Volume I of II

Remedial Design Work Plan Submittal

Remedial Design Work Plan and Pre-Design Investigation Plan

DAVIS LIQUID WASTE SUPERFUND SITE SMITHFIELD, RHODE ISLAND

PREPARED FOR Davis Site Performing Party Group

PREPARED BY ESS Group, Inc.
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Project No. D164-000

March 23, 2012

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Via Overnight Delivery

March 23, 2012

Mr. Byron Mah
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5 Post Office Square, Suite 100
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Boston, Massachusetts 02109-3912

Re: Final Remedial Design Work Plan Submittal
Davis Liquid Waste Superfund Site, Smithfield, Rhode Island
ESS Project No. D164

Dear Byron:

On behalf of the Davis Site Group and pursuant to the RD/RA Consent Decree, Section X, Paragraph a and Appendix B (Statement of Work) Sections V.A (Remedial Design Work Plan), V.B (Pre-Design Investigation Plan) and V.C (Project Operations Plan), enclosed are the following final documents, which have been revised pursuant to the final Comment/Response document (via email dated March 13, 2012) and EPA's approval of the draft revisions (via email dated March 16, 2012).

- Final Remedial Design Work Plan
- Final Pre-Design Investigation Plan
- Final Remedial Design Project Operations Plan
  - Final Appendix A Site Management Plan
  - Final Appendix B Sampling and Analysis Plan
    - Final Appendix B-1 Quality Assurance Project Plan
    - Final Appendix B-2 Field Sampling Plan
  - Final Appendix C Health and Safety Plan

Electronic copies of the enclosed final documents will be provided as soon as possible.

If you have questions or require additional report copies or information, please let us know.

Sincerely,

ESS GROUP, INC.

Jeffrey G. Hershberger, P.G.
Project Manager

EHS SUPPORT CORP.

Nigel Goulding
Project Director

Enclosure (5 copies)
C: Gary Jablonski (RIDEM) (1 copy)
Liyang Chu (Nobis) (1 copy)
Nigel Goulding (EHS) (cover letter only)
Kenny Ogilvie (EHS) (cover letter only)

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  - Appendix B-2 Field Sampling Plan
- Appendix C Health and Safety Plan

Remedial Design Work Plan

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REMEDIAL DESIGN
WORK PLAN
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

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ESS Group, Inc.

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ACRONYMS

ARAR	Applicable or Relevant and Appropriate Requirement
ATZ	Active Treatment Zone
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Contaminant of concern
EPA	Environmental Protection Agency, Region I
FGPS	Final Groundwater Performance Standard
FSA	Former Source Area (encompasses Northern Disposal Area, Southern Disposal Area, Drum Disposal Area and Western Access Road)
ICP	Institutional Controls Plan
IGRG	Interim Groundwater Remediation Goals
LTM Plan	Long-term Monitoring Plan
MNA	Monitored natural attenuation
OU-2	Operable Unit 2 (Overburden Groundwater)
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PDI	Pre-design Investigation
POP	Project Operations Plan
PRP	Potentially Responsible Parties
PSATs	Performance Standards for Active Treatment
RD	Remedial Design
RDWP	Remedial Design Work Plan
RIDEM	Rhode Island Department of Environmental Management
ROD	Record of Decision
Site	Davis Liquid Waste Superfund Site
SOW	Statement of Work
SVOC	semi-volatile organic compounds
TCE	trichloroethene
µg/L	micrograms per liter
VOC	volatile organic compounds

DEFINITIONS

Active Treatment Zone	Refers to the areas of the Former Source Area (FSA) and Overburden Plume where active treatment will be performed. This area will be further defined in the Remedial Design submissions following completion of the baseline groundwater sampling and Pre-design Investigations using the Decision Matrix included in the SOW.
Bedrock Plume	Extent of contaminated groundwater within the bedrock aquifer unit where chemical concentrations exceed the Interim Groundwater Remediation Goals (IGRG) presented in Table 7 of the 2010 ROD Amendment, or the chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) presented in Appendix A of the 2010 ROD Amendment.
Davis Site Group	Davis Site Performing Party Group
Drum Disposal Area	Former disposal area within FSA.
Elevation 404.6 Mean Sea Level	Target excavation depth for Source Remedy
Former Source Area	Defined as the area (vertically and horizontally) where releases of contaminants have occurred and represents the approximate boundary of the Source Control Remedial Action that previously underwent treatment of contaminated unsaturated soil residing above elevation 404.6 feet Mean Sea Level.
Northern Disposal Area	Former disposal area within FSA.
Overburden Plume	Extent of contaminated groundwater in the overburden aquifer unit where chemical concentrations exceed the IGRG presented in Table 7 of the 2010 ROD Amendment, or the chemical-specific ARARs presented in Appendix A of the ROD Amendment.
Plume Core	The portion of the groundwater plumes underlying the FSA and includes the saturated soil which constitute the continuing sources of groundwater contamination as the result of residual contamination presence.

Remedial Design	Identification of the technology and its performance and operational specifications, in accordance with all applicable federal, state, and local laws, including, but not limited to:
	▪ All computations used to, but not limited to, evaluate the appropriateness of technologies, determine quantities or mass of treatment reagents required, mass balances, estimated radii of influence of injection points, number of injection points, number of applications, and the projected effectiveness of the remediation system.
	▪ Materials storage and handling and system layouts for in-situ treatment, treatment of contaminated soils and groundwater, the size and location of units, and treatment rates.
	▪ Scale drawings of all system layouts identified above.
	▪ Quantitative analysis demonstrating the anticipated effectiveness of the Remedial Design to achieve the Performance Standards as defined in the 2010 ROD Amendment and Section IV of the SOW.
	▪ Technical specifications that detail the following:
	  ○ Size and type of each major component.
	  ○ Required performance criteria of each major component.
	▪ Descriptions of monitoring of air, noise, groundwater, surface water, and sediment including equipment, monitoring locations, and data handling procedures.
	▪ Descriptions of access, land easements and/or other Institutional Controls required, to be supplied with the construction plans and specifications.

Remediation Regulations	RIDEM Rules and Regulations for Investigation and Remediation of Hazardous Releases
Settling Defendants	Davis Site Performing Party Group Members
Source Remedy	Completed in 1999 – 2001 and included treatment of soils above Elevation 404.6 Mean Sea Level using low-temperature thermal desorption
Southern Disposal Area	Former disposal area within FSA. Includes the Bunker C Area.
Treated Backfill	Soils previously treated during Source Remedy that were placed above the water table in the FSA.

1.0 INTRODUCTION

The 2010 Record of Decision (ROD) Amendment and Consent Decree (CD), dated July 2011, and its Appendix B: Statement of Work (SOW), prescribes Remedial Action for overburden groundwater (Operable Unit 2 [OU-2]) at the Davis Liquid Waste Superfund Site in Smithfield, Rhode Island (the Site).

The major components of EPA's selected remedy are:

- Pre-design Investigation (PDI)
- Bench-Scale Testing (to nominate candidate treatment reagent for pilot testing)
- Pilot Testing (to assess ability to distribute candidate treatment reagent)
- In-Situ Chemical Reduction and Enhanced Biodegradation (Plume Core and overburden plume except within footprint of wetlands)
- Natural Attenuation (untreated portions of the overburden plume)
- Institutional Controls (groundwater well and groundwater use restrictions)
- Five-Year Reviews

The Draft PDI Plan is provided as a component of this Remedial Design Work Plan (RDWP). In addition to the components of the OU-2 remedy, a number of supplemental investigations are being conducted on surface water and sediment, bedrock groundwater, and potential human health risks associated with the Treated Backfill. The findings of these supplemental studies are intended to support future decisions regarding surface water and sediment, bedrock groundwater, and potential human health risks associated with the Treated Backfill. The decision making framework for interpreting the results of these supplemental studies is also discussed in this document.

1.1 Purpose and Objectives

This RDWP is prepared and submitted for approval to Region I Environmental Protection Agency (EPA) and Rhode Island Department of Environmental Management (RIDEM) by the Settling Defendants (also herein referred to as the Davis Site Group) pursuant to the provisions of the CD and SOW. The primary objective of the RDWP is to establish the process that will be used to design the Active Treatment Program for the OU-2 remedy.

In accordance with the SOW, data and information developed during the PDI will be used to support design decisions for the selected remedy. Three main components of the PDI will be used directly to support design of the remedy; these include the:

- Plume Core Evaluation
- Treated Backfill Evaluation (leachability)
- Bench and Pilot Testing Evaluations

Other components of the OU-2 remedy include preparation of the Long-term Monitoring Plan (LTM Plan) and the Institutional Controls Plan (ICP). This RDWP is also intended to describe the key decision processes involved with planning and implementation of these components of the selected remedy.

The SOW also includes additional provisions for supplemental investigations and assessments of the following:

1. Potential direct contact risks associated with the Treated backfill
2. A Bedrock Groundwater Evaluation
3. A Surface Water and Sediment Evaluation
4. Monitoring of the performance of the monitored natural attenuation (MNA) remedy in the untreated portions of the overburden plume
5. An assessment of fate and transport of constituents in bedrock

Results from these investigation activities will be used to develop and answer other Site considerations such as:

- The feasibility of using natural attenuation as the remedy for bedrock groundwater (Operable Unit 4)
- Development of a management approach for Treated Backfill
- The nature and extent of Surface Water and Sediment Impacts and the need for supplemental evaluations of risk
- The need for implementation of an off-site (residential) well sampling program

The investigation programs developed to address these other Site decisions are iterative in nature and will be modified as necessary to meet the objectives outlined in the SOW and described in more detail in the sections below.

In accordance with the SOW, this RDWP includes the following elements:

1. Statements of the purpose and objectives of this RDWP.
2. Statements of the purpose and objectives of the PDI.
3. Detailed description of the proposed PDI, which includes provisions for:
    - Plume Core Evaluation (pursuant to SOW Section V.B.1).
    - Treated Backfill Evaluation (pursuant to SOW Section V.B.2).
    - Bench and Pilot Testing Evaluation (pursuant to SOW Section V.B.3).

- Surface Water and Sediment Evaluation (pursuant to SOW Section V.B.4).
- Groundwater Evaluation (pursuant to SOW Section V.B.5):
  - Residential Well Monitoring.
  - Groundwater Monitoring.
  - Vapor Intrusion Assessment.
- Fate and Transport and Natural Attenuation Evaluation (pursuant to SOW Section V.B.6).
- Deliverables (pursuant to SOW Section V.B.7).

4. Detailed description of the Remedial Design (RD) Process.
5. Detailed description of Institutional Controls.
6. Detailed description of Long-Term Monitoring.
7. A discussion of how information developed in the PDI will be used to prepare the RD, Institutional Controls and Long-Term Monitoring.
8. A comprehensive schedule that shows start and completion of each of the tasks and deliverables.
9. The approach to Project Management.
10. Key personnel in an organizational chart with written narrative of roles and responsibilities.
11. A discussion on how the Performance Standards will be attained.

1.2 Performance Standards/Cleanup Standards

The design and implementation for the OU-2 remedy and other decisions associated with bedrock groundwater, surface water and sediment, and treated backfill will be determined based on comparison of Site conditions to the Performance Standards specified in the 2010 ROD Amendment and the SOW. These performance standards are outlined below.

Groundwater

- Interim Groundwater Remediation Goals (IGRGs) as presented in Table 7 of the 2010 ROD Amendment.
- Interim Performance Standards for Active Treatment (PSATs) of contaminated groundwater in the Active Treatment Zone (ATZ).
- Final Groundwater Performance Standards (FGPSs) for all contaminated groundwater in the overburden plumes which will be the more stringent of:

- IGRGs as presented in Table 7 of the 2010 ROD Amendment.
- Applicable or Relevant and Appropriate Requirements (ARARs) presented in Appendix A of the 2010 ROD Amendment.

Further discussion on how the Groundwater Performance standards will be used in the design and performance of the remedy is provided in Section 3 of this RDWP.

Unsaturated Zone Soil

- RIDEM GA Leachability Standards for Soil.
- Risk Assessment Guidance for assessment of human health impacts associated with shallow unsaturated zone soils.

Further discussion on how the Performance Standards for unsaturated soil will be used in the design and performance of the remedy and future management decisions is provided in Section 3 of this RDWP.

Surface-Water and Sediment

- EPA Region III Biological Technical Assistance Group Screening Benchmarks for freshwater and for freshwater sediments.
- RIDEM Ambient Water Quality Criteria for Aquatic Life Criteria Freshwater Acute and Chronic, dated July 2006 (and amended in December 2010).

Further discussion on how the Performance Standards for sediment and surface-water will be used in the evaluation of supplemental investigation requirements and future management decisions is provided in Section 3 of this RDWP.

1.3 Selected Remedy

As detailed in the 2010 ROD Amendment, Part 2, Section F, the details of the selected Remedial Action for overburden groundwater (OU-2) at the Site comprise: a PDI, Bench-Scale/Pilot Testing, In-Situ Chemical Reduction and Enhanced Biodegradation, Natural Attenuation, Institutional Controls, and Five-Year Reviews. These major components are summarized below.

1. PDI – Will be performed to assess the following components of the project:
   a. The lateral extent and distribution of impacts within the Plume Core area.
   b. The potential for residual impacts in the Treated Backfill in the Former Source Area (FSA) and the potential for potential leaching impacts to groundwater.
   c. Characterize surface water and sediment quality to assess whether groundwater contaminants are migrating into the wetlands and Latham Brook or whether other Site-related activities have impacted this area of the Site and whether actions are needed.

2. Bench-Scale/Pilot Testing – Concurrent with the performance of the PDI, bench-scale testing using soil and groundwater samples will be performed to select the optimal reducing agent for chemical treatment and substrate for microbial growth for a field-scale pilot test. The field-scale pilot tests will be performed to ascertain the ability to distribute the reagent in the formation (i.e., variable permeability soils or high water table) and the effectiveness in addressing contaminants in the overburden Plume Core.

3. In-Situ Chemical Reduction and Enhanced Biodegradation in Saturated Soil and the Plume Core – Implementation of a chemical reduction and enhanced biodegradation remedy as a single or combined treatment to address impacts in the Plume Core (saturated soils and groundwater in the FSA). The area of the Plume Core and the portion of the overburden plume underlying areas situated outside of the wetlands will be subject to treatment, as generally depicted in Figure 11 of the ROD Amendment. The treatment reagent will be injected using direct-push injection points throughout the Plume Core and the downgradient dissolved overburden plume outside of the wetlands.

4. Institutional Controls – Legal restrictions shall be placed on properties within the limits of the overburden and bedrock contaminant plumes, encompassing four parcels (50-9, 50-29, 50-27, and 50-27A) as well as any areas where installation of new wells has the potential to hydraulically influence the movement of contaminated water from the Site. The restrictions will prohibit the use of contaminated groundwater (that exceed drinking water criteria or risk-based concentrations) and/or restrict the installation of new wells or modification of existing wells until contaminant concentrations have diminished to the Site clean-up goals.

5. Natural Attenuation – Although active remediation would occur at the FSA and portions of the downgradient overburden plume under this remedy, the selected remedy requires that contaminant concentrations in the untreated portions of the overburden aquifer gradually diminish over time through natural attenuation. Both biotic and abiotic natural degradation processes shall gradually attenuate the contaminate mass over an extended period, until all groundwater concentrations have decreased to below clean-up goals.

   Long-Term Monitoring – To monitor natural attenuation processes and to evaluate conditions in environmental media, groundwater, and surface water, each shall be sampled and analyzed three times a year for the first 5 years. The sampling frequency may be modified with EPA's approval, after reasonable opportunity for review and comment by RIDEM, as data needs change. Groundwater samples will be collected from the Plume Core and the down-gradient portions of the plume, and surface water and sediment samples will be collected from wetlands adjacent to the FSA and from Latham Brook.

6. Five-Year Reviews – If after 5 years contaminants remain in groundwater above concentrations acceptable for unlimited Site use and unlimited exposure, a review of Site conditions and risks shall be conducted as required by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

2.0 BACKGROUND AND SITE CONDITIONS

The Site, a former waste disposal facility, is located between Tarkiln Road and Log Road in the northwestern corner of the Town of Smithfield, Providence County, Rhode Island (Figure 2.1). The 7-acre FSA is defined as the area where past disposal and releases of hazardous substances originally occurred and is bounded approximately by the excavation footprint of the source control remedial action initiated in 1999 and completed in 2001 (Figure 2.2). The Site is bounded on the east and west by forested uplands and on the north and south by wetlands and swamp areas of the Nipsachuck Swamp.

The Site is currently undeveloped and used primarily for storage of private property by the property owner. The land use in the vicinity of the Site is primarily semi-rural and consists of low-density residential dwellings. Groundwater beneath the Site is classified as GA by the RIDEM, which is suitable for use as a potable water supply. Currently, the groundwater underlying the Site is not used as a potable supply (EPA, 2010).

The following provides a brief chronology of the actions completed to date at the Site.

- In 1978, approximately 23 off-site drinking water supply wells were identified as having been contaminated with hazardous substances, including volatile organic compounds (VOCs). The Rhode Island Superior Court enjoined the further disposal of hazardous substances at the Site by the owner, William Davis.
- In 1980, the Rhode Island Superior Court ordered RIDEM to conduct a comprehensive environmental investigation at the Site. Surface water and groundwater samples collected from the Site indicated the presence of tetrachloroethene (PCE), chloroform, trichloroethene (TCE), and benzene. Six residences with private drinking water wells were provided with bottled water, as the sample results from these wells were in excess of EPA health advisory concentrations in effect at the time.
- In 1985, the Rhode Island Superior Court ordered the owner, William Davis, to restore the wetlands that had been filled.

2.1 State Actions

1985 – 1986: RIDEM provided bottled water to residences with contaminated drinking water supplies.

1994 – 1995: The State entered into an agreement with the owner, William Davis, to remove stored tires from the Site.

1997 – 2000: RIDEM funded the removal of an estimated 6 million scrap tires from the Site. During this operation, the owner, William Davis, notified EPA and RIDEM of the discovery of nine drums of hazardous materials in various stages of decay, which were removed and disposed of by EPA.

2.2 Federal Actions

1981: A Preliminary Assessment and a Site Inspection were completed by EPA.

1982: EPA evaluated the Site under the Hazard Ranking System and proposed the Site for listing on the National Priorities List.

1983: The Site was listed on the National Priorities List.

1984 – 1987: EPA conducted a Remedial Investigation and a Feasibility Study. The Remedial Investigation identified extensive contamination of soil and overburden and bedrock groundwater at the Site, as well as an extensive tire pile. Contamination of soil, overburden and bedrock groundwater consisted primarily of VOCs, including PCE, TCE, ethylbenzene, benzene, toluene, and xylene. Other contaminants identified included semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), pesticides, and metals.

EPA, following observations of leaking drums of hazardous materials at the Site, implemented an immediate response action and removed and disposed of approximately 600 drums.

The Feasibility Study, completed in 1987, developed a range of source control and management-of-migration remedial alternatives. Information developed during the Remedial Investigation and Feasibility Study was used to develop remedial options to address contaminated private wells, contaminated soil and waste at the Site, and contaminated groundwater.

On September 29, 1987, EPA signed the ROD documenting the selected remedy. The ROD specified a source control component and a management-of-migration component. The source control component required on-site incineration of contaminated soil and creation of an on-site capped hazardous waste landfill for treated soil. The management-of-migration action required that residences with contaminated wells would be connected to a new waterline and on-site groundwater extraction and treatment would be constructed to prevent further migration of contaminated groundwater. A significant component of the cleanup plan was the re-infiltration of treated groundwater into the FSA. The ROD also specified that the best remedial alternative for the historically impacted sediments was management in place.

1996: EPA issued an Explanation of Significant Differences, based on new performance and cost information. The Explanation of Significant Differences changed the source control component of the remedial action from on-site incineration to on-site-low-temperature thermal desorption. Contaminated soil and waste that could not be treated would be sent to an off-site disposal facility rather than being disposed of in an on-site hazardous waste landfill. This work (Operable Unit 3 [Source Remedy]) was completed by the Potentially Responsible Parties (PRPs) in 2003.

1997: EPA and RIDEM completed a new water distribution system (Operable Unit 1 [Waterline Extension]) serving 127 lots along Forge Road, Log Road, Burlingame Road, and Bayberry Road.

2010: EPA completed the Focused Feasibility Study, which evaluated available information to develop a range of remedial alternatives to address contaminated groundwater at the Site.

On September 30, 2010, EPA signed the ROD Amendment amending the 1987 ROD in order to change the extraction and treatment of contaminated groundwater component of the 1987 ROD.

2.3 Potentially Responsible Party Actions

1991: The PRPs completed a pre-design engineering investigation to further characterize contamination in the FSA and to provide additional data to assist in the design of a groundwater extraction and treatment system.

1997 – 2001: The PRPs took the following actions:

- Removed approximately 6.4 million scrap tires from the Site.
- Excavated, removed, and disposed off-site approximately 1,400 drums and 15,000 laboratory containers.
- Completed a PDI including a soil sampling program to determine the extent of soil contamination in excess of the ROD's remedial goals of 2 milligrams per kilogram of total VOCs.
- Excavated and treated approximately 78,000 tons of contaminated soil using an on-site low-temperature thermal desorption system constructed on-site. The approximately 20,000 tons of soil that failed to meet VOC treatment standards or TCLP toxicity criteria were transported off-site for disposal. Following completion of the soil treatment, the structures were decontaminated and dismantled and the work area was re-graded. The excavation was backfilled with gravel overlain by treated soil and the entire disturbed area was covered with 6 inches of topsoil and planted with grass and trees to stabilize the Site.

2001 – 2008: The PRPs performed additional soil sampling to characterize contaminated soil located beneath the water table underlying the FSA. The PRPs also installed additional monitoring wells and performed additional groundwater sampling to develop data to better define contaminant nature and extent at the Site following the source control remedial actions.

2.4 September 2010 ROD Amendment

The 2010 ROD Amendment details the Remedial Action for OU-2 at the Site. The major components of the selected remedy include: PDI, Bench-Scale/Pilot Testing, In-Situ Chemical Reduction and

Enhanced Biodegradation, Natural Attenuation, Institutional Controls, and Five-Year Reviews. Detailed descriptions of these remedy components are memorialized in the OU-2 SOW and Appendices incorporated in the 2011 Consent Decree.

2.5 Brief Overview of Site Conditions

Saturated unexcavated soil (below the water table) in the FSA constitutes the core of the groundwater plume and is a continuing source of groundwater contamination. These soils are situated below elevation 404.6 Mean Sea Level, which was the target depth for the performance of the Operable Unit 3 (Source Remedy). Based on the results of the 2008 Phase 4 investigation in the FSA, ten VOCs were detected in saturated zone soils at concentrations exceeding the applicable screening values used in the Focused Feasibility Study. Five of these VOCs (cis-1,2-dichloroethene, PCE, TCE, vinyl chloride and 1,1-dichloroethane) were also detected in groundwater samples at concentrations exceeding either the RIDEM GA Groundwater Objectives, federal Maximum Contaminant Levels, or EPA tapwater Risk Screening Levels. Based on this data, the EPA and the Davis Site Group estimated that between 521 and 805 pounds of residual VOC mass remained within the Plume Core.

In the Focused Feasibility Study, EPA evaluated the most recent Fall 2008 groundwater sampling data using the federal Maximum Contaminant Levels, the RIDEM GA Groundwater Objectives or the EPA tapwater Regional Screening Levels. The VOCs that were most frequently detected and exceeded the screening values were PCE, TCE, cis-1,2-dichloroethene, vinyl chloride, benzene and 1,1-dichloroethane. Based on this information, these six VOCs were selected as contaminants of concern (COCs) for the OU-2 remedy, although benzene was only detected at concentrations exceeding the screening values in bedrock groundwater. Based on the results of recent groundwater monitoring events (2003 through 2008) and comparison to the screening values, one SVOC (bis(2-chloroethyl) ether), two pesticides (aldrin and dieldrin) and two metals (arsenic and manganese) were also selected as COCs for the OU-2 remedy.

