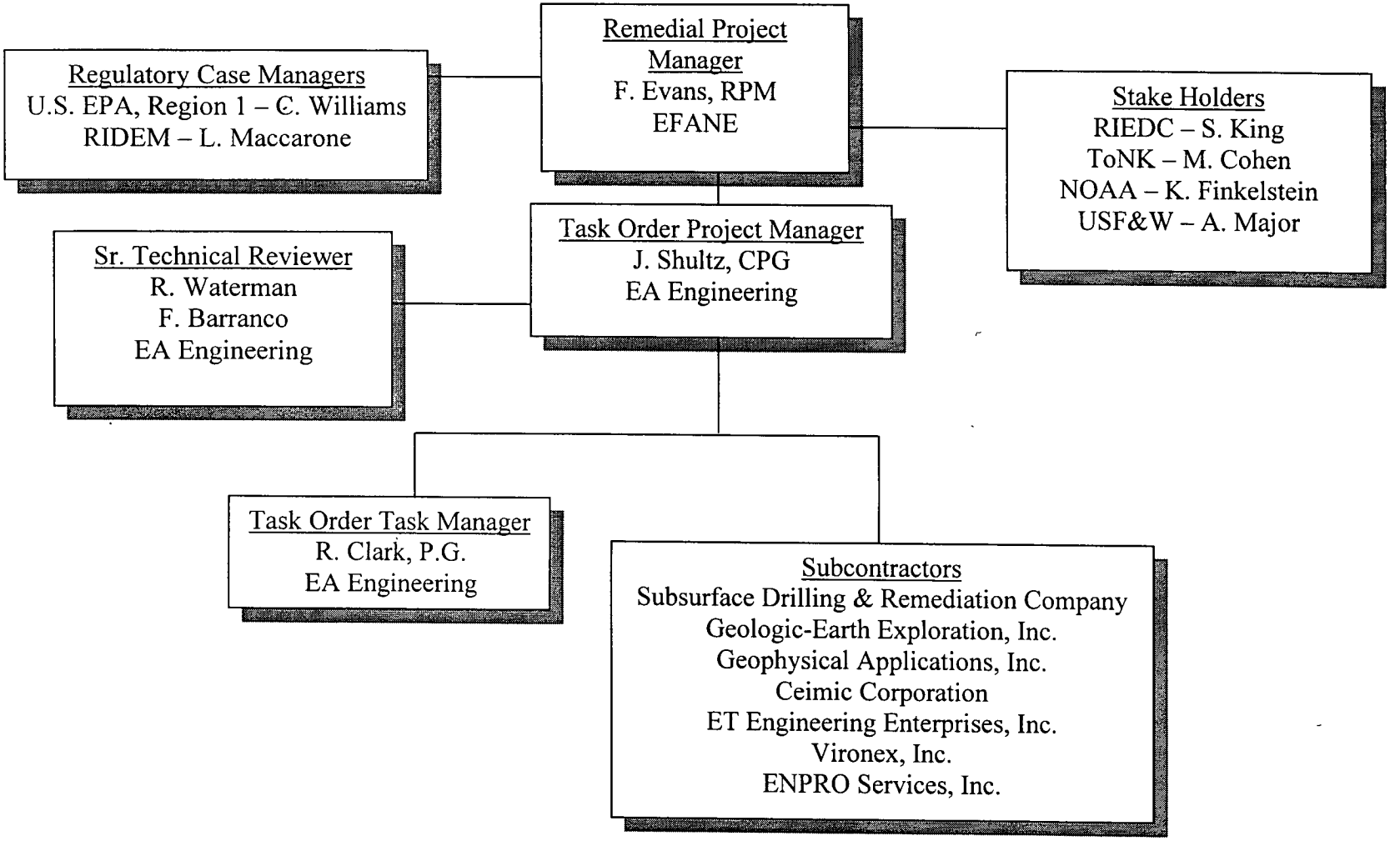
DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
JS	RC	8/26/03	29600.97	BLDG 41
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
JS	JS	AS SHOWN	–	3

EFANE
SITE 16 HRC INJECTION PILOT TEST
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

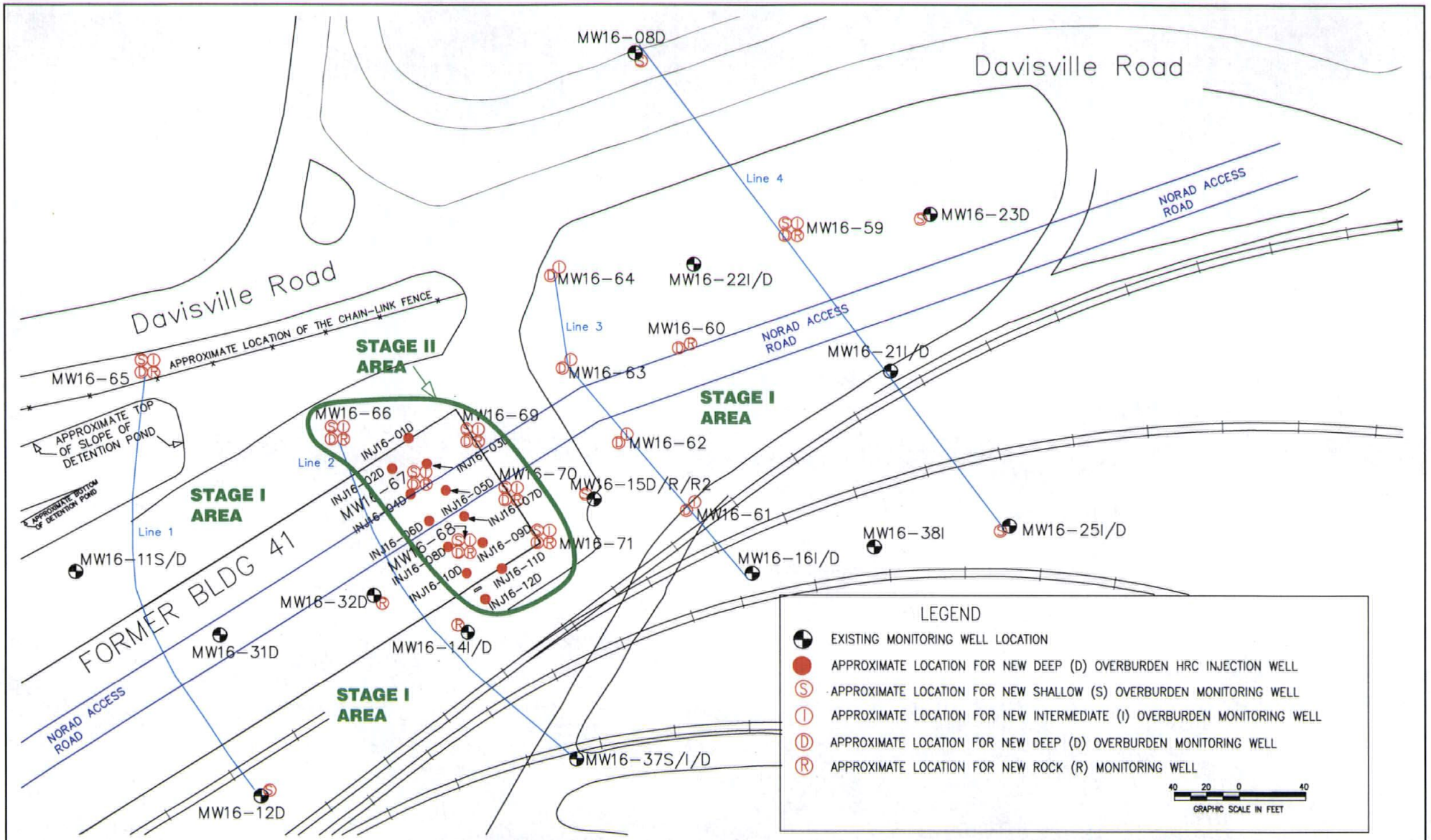
FORMER BUILDING 41 FLOOR PLAN

FIGURE 3

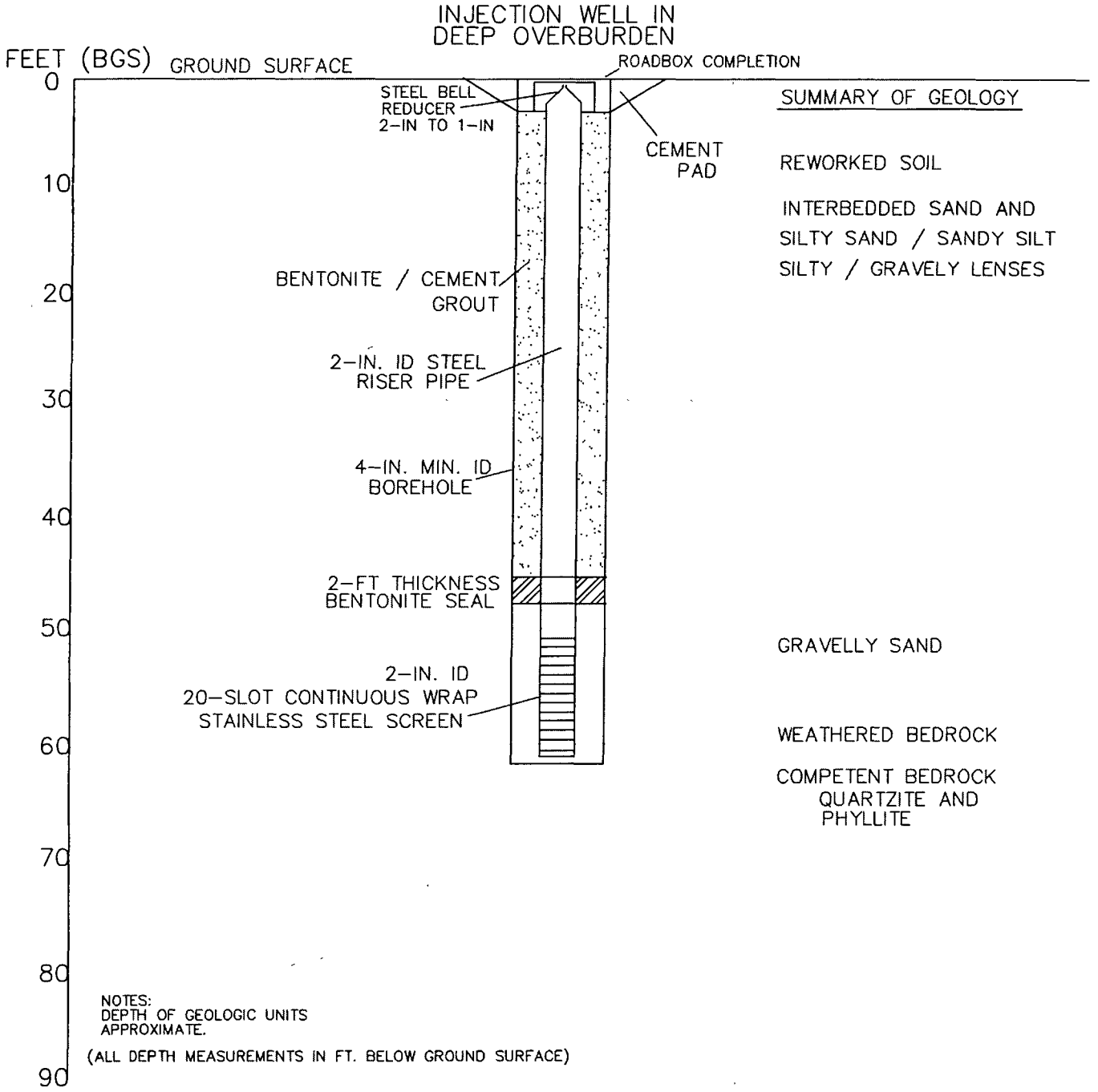
FIGURE 4 PROJECT ORGANIZATION CHART



Site 16, HRC® Injection Pilot Test
NCBC Davisville, Rhode Island



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EFANE SITE 16 HRC INJECTION PILOT TEST FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	HRC INJECTION PILOT STUDY WELL FIELD MAP	DESIGNED BY JAS	DRAWN BY RWC	DATE 7/8/04	PROJECT NO. 2960107	FILE NAME FIG 5
			CHECKED BY RWC	PROJECT MGR. JAS	SCALE AS SHOWN	DRAWING NO. –	FIGURE Figure 5



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EFANE SITE 16 HRC INJECTION PILOT TEST FORMER NCBC DAVISVILLE NORTH KINGSTOWN, RHODE ISLAND	HRC INJECTION WELL SPECIFICATIONS FIGURE 6

TABLE 2-1A PRE-DRILLING WATER LEVEL MEASUREMENT TABLE FOR HRC INJECTION PILOT STUDY

Well Number	Date	Depth to Water (ft bgs)	Time
MW16-01D	4/7/2004	21.57	1317
MW16-01S	4/9/2004	21.66	0953
MW16-02D	4/7/2004	12.41	1337
MW16-02I	4/7/2004	12.68	1340
MW16-02R	4/7/2004	12.63	1339
MW16-02R2	4/7/2004	11.11	1341
MW16-02S	4/9/2004	11.66	0900
MW16-08D	4/7/2004	16.94	1322
MW16-09D	4/7/2004	17.25	1022
MW16-10D	4/7/2004	14.86	1025
MW16-10R	4/7/2004	15.22	1037
MW16-11D	4/7/2004	12.98	0935
MW16-11S	4/9/2004	13.39	0838
MW16-12D	4/7/2004	16.08	1031
MW16-13D	4/7/2004	13.10	1016
MW16-13I	4/7/2004	13.23	1017
MW16-14D	4/7/2004	14.85	0935
MW16-14I	4/7/2004	14.27	0936
MW16-15D	4/7/2004	14.51	1101
MW16-15R	4/7/2004	14.31	1100
MW16-15R2	4/7/2004	15.46	1102
MW16-16D	4/7/2004	11.48	1300
MW16-16I	4/7/2004	11.53	1259
MW16-21D	4/7/2004	9.32	0920
MW16-21I	4/7/2004	8.83	0916
MW16-22D	4/7/2004	16.20	0928
MW16-22I	4/7/2004	16.79	0927
MW16-23D	4/7/2004	12.86	0911
MW16-24D	4/7/2004	9.60	0906
MW16-24I	4/7/2004	9.28	0902
MW16-25D	4/7/2004	11.42	1254
MW16-25I	4/7/2004	10.21	1255
MW16-25R	4/7/2004	10.48	1253
MW16-30D	4/7/2004	13.89	1027
MW16-31D	4/7/2004	14.58	0953
MW16-32D	4/7/2004	15.11	0950
MW16-33D	4/7/2004	11.86	1310
MW16-33I	4/7/2004	11.99	1308
MW16-33S	4/9/2004	11.67	0907
MW16-34D	4/7/2004	13.83	1238
MW16-34I	4/7/2004	13.29	1239
MW16-34S	4/9/2004	13.07	0912
MW16-37D	4/7/2004	12.70	1247

Well Number	Date	Depth to Water (ft bgs)	Time
MW16-37I	4/7/2004	12.23	1245
MW16-37S	4/9/2004	11.98	0924
MW16-38I	4/7/2004	11.26	1257
MW16-40S	4/9/2004	13.58	0856
MW16-41D	4/7/2004	10.09	1332
MW16-41I	4/7/2004	10.64	1333
MW16-41S	4/9/2004	10.03	0858

TABLE 2-1B WATER LEVEL MEASUREMENT TABLE FOR HRC INJECTION PILOT STUDY

Well Number	Date	Depth to Water (ft bgs)	Time	Notes
MW16-01D				
MW16-01S				
MW16-02D				
MW16-02I				
MW16-02R				
MW16-02R2				
MW16-02S				
MW16-08S				
MW16-08D				
MW16-09D				
MW16-10D				
MW16-10R				
MW16-11D				
MW16-11S				
MW16-12S				
MW16-12D				
MW16-13D				
MW16-13I				
MW16-14D				
MW16-14I				
MW16-14R				
MW16-15S				
MW16-15D				
MW16-15R				
MW16-15R2				
MW16-16D				
MW16-16I				
MW16-21D				
MW16-21I				
MW16-22D				
MW16-22I				
MW16-23S				
MW16-23D				
MW16-24D				
MW16-24I				
MW16-25S				
MW16-25D				
MW16-25I				
MW16-25R				
MW16-30D				
MW16-31D				
MW16-32D				

Well Number	Date	Depth to Water (ft bgs)	Time	Notes
MW16-32R				
MW16-33D				
MW16-33I				
MW16-33S				
MW16-34D				
MW16-34I				
MW16-34S				
MW16-37D				
MW16-37I				
MW16-37S				
MW16-38I				
MW16-40S				
MW16-41D				
MW16-41I				
MW16-41S				
MW16-59S				
MW16-59I				
MW16-59D				
MW16-59R				
MW16-60D				
MW16-60R				
MW16-61I				
MW16-61D				
MW16-62I				
MW16-62D				
MW16-63I				
MW16-63D				
MW16-64I				
MW16-64D				
MW16-65S				
MW16-65I				
MW16-65D				
MW16-65R				
MW16-66S				
MW16-66I				
MW16-66D				
MW16-66R				
MW16-67S				
MW16-67I				
MW16-67D				
MW16-67R				
MW16-68S				
MW16-68I				
MW16-68D				
MW16-68R				

Well Number	Date	Depth to Water (ft bgs)	Time	Notes
MW16-69S				
MW16-69I				
MW16-69D				
MW16-69R				
MW16-70S				
MW16-70I				
MW16-70D				
MW16-70R				
MW16-71S				
MW16-71I				
MW16-71D				
MW16-71R				
INJ16-01D				
INJ16-02D				
INJ16-03D				
INJ16-04D				
INJ16-05D				
INJ16-06D				
INJ16-07D				
INJ16-08D				
INJ16-09D				
INJ16-10D				
INJ16-11D				
INJ16-12D				

TABLE 4-1 COMMUNICATION PATHWAYS

Issues Area	Decision Level 1	Decision Level 2	Decision Level 3	Decision Level 4
HRC Injection Pilot Test Sampling/ Field Activities	TO Task Manager R. Clark	TO Project Manager J. Shultz	Navy RPM F.Evans	Federal and State Regulators C. Williams L. Maccarone
Analytical Laboratory Issues and Coordination	TO Task Manager R. Clark	TO Project Manager J. Shultz	Navy RPM F.Evans	Federal and State Regulators C. Williams L. Maccarone
Report Preparation:	TO Task Manager R. Clark	TO Project Manager J. Shultz	Navy RPM F.Evans	Federal and State Regulators C. Williams L. Maccarone
Data Management/GIS Issues	TO Task Manager R. Clark	TO Project Manager J. Shultz	Navy RPM F.Evans	Federal and State Regulators C. Williams L. Maccarone
Chemistry Issues	TO Task Manager R. Clark	TO Project Manager J. Shultz	Navy RPM F.Evans	Federal and State Regulators C. Williams L. Maccarone

NOTE: TO = Task Order.
RPM = Remedial Project Manager.

TABLE 4-2 PROJECT PERSONNEL SIGN-OFF SHEET

Organization:

Project Personnel	Title, Company Name	Telephone Number	Signature[a]	Date Read

(a) Signature indicates agreement to follow Quality Assurance Project Plan as written.

TABLE 6-1 PROJECT SCHEDULE TIMELINE TABLE

Activities	Deliverable	Deliverable Due Date
Prepare Draft HRC® Injection Pilot Study Quality Assurance Project Plan (QAPP)	Draft HRC® Injection Pilot Study QAPP to BCT	18 September 2003
Prepare Final HRC® Injection Pilot Study QAPP	Final HRC® Injection Pilot Study QAPP	19 July 2004
Field Work – Well Drilling and HRC® Injection Drilling, logging, testing, pre-injection GW sampling (begin 19 July and 6 November 2004) HRC® injection (10-16 November 2004)	E-mail of fieldwork progress to BCT	Weekly emails 19 July through 16 November 2004 during periods of active fieldwork
Field Work – GW Monitoring Event (ME)		
ME 01 (begin 12 December 2004)	ME 01 Data Package	25 March 2005
ME 02 (begin 16 January 2005)	ME 02 Data Package	24 April 2005
ME 03 (begin 15 February 2005)	ME 03 Data Package	24 May 2005
ME 04 (begin 17 March 2005)	ME 04 Data Package	23 June 2005
ME 05 (begin 16 April 2005)	ME 05 Data Package	23 July 2005
ME 06 (begin 16 May 2005)	ME 06 Data Package	22 August 2005
ME 07 (begin 17 July 2005)	ME 07 Data Package	21 October 2005
ME 08 (begin 13 September 2005)	ME 08 Data Package	20 December 2005
ME 09 (begin 12 November 2005)	ME 09 Data Package	18 February 2006
ME 10 (begin 10 February 2006)	ME 10 Data Package	19 May 2006
ME 11 (begin 11 May 2006)	ME 11 Data Package	17 August 2006
ME 12 (begin 9 August 2006)	ME 12 Data Package	15 November 2006
ME 13 (begin 7 November 2006)	ME 13 Data Package	13 February 2007
Prepare Draft HRC® Injection Pilot Study Report	Draft HRC® Injection Pilot Study Report to BCT	19 May 2006
Receive Comments from BCT	Written comments from BCT	3 July 2006
Prepare RTC and Final HRC® Injection Pilot Study Report	RTC document and Final HRC® Injection Pilot Study Report to BCT	17 August 2006
Prepare Draft HRC® Injection Pilot Study Report Addendum	Draft HRC® Injection Pilot Study Report Addendum to BCT	14 May 2007
Receive Comments from BCT	Written comments from BCT	28 June 2007
Prepare RTC and Final HRC® Injection Pilot Study Report Addendum	RTC document and Final HRC® Injection Pilot Study Report Addendum to BCT	12 August 2007

TABLE 7-1 SUMMARY OF TARGET COMPOUNDS AND ANALYTES TABLE (REFERENCE LIMIT AND EVALUATION TABLE) HRC INJECTION PILOT STUDY – GROUND WATER

Analyte	CAS Number	Project Action Limit	Project Required Detection Limit	Project Quantitation Limits	Analytical Method		Achievable Laboratory Limits	
					IDL	Method QLs	MDLs	QLs
VOLATILE ORGANIC COMPOUNDS (SW846-5030B/8260B) (µg/L)								
Chloromethane	74-87-3		1.0	1.0	N/A	N/A	0.15	1.0
Vinyl Chloride	75-01-4	2	1.0	1.0	N/A	N/A	0.21	1.0
Bromomethane	74-83-9		1.0	1.0	N/A	N/A	0.15	1.0
Chloroethane	75-00-3		1.0	1.0	N/A	N/A	0.17	1.0
Acetone	67-64-1		5.0	5.0	N/A	N/A	1.73	5.0
1,1-Dichloroethene	540-59-0	7	1.0	1.0	N/A	N/A	0.10	1.0
Methylene Chloride	75-09-2	5	1.0	1.0	N/A	N/A	0.48	1.0
Carbon Disulfide	75-15-0		1.0	1.0	N/A	N/A	0.15	1.0
1,1-Dichloroethane	75-34-3		1.0	1.0	N/A	N/A	0.19	1.0
2-Butanone	78-93-3		5.0	5.0	N/A	N/A	1.33	5.0
Chloroform	67-66-3		1.0	1.0	N/A	N/A	0.19	1.0
1,1,1-Trichloroethane	71-55-6	200	1.0	1.0	N/A	N/A	0.19	1.0
Carbon Tetrachloride	56-23-5	5	1.0	1.0	N/A	N/A	0.21	1.0
1,2-Dichloroethane	107-06-02	5	1.0	1.0	N/A	N/A	0.20	1.0
Benzene	71-43-2	5	1.0	1.0	N/A	N/A	0.19	1.0
Trichloroethene	79-01-6	5	1.0	1.0	N/A	N/A	0.23	1.0
1,2-Dichloropropane	78-87-5	5	1.0	1.0	N/A	N/A	0.29	1.0
Bromodichloromethane	75-27-4		1.0	1.0	N/A	N/A	0.20	1.0
1,2-Dichloroethene (total)	540-59-0	cis 1,2-DCE = 70 trans 1,2-DCE = 100	1.0	1.0	N/A	N/A	0.45	1.0
cis-1,3-Dichloropropene	10061-01-5		1.0	1.0	N/A	N/A	0.20	1.0
Toluene	108-88-3	1,000	1.0	1.0	N/A	N/A	0.20	1.0

(a) Project Action Limits are Rhode Island Department of Environmental Management GA Ground-Water Objectives.

NOTE: IDL = Instrument detection limit.
QL = Quantitation Limit
MDL = Method detection limit.
N/A = Not Applicable

Analyte	CAS Number	Project Action Limit	Project Required Detection Limit	Project Quantitation Limits	Analytical Method		Achievable Laboratory Limits	
					IDL	Method QLs	MDLs	QLs
VOLATILE ORGANIC COMPOUNDS cont. (SW846-5030B/8260B) (µg/L)								
trans-1,3-Dichloropropene	10061-02-6		1.0	1.0	N/A	N/A	0.24	1.0
4-Methyl-2-Pentanone	108-10-1		5.0	5.0	N/A	N/A	0.16	5.0
2-Hexanone	591-78-6		5.0	5.0	N/A	N/A	1.08	5.0
Dibromochloromethane	124-48-1		1.0	1.0	N/A	N/A	0.13	1.0
Chlorobenzene	108-90-7	100	1.0	1.0	N/A	N/A	0.15	1.0
Ethylbenzene	100-41-4	700	1.0	1.0	N/A	N/A	0.19	1.0
Xylenes (total)	1330-20-7	10,000	1.0	1.0	N/A	N/A	0.34	1.0
Bromoform	75-25-2		1.0	1.0	N/A	N/A	0.20	1.0
Styrene	100-42-5	100	1.0	1.0	N/A	N/A	0.14	1.0
1,1,2,2-Tetrachloroethane	79-34-5		1.0	1.0	N/A	N/A	0.21	1.0
NATURAL ATTENUATION PARAMETERS (mg/L)								
Alkalinity (310.1)					NA	Not provided in method	0.299	1
Sulfate by IC (300.0)	14808-79-8				NA	Not provided in method	0.0236	0.1
Total Chloride by IC (300.0)					NA	Not provided in method	0.0129	0.1
Nitrate by IC (300.0)	14797-55-8	10[a]	3.3		NA	Not provided in method	0.0293	0.1
Nitrite by IC (300.0)		1[a]	0.3		NA	Not provided in method	0.0047	0.1
Iron (dissolved) (6010)	7439-89-6	11	3.7		NA	Not provided in method	0.01003	0.1
Manganese (dissolved) (6010)	7439-96-5	0.88	0.3		NA	Not provided in method	0.00078	0.05
Ammonia NH3 (total) (350.2)	7664-41-7				NA	Not provided in method	0.0907	0.1
Dissolved Organic Carbon (415.2)					NA	Not provided in method	0.2	1
Hydrogen Sulfide (376.2)		0.11	0.04		NA	Not provided in method	0.0162	0.05
Methane (SW-846 Method 3810)	74-82-8				NA	Not provided in method	0.000718	0.01
Ethane/Ethene (SW-846 Method 3810)	74-84-0				NA	Not provided in method	0.000718	0.01

TABLE 7-2 SUMMARY OF TARGET COMPOUNDS AND ANALYTES (REFERENCE LIMIT AND EVALUATION TABLE) HRC INJECTION PILOT STUDY – SOIL

Analyte	CAS Number	Project Action Limit (mg/Kg) (dry weight)	Project Required Detection Limit	Project Quantitation Limit (µg/Kg)	Analytical Methods		Achievable Laboratory Limits	
					IDL	Method OLs	MDL[a] (mg/Kg)	OLs (mg/Kg)
VOLATILE ORGANIC COMPOUNDS (SW846-5030B/5035/8260B)[a]								
1,1,2,2-Tetrachloroethane	79-34-5	0.38	0.13		NA	Not provided in method	0.014	0.125
1,1,2-Trichloroethane	79-00-5	0.84	0.28		NA	Not provided in method	0.014	0.125
1,1-Dichloroethane	75-34-3	59	19.67		NA	Not provided in method	0.019	0.125
1,1-Dichloroethene	75-35-4	0.054	0.02		NA	Not provided in method	0.005	0.010[b]
1,2-Dichloroethane	107-06-2	0.35	0.12		NA	Not provided in method	0.013	0.125
1,2-Dichloropropane	78-87-5	0.35	0.12		NA	Not provided in method	0.016	0.125
2-Butanone	78-93-3	730	243.33		NA	Not provided in method	0.008	0.25
2-Hexanone	591-78-6	730	243.33		NA	Not provided in method	0.015	0.25
4-Methyl-2-Pentanone	108-10-1	79	26.33		NA	Not provided in method	0.017	0.25
Acetone	67-64-1	160	53.33		NA	Not provided in method	0.015	0.25
Benzene	71-43-2	0.67	0.22		NA	Not provided in method	0.019	0.125
Bromodichloromethane	75-27-4	1	0.33		NA	Not provided in method	0.015	0.125
Bromoform	75-25-2	62	20.67		NA	Not provided in method	0.017	0.125
Bromomethane	74-83-9	0.39	0.13		NA	Not provided in method	0.015	0.125
Carbon Disulfide	75-15-0	36	12.00		NA	Not provided in method	0.014	0.125
Carbon Tetrachloride	56-23-5	0.24	0.08		NA	Not provided in method	0.022	0.125
Chlorobenzene	108-90-7	15	5.00		NA	Not provided in method	0.017	0.125
Chloroethane	75-00-3	3	1.00		NA	Not provided in method	0.019	0.125
Chloroform	67-66-3	0.24	0.08		NA	Not provided in method	0.003	0.125
Chloromethane	74-87-3	1.2	0.40		NA	Not provided in method	0.016	0.125

NOTE:
(a) MDLs for 5030/5035/8260B are based on normalized aqueous values converted to medium level concentrations
(b) Based on sample preserved with sodium bi-sulfate. The other VOC parameters to be analyzed from sample aliquot preserved with methanol.
IDL = Instrument Detection Limit.
MDL = Method Detection Limit.
OL = Quantitation limit.
NA = Not applicable.
Project Action Limits for Soil = lowest value from the Region 9 Preliminary Remedial Goals and Benchmark values from the Screening Level Ecological Risk Assessment (EA 2001b).

Analyte	CAS Number	Project Action Limit (mg/Kg) (dry weight)	Project Required Detection Limit	Project Quantitation Limit (µg/Kg)	Analytical Methods		Achievable Laboratory Limits	
					IDL	Method OLs	MDL[a] (mg/Kg)	OLs (mg/Kg)
Cis-1,2-Dichloroethene	156-59-2	4.3	1.43		NA	Not provided in method	0.019	0.125
cis-1,3-Dichloropropene	10061-01-5	0.7	0.23		NA	Not provided in method	0.013	0.125
Dibromochloromethane	124-48-1	1.1	0.37		NA	Not provided in method	0.015	0.125
Ethylbenzene	100-41-4	23	7.67		NA	Not provided in method	0.019	0.125
M&p Xylenes		5	1.67		NA	Not provided in method	0.02	0.25
Methylene Chloride	75-09-2	8.9	2.97		NA	Not provided in method	0.015	0.125
o-Xylenes	95-47-6	5	1.67		NA	Not provided in method	0.016	0.125
Styrene	100-42-5	170	56.67		NA	Not provided in method	0.016	0.125
Tetrachloroethene	127-18-4	5.7	1.90		NA	Not provided in method	0.017	0.125
Toluene	108-88-3	52	17.33		NA	Not provided in method	0.02	0.125
Trans-1,2-Dichloroethene	156-60-5	6.3	2.10		NA	Not provided in method	0.016	0.125
trans-1,3-Dichloropropene	10061-02-6	0.7	0.23		NA	Not provided in method	0.012	0.125
Trichloroethene	79-01-6	2.8	0.93		NA	Not provided in method	0.019	0.125
Vinyl Chloride	75-01-4	0.022	0.01		NA	Not provided in method	0.005	0.010[b]

TABLE 7-3 QUALITY CONTROL CRITERIA FOR PRECISION AND ACCURACY FOR MATRIX SPIKES, MATRIX SPIKE DUPLICATES, SURROGATES, AND LABORATORY CONTROL SAMPLES FOR HRC INJECTION PILOT STUDY, NCBC DAVISVILLE

Quality Control Parameter	Spiking Compounds	Accuracy (%R) Water	Precision (%R) Water
SW846-5030B/8260B Volatile Organic Compounds by Gas Chromatograph/Mass Spectrometry			
Surrogate Spike	Toluene-d8	80-116	≤30
	Dibromofluoromethane	82-109	≤30
	1,2-Dichloroethane-d4	83-108	≤30
	Bromofluorobenzene	75-116	≤30
LCS/MS/MSD	Benzene	79-119	≤30
	Toluene	75-123	≤30
	1,2-Dichloroethylene	62-139	≤30
	Chlorobenzene	81-123	≤30
	1,1-Dichloroethene	69-126	≤30
	Trichloroethene	79-118	≤30
	Chlorobenzene	81-123	≤30

ABLE 7-4 MEASUREMENT PERFORMANCE CRITERIA TABLE, HRC INJECTION PILOT STUDY, NCBC DAVISVILLE

Sampling Procedure	Analytical Method/ Standard Operating Procedure	Data Quality Indicators	Measurement Performance Criteria[a]	Quality Control Sample and/or Activity Used to Assess Measurement Performance	Quality Control Sample Assesses Error for Sampling (S), Analytical (A), or Both (S&A)
LOW LEVELS OF VOLATILE ORGANIC COMPOUNDS IN GROUND WATER					
Attachment 2	8260B	Precision – overall	RPD ≤30% when VOC detects for both field duplicate samples are ≥QL RPD ≤40% when gaseous VOC detects for both field duplicate samples are ≥QL	Field Duplicates	S&A
		Precision – laboratory	RPD ≤20% when VOC detects for both field duplicate samples are ≥QL RPD ≤30% when gaseous VOC detects for both field duplicate samples are ≥QL	MS/MSDs	A
		Accuracy/bias	To be within Laboratory Control Limits	MS/MSDs, Laboratory Control Samples	A
		Accuracy/bias	No false-negatives, no false-positives, quantitation within warning limits (± 2σ)	Single Blind PES	A
		Accuracy/bias – Contamination	No target compounds ≥QL	Equipment Blanks, Trip Blanks, Method Blanks, Instrument Blanks	S&A
		Sensitivity	The quantitation limit will be below the Project Action Limit or meet the quantitation limits in Table 12-1A. In all cases except metals, a low level standard is run at the quantitation limit.	Low level standard	A
		Data completeness	95% Overall, 100% Critical Data	Data Completeness Check	S&A
		Comparability	This is the first round of sampling. Subsequent data will be compared to this data set. A criterion of 35% difference for individual VOCs @ ≥QL and a criterion of 45% difference for individual gaseous VOCs @ ≥QL will be used to compare individual analytes from those data sets.	Comparability Check	S&A

(a) If either one or both analytes are below the quantitation limit, then the acceptance criteria shall be < or = (less than or equal to) 200 % RPD.

NOTE: RPD = Relative percent difference.
VOC = Volatile organic compound.
QL = Quantitation limit.
MS = Matrix spike.
MSD = Matrix spike duplicate.
Quality control sample and/or activity; for all analyses except metals, a passing Initial Calibration Curve and the QL verified by annual Method Detection Limit study. For metals, the QL will be verified by annual Method Detection Limit studies.

LOW LEVELS OF VOLATILE ORGANIC COMPOUNDS IN SOIL					
Attachment 2	8260B	Precision – overall	RPD ≤30% when VOC detects for both field duplicate samples are ≥QL RPD ≤40% when gaseous VOC detects for both field duplicate samples are ≥QL	Field Duplicates	S&A
		Precision – laboratory	RPD ≤20% when VOC detects for both field duplicate samples are ≥QL RPD ≤30% when gaseous VOC detects for both field duplicate samples are ≥QL	MS/MSDs	A
		Accuracy/bias	To be within Laboratory Control Limits	MS/MSDs, Laboratory Control Samples	A
		Accuracy/bias	No false-negatives, no false-positives, quantitation within warning limits (± 2σ)	Single Blind PES	A
		Accuracy/bias – Contamination	No target compounds ≥QL	Equipment Blanks, Trip Blanks, Method Blanks, Instrument Blanks	S&A
		Sensitivity	The quantitation limit will be below the Project Action Limit or meet the quantitation limits in Table 12-1A. In all cases except metals a low level standard is run at the quantitation limit.	Low level standard	A
		Data completeness	90% Overall, 100% Critical Data	Data Completeness Check	S&A
		Comparability	This is the first of 3 rounds of sampling. Subsequent data will be compared to this data set. A criterion of 35% difference for individual VOCs @ ≥QL and a criterion of 45% difference for individual gaseous VOCs @ ≥QL will be used to compare individual analytes from those data sets.	Comparability Check	S&A
		Comparability	Does not apply to soil samples	Comparability Check	S&A

TABLE 8-1 ANALYTICAL PROGRAM FOR HRC® INJECTION PILOT STUDY SITE 16, NCBC DAVISVILLE

Media Sample	Analysis	No Field Samples	Quality Control Samples				Totals
			Duplicate	Rinsate	MS/MSD	Trip Blank	
Ground Water (monitoring wells to be sampled during each monitoring event)	Target Compound List Volatile Organic Compounds (GC/MS detection limit, 1 < µg/L) SW-8260	73	8		4/4	10	99
	Alkalinity (310.1)	73	8				81
	Sulfate by IC (300.0)	73	8				81
	Total chloride by IC (300.0)	73	8				81
	Nitrate by IC (300.0)	73	8				81
	Iron (dissolved) (6010)	73	8				81
	Manganese (dissolved) (6010)	73	8				81
	Hydrogen Sulfide (376.2)	73	8				81
	Methane (SW-846 Method 3810)	73	8				81
	Ethane/Ethene (SW-846 Method 3810 GC/FID)	73	8				81
	Field Measured						
	Ferrous Iron (dissolved) Hach Kit DR/700 Series, or similar; 8146	73					73
	Carbon Dioxide (dissolved) Hach Digital Titrator, or similar; 8205	73					73
Soil (2 from each of the 25 new deep borings/wells collected during drilling)	Target Compound List Volatile Organic Compounds (GC/MS SW-8260)	50	5	5	3/3	20	86
	Total Organic Carbon (9060)	50	5				55

NOTE: MS/MSD = Matrix spike/matrix spike duplicate.
GC/MS = Gas chromatograph/mass spectrometry.
GC/FID = Gas chromatograph/flame ionization detector.

1. Temperature Blank and Trip Blank required in every sample cooler.
2. Turnaround time: 28 days for both hard copy and EDD.
3. QA/QC: Level IV Package should Data Validation be required in the future.
4. EDD in Equis-EZ forrmat

TABLE 9-1 SAMPLING LOCATIONS, SAMPLING AND ANALYSIS METHOD/STANDARD OPERATING PROCEDURE REQUIREMENTS

Sampling Location	Location ID Number	Medium/ Matrix	Depth (Units)	Analytical Parameter	Concentration Level	No. of Samples (identify field duplicates and replicates)	Sampling Standard Operating Procedure	Analytical Method/Standard Operating Procedure	Containers (number, size, and type)	Preservation Requirements	Maximum Holding Time (preparation/ analysis)
Monitoring well	73 monitoring wells near the HRC injection site.	Ground water	Screened interval, bladder pump intake	TCL volatile organic compound (25 ml purge, detection limit <1 µg/L) 8260	Low	73 8 duplicate 4 MS 4 MSD	Attachment 2	On file at Ceimic Corporation	3 @ 40 ml glass volatile organic analyte vial	Cool 4°C , HCL<2	14 days
Monitoring well	73 monitoring wells near the HRC injection site	Ground water	Screened interval, bladder pump intake	Methane/ethane/ ethene	Low	73 8 duplicate	Attachment 2	On file at Ceimic Corporation	3 @ 40 ml glass volatile organic analyte vial	Cool 4°C , HCL<2	14 days
Monitoring well	73 monitoring wells near the HRC injection site	Ground water	Screened interval, bladder pump intake	Manganese, Iron	Low	73 8 duplicate	Attachment 2	On file at Ceimic Corporation	1 @ 1-L poly with HNO_3 (total metals), 1 @ 1-L poly with HNO_3 (dissolved metals)	Cool 4°C , HNO3	6 months
Monitoring well	73 monitoring wells near the HRC injection site	Ground water	Screened interval, bladder pump intake	Nitrate	Low	73 8 duplicate	Attachment 2	On file at Ceimic Corporation	250 ml polyethylene bottle	Cool 4°C,	**48 hours**
Monitoring well	73 monitoring wells near the HRC injection site	Ground water	Screened interval, bladder pump intake	Alkalinity, Chloride, Sulfate	Low	73 8 duplicate	Attachment 2	On file at Ceimic Corporation	250 ml polyethylene bottle	Cool 4°C	14 days
Monitoring well	73 monitoring wells near the HRC injection site	Ground water	Screened interval, bladder pump intake	Hydrogen sulfide	Low	73 8 duplicate	Attachment 2	On file at Ceimic Corporation	1000 ml polyethylene bottle	ZnAc/NaOH >9	7 days
Soil	12 HRC injection site borings, 13 MW locations	Soil	2 intervals per boring	TCL volatile organic compounds (8260)	Low	50 5 duplicate 5 rinsate 3 MS 3 MSD	Attachment 2	On file at Ceimic Corporation	3 @ 40 ml VOA, plus one unpreserved 4-oz jar for % moisture	Cool 4°C 1-MeOH 2-sodium bisulfate	14 days
Soil	12 HRC injection site borings, 13 MW locations	Soil	2 intervals per boring	Total Organic Carbon (9060)	Low	50 5 duplicate	Attachment 2	On file at Ceimic Corporation	1 @ 16 oz glass jars	Cool 4°C	7 days

NOTE: TCL = Target Compound List.
MS = Matrix spike.
MSD = Matrix spike duplicate.

TABLE 9-2 FIELD SAMPLING EQUIPMENT CALIBRATION TABLE

Equipment	Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	Standard Operating Procedure Reference
YSI 6-Series water quality meter or similar	Calibrate each probe as per manufacturer's instruction	At beginning of project, daily if fails within 10% check	Check each probe at beginning of work day, within 10%	Recalibrate, replace if does not recalibrate	TO Task Manager or designee	Attachment 2
Flame Ionization Detector	As per manufacturer's instructions	Beginning of workday, check mid-day and end of day	Within 10% of cal gas	Recalibrate, replace if does not recalibrate	TO Task Manager or designee	Attachment 2
Photoionization Detector	As per manufacturer's instructions	Beginning of workday, check mid-day and end of day	Within 10% of span gas	Recalibrate, replace if does not recalibrate	TO Task Manager or designee	Attachment 2
Turbidimeter	As per manufacturer's instructions	Beginning of workday, check mid-day and end of day	Within 10%	Recalibrate, replace if does not recalibrate	TO Task Manager or designee	Attachment 2

NOTE: TO = Task Order.

TABLE 10-1 SAMPLE HANDLING SYSTEM HRC INJECTION PILOT STUDY FOR SITE 16, NCBC DAVISVILLE

GROUND-WATER AND SOIL SAMPLES	
Sample Collection, Packaging, and Shipment	
Sample Collection:	TO Field Staff
Sample Packing:	TO Task Manager or Designee
Coordination of Shipment:	TO Field Staff
Type of Shipment:	Pickup by Ceimic Corp from the Site
Sample Receipt and Analysis	
Responsible Organization:	Ceimic Corp
Sample Receipt:	Ines Bauer
Sample Custody and Storage:	Ines Bauer
Sample Preparation:	Ines Bauer
Sample Determinative Analysis:	Henry Leibovitz
Sample Archival	
Field Sample Storage (No. of days from sample collection):	90
Sample Extract/Digestate Storage (No. of days from extraction/digestion):	365
Sample Disposal	
Responsible Organization:	Ceimic Corp
Responsible Personnel:	Ines Bauer
NOTE: TO = Task Order.	

TABLE 12-1A PROJECT REPORTING LIMITS, ANALYTICAL PRECISION, ACCURACY, AND BIAS FOR AQUEOUS SAMPLES HRC INJECTION PILOT STUDY AT SITE 16, NCBC DAVISVILLE

Analyte	Achievable Laboratory Sensitivity/ Quantitation Limits (QL) (µg/L)	Analytical Precision	Analytical Accuracy/Bias
VOLATILE ORGANIC ANALYTES (8260B)			
Acetone	5	RPD ≤ 40%	54-135
Benzene	1	RPD ≤ 30%	79-119
Bromodichloromethane	1	RPD ≤ 30%	79-121
Bromoform	1	RPD ≤ 40%	75-141
Bromomethane	1	RPD ≤ 30%	51-148
2-Butanone	5	RPD ≤ 40%	49-134
Carbon disulfide	1	RPD ≤ 30%	61-125
Carbon tetrachloride	1	RPD ≤ 30%	75-118
Chlorobenzene	1	RPD ≤ 30%	81-123
Chloroethane	1	RPD ≤ 30%	57-147
Chloroform	1	RPD ≤ 30%	79-119
Chloromethane	1	RPD ≤ 30%	56-146
Dibromochloromethane	1	RPD ≤ 30%	78-134
1,1-Dichloroethane	1	RPD ≤ 30%	82-119
1,2-Dichloroethane	1	RPD ≤ 30%	82-117
1,1-Dichloroethene	1	RPD ≤ 30%	82-119
1,2-Dichloroethene (*cis*)	1	RPD ≤ 30%	78-118
1,2-Dichloroethene (*trans*)	1	RPD ≤ 30%	78-118
1,2-Dichloropropane	1	RPD ≤ 30%	68-125
cis-1,3-Dichloropropene	1	RPD ≤ 30%	72-126
trans-1,3-Dichloropropene	1	RPD ≤ 30%	75-125
Ethylbenzene	1	RPD ≤ 30%	80-126
2-Hexanone	5	RPD ≤ 40%	75-135
4-Methyl-2-pentanone (MIBK)	5	RPD ≤ 40%	76-136
Methylene chloride	1	RPD ≤ 30%	65-136
Styrene	1	RPD ≤ 30%	82-128
1,1,2,2-Tetrachloroethane	1	RPD ≤ 30%	72-127
Tetrachloroethene	1	RPD ≤ 30%	76-120
Toluene	1	RPD ≤ 30%	75-123
1,1,1-Trichloroethane	1	RPD ≤ 30%	56-117
1,1,2-Trichloroethane	1	RPD ≤ 30%	71-127
Trichloroethene	1	RPD ≤ 30%	79-118
Vinyl chloride	1	RPD ≤ 30%	49-157
Xylenes (total)	3	RPD ≤ 30%	82-126
NATURAL ATTENUATION PARAMETERS			
Alkalinity (310.1)	2,000	RPD ≤ 20 %	80-120
Sulfate by IC (300.0)	100	RPD ≤ 30 %	90-107
Total chloride by IC (300.0)	100	RPD ≤ 30 %	90-104
Nitrate by IC (300.0)	100	RPD ≤ 30 %	90-110
Iron (dissolved) (6010)	100	RPD ≤ 20 %	80-120
Iron (dissolved) (6010)	100	RPD ≤ 20 %	80-120
Manganese (dissolved) (6010)	15	RPD ≤ 20 %	80-120
Ammonia NH3 (350.2)	100	RPD ≤ 20 %	80-120

NOTE: RPD = Relative percent difference.

Analyte	Achievable Laboratory Sensitivity/ Quantitation Limits (QL) (µg/L)	Analytical Precision	Analytical Accuracy/Bias
Hydrogen Sulfide (376.2)	1,000	RPD ≤ 20 %	80-120
Methane/Ethane/Ethene (SW-846 Method 3810)	10	RPD ≤ 20 %	65-115

TABLE 12-1B PROJECT REPORTING LIMITS, ANALYTICAL PRECISION, ACCURACY, AND BIAS FOR SOIL SAMPLES HRC INJECTION PILOT STUDY AT SITE 16, NCBC DAVISVILLE

Analyte	Achievable Laboratory Sensitivity/Quantitation Limits (µg/Kg)	Analytical Precision	Analytical Accuracy/Bias
VOLATILE ORGANIC ANALYTES (8260B)			
Acetone	250	RPD ≤40%	35-164
Benzene	125	RPD ≤30%	60-132
Bromodichloromethane	125	RPD ≤30%	70-136
Bromoform	125	RPD ≤40%	55-141
Bromomethane	125	RPD ≤30%	59-165
2-Butanone	250	RPD ≤40%	11-161
Carbon disulfide	125	RPD ≤30%	54-136
Carbon tetrachloride	125	RPD ≤30%	62-133
Chlorobenzene	125	RPD ≤30%	57-137
Chloroethane	125	RPD ≤30%	61-167
Chloroform	125	RPD ≤30%	69-125
Chloromethane	125	RPD ≤30%	70-136
Dibromochloromethane	125	RPD ≤30%	59-142
1,1-Dichloroethane	125	RPD ≤30%	67-128
1,2-Dichloroethane	125	RPD ≤30%	73-121
1,1-Dichloroethene	10	RPD ≤30%	57-136
Cis-1,2-Dichloroethene	125	RPD ≤40%	62-131
Tran-1,2-Dichloroethene	125	RPD ≤40%	61-133
1,2-Dichloropropane	125	RPD ≤30%	60-133
cis-1,3-Dichloropropene	125	RPD ≤30%	62-131
trans-1,3-Dichloropropene	125	RPD ≤30%	61-133
Ethylbenzene	125	RPD ≤30%	55-141
2-Hexanone	250	RPD ≤40%	35-172
4-Methyl-2-pentanone (MIBK)	250	RPD ≤40%	35-172
Methylene chloride	125	RPD ≤30%	65-135
Styrene	125	RPD ≤30%	54-142
1,1,2,2-Tetrachloroethane	125	RPD ≤30%	50-149
Tetrachloroethene	125	RPD ≤30%	47-139
Toluene	125	RPD ≤30%	58-134
1,1,2-Trichloroethane	125	RPD ≤30%	66-129
Trichloroethene	125	RPD ≤30%	60-130
Vinyl chloride	10	RPD ≤30%	71-136
M&P Xylenes	250	RPD ≤40%	53-94
O-Xylenes	125	RPD ≤40%	54-141

NOTE: RPD = Relative percent difference.

TABLE 12-2 FIXED LABORATORY ANALYTICAL METHOD/STANDARD OPERATING PROCEDURE REFERENCE HRC INJECTION PILOT STUDY AT SITE 16, NCBC DAVISVILLE

Reference Number	Fixed Laboratory Performing Analysis	Title, Revision Date, and/or Number	Definitive or Screening Data	Region I NESTS Method Code	Analytical Parameter	Instrument	Modified for Project Work Y or N
GROUND-WATER SAMPLES							
8260B	Ceimic Corporation	GC/MS for Volatile Organics by SW846 Method 8260B Revision Date: 1/16/01	**Definitive**	NA	VOC **Ground Water** 8260B	GC/MS	N
310.1	Ceimic Corporation	Total Alkalinity by EPA Method 310.1	**Definitive**	NA	Alkalinity **Ground Water** 310.1	Orion 720A pH Meter	N
300.0	Ceimic Corporation	Determination of Inorganic Anions by Ion Chromatography, EPA Method 300.0	**Definitive**	NA	Sulfate, total chloride, nitrate, by IC **Ground Water** 300.0	Dionex Model DX-100 Ion Chromatograph	N
3005A/6010B	Ceimic Corporation	SW-846 Acid Digestion for ICP Analysis of Total Metals in Water (Revision Date: 11/13/00) and ICP-OES by SW 846 Method 6010B(Revision Date: 10/27/00)	**Definitive**	NA	Dissolved iron and manganese **Ground Water** 6010	ICP-OES	N
SW-846 Method 3810	Ceimic Corporation	Methane, Ethane, and Ethene Gases in Water Samples by GC analysis of sample headspace dated September 1986, Revised 9/16/03	**Definitive**	NA	Ethane/ethene **Ground Water** GC/FID	GC/FID	N
376.2	Ceimic Corporation	Sulfide Determination; colorimetric, Methylene Blue by EPA Method 376.2	**Definitive**	NA	Hydrogen sulfide **Ground Water** 376.2	Spectronic 21 Spectrophotometer	N
RSK-175	Ceimic Corporation	Methane, Ethane, and Ethene Gases in Water Samples by GC analysis of sample headspace dated 8/11/94	**Definitive**	NA	Methane **Ground Water** RSK-175	GC/FID	N

* Selected Ion Monitoring by GC/MS for increased sensitivity.

NOTE:
- GC = Gas chromatography.
- MS = Mass spectrometry.
- NA = Not applicable.
- VOC = Volatile organic compound.
- EPA = U.S. Environmental Protection Agency.
- TOC = Total organic carbon.
- FID = Flame ionization detector

Reference Number	Fixed Laboratory Performing Analysis	Title, Revision Date, and/or Number	Definitive or Screening Data	Region I NESTS Method Code	Analytical Parameter	Instrument	Modified for Project Work Y or N
SOIL SAMPLES							
5035/8260B	Ceimic Corporation	GC/MS for Volatile Organics by SW846 Method 8260B and Closed System Purge and Trap and Extraction Method SW846-5035 (Revision Date: 5/24/01)	**Definitive**	NA	VOC **Soil** 8260B	GC/MS	N

TABLE 12-3 FIXED LABORATORY INSTRUMENT MAINTENANCE AND CALIBRATION TABLE HRC INJECTION PILOT STUDY AT SITE 16, NCBC DAVISVILLE

Instrument	Activity	List Maintenance, Testing, and Inspection Activities	Frequency of Calibration	Acceptance Criteria	Corrective Action	Person Responsible for Corrective Action	Method/SOP Reference
GROUND-WATER AND SOIL SAMPLES							
MS12, MS17	Volatile Organic Compound Analysis Ground Water	Check connections, replace disposables, bake out instrument, recondition trap and column, perform leak tests	As needed for ICAL and Daily for Continuing Calibration	%RSD $\leq$ 60 %D $\leq$ 60	See Method and SOP No. Q06	M. Panceria	8260B
MS5 and others	Volatile Organic Compound Analysis Ground Water	Check connections, replace disposables, bake out instrument, recondition trap and column, perform leak tests	As needed for ICAL and Daily for Continuing Calibration	Per Method and SOP	See Method and SOP No. Q06	M. Panceria	8260B
Dionex DX-100 IC	Sulfate, total chloride, nitrate, by IC Ground Water	Check connections, replace disposables, clean injector, recondition column, perform leak tests; change suppressor unit as needed	As needed for ICAL and Daily calibration verification	Per Method and SOP	See Method and SOP No. Q06	T. Sawyer	EPA 300.0
PE-01	Dissolved Iron and Manganese Ground Water	Clean torch, replace pump tubing	Daily for ICAL and ICV, after every 10 samples for CCV	Per Method and SOP	See Method and SOP No. Q06	Karolina Wojciechowska	3005A/6010B
Spectronic 21	Hydrogen Sulfide Ground water	Check linearity semi-annually with standardized Na2S	Calibration curve, blank, and mid-range std at the start of each run. CCV/CCB every 10 samples	Per Method and SOP	See Method and SOP No. Q06	Karen Frohlich	EPA 376.2
GC-10	Methane/ethane/ethene Ground Water	Check connections, replace disposables, bake out instrument, change liner, clean injector, recondition column, perform leak tests	As needed for ICAL and daily ICV and continuing calibration every 12 hours thereafter	Per Method and SOP	See Method and SOP No. 3810	I. Bauer	SW-846 Method 3810
MS5 and others	Volatile Organic Compound Analysis Soil	Check connections, replace disposables, bake out instrument, recondition trap and column, perform leak tests	As needed for ICAL and Daily for Continuing Calibration	Per Method and SOP	See Method and SOP No. Q06	M. Panceria	8260B

NOTE: SOP = Standard operating procedure. Copies of laboratory SOP cover pages are provided in Attachment 6. Full copies of the SOPs are maintained by the laboratory.
ICAL = Initial calibration.
ICV = Initial calibration verification.
CCB = Continuing calibration blank.
CCV = Continuing calibration verification.

TABLE 13-1 FIXED LABORATORY ANALYTICAL QUALITY CONTROL SAMPLE TABLE – CEIMIC CORPORATION HRC INJECTION PILOT STUDY AT SITE 16, NCBC DAVISVILLE

Laboratory Quality Control	Frequency/Number	Method/Standard Operating Procedure Quality Control Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator	Measurement Performance Criteria
LOW LEVEL VOLATILE ORGANIC COMPOUNDS IN GROUND WATER (8260B) (SAMPLING SOP ATTACHMENT 7)						
Method Blank	1 per analytical batch and daily after calibration	No analytes ≥1 µg/L QL (5.0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)	Re-analyze before sample analysis. If corrective action ineffective, flag data in final report	A. Marks	Accuracy/bias contamination	No analytes ≥1 µg/L QL (5.0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)
Reagent Blank	NA	NA	NA	NA	NA	NA
Storage Blank	2 per sample delivery group	No analytes ≥1 µg/L QL (5 0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)	Client notified, investigate reason and proposed corrective action formulated and stated; documented in case narrative	A Marks	Accuracy/bias contamination	No analytes ≥1 µg/L QL (5.0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)
Instrument Blank	Per Method and Data Quality Objectives	No carry-over	Instrument maintenance/re-analyze	A. Marks	Accuracy/bias contamination	No carry-over
Laboratory Duplicate	NA	NA	NA	NA	NA	NA
Laboratory Matrix Spike	1 per 20 samples	NA	NA	NA	Bias	NA
Matrix Spike Duplicates	1 per 20 samples	See Tables 7-3 and 12-1A	NA	NA	Precision and bias	See Tables 7-3 and 12-1A
Laboratory Control Sample	1 per analytical batch	See Tables 7-3 and 12-1A	Re-analyze associated batch	A. Marks	Bias	See Tables 7-3 and 12-1A
LFB	NA	NA	NA	NA	NA	NA
Surrogates	4 per sample	%R = 75-125 except for 1,2 DCE-d4 which is 62-139	Re-analyze associated batch	A. Marks	Bias	%R = 75-125 except for 1,2 DCE-d4 which is 62-139
Internal Standards	3 per sample	Retention time < 30 seconds from ICAL standard	Instrument maintenance/re-analyze	A. Marks	Precision and accuracy/bias	Retention time < 30 seconds from ICAL standard
SULFATE, TOTAL CHLORIDE, NITRATE, NITRITE IN GROUND WATER (9056) (SAMPLING SOP ATTACHMENT 7)						
Method Blank	1 per analytical batch	No analytes ≥ QL	Re-analyze associated batch.	R Montalbano	Accuracy/bias contamination	No analytes ≥ QL
Reagent Blank	NA	NA	NA	NA	NA	NA
Storage Blank	NA	NA	NA	R. Montalbano	NA	NA
Instrument Blank	Per Method and Data Quality Objectives	No carry-over	Instrument maintenance/re-analyze	R. Montalbano	Accuracy/bias contamination	No carry-over
Laboratory Duplicate	NA	NA	NA	NA	NA	NA
Laboratory Matrix Spike	1 per 20 samples	See Tables 7-4 and 12-1A	Flag final report	R. Montalbano	Bias	See Tables 7-4 and 12-1A
Matrix Spike Duplicates	1 per 20 samples	See Tables 7-4 and 12-1A	Flag final report.	R. Montalbano	Precision and bias	See Tables 7-4 and 12-1A
Laboratory Control Sample	1 per analytical batch	See Tables 7-4 and 12-1A	Re-analyze associated batch	R Montalbano	Bias	See Tables 7-4 and 12-1A
LFB	NA	NA	NA	NA	NA	NA

DISSOLVED IRON AND MANGANESE IN GROUND WATER (6010B) (SAMPLING SOP ATTACHMENT 7)						
Method Blank	1 per analytical batch	No analytes ≥ QL	Re-analyze associated batch.	R. Montalbano	Accuracy/bias contamination	No analytes ≥ QL
Reagent Blank	NA	NA	NA	NA	NA	NA
Storage Blank	NA	NA	NA	NA	NA	NA
Instrument Blank	NA	NA	NA	NA	NA	NA
Laboratory Duplicate	1 per 20 samples	≤ 20% RPD	Flag final report.	R. Montalbano	Precision	See Tables 7-4 and 12-1A
Laboratory Matrix Spike	1 per 20 samples	%R = 75-125	Perform post spike and flag final report.	R Montalbano	Bias	See Tables 7-4 and 12-1A
Matrix Spike Duplicates	NA	NA	NA	NA	NA	NA
Laboratory Control Sample	1 per analytical batch	See Tables 7-4 and 12-1A	Re-analyze associated batch	R Montalbano	Bias	See Tables 7-4 and 12-1A
LFB	NA	NA	NA	NA	NA	NA
Surrogates	NA	NA	NA	NA	NA	NA
Other Serial Dilution	1 per analytical batch	See SOP	Flag final report	R Montalbano	Matrix effects	See SOP.
Internal Standards	NA	NA	NA	NA	NA	NA
HYDROGEN SULFIDE IN GROUND WATER (376.2) (SAMPLING SOP ATTACHMENT 7)						
Method Blank	1 per analytical batch	No analytes ≥ QL	Re-analyze before sample analysis.	R. Montalbano	Accuracy/bias contamination	No analytes ≥ QL
Laboratory Matrix Spike	1 per 20 samples	NA	NA	NA	Bias	NA
Matrix Spike Duplicates	1 per 20 samples	See Tables 7-4 and 12-1A	NA	NA	Precision and bias	See Tables 7-4 and 12-1A
Laboratory Control Sample	1 per analytical batch	See Tables 7-4 and 12-1A	Re-analyze associated batch	R Montalbano	Bias	See Tables 7-4 and 12-1A
METHANE IN GROUND WATER (3810) (SAMPLING SOP ATTACHMENT 7)						
Method Blank	1 per analytical batch and daily after calibration	No analytes ≥ QL	Re-analyze before sample analysis. If corrective action ineffective, flag data in final report	I Bauer	Accuracy/bias contamination	No analytes ≥ QL
Reagent Blank	NA	NA	NA	NA	NA	NA
Instrument Blank	Per Method and Data Quality Objectives	No carry-over	Instrument maintenance/re-analyze	I. Bauer	Accuracy/bias contamination	No carry-over
Laboratory Duplicate	NA	NA	NA	NA	NA	NA
Laboratory Matrix Spike	1 per 20 samples	NA	NA	NA	Bias	NA
Matrix Spike Duplicates	1 per 20 samples	See Tables 7-4 and 12-1A	NA	NA	Precision and bias	See Tables 7-4 and 12-1A
Laboratory Control Sample	1 per analytical batch	See Tables 7-4 and 12-1A	Re-analyze associated batch	I. Bauer	Bias	See Tables 7-4 and 12-1A
LFB	NA	NA	NA	NA	NA	NA
Surrogates	NA	NA	NA	NA	NA	NA
Internal Standards	NA	NA	NA	NA	NA	NA

ETHANE/ETHENE IN GROUND WATER (3810) (SAMPLING SOP ATTACHMENT 7)						
Method Blank	1 per analytical batch and daily after calibration	No analytes ≥ QL	Re-analyze before sample analysis. If corrective action ineffective, flag data in final report	I. Bauer	Accuracy/bias contamination	No analytes ≥ QL
Reagent Blank	NA	NA	NA	NA	NA	NA
Instrument Blank	Per Method and Data Quality Objectives	No carry-over	Instrument maintenance/re-analyze	I Bauer	Accuracy/bias contamination	No carry-over
Laboratory Duplicate	NA	NA	NA	NA	NA	NA
Laboratory Matrix Spike	1 per 20 samples	NA	NA	NA	Bias	NA
Matrix Spike Duplicates	1 per 20 samples	See Tables 7-4 and 12-1A	NA	NA	Precision and bias	See Tables 7-4 and 12-1A
Laboratory Control Sample	1 per analytical batch	See Tables 7-4 and 12-1A	Re-analyze associated batch	I. Bauer	Bias	See Tables 7-4 and 12-1A
LFB	NA	NA	NA	NA	NA	NA
Surrogates	NA	NA	NA	NA	NA	NA
Internal Standards	NA	NA	NA	NA	NA	NA
LOW LEVEL VOLATILE ORGANIC COMPOUNDS IN SOIL (8260B) (SAMPLING SOP ATTACHMENT 7)						
Method Blank	1 per analytical batch and daily after calibration	No analytes ≥1 µg/L QL (5.0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)	Re-analyze before sample analysis. If corrective action ineffective, flag data in final report	A. Marks	Accuracy/bias contamination	No analytes ≥1 µg/L QL (5 0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)
Reagent Blank	NA	NA	NA	NA	NA	NA
Storage Blank	2 per sample delivery group	No analytes ≥1 µg/L QL (5.0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)	Client notified; investigate reason and proposed corrective action formulated and stated, documented in case narrative	A. Marks	Accuracy/bias contamination	No analytes ≥1 µg/L QL (5.0 µg/L for acetone, methylene chloride, 2-butanone, 4-methyl,2-pentanone, 2-hexanone) (20 ml purge)
Instrument Blank	Per Method and Data Quality Objectives	No carry-over	Instrument maintenance/re-analyze	A. Marks	Accuracy/bias contamination	No carry-over
Laboratory Duplicate	NA	NA	NA	NA	NA	NA
Laboratory Matrix Spike	1 per 20 samples	NA	NA	NA	Bias	NA
Matrix Spike Duplicates	1 per 20 samples	See Tables 7-3 and 12-1A	NA	NA	Precision and bias	See Tables 7-4 and 12-1A
Laboratory Control Sample	1 per analytical batch	See Tables 7-3 and 12-1A	Re-analyze associated batch	A. Marks	Bias	See Tables 7-4 and 12-1A
LFB	NA	NA	NA	NA	NA	NA
Surrogates	4 per sample	%R = 75-125 except for 1,2 DCE-d4 which is 62-139	Re-analyze associated batch	A. Marks	Bias	%R = 75-125 except for 1,2 DCE-d4 which is 62-139
Internal Standards	3 per sample	Retention time < 30 seconds from ICAL standard	Instrument maintenance/re-analyze	A. Marks	Precision and accuracy/bias	Retention time < 30 seconds from ICAL standard

TABLE 16-1 PROJECT ASSESSMENT TABLE

Assessment Type	Frequency	Internal or External	Organization Performing Assessment	Person(s) Responsible for Performing Assessment, Title, and Organizational Affiliation	Person(s) Responsible for Responding to Assessment Findings, Title, and Organizational Affiliation	Person (s) Responsible for Identifying and Implementing Corrective Actions, Title, and Organizational Affiliation	Person (s) Responsible for Monitoring Effectiveness of Corrective Actions, Title, and Organizational Affiliation
Field operations[a]	Daily	Internal	Navy or its designee	TO Task Manager	See Figure 4, Table 4-1	See Figure 4, Table 4-1	TO Task Manager and TO Project Manager
Laboratory analysis soil, ground water[b]	Weekly	Internal	Navy or its designee	TO Task Manager	See Figure 4, Table 4-1	See Figure 4, Table 4-1	TO Task Manager and TO Project Manager

(a) The daily internal assessments of field operations will be performed by the TO Task Manager (or designee) including: review of the daily sample collection forms for completeness of the data required, field measurement equipment checking (and calibration, as necessary) has been completed, and proper temporary storage of collected samples pending transfer to the laboratory. Discrepancies will be resolved before the beginning of the next day's work, except for those related to sample storage that will be corrected immediately.

(b) The weekly internal assessments during laboratory analysis of the samples collected will be performed by the TO Task Manager (or designee) through telephone communication regarding the status of schedule to deliver the results to the TO Project Manager (or designee), sampling holding times, sample container breakage, temperature blanks, or other potential problems that could compromise the integrity of a sample aliquot(s) such that it would not be useable for the project. Problems identified that would compromise the integrity of a sample aliquot(s) will be reported to the TO Project Manager who with consultation of the Navy RPM decide if resampling is necessary and to what extent.

TO = Task Order

TABLE 17-1 QUALITY ASSURANCE MANAGEMENT REPORTS TABLE

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation, Title, and Organizational Affiliation	Report Recipients, Title, and Organizational Affiliation
Verbal Field Activity Reports	Daily	Close of business daily	R. Clark, TO Task Manager	J. Shultz, TO Project Manager
EA Field Progress Summary Table	Weekly during sampling	E-mailed weekly	J. Shultz, TO Project Manager	F. Evans, Navy RPM C. Williams, EPA RPM L. .Maccarone, RIDEM RPM S. King, RIEDC M. Cohen, Town of North Kingstown
Laboratory Analytical Result Data Package (Hardcopy and EDD)	Once	To EA 4 weeks after receipt of last sample	H. Leibovitz, Ceimic Laboratory Manager	J. Shultz, EA Project Manager R. Clark, EA Task Manager

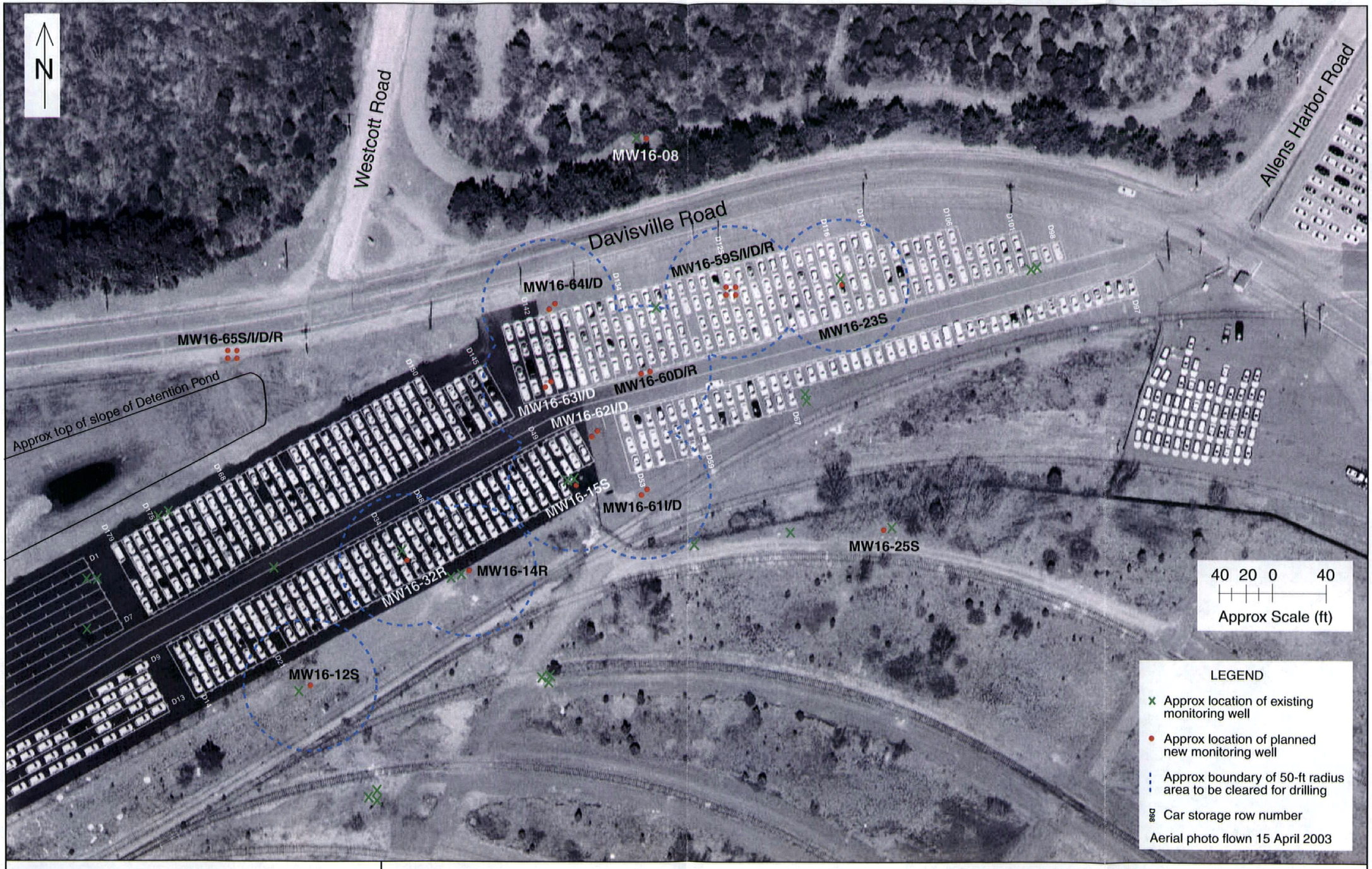
NOTE: RPM = Remedial Project Manager.
EDD = Electronic Data Deliverable.
TO = Task Order.

TABLE 20-1 FORMULAS FOR THE CALCULATION OF DATA QUALITY CHARACTERISTICS FOR CHEMICAL DATA

Characteristic	Formula	Symbols
Precision (as relative percent difference, RPD)	$RPD = \frac{\lvert X1 - X2 \rvert}{(X1 + X2)/2} \times 100$	X1, X2 = Duplicate values
Precision (as relative standard deviation, %RSD)	$\%RSD = \frac{s}{A} \times 100$	s = Standard deviation A = Mean of the measurements
Accuracy (as percent recovery [%R] for samples without a background level of the analyte, such as reference materials, laboratory control samples, and performance evaluation samples)	$\%R = \frac{X}{T} \times 100$	X = Found concentration T = True or assumed concentration
Accuracy (as percent recovery [%R] for measurements in which a known amount of analyte [a spike] is added to an environmental sample)	$\%R = \frac{X - B}{T} \times 100$	X = Found concentration B = Background concentration T = True or assumed concentration
Completeness	$C = \frac{N}{S} \times 100$	C = Completeness (%) N = Number of valid data S = Number of samples collected

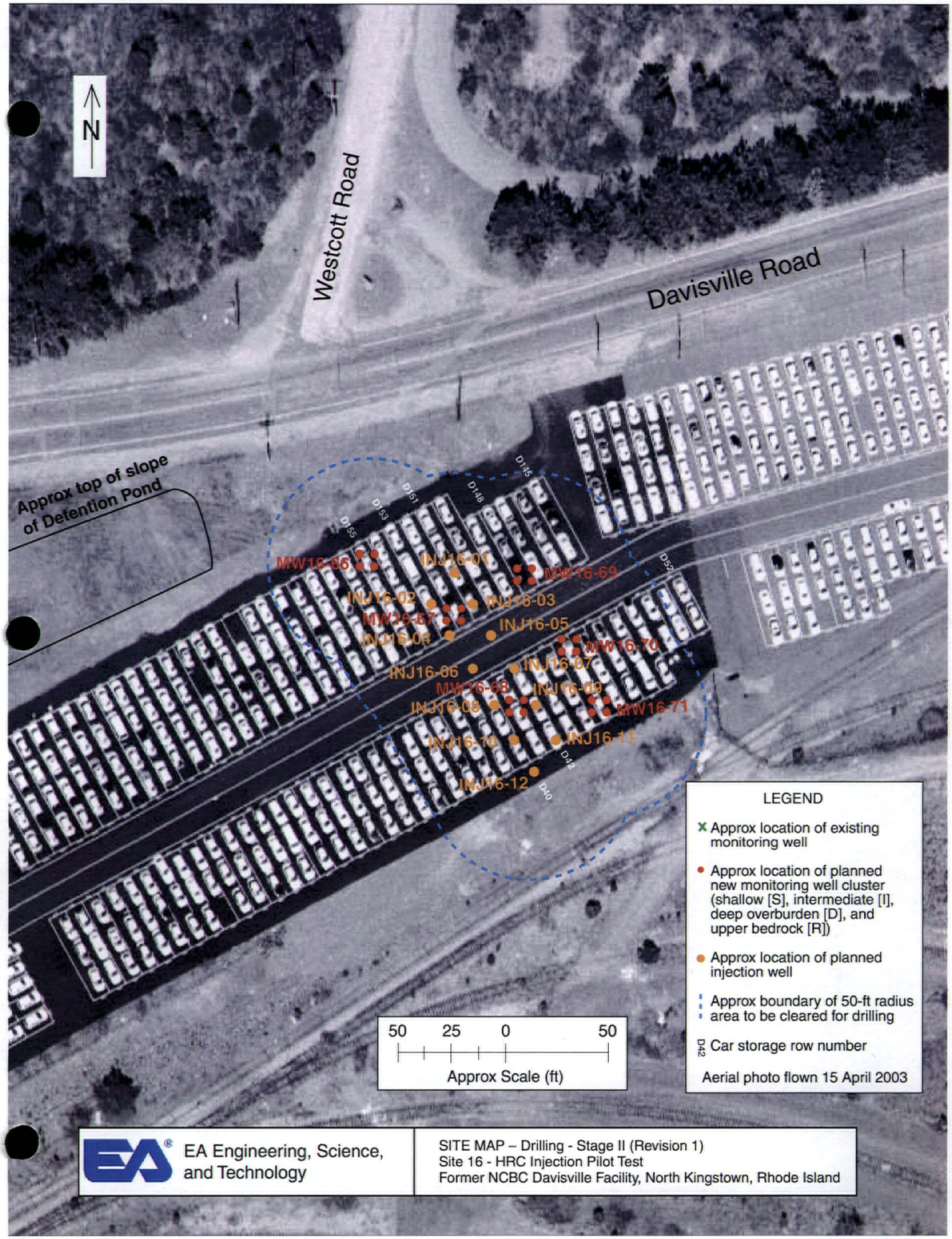
Attachment 1

Additional Site Information



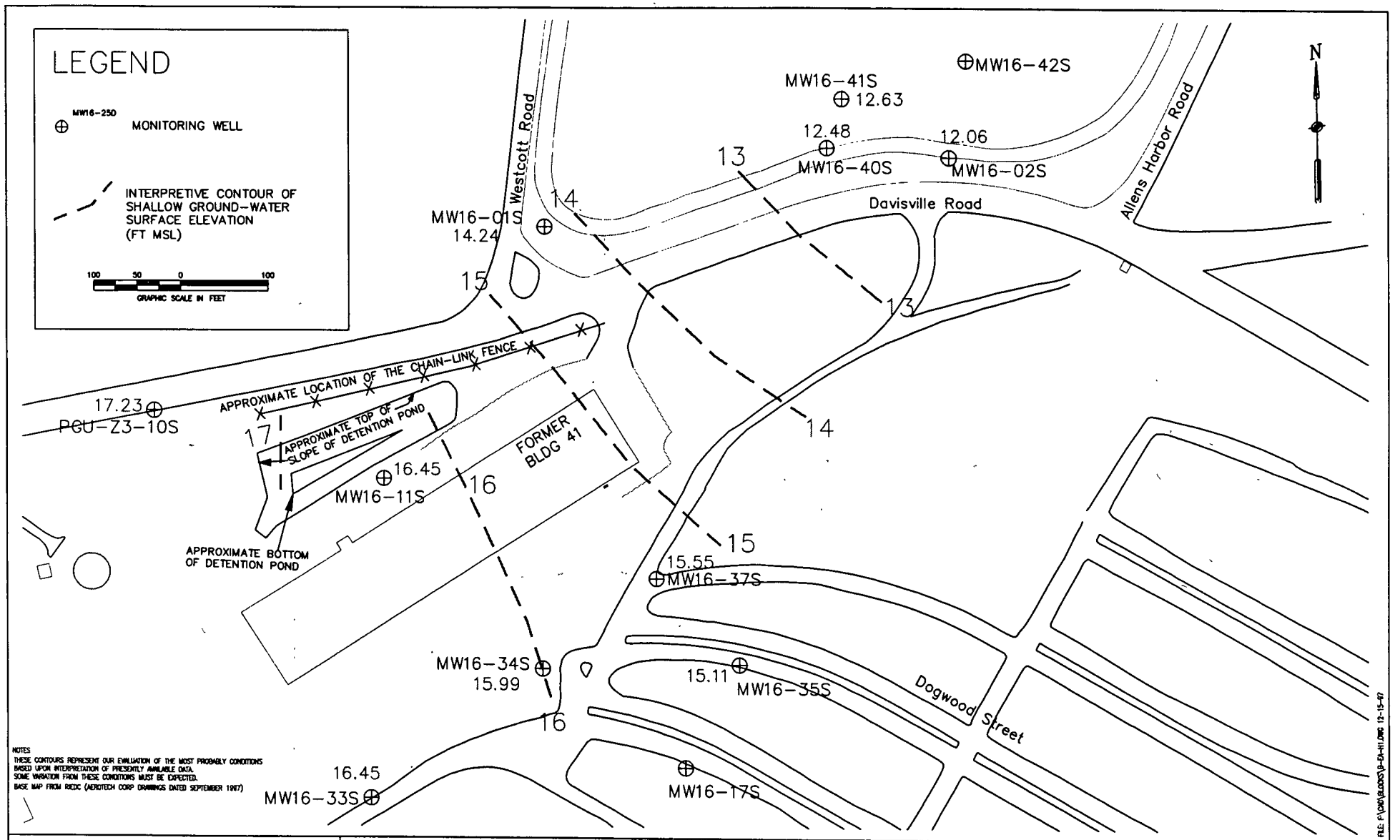
EA Engineering, Science, and Technology

SITE MAP – Drilling - Stage I (Revision 1)
Site 16 - HRC Injection Pilot Test
Former NCBC Davisville Facility, North Kingstown, Rhode Island

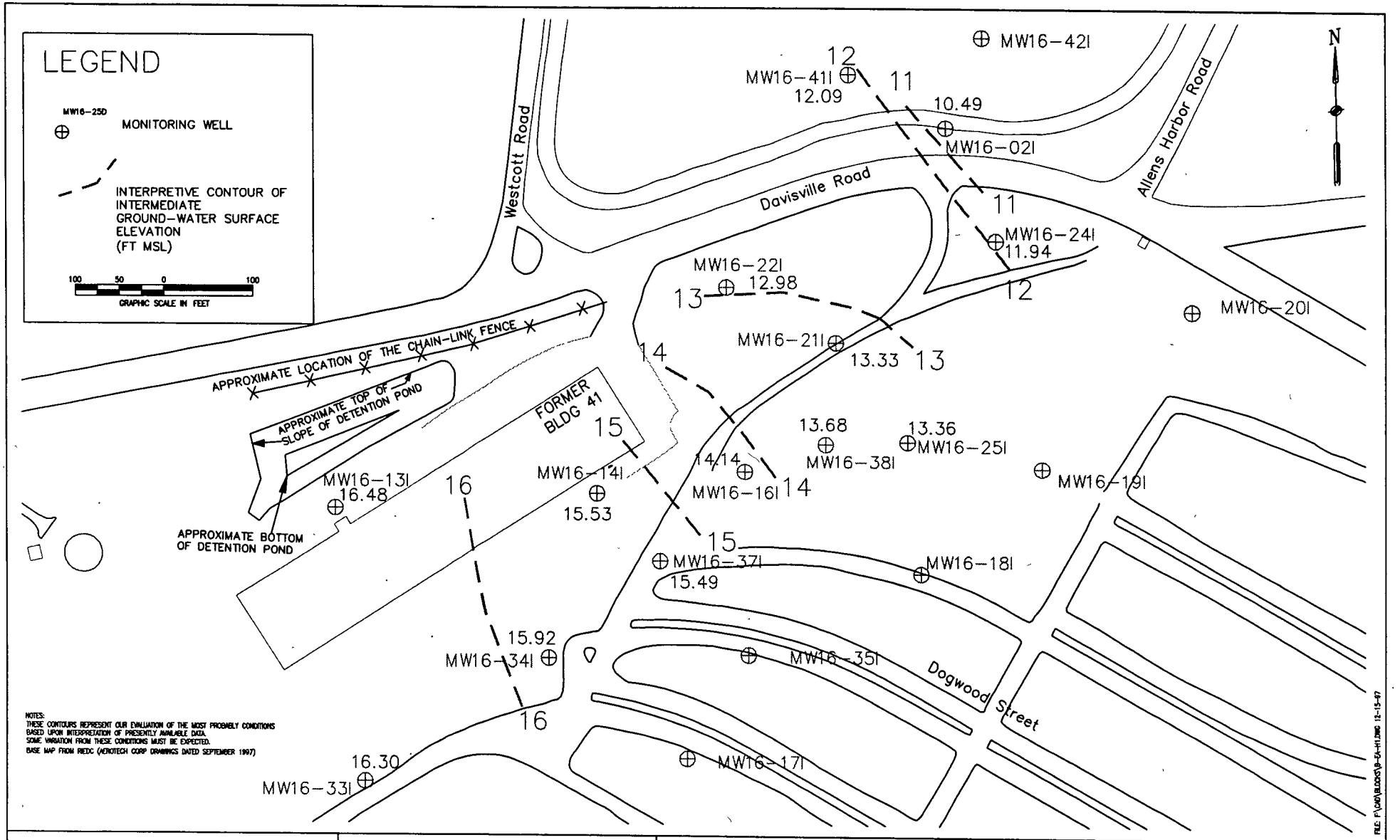


EA Engineering, Science, and Technology

SITE MAP – Drilling - Stage II (Revision 1)
Site 16 - HRC Injection Pilot Test
Former NCBC Davisville Facility, North Kingstown, Rhode Island



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	CFANE SITE 16 HRC PILOT STUDY FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	INTERPRETIVE GROUND-WATER CONTOURS SHALLOW WELLS (APRIL 9 2004)	DESIGNED BY RWC	DRAWN BY RWC	DATE 7/15/04	PROJECT NO. 2960107	FILE NAME SHALLOW
			CHECKED BY JAS	PROJECT MGR. JAS	SCALE NONE	DRAWING NO. –	FIGURE Figure 1

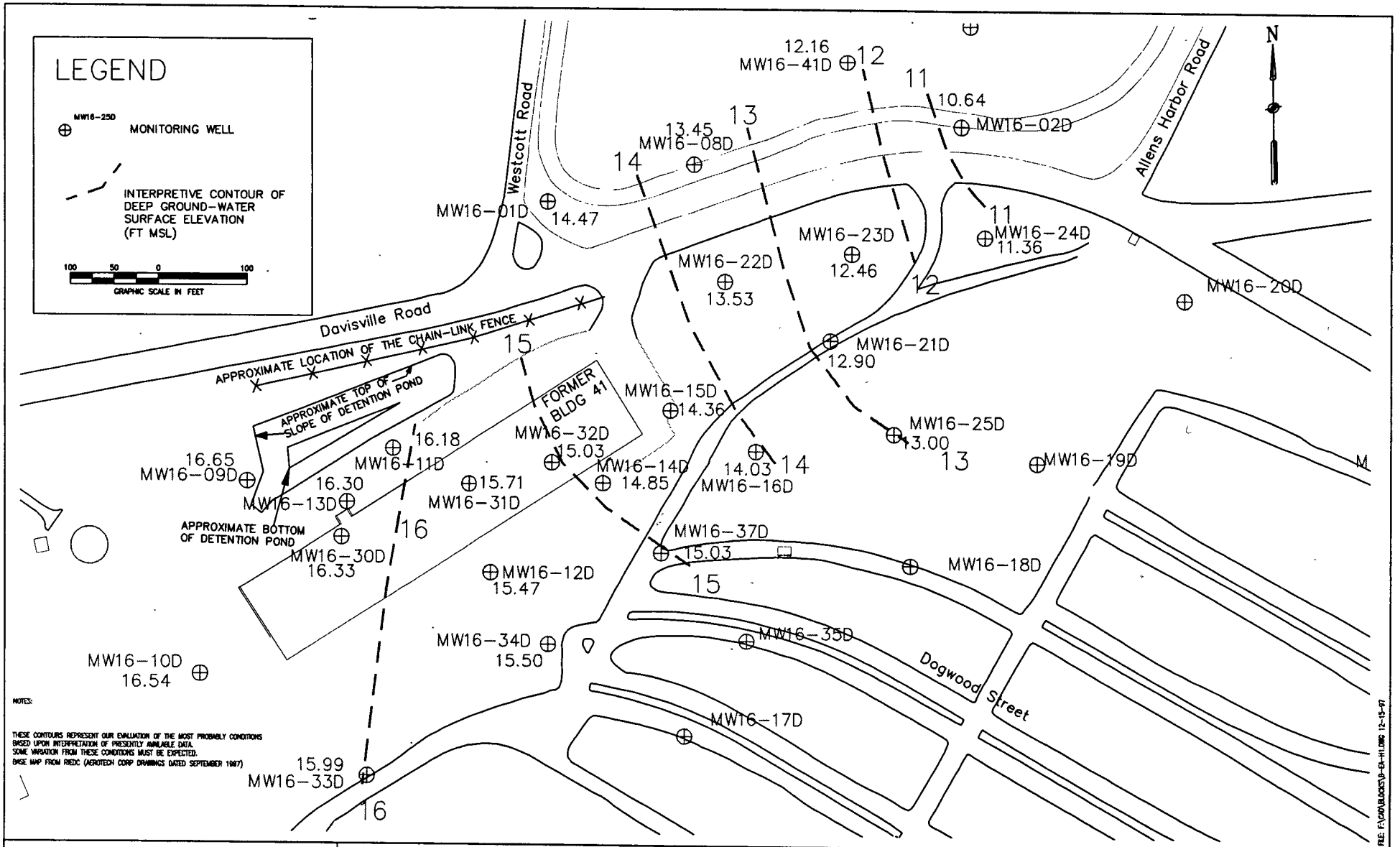


EA ENGINEERING, SCIENCE, AND TECHNOLOGY

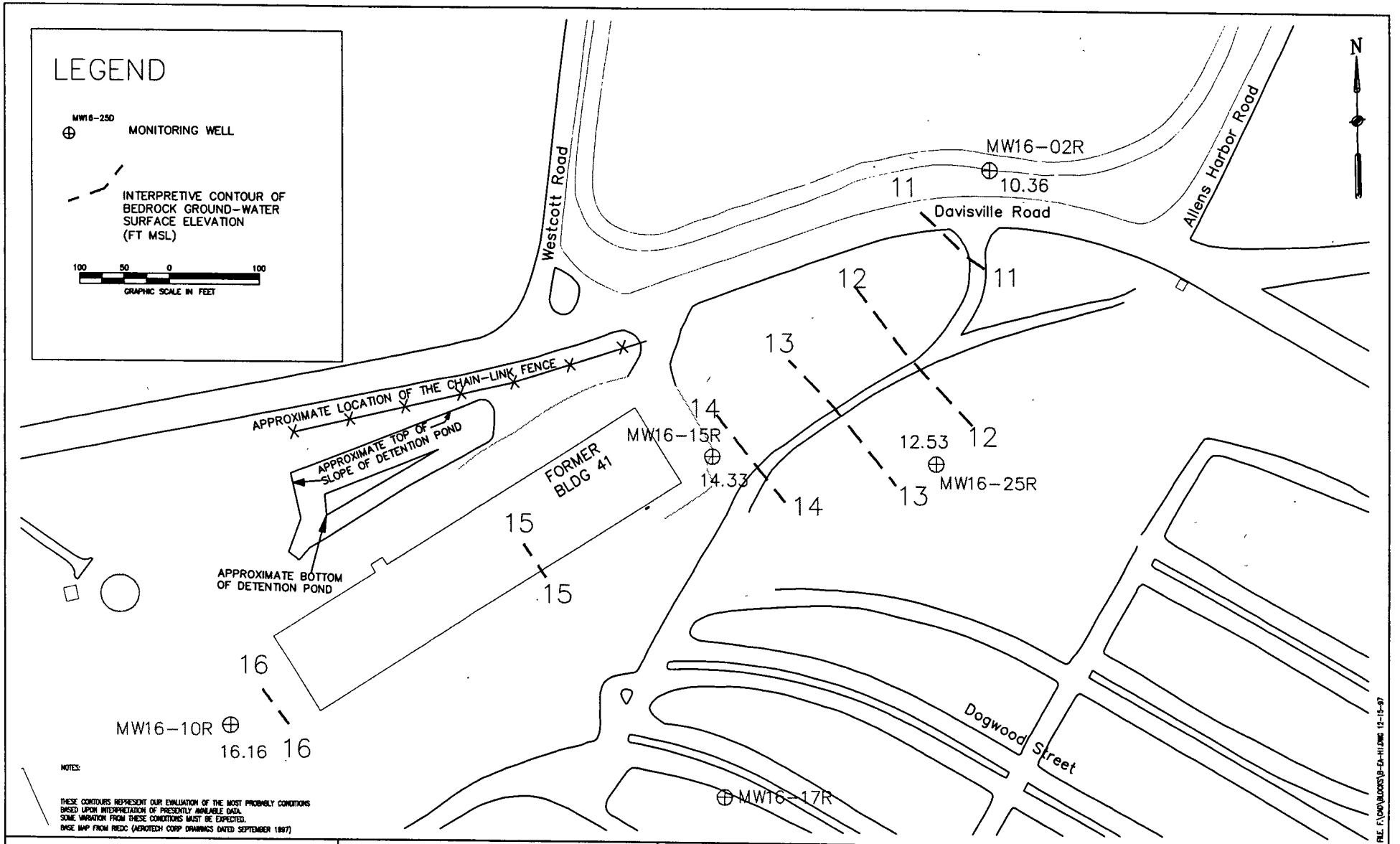
EFANE
SITE 16 HRC PILOT STUDY
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

INTERPRETIVE GROUND-WATER SURFACE CONTOURS
INTERMEDIATE WELLS (APRIL 7 2004)

DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
RWC	RWC	7/15/04	2960107	INTER
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
JAS	JAS	NONE	–	Figure 2



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EFANE SITE 16 PHASE II RI FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	INTERPRETIVE GROUND WATER SURFACE CONTOUR DEEP WELLS (APRIL 7 2004)	DESIGNED BY RWC	DRAWN BY RWC	DATE 7/15/04	PROJECT NO. 296C107	FILE NAME DEEP
			CHECKED BY JAS	PROJECT MGR. JAS	SCALE NONE	DRAWING NO. –	FIGURE Figure 3



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	CTANG SITE 16 PHASE II RI FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	INTERPRETIVE GROUND-WATER SURFACE CONTOURS ROCK WELLS (APRIL 7 2004)	DESIGNED BY RWC	DRAWN BY RWC	DATE 7/15/04	PROJECT NO. 2960107	FILE NAME ROCK
			CHECKED BY JAS	PROJECT MGR. JAS	SCALE NONE	DRAWING NO. –	FIGURE Figure 4

TABLE 1
Summary of Depth to and Elevation of the Ground-Water Table
HRC Injection Pilot Test Area
Site 16
NCBC Davisville, North Kingstown, RI

Well Number	Stickup* (Ft AGS)	Elevation Top of Riser (MSL)	Depth to groundwater (ft below riser)						Elevation of groundwater surface (MSL)					
			10/4/00**	03/29/01	05/02/01	11/20/02	03/24/03	4/7/2004 (shallow wells 4/9/04)	10/4/00**	03/29/01	05/02/01	11/20/02	03/24/03	4/7/2004 (shallow wells 4/9/04)
MW16-01S	2.00	35.90	22.95	20.32	20.26	below top of pump	21.45	21.66	12.95	15.58	15.64		14.45	14 24
MW16-01D	2.11	36.04	22.64	20.38	20.40	23.59	21.34	21.57	13.40	15.66	15.64	12 45	14.70	14 47
MW16-02S	2.84	23.72	12 74	10.42	10 27	12.60 top of pump	11.38	11.66	10.98	13.30	13.45		12 34	12 06
MW16-02I	2.10	23.17	N.I.	N.I.	N.I.	14.57	12.66	12.68	N.I.	N.I.	N.I.	8 60	10 51	10.49
MW16-02D	2.11	23.05	13.22	11.48	11.55	14.18	12.34	12.41	9.83	11.57	11.50	8.87	10.71	10.64
MW16-02R	1 82	22.99	N.I.	11.53	11.61	14.30	12.51	12.63	N.I.	11.46	11.38	8.69	10.48	10 36
MW16-02R2	1.54	22.78	N.I.	N.I	N.I.	13.03	10.99	11.11	N.I.	N.I.	N.I.	9.75	11.79	11 67
MW16-08D	2.44	30.39	N.I.	15.77	15.78	19.33	16.74	16.94	N.I.	14.62	14.61	11.06	13 65	13.45
MW16-09D	-0.45	33.90	N I.	17.04	16.43	18.25	16.90	17.25	N.I.	16.86	17.47	15 65	17 00	16.65
MW16-10D	-0.22	31.40	N.I.	13.94	13.20	15.90	14.44	14.86	N.I.	17.46	18.20	15.50	16.96	16.54
MW16-10R	-0.18	31.38	N.I.	14.10	13.40	16.19	14.71	15.22	N.I.	17.28	17.98	15.19	16.67	16.16
MW16-11S	-0.33	29 43	N.I.	N I.	N.I.	13.64	12.88	12.98	N.I.	N.I.	N.I.	15.79	16.55	16 45
MW16-11D	-0.21	29.57	N.I.	12.26	11.88	14.40	13.09	13.39	N.I.	17.31	17.69	15.17	16.48	16.18
MW16-12D	2.33	31.55	N.I.	15.04	14.51	17.37	15.87	16.08	N.I.	16.51	17.04	14.18	15.68	15.47
MW16-13I	-0.18	29.71	N.I.	N.I	N.I.	14.02	12.80	13.23	N.I.	N.I.	N.I.	15.69	16.91	16 48
MW16-13D	-0.56	29.40	N.I.	12.02	11.52	14.08	13.11	13.10	N.I.	17.38	17.88	15.32	16.29	16.30
MW16-14I	-0.18	29.80	N.I.	N.I.	N.I.	15.42	14.08	14.27	N.I.	N.I.	N.I.	14.38	15.72	15 53
MW16-14D	-0 30	29.70	N.I.	13.60	13.20	16.15	14.51	14.85	N.I.	16.10	16.50	13.55	15 19	14.85
MW16-15D	-0.45	28.87	N.I.	16.27	15.95	16.21	14.27	14.51	N.I.	12.60	12.92	12.66	14.60	14.36
MW16-15R	-0 66	28.64	N.I.	15.11	14.78	16.01	14.04	14.31	N.I.	13.53	13.86	12.63	14.60	14.33
MW16-15R2	-0.67	28.72	N.I.	N.I.	N.I.	17.53	14.95	15.46	N.I.	N.I	N.I.	11.19	13 77	13.26
MW16-16I	2.18	25.67	N I.	N.I.	N.I.	13.17	11.47	11.53	N.I.	N.I.	N.I.	12 50	14.20	14 14
MW16-16D	2.13	25 51	N.I.	10.39	10.06	14.21	11.31	11.48	N.I.	15 12	15.45	11.30	14 20	14 03
MW16-21I	-0.33	22.16	N.I.	N.I	N I.	10.60	8.61	8.83	N.I.	N.I.	N.I.	11.56	13.55	13.33
MW16-21D	-0.33	22.22	N.I.	8.23	7.98	11.11	9.13	9.32	N.I.	13.99	14.24	11.11	13.09	12 90
MW16-22I	-0.29	29.77	N I.	N.I.	N.I.	18.72	16.35	16.79	N.I.	N.I.	N.I.	11.05	13.42	12 98
MW16-22D	-0.31	29 73	N.I.	14.99	14.80	18.22	15.91	16.20	N.I.	14.74	14.93	11.51	13.82	13.53
MW16-23D	-0.16	25.32	N.I.	11.71	11.54	14.69	21.62	12.86	N.I.	13.61	13.78	10.63	3.70	12.46
MW16-24I	-0.21	21.22	N.I	N.I.	N I.	10.83	9.11	9.28	N.I.	N I.	N.I.	10.39	12.11	11.94
MW16-24D	-0.29	20.96	N.I.	8.51	8.39	11.29	9.41	9.60	N.I.	12.45	12.57	9.67	11.55	11 36
MW16-25I	1.91	23.57	N I.	N.I.	N.I.	11.98	10.17	10.21	N.I.	N.I.	N.I.	11.59	13.40	13.36
MW16-25D	2.67	24.42	N.I.	10.42	10.08	13.14	11.33	11.42	N.I.	14.00	14.34	11.28	13.09	13.00
MW16-25R	1.41	23.01	N.I.	9.50	9.11	11.96	10.30	10.48	N.I.	13.51	13.90	11.05	12.71	12 53
MW16-30D	-0.25	30.22	N.I.	N.I.	N.I.	N.A.	13.60	13.89	N.I.	N.I.	N.I.	N.I.	16.62	16.33
MW16-31D	-0 57	30.29	N.I	N.I.	N.I.	15 81	14.88	14.58	N.I.	N.I.	N.I.	14.48	15.41	15.71
MW16-32D	-0.50	30.14	N.I	N.I.	N.I.	16.59	14.88	15.11	N.I.	N.I.	N.I.	13.55	15.26	15.03
MW16-33S	-0 29	28.12	N.I.	N.I.	N.I.	below top of pump	11.4 dry TOP	11.67	N.I.	N.I.	N.I.	BTOP	BTOP	16.45
MW16-33I	-0.34	28.29	N I.	N I.	N.I	13.26	11.60	11.99	N.I	N.I.	N.I.	15.03	16.69	16.30
MW16-33D	-0.58	27.85	N.I.	N.I.	N.I.	13.04	11.48	11.86	N.I.	N.I.	N.I.	14 81	16 37	15.99
MW16-34S	2.30	29.06	N.I.	N.I.	N.I.	below top of pump	12.89 TOP	13.07	N.I	N.I.	N.I.	BTOP	BTOP	15.99
MW16-34I	3.05	29.21	N.I.	N.I.	N I.	14.50	13.18	13.29	N.I.	N.I.	N.I.	14.71	16.03	15.92

TABLE 1
Summary of Depth to and Elevation of the Ground-Water Table
HRC Injection Pilot Test Area
Site 16
NCBC Davisville, North Kingstown, RI

Well Number	Stickup* (Ft AGS)	Elevation Top of Riser (MSL)	Depth to groundwater (ft below riser)						Elevation of groundwater surface (MSL)					
			10/4/00**	03/29/01	05/02/01	11/20/02	03/24/03	4/7/2004 (shallow wells 4/9/04)	10/4/00**	03/29/01	05/02/01	11/20/02	03/24/03	4/7/2004 (shallow wells 4/9/04)
MW16-34D	2 79	29 33	N.I.	N.I.	N.I.	15.21	13.67	13.83	N.I.	N.I.	N.I.	14.12	15.66	15 50
MW16-35S	2.49	26.22	N I.	N.I.	N.I.	12.28	11.10	11.11	N.I.	N.I.	N.I.	13.94	15.12	15 11
MW16-37S	2.19	27.53	N.I.	N.I.	N.I.	15.23	11.95	11.98	N.I.	N.I.	N.I.	12.30	15.58	15.55
MW16-37I	2 27	27.72	N.I.	N.I.	N.I.	13.53	12.11	12.23	N.I	N.I.	N.I.	14.19	15.61	15 49
MW16-37D	2.35	27.73	N.I	N.I.	N.I.	14.14	12.52	12 70	N I.	N.I.	N I	13.59	15.21	15 03
MW16-38I	2.31	24.94	N.I.	N.I.	N.I.	13 03	11.16	11 26	N.I.	N.I.	N.I	11.91	13.78	13 68
MW16-40S	2.35	26.06	N.I.	N.I.	N.I.	16 58	13 18	13 58	N.I.	N.I.	N.I.	9.48	12.88	12 48
MW16-41S	1.93	22.66	N.I.	N.I.	N I.	13 07	9 68	10.03	N.I	N.I.	N.I.	9.59	12.98	12.63
MW16-41I	1.94	22 73	N.I	N.I.	N.I.	13.02	10 51	10.64	N.I.	N.I	N.I.	9.71	12 22	12.09
MW16-41D	1.61	22.25	N.I.	N I.	N.I.	12.25	9.94	10.09	N.I.	N.I.	N.I.	10.00	12.31	12 16
PGU-Z3-10D	NM	42.79	N.M.	N M.	24.32	27.01	27.65	25.96	N.M	N.M.	18.47	15.78	15.14	16 83
PGU-Z3-10S	NM	42.80	N.M.	N.M	23 94	27.11	25 23	25 57	N M.	N.M.	18.86	15 69	17 57	17 23

Ft. BGS - FEET BELOW GROUND SURFACE
MSL - MEAN SEA LEVEL
N.I. - NOT INSTALLED
Stickup* = negative number denotes a flushmounted well, riser below grade
N.M. = Not Measured
** - measured from top of casing (prior to bladder pump installation)
+ - well tidally influenced
N.A. = Not Accessable

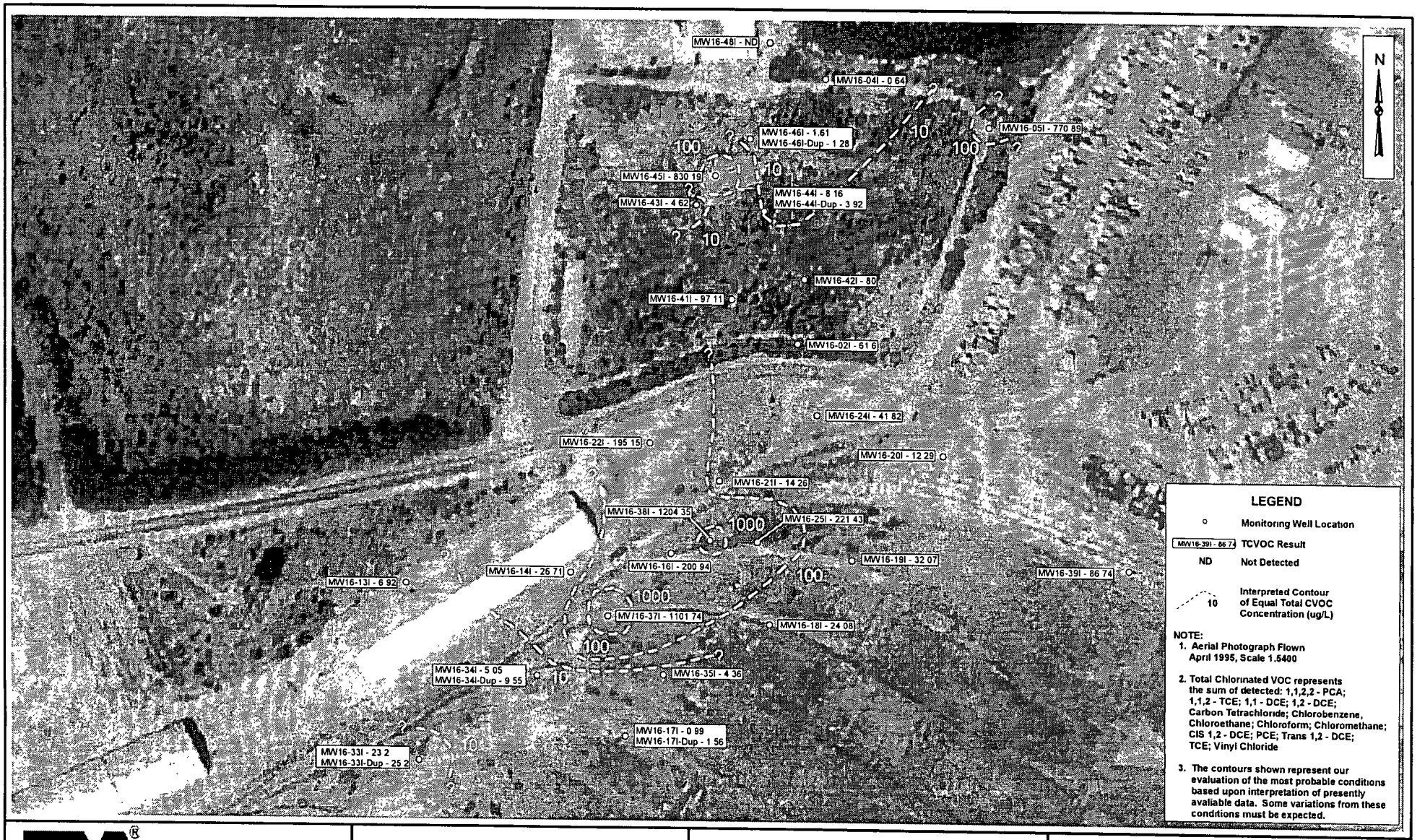
EA ENGINEERING, SCIENCE, AND TECHNOLOGY

70 0 70 140 210 280 Feet

EFANE
SITE 16 PHASE II RI
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

TOTAL CHLORINATED VOLATILE ORGANIC COMPOUNDS (ug/L) DETECTED IN GROUND-WATER SAMPLES COLLECTED FROM SHALLOW WELLS IN NOVEMBER/DECEMBER 2002

FIGURE 4-3



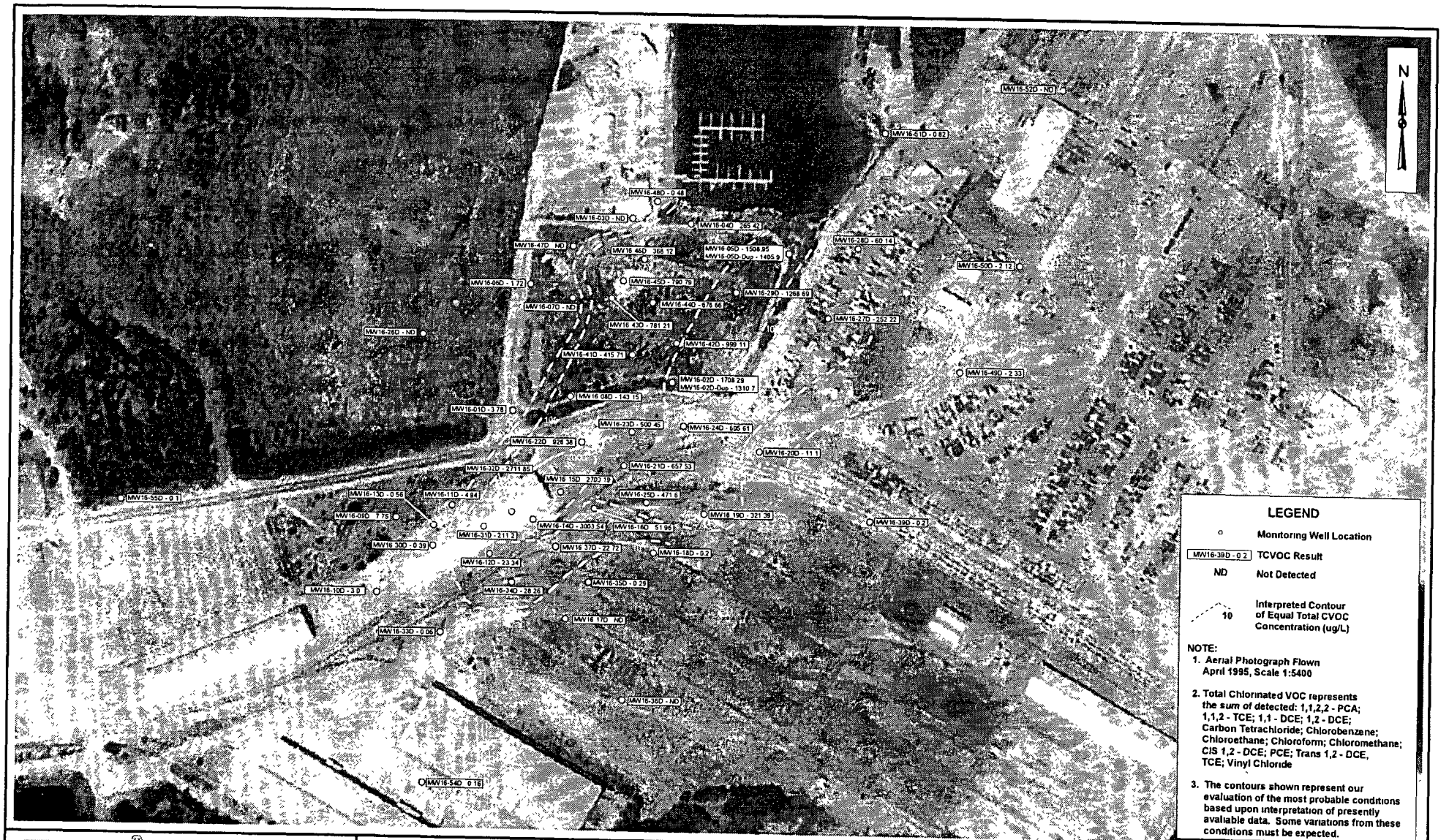
EA ENGINEERING, SCIENCE, AND TECHNOLOGY

80 0 80 160 240 Feet

EFANE
SITE 16 PHASE II RI
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

TOTAL CHLORINATED VOLATILE ORGANIC COMPOUNDS (ug/L) DETECTED IN GROUND-WATER SAMPLES COLLECTED FROM INTERMEDIATE WELLS IN NOVEMBER/DECEMBER 2002

FIGURE 4-6



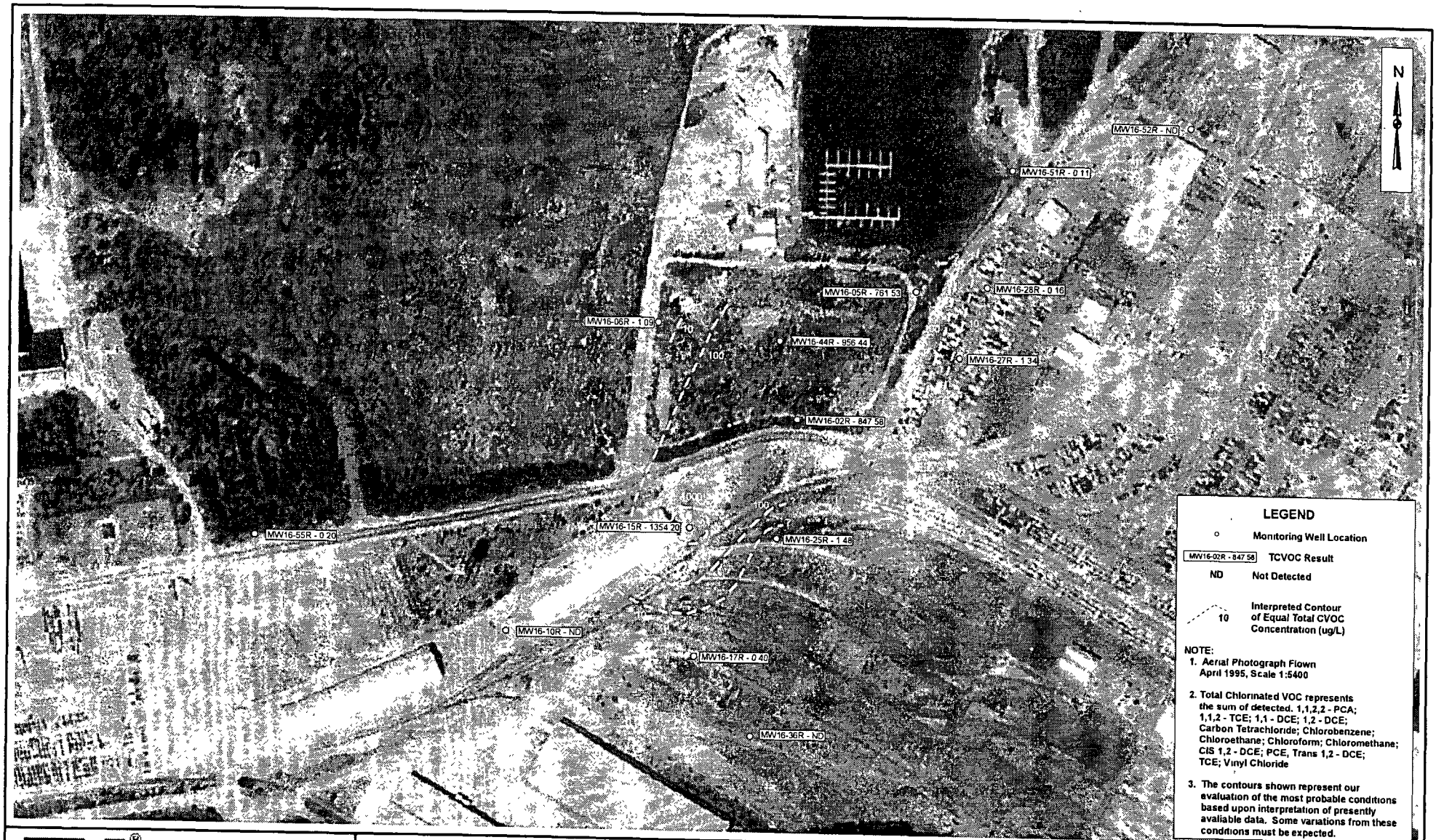
EA ENGINEERING, SCIENCE, AND TECHNOLOGY

60 0 60 120 180 240 300 Feet

EFANE
SITE 16 PHASE II RI
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

TOTAL CHLORINATED VOLATILE ORGANIC COMPOUNDS (ug/L) DETECTED IN GROUND-WATER SAMPLES COLLECTED FROM DEEP WELLS IN NOVEMBER/DECEMBER 2002

FIGURE 4-9



EA ENGINEERING, SCIENCE, AND TECHNOLOGY

200 0 200 400 Feet

EFANE
SITE 16 PHASE II RI
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

TOTAL CHLORINATED VOLATILE ORGANIC COMPOUNDS (ug/L) DETECTED IN GROUND-WATER SAMPLES COLLECTED FROM ROCK WELLS IN NOVEMBER/DECEMBER 2002

FIGURE 4-12

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

90 0 90 Feet

EFANE
SITE 16 PHASE II RI
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

TOTAL CHLORINATED VOLATILE ORGANIC COMPOUNDS (ug/L) DETECTED IN GROUND-WATER SAMPLES COLLECTED FROM DEEP ROCK WELLS IN NOVEMBER/DECEMBER 2002

FIGURE 4-15

OBJECTIVE:
Based on site data from the Phase I and Phase II Remedial Investigations, calculate the average aquifer hydraulic conductivity, average concentration of dissolved phase CVOC, and average concentration of competing electron acceptors for input to Regenesis Software HRC Barrier Design.

ASSUMPTIONS:
Use data on the above parameters collected from deep monitoring well locations near the position of the proposed HRC Pilot Test near the northeast end of former Building 41. Deep monitoring well locations in this area include MW16-14D, MW16-15D, and MW16-32D.

PROCEDURE:
1. Calculation of Average Hydraulic Conductivity (K).
K determined by slug test method for Phase II RI data (Table 3-5).
MW16-14D 1.84 ft/day
MW16-15D 12.77 ft/day
MW16-32D 55.6 ft/day
Average K = (1.84 + 12.77 + 55.6)/3 = 23.4 ft/day

2. Calculation of Hydraulic Gradient (Dh/Dl)
Dh/Dl determined from Phase II RI Ground-Water Surface Contour Map for Deep Wells (Figure 3-26) within area of proposed pilot.
Dh/Dl = (15 ft –12 ft)/470 ft = 3 ft/470 ft = 0.0063 ft/ft

3. Calculation of Average Concentration of Dissolved Phase CVOCs.
Average concentration of CVOC compound elevated in area of pilot calculated from Phase I and Phase II RI data. Elevated CVOCs in this include TCE, PCE, and cis-12DCE.
TCE @ MW16-14D 4900 ug/L (Phase I), 3000 ug/L (Phase II)
TCE @ MW16-15D 6200 ug/L (Phase I), 2700 ug/L (Phase II)
TCE @ MW16-32D N/A (Phase I), 2700 ug/L (Phase II)
Average TCE = (4900 + 3000 + 6200 + 2700 + 2700)/5 = 3900 ug/L

PCE @ MW16-14D <1.0 ug/L (Phase I), 0.3 ug/L (Phase II)
PCE @ MW16-15D 0.7 ug/L (Phase I), 0.67 ug/L (Phase II)
PCE @ MW16-32D N/A (Phase I), 0.618 ug/L (Phase II)
Average PCE = (0.5 + 0.3 + 0.7 + 0.67 + 0.618)/5 = 0.558 ug/L

cis-12DCE @ MW16-14D 5.0 ug/L (Phase I), 1.87 ug/L (Phase II)
cis-12DCE @ MW16-15D 3.0 ug/L (Phase I), 2.18 ug/L (Phase II)
cis-12DCE @ MW16-32D N/A (Phase I), 7.03 ug/L (Phase II)
Average cis-12DCE = (5.0 + 1.87 + 3.0 + 2.18 + 7.03)/5 = 3.82 ug/L

4. Calculation of Average Concentration of Competing Electron Acceptors.

Average dissolved concentration of competing electron acceptors in area of pilot calculated from Phase I and Phase II RI ground-water quality data. Competing electron acceptors requiring evaluation in Regenesis Software include oxygen, nitrate, manganese, iron, and sulfate.

DO @ MW16-14D 0.19 mg/L (Phase I), 0.57 mg/L (Phase II)
DO @ MW16-15D 1.0 mg/L (Phase I), 0.47 mg/L (Phase II)
DO @ MW16-32D N/A (Phase I), 1.78 mg/L (Phase II)
Average DO = (0.19 + 0.57 + 1.0 + 0.47 + 0.08 + 1.78)/6 = 0.68 mg/L

NO_3 @ MW16-14D ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-15D ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-32D N/A (Phase I), <0.1 mg/L (Phase II)
Average NO_3 = (0.05 + 0.05 + 0.05 + 0.05)/4 = 0.05 mg/L

Mn @ MW16-14D 0.424 mg/L (Phase I), 0.290 mg/L (Phase II)
Mn @ MW16-15D 0.190 mg/L (Phase I), 0.150 mg/L (Phase II)
Mn @ MW16-32D N/A (Phase I), <0.015 mg/L (Phase II)
Average Mn = (0.424 + 0.290 + 0.190 + 0.150 + 0.457 + 0.230 + 0.007)/7 = 0.25 mg/L

Fe @ MW16-14D 8.17 mg/L (Phase I), 2.4 mg/L (Phase II)
Fe @ MW16-15D 2.06 mg/L (Phase I), 1.3 mg/L (Phase II)
Fe @ MW16-32D N/A (Phase I), <0.1 mg/L (Phase II)
Average Fe = (8.17 + 2.4 + 2.06 + 1.3 + 7.48 + 2.2 + 0.05)/7 = 3.38 mg/L

SO_4 @ MW16-14D ND (Phase I), 20.0 mg/L (Phase II)
SO_4 @ MW16-15D ND (Phase I), 20.6 mg/L (Phase II)
SO_4 @ MW16-32D N/A (Phase I), 2.27 mg/L (Phase II)
Average SO_4 = (20.0 + 20.6 + 7.73 + 2.27)/4 = 12.6 mg/L

CONCLUSION:

Calculated data will be utilized in Regenesis Software for HRC Barrier Design in Deep Overburden Zone. Additional data collected during installation of Deep Pilot Test Injection Wells will be used to refine design calculations for both the Deep Zone.

HRC Design Software for Barrier Treatment

Regenesis Technical Support: USA (949) 366-8000, www.regenesis.com

Site Name: HRC Pilot Northeast of Building 41 - Deep Overburden Zone
Location: Site 16 - NCBC Davisville, RI
Consultant:

Site Conceptual Model/Extent of Plume Requiring Remediation

Length of Barrier (intersecting gw flow direction)	100	ft		
Depth to contaminated zone	45	ft		
Thickness of contaminated saturated zone	20	ft		
Aquifer soil type	sand	<-(not recognized, enter Kh or Vs below)		
Effective porosity	0.3			
Hydraulic conductivity	23.4	ft/day	=	8.3E-03
Hydraulic gradient	0.006	ft/ft		
Seepage velocity	170.8	ft/yr	=	0.468

Dissolved Phase Electron Donor Demand

	Contaminant Loading Conc (mg/L)	Contaminant Loading Mass (lb)	Stoich. (wt/wt) contam/H_2
Tetrachloroethene (PCE)	0.00	0.00	20.7
Trichloroethene (TCE)	3.90	24.93	21.9
cis-1,2-dichloroethene (DCE)	0.00	0.02	24.2
Vinyl Chloride (VC)	0.00	0.00	31.2
Carbon tetrachloride	0.00	0.00	19.2
Chloroform	0.00	0.00	19.9
1,1,1-Trichloroethane (TCA)	0.00	0.00	22.2
1,1-Dichlorochloroethane (DCA)	0.00	0.00	24.7
Hexavalent Chromium	0.00	0.00	17.3
User added, also add stoichiometric demand	0.00	0.00	0.0
User added, also add stoichiometric demand	0.00	0.00	0.0

Competing Electron Acceptors:

	Electron Acceptor Loading Conc (mg/L)	Electron Acceptor Loading Mass (lb)	Stoich. (wt/wt) contam/H_2
Oxygen	0.68	4.35	8.0
Nitrate	0.05	0.32	12.4
Est. Mn reduction demand (potential amt of Mn2+ formed)	0.25	1.60	27.5
Est. Fe reduction demand (potential amt of Fe2+ formed)	3.38	21.61	55.9
Estimated sulfate reduction demand	12.60	80.56	12.0

Microbial Demand Factor	3	Recommend 1-4x
Safety Factor	2	Recommend 1-4x
Lifespan for one application	1	Year(s)

Injection Spacing and Dose:

Number of rows in barrier	2	rows
Spacing within rows	20	ft on center spacing within rows
Effective spacing perpendicular to flow (ft)	10.0	
Total number of HRC injection locations	10	points
Minimum required HRC dose per foot (lb/ft)	5.5	

Project Summary			
Number of HRC delivery points (adjust as nec. for site)			12
HRC Dose in lb/foot (adjust as nec. for site)			6.0
Corresponding amount of HRC per point (lb)			120
Number of 30 lb HRC Buckets per injection point			4.0
Total Number of 30 lb Buckets			48
Total Amt of HRC (lb)			1,440
HRC Cost		$	7.50
Total Material Cost		**$**	**10,800**
Shipping and Tax Estimates in US Dollars			
Sales Tax	rate: 0%	$	-
Total Matl. Cost w/Tax		$	10,800
Shipping of HRC (call for amount)		$	600
Total Regenesis Material Cost		**$**	**11,400**

Project	Site 16 HRC Injection Pilot Study – NCBC Davisville, RI	Project No.	2960107
Subject	Step 3: Calculations for Transport of HRC Reagent	Sheet No.	1 of 1
	HRC Barrier Treatment Design	Drawing No.	
Computed by	FTB	Date	9/03(rev 7/04)
Checked by		Date	

OBJECTIVE:

Based on site data from the Phase I and Phase II Remedial Investigation Reports and output from Regenesis Software, calculate the distance of travel of HRC reagent based on observed groundwater seepage velocity and four month duration of Pilot Test.

ASSUMPTIONS:

Use calculated data on the average hydraulic conductivity (K), hydraulic gradient (Dh/Dl) and, therefore, average groundwater seepage velocity (V) within the Deep Zone (see Software Input Calculations) to determine average HRC seepage velocity for the Deep Zone. More specifically, average HRC reagent seepage velocity will be 170.8 ft/yr as calculated by Regenesis Software for Deep Zone. Additional data collected during installation of Deep Pilot Test Injection Wells will be used to refine design calculations for the Deep Zone. Although Pilot Test was originally considered for measurement only initially over four months, time duration for complete utilization of one round HRC reagent injection estimated to be one year.

PROCEDURE:

1. Calculation of Travel Distance (D_{HRC})of HRC Reagent over the originally considered Time Duration (T) of Pilot Test.

D_{HRC} = V * T = 170.8 ft/yr * 0.33 yrs = 56.4 ft downgradient of HRC injection rows.

2. Calculation of Travel Distance (D_{HRC})of HRC Reagent over Time Duration (T) for complete utilization of one round of HRC reagent injection.

D_{HRC} = V * T = 170.8 ft/yr * 1.0 yrs = 170.8 ft downgradient of HRC injection rows.

CONCLUSION:

Monitoring well placement for HRC Pilot Test designed to incorporate area of HRC reagent transport from the originally considered four months to approximately one year (i.e., estimated timeframe for complete utilization of one round of HRC injection). Monitoring wells for Pilot Test placed in a longitudinal and transverse array (Figure 5 of QAPP for HRC Pilot Study) to measure the originally considered short term (four months) and long term (one year) effectiveness of HRC to create strongly reducing conditions and enhance anaerobic biodegradation.

Attachment 2

Standard Operating Procedures for Field Sampling

ATTACHMENT 2 STANDARD OPERATING PROCEDURES FOR FIELD SAMPLING

1. STANDARD OPERATING PROCEDURE NO. 1 – GROUND-WATER SAMPLING BY LOW-FLOW PURGE AND SAMPLING METHOD USING DEDICATED BLADDER PUMPS

1.1 SCOPE OF APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to establish the protocol for collecting ground-water samples using dedicated bladder pump systems installed in each monitoring well. The procedures are designed for the collection of ground-water samples with minimum turbidity, and are intended to be used in conjunction with the analyses for the types of ground-water contaminants previously identified at the Site. This SOP was prepared based on draft guidance prepared by U.S. Environmental Protection Agency (EPA) Region 1. All instruments should be calibrated in accordance with EPA Draft Calibration Procedures, included as Attachment 6 of the QAPP.

1.2 EQUIPMENT/MATERIALS

- HRC® Injection Pilot Study Quality Assurance Project Plan (QAPP)
- Flame ionization detector (FID) with and without granular activated charcoal (GAC) filter (and photoionization detector [PID] with 10.6 electron volt [eV] lamp, as needed) calibrated response factor for TCE.
- Well construction data, location map, field data from last sampling event (where applicable)
- Field logbook and Field Record of Well Gauging, Purging, and Sampling forms (attached)
- Electronic water level measuring device, 0.01-ft accuracy for monitoring water level during pumping operations
- Dedicated adjustable-rate bladder pumps
- Tubing:
  - Teflon®-lined polyethylene between the well cap and the flow-through cell
  - Teflon® insert fittings (where required)
- Flow measurement supplies (e.g., graduated cylinder and stop watch)

- Power source (nitrogen tank, generator, battery, etc.)

- Water quality indicator parameter monitoring instruments for measurement of pH, turbidity, specific conductance, Eh, dissolved oxygen, and temperature. Water quality indicator parameters will be measured in the field in accordance with EPA's *Methods for Chemical Analysis of Water and Wastes* [EPA-600/ 4-79-020 (1983)] using the following methods: temperature (Method 170.1), pH (Method 150.1), turbidity (Method 180.1), specific conductance (Method 120.1), and dissolved oxygen (Method 360.1)

- Flow-through cell for water quality probes

- Hach Kit DR/700 Series or similar for field measurements of Ferrous Iron

- Hach Digital Titrator 8205 or similar for field measurements of Carbon Dioxide.

- Decontamination supplies (for monitoring instrumentation)

- Sample bottles and sample preservation supplies (as required by the analytical methods)

- Sample tags or labels

- Coolers with bagged ice for sample bottles

- Gate key for site access and monitoring well key for locked well casings.

1.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing well purging and ground-water sampling. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook and sampling form, as appropriate: site name, project number, field personnel, well identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Check well for damage or evidence of tampering, record pertinent observations in field logbook and sampling form.

- Unlock well and remove well cap (if applicable).

- Measure volatile organic compound (VOC) with a PID/FID instrument at the casing of the well and in the breathing zone, and record the readings in the field logbook and on the sampling form. Compare with action levels in Safety, Health, and Emergency Response Plan (SHERP) (Appendix A, Table 9-1) before proceeding. If an action level(s) is exceeded, follow the 'Required Response' stated in Table 9-1 of Appendix A.

- Measure and record the height of protective casing above the concrete pad or ground surface, as appropriate. This reading is compared to that recorded during well installation as an indication of possible well damage or settling that may have occurred.

- Prepare the bladder pump by checking electrical connections and discharge tubing.

1.4 WELL PURGING AND SAMPLING PROCEDURES

The low-flow sampling protocol will be as follows:

1. Measure Water Level

   Using a properly decontaminated electronic water level indicator and/or oil/water interface probe, measure and record the depth to ground water (0.01 ft) from the top of the monitoring well casing before purging begins. If the well casing does not have a reference point (usually a v-cut or indelible mark in the well casing), make one.

2. Purge Well

   - Purge each well with the adjustable-rate bladder pump dedicated to the well (and dedicated length of Teflon®-lined polyethylene tubing also to be left in each well) until the pH, specific conductance, dissolved oxygen (DO), Eh (if DO is not detected), turbidity (5 nephelometric turbidity units goal) and temperature have stabilized (less than ±0.1 pH units and within 10 percent for turbidity [above 1 nephelometric turbidity units values] and DO, 3 percent for specific conductance and temperature, and ± 10 millivolts for Eh between three consecutive readings at 5-minute intervals). Stabilization of the water level in the well should be achieved. This is defined as no more than 0.02 ft drawdown between the 5-minute measuring intervals and/or 0.3 ft drawdown overall during the purging event. However, it must be noted that the tidal stages impact the pressure head (water level) of the "deep" wells and the water level of some shallow wells, such that water level stabilization will likely be impossible.

   - Dedicated, in-place Teflon®-lined polyethylene tubing with attached bladder pump will already have been installed so that the pump intake is at the approximate middle of the screened interval of the well or within 5 ft of the well bottom, if this zone is screened. For well screens that breach the water table, the pump intake will be placed at the approximate middle of the water column in the well. To minimize sediment/silt

mobilization (turbidity) from the bottom of the well, the pump intake should be kept a minimum of 2–3 ft above the bottom of the well.

- Using the Teflon® insert fitting in the well cap, connect the Teflon®-lined polyethylene tubing (in the well) with a new short length of Teflon®-lined polyethylene tubing. Connect the other end of this short length of tubing to the cleaned flow-through cell of the water quality meter (YSI 6-Series or equivalent). Additionally, a Teflon® "T" fitting will be placed in the tubing prior to the flow-through cell of the water quality meter through which water will be collected for turbidity measurement using a turbidity meter.

- Care will be taken to keep the Teflon®-lined polyethylene tubing full of water in that portion of the tubing above the top of the well during purging and sampling (i.e., to mitigate the presence of air pockets).

- Using the variable speed bladder pump, purge the monitoring well. Start the pump at its lowest speed setting and slowly increase the speed until discharge occurs. Once water reaches the well cap/flow-through cell, decrease the flow rate and check the water level. Adjust pump speed until water level drawdown stabilizes (ideally less then 0.3 ft). Continue purging until indicator field parameters stabilize.

  For wells with low recharge rates with screened intervals that are totally below the water table (or potentiometric surface), do not draw the water level in the well down below the top of the screened interval. Stop the pump when the water level is just above the top of the screened interval, allow time for recharge, and then resume pumping. Repeat this as necessary until the water quality parameters have stabilized as stated above. For very low yield wells, if the recharge rate of a well is lower than the extraction rate capability of the bladder pump and the well is essentially dewatered during purging, then the well should be sampled as soon as the water level has recovered sufficiently to collect the appropriate volume needed for all anticipated samples. Notify the EA Project Manager and record the information in the sampling form.

- Every 5 minutes, measure and record the depth to water (below the top of the well casing), the pumping rate (in milliliters per minute [mL/min]), pH, turbidity, specific conductance, temperature, Eh, DO, and salinity.

- Ideally, stabilization of the water level in the well should be achieved. This is defined as no more than 0.02 ft drawdown between the 5-minute measuring intervals and/or 0.3 ft drawdown overall during the purging event. The pumping rate should be adjusted (decreased) to mitigate drawdown of the water level to within the specified target range. (Ideally, at the pumping rate of 100 mL/min, there would be no drawdown of the water level.) If no more than 0.3 ft of drawdown occurs, the

drawdown is considered negligible and sampling can begin after achieving stabilization of the field-measured water quality parameters. However, it must be noted that the tidal stages impact the pressure head (water level) of the "deep" wells and the water level of some shallow wells such that water level stabilization will not likely be impossible.

- If more than 0.3 ft of drawdown occurs during the purging process in a well that is not influenced by the tide stages then, at a minimum, the volume of water discharged to that point must again be removed from the well, e.g., if 0.5 gal of water was purged from the well prior to stabilization of the water level, then an additional 0.5 gal must be purged whether or not the field-measured water quality parameters have stabilized. The final purge volume must be greater than the stabilized drawdown volume plus pump/tubing volume.

- If the stabilization of the water level or water quality parameters or the recharge rate requires more than 2 hours of purging time for the well, contact the EA Project Manager for discussion and decision as to how to proceed. Purged water will be containerized in drums and labeled in accordance with Section 1.8.

3. Collect Sample

- Field Measure Ferrous Iron and Carbon Dioxide as per manufacturers instructions included with field kit. **NOTE – if Ferrous Iron reading is off scale, dilute another sample with lab grade distilled water and reanalyze, noting on the field form the amount of dilution.**

- Ground-water sampling will continue directly after completion of purging using the same pump and Teflon®-lined polyethylene tubing. The short length of tubing connecting the well cap with the flow-through cell will be disconnected from the cell and ground-water samples will then be taken. VOC samples will be collected first in the following manner:

  — Collect VOC samples directly into the pre-cleaned, pre-preserved sample containers provided and designated by the laboratory.

  — Test VOC sample container will be checked with pH paper to confirm adequate preservation (i.e., pH<2). Additional HCL will be added to the volatile organic analyte (VOA) vials if necessary.

  — VOC vials will be completely filled without headspace above the liquid portion (to minimize volatilization). A check to see that the Teflon®-lined silicone septum is correctly placed in the cap will be undertaken prior to tightly securing the cap. After the cap is sealed, the vials will be inverted, lightly tapped, and

checked for bubbles. If bubbles are present, they will be eliminated by adding additional sample water before the vial is resealed.

The water sample aliquots for the additional analytical parameters, as listed in Table 8-1 of the QAPP, will then be collected in the proper containers, labeled, and sent to the laboratory for analysis. Methods and quality control criteria are stated in Chapter 9 of the QAPP. As each sample is obtained, observations made will be recorded on the Field Sampling form and the field notebook.

1.5 FIELD QUALITY CONTROL

Quality control samples are required to verify that the sample collection and handling process has not affected the quality of the ground-water samples. All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples will be collected for each sample delivery group (SDG) (an SDG may not exceed 20 samples) at the frequency noted:

- Field Duplicate – Required at a frequency of 10 percent per SDG
- Matrix Spike/Matrix Spike Duplicate – Required at a frequency of 5 percent
- Equipment (Rinsate) Blanks and Source Water Blanks – Not necessary because dedicated or new equipment and tubing will be used for those portions of the sampling system that comes in contact with the ground-water sample
- Trip Blank – Required for VOC samples at a frequency of one per sample shipment container
- Temperature Blank – One per sample cooler.

1.6 SAMPLE DESIGNATION, LABELING, HANDLING, CUSTODY, SHIPPING, AND DOCUMENTATION

1.6.1 Sample Designation and Labeling

Once the ground-water samples have been collected, label the appropriate sample bottle with the appropriate sample tag and provide the following data for the chain-of-custody (C-O-C): sample identification number, project number and name, date, time, sampler's signature, number of containers per analyte, analysis requested, and preservative(s) added.

The following sample designation system will be used for the HRC® Injection Pilot Study:

I. Ground-Water Samples

Example: MW16-21S = The ground-water sample from monitoring well 21S at Site 16.

II. Quality Assurance/Quality Control Samples

Example 1: MW16-DUP01

- MW – water sample from monitoring well at Site 16
- DUP01 – First duplicate. The actual well number and depth interval from which the duplicate sample is collected will be recorded in the field notebook and Field Sampling form.

Example 2: TB16-01 = The first trip blank for VOC analysis for monitoring well sampling work at Site 16.

Example 3: MW16-23D-MS/MSD = The matrix spike/matrix spike duplicate for monitoring well 23D at Site 16.

1.6.2 Handling, Custody, and Shipping

Sample containers will be temporarily stored in the refrigerators at the EA Field Office for pick-up by the laboratory (Ceimic Corporation) that is located approximately 20 minutes from the EA Field Office. Complete C-O-C document (provided by the contracted laboratory) entries and record the sampling event in the bound field notebook. Just prior to pick-up of the samples by the laboratory, the properly labeled sample containers will be placed in bubble-wrap (or similar) and packed in coolers with wet ice which has been double bagged with heavy duty polyethylene bags or similar, prior to placement into the sample cooler. Samples will be packed to maintain a temperature of 4°C. As the samples are transferred to the laboratory pick-up staff, the C-O-C form(s) will be signed by both the EA and laboratory staff.

The laboratory will be notified by telephone of the sample pick-up needs at least 24 hours in advance. Laboratory will be notified at least 1 week prior to the beginning of sampling. The sample containers for ground-water matrix are listed in Table 9-1 of the QAPP.

1.6.3 Sample Documentation

The documentation necessary for this HRC® Injection Pilot Study sampling includes the following:

- Field notebook
- C-O-C form
- Field Sampling form.

1.6.3.1 Field Notebook

The Contract Task Order (CTO) Project Manager will control all field notebooks. Field notebooks will be issued to the Field Team Leader. Field notebooks will be bound books that are at least 4.5 × 7 in. in size. Field notebooks will be maintained by the Field Team Leader and other team members to provide a daily record of significant events, observations, and measurements during the field investigation.

All information pertinent to the field survey and/or sampling will be recorded in the notebooks. Field notebook entries will include, at a minimum, the following information:

- Name of author, date and time of entry, and physical/environmental conditions during field activity
- Names and titles of field crew and subcontractors
- Names and titles of any site visitors
- Type of sampling activity
- Location of sampling activity
- Description of sampling point(s)
- Date and time of sample collection
- Sample media (i.e., ground water)
- Number and volume of sample(s) collected
- Analyses to be performed
- Field observations
- Calibration/maintenance requirements of field equipment.

Original data recorded in either the field notebooks, on sample labels, or in the C-O-C records will be written with indelible ink. None of these accountable documents will be destroyed or discarded, even if they are illegible or contain inaccuracies.

If an error is made on an accountable document assigned to an individual, that individual will make all corrections by drawing a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. Any subsequent error discovered on an accountable document will be corrected by the person who made the entry, and will be initialed and dated, as appropriate.

1.6.3.2 Chain-of-Custody Forms

A completed C-O-C form will accompany the samples shipped to the laboratory and will contain the following information:

- Project name and project number
- Name of person(s) collecting samples
- Date and time samples were collected
- Type of sampling conducted (e.g., grab)
- Sample Matrix (i.e., ground water)
- Parameters and method for analysis
- Location of sampling station
- Field filtration and/or preservation methods
- Number and type of containers used
- Signature of field personnel relinquishing sample
- Date and time of custody transfer to overnight courier
- Name of sample courier (e.g., United Parcel Service, Federal Express).

The C-O-C forms provided by the contracted laboratory with the sample containers/coolers will be completed by the sampling team and included with the samples.

1.6.3.3 Field Sampling Form

This document is used by the person sampling to record the physical measurements of the sample information, and also as a reference.

1.7 DECONTAMINATION

Non-dedicated (re-used) sampling equipment (none expected for this ground-water sampling) and field monitoring equipment (e.g., water level and water quality meter probes and cable [that contacts well casing or ground water]) and flow-through cell will be decontaminated prior to use and following sampling of each well. This equipment will be decontaminated by the procedure listed below. Alternative procedures must be approved by the EA Project Manager prior to sampling event.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution (e.g., Liquinox®)
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol be used sparingly in the above sequence.

1.8 INVESTIGATIVE DERIVED WASTE (IDW) MANAGEMENT

This section addresses the procedures for handling, collection, and storage of IDW generated during well sampling activities. Purging/sampling water and other decontamination-related wastes will be containerized in 55-gal steel drums (17E-type for liquid waste and 17H-type for solid wastes). Large volumes of purge water can be consolidated and temporarily stored in 200- to 2,000-gal polyethylene tanks, or similar, staged in the vicinity of the EA field office for temporary storage pending its disposition for proper disposal.

1.8.1 Sampling/Purge Water

Sampling/purge water will be initially containerized in 17E-type, 55-gal drums at the time of generation. The drums will be marked as IDW and labeled with the description of the drum contents, site name, boring/well number, and date the drum was filled. The drummed IDW water will be staged in the vicinity of the EA field office for temporary storage pending its disposition for proper disposal. Large volumes of purge water can be consolidated and temporarily stored in 200- to 2,000-gal polyethylene tanks, or similar, staged in the vicinity of the EA field office for temporary storage pending its disposition for proper disposal.

1.8.2 Decontamination Fluids

Liquid generated as a result of decontamination activities will be collected and containerized initially in17E-type, 55-gal drums at the time of generation. The drums will be marked as IDW and labeled with the description of drum contents, related monitoring well numbers, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal.

1.8.3 Other Waste

Other wastes generated during sampling and decontamination activities, including discarded personal protective equipment, aluminum foil, and other debris, will be collected and

containerized in17H-type, 55-gal drums marked as IDW and labeled with the description of drum contents, related boring/well numbers, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal.

2. STANDARD OPERATING PROCEDURE NO. 2 SOIL BORING SAMPLING AND MONITORING WELL INSTALLATION PROCEDURE

2.1 SCOPE OF APPLICATION

The purpose of this SOP is to establish the protocol for collecting soil samples. The procedure is designed to permit the collection of representative soil samples. This SOP is suitable for collecting soil samples requiring laboratory analyses for contaminants. Soil sampling will be conducted during drilling of soil borings and monitoring wells as shown on Figure 5 in the QAPP.

The collected soil samples will be analyzed for the parameters listed in Table 8-1 of the QAPP.

2.2 EQUIPMENT AND MATERIALS

- HRC® Injection Pilot Study QAPP
- Flame ionization detector (FID) with and without granular activated charcoal (GAC) filter (and photoionization detector [PID] with 10.6 electron volt [eV] lamp, as needed)
- Location map, field data from last sampling event (where applicable)
- Field logbook
- Decontamination supplies (for sampling equipment and monitoring instrumentation)
- Sample bottles and sample tags or labels
- Gate key for site access.

2.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing drilling and soil sampling. Field logbooks and sampling forms should be filled out as the procedure is being performed, as noted.

The drilling activity will be performed using the following guidelines:

- Obtain NCBC Davisville and Rhode Island Economic Development Corporation (RIEDC) approval for profiling and boring locations
- Obtain all clearances for profiling and boring locations: Dig Safe (800-344-7233), NCBC Davisville (401-294-6108), and RIEDC (401-277-3134)

- Mitigate potential contamination of the aquifer by the drilling equipment.

All fieldwork described here in will also be performed in accordance with the Safety, Health, and Emergency Response Plan (SHERP) (Appendix A).

SUBSURFACE UTILITY CLEARENCE

NCBC Davisville, RIEDC, and Dig Safe clearance will be obtained prior to conducting any drilling activities. Location and marking of all underground utilities in the vicinity of each site will be done prior to any drilling. The drilling subcontractor will obtain required drilling permits necessary for completion of the fieldwork. This clearance will be coordinated by the EA Project Manager.

2.4 SAMPLING PROCEDURE

Drilling, Subsurface Soil Sampling, and Monitoring Well Installation

Borings will be advanced for the installation of 12 deep overburden injection wells, and 49 monitoring wells (13 shallow overburden ['S'; soil/water-table interface, approximately 20 ft bgs], 12 intermediate overburden ['I'; 10-ft interval at the silt layer[s], at approximately 40 ft bgs], 13 deep ('D') overburden zone (10-ft interval just above competent bedrock; anticipated to be gravelly sand and/or weathered bedrock to an average depth of 65 ft bgs and 11 rock ('R') (roller-bit drilled borehole approximately 25–30 ft in competent bedrock to an average depth of 90 ft bgs). The location of these wells is shown on Figure 5 in the QAPP.

Drilling will be performed using standard methods, including hollow-stem auger and/or drive and wash with 4- to 6-in diameter steel casing which has been steam-cleaned (in accordance with the Decontamination Procedure in Section 2.7), prior to use at each boring. The following summarizes the methods for the drilling and installation of the monitoring wells:

- Drive and Wash Method for Overburden and Weathered Bedrock ('D') Screened Monitoring and Injection Well – Drive and wash 4-in. diameter temporary steel casing to the top of competent bedrock, tri-cone drill 3 ft into rock to confirm rock, then obtain a 5-ft length of NX-core of the rock. The overburden will be sampled using a 2- to 3-in. inner diameter (ID) split-barrel sampler that is 18 in. or 24 in. in length. Such samples will be collected continuously from ground surface to the top of bedrock or refusal. **[Upon completion of soil sampling for each such well, immediately FAX the boring log to the EA Project Manager/Senior Geologist for review and confirmation of the interval to be screened. The EA Project Manager/Senior Geologist may also need to discuss and confirm the screened interval with the Navy Technical Manager.]** Place bentonite in borehole to top of competent rock and construct a 2-in. ID polyvinyl chloride (PVC) well with 10-ft length screen (6- to 10-slot for monitoring wells and 40- to 60-slot for injection wells), appropriate filter sand, bentonite seal, and cement-bentonite grout the

annular space as the temporary casing is removed unless otherwise directed by the EA Project Manager/Senior Geologist after review of the boring log. In areas of paved surfaces, the well will be completed in a curb-box and with a 2-ft by 2-ft cement pad flush with the paved surface. Monitoring well completions in non-paved areas can be completed approximately 2–3 ft above ground with 4-in. ID steel protective casing and locking cap and a 2-ft by 2-ft cement pad at ground surface.

- Shallow Overburden Water Table ('S') screened monitoring wells - prior to drilling, measure water level at adjacent monitoring wells and consult the table of historical water level measurements (Summary of Depth to Ground-Water Measurements, Site 16; provided in Attachment 1 of the QAPP). Using hollow-stem augers (HSA) and based upon the hydrogeological findings of the 'deep' well of the pair, drill to depth of average about 20 ft below grade, i.e. about 9 ft below the apparent water table. There will be no soil sampling for the shallow wells. Shallow monitoring wells will be screened 9 ft below the deepest depth to water (as measured historically [water level data table in Attachment 1 of the QAPP] and recently in an adjacent monitoring well completed in the overburden). Construct a 2-in. ID PVC well with 10-ft length screen (6- to 10-slot), appropriate filter sand, bentonite seal, and cement-bentonite grout the annular space as the HSA are removed. In areas of paved surfaces, the well will be completed in a curb-box and with a 2-ft by 2-ft cement pad flush with the paved surface. Monitoring well completions in non-paved areas can be completed approximately 2–3 ft above ground with 4-in. ID steel protective casing and locking cap and a 2-ft by 2-ft cement pad at ground surface.

- Intermediate Overburden ('I') screened monitoring wells –
  Using hollow-stem augers (HSA) or drive and wash and based upon the hydrogeological findings of the 'deep' well of the pair, drill to depth of average about 40 ft below grade. There will be no soil sampling for the intermediate wells. Construct a 2-in. ID PVC well with 10-ft length screen (6- to 10-slot), appropriate filter sand, bentonite seal, and cement-bentonite grout the annular space as the HSA are removed. In areas of paved surfaces, the well will be completed in a curb-box and with a 2-ft by 2-ft cement pad flush with the paved surface. Monitoring well completions in non-paved areas can be completed approximately 2–3 ft above ground with 4-in. ID steel protective casing and locking cap and a 2-ft by 2-ft cement pad at ground surface.

- Drive and Wash Method for Upper Bedrock ('R') Monitoring Well – Based upon the depth to bedrock encountered in the adjacent existing deep (D) well, 8-in. ID temporary steel casing will be driven/washed to within approximately 2 ft of the known top of competent bedrock. Then drill a 3-ft deep socket into rock with 6-in. tri-cone. There will be no sampling of the soil overburden. Place and grout 4-in. ID steel casing centered and to the bottom of the hole (allow grout to setup for 24 hours before continuing drilling). Tri-cone drill 25 ft of bedrock beyond the bottom of the 4-in. steel casing. In areas of paved surfaces, the monitoring well 4-in. ID steel casing will be completed in a curb-box

and with a 2-ft by 2-ft cement pad flush with the paved surface. For monitoring well completions in non-paved areas, the 4-in. ID steel casing can be completed approximately 2–3 ft above ground with a locking cap and a 2-ft by 2-ft cement pad at ground surface. The bedrock portion below the 4-in. ID casing will remain as an open borehole, i.e., no PVC well will be constructed.

Soil Boring and Sampling

Drill cuttings will be containerized and handled in accordance with the Investigative Derived Waste (IDW) procedures. The area above the borehole will be monitored with a FID (and PID equipped with a 10.6 electron volt [eV] probe, as needed). The FID and PID will be calibrated each workday before work begins, and checked after lunch, at the end of the day, and as required in the field. The procedures for the calibration of the PID and FID are included in Attachment F of the SHERP (see Appendix A of the QAPP).

Drilling and sampling equipment including drill pipe, sampling tools, and drill casing will be freed of potentially contaminating materials by steam cleaning prior to use at each boring. The drill rig will be steam cleaned prior to use at NCBC Davisville Site 16 and as required by the EA Geologist or Geotechnical Engineer. The rig will be free of leaks, which could potentially contaminate the borings. No petroleum-based grease will be used on drill pipe joints.

Samples will be obtained in soil by driving a 2- to 3-in. ID split-barrel sampler that is 18 in. or 24 in. in length. The sampler will be driven into undisturbed soil by a 140-lb drop hammer free-falling 30 inches. A 300-lb drop-weight may be used with the 3-in. ID split-barrel sampler, but must be noted on the boring log when used. The number of "blows" (hammer drops) required to effect each successive 6 in. of penetration are recorded on the log. The sampler is advanced until one of the following occurs:

a. A total of 50 blows have been applied during any one of the first, second, or third 6-in. increment;

b. There is no observed advance of the sampler during the application of 10 successive blows of the hammer; or

c. A 24-in. sampler is advanced a total of 24 in. or an 18-in. long sampler is advanced a total of 18 in. without the limiting blow counts, as described above, occurring.

For each of the 'deep' ('D') overburden zone monitoring and injection wells, soil samples will be collected continuously using a split-barrel sampler from ground surface to the top of bedrock or refusal which ever is encountered first.

Headspace Vapor Screening

The headspace vapor screening method requires that soil be collected from every split spoon and containerized in at least 2 glass jars. The following methodology will be used:

1. Immediately after opening the split-spoon sampler and after collecting the VOC sample aliquot, if required, a representative portion of the sample will be collected and placed in a clean glass jar. Half-fill two (2) 8- to 16-oz clean glass jars with the sample to be field screened. Cover with a clean sheet of aluminum foil, and apply the screw cap to seal the jar tightly.

2. If the volume of sample recovered is insufficient for all analytical requirements, then the material used in the headspace readings could be utilized for any non-volatile sample aliquot requirements.

3. Allow headspace development for at least 10 minutes. Vigorously shake jars for 15 seconds at the both beginning and end of the headspace development period.

4. If ambient temperature is below 32°F, develop headspace in a heated vehicle or building.

5. After headspace development in at least 2 glass jars, remove screw lid/expose foil seal of each jar. Quickly puncture foil seal of 1 jar with instrument (FID <u>without</u> granular activated charcoal [GAC] filter) sampling probe and then quickly puncture the foil seal of a second jar with instrument (FID <u>with</u> GAC filter), to a point about one-half of the headspace depth. Exercise care to avoid uptake of water droplets or soil particles.

6. Record highest meter reading, which should occur 2–5 seconds following probe insertion. Erratic readings may occur at elevated humidity or at high organic vapor concentrations. Screening data from duplicate jars should be consistent within ± 20 percent.

7. FID, with and without GAC filter (and PID, as needed), field instruments will be operated and calibrated to yield "total organic vapors" in parts per million volume (ppm_v). PID instruments must be operated with a 10.6 eV lamp source. Operation, maintenance, and calibration will be performed in accordance with the manufacturers specifications.

Collection of Soil for Chemical Analyses

Soil sample aliquots will be collected from the split-barrel sampler from the planned intervals and placed in appropriate containers on ice for submittal to the lab for chemical analysis. Soil material will not be composited between sample intervals. Soil sample aliquots planned for VOC analysis will be collected from the split-barrel sampler and quickly placed in the sample containers with methanol preservative provided by the contracted laboratory and placed on ice. Handling, labeling, and shipping of samples is presented in Section 2.6.

- Directly fill the laboratory-provided VOC-aliquot sample containers from the sampling device.

  — For VOC, collect 10 g of soil for each of 3 40-mL volatile organic analysis (VOA) vials, 2 that each contain 10 mL methanol preservative, and 1 that contains sodium bisulfate. In addition, fill one 4-oz jar with soil (unpreserved) for moisture content analysis.

- Combine the remainder of the sample material for non-VOC sample aliquots in a decontaminated, stainless steel bowl, mixed together with a decontaminated stainless steel spoon, then:

  Fill one laboratory-provided 16-oz jar for the following analyses:

  — Total Organic Carbon.

- Label each sample as collected. Those samples (VOC, etc.) requiring cooling will be placed into an ice cooler for delivery to the laboratory.

Water Source

Water for drilling, steam cleaning, and other necessary field activities will be arranged by the drilling contractor from the potable water system/hydrant at NCBC Davisville as coordinated with the RIEDC. The drilling contractor will be responsible for obtaining and transporting all water to the drilling areas for required uses. EA will sample the water at each source and analyze it for the same parameters specified for ground-water samples. This information and documentation of the source of the water (i.e., fire hydrant location) will be is used to evaluate the potential effect the water source may have on the analytical results for samples collected from the borings.

Borehole Logging

The drilling activities will be observed by an EA Geologist or Geotechnical Engineer. The Geologist or Geotechnical Engineer will log the subsurface conditions encountered in the boring and record the information on a soil boring log and rock core log as follows.

Soil Borehole Logging Requirements

Soil samples will be visually classified in the field using a modified Unified Soil Classification System (USCS). Soil borehole logging requirements are:

1. Logs will be prepared in the field, as borings are drilled, by an EA Geologist or Geotechnical Engineer. Each log will include the name of the preparer and the date of the logging activity, and quality control (QC) checked in the office by a Senior Geologist.

2. Borehole depth information will be direct measurements from land surface accurate to 0.1 ft.

3. Logs will be prepared on a Soil Boring Log Form.

4. Relevant information in the log heading will be completed. Location sketches referenced by measured distances or prominent surface features (where present), will be shown on or attached to the log.

5. Log scale will be as shown on the attached form.

6. Material type encountered will be described on the log form. Unconsolidated materials will be described as follows:

   - Descriptive modified USCS classification modified from ASTM D 2488-84

   - Consistency of cohesive materials or apparent density of non-cohesive materials (attached Table)

   - Moisture content assessment, (e.g., dry, moist, wet)

   - Color

   - Other descriptive features (e.g., bedding characteristics, organic materials, macrostructure of fine-grained soils, e.g., root holes and fractures)

   - Fill material will be described including organic and inorganic material (e.g., wood, plastic, glass, paper, metal)

   - The number of hammer blows required to advance a split-barrel sampler shall be recorded for each 0.5-ft advance for each sampling attempt. The number of blows and the number of inches penetrated for an uncompleted 0.5-ft interval shall be recorded (e.g., 75/3 in.). "WOR" or "WHO" will indicate that the sampler was advanced by the weight of the drill rods (WOR) or the weight of the drill rods and hammer without driving (WHO).

7. For each soil sampling attempt the type and diameter of sampler shall be indicated at the appropriate depth.

8. Depth of casing during sampling.

9. Borehole refusal – the maximum depth to which 4-in. diameter casing can be advanced.

10. Borehole and sample diameters and depths at which drilling or sampling methods or equipment change.

11. Total depth of penetration and sampling. The bottom of the hole will be clearly identified on the log with the notation "Bottom of Borehole" or "End of Boring."

12. Document the use of drilling fluids, including source water and additives by brand and product name.

13. Document discernable drilling fluid losses to the geological formation or discernable gains, including depths at which they occur, and estimated volume lost or gained.

14. Depth and type of temporary casing used, if any.

15. Visual/olfactory observations of contamination in samples, cuttings, or drilling fluids, (e.g., staining, odors).

16. FID measurements (and PID measurements, as needed).

Bedrock Borehole Logging Requirements

Bedrock borehole logging requirements are:

1. Logs will be prepared on a Log of Core Boring.

2. The core bit size shall be indicated on the first sheet of each Core Log Form.

3. Information will be recorded on the log in reference to the depth scale of the log.

4. The Geologist or Geotechnical Engineer will record drilling activities in chronological sequence and with respect to the depth scale in the Drilling Log. Equipment changes will be documented with notation of time (24 hour clock), date of occurrence, and depth of the boring at the time of occurrence.

5. Start and stop time (24 hour clock) for each core run will be recorded. Interruptions in coring shall be documented by time of occurrence and description of the problem and its resolution. Coring rates and depths of significant changes in coring rate shall be recorded.

6. The intervals of non-recovered core will be estimated and an evaluation of the reason for loss recorded.

7. Casing depth, changes in core bit size, and changes in color of circulating water/drilling fluid will be recorded. Quantitative estimates of discernable fluid losses and gains to the geological formation and the estimated interval over which they occur will be indicated.

8. A description of special problems and their resolutions will be recorded on the boring log, (e.g., hole caving, recurring problems at a particular depth, plugging of the core barrel, unrecovered tools).

9. A summary description of the completion of the monitoring well will be summarized on the boring log.

10. Core runs will be numbered consecutively down the hole as performed and indicated on the log with horizontal lines at the appropriate depth and the core run number recorded in the lower left quadrant of the Core Log Form for the indicated core run.

11. Total core recovery will be measured to within 0.1 ft and recorded on the log.

12. Total core recovery as a percent of the length of the core run will be determined for each core run and recorded on the log.

13. The Rock Quality Designation (RQD) as a percent of the length of the core run will be calculated for each core run and recorded on the log. The RQD method of determining rock quality is as follows:

    The sum of the total length of core pieces recovered in each run that are at least 4 in. in length and which are hard and sound, divided by the total length of the run, represented as a percentage. If the core is broken by handling or by the drilling process, the fresh broken pieces will be fitted together and counted as one piece.

14. The angle of bedding and schistosity will be recorded as the dip angle as measured from the perpendicular to the core axis.

15. The angle of fracture, joint, fault, or seam surfaces shall be measured from the perpendicular to the core axis and graphically illustrated.

16. The dominant type of coatings or fillings present in fractures or seams will be recorded. Slickensides shall be identified as apparent dip-slip or strike-slip.

17. Standard rock symbols will be used in the graphic log to show major variations in lithology. Minor changes will be documented in the written lithologic log.

18. Rock cores will be visually described for the following parameters:

- Lithology
- Grain size and texture
- Color
- Bedding/Foliation/Banding
- Weathering
- Solution or void conditions.

The upper bedrock wells ("R") will not be cored. Bedrock of the "R" wells will be drilled by roller bit or down-hole hammer. The time required to drill each 1 ft of the bedrock will be recorded on the Log of Core Boring, and the rock cuttings will be sieved from the drilling wash and the description included on the Log of Core Boring (noted a wash/cuttings).

Handling and Storage of Rock Core

Rock cores will be placed in wooden core boxes with the top and bottom of each run clearly labeled. Core will be placed with the top at upper left and bottom at lower right of the core box. For the standard hinged core box, the hinged side is designated the upper side of the box. Any breaks that are made to fit the core into the boxes will be marked as such.

Wooden spacers showing the footage at the beginning of each run will be placed in the boxes. In addition, core boxes will be clearly marked on the inside and outside of top cover and each outside end to identify the job, the boring number, the numerical sequence of the box (e.g., 2 of 7), and the footage interval within the box.

While the rock core is lying in the core box, the visible surface of the core will be rinsed with clean water and a soft brush to remove dried silty drilling fluid. After rinsing of the core, digital photographs will be taken of each box of rock core (the 0–5 ft portion of a tape measure will be placed along the edge of the uppermost length of core for scale).

When it is necessary to split cores for detailed examination, the cores will be handled carefully and put back into the box in the same position as they were prior to splitting.

Borehole Backfilling

If a borehole must be abandoned, bentonite chips or bentonite/cement grout will be placed in the borehole as the backfilling material from the bottom of the boring up to ground surface as the HSA or temporary casing is removed. As the bentonite or bentonite/cement grout is placed, the depth to the top of the bentonite backfill will be measured/monitored with a weighted tape.

2.5 FIELD QUALITY CONTROL FOR SAMPLES

Quality control samples are required to verify that the sample collection and handling process has not affected the quality of the sediment samples. All field quality control samples must be prepared exactly as regular investigation samples with regard to sample volume, containers, and preservation. The following quality control samples will be collected for each SDG.(an SDG may not exceed 20 samples) at the frequency noted.

- Field Duplicate – Required at a frequency of 10 percent per SDG
- Matrix Spike/Matrix Spike Duplicate – Required at a frequency of 5 percent
- Equipment (Rinsate) Blank – Required at a frequency of 10 percent per Monitoring Event because, although each sediment sample corer is dedicated to a specific sampling location, it is re-used at that same specific location for each Monitoring Event
- Trip Blank – Required for VOC samples at a frequency of 1 per sample shipment cooler containing VOC samples
- Temperature Blank – One per sample cooler.

2.6 SAMPLE DESIGNATION, LABELING, HANDLING, CUSTODY, SHIPPING, AND DOCUMENTATION

2.6.1 Sample Designation and Labeling

Once the soil samples have been collected, label the appropriate sample bottle with the appropriate sample tag and provide the following data for the C-O-C: sample identification number, project number and name, date, time, sampler's signature, number of containers per analyte, analysis requested, and preservative(s) added.

EA will employ the following sample designation system:

I. Soil Samples

Example: MW16-33-02-04 = The soil sample collected from monitoring well 33, sample depth 2 to 4 ft bgs, at Site 16.

INJ16-05D – 20-24 = The soil sample collected from injection well 05, sample depth 20 to 24 ft bgs, at Site 16.

II. Quality Assurance/Quality Control Samples

Example 1: MW16-DUP01

- MW16 – soil sample from monitoring well at Site 16
- DUP 1 – First duplicate. The actual well number and depth interval from which the duplicate sample is collected will be recorded in the field notebook.

Example 2: TB16-01 = The first trip blank for VOC analysis for HRC® soil sampling work at Site 16.

Example 3: RB16-01 = The first rinsate blank sample for soil sampling work at HRC® Pilot Test Site 16.

Example 4: MW16-33D-MS/MSD = The matrix spike/matrix spike duplicate for soil sample from soil boring -33D at HRC® Pilot Test Site 16.

2.6.2 Handling, Custody, and Shipping

Sample containers are temporarily stored in the refrigerators at the EA Field Office for pick-up by the laboratory (Ceimic Corporation) that is located approximately 20 minutes from the EA Field Office. Complete chain-of-custody (C-O-C) document (provided by the contracted laboratory) entries and record the sampling event in the bound field notebook. Just prior to pick-up of the samples by the laboratory, the properly labeled sample containers will be placed in bubble-wrap (or similar) and packed in coolers with wet ice which has been double bagged with heavy duty polyethylene bags or similar, prior to placement into the sample cooler. Samples will be packed to maintain a temperature of 4°C. As the samples are transferred to the laboratory pick-up staff, the C-O-C form(s) will be signed by both the EA and laboratory staff.

The laboratory will be notified by telephone of the sample pick-up needs at least 24 hours in advance. Laboratory will be notified at least 1 week prior to the beginning of sampling. The sample containers for ground-water matrix are listed in Table 9-1 of the QAPP.

2.6.3 Sample Documentation

The documentation necessary for this investigation includes the following:

- Field notebook
- C-O-C form
- Field Sampling form.

2.6.3.1 Field Notebook

The CTO Project Manager will control all field notebooks. Field notebooks will be issued to the Field Team Leader. Field notebooks will be bound books that are at least 4.5-in. × 7-in. in size. Field notebooks will be maintained by the Field Team Leader and other team members to provide a daily record of significant events, observations, and measurements during the field investigation.

All information pertinent to the field survey and/or sampling will be recorded in the notebooks. Field notebook entries will include, at a minimum, the following information:

- Name of author, date and time of entry, and physical/environmental conditions during field activity
- Names and titles of field crew and subcontractors
- Names and titles of any site visitors
- Type of sampling activity
- Location of sampling activity
- Description of sampling point(s)
- Date and time of sample collection
- Sample media (i.e., sediment)
- Number and volume of sample(s) collected
- Analyses to be performed
- Field observations.

Original data recorded in either the field notebooks, on sample labels, or in the C-O-C records will be written with indelible ink. None of these accountable documents will be destroyed or discarded, even if they are illegible or contain inaccuracies.

If an error is made on an accountable document assigned to an individual, that individual will make all corrections by drawing a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. Any subsequent error discovered on an accountable document will be corrected by the person who made the entry, and will be initialed and dated, as appropriate.

2.6.3.2 Chain-of-Custody Forms

A completed C-O-C form will accompany the samples shipped to the laboratory and will contain the following information:

- Project name and EA project number
- Name of person(s) collecting samples
- Date and time samples were collected
- Type of sampling conducted (e.g., composite, grab)

- Sample Matrix (i.e., sediment)
- Parameters and method for analysis
- Location of sampling station
- Field filtration and/or preservation methods
- Number and type of containers used
- Signature of EA field personnel relinquishing sample
- Date and time of custody transfer to overnight courier
- Name of sample courier (e.g., United Parcel Service, Federal Express).

The C-O-C forms provided by the contracted laboratory with the sample containers/coolers will be completed by the sampling team and included with the samples.

2.7 DECONTAMINATION

2.7.1 Drill Rig, and Downhole Drill Tools

Equipment (drilling tools/pipe, bits, temporary steel casing) that will be used during drilling activities will be steam cleaned prior to use and before starting each boring. Equipment will be kept off the ground on clean sawhorses, racks, or pallets. If blowing dust is a problem, equipment shall be covered with plastic sheeting during storage. Upon completion of the work, the portions of the drilling rig which came in contact with subsurface soil/drilling fluids will be steam cleaned.

2.7.2 Sampling Equipment

Re-used field monitoring and sampling equipment will be decontaminated prior to use and following sampling of each station by the procedure listed below. The following decontamination procedure will be used:

Flush the equipment with potable water
- Flush with non-phosphate detergent solution
Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol be used sparingly in the above sequence.

2.8 INVESTIGATIVE DERIVED WASTE (IDW) MANAGEMENT

This section addresses the procedures for handling, collection, and storage of IDW generated during field activities. IDW will be managed in accordance with the RIDEM *Guidelines for the*

Management of Investigation Derived Waste (Policy Memo 95-01). Drill cuttings/fluids, purging/sampling water, decontamination fluid, and other decontamination-related wastes will be containerized in 55-gal steel drums (17E-type for liquid waste and 17H-type for solid wastes) or covered roll-off containers.

2.8.1 Drill Cuttings

Drill cuttings will be initially containerized in 17H-type, 55-gal drums and located in the vicinity of the boring/monitoring well, and then, consolidated in roll-offs located in the vicinity of the EA Field Office for temporary storage pending its disposition for proper disposal. Drums will be marked as IDW and labeled with the contents (soil), the soil boring designation number, and the date of collection. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal.

Non-hazardous soil cuttings generated from drilling activities are planned to be transported to and disposed of at the Resource Conservation and Recovery Act (RCRA) Subtitle D facility at the Central Landfill, in Johnston, Rhode Island for use as alternative cover material. Soil IDW determined to be above regulatory levels for disposal at the Central Landfill will be disposed of appropriately in accordance with state and federal regulations.

2.8.2 Decontamination Fluids

Liquid generated as a result of decontamination activities will be collected and containerized initially in 17E-type, 55-gal drums at the time of generation. The drums will be marked as IDW and labeled with the description of drum contents, related boring/well numbers, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal.

2.8.3 Other Waste

Other wastes generated during sampling and decontamination activities, including discarded personal protective equipment, aluminum foil, and other debris, will be collected and containerized in 17H-type, 55-gal drums marked as derived waste and labeled with the description of drum contents, related sampling location designation, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal as solid waste.

2.9 INJECTION AND MONITORING WELLS

This section presents procedures for injection and monitoring well installation, well material specifications, well development, and permeability testing.

2.9.1 Well Construction Materials

2.9.1.1 Well Riser and Screen

Riser pipe will consist of:

- New 2-in. ID threaded, flush-joint, Schedule 40 PVC for the monitoring wells and,
- 2-in. ID threaded, flush-joint steel for the injection wells.

The pipe will bear markings that identify the material. No organic solvents or glue will be used in joining the pipe. The use of a Teflon® tape on threaded joints is acceptable on an as-needed basis, and will be noted on the well construction log.

Well screen material for the deep (D) overburden monitoring will consist of new, commercially fabricated, 10-ft length, threaded, flush-joint, machine-slotted 6- to 10-slot, 2-in. ID Schedule 40 PVC. A threaded PVC cap or plug will be placed on the bottom of such wells.

Well screen material for the deep (D) overburden injection wells will consist of new, commercially fabricated, 10-ft length, threaded, flush-joint, continuous wrap 20-slot, 2-in. ID stainless steel. A threaded cap or plug will be placed on the bottom of such wells. The injection wells will have a 20-slot screens used to allow for the HRC® fluid injection.

No screen is planned to be used in the construction of the monitoring wells completed in the upper bedrock (R).

Well screens and riser will be steam cleaned prior to installation unless they arrive and are maintained onsite in the factory-provided packaging.

2.9.1.2 Filter Pack

The annular space around the well screen will be backfilled with a clean, washed, silica sand to perform as a filter between the formation material and the well screen. It is anticipated that grade #0 sand is an appropriate size for the 6-slot well screens and grade #1 sand is an appropriate size for the 10-slot well screens. It is anticipated that grade #2 sand is an appropriate size for the 20-slot well screens. The grade/type of the filter pack that is used will be included on the well construction diagram.

2.9.1.3 Bentonite Seal

The well seal will be comprised of commercially manufactured bentonite pellets or granules, not exceeding 0.5-in. in diameter.

2.9.1.4 Grout Mixture

The cement grout will consist of Type I or II Portland cement (ASTM-C150) and water added in the proportion of no more than 7 gal per 94-lb bag of cement. Additionally, 3 percent by weight of granular bentonite will be added to the mixture to help reduce shrinkage.

2.9.2 Installation

2.9.2.1 Screened Interval

Part of the wells will be used as locations from which to collect ground-water samples and to measure depth to ground-water. Monitoring wells constructed in bedrock will not be screened.

2.9.2.2 Construction

The screen and riser pipe, as specified in Section 2.9.1.1, will be installed through the driven casing with the screen positioned as described in Section 2.4. For the deep ('D') overburden borings/wells, the 5-ft cored rock portion of the hole will be backfilled with bentonite chips or pellets prior to placement of the PVC or stainless steel screen.

Following placement of the well screen, sand for the filter pack (specified in Section 2.9.1.2) will then be placed by tremie pipe through the annular space between the well pipe and sides of the driven casing. If drilling mud is used to maintain borehole stability during drilling and soil sampling, the mud will be thinned to approximately water viscosity prior to placement of the filter sand. The casing will be withdrawn incrementally as the sand is placed into the annular space. The sand will be placed to approximately 1–2 ft above the top of the screen. A steel-weighted surveyor's tape, or similar, will be used to sound the top of the filter pack during emplacement of the sand pack.

Following placement of the sand, a bentonite seal (specified in Section 2.9.1.3) will be placed through the casing in a manner similar to the filter pack. The bentonite seal will be placed above the filter pack to prevent intrusion of the grout into the filter sand. The minimum thickness of the bentonite seal will be 2 feet. The bentonite seal will be allowed to hydrate a minimum of 1 hour before grouting begins. The quantities of sand and bentonite introduced to the well will be measured and compared to a calculated estimate of the materials required based on well/borehole dimensions.

Following placement of the bentonite seal, the casing will be withdrawn as the remainder of the annular space is sealed with a cement-bentonite grout (specified in Section 2.9.1.4). The grout will be placed in the annular space between the well casing and the boring (or steel casing) from the top of the bentonite seal to the ground surface. Grout will be placed by pumping through a tremie pipe with the lower end of the pipe approximately 3 ft above the top of the bentonite seal. Pumping will continue until undiluted grout flows from the annular space at the ground surface.

Should the top of the bentonite seal occur within 5 ft of the ground surface, the grout will be poured into the borehole annular space from the ground surface.

Following completion of the grouting operation each well will be completed by venting the side of the riser pipe approximately 6 in. from the top with a small drilled hole. A locking expandable cap and a surficial protective steel casing or box will be used to secure the well (Section 2.9.2.3).

2.9.2.3 Protection and Completion of Wells

Throughout the progress of the work, precautions will be taken to mitigate tampering with the well or entrance of foreign material into it. If rain occurs during construction of a well such that sheet flow across ground surface is probable, runoff will be prevented from entering the well during the construction by placing a temporary earthen berm around the well. The well will be further secured by placing a suitable cover over the well at the end of the day until the well construction activity resumes.

In areas of paved surfaces, the well will be completed in a curb-box and with a 2-ft by 2-ft cement pad flush with the paved surface. Monitoring well completions in non-paved areas can be completed approximately 2–3 ft above ground with 4-in. ID steel protective casing and locking cap and a 2-ft by 2-ft cement pad at ground surface. The protective steel casing will be installed in a manner that does not hinder access to the monitoring or injection well for purposes of obtaining samples or water level measurements.

A minimum 2-ft × 2-ft × 4-in. thick concrete pad, sloped away from the well, will be constructed around each well casing with the top outer edge at ground surface.

2.9.3 Well Numbering and Labeling

Monitoring wells will be numbered sequentially for each well location. The following suffixes will also be included: 'S' for shallow water table overburden zone wells, 'I' for intermediate overburden zone monitoring wells completed at the silt layer(s), 'D' for wells completed in the deep overburden/weathered rock zone, 'R' for wells completed in upper competent bedrock. A permanent monitoring well designation will be stenciled on each well with oil-based paint.

3. STANDARD OPERATING PROCEDURE NO. 3
WELL DEVELOPMENT AND BLADDER PUMP INSTALLATION PROCEDURE

3.1 SCOPE OF APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to establish the protocol for well development and bladder pump installation. **Please Note – bladder pumps will be installed in monitoring wells only.** Well development will be conducted at least 48 hours after installation of each monitoring well to be developed. The locations of monitoring wells are shown on Figure 5 in the QAPP.

3.2 EQUIPMENT AND MATERIALS

- HRC® Injection Pilot Study QAPP
- Flame ionization detector (FID) with and without granular activated charcoal (GAC) filter (and photoionization detector [PID] with 10.6 electron volt [eV] lamp, as needed)
- Location map
- Field logbook
- Decontamination supplies
- Generator, pump, clean dedicated tubing, control box
- Well development form
- Gate key for site access and monitoring well key for locked well casings.

3.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing well development. Field logbooks and development forms should be filled out as the procedure is being performed, as noted.

- Enter the following information in the field logbook and on the development form, as appropriate: site name, project number, field personnel, sample station identification, weather conditions, date and time, and equipment used.
- Visually inspect sample station for evidence of changes in physical condition; record pertinent observations in field logbook.

- Measure volatile organic compound (VOC) with an ionization detector (ID) (flame or photo) instrument in the breathing zone and record the reading in the field logbook. Compare with action levels in Safety, Health, and Emergency Response Plan (SHERP) (Appendix A, Table 9-1) before proceeding. If an action level(s) is exceeded, follow the 'Required Response' stated in Table 9-1 of Appendix A.

3.4 WELL DEVELOPMENT AND BLADDER PUMP INSTALLATION PROCEDURE

The monitoring wells will be developed no sooner than 48 hours after grouting is completed. Development protocol will be as follows:

1. Measure static water level. Water levels will be measured using a properly decontaminated water level indicator capable of measuring liquid depth to an accuracy of 0.01 ft.

2. Measure total well depth.

3. Develop the well by alternately surging (via a clean surge block, bailer, or small diameter submersible pump) and pumping to remove "fines" from the well screen and filter sand. When pumping results in discharged water that appears to be relatively clear of turbidity, the well will be surged again. Continue this procedure until little or no sediment enters the well, but for no less than 2 hours. The well will be pumped using a decontaminated electric submersible pump (or centrifugal pump may be used, if the depth to water is less than 15-20 ft below grade). Temperature, pH, specific conductivity, dissolved oxygen (DO), and turbidity of the ground water will be monitored during pumping. For wells with a very silty water discharge, measurement of these parameters should not begin until the discharge water is relatively free of 'fines'. Pumping will continue until these parameters have stabilized (less than $\pm$ 0.2 pH units variation and less than a 10 percent change for other parameters between 4 consecutive readings) and the water is clear and free of "fines." If the parameters have not stabilized after 3 hours of development, contact the EA Project Manager.

   If well yield is too low to permit continuous pumping or bailing, the well will be bailed or pumped dry 3 times. The well will be allowed to recharge for up to 0.5 hr between each bailing or pumping session.

   If water was "lost" to the geological formation during drilling operations, at a minimum, a volume equivalent to the estimated amount "lost" will be removed during development.

4. Development water investigative derived waste (IDW) handling will be performed in accordance with the IDW procedures (Section 3.8).

5. Install the dedicated adjustable-rate bladder pump in each monitoring well (not in injection wells) with the intake set at the depth as determined by the EA Task Manager and Project Manager from the soil sample headspace vapor measurement data and as coordinated with the BRAC Cleanup Team (BCT).

Well Development Records

A Well Development Form will be prepared and completed for each monitoring well installed. The form will be prepared by the EA representative present during the well development operations. Information provided on the Well Development Form will include the following:

- Client, name of project and site, project number, well identification number, and date(s)
- Date, time, and elevation of the static water level and bottom of well before development
- Determination of the gallons of water per well volume
- Method used for development, to include: equipment; size, type, make of bailer and/or pump used during development, and decontamination procedures
- Time spent developing the well by each method, to include the typical pumping rate, as possible, if a pump was used in development
- Estimated volume and physical character of water removed, to include changes in clarity, color, particulates, and odor during development
- Volume and source of water added to the well
- Readings of pH, DO, PID screening, specific conductance, temperature, and turbidity taken before, during, and at the end of development
- Name(s) of individual(s) developing well
- Location of the temporary storage area for the water removed during development.

3.4.1 Field Notebook

The EA Project Manager will control all field notebooks. Field notebooks will be issued to the Field Team Leader. Field notebooks will be bound books that are at least 4.5 × 7 in. in size. Field notebooks will be maintained by the Field Team Leader and other team members to provide a daily record of significant events, observations, and measurements during the field investigation.

All information pertinent to the field survey and/or sampling will be recorded in the notebooks. Field notebook entries will include, at a minimum, the following information:

- Name of author, date and time of entry, and physical/environmental conditions during field activity
- Names and titles of field crew and subcontractors
- Names and titles of any site visitors
- Type of field activity
- Location of field activity
- Date and time of field activity
- Volume of water removed from monitoring well during well development
- Field observations.

Original data recorded in either the field notebooks or on development forms will be written with indelible ink. None of these accountable documents will be destroyed or discarded, even if they are illegible or contain inaccuracies.

If an error is made on an accountable document assigned to an individual, that individual will make all corrections by drawing a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. Any subsequent error discovered on an accountable document will be corrected by the person who made the entry, and will be initialed and dated, as appropriate.

3.4.2 Well Development Form

This document is used by the person developing to record the physical measurements of the well information, and also, as a reference.

3.5 DECONTAMINATION

Field monitoring and well development equipment (e.g., pump, water level and water quality meter probes and cable [that contacts well casing or ground water] and flow-through cell) will be decontaminated prior to use and following sampling of each well by the procedure listed below.

- Flush the equipment with potable water

- Flush with non-phosphate detergent solution
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol be used sparingly in the above sequence.

3.6 INVESTIGATIVE DERIVED WASTE (IDW) MANAGEMENT

This section addresses the procedures for handling, collection, and storage of IDW generated during well development. Decontamination fluid and other decontamination-related wastes will be containerized in 55-gal steel drums (17E-type for liquid waste and 17H-type for solid wastes).

3.6.1 Development Water

Well development water will be initially containerized in 17E-type, 55-gal drums at the time of generation. The drums will be marked as IDW and labeled with the description of the drum contents, site name, boring/well number, and date the drum was filled. The drummed IDW water will be staged in the vicinity of the EA field office for temporary storage pending its disposition for proper disposal. Large volumes of development water can be consolidated and temporarily stored in 200- to 2,000-gal polyethylene tanks, or similar, staged in the vicinity of the EA field office for temporary storage pending its disposition for proper disposal.

3.6.2 Decontamination Fluids

Liquid generated as a result of decontamination activities will be collected and containerized initially in 17E-type, 55-gal drums at the time of generation. The drums will be marked as IDW and labeled with the description of drum contents, related boring/well numbers, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal.

3.6.3 Other Waste

Other wastes generated during development and decontamination activities, including discarded personal protective equipment, aluminum foil, and other debris, will be collected and containerized in 17H-type, 55-gal drums marked as IDW and labeled with the description of drum contents, related sampling location designation, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal as solid waste.

4. STANDARD OPERATING PROCEDURE NO. 4 – *IN SITU* HYDRAULIC CONDUCTIVITY TESTS - SLUG TESTS

4.1 SCOPE OF APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to establish the protocol for performing *in situ* permeability tests on monitoring wells. The tests will be performed after development and return of the water level to static conditions. The purpose of the permeability tests is to estimate the local hydraulic conductivity (K) of the screened formation. The two types of tests that will be performed are a rising head or "slug out" test, where a known volume (slug) is removed the well, and a falling head or "slug in" test, where a known volume (slug) is inserted into the well. The falling head test can not be performed in a well if the static water level is within the screen. Slug tests provide less accurate data than pumping tests, but are preferable to dealing with a large volume of contaminated water that could result from pumping tests.

Data logging will be performed in accordance manufacturers specifications. The recorded data will be evaluated using the Bower and Rice Method (or similar) to estimate the local hydraulic conductivity (K) adjacent to the tested well screen.

4.2 EQUIPMENT/MATERIALS

- HRC® Injection Pilot Study QAPP
- Well Construction Diagram and/or construction details
- Pressure transducer (mini-TROLL or similar)
- Water level indicator
- Laptop computer (data logger)
- Slug of known volume
- Decontamination supplies.

4.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing the hydraulic conductivity analyses. Field logbooks should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook, as appropriate: site name, project number, field personnel, well identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Check well for damage or evidence of tampering, record pertinent observations in field logbook.

- Unlock well and remove well cap (if applicable).

- Measure volatile organic compound (VOC) with a photoionization detector (PID) or FID instrument at the casing of the well and in the breathing zone, and record the readings in the field logbook. Compare with action levels in Safety, Health, and Emergency Response Plan (SHERP) (Appendix A, Table 9-1) before proceeding. If an action level(s) is exceeded, follow the 'Required Response' as stated in Table 9-1 of Appendix A (SHERP).

- Measure and record the height of protective casing and well riser above the concrete pad or ground surface, as appropriate. These measurements are compared to that recorded during well installation as an indication of possible well damage or settling that may have occurred. Measure and record the diameter of the PVC well casing and the total depth of the well.

- Measure the depth to water. If the static water level is not above the screened interval, a falling head test cannot be performed.

- Note the current tidal stage as predicted by a National Oceanic and Atmospheric Administration (NOAA) tide chart for Newport, Rhode Island.

4.4 PROCEDURES

4.4.1 Slug Testing

Slug test procedures will be as follows:

1. Falling Head Test: Connect the transducer to the computer. This step must be taken prior to the computer being turned on or the computer will not recognize the transducer as being connected. Follow the instructions on the data-logging program and lower the transducer into the well when appropriate.

   The transducer must be far enough below the water surface (e.g. 15–20 ft if possible) so that the slug will not hit the transducer, and shallow enough so that the transducer is not on the bottom of the well.

   Analysis of the test assumes an instantaneous rise in the water level, so the slug must be inserted as quickly as possible, but not quickly enough so the water level bounces up and down as a result of the slug's impact with the water surface. Logging should be initiated a fraction of a second before the slug enters the water. This timing often takes practice and is critical because the transducer logs at an increasing exponential rate, meaning that the initial readings are close together and get exponentially farther apart as time passes. The first few seconds are critical in measuring the initial response of the water column to the introduction of the slug. It is important that the transducer logs (records) at least

2 readings of the static water level prior to introduction of the slug to provide a baseline measurement to indicate the static water level height above the transducer.
The next step is to wait for water level stabilization. This must be measured via the transducer, as inserting a water level indicator into the water column may adversely affect water level readings by the transducer. The data logger is not capable of displaying real-time water levels, but it is possible to download water level data while the transducer remains in a logging state. Wait for the water level to return within at least 90 percent of its static water level, at which time logging may be terminated.

2. Rising Head Test: This test is best performed after the falling head test, as static water level stabilization has already occurred with the slug in the well. If the falling head test was not performed prior to this test, then after introduction of the slug, the return of the water level to static conditions must be confirmed and documented prior to initiation of the rising head test (removal of the slug).

   As with the falling head test, transducer logging must commence immediately prior to slug removal. The slug should be removed from the water column immediately after the logging has begun and must be pulled out as quickly as possible. It is imperative that the slug be completely removed from the well as quickly as possible because water falling from the slug rope as well as the slug itself can influence transducer readings. Analysis of the test assumes an instantaneous rise in the water level, so the slug must be removed as quickly as possible. Wait for the water level to return within at least 90 percent of its static water level, at which time logging may be terminated.

3. Review the plot of time versus the difference in water column height from the static water level to confirm that data was collected.

4.4.2 Field Notebook

The EA Project Manager will control all field notebooks. Field notebooks will be issued to the Field Team Leader. Field notebooks will be bound books that are at least 4.5 × 7 in. in size. Field notebooks will be maintained by the Field Team Leader and other team members to provide a daily record of significant events, observations, and measurements during the field investigation.

All information pertinent to the field survey and/or sampling will be recorded in the notebooks. Field notebook entries will include, at a minimum, the following information:

- Name of author, date and time of entry, and physical/environmental conditions during field activity
- Names and titles of field crew and subcontractors
- Names and titles of any site visitors
- Type of field activity

- Location of field activity
- Date and time of field activity
- Field observations.

Original data recorded in the field notebooks will be written with indelible ink. None of these accountable documents will be destroyed or discarded, even if they are illegible or contain inaccuracies.

If an error is made on an accountable document assigned to an individual, that individual will make all corrections by drawing a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. Any subsequent error discovered on an accountable document will be corrected by the person who made the entry, and will be initialed and dated, as appropriate.

4.5 DECONTAMINATION

Equipment that comes in contact with ground water (transducer, water level indicator, slug) will be decontaminated before and after testing is performed at each well. This equipment will be decontaminated by the procedure listed below. Alternative procedures must be approved by the EA Project Manager prior to sampling event. New dedicated slugs will be used at each monitoring well location.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution (e.g., Liquinox®)
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol be used sparingly in the above sequence.

4.6 INVESTIGATIVE DERIVED WASTE (IDW) MANAGEMENT

This section addresses the procedures for handling, collection, and storage of IDW generated during well development. Decontamination fluid and other decontamination-related wastes will be containerized in 55-gal steel drums (17E-type for liquid waste and 17H-type for solid wastes).

4.6.1 Decontamination Fluids

Liquid generated as a result of decontamination activities will be collected and containerized initially in 17E-type, 55-gal drums at the time of generation. The drums will be marked as IDW, labeled with the description of drum contents, related boring/well numbers, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal.

4.6.2 Other Waste

Other wastes generated during slug testing and decontamination activities, including discarded personal protective equipment, disposable gloves, and other debris, will be collected and containerized in 17H-type, 55-gal drums marked as IDW and labeled with the description of drum contents, related sampling location designation, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal as solid waste.

5. STANDARD OPERATING PROCEDURE NO. 5 – HYDROGEN RELEASE COMPOUND (HRC®) INJECTION

5.1 SCOPE OF APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to establish the protocol for performing oversight of HRC® injection into wells for the pilot test (treatability study). The HRC® injection will be performed by an experienced, qualified sub-contractor familiar with HRC® Injection, after well development and return of the water level to static conditions. This treatability study seeks to test the general feasibility and overall applicability of *in situ* anaerobic reductive dechlorination by HRC® reagent within a pilot-scale field test located near the southwestern extent of the greater than 1,000 µg/L dissolved-phase CVOC plume (south of Davisville Road). The field pilot test will generally consist of applying HRC® in an array of 12 injection well pairs near the northeastern end of former Building 41, as shown on Figure 5 in the QAPP.

The field pilot test will generally consist of applying HRC® in a two linear arrays of injection well pairs located across the CVOC plume and monitoring the ground-water quality upgradient, within, and downgradient of the pilot treatment zone over a 4-month period. The HRC® well array will consist of 6 evenly spaced injection well pairs over two parallel lengths of approximately120 ft and oriented approximately perpendicular to the interpreted direction of ground-water flow. Injection wells will be installed for HRC® delivery instead of direct push application because direct-push equipment is not effective and cannot be used for the deep overburden, weathered bedrock, and competent rock zones. Each HRC® injection well pair will consist of an injection well screened within the basal sand/gravel and/or weathered bedrock ('D' well) and a well completed as an open hole in the upper 25 ft of competent rock approximately 25-ft in length ('R' well).

HRC® will be injected into the wells via strategically positioned packers and a pump capable of processing the HRC® material with a viscosity of 20,000 centipoise at flow rates of 3–10 gal per minute at pressures ranging from 200 to 1,500 psig.

The HRC® application will be conducted by a qualified vendor (i.e. Vironex) experienced with the subsurface injection of HRC®. Typically, one injection well can be completed per day using one injection unit, depending on soil type, depths of injection, and experience with HRC®.

5.2 EQUIPMENT/MATERIALS

- HRC® Injection Pilot Study QAPP
- Well Construction Diagram and/or construction details
- Water level indicator
- Decontamination supplies

- Field notebook
- Digital camera
- PPE, including eye protection and gloves
- Calculator.

5.3 PRELIMINARY SITE ACTIVITIES

The following site activities are required prior to performing HRC® Injection. Field logbooks should be filled out as the procedure is being performed, as noted:

- Enter the following information in the field logbook, as appropriate: site name, project number, field personnel, well identification, weather conditions, date and time, equipment used, and quality assurance/quality control data for field instrumentation.

- Check well for damage or evidence of tampering - record pertinent observations in field logbook.

- Unlock well and remove well cap (if applicable).

- Measure volatile organic compound (VOC) with a photoionization detector (PID) or FID instrument at the casing of the well and in the breathing zone, and record the readings in the field logbook. Compare with action levels in Safety, Health, and Emergency Response Plan (SHERP) (Appendix A, Table 9-1) before proceeding. If an action level(s) is exceeded, follow the 'Required Response' as stated in Table 9-1 of Appendix A (SHERP).

- Measure and record depth to water from the top of the casing in the injection well, and in the closest monitoring wells.

- Observe and record subcontractor's HRC® injection activity and volume.

5.4 PROCEDURES

5.4.1 HRC® Injection

Detailed HRC® Injection procedures from Regenesis are attached to this SOP. A subcontractor experienced with HRC® Injection will be performing HRC® Injection. A summary of HRC® Injection procedures is provided below:

- HRC® will be heated (approximately 95°F) and mixed to obtain desirable consistency.

- The delivery hose will be insulated to maintain temperature.

- Preheated HRC® will be poured into a hopper.

- A volume check will be performed prior to injection of HRC®.

  1. Determine the number of pump strokes needed to deliver 3 gal of HRC® using a graduated bucket,

  2. Divide the results from the first step to determine the number of gallons of HRC® delivered by each pump stroke.

  3. Level indicators present in the hopper are in 3-gal increments.

- Connect the delivery hose to the pump outlet and the provided HRC® delivery sub-assembly. Circulate HRC® through the house and the delivery sub-assembly to displace air in the hose.

- Connect the HRC® sub-assembly to the drive rod. After confirming that all of the connections are secure, pump the HRC® through the delivery system to displace the water/fluid in the rods. NOTE: prior to pumping HRC® into the aquifer, close the pup recirculation valve; failure to do so will allow the material to short-circuit into the hopper and change the volume of HRC® delivered per pump stroke.

- The pump engine RPM and hydraulic settings should remain constant through out the day.

- Use the pumps stroke counter and the provided volume/weight conversions to apply the appropriate HRC® volume per injection location (and per vertical foot of contaminated saturated zone). Typical HRC® delivery information example:

Pump stroke volume (gal)	Number of pump strokes	HRC® per stroke (pounds/stroke)
3.0	14	2.4
0.2	1	2.4

Example: for each injection location, install 60 pounds of HRC® across 10 vertical feet of aquifer (6 pounds per vertical foot HRC® dosing rate).

Solutions: 60 lb/10.8 lb per gal ~ 5.6 gal for the injection location
5.6 gal/0.2 gal per stroke ~ 28 pump strokes for the injection location
28 pump strokes/10 vertical feet = 2.8 strokes per vertical foot
2.8 strokes per vertical foot = 8.4 strokes per 3-ft drive rod
2.8 strokes per vertical foot = 11.2 strokes per 4-ft drive rod

- Slowly withdraw the drive rods. While withdrawing each length, pump the pre-determined volume of HRC® into the aquifer across the desired treatment interval. Use the stroke counter and pump on/off switch to control volume of injection.

- Remove one section of rod at a time. The drive rod may contain residual HRC®. Place the rod into a clean, empty bucket and allow the HRC® to drain.

- If aquifer acceptance appears to be low (high pitch squeal from hydraulic system), allow enough time for the aquifer to equilibrate prior to removing the drive rod.

- Remove and clean all rods.

5.4.2 Field Notebook

The EA Project Manager will control all field notebooks. Field notebooks will be issued to the Field Team Leader. Field notebooks will be bound books that are at least 4.5-in. × 7-in. in size. Field notebooks will be maintained by the Field Team Leader and other team members to provide a daily record of significant events, observations, and measurements during the field investigation.

All information pertinent to the field survey and/or sampling will be recorded in the notebooks. Field notebook entries will include, at a minimum, the following information:

- Name of author, date and time of entry, and physical/environmental conditions during field activity
- Names and titles of field crew and subcontractors
- Names and titles of any site visitors
- Type of field activity
- Location of field activity
- Date and time of field activity
- Field observations.

Original data recorded in the field notebooks will be written with indelible ink. None of these accountable documents will be destroyed or discarded, even if they are illegible or contain inaccuracies.