Using the existing Site data and information, EPA performed a baseline risk assessment and supplemental risk evaluation that were documented in the Focused Feasibility Study. EPA stated in the 2010 ROD Amendment that potential future residential exposure to groundwater used as drinking water provide the basis for requiring action under this ROD Amendment. EPA also concluded that additional sampling and evaluation of surface water and sediments that may be affected by Site groundwater and other Site-related activities will be required to determine whether additional actions may be needed.

On the basis of the screening of Site data and the findings of the risk evaluations, EPA established IGRGs for select compounds that are presented in Table 7 in the 2010 ROD Amendment. These IGRGs and the ARARs constitute the FGPSs for the OU-2 remedy.

The active treatment program component of the OU-2 remedy will be designed to target treatment of select chlorinated VOCs (chlorinated ethanes and chlorinated ethenes) that are listed in Table D of the OU-2 SOW. Additionally, Interim PSATs were established for assessment of the performance of

the active treatment component of the OU-2 remedy following the initial treatment application. These standards are also listed in Table D of the SOW.

3.0 REMEDIAL DESIGN PROCESS

As stated in the SOW, the remedy will be designed to achieve the Remedial Action Objectives and Performance Standards outlined above. Standard engineering principals will be applied throughout this process.

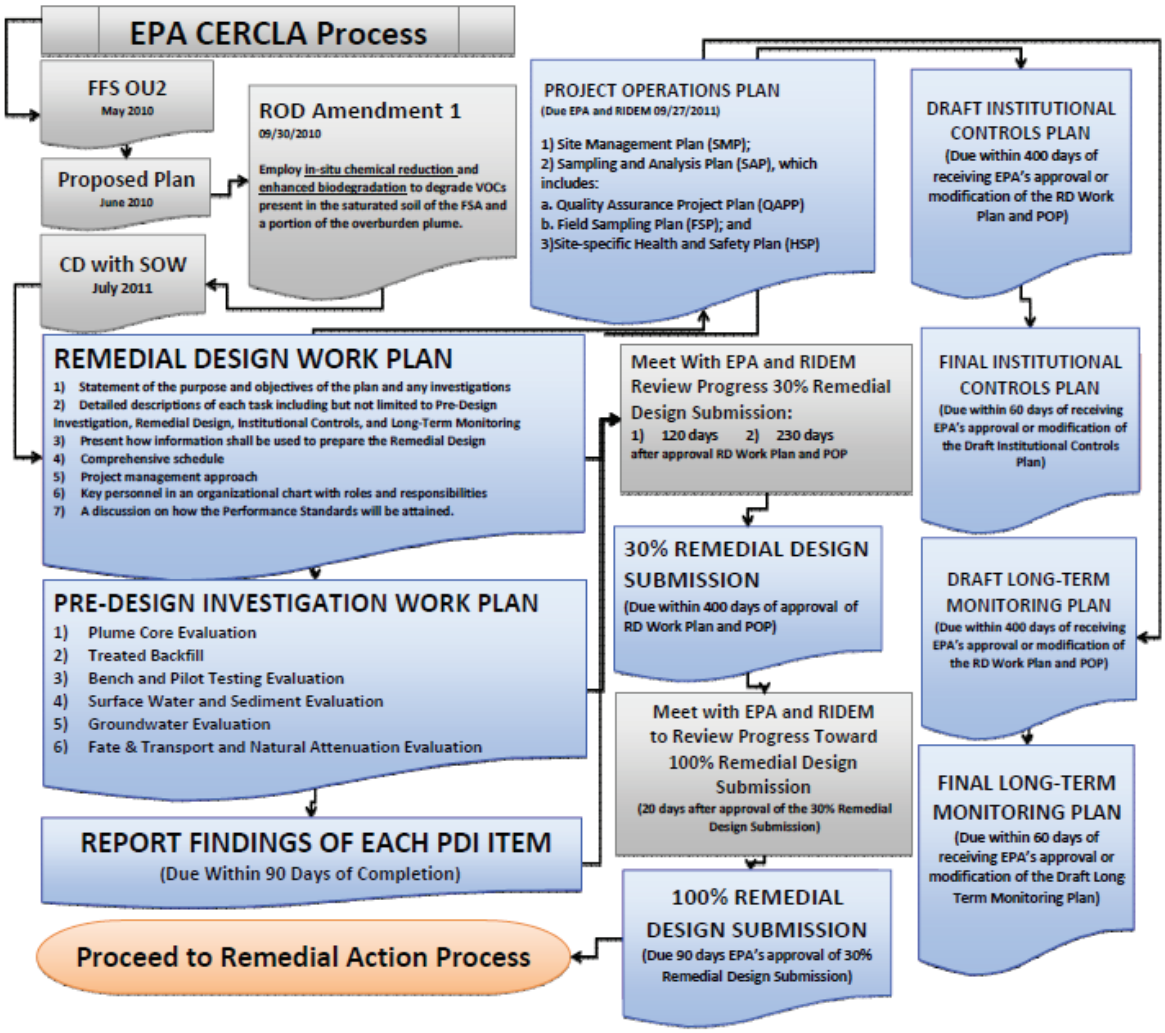
The RD will consider the framework established by EPA for the remedy, historical (pre-ROD) data, pending PDI results, and information obtained during analysis and assessment of the data collected during the RD process. The data and design considerations will form the engineering design bases. These design bases will support the preparation of the 30% and 100% RDs, ICP, and Long-Term Groundwater Monitoring Plan.

In conjunction with the design process, historical and pending PDI data will be utilized to determine the need for, and scope of, future actions for the Treated Backfill, Surface Water and Sediment, and Bedrock Groundwater (Operable Unit 4).

3.1 Technical Approach To Remedial Design

The design of the OU-2 remedy will satisfy the requirements specified in the SOW and will utilize data obtained from the PDI plus historical information and institutional knowledge obtained from technical experts and remediation technology vendors. The following sections discuss the key questions that need to be answered for the design and the key decision pathways that have been prescribed in the SOW. The path to RD is summarized in Figure 3.1.

Figure 3.1
Roadmap to Remedial Design



The technical approach to RD is to leverage the following resources to deliver an effective and timely RD consistent with the spirit and intent of the CD and its SOW, Section V:

- Results of the PDI
- Results of bench and pilot test evaluations
- Consulting services in the disciplines of:
    - remediation engineering
    - geology
    - hydrogeology
    - chemistry
    - biochemistry
    - microbiology
    - toxicology
    - ecologic and human health risk
    - project management
    - remediation construction
    - construction management
    - regulations
    - other sectors as needed
- Effective communication and collaboration with:
    - EPA
    - RIDEM
    - land owner
    - treatment reagent vendors
    - remediation service providers
    - other entities as needed

As shown in Figure 3.1, the scope of work specified by EPA includes:

- Elements and phases of work integral to development of the design for the OU-2 remedy including the PDI.
- Other prescribed elements of the SOW associated with assessment of the Treated Backfill, Surface Water and Sediment, and Bedrock Groundwater (Operable Unit 4).

The key design and management decisions for all components of the project are discussed below.

3.2 Key Design Considerations

As detailed above, the OU-2 remedy comprises implementation of active treatment in the Plume Core and the immediately downgradient portions of the overburden plume (i.e., ATZ), implementation of institutional controls, and establishment of a long-term monitoring program to assess performance and demonstrate achievement of the FGPSs. Key decisions in the process of designing the OU-2 remedy, and in the supplemental investigations program are described below.

Table 3.1 summarizes the key RD considerations. Figure 3.2 shows the Decision Matrix for how the information will be used to prepare the RD.

3.2.1 OU-2 Remedy

1. What is the lateral extent of groundwater exceeding the IGRGs?
2. What is the lateral extent of the ATZ?
3. What is optimal treatment reagent?
4. What is the prospect to effectively use conventional direct-push techniques for delivery of reagent(s)?
5. What are the source and plume architectures with respect to nature and distribution of COC mass and mass flux within each of the various aquifer soil types?
6. What is the contribution of the Treated Backfill to overburden groundwater impacts and how will this affect performance of the Remedy?
7. What is the nature and extent of COCs interaction between the Plume Core and the bedrock and how will this impact performance of the Remedy?
8. What are the meaningful characteristics of the aquifer's hydrogeologic properties, physicochemical properties, biogeochemical properties for each of the various aquifer soil types?
9. What are the meaningful implications of the varying hydrogeologic properties, physicochemical properties, biogeochemical properties of Site soils and how will they impact performance of the Remedy?

10. What are the optimum achievable reagent injection (or delivery) properties (makeup, spacing, injection rate, specific volume)?

11. What are the likely performance expectations of the selected reagents in each of the various aquifer soil types?

12. What are the major factors controlling and/or limiting performance of the Remedy in each aquifer soil type?

13. How can the major factors limiting performance in each of the various aquifer soil types be minimized or overcome in the design and implementation of the Remedy?

14. What are the likely requirements for repeated reagent delivery (e.g., amount, distribution, frequency)?

15. How can remediation performance be effectively and cost-effectively monitored in each of the various aquifer soil types?

3.2.2 Long-Term Monitoring Program

1. What are the current conditions in the Overburden Plume?

2. What is the nature and extent of bedrock groundwater impacts and are they stable?

3. What is the water quality in the Sentry Wells?

3.2.3 Institutional Controls

1. What is the current and future predicted lateral extent of groundwater impacts exceeding the FGPSs?

2. What are the surveyed boundaries of the various land Parcels relative to the current and future predicted lateral extent of groundwater impacts exceeding the FGPSs?

3. What are the potentially complete exposure pathways to be managed via Institutional Controls?

3.2.4 Other Supplemental Site Decisions to be Considered

3.2.4.1 Fate and Transport and Natural Attenuation

1. Is intrinsic or natural attenuation progressing in the overburden aquifer down gradient of the wetlands in accordance with EPA criteria and expectations?

2. What are the bedrock and bedrock groundwater hydrogeologic properties, physicochemical properties, biogeochemical properties that control the fate and transport of COCs?

3. What is the prospect for the bedrock aquifer to naturally attenuate or assimilate impacts?

4. What is the demonstrable lines of evidence that intrinsic biotic and/or abiotic dechlorination is occurring in the bedrock aquifer?

5. What are the rates of intrinsic biotic and abiotic dechlorination?

6. What is a confident estimate of the intrinsic restoration timeframe?

7. Will the intrinsic biotic and abiotic dechlorination rates provide restoration in a 'reasonable' timeframe?

3.2.4.2 Treated Backfill (Human Health)

1. What are the potential human health risks associated with direct contact with treated backfill soil?

3.2.4.3 Surface water and Sediment

1. What is the nature and extent of surface water and sediment impacts?

2. What are the surface water and sediment hydraulic properties and hydrogeologic properties?

3. What is the potential for groundwater to impact surface water and sediment quality?

4. What is the nature and extent of COCs interaction between impacted groundwater and surface water and sediment?

5. What is the magnitude of possible groundwater contributions to surface water and sediment impacts relative to historic contributions?

6. What were the primary mechanisms for past, current, and future delivery of impacts to surface water and sediment?

7. What are the potential ecological and human health risks from surface water and sediments?

8. What is the prospect for the surface water and sediment to naturally attenuate or assimilate impacts?

3.2.4.4 Vapor Intrusion

1. What is the nature and extent of soil and groundwater impacts relative to the prospect of vapor intrusion?

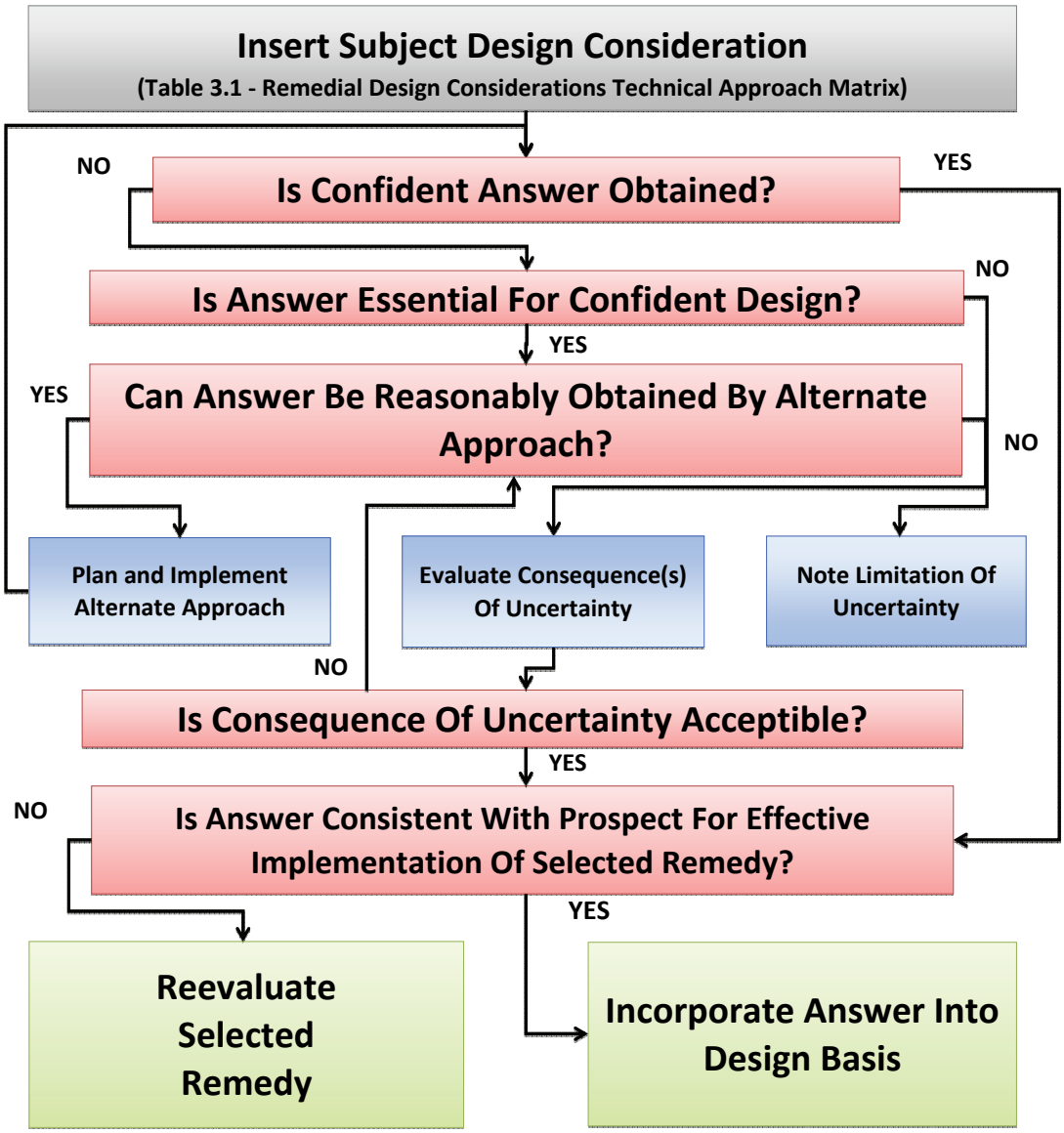
2. What is the prospect for and nature of possible future development activities?

3. What is the process for future structures in the impacted areas (e.g., approvals and permitting)?

4. How does the remedy affect the prospect for vapor intrusion?

The decision matrix for how information will be used to prepare the RD is summarized in Figure 3.2.

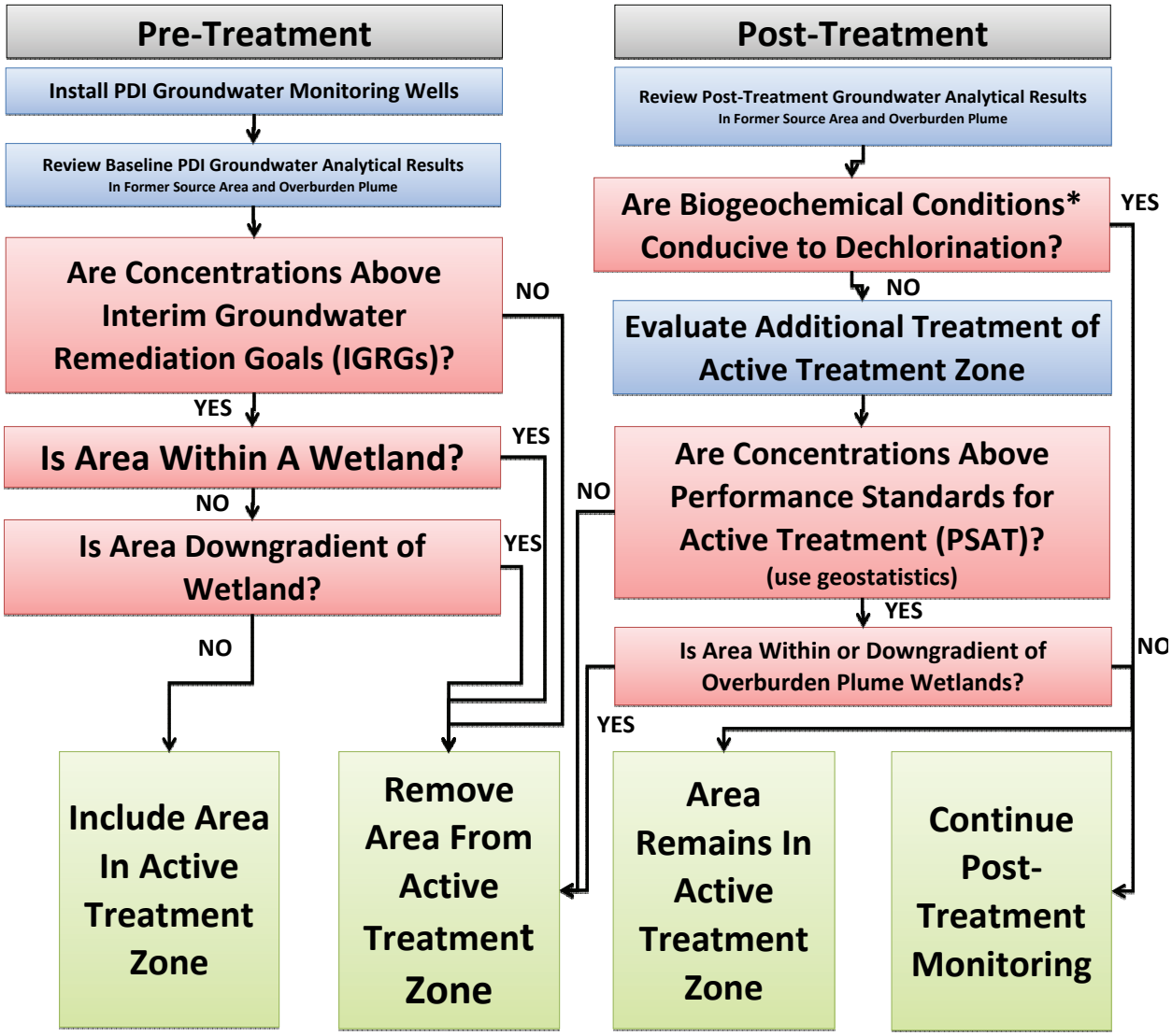
FIGURE 3.2
Remedial Design Considerations Decision Matrix



3.3 Prescribed Framework for Establishing Active Treatment Zone

The SOW outlines the decision processes that will be used to define the ATZ; i.e., areas of the Core Plume and Overburden Plume where active treatment will be performed. The ATZ will be further defined in the 30% RD and/or 100% RD submissions, based on the Decision Matrix – Active Treatment Zone prescribed by Attachment F of the SOW, pending completion of applicable portions of the PDI, which includes baseline groundwater monitoring. Figure 3.3 summarizes the decision making process for establishing the ATZ.

FIGURE 3.3
Process to Establish Active Treatment Zone



In accordance with the decision process for defining the ATZ, performance standards will be used to define the performance of the remedy as follows:

- **IGRGs** – will be used to establish the initial "Pre Treatment" ATZ.
- **Interim PSAT of Contaminated Groundwater in the ATZ** – will be used to assess the performance of the active treatment program and to define the ATZ for subsequent (if required) treatments events. This will likely comprise a portion of the initial "Pre Treatment" ATZ. Active treatment is complete when groundwater concentrations in the plume are below the Interim PSATs.
- **FGPSs** – will be used to define when final cleanup of contaminated groundwater throughout the Site has been achieved.

The technical approach to achieving the Interim PSATs is to apply in situ treatment reagents within the ATZ (where the Pre-Treatment ATZ and the Post-Treatment ATZ are to be defined pursuant to the process described in Figure 3.3) until such time as the Interim PSATs are met, or as otherwise indicated by the outcome of the five-year review process following achievement of the Interim (or Final) PSATs, natural attenuation processes will be utilized to achieve the FGPSs.

The combination of active treatment to aggressively destroy remaining sources of VOC dissolution to overburden groundwater and the accessible higher-strength overburden plume, coupled with institutional controls to prevent human exposure to impacted soil and groundwater plus polishing of the remaining dissolved phase impacts with intrinsic natural attenuation processes, is expected to meet the FGPSs. The LTM Plan will provide the monitoring framework to support adequate verification that the FGPSs have been achieved.

Further discussion on the groundwater performance standards is provided below.

3.4 Groundwater Performance Standards for OU-2 Remedy

The following performance standards are currently prescribed for the OU-2 remedy.

3.4.1 Interim Groundwater Remediation Goals

The IGRGs prescribed in Table 7 of the ROD Amendment will be used to establish the initial "Pre-Treatment" ATZ. The subject IGRGs are listed in Table 3.2 in micrograms per liter (µg/L).

Table 3.2 Interim Groundwater Remediation Goals

Tetrachloroethene	5 µg/L
Trichloroethene	5 µg/L
cis-1,2-Dichloroethene	70 µg/L
Vinyl Chloride	2 µg/L
1,1-Dichloroethane	6 µg/L
Benzene	5 µg/L
Bis(2-chloroethyl)ether	0.03 µg/L
Aldrin	0.002 µg/L

3.4.2 Interim Performance Standards for Active Treatment

The Interim PSATs prescribed in Attachment D of the SOW (Target Design Compounds and Interim PSATs) will be used to establish subsequent "Post-Treatment" ATZs. These Interim PSATs may be assessed and reevaluated based on the performance of the remedy in the bench-scale and pilot testing programs, which are being conducted as part of the PDI. The subject Interim PSATs are listed in Table 3.3.

Table 3.3 Interim Performance Standards for Active Treatment

Tetrachloroethene	10 µg/L
Trichloroethene	25 µg/L
cis-1,2-Dichloroethene	210 µg/L
trans-1,2-Dichloroethene	200 µg/L
Vinyl Chloride	20 µg/L
1,1,1-Trichloroethane	400 µg/L
1,1-Dichloroethane	18 µg/L
Chloroethane	25,000 µg/L

3.4.3 Final Groundwater Performance Standards

The FGPSs for cleanup of contaminated groundwater throughout the Site are specified as the IGRGs as presented in Table 7 of the 2010 ROD Amendment and as the ARARs presented in Appendix A of the 2010 ROD Amendment. The FGPSs are proposed as the lower of the IGRGs (Table 3.2) or ARARs listed below. Long-Term Monitoring activities will be terminated following satisfactory achievement of the FGPSs and concurrence from EPA and RIDEM.