If an error is made on an accountable document assigned to an individual, that individual will make all corrections by drawing a line through the error, entering the correct information, and initialing and dating the correction. The erroneous information will not be obliterated. Any subsequent error discovered on an accountable document will be corrected by the person who made the entry, and will be initialed and dated, as appropriate.

5.5 DECONTAMINATION

Equipment that comes in contact with ground water (water level indicator) will be decontaminated before and after testing is performed at each well. This equipment will be decontaminated by the procedure listed below. Alternative procedures must be approved by the EA Project Manager prior to sampling event.

The following decontamination procedure will be used:

- Flush the equipment with potable water
- Flush with non-phosphate detergent solution (e.g., Liquinox®)
- Flush with tap water to remove all of the detergent solution
- Flush with distilled/deionized water
- Flush with isopropyl alcohol
- Flush with distilled/deionized water.

It is recommended that the detergent and isopropyl alcohol be used sparingly in the above sequence.

5.6 INVESTIGATIVE DERIVED WASTE (IDW) MANAGEMENT

This section addresses the procedures for handling, collection, and storage of IDW generated during well development. Decontamination fluid and other decontamination-related wastes will be containerized in 55-gal steel drums (17E-type for liquid waste and 17H-type for solid wastes).

5.6.1 Decontamination Fluids

Liquid generated as a result of decontamination activities will be collected and containerized initially in 17E-type, 55-gal drums at the time of generation. The drums will be marked as IDW, labeled with the description of drum contents, related boring/well numbers, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal.

5.6.2 Other Waste

Other wastes generated during HRC® Injection testing and decontamination activities, including discarded personal protective equipment, disposable gloves, and other debris, will be collected and containerized in 17H-type, 55-gal drums marked as IDW and labeled with the description of drum contents, related sampling location designation, and the date the drum was filled. The drums will be located in the vicinity of the EA Field Office for temporary storage pending their disposition for proper disposal as solid waste.

EA Engineering, Science, and Technology, Inc.

LOG OF SOIL BORING

Coordinates:	N. 111111 E: 111111
Surface Elevation:	11 11 FT MSL
Well Riser Elevation:	11 11 FT MSL

Job. No. 29601.07	Client EFANE	Location: SITE 16 NCBC Davisville
Drilling Method.		Boring No
Sampling Method: 2" split spoon Driven 24 in with 140 lb hammer		Sheet 1 of 1
Drilling Water Level		Start / Drilling Date/Times / Finish
Date		
Time		
Surface Conditions:		

Sample Type	Inches Driven/In. Recvrd	Dpth Csg.	Samp # / depth (ft)	FID / FID w/ filter	Blows per 6"	Ft bgs		USCS Log	SOIL DESCRIPTION
						1			
						2			
						3			
						4			
						5			
						6			
						7			
						8			
						9			
						10			
						11			
						12			
						13			
						14			
						15			
						16			
						17			
						18			
						19			

Logged by: _____ Date. _____

Drilling Contractor: _____ Driller _____

WELL SPECIFICATIONS:

Diam of Riser _____ Screen Interval: _____ Sandpack: _____ Grout _____

Bottom of Hole _____ Riser Interval. _____ Bentonite: _____ Cover. _____

EA Engineering, Science, and Technology, Inc.

LOG OF CORE BORING

Coordinates:	N 111111 E 111111
Surface Elevation.	11 11 FT MSL
Well Riser Elevation·	11 11 FT MSL

Job No 29601 07	Client EFANE	Location Site 16 NCBC Davisville, North Kingstown, RI
Drilling Method		Boring No.
Core Barrel used·		Sheet 1 of

Packer Test

Tested	NA	
Interval	NA	

See packer test log if applicable

Drilling Times	
Start	Finish

Core Run Run # REC	RQD	Strat-igraphy	Bedding / Fractures (dip & angle)	Filling	Depth in feet	Graphic Log	LITHOLOGIC LOG	DRILLING LOG: Core run Length (ft)	Drill Time/ft (min:sec)	Total Depth (ft bgs)
					65					
					66					
					67					
					68					
					69					
					70					
					71					
					72					
					73					
					74					
					75					
					76					
					77					
					78					
					79					
					80					
					81					
					82					
					83					

NOTES:

Logged by: _____

Drilling Contractor: _____

Driller: _____

Ground Water Field Sampling Form

Project Name: HRC Injection Pilot Study, Site 16 Project No.: 29601.07 Task: 3202 Date:

Well ID: Personnel: Start Time: Finish Time:

Air Monitoring Equipment Used (Make/Model/Serial No.): Photovac 2020

Calibration Information: See calibration log

Ambient Air Reading: ppm Well Headspace Reading: ppm

W ll Data/ Integrity

Well Locked ___ Yes ___ No

Protective Casing Secure ___ Yes ___ No

Concrete Collar Intact ___ Yes ___ No

Other:

Protective Casing Stick Up (ft):

Casing/Well Difference (ft):

Well Material: ___ PVC/ ___ SS/Other

Well Diameter: ___ 2-in. / ___ 4-in./ ___ 6-in./ Other

Water Level Equip. Used: √ Elect. Cond. Probe

___ Interface Probe

___ Press. Transducer

___

Water Level Data Measured from: Top of Riser

Depth to Bottom of Well: (ft) Depth to Pump Intake: (ft)

Depth to Top of Water: (ft) Depth of Screened Interval: (ft)

Fi ld Hach Kit Data

Concentration of Fe: Mg/L

Concentration of CO_2: Mg/L

Analytical Parameter	Check if Field Filtered	Volume Required/ Sample Container	Sample ID	Preservati n Meth d
TCL VOC (detection limit, <1 ug/L)(5030B / 8260B)		3@ 40 ml VOA	MW16-	HCL, < 4°C
Alkalinity, Sulfate, Total Chloride, Nitrate		1 liter poly	MW16-	< 4°C
Dissolved iron, Dissolved manganese	√	1 liter poly	MW16-	HNO_3< 4°C
Hydrogen sulfide		1 liter poly	MW16-	ZnAC / NaOH, < 4°C
Methan / Ethane / Ethene		3@ 40 ml VOA	MW16-	HCL, < 4°C

Equipment Identify equipment used (i.e., pumps, bailers, tubing, filters, etc.)

P = Purge S = Sampl		Equipment Used (serial number)	Decon M thod
P	S	Solinst Water Level Indicator	Alconox, isopropyl, DI
P	S	YSI 600XL Water Quality Meter w/Flow-Through Cell	Alconox, isopropyl, DI
P	S	Geolog dedicated bladder pump and tubing, MP 10 control box, nitrogen tank	NA
P	S	Lamotte 2020 Turbidimeter or similar	NA
P	S	Hach Kit DR-700 or similar (dissolved ferrous iron)	DI
P	S	Hach Kit 8205 or similar (dissolved carbon dioxide)	DI

See calibration log for equipment serial numbers and daily calibration information

Ground Water Field Sampling Form

Project Name: HRC Injection Pilot Study, Site 16 Project No.: 29601.07 Task: 3202 Date: _____

Well ID: _____ Personnel: _____ Start Time: _____ Finish Time: _____

Parameter (units)	Initial	Volume	Volume	Volume	Volume	Volume	Volume
Liters							
Time							
Temperature (°C)							
pH							
Conductivity (ms/cm)							
DO (mg/L)							
Turbidity (NTUs)							
Salinity (ppth)							
Eh (mV)							
Water Level (ft from TOR)							
Flow Rate (mL/min.)							

Parameter (units)	Volume	Volume	Volume	Volume	Volume	Volume	Volum
Liters							
Time							
Temperature (°C)							
pH							
Conductivity (ms/cm)							
DO (mg/L)							
Turbidity (NTUs)							
Salinity (ppth)							
Eh (mV)							
Water Level (ft from TOR)							
Flow Rate (mL/min.)							

Parameter (units)	Volume	Volume	Volume	Volume	Volume	Volume	Volume
Liters							
Time							
Temperature (°C)							
pH							
Conductivity (ms/cm)							
DO (mg/L)							
Turbidity (NTUs)							
Salinity (ppth)							
Eh (mV)							
Water Level (ft from TOR)							
Flow Rate (mL/min.)							

Notes: _____

Ground Water Field Sampling Form

Project Name: HRC Injection Pilot Study, Site 16 Project No.: 29601.07 Task: 3202 Date: _____

Well ID: _____ Personnel: _____ Start Time: _____ Finish Time: _____

Parameter (units)	Initial	Volume	Volume	Volume	Volume	Volume	Volume
Liters							
Time							
Temperature (°C)							
pH							
Conductivity (ms/cm)							
DO (mg/L)							
Turbidity (NTUs)							
Salinity (ppth)							
Eh (mV)							
Water L vel (ft from TOR)							
Flow Rate (mL/min.)							

Parameter (units)	Volume	Volume	Volume	Volume	Volume	Volume	Volum
Liters							
Time							
T mperature (°C)							
pH							
Conductivity (ms/cm)							
DO (mg/L)							
Turbidity (NTUs)							
Salinity (ppth)							
Eh (mV)							
Water Level (ft from TOR)							
Flow Rate (mL/min.)							

Parameter (units)	Volume	Volume	Volume	Volume	Volume	Volume	Volume
Liters							
Time							
Temperature (°C)							
pH							
Conductivity (ms/cm)							
DO (mg/L)							
Turbidity (NTUs)							
Salinity (ppth)							
Eh (mV)							
Water Level (ft from TOR)							
Flow Rate (mL/min.)							

Notes: _____

HACH Digital Titrator
General Description

1.1 Introduction

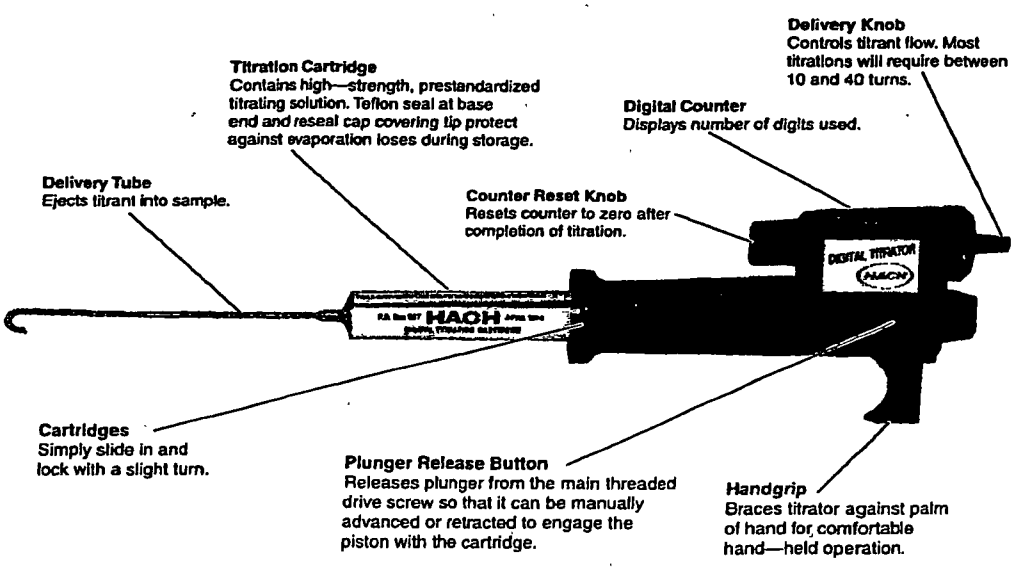
Hach's Digital Titrator is a new concept in titrimetric analysis. It is a precision dispensing device fitted with compact cartridges that contain concentrated titrants. Accurate titrations are made without the bulk and fragility of conventional burets.

A main drive screw in the Digital Titrator controls a plunger which forces the solution from a titration cartridge in a carefully regulated flow. The titrator body is constructed of precision-molded, heavy-duty, chemical- and impact-resistant acetal plastic. Accuracy is rated at ± I% or better for a titration of more than 100 digits. For titrations less than 100 digits the accuracy is ±l digit.

Titration solutions (titrants) are packaged in disposable polypropylene or Kynar containers with Teflon-covered neoprene seals and polyethylene resealable closures to cover the cartridge tips. Each cartridge contains approximately 13 mL of titrating solution, enough for 50- 100 average titrations. Titrant solutions are typically controlled to ±0.5% concentration with normality and tolerances listed on the label. Titrant concentrations are designed for titrations of 10 to 40 turns (100 to 400 digits) of the delivery knob. For the most commonly used concentration ranges, the digits appearing in the counter window correspond to the sample concentration.

The number of digits used in a titration corresponds to the sample concentration in mg/L.

Figure 1 Hach Digital Titrator



To determine the volume in mL, divide the digital titrator reading by 800.

Both portable and fixed-position titrations are possible with the Digital Titrator. The instrument has a grip for hand-held operation or it can be clamped to a TitraStir Stir Plate or laboratory stand for stationary setups. See Figure 1.

Each Digital Titrator comes with five delivery tubes and a methods manual, which covers the most commonly tested parameters and the corresponding titrant cartridges. Right-angle (ninety-degree) delivery tubes for stationary setups are available as an optional accessory.

1.1.1 Following a Procedure for the First Time

Each method is divided into five sections: Procedure, Accuracy Check, Interferences, Summary of Method, and Reagents and Apparatus. For more information about how to select a procedure or for answers to chemical questions, see Hach's Water Analysis Handbook (literature 8376). For more information about chlorine measurement, also see the technical booklet titled Current Technology of Chlorine Analysis for Water and Wastewater (literature 7019).

The Procedure details how to perform the method step-by-step. To select the appropriate sample volume and titration cartridge based on expected sample concentration, use the tables provided in each procedure. If the expected sample concentration is not known, start with one of the smaller sample volumes and determine its approximate concentration. Retest with the appropriate sample size.

The ranges in the table overlap to offer more flexibility. In most procedures, the number of digits used for each concentration range will be 100 to 400 digits.
To determine the actual concentration of the sample, use the correct digit multiplier for the sample volume and titration cartridge used.

Throughout the procedure, the notes will provide additional information.

The Accuracy Check provides a way to verify the results and determine if interferences are present. It also provides a method for checking the performance of reagents, the Digital Titrator and the operator's technique. Further information is provided in APPENDIX A, ACCURACY CHECK AND STANDARD ADDITIONS.

The Interferences section identifies common interferences causing inaccurate results and describes how to eliminate their effects. The interference levels are based on the sample volume that has 1.0 as the digit multiplier. Higher interference levels may be tolerated if a smaller sample is used.

The Summary of Method section discusses the chemical reaction taking place and information that applies to the entire procedure.
The Reagents and Apparatus list concludes the procedure. All the items required to perform the test are listed first and are available from Hach. The items listed in the notes or interferences sections are included in the optional listings.

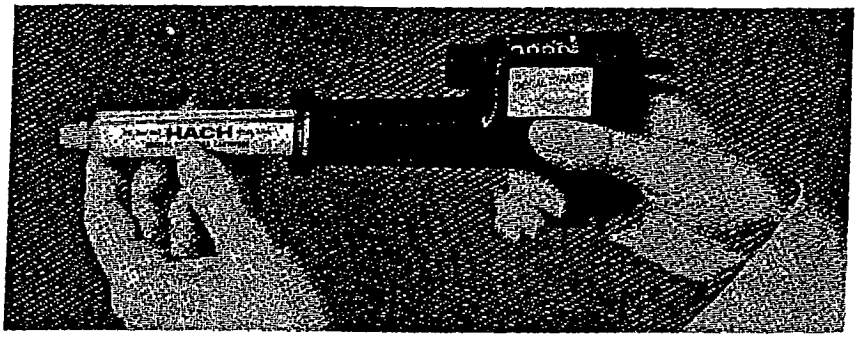
1.2 Step-By-Step

1. Select a sample volume and titration cartridge corresponding to the expected sample concentration from the table given in each procedure.

If the expected sample concentration is not known, start with one of the smaller sample volumes and determine its approximate concentration. Retest with the appropriate sample size.

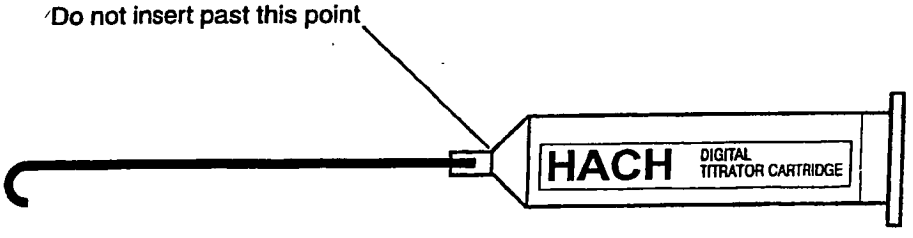
2. Slide the cartridge into the titrator receptacle and lock in position with a slight turn. See Figure 2.

Figure 2 Sliding the Cartridge into Place



3. Remove the polyethylene cap and insert a clean delivery tube into the end of the cartridge until it is tight. See Figure 3. Use a straight tube with a hook at the end for hand-held titrations; use a 90' tube with a hook at the end for stationary setups. Do not insert tube past cartridge extension; see illustration below. In some instances, it might be necessary to remove a small burr on the leading edge of the tube before insertion.

Figure 3 Inserting the Delivery Tube



3. For stationary titrations, use a TitraStir Stir Plate or a clamp holder and clamp to attach the titrator to a laboratory stand. See Figure 4 and Figure 5.

The TitraStir Stir Plate holds the Digital Titrator during the titration and also stirs the sample at a constant speed, leaving the analyst free to detect the endpoint. When a TitraStir Stir Plate is used, substitute or add the following Optional Apparatus.

Figure 4 Using the TitraStir Stir Plate

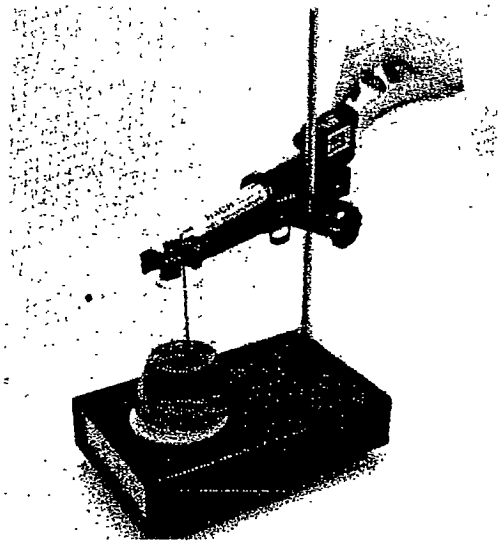
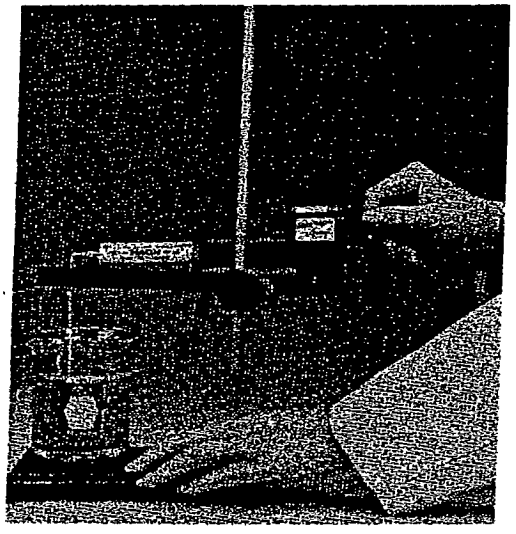


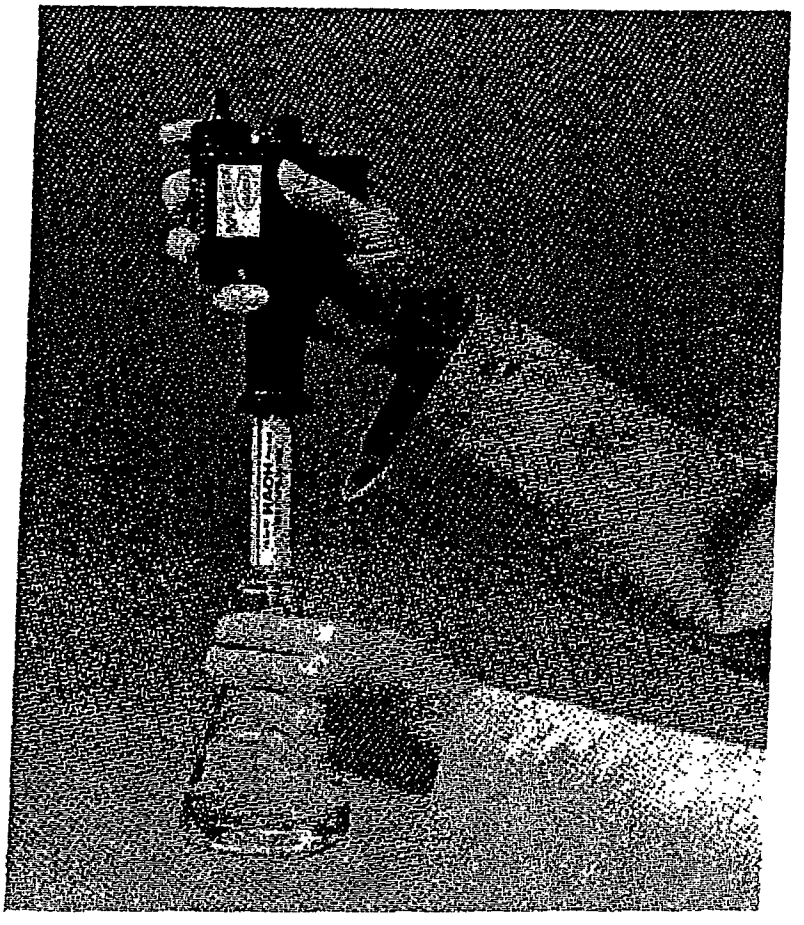
Figure 5 Using a Laboratory Stand



4. To start titirant flowing and flush the delivery tube, hold the tip of the cartridge up. Advance the plunger release button to engage the piston with the cartridge (push the button in and toward the cartridge). Do not expel solution when pushing the piston toward the cartridge. Turn the delivery knob until air is expelled and several drops of solution flow from the tip. As you turn the knob a drive screw pushes a piston against

the cartridge seat and forces liquid out through the delivery tube. Then use the counter reset knob to turn the digital counter back to zero and wipe the tip. The tip can be rinsed with deionized water rather than wiped, if desired.

Figure 6 Titrating the Sample



6. Use the smallest appropriate graduated cylinder or pipet to measure the sample volume from the given table. Transfer the sample into a 125-mL or 250-mL Erlenmeyer flask. Dilute to the appropriate total volume with deionized water if necessary.

NOTE: Sample volume measurements and dilutions (if required) must be made accurately. However final total volume of titrated solution is not critical.

7. Add the necessary reagents to the sample and swirl to mix.

8. Immerse the delivery tube tip in the solution and swirl the flask while titrating. Titrate by turning the delivery knob. Keep turning the knob and swirling the sample until the end point is reached. Record the number of digits that appear in the digital counter window. See Figure 6.

NOTE: The number of digits required will usually range from 100 to 400. In nearly all of the procedures if the digits required is less than 100 or more than 400, an alternate sample volume or titrant cartridge should be used.

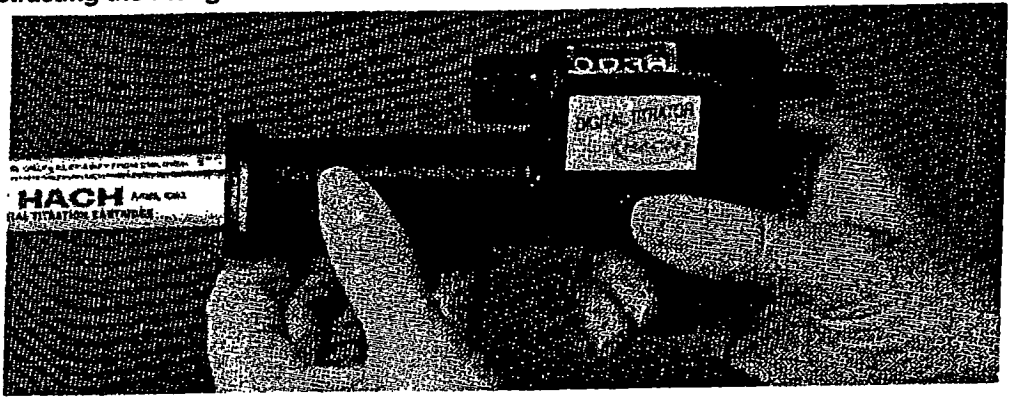
NOTE: Inaccurate results will occur if the delivery tube tip is held out of the solution rather than under the solution surface.

9. Calculate the concentration of your sample by using the following formula:
Digits Required x Digit Multiplier = Sample Concentration

Where:
Digits Required = the number that appeared in the digital counter window in Step 8.
Digit Multiplier = the number from the table given in the procedure. It takes into account the sample dilution and titrant strength.

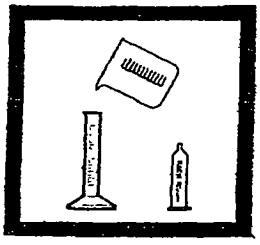
10. After completing testing for the day, press the plunger release button and manually retract the plunger into the body of the titrator. Remove the cartridge. Remove the delivery tube and reseal the cartridge with the polyethylene cap. See Figure 7.

Figure 7 Retracting the Plunger



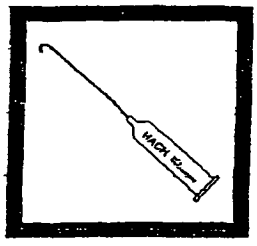
CARBON DIOXIDE (10 to 1000 mg/L as CO_2)

Using Sodium Hydroxide

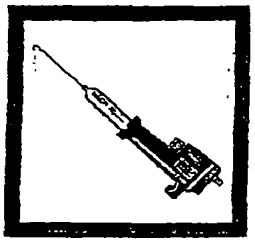


1. Select a sample size and a Sodium Hydroxide (NaOH) Titration Cartridge corresponding to the expected carbon dioxide (CO_2) concentration; see *Table 1*.

***Note:** See Sampling and Storage following these steps.*

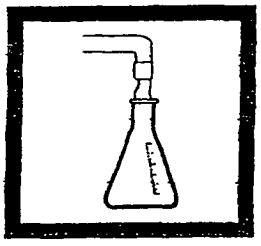


2. Insert a clean delivery tube into the titration cartridge. Attach the cartridge to the titrator body. See *General Description, Step-by-Step* for assembly instructions if necessary.



3. Turn the delivery knob to eject a few drops of titrant. Reset the counter to zero and wipe the tip.

***Note:** For added convenience use the TitraStir® Stir Plate. See General Description, Step 3 in Step-by-Step.*



4. Collect a water sample directly into the titration flask by filling to the appropriate mark.

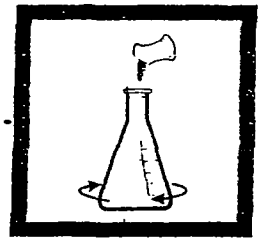
***Note:** Minimize agitation because carbon dioxide may be lost.*

***Note:** For most accurate results, check the calibration of the Erlenmeyer flask by measuring the proper volume in a graduated cylinder. Mark the proper volume on the flask with a permanent marker.*

Table 1

Range (mg/L as CO_2)	Sample Volume (mL)	Titration Cartridge (N NaOH)	Catalog Number	Digit Multiplier
10-50	200	0.3636	14378-01	0.1
20-100	100	0.3636	14378-01	0.2
100-400	200	3.636	14380-01	1.0
200-1000	100	3.636	14380-01	2.0

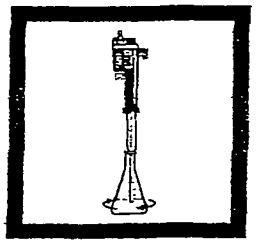
Nov 21 02 09:27a Pine Mass 17819329729 p.2



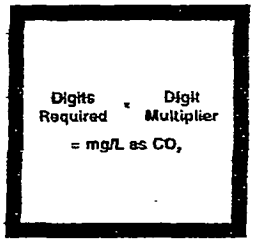
5. Add the contents of one Phenolphthalein Indicator Powder Pillow and mix.

Note: Four drops of Phenolphthalein Indicator Solution may be substituted for the Phenolphthalein Indicator Powder Pillow.

Note: If a pink color forms, no carbon dioxide is present.



6. Place the delivery tube tip into the solution and swirl the flask gently while titrating with sodium hydroxide from colorless to a light pink color that persists for 30 seconds. Record the number of digits required.



7. Calculate:

Total Digits Required x Digit Multiplier = mg/L as CO2

Sampling and Storage

Collect samples in clean plastic or glass bottles. Fill completely and cap tightly. Avoid excessive agitation or prolonged exposure to air. Analyze samples as soon as possible after collection. If immediate analysis is not possible, the samples may be stored for at least 24 hours by cooling to 4 °C (39 °F) or below. Before analysis, warm the samples to room temperature.

Accuracy Check

Standard Additions Method

This accuracy check should be performed when interferences are suspected or to verify analytical technique.

1. Snap the neck off a Carbon Dioxide Standard Solution Voluette® Ampule, 10,000 mg/L CO_2.

Nov 21 02 09:28a Pine Mass 17819329729 p.3

2. Use a TenSette® Pipet to add 0.1 mL of standard to the sample titrated in *step 6*. If using 0.3636 N titrant, use 1.0 mL of standard. Resume titration back to the same end point. Record the number of digits required.

3. Repeat, using additions of 0.2 mL and 0.3 mL (2.0 and 3.0). Titrate to the same end point after each addition.

4. Each addition of standard should require 50 additional digits of titrant. If these uniform increases do not occur, refer to *Appendix A, Accuracy Check and Standard Additions*.

Interferences

- Other acid components in the sample will be titrated and interfere directly in this determination.
- Sodium hydroxide standard solutions tend to lose strength slowly with age and should be checked periodically by titrating a known standard. Check the solution frequently (monthly) by titrating 50 mL of Potassium Acid Phthalate Standard Solution, 100 mg/L CO_2, using Phenolphthalein Indicator Solution. The titration should require 5.00 mL of titrant. If the volume required for this titration is greater than 5.25 mL, discard the sodium hydroxide and replace it with a fresh supply.

Summary of Method

Acidity due to carbon dioxide in a sample is titrated with sodium hydroxide to a phenolphthalein end point. Strong acids are assumed to be absent or of insignificant concentration. Request Hach's *Water Analysis Handbook*, Publication 8376, to obtain additional information on carbon dioxide determinations.

Nov 21 02 09:31a Pine Mass 17819329729 p.4

REQUIRED REAGENTS
(varies with sample characteristics)

Description	Unit	Cat. No.
Carbon Dioxide Reagent Set (about 100 tests)		22727-00
Includes: (1) 942-99, (1) 14378-01, (1) 14380-01		
Phenolphthalein Powder Pillows	100/pkg	942-99
Sodium Hydroxide Titration Cartridge, 0.3636 N	each	14378-01
Sodium Hydroxide Titration Cartridge, 3.636 N	each	14380-01
Water, deionized	4 L	272-56

REQUIRED APPARATUS

Digital Titrator	each	16900-01
Select one or more based on sample concentration:		
Flask, Erlenmeyer, 250 mL	each	505-46
Flask, Erlenmeyer, 125 mL	each	505-43

OPTIONAL REAGENTS

Carbon Dioxide Standard Solution Voluette® Ampules, 10,000 mg/L as CO_2, 10 mL	16/pkg	14275-10
Phenolphthalein Indicator Solution, 5 g/L	100 mL MDB*	162-32
Potassium Acid Phthalate Standard Solution, 100 mg/L as CO_2	100 mL	2261-42
Potassium Acid Phthalate Standard Solution, 400 mg/L as CO_2	500 mL	1885-49

OPTIONAL APPARATUS

Clamp, 2-prong extension, 38 mm	each	21145-00
Clamp Holder	each	326-00
Delivery Tubes, with 180° hook	5/pkg	17205-00
Delivery Tubes, 90° with hook for TitraStir® Stir Plate	5/pkg	41578-00
Pipet, TenSette®, 0.1 to 1.0 mL	each	19700-01
Pipet Tips for 19700-01 TenSette® Pipet	50/pkg	21856-96
Pipet Filler, safety bulb	each	14651-00
sension™1 Basic Portable pH Meter with electrode	each	51700-10
Support Ring Stand	each	563-00
TitraStir® Stir Plate, 115 Vac	each	19400-00
TitraStir® Stir Plate, 230 Vac	each	19400-10
Voluette® Ampule Breaker Kit	each	21968-00

* Contact Hach for larger sizes.

Nov 21 02 09:33a Pine Mass 17819329729 p.5

IRON, FERROUS (0 to 3.00 mg/L)

For water, wastewater, and seawater

1,10 Phenanthroline Method* (Powder Pillows or AccuVac Ampuls)

Using Powder Pillows

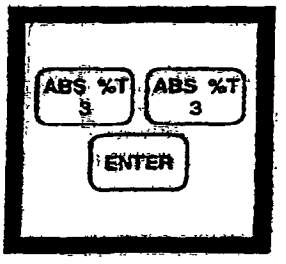
1. Enter the stored program number for Ferrous iron (Fe^{2+})-powder pillows.

Press: **PRGM**

The display will show:

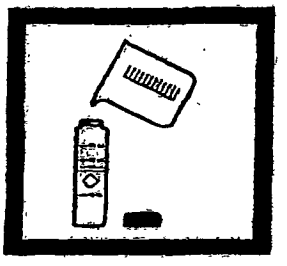
PRGM ?

Note: Analyze samples as soon as possible to prevent oxidation of ferrous iron to ferric iron, which is not determined.

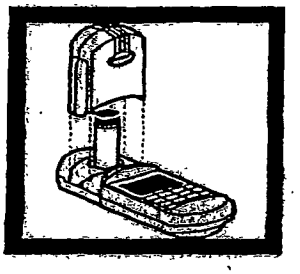


2. Press: **33 ENTER**

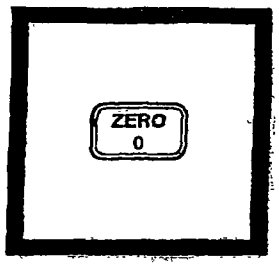
The display will show mg/L, Fe and the **ZERO** icon.



3. Fill a sample cell with 25 mL of sample (the blank).



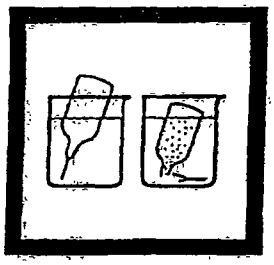
4. Place the blank into the cell holder. Tightly cover the sample cell with the instrument cap.



5. Press: **ZERO**

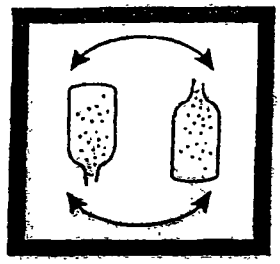
The cursor will move to the right, then the display will show:

0.00 mg/L Fe



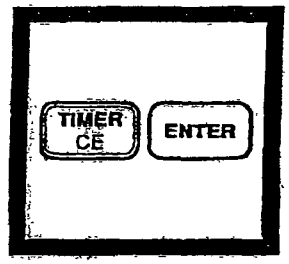
6. Fill a Ferrous Iron AccuVac Ampul with sample.

Note: Keep the tip immersed while the ampul fills completely.



7. Quickly invert the ampul several times to mix. Wipe off any liquid or fingerprints.

Note: Undissolved powder does not affect accuracy.

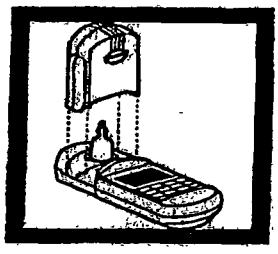


8. Press:

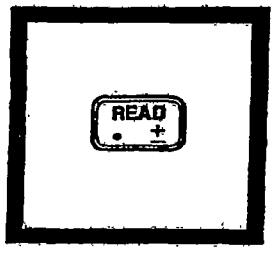
TIMER ENTER

A three-minute reaction period will begin.

Note: An orange color will form if ferrous iron is present.



9. Place the AccuVac ampul into the cell holder. Tightly cover the sample cell with the instrument cap.

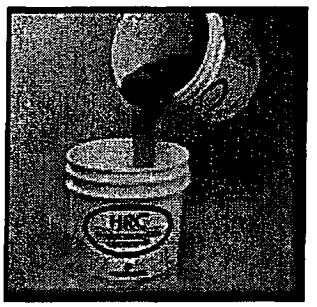


10. Press: **READ**

The cursor will move to the right, then the result in mg/L ferrous iron will be displayed.

Note: Standard Adjust may be performed using a prepared standard (see Standard Adjust in Section 1).

HRC HYDROGEN RELEASE COMPOUND OVERVIEW



Product

HRC is a polylactate ester that is specifically designed to slowly release lactic acid when contacted with water.

Purpose

To time release lactic acid when hydrated which is then metabolized by subsurface microbes that indirectly produce hydrogen. Hydrogen is a key ingredient in an anaerobic contaminant degrading process known as reductive dechlorination. Reductive dechlorination is the mechanism by which chlorinated compounds are biodegraded.

Functionality

HRC is typically applied using direct-injection techniques. This process enables HRC to be pressure injected into the zone of contamination and forced out into the aquifer. Once in the subsurface, HRC will reside within the soil matrix fueling reductive dechlorination for up to 18 months through the slow release of lactic acid.

Product Specifications

- A viscous, honey-like material rated at 20,000 centipoise
- Composition: Tripolylactate and Glycerol
- Non-hazardous, food grade product
- Packaged and delivered in 30 lb. PVC buckets

Field Applications

- Straight HRC application in excavations
- Direct-injection (most common) for source area and permeable reactive barrier applications

B nefits of Use

- Slow-release of lactic acid to support anerobic microbial activity and produce hydrogen in 8 to 10 Nm range which is optimal for reductive dechlorination
- Long-term source of lactic acid/hydrogen to the subsurface (up to 18 months)
- Clean, low-cost, non-disruptive application
- Not limited by presence of surface structures
- No Operations and Maintenance
- Faster and often lower -cost than drawn out natural attenuation
- Complimentary product application design and site analysis from Regenesis

Application Considerations

- Longevity
- Distribution in the aquifer
- Viscosity/Pumping (Heating)

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HRC Bro

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HOW IT WORKS

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How it Works?

HRC is supplied as a viscous liquid for direct injection into contaminated groundwater and saturated soils. This specially formulated product slowly releases lactic acid upon contact with water (Figure 1). This source of lactic acid is then metabolized by microbes to produce hydrogen which is then used in a natural process known as reductive dechlorination (Figure 2). Reductive dechlorination results in the step-by-step biological degradation of chlorinated contaminants. HRC can be used to degrade a range of chlorinated compounds including: degreasing agents (PCE, TCE, TCA and their breakdown products), carbon tetrachloride, chloroform, methylene chloride, certain pesticides/herbicides, perchlorate, nitrate, nitroaromatic explosives and dyes, chlorofluorocarbons, certain metals and radionuclides.

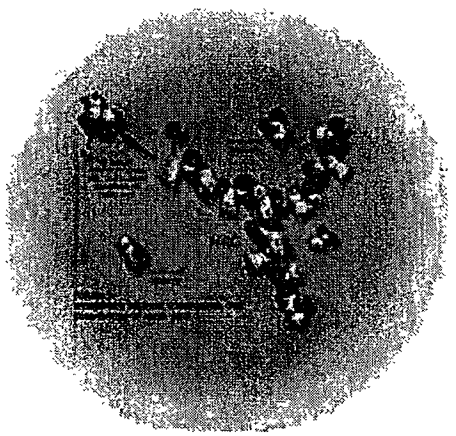

Figure 1 (Click to Enlarge)

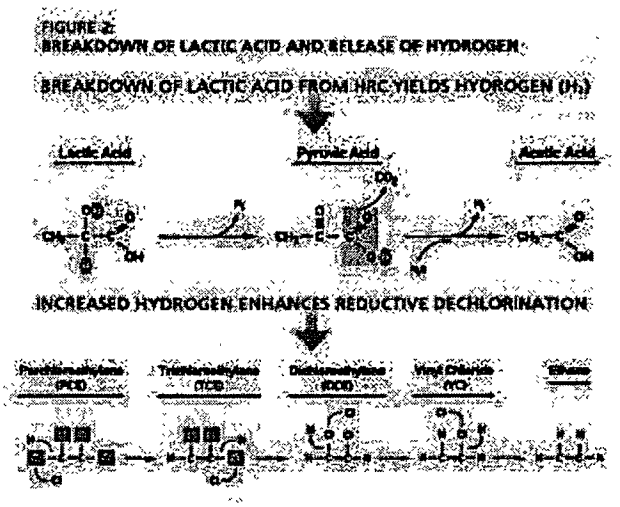

Figure 2 (Click to Enlarge)

More on Reductive Dechlorination

As discussed, reductive dechlorination is a term used to describe the mechanism by which chlorinated hydrocarbons are biologically degraded under anaerobic conditions. In this natural process, anaerobic microbes substitute hydrogen (H) for chlorine (Cl) on chlorinated contaminant molecules, thus dechlorinating the compound. Being a natural process, reductive dechlorination usually proceeds at very slow, unsustainable rates. HRC increases the rate of dechlorination up to several orders of magnitude, rapidly taking the contaminant through a step-wise dechlorination process that ultimately results in the production of non-toxic compounds such as ethene and ethane. Under the influence of HRC, this process may continue at an accelerated rate for up to 18 months.

HRC May Favor Reductive Dechlorination Over Competing Methanogenic Activity

Within the subsurface anaerobic microbial consortium, there exist microbes that use hydrogen primarily for the production of methane (methanogens), and also present are microbes that use hydrogen primarily for dechlorination (reductive dechlorinators). Results from university studies suggest that there is competition for

hydrogen between the reductive dechlorinators and methanogens. High concentrations of hydrogen favor methanogenic activity, whereas reductive dechlorinators are best supported in conditions of low hydrogen concentrations (2-10 nM). With HRC's long-lasting, time-release feature, a more steady and low hydrogen concentration is possible which can optimize reductive dechlorination over competing methanogenic activity.

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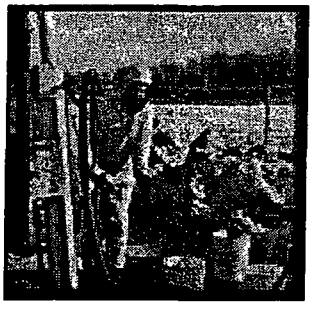
HRC HYDROGEN RELEASE COMPOUND

INSTALLATION INSTRUCTIONS



HRC can be applied to the subsurface in a number of different ways. The application method chosen is often attributed to a range of factors including depth to groundwater, soil type, location and extent of contaminants, remediation objective, etc. Typical installation of HRC involves the use of direct-push technology which can be an extremely cost-effective, efficient and clean way to deliver the product into groundwater.

The following table contains HRC installation instructions for several different types of installations. Please left-click on the title of the paper to view the instructions, or right-click and select "Save As" to download the document to your computer.

Note: All Installation Instructions are in .PDF format and can only be read using Adobe Acrobat® Reader®. Please click the icon below to download the most recent version.

Get Acrobat Reader

Cold Weather and Bedrock Hints
Detailed Installation Procedures
General Safety and Handling
Pump Information

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HRC Bro

REGENESIS

Hydrogen Release Compound (HRC®) Installation Instructions

(HELPFUL HINTS)

Application in Cold Weather Settings:

The viscosity of HRC is directly related to the ambient temperature. As discussed in the Material Overview, Handling, and Safety section, cold weather tends to increase HRC viscosity and decrease ease of pumping. To maintain HRC at a temperature/viscosity at which it is easy to apply:

1. Raise and maintain HRC's temperature to at least 95°F (35°C) prior to pouring it into the pump hopper

2. Insulate the delivery hose and keep the pump and hot water bath inside an enclosed structure such as a cargo van or trailer

3. Periodically check the HRC temperature in the hopper

4. Occasionally re-circulate HRC through the pump and hose to maintain temperature and viscosity

5. The volume of HRC recirculated should not exceed the volume of HRC in the hopper

6. Do not constantly recirculate HRC through the pump and hoses, as this may adversely affect HRC's longevity.

HRC Bedrock Applications:

When contaminants are present in competent bedrock aquifers, the use of direct push technology as a delivery method is not possible. *Regenesis is in the process of developing methods for applying HRC via boreholes drilled using conventional rotary techniques.* To develop the best installation strategy for a particular bedrock site, it is critical that our customers call the technical support department at Regenesis early in the design process.

HRC can be applied into a bedrock aquifer in cased and uncased boreholes. HRC can be delivered by simply filling the borehole without pressure or by using a single or straddle packer system to inject HRC under pressure. Selection of the appropriate

delivery method is predicated on site-specific conditions. The following issues should be considered in developing an HRC delivery strategy:

Is the aquifers transmissivity controlled by fractures?

Backfilling may be the better delivery method in massive, un-fractured bedrock, this is particularly true in an aquifer setting with high permeability and little fracturing

Intervals greater than 10 feet will require a straddle packer system).

- such as found in massive sandstone

- Down-hole packer systems may be more advantageous in fractured bedrock aquifers

- In this case the fracture type, trends, and interconnections should be evaluated and identified

Is the injection and monitoring wells connected by the same fractures?

Determine if it is likely that the HRC injection zone is connected to the proposed monitoring points

If pressure injection via straddle packers is desired, consideration should be given to the well construction. Specific issues to be considered are:

- Diameter of the uncased borehole (*will casing diameter allow a packer system to be used*?)

- Diameter of the casing (same as above)

- Strength of the casing (can it withstand the delivery pressures?)

- Length of screened interval (screened intervals greater than 10 feet will require a straddle packer system).

For direct assistance or answers to any questions you may have regarding these instructions, contact Regenesis Technical Services at 949-366-8000.

REGENESIS, 2003
www.regenesis.com

REGENESIS

Hydrogen Release Compound (HRC®) Installation Instructions

(DETAILED INSTALLATION PROCEDURES)

1. Prior to the installation of HRC, any surface or overhead impediments should be identified as well as the location of all underground structures. Underground structures include but are not limited to: utility lines, tanks, distribution piping, sewers, drains, and landscape irrigation systems.

2. The planned installation locations should be adjusted to account for all impediments and obstacles.

3. Regenesis recommends pre-heating HRC in a hot water bath. Place unopened buckets of HRC into an empty water tank. A Rubbermaid fiberglass Farm Trough Stock Tank (Model 4242-00-GRAY) is typically used for this application and can hold up to 16 buckets of HRC. Hot water (approximately = 130-170°F or 54-77°C) should be added to the tank after the buckets of HRC have been placed inside. When the HRC reaches a minimum temperature of 95°F or 35°C (approximately 20-30 minutes) it is ready to be poured into the pump hopper.

4. Pre-mark the installation locations, noting any points that may have different vertical application requirements or total depth.

5. Set up the direct push unit over each specific point and follow the manufacturer standard operating procedures (SOP) for the direct push equipment. Care should be taken to assure that probe holes remain in the vertical.

6. For most applications, Regenesis suggests using 1.25-inch O.D./0.625-inch I.D Geoprobe brand drive rods. However, some applications may require the use of 2.125-inch O.D./1.5-inch I.D. drive rods.

7. The HRC delivery sub-assemblies that Regenesis currently uses are designed for 1.25-inch Geoprobe rods. Other brands of drive rods can also be used but require the fabrication of a sub-assembly (see Regenesis Website).

8. Advance drive rods through the surface pavement, as necessary, following SOP.

9. Push the drive rod assembly with an expendable tip to the desired maximum depth. Regenesis suggests pre-counting the number of drive rods needed to reach depth prior to starting injection activities.

10. Drop the expendable tip from the drive rods, following SOP.

Note: In some cases, introduction of a large column of air may be problematic. This is particularly the case in deep injections (>50 ft) with large diameter rods (>1.5-inch O.D.)

11. To prevent the injection of air into the aquifer during HRC application, fill the drive rods with water. If water does not remain in the rods due to seepage, glycerine may be substituted.

12. Pour the pre-heated HRC into the pump hopper (up to 40 gallons). Remove the separated HRC from the bucket bottom by tipping the bucket into the hopper and scraping out the smooth residual material. Use the pumps mixing and recirculation features to create a uniform consistency. This typically requires recirculation of approximately one hopper volume. **NOTE:** Do not attempt to mix HRC with water or other liquids to thin or decrease the viscosity of the material. This may adversely affect HRC longevity.

13. A volume check should be performed prior to injecting HRC. Determining the volume displaced per pump stroke can be accomplished in two easy steps.

    Determine the number of pump strokes needed to deliver 3 gallons of HRC (use a graduated bucket for this)

    Divide 3 gallons by the results from the first step to determine the number of gallons of HRC delivered by each pump stroke

    Level indicators present in the hopper are in 3 gallon increments

    The volume of HRC displaced should be confirmed using the HRC level indicators located inside the pump hopper.

14. Connect the 1.25-inch O.D., 1-inch I.D. delivery hose to the pump outlet and the provided HRC delivery sub-assembly. Circulate HRC though the hose and the delivery sub-assembly to displace air in the hose.

15. Connect the HRC sub-assembly to the drive rod. After confirming that all of the connections are secure, pump the HRC through the delivery system to displace the water/fluid in the rods. **NOTE:** Prior to pumping HRC into the aquifer, close the pump recirculation valve; failure to do so will allow material to short-circuit into the hopper and change in the volume of HRC delivered per pump stroke.

16. The pump engine RPM and hydraulic settings should remain constant throughout the day. However, if the hydraulic system starts to "squeal" the pump speed should be decreased until the noise is mitigated.

17. Use the pump's stroke counter and the provided volume/weight conversions to apply the appropriate HRC volume per injection location (and per vertical foot of contaminated saturated zone). Table 1 shows typical HRC delivery information followed by an example calculation.

Table 1. Pump Volum Calculation

Pump Stroke Volume (gallons)	Number of Pump Strokes	HRC Per Stroke (pounds/stroke)
3.0	14	2.4
0.2	1	2.4

Example: For each injection location, install 60 pounds of HRC across 10 vertical feet of aquifer (6 pounds per vertical foot HRC dosing rate).

Solution:

60 pounds/10.8 pounds per gallon ≈ 5.6 gallons for the injection location
5.6 gallons/0.2 gallons per stroke ≈ 28 pump strokes for the injection location
28 pump strokes/10 vertical feet = 2.8 strokes per vertical foot
2.8 strokes per vertical foot = 8.4 strokes per 3 foot drive rod
2.8 strokes per vertical foot = 11.2 strokes per 4 foot drive rod

18. Slowly withdraw the drive rods using Geoprobe Rod Grip or Pull Plate Assembly (Part AT1222-For 1.25-inch drive rods). While slowly withdrawing single lengths of drive rod (3 or 4 feet), pump the pre-determined volume of HRC into the aquifer across the desired treatment interval (Step 13). Use the stroke counter and pump on/off switch to control volume of injection. See Helpful Hints at the end of this section.

19. Remove one section of the drive rod. The drive rod may contain some residual HRC. Place the HRC-filled rod in a clean, empty bucket and allow the HRC to drain. Eventually, the HRC should be returned to the HRC pump hopper for reuse.

20. Observe any indications of aquifer refusal. This is typically indicated by a high-pitched squeal in the pump's hydraulic system or (in the case of shallow applications) HRC "surfacing" around the injection rods or previously installed injection points. If aquifer acceptance appears to be low, allow enough time for the aquifer to equilibrate prior to removing the drive rod.

21. Repeat steps 15 through 20 until treatment of the entire contaminated vertical zone has been achieved.

22. Install an appropriate seal, such as bentonite, above the HRC material through the entire vadose zone. Depending on soil conditions and local regulations, use a bentonite seal via chips or pellets after the probe rods have been removed. This assures that the HRC remains properly placed and prevents contaminant migration from the surface. If HRC continues to "surface" up the direct push borehole, an appropriately sized (oversized) disposable drive tip or wood

plug/stake can be used to plug the hole until the aquifer equilibrates and the HRC stops surfacing.

23. Remove and clean the drive rods as necessary.

24. Finish the borehole at the surface as appropriate (concrete or asphalt cap, if necessary).

25. Periodically compare the pre- and post-injection volumes of HRC in the pump hopper using the pre-marked volume levels. Volume level indicators are not on all pump hoppers. In this case, volume level markings can be temporarily added using known amounts of water and a carpenter's grease pencil (Kiel crayon). We suggest marking the water levels in 3-gallon increments.

26. Move to the next probe point, repeating steps 8 through 20.

For direct assistance or answers to any questions you may have regarding thes instructions, contact Regenesis Technical Services at 949-366-8000.

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Hydrogen Release Compound (HRC®) Installation Instructions

GENERAL GUIDELINES

The best method to deliver HRC into the subsurface is to inject the material through direct push rods using hydraulic equipment. This approach increases the spreading and mixing of HRC into the aquifer. This set of instructions is specific to direct push equipment.

Regenesis has found that very few pumps can adequately deliver HRC to the subsurface. Although other pumps may inject HRC, we have developed the following instructions specifically for use with an R.E. RUPE Company Model ORC/HRC 9-1500 mixing and pumping machine.

Note: We have strong evidence that the recently developed Geoprobe GS-2000 pump can effectively deliver HRC to the subsurface.

The installation of HRC should span the entire vertical contaminated saturated thickness. If the vertical extent of HRC application is confined to a limited interval, then the HRC material should be placed across a vertical zone extending a minimum of 2 feet above and below the screened Interval of monitoring wells to be used to evaluate the performance of the bioremediation project.

MATERIAL OVERVIEW, HANDLING, AND SAFETY

HRC is shipped in 4.25-gallon buckets and each bucket has a gross weight of approximately 32 pounds (net weight of HRC is 30 pounds). At room temperature HRC is a sticky gel with a viscosity of approximately 20,000 centipoise (roughly equivalent to cold honey). The HRC material has a nominal density of 1.3 grams/cubic centimeter or approximately 10.8 pounds per gallon. The viscosity of HRC is temperature sensitive, significant changes in HRC's viscosity are observed with large changes in product temperature. It should be noted that the temperature/viscosity relationship is not linear.

For ease of installation, HRC should be stored in a warm, dry place that is protected from direct sunlight. It is common for stored HRC to settle somewhat in a container. Care should be taken to mix the HRC into a relatively uniform fluid prior to installation. Product uniformity is most easily achieved by pre-heating HRC before pouring it into the pump hopper. Care should be taken to scrape any separated material from the bottom of each bucket. Do not use any "rocky material" in the bottom of the bucket because it could potentially clog the check valves in the machine. Use the Rupe pump's mixing and recirculation features to homogenize the HRC. Pre-heating HRC makes it easier to pour and remix the separated material. Although HRC is manufactured as a food-grade

material that is safe to ingest, field personnel should take precautions while handling and applying HRC. Field personnel should use appropriate safety equipment, including eye protection. The low pH when dissolved in water and the products viscosity make eye protection mandatory. Gloves should be used as appropriate based on the exposure duration and field conditions. A Material Safety Data Sheet is provided with each shipment. Personnel who operate field equipment during the installation process should have appropriate training, supervision, and experience

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Hydrogen Release Compound (HRC®) Installation Instructions

(Pump Information)

Regenesis has evaluated a number of pumps that are capable of delivering 20,000 centipoise HRC to the subsurface at a sufficient pressure and volumetric rate. Although a number of pumps may be capable of delivering the HRC to the subsurface at adequate pressures and volume, each pump has a set of practical issues that make it difficult to manage in a field setting. As a result of this evaluation, Regenesis has determined that the R.E. RUPE Company Model ORC/HRC 9-1500 meets the pressure and volume requirements needed to successfully inject HRC in the field. When applying measured volumes of HRC via probe boreholes, it is useful to know the volume of a single pump stroke and the associated delivery system lines. The following additional information is provided for reference

HRC Physical Characteristics:

Density	1.3 g/cc or 10.8 lbs./gal.
Viscosity	Approx. 20,000 centipoise

Equipment Volume and HRC Weight per length

Equipment	Volume	HRC weight
1 inch OD; 0.625 ID hose (10 feet long)	0.2 gallon	1.8 lbs.
1.25 inch OD; 0625 inch ID drive rod (3 feet length):	0.05 gallon	0.5 lbs.
1.25 inch OD; .625 inch ID drive rod (4 feet length):	0.06 gallon	0.7 lbs.

Before using the Rupe Pump, check the following:

- Fuel level prior to engaging in pumping activities (it's best to start with a full tank)

- Remote control/pump stroke counter LCD display; if no display is present, the electronic counter will need to be replaced (Grainger Stock No. 2A540)

- Monitor pump strokes by observing the proximity switches (these are located on the top of the piston)

Pump Cleaning after HRC Us :

For best results use a hot water (150-170 °F or 66-77 °C) pressure washer to clean equipment and rods periodically throughout the day. Internal pump mechanisms and hoses can be easily cleaned by circulating hot water and a biodegradable cleaner such as Simple Green through the pump and delivery hose. In order to maintain optimal pumping conditions, it is desirable to circulate pure glycerin through the pump after the pump has been thoroughly cleaned. A small volume of glycerin should be left in the pump works and hopper during storage or shipping. Further cleaning and decontamination (if necessary due to subsurface conditions) should be performed according to the equipment supplier's standard procedures and local regulatory requirements.

NOTE: The remote control/pump counter should be kept dry at all times, if it gets wet it will short-circuit and ill need to be replaced.

F r direct assistance or answers to any questions you may have regarding th e instructions, contact Regenesis Technical Services at 949-366-8000.

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EQUIPMENT (PUMPS)

Pump Information for the Injection of ORC®, HRC® and HRC-X™

ORC, HRC and HRC-X are most easily applied to the subsurface through the use of direct-pressurized injection. The pressure injection process can be beneficial in the application and resulting distribution of the product within the subsurface matrix. The greater the distribution achieved upon initial injection of the material the greater the overall distribution of the resulting oxygen or hydrogen.

Pumps are available for purchase and rental from a wide range of vendors and contractors. Please visit our contractors page for more information on pump sources.

Pump Specifications for ORC:

Pressure rating: up to 2,000 psi
Delivery rate: up to 3.6 gpm

Pump Specifications for HRC and HRC-X:

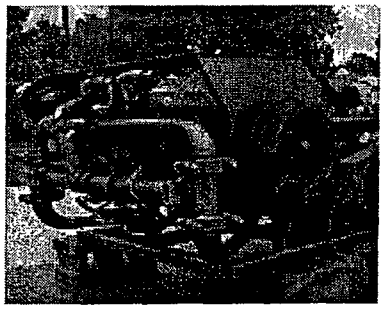
Pressure rating: at least 1,500 psi
Delivery rate: up to 9 gpm

Featur d Pump

Hydrogen Release Compound (HRC®) is a thick, viscous substance. One of the best methods of successfully injecting the product into the subsurface utilizes the HRC/ORC 9-1500 Rupe Pump, designed and manufactured by the R.E. Rupe Co. The patented R.E. Rupe Piston can pump 0 to 9 gallons/minute at pressures of 0 to 1600 PSI. The unit contains a 40 gallon mixing hopper, an 18 horsepower engine, and a 10 gallon hydraulic pump. The Rupe Pump can be used for both HRC and ORC installation. The following attributes make this pump especially useful for HRC injection:

- High pressure positive displacement pump
- Large-diameter outlet facilitates efficient pumping of high viscosity materials
- Heater for thinning HRC in cold weather (optional)
- Fully adjustable flow rate
- Self-contained engine (no compressor necessary)
- Remote operated control panel standard
- Mixer to keep thick material flowable and prevent premature solidification

For further information regarding pricing, utility, and rental of the Rupe Pump, contact the R.E. Rupe Co.



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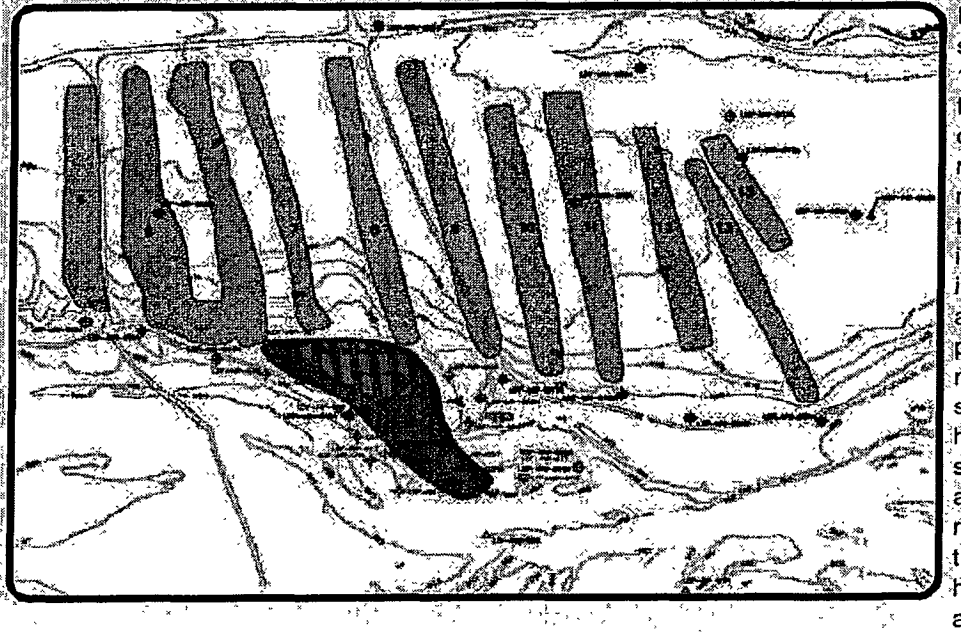
Enhanced Bioremediation of

TCE at Department of Defense Landfill Site

PROJECT BACKGROUND

Subsurface investigations at this 40-acre Northern California Department of Defense (DOD) landfill site revealed elevated levels of TCE in site soils and groundwater. This discovery was made through routine site monitoring, as regulated by the state of California solid waste landfill regulations. Regulators required site clean-up to reduce chlorinated hydrocarbon concentrations below state of California Maximum Contaminant Levels (MCLs). Therefore, trichloroethylene (TCE), dichloroethylene (DCE) and vinyl chloride (VC) concentrations were required to be reduced below 5 ug/L, 6 ug/L and 0.5 ug/L respectively. A detailed feasibility study of the site revealed enhanced biological degradation to be the best remedial option. MACTEC, consultant to the DOD, selected Hydrogen Release Compound (HRC®) to properly and effectively enhance the biodegradation process. HRC was chosen at this site because it is a low-cost and proven, in situ bioremediation technology. It also offers the added benefits of quick remediation timeframe, minimal site disturbance, no operations and maintenance, and no aboveground piping and or machinery often associated with ex situ and other mechanical systems.

APPLICATION



Baseline concentrations at the site for TCE, DCE and VC were 135ug/L, 101 ug/L and ND respectively. Therefore, TCE, DCE and VC concentrations were required to be reduced by 96.3%, 94.1%, and 0% respectively, given the aforementioned regulatory goals. A total of two injection events occurred at the site including a pilot study and full-scale application. In November 2000, the pilot study was conducted to determine the efficacy of HRC use at the site for remediation of chlorinated hydrocarbons. Not only did the pilot study prove that HRC could be an effective technology for the remediation of TCE and its daughter products, it surpassed the hypothesized performance. Within a year and a half after application, TCE and DCE concentrations were degraded below state of California MCLs. As expected, TCE degradation produced daughter products (DCE and VC) that showed the identifiable and typical increase then decrease in concentrations. In February 2002, the full-scale application of HRC was conducted in an attempt to provide more hydrogen for complete biological degradation of the previously mentioned daughter products, primarily VC.

RESULTS

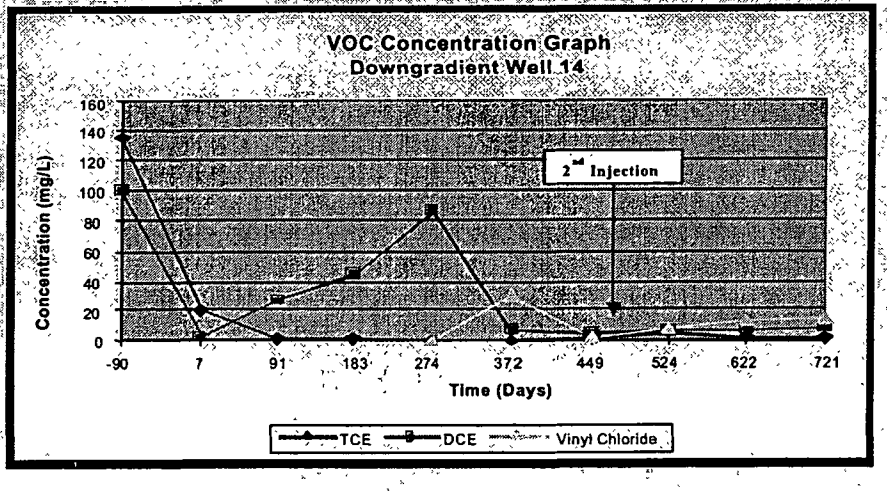
Within two months after the initial application of HRC, TCE concentrations were reduced by 92%. Two years after the initial application, TCE concentrations have been reduced by 99% to 0.75 ug/L and DCE concentrations have been reduced by 91% to 8 ug/L. Additionally, TCE concentrations have remained below state of California MCLs. Although VC concentrations have increased, the result was in-line with pretreatment expectations as VC is a degradation daughter product of TCE. The full-scale application of HRC at the site will supply adequate amounts of hydrogen over time to aid in the degradation of the remaining VC. This site is expected to be granted regulatory closure in the near future as VC concentrations decrease to desired levels.

PROJECT NOTES

Classic degradation pathways are represented in the monitoring data following the first injection, with increases in DCE following decreases in TCE and increases in VC following decreases in DCE. Activity at this site represents the classic biodegradation model for TCE. As hydrogen incrementally replaces chlorine on the chlorinated hydrocarbon molecule, TCE is degraded to DCE and DCE is degraded to VC. This is proof of the effectiveness of reductive dechlorination using HRC.

PROJECT COSTS

The client has estimated a cost savings of over $500,000. These savings are associated with the next best treatment options identified in the feasibility study conducted at the site. The passive yet effective characteristics of HRC minimize intrusiveness while maximizing treatment efficiency and longevity, making it a very cost effective remedial option when compared to other alternatives.



For more information please contact:

Don Smallback
MACTEC, Inc.
Phone: (415) 883-0112

HRC TECHNICAL BULLETIN # 1.1.2

Hydrogen Release Compound HRC®

Biological Reductive Dechlorination of CAHs

Reductive dechlorination is the most prominent mechanism by which chlorinated aliphatic hydrocarbons (CAHs) are biologically degraded under anaerobic conditions. CAHs, commonly used as degreasing solvents (see TB 1.1.1), are hydrocarbons whose hydrogen atoms have been replaced, or substituted, with chlorine atoms. It is in this chlorinated state that these hydrocarbons are considered toxic in groundwater. In order to remedy this problem the chlorine atoms must be removed.

Reductive dechlorination is the process by which anaerobic microorganisms substitute hydrogen (H+) for chlorine on CAHs. Hydrogen, resulting from the breakdown of HRC, acts as a source of electrons which provide the reducing conditions necessary for dechlorination of CAHs, as shown in the Figure 1.

$$RCl + H^+ + 2e^- \longrightarrow RH + Cl$$

Figure 1

Through this process, CAHs can be degraded to form vinyl chloride, and even ethene, as depicted in Figure 2.

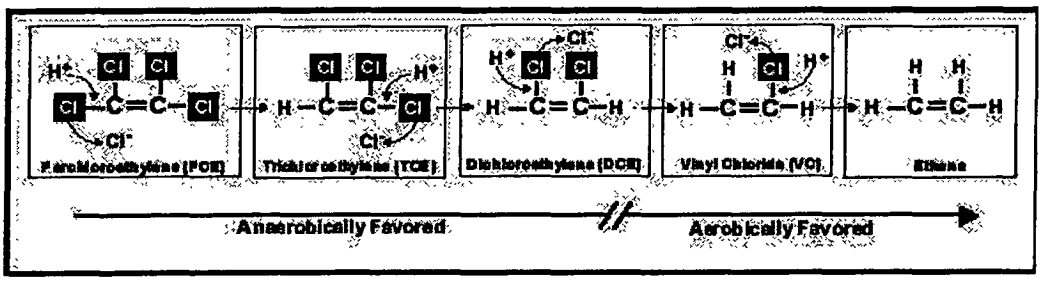


Figure 2

While the degradation rates of PCE and TCE are highest under anaerobic conditions, vinyl chloride will degrade up to four times faster under aerobic conditions (Figure 2). Therefore, optimal results for CAH remediation with HRC may be achieved by combined treatment with Oxygen Release Compound (ORC®) to enhance aerobic bioremediation of vinyl choride.

NOTE: For a complete discussion on reductive dechlorination of CAHs, see the RABITT document (1).

References:

1. Morse, J.M. and B.C. Alleman; Gossett, J.M. and S.H. Zinder; Sewell, G W.; Vogel, C.M. 1997. A Treatability Test for Evaluating the Potential Applicability of the Reductive Anaerobic Biological In Situ Treatment Technology (RABITT) to Remediate Chloroethenes. ESTCP Technical Protocol.

HRC Technical Bulletin Index||HRC Homepage

HRC TECHNICAL BULLETIN # 1.3.1

Hydrogen Release Compound HRC®

Environmentally Safe

Hydrogen Release Compound, HRC, is a polylactate ester that is a food-grade substance. Lactic acid occurs naturally in milk and foods (such as sauerkraut), and is also formed in muscles during exercise. In the subsurface environment, lactic acid products are eventually completely removed either as methane or CO_2 and water, leaving no residue.

The only other ingredient in HRC is food grade magnesium phosphate ($MgPO_4$). Magnesium phosphate is a naturally occurring mineral and is used in fertilizers. Magnesium phosphate has even been used medically as a laxative. In the function of the product phosphorous from the phosphate helps the metabolism of the lactic acid to produce the hydrogen used in reductive dechlorination.

In a review of all of 40CFR141 there is no reference to MCLs for lactic acid or its derivatives pyruvic acid, propionic acid, and acetic acid (see HRC technical bulletin #1.3.2). As with all chemicals, safe handling practices should be used to avoid any excess exposure to skin and any exposure to eyes. A full MSDS is provided with the product. As indicated in the MSDS, there is the potential for skin irritation with large scale exposure or with sensitive individuals. It is recommended that vinyl or rubber protective gloves be worn during handling of the product. Contact with eyes will cause irritation and the use of splash goggles or some other form of eye protection should be considered mandatory.

HRC Technical Bulletin Index||HRC Homepage

HRC TECHNICAL BULLETIN H-2.7.4

Hydrogen Release Compound HRC™

The Formation of Vinyl Chloride Using HRC

We have sometimes been asked "will the use of HRC on chlorinated ethene compounds lead to the formation of vinyl chloride (VC)?" The answer is basically yes, but only as a transitional state as the dechlorination proceeds ultimately producing ethene. In all of the applications of HRC accomplished to date, not one of the sites created a buildup of vinyl chloride that persisted or moved off-site. In the event that there was such a site, a simple ORC oxygen barrier could be installed to degrade the vinyl chloride before leaving the treatment area.

VC is Produced Naturally

VC formation is a natural process. In the scope of natural attenuation, by all chemical processes both biotic and abiotic (reduction by metals), VC will form. Now, if we add organic substrates to the aquifer to accelerate natural attenuation – a sensible and cost effective strategy – we will accelerate the dechlorination process, temporarily forming VC from DCE as the degradation proceeds to ethene. Note that this is true for all organic substrates not just HRC, however, if one uses HRC with its consistent generation of low hydrogen concentrations, then the enhanced rate of VC formation will be minimized. This will effectively give the rate of VC degradation to ethene a chance to keep pace with the formation of VC itself.

VC Degrades Rapidly with Oxygen

As mentioned above, HRC has never been shown to stimulate a significant or permanent buildup of VC. However, in cases where site conditions do not allow the VC to have an adequate residence time in contact with the HRC, it is conceivable that the vinyl chloride could move off-site without conversion to ethene. In this rare case Regenesis recommends that a down gradient passive ORC oxygen barrier be installed, which will stimulate the rapid and complete mineralization of the vinyl chloride moving across the barrier zone. The use of ORC to rapidly degrade vinyl chloride is well documented and is summarized in TB 2.2.2.3 as well as others.

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Hydrogen Release Compound HRC®

HRC Performance Characteristics - Longevity

General Background

Since Hydrogen Release Compound (HRC®) is a time-release product, one of the central issues in site design and one of the most frequently asked questions is "How long does it last"? The short answer is that the basic HRC now sold, specifically defined as a formulation of Glycerol Polylactate (GPL), diluted with glycerol to a viscosity of 20,000 centipoise (cP), is estimated to stimulate reductive dechlorination within the aquifer for about 12 months. The longevity is a function of basic product chemistry and certain biological and geochemical features of the aquifer. HRC has been shown to have a direct effect on contaminants resulting from the lactic acid release and other secondary effects, related to the formation of other organic acids that "borrow hydrogen" and recycled biomass, that have a more prolonged effect on aquifer conditions.

Theoretical Considerations

Longevity as a Function of HRC Chemical Characteristics

Hydrogen Release Compound is a specific article of commerce as described. The "active ingredient", Glycerol (tri) Polylactate (GPL), is one of a family of polylactate esters, defined by our patent, that upon hydration break down to release lactic acid. The exact chemical nature of a specific polylactate ester, such as GPL, is a major factor in product longevity. In essence, the structure and degree of esterification determine viscosity and viscosity is a critical factor in longevity.

Structurally, an ester is the product of a reaction between an organic acid (COOH group) and an alcohol (OH group). In this reaction as shown in Figure 1, the two groups react and water drops out forming the ester linkage, noting that the amount of water removed in esterification can affect viscosity. The example used shows methyl alcohol reacting with lactic acid to form a simple lactate ester (methyl lactate).

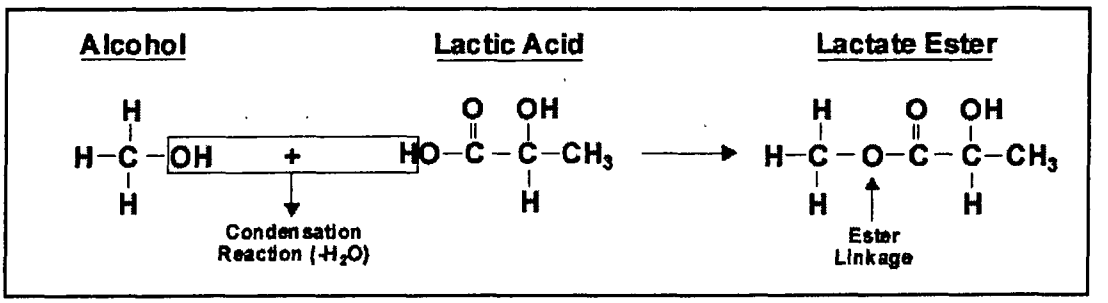

Figure 1. Formation of an Ester.

Polylactate esters are formed from the combination of certain alcohols with a unique lactic acid complex serving as the organic acid group. The alcohols used are compounds such as glycerol (3 OH groups), xylitol (5 OH groups) and sorbitol (6 OH groups). These "foundation" molecules are then esterified with a polylactic acid complex as illustrated in Figure 2.

One of the unique features of the polylactic acid complex is that lactic acid is esterified to itself. This is possible because lactic acid, as shown in Figure 1, has both an OH and a COOH group. As a result we can typically produce trimers or tetramers of lactic acid and create a "polylactic acid complex" or "polylactate complex", which is in turn esterified to the foundation OH donor as described.

The Glycerol (tri) Polylactate (GPL) component of the HRC in commerce is specifically the molecule in Figure 2. However, GPL itself can vary as a function of how many OH positions are actually esterified, so that one could have glycerol (tri) polylactate if all 3 are filled or glycerol (di)polylactate if just 2 are filled. The GPL in HRC is the Glycerol (tri) polylactate ester

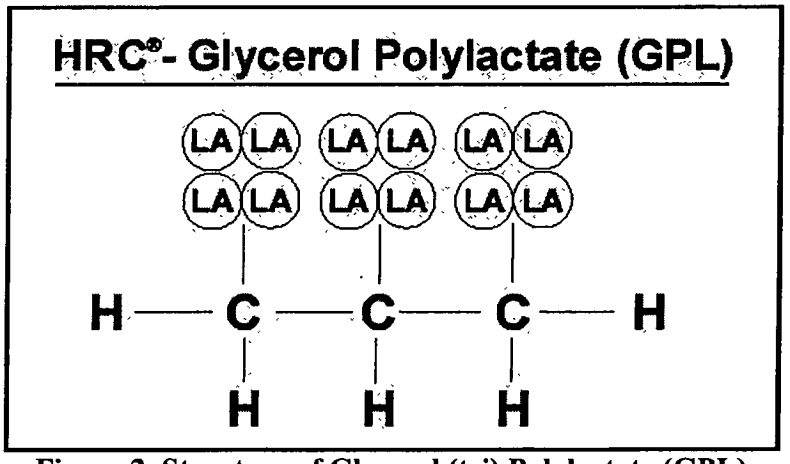

Figure 2. Structure of Glycerol (tri) Polylactate (GPL)

The point of this is to emphasize that the degree of complexity and esterification of the molecule control its viscosity and hence a major component of its reactivity. This in turn controls product longevity under a uniform set of conditions. For example, the (tri)polylactate form of GPL would be more viscous that the (di)polylactate form. Further, a molecule built with tetramers of lactic acid would be more viscous than one made with trimers. As a final example a sorbitol polylactate ester is more viscous than a glycerol polylactate ester, because it is based on 6 carbons rather than 3 carbons.

Viscosity becomes a dominant issue in longevity because it is a measurement of resistance to flow. As a result, viscosity controls the evolution of surface area over time and the speed at which HRC becomes soluble in water. Therefore, if a polylactate formulation becomes less viscous it will spread more, thus exposing more sites to chemical and biological attack. The latter case, involving the enzymatic action of microorganisms, is a particularly powerful mechanism and this will be expanded on later. In essence, "thicker lasts longer", which one would intuitively gather for the reaction of any solute with a solvent.

Returning to viscosity for a moment, we said that it is a measure of resistance to flow and can be measured in a viscometer. In a viscometer, the substance being tested is placed between two plates, one being stationary and one being movable. The amount of force applied to overcome resistance to the movement of the moveable plate is the key variable. Consequently, the units of viscosity in SI units are force-based, e.g., dyne-sec/cm^2 or Poise (P). Typically we measure the viscosity of HRC in centipoise (cP).

To be pumpable for push-point injection, HRC has to be about 20,000 cP (like honey). This is achieved by cutting raw GPL, which is about 200,000 cP (gel-like), with glycerol - by a factor of about 2, noting that the relationship between dilution and viscosity is non-linear. Therefore, we produce a form of HRC at 200,000 cP, as a function of the specific chemical structure, such that when it is cut about 50:50 with glycerol we achieve a pumpable 20,000 cP material.

Longevity as a Function of Aquifer Characteristics

The viscosity of the HRC is still only one side of the equation. The other important feature concerns the environment the HRC is placed into. An experimental model for the dynamics of HRC utilization in the bioremediation of TCE is published in Farone, Koenigsberg and Hughes (1999). Copies of this and other papers cited herein are available on request from Regenesis and it is convenient to use our web site at www.regenesis.com.

The model, which was calibrated with laboratory microcosm tests, clearly demonstrates that the nature and extent of microbial populations has a significant effect on the longevity of HRC. Simply put, most microbes - not just the kinds that ferment lactic acid into hydrogen or those that promote reductive dechlorination - will produce esterases and lipases that degrade HRC and release lactic acid.

Therefore, if an aquifer has a high microbial population it will metabolize a given mass of HRC at a faster rate than if the microbial counts are moderate to low. An example of this is presented in Figure 3 that shows a difference in lactic acid release rates at three different microbial concentrations. Note that this lab test represents a highly accelerated condition relative to field results, because everything is optimized and reacted in close proximity in the test tube environment.

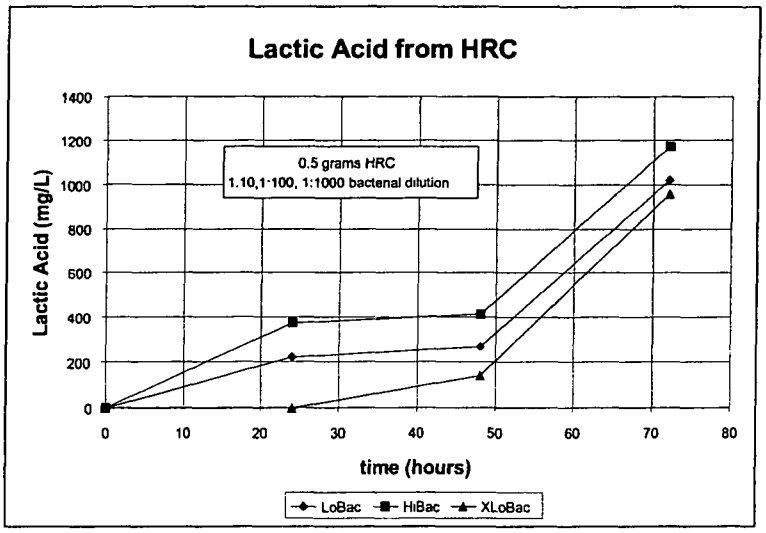

Figure 3. Lactic Acid Release Rates as a Function of Microbial Population.

Early Laboratory Work

Table 1 presents data that reflect a set of minimum times that standard HRC has lasted in the laboratory. Again, note that laboratory tests generally have high rates of activity relative to the field. The tests summarized below, were conducted to test the efficacy of HRC in remediating TCE and were not longevity tests per se. For economic reasons they were only run for about three months to collect the remediation rate data. Still, the tests supply some useful minimums for longevity. The tests were macrocosm studies conducted in Aquifer Simulation Vessels (ASVs) with a flow rate of about 1 ft/day. For a further discussion of the ASV type studies, please refer to TB 2.4.3.

Table 1. Macrocosm (ASV) Tests.

Product	Duration of Test	Presence of Product at Conclusion
GPL 52%/Glycerol 48%	84 days	Yes
GPL 52%/Glycerol 48%	80 days	Yes
GPL 52%/Glycerol 48%	80 days	Yes
GPL 52%/Glycerol 48%	94 days	Yes

Recent Laboratory Work

Recently an ASV study was established to specifically look at both longevity and diffusion issues regarding 20,000 cP HRC and 200,000 cP GPL. 15 g of each formulation was placed in the influent end of the ASV; there was no flow so that diffusion alone would be measured. While the main purpose of the test is covered in TB 2.4.3, it can be noted that, after 66 days, there is still considerable material left in the system of both products. The experiment will be continued until the product is exhausted. This is expected to be about one year for the 20,000 cP HRC and several years for the 200,000 GPL.

Field Results

Data from the Oldest Trials

The most powerful evidence for product longevity is of course the observations made in the field. As presented in Table 2 and graphically in Figure 4, the 20,000 cP HRC will last from 119 days to 580 days. It is important to note that this is a "living table" such that some of the applications are still in progress and the average longevity figures is getting larger. However, based on the range of this field experience and the fact that some tests are still in progress, we claim that 20,000 cP HRC degrades slowly, on average, for nine months (as modulated by certain features in the contaminated aquifer). However, just because the organic acids are gone does not mean the effects are over. Residual hydrogen will still be present and biomass accumulates which will later be available as fermentable carbon. The stimulated biomass is also more able to utilize native carbon as well. Therefore, ~20,000 cP HRC now sold is estimated to stimulate reductive dechlorination within the aquifer for at least 12 months.

Also, some work during the early phase of product development (not cited here) looked at the properties of a 1,000,000 cP sorbitol polylactate hard gel. In one test, the material physically lasted for at least two years at the point of application. In this experiment, which is presented in Dooley, Murray and Koenigsberg (1999), the SPL hard gel was placed in a canister with sufficient holes to allow it to ooze out slowly. It was placed in an injection well and the exposed surface was in contact with a fairly vigorous flow (relative to an aquifer velocity) of 0.25 gal/min. The active recirculation period ended at about 330 days, however, and the canister was retrieved after two years significant HRC was still present.

Regenesis is working on ways of delivering higher viscosity materials directly as "implants" using warmed GPL to lower the viscosity during application and special push-point injection and hollow stem auger techniques. These implants can be used as barriers or source treatments and can be expected to last for several years for very long-term plume management.

Table 2. Longevity Profile of GPL-HRC at 20,000 cP.

Site	Last Field Observation of Organic Acids- Lactic, Butyric, Propionic (in days)	Duration of Data Collection (in days)	Status
Site 1	150	364	Product exhausted before monitoring completed
Site 2	173	173	Product still present at conclusion of monitoring
Site 3	181	181	Product still present at conclusion of monitoring
Site 4	197	197	Product still present at conclusion of monitoring
Site 5	321	321	Product still present at conclusion of monitoring
Site 6	119	119	Product still present; monitoring on-going
Site 7	240	240	Product still present; monitoring on-going
Site 8	243	243	Product still present; monitoring on-going
Site 9	399	399	Product still present; monitoring on-going
Site 10	580	580	Product still present; monitoring on-going

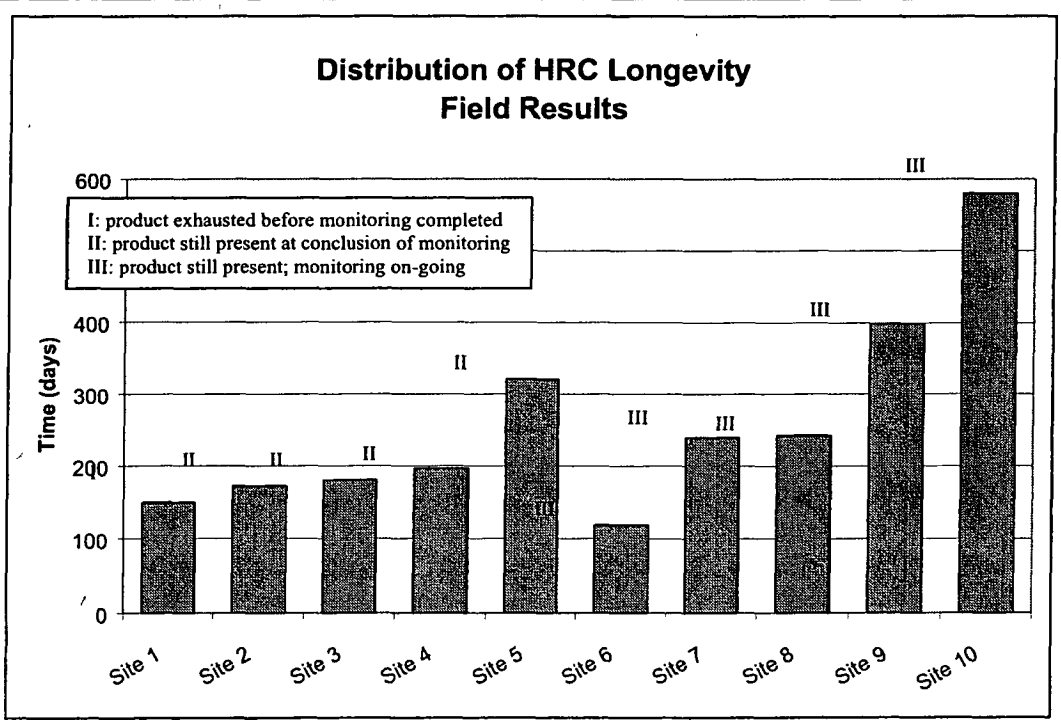

Figure 4.

Secondary Effects

Often we see remediation continuing after HRC breakdown products are no longer in the system. This observation led us to postulate that there may be more than one phase in the effect of adding HRC to the aquifer. Generally, we use the presence of elevated levels of organic acids as the metric, although we can also look at TOC data as well. However, sometimes after the footprint of the HRC is gone we can still see elevated rates of remediation. On further consideration we believe that the organic load to the aquifer that is provided by HRC is not a uni-directional event and that the biomass of microorganisms constructed from HRC can be recycled. This can cause an after effect as could native carbon in the system that might be more responsive to the elevated microbial population levels. While this is clearly not a dominant driver for reductive dechlorination relative to HRC, it apparently can have an impact. Lastly, at the formal exhaustion of the organic acids there is still hydrogen available.

To support this hypothesis we can look at an HRC injection as described in Sheldon, (1999). This experiment was a pilot test with a monitoring well (MW-8) that was clearly in the center of the HRC injection zone. Another well (MW-1) was in the experimental grid but was outside the migration zone for the HRC and its breakdown products during the course of the experiment. Figure 5 shows the nature of the organic acid profile over time and it should be noted that propionic acid is formed from lactic acid and then breaks down to release hydrogen. Acetic acid is generally considered to be a non-hydrogen evolving end point.

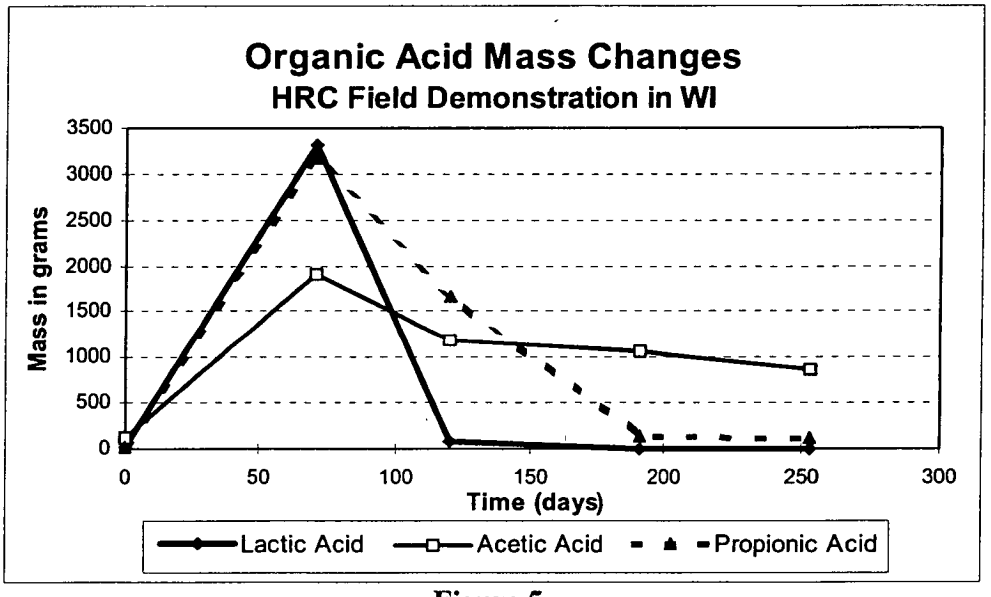

Figure 5.

The total mass of organic acids is calculated from a contouring exercise and the last appearance of lactic acid per se is between 70 and 120 days (the formulation was only about 10,000 cP in this early work). The disappearance of propionic acid between 120 and 190 days is further noted. With this background information we can now examine Table 3 and evaluate the remediation rate differences between the impacted and non-impacted wells (MW8 vs. MW1). It is clear that even after the organic acids are "gone" that there are still rate differences to be accounted for. At least two hypotheses can be presented.

- The HRC is still releasing slowly and is being consumed as fast as it is produced which would still allow remediation to proceed and cause a rate difference.

- The HRC is exhausted, but the organic material is being recycled and or native organic material is being mobilized by growing microbial populations - such that remediation continues.

Flow rates at this site are on the order of 0.5 ft/day and that is not sufficient to flush the system of HRC in the period involved in the study.

Table 3. TCE Degradation Rate Differentials at WI Site

Day	Half Life (d) Well TW01	Half Life (d) Well TW08	Ratio TW01/TW08
0-70	338	29	11.50
70-120	211	43	4.94
120-149	256	53	4.84
149-191	309	45	6.80
191-253	205	38	5.41

Summary

The main active ingredient in Hydrogen Release Compound is a polylactate ester called Glycerol (tri)Polylactate or GPL. Abiotic and microbially mediated hydrolysis of the ester linkage, between glycerol and the polylactate complex, releases the polylactate complex. The polylactate complex is a tetramer of lactic acid (4 lactic acid molecules esterified to themselves) and its degradation results in the release of individual lactic acid molecules which undergo fermentation to release hydrogen. These chemical features and the resultant viscosities, are an important component of longevity.

GPL is manufactured as a highly esterified thick gel and can be subsequently cut to a syrup-like consistency for injection. All other conditions being equal, product viscosity combined with the nature of microbial activity in the aquifer are the key determinants of product longevity. This is essentially a surface area argument. The thinner the material the more it will spread out and be exposed to chemical and biological degradation.

Based on the evidence presented in the laboratory and field, we can claim that ~20,000 cP HRC is estimated to stimulate reductive dechlorination within the aquifer for about 12 months. The longevity of this effect is a function of certain biological and geochemical features of the aquifer. HRC has been shown to promote reductive dechlorination resulting from the lactic acid release and possibly other indirect effects related in part to the formation of a nominal amount of recycling organic material that has a more prolonged effect on aquifer conditions. An "after effect" in the aquifer involving the recycling of carbon may extend the positive remediation effects beyond the formal longevity based on lactic acid release.

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Hydrogen Release Compound HRC®

Distribution of HRC in the Aquifer

General Background

The placement of HRC deposition or injection points is a function of how HRC distributes in the aquifer. Molecular transport in a flow field is well defined in the engineering literature, and these Laws of Mass Transport are applied to the movement of substrate and/or contaminant molecules in an aquifer. Specifically, we would like to apply these laws to the movement of the substrate lactic acid and all its breakdown products, including hydrogen. The Laws of Mass Transport are a compellation and include Darcy's Law (which describes advective flow) and Fick's Law (which describes diffusion). The entire mass transport issue is conveniently presented in a single second order differential equation, generally called the Advection-Dispersion Equation, which ties all of the fundamental processes together, specifically advection, dispersion, diffusion, retardation and consumption.

Anaytical solutions to the Advection-Dispersion Equation (Segol, 1994 – specifically Cleary-Ungs) were used early in the development of HRC to gain a basic theoretical understanding of its potential movement in an aquifer. For further details on the Advection-Dispersion Equation see a basic hydrogeology text such as Applied Hydrogeology by Fetter (1994). A more advanced discussion can be found in Contaminant Hydrogeology (1992), also by Fetter, or Ground Water Models (1990), a collective effort available from the National Research Council.

The use of models was part of a basic "sensitivity analysis" to gauge the relative importance of different parameters (advection, dispersion, diffusion, retardation and consumption) in the HRC distribution process. However, the need for this kind of analysis has now been superceded by actual laboratory and field data sets. As any one familiar with models realizes, the experimental data is worth more than the theoretical projections. While experimental data can be used to calibrate theoretical treatments and make them consistently more accurate, the cost and time that would be involved to gather the key variables at an actual site with enough accuracy is often prohibitive. Also, collecting the data with sufficient accuracy may be a difficult to impossible task.

Under these circumstances, what can we then do to understand the process?

First, as discussed, we have field evidence and this will be presented momentarily. Aside from that there is one theoretical excursion worthy of exploration and that concerns the effects of pure diffusion on the movement of HRC in the aquifer. This is an attractive avenue because it gives a concept of molecular movement independent of hydrogeological and biological conditions. It is a first approximation that grounds us in dealing with the more complex features of an advanced argument.

Theoretical Considerations

As discussed, diffusion is presented as a special case because it is fairly straightforward and manageable and gives an indication of the expected movement in an aquifer under ideal conditions. The important breakdown products of HRC (e.g., lactic acid, pyruvic acid and hydrogen) all extinct logarithmically in accordance with the equation for simple diffusion from a point source. This is the simplest case possible (point source in one dimension). It will be followed with experimentally derived values that will be applied to the more complex case of diffusion from a radial system (areal flux in one dimension). This is representative of a column of HRC dissolving in an enclosed tube perpendicular o to the length.

Returning to the simple case to illustrate a few fundamental concepts we have

$$C\ (x,t) = Co\ [\ \mathrm{erf\,c}\ (x\ /\ 2*(D*t)^{0.5})\ ]$$

Where C is the final concentration at distance x in cm. Co is the initial concentration, erf c is the complementary error function, D is the diffusion coefficient in cm^2/sec and t is time in seconds.

A case is presented below for diffusion from a point source and is graphically represented in Figure 1. The initial concentration of lactic acid is fixed at 1,000 ppm, which is a conservative concentration for the zone of solubilized material at the interface of the HRC solids and the aquifer. In the example below, it is very important to also realize that this result is expressed in a "conservative background" with no biological or chemical consumption and no aquifer matrix tortuosity. Actual migration patterns will invariably be less than these theoretical maxima.

Table 1. Lactic Acid Diffusion from a Point Source

		Concentration ppm	Distance rad. in cm	Distance rad. in ft
		1000	0	0
		816	87	3
Temperature in °C	= 25	642	173	6
Time in Hours	= 8729 (1 Yr)	485	260	9
Maximum Distance in cm	= 865	352	346	11
Initial Lactic Acid Concentration	= 1,000	245	433	14
		163	519	17
		103	606	20
		63	692	23
		36	779	26
		20	865	28

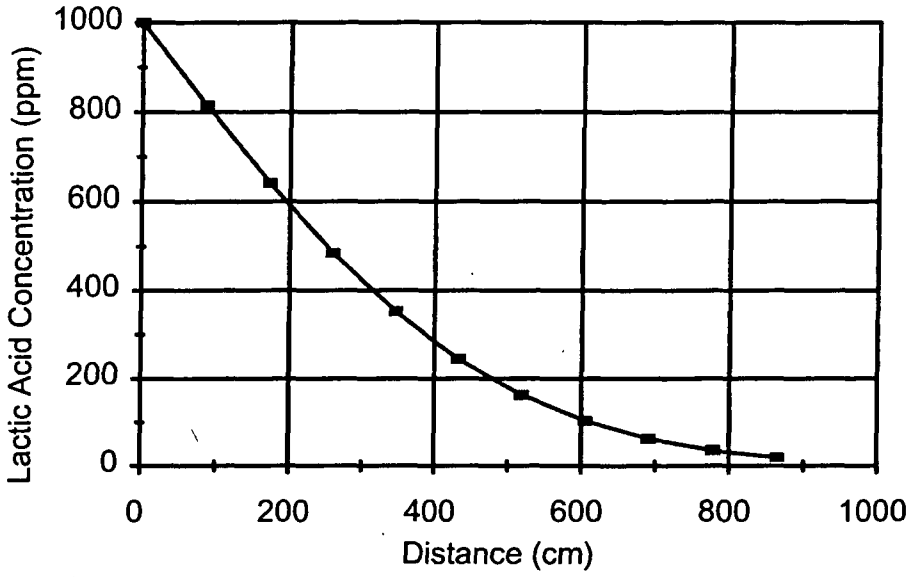

Figure 1. Diffusion of Lactic Acid from a Point Source over 1 Year.