ARARs presented in Appendix A of the 2010 ROD Amendment

- Safe Drinking Water Act -Maximum Contaminant Levels (40 CFR 141.11-141.16)
- Maximum Contaminant Level Goals (40 CFR 141.50-141.55)
- Rhode Island Rules and Regulation for the Investigation and Remediation of Hazardous Materials Releases (DEM-DSR-01-93) (8.03(B)(i))
- Rhode Island Rules and Regulation for Groundwater Quality (Mar 2005)

3.5 SOW-Prescribed Requirements of the Remedial Design

The overarching technical approach to RD is to follow the provisions of Section V (Remedial Design) of the SOW, which prescribes preparation and submittal of the following deliverables for the subject RD in addition to this RDWP:

- Project Operations Plan (POP)
- 30% Design Submission (30% Design)
- ICP
- 100% Design Submission (100% Design)

3.5.1 Project Operations Plan

The draft RD POP has been developed to support data collection, evaluations, and field investigations which are being conducted in accordance with the program outlined in the RDWP and the PDI. The RD POP has been prepared in accordance with Attachment A to the SOW and submitted to EPA and RIDEM in conjunction with this RDWP for review and comment and includes the following supplemental documents:

- Site Management Plan
- Sampling and Analysis Plan:
  - Quality Assurance Project Plan
  - Field Sampling Plan
- Site-specific Health and Safety Plan

The Community Involvement Plan also required by Attachment A of the SOW will be developed by the EPA.

3.5.2 Institutional Controls Plan

The overarching technical approach to preparing and submitting the prescribed ICP is to meet the provisions of SOW Section V.E (ICP). The results of the PDI will be utilized to prepare and submit a draft ICP within 400 days of receiving EPA's and RIDEM's approval or modification of this RDWP and its companion POP. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the Decision Matrix for how the information will be used to prepare the RD.

The ICP developed will include detailed plans and schedules for implementation of Institutional Controls for the Site including where applicable, but not limited to:

- The form of the proposed restrictions.
- Plans presenting the process by which any proposed environmental land use restriction will be recorded in the appropriate local land records office.
- Plans for preparation of survey plans.
- Plans identifying which parcels (or areas of parcels) are proposed for particular restrictions.
- Title-related submittals.
- Subordination agreements.
- Evidence of authority.
- Responsibility for recordation.
- Plans and schedule for compliance monitoring of implemented Institutional Controls including where applicable, but not limited to:
    - Schedule for inspections.
    - Protocol for information to be gathered as part of the inspections (e.g., types of information to be discussed during interviews).
    - Inspection checklist.
    - List of evidence to be gathered during inspections.
    - Inspection reporting.
    - Identity of the firm who will be performing compliance monitoring and reporting.

The Final ICP will be submitted within 60 days of receiving EPA's and RIDEM's approval or modification of the Draft ICP.

The Institutional Controls that will be proposed in the ICP will be designed to allow redevelopment of the Site, where practicable, while still ensuring the effectiveness and integrity of the components of the Remedial Action and protecting human health and the environment. Where applicable, the Institutional Controls will prohibit:

- Use of groundwater for drinking water, industrial process water, or other purposes in areas where groundwater contamination exceeds the IGRGs prescribed in Table 7 of the ROD Amendment.
- Excavation or other activities that might result in exposure to groundwater that exceeds the IGRGs prescribed in Table 7 of the ROD Amendment unless prior approval for such activities is obtained from EPA and RIDEM.
- Any use that is inconsistent with the findings of the human health risk assessment in the ROD or 2010 ROD Amendment.
- Disturbance of any remedial components constructed or maintained as part of the Remedial Action, such as the monitoring wells, to the extent that such disturbance would interfere with the effectiveness of the remedy.

Based on the findings of the PDI, Institutional Controls may also contain other restrictions necessary to protect human health and the environment. Legal restrictions will be placed on properties within the limits of the overburden and bedrock contaminant plumes, potentially encompassing four parcels (50-9, 50-29, 50-27, and 50-27A – to be verified during the PDI) as well as any areas where installation of new wells has the potential to hydraulically influence the movement of contaminated water from the Site. The PDI, as described above, will provide further delineation of the lateral extent of groundwater impacts in the bedrock plume and additional data on the conditions in the overburden plume, which will be used to define the area of institutional controls.

The determination of the lateral extent of the area of institutional controls is the key decision under this component of work.

3.5.3 Long-Term Monitoring Plan

The overarching technical approach to preparing and submitting the prescribed LTM Plan is to meet the provisions of SOW Section V.F (LTM Plan). Results and findings of the PDI will be utilized to prepare a draft LTM Plan which will be presented to EPA and RIDEM within 400 days of receiving EPA's and RIDEM's approval or modification of this RDWP and its companion POP. The data and information developed under the Groundwater Evaluation and Surface Water and Sediment Evaluation components of the PDI (as described in Section 4 below) will be integral to development of the LTM Plan. Table 3.1 summarizes the activities intended to answer each key design consideration for the LTM Plan. Figure 3.2 shows the Decision Matrix through which information will be evaluated for adequacy and finally for design of the LTM program. The LTM Plan will be used to:

- Monitor the long-term performance and progress of the Selected Remedy or modified remedy.
- Monitor aquifer conditions outside of the groundwater plumes that may affect residential parcels,
- Monitor surface water and sediment in the wetlands adjacent to the Site and in Latham Brook.
- Monitor the performance of a natural attenuation remedy in the untreated portions of the overburden plume.
- Monitor conditions within both the overburden and bedrock plumes

The LTM Plan, in accordance with the requirements of the SOW, will:

- Describe the goals and objectives of the monitoring plan as described above.
- Identify sampling locations and frequencies for:
  - Groundwater.
  - Surface water.
  - Residential wells (if required).
- Define a baseline sediment sampling event and monitoring prior to each five year review.
- Prescribe chemical, geochemical, and biological analyses.
- Apply appropriate data interpretation techniques or modeling approaches.
- Define recordkeeping and reporting requirements.
- Present a monitoring well maintenance and integrity program including:
  - Provisions for prompt and proper abandonment of wells deemed to be unusable or unnecessary by EPA and RIDEM.
  - Provisions for inspection, continued maintenance and repair or replacement of any well deemed to be necessary for long-term monitoring by EPA and RIDEM.
  - Plans for Site closure and post-closure monitoring.
- Utilize the POP, updated or revised as necessary, to support fieldwork conducted according to the LTM Plan.

The Final LTM Plan will be submitted within 60 days of receiving EPA's and RIDEM's approval or modification of the Draft LTM Plan.

From the initiation of the PDI until completion of the in-situ treatment component of the Remedial Action, monitoring of groundwater will be performed three times per year or as otherwise agreed by EPA and RIDEM. For the first five years, annual monitoring of surface water shall be performed and sediment sampling, following the initial baseline sampling event, will be performed every five years in support of the Five-Year Review process. The SOW specifies sampling of sentry wells up to three times per year.

Focused monitoring of groundwater quality within the FSA targeted at assessing the remedy performance in the ATZ will be specified in the 30% and 100% designs.

It is anticipated that, following implementation of the remedy, a LTM program will be established to monitor the performance of the remedy, natural attenuation processes (in both the overburden and bedrock) and the nature and extent of impacts. This monitoring program will incorporate sampling of:

1. Overburden and bedrock plumes (both target COCs and geochemical parameters).
2. Surface water and sediment samples within the wetlands adjacent to the FSA and from Latham Brook.
3. Sentry wells and, if required, residential wells.

Sampling frequencies, analytes and data interpretation methods will be specified in the LTM Plan for these matrices and well types and will be sufficient to meet the Site and remediation objectives. It is anticipated that the adequacy of the Long-Term Monitoring program will be reviewed in conjunction with the 5 year reviews.

3.6 Remedial Design Process

3.6.1 Remedial Design Submissions (30% And 100% RD)

This RDWP describes the RD process required to produce a final design and contract document package suitable for bidding and construction. To achieve this outcome and manage the design development process, the work is organized into Pre-Design and Design activities, with the RD further segregated into 30% and 100% design stages. These assessment and design phases are intended to progressively build the necessary understanding and detail from a conceptual design through to final construction documents.

Each sequential design milestone will be submitted to EPA and RIDEM for review and approval in accordance with the SOW as discussed below.

Considering the scope and iterative nature of the PDI activities and the design elements for the remedy that still have to be defined, it is necessary to follow a robust, yet flexible evaluation and design process that allows for adjustment to, and refinement of, the PDI components of work as well as the design elements. The iterative nature of the PDI components is described below. As this data is collected and decisions finalized; key components will be incorporated into the 30%

design document. The requirements of the 30% and 100% design milestones are presented in detail in the SOW and comprise the following:

30% Remedial Design	100% Remedial Design
Results of all pre-design field investigations	Final Construction Design Documentation (Plans, Specifications etc.)
Design criteria including descriptions and design requirements,	Bid Documents
Basis of design including summary of assumptions.	Contingency Plan for Emergency and Accident Planning – which will address both construction workers and the local affected population
Project delivery strategy, including permits plan, easement and access requirements.	Constructability Review Report that evaluates the suitability of the project and its components in relation to the Site
Preliminary plans, drawings, sketches, and calculations, draft drawings and technical specifications list.	Performance Standard/ ARAR Attainment Plan – which will detail how Interim PSATs will be met and include a statement of all the assumptions, drawings and specifications necessary to support an analysis of compliance with the Interim PSATs and Soil Performance Standards, if applicable;
Draft Remedial Action Construction Schedule and Cost, and	A correlation of the design plans and specifications
A discussion of how the Interim PSATs and Soil Performance Standards, if applicable, will be met by the active remedy design.	A schedule for implementation of the Remedial Action
	A summary of changes made to the 100% RD based on EPA's review and approval or modification, after reasonable opportunity for review and comment by RIDEM, on the 30% RD

3.6.2 30% Remedial Design Submission

The overarching technical approach to preparing and submitting the prescribed Draft 30% RD Submission (30% Design) is to meet the provisions of SOW Section V.D (30% RD Submission). In accordance with the submittal requirements summarized in the above Table, the approach requires:

- Utilization of the PDI data to deliver a conceptual design to EPA within 400 days of receiving EPA's and RIDEM's approval or modification of this RDWP and its companion POP.
- Meet twice with EPA and RIDEM to review 30% Design progress:
    1. About 120 days after receiving EPA's approval or modification of this RDWP and its companion POP.

2. About 230 days after receiving EPA's approval or modification of this RDWP and its companion POP.

3.6.3 100% Remedial Design Submission

The overarching technical approach to preparing and submitting the prescribed Draft 100% RD Submission (100% Design) is to meet the provisions of SOW Section V.G (100% RD Submission). In accordance with the submittal requirements summarized in the Table above, the approach requires:

- Development and submittal of the 100% Design within 90 days of receiving EPA's and RIDEM's approval or modification of the Draft 30% RD.
- Meet once with EPA and RIDEM to review 100% Design progress about 20 days after receiving EPA's approval or modification of Draft 30% RD.

3.7 Supplemental Design Activities

In conjunction with the design data collected during the PDI process, Basic Design Elements will be applied to the engineering design process, where appropriate. Typical design elements considered in the Design Process include:

- Land Surveying and Base Map Development
- Staging and Site Preparation
- Material & Equipment Availability and Durability
- Waste Disposal
- Environmental Monitoring and Controls
- Sequencing and Schedules

These design elements and the scope of work necessary to complete assessment and consideration in the design is detailed in the sections below.

3.7.1 Land Surveying and Base Map Development

Sufficient survey data will be collected to support the design and construction process. This survey data will support the preparation of the base and design map/drawings, as well as support the institutional control documents.

The land survey will include the following:

1. Topographic contours
2. Edge of water and the wetland features

3. Site features, including but not limited to roadways, paths, drainage, culverts fences etc.
4. Underground utilities (if present)
5. Bench marks in the Site Vicinity
6. Property and easement boundaries (if present)
7. All soil borings conducted as part of the PDI
8. All groundwater monitoring wells
9. Historic (estimated) and existing surface water and sediment sampling locations

3.7.2 Staging and Site Preparation

No specific Site restrictions (such as work adjacent to rail, gas easements, etc.) have been identified at the Site. Given that the SOW does not require active treatment in the wetland areas, there are limited access constraints to the Plume Core and the targeted area of the overburden plume. No major Site preparation activities are anticipated which need to be included in the design.

3.7.3 Material and Equipment Availability and Durability

In accordance with the SOW both the reagents and delivery equipment will be evaluated and selected as part of the engineering design process. The bench scale testing program will address the reagents while the pilot test will assess injection methodologies and approaches.

The type of injection technology selected and its availability based on the anticipated scale of the project and durability given subsurface conditions (presence of boulders and cobbles) will be a key consideration in the decision process.

Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the Decision Matrix for how the information will be used to prepare the RD.

3.7.4 Waste Disposal

Materials for off-site disposal (drill cuttings from well installation, waste reagents, etc.) will be managed in accordance with the Site Management Plan. Based on the remedial technology selected for OU-2 it is not anticipated that large volumes of investigation-derived or remediation waste will require management.

3.7.5 Environmental Controls and Monitoring

The proposed remedial works (as currently specified in the SOW) will not result in large scale movement of earth. As a result, erosion, sediment and dust and odor controls are unlikely to be required.

Management practices will have to be established for the handling and storage of reagents, as these chemicals if released directly to surface water could impact on ecological communities. Consistent with the SOW and standard operating practices, injection activities will not be conducted in the wetlands and peripheral (buffer) areas adjacent to the wetland structures due to the potential for chemical discharges (either at surface or in the subsurface) to surface water.

Surface water inspections and monitoring protocols will be developed in the design documents and established during the remedial action construction activities. Surface water quality will be assessed and monitored daily during the period in which injection activities are conducted at the locations closest to surface water. If discharges to surface water are observed, injection activities at this location will have to be terminated.

3.7.6 Sequencing and Scheduling

Based on the scale of this remediation program, detailed sequencing and scheduling of Site activities will need to be developed. This sequencing and scheduling will consider:

1. Accessibility – some low lying areas of the Site may be inaccessible during high rainfall periods of the year.

2. Availability of reagent materials – the scale of the project may lead to reagent use that is greater than the current stocks. Pre-purchasing of reagents and/or detailed scheduling and sequencing (for just in time delivery of materials) will likely be required.

3. Warehousing and Delivery of Reagents to Site – reagents need to be kept dry prior to injection. Coordination of off-Site storage and minimizing of material volumes stored on-Site will be required for project execution.

4. Equipment and Staff resourcing – scheduling of equipment and staff resources will be conducted to facilitate adequate time for equipment maintenance and management of worker fatigue.

5. Displacement of impacted groundwater and reagents into surface water – consistent with the controls discussed in 3.7.5, injection activities will likely be sequenced from the periphery of the plume core inwards to prevent progressive displacement of higher concentration groundwater into peripheral areas.

4.0 PRE-DESIGN INVESTIGATION TASKS

This section discusses the general scope of the PDI and Groundwater Monitoring tasks and how this information will be used to prepare the RD, the Remedial Action, Institutional Controls, and Long-Term Monitoring, as prescribed by the SOW. Associated with these investigation tasks and consistent with the key considerations discussed in Section 3, a number of decision processes will be considered during implementation of each of the PDI tasks.

Details of the proposed PDI are presented in the Draft PDI Plan. A summary of the planned PDI is provided in this RDWP in order to meet the specific provisions of Section V.A.3 of the SOW.

The PDI activities can be divided into the following scopes of work:

1. **PDI** – activities intended to directly support determination of the design elements of the overburden groundwater remedy. These tasks include the:
   - Plume Core Evaluation.
   - Treated Backfill Evaluation (leachability).
   - Bench and Pilot Testing Evaluation.
2. **Groundwater Evaluation** – investigation activities primarily focused on:
   - Delineation of impacts in bedrock.
   - Collection of data on current COC concentrations and biogeochemical conditions in the overburden plume.
   - Collection of data on current COC concentrations and biogeochemical conditions in the bedrock plume.
   - Assessment of potential for off-site migration of Site COCs.
3. **Fate and Transport and Natural Attenuation Evaluation** – investigation activities focused on:
   - Assessing natural attenuation processes in bedrock.
   - Assessing performance of MNA remedy in the Overburden Plume downgradient of the wetlands.
4. **Surface Water and Sediment Evaluation** – investigation activities focused on characterization of surface water and sediment quality in the wetlands and Lathams Brook in the area of the Overburden Plume.

For the purposes of this RDWP, the PDI will focus on providing data to support the design of the active treatment program for the OU-2 remedy. In addition, the Groundwater Evaluation and the Surface Water and Sediment Evaluation will provide data and information to support the development of the LTM Plan and the ICP.

The Fate and Transport and Natural Attenuation Evaluation will also be utilized to support decisions associated with management of bedrock groundwater (Operable Unit 4). The Surface Water and Sediment Evaluation will provide data and information to support other decision. Data collected from the PDI will also be used to evaluate potential human health risks associated with the Treated Backfill.

As discussed above, the RD process will consider data collected from historic (pre-amended ROD) investigations and data collected from the PDI to support completion of the RD process and the development of a Final ICP and the LTM Plan. The interpretation of the results and evaluations that will be used to support the key remedial decisions are described in Section 3 of this RDWP.

Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the Decision Matrix for how the information will be used to prepare the RD.

4.1 Plume Core Evaluation

The Plume Core evaluation is being conducted to characterize the type and extent of contaminants (both soil and groundwater) that are underlying the approximate boundary of the FSA. This evaluation is designed to provide the following data needed for design of the remedy:

- Better estimates of contaminant mass within the saturated zone which will be subject to treatment.
- Better definition of the lateral and vertical distribution of impacts and the distribution relative to different soil types which may impact treatment efficacy.
- Characterization of physical and geochemical conditions that may affect in-situ treatment or reagent injection and distribution.

Further details on the Plume Core Evaluation are provided in the Draft PDI Plan, including the scope of work and provisions for the collection of soil and groundwater samples for VOCs, SVOCs, pesticides, PCBs, and metals, and groundwater data to support the identification of the initial ATZ.

A statistically significant data set representative of the Plume Core contaminant distribution will be collected as part of this scope of work to characterize conditions, define the lateral and vertical limits of treatment design, and refine the scope of the proposed bench-scale testing program. Details on the geo-statistical methods are also contained in the Draft PDI Plan.

Key questions that will need to be answered as part of this component of work include:

1. What is the lateral extent of impacts that should be addressed by the remedy?
2. What are the likely physical and geochemical controls on biotic and abiotic processes and how will these affect the remedy?
3. Based on the distribution of impacts, the majority of the mass is within which lithologic units?
4. Based on the physical and geochemical controls identified, modifications to the bench-scale testing program may be made to assess the performance of the various reagents, assess the key controls on the efficacy of the remedy and mitigate geochemical conditions (for example, pH)?

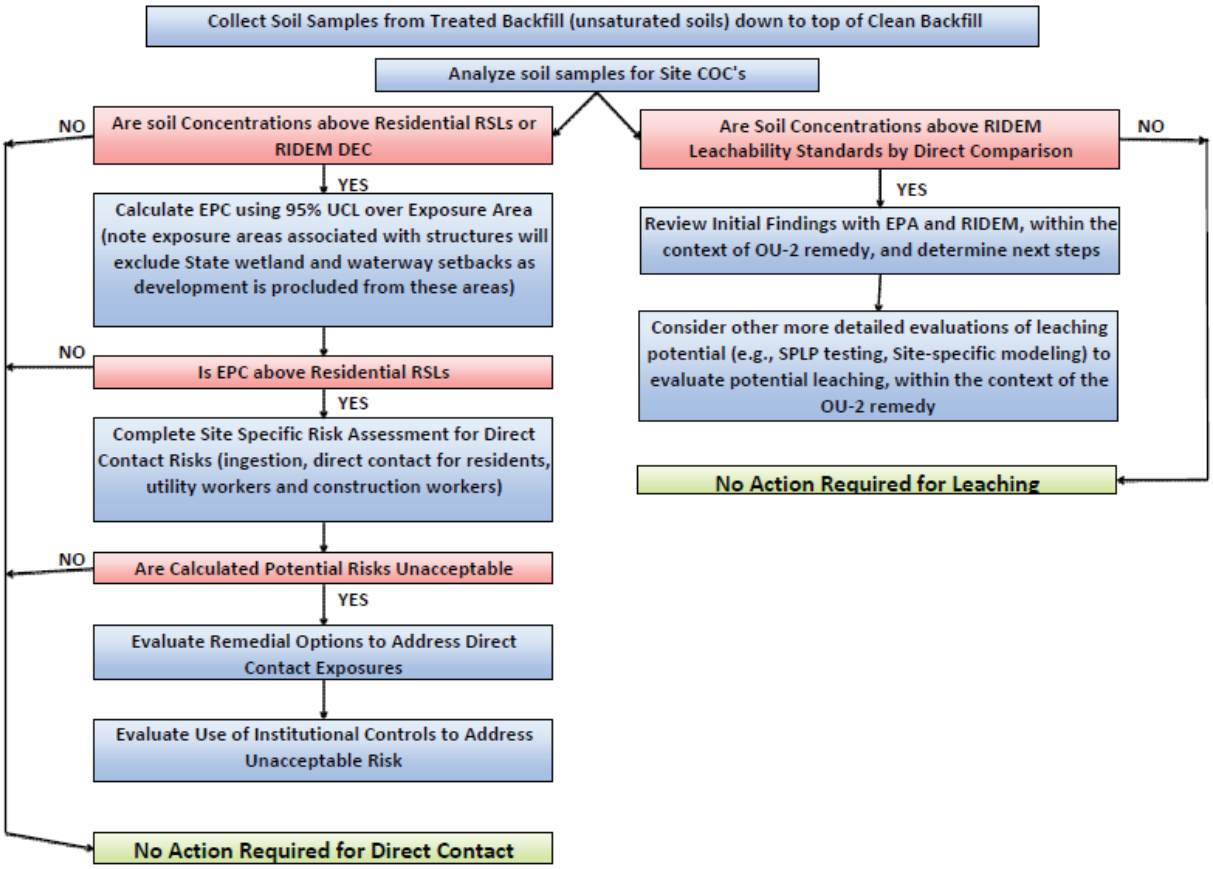
These key controls and implications of the bench scale testing program are discussed in further detail in the Draft PDI Plan. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the Decision Matrix for how the information will be used to prepare the RD.

4.2 Treated Backfill Evaluation

The goal of this evaluation is to collect information to better assess whether previously Treated Backfill within the FSA contains residual contaminants that may pose continued threats to groundwater quality or to human health or the environment. Further details on the Treated Backfill Evaluation are provided in the Draft PDI Plan, including the scope of work and provisions for the collection of soil within the Treated Backfill. Soil samples of the Treated Backfill will be characterized for VOCs, SVOCs, pesticides, PCBs and metals in accordance with requirements specified in the SOW.

The sampling locations and depths are limited to the surveyed area of Treated Backfill and the elevations above 409.6 (as-built treated backfill placement elevation) consistent with the information contained in the Remedial Action Report (Loureiro Engineering Associates, 2002). A sampling grid has been established over the Treated Backfill area to accommodate a sampling density suitable for use of geostatistical techniques and human health risk assessment. The rationale for the sampling frequency is described in detail in the Draft PDI Plan. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the decision matrix for how the information will be used to prepare the RD. Figure 4.1 presents the Treated Backfill decision matrix which summarizes the technical approach and strategy for decision making with respect to the Treated Backfill.