Results show that to achieve a lactic acid concentration of 20 ppm, provisionally enough to treat about 1 ppm of chlorinated hydrocarbon, sources can be as far apart as 56 feet as two 28 foot radii converge between application points. Again, this is in a non-consumptive environment with no path length tortuosity and in a one dimensional diffusion situation. As we will see the more exact result, which is connected to an actual experimental measurement of the diffusion coefficient and involves tortuosity and consumption, values are presented that are about 40 percent of those presented in the above analysis.

The point of this simple exercise is to emphasize that "diffusion matters". Essentially, because the driving force is substantial at 1,000 ppm (versus, say, oxygen at 25 ppm), we can document a fairly vigorous movement of lactic acid and its breakdown products. Diffusion is actually a major driving force in low to moderate flow environments (noting that 0.1 ft/day = 36.5 ft/yr). It is also a valuable force in actually achieving contact between contaminant and substrate, because diffusion is an excellent way to distribute materials in the sub-surface relative to the injection of liquids – an activity that creates preferential flow paths and mixing problems.

Laboratory Results

The next level to examine is laboratory performance. In this instance we performed an ASV test. For further details about the ASV macrocosm test please refer to TB 2.4.3; an illustration of this experimental system is provided in Figure 2.

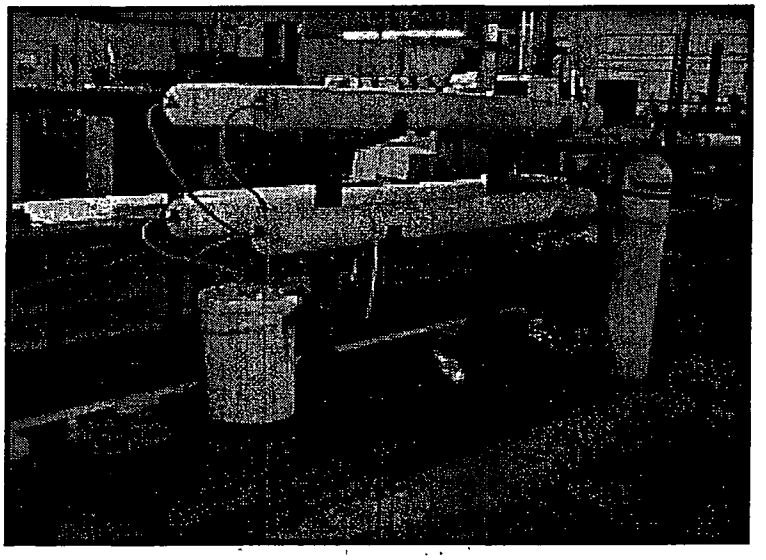

Figure 2. Aquifer Simulation Vessel (ASV)

The purpose of this ASV study was to accomplish two goals. The first was to determine if the viscosity of the HRC affects the longevity of the product. A high viscosity "implant quality" GPL (approximately 200,000 cP) and the injectable HRC (20,000 cP) were compared. The second goal was to determine the diffusion rate for the two different materials in different compositions of soil. Details on the product viscosity issues and the longevity results are provided in TB 2.8.1.

In establishing the test, a soil sample with an active population of TCE degraders is homogenized by manual stirring and the soil is packed into a series of 6.0-foot long tubes with an internal diameter of 5.75 in. The tube therefore has a volume of 2,025 in^3, and approximately 30% of that volume is pore space. A solution of 25 ppm of TCE was passed through the ASVs to make the concentration of TCE constant throughout. The pumps, which normally are used in the ASV for continuous flow experiments, were turned off and 15 g of HRC was loaded into the front end of each of tube. The ASVs were analyzed monthly until a reasonable diffusion rate was determined, and the experiment was continued to gather HRC longevity data.

Four ASV tubes were set up. Two were packed with 10% loam and 90% clay with 25 ppm of TCE. One of the ASVs was injected with HRC (20,000 cP) and the other with high viscosity GPL (200,000 cP). The other two ASVs were packed with 10% loam and 90% sand with 25 ppm of TCE and each received one of the two different viscosity materials. The flow of TCE solution was stopped once the HRC was injected and the movement of HRC and its by-products was left to diffusion.

The four ASVs were analyzed on day 3 after injection to see if there was any lactic acid present at the six-inch port in order to determine diffusion rates. Lactic acid was present and thus the 12-inch port was analyzed and used to determine the diffusion rates. The results are presented in Table 2.

Table 2. Diffusion in an ASV.

ASV Composition	Rate	GPL-HRC Viscosity
90% Sand-10% Loam	3 in/day	196,000 Cp
90% Clay-10% Loam	4 in/day	196,500 Cp
90% Sand-10% Loam	4 in/day	21,500 Cp
90% Clay-10% Loam	4 in/day	21,500 Cp

The lower viscosity material releases lactic acid at higher rate than the higher viscosity material (Table 3). The major difference between the low viscosity and high viscosity is the amount of lactic acid that diffuses out to a given location with time. As discussed in TB 2.8.1, all other conditions being equal, product viscosity combined with the nature of microbial activity in the aquifer are the ultimate key determinants of product degradation rates. This is essentially a surface area argument. The thinner the material the more it will spread out and be exposed to general chemical and biological degradation. Consequently, the low viscosity material can generate larger concentrations at greater distances from the source, but it will be consumed more readily.

Pyruvic acid is a breakdown product for lactic acid, on the way to acetic acid; a mole of hydrogen is produced at each step. For further details see TB 1.1.3. In Tables 3 through 6, the low viscosity material is already starting to convert to acetic acid, while the higher viscosity product does not have any acetic acid present and is still releasing lactic acid.

The major difference between the low viscosity (20,000 cP) and high viscosity (200,000 cP) products is the amount that diffuses out to a given location with time. This is exactly what is expected. Because bacteria metabolize the low viscosity material more quickly, the concentrations seen at various distances are larger. Of course, the "source" concentration will be used up sooner so that the higher concentrations of lactic acid are offset by the time the lactic acid will be present.

In both cases substantial concentrations of lactic acid (10 – 90 ppm) are seen 1 ft from the source in three days. By day 6, significant concentrations of lactic acid (14-132 ppm) were seen at 2 ft from the source. The concentrations of the low viscosity material are much higher, as would be expected.

Table 3. Organic Acid Data for ASV #1-90% Sand-10% Loam-High Viscosity

	Lactic Acid Results (mg/L)				Pyruvic Acid Results (mg/L)				Acetic Acid Results (mg/L)			
Days	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**
1.0 ft	10.6				0				0			
1.5 ft		2.12				0				0		
2.0 ft			2.74	1.68			0.13	0.07			0	0
2.5 ft												

Table 4. Organic Acid Data for ASV #4-90% Clay-10% Loam-High Viscosity

	Lactic Acid Results (mg/L)				Pyruvic Acid Results (mg/L)				Acetic Acid Results (mg/L)			
Days	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**
1.0 ft	13.3				0				0			
1.5 ft												
2.0 ft		14.2	8.79	23.2		0	0.07	0		0	0	0
2.5 ft												

Table 5. Organic Acid Data for ASV #2-90% Sand-10% Loam-Low Viscosity

	Lactic Acid Results (mg/L)				Pyruvic Acid Results (mg/L)				Acetic Acid Results (mg/L)			
Days	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**
1.0 ft	12.3				0				0			
1.5 ft												
2.0 ft		59.9	1.64	1.26		0	0.09	0.07		0	0	46.4
2.5 ft												

Table 6. Organic Acid Data for ASV #3-90% Clay-10% Loam-Low Viscosity HRC

	Lactic Acid Results (mg/L)				Pyruvic Acid Results (mg/L)				Acetic Acid Results (mg/L)			
Days	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**	**3**	**6**	**36**	**66**
1.0 ft	93.1				0				0			
1.5 ft												
2.0 ft		132	138	445		0	0	0		0	27.2	1498
2.5 ft												

In contrast to the previous treatment of diffusion we have here an actual experimental result. Since the diffusion is for a cylinder of HRC rather than a point source we refer to a different equation (Segol, 1994). The basis is:

$$0.6 = \frac{Dt}{r^2} \qquad [1]$$

Where D is the diffusion coefficient in cm^2/sec, t is time in seconds and r is the radius of diffusion in cm.

This is for a cylinder where we want the concentration to be 2% of the source, e.g. 20 ppm if the source is 1,000 ppm. Fitting the data and converting to the English System, using an average value from the experiments of 1 foot in 3 days, gives an effective diffusion coefficient of 0.2 ft^2/day and thus a fairly straightforward and usable diffusion rule is derived:

$$t = 3\,x^2 \qquad [2]$$

Where t is the time in days it takes the front to move out a distance x in feet. Thus, it takes about 300 days to move 10 feet or about 11 feet per year. If a higher concentration is used at the source, the time will decrease. We cannot really project exact amounts at various distances from the data because it is difficult to gauge bacterial utilization rates and localized substrate concentrations. What we do get is a sense of diffusional movement as a function of time at a level quite adequate for project design purposes.

Other observations from the data are as follows. Recall that the soil was infused with a solution of 25 ppm of TCE. For the low viscosity HRC, for example, about 3 times more acetic acid than lactic appears at 2.0 ft on day 66 compared to a ratio of 1 acetic acid to 5 of lactic acid on day 36. There is very little acetic acid seen with the high viscosity material. This indicates a larger potential "waste" factor for very low viscosity materials, such that more hydrogen is produced per unit time than can be used for reductive dechlorination. This would lead to off-gassing of hydrogen and/or the production of excess methane with implications for using liquid substrates like lactic acid or molasses.

Ultimately the point of all this is to determine injection point spacing. A highly detailed answer depends on the bacterial activity and product viscosity, but nominally it appears that diffusion alone

will drive the lactic acid out several feet in two months. The data suggest that 10 ft points will work if coverage is desired in two to three months. The distance between 10 ft points where coverage occurs is where the two fronts meet at a 5 ft distance from both injection points. Placing 5 for x in equation [2] results in a time of 75 days. If injection wells were placed 20 feet apart they would meet at a distance of 10 feet from each point. This would occur in 300 days according to equation [2]. In a year the distance increases to 11 feet. Note that this assumes no advection whatsoever. The motive force is simply diffusion.

Field Results

The data in Table 7 provide an excellent cross section of results across 10 sites. These are the same 10 sites referenced in the longevity Technical Bulletin (TB 2.8.1). The sites have a range of groundwater velocities from essentially static (Site 1) to moderate flow rates of about 128 ft/yr. (Site 5). All of these sites were treated with 20,000 cP HRC injections, noting that an "injection" is not a process that sends material as far from the injection point as might happen with thin liquids. Therefore, the movement as measured is due to the net mass transport forces of advection, dispersion, diffusion, retardation and consumption. Overall it seems that HRC applied to an aquifer can move quite readily.

Table 7. Movement of Organic Acids in the Field.

ID	Distances and Days to Wells	GW Velocity (ft/yr)	Potential Yearly Movement (ft)
Site 1	8' in 89 days (OW-201-S)	0.15	33
Site 2	20' in 32 days (MW-8, 23 and 27)	110	228
Site 3	16' in 35 days (MW-31)	110	167
Site 4	15' in 154 days (MW-3)	27.4	36
Site 5	32' in 31 days (IMPM-6)	128	377
Site 6	NA*	14.6	NA
Site 7	5' in 33 days (TWM-B)	< 36.5	55
Site 8	20' in 30 days (MW-26)	102	243
Site 9	140' in 140 days (MW-9)	< 36.5	365
Site 10	25' in 120 days (RW-68)	73	76

* NA (not applicable): acids data, which was supposed to be collected at 30 days was not collected until 77 days post-application. At this time acids were detected in monitoring wells, but they were all within a few feet from the HRC grid area. There were no monitoring points downgradient from the grid that were useful in this analysis.

One of the most interesting observations from this data set is the fact that Site 1 is essentially driven by diffusion and is also affected by retardation and, more importantly, consumption. Therefore, we note that there is at least 33 ft of movement per year under these conditions. Recognize that the thesis throughout the entire presentation is the justification for placing 20,000 cP material at 10 ft centers and 200,000 cP material at 20 ft centers.

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Hydrogen Release Compound HRC®

Bedrock Application of HRC

General Background

HRC delivery techniques into bedrock aquifers are generally determined by aquifer characteristics and borehole drilling techniques.

HRC can be delivered into cased or open-hole completed groundwater wells via two general installation procedures: A) injection using down-hole packers and B) backfill/tremie-backfill methods. The HRC installation method should be a function of the aquifer material type, the nature and presence of fractures and the potential radius of influence

Technical Approach

- Fractured Aquifer Setting:

Typically, the best delivery conduit in a fractured bedrock aquifer is an open-hole completed well bore. Open-hole well completion method does not have casing material or gravel pack and allows HRC direct contact with the fracture. This direct contact can be via tremie-backfill or packer assisted delivery methods. In many cases its advantageous to apply HRC in conjunction with a packer system. The down hole packer can be used as a single or double "straddle" system, depending how much application focus is desired (Figures 1-1 and 1-2). To successfully place HRC into direct contact with the fracture system under pressure the operator must apply HRC at a pressure that does not exceed the inflation pressure of the down-hole packer/packers. This method provides a "rifle shot" application of HRC into defined sections of the aquifer that are responsible for the majority of the contaminant transport. To date, the use of HRC in fractured bedrock has not resulted in detectable levels of aquifer obstruction. This is likely because HRC completely biodegrades in the aquifer.

A second delivery method is to tremie backfill an open-hole completed well bore. This approach is a low-resolution application method. It relies on the volumetric backfill of the entire saturated section of the borehole with HRC material. This delivery approach relies on direct contact of HRC with the fractures and the tendency of HRC to "seep" into the fractures (Figure 1-4).

A third delivery method/option is HRC application via small diameter delivery wells (2-inch). These delivery wells are typically completed at surface to allow connection to a pump so HRC can be delivered under pressure. This method has low application resolution because it requires the wells annular space being filled prior to HRC entering the aquifer material (Figure 1-3).

- Non-Fractured (Massive) Aquifer Setting:

Typically, the best delivery method in massive aquifers is an open-hole completed well bore. In this aquifer setting no developed fracture systems are present to conduct the HRC beyond the well bore. The HRC remains in the well bore as a column. The lactic acid created from HRC is delivered into the aquifer via advection and diffusion. Delivery of HRC is accomplished via typical tremie techniques (Figure 1-4).

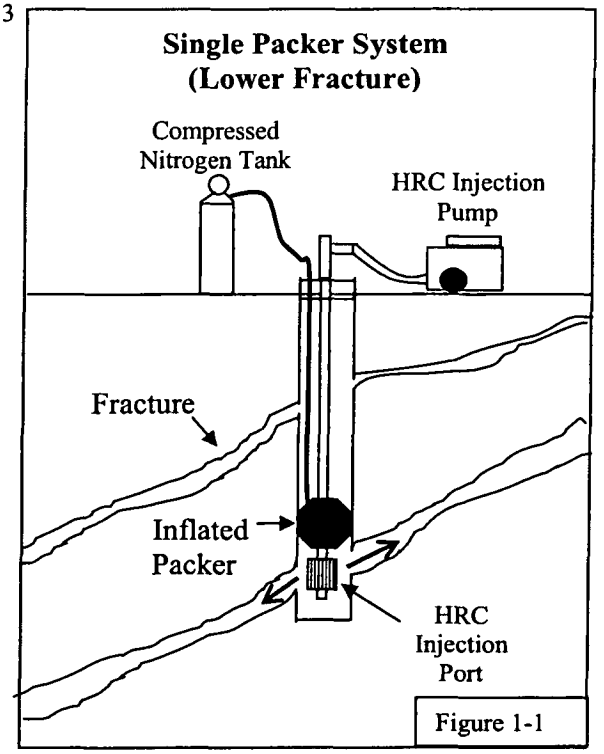

Figure 1-1

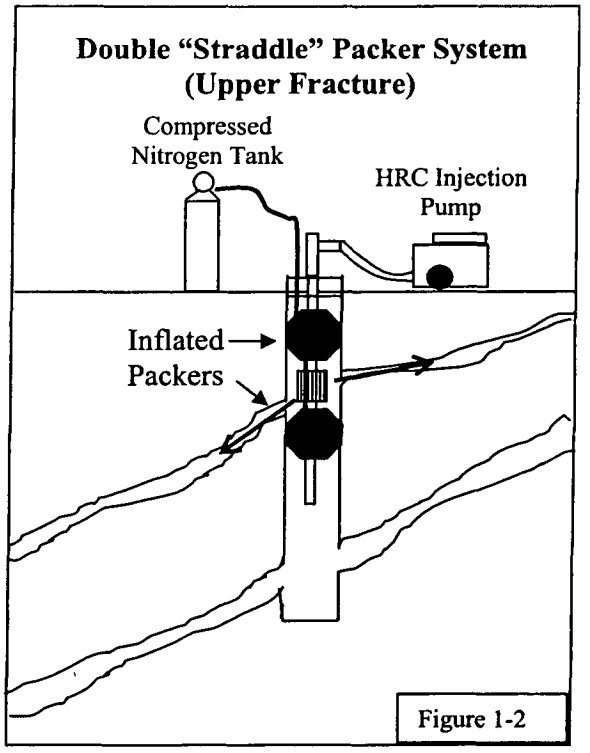

Figure 1-2

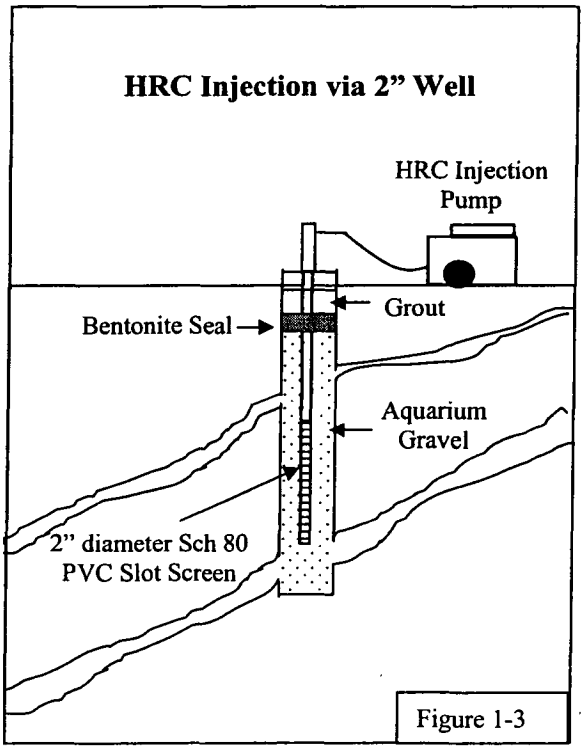

Figure 1-3

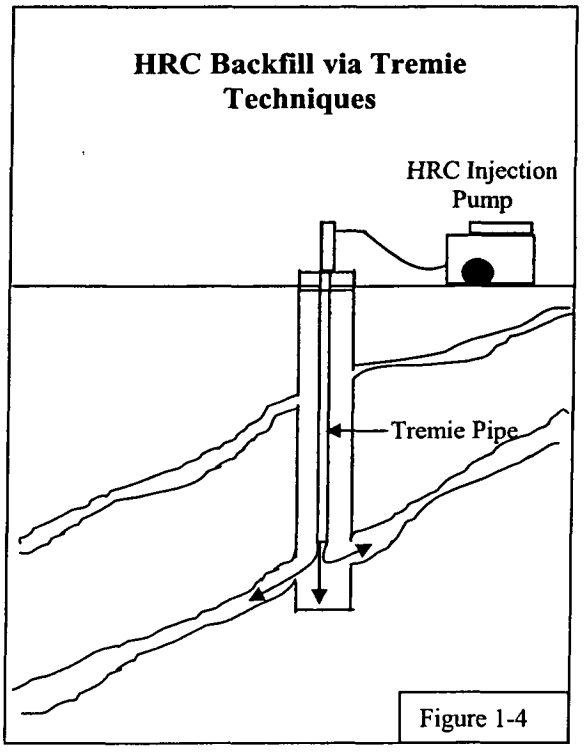

Figure 1-4

Hydrogen Release Compound HRC®

How does Hydrogen in HRC finally get to the chlorinated hydrocarbons?

Background
Our customers sometimes ask about the convoluted process whereby electrons need to "run the gauntlet" relative to other electron scavenging reactions in the sub-surface – before "our electrons" can become available to do what is desired, i.e. achieve the destruction of chlorinated hydrocarbons by reductive dechlorination . To that end here is a brief synopsis of a complex issue.

Summary
In many ways this is a story we can think of as "the dance of the electrons". What we are trying to do is get electrons, using hydrogen as the carrier, to the chlorinated hydrocarbons; noting that in this case the hydrogen itself has value as the functional group that will replace chlorine on the contaminant molecules.

In nature, this process is not easily performed because there are other reactions that "sit on top of" reductive dechlorination in a hierarchy ruled by certain laws of physical chemistry. Sometimes these rules are described with reference to oxidation-reduction or redox potential, and sometimes people invoke the concept of Gibbs Free Energy or just free energy. Let's take a minute with these subjects first as they are seminal to the discussion to follow.

Oxidation – Reduction Reactions
The oxidation-reduction reactions are key chemical events in that they are about the net movement of electrons from one reactant to another. In describing this movement of electrons, oxidation describes a loss of electrons and reduction describes a gain of electrons. If the concept of reduction being a gain is counter-intuitive just realize that in an algebraic sense it is a gain of a negative charge and is therefore a reduction. These reactions always occur in couples so that if one compound is oxidized the other is reduced.

To further round out some terminology, the compound that is reduced (gains electrons) is seen as the oxidizing agent because some other compound was oxidized (lost electrons) in the process. An alternative way to express this is that oxidizing agents become reduced because they remove electrons (and thus gain them) whereas reducing agents become oxidized because they give up electrons (and thus loose them).

Redox potential is equivalent to ORP which stands for Oxidation Reduction Potential. It is a measurement of potential electron flow in a system and is a framework on which various oxidation-reduction couples are situated. A positive ORP, measured in millivolts (mV), is indicative of an

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aerobic environment because oxygen is an electron acceptor – seeking electrons from other sources. If it is present then there is a potential for electron flow in its direction and the ORP of the system is positive. In the absence of oxygen there is an attenuated potential for electron flow and the ORP is therefore less positive and can actually be negative. We focus on oxygen in this case because of the aerobic –anaerobic context of the discussion, whereas an actual ORP measurement is not completely tied to oxygen dynamics (but tends to be dominated by it).

Free Energy

The use of the free energy concept runs in parallel here and sometimes forms the basis for describing the preference of how compounds will react (from a less stable high-energy state to a more stable low-energy state) . For our purposes we will focus on the electron flow hierarchy, whereas "energy availability" relationships that are related to electron flow, are in the background. In some ways the energy issue is used when we bring the microorganisms into the discussion and call them the oxidizers or the reducers. They are, of course, trying to capitalize on the reactions in which electrons are flowing so they can capture the energy. This is an important part of the story, because as we will see, an organism that reduces nitrate is going to dominate an organism that reduces a chlorinated hydrocarbon because the nitrate sits above the chlorinated compound on the ORP scale (more positive) and has more free energy available.

So, to bring this all into focus for the purpose of the performance of HRC this is how it works. The major chemical species in the hierarchy and their "signature ORP value" are as follows:

	Chemical Species	"Midpoint" ORP in mV	
Environment is Aerobic			Higher Free Energy
	Oxygen	+820	
Environment is Anaerobic			Lower Free Energy
	Nitrate	>+740	
	Manganese	+520	
	Iron	-50	
	Sulfate	-220	
	Carbon Dioxide	<-240	

Now, we also must recognize that reductive dechlorination *occurs in a range* from about -200 to -300, or slightly above sulfate and slightly below carbon dioxide.

We are putting HRC into solution where it is converted primarily to lactic acid and that will degrade by fermentation through a series of other organic acids (such as pyruvic and acetic) releasing hydrogen along the way. The hydrogen is a proton with one electron and this is why we call HRC an electron donor. It will donate electrons to the chlorinated hydrocarbon (so in fact it is a reducing agent that is being oxidized) while the chlorinated hydrocarbon becomes the oxidizing agent (that is being reduced). This reaction results in the dechlorination of the molecule - as the hydrogen and its electron are substituted for the chlorine which leaves (without its electron – hence Cl^-); this is why we call it reductive dechlorination. Note that this is anaerobic metabolism and that in aerobic metabolism the roles are reversed. Oxygen is an electron acceptor and the contaminant

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(an organic molecule such as a benzene or lactic acid) is the electron donor. Oxygen is reduced and the contaminant is oxidized.

Objective of HRC Application

The object of the HRC application is then to get this hydrogen/electron resource into the -200 to -300 range redox environment where it can be utilized in reductive dechlorination, but of course we have to run a gauntlet to get there if the initial ORP is above that point. All of the species that sit above our objective or target – the chlorinated hydrocarbons – are therefore considered to be Competing Electron Acceptors or CEAs, because that is exactly what they are from our perspective given our objective. We don't want competition for electrons, we want them to be used to reduce chlorinated hydrocarbons. Most of the time we are starting with an aerobic environment, so we are up in the oxygen range and have to take that on first.

Since we have oxygen in play we are in an aerobic environment. The lactic acid is seen as the organic electron donor and oxygen is consumed aerobically. Note that lactic acid has not gotten to the fermentation stage to make hydrogen yet, because fermentation is an anaerobic process. The lactic acid is just oxidized – but we are wasting resources that will never make hydrogen. The good news is that *there is very little oxygen to drive this wasteful process.* The irony of it is that when we are degrading petroleum hydrocarbons we complain that there is not enough oxygen, under the best of conditions in cold water it might be as high a 10 ppm. So, when we are going after chlorinated hydrocarbons we are looking to reduce them and the limited oxygen content of water works to our advantage.

When the oxygen is gone the microbes (now anaerobes) move onto nitrate. By this time we have made some hydrogen via fermentation and that will be consumed by nitrate reactions (by denitrifying microbes). Again, the good news is that with some rare exceptions that tie into fertilizer-mediated groundwater impacts, dissolved nitrate concentrations are also pretty low – only a bit higher than oxygen on average. After this step, we are really starting to get anaerobic.

We then confront manganese and while we should discuss it technically, it is a micro-constituent of most groundwater and is very inconsequential as a CEA. Moving onto iron, same thing; there is typically about as much iron as there is nitrate in a range that runs from the manganese levels (1 ppm or less) to levels that parallel nitrate when it is considered high (around 100 ppm). All in all, these combined CEA impacts are relatively minor, but when added up they should be accounted for and we do so in our design software. As a final note, these CEA neutralization reactions should be seen in a proper molar context. Consequently, one should realize that absolute weights (as in mg/L) may be easier to handle in light of the molar based stoichiometry calculations that determine the actual amount of HRC required to do the job.

This brings us to sulfate which is the only CEA of any real concern. Sulfate can range from trace levels on the order of a few ppm to as high as 7000 ppm (the worst we have seen) in highly alkaline desert environments which are clearly the exception. Even though sulfate can be of concern in some cases there is a lot of misconception about the degree to which it is a problem and, beyond that, how it can be fixed when it is a problem.

As we enter a discussion on sulfate bear in mind that we have already entered the reductive dechlorination zone. So in summary, even though we are in a realm where sulfate can scavenge electrons there are several important points to consider.

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1) The reactions, sulfate reduction and reductive dechlorination are not necessarily mutually exclusive. Because of the overlap they can run simultaneously. So, while electrons can "get wasted" in the process, contrary to "common belief", sulfate reduction may not block reductive dechlorination. Basically, sulfate does not have to be eliminated in order to open up an opportunity for reductive dechlorination to occur. Further, for the most part sulfate is reduced by sulfate reducing bacteria and chlorinated hydrocarbons by reductive dechlorinators; two different populations, two different action centers.

2) Since monitoring wells are sampling across all intervals in their domain, sometimes high sulfate is confined to a certain strata (like one with a gypsum vein) and this is not where the contaminant is located. Only involved multi-level sampling can sort this out.

3) Most importantly, in light of the above, various researchers have been asking why there doesn't seem to be a problem with reductive dechlorination on some sites with high sulfate. This is not expected and fairly recently got some researchers thinking. The answer is that it is not about the sulfate *but rather the by-product of sulfate reduction which is sulfide.* In a word – sulfide is *toxic* to microorganisms- *unless* – it is precipitated by iron to form iron sulfide. So, sites with high iron convey an "immunity" to sites with high sulfate and that explains why we can't have a rigid rule about high sulfate inhibition in the field. In fact, we are aware of at least two sites in the Colorado desert, with 2500 and 4000 ppm of sulfate respectively, that are dechlorinating without prejudice; as you would suspect they have high iron. Regenesis is now working on a special variant of HRC, that is about to be field tested, that will contain an affordable time-release organic iron complex that will facilitate limiting the potential inhibitory effects of sulfate by tying up the sulfide.

So, at the end of the story we come to carbon dioxide which when reduced in the presence of hydrogen makes methane. Methane is not good to have and in fact, HRC provides a key advantage by virtue of its slow-release characteristics. The fact is that methane is generated by yet another class of microbes called methanogens and while they might be in the aquifer they only can make methane when hydrogen concentrations are high. In fact, it has been shown that the enzymes they produce to make methane are not activated until a certain partial pressure of hydrogen is achieved.

The injection of any easily flowing, readily soluble liquid organic material (such as a sugar solution) will promote too much methane production because fermentation will be accelerated (due to the higher surface area that accompanies the lower viscosity) and more hydrogen will form relative to a slow-release source (that has high viscosity and for the most part stays in place). Therefore, in the competition between reductive dechlorinators and methanogens, the methanogens can be kept at bay in the zone of ORP overlap by offering hydrogen at a rate that is sub-optimal for methanogens. HRC's slow release chemistry therefore offers a distinct advantage in this circumstance.

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HRC TECHNICAL BULLETIN # 1.1.4

Hydrogen Release Compound HRC®

Competition for Hydrogen Between Reductive Dechlorinators and Other Microorganisms

The microbial population that inhabits the subsurface under conditions of low redox potential is sometimes referred to as the "anaerobic web". This is a revealing term which reflects the lack of knowledge we face when dealing with the microbial dynamics of the subsurface. One of the major challenges for some microbiologists is to better define this microcosm - but it is not an easy task. The anaerobic web is an ecosystem every bit as complex as those we experience at our sensory scale.

Among the complexities of the entire problem we want to focus in on a few relevant issues as they pertain to the dynamics of HRC and reductive dechlorination. A series of microbially mediated events can be set forth as follows:

1. First, the aquifer has to be driven anaerobic if it is not already in that condition. Obviously, this has to be achieved to support the growth and development of anaerobic microorganisms. To achieve this state, all the oxygen and the other electron acceptors such as nitrate and sulfate have to be consumed. As detailed in Technical Bulletin 2.6.1, this condition can be achieved by providing substrates such as lactic acid to the aquifer. HRC is a source of this lactic acid and its metabolism by anaerobic microorganisms to carbon dioxide and water "burns up" all of the electron acceptors.

2. Now the stage is set for the important reactions that remove chlorinated hydrocarbons. Recognize that the redox potential goes from positive to negative as electron acceptors are consumed. As soon as electron acceptors are gone the dynamics of the microbial web shift; as redox potential shifts so do the dominant species of microoganisms in the aquifer. As low to moderate negative redox conditions form, certain kinds of fermentative microorganisms can thrive that will attack the HRC derived lactic acid and turn it first into pyruvic acid and then acetic acid. It is through this process that the hydrogen is formed; one mole of H_2 is derived in the conversion of lactic acid to pyruvic acid and another mole of H_2 is derived from the conversion of pyruvic acid to acetic acid. Further details can be found in Technical Bulletin 1.1.3.

3. The hydrogen formed by fermentative microorganisms is now available for reductive dechlorination - however, there are other competing microbial processes that also demand hydrogen. The most common of these is methanogenesis. As the name implies this is a methane generating reaction that involves the combination of CO_2 with hydrogen.

Recently, some of the experts in the field of reductive dechlorination, including laboratory groups at Cornell and Stanford as represented in the references given, have offered the hypothesis that there is competition for hydrogen between reductive dehalogenators and methanogens. They believe that a low concentration of hydrogen favors the reductive dehalogenators and starves out the methanogens that have a larger appetite for hydrogen.

With an excess of hydrogen in the system the methanogens are favored and crowd out the reductive dehalogenators. The objective would then be to keep hydrogen concentrations low. This can be accomplished with the use of slow release organic acid materials such as HRC.

Returning to the subject of anaerobic web complexity, we have to remind the reader that the rules are not so standardized. In fact, some of the organisms that generate the hydrogen may also perform reductive dechlorination. Also, both reductive dechlorinators and methanogens may co-exist in some systems so that "everyone is satisfied". Lastly, not everyone accepts the hydrogen competition theory and there are dissenting opinions which have not yet reached the literature, but will in the near future.

HRC provides a basis for designing a low-cost passive system for plume control. When designing as HRC remediation system one must consider all competing uses for the hydrogen generated. If in a given aquifer system the dynamics of

hydrogen competition are present, and if HRC hydrogen generation is minimal enough given hydrogeological and microbial conditions, then there is a basis for expecting an additional benefit from using the HRC.

References

1. Fennel, D.E., J.M Gossett and S.H. Zinder. 1997. Environmental Science & Technology. 31: 918-926.

2. Yang, Y. and L. McCarty. 1998. The First International Conference on Remediation of Chlorinated and Recalcitrant Compounds. Platform Presentation. Monterey, California, May 19, 1998.

HRC Technical Bulletin Index||HRC Homepage

Attachment 3

Resumes of Key Project Team Member

(Resumes are needed from the Navy, RIDEM, EPA, Town of North Kingstown, and CDW Consultants)

James A. Shultz, CPG
Senior Geologist/Project Manager

Mr. Shultz has more than 26 years of experience conducting and managing numerous hazardous waste site investigations for the Department of Defense, and public and private sector clients; ground water availability studies for municipal and private sector clients; and site investigations, remediation studies, tank removals, and bay drain closures at retail gasoline service stations. He is a Certified Professional Geologist responsible for the management, design, and implementation of geological and hydrogeological investigations, and the coordination of these disciplines in multidisciplinary projects. Mr. Shultz has project management, marketing support, and Senior Technical Reviewer responsibility for hydrogeological services at the EA Boston office.

Education

B.S.; Pennsylvania State University; Geology; University Park, Pennsylvania; 1971

R gistrations/Certifications

Certified Professional Geologist; American Institute of Professional Geologists; CPG-6087

Training

Hazardous Waste Operations Annual Refresher; 2001
Understanding the Massachusetts Contingency Plan, Northeastern University, Massachusetts; 1995
Short Course, University of Waterloo, Canada, Contaminant Hydrogeology; 1983
Short Course, University of Waterloo, Canada, Field Methods of Contaminant Hydrogeology; 1981
Short Course, Princeton University, Groundwater Pollution and Hydrology; 1980

Professional Experience

Hazardous Waste—Developed extensive expertise in the planning and performance of site investigations and remedial investigations. Supervised and performed numerous ground water contamination studies at proposed and existing facilities for the Department of Defense, nuclear power industry, regulatory agencies, and the chemical/petroleum and high technology industries. These studies included the development of programs for the location and installation of monitoring devices, a wide variety of sampling programs, soil vapor contaminant assessments®, site evaluations, and coordination with regulatory agencies.

Remedial Investigation/Feasibility Studies—Project Manager for performance of a remedial investigation/feasibility study under the Navy Base Realignment and Closure Act Program at three Installation Restoration Program Sites at Naval Construction Battalion Center Davisville, Rhode Island (former Navy SeaBee Training facility), including a closed landfill and two chlorinated solvent (chlorinated volatile organic compound) release sites. Work includes the preparation of investigative work plans and safety and health plans; seismic and magnetometer geophysical surveys; hydroprobe screening of ground water; installation of soil borings and monitoring wells; offshore drilling and soil and ground water sampling from a barge platform in a harbor; multimedia environmental sampling including low flow sampling of ground water; aquifer characterizations; evaluation and reporting of the hydrogeology and nature and extent of chlorinated volatile organic compounds, metals, polycyclic aromatic hydrocarbons, and polychlorinated biphenyls within complex hydrogeological conditions (unconsolidated sediment and bedrock); input to the development of long-term monitoring plans and Preliminary Remediation Goals; risk assessment; assessment of potential for natural attenuation of chlorinated volatile organic compounds; evaluation of remedial alternatives including natural attenuation, pump and treat, *in situ* treatment, landfill capping and containment, and wetland enhancement/creation; and remedial design for the landfill site. The work also involves coordination with state and federal regulatory agencies, and support of and periodic presentations at the Base Realignment and Closure Act closure team and Restoration Advisory Board meetings.

Project Manager for remedial investigation of three adjacent landfills and former filter beds, a Superfund site at Hanscom Air Force Base, Massachusetts for the U.S. Army Corps of Engineers (USACE)–Omaha and Baltimore districts. The work was performed under Comprehensive Environmental Response, Compensation, and Liability Act and included preparation of the field investigative work plan and safety and health plan, with coordination and approval from U.S. Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Protection; installation of additional soil borings and monitoring wells; sampling of soil, surface sediment, soil gas, ground water (low flow method), and surface water and sediment; aquifer characterization; evaluation and reporting of the hydrogeology and nature and extent of Target Analyte List metals and Target Compound List organics in soil, sediment, ground water, and surface water; and evaluation of the nature and extent of landfilled material.

For high-tech industrial clients, managed numerous remedial investigations of landfills, lagoons, and/or subsurface tanks that were leaking chlorinated solvents (degreasers) which involved evaluation of soluble and pure phase solvent migration in the subsurface.

On a client confidential basis for the pharmaceutical industry, supervised and participated in remedial investigation of inactive landfills with contaminants ranging from pharmaceutical raw materials and intermediate to benzene and heavy metals.

Hydrogeological Investigations—Project Manager for hydrogeological investigation and preliminary assessment of remedy alternatives for a chlorinated volatile organic compound plume in ground water beneath the former Nike PR-58 missile site in North Kingstown, Rhode Island, for the USACE–New England District. Work includes preparation and implementation of field Work Plan, including Quality Assurance Project Plan and Site-Specific Health and Safety Plan, to investigate a chlorinated volatile organic compound release and plume migration in deep soil and bedrock zones. The field work includes seismic geophysical surveys; soil vapor contaminant assessment, drilling and installation of monitoring wells in the deep soil and intervals of bedrock, sampling and analysis of soil, and low-flow sampling of ground water; data validation; and data management using EQuIS and ArcView software. Following data collection, work involves evaluation and reporting of the hydrogeology and nature and extent of chlorinated volatile organic compounds within complex hydrogeological conditions (unconsolidated sediment and bedrock); assessment of potential for natural attenuation of chlorinated volatile organic compounds; preliminary assessment of remedy alternatives e.g., natural attenuation, pump and treat, *in situ* treatment. In conjunction with USACE, coordination with and presentations to EPA-Region 1, Rhode Island Department of Environmental Management, and the public.

Project Manager for hydrogeological investigation of a petroleum release site (Motor Pool) at Hanscom Air Force Base, Massachusetts for the USACE–Omaha and Baltimore districts. Areas of concern included 10,000-gal fuel underground storage tanks, a former waste oil underground storage tank, and an oil/water separator. Work was performed under the Massachusetts Contingency Plan and included preparation of a field investigation work plan and safety and health plan, installation of additional soil borings and monitoring well, sampling of soil and ground water, evaluation and reporting of hydrogeology and nature and extent of petroleum and chlorinated volatile organic compounds, and providing a Licensed Site Professional Opinion and Scoring of the site.

For the New Jersey Department of Environmental Protection, principal investigator for the hydrogeological study portion of a remedial investigation/feasibility study for the Burnt Fly Bog site. Responsibilities also included preparation of the Quality Assurance Project Plan in accordance with EPA guidelines.

Natural Resources—Project Manager for a natural resource inventory/environmental sensitivity screening for the U.S. Postal Service, New Hampshire District, at 25 of their facilities. The purpose of this pilot project was to help facilitate future proactive environmental management decisions related to the 240 U.S. Postal Service facilities located throughout New Hampshire by beginning with a subset of 25 selected pilot facilities. The work identified locations of key natural resource features such as wetlands and streams as well as significant anthropogenic improvements (i.e., underground storage tanks, and manufacturing facilities that either generate or store hazardous materials or wastes) in the vicinity of each facility. The information was collected and compiled in a user-friendly Geographic Information System database as coordinated with the U.S. Postal Service's content and format needs. The database is accessed by ArcView software for graphic presentation and viewing, and printing of figures of the results for each site. Maps of the identified features

within 0.5 mi of each of the 25 pilot sites were prepared from the developed database.

Sit Investigations—Project Manager for a 16-site investigation at the Letterkenny Army Depot (Chambersburg, Pennsylvania) for the U.S. Department of Defense, U.S. Army Toxic and Hazardous Materials Agency. Sites investigated ranged from open detonation and burning grounds to spill and burial sites and a waste oil underground storage tank.

Supervised and performed numerous ground water contamination studies at proposed and existing facilities for the nuclear power industry, regulatory agencies, and the chemical/petroleum and high technology industries. These studies included development of programs for the location and installation of monitoring devices, a wide variety of sampling programs, soil vapor contaminant assessments, site evaluations, and coordination with regulatory agencies. The work has been performed in various geological environments of the New England and mid-Atlantic regions.

For the chemical industry, performed evaluation of soil and ground water contaminated by a variety of pesticides and herbicides at a blending and distribution facility.

Supervised the field investigation of a land farm operation and abandoned dumps for the petroleum industry, including contamination of sediment and ground water by toxic metals and aromatic hydrocarbons.

For the New York State Department of Environmental Conservation (NYSDEC), Project Manager of 13 New York State Superfund Phase II site investigations which included collection/evaluation of existing literature, site reconnaissance, geophysical surveying, well installation, sampling, data evaluation, and completion of Hazard Ranking Scoring. Participated in 69 New York State Superfund site investigations for NYSDEC which included collection/evaluation of existing data, site reconnaissance, and completion of Hazard Ranking Scoring.

Underground Storage Tank Management—Developed expertise in the planning and performance of site investigations and removal for underground storage tank sites and bulk petroleum storage facilities. Project Manager for petroleum spill sites located in Florida for which remedial action plans were being implemented and/or modified. Project activities included senior hydrogeological review of existing field data and remedial system operational data; provide recommendations for additional subsurface investigation and remedial system modification to increase system effectiveness; remediation system construction package preparation; remedial system installation or system modification; and operations and maintenance coordination for air sparging, vapor extraction, ground water pump and treat, and/or free-phase product recovery systems.

Project Manager for numerous soil vapor contaminant assessments and Phase I environmental investigations (hydrogeological studies) at gasoline service stations, convenience stores, and industrial sites located in the mid-Atlantic and New England areas, Virginia, and Texas. Project Manager for environmental oversight and documentation projects at gasoline service stations during removal/replacement of underground storage tanks which included documentation of underground storage tank and subsurface conditions, environmental measurements, sampling, and classification of excavated material for disposal.

Project Manager for closure of dry wells/industrial leaching pools for major oil company at several gasoline service station sites on Long Island, New York, under the EPA Class V Underground Injection Control Program. This work involved the cleaning and grouting of all service bay drains and discharge pipes; removal and disposal of dry well contents; excavation/disposal of dry well and adjacent sediment; and close coordination with the client, dealer, county health department, and EPA.

Project (or field) Manager for remedial investigation and baseline environmental investigations at bulk petroleum storage terminals located in New York State for major oil companies. Projects included evaluation of existing data, development and implementation of field survey and environmental measurement programs (soil vapor contaminant assessment, test borings, monitoring wells, multi-media sampling and analysis, and aquifer tests); data evaluation and reporting of findings and recommendations related to extent, character, and remediation of detected contamination; client contact; and interface with regulatory agencies.

Ground Water Supply—Managed and participated in ground water supply availability studies for various municipal, industrial, and residential development clients of various site locations in the lower Hudson River

Valley of New York State. The projects involved evaluations ranging from specific properties to large areas through the use of remote sensing and reconnaissance/confirmatory field mapping to aid in the selection and prioritization of potential water development areas. Performed detailed geophysical surveys and confirmatory test borings within selected site areas to aid in the location, design, and installation of test wells. Performed long-term pumping tests for evaluation of aquifer characteristics and potential long-term yield. Located, designed, and supervised installation of production wells completed in sand, gravel, and/or bedrock for municipal and private sector clients. Developed Water Supply Application for submittal to NYSDEC and New York State Department of Health.

Provided hydrogeological consulting services to the Town of Monroe, New York, Planning Board and the Town of Hamptonburgh, New York, including recommendations to the Towns after technical review of hydrogeologic data for planned ground water supplies presented to them by developers in support of requests for proposed residential subdivisions.

For Pennsylvania Power and Light Company, field geologist responsible for the installation and sampling of monitoring wells at the Susquehanna Nuclear Generating Station in accordance with the Nuclear Regulatory Commission's requirements.

Facilities Siting—Field geologist and project coordinator on geological field investigations for proposed nuclear-fueled electric generating station site areas located in Pennsylvania, New Jersey, and New York.

For the Appalachian Regional Commission, principal investigator for regional mapping of geologic natural hazard phenomena (landsliding and collapse due to coal mining or karst) within the entire Appalachian Region from published literature.

International Experience—For the Nicaraguan government under a U.S. Agency for International Development contract, performed onsite geologic field mapping, compilation, and evaluation of volcanic deposit stratigraphy (generally pyroclastic, base surge, lava, or ash), and drafting of geological cross-sections and report sections for use in a seismic and volcanic risk evaluation of four rural city areas in that Central American country.

Professional Affiliations/Memberships

National Ground Water Association

Sel cted Publications and Presentations

Kramer, C., J.A. Shultz, and J.W. Ashley. 1991. Chapter 8: Monitoring Well Post Installation Considerations. *Practical Handbook of Groundwater Monitoring*. Lewis Publishers, Inc.

Kruse, A. and J. Shultz. 1978. Base Surge Deposits of the Nicaraguan Volcanic Masaya Abstract. Geological Society of America, Cordilleran Section.

Robin Clark, P.G.
Geologist

Ms. Clark is a geologist with more than 7 years of experience in implementation of geotechnical and hydrogeologic field investigations, including site supervision for soil boring, piezometer, and monitoring well drilling and installation; collection of soil and water samples for laboratory analysis; development and sampling of ground water monitoring wells utilizing the U.S. Environmental Protection Agency (EPA) Region 1 Low Stress (low-flow) Procedure (including natural attenuation); and site assessment inspections. She has been involved with remedial investigation reports utilizing her research, technical writing, data compilation, and calculation skills. She has also worked on projects under the Massachusetts Contingency Plan, including Phase I and II investigations and reports, tier classification, numerical ranking, immediate response action plans and status reports, and release abatement measure plans and reports, as well as research projects for Woods Hole Oceanographic Institute and the Massachusetts Department of Energy. Her experience on these projects includes sample preparation and curation of rock samples, creation of thin sections for petrographic analysis, soil moisture monitoring equipment installation, and maintenance that included weekly monitoring for data entry into an agricultural computer modeling program. Ms. Clark is also experienced in soil identification, soil mapping, ground penetrating radar, and conservation farm planning.

Education

Microsoft Certified Professional (NT Server 4.0); Massachusetts School of Information Technology; 2000
B.S.; Bridgewater State College; Earth Science (Major), Geology Concentration (Art/Photography Minor); 1993

R gistrations/Certifications

Licensed Professional Geologist; State of New Hampshire; No. 419

Training

American Red Cross Adult CPR; 2000
8-Hour National Safety Council First Aid; 2000
8-Hour Hazardous Waste Operations Refresher (29 CFR 1910.120); 2001
8-Hour Hazardous Waste Operations Management and Supervisor Certification Program; 1996
American Red Cross Prevention of Disease Transmission Course; 1996
40-Hour OSHA Hazardous Waste Operations Site Safety and Health Training; 1995

Professional Experience

Remedial Investigations—Experience in remedial investigations on Superfund sites in Massachusetts, Maine, Connecticut, and Rhode Island, including supervising drilling subcontractors during drilling of soil borings and installation of monitoring wells and piezometers; development and sampling of monitoring wells (EPA Region 1 Low Stress Methodology); data compilation and calculations; technical writing for remedial investgation report, including drawing interpretive ground water contour maps; and creating geologic cross-sections. Responsible for field screening and selection of soil samples for laboratory analysis. Responsible for monitoring safety and health of onsite personnel during drilling and well installation; served as site Safety and Health Officer and Field Team Leader.

Environmental Site Assessments— Performed various preliminary site assessments including Phase I site assessments, and environmental baseline surveys for the identification of existing/past areas or operations which may adversely affect the environmental conditions at a site. Responsibilities included building inspections, record searches, visual inspections; aerial photograph reviews, Sanborn Map reviews, interviews with site personnel (past and current), owners, nearby residents, and local government officials; and technical report writing.

Selected EA Project Experience

Project Title—Phase III Remedial Investigation, Naval Construction Battalion Center, Davisville, Sites 02 and 03; Study Areas 01 and 04, and the NIKE PR-58 Site
Client Name—Department of the Navy, Northern Division, Naval Facilities Engineering Command
Project Dates—1995–1996, 1997–1998, 2000 – Present
Project Role—Data compilation, technical report writing, inspector for drilling and installation of piezometers and monitoring wells, and development and sampling of monitoring wells.

Project Title—Phase III Remedial Investigation, Naval Construction Battalion Center, Davisville, Sites 02 and 03; Study Areas 01 and 04, and the NIKE PR-58 Site
Client Name—Department of the Navy, Northern Division, Naval Facilities Engineering Command
Project Dates—December 1996, 1998, 2000 – Present
Project Role—Site Safety and Health Officer and Field Team Leader during the ground water sampling events, which included EPA Region I low-flow sampling for natural attenuation.

Proj ct Title—Phase III Remedial Investigation, Naval Construction Battalion Center, Davisville, Site 07, Calf Pasture Point
Client Name—Department of the Navy, Northern Division, Naval Facilities Engineering Command
Project Dates—1995–1996, 2000 – Present
Project Role—Inspector for drilling of monitoring wells and soil borings, including installation of monitoring wells. Monitored safety and health of field personnel during drilling and well installation. Performed ground water tidal monitoring, collected water levels, and compiled data. Performed monitoring well development and ground water sampling using EPA Region I Low Stress (low-flow) methodology. Technical report writing for Phase III Remedial Investigation included background research from previous remedial investigation and summation of field procedures. Compiled field data for data tables and created geologic cross-sections and interpretive ground water contour maps for remedial investigation.

Project Title—Phase III Remedial Investigation, Naval Construction Battalion Center, Davisville, Offshore Geotechnical Sampling and Confirmation Study at Site 09
Client Name—Department of the Navy, Northern Division, Naval Facilities Engineering Command
Project Dates—1997
Project Role—Field Team Leader for Offshore Geotechnical Sampling and Confirmation Study at Site 09. This project included collection of soil and ground water samples from beneath Allen Harbor utilizing a drill rig on a barge. All points surveyed with differential Global Positioning System.

Proj ct Title—Phase III Remedial Investigation, Naval Construction Battalion Center, Davisville, Site 09, Allen Harbor Landfill
Client Name—Department of the Navy, Northern Division, Naval Facilities Engineering Command
Proj ct Dates—1996
Proj ct Role—Magnetometer survey to determine extent of Allen Harbor Landfill along the shoreline, including points in Allen Harbor, using a Proton Precession magnetometer. This survey included utilizing Global Positioning System with TDC1 Asset Surveyor for geographical log of all points during the magnetometer survey.

HENRY E. LEIBOVITZ
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Dr. Leibovitz has eighteen years of experience in laboratory management including GC/MS and chromatography and in chromatographic research.

EDUCATION:

UNIVERSITY OF RHODE ISLAND 1991
Ph.D. Biological Sciences

AUBURN UNIVERSITY 1981
M.S. Aquaculture Nutrition

SYRACUSE UNIVERSITY 1979
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EXPERIENCE:

2001-present	CEIMIC CORPORATION Narragansett, Rhode Island Laboratory Manager
1996 - 2001	CEIMIC CORPORATION Narragansett, Rhode Island Organic Laboratory Manager
1993 - 1996	CEIMIC CORPORATION Narragansett, Rhode Island Chromatography and Extraction Laboratories Manager
1991 - 1992	CEIMIC CORPORATION Narragansett, Rhode Island GC Laboratory Manager
1983 - 1991	UNIVERSITY OF RHODE ISLAND Kingston, Rhode Island Food and Nutrition Research Center GC Laboratory Supervisor
1981 - 1983	LOUISIANA STATE UNIVERSITY Baton Rouge, Louisiana Research Associate

Attachment 4

Geophysical Applications Standard Operating Procedures

Standard Operating Procedures for Borehole Geophysical Surveys

Geophysical Applications, Inc.
November 2000

Purpose

This document provides guidelines for planning and conducting borehole geophysical logging surveys. These surveys are typically performed to help characterize overburden or bedrock stratigraphy or lithology, and also to identify and characterize water-bearing bedrock fractures.

Pre-Survey Planning

Data requirements will be reviewed with the client to determine the survey objectives. Possible objectives include measuring depths to geologic strata, or locating bedrock fractures with to help place monitoring well screens.

Background information should be requested from the client that may assist design of effective surveys. Such information may include:

- borehole diameter, depth, and type of well construction
- previous geologic or geophysical logging results from the site vicinity
- available descriptions of regional geology.

The survey goals shall be reviewed with the client, and the logging suite shall be revised to address, to the extent possible, the client's objectives.

Equipment Preparation

An equipment checklist will be prepared before loading equipment into the field vehicle. Project-specific requirements (such as downhole pumps or materials needed for equipment decontamination) will be indicated on the equipment checklist.

Instrumentation will be functionally checked and cleaned before mobilization. The field geophysicist will initial and date the checklist when all equipment is loaded, and a copy of the completed checklist will be placed in the project files.

Site Preparation

The logging equipment shall be mobilized to the jobsite, and unpacked. Generators or equipment boxes removed from the field vehicle shall be placed in visible locations where they are unlikely to be run over by vehicles or tripped over by pedestrians.

Data Acquisition

General

A field book shall be maintained describing the wells or boreholes logged, the logging probes used, datafile names, preset starting depths for each logging probe, or other field observations. Each field book shall be labeled with the client's name, site name, job number, and dates of work.

Borehole logging instrumentation shall be assembled consistent with the manufacturer(s) instructions. A tripod or pulley shall be positioned over the borehole to be logged, to guide the logging probe into the borehole. A thin coating of silicone grease shall be applied to each o-ring that protects electrical connections between the cablehead and a logging probe. Excess grease shall be wiped off the cablehead and probe exterior after assembly.

Chemical-resistant gloves (or other protective clothing, as required by the site health and safety plan) shall be worn when handling possibly-contaminated wirelines and logging probes.

G ophysical Logging

If geophysical logging is to be performed, the desired logging probe shall be attached to the cablehead. The logging software shall be initiated, and the correct probe driver selected.

The logging probe shall be positioned so that either the probe top or cablehead top is equal to the ground surface or casing top. The probe's preset depth shall be calculated and entered into the data-acquisition software. The preset depth typically consists of the probe length provided by the manufacturer, minus the casing stickup height, plus the cablehead length (if the cablehead top is at the casing top).

A log datafile shall be opened, and data recording initiated after any necessary instrument-setting adjustments (most logs can be recorded with default probe-driver settings). The acoustic televiewer recording window shall be adjusted so as to ignore reflections that occur inside the televiewer probe (typical minimum recording time of 82 microseconds).

Logging shall be performed at a speed suitable for the data being recorded. Fluid temperature and fluid resistivity logs shall be obtained in an undisturbed water column (to the extent possible) at a slow downward logging speed (typically less than 5 feet per minute). Caliper logs may be recorded at 10 to 15 feet per minute, while logging upwards. Polyprobe or natural gamma logs may be recorded at speeds up to 15 feet per minute, while logging either upward or downward. Acoustic or optical televiewer probes shall be lowered at speeds less than 15 feet per minute. Acoustic or optical televiewer data shall generally be recorded only while logging upward at speeds permitted by the

data acquisition software (typically less than 3 feet per minute, depending upon the data-acquisition parameters).

Acoustic and optical televiewer probes shall be utilized only after less-expensive logging probes (typically including at least a caliper log) have been lowered and raised through the borehole.

Heat-pulse flowmeter logging is performed at discrete intervals. The flowmeter's centralizers shall be selected so as to center the flowmeter probe within the borehole. The flowmeter's diverter petals shall be selected so as to provide as positive a seal as is possible between the borehole wall and the flowmeter probe. Flowmeter measurement depths shall be selected above or below suspected bedrock fractures, typically based on visual inspection of preliminary caliper, fluid temperature, and fluid resistivity logs. Flowmeter measurements shall be repeated at each depth interval until the measured flow values agree within $\pm$ 0.1 gallons per minute (gpm).

If both ambient and pumping flowmeter data are recorded, the ambient measurements shall be obtained during the downward run, and the pumping measurements shall be obtained during the upward run.

The logging wireline shall be de-contaminated with an Alconox wash and tap water rinse while raising the logging probe upward out of the borehole. The probe and any accessories (centralizers, pumps, etc.) shall be de-contaminated in a similar manner.

All geophysical-log data-files shall be stored on the field computer, and copied on-site onto another media (floppy disk, Zip disk, etc.) to assure redundant data storage.

Data Analysis

Geophysical log data shall be plotted using WellCAD or equivalent software. Each log shall be annotated with the client's name, project location, and well or borehole designation.

Log plot scales shall be selected so as to present as much detail as possible. Wrap-around of one or two times the log-display panel shall be acceptable. If more than one or two wrap-arounds are needed to display both large and small inflections on the same log, then that log shall be presented using two or more scales (on the same or different pages).

The logs shall be edited for spurious data values (e.g. electric logs above the water table or within steel casing), and annotated (or discussed in an accompanying report text).

Any site-specific limitations of the geophysical log data shall be noted on the log, or in the accompanying report text.

Attachment 5

Data Structure

Attachment 3 - Custom Equis-Import Format

*	Field	DataType	Length	Description	Valid Values
1	Sys_Sample_Code	Text	20	Unique identifier. Concatenation of sys_loc code * sample type & matrix * sample date.	
2	Sample_Type_Code	Text	10	Code which distinguishes between different type of sample.	"N" for normal sample, "FD" for field duplicate sample, "MB" for method blank, "TB" for trip blank, "RB" for rinsate blank, "AB" for ambient or field blank, "MS" for matrix spike, "MD" for matrix spike duplicate
3	Lab_method	Text	35	Laboratory analytic method name or description.	
4	Sample_date	Date		Date sample was collected (in MM/DD/YY format for EDD).	
5	Analysis_Date	Date		Date of sample analysis (in MM/DD/YY format for EDD).	
6	Total_or_Dissolved	Text	1	Identifies whether water samples were submitted for total or dissolved (inorganic) analysis.	"T" for total concentration, "D" for dissolved or filtered concentration
7	Test_Type	Text	10	Type of analytical test.	"Initial" for first run. "Reanalysis" for subsequent runs. "Re-extration" for re-extrated samples
8	Sample_Matrix_Code	Text	10	Code which distinguishes between different type of sample matrix.	"WG" for ground water, "SW" for surface water, "SO" for soil, "SD" for sediment, "W" for lab and field qc blanks (method blanks,trip blanks, field blanks, rinsate blanks)
9	Basis	Text	10	"Wet" for wet-weight basis reporting, "Dry" for dry-weight basis reporting.	
10	Dilution_Factor	Single		Test dilution factor.	
11	Lab_Prep_Method_Name	Text	35	Laboratory sample preparation method name or description.	
12	Ext_date	Date		Extraction date.	
13	Percent_Moisture	Text	5	Percent moisture of the sample portion used in this test.	
14	Lab_Sample_Id	Text	20	Laboratory LIMS sample identifier.	
15	Batch_Id	Text	255	Sample batch id.	
16	Cas_Rn	Text	15	Chemical Abstract Registry number.	
17	Chemical_Name	Text	75	Analyte name.	
18	Organic_YN	Boolean		Indicates whether analyte is organic or inorganic.	-1 for organic, 0 for inorganic
19	Result_Value	Text	20	Analytical result value.	
20	Result_Type_Code	Text	10	Type of analytical result.	"TRG" for target results, "TIC" for tenatively identified compounds, "SUR" for surrogates, "IS" for internal standards, "SC" for spiked compounds
21	Detect_Flag	Text	2	Indicates whether or not an analyte was deteceted.	"Y' for detected result; "N' for non-detected results.
22	Lab_Qualifiers	Text	7	Qualifier flags assigned by the laboratory.	
23	Method_detection_limit	Text	20	Method detection limit	
24	Reporting_Detection_Limit	Text	20	Detection limit used for reporting.	
25	Result_Unit	Text	15	Units of measurement for the result.	
26	Validator_qualifiers	Text	7	Validator qualifiers.	

Attachment 3 - Cust m Equis-Import Format

27	Interpreted_Qualifiers	Text	7	Most appropriate qualifier. Validator's qualifier if th exist, otherwise lab qualifier.	
28	Sys_loc_code	Text	20	Unique location name.	
29	Parent_sample_code	Text	20	sys_sample code of parent sample of field duplicate.	
30	Site_Code	Text	20	Unique code for site or area.	
31	Sample_name	Text	30	Chain-of-custody field identification.	
32	Location_name	Text	30	Location name.	
33	Location_description	Text	70	Description of location.	
34	Start_depth	Double		Top depth of sample.	
35	End_depth	Double		Bottom depth of sample.	
36	Depth_unit	Text	15	Depth unit.	
37	Source	Text	50	Name of source file	EDD file name
38	Lab_Name	Text	10	Lab Name	
39	Task Code	Text	10	Task Code	
40	Associate_Blank	Text	255		

NOTE: Shaded cells to be completed by laboratory

Attachment 6

EPA Draft Calibration Procedures

EA ENGINEERING SCIENCE & TECHNOLOGY
MAY 15 2000
RECEIVED

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION 1

DRAFT CALIBRATION OF FIELD INSTRUMENTS
(temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction potential [ORP], and turbidity)

I. SCOPE & APPLICATION

The purpose of this standard operating procedure (SOP) is to provide a framework for calibrating field instruments used to measure water quality parameters for ground water and surface water. Water quality parameters include temperature, pH, dissolved oxygen, conductivity/specific conductance, oxidation/reduction potential [ORP], and turbidity. This SOP supplements, but does not replace, EPA analytical methods listed in 40 CFR 136 and 40 CFR 141 for temperature, dissolved oxygen, conductivity/specific conductance, pH and turbidity.

This SOP is written for instruments that utilize multiple probes (temperature, pH, dissolved oxygen, conductivity/specific conductance, and/or oxidation/reduction potential [ORP]) and the probe readings for pH, dissolved oxygen, and specific conductance are automatically corrected for temperature. Communications to the instrument (programming and displaying the measurement values) are performed using a display/logger or a computer. Information sent to the instrument is entered through the keypad on the display/logger or computer. It is desirable that the display/logger or computer have data storage capabilities. If the instrument does not have a keypad, follow the manufacturer's instructions for entering information into the instrument.

For ground water monitoring, the instrument must be equipped with a flow-through-cell, and the display/logger or computer display screen needs to be large enough to simultaneously contain the readouts of each probe in the instrument. Turbidity is measured using a separate instrument because turbidity cannot be measured in a flow-through-cell. This procedure is applicable for use with the EPA Region 1 Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells.

II GENERAL

All monitoring instruments must be calibrated before they are used to measure environmental samples. Part of the calibration is performed prior to the field event. For instrument probes that rely on the temperature sensor (pH, dissolved oxygen, conductivity/specific conductance, and

oxidation/reduction potential [ORP]), each temperature sensor needs to be checked for accuracy against a thermometer that is traceable to the National Institute of Standards and Technology (NIST) . Before any instrument is calibrated or used to perform environmental measurements, the instrument must stabilize (warm-up) according to manufacturer's instructions.

Most instruments will require at least two standards to bracket the expected measurement range, that is, one standard less than the expected value and one higher. Calibration must be performed at the beginning of each sampling day prior to sample collection. To determine if the instruments have remained in calibration during transport to each sampling location, use one of the previously used standards as a check standard at the sampling site. If the check measurement does not agree with the initial calibration or to within the specifications of the instrument, then the instrument must be re-calibrated. When an environmental sample measurement falls outside the calibration range, the instrument must be re-calibrated to bracket the new range before continuing measurements.

This SOP requires that the manufacturer's instruction manual (including the instrument specifications) accompany the instrument into to the field.

III. CALIBRATION PROCEDURES

Prior to calibration, all instrument probes must be cleaned according to the manufacturer's instructions. Failure to perform this step (proper maintenance) can lead to erratic measurements.

Program the multi-probe instrument so that the following parameters to be measured will be displayed: temperature, pH, percent dissolved oxygen, mg/l dissolved oxygen, conductivity, specific conductance, and ORP.

The volume of the calibration solutions must be sufficient to cover both the probe and temperature sensor (see manufacturer's instructions for additional information).

While calibrating or measuring, make sure there are no air bubbles lodged between the probe and the probe guard

TEMPERATURE

Most instrument manuals state there is no calibration of the temperature sensor, but the temperature sensor must be checked to determine its accuracy This accuracy check is performed

at least once per year and the accuracy check date/information is kept with the instrument. If the accuracy check date/information is not included with the instrument or the last check was over a year, the temperature sensor accuracy needs to be checked at the beginning of the sampling event. If the instrument contains multiple temperature sensors, each sensor must be checked.

Verification Procedure

1. Allow a container filled with water to come to room temperature.

2. Place a thermometer that is traceable to the National Institute of Standards and Technology (NIST), and the instrument's temperature sensor into the water and wait for both temperature readings to stabilize.

3. Compare the two measurements. The instrument's temperature sensor must agree with the reference thermometer measurement within the accuracy of the sensor (usually ±0.15°C). If the measurements do not agree, the instrument may not be working properly and the manufacturer needs to be consulted.

pH (electrometric)

The pH of a sample is determined electrometrically using a glass electrode.

Choose the appropriate buffered standards that will bracket the expected values at the sampling locations. For ground water, the pH will usually be close to seven. Three standards are needed for the calibration: one close to seven, one at least two pH units below seven and the other at least two pH units above seven. For those instruments that will not accept three standards, the instrument will need to be re-calibrated if the water sample's pH is outside the initial calibration range described by the two standards.

Calibration Procedure

1. Allow the buffered standards to equilibrate to the ambient temperature

2. Fill calibration containers with the buffered standards so each standard will cover the pH probe and temperature sensor

3. Remove probe from its storage container, rinse with distilled water, blot dry with soft tissue.

4. Select monitoring/run mode. Immerse probe into the initial standard (e.g., pH 7).

5. Stir the standard until the readings stabilize. If the reading does not change within 30 seconds, select calibration mode and then select "pH". Enter the buffered standard value into instrument. Select monitoring/run mode. The readings should remain within manufacturer's specifications; if they change, re-calibrate. If readings continue to change after re-calibration, consult manufacturer.

6. Remove probe from the initial standard, rinse with distilled water, and blot dry.

7. Immerse probe into the second standard (e.g., pH 4). Repeat step 5.

8. Remove probe from the second standard, rinse with distilled water, and blot dry. If instrument only accepts two standards, the calibration is complete. Go to step 11. Otherwise continue.

9. Immerse probe in third buffered standard (e.g., pH 9) and repeat step 5.

10. Remove probe from the third standard, rinse with distilled water, and blot dry.

11. Select monitoring/run mode, if not already selected. To ensure that the initial calibration standard (e.g., pH 7) has not changed, immerse the probe into the initial standard. Wait for the readings to stabilize. The reading should read the initial standard value within the manufacturer's specifications. If not, re-calibrate the instrument. If re-calibration does not help, the calibration range may be too great. Reduce calibration range by using standards that are closer together

12. The calibration is complete Place pH probe in its storage container

DISSOLVED OXYGEN

Dissolved oxygen (DO) content in water is measured using a membrane electrode The DO probe's membrane and electrolyte solution should be replaced prior to the sampling period Failure to perform this step may lead to erratic measurements

Calibration Procedure

1. Gently dry the temperature sensor according to manufacturer's instructions.

2. Place a wet sponge or a wet paper towel on the bottom of the DO calibration container.

3. Place the DO probe into the container without the probe coming in contact with the wet sponge or paper towel. The probe must fit tightly into the container to prevent the escape of moisture evaporating from the sponge or towel.

4. Allow the confined air to become saturated with water vapor (saturation occurs in approximately 10 to 15 minutes). During this time, turn-on the instrument to allow the DO probe to warm-up. Select monitoring/run mode. Check temperature readings. Readings must stabilize before continuing to the next step.

5. Select calibration mode; then select "DO %".

6. Enter the local barometric pressure (usually in mm of mercury) for the sampling location into the instrument. This measurement must be determined from an on-site barometer. Do not use barometric pressure obtained from the local weather services unless the pressure is corrected for the elevation of the sampling location. [Note: inches of mercury times 25.4 mm/inch equals mm of mercury or consult Oxygen Solubility at Indicated Pressure chart attached to the SOP for conversion at selected pressures].

7. The instrument should indicate that the calibration is in progress. The instrument will take approximately one minute to calibrate. After calibration, the instrument should display percent saturated DO.

8. Select monitoring/run mode. Compare the DO mg/l reading to the Oxygen Solubility at Indicated Pressure chart attached to the SOP. The numbers should agree. If they do not agree to the accuracy of the instrument (usually ± 0.2 mg/L), repeat calibration If this does not work, change the membrane and electrolyte solution

9 Remove the probe from the container and place it into a 0 0 mg/L DO standard (see note) The standard must be filled to the top of its container and the DO probe must fit tightly into the standard's container (no head space) Check temperature readings They must stabilize before continuing

10. Wait until the "mg/l DO" readings have stabilized. The instrument should read 0.0 mg/L or to the accuracy of the instrument (usually ± 0.2 mg/L). If the instrument cannot reach these values, it will be necessary to clean the probe, and change the membrane and electrolyte solution. If this does not work, prepare a new 0.0 mg/L DO standard. If these measures do not work, contact manufacturer.

Note: To prepare a zero mg/L DO standard follow the procedure stated in Standard Methods (Method 4500-O G). The method basically states to add excess sodium sulfite (until no more dissolves) and a trace amount of cobalt chloride to water. The standard container must be completely filled (no head space). This solution is prepared prior to the sampling event. If some of the solution is lost during instrument calibration, add more water to the container so that the standard is stored with no head space.

SPECIFIC CONDUCTANCE

Conductivity is used to measure the ability of an aqueous solution to carry an electrical current. Specific conductance is the conductivity value corrected to 25°C.

Most instruments are calibrated against a single standard which is near, but below the specific conductance of the environmental samples. A second standard which is above the environmental sample specific conductance is used to check the linearity of the instrument in the range of measurements.

Calibration Procedure

1. Allow the calibration standard to equilibrate to the ambient temperature.

2. Remove probe from its storage container, rinse the probe with a small amount of the conductivity/specific conductance standard (discard the rinsate), and place the probe into the conductivity/specific conductance standard.

3. Select monitoring/run mode Wait until the probe temperature has stabilized

DRAFT

4. Look up the conductivity value at this temperature from the conductivity versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. You may need to interpolate the conductivity value between temperatures. Select calibration mode, then conductivity. Enter the temperature corrected conductivity value into the instrument.

5. Select monitoring/run mode. The reading should remain within manufacturer's specifications. If it does not, re-calibrate. If readings continue to change after re-calibration, consult manufacturer.

6. Read the specific conductance on the instrument and compare the value to the specific conductance value on the standard. The instrument value should agree with the standard within the manufacturer's specifications. If not, re-calibrate. If the re-calibration does not correct the problem, the probe may need to be cleaned or serviced by the instrument manufacturer.

7. Remove probe from the standard, rinse the probe with a small amount of the second conductivity/specific conductance standard (discard the rinsate), and place the probe into the second conductivity/specific conductance standard. The second standard will serve to verify the linearity of the instrument. Read the specific conductance value from the instrument and compare the value to the specific conductance on the standard. The two values should agree within the specifications of the instrument. If they do not agree, re-calibrate. If readings do not compare, then the second standard may be outside the linear range of the instrument. Use a standard that is closer, but above the first standard and repeat the verification. If values still do not compare, try cleaning the probe or consult the manufacturer.

8. When monitoring ground water or surface water, use the specific conductance readings.

OXIDATION/REDUCTION POTENTIAL (ORP)

The oxidation/reduction potential is the electrometric difference measured in a solution between an inert indicator electrode and a suitable reference electrode The electrometric difference is measured in millivolts and is temperature dependent

Calibration or Verification Procedure

1. Allow the calibration standard (a Zobell solution) to equilibrate to ambient temperature.

2. Remove the probe from its storage container, and place it into the standard.

3. Select monitoring/run mode.

4. While stirring the standard, wait for the probe temperature to stabilize, then read the temperature.

5. Look up the millivolt (mv) value at this temperature from the millivolt versus temperature correction table usually found on the standard bottle or on the standard instruction sheet. You may need to interpolate millivolt value between temperatures. Select "calibration mode", then "ORP". Enter the temperature-corrected ORP value into the instrument.

6. Select monitoring/run mode. The readings should remain unchanged within manufacturer's specifications. If they change, re-calibrate. If readings continue to change after re-calibration, consult manufacturer.

7. If the instrument instruction manual states that the instrument is factory calibrated, then verify the factory calibration against the standard. If they do not agree within the specifications of the instrument, the instrument will need to be re-calibrated by the manufacturer.

TURBIDITY

The turbidity method is based upon a comparison of intensity of light scattered by a sample under defined conditions with the intensity of light scattered by a standard reference suspension. A turbidimeter is a nephelometer with a visible light source for illuminating the sample and one or more photo-electric detectors placed ninety degrees to the path of the light source

Some instruments will only accept one standard For these instruments, the standards will serve as check points

DRAFT

Calibration Procedures

1. Allow the calibration standards to equilibrate at the ambient temperature. The use of commercially available polymer primary standards (AMCO-AEPA-1) is preferred, however, the standards can be prepared using Formazin according to the EPA analytical Method 180.1.

2. If the standard cuvette is not sealed, rinse a cuvette with deionized water. Shake the cuvette to remove as much water as possible. Do not wipe dry the inside of the cuvette because lint from the wipe may remain in the cuvette. Add the standard to the cuvette.

3. Before performing the calibration procedure, make sure the cuvettes are not scratched and the outside surfaces are dry, free from fingerprints and dust. If the cuvette is scratched or dirty, discard or clean the cuvette respectively.

4. Zero the instrument by using either a zero or 0.02 NTU standard. A zero standard (approximately 0 NTU) can be prepared by passing distilled water through a 0.45 micron pore size membrane filter.

5. Using a standard in the range of 5 - 20 NTUs, calibrate according to manufacturer's instructions or verify calibration if instrument will not accept a second standard. If verifying, the instrument should read standard value to within the specifications of the instrument. If the instrument has range of scales, check each range that will be used during the sampling event with a standard that falls within that range.

7. Using a standard between 20 and 100 NTUs, calibrate according to manufacturer's instructions or verify calibration if instrument does not accept a third standard. If verifying, the instrument should read standard value to within the specifications of the instrument. If the instrument has range of scales, check each range that will be used with the proper standard for that scale.

IV. DATA MANAGEMENT AND RECORDS MANAGEMENT

All calibration records must be documented in the project's log book. At a minimum, include the instrument manufacturer, model number, instrument identification number, standards used to calibrate the instruments (including source), calibration date, and the instrument readings

draft

References

Standard Methods for the Examination of Water and Wastewater, 19th edition, 1995.

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983.

Turbidity - Methods for the Determination of Inorganic Substances in Environmental Samples, EPA/600/R-93/100, August 1993.

Oxygen Solubility at Indicated Pressure

Temp	Pressure (Hg)							
	760	755	750	745	740	735	730	mm
°C	29.92	29.72	29.53	29.33	29.13	28.94	28.74	in
0	14.57	14.47	14.38	14.28	14.18	14.09	13.99	mg/l
1	14.17	14.08	13.98	13.89	13 79	13.70	13.61	
2	13.79	13.70	13.61	13.52	13.42	13 33	13.24	
3	13.43	13.34	13.25	13 16	13 07	12-98	12.90	
4	13.08	12 99	12.91	12 82	12.73	12.65	12.56	
5	12.74	12.66	12.57	12.49	12.40	12.32	12.23	
6	12.42	12.34	12.26	12.17	12.09	12.01	11.93	
7	12.11	12.03	11.95	11.87	11.79	11.71	11.63	
8	11.81	11.73	11.65	11.57	11.50	11.42	11.34	
9	11.53	11.45	11.38	11.30	11.22	11.15	11.07	
10	11.28	11.19	11.11	11.04	10.96	10.89	10.81	
11	10.99	10.92	10.84	10.77	10.70	10.62	10.55	
12	10.74	10.67	10.60	10.53	10.45	10.38	10.31	
13	10.50	10.43	10.36	10.29	10.22	10.15	10.08	
14	10.27	10.20	10.13	10.06	10.00	9.93	9.86	
15	10.05	9.98	9.92	9.85	9.78	9.71	9.65	
16	9.83	9.76	9.70	9.63	9.57	9.50	9.43	
17	9.63	9.57	9.50	9.44	9.37	9.31	9.24	
18	9.43	9.37	9.30	9.24	9.18	9.11	9.05	
19	9.24	9.18	9.12	9.05	8.99	8.93	8.87	
20	9.06	9.00	8.94	8.88	8.82	8.75	8.69	
21	8.88	8.82	8.76	8.70	8.64	8.58	8.52	
22	8.71	8.65	8.59	8.53	8.47	8.42	8.36	
23	8.55	8.49	8.43	8.38	8.32	8.26	8.20	
24	8.39	8.33	8.28	8.22	8.16	8.11	8.05	
25	8.24	8.18	8.13	8.07	8.02	7.96	7.90	
26	8.09	8.03	7.98	7.92	7.87	7.81	7.76	
27	7.95	7.90	7.84	7.79	7.73	7.68	7.62	
28	7.81	7.76	7.70	7.65	7.60	7.54	7.49	
29	7.68	7.63	7.57	7.52	7.47	7.42	7.36	
30	7.55	7.50	7.45	7.39	7.34	7.29	7.24	
31	7.42	7.37	7.32	7.27	7.22	7.16	7.11	
32	7.30	7.25	7.20	7.15	7.10	7.05	7.00	
33	7.08	7.13	7.08	7.03	6.98	6.93	6.88	
34	7.07	7.02	6.97	6.92	6.87	6.82	6.78	
35	6.95	6.90	6.85	6.80	6.76	6.71	6.66	
36	6.84	6.79	6.76	6.70	6.65	6.60	6.55	
37	6.73	6.68	6.64	6.59	6.54	6.49	6.45	
38	6.63	6.58	6.54	6.49	6.44	6.40	6.35	
39	6.52	6.47	6.43	6.38	6.35	6.29	6 24	
40	6.42	6.37	6.33	6.28	6 24	6 19	6.15	
41	6.32	6.27	6.23	6 18	6 14	6 09	6.05	
42	6 22	6 18	6 13	6.09	6.04	6 00	5 95	
43	6 13	6 09	6 04	6.00	5 95	5 91	5 87	
44	6 03	5 99	5 94	5 90	5 86	5 81	5 77	
45	5.94	5 90	5 85	5 81	5 77	5 72	5 68	

(Continued)

Source Draft EPA Handbook of Methods for Acid Deposition Studies Field Operations for Surface Water

Oxygen Solubility at Indicated Pressure (continued)

Temp	Pressure (Hg)								
	725	720	715	710	705	700	695	690	mm
°C	28.54	28.35	28.15	27.95	27.76	27.56	27.36	27.17	in
0	13.89	13.80	13.70	13.61	13.51	13.41	13 32	13.22	mg/l
1	13 51	13.42	13.33	13.23	13 14	13.04	12 95	12.86	
2	13.15	13.06	12.07	12.88	12 79	12.69	12.60	12.51	
3	12.81	12.72	12 63	12.54	12.45	12.36	12 27	12.18	
4	12.47	12.39	12.30	12 21	12.13	12.04	11.95	11.87	
5	12.15	12.06	11 98	11.89	11.81	11.73	11.64	11.56	
6	11.84	11.73	11.68	11.60	11.51	11.43	11.35	11.27	
7	11.55	11.47	11.39	11.31	11.22	11.14	11.06	10.98	
8	11.26	11.18	11.10	11.02	10.95	10.87	10.79	10.71	
9	10.99	10.92	10.84	10.76	10.69	10.61	10.53	10.46	
10	10.74	10.66	10.59	10.51	10.44	10.36	10.29	10.21	
11	10.48	10.40	10.33	10.28	10.18	10.11	10.04	9.96	
12	10.24	10.17	10.10	10.02	9.95	9.88	9.81	9.46	
13	10.01	9.94	9.87	9.80	9.73	9.66	9.59	9.52	
14	9.79	9.72	9.65	9.68	9.51	9.45	9.38	9.31	
15	9.58	9.51	9.44	9.58	9.31	9.24	9.18	9.11	
16	9.37	9.30	9.24	9.17	9.11	9.04	8.97	8.91	
17	9.18	9.11	9.05	8.98	8.92	8.85	8.79	8.73	
18	8.99	8.92	8.86	8.80	8.73	8.67	8.61	8.54	
19	8.81	8.74	8.68	8.62	8.56	8.49	8.43	8.37	
20	8.63	8.57	8.51	8.45	8.39	8.33	8.27	8.21	
21	8.46	8.40	8.34	8.28	8.22	8.16	8.10	8.04	
22	8.30	8.24	8.18	8.12	8.06	8.00	7.95	7.89	
23	8.15	8.09	8.03	7.97	7.91	7.86	7.80	7.74	
24	7.99	7.94	7.88	7.82	7.76	7.71	7.65	7.59	
25	7.85	7.79	7.74	7.68	7.60	7.57	7.51	7.46	
26	7.70	7.65	7.59	7.54	7.48	7.43	7.37	7.32	
27	7.57	7.52	7.46	7.41	7.35	7.30	7.25	7.19	
28	7.44	7.38	7.33	7.28	7.22	7.17	7.12	7.06	
29	7.31	7.26	7.21	7.15	7.10	7.05	7.00	6.94	
30	7.19	7.14	7.08	7.03	6.98	6.93	6.88	6.82	
31	7.06	7.01	6.96	6.91	6.86	6.81	6.76	6.70	
32	6.95	6.90	6.85	6.80	6.70	6.70	6.64	6.59	
33	6.83	6.78	6.73	6.68	6.83	6.58	6.53	6.48	
34	6.73	6.68	6.63	6.58	6.53	6.48	6.43	6.38	
35	6.61	6.56	6.51	6.47	6.42	6.37	6 36	6.27	
36	6.51	6.46	6.41	6.36	6.31	6.27	6.22	6.17	
37	6.40	6.35	6.31	6.26	6.21	6.16	6.12	6.07	
38	6.30	6.26	6.21	6.16	6.12	6.07	6.02	5.98	
39	6.26	6.15	6.11	6.06	6 01	5 97	5 92	5.87	
40	6.10	6 06	6.01	5.96	5 92	5.86	5 83	5 78	
41	6.00	5 96	5.91	5 87	5 82	5.78	5 73	5 69	
42	5.91	5 86	5 82	5.77	5 73	5.69	5 64	5 60	
43	5.82	5 78	5 73	5 69	5 65	5 60	5 56	5 51	
44	5 72	5 68	5 64	5 59	5 55	5 51	5 46	5 42-	
45	5 64	5 59	5 55	5.51	5 47	5 42	5 38	5 34	

Source Draft EPA Handbook of Methods for Acid Deposition Studies, Field Operations for Surface Water Chemistry, EPA/600/4-89/020, August 1989

Attachment 7

Laboratory SOP Cover Pages

CEIMIC CORPORATION

Standard Operating Procedure

No. 3810

TITLE:

METHANE, ETHANE AND ETHENE GASES IN WATER SAMPLES BY GAS CHROMATOGRAPHY ANALYSIS OF SAMPLE HEADSPACE

FINAL

Approved By:

QA/QC Officer

Laboratory Manager

Laboratory Supervisor

JUN 1 2001

Previous Revision Date: 3/27/00

Date Revised: 5/14/2001

Control No.: 3810-1

Note: This document may not be copied. Controlled copies of this document are available from the QA/QC Officer. The original is stamped with a red stamp.

CEIMIC CORPORATION

Standard Operating Procedure

No. 9038

TITLE:

SULFATE BY EPA METHOD 375.4
SW846 METHOD 9038, STANDARD METHOD 4500-SO_4^{2-}

Approved By:

QA/QC Officer

Laboratory Manager

Laboratory Supervisor

Previous Revision Date: 12/14/2000

Date Revised: 2/26/2002

Control No.: _____

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CEIMIC CORPORATION

Standard Operating Procedure

No. 9056

TITLE:

DETERMINATION OF INORGANIC ANIONS BY ION CHROMATOGRAPHY (METHOD SW9056)

Approved By:

QA/QC Officer

Laboratory Manager

Laboratory Supervisor

Previous Revision Date: 11/16/2000

Date Revised: 10/31/2001

Control No.: _____

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CEIMIC CORPORATION

Standard Operating Procedure

No. 9060

TITLE:

TOTAL ORGANIC CARBON BY EPA METHOD 415.1 / SW846 METHOD 9060A

Approved By:

QA/QC Officer

Laboratory Manager

Laboratory Supervisor

Previous Revision Date: 1/14/99

DateRevised: 11/1/2000

Control No.: _____

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CEIMIC CORPORATION

Standard Operating Procedure

No. WC02

TITLE:

ALKALINITY, TOTAL (TITRIMETRIC, pH 4.5)

Approved By:

QA/QC Officer

Laboratory Manager

Laboratory Supervisor

Previous Revision Date: 9/22/00

Date Revised: 9/12/2001

Control No.: _____

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CEIMIC CORPORATION

Standard Operating Procedure

No. WC.35

TITLE:
SULFIDE (METHYLENE BLUE METHOD)
BY STANDARD METHOD 4500-S^{2-} D

Approved By:

QA/QC Officer

Laboratory Manager

Laboratory Supervisor

Previous Revision Date: 11/24/2000

Date Revised: 2/28/2002

Control No.: _____

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CEIMIC CORPORATION

Standard Operating Procedure

No. 6010B

TITLE:
INDUCTIVELY COUPLED PLASMA - ATOMIC EMISSION SPECTROSCOPY BY SW846 METHOD 6010B

FINAL

Approved By:

QA/QC Officer

Laboratory Manager

Laboratory Supervisor

DATE ISSUED
OCT 30 2000

Previous Revision Date: 2/29/00

Date Revised: 10/27/2000

Control No.: 6010B-1

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CEIMIC CORPORATION

Standard Operating Procedure

No. 8260B

TITLE:

GAS CHROMATOGRAPHY/MASS SPECTROMETRY FOR VOLATILE ORGANICS BY SW846 METHOD 8260B

FINAL

Approved By:

James. Baker

QA/QC Officer

Laboratory Manager

Matthew V. Pereira

Laboratory Supervisor

DATE ISSUED

JAN 1 2001

Previous Revision Date: 12/27/00

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CEIMIC CORPORATION

Standard Operating Procedure

No. 5035

TITLE:

CLOSED SYSTEM PURGE AND TRAP AND EXTRACTION FOR VOLATILE ORGANICS IN SOIL & WASTE SAMPLES

FINAL

Approved By:

James M. Badger

QA/QC Officer

Laboratory Manager

Matthew V. Pancieza

Laboratory Supervisor

DATE ISSUED

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Safety, Health, and Emergency Response Plan
HRC Injection Pilot Study - Site 16

Naval Construction Battalion Center Davisville
North Kingstown, Rhode Island

Contract No. N62472-92-D-1296
Task Order No. 0107

Prepared for

Department of the Navy
Engineering Field Activity Northeast
10 Industrial Highway
Mail Stop No. 82
Lester, Pennsylvania 19113-2090

Prepared by:

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April 2004
Version: FINAL
EA Project No. 29601.07.3101

Safety, Health, and Emergency Response Plan
HRC Injection Pilot Study – Site 16

Naval Construction Battalion Center Davisville
North Kingstown, Rhode Island

Contract No. N62472-92-D-1296
Task Order No. 0107

Kris H. Hoiem

Kris Hoiem, Certified Industrial Hygienist
Program Safety and Health Officer

8 April 2004
Date

Jim Shultz

Jim Shultz
CTO Manager

8 April 2004
Date

April 2004
Version: FINAL
EA Project No. 29601.07.3101

CONTENTS

Page

LIST OF FIGURES
LIST OF TABLES
LIST OF ACRONYMS

1. SITE INFORMATION 1
2. PERSONNEL 2

2.1 Key Personnel 2
2.2 Responsibilities 2

2.2.1 Contract Task Order Manager 2
2.2.2 Site Safety and Health Officer 3
2.2.3 Site Manager 3
2.2.4 Field Personnel and Subcontractors 4

2.3 Visitors 4

3. PURPOSE AND WORK SCOPE 5

4. SITE DESCRIPTION 6

4.1 Site Location and Description 6

5. HAZARD ANALYSIS 7

5.1 Hazard Communication 7
5.2 Chemical Hazards 7
5.3 Physical and Biological Hazards 8

6. EMPLOYEE TRAINING ASSIGNMENTS 9

6.1 All Site Workers 9
6.2 Site Manager 9
6.3 First Aid/CPR 9
6.4 Pre-Entry Briefing 9
6.5 Subcontractor Training 10

7. MEDICAL SURVEILLANCE 11

8. PERSONAL PROTECTIVE EQUIPMENT 12

Page

9. ENVIRONMENTAL MONITORING 13

9.1 Environmental Monitoring and Action Levels 13
9.2 Calibration of Monitoring Instruments 13

10. SITE CONTROL 14

10.1 Work Zones 14
10.2 Safe Work Practices 14

11. DECONTAMINATION PROCEDURES 16

11.1 Personnel Decontamination 16
11.2 Equipment Decontamination 16
11.3 Waste Disposal Procedures 16

12. EMERGENCY RESPONSE PLAN 17

12.1 Emergency Recognition 17
12.2 Procedures for Handling Emergency Incidents 17
12.3 Medical Emergencies 18
12.4 Fire/Explosion Emergencies 20
12.5 Emergency Telephone Numbers 20

13. CONFINED SPACE ENTRY PROCEDURES 21

14. SPILL CONTAINMENT PROCEDURES 22

ATTACHMENT A: MATERIAL SAFETY DATA SHEETS
ATTACHMENT B: POTENTIAL HAZARDOUS SUBSTANCES
ATTACHMENT C: PHYSICAL AND BIOLOGICAL HAZARD INFORMATION SHEETS
ATTACHMENT D: SITE SAFETY, HEALTH, AND EMERGENCY RESPONSE REVIEW RECORD
ATTACHMENT E: SITE SAFETY AND HEALTH ACTIVITY REPORT
ATTACHMENT F: MONITORING INSTRUMENT CALIBRATION PROCEDURES
ATTACHMENT G: ENVIRONMENTAL MONITORING RECORD
ATTACHMENT H: SITE ENTRY AND EXIT LOG
ATTACHMENT I: ROAD MAP FROM THE SITE TO THE HOSPITAL
ATTACHMENT J: ACCIDENT INVESTIGATION REPORT

LIST OF TABLES

Number	Title
5-1	Reported maximum concentrations of previously detected analytes.
5-2	Task-specific activity hazard analysis.
6-1	Site worker training and physical examination record.
8-1	Personal protective equipment requirements.
9-1	Environmental monitoring requirements.
12-1	Emergency information.

LIST OF FIGURES

Number	Title
1	Site locus map.
2	HRC pilot test vicinity, deep zone total CVOC (ug/L) detected in November / December 2002.
3	Site Map.

1. SITE INFORMATION

Site: Naval Construction Battalion Center (NCBC) Davisville, North Kingstown, Rhode Island

Location: Site 16 (Figures 1 and 2)

Field Activities – Remedy Pilot Study for Dissolved Chlorinated Volatile Organic Compounds in Ground Water to include:

- Advancement of soil borings
- Installation, development, and testing of injection and monitoring wells
- Borehole geophysical logging of wells completed in competent bedrock
- Collect ground-water samples from monitoring wells
- Collect soil samples from borings.
- Water level measurements from wells.
- Injection of hydrogen release compound (HRC®) into injection wells.

2. PERSONNEL

2.1 KEY PERSONNEL

Contract Task Order (CTO) Manager:	Jim Shultz, CPG (508) 485-2982
Program Safety and Health Officer:	Kris Hoiem, CIH (410) 771-4950
Site/Task Manager*:	Robin Clark (508) 485-2982
Site Safety and Health Officer (SSHO):	TBD (508) 485-2982
Field Personnel:	Brian Anderson, Tom Biolsi, Dan Bishuk, Robert Casey, John Clark, Robin Clark, Sarah Roberts, Colleen Dill, James Gatherer, Curt Ilker, Bob Haras, Jennifer Martin, Barbara O'Grady, Jill Parrett, Jim Shultz, Kim Shutty, Robert Wasserman, Matt Levinson, Sam Whitin, Charlie Springer, Paul Probasco, Frank Barranco, Jim Ropp.
* Certification of 8-hour supervisor's training for Hazardous Waste Operations is required for Site Manager.	

2.2 RESPONSIBILITIES

The responsibilities for safety and health-related issues for Program operations are as follow.

2.2.1 Contract Task Order Manager

The responsibilities of the CTO Manager include:

- Assuring compliance with the Program Safety and Health Management Plan and this Safety, Health, and Emergency Response Plan (SHERP)
- Coordinating with the designated Navy Technical Representative
- Overseeing the preparation of the SHERP
- Providing overall supervisory control for safety and health protocols in effect for the project
- Assigning the Site Manager and Site Safety and Health Officer (SSHO) and assuring that the assigned onsite staff will enforce provisions of the approved SHERP

- Assuring adequate resources are available for safety and health.

2.2.2 Site Safety and Health Officer

The SSHO will be onsite throughout the project and will be responsible for daily compliance with site safety and health requirements. The duties of the SSHO include:

- Stopping work, and directing shut-down of the work site when imminent safety or health risks exist or as outlined in this SHERP
- Implementing usage of forms provided in attachments
- Implementing the SHERP
- Providing an initial safety and health briefing to site workers and visitors
- Reviewing training and medical records prior to site work
- Evaluating reported hazardous conditions and recommending corrective action
- Conducting necessary monitoring
- Establishing and ensuring compliance with site control areas and procedures
- Ensuring decontamination of personnel, tools, and equipment
- Supervising the distribution, use, maintenance, and disposal of personal protective clothing and equipment
- Investigating and preparing incident reports as necessary.

2.2.3 Site Manager

The Site Manager (or the Senior Site Supervisor in the absence of the Site Manager) during an emergency will be responsible for initiating and coordinating responses. The Site Manager will:

- Work with the SSHO to identify and evaluate hazards
- Be responsible for initiating the evacuation of the work site when needed or as directed by the SSHO, communicating with offsite emergency responders, and coordinating activities of onsite and offsite emergency responders
- Determine if the abatement of hazardous conditions is sufficient prior to allowing resumption of work operations after an emergency.

2.2.4 Field Personnel and Subcontractors

Employees (including subcontractor and consultant employees) will be responsible for:

- Following this SHERP and applicable safety and health rules, regulations, and procedures
- Using required controls and safety devices, including personal protective equipment
- Notifying his/her supervisor of suspected safety or health hazards
- Complying with training and medical requirements.

2.3 VISITORS

Visitors will be required to read and verify their understanding and willingness to comply with this SHERP. Visitors will remain in an observation area and will not be allowed in the Work Zone unless they have complied with the appropriate Occupational Safety and Health Act (OSHA) training and medical requirements and have the permission of the CTO Manager or the SSHO.

3. PURPOSE AND WORK SCOPE

The objectives of the HRC® Injection Pilot Study at Site 16 are in accordance with the Final Quality Assurance Project Plan (QAPP).

4. SITE DESCRIPTION

4.1 SITE LOCATION AND DESCRIPTION

The HRC Injection Pilot Study area is located within the east central portion of the Site 16 investigation area (Figure 1). This area south of Davisville Road slopes gently toward the east and includes former Building 41 and adjacent paved areas, and a generally grass and weed covered area of several old railroad spurs located south and east of ormer Building 41. Building 41 was demolished and the area re-graded and paved by RIEDC in October 2002. A large part of the pilot study area is being used as a parking lot to temporarily store new cars. Refer to Section 2.2.2 of the Final QAPP dated April 2004 for a summary of the site history and additional description of the site. A more complete description of the Site can be found in the Phase I RI (EA 2001) and Phase II Hydrogeologic Investigation Report (EA 2003). A summary of previous investigations of the site is provided in Section 5.2 of the QAPP.

Based on the Phase I RI and Phase II Hydrogeologic Investigation data, the predominant contamination identified in ground water is a plume of dissolved chlorinated volatile organic compounds (CVOC), particularly trichloroethylene (TCE), in the deep overburden and upper competent bedrock ground-water zones.

Based on the data available for Site 16 through the Phase II hydrogeological investigation and a preliminary screening of remedy technologies, the Navy selected HRC® injection for a pilot study to assess its potential as a practical solution for CVOC in ground water at the site. Refer to Sections 6.1.1 and 6.1.2 of the Final QAPP dated April 2004 for a summary of the use of HRC® to accelerate anaerobic bioremediation and pilot-scale testing.

5. HAZARD ANALYSIS

5.1 HAZARD COMMUNICATION

A Material Safety Data Sheet (MSDS), as well as the volume, for each chemical supplied by EA shall be kept on the site with the SHERP. The MSDS sheets are contained in Attachment A. EA employees and EA subcontractors shall be informed of the location of MSDSs. Subcontractors must inform EA about any hazardous substances that they bring to the site and provide the appropriate MSDSs and quantities. Chemicals brought on the site must be properly labeled in accordance with the OSHA Hazard Communication requirements (29 CFR 1910.1200) and the EA Hazardous Materials Control program.

Chemicals supplied by EA:

- Liquinox
- Isopropanol
  Isobutylene (Calibration Gas)
- Hydrochloric acid (HCL)
- Nitric Acid (HNO_3)
- Sulfuric Acid (H_2SO_4)
- Zinc Acetate (ZnAc)
  Sodium Hydroxide (NaOH).
  Hydrogen Release Compound (HRC®)
- Methanol
- Sodium Bisulfate.

5.2 CHEMICAL HAZARDS

Potential hazardous substances known or suspected to be present at this site include soil and ground water impacted with CVOC. A tabulated list of reported maximum concentrations of previously detected analytes at NCBC Davisville Site 16 is presented in Table 5-1. These substances were identified through record searches and previous investigations. If additional file information becomes available which indicates that other chemicals may be encountered during the field activities, this SHERP will be revised.

Potential hazardous substances are outlined in Attachment B. Task-Specific Activity Hazard Analysis has been provided in Table 5-2. The worker exposure limits, including Permissible Exposure Limits/Threshold Limit Values (PEL/TLV) and the Immediately Dangerous to Life or Health (IDLH) values, for these hazardous substances are also included. The expected exposures (e.g., inhalation, dermal contact, and ingestion) to these hazardous substances per field activity (sample collection in accordance with the Standard Operating Procedures (Attachment 4 of the QAPP) are summarized below:

- Water Sampling – Ground-water sampling will take place outside. Chemical hazards may involve the exposure to CVOC dissolved in ground water. Possible routes of exposure include ingestion, skin absorption, and inhalation of vapors volatilizing from the ground water.