FIGURE 4.1
Treated Backfill Decision Matrix



Decision Making Framework for Assessment of Leaching to Groundwater

The potential for leaching COCs from unsaturated zone soils is being conducted to determine potential impacts on the remedial goals and approach for groundwater, as stated in the ROD Amendment and SOW. The leaching potential of VOCs in soil will initially be evaluated by comparing Treated Backfill soil data to the applicable RIDEM Remediation Regulation Leachability Criteria. If no exceedances are noted then no further assessment of leaching potential will be conducted. As necessary, the nature and distribution of the data will be discussed with EPA and RIDEM, within the context of the OU-2 remedy, to determine what subsequent steps are required.

As stated in the SOW, more detailed evaluations of leaching potential (e.g., SPLP testing, Site-specific modeling) may be proposed for approval by EPA, after reasonable opportunity for review and comment by the RIDEM, and implemented in a manner consistent with the remedial goals and approach for groundwater, as stated in the ROD Amendment.

Decision Making Framework for Assessment of Potential Human Health Risks

In accordance with the SOW, threats to human health through direct exposures will be initially evaluated by comparison to risk-based criteria (i.e., EPA's Regional Screening levels) or regulations (i.e., RIDEM Direct Exposure Criteria).

Based on the regulatory framework outlined in the SOW, and consistent with the decision making framework discussed above for assessment of leaching to groundwater, a tiered evaluation program is proposed for the assessment of the potential for risks to human health.

Consistent with the decision framework outlined in Figure 4.1, this framework will comprise initial screening of all soil results against EPA Regional Screening Levels and/or RIDEM Direct Exposure Criteria and then a tiered assessment program utilizing standard geo-statistical techniques (used to define the Exposure Point Concentrations) and a quantitative risk assessment. The assessment of potential Human Health Risk will be conducted in accordance with the procedures outlined in the Risk Assessment Guidance and RIDEM regulations and guidance and is detailed in the PDI Plan.

4.3 Groundwater Evaluation

The Groundwater Evaluation detailed in the PDI is designed to assess the extent of impacts in the overburden and bedrock plumes prior to remediation and will lead to development of the LTM Plan that will be implemented during, and after remediation, to assess the potential for off-Site groundwater impacts. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the decision matrix for how the information will be used to prepare the RD.

The components of work comprise:

1. A residential well monitoring and assessment program.

2. Development and Implementation of a Groundwater Monitoring Program.

3. Bedrock Characterization of the downgradient areas.

4. Vapor Intrusion Assessment.

4.3.1 Residential Well Monitoring

The evaluation will assess whether contaminated Site groundwater is potentially impacting groundwater on off-Site areas identified during the public comment period. This includes, but is not limited to, residential properties along Log Road, Williams Road, the Upper Sprague Reservoir, and the YMCA's Shephard Reservation property. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the Decision Matrix for how the information will be used to prepare the RD.

In accordance with the SOW the following phased evaluation program is proposed as follows:

- Phase 1 – Establishment and sampling of sentry wells with the work comprising:

  a. An evaluation of groundwater flow relative to the Site and the residential and recreational areas identified above. This has been completed and is included in the PDI.

  b. Installation and sampling (up to three times per year) of four new sentry monitoring wells (in the bedrock only) down-gradient of the Site plumes.

If the results of the monitoring of the four new sentry wells suggest that Site contaminants may be migrating towards off-Site residential properties, proceed with the following additional evaluations:

- Phase 2 – Identification and sampling of residential and recreational property private supply wells located downgradient of the Site plumes. These wells will be included in the annual sampling program.

  The sentry wells will be sampled to assess both geochemical conditions and COC concentrations. The PDI Plan currently proposes sampling for VOCs, arsenic, and manganese in the sentry wells to meet this objective. If residential well sampling is required in the future, the selected residential wells will be analyzed for VOCs, SVOCs, and metals. Detections of VOC groundwater concentrations above the FGPSs in the samples collected from the sentry wells will trigger the following actions:

  - Resampling of the sentry well to verify the analytical results.

  - If the results are confirmed in the resampling, initiate the Phase 2 residential well sampling program.

Detection of metal concentrations above the applicable FGPSs in sentry wells will trigger the following actions:

- Continued monitoring of sentry wells for two additional sampling events.

- Assessment of metal groundwater concentrations relative to Site background.
- Assessment of available local and regional groundwater data to assess ranges of detected metals concentrations.
- If the results are confirmed in the resampling and are above background, initiate the Phase 2 residential well sampling program.

No additional decisions and actions are planned for the Residential Well Monitoring program, except as required for the Five-Year Review process.

4.3.2 Implementation of Groundwater Monitoring Program

In accordance with the SOW, groundwater samples will be collected from the 43 existing monitoring wells sampled during the Phase 4 (Fall 2008) monitoring program and any new overburden and bedrock wells to be installed in accordance with this SOW. The number and location of all monitoring wells and the rationale for new wells is documented in the Draft PDI Plan.

Groundwater samples from these new wells are being analyzed for VOCs, SVOCs, pesticides, and metals during the initial year of the monitoring program. Subsequent monitoring will focus on VOCs. The need to perform ongoing monitoring for the additional parameters (SVOCs, pesticides, and metals) will be determined based on the results of the initial year of monitoring.

Monitoring of groundwater will be performed three times per year from the initiation of the PDI until the completion of the in-situ treatment component of the Remedial Action unless modified through agreement with EPA and RIDEM. In addition groundwater samples from selected wells will be sampled for geochemical parameters (e.g., chloride, sulfate, sulfide, nitrate, nitrite, alkalinity, total organic carbon, ethene, ethane, methane, acetylene, and hydrogen) and/or for microbiological analytes or microcosm studies as needed to support the natural attenuation evaluation described below.

It is currently anticipated that three sampling events will be performed during 2012 and the data from these events, in conjunction with historic data and information, will be used in the development of the LTM Plan. It is anticipated that any changes to the groundwater monitoring program will be proposed in the LTM Plan (refer to Section 3 herein) following completion of the PDI investigation activities.

4.3.3 Additional Monitoring Wells

The Draft PDI Plan proposes that eight (8) additional shallow and deep bedrock monitoring wells (not including the sentry wells described above) will be installed in areas that are geologically down-dip, hydraulically downgradient or within the FSA to provide a more fully characterized bedrock aquifer. These wells will complement the existing monitoring well network.

In addition, a series of overburden groundwater monitoring well transects (anticipated to be two transects of three multi-level well clusters) will be established in the overburden plume

downgradient of the wetlands to evaluate the performance of natural attenuation processes in the untreated portion of the plume and the ongoing contribution of the wetlands to downgradient areas in the overburden.

No actions or decisions are planned from these investigations. However, data from these investigations may prove valuable in some of the actions and decisions discussed above including:

1. Delineating the extent of impacts in bedrock in the Plume Core and downgradient plume areas.
2. Provision of additional wells in which the fate and transport of constituents in bedrock can be assessed.
3. Supplemental monitoring wells that can be incorporated into the LTM Plan.
4. Wells that can be used to assess the fate and transport of constituents in the untreated overburden plume and to define the potential flux from the impacted wetlands to the overburden aquifer located downgradient of the wetlands.

Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the Decision Matrix for how the information will be used to prepare the RD.

4.3.4 Vapor Intrusion Assessment and Response Plan

A vapor intrusion assessment and response plan only has to be prepared in response to a proposal by a property owner to construct an occupied structure within, or in close proximity to, the Overburden Plume. A number of activities will be conducted as part of the PDI that will assist in the future development of this plan. The Plume Core and Groundwater Evaluations described above will provide better definition of the lateral extent of groundwater impacts and the area in which vapor intrusion assessments may have to be conducted. In addition, remediation of groundwater at the Site will provide direct benefits by reducing vapor concentrations and the need for a vapor intrusion assessment.

Table 3.1 summarizes the activities which may assist in future development of the vapor intrusion assessment and response plan. Based on the efficacy of the groundwater remedy and the result of the treated backfill evaluation, the necessity for the requirement to perform a vapor intrusion assessment and response plan, if requested by EPA and/or RIDEM, will be re-evaluated as part of the Five-Year Review process. The design of the OU-2 remedy will not receive inputs from the vapor intrusion assessment scope of work described above.

4.4 Fate and Transport and Natural Attenuation Evaluation

The goal of this evaluation is to assess the fate and transport of COCs and natural attenuation processes in the bedrock plume throughout the Site. Consistent with the SOW, the goal of these evaluations is to demonstrate that natural attenuation is occurring at a sufficient rate to merit selection of MNA as the remedial action for the bedrock plume and to evaluate the performance of

the selected MNA remedy for the untreated portions of the overburden plume. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the decision matrix for how the information will be used to prepare the RD.

The SOW requires the collection of three "lines of evidence" in accordance with EPA's OSWER Guidance 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites.* These lines of evidence comprise:

1. Historical groundwater chemistry data that demonstrates a clear and meaningful trend of sequential decay and decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points. This will comprise an update to the trend evaluations previously conducted.

2. Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the Site, and the rate at which such processes will reduce contaminant concentrations to required levels.

3. Data from field or microcosm studies (conducted in or with actual contaminated Site media), which directly demonstrates the occurrence of a particular natural attenuation process at the Site and its ability to degrade the COCs (typically used to demonstrate biological degradation processes only).

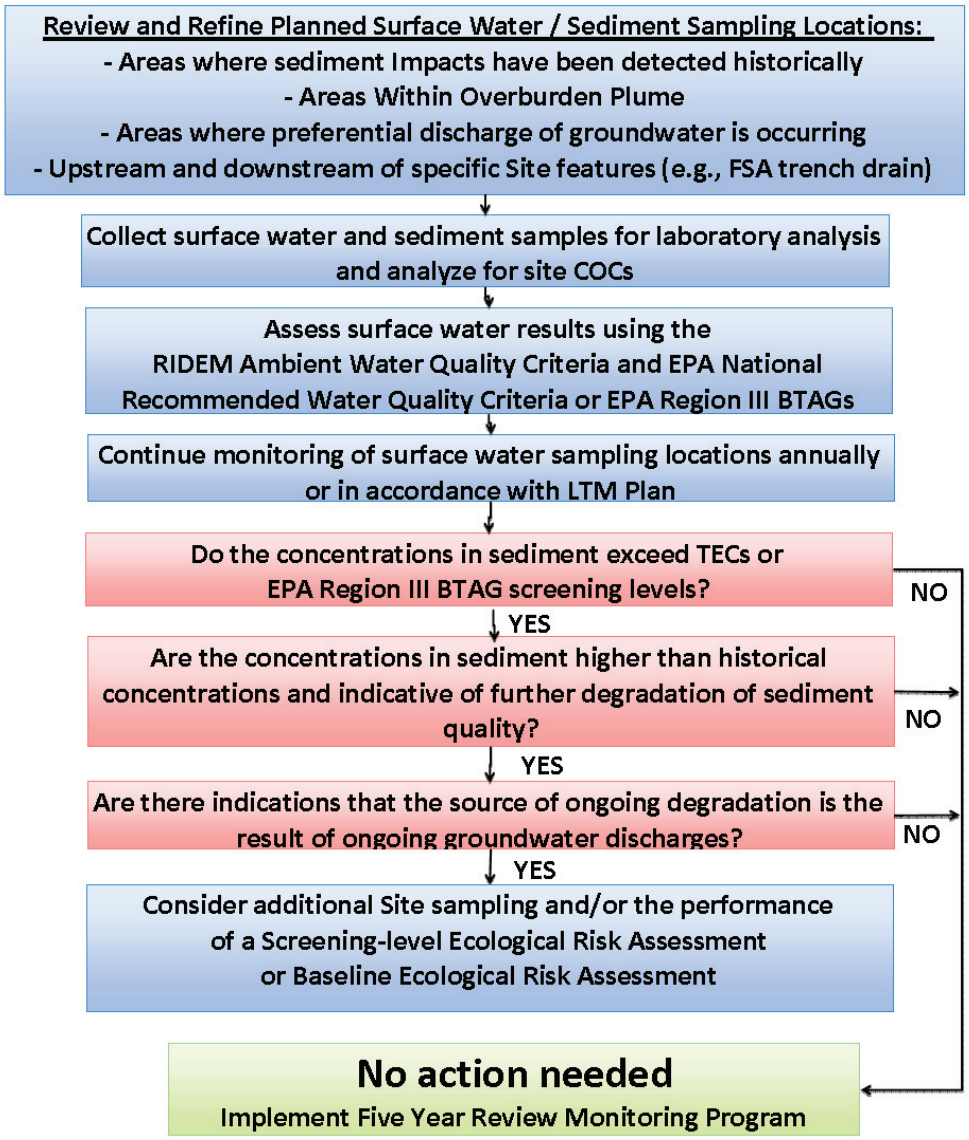
In addition supplemental assessments of fate and transport, plume stability and hydraulic conductivity will be conducted to better define the constraints on natural attenuation processes or (if required) active remediation. The scope of these supplemental investigations will include screening for dense non-aqueous phase liquid presence, geophysical logging of bedrock wells, hydraulic conductivity testing in select bedrock wells and microbiological analysis of either groundwater samples or biotraps to assess the presence of viable bacterial populations and to quantify degradation rates. Microcosm analysis may also be utilized, if warranted.

In conjunction with the assessment of MNA processes within the bedrock, performance monitoring of natural attenuation processes will be conducted in the overburden plume in areas where PSATs have been met and in the untreated portion of the overburden plume located downgradient of the wetlands consistent with the OSWER Guidance 9200.4-17P. Further details on this evaluation are provided in the PDI Plan.

4.5 Surface Water and Sediment Evaluations

The goal of this evaluation is to assess potential impacts associated with historic Site activities and the potential for ongoing discharges of contaminated groundwater from the FSA into the adjacent wetlands and Latham Brook. Information and data developed under this evaluation will be used in the formulation of the LTM Plan and identification of a long term management approach for sediment. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the decision matrix for how the information will be used to prepare the RD. Figure 4.2 summarizes the approach to evaluation and decision making for this evaluation.

FIGURE 4.2
Surface Water and Sediment Decision Matrix



Consistent with the SOW and findings of historic investigations, a number of sources of impact need to be considered in the design of the investigation. These comprise:

- Groundwater hydrogeology and overburden and bedrock plume geometry and the potential for impacted groundwater to discharge to surface water.
- Historical waste disposal practices and proximity to the core plume areas.
- Historical dewatering activities which resulted in the discharge of untreated groundwater to the wetlands and Latham Brook.
- Ongoing dewatering activities where groundwater from the overburden in the Plume Core is captured by a reported trench drain and discharged directly to the unnamed stream.

Detailed discussion of the surface water and sediment sampling scope and rationale is contained in the PDI Plan. This investigation includes assessment of the above sources of impact within the wetland areas, the unnamed stream, and Latham Brook. Following the characterization of the wetland areas within the overburden plume, surface water, and sediment sampling locations will be finalized. Both surface water and sediment samples will be collected (with a large number of surface water and sediment samples being co-located) with surface water samples analyzed for VOCs, SVOCs, and metals and sediment samples will be analyzed for VOCs, SVOCs, pesticides, PCBs and metals.

In accordance with the SOW and the decision framework outlined in Figure 4.2, a tiered evaluation of the surface water and sediment will be conducted. Surface water data will initially be screened against both the RIDEM Ambient Water Quality Criteria (AWQC) and EPA National Recommended Water Quality Criteria (NRWQC). If there are no RIDEM AWQC or NRWQC for a chemical, it should be screened against EPA Region III Biological Technical Assistance Group screening benchmarks (BTAG) for freshwater. Sediment data will initially be screened against Threshold Effect Concentrations (TECs) in Macdonald et al (2000). If there is no TEC for a chemical, then it should be screened against the EPA Region III BTAG. If exceedances of screening criteria are present in the data set then more detailed assessments will be conducted in subsequent phases of the evaluation program. These assessments will include:

1. An assessment of current surface water and sediment data against historic data to determine if concentrations are consistent and appear stable :
    a. If concentrations are similar to historic concentrations then, consistent with the SOW, long term monitoring will be implemented to verify conditions and the stability of surface water and sediment concentrations.
    b. If concentrations are higher, supplemental investigations and a detailed spatial assessment (as described below) will be conducted.
2. Assessment of spatial distribution of data to determine the impact of both historic and ongoing sources of impact (other than groundwater discharges) on surface water and sediment quality:

a. If sources of impact are not identified as ongoing discharges to groundwater, then groundwater/surface water interactions do not need to be considered in the remedy design.

b. If groundwater is an ongoing source of impact above screening levels, then the benefits of the proposed remedy for surface water quality will need to be considered in the design.

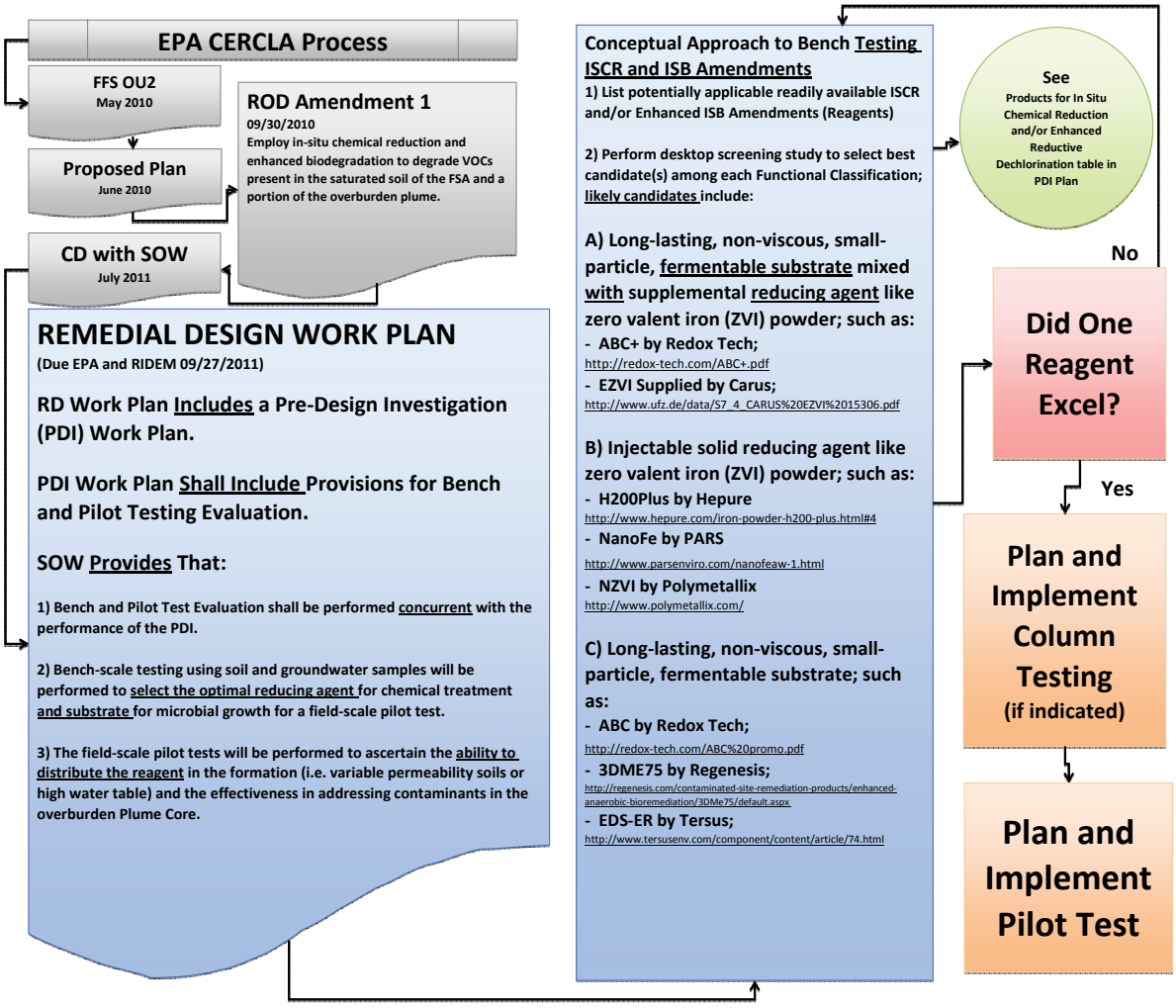
On the basis of this evaluation, the need for further assessments and evaluations (for example further sampling or Site characterization or the performance of a Baseline Ecological Risk Assessment) will be considered.

4.6 Bench and Pilot Testing Evaluation

In accordance with the SOW, the bench- scale tests will be designed to select the optimal reducing agent for chemical treatment and substrate for microbial growth in the field scale pilot test. In addition, the bench-scale tests provide an opportunity under 'ideal and optimized' conditions to also assess the key controls and limitations on reductive dechlorination (both biotic and abiotic) and the longevity of these reagents. The field-scale pilot test will be performed to ascertain the ability to distribute the reagent in the formation (i.e., variable permeability soils or high water table) and the effectiveness in addressing contaminants in the overburden Plume Core.

The detailed plans for bench-scale and pilot testing are provided in the Draft PDI Plan. The general strategy for bench-scale and pilot testing is shown in Figure 4.3.

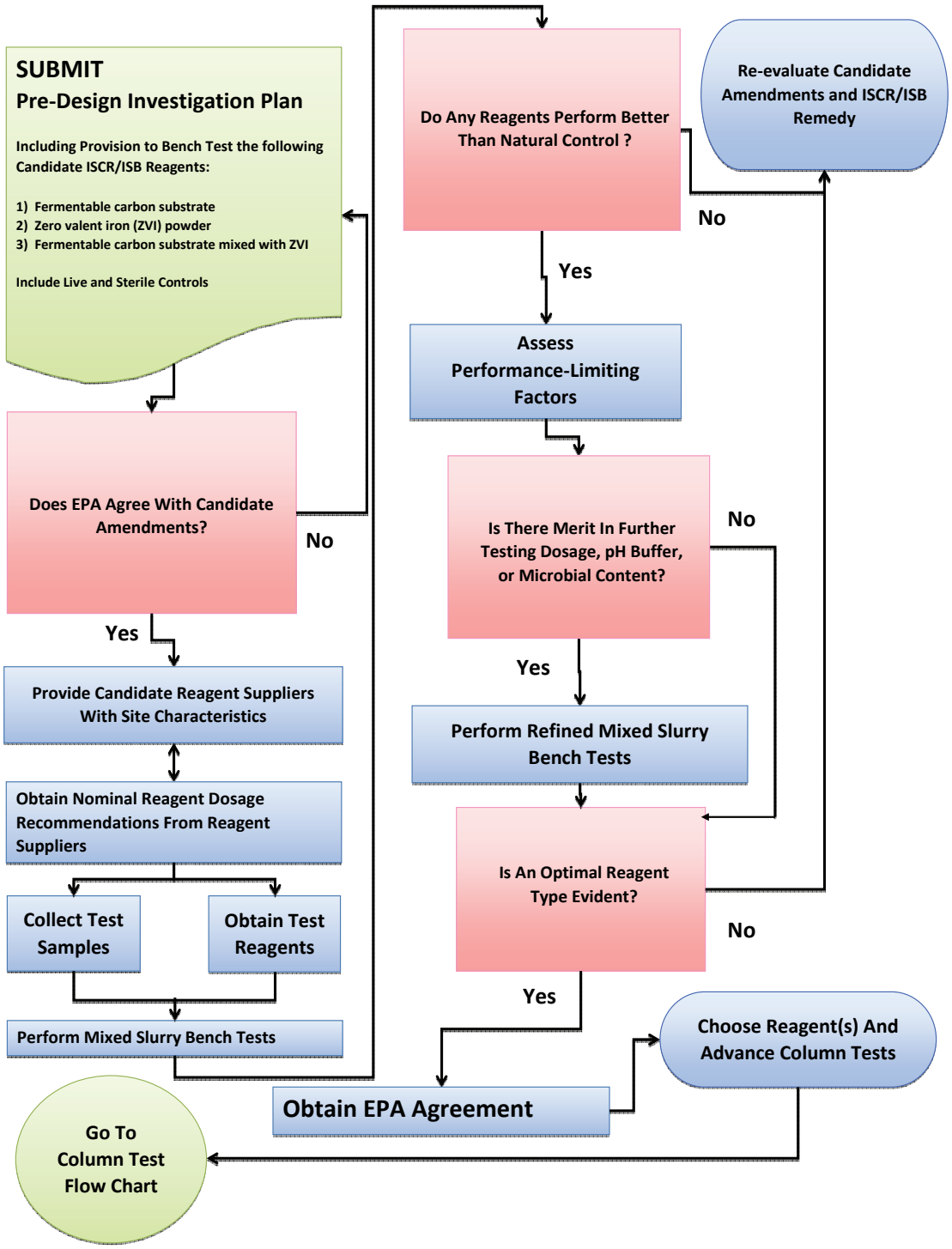
Figure 4.3
Roadmap to Bench and Pilot Testing



4.6.1 Bench-Scale Testing Program

A phased program of bench-scale testing has been developed recognizing the strengths and weaknesses of the two primary methods of bench-scale testing for reagents (mixed slurry phase and column tests). This phased program of testing is summarized in following Figure 4.4.