- Soil Sampling – Soil sampling will take place outside. Chemical hazards may involve exposure to CVOC. Possible routes of exposure include inhalation, ingestion, and skin absorption.

- HRC® Injection – HRC® Injection will take place outside. Chemical hazards may involve exposure to HRC®. Possible routes of exposure include inhalation, ingestion, and skin absorption.

During all phases of the fieldwork, strict adherence to the monitoring procedures in Section 9 will be conducted to help protect against inhalation of vapors from potential or known chemicals of concern. The proper personal protective equipment (PPE) will protect against other types of exposure to the chemical hazards.

5.3 PHYSICAL AND BIOLOGICAL HAZARDS

Physical and Biological Hazard Information Sheets give potential hazards and protective measures. If additional hazards are encountered on the site, they will be added to this SHERP.

The following hazard sheets are included in Attachment C:

- Electrical hazards
- Compressed gas cylinder handling
- Biological hazards
- General physical hazards
- Noise hazards
- Fire/explosion hazards
- Heat stress
- Materials handling/moving/lifting
- Cold stress
- Drum handling.

6. EMPLOYEE TRAINING ASSIGNMENTS

Dates of employee training are documented in Table 6-1. Any person who does not meet these training requirements is prohibited from engaging in site operations. Once the SHERP has been signed by the CTO Manager, no other personnel may be added to the project field work without prior written approval by the CTO Manager or SSHO, who must review the proposed employee's training and medical status. The following training must be completed prior to the start of work operations:

6.1 ALL SITE WORKERS

- Prior to project start-up, 40 hours of initial offsite Hazardous Waste Operations Training
- Eight-hour annual Hazardous Waste Operations Refresher Training (if more than 12 months have passed since 40-hour initial training or previous 8-hour refresher).

6.2 SITE MANAGER

- Above requirements for site workers, plus one-time 8-hour Supervisor's Hazardous Waste Operations Training.

6.3 FIRST AID/CPR

At least one onsite worker must be currently certified in both first aid and cardiopulmonary resuscitation (CPR) by the American Red Cross or equivalent organization. First aid training must be updated every 3 years, and CPR training must be updated annually or as required by the certification.

6.4 PRE-ENTRY BRIEFING

All site workers will read the SHERP and indicate their understanding of the requirements by signing Attachment D, Site Safety and Health Review Record. The SSHO must check the training status of all onsite personnel, and then brief workers on the potential hazards at the site and protective measures to be implemented, both prior to entry and daily during the work. An evacuation location to be used in the event of an emergency must be designated and known to all personnel. This location should be an upwind point from site activities, in an area not expected to be affected by emergency situations onsite. Authorized visitors are not permitted to enter areas where they may be exposed to hazardous substances if they do not meet the training requirements summarized above in Section 6.1.

6.5 SUBCONTRACTOR TRAINING

Prior to the start of work operations, the CTO Manager will obtain a written list of subcontractor personnel to be present onsite and written certification from subcontractor management that these workers meet the training requirements summarized above in Section 6.1.

Non-hazardous waste site workers will have been trained to meet applicable OSHA requirements specific to their work. Training records and certification letters will be managed and maintained per EA's BRAC Program Management Plan.

7. MEDICAL SURVEILLANCE

Hazardous waste site workers must have satisfactorily completed a comprehensive medical examination by a licensed physician within 12 months prior to the start of site operations. Non-hazardous waste site workers will be medically examined to meet OSHA requirements specific to their job. The date of medical examination of each site worker will be recorded in Table 6-1. Subcontractors will provide this information in writing to the CTO Manager for their workers onsite prior to startup of field activities. Medical surveillance protocols shall comply with 29 CFR 1910.120.

8. PERSONAL PROTECTIVE EQUIPMENT

Based on evaluation of the potential safety and health hazards (Section 5), the required initial level of PPE is Level D and is presented in Table 8-1 for each work task. Attachment E will be completed by onsite personnel when changes in PPE are necessary due to changed site conditions not specifically addressed in the original plan. Upgrade and downgrade PPE levels are listed below:

- **Upgrade PPE Level C** – Components: steel toe/steel shank neoprene safety boots, polycoated Tyvek coveralls, latex inner gloves, nitrile or neoprene outer gloves, and full-face air purifying respirator with Type P100 and/or organic vapor cartridges, vinyl or rubber gloves for contact with HRC® .

- **Downgrade PPE Level** – None.

Only the SSHO can authorize an upgrade or downgrade in the PPE level worn onsite, using only those criteria presented in Section 9. All changes in PPE levels must be documented on Attachment E, along with the rationale for the PPE changes. When respirators are required, site workers must have been successfully fit-tested within 12 months prior to the start of work operations.

Subcontractors are required to supply their workers with the appropriate PPE.

The SSHO will review appropriate procedures for donning and doffing PPE prior to the start of work tasks. All PPE must be inspected by site workers prior to use and regularly during use. If any site worker experiences a failure or alteration of PPE that affects the level of protection offered, that person will immediately leave the work zone. Re-entry will not be permitted until the equipment has been repaired or replaced.

Hearing protection will be made available and must be worn whenever noise levels exceed 85 dB (noise level at which a normal conversation cannot be understood at a 3-ft distance). The hearing protectors will have a noise reduction rating sufficient to reduce the sound level to below 85 dB.

9. ENVIRONMENTAL MONITORING

9.1 ENVIRONMENTAL MONITORING AND ACTION LEVELS

Task-specific environmental monitoring requirements are summarized in Table 9-1, including the type of monitoring to be performed, the frequency and location of monitoring, action levels, and required responses if action levels are detected. Only personnel trained in proper use and calibration may operate the monitoring instruments. Calibration procedures for the photo ionization detector (PID) are contained in Attachment F.

Where it has been determined that there may be personnel exposure to vapor concentrations of hazardous substances, appropriate direct-reading air monitoring and integrated air sampling will be done in accordance with applicable regulations.

Initial and detectable measurements will be logged on the Environmental Monitoring Record, Attachment G. Each exceedance of an action level will also be documented on Attachment G, along with the corrective action taken. If no detectable levels are measured, this will be documented on Attachment G at least once every 30 minutes.

9.2 CALIBRATION OF MONITORING INSTRUMENTS

The calibration of the FID or PID vapor monitoring instrument must be performed at the beginning of each day of use and at least once during the day. The calibration of the instrument must be checked according to the manufacturer's recommendations. Calibration data will be logged into the field notebook to show the date, calibration material type, and concentrations and actual reading obtained.

10. SITE CONTROL

10.1 WORK ZONES

Proposed work zone for ground-water sampling is an approximately 10-ft radius from the sampling point and will be marked off with traffic cones (defined as the Hot Zone), where necessary.

Personnel who enter the work zones shall sign the Site Entry and Exit Log, Attachment H.

10.2 SAFE WORK PRACTICES

Safe work practices to be followed by site workers include:

- Eating, drinking, chewing gum or tobacco, and smoking are prohibited in the work zone.
- Hands and face must be thoroughly washed upon leaving the work area.
- Personnel must not take prescription drugs unless specifically approved by a licensed occupational physician who is familiar with the issues of worker exposure to hazardous materials.
- When respirators are required, facial hair that interferes with the face-to-face piece fit of the respirator will not be permitted.
- Personnel onsite must use the buddy system; visual contact must be maintained between team members at all times when 2-way radio communication is not possible. When 2-way radio communication is available, onsite personnel will maintain contact via radio and can be up to 1 mi apart.
- If dust is being visually generated in the Work Zone, the SSHO will advise on procedures for misting or wetting the soil to prevent possible exposure from inhalation of soil contaminants.
- Possessing, using, purchasing, distributing, selling, or having controlled substances onsite during the work day, including meal or break periods onsite, is strictly prohibited.
- The use or possession of alcoholic beverages onsite is prohibited. Similarly, reporting to work or performing one's job assignments under the influence of excessive levels of alcohol is not permitted.

- Nearest telephone - mobile telephone in EA vehicle, EA Field Office (401) 294-5893, and at the RIEDC Headquarters, located at 30 Enterprise Drive (i.e., near the former NCBC Davisville main exit).

11. DECONTAMINATION PROCEDURES

11.1 PERSONNEL DECONTAMINATION

Remove and discard boot covers, if worn. Wash boots with detergent and water; rinse. Wash outer gloves with detergent and water, rinse, and remove. Remove disposable coveralls, then respirator, if worn. Remove and discard inner gloves, if worn. Wash hands, face, and other exposed skin with soap and water. Shower and shampoo as soon as possible at the end of the work day, before dining or social activities. Place non-disposable coveralls in plastic bags prior to leaving the site.

11.2 EQUIPMENT DECONTAMINATION

Safety and health monitoring instruments used onsite will be wet-wiped with clean water prior to removing them from the site. When respirators are used, wet-wipe exteriors upon exiting work areas and clean with a manufacturer-recommended sanitizer, then hang to drip dry, and place in plastic bags for protection against dust. Change respirator cartridges at least daily, when breakthrough occurs, or when breathing resistance becomes high, whichever occurs first. Used cartridges shall be damaged to prevent accidental reuse.

Sampling equipment must be decontaminated in accordance with Sections 9.3 of the Final QAPP dated April 2004. Discoloration, stains, corrosive effects, and substances adhering to objects may indicate that contaminants have not been removed. Consideration will be given to using wipe tests when conditions warrant.

11.3 WASTE DISPOSAL PROCEDURES

Waste solids generated during work activities (including disposable gloves, respirator cartridges) will be drummed (or bagged), labeled, and properly disposed in accordance with Section 9.2 of the Final QAPP dated April 2004. Liquids from decontamination and sampling procedures will be collected for disposal in accordance with Section 9.2 of the Final QAPP dated April 2004.

12. EMERGENCY RESPONSE PLAN

12.1 EMERGENCY RECOGNITION

Prior to work start-up, personnel must be familiar with this Emergency Response Plan. The Site Manager must make this SHERP available for review and copying by all field personnel. Field personnel will sign the Safety and Health Review Record (Attachment D). The location of evacuation areas and exit routes should be reviewed. Emergency telephones cell phones with EA field staff, at the EA Field Office along Marine Drive, and at 30 Enterprise Drive in the RIEDC office. The location of the nearest operating telephone for emergency use should be determined. Emergency telephone numbers are provided in Table 12-1.

Field personnel must immediately stop work, tend to injured personnel, evacuate the Work Zone, and report to the Site Manager any of the following potential emergency situations:

- Personal injury
- Fire
- Explosion
- Chemical release.

Onsite emergencies will be handled by offsite emergency support personnel upon their arrival. In case of a hazardous materials emergency, the Site Manager or SSHO onsite will take control and direct the emergency response until the arrival of the emergency responders. The Site Manager, the Program Safety and Health Officer, or the SSHO will work with the emergency responders to identify and evaluate hazards. Emergency responses and communications will be coordinated and controlled through the Onsite Incident Commander, designated by the emergency responders.

12.2 PROCEDURES FOR HANDLING EMERGENCY INCIDENTS

In the event of an emergency, the information available at that time must be properly evaluated and the appropriate steps taken to implement the Emergency Response Plan. The Site Manager (or SSHO if the Site Manager is part of the emergency) shall assume command of the situation. He/she must call the appropriate emergency services, evacuate personnel to the predesignated evacuation location as needed, and take other steps necessary to gain control over the emergency. Emergency telephone numbers, directions to the nearest hospital, and the location of the nearest telephone and other site communication equipment are presented in Table 12-1. Give the following information when reporting an emergency:

- Name and location of person reporting
- Location of accident/incident
- Name and affiliation of injured party
- Description of injuries, fire, spill, or explosion

- Status of medical aid and/or other emergency control efforts
- Details of any chemicals involved
- Summary of accident, including suspected cause and time it occurred
- Temporary control measures taken to minimize further risk.

This information is not to be released under any circumstances to parties other than those listed in this section and emergency response team members.

Once emergency response agencies have been notified, the EA CTO Manager, EA Program Safety and Health Manager, and the Navy Engineering Field Activity Northeast (EFANE) Remedial Project Manager (RPM) must be notified immediately.

12.3 MEDICAL EMERGENCIES

Personnel should always be alert for signs and symptoms of illnesses related to chemical, physical, and disease factors onsite. Severe injuries resulting from accidents must be recognized as emergencies and treated as such. At least one employee currently trained in first aid/CPR must be present onsite.

In a medical emergency, the Site Manager (or the SSHO if the Site Manager is not available) must sound the emergency alarm, upon which all work must stop and personnel must move to the decontamination area:

- If the emergency situation cannot be conveyed by word of mouth, an air/car horn, or other alarm device will be sounded
- One continuous blast of the air/car horn will be used as the emergency signal
- Personnel currently trained in first aid and CPR will evaluate the nature of the injury, decontaminate the victim if the victim can be moved safely, and initiate first aid assistance immediately
- First aid will be administered only to limit further injury and stabilize the victim
- The local Emergency Medical Services must be notified immediately if needed
- Victims that are heavily contaminated with toxic or dangerous materials should be decontaminated before being transported from the site
- No persons will re-enter the Work Zone until the cause of the injury or symptoms has been determined and controlled

- A fellow EA worker must accompany injured workers to the hospital to inform the admitting clerk that the injury is work-related and to assist in completing the insurance forms.

A road map to the Kent County Memorial Hospital, located approximately 15 minutes from the site, is presented in Attachment I.

Personnel will not transport victims to emergency medical facilities unless:

- The injury does not pose immediate threat to life, and transport to the emergency medical facility can be accomplished without the risk of further injury.

The Site Manager must complete an Accident Investigation Report (Attachment J) and submit it to the CTO Manager and BRAC Program Manager. The EA Program Manager will submit the report to the EFANE RPM within 24 hours of the following types of incidents:

- Job-related injuries and illnesses
- Accidents resulting in loss or damage to property
- All accidents involving vehicles and/or vessels, whether or not they result in damage to property or personnel
- Accidents in which there may have been no injury or property damage, but which have a high probability of recurring with at least a moderate risk to personnel or property
- An accident which results in a fatality or the hospitalization of three or more employees must be reported within 8 hours to the U.S. Department of Labor via the EA Human Resources representative. Subcontractors are responsible for notification involving their employees.

First aid/emergency equipment is available at the following locations:

- First Aid Kit: EA vehicle, EA Field Office
- Eye Wash: EA vehicle, EA Field Office
- Fire Extinguisher: EA vehicle, EA Field Office
- Emergency Alarm: EA vehicle horn.

The eye wash kit must be portable and capable of supplying at least a 15-minute supply of potable water to the eyes.

12.4 FIRE/EXPLOSION EMERGENCIES

Fire and explosion must be immediately recognized as an emergency. The Site Manager (or SSHO if the Site Manager is not available) must order evacuation and sound the emergency signal. Personnel must decontaminate and be evacuated to the predesignated evacuation location. If the emergency situation cannot be conveyed by word of mouth, a vehicle horn will be sounded. One continuous blast of the vehicle horn will be used as the emergency signal. The local emergency services must be notified. Only persons properly trained in fire suppression, spill control, and other emergency response procedures should attempt to deal with these situations. Other than small fires or spills, local emergency response services must be notified to handle the emergency. The Site Manager should take measures to reduce injury and illness, primarily by evacuating personnel as quickly as possible. He/she must then notify the CTO Manager. Cleanup after such events may require specialized services. The CTO Manager will determine proper cleanup actions. Site personnel will not resume work during or after a fire/explosion incident until the Site Manager has directed that the incident is over and work may resume. During the incident, site personnel will remain outside the incident area and obey the instructions of the Site Manager.

12.5 EMERGENCY TELEPHONE NUMBERS

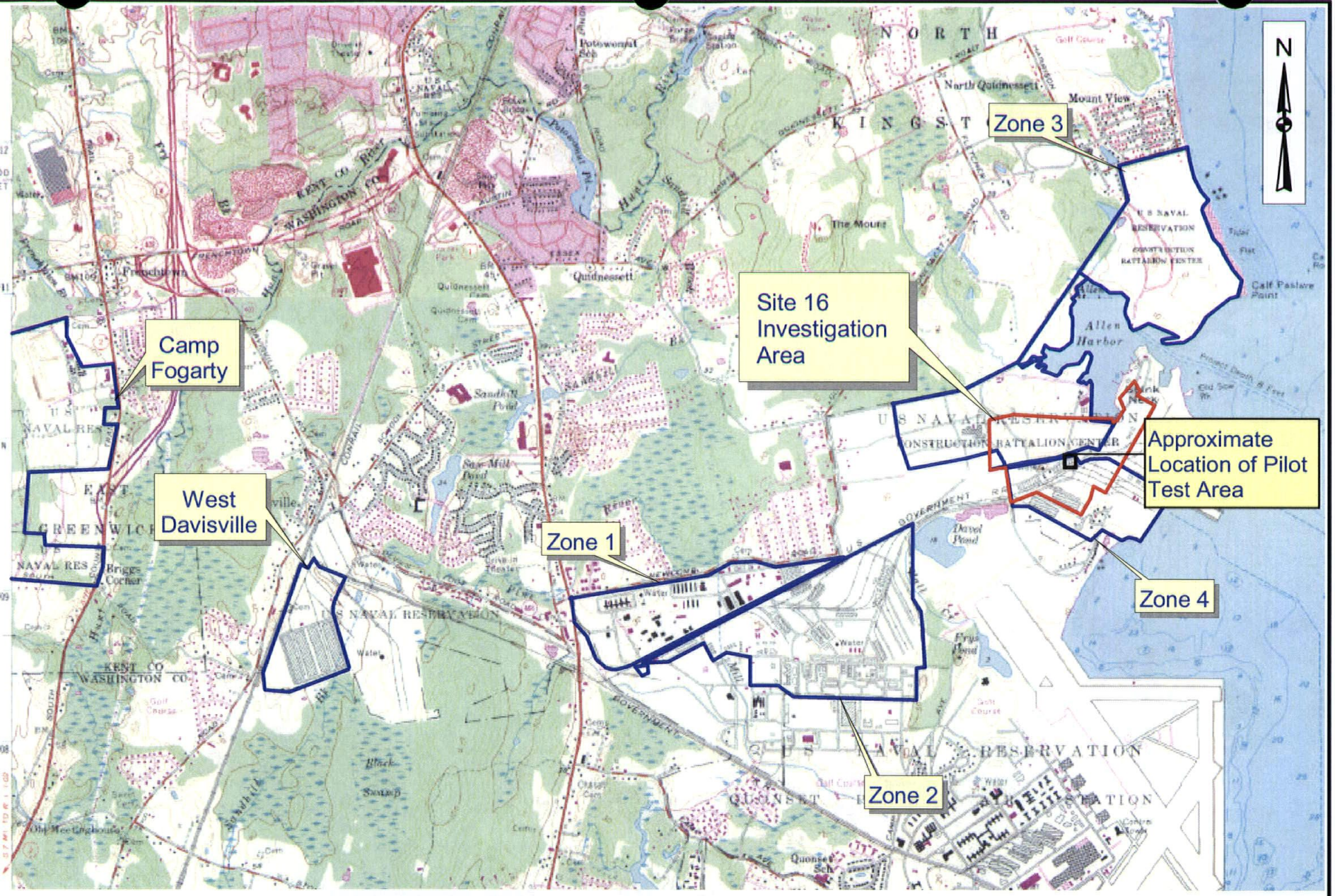
The directions to the nearest telephone and site-specific telephone numbers are listed in Table 12-1.

13. CONFINED SPACE ENTRY PROCEDURES

No confined space entry is permitted or anticipated under this CTO.

14. SPILL CONTAINMENT PROCEDURES

Small incidental spills; i.e., those that cause no injury to personnel or the public, should be cleaned up quickly. For large spills (i.e., those that contaminate personnel or the environment), attend to first aid measures first, stop the source of the spill if possible, and then notify the EA Program Manager and the Navy. The Site Manager (or the SSHO in his/her absence) will notify the CTO Manager as soon as possible. Spills of hazardous materials or wastes that are listed by EPA as having a reportable quantity value must be reported to appropriate federal, state, and local agencies if a reportable quantity or greater is released. It is the Navy's responsibility to contact other appropriate federal, state, and local agencies. Emergency telephone numbers are provided in Table 12-1.

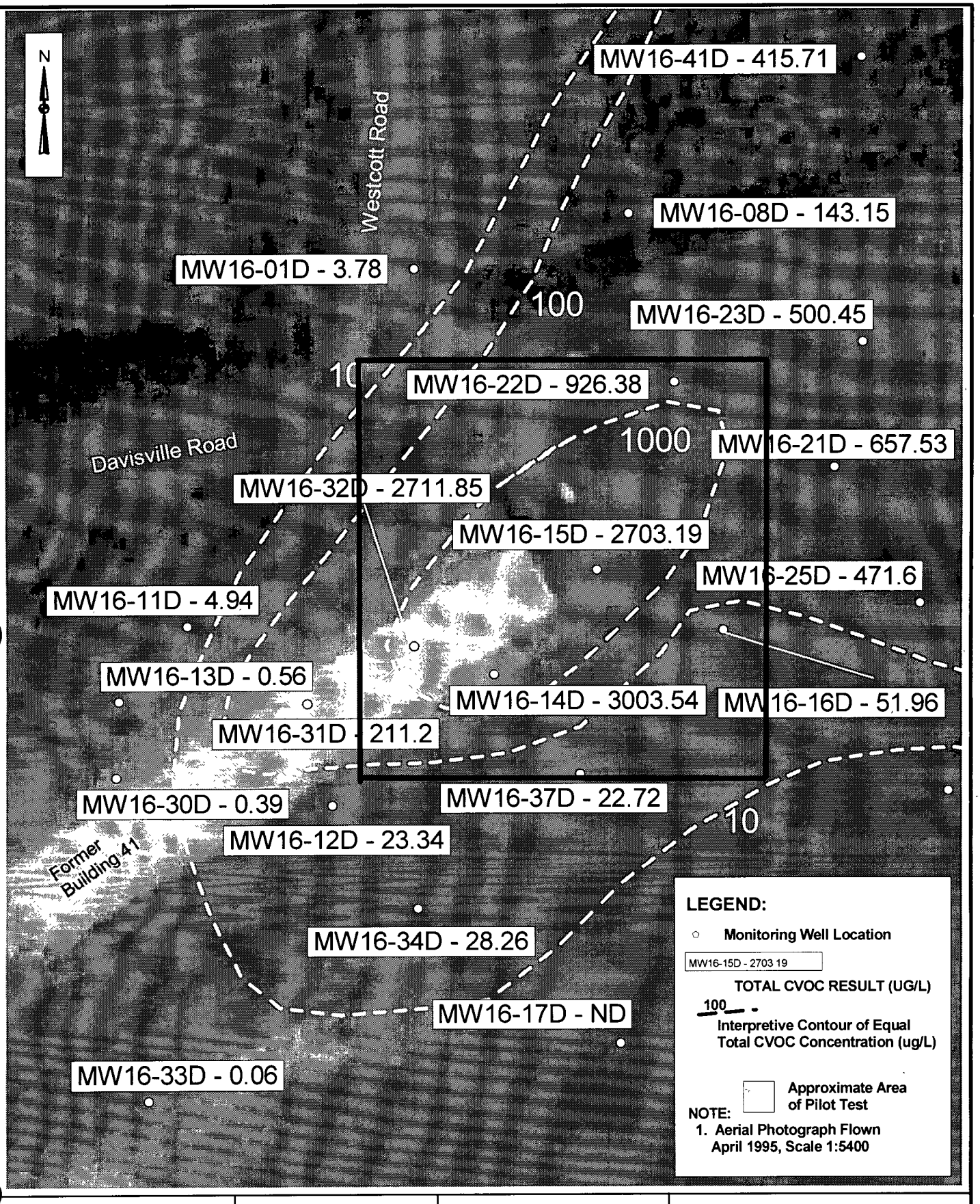


EA ENGINEERING, SCIENCE AND TECHNOLOGY, INC.

EFANE
SITE 16 HRC INJECTION PILOT TEST
FORMER NCBC DAVISVILLE FACILITY,
NORTH KINGSTOWN, RHODE ISLAND

SITE LOCUS MAP

FIGURE 1



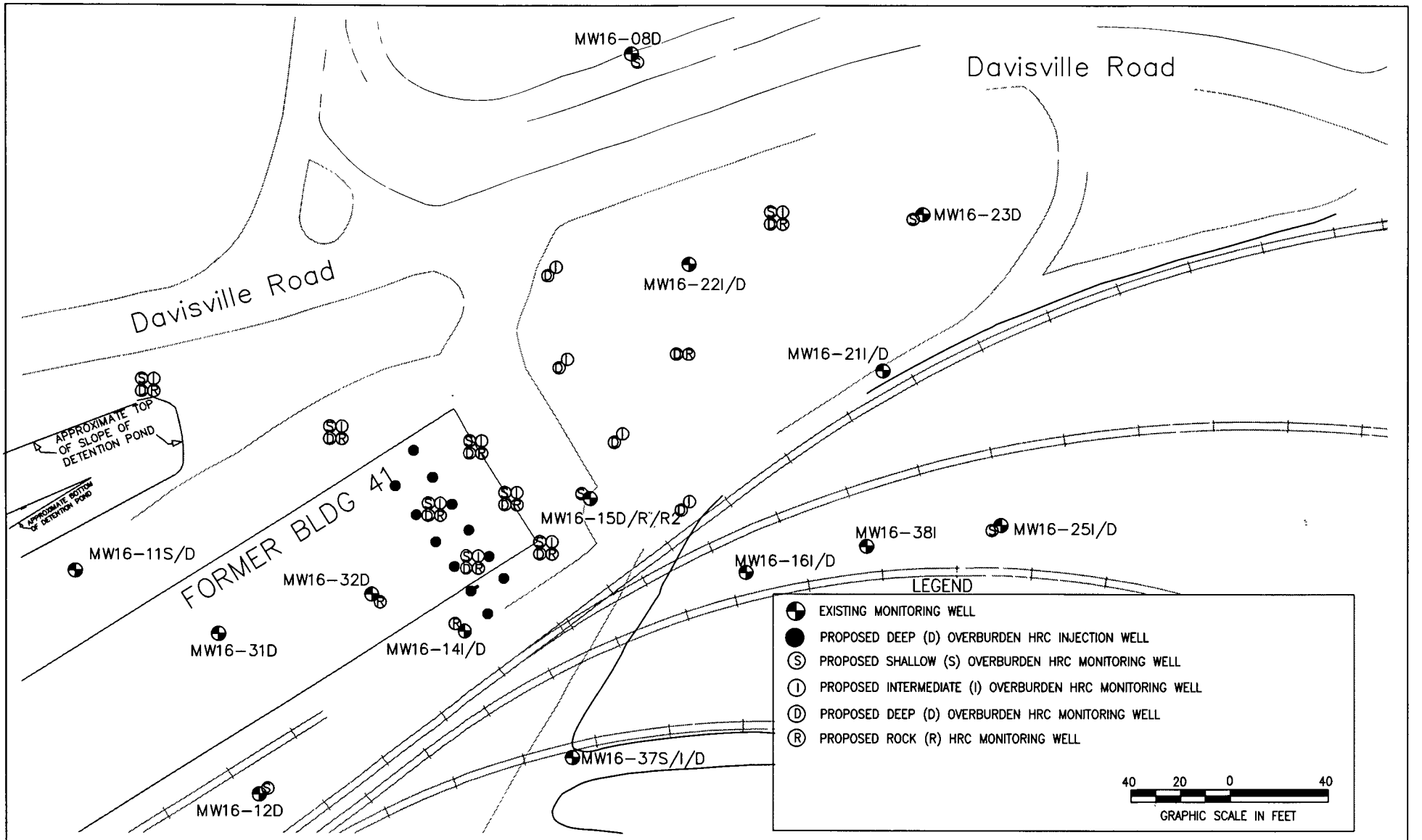
EA ENGINEERING, SCIENCE, AND TECHNOLOGY

40 0 40 80 Feet

EFANE
HRC INJECTION PILOT STUDY
SITE 16 NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

HRC PILOT TEST VICINITY
DEEP ZONE TOTAL CVOC (UG/L)
DETECTED IN NOVEMBER / DECEMBER 2002

FIGURE 2



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EFANE SITE 16 HRC INJECTION PILOT TEST FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	SITE MAP	DESIGNED BY JAS	DRAWN BY RWC	DATE 4/2/04	PROJECT NO. 2960107	FILE NAME FIG 3
			CHECKED BY RWC	PROJECT MGR. JAS	SCALE AS SHOWN	DRAWING NO. –	FIGURE Figure 3

TABLE 5-1 REPORTED MAXIMUM CONCENTRATIONS OF PREVIOUSLY DETECTED ANALYTES

Chemical Analyte	Soil mg/kg	Ground Water µg/L
1,1,1-Trichloroethene	—	1
1,1-Dichloroethene	—	14
2-Butanone	0.010	6
2-Methylnaphthalene	49.0	21*
4,4'-DDE	—	—
4,4'-DDT	0.037	—
4-Methyl-2-Pentane	—	2
Acenaphthene	5.3	0.8*
Acetone	75	750J
Alpha BHC	—	—
Aluminum	12,400	45,000
Anthracene	2,.8	0.4*
Antimony	8.7	1.7
Arsenic	10.6	23.4
Barium	1,100	260
BEHP	—	13*
Benzene	—	9
Benzo(a)Anthracene	4.8	0.4*
Benzo(a)Pyrene	2.7	0.2*
Benzo(b)Fluoroanthene	7.4	0.2
Benzo(k)Fluoroanthene	2.3	0.1J*
Benzo[g,h,i]Perylene	2.7	—
Beryllium	0.74	0.8J
Beta BHC	—	—
bis(2-Ethylhexyl) Phthalate	0.560	18J
Cadmium	2.4	0.97
Calcium	23,400	534,000
Carbazole	0.550J	—
Carbon Disulfide	0.011	4
Chloroethane	—	2J
Chromium	67.2	330J
Chrysene	5.3	0.6*
cis-Dichloroethylene	—	250*
Cobalt	10.6	10.2
Copper	452	76J
Dibenz[a,h]Anthracene	0.42	—
Dibenzo Furan	—	—

NOTES:
mg/kg = Milligrams per kilogram.
µg/L = Micrograms per liter.
— = Either data was not available or analyte concentration was not detected above the laboratory method detection limit.
* = Probe collected ground-water sample, April - May 2000. Data not validated.
J = Estimated value.

Chemical Analyte	Soil mg/kg	Ground Water µg/L
Dieldrin	—	0.02
Di-n-Octyl-Phthalate	—	—
Dioxin TEQ**	Surface soil = 45.2 ppt Subsurface soil = 496.7 ppt	—
Endrin Ketone	—	—
Endrin	—	0.0039
Endrin Aldehyde	0.047	—
Ethylbenzene	—	1.73
Fluoranthene	7.9	2*
Fluorene	5.1J	1*
Gamma Chloride	0.089J	—
Heptachlor Epoxide	—	0.02
Indeno[1,2,3-cd]Pyrene	2.5	—
Iron	54,300	78,000J
Lead	2,650	99.5J
Magnesium	4,910	146,000
Manganese	587J	5,270
Mercury	0.96	0.27J
Methylene Chloride	0.230J	6.97J
Napthalene	—	0.6
Nickel	34.5	420
o-Xylene	—	0.5
PCB 1260	0.019	—
Phenanthrene	13.0J	7
Potassium	1,900	230,000
Pyrene	6.6	2*
Selenium	0.92	87.1
Silver	6.8	9.2
Sodium	596	1,880,000
Thallium	0.65J	0.53
Toluene	—	12
Total Dichloroethylene	—	255*
TPH	1,750	—
trans-Dichloroethylene	—	53*
Trichloroethylene	5.4	5,300*
Vanadium	18.9	29.9J
Vinyl Chloride	—	36
Zinc	1,610J	650J

NOTES:
** = The Agency for Toxic Substances and Disease Registry action level is 1 part per billion in residential soil.
ppt = Parts per trillion.

TABLE 5-2 TASK-SPECIFIC ACTIVITY HAZARD ANALYSIS

Task	Potential Hazards	Hazard Control Measures
Mobilization/Demobilization	Chemical Exposure	• Review summary of known and potential chemicals of concern, be familiar with potential routes of exposure, and symptoms. • Follow recommended procedures for implementing appropriate level of PPE. • Review MSDS with workers before work begins and follow recommended procedures for handling and storage of acids, as per MSDS (Attachment A). • Wear gloves, tyveks, and eye protection to avoid dermal and eye contact in case of leak or splash.
	General Safety Hazards (slips, trips, falls, cuts, etc.)	• Clear walkways, work areas of equipment, tools, debris. • Watch for accumulation of water on walkways and work surfaces. • Mark, identify, or barricade obstructions. • Wear cut-resistant work gloves when the possibility of lacerations or other injury caused by sharp or protruding objects occurs.
	Heavy Equipment Hazards	• Isolate equipment swing areas. • Make eye contact with operators before approaching equipment. • Understand and review hand signals. • Wear hard hats and steel-toe safety shoes to prevent injuries.
	Noise	• Position equipment down wind and as far away as practical. • Wear hearing protection if it is difficult to hold a conversation at a distance of 3 ft.

Task	Potential Hazards	Hazard Control Measures
Mobilization/Demobilization (continued)	Material Handling, Moving, Lifting	• Observe proper lifting techniques. • Obey sensible lifting limits (60-lb maximum per person manual lifting). • Use mechanical lifting equipment (hand carts, trucks, etc.) to move large awkward loads. • Use two or more persons for heavy bulk lifting.
	Vehicle and Pedestrian Traffic	• Use orange traffic cones. • Use reflective warning vests if exposed to vehicular traffic. • Locate staging areas in locations with minimal traffic.
	Fire/Explosion	• Eliminate sources of ignition from the work area. • Prohibit smoking in the work areas. • Provide ABC (or equivalent) fire extinguishers in work areas. • Store flammable liquids in well ventilated areas.
	Electrical	• Identify electrical utility hazards prior to sampling. • Inspect work areas for spark sources, maintain safe distances, properly illuminate work areas, and provide barriers to prevent inadvertent contact. • Maintain minimum clearance distances for overhead energized electrical lines as specified in Attachment C.
	Weather	• Monitor marine radio for up-to-date severe weather forecasts. • Discontinue work during thunderstorms and severe weather events.
	Cold Stress	• Monitor of cold stress as recommended in Attachment C.
	Heat Stress	• Monitor for heat stress as recommended in Attachment C.

Task	Potential Hazards	Hazard Control Measures
Mobilization/Demobilization (continued)	Insect Bites/Poisonous Plants	• Wear protective outer clothing and insect repellant. • Workers with allergies should carry antidote kits, if necessary.
Site Reconnaissance/Ground Survey	General Safety Hazards (slips, trips, falls, cuts, etc.)	• Clear walkways, work areas of equipment, tools, debris. • Watch for accumulation of water on walkways and work surfaces. • Mark, identify, or barricade obstructions. • Wear cut-resistant work gloves when the possibility of lacerations or other injury caused by sharp or protruding objects occurs.
	Vehicle and Pedestrian Traffic	• Use orange traffic cones. • Use reflective warning vests if exposed to vehicular traffic. • Locate staging areas in locations with minimal traffic.
	Weather	• Monitor radio for up-to-date severe weather forecasts. • Discontinue work during thunderstorms and severe weather events.
	Cold Stress	• Monitor for cold stress as recommended in Attachment C.
	Heat Stress	• Monitor for heat stress as recommended in Attachment C.
	Insect Bites/Poisonous Plants	• Wear protective outer clothing and insect repellant. • Workers with allergies should carry antidote kits, if necessary.

Task	Potential Hazards	Hazard Control Measures
Drilling and Coring	Chemical Exposure	• Wear appropriate PPE, including gloves to minimize dermal contact and eye protection to minimize splash hazards. • Monitor organic vapors using a FID (flame ionization detector) or PID (photoionization detector).
	Noise	• Position equipment down wind and as far away as practical. • Wear hearing protection if it is difficult to hold a conversation at a distance of 3 ft.
	General Safety Hazards (slips, trips, falls, etc.)	• Clear walkways, work areas of equipment, tools, debris. • Watch for accumulation of water on walkways and work surfaces. • Mark, identify, or barricade obstructions. • Wear cut-resistant work gloves when the possibility of lacerations or other injury caused by sharp or protruding objects occurs.
	Material Handling, Moving, Lifting	• Observe proper lifting techniques. • Obey sensible lifting limits (60-lb maximum per person manual lifting). • Use mechanical lifting equipment (hand carts, trucks, etc.) to move large awkward loads. • Use two or more persons for heavy bulk lifting.
	Heavy Equipment Hazards	• Isolate equipment swing areas. • Make eye contact with operators before approaching equipment. • Understand and review hand signals. • Wear hard hats and steel-toe safety shoes to prevent injuries.
	Fire/Explosion	• Eliminate sources of ignition from the work area. • Prohibit smoking in the work areas. • Provide ABC (or equivalent) fire extinguishers in work areas. • Store flammable liquids in well-ventilated areas.

Task	Potential Hazards	Hazard Control Measures
Drilling and Coring (continued)	Weather	• Monitor radio for up-to-date severe weather forecasts. • Discontinue work during thunderstorms and severe weather events.
	Cold Stress	• Monitor for cold stress as recommended in Attachment C.
	Heat Stress	• Monitor for heat stress as recommended in Attachment C.
	Electrical	• Identify electrical utility hazards prior to sampling. • Inspect work areas for spark sources, maintain safe distances, properly illuminate work areas, and provide barriers to prevent inadvertent contact. • Maintain minimum clearance distances for overhead energized electrical lines as specified in Attachment C.
	Utilities	• Contact local utility companies to identify utility right-of-ways prior to sampling. • Contact DigSafe (1-800-344-7233) prior to drilling. • Be aware of unanticipated hazards.
	Insect Bites/Poisonous Plants	• Wear protective outer clothing and insect repellant. • Workers with allergies should carry antidote kits, if necessary.

Task	Potential Hazards	Hazard Control Measures
Monitoring Well Installation/Water-Level Measurement/Soil and Ground-Water Sampling/ Waste Management/Equipment Decontamination	Chemical Exposure	• Review MSDS with workers before work begins and follow recommended procedures for handling and storage of nitric acid, hexane, and methanol as per MSDS (Attachment A). • Wear appropriate PPE, including gloves to minimize dermal contact and eye protection to minimize splash hazards.
	General Safety Hazards (slips, trips, falls, cuts, etc.)	• Clear walkways, work areas of equipment, tools, debris. • Watch for accumulation of water on walkways and work surfaces. • Mark, identify, or barricade obstructions. • Wear cut-resistant work gloves when the possibility of lacerations or other injury caused by sharp or protruding objects occurs.
	Material Handling, Moving, Lifting	• Observe proper lifting techniques. • Obey sensible lifting limits (60-lb maximum per person manual lifting). • Use mechanical lifting equipment (hand carts, trucks, etc.) to move large awkward loads. • Use two or more persons for heavy bulk lifting.
	Noise	• Position equipment down wind and as far away as practical. • Wear hearing protection if it is difficult to hold a conversation at a distance of 3 ft.
	Fire/Explosion	• Eliminate sources of ignition from the work area. • Prohibit smoking in the work areas. • Provide ABC (or equivalent) fire extinguishers in work areas. • Store flammable liquids in well-ventilated areas.
	Weather	• Monitor radio for up-to-date severe weather forecasts. • Discontinue work during thunderstorms and severe weather events.

Task	Potential Hazards	Hazard Control Measures
Monitoring Well Installation/Water-Level Measurement/Soil and Ground-Water Sampling/ Waste Management/Equipment Decontamination (continued)	Cold Stress	• Monitor for cold stress as recommended in in Attachment C.
	Heat Stress	• Monitor for heat stress as recommended in Attachment C.
	Insect Bites/Poisonous Plants	• Wear protective outer clothing and insect repellant. • Workers with allergies should carry antidote kits, if necessary.
Seismic Refraction and Profiling	General Safety Hazards (slips, trips, falls, cuts, etc.)	• Clear walkways, work areas of equipment, tools, debris. • Watch for accumulation of water on walkways and work surfaces. • Mark, identify, or barricade obstructions. • Wear cut-resistant work gloves when the possibility of lacerations or other injury caused by sharp or protruding objects occurs.
	Material Handling, Moving, Lifting	• Observe proper lifting techniques. • Obey sensible lifting limits (60-lb maximum per person manual lifting). • Use mechanical lifting equipment (hand carts, trucks, etc.) to move large awkward loads. • Use two or more persons for heavy bulk lifting.
	Electrical	• Identify electrical utility hazards prior to sampling. • Inspect work areas for spark sources, maintain safe distances, properly illuminate work areas, and provide barriers to prevent inadvertent contact. • Maintain minimum clearance distances for overhead energized electrical lines as specified in Attachment C.
	Weather	• Monitor marine radio for up-to-date severe weather forecasts. • Discontinue work during thunderstorms and severe weather events.

Task	Potential Hazards	Hazard Control Measures
Seismic Refraction and Profiling (continued)	Utilities	• Contact local utility companies to identify utility right-of-ways prior to sampling. • Contact DigSafe (1-800-344-7233) prior to seismic refraction. • Be aware of unanticipated hazards.
	Cold Stress	• Monitor for cold stress as recommended in in Attachment C.
	Heat Stress	• Monitor for heat stress as recommended in Attachment C.
	Insect Bites/Poisonous Plants	• Wear protective outer clothing and insect repellant. • Workers with allergies should carry antidote kits, if necessary.
Sample Handling	Chemical Exposure	• Review MSDS with workers before work begins and follow recommended procedures for handling and storage of chemicals as per MSDS (Attachment A). • Wear appropriate PPE, including gloves to minimize dermal contact and eye protection to minimize splash hazards.
	General Safety Hazards (slips, trips, falls, cuts, etc.)	• Clear walkways, work areas of equipment, tools, debris. • Watch for accumulation of water on walkways and work surfaces. • Mark, identify, or barricade obstructions. • Wear cut-resistant work gloves when the possibility of lacerations or other injury caused by sharp or protruding objects occurs.
	Material Handling, Moving, Lifting	• Observe proper lifting techniques. • Obey sensible lifting limits (60-lb maximum per person manual lifting). • Use mechanical lifting equipment (hand carts, trucks, etc.) to move large awkward loads. • Use two or more persons for heavy bulk lifting.

TABLE 6-1 SITE WORKER TRAINING AND PHYSICAL EXAMINATION RECORD

Name	HAZWOPER 40-Hour Initial	HAZWOPER Annual	Respirator Fit Test	First Aid[a] (Date of Expiration)	CPR[a] (Date of Expiration)	Supervisor[b]	Medical Exam
Andersen, Brian	10/13/89	01/30/03	---	11/11/05	11/14/04	03/14/90	02/03
Barranco, Frank	01/89	11/26/01	11/15/03	---	---	01/89	11/15/03
Casey, Robert	11/01/01	10/30/02	11/01/01	05/01/05	05/01/04	---	11/07/02
Clark, John	05/14/98	04/15/02	05/14/98	04/12/05	04/12/04	08/11/00	07/08/02
Clark, Robin	05/95	03/03	02/02	03/05	03/04	09/96	08/03
Dill, Colleen	01/14/00	02/10/03	---	10/25/03	10/25/02	---	10/02
Gatherer, James	01/04/99	05/27/03	02/19/01	08/30/02	08/30/01	---	01/01
Haras, Bob	10/13/89	02/24/04	---	11/11/05	11/14/04	12/16/94	04/03
Ilker, Kurt	05/19/95	01/12/04	---	08/30/02	08/31/03	01/22/97	08/07/03
Levinson, Matt	06/27/96	05/09/03	---	---	---	---	12/19/03
Martin, Jennifer	05/20/99	05/14/03	---	04/12/05	04/12/04	08/11/00	06/04/03
O'Grady, Barbara	04/30/99	12/03	---	10/25/03	11/02	---	05/03
Parrett, Jill	08/00	01/30/03	08/24/01	03/05	03/04	---	09/02
Probasco, Paul	2002	---	---	---	---	---	08/02
Roberts, Sarah	03/02	02/03	---	03/05	03/04	---	04/03
Ropp, James	02/94	06/06/03	04/95	03/05	03/04	---	11/99
Shultz, James	03/84	03/03	---	03/05	03/04	02/93	12/03
Shutty, Kim	10/13/89	07/24/03	---	08/30/04	08/31/03	12/16/94	05/02
Springer, Charles	09/15/00	03/03	---	01/31/06	01/31/05	09/16/00	06/03
Wasserman, Rob	10/99	01/21/02	---	11/11/05	11/14/04	02/18/02	07/02
Whitin, Sam	02/00	04/03/03	02/19/02	03/05	03/04	---	07/03
Biolsi, Tom	12/15/97	03/12/03	02/18/99	10/25/03	10/25/02	12/11/98	10/02

NOTES:
No employees other than those listed above are permitted to work onsite without prior written approval by the Project Manager or SHSO.
(a) = At least one person onsite must have current certification in first aid/CPR for all tasks.
(b) = At a minimum, the Site Manager must have had supervisor's training.
--- = Data not available or expired.

TABLE 8-1 PERSONAL PROTECTIVE EQUIPMENT REQUIREMENTS

Equipment	Level D	Level C
Hard hat	NR[a]	NR[a]
Safety glass/splash shield	X/O	X/O
Work clothes	X	O
Boots, safety with steel toe/steel shank	X	NR
Boots, chemical resistant with steel toe and shank, or boot covers to go over safety boots	NR	X
Gloves, inner and outer, chemical resistant	O	X
Air-purifying full-face or half-face respirator	NR	X
Chemical-resistant clothing	NR	X
Disposable boot protectors	NR	O
Hearing protection	O	O

NOTE: X = Required.
O = Optional.
NR = Not required.
X* = If permitted.

a. Hard hat will be required while within the Exclusion Zone of the drilling rig, due to overhead hazards.

TABLE 9-1 ENVIRONMENTAL MONITORING REQUIREMENTS

SITE: NCBC Davisville Site 16

Step/Task	Instrument	Frequency and Location	Action Levels	Required Response
Water Sampling Soil Sampling Soil boring Well installation HRC® Injection	PID or FID	Initially and approximately every 10 to 15 minutes in the breathing zone	0-1 ppm above background in breathing zone for 5 minutes	Evacuate to a safe upwind location and wait for levels to dissipate; retest the area after 15 minutes. If levels have not dissipated, continue work in Level C PPE *.
			Sustained 1-5 ppm above background in breathing zone	Continue work in Level C PPE *. Monitor continuously.
			>5 ppm above background in breathing zone	Evacuate to a safe upwind location immediately. Retest the area after 15 minutes wearing Level C PPE *. If levels have not dissipated in 30 minutes, contact the Project Manager and Program Safety and Health Officer.
After HRC® injection, during ground-water sampling and water level measurement	Drager tube to confirm Vinyl Chloride	As needed to confirm if vinyl chloride is present and at what concentration when PID or FID (filtered value) readings are sustained in the breathing zone above 1 ppm	Confirmation of presence of vinyl chloride by Drager tube	Evacuate to a safe upwind location immediately. Retest the area after 15 minutes wearing Level C PPE *. If levels have not dissipated in 30 minutes, contact the EA CTO Manager and EA Program Safety and Health Officer.

NOTE: *Change respirator cartridges at least daily, when breakthrough occurs, or when breathing resistance becomes high, whichever occurs first.

FID = Flame ionization detector.
PID = Photoionization detector.
PPE = Personal protective equipment.

TABLE 12-1 EMERGENCY INFORMATION

SITE: NCBC Davisville Site 16

Nearest telephone (give location, directions, and telephone number):

1. EA Field Office on Marine Road (401) 294-5893
2. RIEDC Headquarters, 30 Enterprise Drive, Exit Site by traveling west on Davisville Road, Proceed approximately 1.25 miles to traffic light (prior to overpass), turn right onto Enterprise Drive and follow approximately 0.25 mile to RIEDC headquarters building that will be on the left (south) side of the road. (401) 295-0044

Other site communication equipment: Cellular telephone in EA vehicle
EA Field Office, Davisville RI (401) 294-5893

	Name	Phone Number
Police:	8166 Post Road, North Kingstown, RI	911 or (401) 294-3311
Fire:	8150 Post Road, North Kingstown, RI	911 or (401) 294-3344
Ambulance:	8150 Post Road, North Kingstown, RI	911 or (401) 294-3344
Hospital:	Kent County Memorial Hospital 445 Toll Gate Road, Warwick, RI	(401) 267-2541

Directions to Hospital:

Exit the site by traveling west approximately 1.5 miles along Davisville Road to the intersection with US Route 1.
Proceed under U.S. Route 1 overpass onto Devil's Foot Road.
Continue approximately 2 miles on Devil's Foot Road and turn right onto Route 4.
Take Route 4 North to Route 95 North.
Take the first exit off of Route 95 onto Route 117.
Take a left onto Route 117.
Proceed one block to a traffic light and turn right.
Follow road and bear right at first intersection.
Follow road to the end and take a left onto Toll Gate Road.
Hospital will be on your right.

NATIONAL RESPONSE CENTER: 1 (800) 424-8802
NATIONAL POISON CONTROL CENTER 1 (800) 222-1222

Project Manager: Jim Shultz	(508) 485-2982 x208 (work)
Site Manager: Robin Clark	(508) 485-2982 x204 (work) (508) 272-3069 (cell)
Site Safety and Health Officer: TBD	(508) 485-2982 (work)
Program Manager: Ken Kilmer	(410) 771-4204 (work)
Program Safety and Health Officer: Kris Hoiem, CIH	(410) 771-4950 (work)
EA Medical Services: Dr. Jerry Berke, Corp Medical Director Health Resources Corp. 600 West Cummings Park, Suite 3400 Woburn, MA 01810	(781) 935-8581 (800) 455-0818
Poison Control Center	(800) 222-1222
In case of accident or exposure, contact EA Human Resources within 24 hours	(410) 584-7000

NOTE: The Project Manager will verify telephone numbers and check with the emergency responder to ensure coordination. The medical facility will be contacted to determine the ability and desire to treat potentially contaminated patients.

Attachment A

Material Safety Data Sheets

MATERIAL SAFETY DATA SHEET

Last Revised: March 10, 2003

Section 1 - Material Identification

Supplier: Regenesis Bioremediation Products, Inc.
1011 Calle Sombra
San Clemente, CA 92673
Telephone: (949) 366-8000
Facsimile: (949) 366-8090
Email: info@regenesis.com

Chemical Name: Glycerol Tripolylactate
Chemical Family: Organic Chemical
Trade Name: Hydrogen Release Compound (HRC®)

Section 2 - Chemical Identification

CAS#	Compound	Percent Composition
201167-72-8	Glycerol Tripolylactate	52.5 - 65.0%
56-81-5	Glycerol	35.0 - 47.5%

Section 3 - Physical Data

Melting Point: NA
Boiling Point: ND
Flash Point: ND
Density: 1.347
Solubility: Acetone and DMSO
Appearance: Amber semi-solid
Odor: Not detectable
Vapor Pressure: None

Section 4 - Fire and Explosion Hazard Data

Extinguishing Media: Carbon Dioxide, Dry Chemical Powder or Appropriate Foam.

Water may be used to keep exposed containers cool.

For large quantities involved in a fire, one should wear full protective clothing and a NIOSH approved self contained breathing apparatus with full face piece operated in the pressure demand or positive pressure mode as for a situation where lack of oxygen and excess heat are present.

Section 5 - Toxicological Information

Acute Effects: May be harmful by inhalation, ingestion, or skin absorption.

May cause irritation. To the best of our knowledge, the chemical, physical, and toxicological properties of the glycerol tripolylactate have not been investigated. Listed below are the toxicological information for glycerol and lactic acid.

RTECS#: MA8050000
Glycerol

Irritation data: SKN-RBT 500 MG/24H MLD 85JCAE-,207,1986
EYE-RBT 126 MG MLD BIOFX* 9-4/1970
EYE-RBT 500 MG/24H MLD 85JCAE-,207,1986
Toxicity data: ORL-MUS LD50:4090 MG/KG FRZKAP (6),56,1977
SCU-RBT LD50:100 MG/KG NIIRDN 6,215,1982
ORL-RAT LD50:12600 MG/KG FEPRA7 4,142,1945
IHL-RAT LC50: >570 MG/M3/1H BIOFX* 9-4/1970
IPR-RAT LD50: 4420 MG/KG RCOCB8 56,125,1987
IVN-RAT LD50:5566 MG/KG ARZNAD 26,1581,1976
IPR-MUS LD50: 8700 MG/KG ARZNAD 26,1579,1978
SCU-MUS LD50:91 MG/KG NIIRDN 6,215,1982
IVN-MUS LD50: 4250 MG/KG JAPMA8 39,583,1950
ORL-RBT LD50: 27 GM/KG DMDJAP 31,276,1959
SKN-RBT LD50:>10GM/KG BIOFX* 9-4/1970
IVN-RBT LD50: 53 GM/KG NIIRDN 6,215,1982
ORL-GPG LD50: 7750 MG/KG JIHTAB 23,259,1941

Target Organ data: Behavioral (headache), gastrointestinal (nausea or vomiting), Paternal effects (spermatogenesis, testes, epididymis, sperm duct), effects of fertility (male fertility index, postimplantation mortality).

RTECS#: OD2800000
Lactic acid

Irritation data: SKN-RBT 5MG/24H SEV 85JCAE -,656,86
EYE-RBT 750 UG SEV AJOPAA 29,1363,46
Toxicity data: ORL-RAT LD50:3543 MG/KG FMCHA2-,C252,91
SKN-RBT LD50:>2 GM/KG FMCHA2-,C252,91
ORL-MUS LD50: 4875 MG/KG FAONAU 40,144,67
ORL-GPG LD50: 1810 MG/KG JIHTAB 23,259,41
ORL-QAL LD50: >2250 MG/KG FMCHA2-,C252,91

Only selected registry of toxic effects of chemical substances (RTECS) data is presented here. See actual entry in RTECS for complete information on lactic acid and glycerol.

Section 6 - Health Hazard Data

Handling: Avoid continued contact with skin.
Avoid contact with eyes.
In any case of any exposure which elicits a response, a physician should be consulted immediately.

First Aid Procedures:

Inhalation: Remove to fresh air. If not breathing give artificial respiration. In case of labored breathing give oxygen. Call a physician.
Ingestion: No effects expected. Do not give anything to an unconscious person. Call a physician immediately.
Skin Contact: Flush with plenty of water. Contaminated clothing may be washed or dry cleaned normally.
Eye contact: Wash eyes with plenty of water for at least 15 minutes lifting both upper and lower lids. Call a physician.

Section 7 - Reactivity Data

Conditions to Avoid: Strong oxidizing agents, bases and acids
Hazardous Polymerization: None known
Further Information: Hydrolyses in water to form Lactic Acid and Glycerol.

Section 8 - Spill, Leak or Accident Procedures

After Spillage or Leakage: Neutralization is not required. This combustible material may be burned in a chemical incinerator equipped with an afterburner and scrubber.
Disposal: Laws and regulations for disposal vary widely by locality. Observe all applicable regulations and laws. This material, may be disposed of in solid waste.
Material is readily degradable and hydrolyses in several hours.
No requirement for a reportable quantity (CERCLA) of a spill is known.

Section 9 - Special Protection or Handling

Should be stored in plastic lined steel, plastic, glass, aluminum, stainless steel, or reinforced fiberglass containers.

Protective Gloves: Vinyl or Rubber
Eyes: Splash Goggles or Full Face Shield
Area should have approved means of washing eyes.
Ventilation: General exhaust.
Storage: Store in cool, dry, ventilated area.
Protect from imcompatible materials.

Section 10 - Other Information

This material will degrade in the environment by hydrolysis to lactic acid and glycerol.
Materials containing reactive chemicals should be used only by personnel with appropriate chemical training.

The information contained in this document is the best available to the supplier as of the time of writing. Some possible hazards have been determined by analogy to similar classes of material. No separate tests have been performed on the toxicity of this material. The items in this document are subject to change and clarification as more information becomes available.

LEARN MORE
Have a Regenesis Expert Answer Your Questions

SITE EVALUATION
Request a Free Evaluation of the Use of ORC, HRC or HRC-X at Your Site

Brochures:
HRC Brochure (PDF)

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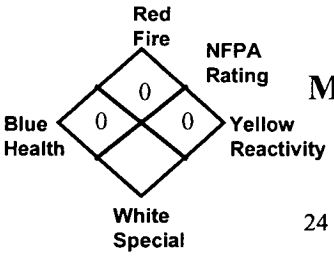

Liqui-Nox ®

MATERIAL SAFETY DATA SHEET

Alconox, Inc.
30 Glenn Street. Suite 309
White Plains, NY 10603
24 Hour Emergency Number – Chem-Tel (800) 255-3924

I. IDENTIFICATION

Product Name (as appears on label)	LIQUI-NOX
CAS Registry Number:	Not Applicable
Effective Date:	January 1, 1999
Chemical Family:	Anionic Liquid Detergent
Manufacturer Catalog Numbers for sizes	1232, 1201, 1215 and 1255

II. HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

There are no hazardous ingredients in LIQUI-NOX™ as defined by the OSHA Standard and Hazardous Substance List 29 CFR 1910 Subpart Z.

III. PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point (F):	214°F
Vapor Pressure (mm Hg):	No Data
Vapor Density (AIR=1):	No Data
Specific Gravity (Water=1):	1.075
Melting Point:	Not Applicable
Evaporation Rate (Butyl Acetate=1):	Slower
Solubility in Water:	Completely soluble in all proportions.
Appearance:	Yellow liquid, nearly odorless

IV. FIRE AND EXPLOSION DATA

Flash Point:	None (Cleveland Open Cup)
Flammable Limits:	LEL: No Data UEL: No Data
Extinguishing Media:	Water, dry chemical, CO_2, foam
Special Fire fighting Procedures:	Self-contained positive pressure breathing apparatus and protective clothing should be worn when fighting fires involving chemicals.
Unusual Fire and Explosion Hazards:	None

V. REACTIVITY DATA

Stability:	Stable
Conditions To Avoid:	None
Incompatibility (Materials To Avoid):	Oxidizing agents.
Hazardous Decomposition or Byproducts:	May release SO_2 on burning

VI. HEALTH HAZARD DATA

Route(s) of Entry:	Inhalation? No Skin? Yes Ingestion? Yes
Health Hazards (Acute and Chronic):	Skin contact may prove locally irritating, causing drying and/or chapping. Ingestion may cause discomfort and/or diarrhea.
Carcinogenicity:	NTP? No IARC Monographs? No OSHA Regulated? No
Signs and Symptoms of Exposure:	Prolonged skin contact may cause drying and/or chapping.
Medical Conditions Generally Aggravated by Exposure:	Not established. Unnecessary exposure to this product or any industrial chemical should be avoided.
Emergency and First Aid Procedures:	Eyes: Immediately flush eyes with water for at least 15 minutes. Call a physician. Skin: Flush with plenty of water. Ingestion: Drink large quantities of water or milk. Do not induce vomiting. If vomiting occurs administer fluids. See a physician for discomfort.

VII. PRECAUTIONS FOR SAFE HANDLING AND USE

Steps to be Taken if Material is Released or Spilled:	Material foams profusely. For small spills recover as much as possible with absorbent material and flush remainder to sewer. Material is biodegradable.
Waste Disposal Method:	Small quantities may be disposed of in sewer. Large quantities should be disposed of in accordance with local ordinances for detergent products.
Precautions to be Taken in Storing and Handling:	No special precautions in storing. Use protective equipment when handling undiluted material.
Other Precautions:	No special requirements other than the good industrial hygiene and safety practices employed with any industrial chemical.

VIII. CONTROL MEASURES

Respiratory Protection (Specify Type):	Not Required
Ventilation:	Local Exhaust-Normal Special-Not Required Mechanical-Not Required Other-Not Required
Protective Gloves:	Impervious gloves are recommended.
Eye Protection:	Goggles and/or splash shields are recommended.
Other Protective Clothing or Equipment:	Not required
Work/Hygienic Practices:	No special practices required

THE INFORMATION HEREIN IS GIVEN IN GOOD FAITH BUT NO WARRANTY IS EXPRESSED OR IMPLIED.

ISOBUTYLENE- MATERIAL SAFETY DATA SHEET

TABLE OF CONTENTS:

1. Chemical Product and Company Identification
2. Composition, Information on Ingredients
3. Hazards Identification
4. First Aid Measures
5. Fire Fighting Measures
6. Accidental Release Measures
7. Handling and Storage
8. Exposure Controls, Personal Protection
9. Physical and Chemical Properties
10. Stability and Reactivity
11. Toxicological Information
12. Ecological Information
13. Disposal Considerations
14. Transport Information
15. Regulatory Information
16. Other Information

24 Hour EMERGENCY CONTACT

U.S- CHEMTREC 1-800-424-9300
CANADA- ANUTEC 613-996-6666

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Up to Table of Contents

Matheson Tri-Gas, Inc.

The telephone numbers listed below are emergency numbers, please contact your local branch for routine inquiries.

USA
959 Route 46 East
Parsippany, New Jersey
07054-0624 USA
Phone: 973-257-1100

CANADA
530 Watson Street
Whitby, Ontario
L1N 5R9 Canada
Phone: 905-668-3570

SUBSTANCE: ISOBUTYLENE
SYMBOL: C_4H_8

TRADE NAMES/SYNONYMS:
2-METHYLPROPENE; ISOBUTYLENE; LIQUIFIED PETROLEUM GAS; 2-METHYL-1-PROPENE; L.P.G.; GAMMA-BUTYLENE; ASYM-DIMETHYL ETHYLENE; UN 1055; MAT11610; RTECS UD0890000

CHEMICAL FAMILY: hydrocarbons, aliphatic

CREATION DATE: Jan 24 1989
REVISION DATE: Mar 16 1999

2. COMPOSITION, INFORMATION ON INGREDIENTS

Up to Table of Contents

COMPONENT: ISOBUTENE

CAS NUMBER: 115-11-7

EC NUMBER (EINECS): 204-066-3

EC INDEX NUMBER: 601-012-00-4

PERCENTAGE: 100.0

3. HAZARDS IDENTIFICATION

Up to Table of Contents

NFPA RATINGS (SCALE 0-4): HEALTH=1 FIRE=4 REACTIVITY=0

WHMIS CLASSIFICATION: AB

EC CLASSIFICATION (ASSIGNED):
F+ Extremely Flammable

R 12

EC Classification may be inconsistent with independently-researched data.

EMERGENCY OVERVIEW:

Color: colorless

Physical Form: liquefied gas
Odor: petroleum odor

Major Health Hazards: central nervous system depression, difficulty breathing

Physical Hazards: Flammable gas. May cause flash fire.

POTENTIAL HEALTH EFFECTS:

INHALATION:
Short Term Exposure: irritation, nausea, vomiting, headache, symptoms of drunkenness, disorientation, tingling sensation, suffocation, convulsions, coma
Long Term Exposure: no information on significant adverse effects

SKIN CONTACT:
Short Term Exposure: irritation (possibly severe)
Long Term Exposure: no information is available

EYE CONTACT:
Short Term Exposure: irritation, blurred vision
Long Term Exposure: no information on significant adverse effects

INGESTION:
Short Term Exposure: frostbite
Long Term Exposure: no information is available

CARCINOGEN STATUS:
OSHA: N

NTP: N
IARC: N

4. FIRST AID MEASURES

Up to Table of Contents

INHALATION:
When safe to enter area, remove from exposure. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Keep warm and at rest. Get medical attention immediately.

SKIN CONTACT:
Wash if needed. If frostbite, freezing, or cryogenic burns occur, warm affected area in warm water. If this is not available, gently wrap affected parts in blankets. Allow circulation to return naturally. Get medical attention immediately.

EYE CONTACT:
Wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of chemical remains. Continue irrigating with normal saline until ready to transport to hospital. Cover with sterile bandages. Get medical attention immediately.

INGESTION:
If vomiting occurs, keep head lower than hips to help prevent aspiration. Get medical attention, if needed.

NOTE TO PHYSICIAN:
For inhalation, consider oxygen.

5. FIRE FIGHTING MEASURES

Up to Table of Contents

FIRE AND EXPLOSION HAZARDS:
Severe fire hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive above flash point.

EXTINGUISHING MEDIA:
carbon dioxide, regular dry chemical

Large fires: Flood with fine water spray.

FIRE FIGHTING:
Move container from fire area if it can be done without risk. Cool containers with water spray until well after the fire is out. Stay away from the ends of tanks. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Stop leak if possible without personal risk. Let burn unless leak can be stopped immediately. For smaller tanks or cylinders, extinguish and isolate from other flammables. Evacuation radius: 800 meters (1/2 mile). Do not attempt to extinguish fire unless flow of material can be stopped first. Flood with fine water spray. Cool containers with water spray until well after the fire is out. Apply water from a protected location or from a safe distance. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas. Evacuate if fire gets out of control or containers are directly exposed to fire. Evacuation radius: 500 meters (1/3 mile). Consider downwind evacuation if material is leaking. Stop flow of gas.

FLASH POINT:

-105 F (-76 C)

AUTOIGNITION:
869 F (465 C)

6. ACCIDENTAL RELEASE MEASURES

Up to Table of Contents

OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Do not touch spilled material. Stop leak if possible without personal risk. Reduce vapors with water spray. Keep unnecessary people away, isolate hazard area and deny entry. Remove sources of ignition. Ventilate closed spaces before entering.

7. HANDLING AND STORAGE

Up to Table of Contents

Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.106. Grounding and bonding required. Keep separated from incompatible substances.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

Up to Table of Contents

EXPOSURE LIMITS:

ISOBUTENE:
No occupational exposure limits established.

VENTILATION: Provide local exhaust ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: For the gas: Protective clothing is not required. For the liquid: Wear appropriate protective, cold insulating clothing.

GLOVES: Wear insulated gloves.

RESPIRATOR: Under conditions of frequent use or heavy exposure, respiratory protection may be needed. Respiratory protection is ranked in order from minimum to maximum. Consider warning properties before use.
Any supplied-air respirator with a full facepiece that is operated in a pressure-demand or other positive-pressure mode.
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus with a full facepiece.

9. PHYSICAL AND CHEMICAL PROPERTIES

Up to Table of Contents

PHYSICAL STATE: gas

COLOR: colorless

PHYSICAL FORM: liquefied gas

ODOR: petroleum odor

MOLECULAR WEIGHT: 56.12

MOLECULAR FORMULA: C4-H8

BOILING POINT: 19 F (-7 C)

FREEZING POINT: -220 F (-140 C)

VAPOR PRESSURE: 1.96 mmHg @ 20 C

VAPOR DENSITY (air=1): 1.9

SPECIFIC GRAVITY (water=1): 0.5879 @ 25 C

WATER SOLUBILITY: almost insoluble

PH: Not applicable

VOLATILITY: Not applicable

ODOR THRESHOLD: Not available

EVAPORATION RATE: Not applicable

COEFFICIENT OF WATER/OIL DISTRIBUTION: Not applicable

SOLVENT SOLUBILITY:
Soluble: organic solvents, alcohol, ether, sulfuric acid

10. STABILITY AND REACTIVITY

Up to Table of Contents

REACTIVITY:
Stable at normal temperatures and pressure.

CONDITIONS TO AVOID:
Avoid heat, flames, sparks and other sources of ignition. Minimize contact with material. Containers may rupture or explode if exposed to heat.

INCOMPATIBILITIES: oxidizing materials

HAZARDOUS DECOMPOSITION:
Thermal decomposition products: oxides of carbon

POLYMERIZATION:

Will not polymerize.

11. TOXICOLOGICAL INFORMATION

Up to Table of Contents

ISOBUTENE:

TOXICITY DATA:
620 gm/m3/4 hour(s) inhalation-rat LC50

ACUTE TOXICITY LEVEL:
Relatively Non-toxic: inhalation

TARGET ORGANS:
central nervous system

12. ECOLOGICAL INFORMATION

Up to Table of Contents

Not available.

13. DISPOSAL CONSIDERATIONS

Up to Table of Contents

Dispose in accordance with all applicable regulations. Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): D001.

14. TRANSPORT INFORMATION

Up to Table of Contents

U.S. DOT 49 CFR 172.101. SHIPPING NAME-UN NUMBER; HAZARD CLASS; PACKING GROUP; LABEL:
Isobutylene-UN1055; 2.1; Flammable gas

15. REGULATORY INFORMATION

Up to Table of Contents

U.S. REGULATIONS:
TSCA INVENTORY STATUS: Y

TSCA 12(b) EXPORT NOTIFICATION: Not listed

CERCLA SECTION 103 (40CFR302.4): N

SARA SECTION 302 (40CFR355.30): N

SARA SECTION 304 (40CFR355.40): N

SARA SECTION 313 (40CFR372.65): N

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40CFR370.21):
ACUTE: Y
CHRONIC: N
FIRE: Y
REACTIVE: N
SUDDEN RELEASE: Y

OSHA PROCESS SAFETY (29CFR1910.119): N

STATE REGULATIONS:
California Proposition 65: N

EUROPEAN REGULATIONS:

EC NUMBER (EINECS): 204-066-3

EC RISK AND SAFETY PHRASES:

R 12	Extremely flammable.
S 2	Keep out of reach of children.
S 9	Keep container in a well-ventilated place.
S 16	Keep away from sources of ignition - No smoking.
S 33	Take precautionary measures against static discharges.

16. OTHER INFORMATION

Up to Table of Contents

Matheson Tri-Gas makes no express or implied warranties, guarantees or representations regarding the product or the information herein, including but not limited to any implied warranty of merchantability or fitness for use. Matheson Tri-Gas shall not be liable for any personal injury, property or other damages of any nature, whether compensatory, consequential, exemplary, or otherwise, resulting from any publication, use or reliance upon the information herein.

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MATERIAL SAFETY DATA SHEET
EM SCIENCE

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Manufacturer.....:
EM SCIENCE
A Division of EM Industries
P.O. Box 70
480 Democrat Road
Gibbstown, N.J. 08027

Preparation Date.: 1/6/00

Information Phone Number.: 856-423-6300
Hours: Mon. to Fri. 8:30-5
Chemtrec Emergency Number: 800-424-9300
Hours: 24 hrs a day

Catalog Number(s):
PX1837A PX1837AG

Product Name:
Isopropyl Rubbing Alcohol
Synonyms:
Isopropyl Alcohol, 70%, USP
Chemical Family:
Aliphatic alcohol solution
Formula:
$CH_3CHOHCH_3$ in water
Molecular Weight.:
N/A

2. COMPOSITION / INFORMATION ON INGREDIENTS

Component	CAS #	Appr %
Isopropyl Alcohol	67-63-0	70%
Water	7732-18-5	30%

Approx. % as vol/vol

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
FLAMMABLE LIQUID AND VAPOR.
MAY CAUSE EYE INJURY.
HARMFUL IF INHALED OR SWALLOWED.

Appearance:
Clear, colorless liquid; characteristic odor

POTENTIAL HEALTH EFFECTS (ACUTE AND CHRONIC)

Symptoms of Exposure:
Effects of ingestion or inhalation: nausea, intoxication, central nervous system depression, headache, decreased

blood rate, coma. High vapor concentrations cause irritation of eyes and respiratory system. Contact may cause eye injury, skin irritation.

Medical Cond. Aggravated by Exposure:
Respiratory and skin conditions.

Routes of Entry:
Inhalation, ingestion or skin contact

Carcinogenicity:
The material is not listed (IARC, NTP, OSHA) as cancer causing agent.

4. FIRST AID MEASURES

Emergency First Aid:
GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE.
Skin: Wash thoroughly with soap and water.
Eyes: Immediately flush thoroughly with water for at least 15 minutes.
Inhalation: Remove to fresh air; give artificial respiration if breathing has stopped.
Ingestion: If conscious, drink water and induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person.

5. FIRE FIGHTING MEASURES

Flash Point (F): 53F (tcc) (for IPA)
Flammable Limits LEL (%): N/A
Flammable Limits UEL (%): N/A
Extinguishing Media:
Dry chemical, CO_2, "alcohol" foam.
Water spray to cool fire-exposed containers.

Fire Fighting Procedures:
Wear self-contained breathing apparatus.

Fire & Explosion Hazards:
Dangerous fire and explosive hazard. Vapor can travel distances to ignition source and flash back. Hot organic chemical vapors or mists are susceptible to sudden spontaneous combustion when mixed with air. Ignition may occur at temperatures below published autoingnition or ignition temperatures. Ignition temperatures decrease with increasing vapor volume and vapor/air contact time and are influenced by pressure changes. Ignition may occur at typical elevated temperature process conditions, especially in process operating under vacuum if subjected to sudden ingress of air, or outside process equipment operating under elevated pressure if sudden escape of vapors or mists to the atmosphere occurs. Exposure to air and/or direct sunlight may cause the formation of peroxides which may be explosive, especially during the distillation or evaporation of IPA mixtures.

6. ACCIDENTAL RELEASE MEASURES

Spill Response:

Evacuate the area of all unnecessary personnel. Wear suitable protective equipment listed under Exposure / Personal Protection. Eliminate any ignition sources until the area is determined to be free from explosion or fire hazards. Contain the release and eliminate its source, if this can be done without risk. Take up and containerize for proper disposal as described under Disposal. Comply with Federal, State, and local regulations on reporting releases. Refer to Regulatory Information for reportable quantity and other regulatory data.
EM SCIENCE recommends Spill-X absorbent agents for various types of spills. Additional information on the Spill-X products can be provided through the EM SCIENCE Technical Service Department (856) 423-6300. The following EM SCIENCE Spill-X absorbent is recommended for this product:

SX0863 Solvent Spill Treatment Kit

7. HANDLING AND STORAGE

Handling & Storage:
Keep container closed. Store in a cool area away from ignition sources and oxidizers. Do not breathe vapor. Do not get in eyes. Avoid prolonged, or repeated, skin contact. Electrically ground all equipment when handling this product. Check peroxide content before heating.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS AND PERSONAL PROTECTIVE EQUIPMENT:
Ventilation, Respiratory Protection, Protective Clothing, Eye Protection:
Respiratory Protection: If workplace exposure limit(s) of product or any component is exceeded (see TLV/PEL), a NIOSH/MSHA approved air supplied respirator is advised in absence of proper environmental control. OSHA regulations also permit other NIOSH/MSHA respirators (negative pressure type) under specified conditions (see your safety equipment supplier). Engineering and/or administrative controls should be implemented to reduce exposure. Material should be handled or transferred in an approved fume hood or with adequate ventilation. Protective gloves (Butyl Rubber, PVC or equivalent) should be worn to prevent skin contact. Safety glasses with side shields must be worn at all times.

Work/Hygenic Practices:
Wash thoroughly after handling. Do not take internally. Eye wash and safety equipment should be readily available.

EXPOSURE GUIDELINES

OSHA - PEL:

	TWA		STEL		CL		
Component	PPM	MG/M3	PPM	MG/M3	PPM	MG/M3	Skin
Isopropyl Alcohol	400	980	500	1225			
Water							

ACGIH - TLV:

	TWA		STEL		CL		
Component	PPM	MG/M3	PPM	MG/M3	PPM	MG/M3	Skin
Isopropyl Alcohol	400	983	500	1230			
Water							

If there are no exposure limit numbers listed in the Exposure Guidelines chart, this indicates that no OSHA or

ACGIH exposure limts have been established.

9. PHYSICAL AND CHEMCIAL PROPERTIES

Boiling Point (C 760 mmHg) : N/A
Melting Point (C) : N/A
Specific Gravity (H_20 = 1) : N/A
Vapor Pressure (mm Hg) : N/A
Percent Volatile by vol (%): N/A
Vapor Density (Air = 1) : N/A
Evaporation Rate (BuAc = 1): N/A
Solubility in Water (%) : Miscible
Appearance :
Clear, colorless liquid; characteristic odor

10. STABILITY AND REACTIVITY

Stability: Yes

Hazardous Polymerization:
Does not occur

Hazardous Decomposition:
CO_x

Conditions to Avoid:
Heat; contact with ignition sources. Exposure to air and/or direct sunlight.

Materials To Avoid:

```
( ) Water
(X) Acids
( ) Bases
( ) Corrosives
(X) Oxidizers
(X) Other: Halogens and halogen compounds; aldehydes,
hydrogen-palladium  combination, chlorine, ethylene
oxide, isocyanates
```

11. TOXICOLOGICAL INFORMATION

Toxicity Data
None established

Toxicological Findings:
None
Cited in Registry of Toxic Effects of Chemical Substances (RTECS)

12. DISPOSAL CONSIDERATIONS

EPA Waste Numbers: D001

Treatment:
Incineration, fuels blending or recycle. Contact your local permitted waste disposal site (TSD) for permissible treatment sites.
ALWAYS CONTACT A PERMITTED WASTE DISPOSER (TSD) TO ASSURE COMPLIANCE WITH ALL CURRENT LOCAL, STATE AND FEDERAL REGULATIONS.

13. TRANSPORT INFORMATION

DOT Proper Shipping Name:
Isopropyl Alcohol Solution

DOT ID Number :
UN1219

14. REGULATORY INFORMATION

TSCA Statement:
This product is a "Mixture". The CAS numbers of all components are listed on the TSCA Inventory.

Component	SARA EHS (302)	SARA EHS TPQ (lbs)	CERCLA RQ (lbs)
Isopropyl Alcohol			
Water			

Component	OSHA Floor List	SARA 313	DeMinimis for SARA 313 (%)
Isopropyl Alcohol	Y	Y	0.1
Water			

If there is no information listed on the regulatory information chart, this indicates that the chemical is not covered by the specific regulation listed.

15. OTHER INFORMATION

Comments:
None

NFPA Hazard Ratings:
Health : 1
Flammability : 3
Reactivity : 0
Special Hazards :

Revision History: 4/8/98 5/26/98 9/9/99

| = Revised Section

N/A = Not Available

N/E = None Established

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Material Safety Data Sheet

Revision Issued: 4/13/2000 Supercedes: 6/09/98 First Issued: 12/01/85

Section I - Chemical Product And Company Identification

Product Name: Nitric Acid

CAS Number: 7697-37-2 HBCC MSDS No. CN03300

HILL BROTHERS Chemical Co.

1675 NORTH MAIN STREET • ORANGE, CALIFORNIA 92867-3499
(714) 998-8800 • FAX: (714) 998-6310
http://hillbrothers.com

1675 No. Main Street, Orange, California 92867
Telephone No: 714-998-8800 | Outside Calif: 800-821-7234 | Chemtrec: 800-424-9300

Section II - Composition/Information On Ingredients

			Exposure Limits (TWAs) in Air		
Chemical Name	CAS Number	%	ACGIH TLV	OSHA PEL	STEL
Nitric Acid	7697-37-2	30-71	2 ppm	2 ppm	4 ppm

Section III - Hazard Identification

Routes of Exposure: Nitric acid can affect the body if it is inhaled or swallowed, or if it comes in contact with the eyes or skin.

Summary of Acute Health Hazards

Ingestion: Can cause irritation and severe corrosive burns to mouth, throat, and stomach, and may be fatal if swallowed.

Inhalation: Gases or acid mist can cause severe irritation or corrosive burns to the upper respiratory system, including nose, mouth, and throat. Lung irritation, nitrogen oxide poisoning, and pulmonary edema can also occur. May cause severe breathing difficulties which may be delayed in onset.

Skin: Can cause severe corrosive burns or irritation. May stain the skin bright yellow.

Eyes: Can cause irritation, corneal burns, conjunctivitis, and may cause blindness. Contact lenses should not be worn when working with this material.

Summary of Chronic Health Hazards: N/A

Effects of Overexposure: Possible acute pulmonary edema, chronic obstructive pulmonary disease, or chronic bronchitis from inhalation. The vapor and mist may erode the exposed teeth. On the skin or through ingestion, the liquid may cause pain and severe and penetrating burns. In contact with the eyes, the liquid produces severe burns which may lead to visual impairment or blindness.

Medical Conditions Generally Aggravated by Exposure: Skin disorders and respiratory (asthma-like) disorders.

Note to Physicians: Nitric Acid vapors contain nitrogen oxides. Acute overexposure by inh alation can result in delayed pulmonary edema. Observe affected patients for delayed effects up to 48 hours after exposure. Screen patients with chest x-ray, arterial blood gas, methemoglobinemia level, and pulmonary function tests. Bronchiolitis obliterans may develop weeks after exposure.

Section IV - First Aid Measures

Ingestion: DO NOT INDUCE VOMITING. Drink large amounts of water to dilute acid. GET PROMPT MEDICAL ATTENTION.

Inhalation: If inhaled, will cause difficult breathing or loss of consciousness. Move to fresh air. If breathing has stopped, give artificial respiration. If breathing is difficult, give oxygen. GET PROMPT MEDICAL ATTENTION.

Skin: Promptly flush with plenty of soap and water for at least 15 minutes. Remove contaminated clothing. Wash clothing before reuse. GET PROMPT MEDICAL ATTENTION.

Eyes: Wash eyes immediately with large amounts of water, for at least 30 minutes, lifting the lower and upper lids. Contact lenses should not be worn when working with this material. Do not allow victim to rub or keep eyes closed. GET PROMPT MEDICAL ATTENTION.

Section V - Fire Fighting Measures

Flash Point: Not Flammable

Autoignition Temperature: N/A

Lower Explosive Limit: N/A

Upper Explosive Limit: N/A

Unusual Fire and Explosion Hazards: Will accelerate the burning of combustible materials and can cause ignition by contact with combustible materials. Contact with common materials may generate hydrogen gas, which can form flammable mixtures with air.

Extinguishing Media: Use water in flooding quantities as fog on adjacent fires.

Special Firefighting Procedures: Water spray may be useful in minimizing or dispersing vapors and cooling equipment exposed to heat and flame. In danger area, wear bunker gear and self-contained breathing apparatus for fires beyond the incipient range (29CFR 1910.156)

Section VI - Accidental Release Measures

Spills may need to be reported to the National Response Center (800/424-8802) DOT Reportable Quantity (RQ) is 1000 pounds Adequate ventilation is required to eliminate any nitrogen oxides released and, if soda ash or limestone is used, CO_2. Stay upwind and away from spill. Keep all ignition sources and hot metal surfaces away from spill/release. Keep material out of water sources and sewers. Build dikes using inert material (i.e. dry sand or earth) to contain flow as necessary. Dilute spills or leaks with plenty of water. Neutralize residue with sodium bicarbonate, then place into a chemical waste container. A vapor suppressing foam may be used to reduce vapors.

Section VII - Handling and Storage

Avoid inhalation of vapors or mists and all bodily contact. Keep away from incompatible substances. Store in a cool, well-ventilated, properly drained area out of the sun. Avoid storage on wood floors or near wooden walls, etc. Diking of storage tanks if recommended. Protect from physical damage. Keep containers tightly closed. Do not get in eyes, on skin, or on clothing. Remove contaminated clothing and wash before reuse.

Section VIII - Exposure Controls/Personal Protection

Respiratory Protection: Only respirators approved by MSHA or NIOSSH are permissible. Only non-oxidizable sorbents are allowed. A chemical cartridge respirator is not recommennded due to the potential for exposure limits being exceeded prior to odor breakthrough. See SUPPLEMENTAL INFORMATION section.

Respirator Selection

100 ppm or less (250 mg/m^3 or less): GMOVS/SAF/SCBAF/SA:PD,PP,CF

100 ppm or greater (250 mg/m^3 or greater), or entry and escape from unknown concentrations: GMS/SCBA

Ventilation: Ventilation sufficient to reduce mists and nitrogen oxide concentrations below permissible TLV levels. Mechanical exhaust systems or closed ventilated systems may be required. Always keep the nitric acid vapor concentration levels below 2 ppm (5 mg/m^3).

Protective Clothing: Impervious clothing should be used to prevent any possibility of physical contact with liquid nitric acid. Clothing may include a rubber acid suit, hood, boots and gloves, and an air mask and chemical goggles.

Eye Protection: Splash-proof safety goggles should be used if the possibility of liquid nitric acid contacting the eyes exists. Do not wear contact lenses. Eight-inch minimum face sheilds should be used.

Other Protective Clothing or Equipment: N/A

Work/Hygienic Practices: Facilities for quick drenching of the body, in addition to an eye-wash fountain, should be provided within the immediate work area for emergency use. Employees who handle nitric acid should wash their hands before eating, smoking, or using toilet facilities.

Section IX - Physical and Chemical Properties

Physical State: Liquid

pH: 1-2

% Acid in Solution:	30	40	56-71

Melting Point/Range:	-42°C@68%	-44°F	31°F

Appearance/Color/Odor: Watery liquid, colorless, yellow, or red fuming liquid with a suffocating, acrid odor.
Solubility in Water: 100% **Molecular Weight:** 63 (solute)

% Acid in Solution	30	40	56-71
Vapor Pressure(mmHg)	5-10	<3@70°F	2.9@68°F

% Acid in Solution	30	40	56-71
Specific Gravity(Water=1)	1.18-1.19	1.2-1.41	1.41

% Acid in Solution	30	40	56-71
Vapor Density(Air=1)	> 1	< 3	1.5-1.7

% Acid in Solution	30	40	56-71
Weight/Gallon (Lbs.)	9.8-9.9	10-11	11.7

Evaporation Rate (N-Butyl Acetate=1): < 1 **% Volatiles:** 100% (by volume)
Boiling Point/Range: 244-251°F @ 68% **How to detect this compound :** N/A

Section X - Stability and Reactivity

Stability: Stable **Hazardous Polymerization:** N/A
Conditions to Avoid: Avoid exposure to direct sunlight.
Materials to Avoid: Most metals, metallic powders, alcohol, charcoal, turpentine, hydrogen sulfide, wood excelsior, paper, cotton and similar organic materials. Alkalies, carbon, carbonates, cyanides, diborane organic chemicals, fluorine, phosphine, sulfides, thiocyanates. Nitric Acid is corrosive or incompatible with many common materials including mild steel, PVC, viton, and rubber.
Hazardous Decomposition Products: Toxic gases and vapors such as Nitrogen Oxides.

Section XI - Toxicological Information

Nitric acid vapor or mist is an irritant of the eyes, mucous membranes, and skin. When nitric acid is exposed to air or comes in contact with organic matter, it decomposes to yield a mixture of toxic oxides of nitrogen, including nitric oxide and nitrogen dioxide. Exposure to high concentrations of nitric acid vapor or mist causes pneumonitis and pulmonary edema which may be fatal; onset of symptoms may be delayed for 4 to 30 hours. In contact with the eyes, the liquid produces severe burns which may result in permanent damage and visual impairment. On the skin, the liquid or concentrated vapor produces immediate, severe and penetrating burns; concentrated solutions cause deep ulcers and stain the skin a bright yellow or yellowish brown color. The vapor and mist may erode the exposed teeth. Ingestion of the liquid will cause immediate pain and burns of the mouth, esophagus, and gastrointestinal tract.

Section XII - Ecological Information

N/A

Section XIII - Disposal Considerations

Nitric acid may be disposed of by neutralizing with water and alkaline material (such as soda ash, lime, etc.) and disposing in a secured sanitary landfill. Disposal of nitric acid may be subject to federal, state, and local regulations. Users of this product should review their operations in terms of applicable federal, state, and local laws and regulations, then consult with the appropriate regulatory agencies before discharging or disposing of waste material.

Section XIV - Transport Information

DOT Proper Shipping Name: NITRIC ACID
DOT Hazard Class/ I.D. No.: 8, UN2031, II

Section XV - Regulatory Information

Reportable Quantity: 1000 Pounds (454 Kilograms) (85 Gals.)
NFPA Rating: Health - 3; Fire - 0; Reactivity - 0; Other - (Oxidizer)
0=Insignificant 1=Slight 2=Moderate 3=High 4=Extreme
Carcinogenicity Lists: No **NTP:** No **IARC Monograph:** No **OSHA Regulated:** Yes
Section 313 Supplier Notification: This product contains the following toxic chemcial(s) subject to the reporting requirements of SARA TITLE III Section 313 of the Emergency Planning and Community Right-To Know Act of 1986 and of 40 CFR 372:

CAS #	Chemical Name	% By Weight
7697-37-2	Nitric Acid	30-71%

Section XVI - Other Information

Synonyms/Common Names: Aqua Fortis; Hydrogen Nitrate; HNO3
Chemical Family/Type: Inorganic acid
Sections changed since last revision: II, IX, XV
IMPORTANT! Read this MSDS before use or disposal of this product. Pass along the information to employees and any other persons who could be exposed to the product to be sure that they are aware of the information before use or other exposure. This MSDS has been prepared according to the OSHA Hazard Communication Standard [29 CFR 1910.1200]. The MSDS information is based on sources believed to be reliable. However, since data, safety standards, and government regulations are subject to change and the conditions of handling and use, or misuse are beyond our control, **Hill Brothers Chemical Company** makes no warranty, either expressed or implied, with respect to the completeness or continuing accuracy of the information contained herein and disclaims all liability for reliance thereon. Also, additional information may be necessary or helpful for specific conditions and circumstances of use. It is the user's responsibility to determine the suitability of this product and to evaluate risks prior to use, and then to exercise appropriate precautions for protection of employees and others.

http://hillbrothers.com/index.htmlhttp://hillbrothers.com/index.html

MATERIAL SAFETY DATA SHEET
EM SCIENCE

|1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Manufacturer.....:
EM SCIENCE
A Division of EM Industries
P.O. Box 70
480 Democrat Road
Gibbstown, N.J. 08027

Preparation Date.: 7/21/00

Information Phone Number.: 856-423-6300
Hours: Mon. to Fri. 8:30-5
Chemtrec Emergency Number: 800-424-9300
Hours: 24 hrs a day

Catalog Number(s):
HX0603 HX0603I HX0603P HX0603Y 314 315 317 321
HX0603T HX0603TP HX0606 HX0603PS 0003147W 00031487
HX0607 ACS393

Product Name:
Hydrochloric Acid
Synonyms:
Muriatic Acid, 23 deg. Be
Chemical Family:
Inorganic Acid
Formula:
HCl
Molecular Weight.:
36.46

2. COMPOSITION / INFORMATION ON INGREDIENTS

Component	CAS #	Appr %
Hydrochloric Acid	7647-01-0	100%

Approximate per cent indicates that this product is a concentrated acid. Hydrochloric acid is approximately 37%.

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW
CAUSES SEVERE BURNS.
MAY BE FATAL IF INHALED OR SWALLOWED.
VAPOR EXTREMELY IRRITATING.
May Cause Damage To Respiratory Passages and Lungs.

Appearance:
Clear, colorless liquid; acrid odor

POTENTIAL HEALTH EFFECTS (ACUTE AND CHRONIC)

Symptoms of Exposure:
Eye contact causes severe burns and permanent eye damage. Skin contact causes severe burns, possible deep ulceration. Inhalation causes damage to nasal and respiratory passages, pulmonary edema. Ingestion causes burns of mouth, throat and gastrointestinal tract.

Medical Cond. Aggravated by Exposure:
Respiratory conditions

Routes of Entry:
Inhalation, ingestion or skin contact.

Carcinogenicity:
The material is not listed (IARC, NTP, OSHA) as cancer causing agent.

4. FIRST AID MEASURES

Emergency First Aid:
GET MEDICAL ASSISTANCE FOR ALL CASES OF OVEREXPOSURE.
Skin: Immediately flush thoroughly with large amounts of water.
Eyes: Immediately flush thoroughly with water for at least 15 minutes.
Inhalation: Remove to fresh air; give artificial respiration if breathing has stopped.
Ingestion: do not induce vomiting; give water or milk if conscious; get medical attention.

5. FIRE FIGHTING MEASURES

Flash Point (F): Noncombustible
Flammable Limits LEL (%): N/A
Flammable Limits UEL (%): N/A
Extinguishing Media:
Water spray

Fire Fighting Procedures:
Wear self-contained breathing apparatus and protective clothing.

Fire & Explosion Hazards:
Contact with metals produces hydrogen which may form explosive mixtures with air.

6. ACCIDENTAL RELEASE MEASURES

Spill Response:
Evacuate the area of all unnecessary personnel. Wear suitable protective equipment listed under Exposure / Personal Protection. Eliminate any ignition sources until the area is determined to be free from explosion or fire hazards. Contain the release and eliminate its source, if this can be done without risk. Take up and containerize for proper disposal as described under Disposal. Comply with Federal, State, and local regulations on reporting releases. Refer to Regulatory Information for reportable quantity and other regulatory data.
EM SCIENCE recommends SPILL-X neutralizers and absorbent agents for various types of spills. Additional

information on the SPILL-X products can be provided through the EM SCIENCE Technical Service Department (856) 423-6300. The following EM SCIENCE SPILL-X neutralizer and absorbent is recommended for this product:

SX0861 Spill-X-A Acid Spill Treatment Kit

7. HANDLING AND STORAGE

Handling & Storage:
Keep container tightly closed. Store in a cool, well-ventilated area separated from incompatible materials. Do not breathe vapor. Do not get in eyes, on skin, or on clothing. Handle empty containers with caution. Add acid cautiously to water when diluting - never add water to acid.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

ENGINEERING CONTROLS AND PERSONAL PROTECTIVE EQUIPMENT:
Ventilation, Respiratory Protection, Protective Clothing, Eye Protection:
Respiratory Protection: If workplace exposure limit(s) of product or any component is exceeded (see TLV/PEL), a NIOSH/MSHA approved air supplied respirator is advised in absence of proper environmental control. OSHA regulations also permit other NIOSH/MSHA respirators (negative pressure type) under specified conditions (see your safety equipment supplier). Engineering and/or administrative controls should be implemented to reduce exposure. Material must be handled or transferred in an approved fume hood or with equivalent ventilation. Protective gloves (Neoprene, Nitrile or equivalent) must be worn to prevent skin contact. Safety glasses with side shields must be worn at all times.

Work/Hygenic Practices:
Wash thoroughly after handling. Do not take internally. Eye wash and safety equipment should be readily available.

EXPOSURE GUIDELINES

OSHA - PEL:

	TWA		STEL		CL		
Component	PPM	MG/M3	PPM	MG/M3	PPM	MG/M3	Skin
Hydrochloric Acid							
					5	7	

ACGIH - TLV:

	TWA		STEL		CL		
Component	PPM	MG/M3	PPM	MG/M3	PPM	MG/M3	Skin
Hydrochloric Acid							
			5	7.5	5	7.5	

If there are no exposure limit numbers listed in the Exposure Guidelines chart, this indicates that no OSHA or ACGIH exposure limts have been established.

9. PHYSICAL AND CHEMCIAL PROPERTIES

Boiling Point (C 760 mmHg) : 110C 20.24%
Melting Point (C) : -74C
Specific Gravity (H_20 = 1) : 1.1885
Vapor Pressure (mm Hg) : 160 20C
Percent Volatile by vol (%): 99.9+%

Vapor Density (Air = 1) : 1.25
Evaporation Rate (BuAc = 1): 2.0
Solubility in Water (%) : Miscible
Appearance :
Clear, colorless liquid; acrid odor

10. STABILITY AND REACTIVITY

Stability: Yes

Hazardous Polymerization:
Does not occur

Hazardous Decomposition:
Toxic hydrogen chloride gas

Conditions to Avoid:
Heat; contact with metals.

Materials To Avoid:

```
( ) Water
( ) Acids
(X) Bases
( ) Corrosives
( ) Oxidizers
(X) Other: Alkalies and amines; contact with metals
produces hydrogen
```

11. TOXICOLOGICAL INFORMATION

Toxicity Data

```
ihl-hmn LDLo: 1300 ppm/30M
orl-rbt LD50: 900 mg/kg
```

Toxicological Findings:
Test on laboratory animals indicate material may produce adverse
mutagenic and reproductive effects.
Cited in Registry of Toxic Effects of Chemical Substances (RTECS)

12. DISPOSAL CONSIDERATIONS

EPA Waste Numbers: D002

Treatment:
Specified Technology - Neutralize to pH 6-9. Contact your local permitted waste disposal site (TSD) for permissible treatment sites.
ALWAYS CONTACT A PERMITTED WASTE DISPOSER (TSD) TO ASSURE COMPLIANCE WITH ALL CURRENT LOCAL, STATE AND FEDERAL REGULATIONS.

13. TRANSPORT INFORMATION

DOT Proper Shipping Name:
Hydrochloric Acid

DOT ID Number :
UN1789

14. REGULATORY INFORMATION

TSCA Statement:
This product is a "Mixture". The CAS numbers of all components are listed on the TSCA Inventory.

Component	SARA EHS (302)	SARA EHS TPQ (lbs)	CERCLA RQ (lbs)
Hydrochloric Acid	Y	500	5000

Component	OSHA Floor List	SARA 313	DeMinimis for SARA 313 (%)
Hydrochloric Acid	Y	Y	1.0

If there is no information listed on the regulatory information chart, this indicates that the chemical is not covered by the specific regulation listed.