Figure 4.4
Mixed Slurry Bench Testing Flow Chart



The key objectives of the bench-scale testing program are as follows:

1. Define what type of reagents is most applicable to the Site.
2. Define the major controlling/limiting factors identified in the bench-scale tests that need to be considered in the design.
3. Assess the potential impediments to effective implementation which need to be considered in the pilot test and design.
4. Assess the likely longevity of reagents in the subsurface in order to define the treatment frequency.

To facilitate this assessment, and based on the complexity of Site conditions, the bench-scale testing program comprises two elements as further detailed in Draft PDI Plan:

1. **Mixed Slurry Microcosms** – facilitate assessment of degradation under conditions of mixed systems with the opportunity for direct contact with the reagents.
2. **Column Tests** – facilitates the assessment of degradation where direct contact does not occur (particularly important for the finer grained soils – diffusive and advective transport of reagents), and other key design components including longevity, geochemical changes and indicators of reduction and back diffusion and concentration rebound.

Following completion of the bench-scale testing program the following key design parameters will be defined:

- Reagent selection
  - dosage
  - concentration
  - specific volume
  - rate
- Reagent supplements
  - pH buffer
  - nutrients
- Anticipated reagent longevity
- Indicator parameters for degradation that should be included in the pilot test and remediation monitoring programs

These design parameters will be utilized to develop refine the pilot testing program (detailed in the Draft PDI Plan) and screen injection technologies and approaches that should be evaluated in the pilot testing program. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the decision matrix for how the information will be used to prepare the RD.

Further strategy and technical approach for mixed slurry microcosm testing is shown on Figure 4.5 and Figure 4.6. Further strategy and technical approach for bench-scale column testing is shown on Figure 4.7.

Figure 4.5 - Bench Testing Strategy: Mixed Slurry Microcosm Reagents, Laboratory, and Samples

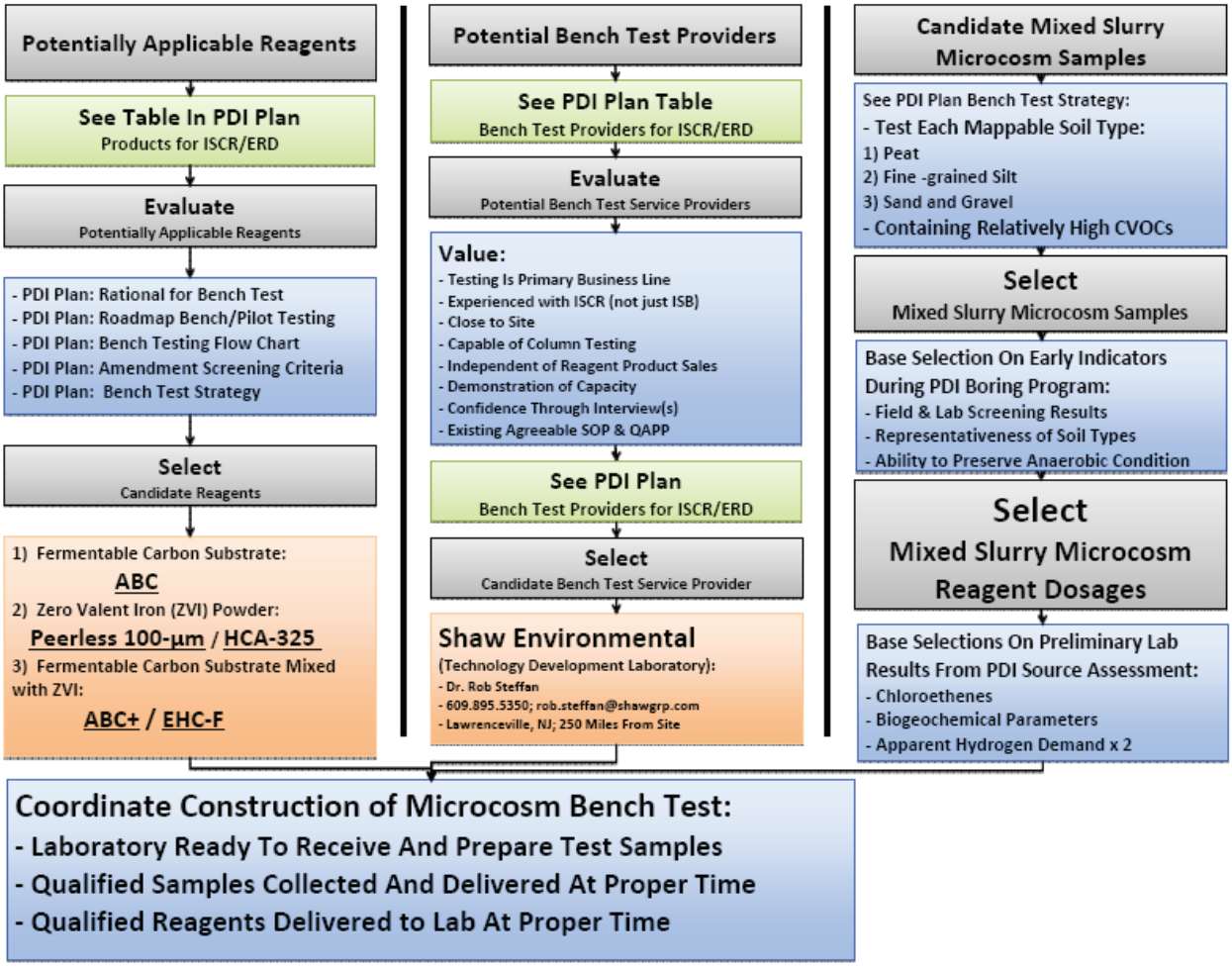


Figure 4.6
Bench Testing Strategy: Mixed Slurry Microcosm Decision-Making Flow Chart

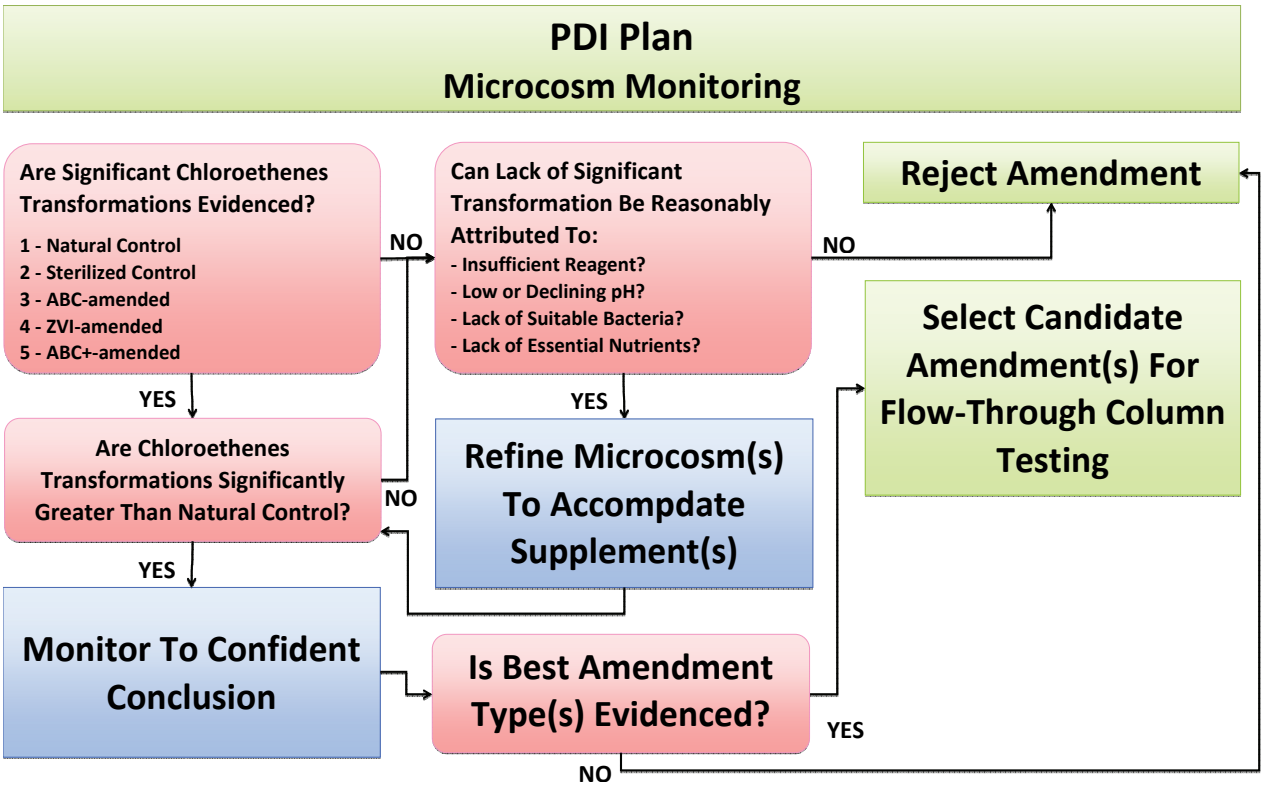
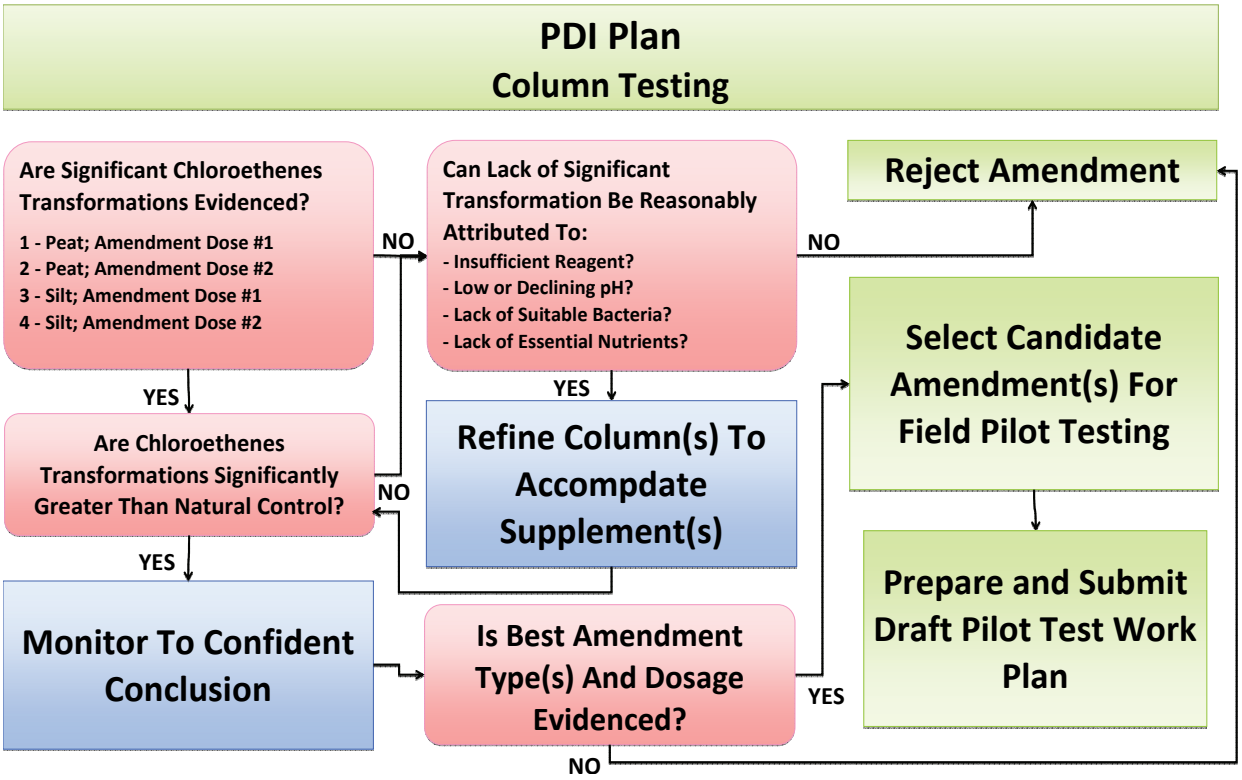


Figure 4.7
Bench Testing Strategy: Column Test Decision-Making Flow Chart



4.6.2 Pilot Testing

The pilot testing will identify potential injection/delivery systems that can be used to distribute the treatment reagents into the ATZ and develop data needed to design the effective distribution of treatment reagent into the subsurface overburden materials in the ATZ. Provisions for pilot testing are further detailed in the Draft PDI Plan.

The pilot test will focus on the delivery and distribution of the reagents selected from the bench-scale trials in the lithologic units which are determined critical for remediation of groundwater. The lateral and vertical mass distribution and distribution of COCs in different lithologic units will be determined in the plume core evaluation. For the purposes of the pilot test, the area of greatest impacts within the Plume Core will be targeted for the pilot test, with the assessment of performance focused on the more recalcitrant soil types where mass is likely preferentially distributed and where delivery and distribution will be more challenging.

Key information gathered during the PDI and bench-scale trials which will affect the scope of the pilot test include:

1. Ease of drilling in the Plume Core area – as part of the Plume Core investigation direct push drilling techniques will be utilized to collect soil samples. The ease of sample collection will give a good indication of the ease with which direct push techniques can be used for the injection of reagents into the subsurface.

2. The chemical reagents and dosage rates – the physical properties of the reagents (density, viscosity, etc.) vary by both reagent and dosage rate.

In addition to the information collected from the PDI, the selected reagents and dosage rates will also likely impact on the methodologies employed in the pilot test. The physical properties of the reagents (density, viscosity, etc.) are highly variable and, based on both the reagents and dosages selected, the range of physical properties of the reagents can be variable. These variable properties have direct impacts on the injection methodologies that will be potentially viable and pilot tested at the Site. The key elements that will be defined in the pilot test include:

- Reagent delivery approach
- Injection point spacing and distribution of reagent in the subsurface
- Frequency of injection
- Verification and validation of bench scale performance (as much as practical given schedule constraints)
- Monitoring requirements and frequency

As part of the pilot testing, and in order to assess the efficiency of subsurface delivery, a combination of investigative and monitoring techniques will be used. The investigative and monitoring approaches, dependent on the reagent selected, could include any combination of the following:

1. Quantification of reagent injection volumes by depth intervals and location to estimate reagent subsurface mass.

2. Monitoring of groundwater concentrations and general water chemistry in discrete screened monitoring wells.

3. Post injection soil sampling at select locations and assessment of soil geochemistry (pH, redox, TOC and iron content).

4. Geophysical techniques for assessment of changes in soil conductivity and resistivity (only applicable to reagents that contain iron).

5. Post injection and long-term monitoring of COC concentrations in groundwater within the treatment area.

A draft Pilot Test Work Plan will be prepared and submitted to EPA and RIDEM for review and approval pending the outcome of the bench-scale tests and the relevant portions of the PDI. Table 3.1 summarizes the activities intended to answer each key design consideration. Figure 3.2 shows the decision matrix for how the information will be used to prepare the RD.

5.0 PROJECT ORGANIZATION

The project organization is summarized in Figure 5.1 and highlights the relationships among the Agencies, Settling Defendants, Project Coordinator/Supervising Contractor, and the project investigation and design team. Key roles and responsibilities for each of these entities are summarized in the Sections below.

5.1 EPA Project Personnel

The EPA is the lead agency responsible for managing the implementation of the investigation and remediation activities at the Site. Byron Mah will serve as the EPA Region I Remedial Project Manager, and as such is primarily responsible for the following items related to the investigation and remediation activities proposed for the Site:

- Conducting/coordinating the EPA review and approval of the RD/remedial action submittals.
- Coordinating, directing, reviewing, and approving the work that the Davis Site Group and their Contractors/Consultants perform to assure compliance with the NCP, ROD, CD, and SOW.
- Conducting public meetings and providing an Administrative Record for the public.

5.2 RIDEM Involvement

RIDEM will provide review and comment regarding the State regulatory aspects of this project. In addition to the RIDEM review of state regulatory aspects, RIDEM based leaching to groundwater standards have been specified in the SOW. Their review process for the RD/remedial action documents will occur concurrently with that of the EPA as described in the SOW. Gary Jablonski will serve as the RIDEM Project Manager.

5.3 Settling Defendants

The Settling Defendants (i.e., Davis Site Group) for the Davis Liquid Waste Superfund Site include:

- Ashland, Inc.
- The Black and Decker Corporation
- FKI Industries Inc. f/k/a Acco-Bristol Division of Babcock Industries Inc.
- Bristol, Inc.
- Morton International, LLC
- Rohm and Haas Company

- Life Technologies Corporation

The Davis Site Group is responsible for implementation of the investigations and the design, construction and maintenance of the selected remedy.

5.3.1 Project Coordinator

The Davis Site Group has designated Mr. Kenny Ogilvie from EHS Support Corporation (EHS Support) as the Project Coordinator. The Project Coordinator is responsible for administration of the Davis Site Group's actions required by the RD/remedial action CD and SOW. The Project Coordinator is responsible for implementing the project and has the authority to commit the resources necessary to meet project objectives and requirements. The Project Coordinator's primary function is to ensure that technical, financial, and scheduling objectives are achieved successfully. The Project Coordinator functions as the major point of contact and controls matters concerning the project. The Project Coordinator is responsible for defining project objectives, developing a detailed schedule, and establishing project policy and procedures to address the specific needs of the project.

5.3.2 Supervising Contractor

The Davis Site Group has designated ESS Group, Inc. as the Supervising Contractor with responsibility for directing and supervising all actions all called for in the RD/remedial action CD and SOW. Jeffrey Hershberger will serve as the Project Manager for ESS Group, Inc.

5.3.3 Project Design Team

The Project Design Team comprises consultant resources from both ESS Group Inc. and EHS Support. Nigel Goulding from EHS Support will serve as the Technical Director for implementation of the investigation and remediation activities as outlined in the CD and SOW.

The following list provides the main subcontractors identified to date to support the investigation activities and RD (followed by the general role each is filing on the project team):

- New Environmental Horizons – Project Data Quality and Validation Services
- Shaw Environmental Inc. – Bench-Scale Treatability Testing Services
- Redox Tech – In-situ Remediation Reagent Supplier and Delivery Services
- Test America – Principal Analytical Testing Laboratory Services
- Microseeps – Specialty Analytical Testing Services
- Microbial Insights – Specialty Analytical Testing Services
- Geophysical Applications – Geophysical Testing Services

6.0 PROJECT SCHEDULE

The RD Schedule (Figure 6.1) identifies the deliverables and associated timeframes for the RD effort, based on the requirements of the RD/remedial action CD and SOW, assuming EPA and RIDEM review duration periods as shown therein. The Schedule includes approximate duration for EPA and RIDEM review and approval period, which may vary from what has been assumed and impact later submittal deadlines that depend on the timing of preceding approvals and other tasks, and other factors (e.g., weather). The SOW provides the following durations for select RD milestones:

- 30% RD, within 400 days from approval of the RDWP and associated POP, unless EPA extends the deadline.
- 100% RD, within 90 days following EPA's approval or modification of the 30% RD, unless EPA extends the deadline.

It should be noted that the Remedial Action items specified in the SOW have not been included on Figure 6.1 for clarity and focus on the RD.

The PDI schedule demonstrates the anticipated timeframes and interdependencies of the individual PDI tasks outlined in this RDWP. The schedule assumes the RDWP will be approved of by November 29, 2011. The actual schedule for the majority of the tasks shown on Figure 6.1 will be dependent on the approval of the RDWP, PDI Plan and the RD POP. It should be noted that the RD Schedule will be updated as necessary to reflect changes or modifications in the schedule based on the actual dates of approval, schedule modifications and to reflect changes in the schedule for PDI field activities that may be necessary due to weather conditions or other schedule impacts.