15. OTHER INFORMATION

Comments:
None

NFPA Hazard Ratings:
Health : 3
Flammability : 0
Reactivity : 0
Special Hazards :

Revision History: 11/1/83 3/1/84 11/1/84 12/8/86 10/27/87 2/20/90 3/1/91 11/26/91 12/8/92 4/27/93 3/3/94 3/9/95 1/31/97 3/18/97 8/27/98
| = Revised Section

N/A = Not Available

N/E = None Established

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PERKIN-ELMER -- METHANOL - METHANOL SOLVENT BASE
MATERIAL SAFETY DATA SHEET
NSN: 681000N041199
Manufacturer's CAGE: 46555
Part No. Indicator: A
Part Number/Trade Name: METHANOL

==========

General Information

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Item Name: METHANOL SOLVENT BASE
Company's Name: PERKIN-ELMER CORP
Company's Street: 761 MAIN AVE
Company's City: NORWALK
Company's State: CT
Company's Country: US
Company's Zip Code: 06859
Company's Emerg Ph #: 203-762-4464
Company's Info Ph #: 203-762-1000
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SMJ
Date MSDS Prepared: 02APR92
Safety Data Review Date: 12APR93
MSDS Serial Number: BSGBC
Hazard Characteristic Code: NK

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Ingredients/Identity Information

==========

Proprietary: NO
Ingredient: METHANOL; (METHYL ALCOHOL)
Ingredient Sequence Number: 01
NIOSH (RTECS) Number: PC1400000
CAS Number: 67-56-1
OSHA PEL: 200PPM;250PPM STEL,S
ACGIH TLV: 200PPM;250PPM STEL,S

Proprietary: NO
Ingredient: SUPDAT:STRONG OXIDIZING AGENTS, SULFURIC ACID. MAY REACT W/ ALUMINUM TO GEN FLAMM HYDROGEN GAS. ATTACKS VARIOUS (ING 3)
Ingredient Sequence Number: 02
NIOSH (RTECS) Number: 9999999ZZ
OSHA PEL: NOT APPLICABLE
ACGIH TLV: NOT APPLICABLE

Proprietary: NO
Ingredient: ING 2:RUBBER, PLASTIC & COATING FORMULATIONS.
Ingredient Sequence Number: 03
NIOSH (RTECS) Number: 9999999ZZ
OSHA PEL: NOT APPLICABLE
ACGIH TLV: NOT APPLICABLE

Proprietary: NO
Ingredient: EFTS OF OVEREXP:LIVER ENLARGEMENT, VISUAL IMPAIRMENT & BLINDNESS CAN OCCUR.
Ingredient Sequence Number: 04
NIOSH (RTECS) Number: 9999999ZZ

OSHA PEL: NOT APPLICABLE
ACGIH TLV: NOT APPLICABLE

Proprietary: NO
Ingredient: FIRST AID PROC:15 MINUTES, OCCASIONALLY LIFTING UPPER & LOWER EYELIDS. IF IRRIT CONTINUES, GET MED ATTN IMMED.
Ingredient Sequence Number: 05
NIOSH (RTECS) Number: 9999999ZZ
OSHA PEL: NOT APPLICABLE
ACGIH TLV: NOT APPLICABLE

Physical/Chemical Characteristics

Appearance And Odor: CLEAR LIQUID; SLIGHT ALCOHOL ODOR.
Boiling Point: 147F,64C
Melting Point: N/A
Vapor Pressure (MM Hg/70 F): 100 @21.2C
Vapor Density (Air=1): 1.1
Specific Gravity: 0.8 (H*2O=1)
Evaporation Rate And Ref: 4.6 (BUTYL ACETATE=1)
Solubility In Water: SOLUBLE

Fire and Explosion Hazard Data

Flash Point: 51.8F,11C
Lower Explosive Limit: 6%
Upper Explosive Limit: 36%
Extinguishing Media: DRY CHEMICAL, FOAM OR CARBON DIOXIDE (CO*2).
Special Fire Fighting Proc: WEAR NIOSH/MSHA APPRVD SCBA & FULL PROT EQUIP (FP N). EVACUATE ALL PERS NOT ENGAGED IN FIRE FIGHTING. WATER FOG MAY BE USED TO COOL EXPOSED EQUIP & (SUPDAT)
Unusual Fire And Expl Hazrds: HIGHLY FLAMMABLE VAPORS, WHICH ARE HEAVIER THAN AIR, CAN ACCUMULATE IN LOW AREAS & SPREAD ALONG GROUND OR FLOOR TO POINTS AWAY FROM SITE OF LIQUID.

Reactivity Data

Stability: YES
Cond To Avoid (Stability): AVOID POTENTIAL IGNITION SOURCES SUCH AS OPEN FLAMES, ELECTRIC ARCS, HOT SURFACES & SOURCES OF SPARKS.
Materials To Avoid: EXTREMELY VIOLENT/EXPLO RXNS HAVE BEEN REPORTED TO OCCUR WHEN MATL IS ALLOWED TO COME INTO CONT W/FOLLOWING (SUPDAT)
Hazardous Decomp Products: CARBON MONOXIDE & FORMALDEHYDE MAY BE LIBERATED WHEN HEATED TO DECOMPOSITION.
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT

Health Hazard Data

LD50-LC50 Mixture: NONE SPECIFIED BY MANUFACTURER.
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: YES
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: ACUTE:INHAL:EXPOS TO METHANOL AT CONCS ABOVE TLV/SHORT TERM EXPOS LIM CAN PRDCE IRRIT OF MUC MEMBS, NAUS, VOMIT, NARCOSIS, HDCH & DEPRESS OF CNS. METHANOL ATTACKS OPTIC NERVE, PRDCG

BLURRED VISION & BLINDNESS. CAN CAUSE DEATH. METHANOL IS ELIM VERY SLOWLY FROM BODY & CAN THUS BE CONSIDERED TO BE (EFTS OF OVEREXP)
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NOT RELEVANT
Signs/Symptoms Of Overexp: HLTH HAZ:CUMULATIVE POISON. INGEST:POIS BY INGEST. SYMPS ARE SIM TO INHAL. CAN CAUSE DEATH. SKIN:CAN BE ABSORBED THRU UNBROKEN SKIN. SYMPS ARE SIM TO INHAL. IRRIT. MAY CAUSE DRYNESS, REDDENING & CRACKING BY REMOVING NATURAL OILS. EYE:IRRIT. CHRONIC:PRLNG/RPTD OVEREXP TO METHANOL CAN RSLT IN CUMULATIVE POIS. (ING 4)
Med Cond Aggravated By Exp: CONSULT MD PRIOR TO ASSIGNING WORKERS W/ RESPIRATORY, SKIN, OCULAR OR CNS DISORDERS TO TASKS REQUIRING THE USE OF METHANOL.
Emergency/First Aid Proc: INHAL:MOVE PERSON TO FRESH AIR. ADMIN OXYGEN IF PERSON EXPERS DFCLTY IN BRTHG. INGEST:IMMED INDUCE VOMIT BY ADMIN 2 GLASSES OF WATER & STICKING FINGER DOWN VICTIM'S THROAT. NEVER ADMIN ANYTHING BY MOUTH TO UNCON PERSON. IMMED CONT LOCL POIS CTL CTR. SKIN: REMOVE CONTAM CLTHG, THEN FLUSH W/WATER FOR AT LST 15 MINS. WASH CLTHG THORO, & SEPARATELY, BEFORE RE-USE. EYE:FLUSH W/WATER FOR AT LST (ING 5)

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: ELIMINATE POTENTIAL SOURCES OF IGNITION. BLOCK ENTRY TO SEWERS, STREAMS, RIVERS & BODIES OF WATER. ABSORB W/DRY INERT MATERIAL. TRANSFER TO DISPOSAL DRUMS USING NON-SPARKING TOOLS & EQUIPMENT.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: COMPLY W/ALL FEDERAL, STATE & LOCAL REGULATIONS.
Precautions-Handling/Storing: STORE IN A COOL, DRY WELL-VENTILATED AREA, AWAY FROM POTENTIAL SOURCES OF IGNITION. KEEP SEPARATED FROM INCOMPATIBLE MATERIALS.
Other Precautions: AVOID INHALATION, INGESTION & CONTACT W/EYES & SKIN. KEEP CONTAINER TIGHTLY SEALED WHEN NOT IN USE.

Control Measures

Respiratory Protection: WEAR NIOSH/MSHA APPROVED RESPIRATOR.
Ventilation: LABORATORY HOOD OR LOCAL EXHAUST.
Protective Gloves: CHEMICAL RESISTANT GLOVES.
Eye Protection: CHEM RESIS GOGG & FACESHIELD.
Other Protective Equipment: CHEMICAL RESISTANT CLOTHING. EMERGENCY EYE WASH & DELUGE SHOWER (FP N).
Work Hygienic Practices: WASH THOROUGHLY AFTER USE.
Suppl. Safety & Health Data: FIRE FIGHT PROC:CNTNRS. WATER SPRAYED DIRECTLY ON FIRE WILL CAUSE BURNING LIQ TO FLOAT & FIRE TO SPREAD. MATLS TO AVOID:MATLS:CHROMIC ANHYDRIDE, IODINE + ETHANOL + MERCURIC OXIDE, LEAD PERCHLORATE, NITRATES, PERCHLORIC ACID, PHOSPHOROUS TRIOXIDE, POTASSIUM HYDROXIDE + CHLOROFORM, SODIUM HYDROXIDE + CHLOROFORM,(ING 2)

Transportation Data

Disposal Data

Label Data

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Label Required: YES
Technical Review Date: 12APR93
Label Date: 07APR93
Label Status: G
Common Name: METHANOL
Chronic Hazard: YES
Signal Word: DANGER!
Acute Health Hazard-Slight: X
Contact Hazard-Slight: X
Fire Hazard-Severe: X
Reactivity Hazard-None: X
Special Hazard Precautions: FLAMM LIQ! POISON! STORE IN A COOL, DRY, WELL-VENTED AREA, AWAY FROM POTNTL SOURCES OF IGNIT. AVOID INHAL, INGEST & CONTACT W/EYES & SKIN. ACUTE:INHAL:IRRIT OF MUC MEMBS, NAUS, VOMIT, NARCOSIS, HDCH & DEPRESS OF CNS. METHANOL ATTACKS OPTIC NERVE, PRODUCING BLURRED VISION & BLINDNESS. CAN CAUSE DEATH. METHANOL IS CONSIDERED TO BE A CUMULATIVE POISON. INGEST:POIS SYMPS ARE SIM TO INHAL. CAN CAUSE DEATH. SKIN:CAN BE ABSORBED. SYMPTOMS SIM TO INHAL. IRRIT, DRYNESS, REDDENING & CRACKING. EYE:IRRIT. CHRONIC:PRLNG/RPTD OVEREXP TO METHANOL CAN RESULT IN CUMULATIVE POIS. LIVER ENLARGEMENT, VISUAL IMPAIRMENT & BLINDNESS CAN OCCUR.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: PERKIN-ELMER CORP
Label Street: 761 MAIN AVE
Label City: NORWALK
Label State: CT
Label Zip Code: 06859
Label Country: US
Label Emergency Number: 203-762-4464

WARD'S NATURAL SCIENCE ESTABLISHMENT -- SODIUM BISULFATE - SODIUM BISULFATE
MATERIAL SAFETY DATA SHEET
NSN: 681000D003523
Manufacturer's CAGE: 63759
Part No. Indicator: A
Part Number/Trade Name: SODIUM BISULFATE

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General Information

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Item Name: SODIUM BISULFATE
Company's Name: WARD'S NATURAL SCIENCE ESTABLISHMENT INC.
Company's P. O. Box: 92912
Company's City: ROCHESTER
Company's State: NY
Company's Country: US
Company's Zip Code: 14692-9012
Company's Emerg Ph #: 716-226-6177/334-4222/800-424-9300
Company's Info Ph #: 716-359-2502
Record No. For Safety Entry: 001
Tot Safety Entries This Stk#: 001
Status: SE
Date MSDS Prepared: 30SEP92
Safety Data Review Date: 03AUG95
Supply Item Manager: CX
MSDS Preparer's Name: ALEXANDER A. PICCIRILLI
MSDS Serial Number: BXGCN
Specification Number: UNKNOWN
Spec Type, Grade, Class: UNKNOWN
Hazard Characteristic Code: C1
Unit Of Issue Container Qty: 2.5 KG
Type Of Container: UNKNOWN
Net Unit Weight: 5.5 LBS
NRC/State License Number: NOT RELEVANT

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Ingredients/Identity Information

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Proprietary: NO
Ingredient: SODIUM HYDROGEN SULFATE
Ingredient Sequence Number: 01
Percent: 100
NIOSH (RTECS) Number: VZ1860000
CAS Number: 7681-38-1
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NONE RECOMMENDED

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Physical/Chemical Characteristics

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Appearance And Odor: WHITE CRYSTALLINE POWDER - ODORLESS
Boiling Point: DECOMPOSES
Melting Point: 598F,314C
Specific Gravity: 2.435
Decomposition Temperature: UNKNOWN
Evaporation Rate And Ref: NOT RELEVANT
Solubility In Water: 54% @ 68F (20C)
Viscosity: NOT RELEVANT

Corrosion Rate (IPY): UNKNOWN

Fire and Explosion Hazard Data

Flash Point: NONE
Extinguishing Media: WATER SPRAY, CARBON DIOXIDE, FOAM OR DRY CHEMICAL FOR SURROUNDING FIRE. REACTS WITH WATER OR STEAM.
Special Fire Fighting Proc: WEAR PROTECTIVE CLOTHING AND NIOSH-APPROVED SELF-CONTAINED BREATHING APPARATUS. SEE 1990 EMERGENCY RESPONSE GUIDEBOOK, DOT P 5800.5, GUIDE NO 60.
Unusual Fire And Expl Hazrds: EMITS HIGHLY TOXIC GASES.

Reactivity Data

Stability: YES
Cond To Avoid (Stability): MOISTURE (SULFURIC ACID IS LIBERATED ON CONTACT).
Materials To Avoid: STRONG OXIDIZING AGENTS, ALKALIES, WATER
Hazardous Decomp Products: SULFUR DIOXIDE
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): NOT RELEVANT

Health Hazard Data

LD50-LC50 Mixture: LD50 (ORAL, RAT) IS NOT KNOWN.
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: NO
Route Of Entry - Ingestion: YES
Health Haz Acute And Chronic: TARGET ORGANS:EYES, SKIN, RESPIRATORY & GI TRACTS. ACUTE- CORROSIVE. EYES/SKIN:MAY CAUSE SEVERE IRRITATION & BURNS. INHALATION:DUST MAY CAUSE UPPER RESPIRATORY TRACT IRRITATION. INGESTION:MAY BE FATAL IF SWALLOWED. CAN CAUSE SEVERE BURNS, HEADACHE, NAUSEA, VOMITING, DIZZINESS, GASTROINTESTINAL IRRITATION. CHRONIC-UNK.
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NONE
Signs/Symptoms Of Overexp: CORROSIVE. SEVERE IRRITATION, BURNS, HEADACHE, NAUSEA, VOMITING, DIZZINESS
Med Cond Aggravated By Exp: PERSONS WITH PRE-EXISTING SKIN DISORDERS OR IMPAIRED RESPIRATORY FUNCTION MAY BE MORE SUSCEPTIBLE TO THE EFFECTS OF THE SUBSTANCE.
FLUSH WITH WATER FOR AT LEAST 15 MINUTES. HOLD EYELIDS OPEN. REMOVE CONTAMINATED CLOTHING. INHALED:REMOVE TO FRESH AIR. PROVIDE CPR/OXYGEN IF NEEDED. ORAL:DO NOT INDUCE VOMITING. IF CONSCIOUS, DRINK LARGE AMOUNT OF WATER. FOLLOW WITH MILK OF MAGNESIA, VEGETABLE OIL OR BEATEN EGGS. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

Precautions for Safe Handling and Use

Steps If Matl Released/Spill: WEAR PROTECTIVE EQUIPMENT. VENTILATE AREA. SWEEP UP AND PLACE IN A SUITABLE CONTAINER. DISSOLVE IN WATER. NEUTRALIZE WITH SODA ASH AND FLUSH TO SEWER WITH LARGE AMOUNT OF WATER, IF PERMITTED.
Neutralizing Agent: SODA ASH
Waste Disposal Method: DISCHARGE, TREATMENT OR DISPOSAL MAY BE SUBJECT TO LOCAL, STATE AND FEDERAL REGULATIONS. DISSOLVE IN WATER. NEUTRALIZE AND

FLUSH TO SEWER IF ALLOWED.
Precautions-Handling/Storing: STORE IN TIGHTLY CLOSED CONTAINER IN DRY PLACE AWAY FROM INCOMPATIBLE MATERIALS.
Other Precautions: USE WITH ADEQUATE VENTILATION. DO NOT GET IN EYES, ON SKIN OR ON CLOTHING. DO NOT GENERATE DUST. DO NOT BREATHE DUST, MIST OR FUMES. KEEP OUT OF REACH OF CHILDREN. WASH THOROUGHLY AFTER HANDLING. FOR LABORATORY USE ONLY.

Control Measures

Respiratory Protection: NONE NORMALLY REQUIRED. IF DUSTY CONDITIONS PREVAIL, WORK IN VENTILATION HOOD OR WEAR NIOSH-APPROVED DUST RESPIRATOR.
Ventilation: ADEQUATE
Protective Gloves: RUBBER
Eye Protection: SAFETY GLASSES WITH SIDE SHIELDS/GOGGLES
Other Protective Equipment: RUBBER BOOTS, RUBBER APRON, EYE WASH FOUNTAIN, SAFETY SHOWER
Work Hygienic Practices: OBSERVE GOOD INDUSTRIAL HYGIENE PRACTICES AND RECOMMENDED PROCEDURES. WASH THOROUGHLY BEFORE EATING, DRINKING/SMOKING.

Transportation Data

Trans Data Review Date: 95215
DOT PSN Code: DWZ
DOT Proper Shipping Name: CORROSIVE SOLIDS, N.O.S.
DOT Class: 8
DOT ID Number: UN1759
DOT Pack Group: II
DOT Label: CORROSIVE
IMO PSN Code: ESJ
IMO Proper Shipping Name: CORROSIVE SOLID, N.O.S. o
IMO Regulations Page Number: 8151
IMO UN Number: 1759
IMO UN Class: 8
IMO Subsidiary Risk Label: -
IATA PSN Code: HMF
IATA UN ID Number: 1759
IATA Proper Shipping Name: CORROSIVE SOLID, N.O.S. *
IATA UN Class: 8
IATA Label: CORROSIVE
AFI PSN Code: HMF
AFI Prop. Shipping Name: CORROSIVE SOLID, N.O.S.
AFI Class: 8
AFI ID Number: UN1759
AFI Pack Group: II
AFI Basic Pac Ref: 12-7
N.O.S. Shipping Name: SODIUM BISULFATE

Disposal Data

Label Data

Label Required: YES
Technical Review Date: 03AUG95
MFR Label Number: NOT RELEVANT

Label Status: F
Common Name: SODIUM BISULFATE
Signal Word: DANGER!
Acute Health Hazard-Severe: X
Contact Hazard-Severe: X
Fire Hazard-None: X
Reactivity Hazard-Slight: X
Special Hazard Precautions: TARGET ORGANS:EYES, SKIN, RESPIRATORY & GI TRACTS. ACUTE- CORROSIVE. EYES/SKIN:MAY CAUSE SEVERE IRRITATION & BURNS. INHALE:MAY CAUSE IRRITATION. ORAL:MAY BE FATAL IF SWALLOWED. CHRONIC-UNKNOWN. STORE AWAY FROM INCOMPATIBLES. SWEEP UP & PLACE IN A SUITABLE CONTAINER. DISSOLVE IN WATER. NEUTRALIZE WITH SODA ASH. FIRST AID- GET IMMEDIATE MEDICAL ATTENTION. EYES/SKIN:FLUSH WITH WATER FOR AT LEAST 15 MINUTES. HOLD EYELIDS OPEN. REMOVE CONTAMINATED CLOTHING. INHALED:REMOVE TO FRESH AIR. PROVIDE CPR/OXYGEN IF NEEDED. ORAL:DO NOT INDUCE VOMITING. IF CONSCIOUS, DRINK LARGE AMOUNT OF WATER. FOLLOW WITH MILK OF MAGNESIA, VEGETABLE OIL OR BEATEN EGGS.
Protect Eye: Y
Protect Skin: Y
Label Name: WARD'S NATURAL SCIENCE ESTABLISHMENT INC.
Label P.O. Box: 92912
Label City: ROCHESTER
Label State: NY
Label Zip Code: 14692-9012
Label Country: US
Label Emergency Number: 716-226-6177/334-4222/800-424-9300
Year Procured: 1995

ZINC ACETATE

MSDS Number: Z1140 --- *Effective Date: 10/29/01*

1. Product Identification

Synonyms: Acetic acid, zinc salt, dihydrate; zinc diacetate; zinc acetate dihydrate
CAS No.: 557-34-6 (Anhydrous) 5970-45-6 (Hydrate)
Molecular Weight: 219.50
Chemical Formula: (CH3COO)2Zn 2H2O
Product Codes: J.T. Baker: 4296, 4297, 4304, 5658
Mallinckrodt: 8740

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Zinc Acetate	557-34-6	98 - 100%	Yes

3. Hazards Identification

Emergency Overview

WARNING! HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 1 - Slight
Flammability Rating: 1 - Slight
Reactivity Rating: 0 - None
Contact Rating: 2 - Moderate
Lab Protective Equip: GOGGLES; LAB COAT
Storage Color Code: Orange (General Storage)

Potential Health Effects

Inhalation:
Causes irritation to the respiratory tract. Symptoms may include coughing, shortness of breath.
Ingestion:
Irritation of the mucous membranes due to hydrolysis and formation of acid in the stomach can occur. Large amounts can produce stomach cramps, stricture of the esophagus, nausea, and vomiting.
Skin Contact:
Causes irritation to skin. Symptoms include redness, itching, and pain.
Eye Contact:
Causes irritation, redness, and pain.
Chronic Exposure:
No information found.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or impaired respiratory function may be more susceptible to the effects of the substance.

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4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
Ingestion:
Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention.
Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Get medical attention. Wash clothing before reuse. Thoroughly clean shoes before reuse.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

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5. Fire Fighting Measures

Fire:
Not considered to be a fire hazard.
Explosion:
Not considered to be an explosion hazard.
Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained

breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Pick up and place in a suitable container for reclamation or disposal, using a method that does not generate dust. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Isolate from incompatible substances. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
None established.
Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures as low as possible. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
For conditions of use where exposure to dust or mist is apparent and engineering controls are not feasible, a particulate respirator (NIOSH type N95 or better filters) may be worn. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection:
Wear protective gloves and clean body-covering clothing.
Eye Protection:
Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:
White crystals or powder.
Odor:
Slight acetic acid (vinegar) odor.
Solubility:
43g in 100g water.
Density:
1.74
pH:
No information found.
% Volatiles by volume @ 21C (70F):
0
Boiling Point:
Decomposes.
Melting Point:
237C (459F)
Vapor Density (Air=1):
No information found.
Vapor Pressure (mm Hg):
No information found.
Evaporation Rate (BuAc=1):
No information found.

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10. Stability and Reactivity

Stability:
Loses water of hydration above 100C.

Hazardous Decomposition Products:
Freshly-formed zinc oxide or zinc oxide fumes at high temperatures (over 800C).
Hazardous Polymerization:
Will not occur.
Incompatibilities:
No incompatibility data found. Oxidizing agents, zinc salts in general, alkalis and their carbonates, oxalates, phosphates, sulfides.
Conditions to Avoid:
Heat, flames, ignition sources and incompatibles.

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11. Toxicological Information

Oral rat: LD50: 2510 mg/kg. Reproductive effects cited. Mutation references cited.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Zinc Acetate (557-34-6)	No	No	None

12. Ecological Information

Environmental Fate:
No information found.
Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Not regulated.

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Zinc Acetate (557-34-6)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\----------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Zinc Acetate (557-34-6)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\----------

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                                          -SARA 302-    ------SARA 313----
--
  Ingredient                              RQ    TPQ     List  Chemical
Catg.
  ---------------------------------------  ---   -----   ----  ------------
--
  Zinc Acetate (557-34-6)                 No    No      No    Zinc compoun

  --------\Federal, State & International Regulations - Part 2\--------------
--
                                                        -RCRA-    -TSCA-
  Ingredient                              CERCLA        261.33     8(d)
  ---------------------------------------  ------      ------    ------
  Zinc Acetate (557-34-6)                 1000          No         No


Chemical Weapons Convention:  No     TSCA 12(b):  No     CDTA:  No
SARA 311/312:  Acute: Yes      Chronic: No   Fire: No  Pressure: No
Reactivity: No          (Pure / Solid)
```

Australian Hazchem Code: No information found.
Poison Schedule: No information found.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **1** Flammability: **0** Reactivity: **0**
Label Hazard Warning:
WARNING! HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT.
Label Precautions:
Avoid contact with eyes, skin and clothing.
Avoid breathing dust.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Label First Aid:
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. If swallowed, induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconscious person. In all cases, get medical attention.
Product Use:
Laboratory Reagent.

Revision Information:
MSDS Section(s) changed since last revision of document include: 1, 8.
Disclaimer:
****
Mallinckrodt Baker, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. MALLINCKRODT BAKER, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, MALLINCKRODT BAKER, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.
****
Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

MSDS Material Safety Data Sheet

From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865

Mallinckrodt CHEMICALS J.T.Baker

24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response in Canada
CANUTEC: 613-996-6666

Outside U.S. and Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

SODIUM HYDROXIDE SOLUTIONS (MORE THAN 10% NaOH)

MSDS Number: S4037 --- *Effective Date: 08/02/01*

1. Product Identification

Synonyms: Caustic soda solution; lye solution; sodium hydroxide liquid; sodium hydrate solution,Sodium Hydroxide Concentrate Solution StandARd(R), Sodium Hydroxide, DILUT-IT(R) Analytical Concentrates, sodium hydroxide volumetric solutions
CAS No.: 1310-73-2
Molecular Weight: 40.00
Chemical Formula: NaOH in water
Product Codes:
J.T. Baker: 0337, 3719, 3725, 3727, 3729, 4689, 4690, 5000, 5661, 5666, 5668, 5669, 5671, 5672, 5674, 5676
Mallinckrodt: 6290, 7701, 7703, 7705, 7706, 7775, H369, H382, H385, V038, V039, V264

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Sodium Hydroxide	1310-73-2	10 - 60%	Yes
Water	7732-18-5	40 - 90%	No

3. Hazards Identification

Emergency Overview

POISON! DANGER! CORROSIVE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. CAUSES BURNS TO ANY AREA OF CONTACT. REACTS WITH WATER, ACIDS AND OTHER MATERIALS.

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 3 - Severe (Poison)
Flammability Rating: 0 - None
Reactivity Rating: 2 - Moderate
Contact Rating: 4 - Extreme (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: White Stripe (Store Separately)

Potential Health Effects

Inhalation:
Severe irritant. Effects from inhalation of mist vary from mild irritation to serious damage of the upper respiratory tract, depending on severity of exposure. Symptoms may include sneezing, sore throat or runny nose. Severe pneumonitis may occur.
Ingestion:
Corrosive! Swallowing may cause severe burns of mouth, throat, and stomach. Severe scarring of tissue and death may result. Symptoms may include bleeding, vomiting, diarrhea, fall in blood pressure. Damage may appears days after exposure.
Skin Contact:
Corrosive! Contact with skin can cause irritation or severe burns and scarring with greater exposures.
Eye Contact:
Corrosive! Causes irritation of eyes, and with greater exposures it can cause burns that may result in permanent impairment of vision, even blindness.
Chronic Exposure:
Prolonged contact with dilute solutions or dust has a destructive effect upon tissue.
Aggravation of Pre-existing Conditions:

Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.
Ingestion:
DO NOT INDUCE VOMITING! Give large quantities of water or milk if available. Never give anything by mouth to an unconscious person. Get medical attention immediately.
Skin Contact:
Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Call a physician, immediately. Wash clothing before reuse.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

Note to Physician:
Perform endoscopy in all cases of suspected sodium hydroxide ingestion. In cases of severe esophageal corrosion, the use of therapeutic doses of steroids should be considered. General supportive measures with continual monitoring of gas exchange, acid-base balance, electrolytes, and fluid intake are also required.

5. Fire Fighting Measures

Fire:
Not considered to be a fire hazard. Hot or molten material can react violently with water.
Can react with certain metals, such as aluminum, to generate flammable hydrogen gas.
Explosion:
May cause fire and explosions when in contact with incompatible materials.
Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire. Adding water to caustic solution generates large amounts of heat.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

6. Accidental Release Measures

Ventilate area of leak or spill. Keep unnecessary and unprotected people away from area of spill. Wear appropriate personal protective equipment as specified in Section 8. Contain and recover liquid when possible. Do not flush caustic residues to the sewer. Residues from spills can be diluted with water, neutralized with dilute acid such as acetic, hydrochloric or sulfuric. Absorb neutralized caustic residue on clay, vermiculite or other inert substance and package in a suitable container for disposal. US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRACIT(R)-2 or BuCAIM(R) caustic neutralizers are recommended for spills of this product.

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7. Handling and Storage

Keep in a tightly closed container. Protect from physical damage. Store in a cool, dry, ventilated area away from sources of heat, moisture and incompatibilities. Store above 16C (60F) to prevent freezing. Always add the caustic to water while stirring; never the reverse. Containers of this material may be hazardous when empty since they retain product residues (vapors, liquid); observe all warnings and precautions listed for the product. Do not store with aluminum or magnesium. Do not mix with acids or organic materials.

---

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
- OSHA Permissible Exposure Limit (PEL):
2 mg/m3 Ceiling
- ACGIH Threshold Limit Value (TLV):
2 mg/m3 Ceiling

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, a half facepiece particulate respirator (NIOSH type N95 or better filters) may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest.. A full-face piece particulate respirator (NIOSH type N100 filters) may be worn up

to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator.
WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. Physical and Chemical Properties

Physical data is displayed for 10%, 30% and 50% aqueous sodium hydroxide solutions. (Merck Index).

Appearance:
Clear, colorless solution.

Odor:
Odorless.

Solubility:
Completely miscible with water.

Density:
10% solution - 1.11; 30% solution - 1.33; 50% solution - 1.53

pH:
14.0 (10%, 30% and 50% solutions)

% Volatiles by volume @ 21C (70F):
No information found.

Boiling Point:
For 10% solution = 105C (221F); for 30% solution = 115C (239F); for 50% solution = 140C (284F).

Melting Point:
For 10% solution = -10C (14 F); for 30% solution = 1C (34F); for 50% solution = 12C (53.6F).

Vapor Density (Air=1):
No information found.

Vapor Pressure (mm Hg):
13 @ 60C (140F) (50% solution)

Evaporation Rate (BuAc=1):
No information found.

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10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.
Hazardous Decomposition Products:
Sodium oxide. Decomposition by reaction with certain metals releases flammable and explosive hydrogen gas.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Sodium hydroxide in contact with acids and organic halogen compounds, especially trichloroethylene, may causes violent reactions. Contact with nitromethane and other similar nitro compounds causes formation of shock-sensitive salts. Contact with metals such as aluminum, magnesium, tin, and zinc cause formation of flammable hydrogen gas. Sodium hydroxide, even in fairly dilute solution, reacts readily with various sugars to produce carbon monoxide. Precautions should be taken including monitoring the tank atmosphere for carbon monoxide to ensure safety of personnel before vessel entry.
Conditions to Avoid:
Heat, moisture, incompatibles.

11. Toxicological Information

Sodium hydroxide: irritation data: skin, rabbit: 500 mg/24H severe; eye rabbit: 50 ug/24H severe. Investigated as a mutagen.

--------\Cancer Lists\----------

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Sodium Hydroxide (1310-73-2)	No	No	None
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate:
No information found.
Environmental Toxicity:
No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste facility. Although not a listed RCRA hazardous waste, this material may exhibit one or more characteristics of a hazardous waste and require appropriate analysis to determine specific disposal requirements. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

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14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: SODIUM HYDROXIDE SOLUTION
Hazard Class: 8
UN/NA: UN1824
Packing Group: II
Information reported for product/size: 360LB

International (Water, I.M.O.)

Proper Shipping Name: SODIUM HYDROXIDE, SOLUTION
Hazard Class: 8
UN/NA: UN1824
Packing Group: II
Information reported for product/size: 360LB

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15. Regulatory Information

--------\Chemical Inventory Status - Part 1\--------

Ingredient	TSCA	EC	Japan	Australia
Sodium Hydroxide (1310-73-2)	Yes	Yes	Yes	Yes
Water (7732-18-5)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\--------

Ingredient	Korea	Canada DSL	Canada NDSL	Phil.

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  ---------------------------------------------  -----  ---   ----  -
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  Sodium Hydroxide (1310-73-2)                     Yes   Yes   No
Yes
  Water (7732-18-5)                                Yes   Yes   No
Yes

  --------\Federal, State & International Regulations - Part 1\--------
--------
                                              -SARA 302-    ------SARA
313------
  Ingredient                                  RQ    TPQ     List
Chemical Catg.
  ----------------------------------------  ---   -----   ----  ------
--------
  Sodium Hydroxide (1310-73-2)                No    No      No
No
  Water (7732-18-5)                           No    No      No
No

  --------\Federal, State & International Regulations - Part 2\--------
--------
                                                          -RCRA-    -
TSCA-
  Ingredient                                  CERCLA     261.33     8(d)
  ----------------------------------------  ------     ------    -----
-
  Sodium Hydroxide (1310-73-2)                1000       No         No
  Water (7732-18-5)                           No         No         No


Chemical Weapons Convention:  No     TSCA 12(b):  No     CDTA:  No
SARA 311/312:  Acute: Yes      Chronic: Yes  Fire: No  Pressure: No
Reactivity: Yes         (Mixture / Liquid)
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Australian Hazchem Code: 2R
Poison Schedule: S6
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **1**
Label Hazard Warning:
POISON! DANGER! CORROSIVE. MAY BE FATAL IF SWALLOWED. HARMFUL IF INHALED. CAUSES BURNS TO ANY AREA OF CONTACT. REACTS WITH WATER, ACIDS AND OTHER MATERIALS.
Label Precautions:

Do not get in eyes, on skin, or on clothing.
Do not breathe mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.

Label First Aid:

If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If inhaled, remove to fresh air. If not breathing give artificial respiration. If breathing is difficult, give oxygen. In all cases get medical attention immediately.

Product Use:

Laboratory Reagent.

Revision Information:

MSDS Section(s) changed since last revision of document include: 8.

Disclaimer:

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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

SULFURIC ACID, 52 - 100 %

MSDS Number: S8234 --- *Effective Date: 02/18/02*

1. Product Identification

Synonyms: Oil of vitriol; Babcock acid; sulphuric acid
CAS No.: 7664-93-9
Molecular Weight: 98.08
Chemical Formula: H2SO4 in H2O
Product Codes:
J.T. Baker: 5030, 5137, 5374, 5802, 5815, 5889, 5897, 5960, 5961, 5971, 5997, 6902, 9673, 9674, 9675, 9676, 9679, 9680, 9681, 9682, 9684, 9687, 9691, 9693, 9694
Mallinckrodt: 2468, 2876, 2878, 2900, 2904, 3780, 4222, 5524, 5557, H644, H976, H996, V344, V651, XL003

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Sulfuric Acid	7664-93-9	52 - 100%	Yes
Water	7732-18-5	0 - 48%	No

3. Hazards Identification

Emergency Overview

POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR CONTACTED WITH SKIN. HARMFUL IF INHALED. AFFECTS TEETH. WATER REACTIVE. CANCER HAZARD. STRONG INORGANIC ACID MISTS CONTAINING SULFURIC ACID CAN CAUSE CANCER. Risk of cancer depends on duration and level of exposure.

SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 4 - Extreme (Poison)
Flammability Rating: 0 - None

Reactivity Rating: 2 - Moderate
Contact Rating: 4 - Extreme (Corrosive)
Lab Protective Equip: GOGGLES & SHIELD; LAB COAT & APRON; VENT HOOD; PROPER GLOVES
Storage Color Code: White (Corrosive)

Potential Health Effects

Inhalation:
Inhalation produces damaging effects on the mucous membranes and upper respiratory tract. Symptoms may include irritation of the nose and throat, and labored breathing. May cause lung edema, a medical emergency.
Ingestion:
Corrosive. Swallowing can cause severe burns of the mouth, throat, and stomach, leading to death. Can cause sore throat, vomiting, diarrhea. Circulatory collapse with clammy skin, weak and rapid pulse, shallow respirations, and scanty urine may follow ingestion or skin contact. Circulatory shock is often the immediate cause of death.
Skin Contact:
Corrosive. Symptoms of redness, pain, and severe burn can occur. Circulatory collapse with clammy skin, weak and rapid pulse, shallow respirations, and scanty urine may follow skin contact or ingestion. Circulatory shock is often the immediate cause of death.
Eye Contact:
Corrosive. Contact can cause blurred vision, redness, pain and severe tissue burns. Can cause blindness.
Chronic Exposure:
Long-term exposure to mist or vapors may cause damage to teeth. Chronic exposure to mists containing sulfuric acid is a cancer hazard.
Aggravation of Pre-existing Conditions:
Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

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4. First Aid Measures

Inhalation:
Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician immediately.
Ingestion:
DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Call a physician immediately.
Skin Contact:
In case of contact, immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. Excess acid on skin can be neutralized with a 2% solution of bicarbonate of soda. Call a

physician immediately.
Eye Contact:
Immediately flush eyes with gentle but large stream of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Call a physician immediately.

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5. Fire Fighting Measures

Fire:
Concentrated material is a strong dehydrating agent. Reacts with organic materials and may cause ignition of finely divided materials on contact.
Explosion:
Contact with most metals causes formation of flammable and explosive hydrogen gas.
Fire Extinguishing Media:
Dry chemical, foam or carbon dioxide. Do not use water on material. However, water spray may be used to keep fire exposed containers cool.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Structural firefighter's protective clothing is ineffective for fires involving this material. Stay away from sealed containers.

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6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Neutralize with alkaline material (soda ash, lime), then absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer! US Regulations (CERCLA) require reporting spills and releases to soil, water and air in excess of reportable quantities. The toll free number for the US Coast Guard National Response Center is (800) 424-8802.

J. T. Baker NEUTRASORB® or TEAM® 'Low Na+' acid neutralizers are recommended for spills of this product.

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7. Handling and Storage

Store in a cool, dry, ventilated storage area with acid resistant floors and good drainage. Protect from physical damage. Keep out of direct sunlight and away from heat, water, and incompatible materials. Do not wash out container and use it for other purposes. When diluting, always add the acid to water; never add water to the acid. When opening metal containers, use non-sparking tools because of the possibility of hydrogen gas being present. Containers of this material may be hazardous when empty since they retain

product residues (vapors, liquid); observe all warnings and precautions listed for the product.

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8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
For Sulfuric Acid:
- OSHA Permissible Exposure Limit (PEL) -
1 mg/m3 (TWA)
- ACGIH Threshold Limit Value (TLV) -
1 mg/m3(TWA), 3 mg/m3 (STEL), A2 - suspected human carcinogen for sulfuric acid contained in strong inorganic acid mists.

Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded and engineering controls are not feasible, a full facepiece respirator with an acid gas cartridge and particulate filter (NIOSH type N100 filter) may be worn up to 50 times the exposure limit, or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P particulate filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air purifying respirators do not protect workers in oxygen-deficient atmospheres. Where respirators are required, you must have a written program covering the basic requirements in the OSHA respirator standard. These include training, fit testing, medical approval, cleaning, maintenance, cartridge change schedules, etc. See 29CFR1910.134 for details.

Skin Protection:
Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:
Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. Physical and Chemical Properties

Appearance:
Clear oily liquid.

Odor:

Odorless.
Solubility:
Miscible with water, liberates much heat.
Specific Gravity:
1.84 (98%), 1.40 (50%), 1.07 (10%)
pH:
1 N solution (ca. 5% w/w) = 0.3; 0.1 N solution (ca. 0.5% w/w) = 1.2; 0.01 N solution (ca. 0.05% w/w) = 2.1.
% Volatiles by volume @ 21C (70F):
No information found.
Boiling Point:
ca. 290C (ca. 554F) (decomposes at 340C)
Melting Point:
3C (100%), -32C (93%), -38C (78%), -64C (65%).
Vapor Density (Air=1):
3.4
Vapor Pressure (mm Hg):
1 @ 145.8C (295F)
Evaporation Rate (BuAc=1):
No information found.

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10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage. Concentrated solutions react violently with water, spattering and liberating heat.
Hazardous Decomposition Products:
Toxic fumes of oxides of sulfur when heated to decomposition. Will react with water or steam to produce toxic and corrosive fumes. Reacts with carbonates to generate carbon dioxide gas, and with cyanides and sulfides to form poisonous hydrogen cyanide and hydrogen sulfide respectively.
Hazardous Polymerization:
Will not occur.
Incompatibilities:
Water, potassium chlorate, potassium perchlorate, potassium permanganate, sodium, lithium, bases, organic material, halogens, metal acetylides, oxides and hydrides, metals (yields hydrogen gas), strong oxidizing and reducing agents and many other reactive substances.
Conditions to Avoid:
Heat, moisture, incompatibles.

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11. Toxicological Information

Toxicological Data:
Oral rat LD50: 2140 mg/kg; inhalation rat LC50: 510 mg/m3/2H; standard Draize, eye rabbit, 250 ug (severe); investigated as a tumorigen, mutagen, reproductive effector.
Carcinogenicity:
Cancer Status: The International Agency for Research on Cancer (IARC) has classified "strong inorganic acid mists containing sulfuric acid" as a known human carcinogen, (IARC category 1). This classification applies only to mists containing sulfuric acid and not to sulfuric acid or sulfuric acid solutions.

--------\Cancer Lists\----------
-

Ingredient	---NTP Carcinogen--- Known	Anticipated	IARC Category
Sulfuric Acid (7664-93-9)	No	No	None
Water (7732-18-5)	No	No	None

12. Ecological Information

Environmental Fate:
When released into the soil, this material may leach into groundwater. When released into the air, this material may be removed from the atmosphere to a moderate extent by wet deposition. When released into the air, this material may be removed from the atmosphere to a moderate extent by dry deposition.
Environmental Toxicity:
LC50 Flounder 100 to 330 mg/l/48 hr aerated water/Conditions of bioassay not specified;
LC50 Shrimp 80 to 90 mg/l/48 hr aerated water /Conditions of bioassay not specified;
LC50 Prawn 42.5 ppm/48 hr salt water /Conditions of bioassay not specified.
This material may be toxic to aquatic life.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved incinerator or disposed in a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: SULFURIC ACID (WITH MORE THAN 51% ACID)
Hazard Class: 8
UN/NA: UN1830
Packing Group: II
Information reported for product/size: 440LB

International (Water, I.M.O.)

Proper Shipping Name: SULPHURIC ACID (WITH MORE THAN 51% ACID)
Hazard Class: 8
UN/NA: UN1830
Packing Group: II
Information reported for product/size: 440LB

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\--------

Ingredient	TSCA	EC	Japan	Australia
Sulfuric Acid (7664-93-9)	Yes	Yes	Yes	Yes
Water (7732-18-5)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\--------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Sulfuric Acid (7664-93-9)	Yes	Yes	No	Yes
Water (7732-18-5)	Yes	Yes	No	Yes

--------\Federal, State & International Regulations - Part 1\--------

Ingredient	-SARA 302- RQ	TPQ	------SARA 313---- List	Chemical Catg.
Sulfuric Acid (7664-93-9)	1000	1000	Yes	No
Water (7732-18-5)	No	No	No	No

--------\Federal, State & International Regulations - Part 2\----------
--

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Sulfuric Acid (7664-93-9)	1000	No	No
Water (7732-18-5)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: Yes
SARA 311/312: Acute: Yes Chronic: Yes Fire: No Pressure: No
Reactivity: Yes (Pure / Liquid)

Australian Hazchem Code: 2P
Poison Schedule: None allocated.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

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16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **2** Other: **Water reactive**
Label Hazard Warning:
POISON! DANGER! CORROSIVE. LIQUID AND MIST CAUSE SEVERE BURNS TO ALL BODY TISSUE. MAY BE FATAL IF SWALLOWED OR CONTACTED WITH SKIN. HARMFUL IF INHALED. AFFECTS TEETH. WATER REACTIVE. CANCER HAZARD. STRONG INORGANIC ACID MISTS CONTAINING SULFURIC ACID CAN CAUSE CANCER. Risk of cancer depends on duration and level of exposure.
Label Precautions:
Do not get in eyes, on skin, or on clothing.
Do not breathe mist.
Keep container closed.
Use only with adequate ventilation.
Wash thoroughly after handling.
Do not contact with water.
Label First Aid:
In all cases call a physician immediately. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before re-use. Excess acid on skin can be neutralized with a 2% bicarbonate of soda solution. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen.
Product Use:
Laboratory Reagent.

Revision Information:
MSDS Section(s) changed since last revision of document include: 3.
Disclaimer:
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Mallinckrodt Baker, Inc. provides the information contained herein in good faith but makes no representation as to its comprehensiveness or accuracy. This document is intended only as a guide to the appropriate precautionary handling of the material by a properly trained person using this product. Individuals receiving the information must exercise their independent judgment in determining its appropriateness for a particular purpose. MALLINCKRODT BAKER, INC. MAKES NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, INCLUDING WITHOUT LIMITATION ANY WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE INFORMATION SET FORTH HEREIN OR THE PRODUCT TO WHICH THE INFORMATION REFERS. ACCORDINGLY, MALLINCKRODT BAKER, INC. WILL NOT BE RESPONSIBLE FOR DAMAGES RESULTING FROM USE OF OR RELIANCE UPON THIS INFORMATION.
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Prepared by: Environmental Health & Safety
Phone Number: (314) 654-1600 (U.S.A.)

Attachment B

Potential Hazardous Substances

ATTACHMENT B
POTENTIAL HAZARDOUS SUBSTANCES

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
Acenaphthene	1200 ppm (sediment)				
Acetone	120 ppm (sediment)	1000 ppm (O) 500 ppm (A)	2500 ppm [10%LEL]	Inhalation, Ingestion, Contact: skin, eyes	Irritant: eyes, nose, throat. Dizziness, CNS depression, dermatitis.
Aluminum	12,400 ppm (soil)	10 mg/ m^3 (A) 15 mg/ m^3 (O)	N.D.	Inhalation, Contact	Irritate eyes, skin, resp system.
Anthracene	2.8 ppm (soil)	0.1 mg/ m^3 (A) 0.2 mg/ m^3 (O)	Ca [80 mg/m^3]	Inhalation, Contact	Dermatitis, bronchitis, [carcinogen]
Antimony	8.7 ppm (soil)	0.5 mg/m^3 (O)(A)	50 mg/m^3	Inhalation; Ingestion; Skin and/or eye contact	Irritation eyes, skin, nose, throat, mouth; cough; headaches; dizziness; nausea; vomiting; diarrhea; stomach cramps; insomnia; anorexia; unable to smell properly
Arsenic	10.6 ppm (soil)	0.01 mg/m^3 (O,A) (Inorganic forms)	5 mg/m^3 Ca	Inhalation; Ingestion; Skin absorption; Skin and/or eye contact	Ulceration of nasal septum; dermatitis; GI disturbances; peripheral neuropathy; respiratory irritation; hyperpigmentation of skin

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
BHC (Alpha, Beta)	0.035 ppb (SEEP/Outfall)	0.5 mg/m^3 [skin] (O, A)	50 mg/m^3	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; headache; nausea; clonic convulsions; respiratory difficulty; cyanosis; aplastic anemia; muscle spasm; in animals: liver, kidney damage.
Barium	1100 ppm (soil)				
BEHP	13 ppb (ground water)				
Benzene	9 ppb (ground water)	Ca 0.1 ppm (A) 1 ppm (S, A) 1 ppm (O) 5 ppm (S, O)	Ca [500 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, respiratory system; dizziness; headache, nausea, staggered gait; anorexia, lassitude (weakness, exhaustion); dermatitis; bone marrow depression; [potential occupational carcinogen.
Benzo(a)pyrene	370 ppm (sediment)	0.1 mg/m^3 (A) 0.5 mg/m^3 (O)	80 mg/m^3 Ca	Inhalation; Skin and/or eye Contact	Dermatitis, bronchitis, [carcinogen]
Beryllium	0.74 ppm (soil)	0.002 mg/m^3 (O,A)	[4 mg/m^3 (as Be)] Ca	Inhalation; Skin and/or eye Contact	Berylliosis (chronic exposure): anorexia, low-weight, weak, chest pain, cough, clubbing of fingers, cyan, pulm insufficiency; irritable eyes; dermatitis; [carcinogen]
Bis (2-Ethylhexyl)-phthalate	13 ppm (sediment)	5 mg/m^3 (A) 10 mg/m^3 (S) 5 mg/m^3 (O)	Ca 5000 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, mucous membrane; in animals: liver damage; teratogenic effects; [potential occupational carcinogen].

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
2-Butanone	0.010 ppm (soil)	200 ppm (590 mg/m^3) (A) 300 ppm (885 mg/m^3) (S) 200 ppm (590 mg/m^3) (O)	3000 ppm	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose; headache; dizziness; vomiting; dermatitis.
Cadmium	2.4 ppm (soil)	Ca 0.005 mg/m^3 (O)	Ca 9 mg/m^3	Inhalation, Ingestion	Pulmonary edema, dyspnea (breathing difficulty), cough, chest tightness, substernal (occurring beneath the sternum) pain; headache; chills, muscle aches; nausea, vomiting, diarrhea; anosmia (loss of the sense of smell), emphysema, proteinuria, mild anemia; [potential occupational carcinogen].
Calcium	234,000 ppm (soil)				
Carbon Disulfide	6 ppm (sediment)	1 ppm (3 mg/m^3) (A)10 ppm (30 mg/m^3) [skin] (S) 20 ppm C 30 ppm 100 ppm (30-minute maximum peak) (O)	500 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Dizziness, headache, poor sleep, lassitude (weakness, exhaustion), anxiety, anorexia, weight loss; psychosis; polyneuropathy; Parkinson-like syndrome; ocular changes; coronary heart disease; gastritis; kidney, liver injury; eye, skin burns; dermatitis; reproductive effects.
Carbazole	0.550 ppm (soil)				

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
Chloroethane	2 ppb (ground water)	1000 ppm (O)	3800 ppm [10% LEL]	Inhalation, skin absorption (liquid), ingestion (liquid), skin and/or eye contact	Incoordination, inebriation; abdominal cramps; cardiac arrhythmias, cardiac arrest; liver, kidney damage.
Chromium	67.2 ppm (soil)	0.5 mg/m^3 (A) 1.0 mg/m^3 (O)	250 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin; lung fibrosis (histologic).
Chrysene	2000 ppm (sediment)	0.2 mg/m3 (A,O), Ca	[80 mg/m^3] Ca	Inhalation, Contact: skin, eyes	Dermatitis, bronchitis, [carcinogen]
Cobalt	37.9 ppm (sediment)	0.05 mg/m^3 (A) 0.1 mg/m^3 (O)	20 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Cough, dyspnea (breathing difficulty), wheezing, decreased pulmonary function; weight loss; dermatitis; diffuse nodular fibrosis; respiratory hypersensitivity, asthma.
Copper	9290 ppm (sediment)	1.0 mg/m^3 (O,A)	100 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, respiratory system; cough, dyspnea (breathing difficulty), wheezing; [potential occupational carcinogen.
4,4'-DDE	1.7 ppm (sediment)				
4,4'-DDT	1.8 ppm (sediment)	0.5 mg/ m^3 (A) 1 mg/ m^3 (O)	Ca [500 mg/ m^3]	Inhalation, Absorption, Ingestion, Contact	Irritation eyes, skin; paresthesia tongue, lips, face; tremor; anxiety, dizziness, confusion, malaise (vague feeling of discomfort), headache, lassitude (weakness, exhaustion); convulsions; paresis hands; vomiting; [potential occupational carcinogen].

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
Dibenz[a,h]anthracene	0.42 ppm (soil)				
Dibenzo furan	12 ppb (SEEP/Outfall)				
1,1-Dichloroethene	2 ppb (ground water)	Ca (A) None (O)	Ca None	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, throat; dizziness, headache, nausea, dyspnea (breathing difficulty); liver, kidney disturbance; pneumonitis; [potential occupational carcinogen].
Dieldrin	0.02 ppb (ground water)	0.25 mg/m^3 (O, A) Ca	50 mg/m^3 Ca	Inhalation; Ingestion; Skin absorption; Skin and/or eye contact	Head, dizziness; vomit, sweat, myoclonic limb jerks, tonic convulsions; [carcinogen]
Di-N-octyl-phthalate	1 ppb (ground water)	5 mg/m^3 (A) 10 mg/m^3 (S) 5 mg/m^3 (O)	Ca 5000 mg/m^3	Inhalation, ingestion, skin and/or eye contact.	Irritation eyes, mucous membrane; in animals: liver damage; teratogenic effects; [potential occupational carcinogen].
Endrin	0.0039 ppb (ground water)	0.1 mg/m^3 (O, A)	2 mg/m^3	Inhalation; Skin Absorption; Ingestion; Skin and/or eye Contact	Epileptic convulsions; stupor, head, dizziness, abdominal discomfort, vomit, insomnia, aggressiveness, weak
Endrin Aldehyde	0.047 ppm (soil)				
Endrin Ketone	1.6 ppm (sediment)				

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
Ethylbenzene	0.7 ppb (ground water)	50 ppm (215 mg/m^3) (A) ST 100 ppm (425 mg/m^3) 100 ppm (O)	700 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, nose, respiratory system; headache, lassitude (weakness, exhaustion), dizziness, confusion, malaise (vague feeling of discomfort), drowsiness, unsteady gait; narcosis; defatting dermatitis; possible liver injury; reproductive effects
Fluoranthene	9800 ppm (sediment)				
Fluorine	800 ppm (sediment)	0.1 ppm (0.2 mg/m^3) (A,O)	25 ppm	inhalation, skin and/or eye contact	Irritation eyes, nose, respiratory system; laryngeal spasm, wheezing; pulmonary edema; eye, skin burns; in animals: liver, kidney damage
Gamma Chloride	1.7 ppm (sediment)				
Gasoline	1750 ppm (soil)	[N.D.]	Ca [N.D.]	Inhalation; Ingestion; Skin absorption; Skin and/or eye contact	Irritable eyes, skin, mucus membranes, dizziness, slurred speech, convulsions, possible liver, kidney damage
Heptachlor Epoxide	1.2 ppm (ground water)	0.5 mg/m^3 (O, A)	35 mg/m^3 Ca	Inhalation; Ingestion; Skin and/or eye Contact	Light-headed, giddiness, stupor, loss of appetite, dermatitis
Indeno[1,2,3-cd]pyrene	270 ppm (sediment)	0.2 mg/m^3 (A) 0.5 mg/m^3 (O)	80 mg/m^3 Ca	Inhalation; Skin and/or eye Contact	Dermatitis, bronchitis, [carcinogen]
Iron	72900 ppm (sediment)	5 mg/m^3 (A) 10 mg/m^3 (O)	2500 mg/m^3	Inhalation	Benign pneumoconiosis with X-ray shadows indistinguishable from fibrotic pneumoconiosis (siderosis)

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
Lead	2650 ppm (soil)	0.5 mg/m^3 (A) 0.05 mg/m^3 (O)	100 mg/m^3 Pb	Inhalation; Ingestion; Skin and/or eye Contact	Weak; insomnia; facial pallor; low-weight; constipation; abdominal pain; anemia; gingival lead line; tremor; encephalopathy; kidney disease; irritable eyes
Manganese	788 ppm (sediment)	1 mg/m^3 (A) 3 mg/m^3 (S) 5 mg/m^3 (O)	500 mg/m^3	Inhalation, ingestion.	Parkinson's; asthenia, insomnia, mental confusion; metal fume fever: dry throat, cough, chest tightness, dyspnea (breathing difficulty), rales, flu-like fever; low-back pain; vomiting; malaise (vague feeling of discomfort); lassitude (weakness, exhaustion); kidney damage
Magnesium	4910 ppm (soil)				
4-Methyl-2-Pentane	2 ppb (groundwater)	25 ppm (100 mg/m^3) (A) 40 ppm (165 mg/m^3) [skin] (ST) 25 ppm (100 mg/m^3) [skin] (O)	400 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; headache, drowsiness; dermatitis; in animals: narcosis.
Mercury	0.96 ppm (soil)	0.05 mg/m^3 [skin, vapor] (A) 0.1 mg/m^3 (O)	10 mg/m^3	inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; cough, chest pain, dyspnea (breathing difficulty), bronchitis, pneumonitis; tremor, insomnia, irritability, indecision, headache, lassitude (weakness, exhaustion); stomatitis, salivation; gastrointestinal disturbance, anorexia, weight loss; proteinuria.
Methylene Chloride	0.230 ppm (soil)	Ca (A) 25 ppm (O) 125 ppm (ST)	Ca [2300 ppm]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin; lassitude (weakness, exhaustion), drowsiness, dizziness; numbness, tingle limbs; nausea; [potential occupational carcinogen]

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
2-Methylnaphthalene	49.0 ppm (soil)				
Napthalene	0.6 ppb (ground water)	10 ppm (50 mg/m^3) (A,O) 15 ppm (75 mg/m^3) (S)	250 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes; headache, confusion, excitement, malaise (vague feeling of discomfort); nausea, vomiting, abdominal pain; irritation bladder; profuse sweating; jaundice; hematuria (blood in the urine), renal shutdown; dermatitis, optical neuritis, corneal damage.
Nickel	54.5 ppm (sediment)	Ca 0.015 mg/m^3 (A) 1 mg/m^3 (O)	Ca [10 mg/m^3]	Inhalation, ingestion, skin and/or eye contact	Sensitization dermatitis, allergic asthma, pneumonitis; [potential occupational carcinogen] .
PCB 1260	36 ppm (sediment)	Ca 0.001 mg/m^3 (A) 1 mg/m^3 [skin] (O)	Ca [5 mg/m^3]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes; chloracne; liver damage; reproductive effects; [potential occupational carcinogen].
Phenanthrene	790 ppm (sediment)	0.2 mg/m3 (A,O), Ca	[80 mg/m^3] Ca	Inhalation, Contact: skin, eyes	Dermatitis, bronchitis, [carcinogen]
Pyrene	5400 ppm (sediment)	0.2 mg/m3 (A,O), Ca	[80 mg/m^3] Ca	Inhalation, Contact:skin, eyes	Dermatitis, bronchitis, [carcinogen]
Selenium	1.1 ppm (sediment)	0.2 mg/m^3 (A,O)	1 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; visual disturbance; headache; chills, fever; dyspnea (breathing difficulty), bronchitis; metallic taste, garlic breath, gastrointestinal disturbance; dermatitis; eye, skin burns; in animals: anemia; liver necrosis, cirrhosis; kidney, spleen damage.

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
Silver	6.8 ppm (soil)	0.01 mg/m^3 (A, O)	10 mg/m^3	Inhalation, ingestion, skin and/or eye contact	Blue-gray eyes, nasal septum, throat, skin; irritation, ulceration skin; gastrointestinal disturbance.
Sodium	1880 ppm (ground water)				
Thallium	0.65 ppm (soil)	0.1 mg/m^3 [skin] (O, A)	15 mg/m^3	Inhalation, skin absorption, ingestion, skin and/or eye contact	Nausea, diarrhea, abdominal pain, vomiting; ptosis, strabismus; peri neuritis, tremor; retrosternal (occurring behind the sternum) tightness, chest pain, pulmonary edema; convulsions, chorea, psychosis; liver, kidney damage; alopecia; paresthesia legs.
Toluene	12 ppb (ground water)	100 ppm (375 mg/m^3) (A) 150 ppm (560 mg/m^3) (S) 200 ppm (O) C 300 ppm 500 ppm (10-minute maximum peak)	500 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, nose; lassitude (weakness, exhaustion), confusion, euphoria, dizziness, headache; dilated pupils, lacrimation (discharge of tears); anxiety, muscle fatigue, insomnia; paresthesia; dermatitis; liver, kidney damage.
Total Dichloroethylene	255 ppb (ground water)	Ca (A) None (O)	Ca [N.D.]	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, throat; dizziness, headache, nausea, dyspnea (breathing difficulty); liver, kidney disturbance; pneumonitis; [potential occupational carcinogen].
Trichloroethylene (TCE)	5.4 ppm (soil)	25 ppm	1000 ppm Ca	Inhalation; Ingestion; Skin absorption; Skin and/or eye contact	Irritation to eyes, skin; head vertigo; visual disturbance; fatigue; giddiness; tremors; drowsiness; headaches; vomiting; dermatitis; cardiac arrhythmias; paresthesia; liver injury [potential carcinogen]

Substance	Maximum Levels in Media (Soil, Water, Air)	PEL (O) or TWA(A), STEL(S)	IDLH	Route of Exposure	Symptoms
Vanadium	22.9 ppm (sediment)	0.05 mg V/m^3 (A) 0.5 mg V_2O_5/m^3 (resp) (O)	35 mg/m^3 (as V)	Inhalation, ingestion, skin and/or eye contact	Irritation eyes, skin, throat; green tongue, metallic taste, eczema; cough; fine rales, wheezing, bronchitis, dyspnea (breathing difficulty).
o-xylene	0.5 ppb (ground water)	100 ppm (435 mg/m^3) (A) 150 ppm (655 mg/m^3) (S) 100 ppm (435 mg/m^3) (O)	900 ppm	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes, skin, nose, throat; dizziness, excitement, drowsiness, incoordination, staggering gait; corneal vacuolization; anorexia, nausea, vomiting, abdominal pain; dermatitis.
Vinyl Chloride	36 ppb (water)	1 ppm (O, A) 5 ppm (S)	N.D. [Ca]	Inhalation, Contact [liquid]: skin, eyes	Weakness, abdominal pain, GI bleeding, enlarged liver, cyanosis of extremities, [liquid]: frostbite. [carcinogen]
Zinc	1610 ppm (soil)				

NOTE:
- IDLH = Immediately Dangerous to Life and Health.
- N.D. = Not Determined.
- O PEL = OSHA Permissible Exposure Limit.
- A TWA = American Conference of Governmental Industrial Hygientists –Threshold Limit Value - Time Weighted Average
- S STEL = Short-Term Exposure Limit (15 min)
- Ca = Carcinogen

Media Description:
1. Soil (Surface to 10-Ft Below Grade) (mg/kg)
2. Surface Soil (mg/kg)
3. Sediment (mg/kg)
4. Ground Water Shallow (ug/L)
5 Ground-Water Deep (ug/L)
6. Ground-Water Bedrock (ug/L)

Attachment C

Physical and Biological Hazard Information Sheets

ATTACHMENT C

PHYSICAL HAZARD INFORMATION SHEET: ELECTRICAL HAZARDS

Overhead power lines, electrical wiring, electrical equipment, and buried cables pose risks to workers of electric shock, burns, muscle twitches, heart fibrillation, and other physical injuries, as well as fire and explosion hazards. In accordance with Occupational Safety and Health Act's (OSHA's) standard for Electrical Safety-Related Work Practices (29 CFR 1910.331-.335), protective measures must be taken when working near live electrical parts, including but not limited to:

- Insulation and guarding of life parts
- Grounding

  De-energizing live parts followed by lockout/tagout to prevent inadvertent reactivation of the parts
- Electric protective devices (e.g., insulated tools)
- Safe work practices, including:

  — Inspection of work area to identify potential spark sources
  — Maintenance of a safe distance from all live electrical parts
  — Proper illumination of work areas
  — No "blind reaching" around live electrical equipment
  — Provision of barriers, shields, or insulation to prevent inadvertent contact with live parts
  — Use of non-conductive, intrinsically safe equipment near live parts.

Overhead lines pose electrical hazards at many sites, particularly for work involving the use of equipment with elevated parts (e.g., drill rigs, backhoes). If overhead lines cannot be de-energized prior to the start of work, the following minimum distances must be maintained between the lines and both site workers and the longest conductive object present (including vehicles with elevated structural parts):

- 10 ft from overhead lines with voltage of 50 kV or less
- 10 ft plus 4 in. for every 10 kV over 50 kV for overhead lines with voltages greater than 50 kV. For example, the minimum distance that must be maintained from a 250 kV line is 16.5 ft.

PHYSICAL HAZARD INFORMATION SHEET: ELECTRICAL HAZARDS (Continued)

EA personnel are not permitted to work on electric parts of equipment that have not been de-energized, locked out, and tagged by personnel trained to work with electrical equipment. No EA employee may work near energized exposed live parts without the use of any protective measures. Personal protective equipment designed to protect against electrical hazards may be specified for certain work operations. The Project Manager is responsible for ensuring that appropriate safety measures are implemented to protect against electrical safety hazards on their sites.

Lightning is a hazard during outdoor operations, particularly for workers handling metal equipment. To eliminate this hazard, weather conditions should be monitored and work suspended at the discretion of the Site Safety and Health Officer (SHSO) during electrical storms.

Site-Specific Hazards and Protective Measures
Generator: Use proper precautions while working with electrical connections. DO NOT USE wires if frayed or bare wires are exposed.
A ground fault circuit interrupter (GFCI) is required on all electrical equipment used outside if run off a regular circuit or generator greater than 5,000 watts.

PHYSICAL HAZARD INFORMATION SHEET: HEAVY EQUIPMENT HAZARDS

The use of heavy equipment (e.g., backhoes, dump trucks, generators, compressors, etc.) may pose a variety of health and safety hazards to site workers.

All heavy equipment work must be conducted only by trained, experienced personnel. Equipment backing up, swinging loads, buckets, booms, and counter-weights pose serious hazards to ground personnel. If possible, EA personnel must remain outside the turning radius of any large, moving equipment. At a minimum, EA personnel must maintain visual contact with the equipment operator when the equipment is active.

No EA personnel are permitted to work underneath heavy equipment, because this practice poses serious crushing hazards.

Belts, pulleys, sheaves, gears, chains, shafts, clutches, drums, flywheels, and other moving parts of equipment can pose injury hazards. No guard, safety appliance, or other device may be removed or made ineffective unless repairs or maintenance are required, and then only after power has been shut off and locked out. Safety devices must be replaced once repair/maintenance is complete.

Exhaust from all equipment powered by steam or combustion engines must be properly located so that release of exhaust does not endanger workers or obstruct the view of the operator. Gasoline-operated equipment must be re-fueled properly to prevent fire hazards; power must be off, no smoking allowed, and proper dispensing equipment must be used.

When not operational, equipment shall be set and locked so that it cannot be activated, released, dropped, etc. Backhoe buckets must be lowered to the ground.

Site-Specific Hazards and Protective Measures
Heavy Equipment: There is no heavy equipment anticipated onsite during this sampling program; however, if encountered, use proper precautions as described above and make certain that you get eye contact with the driver if in the vicinity of heavy equipment to let him know you are in the area.
Generator: Use proper precautions when lifting or moving the generator or sampling equipment. Use at least two people to lift generator off of tail-gate and bend at the knees.

PHYSICAL HAZARD INFORMATION SHEET: VEHICLE AND PEDESTRIAN TRAFFIC

Traffic at certain sites, particularly active sites in busy areas, presents a hazard to site personnel. Equipment must be located in an area that does not present hazards to bystanders. Barriers must be used to separate the work areas from both vehicle and pedestrian traffic areas and to prevent inadvertent entry of either type of traffic into the work area. The demarcated area must include adequate buffer zones between the actual work area and traffic areas. Standard traffic cones are not considered adequate for these situations, due to their low vertical profile. Taller, 28-in. cones can be effectively modified with warning flags and barricade tape. Safety pennants and plastic or steel "A" frame type barricades may also be used in high traffic areas. Flashing warning lights may also be necessary. Barriers demarcating the work areas and buffer zone are required even if the site is inactive during work operations.

Employees exposed to public vehicular traffic shall be provided with, and shall wear, warning vests or other suitable garments marked with or made of reflectorized or high-visibility material.

In excavation areas, excavated soil materials may be placed between the hole and traffic areas to act as a barrier to both vehicle and pedestrian traffic. Such material must be placed in a manner which will not pose engulfment hazards to either site workers or bystanders.

Site-Specific Hazards and Protective Measures
Traffic: At times there will be several sampling teams onsite. Use proper precautions and follow traffic laws applicable to the Rhode Island or NCBC Davisville. Speed limit 10 mph, in the field, or as otherwise posted.

PHYSICAL HAZARD INFORMATION SHEET: BIOLOGICAL HAZARDS

INSECT BITES/STINGS

Protective outer clothing such as gloves, hard hats, and coveralls can help reduce the potential for insect bites and stings. Insect bite symptoms include redness, rash, swelling, chills, fever, diarrhea, and vomiting. Any worker who has been bit or stung and shows symptoms of a severe reaction should seek medical assistance immediately. Workers who know of any allergies they may have to any insects must advise their employer prior to engaging in any field activities and may want to carry antidote kits.

To prevent contact with disease-carrying ticks, wear long-sleeved shirts, long pants, and boots that extend above the ankle with socks pulled over pants cuffs. Permanone insecticide may be used to kill disease-bearing ticks and may be sprayed only on the outside of clothing (not directly on skin). Frequently check clothing, skin, and hair for the presence of ticks at the end of the work day. If a tick attaches to the body, remove by gently tugging with tweezers where the mouth parts enter the skin. Do not kill the tick prior to removal.

POISONOUS PLANTS

Poisonous plants such as poison ivy may be present on certain sites during part of the year. Know how to recognize these plants and avoid contact. If contact occurs, wash affected areas with soap and water immediately.

SNAKES/RODENTS

On occasion, field workers may come into contact with snakes and/or rodents (rats, gophers, etc.). In case of a snake bite, which can be fatal, workers must immediately seek medical assistance and report the incident to the SHSO and Site Manager, according to the procedures delineated in the Site Specific Health and Safety Plan (SSHSP). Prompt medical attention is also required for rodent bites since many rodents carry rabies and other diseases. Field workers must report rodent bites to the SHSO and Site Manager immediately according to SSHSP requirements.

Site-Specific Hazards and Protective Measures: Biological hazards will be present due to the time of the year for the planned activities. Workers should keep as much skin as possible covered to protect against bites, stings, etc.

PHYSICAL HAZARD INFORMATION SHEET: GENERAL PHYSICAL HAZARDS

Hazardous waste and other field operation sites include many basic safety hazards, such as:

- Holes, ditches, etc., posing fall, cave-in, and other hazards
- Precariously positioned objects, which may cause crushing or other injuries
- Sharp objects (e.g., nails, metal shards, glass), which may cause cuts, injection, or other injuries
- Slippery surfaces, posing slip and fall hazards
- Steep grades and/or uneven terrain, posing slip, trip, and fall hazards
- Unstable surfaces (e.g., walls that may cave-in, unstable underground structures) which may pose fall, crushing, or other injuries.

Basic safety hazards can directly injure workers and create additional hazards. For example, a person may trip due to uneven terrain, fall and be cut on rusty metal shards, and become inoculated with contaminants adhering to the metal.

Site personnel should look constantly, closely, and carefully for these basic safety hazards and immediately inform the SHSO of any conditions that they feel may be hazardous.

Site-Specific Hazards and Protective Measures
Exert extra precaution while working around wet surfaces while collecting samples. Keep work area neat and orderly to prevent trip hazards.

PHYSICAL HAZARD INFORMATION SHEET: FIRE/EXPLOSION HAZARDS

Explosion and fire hazards may be present at various sites due to ignition of chemicals, agitation of shock-sensitive compounds, the sudden release of materials under pressure, etc. All site operations must be conducted in accordance with local fire codes and regulations. Continuous monitoring for combustible gases is required at sites where such gases may be present during spark-generating operations. Fire extinguishers and other fire-fighting provisions may also be necessary. Site personnel must be trained in the use of such fire-fighting equipment prior to the start of work operations. Site-specific requirements for monitoring and fire emergency equipment must be specified in the SSHSP.

Site-Specific Hazards and Protective Measures
Gasoline for generators: Use proper precautions while in the vicinity of or handling gasoline for generators. If there is a spill wipe it up immediately and discard the absorbent material appropriately.
Fire caused by running vehicles: While parked on grass, turn off your engine. Grass touching the HOT under carriage of the vehicle could cause a fire.
Drums: If abandoned drums are encountered DO NOT OPEN. Notify the Contract Task Order Manager.

PHYSICAL HAZARD INFORMATION SHEET
NOISE HAZARDS

Work around large equipment often creates excessive noise. The effects of noise can include:

- Workers being startled, annoyed, or distracted
- Physical damage to the ear, pain, and temporary and/or permanent hearing loss
- Communication interference that may increase potential hazards due to the inability to warn of danger and provide for proper safety precautions to be taken.

If workers are subjected to noise exceeding an 8-hour time-weighted average sound level of 85 decibels on the A-weighted scale (dBA), feasible administrative or engineering controls shall be instituted to reduce noise levels to or below the permissible values. All personnel exposed to excessive noise levels shall be provided with and shall wear a hearing protection device which effectively protects the workers. OSHA regulations on noise can be found in 29 CFR Part 1910.95.

Site-Specific Hazards and Protective Measures:
Generators: If possible, position the generator a safe distance downwind of the sampling location. This will allow workers to proceed without hearing protection because the wind will carry sound away from work area. Regardless, if you can not hold a conversation with someone at a distance of 3 ft, use hearing protection.

PHYSICAL HAZARD INFORMATION SHEET: MATERIAL HANDLING/MOVING/LIFTING

Improper materials handling accounts for a large number of occupational injuries. Materials handling at hazardous waste sites can vary from heavy equipment handling to manually handling items. Hazards associated with materials handling include physical injury, detonation, fire, explosion, and vapor generation.

When using equipment to move materials, proper work practices must be followed. Equipment used must be designed for the task to be performed. Equipment must be inspected regularly by the SHSO and the Site Manager, and damaged or defective equipment must be removed from service. Planning is critical when handling materials. The Site Manager, in conjunction with the CTO Manager, must plan where the materials are to be moved, taking into consideration the current location of such materials and hazards associated with moving them. Routes for moving materials must be clearly outlined, with paths cleaned of all obstructions so materials may be transported.

Injuries to the back and abdominal muscles from improper lifting of loads is one of the most common occupational injuries reported. Such injuries can range from relatively mild strains to major permanently disabling injuries. Before lifting any load, personnel should consider the overall weight, distribution of weight, unwieldiness or awkwardness of the load, distance to be carried, obstacles to be negotiated, site conditions, and visibility. Loads should be inspected for slivers, sharp edges, slippery surfaces, etc. prior to lifting.

Loads should be lifted using the power of the leg muscles rather than the back, stomach, or arm muscles. Approach the item to balance the load evenly. Never bend over when lifting. The back should be kept straight and the arms nearly parallel with the body. The knees should be bent to grasp the load. Lifting should be done by straightening the legs, holding the load as close to the body as possible, and the back remaining as straight as possible.

Bulky, heavy loads should be handled by at least two people, ensuring that the load is level and evenly distributed between all personnel helping to carry it. All carriers should know the destination and path for the load.

Site-Specific Hazards and Protective Measures
Generator
Gasoline
Acid Preservatives
As mentioned in the previous sections exercise proper precautions and always work in a safe manner.

PHYSICAL HAZARD INFORMATION SHEET: COLD STRESS

Cold stress hazards are most likely to occur at low temperatures or low wind chill factors, with wet, windy conditions also contributing to risks. All personnel should be familiar with cold stress symptoms, which include:

- **Hypothermia**—Cold-induced decreasing of the core body temperature that produces shivering, numbness, drowsiness, and muscular weakness. If severe enough, it can lead to unconsciousness and death.

- **Frostbite**—Constriction of blood vessels in the extremities, decreasing the supply of warming blood. May result in formation of ice crystals in the tissues, causing tissue damage. Condition may range from frostnip which is a numbing of extremities, to deep-freezing tissue beneath the skin. Symptoms include white or grayish skin, blisters, numbness, mental confusion, failing eyesight, fainting, shock, and cessation of breathing. Death may occur from heart failure.

Pain in the extremities may be the first warning of cold stress, and precautions (see below) should be taken to reduce exposure. Maximum severe shivering must be taken as a sign of immediate danger to the worker, and exposure to cold must be immediately terminated. Personnel exhibiting signs and symptoms of cold stress must be removed from the site, decontaminated, and given appropriate first aid. Emergency medical services must be contacted if symptoms are severe (e.g., more than numbness of the extremities or shivering). When air temperatures are less than 36° F (including wind chill), workers who become immersed in water or whose clothing becomes wet must be immediately provided a change of clothing and be treated for hypothermia.

To prevent cold stress when air temperature is less than 40° F (including wind chill), personnel should wear layers of loose-fitting clothing including insulated coveralls, head covering, and boots. Protection of the hands, feet, and head is particularly important because these are likely to be injured first by cold. However, actual injury to hands, feet, and head is not likely to occur without prior development of early signs of hypothermia such as numbing and shivering. Bare skin contact with cold surfaces (below 20° F) must be avoided. Personnel should wear wind-resistant outer shell to decrease wind chill effects. No continuous exposure to cold is permitted when the air speed and temperature results in an equivalent chill temperature of 26° F or less.

A temperature-dependent work regimen limiting lengthy periods of outdoor activity may be necessary. Workers entering heated shelters should remove the outer layer of clothing and loosen remaining clothing to permit sweat evaporation. Dehydration must be avoided by drinking warm drinks or soups.

PHYSICAL HAZARD INFORMATION SHEET: HEAT STRESS

Personnel working under high-temperature conditions or wearing protective clothing while working in warm temperatures are subject to heat stress. Symptoms of heat stress may include:

- **Heat Cramps**—Muscle spasms in the abdomen or limbs. Frequent rest periods and fluid intake are appropriate measures to prevent or reduce heat cramps.

- **Heat Exhaustion**—Severe dehydration; pale, clammy skin; profuse sweating; dizziness, light-headedness; slurred speech; rapid pulse; confusion; fainting; fatigue; cool skin; nausea. Affected personnel should be escorted from the site, decontaminated promptly, set in cool, shaded area, and given fluids slowly.

- **Heat Stroke**—Life-threatening condition occurring when the body's temperature-regulating system improperly functions. Hot dry skin; rapid, deep breathing; lack of perspiration; delirium; high fever (often 106° F or more), nausea; unconsciousness. Brain damage and/or death may occur, if body temperature is not reduced. Provide fluids, use cooling devices (hose-down or shower), call emergency medical services or transport to hospital immediately.

Prevent heat stress by resting frequently in a shaded area and consuming large quantities of fresh potable water (more than amount needed to simply "quench thirst"). Drink at least 8 oz of water or Gatorade® every 2 hours when temperatures exceed 75 ° F.

If heat stress symptoms are wide-spread among workers or observed frequently, the SHSO should implement an appropriate work-rest period so that after 1 minute of rest, a person's heart rate (HR) does not exceed 110 beats per minute (bpm) based on pulse. If the HR exceeds 110 bpm, the next work period should be shortened by 33%, while the length of the rest period remains the same. If the HR is 110 bpm at the beginning of the next rest period, the following work cycle should be reduced by 33%. A healthy individual's resting HR is usually 60 to 72 bpm.

PHYSICAL HAZARD INFORMATION SHEET: COMPRESSED GAS CYLINDER HANDLING PROCEDURES

Compressed gas cylinders must be examined as soon as they are received. If there are any signs of damage or leakage, they must be moved to a safe, isolated area and returned to the supplier as soon as possible. The greatest care must be exercised in the handling of cylinders. They must never be dripped or banged against each other. Nothing should be allowed to fall on them. They must be stored upright in a safe, well ventilated area, away from any source of heat and away from electrical wiring. They must be secured in the upright position by chain, cable, or other suitable means of keeping them from tumbling.

Most cylinders are provided with a steel protective cap that screws on over the valve. Except when cylinders are in use, these caps should remain screwed down to the last thread.

When cylinders are moved, special hand trucks should be used. When in transit, the cylinders should be lashed to the cradles of trucks in as near an upright position as possible.

Storage areas must be fire-resistant, clean, free of combustible materials, and well lighted. Cylinders of oxygen must never be stored near cylinders containing flammable gases. Empty cylinders must be marked MT and kept from full ones. Full cylinders must be positively identified as to the gases they contain.

Improper handling of compressed gas cylinders can produce a hazard called "rocketing". If an accidental rupture occurs, or if a valve assembly is snapped off, a cylinder can blast its way through a concrete wall.

Occupational Safety and Health Administration standards require the employer to ensure that unloading operations are performed by reliable persons properly instructed. Employees should know the chemical and physical hazards with which they work, and must be thoroughly familiar with the types of personal protective equipment provided for their safety. They also should be instructed in first-aid procedures.

Site-Specific Hazards and Protective Measures
Nitrogen tanks will be used during ground-water sampling
Tanks will be transported to monitoring well locations via EA vehicle. Tanks will be removed from the vehicle and secured to monitoring well or placed safely on the ground during ground-water sampling.
Tanks will be stored upright and strapped to a secure structure. Empty tanks will be marked "MT" and stored separately.

Attachment D

Site Safety, Health, and Emergency Response Review Record

ATTACHMENT D
SITE SAFETY, HEALTH, AND EMERGENCY RESPONSE REVIEW RECORD

SITE: NCBC Davisville Site 16
Project No. 29601.07.3101

I have read the Site Safety, Health, and Emergency Response Plan for this site and have been briefed on the nature, level, and degree of exposure anticipated as a result of participation in this project. I agree to conform to the requirements of this Plan.

Name	Signature	Affiliation	Date

Attachment E

Site Safety and Health Activity Report

ATTACHMENT E
SITE SAFETY AND HEALTH ACTIVITY REPORT

SITE: NCBC Davisville Site 16 Project No. 29601.07.3101		
Weather Cond.:		Onsite Hours: From To
Changes in PPE Levels[a]	Work Operations	Reasons for Change
Site Safety and Health Plan Violations	Corrective Action Specified	Corrective Action Taken (Yes/No)
Observations and Comments:		
Completed by:_____ Site Health and Safety Officer Date		
(a) Only the Site Health and Safety Officer may change personal protective equipment levels, using only criteria specified in Health and Safety Plan.		

Attachment F

Monitoring Instrument Calibration Procedures

Calibrating 2020 with the Flow-Match Regulator

1. Ensure the short sample probe is connected to the 2020 inlet. If you are using the long probe for sampling, then ensure the long probe is connected to 2020.

NOTE: *Ensure the sample probe is free of any contamination as this will effect the calibration*

2. Press the ENTER key.

3. Select "Set", "Cal" and then "Mem".

4. Select the desired Cal Memory. 2020 has 15 Cal Memories and can be calibrated with 15 different span gases or response factors if required. Only one Cal Memory can be used at a time. Each Cal Memory stores a different response factor, zero point, sensitivity, and alarm levels.

5. Select "Chng" and then "User". Enter a name for the calibration memory.

   Press the ENTER key and enter a response factor (RF). Refer to page 159 for a list of Response Factors. If the compound is not listed or you are measuring gas mixtures, then enter a value of 1.0. The concentration detected by 2020 will be multiplied by the response factor before it is displayed and logged.

6. Press the ENTER key and enter an alarm level for STEL, TWA and PEAK.

7. Press ENTER and expose 2020 to a supply of zero air.

8. Select "Set", "Cal" and "Zero". Allow 2020 to set its zero point.

9. Select "Set", "Cal" and "Span". 2020 asks for the span gas concentration. Enter the known span gas

concentration, without pressing the ENTER key to confirm it.

10. Insert the 2020 sample probe into the adapter tubing from the regulator. See *Figure 11*.

11. Ensure the calibration gas cylinder is upright and open the regulator by turning the valve counter clockwise. Open the regulator until the ball is 1/8" from its rest position.

NOTE: *Do not set the flow rate too high.*

12. Press the ENTER key. 2020 sets its sensitivity.

13. When the display reverts to the default display, 2020 is calibrated and ready for use.

14. Remove the adapter tubing from the inlet and close the regulator.

If you turn off 2020 in the middle of zeroing or spanning, the next time you turn it on it will display a Cal status. This indicates that you need to calibrate 2020.

NOTE: *While the Cal status is active, all alarms are deactivated.*

Calibration Using a Gas Bag

Preparing the Calibration Gas Bag and the Zero Air Bag

WARNING

Observe proper handling techniques for all gases! See Compressed Gases *on page 23.*

Use the calibration kit (Part No. MX390033) as follows:

1. Connect the regulator to the calibration gas cylinder.

   If you are using a portable tank of calibration gas, connect the regulator (Part No. 600649) directly to the tank.

   If you are using a large cylinder of calibration gas, you must obtain a high purity regulator as specified in *Support Equipment and Consumables* on page 26. Isobutylene in air is usually supplied with a standard CGA 590 cylinder valve outlet. Obtain a regulator with the matching fitting. Connect the regulator to the tank of calibration gas. Tighten the regulator onto the tank with a wrench. Do not over-tighten.

NOTE: *Do not force the connection.*

Do not use Teflon tape with CGA fittings. In general, these fittings are designed for metal to metal sealing.

Do not use adapters to connect one CGA fitting to another type of CGA fitting. If the regulator does not match the outlet on your calibration tank, contact your specialty gas supplier.

2. Attach the knurled nut on the gas bag adapter to the regulator. Finger-tighten the fitting.

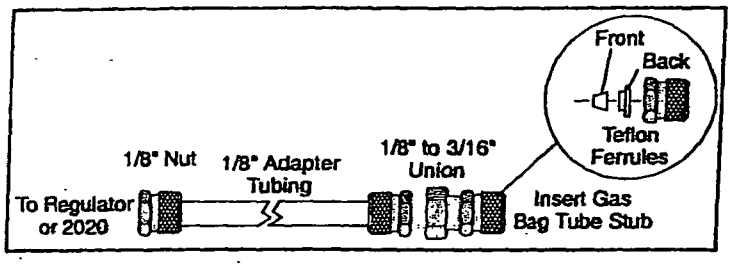


Figure 12 Gas Bag Adapter

3. Loosen the knurled nut on the reducing union of the gas bag adapter.

NOTE: ***Do not remove the nut from the union as the Teflon ferrules contained inside the nut may be lost. See Figure 12.***

4. Insert the tube stub from the gas bag into the knurled nut. Tighten the knurled nut and ensure the tube stub is secure. If the gas bag is not secure, ensure you have inserted the tube stub far enough into the knurled nut. Do not over-tighten the fitting.

NOTE: ***Over-tightening the Teflon ferrules will result in damage to the ferrules!***

5. The union should be connected to the gas bag adapter. If it is not, then tighten the nut on the adapter tube to the union.

6. Flush and fill the gas bag. See *Using the Gas Bag* on page 158 for instructions.

7. Remove the knurled nut on the adapter tube from the regulator.

8. Repeat this procedure, if necessary, to prepare a bag of zero air.

NOTE: *Do not use the same gas bag or gas bag adapter for the bag of zero air. You will contaminate the bag of zero air.*

Calibrating 2020 with a Gas Bag

1. Disconnect the probe from the 2020.
2. Press the ENTER key.
3. Select "Set", "Cal" and then "Mem".
4. Select the desired Cal Memory. 2020 has 15 Cal Memories and can be calibrated with 15 different span gases or response factors if required. Only one Cal Memory can be used at a time. Each Cal Memory stores a different response factor, zero point, sensitivity, and alarm levels.
5. Select "Chng" and then "User". Enter a name for the calibration memory.
6. Press the ENTER key and enter a response factor.
7. Press the ENTER key and enter an alarm level for each mode.
8. Press the ENTER key and enter a response factor. Refer to page 159 for a list of Response Factors.

   If the compound is not listed or you are measuring gas mixtures, then enter a value of 1.0. The concentration detected by 2020 will be multiplied by the response factor before it is displayed and logged.
9. Connect the supply of zero air. If you are using a gas bag with zero air, open the bag and connect the gas bag adapter to the inlet.

10. Select "Set", "Cal" and "Zero". The 2020 sets its zero point.

11. Select "Set", "Cal" and "Span". The 2020 asks for the span gas concentration. Enter the known span gas concentration, without pressing the ENTER key to confirm it.

12. Open the bag and then connect the gas bag adapter to the inlet. Press ENTER. 2020 sets its response factor.

NOTE: *Readings may fluctuate slightly as the gas bag empties. Do not allow 2020 to evacuate the bag completely.*

13. When the display reverts to the default display, 2020 is calibrated and ready for use. Remove the span gas bag from the inlet.

If 2020 is powered off in the middle of zeroing or spanning, it will power on displaying a Cal status. This indicates that you need to calibrate 2020. While the Cal status is active, all alarms are inactive.

Programming the Cal Memories

2020 has 15 Cal Memories and can be calibrated with 15 different span gases or response factors if desired.

To program the Cal Memories:

1. If you will be calibrating directly from the portable cylinder, connect a flow-match regulator (Part No. MX350006) to each tank. You must use a separate regulator for each compound to prevent cross contamination.

   If you are using gas bags, prepare the bags of calibration gas as outlined in *Calibration Using a Gas Bag* on page 67. Use a different gas bag and gas bag adapter for each concentration and for each type of calibration gas. You can use the same gas bag to zero

all the Cal Memories, however, you must refill the bag before zeroing each Cal Memory.

2. Select "Set", "Cal" and "Mem".

3. Select the desired Cal Memory (1 to 15) with the "Next" and "Prev" keys.

4. Press "Chng" to change the parameters of the Cal Memory. Select "User" or "Lib".

5. If you selected "User", enter the name, response factor and alarm levels.

6. If you entered "Lib", use the "Next" and "Prev" keys to select the required library. See page 164 for a list of Library entries.

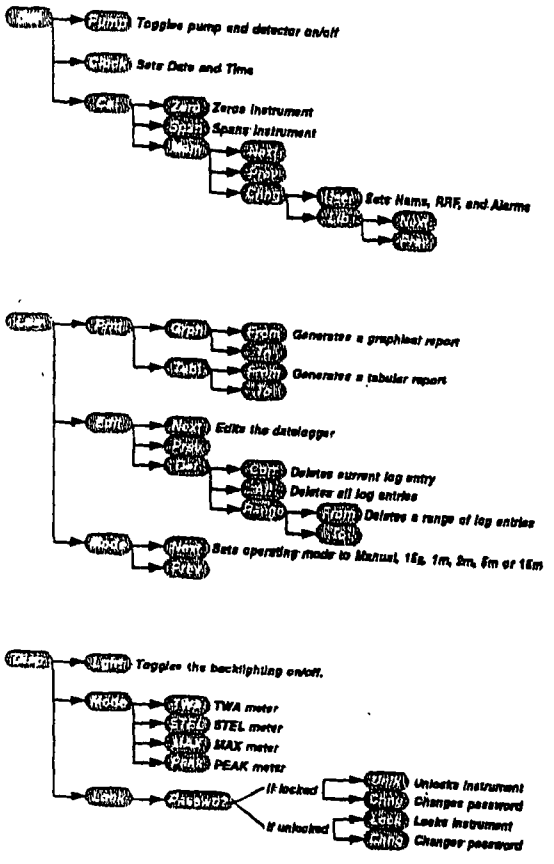
NOTE: ***It does not matter which Cal Memory is selected or which response factor is entered, 2020's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.***

7. Calibrate the instrument as described in *Calibration Using the Flow-Match Regulator* on page 64. When the calibration is completed, the calibration information is automatically stored in the selected Cal Memory.

8. Repeat this procedure for each Cal Memory you need.

Whenever the instrument is calibrated, 2020 updates the selected Cal Memory only. Each Cal Memory must be calibrated at least once a day. Frequency of calibration will depend on ambient conditions and instrument response. If ambient conditions change or the response has drifted, a calibration must be performed for each Cal Memory to ensure reliable operation.

2020 Function Map



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Fax (203) 761-2677

2020 Instrument Status

The instrument status is shown on the left side of the first line of the status display. Each status has a priority assigned to it. If more than one status is in effect, then the status with the highest priority is displayed until the condition is corrected or until the option is turned off. Refer to the 2020 User's Manual for details of operation.

Status	Description
Fall1	Zero fault. See Section 6.2.
Fall2	Span fault. See Section 6.2
Fall3	Lamp fault. See Section 6.2.
Fall4	Pump fault. See Section 6.2.
Cal	The last calibration was incomplete.
Over	Instrument over-range. See Section 6.2.
ALPK	PEAK alarm level has been exceeded.
ALST	STEL alarm level has been exceeded.
ALTW	TWA alarm level has been exceeded.
LBAT	Battery pack power is low.
ELog	The datalogger is full.
TWA	TWA display mode.
MAX	MAX display mode.
STEL	Peak display mode.
AUTO	Peak display mode.
Loc	Locate site.
BkGd	Record background reading.
Samp	Record sample reading.

SECTION IV

CALIBRATION

4.1 GENERAL

The Model 580B Organic Vapor Meter is indeed a quantitative instrument and can certainly be used as such. It makes use of the Photoionization Detection System using a lamp with an ionization energy of 10.0 eV which is standard in the Model 580B. Almost all organic materials will be ionized at this energy level. There are some organic materials, such as a few of the freons, methane, ethane and propane that are not ionized and thus will not be detected. The ionization potentials for the various organic materials will simply tell whether the material will be detected by the Photoionization Detector. It does not give any clue as to the sensitivity of the detector for that particular material. Certainly, different organic vapors will have different sensitivities. It is important to understand that the Model 580B does indeed sense most organic vapors and that its response to these different organic vapors will be different.

In this section of the manual, the aspects of calibrating the Model 580B for various vapors will be discussed. In the following section discussing applications, various ways of using the features of the Model 580B will be explained along with the various methods for calibration of the 580B. There will also be applications of the Model 580B in specific instances where the organic vapors or the mixtures of organic vapors are completely unknown. The 580B can be an extremely useful tool, even in areas such as those.

4.2 FACTORY CALIBRATION TEST OF THE MODEL 580B

The Model 580B has been tested for calibration and linearity tested at the factory. The particular gas chosen for this calibration is isobutylene. The Model 580B has good response for isobutylene. Isobutylene standards prepared in air are relatively stable with time, undergoing no serious adsorption or reaction problems. The test information is included in the instrument packet. In addition to the above test a benzene standard is also run. It is important to note that the instrument was not calibrated. It was tested for calibration. Therefore, it should be calibrated by the operator before use.

4.3 METHODS OF GENERATING CONCENTRATIONS OF VARIOUS MATERIALS IN AIR

This section is not intended to be all inclusive as far as the preparation of gas and vapor standards in air are concerned. Only those methods that have been found most practical for the calibration of the 580B are discussed here. There are basically two types of standards, cylinder and bag.

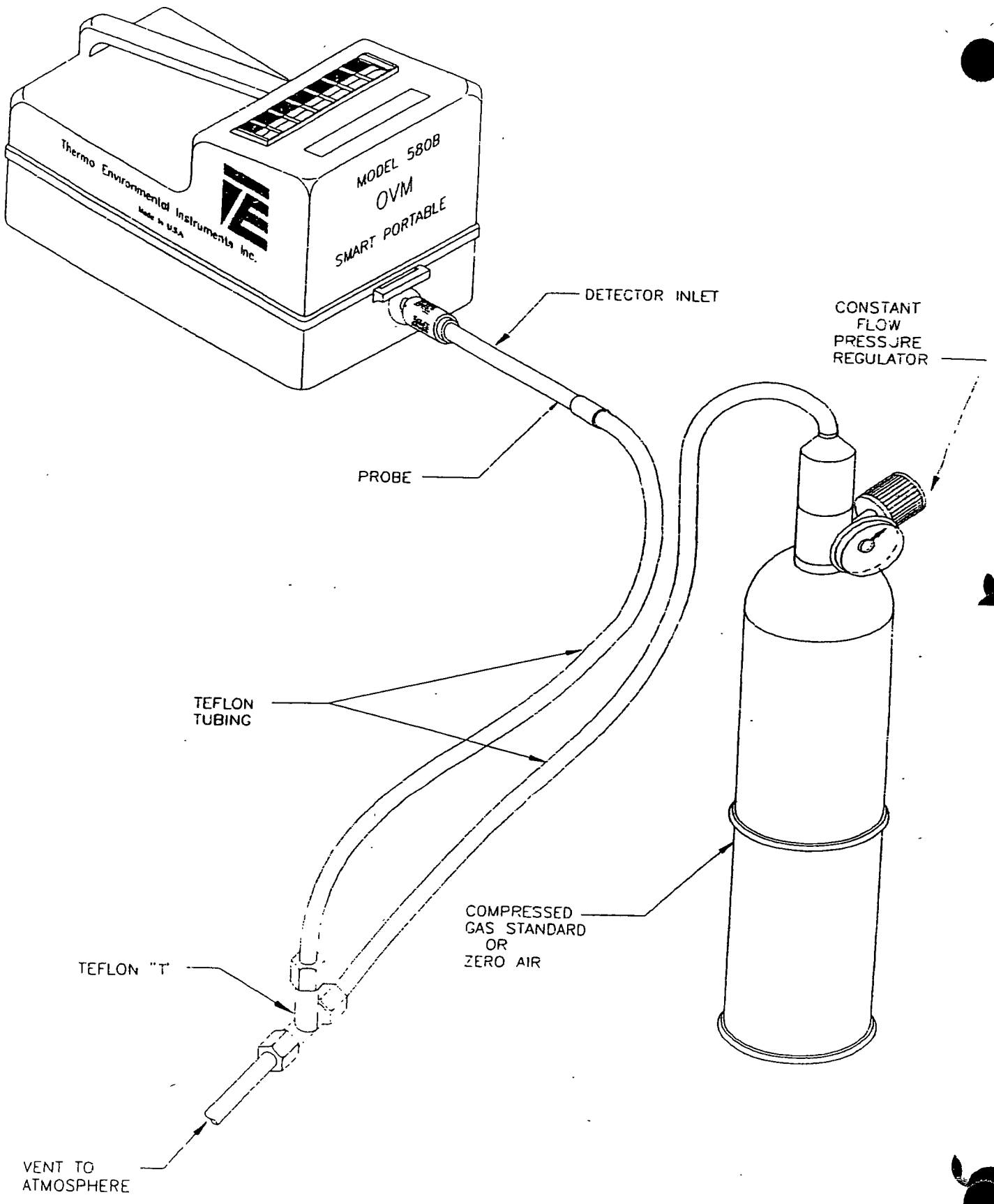


Figure 4.1
Cylinder Calibration

4.3.1 CYLINDER STANDARDS

Certainly commercially available standard cylinders of gaseous materials in air offer the most convenient method of calibration. However, these are static standards. Standards prepared in this fashion in air for vapors of various organic liquids often show concentration reduction with time due to adsorption problems. In general, gases when mixed with air will maintain their concentrations with time since adsorption is generally not a problem.

However, some gases are sufficiently reactive that chemical reaction of the gas will cause a reduction of it in air. These precautions must be observed when using commercially prepared standards for calibration of the Model 580B. It is for this reason that isobutylene in air was chosen as a reference standard for factory calibration. TEI offers a cylinder standard which includes both zero and isobutylene standards. A constant flow pressure regulator sets the flow needed for calibration of the 580B. Figure 4.1 illustrates the physical calibration procedure. The inlet to the 580B is connected to the "T" as shown. It is important that this connection is tangent to the gas flow. The "T" is connected to the regulator on the standard cylinder. It is important that a length of tubing is attached to the "T" location. This prevents diffusion of ambient air into sample line. The regulator and tubing assembly will have to be moved between both the zero air and standard cylinder.

4.3.2 BAG STANDARDS (ISOBUTYLENE)

Bag standards can be prepared in a laboratory and in general are reasonable ways of calibrating the Model 580B. However, it is important that these standards be used shortly after their preparation to reduce the significance of any adsorption problems. Static standards prepared for calibration of the Model 580B are best prepared in collapsible plastic bags. This is opposed to a fixed volume container. The sampling rate of the 580B, which is 500 ml/min, requires an appreciable amount of sample. Even one minute's sampling out of a fixed container will remove 500 ml/min from it. This should not significantly reduce the pressure inside the container. Thus, the collapsible bag provides the best means as opposed to a fixed volume. A 5 gallon polyethylene bag is a convenient size to use for the preparation of static standard.

A tube is inserted into the opened end of the bag and the bag opening then sealed around the tube. The tube should have a cutoff valve or some means of closing the volume of the bag. The volume of air introduced into the bag must be measured. This is most conveniently measured by a wet test meter. However, a source of air flowing through a flow meter can be used if the flow can be held constant, then time is a measure of the volume of the air placed into the bag. All air is expelled from the bag by completely collapsing it prior to connection to the source of air.

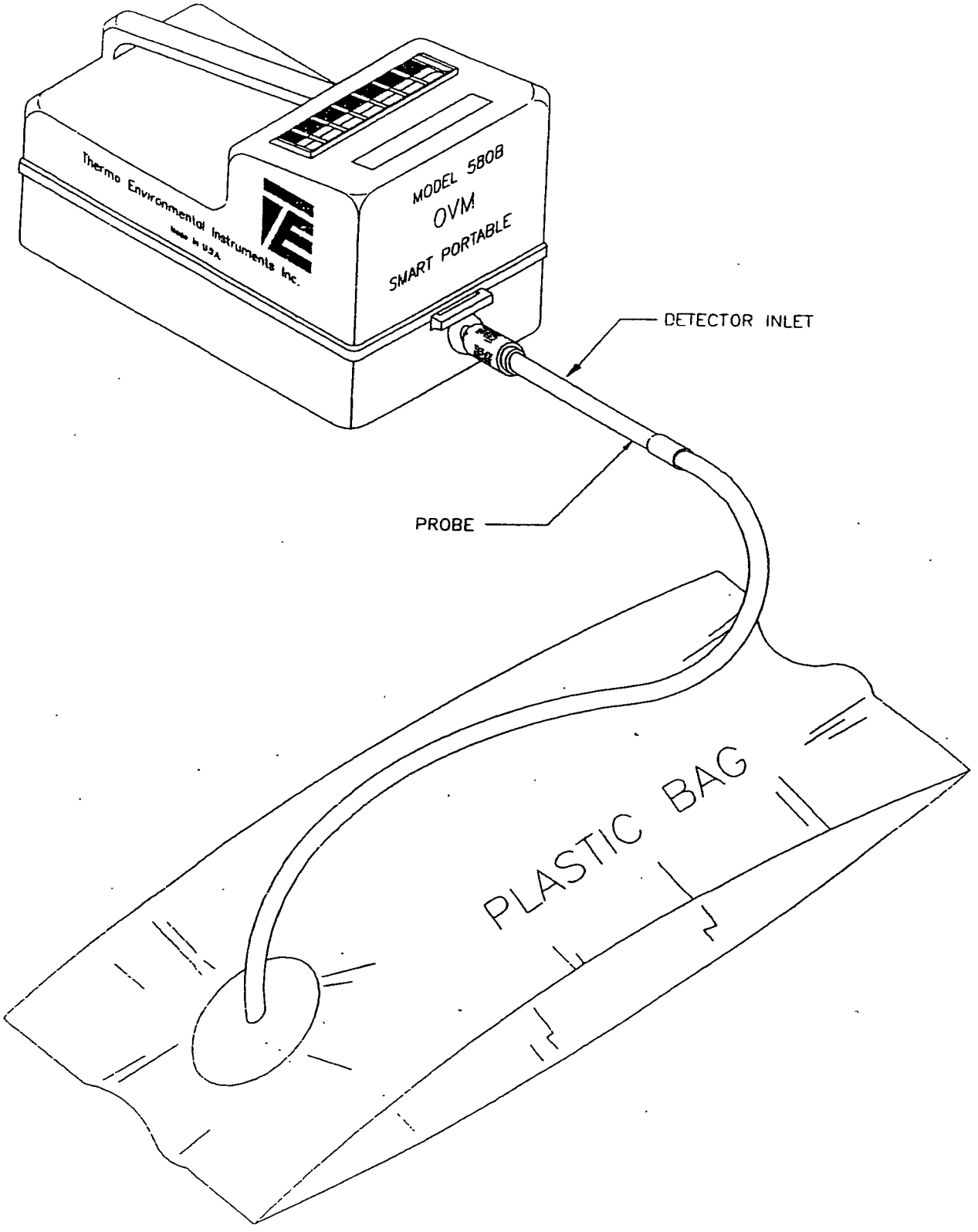


Figure 4.2
Bag Calibration

It can then be connected to a wet test meter or flow meter via a short length of rubber tubing hooked to the plastic tube of the bag. The air flow is started into the bag at a rate of approximately 5L/min. A total of 10 liters is a convenient volume for a 5 gallon bag. This would mean approximately 2 minutes for filling the bag. Figure 4.2 illustrates the physical configuration needed to develop bag standards.

For gaseous samples, the trace organic will be added via a glass hypodermic syringe. The 1 cc Tuberculin syringe is a convenient size. For an isobutylene standard, the 1 cc syringe is flushed with pure isobutylene and then filled to the 1cc mark. While the air is flowing into the plastic bag, the short piece of rubber tubing is pierced by the needle from the 1 cc syringe and the plunger slowly depressed such that the 1 cc of isobutylene is added to the air flowing into the plastic bag. When 10 liters of air have been added to the plastic bag, the flow is immediately stopped and the valve on the tube or the closing clamp is applied to contain the air and isobutylene within the plastic bag. It is best at this stage of the procedure not to rely solely on the diffusion of isobutylene to form a uniform mixture inside the plastic bag. Slight kneading of the plastic bag will hasten the mixing of the isobutylene in air. The plastic tube from the bag is then connected to the probe on the Model 580B via a short length of rubber tubing and the valve on the plastic tube immediately opened. The Model 580B withdraws a sample from the bag at the sampling rate of 500 ml/min. Thus, 10 liters of sample in the bag will provide approximately 20 minutes. Certainly the calibration of the 580B can be accomplished in a shorter period of time. The concentration of isobutylene in ppm by volume will be equal to the sample size, which was 1 cc, divided by the volume of the bag in liters, which would be 10 liters, times 1000. In this particular instance, the concentration would be:

$$\text{Conc (ppm by Vol)} = \frac{\text{1cc Isobutylene} \times 1000}{\text{10 L Air}} = 100 \text{ ppm}$$

4.3.3 BAG STANDARDS (ORGANICS)

On occasion there is the need to prepare standards other than the normal calibration standard. As mentioned previously, isobutylene was chosen as a standard because of its stability. If other standards are to be used, it is best to develop a relation of the other standard to a standard of known stability like isobutylene. If this procedure is followed, a response factor can be developed by comparing the other organic standard to isobutylene this technique will be discussed in a later section. The following is a suggested technique for preparing other standards.

For organic materials, which are normally liquids at room temperature, the procedure is essentially the same except that an extremely small liquid sample is injected into the flowing air stream rather than the gas sample. This technique works well

only for relatively volatile organic materials. The flowing air stream must vaporize all of the material or the calculation will be off. If the material is not rapidly volatile in that flowing air stream, the liquid should be injected through the surface of the plastic bag. Immediately after withdrawing the needle, the hole in the plastic bag should be covered with a piece of plastic tape.

Again, significant kneading of the bag will hasten the evaporation of the sample and mixing of the vapor into the air to provide homogeneous samples. The introduction of this sample into the 580B is the same as before. The calculation of the concentration of the vapor in air is a two-step procedure whereby the small volume of liquid injected into the air stream and into the plastic bag is converted to a volume of vapor. This volume of vapor is then used in the same manner as the volume of gas in the case of isobutylene. The following equations apply:

$$\text{Volume Vapor (uL)} = \frac{\text{Liquid Volume (ul)} \times \text{Liquid Density} \times 24.45}{\text{Molecular Weight}}$$

The above equation gives the vapor volume at atmospheric pressure (760 torr) and 25° C (77F).

Then:

$$\text{Concentration (ppm by Volume)} = \frac{\text{Vapor Volume (ul)} \times 1000}{\text{Air Volume (liters)}}$$

The following is a sample calculation for benzene:

Liquid Volume = 2 ul

Benzene Density = 0.879 g/cc

Molecular Weight Benzene = 78.1

Air Volume = 10 Liters

$$\text{Vapor Volume} = \frac{2 \times 0.879 \times 24.45 = 0.55 \text{ ul}}{78.1} \quad \text{Benzene Vapor}$$

$$\text{Conc} = \frac{0.55 \times 1000}{10} = 55 \text{ ppm (vol)}$$

The syringe used for the measurement of liquids in this particular instance is a small volume-type such as those manufactured by the Hamilton Company. A convenient size syringe is the 10 microliter volume.

4.4 580B CALIBRATION

The following procedure is applicable for both Cylinder and Bag Standards. The sequence requires both Zero gas and Span gas to be used. Span gas can be either contained as a cylinder or bag, in either case the exact concentration used must be known. This concentration will be entered to the 580 when the program provides its entry. With respect to Zero gas, there are several choices. Obviously a certified zero air standard in a cylinder presents no problem. Another choice would be to build a zero air standard in a bag. This can be simply accomplished with the set-up in Figures 4.1 and 4.2 using a charcoal scrubber to remove all the hydrocarbons present in the air. Charcoal does not absorb Methane; this does not cause a problem because the PID does not respond to it. Another approach which could be used in an emergency is to use room air unscrubbed.

This is acceptable if you know that there are no hydrocarbons present or they are exceptionally low in concentration. However, it is not recommended as a standard practice. The physical set up for cylinder calibration is illustrated in Figure 4.1; bag calibration in Figure 4.2.

4.4.1 CALIBRATION ROUTINE

(A) Set-up calibration assembly with zero air cylinder or bag as described in Figures 4.1 and 4.2.
(B) Model 580B set-up and zero calibration.

1. Power-up instrument using power plug.
2. Depress ON/OFF Key to ignite lamp and initiate sample pump.
3. Depress MODE/STORE Key.
4. Depress-/CRSR Key in response to LOG THIS VALUE? Prompt.
5. Depress-/CRSR Key to select Parameters Mode from the Main Menu.
6. Depress +/INC Key to advance thru the Run Mode selection parameter prompt.
7. Depress +/INC Key to advance thru the Auto Logging Mode selection parameter prompt.
8. Depress +/INC Key to advance thru the Average Time selection parameter prompt.
9. Depress +/INC Key to advance thru the Alarm Setting parameter prompt.
10. Depress +/INC Key to advance thru Lamp Selection parameter prompt.
11. Depress +/INC Key to advance thru Response Factor Setting parameter prompt.
12. Depress RESET Key to initiate calibration sequence.
13. Depress-/CRSR Key to decline restoration of the backup calibration.
14. Connect outlet of calibration tubing assembly to the Model 580B Detector Inlet as illustrated in Figure 4.2.
15. Introduce Zero Air to Model 580B by opening flow regulator.

16. Depress RESET Key to "Zero" Model 580B.
17. Close Flow Regulator.

(C) Span Calibration - assuming that the Span gas has a concentration of 250 ppm isobutylene the following procedure is followed:

18. Simultaneously Depress RESET and -/CRSR Keys to activate the movable cursor.
19. Repeat Step 18 until the cursor is at the ones place.
20. Simultaneously Depress RESET and +/INC Keys to increment the ones place value.
21. Repeat Step 20 until the ones place value reads 0.
22. Repeat Step 18 to move cursor to the tens place.
23. Repeat Step 20 until the tens place value reads 5.
24. Repeat Step 18 to move the cursor to the hundreds place.
25. Repeat Step 20 until the hundreds place value reads 2.
26. Repeat Step 18 to move the cursor to the thousands place.
27. Repeat Step 20 until the thousands place value reads 0.
28. The LCD should now read:

SPAN PPM = 0250
"+" TO CONTINUE

29. Depress +/INC to accept the span conc. value.
30. Connect isobutylene cylinder (250 ppm) to calibration tubing assembly.
31. Connect outlet of calibration tubing assembly to the Model 580B Detector Inlet.
32. Introduce isobutylene standard to Model 580B by opening flow regulator.
33. Reset key to "CALIBRATE" Model 580B.
34. Close Flow Regulator.
35. Depress +/INC. Key in response to "RESET" TO CALIBRATE message.
36. Depress MODE/STORE to return to the Run Mode.

The instrument has been calibrated and is ready to make measurements.

4.5 DETERMINATION OF RESPONSE FACTORS

As mentioned above, the Model 580 can be calibrated with isobutylene but be set to read correctly, the concentration of another substance. This is done by using the Response Factor that is set in the parameter routine. The default for the response factor is 1.0. The Response Factor is the number that is multiplied by the measured concentration to obtain the correct concentration of the measured component. If the chemical to be measured is less sensitive on a PID than the standard, (usually isobutylene) then the Response Factor is greater than 1.0. If it is more sensitive than the standard then the Response Factor is less than 1.0.

The reason for a Response Factor is practicality. If it is

know that the sample to be measured contains only benzene and therefore the user would like to read benzene concentration directly, there are two approaches. The user could make a bag standard daily of benzene vapor in air and calibrate the 580 directly. Or the Response Factor could be used. In the latter case a bag with benzene is made only once for comparison to a cylinder of a stable standard (such as isobutylene). Then daily, the Model 580 is calibrated with the cylinder standard, a simple operation compared to the work of preparing a bag standard.

As an example, if the bag containing 55 ppm benzene in air as prepared above were measured in a 580 calibrated against isobutylene, the concentration might have been read as 91 ppm. thus the 580 is more sensitive for benzene than for isobutylene.

The Response Factor can now be calculated as:

$$\text{Response Factor (RF)} = \frac{\text{Factor STD Concentration}}{\text{580 Reading of Factor STD}}$$

$$RF = 55/91 = 0.604$$

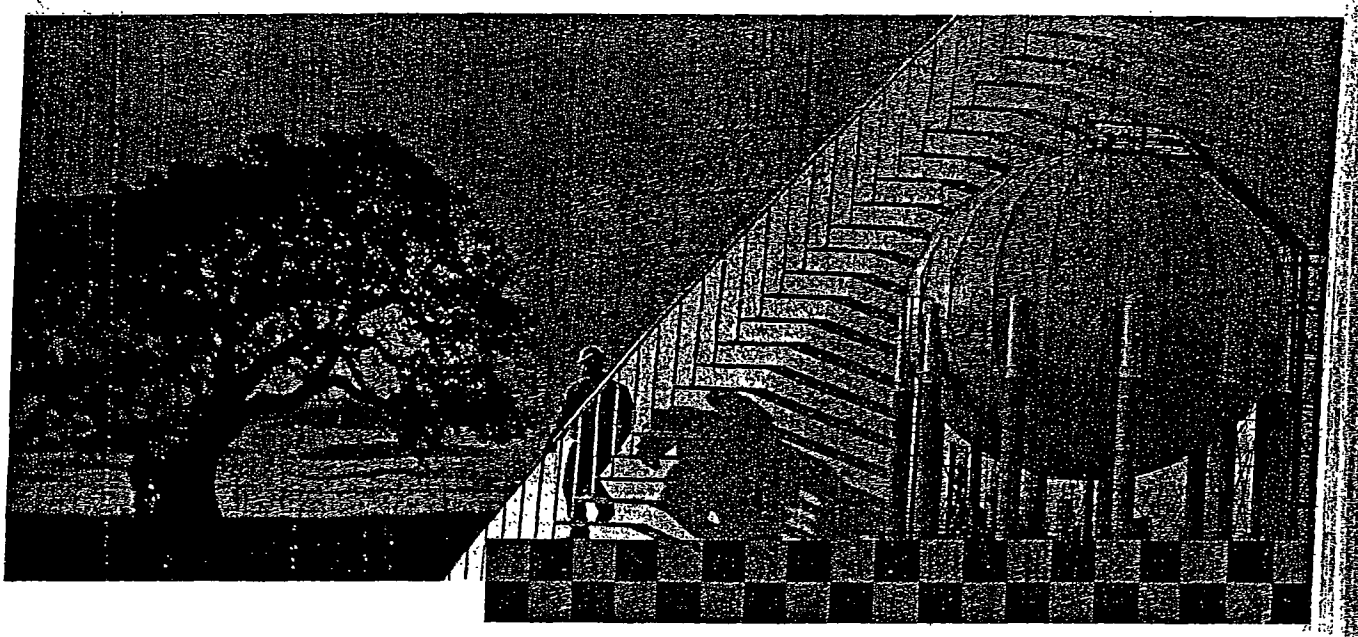
When 0.60 is entered into the 580 as the Response Factor, the 580 will read 55 ppm for the bag.

Now the 580 need only be calibrated using an isobutylene standard and a Response Factor of 0.60 to correctly respond to benzene.

VOC DETECTION

Photovac MicroFID

Portable Flame Ionization Detector



Instrument Manual

PerkinElmer™
instruments.

Calibration

General Information

MicroFID must be calibrated in order to display concentration in ppm units equivalent to the calibration gas. First a supply of zero air, which contains no ionizable gases or vapors, is used to set MicroFID's zero point. Then, calibration gas, containing a known concentration of an ionizable gas or vapor, is used to set the sensitivity.

Occasionally clean ambient air will be suitable as zero air. Due to MicroFID's sensitivity, outdoor air is usually unsuitable for calibration. A charcoal filter (Part No. MX396021, MX396022) may be connected to the instrument to produce clean air from otherwise unsuitable ambient air. For best results, use a commercial source of zero grade air and a second sampling bag. Zero air should have not more than 0.1 ppm total hydrocarbons (THC).

Methane in air is recommended as span gas. The concentration of the calibration gas will depend on your application. When ordering calibration gas, specify methane in hydrocarbon free air. Balance air should have not more than 0.1 ppm total hydrocarbons (THC).

Method 21 protocol requires that commercial cylinders of calibration gas be analyzed and certified to be within +/- 2% accuracy and that a shelf life must be specified on the cylinder. At the end of the shelf life, the cylinder must be replaced or re-analyzed.

Preparing the Calibration Gas Bag and the Zero Air Bag

Use the calibration kit (Part No. MX396011) as follows:

WARNING

Observe proper handling techniques for all gases! See Warnings and Safety Practices *on page 22.*

1. Connect the regulator to the calibration gas cylinder.

   If you are using a portable tank of calibration gas, connect the regulator supplied with the calibration kit.

   If you are using a large cylinder of calibration gas, you must obtain a high purity regulator as specified in *Support Equipment and Consumables* on page 28. Methane in air is usually supplied with a standard CGA 590 cylinder valve outlet. Obtain a regulator with the matching fitting. Connect the regulator to the tank of calibration gas.

NOTE: *Do not force the connection.*

Do not use Teflon tape with CGA fittings. In general, these fittings are designed for metal to metal sealing.

Do not use adapters to connect one CGA fitting to another type of CGA fitting. If the regulator does not match the outlet on your calibration tank, contact your specialty gas supplier.

2 Tighten the regulator onto the tank with a wrench. Do not over-tighten.

3. Attach the knurled nut on the gas bag adapter to the regulator. Finger-tighten the fitting.

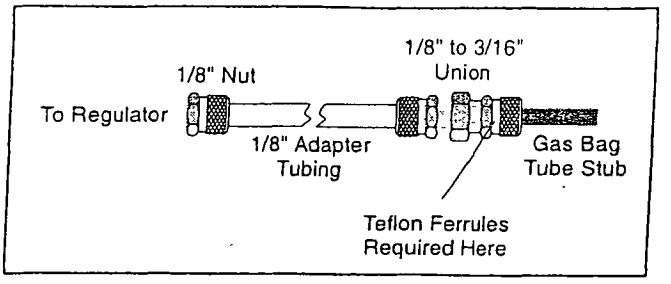


Figure 10 Gas Bag Adapter

4. Loosen the knurled nut on the reducing union of the gas bag adapter.

NOTE: *Do not remove the nut from the union, as the Teflon ferrules contained inside the nut may be lost. See* Figure 10.

5. Insert the tube stub from the gas bag into the knurled nut. Tighten the knurled nut and ensure the tube stub is secure. If the gas bag is not secure, ensure you have inserted the tube stub far enough into the knurled nut. Do not over tighten the fitting.

Over-tightening the Teflon ferrules will result in damage to the ferrules.

CAUTION

6. The union should be connected to the gas bag adapter. If it is not, then tighten the nut on the adapter tube to the union.

7. Open the gas bag valve. Turn the knurled plastic knob counter clockwise to loosen it, then use the knurled collar on the valve tube to gently push the valve tube toward the bag.

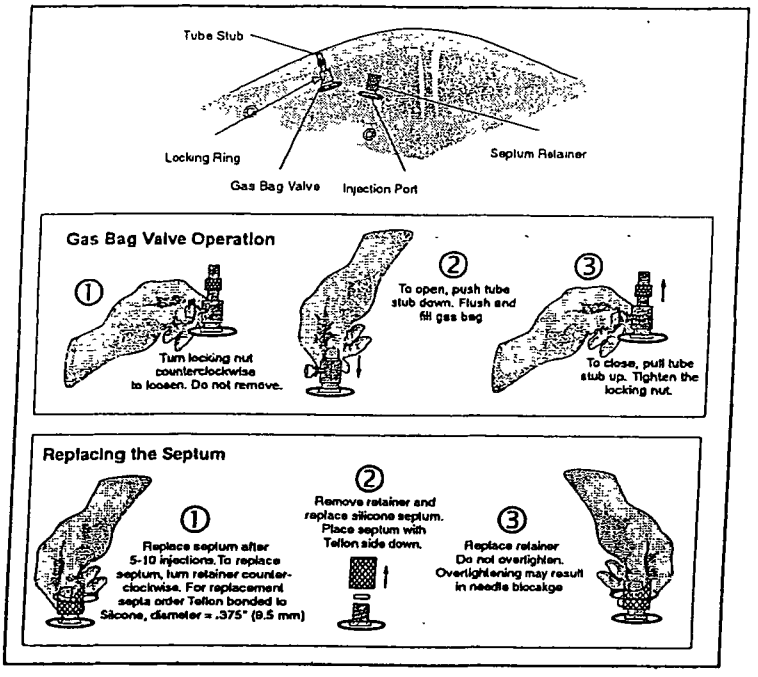


Figure 11 Using the Gas Bag

8. Turn the regulator knob counter clockwise about half a turn to start the flow of gas. Fill the gas bag about half full and then close the regulator.

9. Disconnect the gas bag from the gas bag adapter and empty the bag. Flush the bag a few times with the calibration gas and then fill it.

10. Close the gas bag valve. Gently pull the valve tube away from the bag, and then turn the knurled plastic knob clockwise to tighten it against the valve tube.

11. Remove the knurled nut on the adapter tube from the regulator.

12. Repeat this procedure, if necessary, to prepare a bag of zero air.

NOTE: *Do not use the same gas bag or gas bag adapter for the bag of zero air. You will contaminate the bag of zero air.*

Calibrating MicroFID

To calibrate MicroFID:

1. Press CAL and select the desired Cal Memory. MicroFID has 10 Cal Memories and can be calibrated with 10 different span gases or response factors if desired. Only one Cal Memory can be used at a time. Each Cal Memory stores a different response factor, zero point, sensitivity, and alarm level

2. Enter the desired response factor and press ENTER. Refer to *Response Factors* on page 148 for a list of Response Factors. If the compound is not in this list or you measuring gas mixtures then enter a value of 1.00. The concentration detected by MicroFID will be multiplied by the response factor before it is displayed and logged.

3. Select Low Range or High Range and press ENTER. Use Low Range if you are sampling concentrations between 0.5 and 2000 ppm (methane equivalents). Use High Range if you are sampling concentrations between 10 and 50,000 ppm (methane equivalents)

4. Connect the supply of zero air. If you are using room air press ENTER.

5. If you are using a charcoal filter, connect the filter as outlined in *Charcoal Filters* on page 95. Press ENTER and MicroFID will set its zero point.

NOTE: *The charcoal filter does not filter methane or ethane. If these compounds are present, use a gas bag with a supply of commercial zero air.*

6. If you are using a gas bag with zero air, connect the gas bag adapter to the inlet. Open the bag and press ENTER. MicroFID sets its zero point.

7. MicroFID then asks for the span gas concentration. Enter the known span gas concentration and then connect the gas bag adapter to the inlet. Open the bag.

8. Press ENTER and MicroFID sets its sensitivity.

NOTE: *Readings may fluctuate slightly as the gas bag empties. Do not allow the MicroFID to evacuate the bag completely.*

9. When MicroFID's display reverts to normal, it is calibrated and ready for use. Remove the span gas bag from the inlet.

10. Press the ALARM key and enter the alarm level for the selected Cal Memory.

Programming the Cal Memories

MicroFID has 10 Cal Memories and can be calibrated with 10 different span gases or response factors if desired.

To program the Cal Memories:

1. Prepare the bags of calibration gas as outlined in *Preparing the Calibration Gas Bag and the Zero Air Bag* on page 66. Use a different gas bag and gas bag adapter for each concentration and for each type of calibration gas.

   You can use the same gas bag to zero all the Cal Memories; however, you must refill the bag for each Cal Memory.

2. Press CAL and select the desired Cal Memory (1 to 10) with the ARROW keys.

3. Enter the desired response factor and press ENTER. See *Response Factors* on page 148.

NOTE: *It does not matter which Cal Memory is selected or which response factor is entered, MicroFID's response is not specific to any one compound. The reading displayed represents the total concentration of all ionizable compounds in the sample.*

4. Select the Low Range or High Range and press ENTER. The range will depend on the concentration of the calibration gas. Use Low range if you are sampling concentrations between 0.5 and 2000 ppm (methane equivalents). Use High Range if you are sampling

concentrations between 10 and 50,000 ppm (methane equivalents).

5. You will now be prompted to connect a supply of zero air. You can use ambient air, a charcoal filter (Part No. MX396021, MX396022) to clean ambient air or, for best results, use a clean sampling bag filled with zero grade air.

6. After MicroFID has set its zero point, you then enter the concentration of the calibration gas and then connect the calibration gas. MicroFID sets its sensitivity for the specified Cal Memory. The span gas concentration, response factor and alarm level entered here are specific to the selected Cal Memory only.

When the calibration is completed it is automatically stored in the selected Cal Memory.

7. Press the ALARM key and enter the alarm level for the selected Cal Memory.

8. Repeat this procedure for each Cal Memory you need.

When calibrating MicroFID, ensure the instrument is level. If MicroFID is tilted side to side, gravity will affect the flame height and cause erroneous readings

Whenever the instrument is calibrated, MicroFID updates the selected Cal Memory only. Each Cal Memory must be calibrated at least once a day. Frequency of calibration will depend on ambient conditions and instrument response. If ambient conditions change or the response has drifted, a calibration must be performed for each Cal Memory to ensure reliable operation.

High Sensitivity Operation

MicroFID can be used as a high sensitivity leak detector. In high sensitivity operation, MicroFID does not read in ppm units equivalent to the calibration gas, but displays a reading proportional to the total concentration of ionizable gases and vapors detected.

During calibration, no span gas is required. MicroFID zeros its reading with zero air and then sets itself to maximum sensitivity.

To use the High Sensitivity option:

1. Press SETUP. Select the 0-20 ppm display range with the ARROW keys and press ENTER.

2. Press CAL. Under Cal Memory, use the ARROW keys to select High Sensitivity and press ENTER.

3. Press EXIT. Select the bar graph with the DISPLAY key.

4. Press CAL and calibrate MicroFID with zero air. You should use a supply of commercial zero grade air and a gas sampling bag when zeroing MicroFID for high sensitivity operation.

As MicroFID samples air closer to the leak, the length of the shaded area on the display increases.

MicroFID's 3 second response time and detection limit of 0.5 ppm methane permit fast detection of small leaks.

Method 21 Operation

Method 21 is a US EPA protocol for the determination of volatile organic compound (VOC) leaks in process equipment. MicroFID has a Method 21 mode that facilitates Method 21 measurements. The STAR 21 Software (Part No. MX396027) provides more comprehensive data management consistent with the Method 21 protocol. Contact PerkinElmer for more information.

You must be familiar with the Method 21 protocol to use MicroFID for Method 21 monitoring. You must use the specifications outlined in the Method 21 documentation for programming MicroFID's Cal Memories and monitoring the sites.

As part of Method 21 operation, you must setup MicroFID to monitor various locations. Since each location may contain

different compounds and concentration ranges you will store a Cal Memory and the associated response factor and alarm level as part of each event. In this way you can sample numerous locations without having to re-calibrate MicroFID at each location.

You can enter the monitoring schedule in one of two methods. Regardless of the method you use to enter the monitoring schedule; you must calibrate the required Cal Memories before you enter the monitoring schedule.

Calibration

You must determine the number of calibration standards that will be required to perform Method 21 monitoring for your site. Refer to the Method 21 documentation for details.

To program your cal memories:

1. Prepare the bags of calibration gas as outlined in *Preparing the Calibration Gas Bag and the Zero Air Bag* on page 66. Use a different gas bag and gas bag adapter for each concentration and for each type of calibration gas.

   You can use the same gas bag to zero all the Cal Memories; however, you must refill the bag for each Cal Memory.

2. Press CAL and select the desired Cal Memory (1 to 10) with the ARROW keys.

3. Enter the desired response factor and press ENTER. See *Response Factors* on page 148.

NOTE: *It does not matter which Cal Memory is selected or which response factor is entered, MicroFID's response is not specific to any one compound. The displayed reading represents the total concentration of all ionizable compounds in the sample.*

4. Select the Low Range or High Range and press ENTER. The range will depend on the concentration of the calibration gas. Use Low Range if you are sampling concentrations between 0.5 and 2000 ppm (methane equivalents). Use High Range if you are sampling

concentrations between 10 and 50,000 ppm (methane equivalents).

5. Follow the displayed calibration instructions. When the calibration is completed it is automatically stored in the selected Cal Memory. The span gas concentration and response factor entered here are specific to the selected Cal Memory only.

6. Press the ALARM key and enter the alarm level for the selected Cal Memory.

Whenever the instrument is calibrated, MicroFID updates the selected Cal Memory only. Each Cal Memory must be calibrated at least once a day. Frequency of calibration will depend on ambient conditions and instrument response. If ambient conditions change or the response has drifted, a calibration must be performed for each Cal Memory to ensure reliable operation.

Programming the Monitoring Schedule in the Field

The easiest way of entering the Method 21 information is to go to each site and enter the required information. In this way, the schedule will be entered into the instrument in the exact manner in which it will be used.

To program the monitoring schedule:

1. Press the SETUP key. Press ENTER until "Interval" is displayed. Use the ARROW keys to select Method 21 as the Interval. Press ENTER.

2. You will be prompted to clear the datalogger. If you want to save the contents of the datalogger, press EXIT. You must print or save the data to disk. See *PRINT Key* on page 55, *GRAPH Key Mode* on page 58 or *Computer* on page 88 for details of printing or saving your data. Press ENTER to clear the datalogger.

3. Go to the first site to be monitored. You can enter the sites in any order; however, using the schedule after it has been

stored is easier if the sites are stored in the order in which they will be monitored.

4. Press the EVENT key. Use the ARROW keys to select "Insert". Press ENTER. Use the keypad to enter an event name up to 16 characters long. To obtain alphabetic characters you must use the STAR 21 software (Part No. MX396027).

   If your site is bar coded, use the ARROW keys to select "Scan". Press ENTER to activate the bar code reader. The bar code reader will remain activated until you scan a code. If no bar code is scanned within 15 seconds the bar code reader will be deactivated. See *Bar Code Reader* on page 103 for details of connecting the bar code reader to MicroFID.

   It is possible to enter an event name that already exists in the datalogger. When you select "Insert" or "Scan" you can enter the name of an event that already exists in the datalogger. MicroFID will not overwrite the existing event. It will insert an event with the same name. In this way you can create multiple copies of the same schedule in the datalogger. You can see the duplicate events when you print the contents of the datalogger.

5. Press the CAL key and select the calibration memory to be used for this site. Press ENTER and then press EXIT.

6. Press SETUP and enter a 2-digit repair code for this location. See *SETUP Key* on page 50 for a description of Repair code. This step is optional.

7. When you return to the default display, the instrument status will be "Locate". You should be at the site. If not, locate the site. If the event name is greater than 3 characters the bottom line of the display will scroll from right to left.

8. Once you have located the designated site, press ENTER. The instrument status will change to "BkGnd". A background measurement must be made as specified in the Method 21 protocol. When you have an accurate background, press ENTER. MicroFID will record the

maximum background concentration when you press the ENTER key.

9. The instrument status will now be "Sample". Take a sample measurement, as specified in the Method 21 protocol. When you have an accurate sample, press ENTER. MicroFID will record the maximum sample concentration when you press the ENTER key.

10. The instrument status will again be Locate. At this time, since there are no other locations stored in the datalogger the same event will be displayed.

11. Press EXIT at anytime to return to the beginning of the current event and repeat the readings.

12. To store the next location, go the next site and press the EVENT key. Select "Insert" or "Scan" to enter an event name.

13. Press the CAL key and select the calibration memory to be used for this site.

14. Press SETUP and enter a repair code for this location.

15. When you return to the default display, the instrument status will be "Locate". Record a background and sample reading for this site. You will now have two events recorded in the datalogger.

16. Repeat this procedure for all sites that must be monitored. You can record data for up to 250 sites.

17. Once all event entries have been recorded in the datalogger, you may want to download them to a computer to perform your own calculations.

End of Calibration Procedure

Response Factors for Gases and Vapors

In situations where only a single pure compound is present in air, MicroFID should be calibrated with a standard of that specific compound as span gas. MicroFID's 10 Cal Memories can be used to store calibration information for 10 different span gases.

MicroFID's reading will always be influenced by any other ionizable compounds present in the air sample. Even if MicroFID has been calibrated with a specific compound, its response is not specific and the presence of another ionizable impurity may render the numerical result invalid.

It is often impractical to carry a range of different standards into the field. Approximate results can be obtained by calibrating MicroFID with the recommended span gas and entering the appropriate response factor. The response factor is based on the ratio of the

response of the specific compound to the response of the span gas. The response factor multiplies MicroFID's reading then displays and records it (if the datalogger is on).

Response Factors on page 148 provides a list of response factors from which approximations can be made for guidance purposes. Data extrapolated from the use of response factors must be regarded as interim and approximate only. The response factors in the list should be used only for concentrations up to 500 ppm of the specific compound, as response factors change with concentration.

To use the response factors:

1. Press the CAL key and enter the response factor for the specific compound.

2. Calibrate MicroFID with zero air and 500 ppm methane as described in *Calibration* on page 65.

3. Expose MicroFID to the sample. The displayed reading is the approximate concentration of the specific compound.

The response factors on page 148 serve as a guide to concentrations measured by MicroFID.

Results are expected to be accurate to within +/-10 ppm or +/-25% of result, whichever is greater. Accuracy of response factors to other gases and vapors may differ from that stated.

NOTE: *It does not matter which Cal Memory is selected or which response factor is entered, MicroFID's response is not specific to any one compound. The displayed reading represents the total concentration of all ionizable compounds in the sample.*

Preparing for Field Operation

Field Check List

The following items should be carried into the field to reduce or eliminate instrument down time. If you will be in the field for a single 8-10 hour day, you should include the following accessories:

- Spare battery pack (Part No. MX396005 or MX396006)
- Long sample probe (Part No. MX396018)
- Calibration kit(s) (Part No. MX396011)
- Tank(s) of calibration gas (Part No. MX396028)
- Spare gas bag for zero air (Part No. MX396017)
- Gas bag adapter for zero air (Part No. MX396010)
- Supply of commercial zero air
- Charcoal filters (Part No. MX396021, MX396022)
- Shoulder strap (Part No. MX395002)
- Spare inlet filters (Part No. MX396020 or MX396015)
- Bar code reader and interface module (Part No. MX396054)
- Spare 9 volt battery for bar code reader
- Carrying case (Part No. MX396007)
- Headset (Part No. MX396053)
- MicroFID Instrument Manual (Part No. MX396003)

Table 3 Check List for Field Operation

If you will be in the field for more than one day you should include the following additional items:

• Battery chargers (Part No. MX396013 or MX396014). Take one charger for each battery pack.
• Hydrogen and refill adapter (Part No. MX396004)
• Printer cable (Part No. MX396051)
• Computer and associated cables

Table 4 Additional Field Items

Operational Check List

Before beginning field work, set up and calibrate MicroFID for your particular application. Ensure the instrument is in working order before heading into the field.

To prepare MicroFID for field work:

1. Ideally, you should not transport MicroFID with the hydrogen cylinder filled. If it is possible to fill the internal hydrogen cylinder when you arrive at your destination then do so. If not, then you must fill the cylinder before you leave and observe all precautions for handling compressed, flammable gases. See *Warnings and Safety Practices* on page 22.

   If you are travelling by passenger aircraft, you must make arrangements to fill the hydrogen cylinder when you arrive at your destination. You cannot transport MicroFID by passenger aircraft unless the internal hydrogen cylinder is empty. See *Emptying the Hydrogen Cylinder* on page 110 more information.

2. Press the BATT key and ensure the battery pack is fully charged. The voltage should be 9 volts.

3. Press the SETUP key and ensure the correct date and time are entered.

4. Program and calibrate all the Cal Memories you will be using. See *Calibration* on page 65. After calibration is complete, sample the bag of calibration gas and the bag of zero air to ensure MicroFID has been calibrated correctly.

5. Press the MAX key and clear the Max register if necessary.

6. If you are using an averaging interval, you may also want to delete all events from the datalogger to avoid confusion between different days' data and to avoid running out of space in the datalogger. See *EVENT Key* on page 51.

7. If you are performing Method 21 monitoring ensure you have programmed and calibrated all the Cal Memories. You must also program your monitoring schedule. See *Method 21 Operation* on page 72 for more information.

Dräger-Röhrchen 81 01 721 Vinylchlorid 0,5/b

DEUTSCH

Gebrauchsanweisung 234-8101721 · 6. Ausgabe · November 2000

Anwendungsbereich
Bestimmung von Vinylchlorid in Luft oder technischen Gasen.

Funktionsweise
Das Prüfröhrchen enthält zwei Schichten: eine hellbraune Vorschicht und eine weiße Anzeigeschicht.
Wird Luft oder eine Gasprobe durch das Röhrchen gesaugt, verfärbt sich die Anzeigeschicht violett unter Einfluß von Vinylchlorid.

Reaktionsprinzip
Vinylchlorid + Chromat ⟶ Cl_2
Cl_2 + Dimethylnaphtidin ⟶ violettes Reaktionsprodukt

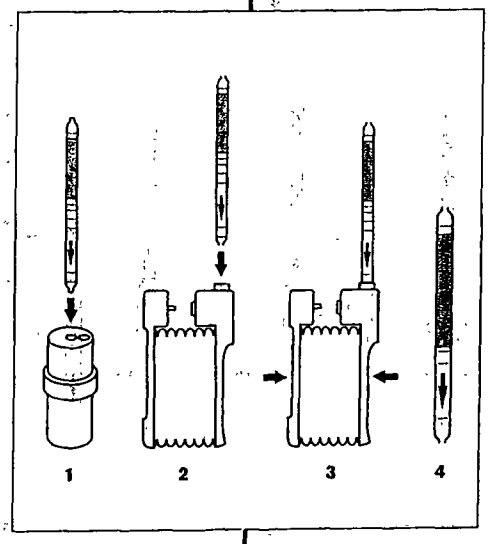
Umgebungsbedingungen
- Temperatur: 10°C bis 30°C.
- Feuchtigkeit: max. 20 mg/L (entspr. 100% r.F. bei 23°C).
- Luftdruck: zur Korrektur die Anzeige mit Faktor F multiplizieren.

$$F = \frac{1013}{\text{tatsächlicher Luftdruck (hPa)}}$$

Voraussetzungen
- Röhrchen nur zusammen mit folgenden Dräger-Pumpen verwenden: Modell 21/31, accuro, accuro 2000 oder Quantimeter 1000. Bei Verwendung anderer Pumpen kann es zu erheblichen Meßfehlern kommen.
- Gebrauchsanweisung der Pumpe beachten.
- Vor jeder Meßreihe die Pumpe mit ungeöffnetem Röhrchen auf Dichtheit prüfen.
- Meßwert gilt nur für Ort und Zeitpunkt der Messung.

Messung durchführen und auswerten
1 Beide Spitzen des Röhrchens im Röhrchen-Öffner abbrechen.
2 Röhrchen dicht in die Pumpe einsetzen. Pfeil zeigt zur Pumpe.
- Meßbereich wählen:
  0,5 bis 5 ppm (5 Hübe, Skale n = 5)
  5 bis 30 ppm (1 Hub, Skale n = 1)

3 Luft- oder Gasprobe durch das Röhrchen saugen. Meßdauer: bei 1 Hub ca. 30 Sekunden.
4 Gesamte Länge der violetten Verfärbung ablesen.
- Wert mit dem Faktor F für die Luftdruckkorrektur multiplizieren.
  Ergebnis im Meßprotokoll notieren.
  Relative Standardabweichung: ± 15% bis 20%.
- Mögliche Querempfindlichkeiten beachten.
- Pumpe nach Gebrauch mit Luft spülen.



TRK-Wert (D 1998): 3 bzw. 2 ppm Vinylchlorid
1 ppm Vinylchlorid = 2,6 mg Vinylchlorid/m³
1 mg Vinylchlorid/m³ = 0,38 ppm Vinylchlorid (bei 20°C, 1013 hPa)

Querempfindlichkeiten
- 100 ppm Chlorwasserstoff, 20 ppm Chlor, 10 ppm Tetrachlorkohlenstoff, 10 ppm Chloroform oder 5 ppm Perchlorethylen werden nicht angezeigt.
- Trichlorethylen und Chlorbenzol werden mit geringerer Empfindlichkeit angezeigt.
- 1,1-Dichlorethylen wird mit ca. gleicher Empfindlichkeit angezeigt.
- Unter Einfluß von Dämpfen organischer Lösemittel wird ein Teil der Oxidationsschicht verbraucht, die Anzeige fällt entsprechend niedriger aus.
  Beispiele: 5 ppm Vinylchlorid + 100 ppm Butadien
  5 ppm Vinylchlorid + 10 ppm Ethylen
  Anzeige: 0,5 ppm Vinylchlorid

Entsorgen
Hautkontakte mit der Füllmasse vermeiden: Inhalt ätzt.
Sicher vor Unbefugten lagern. Beim Entsorgen Sicherheitsratschläge S 2-13-20-21-22-26-28-30-44 beachten. Benutzte Röhrchen und Röhrchen mit überschrittener Verbrauchszeit können in der Verpackung an die Dräger Sicherheitstechnik GmbH zurückgegeben werden.

Weitere Informationen
Auf der Verpackungsbanderole finden Sie Bestellnummer, Verbrauchsdatum, Lagertemperatur und Seriennummer. Bei Rückfragen die Seriennummer angeben. Weiterführende Informationen über die Gasanalyse mit Dräger-Röhrchen auf Anforderung.

Dräger Tube 81 01 721 Vinyl Chloride 0.5/b

ENGLISH

Instructions for Use 234-8101721e · 6th Edition · November 2000

Application Range
Determination of vinyl chloride in air or technical gases.

Mode of Operation
The tube contains two layers: a light-brown pre-layer and a white indicating layer. When air or a gas sample are sucked through the tube, the indicating layer changes colour to violet in the presence of vinyl chloride.

Principle of Reaction
Vinyl chloride + chromate ⟶ Cl_2
Cl_2 + dimethyl naphtidine ⟶ violet reaction product

Ambient Conditions
- Temperature: 10°C to 30°C.
- Humidity: max. 20 mg/L (corresp. 100% r.h. at 23°C).
- Atmospheric pressure: for correction of the reading, multiply by factor F.

$$F = \frac{1013}{\text{actual atmospheric pressure (hPa)}}$$

Prerequisites
- The tubes may only be used in conjunction with the following Dräger Pumps: Model 21/31, accuro, accuro 2000 or Quantimeter 1000. Should other pumps be used, this may result in considerable measurement errors.
- Observe the Instructions for Use of the pump.
- Before each series of measurement, check the pump for leaks with an unopened tube.
- The measured value is applicable only to the place and date of measurement.

Measurement and Evaluation
1 Break off both tips of the tube in the tube opener.
2 Insert the tube tightly in the pump. Arrow points towards the pump.
- Selecting the measuring range:
  0.5 to 5 ppm (5 strokes, scale n = 5)
  5 to 30 ppm (1 stroke, scale n = 1)

3 Suck air or gas sample through the tube. Measuring period: for 1 stroke approx. 30 seconds.
4 Read the entire length of the violet discoloration.
- Multiply the value by factor F for correction of the atmospheric pressure.
  Enter the result in the measurement record.
  Relative standard deviation: ± 15% to 20%.
- Observe possible cross sensitivities.
- Flush the pump with air after operation.

TLV (USA 1999): 1 ppm Vinyl Chloride
1 ppm vinyl chloride = 2.6 mg vinyl chloride/m³
1 mg vinyl chloride/m³ = 0.38 ppm vinyl chloride (at 20°C, 1013 hPa)

Cross Sensitivities
- 100 ppm hydrogen chloride, 20 ppm chlorine, 10 ppm carbon tetrachloride, 10 ppm chloroform or 5 ppm perchloroethylene are not indicated.
- Trichloroethylene and chlorobenzene are indicated with less sensitivity.
- 1.1-dichloroethylene is indicated with almost identical sensitivity.
- Vapours of organic solvents consume part of the oxidation layer so that the resultant reading is somewhat lower.
  Examples: 5 ppm vinyl chloride + 100 ppm butadiene
  5 ppm vinyl chloride + 10 ppm ethylene
  Reading: 0.5 ppm vinyl chloride

Disposal
Avoid skin contact with the tube filling. Contents are corrosive.
Keep out of reach of unauthorized persons. For disposal, observe safety recommendations S 2-13-20-21-22-26-28-30-44.

Additional Information
The package strip indicates order number, shelf life, storage temperature and serial number. State the serial number for inquiries. Further information with respect to gas analysis with Dräger tubes will be submitted on request.

Dräger Sicherheitstechnik GmbH · Germany · Revalstraße 1 23560 Lübeck

Attachment G

Environmental Monitoring Record

ATTACHMENT G
ENVIRONMENTAL MONITORING RECORD

SITE: NCBC Davisville Site 16 Project No. 29601.07.3101

INSTRUMENT: _____

CALIBRATION: Gas: _____ Conc: _____ Span: _____

Time	Monitoring Location	Reading	Corrective Action Taken[a]

Comments:

(a) Corrective actions taken must be documented whenever readings at or above action levels are reached.

Recorded By: _____

Site Health and Safety Officer Date

Attachment H

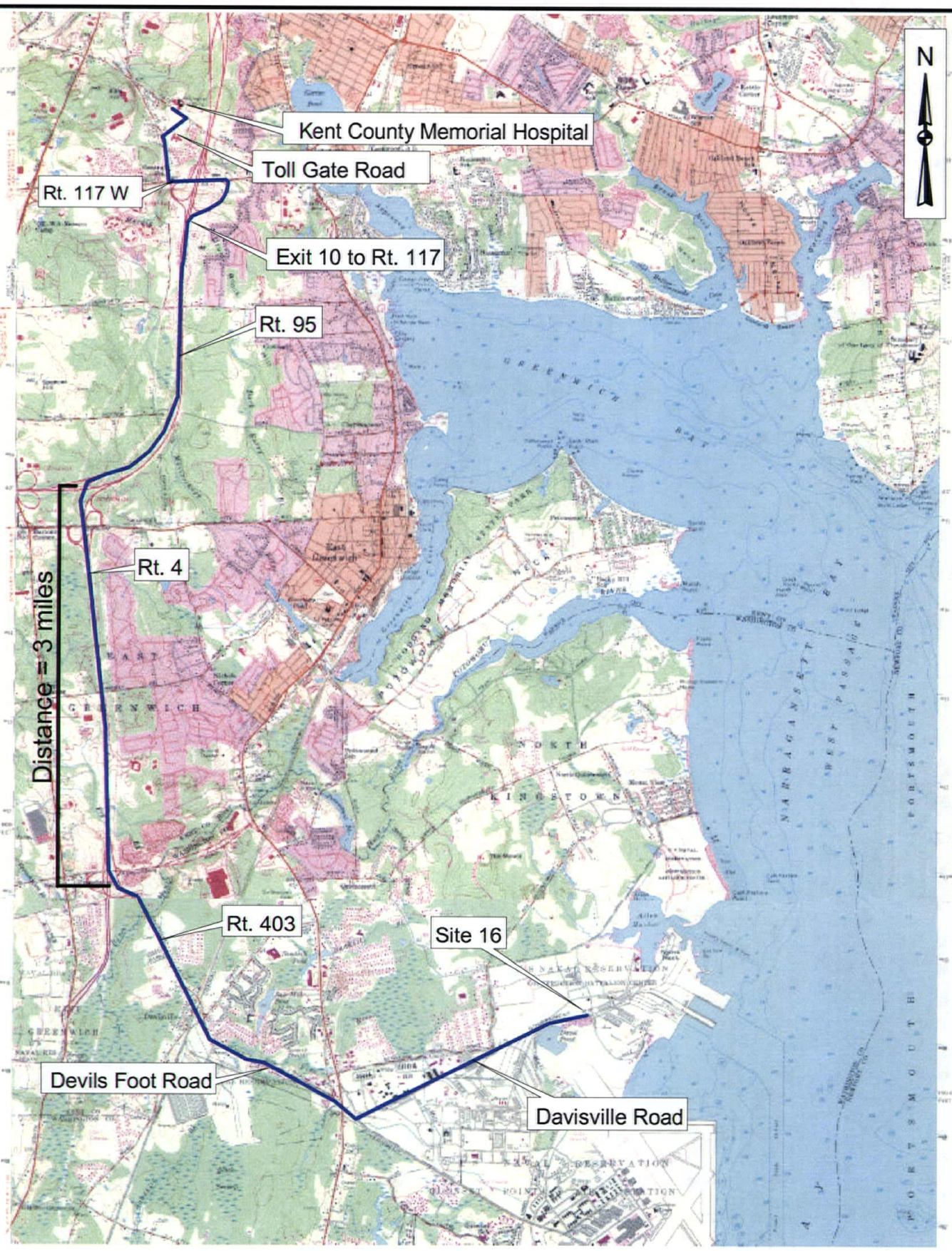
Site Entry and Exit Log

ATTACHMENT H
SITE ENTRY AND EXIT LOG

Date	Name	Representing	Time	
			In	Out

Attachment I

Road Map from the Site to the Hospital



EA ENGINEERING, SCIENCE AND TECHNOLOGY, INC.

EFANE
Site 16 HRC Injection Pilot Test
Former NCBC Davisville Facility
North Kingstown, Rhode Island

HOSPITAL ROUTE MAP

Attachment J

Accident Investigation Report

ACCIDENT/LOSS REPORT

THIS REPORT MUST BE COMPLETED BY THE INJURED EMPLOYEE'S SUPERVISOR AND FAXED TO EA CORPORATE HUMAN RESOURCES WITHIN 24 HOURS OF ANY ACCIDENT. THE FAX NUMBER IS (410) 771-1780.

NOTE: WHENEVER AN EMPLOYEE IS SENT FOR MEDICAL TREATMENT FOR A WORK RELATED INJURY OR ILLNESS, PAGE 4 OF THIS REPORT MUST ACCOMPANY THAT INDIVIDUAL TO ENSURE THAT ALL INVOICES/BILLS/CORRESPONDENCE ARE SENT TO CORPORATE CENTER FOR TIMELY RESPONSE.

DATE OF ACCIDENT: _____ TIME OF ACCIDENT: _____

EXACT LOCATION WHERE ACCIDENT OCCURRED (including street, city, and state): ____

_____

_____

_____

NAME OF INJURED EMPLOYEE: _____

HOME ADDRESS: _____

HOME PHONE: _____ DATE OF BIRTH: _____ AGE: _____ SEX: ☐ MALE ☐ FEMALE MARITAL STATUS: _____

SOCIAL SECURITY NUMBER: _____ DATE OF HIRE: _____

NUMBER OF DEPENDENTS: _____

EMPLOYEE JOB TITLE: _____

DEPARTMENT IN WHICH REGULARLY EMPLOYED: _____

EXPLAIN WHAT HAPPENED (include what the employee was doing at the time of the accident and how the accident occurred): _____

_____

_____

_____

_____

_____

_____

DESCRIBE THE INJURY AND THE SPECIFIC PART OF THE BODY AFFECTED (i.e., laceration, right hand, third finger, second joint): _____

_____

_____

OBJECT OR SUBSTANCE THAT DIRECTLY INJURED EMPLOYEE: _____

_____

NAME AND ADDRESS OF THE PHYSICIAN (if medical attention was administered): _____

_____

_____

* PLEASE ATTACH THE PHYSICIAN'S WRITTEN RETURN TO WORK SLIP *

NOTE: A PHYSICIAN'S RETURN TO WORK SLIP IS REQUIRED PRIOR TO ALLOWING THE WORKER TO RETURN TO WORK.

IS THE EMPLOYEE EXPECTED TO LOSE AT LEAST ONE FULL DAY OF WORK? ____
WAS THE EMPLOYEE ASSIGNED TO RESTRICTED DUTY? _____
NUMBER OF DAYS AND HOURS EMPLOYEE USUALLY WORKS PER WEEK: _____
LIST ALL PPE EMPLOYEE WAS WEARING AND ALL SAFETY DEVICES IN USE AT THE TIME OF THE ACCIDENT: _____

_____

_____

_____

DESCRIBE THE PREVENTIVE MEASURES TAKEN TO AVERT A RECURRENCE OF THIS TYPE OF INCIDENT: _____

_____

_____

_____

_____

_____

DATE WHEN MEASURES WERE IMPLEMENTED AND BY WHOM: _____

_____

AUTOMOBILE ACCIDENT INFORMATION

AUTHORITY CONTACTED AND REPORT NO.: _____
EA EMPLOYEE VEHICLE YEAR, MAKE, AND MODEL: _____
V.I.N.: _____ PLATE/TAG NO: _____
OWNER'S NAME AND ADDRESS: _____

_____

_____

DRIVER'S NAME AND ADDRESS: _____

_____

_____

RELATION TO INSURED: _____ DRIVER'S LICENSE NO.: _____
DESCRIBE DAMAGE TO YOUR PROPERTY: _____

_____

_____

DESCRIBE DAMAGE TO OTHER VEHICLE OR PROPERTY: _____

_____

OTHER DRIVER'S NAME AND ADDRESS: _____

OTHER DRIVER'S PHONE: _____

OTHER DRIVER'S INSURANCE COMPANY AND PHONE: _____

LOCATION OF OTHER VEHICLE: _____

NAME, ADDRESS, AND PHONE OF OTHER INJURED PARTIES: _____

WITNESS

NAME: _____ PHONE: _____

ADDRESS: _____

STATEMENT: _____

SIGNATURE: _____

NAME: _____ PHONE: _____

ADDRESS: _____

STATEMENT: _____

SIGNATURE: _____

DATE OF THIS REPORT: _____ REPORT PREPARED BY: _____

I have read this report and the contents as to how the accident/loss occurred are accurate to the best of my knowledge.

Signature: _____ Date: _____

Injured Employee

I am seeking medical treatment for a work related injury/illness.

Please forward all bills/invoices/correspondence to:

EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.

CORPORATE OFFICE

11019 MCCORMICK ROAD

HUNT VALLEY, MD 21031

ATTENTION: Patricia Noppenberger

(410) 771-1625

INCIDENT REPORT

THIS REPORT IS TO BE COMPLETED WHEN A NEAR MISS OCCURS THAT COULD HAVE POTENTIALLY RESULTED IN SERIOUS PHYSICAL HARM. PLEASE FAX THIS FORM TO EA CORPORATE SAFETY AND HEALTH DEPARTMENT AT (630) 574-3060, ATTN: CLAY BOCK.

EXPLAIN WHAT HAPPENED (include what the employee was doing at the time of the near miss and how it occurred): _____

REPORT PREPARED BY: _____ DATE: _____

Revised 04\26\94

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

Southborough Technology Park
333 Turnpike Road
Southborough, MA 01772
Tel. 508-485-2982
Fax. 508-485-5742

LETTER OF TRANSMITTAL

TO:
Fred Evans
EFANE (Code 1823/FE)
North Loop & American Way, Building G
Lester, PA 19113-2090
(610) 595-0567 Ext. 159

DATE: 8 December 2003	JOB NO. 29601.07.3101
ATTENTION: Fred Evans	
RE: RTC to QAPP for HRC Injection Pilot Study, Site 16, NCBC Davisville, North Kingstown, RI	
Contract No. N6247-92-D-1926, CTO 107	

WE ARE SENDING YOU [X] Attached [ ] Under separate cover via _____ the following items:

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications
[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
3	December 2003		Navy's Responses to EPA's & RIDEM's Comments QAPP for HRC Injection Pilot Study, Site 16, NCBC Davisville, North Kingstown, RI

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit _____ copies for approval

[X] For your use [ ] Approved as noted [ ] Submit _____ copies for distribution

[ ] As requested [ ] Returned for corrections [ ] Return _____ corrected prints

[X] For review and comment [ ] _____

[ ] **FOR BIDS DUE** _____ 19_____ [ ] PRINTS RETURNED AFTER LOAN TO US
REMARKS

Fred,
The enclosed copy of the referenced responses to comments is for your use and file.
At your request and on behalf of the Navy, we have provided copies to the BCT for their review and consideration.
Thank you,

COPY TO _____**See Below**_____ **SIGNED** _____
JIM SHULTZ, CTO MGR

D. Barney – NCBC CSO (1 copy), C. Williams – EPA (5 copies), R. Gottlieb – RIDEM (1 copy),
S. King – RIEDC (1 copy), M. Cohen – ToNK (1 copy), K. Campbell – CDW Consultants (2 copies),
K. Carr – USF&W (1 copy), K. Finkelstein – NOAA (1 copy), J. Shultz – EA Boston (1 copy), R. Clark – EA Boston (1 copy),
F. Barranco – EA Loveton (1 copy), Project File – EA Boston (1 copy), K. Kilmer – EA PMO (1 copy),
B. Lesinski – EA PMO (w/o enclosure)

If enclosures are not as noted, kindly notify us at once

RESPONSES TO EPA COMMENTS DATED 16 OCTOBER 2003 ON THE SITE 16 QAPP FOR HRC INJECTION PILOT STUDY NAVAL CONSTRUCTION BATTALION CENTER DAVISVILLE NORTH KINGSTOWN, RHODE ISLAND

NAVY'S GENERAL RESPONSE (PILOT STUDY CONSIDERATIONS AND DESIGN)