Tables

TABLE 3.1
REMEDIAL DESIGN CONSIDERATIONS
TECHNICAL APPROACH MATRIX
Davis Liquid Waste Superfund Site

Design Consideration		Technical Approach Intended To Garner Answer in Whole or Part															
ID No.	Description	Pre-Design Investigation					Groundwater Investigation			Fate & Transport and Natural Attenuation		Surface Water and Sediment Evaluation		Other			
		Plume Core	Treated Backfill	Mixed Slurry Bench Tests	Column Tests	Pilot Test	Sentry Wells	New Monitoring Wells	Sitewide Ground Water	Bedrock Demon-stration	OB MNA Monitor	Wetland Character-ization	Sampling	CSM	LTM	I & I	PJ
1	What is the lateral extent of groundwater exceeding the Interim Groundwater Remediation Goals (IGRGs)?	P							P					P	s		s
2	What is the lateral extent of the Active Treatment Zone (ATZ)?	P							P					P			s
3	What is optimal treatment reagent?	s		P	P	s								P	s		s
4	What is the prospect to effectively use conventional direct push techniques for delivery of reagent(s)?	P				P								s			s
5	What are the source and plume architectures with respect to nature and distribution of COC mass and mass flux within each of the various aquifer soil types?	P				P								s			s
6	What is the contribution of the Treated Backfill to overburden groundwater impacts and how will this affect performance of the Remedy?	s	P											P			s
7	What is the nature and extent of COCs interaction between the Plume Core and the bedrock and how will this impact on the performance of the Remedy?	P						P	s	P				P	P		s
8	What are the meaningful characteristics of the varying hydrogeologic properties, physicochemical properties, biogeochemical properties for each of the various aquifer soil types?	P		P					s		s			s			s
9	What are the meaningful implications of the aquifer's hydrogeologic properties, physicochemical properties, biogeochemical properties of site soils and how will they impact performance of the Remedy?	s		P	P	P								s			s
10	What are the optimum achievable reagent injection (or delivery) properties (makeup, spacing, injection rate, specific volume)?	s	s	s	s	s			s	s	s			s		s	s
11	What are the likely performance expectations of the selected reagents in each of the various aquifer soil types?	s		P	P	P								s		s	s

TABLE 3.1
REMEDIAL DESIGN CONSIDERATIONS
TECHNICAL APPROACH MATRIX
Davis Liquid Waste Superfund Site

Design Consideration		Technical Approach Intended To Garner Answer in Whole or Part															
ID No.	Description	Pre-Design Investigation					Groundwater Investigation			Fate & Transport and Natural Attenuation		Surface Water and Sediment Evaluation		Other			
		Plume Core	Treated Backfill	Mixed Slurry Bench Tests	Column Tests	Pilot Test	Sentry Wells	New Monitoring Wells	Sitewide Ground Water	Bedrock Demon-stration	OB MNA Monitor	Wetland Character-ization	Sampling	CSM	LTM	I & I	PJ
12	What are the major factors controlling and/or limiting performance of the Remedy in each of the aquifer soil types?	s		s	P	P					P			s		P	P
13	How can the major factors limiting performance in each of the various aquifer soil types be minimized or overcome in the design and implementation of the Remedy?	s		P	P	P			s		P			s		P	P
14	What are the likely requirements for repeated reagent delivery (e.g., amount, distribution, frequency)?			s	P	s								s		P	P
15	How can remediation performance be effectively and cost-effectively monitored in each soil types?	P			P	P								P			s
Long Term Monitoring Program:																	
1	What are the current conditions in the Overburden Plume?	P							P	s	P			P	s		s
2	What is the nature and extent of bedrock groundwater impacts and are they stable?						s	P	P	P				P	s		s
3	What is the water quality in the Sentry Wells and what potential risks exist?						P							P	s		s
Institutional Controls:																	
1	What is the current and future predicted lateral extent of groundwater impacts exceeding the Final Groundwater Performance Standards?	P					P	P	P	s	P			P	P		s
2	What are the surveyed boundaries of various land Parcels relative to the current and future predicted lateral extent of groundwater impacts exceeding the Final Groundwater Performance Standards?	s					P	s	P					s	P		s
3	What are the potentially complete exposure pathways to be managed via Institutional Controls?	P	P				P	P	P	s	s		P	P	P	s	s

TABLE 3.1
REMEDIAL DESIGN CONSIDERATIONS
TECHNICAL APPROACH MATRIX
Davis Liquid Waste Superfund Site

Design Consideration		Technical Approach Intended To Garner Answer in Whole or Part															
ID No.	Description	Pre-Design Investigation					Groundwater Investigation			Fate & Transport and Natural Attenuation		Surface Water and Sediment Evaluation		Other			
		Plume Core	Treated Backfill	Mixed Slurry Bench Tests	Column Tests	Pilot Test	Sentry Wells	New Monitoring Wells	Sitewide Ground Water	Bedrock Demon-stration	OB MNA Monitor	Wetland Character-ization	Sampling	CSM	LTM	I & I	PJ
Fate and Transport and Natural Attenuation:																	
1	Is intrinsic or natural attenuation progressing in the Untreated Overburden in accordance with EPA criteria and expectations?			s					P		P			s	s		s
2	What are the bedrock and bedrock groundwater hydrogeologic properties, physicochemical properties, biogeochemical properties which control the fate and transport of COCs?							P	P	P				P	P		P
3	What is the prospect for the bedrock aquifer to naturally attenuate or assimilate impacts?							P	P	P				P	P		P
4	What is the demonstrable occurrence of intrinsic biotoc and/or abiotic dechlorination in bedrock?						s	P	P	P				P	P		s
5	What are the rates of intrinsic biotic and abiotic dechlorination in bedrock?						s	s	s	P				s			s
6	Will the intrinsic biotic and abiotic dechlorination rates provide restoration in 'reasonable' timeframe?							s	s	P	MNA Monitor			P	P		s
Treated Backfill:																	
1	What are the potential human health risks associated with direct contact with treated backfill soil?		P											P			P
Surface-water and Sediment:																	
1	What is the nature and extent of surface water and sediment impacts?								s		s	P	P	P	s		s
2	What are the surface water and sediment hydraulic properties and hydrogeologic properties?											P	P	s			s
3	What is the potential for groundwater to impact surface water and sediment quality?	P							P	s	P	P	P	P	s		s
4	What is nature and extent of COCs interaction between impacted groundwater and surface water and sediment?	P							s	s	P	P	P	P	s		s
5	What is the magnitude of possible groundwater contributions to surface water and sediment impacts relative to historic contributions?	s						s	s	s	s	P	P	P	s		s

TABLE 3.1
REMEDIAL DESIGN CONSIDERATIONS
TECHNICAL APPROACH MATRIX
Davis Liquid Waste Superfund Site

Design Consideration		Technical Approach Intended To Garner Answer in Whole or Part															
ID No.	Description	Pre-Design Investigation					Groundwater Investigation			Fate & Transport and Natural Attenuation		Surface Water and Sediment Evaluation		Other			
		Plume Core	Treated Backfill	Mixed Slurry Bench Tests	Column Tests	Pilot Test	Sentry Wells	New Monitoring Wells	Sitewide Ground Water	Bedrock Demon-stration	OB MNA Monitor	Wetland Character-ization	Sampling	CSM	LTM	I & I	PJ
6	What were the primary mechanisms for past, current, and future delivery of impacts to surface water and sediment?	P							s		s	P	P	P	s	P	s
7	What are the potential ecological and human health risks from surface water and sediments?										s	P	P	P	s		P
8	What is the prospect for the surface water and sediment to naturally attenuate or assimilate impacts?	s									s	P	P	P	P		s
Vapor Management Assessment and Plan:																	
1	What is nature and extent of soil and groundwater impacts relative to the prospect of vapor intrusion?	P	P				P	P	P					P	P		s
2	What is the prospect for and nature of possible future development activities?													s		P	s
3	What is the process for future building (e.g., approvals and permitting)?															P	
4	How does the remedy affect the prospect for vapor intrusion?	s		P	P	P					P			P	P		s

Notes:
P Primary component in answering key design and management questions
s Secondary component in answering key design and management questions
OB - Overburden
MNA - monitored natural attenuation
CSM - conceptual site model
LTM - long-term monitoring
I&I - inquiries and interviews
PJ - professional judgement

Figures

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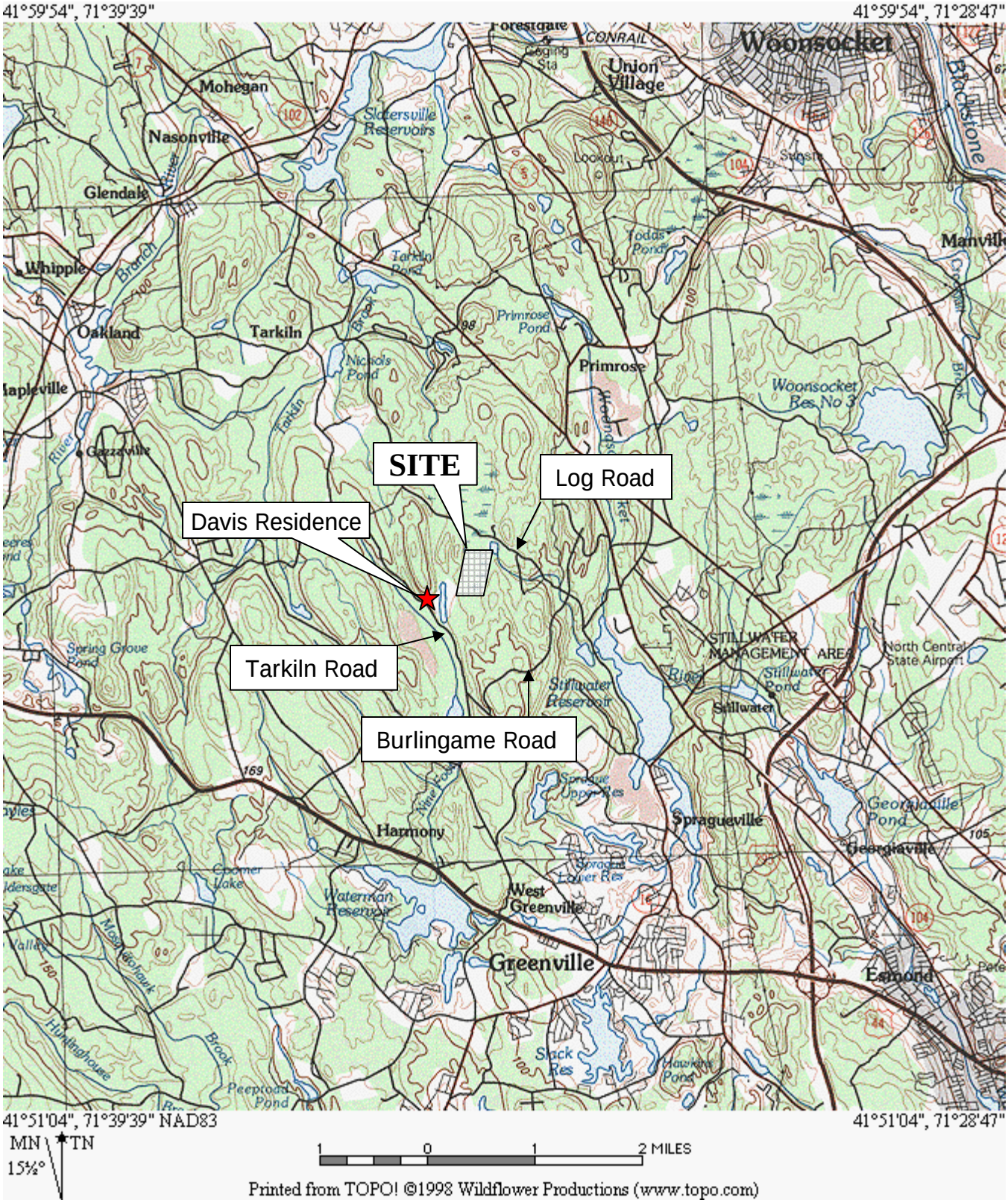

ESS Group Inc.
Engineers
Scientists
Consultants

Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Scale: As Noted
Extent of Site As Shown is Approximate

Site Locus Map

Figure 2.1

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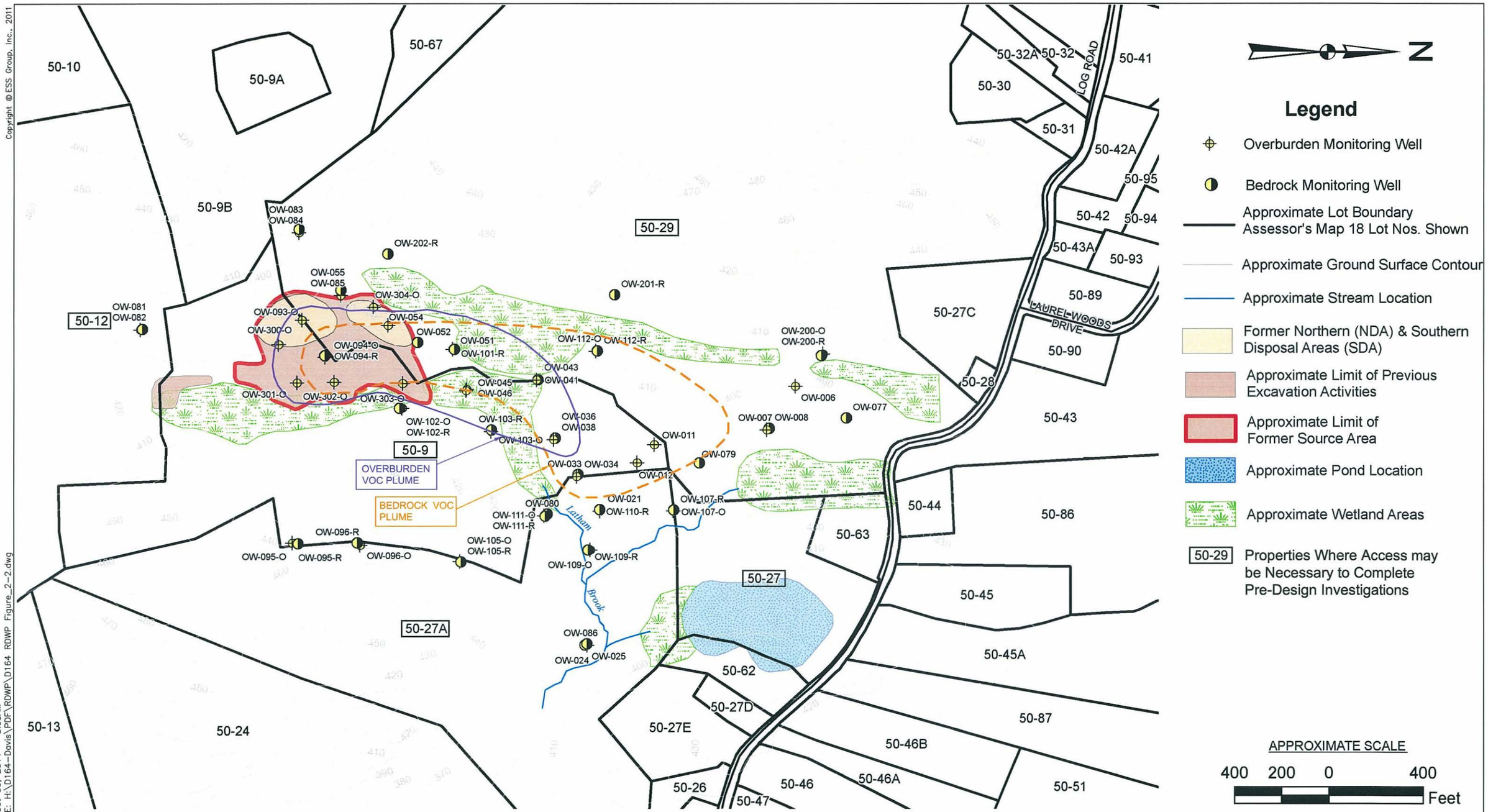


Source: Nobis Engineering, Inc., Figure 1-2 entitled:"SITE AND SURROUNDING AREA", Davis Liquid Waste Site, Smithfield, Rhode Island, Dated: 09/28/09 Rev. 00

DATE: Oct 06, 2011 – 8:05AM
FILENAME: H:\D164-Davis\PDF\RDWP\D164 RDWP Figure_2-2.dwg

ESS Group, Inc.
Engineers
Scientists
Consultants

Davis Liquid Waste Superfund Site
Smithfield, Rhode Island
Project No. D164-000

0 400 FEET
Date: September 2011

Site Plan with Parcel Layout

Figure 2.2

FIGURE 5.1

PROJECT ORGANIZATION CHART – DAVIS LIQUID WASTE SUPERFUND SITE

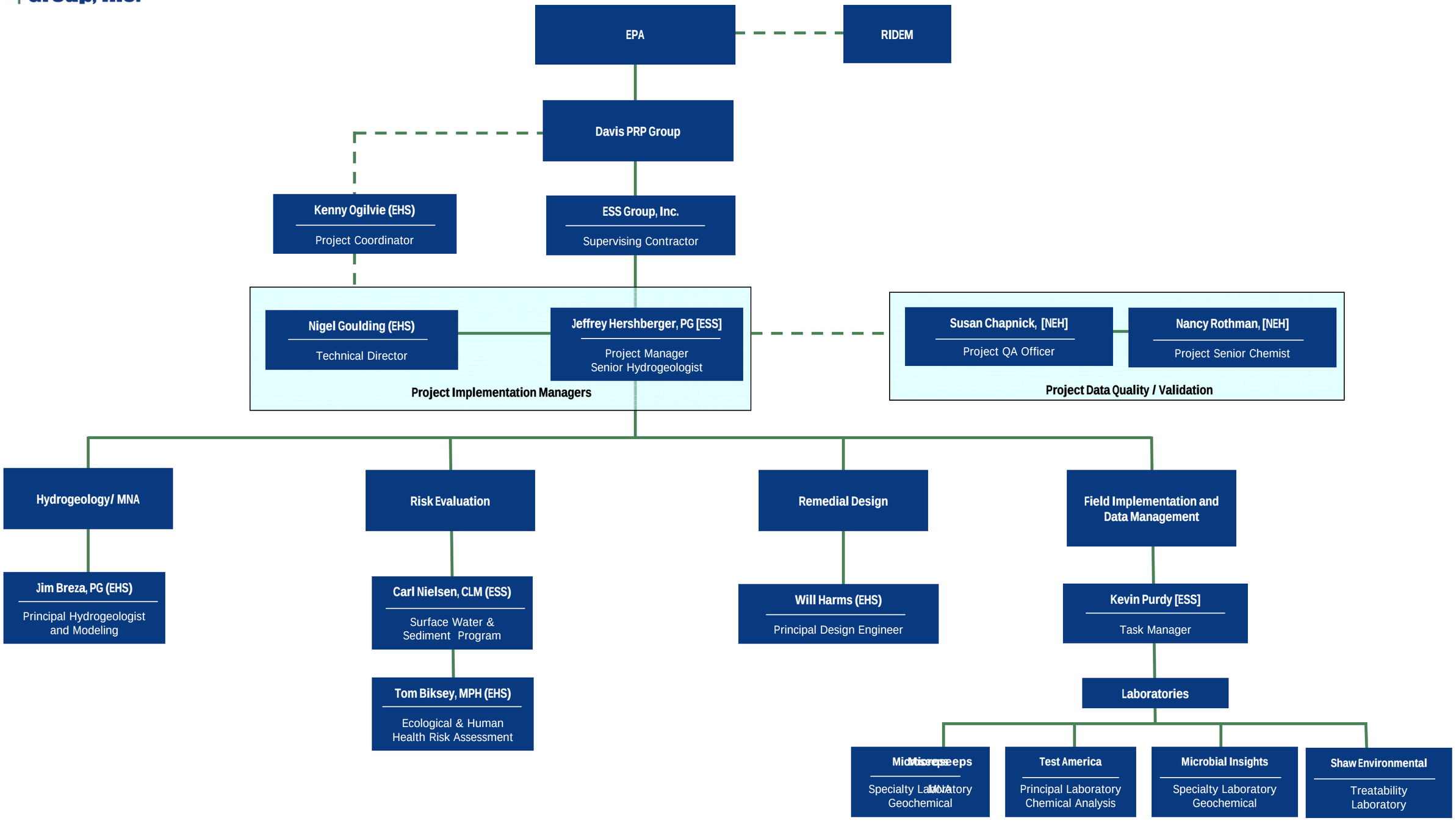
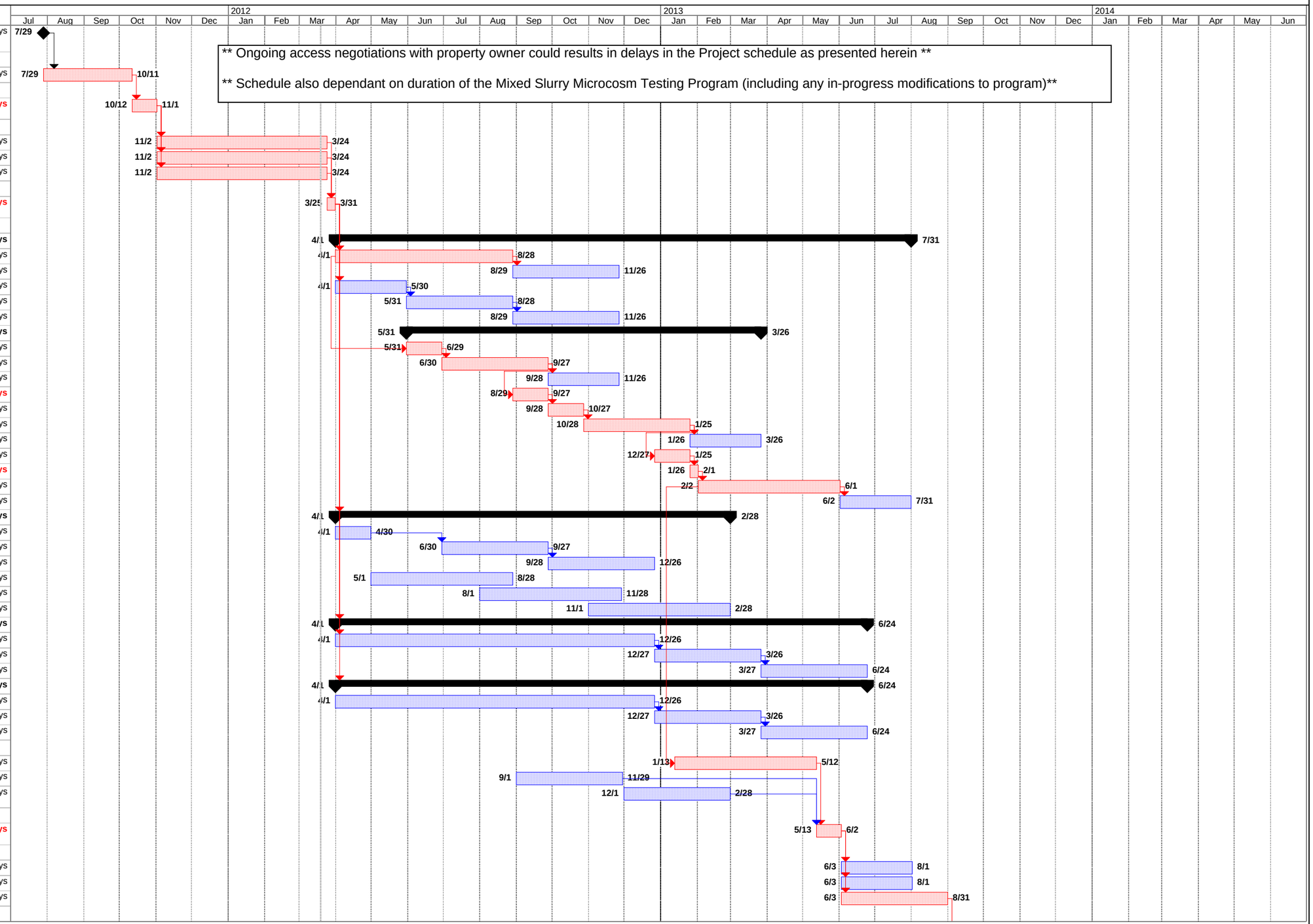


FIGURE 6.1
REMEDIAL DESIGN IMPLEMENTATION SCHEDULE
Davis Liquid Waste Superfund Site

Title: RD Work Plan Rev 1
Date: March 23, 2012

ID	Task Name	Duration
1	**Receipt of SD Signatures / Lodging of CD**	0 days
2		
3	**Draft RDWP, PDI Plan, POP (V.A,B,C)**	75 days
4		
5	**EPA Review of Draft RDWP, Draft PDI Plan, & Draft POP**	**21 days**
6		
7	**Final Remedial Design Work Plan**	144 days
8	**Final Pre-Design Investigation Plan**	144 days
9	**Final Project Operations Plan**	144 days
10		
11	**EPA Approval of Final RDWP, PDI Plan, & POP**	**7 days**
12		
13	**Pre-Design Investigation**	**487 days**
14	Plume Core Evaluation (Field)	150 days
15	Plume Core Evaluation Evaluation and Reporting	90 days
16	Treated Backfill Evaluation (Field)	60 days
17	Treated Backfill Data Evaluations	90 days
18	Treated Backfill Evaluation Reporting	90 days
19	**Bench-Scale Testing**	**300 days**
20	Preparation and Sample Collection	30 days
21	Mixed Slurry Testing	90 days
22	Extended Slurry Testing	60 days
23	**EPA Concurrence on Column Testing**	**30 days**
24	Preparation and Sample Collection	30 days
25	Column Testing	90 days
26	Extended Column Testing	60 days
27	**Pilot Testing Work Plan (PTWP)**	30 days
28	**EPA Review and Approval of PTWP**	**7 days**
29	Pilot Testing	120 days
30	Extended Pilot Testing	60 days
31	**Groundwater Evaluation**	**334 days**
32	Borehole Geophysical Logging	30 days
33	Well Installation (Sentry, MWs, Transects)	90 days
34	Well Installation Reporting	90 days
35	Groundwater Monitoring and Reporting I	120 days
36	Groundwater Monitoring and Reporting II	120 days
37	Groundwater Monitoring and Reporting III	120 days
38	**F&T / Natural Attenuation Evaluation**	**450 days**
39	F&T/NA (Field)	270 days
40	F&T/NA Data Evaluation	90 days
41	F&T/NA Reporting	90 days
42	**Surface Water/Sediment Evaluation**	**450 days**
43	SW/Sediment (Field)	270 days
44	SW/Sediment Data Evaluation	90 days
45	SW/Sediment Reporting	90 days
46		
47	**30% REMEDIAL DESIGN (V.D)**	120 days
48	**Draft Institutional Controls Plan (V.E)**	90 days
49	**Draft Long-Term Monitoring Plan & POP (V.F)**	90 days
50		
51	**EPA Review of 30% Design, Draft IC Plan, Draft LTM Plan & POP**	**21 days**
52		
53	**Final Institutional Controls Plan (V.E)**	60 days
54	**Final Long-Term Monitoring Plan (V.F)**	60 days
55	**100% Remedial Design (V.G)**	90 days
56		

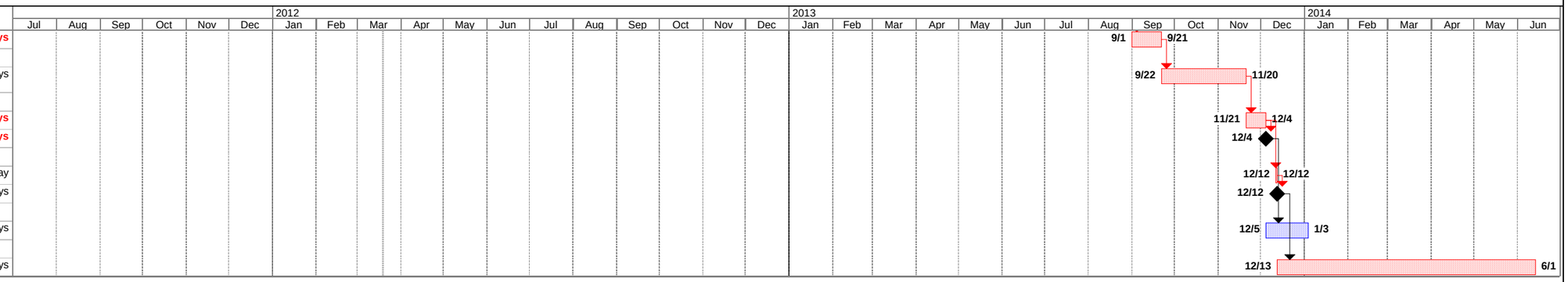


Project: Davis Liquid Site
Date: Mon 3/19/12

Task | Critical Task | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Group By Summary

FIGURE 6.1
REMEDIAL DESIGN IMPLEMENTATION SCHEDULE
Davis Liquid Waste Superfund Site

ID	Task Name	Duration
57	**EPA Review & Approval of 100% Remedial Design**	**21 days**
58		
59	**Draft Remedial Action Work Plan (RAWP) and Revised POP (VI.A)**	60 days
60		
61	**EPA Review of Draft RAWP & Revised POP**	**14 days**
62	**EPA NOTICE TO PROCEED (VI.B)**	**0 days**
63		
64	**Pre-Construction Conference (VI.C)**	1 day
65	**Construction Initiation (VI.D)**	0 days
66		
67	**Final RAWP & Revised POP (VI.A.5)**	30 days
68		
69	**1st Round of Injection**	183 days



Project: Davis Liquid Site
Date: Mon 3/19/12

Task | Critical Task | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Group By Summary

Pre-Design Investigation Plan

DAVIS LIQUID WASTE SUPERFUND SITE
SMITHFIELD, RHODE ISLAND

PREPARED FOR Davis Site Performing Party Group

PREPARED BY

ESS Group, Inc.
401 Wampanoag Trail, Suite 400
East Providence, Rhode Island 02915

EHS Support Corporation
4796 Brittonhurst Drive
Hilliard, Ohio 43026

Project No. D164-000

March 23, 2012

www.essgroup.com

PRE-DESIGN INVESTIGATION PLAN
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Prepared For:

Davis Site Performing Party Group

Prepared by:

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ESS Project No. D164.000

March 23, 2012

ESS Group, Inc.

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ACRONYMS

1,1,1-TCA	1,1,1-trichloroethane
1,1-DCA	1,1-dichloroethane
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Requirement
Bgs	Below ground surface
BTAG	Biological Technical Assistance Group (EPA Region III)
CD	Remedial Design / Remedial Action Consent Decree
cfs	Cubic feet per second
Cis-1,2-DCE	Cis-1,2-dichloroethene
COC	Contaminant of Concern
CSM	Conceptual Site Model
DEC	RIDEM Direct Exposure Criteria
DNAPL	Dense non-aqueous phase liquid
DO	Dissolved oxygen
EPA	United States Environmental Protection Agency, Region I
EPC	Exposure point concentration
ERD	Enhanced reductive dechlorination
ET	Evapotranspiration
FGPS	Final Groundwater Performance Standard
FSA	Former Source Area (encompasses NDA, SDA, Drum Disposal Area and Western Access Road)
FSP	Field Sampling Plan
gpm	Gallons per minute
ICP	Institutional Controls Plan
IDW	Investigation-Derived Waste
IGRG	Interim Groundwater Remediation Goals
ISB	In-situ bioremediation
ISCR	In-situ Chemical Reduction
kg	Kilograms
lbs	Pounds
LTM Plan	Long-term Monitoring Plan
mg/Kg	Milligrams per kilogram
mg/L	Milligrams per liter
MNA	Monitored natural attenuation
MSL	Above mean sea level
NA	Natural Attenuation
NAPL	Non-aqueous phase liquid
NDA	Northern Disposal Area
ORP	Oxidation reduction potential
OU-1	Operable Unit 1 (Waterline Extension)
OU-2	Operable Unit 2 (Overburden Groundwater)
OU-3	Operable Unit 3 (Source Remedy)

OU-4	Operable Unit 4 (Bedrock Groundwater)
PCBs	Polychlorinated biphenyls
PCE	Tetrachloroethene
PDI	Pre-design Investigation
POP	Project Operations Plan
ppm	Parts per million
PSAT	Interim Performance Standards for Active Treatment
QA/QC	Quality assurance / quality control
QAPP	Quality Assurance Project Plan
RD/RA	Remedial design / remedial action
RDWP	Remedial Design Work Plan
RIDEM	Rhode Island Department of Environmental Management
RIDEM GA	RIDEM GA Groundwater Objectives
RIDEM GA-LC	RIDEM GA Leachability Criteria
ROD	Record of Decision
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SDA	Southern Disposal Area
Site	Davis Liquid Waste Superfund Site
SMP	Site Management Plan
SOW	Remedial Design / Remedial Action Statement of Work
SPLP	Synthetic Precipitation Leaching Procedure
SVOC	Semi-volatile organic compounds
TCE	Trichloroethene
TOC	Total organic carbon
ug/Kg	Micrograms per kilogram
ug/L	Micrograms per liter
VOC	Volatile organic compounds
ZVI	Zero valent iron

DEFINITIONS

Active Treatment Zone	Refers to the areas of the Former Source Area (FSA) and Overburden Plume where active treatment will be performed. This area will be further defined in the Remedial Design submissions following completion of the baseline groundwater sampling and Pre-Design Investigations using the Decision Matrix included in the SOW.
Bedrock Plume	Extent of contaminated groundwater within the bedrock aquifer unit where chemical concentrations exceed the Interim Groundwater Remediation Goals presented in Table 7 of the 2010 ROD Amendment, or the chemical-specific ARARs presented in Appendix A of the 2010 ROD Amendment.
Davis Site Group	Davis Site Performing Party Group
Drum Disposal Area	Former disposal area within FSA.
Elevation 404.6 MSL	Target excavation depth for Source Remedy
Former Source Area	Defined as the area (vertically and horizontally) where releases of contaminants have occurred and represents the approximate boundary of the Source Control Remedial Action that previously underwent treatment of contaminated unsaturated soil residing above elevation 404.6 feet Mean Sea Level (MSL).
Northern Disposal Area	Former disposal area within FSA.
Overburden Plume	Extent of contaminated groundwater in the overburden aquifer unit where chemical concentrations exceed the Interim Groundwater Remediation Goals presented in Table 7 of the 2010 ROD Amendment, or the chemical-specific Applicable or Relevant and Appropriate Requirements (ARARs) presented in Appendix A of the ROD Amendment.
Plume Core	The portion of the groundwater plumes underlying the Former Source Area and includes the saturated soil which constitute the continuing sources of groundwater contamination as the result of residual contamination presence.
Remediation Regulations	RIDEM Rules and Regulations for Investigation and Remediation of Hazardous Releases
Settling Defendants	Davis Site Performing Party Group Members
Source Remedy	Completed in 1999 – 2001 and included treatment of soils above Elevation 404.6 MSL using low-temperature thermal desorption
Southern Disposal Area	Former disposal area within FSA. Included the Bunker C Area.
Treated Backfill	Soils previously treated during Source Remedy that were placed above the water table in the FSA.

1.0 INTRODUCTION

This document presents the Pre-Design Investigation (PDI) Plan that is required to be prepared and implemented in accordance with the OU-2 Statement of Work (SOW) for the performance of the OU-2 Remedy for Overburden Groundwater. The PDI Plan documents the rationale and sampling strategy and approaches to complete the following six distinct investigation tasks.

- Plume Core Evaluation
- Treated Backfill Evaluation
- Bench and Pilot Testing Evaluation
- Groundwater Evaluation
- Fate and Transport and Natural Attenuation Evaluation
- Surface Water and Sediment Evaluation

Data and information generated during the performance of these evaluations will be used to support the design of the active treatment component of the OU-2 remedy and development of the Long-Term Monitoring Plan and the Institutional Controls Plan, and to support other Site decisions associated with the previously treated backfill (human health risk evaluation), bedrock groundwater (OU-4) and surface water and sediment.

1.1 Background

The Davis Liquid Waste Superfund Site (the Site), a former waste disposal facility, is located between Tarkiln Road and Log Road in the northwestern corner of the Town of Smithfield, Providence County, Rhode Island (Figure 1.1). The 7-acre Former Source Area (FSA) is defined as the area where past disposal and releases of hazardous substances originally occurred and is bounded approximately by the excavation footprint of the source control remedial action initiated in 1999 and completed in 2001 (Figure 1.2). The Site is bounded on the east and west by forested uplands and on the north and south by wetlands and swamp areas of the Nipsachuck Swamp.

A large portion of the Site is located on Lot 9, Plat 50 of the Town of Smithfield Tax Assessor's maps (Figure 1.2). Additionally, a portion of the Site is located on the abutting parcel, Lot 29, Plat 50. Access to the Site is from Tarkiln Road on an unpaved roadway/easement west of the Site and a right-of-way to Log Road located north of the Site (Smithfield, 2006; Smithfield, 2008a). The Site consists of primarily undeveloped land that is vegetated by shrubs, trees, and wetlands flora.

The Site was reportedly used for a 5-year period in the 1960s and the early 1970s for the disposal of municipal solid wastes by the Town of Smithfield, RI. Between 1976 and 1977, the owner, William Davis, used the Site to dispose of liquid and solid wastes containing hazardous substances. Wastes were disposed of by direct discharge from tank trucks into unlined lagoons and seepage pits. Drums containing chemicals and laboratory containers were buried onsite or were crushed. Wastes and contaminated soil were reportedly excavated from the lagoons and pits and were dumped at several on-site locations and covered with soil. Construction debris was also reportedly burned at the Site.

The Site is situated adjacent to the Nipsachuck Swamp, which constitutes the headwaters of Latham Brook. The Brook drains into the Stillwater Reservoir (not a drinking water supply) and the Woonasquatucket River, and eventually into Narragansett Bay. Much of the Site is located within a 100-year flood zone. Land within a 1-mile radius of the Site is primarily semi-rural, with some low-density residential dwellings situated nearby.

1.2 Pre-Design Investigation

For the purposes of this work plan, the Pre-Design Investigation will refer to the tasks required to support the design of the active treatment component of the OU-2 remedy (Plume Core Evaluation, Treated Backfill Evaluation and Bench and Pilot Testing Evaluation). The other field programs that will be described herein include the following:

- Groundwater Evaluation
  - Residential Well Monitoring (Sentry Wells)
  - Groundwater Monitoring (including additional monitoring wells)
  - Vapor Intrusion Assessment (deferred)
- Fate and Transport and Natural Attenuation Evaluation
- Surface Water and Sediment Evaluation

1.3 Purpose and Objectives

The purpose and objectives for the PDI tasks were detailed in the SOW and are reiterated in the following sections to provide the basis for the detailed scopes of work provided in subsequent sections of the plan. The decision making processes are also reiterated in the subsequent sections and are provided in greater detail within the Remedial Design Work Plan (RDWP).

1.3.1 Pre-Design Investigation

The PDI includes the Plume Core Evaluation, the Treated Backfill Evaluation and the Bench and Pilot Testing Programs. The data and information generated under these tasks will be used to develop the design for the active treatment component of the OU-2 remedy.

1.3.1.1 Plume Core Evaluation

The goal of this evaluation is to characterize the type and extent of contaminants (both soil and groundwater) that are underlying the approximate boundary of the FSA. This evaluation will provide better estimates of the contaminant mass to be addressed during remediation, the distribution of the mass within various stratigraphic layers and will collect data for other parameters that may affect in-situ treatment or reagent injection and distribution. Information developed will also be used to support the design of the bench scale testing program and the design of the active treatment program of the OU-2 remedy.

1.3.1.2 Treated Backfill Evaluation

The goal of this evaluation is to collect information to better assess whether previously treated backfill within the FSA contains residual contaminants that may pose continued threats to groundwater quality or to human health or the environment. A decision making process for evaluation of the data generated during this PDI task was presented in the RDWP.

1.3.1.3 Bench and Pilot Testing Evaluation

The goal of this evaluation is to collect the appropriate bench and field information (site-specific geochemical, biological, etc.) to design a remedy (in-situ chemical reduction (ISCR) and enhanced bioremediation) for the Active Treatment Zone as identified in the 2010 ROD Amendment. This task will directly utilize data and information generated during the performance of Plume Core Evaluation and the Treated Backfill Evaluation.

1.3.2 Groundwater Investigation

The goal of this evaluation is to establish a groundwater monitoring program that will be used to assess the status of the overburden and bedrock plumes prior to, during, and after remediation, and to assess the potential for off-Site groundwater impacts. Information and data developed under this investigation will be used in the formulation and refinement of the Long-Term Monitoring Plan, as appropriate. Information generated during the performance of this task will also be used in the development of the Institutional Controls Plan. Included within the Groundwater Investigation are the following tasks:

- Groundwater Monitoring (including the installation of additional monitoring wells)
- Residential Well Monitoring
- Vapor Intrusion Assessment

1.3.3 Fate and Transport and Natural Attenuation Investigation

The goal of this investigation is to assess the fate and transport of impacts and natural attenuation processes in the bedrock plume throughout the Site. A strategy and monitoring program will be developed to demonstrate whether natural attenuation is occurring at a sufficient rate to merit selection of Monitored Natural Attenuation (MNA) as the remedial action for the bedrock plume and to monitor the performance of the selected MNA remedy for the untreated portions of the overburden plume.

1.3.4 Surface Water and Sediment Investigation

The goal of this evaluation is to assess potential impacts associated with historic Site activities and the potential for ongoing discharges of contaminated groundwater from the FSA into the adjacent wetlands and Latham Brook. The various types of wetland areas located proximal to the FSA and within the overburden plume will be characterized to support the selection of surface

water and sediment sampling locations. Information and data developed under this evaluation will also be used in the formulation of the Long-Term Monitoring Plan, as appropriate.

2.0 CONCEPTUAL SITE MODEL

2.1 Physical Setting

The Site is located in the Latham Brook watershed that is a sub-basin of the Woonasquatucket River watershed. Nipsachuck Swamp is located in the headwaters of the Latham Brook basin. The location of the Site is shown on Figure 1.1 and the Nipsachuck Swamp and Latham Brook drainage basin is presented on Figure 2.1. The general flow directions of surface water and shallow groundwater within the basin are from the south, west, and north towards the wetland and bog areas in the central portions of the basin that comprise the Nipsachuck Swamp. The basin outlet is Latham Brook located east of the Site, which flows generally southeast and eventually into Stillwater Reservoir.

The aerial photograph on Figure 2.2 shows the surface features at the Site and surrounding areas. The Site is located in the southwest quadrant in the figure with an approximate size of 15 acres. The major contaminant source areas, South Disposal Area (SDA) and North Disposal Area (NDA), and the source remediation area, which were delineated by the previous investigators, are part of the Site. North and east of the Site, there are three areas of swamps or wetlands (Figure 2.2): open waters, Latham Brook and wetland vegetation.

The topographic map (Figure 2.1) shows that the study area is bounded by the north-south trending hills to the west and to the east. In between, the ground surface is fairly flat, ranging from an elevation of 404 to 410 feet above mean sea level (MSL). The upland ridges to the west, north, and south of the study area crest at elevations of up to 480 ft MSL. The basin outlet (Latham Brook) is through a small topographically low valley. The surface elevation drops from 400 ft to 370 ft in a short distance to the east/southeast of the basin outlet.

Latham Brook and a small tributary that originates from the east of the FSA provide surface water drainage for the basin. About 200 feet east of their junction where monitoring wells OW-024, OW-025, and OW-086 are located, the stream makes a steep drop with a change of elevation of approximately 10 feet in a distance of 60 feet. At this point the ground elevation is approximately 383 feet MSL, or approximately 20 feet below the surface of much of the Site. About 1,600 feet further east as the brook crosses under Bayberry Road, the elevation decreases by an additional 28 feet. Latham Brook enters Stillwater Reservoir, which is 1.5 miles southeast of the Site at an elevation of approximately 210 feet MSL (Figure 2.1).

There are no public water supply wells located in the Site's vicinity. The Town of Smithfield's public water supply is purchased through the Providence Water Supply Board (Smithfield, 2007). The majority of the homes located near the Site are provided municipal water through a public water system extension that was installed as part of the remedial actions for the Site.

2.2 Geologic Framework

The stratigraphy of the study area consists of approximately 10 to 40 ft of overburden materials overlying bedrock. The geology of the Site and study area is discussed below.

2.2.1 Overburden

The overburden lithology at the Site primarily consists of sandy ground moraine deposits (Pleistocene-Wisconsin in age) and local swamp deposits (Holocene in age (CDM, 1986; ESS, 2004). Ground moraine deposits generally consist of an upper till layer comprised of loose medium to coarse sands and gravels, and a lower till of compacted clayey sands. The thickness of the overburden deposits is highly variable across the Site and ranges from 8 to 37 feet.

In the FSA, where excavation has occurred, treated backfill material consisting of screened and treated soils was emplaced under 6 inches of topsoil. Beneath the treated backfill (at an elevation of 409.6 feet MSL) is five feet of clean fill and material that was screened out of the previously treated soils. Underlying the treated backfill and the clean fill / screened material are the Plume Core saturated soils. Figure 2.3 presents a conceptual schematic of the FSA.

The central portion of the study area, in the immediate vicinity of and downgradient of the FSA, is dominated by wetland and bog areas, which are part of the Nipsachuck Swamp. These wetlands extend to the north of the study area across Log Road (Figure 2.1). Based on the finding of the numerous previous investigations, organic peat deposits appear to be present underlying and immediately adjacent to these wetland areas. The peat deposits range in thickness from approximately 1 to 10 ft. The peat deposits always overlay the glacial deposits (fine-grained silts and fine sands and the sandy ground moraine deposits).The lower, more compact and less permeable, glacial till deposits are rarely observed and, where observed, occur directly above the bedrock surface (ESS, 2004).

2.2.2 Bedrock

The overburden materials at the Site are primarily underlain by two metamorphic bedrock formations: Nipsachuck Gneiss and Absalona Formation. The Nipsachuck Gneiss (Pre-Cambrian in age) is the primary rock type underlying the Site. It is characterized as a gray, very hard, medium to coarse grained equigranular gneiss with light, 70-75 degree foliation, and composed primarily of quartz, feldspar (albite and microperthite), and biotite. The Absalona Formation is also Pre-Cambrian in age and is characterized as a porphyroblastic biotite gneiss. The Absalona Formation is primarily located in the southeast quadrant of the Site (ESS, 2004).

An intrusive diorite dike (Triassic in age), trending north-south and extending north to Log Road, occurs in the northeast and southeast quadrants of the Site. The approximate location of the dike is illustrated in Figure 2.1. The dike is characterized as a black, green, and white, hard, medium grained equigranular diorite or ophitic texture and composed primarily of feldspar (albite), biotite, and chlorite (ESS, 2004). The dike is located in the general area of the basin outlet at Latham Brook and is characterized as a low-hydraulic conductivity feature (1×10^{-5} to 1×10^{-9} cm/sec;

CDM, 1986; ESS, 2004), which is believed to have strong influences on groundwater flow conditions in both the overburden and bedrock (URS, 2006).

Depth to bedrock is highly variable across the Site, ranging from 8 to 37 ft below ground surface (bgs). Bedrock structural surface topography generally slopes from the flanking (surrounding) upland areas towards the central portion of the Site before becoming relatively level in the wetland and bog areas. The core of the uplands located east and west of the Site is bedrock. The bedrock surface contours are illustrated in Figure 2.4 (ESS, 2004).

Evidence of weathered bedrock is documented as being highly variable at the Site. The upper 10 to 30 feet of bedrock is fractured or severely weathered (URS, 2006). Moderately weathered bedrock often exhibited weathering effects such as slight mineral discoloration, interbedded sand lenses, and a significant loss of strength as compared to fresh rock (ESS, 2004). Severely weathered bedrock was reduced in strength to a strong soil, where the rock "fabric" remained clear and evident. Completely weathered bedrock was reduced in effect to a soil where the rock "fabric" was discernible only in isolated locations.

Bedrock fractures observed in the vicinity of the Site during drilling activities appear to exhibit a north-south striking trend while dipping to the east and west. Measurements conducted on outcrops of the Nipsachuck Formation (granitic gneiss) to the west of the Site exhibit fractures dipping to the east at approximately 20 to 30° (Richmond, 1952). As in most bedrock settings, groundwater flow within the crystalline rock is inferred to be primarily transmitted via various types of discontinuities (e.g., fractures, joints, bedding planes, etc.) as well as being driven by local and regional hydraulic gradients (ESS, 2004).

To date, no borehole geophysical investigations have been performed in the study area. Therefore, information is limited with respect to the bedrock fracture network such as schistosity/foliation patterns, spatial distribution of fractures and connectivity of the fractures between the FSA and downgradient areas.

2.3 Hydrogeologic Framework

The overburden and bedrock water-bearing zone characteristics are presented below. Groundwater underlying the Site and adjacent areas has been classified as GA, which are known or presumed to be suitable for drinking water use without treatment. However elevated concentrations of iron, manganese and arsenic have been observed regionally which could make it unsuitable in some locations for use without treatment.

2.3.1 Surface Water Hydrology

The Site is located within the Latham Brook watershed, which is a subbasin of the Woonasquatucket River Basin (Figure 2.1). The Nipsachuck Swamp, located in the central portion of the Site, represents the headwaters of Latham Brook, which drains into the Woonasquatucket River and eventually into Narragansett Bay at Providence. Annual precipitation in the area ranges between 42 and 46 inches based on climatic data from nearby monitoring stations (ESS, 2004; URS, 2006).