The proposed location of the HRC® injection pilot test was selected based on the available site data to test the general feasibility and overall applicability of *in situ* HRC® injection within a pilot scale field test located near the southwestern (upgradient) extent of the >1,000 µg/L portion of the detected CVOC plume (vicinity of former Building 41) to enhance biodegradation rate of the CVOC. This location would result in minimizing the amount of the detected >1,000 µg/L CVOC plume that would be located upgradient of the pilot test area. Also, the location was selected to maximize the degree of CVOC plume area cutoff and, therefore, to optimize subsequent downgradient biological attenuation effects as HRC® is transported within the aquifer. The observed concentration of total CVOC in this area (maximum of 6,200 µg/L and 2,700 µg/L of TCE at MW16-15D during the Phase I and II investigations, respectively) is reflective of dissolved-phase and sorbed-phase (to aquifer solids) CVOC mass. Based on the available site data, we do not believe that the CVOC concentrations detected in deep ground water represent the presence of DNAPL. The Phase II investigation data indicate a decrease in total CVOC concentration from the proposed test area to 23-53 µg/L approximately 100 ft toward the southeast and to 23–211 µg/L approximately 150–100 ft toward the southwest and west. Assuming an approximately 50-yr-old release, this suggests that if there is a high concentration undetected source area (DNAPL) nearby, it apparently attenuates quickly over a relatively short distance to the nearby existing monitoring wells. Given the short distance of attenuation, this scenario is not realistic, and is possible only if intrinsic biodegradation is actively occurring. However, the monitored natural attenuation scoring performed for the Phase II investigation does not support a scenario with significant intrinsic biodegradation. These findings, therefore, do not support the existence of a potential undetected DNAPL 'source area'.

Through the installation and baseline sampling of the monitoring and injection wells for the proposed pilot test, the understanding of the site character would be significantly increased. If the baseline sample results were to indicate the presence of a high concentration source area (DNAPL) at one or more of these new wells, the design and type of the pilot test would be reconsidered. Unfortunately, relocating the pilot test area would not seem to allay the EPA concern for a potential undetected nearby 'source area', because this problem would seem to be present almost no matter where the pilot test could be relocated within the main detected CVOC plume area.

Regarding a concern that the detected TCE concentrations are too high for the proposed pilot test, numerous field and laboratory enhanced bioremediation studies (see, for example, Selected Battelle Conference Papers 1999-2000 *in Accelerated Bioremediation of Chlorinated Compounds in Groundwater*, Edited by Stephen Koenigsberg) have shown that dissolved CVOC concentrations observed as high as 10 mg/L are directly susceptible to anaerobic biodegradation

pathways. Therefore, the concentration of TCE and other CVOCs detected beneath the northeast end of the former Building 41 are not deemed as too high in concentration to assess the potential for and applicability of an enhanced bioremediation remedy via the proposed pilot test. Based on this information, no change is recommended for the location of the pilot test.

Based upon the available site data and the results of the "Preliminary Identification and Screening of Remedial Action Technologies IR Program Site 16, NCBC Davisville, North Kingstown, Rhode Island" dated September 2003 prepared by EA for the Navy, the Navy selected a pilot test of HRC® injection to evaluate this technology for potential future remediation of the CVOC in deep ground water at the site. The primary objective of the proposed HRC® pilot test is to directly assess the overall site-specific efficacy, site-specific ability to deliver the HRC®, and the rate of performance of enhanced bioremediation as a ground-water plume area cutoff technique (thus sufficient number of wells to reach across the plume; Figures 2 and 5 in the Draft QAPP), and secondarily, as a by-product of the pilot test, to significantly decrease the CVOC concentration in the upgradient (southwestern) portion of the CVOC plume area. The objectives would include quantification of the parameters necessary to optimize enhanced bioremediation, such as biodegradation rates, the ratio of daughter products, and the mass of HRC that would be required for implementation of this remedy method. Both the deep and rock ground-water zones were targeted in the pilot testing because the majority of the detected CVOC mass is located in these ground-water zones. However, the Navy proposes to revise the pilot test to include injection into only the deep overburden ground-water zone using the 12 locations originally planned.

As stated during the Navy's 2 October 2003 telephone conference call with EPA and RIDEM project team members, the 4-month pilot test presented in the draft QAPP was stated because it is the maximum period that could be completed and reported within the remaining time of EA's CLEAN II contract. However, this does not preclude the Navy continuing the test sampling/ monitoring field activity/data collection with another Navy contractor beyond the 4 months stated in the draft QAPP. Secondly, in general terms, a 4-month test is on the short end of HRC® pilot test duration as recommended by Regenesis. The average HRC® test duration as recommended by Regenesis is 6 months to 1 year, though this is not to say that shorter duration tests with HRC® have not been applied. The experience of Regenesis (personal communication through several conference calls regarding the pilot test design) is, however, that the geochemical alteration of the subsurface environment (to reducing conditions) and the acclimation of intrinsic microorganisms will occur within an approximate 3-month period, particularly with the use of HRC® Primer, which has an accelerated release capacity. Therefore, the evaluation criteria for the success of the pilot test over a 4-month period were proposed as stated (geochemical conversion of ground water and the onset of CVOC decline) in the draft QAPP to indicate realistic expectations for that period. However, the QAPP will be revised to include a 12-month pilot test that will begin with EA and will be completed by another Navy contractor.

The design of the pilot test is based on the use of "HRC® Design Software for Barrier Treatment" by Regenesis. All available design information and software from Regenesis was accessed and utilized to design the HRC® pilot test for Site 16. In addition, several direct conversations with Regenesis technical support were conducted to evaluate site-specific factors

and test objectives. The pilot test design information (specifically the portion for the deep overburden ground-water zone) is provided as Attachment 1 to these responses to comments. The available Phase I and II slug test data, particularly that for existing wells (MW16-14D, MW16-15D, and MW16-32D) located in the proposed pilot test area, were used to estimate the range of potential transport velocities of ground water and to assess test design criteria for emplacement and transport of HRC® reagent within the deep and rock ground-water zones. The range of potential ground-water linear velocities (approximately 0.3 to 1 ft/day) was established based on review of this data. The test design criteria including injection well locations (two rows of 6 well pairs), monitoring well locations, and well spacing were originally developed based on this potential range of velocities for a 4-month pilot test duration. Although the HRC injection wells in a given injection well row are proposed on 20-ft centers (see QAPP Figure 5), the offset location of the injection wells in the adjacent downgradient row allows for an effective transverse spacing between injection wells of 10 ft. Two rows of injection wells were designed to optimize ground-water contact with emplaced HRC® reagent. The radius of influence for each injection well, therefore, was designed for approximately 5 ft. This radius of influence was determined based on site-specific information and the experience of Regenesis with HRC® injection.

Monitoring well locations were selected along and transverse to the direction of interpreted ground-water flow at varying distances from the injection array to observe the results from the injection event, ranging from locations between the 2 rows of injection wells to a maximum of approximately 200 ft downgradient (northeast) from the injection wells. Use of these distances was based on the assumption that some of the material might advance laterally with ground water flowing at the slowest estimated rates and some at the fastest estimated rates in the injection pilot test vicinity. Monitoring of both the deep overburden (D) and upper bedrock (R) ground-water zones is still proposed for the revised pilot test. The injection well array was positioned so 4 of the exiting wells could be used, decreasing the number of new monitoring wells needed. Additionally, monitoring wells screened in the intermediate (I) and shallow (S) ground-water zones will be added to the 7 monitoring well clusters located nearest the injection well array (i.e., those located between and just northeast of the injection well rows) to monitor for the formation and upward migration of vinyl chloride (VC) as a degradation product. VC will also be monitored for in existing wells MW16-14I, -16I, -21I, and -22I. The production of VC is expected; however, Regenesis' experience has been that this occurs several months after the injection of the HRC® and continues over a relatively short time (a few months). It is important to note that the elevated VC concentrations are only temporary and short-lived. Currently, the ground surface of the pilot test area is paved or grass covered and contains no buildings. If VC is found to be migrating upward so as to result in an unacceptable release to the atmosphere, it could be addressed, for example, by the injection of ORC® to accelerate the degradation of the VC.

EPA's GENERAL COMMENTS

EPA does not concur with the proposed HRC Injection Pilot Study. There are several issues that are described in detail in the paragraphs below. The first concern is that the proposed study has the potential to generate significant mass of vinyl chloride in site groundwater if the degradation

process is successful. A second concern is that the pilot study has not been designed rigorously enough to yield significant useful data. An additional concern is that the proposed location of the study is in a potential zone of discharge of chlorinated volatile organic compound (CVOC) contamination emanating from an up gradient location. A fourth concern is that the proposed "pilot study" actually appears to be a full-scale remedial effort.

Comment 1: Vinyl Chloride Generation

The QAPP mentions in several locations that while vinyl chloride will be generated, its production is not a concern. In particular, it refers to the existing vinyl chloride present in site groundwater as a result of ambient degradation of CVOC contaminants. Review of the Phase II Remedial Investigation, however, indicates that vinyl chloride in groundwater is limited primarily to the "Central Area" of Site 16 with the highest concentrations being detected at 36 micrograms per liter (µg/L) at MW16-41S. Down gradient of the proposed pilot study location the highest vinyl chloride concentrations were found at MW16-29D which had a measured concentration of 1.0 µg/L.

Review of the literature for HRC® indicates that significant vinyl chloride will be produced if the material is successful at degrading trichloroethylene (TCE). An example is the case study supplied in the HRC® literature contained in Attachment 1. The case study "Enhanced Bioremediation of TCE at Department of Defense Landfill Site" includes a depiction on a graph titled "VOC Concentration Graph Down gradient Monitoring Well 14." This graph shows depletion of 135 milligrams (actually micrograms?) per liter (mg/L) of TCE and 101 mg/L of DCE with subsequent generation of approximately 30 mg/L of vinyl chloride. This occurred in 372 days (approximately one year) with only one injection of HRC®. This suggests a conversion ration of approximately 13% of the TCE/DCE mass to vinyl chloride. Ultimately, vinyl chloride may be converted to innocuous end products. However, in the interim, this data suggests that extremely high concentrations of vinyl chloride may be produced upon implementation of this pilot study.

The proposed study is targeted for a location where TCE has recently been detected at a concentration as high as 6,300 µg/L of CVOC. This concentration was found in groundwater at MW16-15D. Conversion of this TCE mass to vinyl chloride at the ratio provided on the literature graph will result in a value of 819 µg/L. Conversion of TCE to this concentration of vinyl chloride represents a potentially far greater risk to down gradient receptors than the TCE. In addition, the mobility of vinyl chloride is faster than TCE and will likely migrate relatively rapidly away from the pilot study area. Further, the Navy appears to be of the opinion that a source exists at the northeast end of the former Building 41 where they have suggested that solvents were either dumped to the ground or into a storm catch basin. If that is the case, then the concentrations of TCE in the source area are likely to be higher than those detected in down or cross gradient monitoring wells with associated higher concentrations of vinyl chloride.

Response— Please refer to the last paragraph of the Navy's General Response to EPA's comments.

Comment 2: Pilot Study Basis of Design

There are several concerns related to the basis of design for this pilot study. These concerns are related to the stated objectives, design values used or not provided, and pilot study layout. While a layout of wells has been provided, and literature from the vendor enclosed in the attachments, there is no accompanying design information and no reference to any other literature other than that provided by the vendor, even though guidance documents and literature articles providing design guidelines have been published and are readily available. Regenesis provides basic instruction for design of HRC® application. At a minimum, this analysis should be provided in an attachment to support the proposed pilot study. From review of the QAPP it is not clear that the proposed HRC® injection pilot study will yield significantly meaningful data commensurate with the expenditure of funds.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 2A: Seepage Velocity

The design of the pilot study relies on several parameters as detailed in the Regenesis HRC® literature and software program (Version 3.1, 2002). Included as input parameters are values of hydraulic conductivity, contaminant concentration, and contaminant mass. In particular, the QAPP states that it used a value of 1 foot per day for "time of HRC® release dosing requirements and injection well spacing." However, review of the data in the Phase I and Phase II Remedial Investigations appears to show a conflict with that value.

The geometric mean of the hydraulic conductivity values for the monitoring wells within the area of the proposed pilot test is approximately 13.5 feet/day. This value is for MW16-14D, MW16-15D, MW16-21D, MW16-22D, and MW16-32D (Table 3-5 of the Phase II Remedial Investigation). The hydraulic gradient through the site area from MW16-32D to MW16-21D and/or MW16-22D is approximately 0.006 feet/foot. Using an effective porosity of 0.25 this results in a groundwater seepage velocity of approximately 0.324 feet/day, not 1 foot/day.

However, even this value is somewhat uncertain when using the values of hydraulic conductivity provided by the Navy in the Phase I Remedial Investigation (Table 3-4). That table gives much higher values of hydraulic conductivity for the four wells slug tested at that time (MW16-32D was not constructed). The geometric mean of the rising head slug test hydraulic conductivity values from the Phase I report result in a hydraulic conductivity of approximately 121.5 feet/day. These values are an order of magnitude higher

than those provided in the Phase II report. However, this discrepancy was never explained in the Phase II report. Using this value for hydraulic conductivity, the seepage velocity is approximately 2.92 feet per day.

Review of the proposed groundwater monitoring wells shown on Figure 5 shows that the down gradient wells are located approximately 30 and 110 feet away for the first line and the second line of wells. If the groundwater seepage velocity is 1 foot/day, groundwater will be detected at the first line within one month, less time than what Regenesis states is sufficient time for acclimation of microorganisms and for significant biodegradation to occur. Travel time to the second line of wells is approximately four months, the maximum length of the pilot test. If the groundwater seepage velocity is only 0.33 feet/day, groundwater will reach the first line in just over three months but not reach the second line during the time frame of the pilot test. On the other hand, if the groundwater seepage velocities using data from the Phase I report are the most correct, groundwater will have migrated past the second line of monitoring wells in just over five weeks, again, less time than is necessary for microbial populations to acclimate to the HRC® and begin significant biodegradation.

It is recognized that HRC® will be continually released and any effects may be observed at the four month interval. However, this may only occur is the groundwater seepage velocity is slow. If considerable transport is occurring, there will not be effective monitoring down gradient since the reactions will not be significant until sufficient elapse time has occurred. Groundwater velocity also affects dispersion. Since dispersion is the mechanism for HRC® distribution this has the potential to affect injection well spacing. While a worse case scenario can be used for injection well spacing, this approach may result in excessive numbers of wells.

Response— Please refer to the Navy's General Response to EPA's comments.

Regarding the hydraulic conductivity values presented in the Phase II Hydrogeological Report for Site 16, the slug test data from both the Phase I and II investigations were re-calculated during the writing of the Phase II Investigation Report using the same software and method (AquaSolv) for consistency, resulting in the values shown in Table 3-5 which were used in the design of the pilot test. The recalculated hydraulic conductivity values for the Phase I slug test data supercede those presented in the Phase I report. This will be noted in the text of the next version of the Phase II investigation report. Also, refer to Attachment 1 for the pilot test design information.

Comment 2B: HRC® Injection and Monitoring Well Layout

Review of the proposed location of the HRC® injection and monitoring wells (Figure 5) does not result in an understanding of the Navy's design approach. There is also no supporting documentation in the text or attachments relative

specifically to this site (i.e. vendor literature only). There is no design documentation for the spacing of the injection wells. At present, they are shown 25 feet apart with the rows 25 feet apart. The separation of the injection points and rows of points should be based on site conditions including groundwater seepage velocity and also contaminant mass in the groundwater. Effective use of HRC® requires that it be installed in accordance with established design procedures. The analysis performed, if any, should be included in the attachments.

Although the source for the CVOC in groundwater has not been identified, the Navy appears to assert that it is at the northeast corner of the former Building 41. If that assumption is correct, it also implies that the groundwater at that location likely has CVOC concentrations higher than that detected in surrounding groundwater, to date. How is this contaminant mass known for use in the pilot study design? Additionally, this creates a problem in that injection of HRC® is proposed for locations just up gradient of this "source" area (Figure 5). Also, at least four and possibly seven of the new monitoring wells are located up gradient of this suspected "source" area.

Aside from the problems of uncertain groundwater seepage velocity, and unknown CVOC mass, there is no mechanism to evaluate the loss of CVOC mass in down gradient wells as a function of injection of HRC®. That is, while contaminated groundwater at a presumed known concentration of CVOC (MW16-32D?) moves through the HRC® injection well lines, and begins the acclimation process of biodegradation, it soon passes through the suspected zone of higher CVOC contamination. This zone will contribute additional CVOC mass to the moving groundwater prior to it migrating down gradient to the next set of monitoring wells. Therefore, true assessment of the loss of CVOC will not be possible.

In addition to the presumed "source" area that has no data to either support its existence or to quantify its strength, the only data available for assessment of the "plume" are from MW16-32D up gradient, MW16-14D, up and cross gradient and MW16-15D/R. Only MW16-15D/R is within the width of the apparent down gradient groundwater migration pathway from the HRC® injection lines. Even that well is located to the periphery of the down gradient flow paths of HRC® injection wells. In essence, there is no groundwater quality data for the area proposed for injection of the HRC® i.e. within the northeast end of the former Building 41, or at or in front of the HRC® injection lines.

It is not clear how evaluation of the effectiveness of the HRC® injection pilot test can be made. Certainly groundwater quality data can be obtained during installation of the proposed groundwater monitoring wells, though this approach is somewhat after the fact. This pilot test appears to be planned to be implemented "blind." For a pilot test to garner the most useful data, the starting ambient conditions must be quantified.

An additional observation is the layout of a line of the largest number of monitoring wells appears to be oriented from MW16-14D through MW16-15D to a location between MW16-21D and MW16-22D. This line of wells like MW16-15D lies on the periphery of the treatment zone. Typical design is to place a line such as this along the primary axis of plume/treatment zone migration. Therefore, this line should be centered between the injection lines and extending down gradient. The purpose of these wells along the southern boundary is not clear.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 2C: Pilot Study Objectives

The scope and scale of the proposed pilot study does not correlate with the stated objectives of the study. The stated objectives of the pilot study only require that reducing conditions be established, TCE be observed to decline, and 1, 2-*cis* DCE be observed to increase. While introduction of HRC® will likely further create reducing conditions, it is noted from the Phase II Remedial Investigation (Table 5-2) that MW16-15R is already strongly reducing. Other wells were not evaluated (scored) but do include parameters indicative of at least trending to reducing conditions. Also, the problem noted with flow through the "source" area will mask the ability to assess the diminishment of TCE such that it may be possible that no loss of TCE would be observed even if biodegradation were occurring. In addition, the uncertainties associated with the groundwater seepage velocities also limit the ability to fulfill this objective. Finally, simple "sufficient onset of the generation of CVOC daughter products (e.g. at a minimum 1, 2-cis DCE)" as stated, is a very loose and nebulous pilot test design parameter. MW16-15R already has up to 110 µg/L of 1, 2-cis DCE.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 2D: Microbial Environment

Last, the purpose of injection of HRC® is stated to enhance bioremediation of the CVOC constituents. However, review of site groundwater quality indicates that the pH of groundwater in the proposed pilot test area may not be conducive to microbial activity. Data from the Phase II Remedial Investigation gives groundwater pH values of 12.53 for MW16-32D and 12.02 for MW16-15R2. Microbial activity is usually limited to a pH value of 5.0 to 9.0 with optimal activity around 6.0 to 7.0. The pH of groundwater from several other wells does fall into the more acceptable range. However, the uncertainty presented by the elevated pH of the two wells listed calls into question the applicability of HRC® at this location. This is of particular concern since there is no groundwater quality information for the largest area where the HRC® is targeted for injection.

This table is limited to pH values above 8.0 although there are 15 wells with values above 7.0 but below 8.0 that are also documented in table 2-4 of the June 2003 Groundwater Report and several noted in the CED area ME#1&2. Several of the wells in the table are included in the area of the proposed enhanced bioremediation pilot study.

Monitoring Well	Groundwater pH value in various sampling events			
	1995/1996	2000	2001	2002
EA110R*	NI/8.83	8.48	8.67	(2003) 8.93
EA111R*	NI/6.51	7.64	6.43	(2003) 11.90
MW03-14R2*		12.3		
MW55D/R/R2*				8.08/11.12/12.37
EA116R2%		12.17		
EA112R2%		9.7		
MW16-32D@				12.53
MW16-15R2@				12.04
MW16-02R2				12.45
MW16-06R				8.24
MW16-05R				8.90
MW16-10R			8.78	7.55
MW16-23D			8.20	6.25
MW16-25R			7.32	8.54
MW16-36R				10.25
MW16-54D				10.36

NOTE:
* = Upgradient wells to the proposed site 16 pilot study.
@ = Wells included in the proposed site 16 pilot study.
NI = Not installed.
% = Wells in northeast direction from MW03-14 along bedrock trough with high contamination.

Response— Although alkaline pH conditions have been measured in a few monitoring wells in the general area of the proposed pilot test (for example, pH of 12.0 and 12.5 at MW16-15R2 and MW16-32D, respectively, in 2002), most observed pH measurements of ground water from deep and rock wells in the area are between 5 and 7, conditions which are amenable to biodegradation, including MW16-14D, -15D and -15R located at the proposed test area (Figure 8). Observations of alkaline pH conditions are likely localized resulting from well construction (e.g., grout that migrated into a few of the bedrock fractures during setting of the steel casing). Therefore, this is not believed to be representative of area-wide aquifer conditions and should not significantly effect an HRC® Pilot Test. In addition, the release of hydrogen from lactic acid upon hydration of HRC® reagents is designed to lower pH conditions to acceptable levels for anaerobic biodegradation.

Comment 3: Up Gradient Source Area Discharge Zone

The Navy apparently believes that the area at the northeast end of the former Building 41 is a source area. EPA concurs with this to the extent that it appears that highest concentrations of CVOC constituents appear to be manifesting themselves at that location. However, EPA interprets the "source" at that location to have the potential to have originated from an up gradient release area. Rationale for this interpretation have been provided previously including extremely high CVOC source(s) up gradient, up gradient/down gradient recharge/discharge relationships, alignment of a significant bedrock trough, distribution of elevated pH in groundwater combined with potential elevated pH source areas up gradient.

Additionally, review of the groundwater data for MW16-15R, located in the area of concern shows indications of documenting this interpretation. Both MW16-15D and MW16-15R have exhibited very high CVOC concentrations. There has not been any release area identified near the former Building 41 area to explain the observed CVOC concentrations. However, groundwater elevations at the MW16-15D/R are either strongly upward (discharging) or at times neutral (Phase II Remedial Investigation Table 3-4). Potentially the most telling is the chemical analyses shown on Table 4-9 of the same document. The *ethane* concentration in MW16-15R is shown to be 9.1 µg/L. Low levels of chloroethane constituents have been detected in a number of monitoring wells including up to 4.0 µg/L of 1, 1 TCA in MW16-21D. These have been dismissed by the Navy as "contaminants" to TCE production. EPA would disagree with that interpretation. It is not likely that the 9.1 µg/L of ethane suggests TCE contamination with trace chloroethanes. This concentration suggests the near end product of degradation of larger concentrations of chloroethanes. These constituents have been released in significant mass up gradient.

While there may be disagreement concerning this interpretation, there is at present insufficient data in the area to the north of the former Building 41 footprint (i.e. Davisville Road) and the northeast end of the former building footprint (i.e. area of the Navy inferred source). To that extent, implementation of the HRC® injection pilot test in the area proposed will have the potential to obfuscate the actual contaminant distribution and migration pathways. Conduct of activities in this area should not be performed until there is resolution of the contaminants' distribution and origin in this area. Understanding this is paramount to effective design of any remedial system including the proposed pilot study.

Response— Regarding the upgradient source area (former PR-58 Nike Site and Navy Site 03 areas) issue, please refer to the Navy's 12 November 2003 letter 'Site 16 Hydrogeological Concerns', the Navy's evaluation of concerns presented by EPA during the 11 September 2003 BCT meeting. As stated in the Navy's General Response to EPA's comments, through the installation and baseline

sampling of the monitoring and injection wells for the proposed pilot test, the understanding of the site character would be significantly increased. If the baseline sample results were to indicate the presence of a high concentration source area (DNAPL) at one or more of these new wells, the design and type of the pilot test would be reconsidered.

Comment 4: Pilot Study Scale

Review of the proposed HRC® Injection Pilot Study QAPP does not suggest that the study is, in fact, a "pilot study." The level of resources being applied and the extent of the area of the study actually suggest that it is a full scale remedial effort targeted at a presumed source area. The QAPP lists a total of 12 deep overburden HRC® injection wells, 12 bedrock HRC® injection wells, 13 new deep overburden monitoring wells, and 15 new bedrock monitoring wells. Geophysical borehole logging will be performed on 27 bedrock wells. This level of effort in conjunction with soil sampling, slug testing, etc. is a major level of effort not associated with pilot studies. This work is usually associated with remediation system pre-design investigation and remedial system implementation.

Additionally, the same company that authored this document recently submitted a Draft Preliminary Identification and Screening of Remedial Action Technologies for Ground Water (EA, September 2003) for this site. The document concludes that HRC® injection is a viable remedial alternative for this site, and recommends that a treatability study be performed. A pilot study on the scale proposed in this document constitutes much more than a treatability study, even though it is referred to as such in this document. Guidance on conducting treatability studies for evaluation of anaerobic dechlorination of groundwater contaminants is provided in the literature and in publications available from the U.S. Department of Defense's Environmental Security Technology Certification Program website.

Given the stated objectives of the pilot study in this QAPP, this level of effort is excessive and is not warranted, even if the limitations expressed in the preceding paragraphs were not applicable. It would be more rational to use available resources to help resolve the source of the elevated CVOC issue (by installing more monitoring wells) <u>prior to</u> the pilot study. A proposed remedial program that is not founded on basic understanding of the area intended to be treated, is a "blind" approach.

Therefore, EPA does not concur with the implementation of the proposed pilot test. There is sufficient literature to document that HRC® can create reducing conditions, reduce TCE concentrations in groundwater, and generate degradation "daughter" products. This assessment does not require a pilot study, let alone one of the magnitude, limited usefulness and potential risks posed by the one described in this QAPP.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 5: Recommendation

If a pilot test has to be performed, EPA recommends one be conducted that gains useful data, minimizes potential excessive contaminant generation (i.e. vinyl chloride), and is significantly less costly to the Navy. The recommended area for conduct of this pilot test should be further to the east of the proposed site. The HRC® injection points should be no closer to the former Building 41 footprint than a line parallel to MW16-22D. Monitoring of the effects of injection can be accomplished in the area to the east toward MW16-23D and MW16-24D. The benefits of this area is that it is better defined in terms of CVOC contamination and has a lower relative starting concentration of CVOC that would result in lower potential vinyl chloride mass production.

Additionally, a smaller level of effort will yield satisfactory scale up design information. The HRC® injection can be accomplished with overburden injection wells only. To accomplish the stated objectives and develop design parameters there is no need to construct the 12 bedrock injection wells. In fact, the actual number of deep overburden injection wells may also be reduced to 8 or 10. The pilot study design also needs to be more detailed with particular attention being given to observing not only just TCE loss, and the product of degradation products, but the types of products (1, 2-cis DCE, vinyl chloride, ethylene, etc.) along with time elapsed in order to develop site specific degradation constants and also to ascertain whether vinyl chloride can actually be destroyed in a sufficient time frame.

In concert with the reduced pilot scale study, there should be an effort to resolve the issue of the origin of the CVOC at the northeastern end of the former Building 41 footprint. This activity can be incorporated into the pilot study effort without significant additional cost, and yet yield important design information relative to any possible full scale future remedial action. In addition to the reduced number of HRC® injection wells, there will be a reduced requirement for monitoring well clusters. The reduced scale pilot study can be conducted with no more than 6 or 7 new deep overburden monitoring wells. This would eliminate in addition to the 12 bedrock HRC® injection wells, 13 bedrock, monitoring wells and 6 or 7 overburden monitoring wells. Two or three of the 13 bedrock monitoring wells eliminated from the pilot study should be used to investigate the area at the northeast end of the former Building 41 footprint and along Davisville Road, as previously recommended. Two or three of the 6 or 7 eliminated overburden monitoring wells could likewise be used in this endeavor, all as part of a re-scoped pilot study.

Response— Please refer to the Navy's General Response to EPA's comments. Additionally, the injection wells have been located within the southwestern end of the area of

elevated CVOC concentrations in deep ground water. A pilot test is planned, in part, to assess the site-effectiveness of a remedy technique; and therefore, would be located within an area of contaminated ground water as has been done for the proposed pilot test at Site 16. The Navy does not understand why moving the pilot test area northeast to the EPA-recommended location is better. Based on the March 2001 total CVOC results for wells in that area (MW16-21D, 1,904 µg/L; MW16-22D, 2,611 µg/L, and MW16-23D, 3,504 µg/L), it seems to have the same potential problems as EPA has voiced for the proposed injection test area.

SPECIFIC COMMENTS

Comment 6: **Page 2-8 of 2-14, Section 2-1, and Second Paragraph, All Bullets:** The description contained in the last portion of this paragraph is confusing. This location still has significant CVOC up gradient as indicated by the analytical results for MW16-32D and MW16-14D. Also, there is no documentation that an additional up gradient source that contributes to the observed contamination in the vicinity of MW16-15D/R, etc. does not exist. Secondly, the description of a pilot scale field test for future remediation of the source area does not correlate with the bulleted items. What is listed under the bullets appears to be a full scale remedial effort.

Response— The Navy disagrees. Refer to the Navy's response to EPA's General Comment No. 3. The Navy believes that a reasonable explanation for the elevated CVOC concentrations in this area is the result of spills outside former Building 41 from the historical activities in the early 1950s. Please refer to the fourth paragraph of the Navy's General Response to EPA's comments. We are not trying to create reducing conditions, but are trying to enhance (accelerate) the effects of the naturally occurring reducing conditions and document the results. The CVOC plume area covers a distance of nearly 0.25 mile. Therefore, it is difficult to understand how a pilot test at one end of that area would be considered as "a full scale remedial effort."

Comment 7: **Page 2-9 of 2-14, Bullet:** This statement suggests that the pilot test does not need to be performed at all. If the only objective is to see if HRC® works, that can be answered by detailed review of the literature and other case histories. Comparisons with similar hydrogeological and contaminant settings can be made. Also, if there is a need to actually apply HRC® to this site, there is no justification for performing the pilot study on such a large scale. A much smaller implementation would be totally sufficient to achieve the stated purpose. What is outlined in this QAPP is a full scale remedial effort. As an example there is no need for injection of HRC® in bedrock wells to prove its viability. Also, the number of overburden injection is excessive as are the number of groundwater monitoring well clusters.

Response— Please refer to the Navy's response to EPA's Comment No. 6.

Comment 8: **Page 5-4 and 5-5 of 5-5, Section 5.7:** As gleaned from the text in this section there is still no documentation identifying the location of the source of CVOC contributing to the observed contamination around the northeastern end of the former Building 41 footprint. Because of this, implementation of a pilot study at that location is not warranted. This is especially so given that the Navy has implied that is where the source of the observed CVOC contamination is located. It is totally unsound to implement a pilot study in an area of potentially high, unknown CVOC concentrations assuming that the concentrations are in range of 1,000 µg/L of CVOC. A review of Figure 5 does not show any previously existing groundwater monitoring wells in the area of the proposed HRC® injection well lines. While new monitoring wells are planned, the actual concentration of CVOC in groundwater at that location will not be known until then.

Response— Please refer to the Navy's General Response to EPA's comments and the Navy's response to EPA's Comment No. 6. The 2 rows of injection wells were purposefully located in between three existing wells (MW16-14D, -15D, and -32D) where the total CVOC was detected at 2,700–3,000 µg/L in the Nov-Dec 2002 samples and reasonably assumed to be representative of the intervening area. These three wells are located only about 55–150 ft from one another.

Comment 9: **Page 6-1 of 6-5, First Paragraph:** This paragraph states that the intent is to apply HRC® in "a potential source area." The assumption of a source area at the proposed location is total conjecture at this point. Through conduct of the Phase I and Phase II Remedial Investigations, there has been no supporting data for this interpretation. The rationale for implementing a full scale remedial effort (not a pilot study as stated) in an area of unknown CVOC concentration is not understood. This approach is contradictory to sound remedial engineering practice. If the Navy is privy to information regarding a contaminant source at this location, that information should be included in the Phase II Remedial Investigation Report.

Response— Please refer to the Navy's response to EPA's Comment No. 6. Yes, it is assumed to be a 'potential source area' with a concentration of 3–6 mg/L total CVOC based on the March 2001 and Nov-Dec 2002 samples that resulted from historical releases in the immediate vicinity. However, the specific location of the release(s) has not been encountered and may never be; although it is currently believed that because of the distances between these three wells and the similar CVOC concentrations detected in samples from them, the original source(s) has dispersed/diffused into what is currently detected here.

Comment 10: **Section 6.1 Project Overview Page 6-2:** The HRC material appears to have a high viscosity. It is unclear whether the HRC moves slower than ground water or whether the HRC mixes with ground water and moves as fast or faster. If the

contaminant moves without being interacted (or retarded), then any injected fluid will just displace but barely mix with the contaminant. Please provide the mechanism on how the HRC material interacts with contaminated ground water at depth.

Response— For a summary of the mechanism, please refer to Attachment 1 of the QAPP—specifically, the Regenesis insert entitled "How It Works" and "Distribution of HRC in the Aquifer."

Comment 11: **Page 6-2 of 6-5, Third Paragraph:** The use of a groundwater seepage velocity of 1 foot/day is not supported by the data provided in the Phase I or Phase II Remedial Investigations. Hydraulic conductivity and gradient data from the Phase II results in a groundwater seepage velocity of approximately 0.33 feet/day. Somewhat perplexing though is that the hydraulic conductivity values given in the Phase I Remedial Investigation for the same monitoring wells conflict with values given in the Phase II Remedial Investigation report. Those values result in a velocity of almost 3 feet/day. The Navy has not explained this differential. The knowledge of actual groundwater seepage velocity is critical to design of the pilot study in order to establish appropriate groundwater monitoring points to maximize data from the test.

Response— Slug test data from both the Phase I and II investigations were recalculated during the writing of the Phase II Investigation Report using the same software and method (AquaSolv) for consistency, resulting in the values shown in Table 3-4. This will be noted in the text of the report. Please refer to the Navy's response to EPA's Comment No. 2B.

Comment 12: **Page 6-2 of 6-5, Fourth Paragraph:** This paragraph is somewhat dismissive of the potential threat due to vinyl chloride generation. Review of the site data in the Phase II Remedial Investigation data shows that vinyl chloride is present only at a concentration of 1.0 µg/L in MW16-29D down gradient from the proposed pilot test location. Vinyl chloride is somewhat higher at several locations in the Central Area of Site 16, but even then, no higher than 36 µg/L of vinyl chloride. Conversion of high concentrations of TCE is likely to generate very high concentrations of vinyl chloride at least as interim degradation products. Review of the HRC® literature enclosed in the Attachment shows that even with a single application of HRC® significant concentrations of vinyl chloride existed in the down gradient monitoring well a year after HRC® application. The production of vinyl chloride is not an insignificant issue. The pilot study must not result in generation of significant quantities of degradation products that pose a greater risk to down gradient receptors. This is a major concern and needs to be addressed prior to implementation of the pilot study, especially since the Navy implies that the pilot test will be conducted in a "potential source area" which has not been quantified.

Response— Please refer to the Navy's responses to EPA's Comment Nos. 1 and 9.

Comment 13: **Page 6-2 of 6-5, Second Bullet, First Paragraph:** Groundwater sampling is scheduled to end with a final sampling round conducted four months after HRC® application. The information regarding HRC® supplied in Attachment 1 indicates that HRC® may augment bioremediation in an aquifer for at least a year after injection. The proposed length of the pilot study will very likely not provide complete information on the results of the HRC® injection.

Response— Please refer to the fifth paragraph of the Navy's General Response to EPA's comments.

Comment 14: **Page 6-2 of 6-5, Second Bullet, Last Paragraph:** MW16-32D is not, as stated, an "up gradient" monitoring well. This well has had significant concentrations of CVOC constituents (TCE) recently detected in groundwater.

Response— MW16-32D is located upgradient of the injection wells. Please refer to the Navy's responses to EPA's General Comment No. 5.

Comment 15: **Page 6-3 of 6-5, Last Paragraph:** See Specific Comment above.

Response— Please refer to the Navy's response to EPA's 'Specific Comment above'.

Comment 16: **Page 6-4 of 6-5, Section 6.1.2:** The description of pilot testing is totally inadequate. It appears that the pilot study is being implemented in a "cookie cutter" approach. There is no data to provide information on groundwater quality in the "potential source area" where the HRC® injection will occur. There is no identification of what design parameters are intended to be monitored for (degradation rates? ratio of daughter products? mass of HRC® required? etc.). There is also no documentation for the proposed layout of HRC® injection wells, mass of material to be injection, rationale for monitoring frequency (correlated with groundwater seepage velocities), spacing of the injection wells, etc. At a minimum, a brief description of the pilot study design calculations and assumptions, including Regenesis software results (if used) should be provided. Furthermore, justification for the scope/scale of the proposed pilot test should be provided. Given the stated purpose of this pilot test, there is no justification provided for the injection of HRC® in bedrock and even the total number of overburden injection wells. Why will extensive slug testing and geophysical logging be performed after the fact, i.e. after design of the pilot test?

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 17: **Page 7-1 of 7-1, Section 7.2:** The performance criteria set forth in this section does not support the conduct of a pilot study. The second paragraph of this section states "Pilot testing will be deemed successful if there is "a significant onset of the generation of the chlorinated daughter products (i.e., cis-1, 2-DCE)

within the pilot test area by the conclusion of the pilot test." This is an extremely loose criterion that does not justify the scale of the proposed test. This information can be deduced from the literature. If a field test is desired, the objective can be accomplished on a far smaller scale.

Response— Please refer to the Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 18: **Page 7-1 of 7-1, Section 7.2, Item 1:** The deep and bedrock groundwater at the site is known to be either strongly reducing (i.e. MW16-15R) or somewhat reducing. Application of any biodegradable organic material, whether HRC®, methanol/ethanol, molasses, etc. will create "strongly reducing conditions." This criterion does not warrant application of HRC®.

Response— Please refer to the Navy's General Response to EPA's comments.

Comment 19: **Page 7-1 of 7-1, Section 7.2, Item 2:** Because of the planned location of the pilot test injection wells in a "potential source area" or in a discharge area from migrating up gradient releases, there is a strong possibility that "onset of decline of dissolved parent chlorinated (TCE)" will be masked and not observed.

Response— Please refer to the Navy's response to EPA's Comment Nos. 3 and 14.

Comment 20: **Page 7-1 of 7-1, Section 7.2, Item 3:** What does "sufficient onset of the generation of CVOC daughter products (e.g. at a minimum 1, 2-cis DCE)" mean? This daughter product is already present in MW16-15R. What constitutes "sufficient"?

Response— The Navy considered "sufficient" to be increasing concentration of cis-1,2-DCE, not just the few parts per billion present under ambient conditions. However, the QAPP will be revised to include a 12-month pilot test. Please refer to the Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 21: **Page 7-1 of 7-1, Last Sentence:** The 50 to 70 percent reduction of parent CVOC over a 6 to 8 month time frame suggests that there may be minimal reduction in the much shorter time frame of 1 to 4 months. What percent of parent CVOC reduction then would be considered "successful" in the shorter time frame?

Response— The QAPP will be revised to include a 12-month pilot test. Please refer to the Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 22: **Section 7.2 Measurement Performance Criteria:** The monitoring period should be extended more than 1 year as long or as HRC resides within soil matrix.

Response— Please refer to the fifth paragraph of the Navy's General Response to EPA's comments.

Comment 23: **Page 8-1 of 8-2, Third Paragraph:** This paragraph states that the pilot test will be at a location with minimal input of CVOC from up gradient. However, this dismisses the potential for contribution from up gradient such as the Nike PR-58 site and/or Site 03 or some other contributor. It also does not explain the past high concentrations of CVOC (TCE) observed at MW16-32D an "up gradient" well. Additionally, this assumption is made even though the Navy calls this location a "potential" source area. Finally, there is no data provided in either the Phase I or Phase II Remedial Investigations to support the assumption that the area at the northeast corner of the former Building 41 footprint is a "potential source area." The logic of this approach is not understood

Response— Please refer to the Navy's responses to EPA's Comment Nos. 3 and 14.

Comment 24: **Page 18-1 of 18-1, 1st Paragraph:** The text states that data validation "is not anticipated for data obtained from the pilot test." However, page 14-1 of 14-1 states that groundwater data collected "will be added to the site database for comparison of before and after" concentrations, and "soil data will be added to the database for additional characterization of the nature and extent of CVOC in deep soil in the specific area of the HRC pilot test." If there is an intention to rely upon this data for long term remedial decision-making, the appropriate validation should be conducted on this laboratory data set.

Response— The data are planned for assessment of the pilot test, not for long-term remedial decision-making.

Comment 25: **Figure 2:** Inspection of this figure in conjunction with Figure 5 shows that the proposed locations of the HRC® injection wells are not up gradient of the CVOC mass. MW16-32D has a concentration of 2,711 µg/L of CVOC. The concentration was even higher during the last sampling of this well. MW16-14D has significant CVOC at a concentration of 3,003 µg/L of CVOC. This well is also "up gradient" of the line of injection wells. Both of these concentrations are equal to or higher than the one down gradient well, MW16-15D with a concentration of 2,703 µg/L of CVOC. The distribution of CVOC depicted on this figure in concert with other remedial investigation data actually suggests an input to this area from the west northwest of MW16-15D along Davisville Road. Investigations within the former Building 41 did not identify a source beneath the building (i.e. MW16-32D). No source was identified at the MW16-15D location. While CVOC was identified at the MW16-37D location, it was interpreted to be noncontributory to the pilot study area. Since MW16-32D and MW16-14D lie up gradient of the HRC® injection lines and no surface release source area has been identified, the origin of this CVOC contamination can only be from a direction to the northwest of the northeastern end of the former Building 41. The Navy should provide a rationale (data) to support their

interpretation that the location of the HRC® injection well lines are in the area of a "potential source."

Response— Please refer to the Navy's response to EPA's Comment No. 14.

Comment 26: **Figure 5:** The rationale for the HRC® injection well and groundwater monitoring well layout is not understood. Why are the injection wells located down gradient of the two highest contaminated wells, i.e. MW16-32D and MW16-14D? If the "potential source area" is presumed to lie just down gradient of the injection wells shown, why is the majority of the groundwater monitoring wells situated along the southeastern periphery of the flow path from the injection wells? Why are the bulk of the injection wells installed over an area for which there is no data? The majority of the wells are positioned within the former Building 41 footprint in an area for which there are no monitoring wells or soil borings.

Also not explained is the basis of design for the number and location of injection wells. The "Design Manual" supplied by Regenesis states that design is impacted by groundwater velocity, plume size, contaminant mass, and time to reach target CVOC reduction goals. It is also affected by microbial and electron acceptor demand for the organic material in HRC®. The major design issues are (1) the amount of HRC® or HRC X (S) that will be required to support biodegradation for a given CVOC mass and associated additional demands such as dissolved oxygen, iron, etc; and (2) the number and configuration of the HRC® delivery locations to effectively distribute the HRC® to the zone of contamination. Nowhere in this QAPP is this analysis provided. The design arrangement appears to be a barrier configuration. What is the basis for injection well spacing? What is the basis for the mass of HRC® to be placed into each injection well? How far down gradient are loss of TCE and production of 1, 2-cis DCE and vinyl chloride expected to occur for the soils, groundwater velocities, contaminant mass, electron acceptors, microbial population etc. present?

Response— The two northeasternmost monitoring wells will be moved slightly toward the northwest so they are closer to the centerline of the flow from the test area. Please refer to the Navy's General Response to EPA's comments and the Navy's response to EPA's Comment No. 14.

Comment 27: **Figure 6:** What is the rationale for construction and injection into competent bedrock? This figure suggests that there is minimal potential for effective use of HRC® to be injected at this interval. That is, the bedrock is depicted as being "competent" versus weathered or highly fractured. Injection of HRC® into the bedrock, even if weathered or highly fractured will not yield significantly increased information for the stated purpose of this pilot study.

Response— Injection into the upper bedrock ground-water zone has been deleted from the revised pilot test.

Comment 28: **Tables 7-1 and 8-1:** EPA Region 1 has replaced RSK-175 (the method listed in these tables for methane) with an updated method that is also used to analyze for ethane and ethene. The method can be found at the following website: www.epa.gov/region1

Response— The new method will be used and added to the QAPP.

Comment 29: **Table 7-4, Page 2 of 2:** The table refers to comparability criteria, which most likely do not apply to the soil sampling event since the soil at each specific sampling location cannot be sampled more than once.

Response— Agreed; it will be deleted.

Comment 30: **Attachment 1, Regenesis Literature, Enhanced Bioremediation of TCE at Department of Defense Landfill Site:** This case study suggests that in addition to 1, 2-cis DCE being produced during degradation significant mass of vinyl chloride is produced. This production peaks approximately one year after the initial, single application of HRC®. This presents two concerns. The first is the vinyl chloride itself. At the ratio of production shown on the graph, the concentrations of vinyl chloride will dramatically increase in down gradient groundwater. The second is that this will occur long after the completion of the pilot study. Therefore, there is no mechanism to evaluate the adverse impacts of remedial activity using HRC®.

Regenesis literature dismisses the vinyl chloride problem as stating that it has not been a problem on any of its sites. There is a caveat though that if there is a problem it can be corrected with installation of oxygen (i.e. injection wells using ORC® or oxygen release compound also supplied by Regenesis. With all due respect to Regenesis, the vendor, vinyl chloride can exist for significant time without degradation. It should be noted that degradation of vinyl chloride is not favored in reducing or anaerobic environments. Also vinyl chloride will have a greater mobility in groundwater. Therefore, there is the risk that implementation of this relatively large scale pilot study will pose a greater hazard to down gradient receptors. How will this risk be mitigated given that the pilot study will be over for some time?

Response— Please refer to the Navy's response to EPA's Comment No. 1.

Comment 31: **Attachment 1 Section 5.4.1 HRC Injection:** Typo? Change the heating temperature from "95 C" to "95 F."

Response— The typo will be changed from "95 C" to "95°F."

Comment 32: Appendix, Safety, Health, and Emergency Response Plan (SHERP), Page 18 of 27, Section 9.1, First Paragraph: The text mentions calibration and use of a PID to conduct air monitoring at the site. An FID, widely accepted as being more useful and accurate to measure CVOCs in air, is mentioned in various field sampling SOPs in Attachment 1. An FID should therefore be referred to in the SHERP rather than the PID.

Response— The PID is appropriate and will be used for health and safety monitoring. The FID also detects methane, which is not anticipated to be an issue in this part of the Site 16 investigation area.

RESPONSES TO RIDEM COMMENTS DATED 23 OCTOBER 2003 ON THE SITE 16 QAPP FOR HRC INJECTION PILOT STUDY OF SEPTEMBER 2003 NAVAL CONSTRUCTION BATTALION CENTER DAVISVILLE NORTH KINGSTOWN, RHODE ISLAND

Comment 1: **Page 6-1, Section 6.1, Project Overview, Bullet 2;** This bullet notes that the two soil samples will be collected from the soil samples with the highest headspace vapor reading. Visual and olfactory signs should also be considered when selecting the samples for laboratory analysis. In many instances high headspace readings do not necessarily translate into high analytical results.

Response— Agreed. Visual and olfactory signs will be added to the criteria for selecting the samples for laboratory analysis.

Comment 2: **Page 6-1, Section 6.1, Project Overview, Bullet 5, Paragraph 2;** This paragraph states that monitoring of the HRC pilot test will occur over a period of four months. This time period seems inadequate. Hydraulic conductivity values, in general, from Table 3-5 of Site 16 Phase II RI seem to be in the range of 10^0 to 10^1. Hydraulic gradient values in general, from Table 3-4 of Site 16 Phase II RI, seem to be in the range of 10^{-3} to 10^{-2}. This would give a groundwater velocity of less that one foot per day as noted in paragraph 4 of this section.

Even if one were to assume that all the contamination at Site 16 came from the NIKE PR58 site, which is about one mile away, then at a groundwater flow velocity of one foot per day and initial contamination occurring approximately 50 years ago Site 16 should have been flushed through twice with this contamination. Since high concentrations of CVOC exist at both sites it is clear that CVOC does not move nearly as fast as the groundwater or there is a continuing source. In addition, the reactions must take place at a fairly slow rate since concentrations of vinyl chloride, a breakdown product, are not that high. Therefore, monitoring for four months may not be a sufficient amount of time to determine the effectiveness of this pilot study.

Response— Please refer to Navy's General Response to EPA's comments, particularly the fifth paragraph.

Comment 3: **Section 6, Project Description and Schedule, General Comment;** Please explain how it was determined that twelve injection wells are needed for the pilot study and how the number of monitoring wells were determined. Also state what area is expected to be treated and what the radius of influence of the pilot test will be.

Response— Please refer to Navy's General Response to EPA's comments.

Comment 4: **Section 6, Project Description and Schedule, General Comment;** It is noted that vinyl chloride will be produced as a by-product of the HRC injection. Since the purpose of the HRC is to enhance the degradation of CVOC please state if calculations have been prepared to determine how much vinyl chloride (degradation product) will be produced as a result of this pilot study. RIDEM considers vinyl chloride to be more toxic than TCE and therefore would be concerned about its impact on human health and the environment. In addition, please state if any contingency plans have been developed to deal with a significant increase in vinyl chloride.

Response— Please refer to Navy's General Response to EPA's comments, particularly the last paragraph.

Comment 5: **Page 6-3, Section 6.1.1, Use of HRC...., Paragraph 2;** This paragraph makes two points about the use of HRC 1) that HRC is used in tandem with other technologies, and 2) that more than one round of HRC injection could be needed. Please state what other types of technology would be used in conjunction with HRC and would this be necessary at this site and since there are five source areas would a continuing influx of new contaminated water eventually require a new application of HRC.

Response— The comment references a general statement in the QAPP about an alternative use of HRC®. Such tandem technologies have not yet been determined for Site 16. This project is a pilot test for a technology that appears to be very promising for this site. The results of this project will be included in the future Feasibility Study for this site which will recommend the remedy.

Comment 6: **Page 6-4, Section 6.1.1, Use of HRC...., Paragraph 1;** This paragraph states that VC gas would not be expected to enter the vadose zone for many years (if not decades). The rate at which gas will travel through the soil will in part be dependant on the type of soil at the site. Soil gas surveys are routinely used at sites where chlorinated solvents have been released to the environment to map out plume locations. At one such superfund site in Rhode Island, chlorinated solvents were dumped during the late 1970's. In 1985 soil gas measurements were successfully used to map out the plume (a period of less than 10 years). In order to determine the approximate amount of gas to be produced a mass balance calculation would need to be prepared in conjunction with the calculations requested in comment #4.

Response— Only trace concentrations of VC have been detected to date in ground-water samples from monitoring wells. Performance of a soil gas study in the near future to assess VC release from this proposed pilot test would not be useful, but would be considered in the future.

Comment 7: **Table 7-1;** Project action, detection, laboratory and quantitation limits are expressed in mg/l. please state if this is an error and they should be expressed as ug/l.

Response— The units for the VOC parameters will be changed to µg/L. The remainder of the table is correct with mg/L.

Comment 8: **Page 8-1, Section 8.2, Ground-Water Sampling from Monitoring Wells, Paragraph 1, Sentence 1;** This sentence states that 63 wells will be installed for the pilot study while Section 2.1, Bullet 1 implies that 52 wells will be installed. Please clarify.

Response— The referenced sentence in Section 8.2 will be changed to '52' wells.

Comment 9: **Page 9-1, Section 9.4, Field Equipment Maintenance, Testing, Calibration, and Inspection;** It is stated that each piece of equipment will be checked to determine that it is within 10% of its calibration standard. If, at then end of the day, it is found that the piece of equipment exceeds its calibration standard please state if those samples will be retaken.

Response— The soil samples would not be re-collected. There is not a way to re-collect such samples from the same borehole, and samples from an adjacent borehole would not provide the same sample because of the heterogeneity of the soil.

Comment 10: **Page 15-1, Section 15.1, Project Documentation and Records;** This paragraph states that project documentation will be retained and maintained by the contractor. Should the Navy change contractors please state if the Navy, its new contractor, and interested stakeholders will still have access to the information generated in this pilot study.

Response— The referenced sentence will be revised as follows: "The field records will be maintained and retained by EA <u>until the end of the project or the end of the contract with the Navy, which ever comes first, at which time the field records will be transferred to the Navy</u>."

Comment 11: **Page 16-1, Section 16, Paragraph 2;** Please note that under its authority RIDEM can issue a cease and desist order if it is found that work being performed is inconsistent with RIDEM Rules and Regulations or is adversely affecting the environment.

Response— Comment noted.

Comment 12: **Attachment 1, Sections 1.8, 1.8.1, 1.8.2, 1.8.3 Investigative Derived Waste (IDW) Management;** Each one of these sections notes that there will be temporary storage pending its disposition for proper disposal. Please define what proper disposal means in each of these sections.

Response— Depending upon whether the characterization of the material is determined to be non-hazardous or hazardous waste, a disposal method/firm will be selected that can legally handle such waste material.

Attachment 1

OBJECTIVE:
Based on site data from the Phase I and Phase II Remedial Investigations, calculate the average aquifer hydraulic conductivity, average concentration of dissolved phase CVOC, and average concentration of competing electron acceptors for input to Regenesis Software HRC Barrier Design.

ASSUMPTIONS:
Use data on the above parameters collected from deep monitoring well locations near the position of the proposed HRC Pilot Test near the northeast end of former Building 41. Deep monitoring well locations in this area include MW16-14D, MW16-15D, and MW16-32D.

PROCEDURE:
1. Calculation of Average Hydraulic Conductivity (K).
K determined by slug test method for Phase II RI data (Table 3-5).
MW16-14D 1.84 ft/day
MW16-15D 12.77 ft/day
MW16-32D 55.6 ft/day
Average K = (1.84 + 12.77 + 55.6)/3 = 23.4 ft/day

2. Calculation of Hydraulic Gradient (Dh/Dl)
Dh/Dl determined from Phase II RI Ground-Water Surface Contour Map for Deep Wells (Figure 3-26) within area of proposed pilot.
Dh/Dl = (15 ft –12 ft)/470 ft = 3 ft/470 ft = 0.0063 ft/ft

3. Calculation of Average Concentration of Dissolved Phase CVOCs.
Average concentration of CVOC compound elevated in area of pilot calculated from Phase I and Phase II RI data. Elevated CVOCs in this include TCE, PCE, and cis-12DCE.
TCE @ MW16-14D 4900 ug/L (Phase I), 3000 ug/L (Phase II)
TCE @ MW16-15D 6200 ug/L (Phase I), 2700 ug/L (Phase II)
TCE @ MW16-32D N/A (Phase I), 2700 ug/L (Phase II)
Average TCE = (4900 + 3000 + 6200 + 2700 + 2700)/5 = 3900 ug/L

PCE @ MW16-14D <1.0 ug/L (Phase I), 0.3 ug/L (Phase II)
PCE @ MW16-15D 0.7 ug/L (Phase I), 0.67 ug/L (Phase II)
PCE @ MW16-32D N/A (Phase I), 0.618 ug/L (Phase II)
Average PCE = (0.5 + 0.3 + 0.7 + 0.67 + 0.618)/5 = 0.558 ug/L

cis-12DCE @ MW16-14D 5.0 ug/L (Phase I), 1.87 ug/L (Phase II)
cis-12DCE @ MW16-15D 3.0 ug/L (Phase I), 2.18 ug/L (Phase II)
cis-12DCE @ MW16-32D N/A (Phase I), 7.03 ug/L (Phase II)
Average cis-12DCE = (5.0 + 1.87 + 3.0 + 2.18 + 7.03)/5 = 3.82 ug/L

4. Calculation of Average Concentration of Competing Electron Acceptors.

Average dissolved concentration of competing electron acceptors in area of pilot calculated from Phase I and Phase II RI ground-water quality data. Competing electron acceptors requiring evaluation in Regenesis Software include oxygen, nitrate, manganese, iron, and sulfate.

DO @ MW16-14D 0.19 mg/L (Phase I), 0.57 mg/L (Phase II)
DO @ MW16-15D 1.0 mg/L (Phase I), 0.47 mg/L (Phase II)
DO @ MW16-15R 0.08 mg/L (Phase I), N/A mg/L (Phase II)
DO @ MW16-32D N/A (Phase I), 1.78 mg/L (Phase II)
Average DO = (0.19 + 0.57 + 1.0 + 0.47 + 0.08 + 1.78)/6 = 0.68 mg/L

NO_3 @ MW16-14D ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-15D ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-15R ND (Phase I), <0.1 mg/L (Phase II)
NO_3 @ MW16-32D N/A (Phase I), <0.1 mg/L (Phase II)
Average NO_3 = (0.05 + 0.05 + 0.05 + 0.05)/4 = 0.05 mg/L

Mn @ MW16-14D 0.424 mg/L (Phase I), 0.290 mg/L (Phase II)
Mn @ MW16-15D 0.190 mg/L (Phase I), 0.150 mg/L (Phase II)
Mn @ MW16-15R 0.457 mg/L (Phase I), 0.230 mg/L (Phase II)
Mn @ MW16-32D N/A (Phase I), <0.015 mg/L (Phase II)
Average Mn = (0.424 + 0.290 + 0.190 + 0.150 + 0.457 + 0.230 + 0.007)/7 = 0.25 mg/L

Fe @ MW16-14D 8.17 mg/L (Phase I), 2.4 mg/L (Phase II)
Fe @ MW16-15D 2.06 mg/L (Phase I), 1.3 mg/L (Phase II)
Fe @ MW16-15R 7.48 mg/L (Phase I), 2.2 mg/L (Phase II)
Fe @ MW16-32D N/A (Phase I), <0.1 mg/L (Phase II)
Average Fe = (8.17 + 2.4 + 2.06 + 1.3 + 7.48 + 2.2 + 0.05)/7 = 3.38 mg/L

SO_4 @ MW16-14D ND (Phase I), 20.0 mg/L (Phase II)
SO_4 @ MW16-15D ND (Phase I), 20.6 mg/L (Phase II)
SO_4 @ MW16-15R ND (Phase I), 7.73 mg/L (Phase II)
SO_4 @ MW16-32D N/A (Phase I), 2.27 mg/L (Phase II)
Average SO_4 = (20.0 + 20.6 + 7.73 + 2.27)/4 = 12.6 mg/L

CONCLUSION:

Calculated data will be utilized in Regenesis Software for HRC Barrier Design in Deep Overburden Zone. Based on lack of data for Rock Zone, will use average of Phase I and Phase II data for MW16-15R, when available, for input to Regenesis Software in Rock Zone. Additional data collected during installation of Deep and Rock Pilot Test Injection Wells

will be used to refine design calculations for both the Deep and Rock Zones.

HRC Design Software for Barrier Treatment

Regenesis Technical Support: USA (949) 366-8000, www.regenesis.com

Site Name: HRC Pilot Northeast of Building 41 - Deep Overburden Zone
Location: Site 16 - NCBC Davisville, RI
Consultant:

Site Conceptual Model/Extent of Plume Requiring Remediation

Length of Barrier (intersecting gw flow direction)	120	ft		
Depth to contaminated zone	45	ft		
Thickness of contaminated saturated zone	20	ft		
Aquifer soil type	sand	<-(not recognized, enter Kh or Vs below)		
Effective porosity	0.3			
Hydraulic conductivity	23.4	ft/day	=	8.3E-03
Hydraulic gradient	0.006	ft/ft		
Seepage velocity	170.8	ft/yr	=	0.468

Dissolved Phase Electron Donor Demand

	Contaminant Loading Conc (mg/L)	Mass (lb)	Stoich. (wt/wt) contam/H_2
Tetrachloroethene (PCE)	0.00	0.00	20.7
Trichloroethene (TCE)	3.90	29.92	21.9
cis-1,2-dichloroethene (DCE)	0.00	0.03	24.2
Vinyl Chloride (VC)	0.00	0.00	31.2
Carbon tetrachloride	0.00	0.00	19.2
Chloroform	0.00	0.00	19.9
1,1,1-Trichloroethane (TCA)	0.00	0.00	22.2
1,1-Dichlorochloroethane (DCA)	0.00	0.00	24.7
Hexavalent Chromium	0.00	0.00	17.3
User added, also add stoichiometric demand	0.00	0.00	0.0
User added, also add stoichiometric demand	0.00	0.00	0.0

Competing Electron Acceptors:	Electron Acceptor Loading Conc (mg/L)	Mass (lb)	Stoich. (wt/wt) contam/H_2
Oxygen	0.68	5.22	8.0
Nitrate	0.05	0.38	12.4
Est. Mn reduction demand (potential amt of Mn2+ formed)	0.25	1.92	27.5
Est. Fe reduction demand (potential amt of Fe2+ formed)	3.38	25.93	55.9
Estimated sulfate reduction demand	12.60	96.67	12.0

Microbial Demand Factor	3	Recommend 1-4x
Safety Factor	2	Recommend 1-4x
Lifespan for one application	1	Year(s)

Injection Spacing and Dose:

Number of rows in barrier	2	rows
Spacing within rows	20	ft on center spacing within rows
Effective spacing perpendicular to flow (ft)	10.0	
Total number of HRC injection locations	12	points
Minimum required HRC dose per foot (lb/ft)	5.5	

Project Summary			
Number of HRC delivery points (adjust as nec. for site)			12
HRC Dose in lb/foot (adjust as nec. for site)			5.5
Corresponding amount of HRC per point (lb)			111
Number of 30 lb HRC Buckets per injection point			3.7
Total Number of 30 lb Buckets			45
Total Amt of HRC (lb)			1,350
HRC Cost		$	7.50
Total Material Cost		**$**	**10,125**
Shipping and Tax Estimates in US Dollars			
Sales Tax	rate: 0%	$	-
Total Matl. Cost w/Tax		$	10,125
Shipping of HRC (call for amount)		$	-
Total Regenesis Material Cost		**$**	**10,125**

Project	Site 16 HRC Injection Pilot Study – NCBC Davisville, RI	Project No.	2960107
Subject	Step 3: Calculations for Transport of HRC Reagent	Sheet No.	1 of 1
	HRC Barrier Treatment Design	Drawing No.	
Computed by	FTB	Date	9/03
Checked by		Date	

OBJECTIVE:

Based on site data from the Phase I and Phase II Remedial Investigation Reports and output from Regenesis Software, calculate the distance of travel of HRC reagent based on observed groundwater seepage velocity and four month duration of Pilot Test.

ASSUMPTIONS:

Use calculated data on the average hydraulic conductivity (K), hydraulic gradient (Dh/Dl) and, therefore, average groundwater seepage velocity (V) within the Deep Zone (see Software Input Calculations) to determine average HRC seepage velocity for the Deep and Rock Zones. Due to lack of K data for Rock Zone, average groundwater seepage velocity will be assumed as same as Deep Zone. More specifically, average HRC reagent seepage velocity will be 170.8 ft/yr as calculated by Regenesis Software for Deep and Rock Zones. Additional data collected during installation of Deep and Rock Pilot Test Injection Wells will be used to refine design calculations for both the Deep and Rock Zones. Although Pilot Test measured only initially over four months, time duration for complete utilization of one round HRC reagent injection estimated to be one year.

PROCEDURE:

1. Calculation of Travel Distance (D_{HRC})of HRC Reagent over Time Duration (T) of Pilot Test.

D_{HRC} = V * T = 170.8 ft/yr * 0.33 yrs = 56.4 ft downgradient of HRC injection rows.

2. Calculation of Travel Distance (D_{HRC})of HRC Reagent over Time Duration (T) for complete utilization of one round of HRC reagent injection.

D_{HRC} = V * T = 170.8 ft/yr * 1.0 yrs = 170.8 ft downgradient of HRC injection rows.

CONCLUSION:

Monitoring well placement for HRC Pilot Test designed to incorporate area of HRC reagent transport from four months to approximately one year (i.e., estimated timeframe for complete utilization of one round of HRC injection). Monitoring wells for Pilot Test placed in a longitudinal and transverse array (Figure 5 of QAPP for HRC Pilot Study) to measure short term (four months) and long term (one year)effectiveness of HRC to create strongly reducing conditions and enhance anaerobic biodegradation.

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

Southborough Technology Park
333 Turnpike Road
Southborough, MA 01772
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LETTER OF TRANSMITTAL

TO:
Fred Evans
EFANE (Code 1823/FE)
10 Industrial Hwy MS82
Lester, PA 19113-2090
(610) 595-0567 Ext. 159

DATE: 23 February 2004	JOB NO. 29600.99.9310
ATTENTION: Fred Evans	
RE: BCT Meeting Notes, NCBC Davisville, North Kingstown, RI	
Contract No. N6247-92-D-1926, CTO 99	

WE ARE SENDING YOU [X] Attached [ ] Under separate cover via _____ the following items:
[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications
[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
3			Notes of the 12 December 2003 BCT Meeting, NCBC Davisville, North Kingstown, RI

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[ ] For approval [ ] Approved as submitted [ ] Resubmit _____ copies for approval
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[ ] For review and comment [ ] _____

[ ] **FOR BIDS DUE** _____19_____ [ ] PRINTS RETURNED AFTER LOAN TO US
REMARKS

Fred,
The enclosed copies of the notes of the 12 December 2003 BCT Meeting are for your use and file. On behalf of the Navy EFANE, we are also submitting copies to the BCT for their use and file.
Thank you,

COPY TO _____**See Below**_____ **SIGNED** _____
JIM SHULTZ, CTO MGR

D. Barney – NCBC CSO (1 copy), C. Williams – EPA (5 copies), R. Gottlieb – RIDEM (1 copy), S. King – RIEDC (1 copy), M. Cohen – ToNK (1 copy), K. Campbell – CDW Consultants (2 copies), K. Carr – USF&W (1 copy), K. Finkelstein – NOAA (1 copy), J. Shultz – EA Boston (1 copy), R. Clark – EA Boston (1 copy), Project File – EA Boston (1 copy)

If enclosures are not as noted, kindly notify us at once

NOTES FOR THE 12 DECEMBER 2003 BCT MEETING AT THE RIEDC HQ (0900-1230 HOURS) SITE 16 HRC PILOT TEST

ATTENDEES

Fred Evans (Navy)
Jim Shultz (EA)
Christine Williams (EPA-Region 1)
Bill Brandon (EPA-Region I)
Richard Gottlieb (RIDEM)

Ms. Williams asked if anyone had heard anything new from Mr. Al Lemire (USACE RPM) regarding the PR-58 Nike Site Steam Enhanced Remediation (SER) Pilot Test Work Plan and responses to RIDEM and EPA comments to that document. Mr. Shultz said that he knew of nothing new since Mr. Lemire's statements during the RAB meeting last night including that the submittal of USACE's responses to comments were planned for next week.

As EPA began the Site 16 discussion with reference to connection with the CVOC plume from the former PR-58 Nike Site, Mr. Evans stated that the Navy's position is that while Site 16 is downgradient from the PR-58 Nike Site, the Navy believes that, based on the information available, there is not a connection of the CVOC plume from the PR-58 Nike Site to Site 16, and further, that even during Mr. Conrad Leszkiewicz's presentation at the previous BCT meeting in September 2003, he had said that connection of the 2 CVOC plume areas was a 'stretch'. Ms. Williams said that EPA's position is that Site 16 has 3 separate source areas: the former Building 41 area, the former fire fighting training area, and the old railroad spur area; and that there is a de minimis contribution from the PR-58 Nike/Navy Site 03 areas, but that the de minimis contribution would not hold up the Record of Decision (ROD) for Site 16. Mr. Gottlieb asked what difference this makes on the Site 16 remedy. Ms. Williams said that it makes no difference to the remedy, but it is important to the Administrative Record for Site 16, which includes the Navy's letter "Evaluation of Concerns" dated 12 November 2003 that addresses only two of the points of evidence [for connection of the PR-58 Site/Site 03 CVOC plume with Site 16] that EPA presented during the 11 September 2003 BCT meeting, and then dismisses those two lines of evidence. Ms. Williams stated that the science works. From their perspective, EPA wants the record to be straight on this.[1] Mr. Brandon agreed with Ms. Williams and said that trace concentrations of daughter products of the CVOC detected at the PR-58 Nike Site have been

[1] Post Meeting Note: The notes of the 11 September 2003 BCT meeting include a copy of the EPA presentation material (handout provided during the meeting), which lists and documents all of the EPA's points of evidence that were presented. However, as stated in the 11 September 2003 BCT meeting notes, "Two additional figures were shown as part of EPA's presentation, but copies were not provided to the attendees. These included colored tag maps of the available field measured pH data for ground water just prior to sample collection and the vertical hydraulic gradient data ..." Copies of these two figures were not provided by EPA to the meeting attendees for their further consideration and detailed understanding of EPA's position and, additionally, one of these figures included the key hydraulic mechanism (vertical gradient data) that was foundational for EPA's interpretation that the CVOC deep plume from the PR-58 Nike Site has migrated downward beneath the Navy's monitoring wells south of Site 03 (along the lateral ground-water path between the PR-58 Nike Site and the Navy's Site 16) and then migrates upward to Site 16 in the vicinity of former Building 41. Therefore, the Navy prepared their own set of related figures for these 2 key EPA 'lines of evidence' and submitted them for the record along with the response dated 12 Nov 2003.

detected in samples from the Site 16 CVOC plume area. He further said that there will be a SER pilot test at the former PR-58 Nike Site and that that would cause the release of CVOC that are currently not moving (migrating in the subsurface). Therefore, there is a need for upgradient and downgradient monitoring of the Site 16 HRC® injection pilot test.

Referring to the Navy's 8 December 2003 responses to EPA's comments (RTC), Ms. Williams stated that EPA is pleased that the Navy has deleted the bedrock from the proposed HRC® injection pilot test. Mr. Brandon said that he feels that a lot of the changes presented in the Navy's RTC are in the right direction. As a result of Mr. Gottlieb's questions (Is EPA stating that there is not enough site characterization? What else is needed?), Mr. Brandon said that:

- For the overall investigation area, there are ground-water contour maps from which ground-water flow lines can be interpreted; however, the requested Site 16 pilot test monitoring is only in a limited portion of the overall area;

- Hydraulic testing (tracer, pumping test, injection test) is needed to observe the responses in surrounding wells [e.g., pumping a deep well in the proposed injection zone below silt lense(s) could mute response in shallower wells] to aid in the selection of proper monitoring wells for the pilot test;

- The Navy has done a reasonable job of characterizing Site 16, but now there is need to have a detailed preparation, performance, and monitoring of the proposed Site 16 pilot test that would then provide good results.

Mr. Brandon stated that HRC® was not appropriate for use at the site because of the magnitude of the CVOC concentrations detected. Mr. Shultz disagreed, based on information from Regenesis that HRC® has been effective at sites with total CVOC at 10 mg/L compared to the highest concentrations detected at Site 16 that range from 3 to 6 mg/L. Any further discussion of this issue should include Regenesis. Ms. Williams further stated that EPA believes that the Navy's proposed 2 rows of 6 HRC® injection wells should be relocated west of the source area so the HRC® could be injected upgradient, allowing the HRC® to move through the source area, and then observe the results. Mr. Gottlieb summarized the Navy's reason for leaving the pilot test where the Navy proposed it, as was explained in the Navy's 8 December 2003 RTC.
Ms. Williams said that she understood what Mr. Gottlieb said and that that is what the Navy has been stating. Mr. Gottlieb asked if the following summarized EPA's concerns: the hydrogeology of the pilot test area is not sufficiently understood and the pilot test is located in the wrong area. Ms. Williams agreed. Mr. Gottlieb said that there is already a large amount of site data, but based on the above discussions, asked what additional level of detail the EPA needed so the Navy's proposed HRC® pilot test could move forward?

(Just prior to beginning today's BCT meeting, Ms. Williams and Mr. Brandon received an expected FAX of a memo[?] from Mr. Conrad Leszkiewicz with his input because he was not available to attend today's meeting in person. They referred to it during the remainder of the meeting. Because copies of this document were not shared with the other attendees, the following portion of the meeting notes are organized into 5 main issues that were raised by EPA and were apparently related to the content of the memo.)

1. Upgradient monitoring
EPA requested the addition of 2 upgradient monitoring well clusters (D/R) to be located northwest of MW16-32D. These locations are shown on the attached Figure 5, which is a formal version of the hand-annotated figure that developed during this meeting. Mr. Evans agreed to add these 2 well clusters.

2. Monitoring for vinyl chloride
Vinyl chloride is a natural degradation product of trichloroethene (TCE), but because the injected HRC® will enhance (speed up) the *in situ* natural biodegradation rate, vinyl chloride will be formed at a higher concentration for a few months as the enhanced degradation process proceeds through vinyl chloride to ethene. In the Navy's 8 December 2003 RTC, shallow (S) and intermediate (I) depth interval screened wells have been added to 7 of the proposed monitoring well clusters. Additionally, 5 of the existing well clusters that are proposed for monitoring include intermediate (I) depth interval screened wells. Refer to the attached Figure 5 for the location of these wells.

3. Monitoring
Monitoring for 2 years was requested and several frequencies for sampling were discussed. The following monitoring frequency was tentatively accepted: monthly for the first 6 months after HRC® injection, every other month for the second 6 months, and quarterly for the succeeding 12 months; except when the vinyl chloride formation begins, at which point monitoring would be monthly until the vinyl chloride concentrations return to those prior to the HRC® injection, or the end of the pilot study. The wells to be included are: MW16-14I/D/R, MW16-15D/R/R2, MW16-32D/R, the Navy's proposed 12 D/R and 7 S/I monitoring well clusters, and the 2 new upgradient D/R monitoring well clusters discussed today (refer to the attached Figure 5). Baseline (pre-pilot test) sampling would include all of the wells on the attached Figure 5. Periphery monitoring wells (MW16-16I/D, MW16-38I, MW16-21I/D, and MW16-22I/D) could be sampled quarterly.

4. pH issue
In response to Ms. Williams' question regarding the reporting of pH for ground-water sample results, Mr. Shultz stated that pH would be reported the same as it has been in the past, as part of the low-flow ground-water purging and sampling process. It would be listed on the field sampling forms for each well each time it is sampled, and the final pH value field-measured just prior to collection of the sample from a well would be included in the summary table that would be included in the project report (as done previously for various NCBC Davisville sites).
Mr. Brandon expressed pleasure with this and said that Navy and EPA were coming together to resolve EPA's concerns, but that they would have to discuss today's tentative agreements with the other members of their project team.

Regarding the previous elevated pH detections in various wells located in the area from the former PR-58 Nike/Navy Site 03 area to Site 16, Mr. Brandon presented a color-annotated cross section he had prepared of monitoring wells that extended between each of these site areas, which seemed to indicate an 'upwelling' of elevated pH at MW16-32D. Mr. Shultz refer to the Navy's 12 November 2003 evaluation of 2 key EPA concerns which included the following:

> *...Most of these wells are completed in competent bedrock with steel casing bentonite-cement grouted in place down to the open or screened portion of the well. There is a good potential for a minor amount of the grout to have migrated into naturally present fractures in the rock near the top of the open or screened interval and which caused the elevated pH measured during sampling. As monitoring wells are not regularly pumped and are sampled (purged) perhaps once per year or less, this limited activity has apparently not removed ground water near the well with the elevated pH...*

In response to a question from Mr. Evans about the well installation method used by the Navy, Mr. Brandon said that he did not have an alternative suggestion for the installation of monitoring wells completed in bedrock. Mr. Brandon further stated that there will be a need to monitor the pH in the monitoring wells, but that the elevated pH levels previously measured in wells at the site would probably not impact the HRC® pilot test. In response to Ms. Williams' request to redevelop MW16-32D, Mr. Evans said that he would discuss it with his project team.[2]

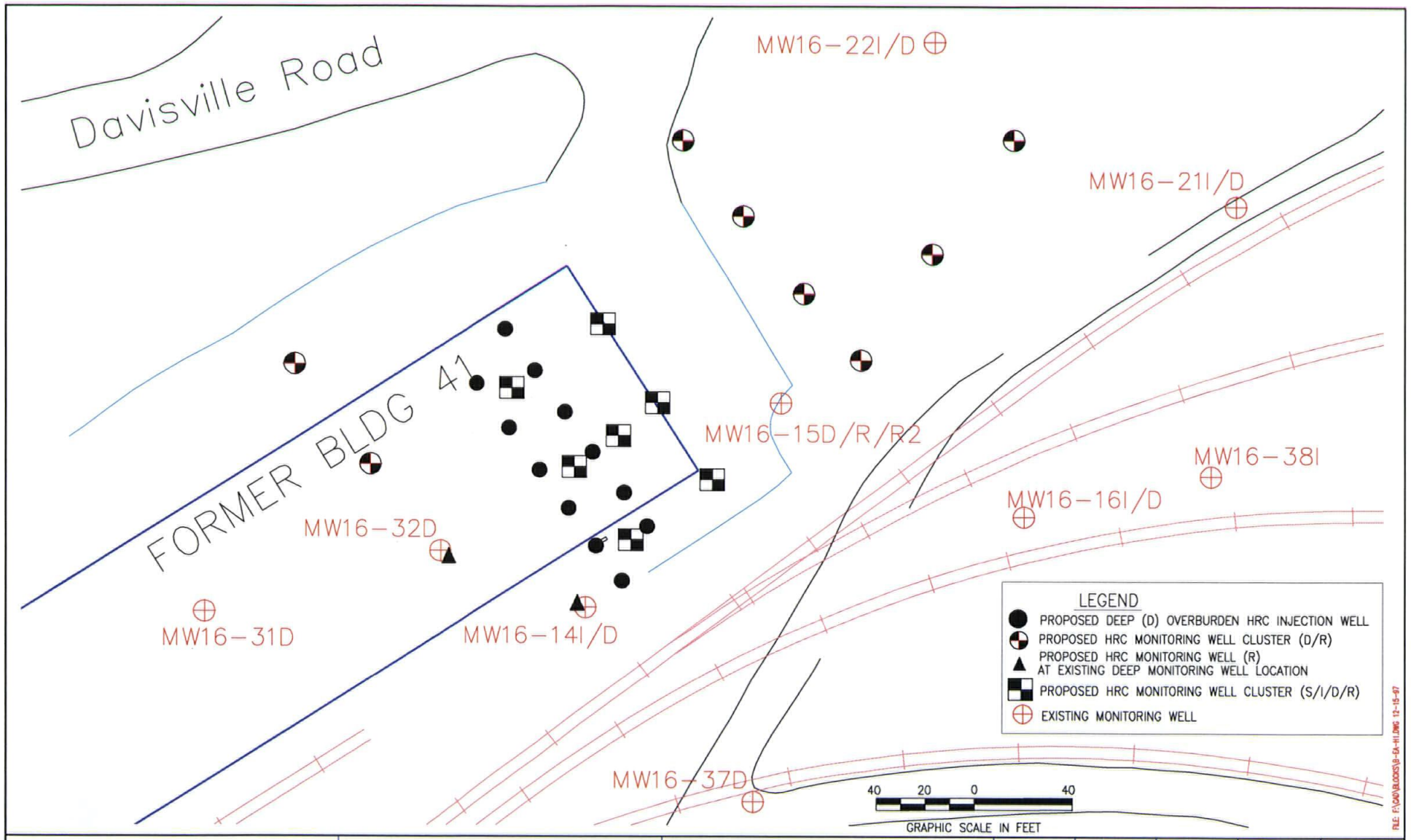
5. <u>What if a NAPL source area is encountered during drilling of the injection/monitoring well field?</u>
In response to this issue, Mr. Shultz referred to the statement in the Navy's 8 December 2003 RTC:

> *...If the...results were to indicate the presence of a high concentration source area (DNAPL) at one or more of these new wells, the design and type of the pilot test would be reconsidered.*

Ms. Williams asked a related question about moving the injection wells east to the MW16-22 vicinity. This was one of EPA's comments (Comment No. 5) that was addressed by the Navy's 8 December 2003 RTC, which stated that the March 2001 total CVOC results for wells in that area (MW16-21D, 1,904 µg/L; MW16-22D, 2,611 µg/L, and MW16-23D, 3,504 µg/L) are very similar to the total CVOC concentrations detected in the proposed pilot test area, and therefore the MW16-22 area would seem to have the same EPA concerns as the pilot test area proposed by the Navy.

Mr. Evans asked when there could be agreement with the well location and monitoring issue resolutions that have been discussed today. Ms. Williams said that she could not commit to a time before Christmas.

2 The Navy has discussed this and agrees with redeveloping monitoring well MW16-32D as part of the pilot study.



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EFANE SITE 16 HRC INJECTION PILOT TEST FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	SITE MAP (Revised as a result of the 12 Dec 03 BCT Meeting)	DESIGNED BY JAS	DRAWN BY RWC	DATE 1/5/04	PROJECT NO. 2960107	FILE NAME FIG 5
			CHECKED BY RWC	PROJECT MGR. JAS	SCALE AS SHOWN	DRAWING NO. –	FIGURE Figure 5

FILE: F:\CAD\BLDGS\B-EA-H1.DWG 12-15-97

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

Southborough Technology Park
333 Turnpike Road
Southborough, MA
01772
Tel. 508-485-2982
Fax. 508-485-5742

LETTER OF TRANSMITTAL

TO:
Fred Evans
EFANE (Code 1823/FE)
North Loop & American Way, Building G
Lester, PA 19113-2090
(610) 595-0567 Ext. 159

DATE: 23 March 2004	JOB NO. 29601.07.3101
ATTENTION: Fred Evans	
RE: 2nd RTC to QAPP for HRC Injection Pilot Study, Site 16, NCBC Davisville, North Kingstown, RI	
Contract No. N6247-92-D-1926, CTO 107	

WE ARE SENDING YOU [X] Attached [ ] Under separate cover via _____ the following items:

[ ] Shop drawings [ ] Prints [ ] Plans [ ] Samples [ ] Specifications
[ ] Copy of letter [ ] Change order [ ] _____

COPIES	DATE	NO.	DESCRIPTION
3	March 2004		Navy's Responses to EPA's Second Comments to the QAPP for HRC Injection Pilot Study, Site 16, NCBC Davisville, North Kingstown, RI

THESE ARE TRANSMITTED as checked below:

[ ] For approval [ ] Approved as submitted [ ] Resubmit _____ copies for approval
[X] For your use [ ] Approved as noted [ ] Submit _____ copies for distribution
[ ] As requested [ ] Returned for corrections [ ] Return _____ corrected prints
[ ] For review and comment [ ] _____

[ ] **FOR BIDS DUE** _____19_____ [ ] PRINTS RETURNED AFTER LOAN TO US
REMARKS

Fred,
The enclosed hardcopies of the files emailed yesterday of the Navy Responses to EPA's Second Comments to the QAPP for HRC Injection Pilot Study at Site 16 are for your use and file.

At your request and on behalf of the Navy, we are providing the hardcopies to the BCT (files were emailed yesterday) for their review and use. The Navy looks forward to discussing and resolving these with the BCT during the scheduled 30 March 2004 Technical Meeting at RIDEM's office.
Thank you,

COPY TO _____**See Below**_____ **SIGNED** _____
JIM SHULTZ, CTO MGR

D. Barney – NCBC CSO (1 copy), C. Williams – EPA (5 copies), R. Gottlieb – RIDEM (1 copy), S. King – RIEDC (1 copy), M. Cohen – ToNK (1 copy), K. Campbell – CDW Consultants (2 copies), K. Carr – USF&W (1 copy), K. Finkelstein – NOAA (1 copy), J. Shultz – EA Boston (1 copy), R. Clark – EA Boston (1 copy), F. Barranco – EA Loveton (1 copy), Project File – EA Boston (1 copy), K. Kilmer – EA PMO (1 copy)

If enclosures are not as noted, kindly notify us at once

RESPONSES TO EPA TECHNICAL MEMORANDUM DATED 5 FEBRUARY 2004 ON THE SITE 16 QAPP FOR HRC INJECTION PILOT STUDY OF SEPTEMBER 2003 NAVAL CONSTRUCTION BATTALION CENTER DAVISVILLE NORTH KINGSTOWN, RHODE ISLAND

GENERAL COMMENTS

[This Technical Memorandum has been formatted to facilitate response by separating the text in the subheaded sections into numbered items, as deemed appropriate.]

The purpose of the technical memorandum is to identify the locations for needed additional groundwater monitoring to adequately evaluate the effectiveness of the proposed HRC® pilot study and provide sufficient monitoring of potential down gradient groundwater quality impacts. The recommendations provided in this technical memorandum are based upon review of the HRC® Pilot Study QAPP, Navy responses to USEPA comments on that document, and the Site 16 Phase I and II Remedial Investigations Reports. In order for the proposed HRC® pilot study to maximize the usefulness of data collected, and provide protection of human health and the environment, it must achieve at least four objectives.

1. Provide adequate quantification of background or "up gradient" groundwater quality for inflowing groundwater not altered by the effects of HRC® injection.

2. Provide adequate delineation of the extent of the inferred localized source area in the vicinity of the HRC® pilot test.

3. Provide a proper frame work for effective evaluation of the resulting groundwater quality changes resulting from the injection and subsequent effects of HRC®.

4. Provide accurate monitoring of down gradient groundwater for adverse degradation products resulting from the injection of HRC®.

Achievement of these objectives is limited by continuing data gaps related to groundwater quality and hydraulics in the area north of the former Building 41 footprint and just south of Davisville Road, and groundwater hydraulics down gradient of that location, particularly in the shallow groundwater zone. In particular, the groundwater flow patterns up gradient and down gradient of the proposed pilot test location are, at best, variable and to the north of the former Building 41 location, undefined. This uncertainty has the potential to significantly impact evaluation of the pilot study effectiveness and fully assess down gradient impacts from the proposed HRC® pilot study.

Therefore, the following general monitoring well locations are recommended and depicted on the attached figure. These recommendations make maximum use of existing Phase I and II Remedial Investigation wells and planned pilot study monitoring wells. Two new monitoring well quadruplets are recommended in addition to four shallow groundwater monitoring wells in the down gradient area that is presently devoid of them. The new quadruplet wells should be

located after additional geophysics is used to fill in data gaps of the knowledge of the top of bedrock north of the former Building 41. The pilot study injection/extraction and internal monitoring wells should be located/installed after the new monitoring wells have been installed and sampled for VOC and groundwater surface contour maps have been prepared.

Background Monitoring

1. Background monitoring locations must not be impacted by significant contributing contaminant levels that might affect the observed results of the pilot test. The background or "up gradient" monitoring wells proposed in the pilot study are not background wells and therefore, do not fulfill this objective. A true up gradient background line of wells should be established. This line should consist of the wells at locations MW16-12, MW16-31, MW16-11, and a new well quadruplet north of the former Building 41 location and just south of Davisville Road. This is shown as Line 1 on the attached figure.

   Response: The Navy agrees with this 'Line 1' of monitoring wells as shown on the attached figure. However, some of the existing wells were not accurately located on the figure provided by EPA, the locations for EPA's additional or moved wells were added to the CAD file for this drawing so that the existing monitoring wells plot in their proper locations. The monitoring well locations, which were added or moved by EPA, are shown by 'red' colored symbols. The additional monitoring well location was generally agreed to during the 12 December 2003 BCT meeting. However, it is assumed that the actual location of the added well quadruplet can adjusted in the field so it is not within the relatively new storm water retention pond in that area, but rather located south of Davisville Road and north of the existing chain-link fence.

2. The Navy should also gather shallow groundwater data at the available shallow wells at locations MW16-33 and MW16-34. If these are not planned to be included in the groundwater sampling program then Navy should install a shallow well at the MW16-12 location to tighten up-gradient control.

   Response: The Navy plans to install and sample a shallow well at the MW16-12 location.

Source Area Monitoring

3. The wells referred to in the pilot study work plan as "background wells" are actually source area wells, not background wells. That is, MW16-14D and MW-32D exhibit high levels of chlorinated volatile organic contamination. Monitoring of those wells is acceptable if used for the first purpose, source area monitoring, keeping in mind that there has not been a delineation of the inferred source area described in the pilot study work plan. Specifically, there is a data gap to the north side of the former Building 41 footprint.

   Response: Comment noted.

4. Also, MW16-37S/I has been shown to be a major potential contributing source area that could impact groundwater quality in the down gradient area of the pilot test and mask results.

In order to fully assess this "source area," a line of wells including MW-37S/I/D, MW16-14D, MW16-32D, and a new monitoring well quadruplet installed on the north side of the former Building 41 footprint is needed. This is shown as Line 2 on the attached figure. EPA agrees with the Navy's original proposal to add rock wells to locations MW16-32 and MW16-14 to further expand our understanding of the bedrock system in this source area, however, would be willing to negotiate the removal of these proposed rock wells for this pilot study due to the focus of the pilot study being in the overburden.

Response: The Navy agrees with this 'Line 2' of monitoring wells. The additional monitoring well location was generally agreed to during the 12 December 2003 BCT meeting. However, it is assumed that the actual location of the added well quadruplet can adjusted in the field to lessen its impact on that area where new cars are parked.

Near-Term Down Gradient Monitoring

5. Several proposed groundwater monitoring wells are proposed within and immediately adjacent to the HRC® pilot injection points. These wells are interpreted by EPA to be process monitoring wells, rather than down gradient monitoring wells. The first line of true near-term down gradient monitoring wells is interpreted to be the line of four proposed well locations that align with MW16-16 I & D. However, these wells are not optimally positioned due to the uncertainties in groundwater flow patterns from the area of HRC® injection. Therefore, it is recommended that the positions of those wells be adjusted as shown on the attached figure. Those wells, along with MW16-16 I & D constitute Line 3. No additional new well locations are required for this line. EPA requests that these proposed well clusters to consist of intermediate and deep wells rather than deep and rock wells since the pilot study focus has changed from the bedrock system to the deep overburden.

   Response: Two of the 'process monitoring' well quadruplets have been deleted so those resources can be used at the 2 new well quadruplet locations (Lines 1 and 2). The Navy agrees with the minor shifting of the proposed monitoring wells along Line 3 with the following minor revision: move the southern 2 proposed monitoring wells each 5-10 ft northwest along Line 3 for better coverage of the migration of the main plug of the injected HRC® and so the southern of these 2 well pairs is a minimum of 10 ft from the railroad tracks.

Longer-Term Down Gradient Monitoring

6. A second line of down gradient monitoring is necessary to evaluate groundwater quality changes resulting from the proposed pilot study. This line is shown on the attached figure as Line 4. It consists of existing monitoring wells MW16-25D, MW16-21I and D, MW16-23D, and MW16-08D along with augmentation by two additional well clusters already proposed. The two wells located down gradient of the Line 3 wells, should be shifted as shown on the attached figure. One should be moved to between MW16-23D and MW16-08D, just south of Davisville Road and the other to between MW16-21D and MW16-25D. No additional well locations are required for this line. The well clusters should consist of shallow, intermediate, and deep well screens.

Response: The Navy agrees with this 'Line 4' of monitoring wells with the following suggestions: 1) MW16-25 will be used in lieu of the southernmost of EPA-proposed well triplets because it is too close to MW16-25 to be cost effective, and 2) the installation of a rock (R) well to northern proposed well triplet (now a quadruplet) location so the potential downward migration from the injection interval (deep overburden) can be assessed. The rock well will also provide important vertical hydraulic gradient data between the deep overburden and the upper bedrock zones. Additionally, the Navy believes that a deep overburden and upper bedrock monitoring well pair is still appropriate to be located between Lines 3 and 4 so the migration of the HRC® can be tracked along the length of its interpreted flow path approximately midway from the nearest rock monitoring well toward both the northeast and southwest directions.

Shallow Groundwater Hydraulics

7. Shallow groundwater flow patterns are not resolved up-gradient, at, nor down gradient of the proposed pilot test. Therefore, EPA believes it is necessary to construct a shallow monitoring well at MW16-15D, MW16-08, MW16-23D, and MW16-25D to complete resolution of down-gradient shallow groundwater flow patterns and assist in monitoring of shallow groundwater quality. In the previous paragraphs EPA has requested either a shallow well screen be installed at the MW16-12 location or that MW16-33 S and MW34S be included for gauging as part of the pilot test. Additionally, the two new monitoring well locations north of former Building 41 have been requested to have shallow well screens installed.

   Response: The Navy agrees with the installation of the 4 shallow monitoring wells. Please see the Navy's responses to EPA Comment No. 2 regarding MW16-12 and EPA Comment Nos. 1 and 4 regarding the two new monitoring well locations north of former Building 41.

NAVY RESPONSES TO EPA COMMENTS DATED 5 APRIL 2004 ON THE TECHNICAL MEMORANDUM DATED 5 FEBRUARY 2004 ON THE SITE 16 QAPP FOR HRC INJECTION PILOT STUDY OF SEPTEMBER 2003 NAVAL CONSTRUCTION BATTALION CENTER DAVISVILLE NORTH KINGSTOWN, RHODE ISLAND

GENERAL COMMENTS

Overall, the recommendations provided by the EPA have been accepted by the Navy and will be incorporated into the pilot study. There are a couple of relatively minor variations that are suggested by the Navy that EPA deems acceptable to the monitoring well location plan and which should not adversely impact monitoring of the HRC® Pilot Study when implemented. The minor adjustments are discussed below along with a couple of additional concerns, one of which may be of significant impact.

BACKGROUND MONITORING

Comment 1: *Comment addressed.* The Navy concurs with the installation of the additional bedrock monitoring well quadruplet and the proposed locations of the additional monitoring wells along Line 1. However, the Navy does suggest adjustment of the proposed location so as not to impact a storm water retention basin that apparently is not in place to the north of the former Building 41 location. The new location should not be an issue so long as it is close to the depicted location.

However, the heretofore unknown presence of the storm water retention basin is a potentially major problem. Description of the storm water structure as a "retention" basin as opposed to "detention" basin suggests that storm water runoff will be recharged to the site subsurface at this location. It appears that storm water will be retained within the basin and be allowed to infiltrate to the subsurface. The specific location, dimensions, capacity, and design operational characteristics of the storm drain have not been included in the responses to comments, but are inferred to be between the former Building 41 footprint, MW16-11D, and the two new proposed monitoring well quadruplets. Recharge of storm water at his location has the potential to significantly alter the local groundwater flow patterns in the area through creation of a groundwater mound, at least intermittently below the footprint of the retention basin. Mounding of groundwater at this location has the potential to deflect groundwater migrating into this location from up gradient to more northerly and southerly directions.

This groundwater mound also has the potential to alter the groundwater flow paths from the proposed HRC® Pilot Test location. The inferred location of this storm water retention basin has the potential to push groundwater into a more southeasterly direction from the anticipated east to northeast direction of

groundwater migration from the HRC® Pilot Test location. How this would impact the proposed monitoring well locations is unknown at this time without further information concerning the design characteristics of the storm water retention basin. It should also be noted that even if this basin is more accurately described as a storm water "detention" basin, considerable infiltration and subsequent groundwater mounding can still occur unless the basin is lined.

An additional concern is the impact that this storm water retention basin may have or have already had, on the identification of potential sources of chlorinated volatile organic compounds (CVOC) in that location. Excavation of soils to construct the storm water retention basin may have removed evidence of a surface release in that area. While the exact location of the basin relative to the former Building 41 footprint is not specifically identified, it appears to be in the area that could be providing contamination observed at monitoring wells at the eastern end of the former Building 41 footprint. Further, addition of significant volumes of storm water runoff to the subsurface at this location has the potential to dilute the ambient concentrations of CVOC in the groundwater in this area. Therefore, additional information is needed concerning the basis of design for this storm water retention basin and impacts to site groundwater.

Response— As agreed during the BCT Meeting of 30 March 2004, depth to water was measured in 50 existing monitoring wells in the vicinity of the planned HRC® injection pilot study prior to initiating the well drilling portion of the pilot study. The attached Figure A shows the area within which it was agreed to obtain the water level measurements. These measurements were to be obtained on 7 and 9 April 2004 following a significant rain event on 31 March and 1 April 2004 (approximately 3.4 in. of rain was measured at the Providence T F Green State AR station). The interpretive contouring of the related water surface elevation data is provided on Figures 1-4 (attached), and show that the data is similar to that for data collected for the Site 16 Phase II Hydrogeological Investigation in November 2002 and March 2003. There is no apparent mounding of the ground water shown for the April 2004 data. This suggests that if there is ground-water mounding related to infiltration of collected storm water run-off through the relatively new and unlined detention/retention pond into the ground, it is apparently minor and/or very short lived. The approximate location of the detention pond is also shown on the attached Figures 1-4.

The relatively new and unlined detention/retention pond was constructed Fall 2002 during the time that Building 41 was demolished and the area re-paved. Therefore, both the April 2004 ground-water level measurements and the two rounds of measurements for the Site 16 Phase II Hydrogeological Investigation appear to have occurred after construction of the pond. RIEDC has provided a portion of the design drawing that included the planned detention pond (copy attached). RIEDC also located a copy of the related drainage computation document (copy attached).

With regard to the EPA's concern for the potential "impact that this storm water retention basin may have or have already had, on the identification of potential sources of chlorinated volatile organic compounds (CVOC) in that location," the detention pond was constructed into a hillside that was located between the former Building 41 and Davisville Road. Based on the Site 16 Phase II Investigation results for total CVOC detected (November-December 2002) in ground-water samples from MW16-11S (0.9 μg/L) and MW16-13I (6.92 μg/L), that area does not appear to have been a potential source area. These two monitoring wells are located just south of the detention pond. Additionally, the total CVOC detected in ground-water samples from MW16-11D and MW16-13D were only 4.94 μg/L and 0.56 μg/L, respectively.

Comment 2: *Comment addressed.* The installation of a shallow monitoring well at the MW16-12D location will fulfill the recommendation for either a shallow well at this location or groundwater elevation measurements at MW16-33S and MW16-34S. However, since there is little cost to measuring groundwater elevations for these two wells and more data points usually strengthens development of groundwater flow contours, elevation measurements for those two wells are still desirable.

Response— The Navy has added MW16-33S and MW16-34S for water level measurement.

SOURCE AREA MONITORING

Comment 3: *Comment addressed.*

Comment 4: *Comment addressed.* However, as with the request for flexibility in positioning the new monitoring well quadruplet for Line 1, the heretofore unknown storm water retention basin may impact the quality data obtained from this well. If the location of the retention basin is as inferred in Comment 1, this quadruplet now will lie immediately down gradient of the storm water retention basin. This will impact groundwater characteristics in this well by potentially diverting inflowing up gradient water and diluting ambient groundwater of CVOC and possibly adding organics included in runoff. This last aspect has the potential to place an additional demand on HRC ® requirements if the organic loading is significant and groundwater migrates into the treatment zone.

If the location adjustment flexibility suggested by the Navy is relatively minor, slight movement of this well location should not be a significant concern (the relatively new storm water retention basin notwithstanding). However, the area proposed is in a location that has not yet been evaluated for presence of the source that is inferred to be at the eastern end of the former Building 41 footprint. Movement of the well should not be to such an extent that it would be outside this potential source area (assuming that excavation for the storm water retention basin

has not removed evidence of any prior surface release in this vicinity).

Response— See the Navy's response to EPA Comment No. 1.

NEAR-TERM DOWN GRADIENT MONITORING

Comment 5: *Comment addressed.* The slight adjustments suggested by the Navy are acceptable so long as there remains relatively uniform distribution of the monitoring well locations from MW16-16I/D to near Davisville Road. Because of the uncertainties of groundwater flow directions, especially in the shallow zone, which appear to be potentially exacerbated by the relatively new storm water retention basin, adequate, uniform coverage along this line is necessary. Additionally, if analysis of potential mounding and changes in groundwater flow patterns that result from recharge beneath the storm water retention basin cause deflection of shallow groundwater further to the southeast, it may be necessary to move the northernmost well to the south of MW16-16I/D.

Response— Moving of the referenced well is not anticipated to be necessary. See the Navy's response to EPA Comment No. 1.

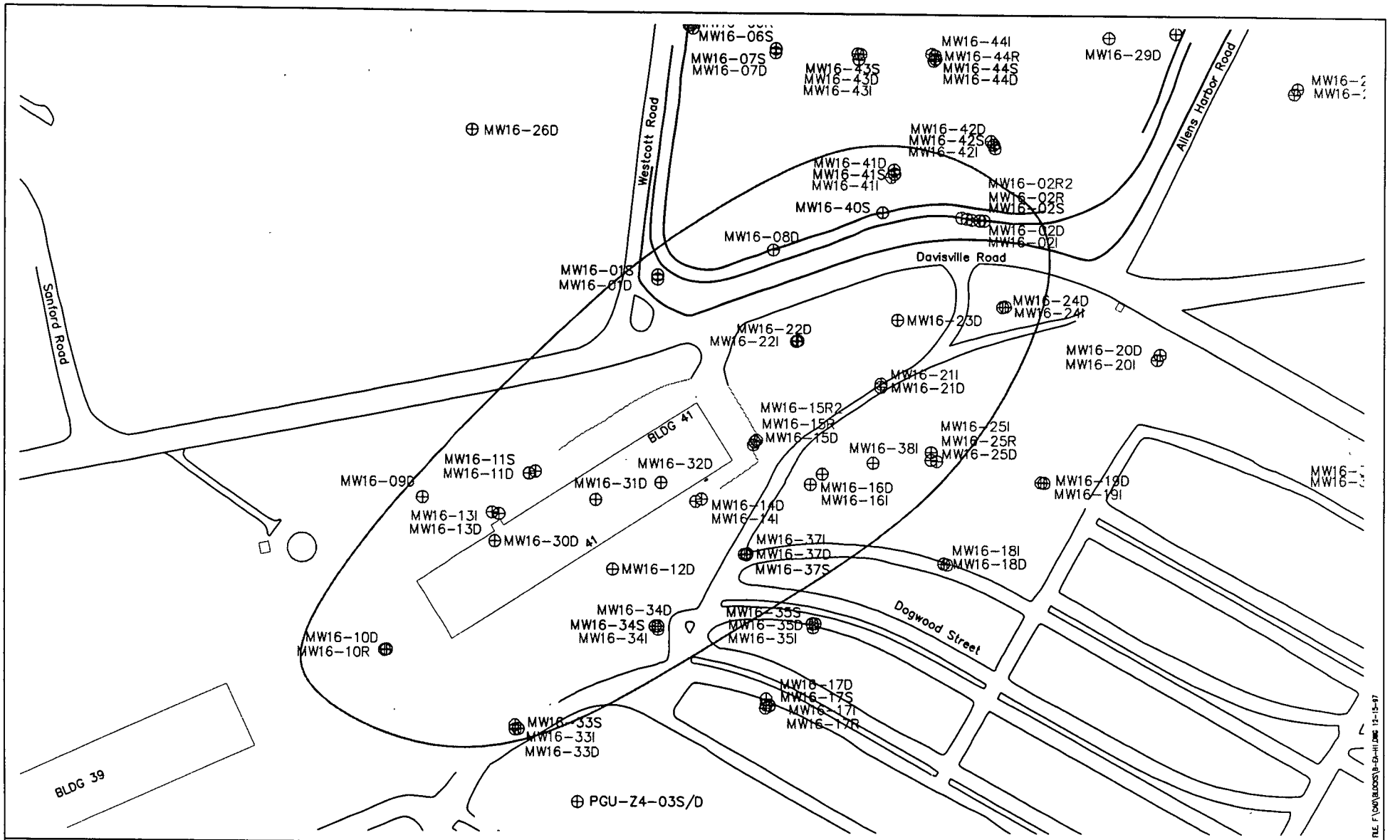
LONGER-TERM DOWN GRADIENT MONITORING

Comment 6: *Comment addressed.* The positioning of monitoring wells suggested by the Navy is acceptable. However, as with Comment 5, if the impact of the storm water retention basin is to push groundwater further to the southeast, the additional monitoring well cluster that the Navy proposes to leave between Line 3 and Line 4 may need to be installed to the south of MW16-25D.

Response— Moving of the referenced well is not anticipated to be necessary. See the Navy's response to EPA Comment No. 1.

Comment 7: *Comment addressed.* However, some assessment of the shallow groundwater elevation beneath the relatively new, heretofore unknown, storm water retention basin should be made. This elevation may be fluid depending upon storm water runoff events and amount of expected infiltration to the subsurface. Therefore, a mounding analysis should be performed for this basin.

Response— The referenced pond does not appear to have much impact on the shallow ground water. See the Navy's response to EPA Comment No. 1. Additionally, ground-water level measurement will continue during the HRC® injection pilot study which will add several monitoring wells screened in the shallow and intermediate overburden zones in this area, enhancing the ability to assess the impact from the detention pond.

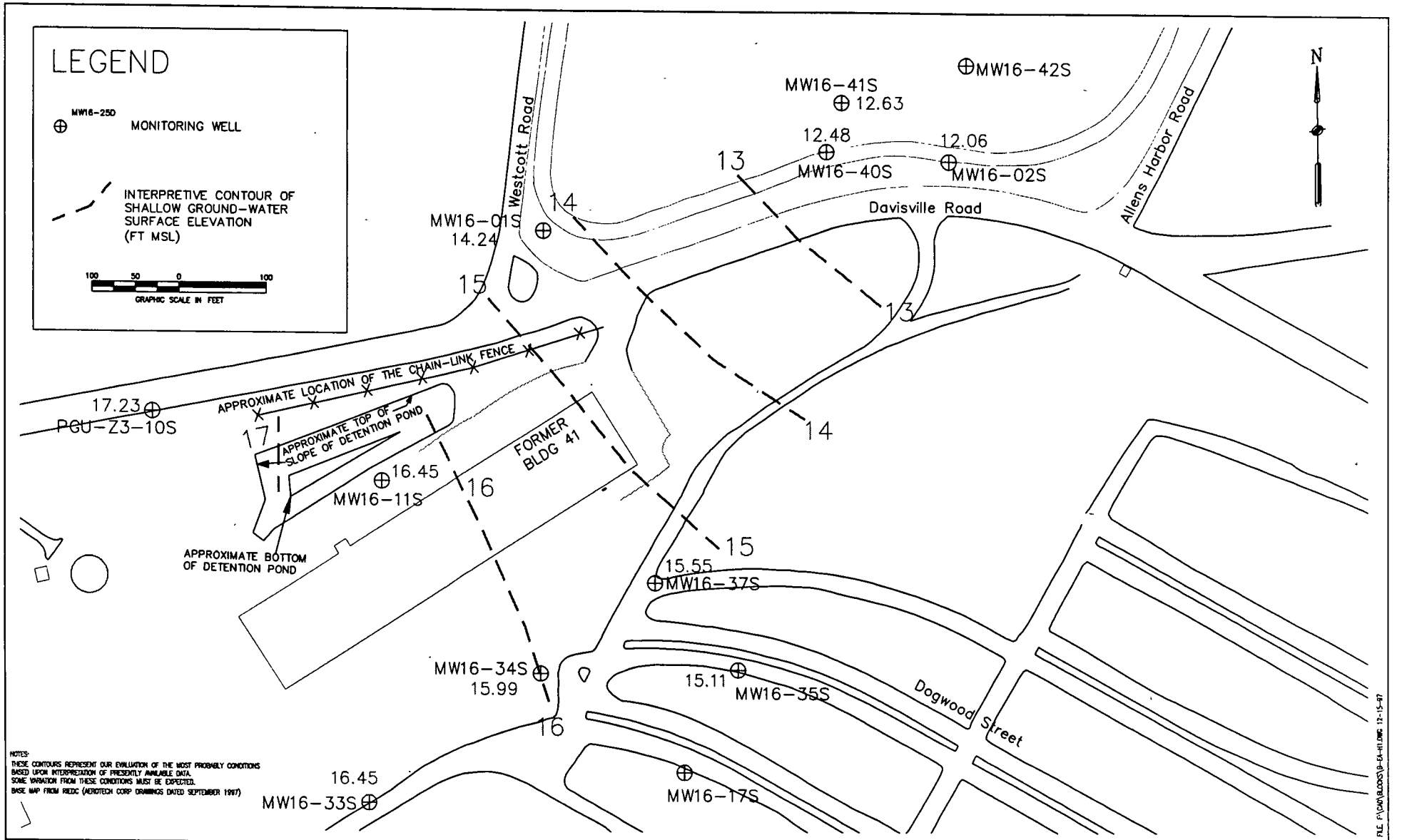


EA ENGINEERING, SCIENCE, AND TECHNOLOGY

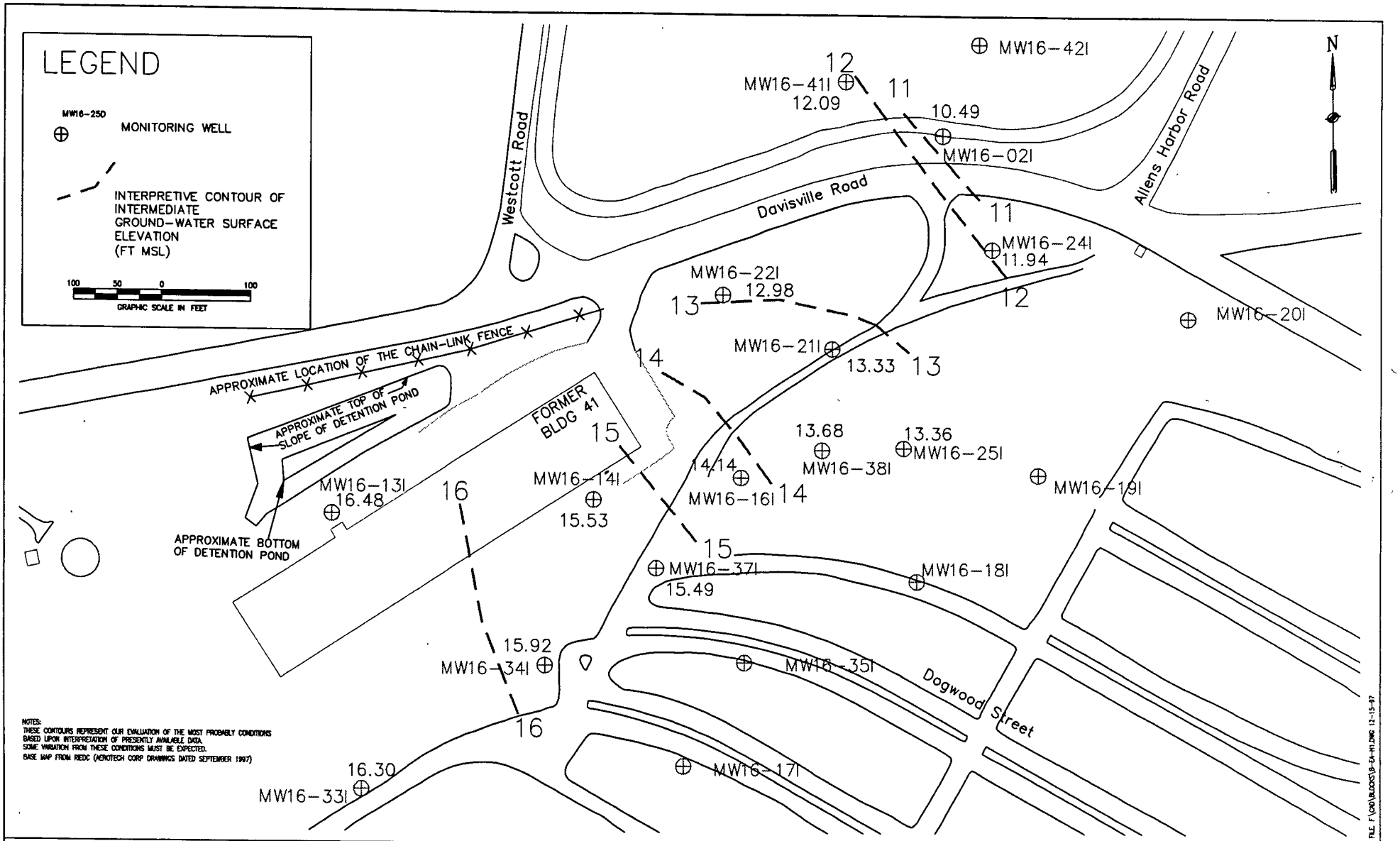
FTANC
SITE 16 HRC PILOT STUDY
FORMER NCBC DAVISVILLE FACILITY
NORTH KINGSTOWN, RHODE ISLAND

PRE-DRILLING WATER LEVEL MEASUREMENT LOCATIONS

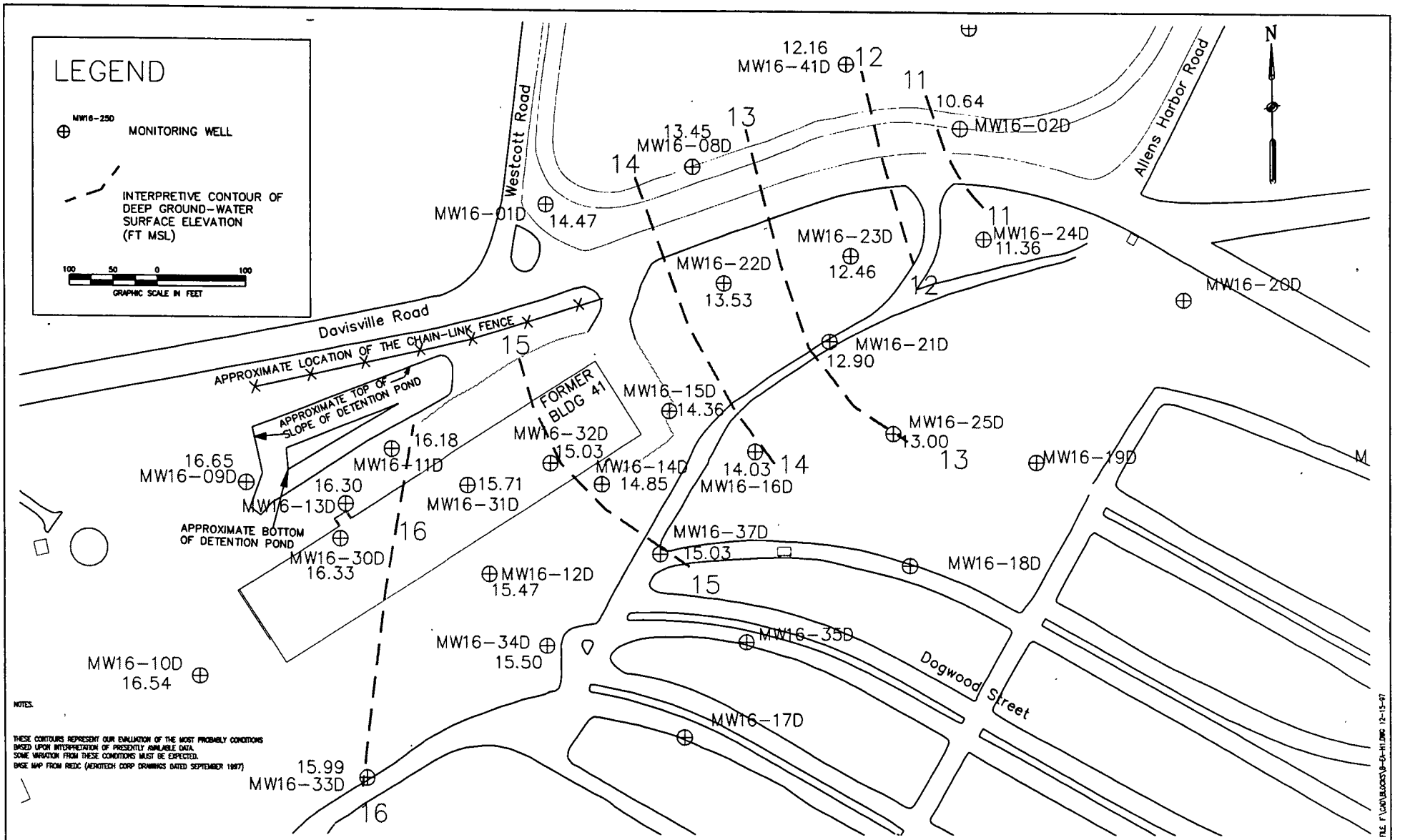
DESIGNED BY	DRAWN BY	DATE	PROJECT NO.	FILE NAME
JAS	RWC	4/1/04	2960C97	Water level
CHECKED BY	PROJECT MGR.	SCALE	DRAWING NO.	FIGURE
RWC	JAS	NONE	-	Figure B



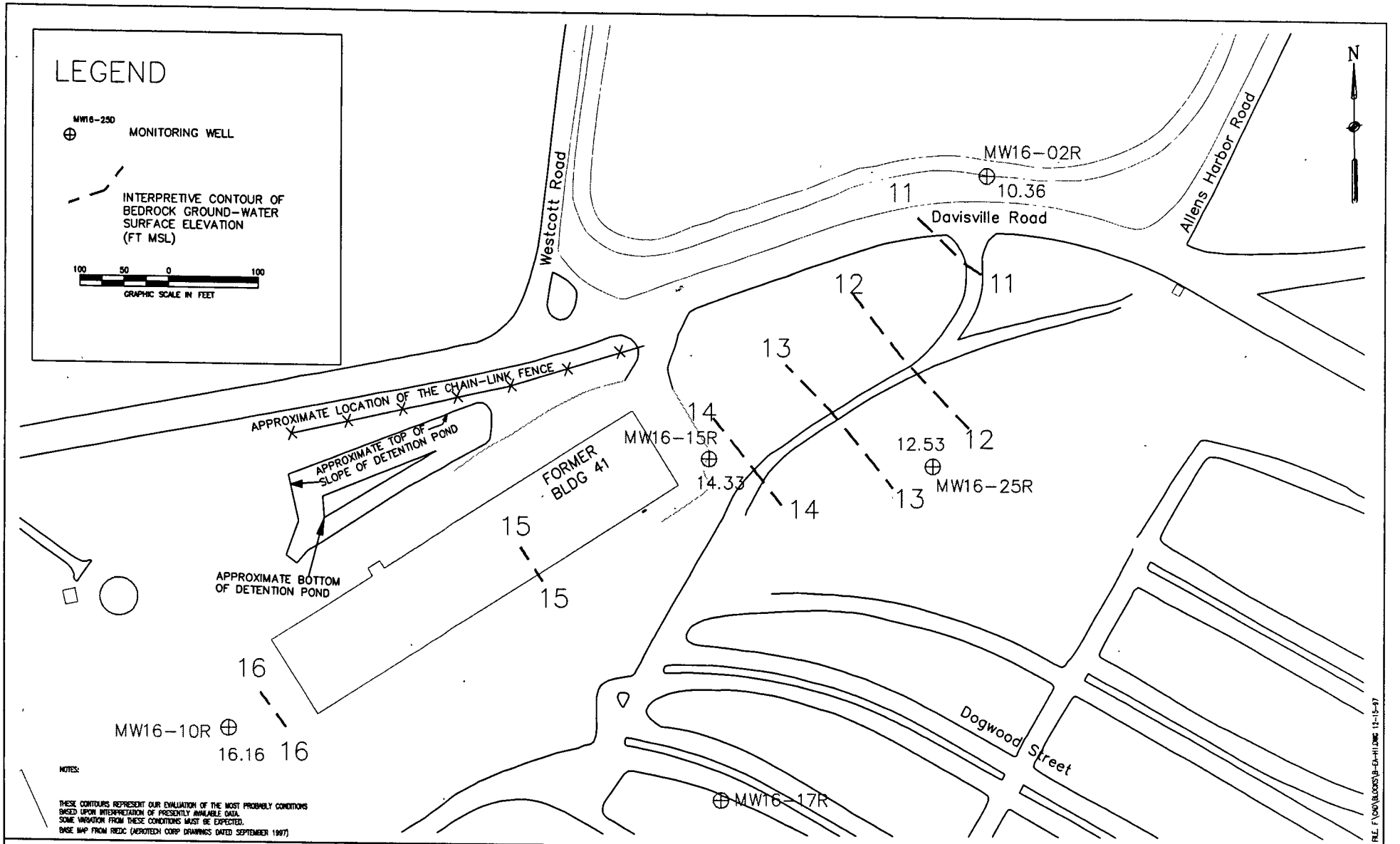
EA ENGINEERING, SCIENCE, AND TECHNOLOGY	CFANE SITE 16 HRC PILOT STUDY FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	INTERPRETIVE GROUND-WATER CONTOURS SHALLOW WELLS (APRIL 9 2004)	DESIGNED BY RWC	DRAWN BY RWC	DATE 7/15/04	PROJECT NO 2960'07	FILE NAME SHALLOW
			CHECKED BY JAS	PROJECT MGR. JAS	SCALE NONE	DRAWING NO –	FIGURE Figure



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EFANE SITE 16 HRC PILOT STUDY FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	INTERPRETIVE GROUND WATER SURFACE CONTOURS INTERMEDIATE WELLS (APRIL 7 2004)	DESIGNED BY RWC	DRAWN BY RWC	DATE 7/15/04	PROJECT NO 296C107	FILE NAME INTER
			CHECKED BY JAS	PROJECT MGR JAS	SCALE NONE	DRAWING NO -	FIGURE Figure 2

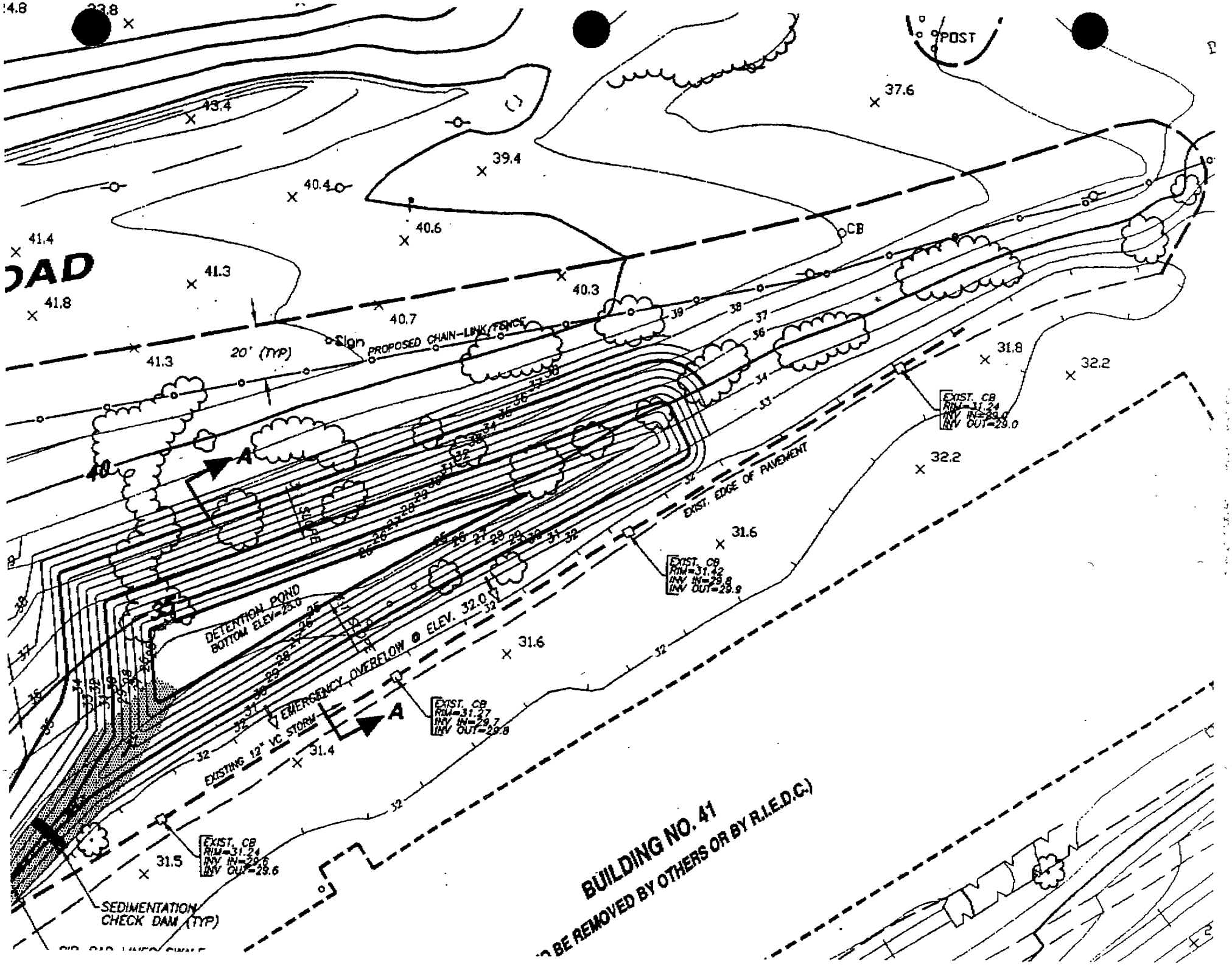


EA ENGINEERING, SCIENCE, AND TECHNOLOGY	EFANE SITE 16 PHASE II RI FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	INTERPRETIVE GROUND-WATER SURFACE CONTOUR DEEP WELLS (APRIL 7 2004)	DESIGNED BY RWC	DRAWN BY RWC	DATE 7/15/04	PROJECT NO. 2960107	FILE NAME DFEP
			CHECKED BY JAS	PROJECT MGR. JAS	SCALE NONE	DRAWING NO –	FIGURE Figure 3



EA ENGINEERING, SCIENCE, AND TECHNOLOGY	DFANF SITE 16 PHASE II RI FORMER NCBC DAVISVILLE FACILITY NORTH KINGSTOWN, RHODE ISLAND	INTERPRETIVE GROUND-WATER SURFACE CONTOURS ROCK WELLS (APRIL 7 2004)	DESIGNED BY RWC	DRAWN BY RWC	DATE 7/15/04	PROJECT NO 2960'07	FILE NAME ROCK
			CHECKED BY JAS	PROJECT MGR. JAS	SCALE NONE	DRAWING NO –	FIGURE Figure 4

REF. F:\CAD\BLOCKS\B-EA-H1.DWG 12-15-97


POST
CB
Sign
PROPOSED CHAIN-LINK FENCE
20' (TYP)
DETENTION POND
BOTTOM ELEV=25.0
EMERGENCY OVERFLOW @ ELEV. 32.0
EXISTING 12" VC STORM
EXIST. EDGE OF PAVEMENT
EXIST. CB
RIM=31.24
INV IN=29.6
INV OUT=29.6
EXIST. CB
RIM=31.42
INV IN=29.8
INV OUT=29.9
EXIST. CB
RIM=31.27
INV IN=29.7
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EXIST. CB
RIM=31.24
INV IN=29.0
INV OUT=29.0
SEDIMENTATION
CHECK DAM (TYP)
BUILDING NO. 41
BE REMOVED BY OTHERS OR BY R.I.E.D.C.)

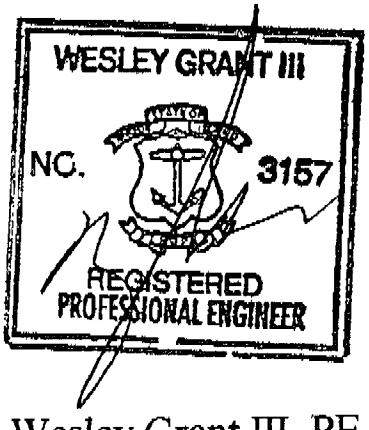
DRAINAGE COMPUTATIONS
NORAD SITE 41

For:

NORAD
NORTH ATLANTIC DISTRIBUTION INC.
DAVISVILLE INDUSTRIAL PARK
100 TIDAL DRIVE
NORTH KINGSTOWN, RHODE ISLAND 02852

By:

Environmental Planning & Surveying, Inc.
52 Dugway Bridge Road – P.O. Box 248
West Kingston, Rhode Island 02892



Wesley Grant III, PE

RECEIVED
JUL - 3 2002
RIEDC
ENGINEER

EXISTING CONDITIONS

This entire site consists of Quonset soils. This is a hydrologic group "A". The cover on this site was grass and used as part of the water distribution system. The grass area is in fair condition and steep sloped. The drainage from this area was directed into the existing systems that supported disposal of surface water from Building #39 area and Building #41. Building #39's drainage disposes in Davol Pond. Drainage from building #41 disposes in Narragansett Bay.

Existing conditions yield a Cn of 49 (Tr55 Figure 2-2a).

$$\frac{1.0(\text{fig. } 2\text{-}1) \times 81{,}000 \text{ sf}}{12} = 6{,}750 \text{ cf}$$

Based on a 25 yr. Rain of 5.8" in 24 hr. period.

PROPOSED CONDITIONS

The flows on the site will be directed so that approx. one acre of drainage will flow towards building #41 away from building #39. The proposed work consists of removing the grass knoll and grading entire area towards building # 41. The grass area as shown will be paved to park approx. 168 autos as part of the NORAD operation thus reducing grass area and adding pavement area. The rest of the lot will remain as is with no new additional impervious. The designed retention pond will retain the excess flows from 25-year frequency rainfall. When full and this amount of flow is removed, an overflow into the existing drain could be provided.

Proposed conditions yield a Cn of 98 (Tr55 Figure 2-2a).

$$\frac{5.7(\text{fig. 2-1}) \times 81{,}000 \text{ sf}}{12} = 38{,}475 \text{ cf}$$

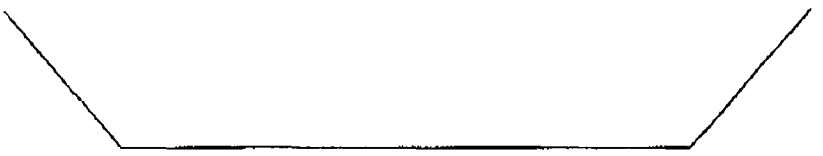
Based on a 25 yr. Rain of 5.8" in 24 hr. period.

POST 38,475 cf - PRE.= 6750 cf = 31,725 cu ft increase

Net flow on site is a 31,725 cu ft. increase (see sheet hydrograph summary report for 25 yr.)

POND DESIGN

Estimated water table is elevation 16.20'. This elevation was determined by test borings in area of proposed additions for building #39 this test pit was dug in the same soils group, Quonset and located at approx. elevation 34.20'. The proposed pond will be dug into existing grass area and constructed with a 2:1 sloped which will be loamed. Bottom of pond to be lined with 3"-6" stone. Bottom elev. To be 25.0.



Discharge concepts

A. Use a top of pond area of 10263. sf at elev. 30.0. This elevation is based on an overflow into the existing system through a 10" discharge pipe into an existing basin.

B. Use a top of pond area of 14,447 sf if a total flood with using the existing catch basin's as the inlets rather than constructing a new pipe outlet to a catch basin.

AREA of POND (at specified levels)

ELEV		VOL
32.0	14,447 sf	
		13,272 cf
31.0	12,096 sf	
		11,180 cf
30.0	10,263 sf	
		9,689 cf
29.0	9,115 sf	
		8,557 cf
28.0	7,999 sf	
		7,456 cf
27.0	6,914 sf	
		6,388 cf
26.0	5862 sf	
		5,352 cf
25.0	4842 sf	

volume of pond below elev. 30.0 = 37,442 cf
volume of pond below elev. 32.0 = 61,894 cf

This Engineer recommends B concept. The existing system is positioned in such a manor so the existing basins will accept overflow with out changing the existing openings. At the level when overflow would occur none of the pavement in the area would be covered with water. Considering volume of pond @61,894 cf plus seepage out potential of 37,000 cf in a 24hr period. I find the system "B" more than answers the need of pond storage and disposal with out impacting the existing drainage system.

STATE OF RHODE ISLAND — SHEET NUMBER 87

PRE

NORAD BLD 41

Table 2-2a.—Runoff curve numbers for urban areas[1]

Cover description		Curve numbers for hydrologic soil group—			
Cover type and hydrologic condition	Average percent impervious area[2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.)[3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)[4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)[5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1]Average runoff condition, and $I_a = 0.2S$.
[2]The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3]CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4]Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5]Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4, based on the degree of development (impervious area percentage) and the CN's for the newly-graded pervious areas.

POST
NORAD BLD 41

Table 2-2a.—Runoff curve numbers for urban areas[1]

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Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
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Worksheet 2: Runoff curve number and runoff

Project NORAD By WG Date 6/27/02

Location BLD 41 Checked ____ Date ____

Circle one: Present (Developed)

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☐ acres ☐ mi² ☐ %	Product of CN x area
QUONSET A	PAVED	98			1.86	
		98			1.86	
	Totals =				1.86	

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ____ = ____; Use CN = 98

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency ..... yr			
Rainfall, P (24-hour) ..... in			
Runoff, Q ..... in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)			

Worksheet 2: Runoff curve number and runoff

Project NORAD By WG. Date 6/29/02

Location BLD 41 Checked ____ Date ____

Circle one: (Present) Developed

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/ Table 2-2	CN 1/ Fig. 2-3	CN 1/ Fig. 2-4	Area ☐ acres ☐ mi² ☐ %	Product of CN x area
QUONSET GROUP A	GRASS – FAIR	49			1.86	
		49			1.86	
				Totals =	1.86	

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ____ = ____; Use CN = 49

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr			
Rainfall, P (24-hour)	in			
Runoff, Q ..... (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in			

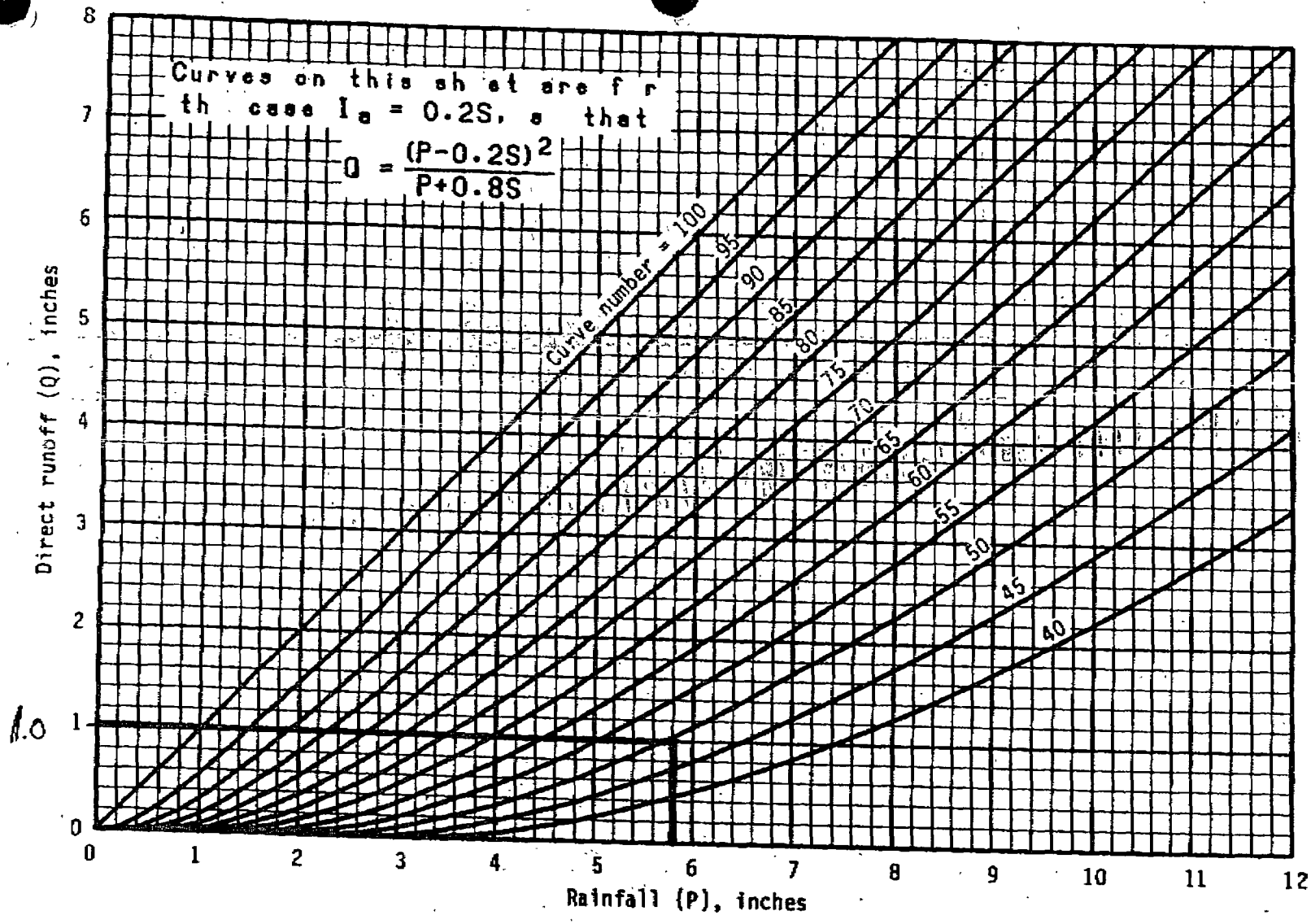

Figure 2-1.—Solution of runoff equation.

25YR. RAIN FALL=
5.8" IN 25YR.

PRE.

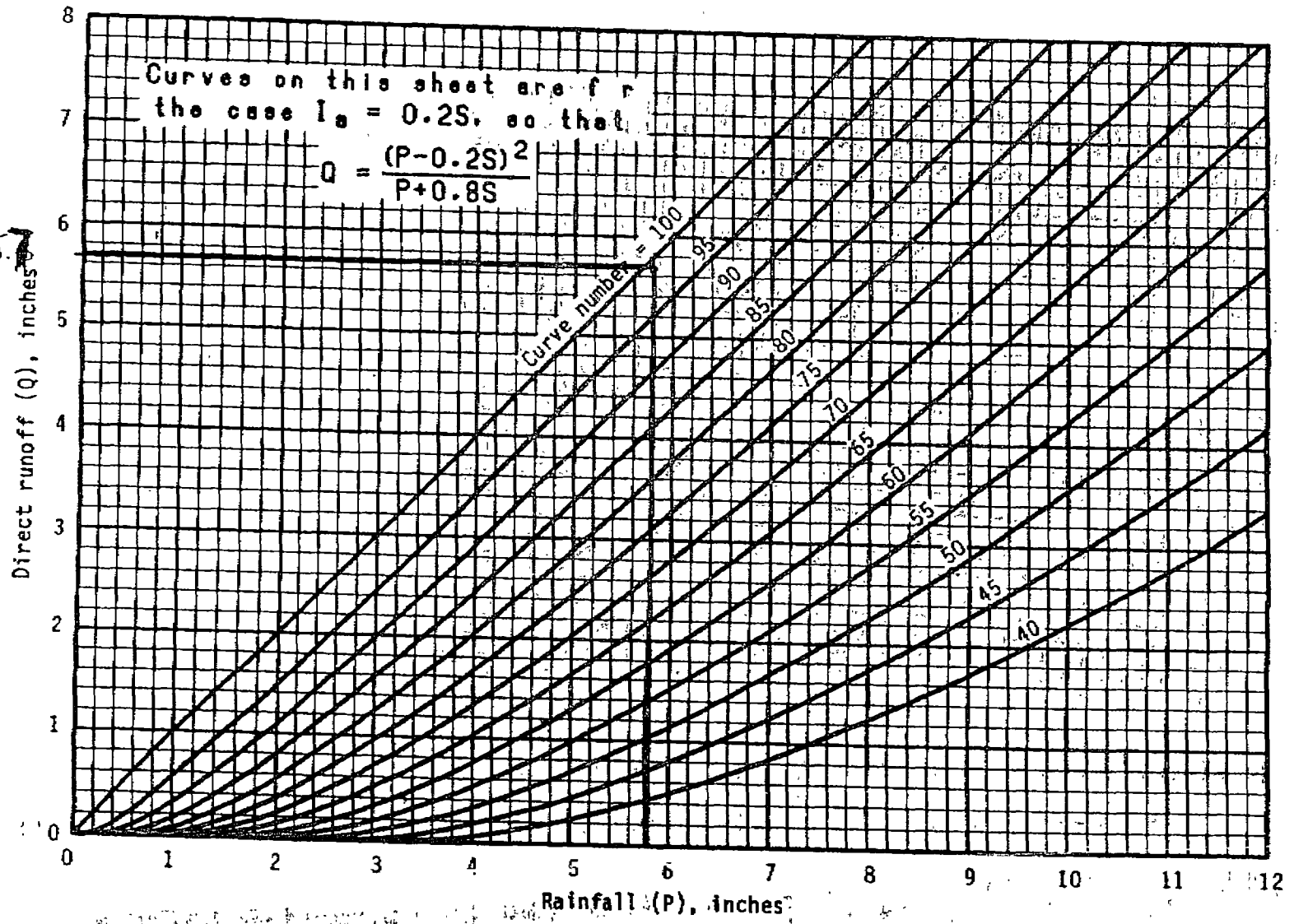

Figure 2-1.—Solution of runoff equation.

Post.