2.3.1.1 Wetland

The Nipsachuck Swamp and associated areas surrounding the Site are primarily classified as Palustrine (ecological system), forested (class), and broad-leaved deciduous (subclass) wetlands (CDM, 1986). Deposits within the swamp consist of peat, silt, and clay as demonstrated in the boring logs for OW-102-O, and OW-44 through OW-47. The swamp deposits are characterized as having a high porosity and low permeability, which allows for large storage of groundwater but functions poorly for lateral and/or vertical transport of groundwater and contaminants (CDM, 1986). As a result of these conditions, the wetlands provide a large area for flood water detention, groundwater discharge, and evapotranspiration (ET) (URS, 2006). Additionally, the wetlands at the Site play an important role in the natural attenuation of contaminated groundwater by providing anaerobic, reducing, and oxygen depleted conditions favorable to reductive dechlorination.

2.3.1.2 Latham Brook

Latham Brook is the surface water outlet for the basin (Figure 2.1). Latham Brook receives water from surface runoff, direct discharge from groundwater, and direct discharge from wetland water. Stream flow calculations performed by CDM (1986) estimate monthly flow rates ranging from 5.0×10^5 ft^3/month (83 gallons per minute [gpm]) in October to 1.5×10^6 ft^3/month (278 gpm) in February at the upstream weir of the brook. Minimum base flow has been estimated to be 50 to 70 gpm (URS, 2006). ESS conducted stream flow measurements in Latham Brook on May 24, 2006 near well couplet OW-24/OW-25 and estimated flows ranging from 2.8 to 4.65 cubic feet per second (cfs) or 1257 to 2073 gpm. Compared to CDM's estimates, these stream flow rates may represent a relatively high flow conditions (URS, 2006).

2.3.2 Groundwater Flow

Groundwater beneath the study area is shallow, varying from 0 to 10 feet below ground surface. Seasonal groundwater level fluctuation varies from 2 to 5 feet (CDM, 1986).

2.3.2.1 Overburden and Bedrock

Figures 2.5 and 2.6 (ESS, 2009) depict potentiometric surface maps for overburden and bedrock, respectively for the October 31, 2008 measurement event. Both maps are consistent with historical representations of groundwater flow conditions as presented in RI report (CDM, 1986) and Pre-Design Engineering Report II (WCC, 1993). Groundwater flow in the region is generally controlled by topography and influenced by geologic structure as it flows from the surrounding till and bedrock upland areas north, south, and west of the Site towards the topographically low wetlands and basin outlet at Latham Brook (URS, 2006).

Overburden groundwater flow originates from upland areas in the west, south, and southeast and converges towards the central portions of the Site (Nipsachuck Swamp) before discharging through the area where Latham Brook exits the Site. Groundwater flow in the vicinity of the former disposal areas is generally towards the northeast into the wetland and

bog areas. The majority of groundwater flow within the overburden passes through the relatively narrow till and bedrock uplands on the eastern portion of the Site (Figure 2.5). It is conceptualized that the overburden groundwater flows over the top of the diorite dike in a fashion similar to a weir. This weir effect causes upgradient overburden groundwater to pool on the west side of the dike creating a low gradient (flat) potentiometric surface.

Bedrock groundwater flow mimics overburden flow as it converges towards the wetlands and central portions of the basin from the surrounding uplands (Figure 2.6). Historical bedrock groundwater elevation data consistently demonstrates that shallow bedrock flow is predominately from the eastern, southern and western upland areas, flows towards the central basin and then flows in a northern direction perpendicular to the diorite dike area (ESS, 2007) before turning east and flowing through the Latham Brook basin outlet.

2.3.2.2 Gradients

Both the overburden and bedrock groundwater elevation data exhibit relatively flat horizontal gradients with respect to the surrounding upland areas as groundwater flow crosses the basin before discharging to Latham Brook. The horizontal gradient crossing the central portion of the study area is approximately 0.0008 ft/ft as groundwater elevations essentially approximates the water surface of the swamp. In areas upgradient and downgradient of the diorite dike south of Log Road, horizontal gradients for both the overburden and bedrock groundwater steepen significantly to approximately 0.002 ft/ft before increasing to approximately 0.01 ft/ft as groundwater flow crosses the dike. Due to the dike's low hydraulic conductivity and permeability relative to the surrounding granitic gneiss (Nipsachuck Formation), the dike essentially retards flow coming from the west and creates a "backwater effect" in the bedrock. This is evident in the flattening out of the potentiometric contours for both the overburden and bedrock to the west of the dike (CDM, 1986; URS, 2006; ESS, 2007).

2.3.2.3 Vertical Flow

Vertical hydraulic gradients between the overburden and bedrock (used to indicate the upward or downward movement of groundwater) at the Site are variable and reversible, depending on the season. In general, upward vertical gradients are observed in the central study area, which are typically indicative of groundwater discharge areas, such as surface water bodies and wetlands (URS, 2006). Downward vertical gradients are typically indicative of groundwater recharge areas, such as upland areas. The seasonal variations occur in areas where vertical gradient is not strong, thus it is influenced by groundwater recharge or groundwater ET.

A downward vertical component of groundwater flow is observed in the upland wells (typically wells OW95-O/R, OW-96-O/R, OW-105-O/R, and OW-83/OW-84) and is consistent with the nature of these areas as recharge zones (URS, 2006). Upward vertical gradients are predominant within the FSA. An upward vertical component of groundwater flow is also observed in the Northeast Quadrant of the study area (typically wells OW-38/OW-36, OW-

21/OW-110-R, OW-08/OW-07, and OW24/OW-25). These well nests are located near Latham Brook in the central-east portion of the basin, and the upward vertical gradients are consistent with the nature of this area as a discharge zone. Well nest OW-24/OW-25/OW-86 is located in the topographically low valley and the vertical gradient is upward, indicating that groundwater discharges upward to Latham Brook. In the center of the basin (in and near the FSA), vertical gradients are slightly upward with some seasonal variations, meaning that groundwater flow is primarily horizontal with minor upward gradients in these areas (ESS, 2004; URS, 2006). This is consistent with the nature of the flow pattern in which groundwater converges from west, south, and east toward the central area.

Groundwater elevation data from deep bedrock wells indicate an upward vertical gradient from the deep bedrock to the shallow bedrock. This observation is evident in well couplets located upgradient of the FSA (OW-81/OW-82), downgradient of the FSA (OW-80/OW-111-R) and on the east side of the diorite dike (OW-25/OW-86). The upward hydraulic gradient in these areas suggests bedrock groundwater is discharging into Latham Brook (URS, 2006) and into the overburden.

2.3.2.4 Recharge

Recharge to groundwater is predominately from direct infiltration of precipitation and from surface runoff over till-covered hills. During storm events, the flooding wetland may also recharge the groundwater beneath for a short time. Groundwater recharge was estimated by CDM (1986) as 32 inches of the 46 inches of annual precipitation. This estimate appears to be high and it is anticipated that groundwater recharge values closer to approximately 20 inches per year would be more realistic, particularly assuming that ET water losses probably approximate 50% of the annual precipitation.

2.3.2.5 Discharge

Groundwater discharge within the Site area is primarily through ET and to surface water bodies. In the areas where the water table is at or within a few feet of the land surface, ET occurs directly from the groundwater table (URS, 2006). Groundwater also discharges to wetlands, as groundwater converges to the central wetland area. Some of the wetland water discharges to the discrete channels of Latham Brook. East of the wetlands, groundwater directly discharges to Latham Brook along the course of the channel as evidenced by the strong upward gradients observed at well clusters. Groundwater flow out of the basin is predominantly through the narrow valley along Latham Brook. From this point of view, the groundwater basin where the Site is located may be considered as a closed basin (URS, 2006).

2.3.3 Aquifer Properties

2.3.3.1 Overburden

Hydraulic conductivities for unconsolidated sediments at the Site have been estimated to be between 0.5 ft/day and 510 ft/day, which are consistent with published values for well-sorted

sands associated with glacial outwash deposits (CDM, 1986; WCC, 1993; and ESS, 2004). Using a representative average site-wide overburden hydraulic conductivity of 28.35 ft/day (1 x 10-2 cm/sec), a hydraulic gradient of 0.002 feet/foot (as measured across the central portion of the Site downgradient of the former disposal areas), and a literature value for porosity of 0.2 (Fetter, 2001), an average linear groundwater velocity of approximately 0.3 ft/day (110 feet/year) was calculated for the overburden (ESS, 2004).

2.3.3.2 Bedrock

Based on the aquifer tests data compiled and analyzed by CDM (1986) and WCC (1993), hydraulic conductivities for the Nipsachuck Gneiss are estimated to range from 2.8×10^{-6} ft/day at OW-82 to 28 ft/day at OW-94-R. The hydraulic conductivity of the diorite dike ranges from 2.8×10^{-6} to 2.8×10^{-2} ft/day (CDM, 1986; ESS, 2004).

Because of heterogeneities associated with bedrock hydraulic conductivity and porosity as a result of fracturing and weathering, it is difficult to calculate a representative groundwater velocity with a level of certainty. Average linear velocity calculations for bedrock would require the assumption of isotropic conditions throughout the bedrock and thus, would not account for flow within transmissive bedrock fractures (where detailed data are unavailable) and may misrepresent actual conditions. However, groundwater velocity within bedrock is expected to be significantly lower than groundwater flow within the overburden based on initial comparisons of estimated hydraulic conductivities (ESS, 2004).

Weathered bedrock was observed at various boring locations across the Site, particularly in the eastern portion of the study area. The weathering in these zones may allow vertical flow of groundwater from the overlying unconsolidated deposits into the bedrock or vice versa (URS, 2006). In some areas, weathered bedrock may exhibit lower hydraulic conductivities due to the presence of silts and clays derived in place during the weathering process, and may limit vertical flow of groundwater (ESS, 2004).

2.4 Nature and Extent of Soil Contamination

This section presents the current understanding of the nature and extent of soil VOCs contamination remaining at the Site following the remedial action activities completed in 2001.

2.4.1 Former Source Area

The FSA is defined as the area where past disposal and releases of hazardous substances occurred prior to the remedial action activities. The approximate boundary of the FSA is depicted on Figure 2.7. General categories of wastes believed to have been disposed of at the Site reportedly include: sludge (paint pigments and metals), solvents (halogenated and non-halogenated), inks, laboratory pharmaceuticals, manufacturing residues and miscellaneous chemical processing wastes (acids, caustics, pesticides, phenols, halogens, and metals), solids (fly ash and metals), municipal solid waste, tires, and waste oils (CDM, 1986). Disposal of these materials occurred via direct discharge of waste from tank trucks and drums into unlined lagoons (referred to as the NDA and SDA), direct burial of drums and smaller containers, and/or burial of

solid waste materials. Information regarding the approximate volumes of liquid wastes disposed of is not available. During remedial activities, between 1,400 and 2,200 drums or drum parts, 15,000 miscellaneous laboratory containers, 20,000 tons of contaminated soil, and 6.4 million tires were excavated and/or removed from the property for off-site disposal. Additionally, approximately 78,000 tons of contaminated soil was excavated and treated at the Site, and replaced as excavation backfill (LEA, 2001).

2.4.2 Conceptual Contaminant Releases

It is conceptualized that the liquid wastes disposed of either via direct discharge or via drum/container burial and subsequent crushing, migrated vertically through the vadose zone to the water table. It is further conceptualized that as the waste migrated through the vadose zone, contaminants were adsorbed to soil particles. At the water table, the majority of liquid waste material spread laterally and those materials that are denser than water continued to migrate vertically through the saturated zone while continually sorbing to soil particles (most likely fine grain material such as silt/clay and highly organic material such as peat) and dissolving into overburden groundwater. Lighter materials remained at or near the water table, migrating vertically with seasonal fluxes in the groundwater surface elevation. This migration likely caused a "smear-zone" of contaminants sorbed onto soils at or near the capillary fringe. Precipitation migrating through the vadose zone interacted with contaminated solid wastes and impacted soil. As the precipitation percolated through the soil and solid waste, it dissolved sorbed contaminants and entered groundwater as recharge, creating a dissolved phase groundwater contaminant plume. Because the top of the bedrock is weathered and highly fractured near the bedrock overburden contact, non-aqueous phase contaminants may have entered into the bedrock unit. The above conceptualization was adapted from Nobis Engineering, Inc. (Nobis) Site Conceptual Model report dated February 2009 (Nobis, 2009a) with some interpretation added based on our understanding of the Site conditions.

2.4.3 Soil Contamination - VOCs

The overburden at the Site can be separated into three categories: 1) unexcavated unsaturated soil; 2) treated unsaturated soil backfill; and 3) saturated unexcavated/untreated soil. A cross-sectional view through the FSA illustrating the soil categories after the completion of the soil excavation/treatment program are depicted in Figure 2.8. The potential impact to these soils based on an evaluation of soil samples collected prior to and after the completion of the soil remediation activities was conducted by Nobis and the results of the evaluation presented in the report titled "Technical Memorandum for Conceptual Site Model" dated February 2009 (Nobis, 2009a) and Conceptual Site Model Technical Memorandum Addendum dated November 2009 (Nobis, 2009b). Discussed below is a synopsis of Nobis' findings.

2.4.3.1 Unexcavated Unsaturated Soil

Evaluation of unexcavated unsaturated soil data indicates only a limited presence of VOCs. Only methylene chloride (21 samples) and PCE (1 sample) were detected at concentrations in excess of the RIDEM GA Leachability Criteria values. Methylene chloride may be a laboratory

contaminant and is only present at very low concentrations (Nobis, 2009a). PCE was detected at 0.54 mg/Kg in one post-excavation, sidewall sample collected from the southern extent of the SDA at an approximate elevation of 406 ft MSL. If the methylene chloride is a laboratory contaminant and based on only one PCE concentration above the RIDEM Leachability Criteria, it is reasonable to conclude that the soil outside of the source control excavation footprint is unlikely to be considered a continuing source of groundwater contamination (Nobis, 2009a). According to Nobis (2009a), soils in this category do not appear to represent a threat to groundwater quality.

2.4.3.2 Treated Unsaturated Soil Backfill

Unsaturated contaminated soil excavated from the SDA and NDA and surrounding areas was treated using low-temperature thermal desorption. After treatment was completed, several samples of the treated soil were collected to determine compliance with the ROD treatment goals [less than 2 milligrams per kilogram (mg/kg) of total VOCs]. If sample results confirmed that the treatment goal was met, the soil was staged for use as excavation backfill; otherwise, non-compliant soil was either retreated or staged for off-site disposal. Approximately 350 soil samples were collected from the treated soil. Of these samples, a random population of 73 samples was selected by Nobis for statistical evaluation (40 from the western treatment room and 33 from the eastern treatment room).

Evaluation of unsaturated treated backfilled soil data indicates total VOCs are present at concentrations up to 2 mg/kg. Concentrations of individual VOCs were found to exceed their respective RIDEM GA Leachability Criteria values and EPA Soil Screening Levels. Although methylene chloride was detected in these soil samples, it may be a laboratory contaminant. Nobis (2009a) estimated a mass of 86 pounds (lbs) (39 kg) of total VOCs could be sorbed to the treated backfilled soil within the FSA.

According to Nobis (2009a), it appears, based on their soil data evaluation, that the contaminant mass associated with the treated soil used as backfill may be a continuing source of VOCs to groundwater at the Site. However, it is our belief that the treated backfill is not a significant continuing source of VOCs to groundwater and leaching from these soils will not significantly impact the VOC concentrations in the underlying groundwater or the longevity of the overburden plume based on preliminary leaching analysis that was performed during the SOW negotiations.

2.4.3.3 Saturated Unexcavated/Untreated Soil

Evaluation of unexcavated saturated soil was performed on soil samples collected during the Phase 4 investigation conducted in Fall 2008. The soil samples were collected from the saturated soils underlying the foot print of the FSA. The Phase 4 investigation soil analytical results were evaluated to assess whether unexcavated soil in the saturated zone underlying the FSA represented a continuing source of groundwater contamination. The location of the soil borings and a cross-section view of the FSA presenting the results of the field headspace

measurements and soil analytical data are presented in Figures 2.9, 2.10, 2.11, and 2.12, respectively.

Nobis (2009b) compared the soil analytical results to several soil leaching criteria to help identify chemicals that pose potential threats to groundwater quality. These criteria include the EPA's April 2009 Regional Screening Levels (RSLs) (EPA, 2009), the Rhode Island Department of Environmental Management (RIDEM)'s Rules and Regulations for the Investigation, and Remediation of Hazardous Materials Releases (or Remediation Regulations) GA Leachability Criteria (RIDEM GA LC) (RIDEM, 1996).

Seventy-nine soil samples were collected from depths that ranged between 5 and 38 ft below grade. VOCs were detected above reporting limits at depths ranging between 6 and 30 ft below grade. Of these samples, all but three samples were collected from below the water table. Ten VOCs exceeded the leaching screening values, which suggest that these VOCs are present in soil at concentrations that could result in groundwater concentrations that exceed MCLs, the RIDEM Remediation Regulations GA Groundwater Objectives (RIDEM GA Objectives), or exceed risk-based concentrations that are protective of human health (Nobis, 2009b). The ten COCs are: 1,1,-DCA, 1,2,4-trichlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, cis,1-2-DCE, ethylbenzene, PCE, TCE, vinyl chloride and xylenes.

Soil with VOC concentrations exceeding the leaching screening criteria were identified throughout the FSA. Some detections corresponded with past identified disposal areas (i.e., SDA, NDA, Drum Disposal Area).

Nobis (2009b) estimated that the saturated soil in the FSA contain an estimated 123 pounds (lbs) (56 kg) of total COCs mass and 521 lbs (237 kg) of total VOCs mass.

ESS also developed an estimation of residual total VOC mass in the FSA. The estimate was based on the Phase 4 investigation data. The results of the VOC mass evaluation estimated that approximately 315 lbs (143 kg) of CVOC and 805 lbs (366 kg) of total VOC mass remains in the unconsolidated deposits within the FSA (ESS, 2009). In summary, the total VOC mass estimates developed by Nobis and ESS range from 521 lbs to 805 lbs.

According to Nobis' (2009b) evaluation of the Phase 4 investigation data, it appears that the VOC mass located in saturated soil below the previous remedial excavation contains contaminant mass that could be a continuing source of groundwater contamination at the Site.

2.5 DNAPL

Past disposal history (i.e., direct discharge to ground, burial of drums, etc.) and the types chemicals released (i.e., spent chlorinated solvents, paints, inks, industrial chemicals), and relatively shallow depth to the water table, suggest that DNAPLs could be present at the Site. However, the 2008 soil investigation field tests (hydrophobic dye screening of soil samples) within the FSA detected only the possible presence of a Non-Aqueous Phase Liquid (NAPL) in one soil sample, which could not be

confirmed as a DNAPL by laboratory analytical results. Review of soil and groundwater data collected from the FSA is inconclusive regarding the potential presence of DNAPLs (Nobis, 2009b).

Within the southeastern portion of the FSA, there appears to be a sorbed VOC mass present (Nobis, 2009b), which may possibly be DNAPL, either in the soil and/or in the aquifer that causes the persistent, elevated groundwater VOC concentrations. However, the detected groundwater concentrations are not indicative of DNAPL presence, as the detected concentrations were well below the 1 percent of the pure solubility value used to assess the potential for DNAPL presence. No direct evidence of DNAPL in the bedrock has been observed in the FSA.

2.6 Nature and Extent of Groundwater Contamination

The section describes the current nature and extent of groundwater impacts in the overburden and bedrock aquifers. The Phase 4 investigation groundwater analytical results are the primary source of data for this discussion. The discussion is separated into overburden deposits and bedrock and utilizes the analytical results of the most recent historic sampling events (i.e., recent Phase 1, Phase 2, and Phase 3 sampling, and the 1991 sampling performed by Woodward-Clyde) for comparison to the Phase 4 investigation data collected in Fall 2008 (ESS, 2002, 2004, 2005, 2006, and Woodward-Clyde, 1993). The groundwater data were compared against the RIDEM GA Groundwater Quality Standards to identify the extent of VOCs present in the overburden and bedrock aquifers that exceed potential regulatory criteria.

The following sections discuss the groundwater VOC analytical results for the Fall 2008 monitoring event.

2.6.1 Overburden

During the Phase 4 investigation, groundwater samples were collected from 24 monitoring wells completed within the overburden deposits within the study area. Table 2.1 summarizes the compounds detected in the overburden during the Fall 2008 monitoring event as well as the previous Phase 1, Phase 2 and Phase 3 sampling events (ESS, 2002, 2004, 2005, and 2006), and the 1991 sampling event (Woodward-Clyde, 1993). Figure 2.13 presents an isoconcentration map of the total volatile organic compounds (TVOC) detected in the existing overburden deposit monitoring wells during the Fall 2008 monitoring event. Figures 2.14 and 2.15 present isoconcentration maps of the detected TCE and PCE concentrations in the unconsolidated deposit monitoring wells. An isoconcentration map is not provided for benzene for the overburden deposit monitoring wells since it was not detected in these wells at concentrations exceeding the RIDEM GA Groundwater Quality Standard of 5 micrograms per liter (ug/L).

Review of the data provides the following key observations:

- Consistent with the recent groundwater sampling results, the highest TVOC concentrations were detected in the vicinity of and immediately downgradient from the former disposal areas.

- Consistent with the recent groundwater sampling results, target VOC (TCE and PCE) concentrations in exceedance of Site criteria remain limited to the immediate vicinity of and immediately downgradient from the FSA.
- Elevated concentrations of daughter product VOCs (1,1 DCA, cis-1,2-DCE and vinyl chloride) relative to parent product VOCs (1,1,1-TCA, PCE and TCE) at overburden monitoring wells continue to provide compelling evidence of ongoing biodegradation processes in both FSA and downgradient monitoring wells.
- Based on a review of the historic analytical results and the results of the recent sampling events (2002 through 2008), it appears that the VOC plume in the overburden deposits is stable (ESS, 2009). This is visually depicted in Figure 2.16 which presents an overlay of the TVOC isoconcentration contours from the Phase 2, Phase 3 and Phase 4 sampling events.
- The nature and extent of the impacted groundwater within the overburden deposits continues to be well defined by the existing monitoring well network over the majority of the Site. The extent of VOC impacts within the overburden deposits is consistent with the current understanding of groundwater flow paths and hydrogeology at the Site and the representation of Site fate and transport characteristics as presented in the Draft Groundwater Fate and Transport Modeling report (URS, 2006). Thus, the existing monitoring well network is sufficient to support the Conceptual Site Model and to continue to monitor groundwater conditions at the Site.

2.6.2 Bedrock

During the Phase 4 investigation, groundwater samples were collected from 19 monitoring wells completed in the bedrock within the study area. Table 2.2 summarizes the compounds detected in the bedrock during the Fall 2008 monitoring event as well as the previous Phase 1, Phase 2 and Phase 3 sampling events (ESS, 2002, 2004, 2005, and 2006), and the 1991 sampling event (Woodward-Clyde, 1993). Figure 2.17 presents an isoconcentration map of the TVOC concentrations detected in the bedrock monitoring wells during the Fall 2008 monitoring event. Figures 2.18 and 2.19 present isoconcentration maps of the detected TCE and PCE concentrations, respectively, in the bedrock monitoring wells.

Review of the data provides the following key observations:

- The highest TVOC concentrations detected in the Fall 2008 monitoring event were located within the former disposal areas (OW-94-R) and in the vicinity of the wetland areas located to the north of the Northern Disposal Area (monitoring well locations OW-101-R, OW-41 and OW-112-R). This is consistent with the results of the previous Phase 2 and Phase 3 sampling events.
- The TCE isoconcentration map (Figure 2.18) shows two areas of elevated TCE concentrations, one located in the immediate vicinity of the former Southern Disposal Area at OW-94-R and the other located in the area of monitoring well OW-112-R and extending hydraulically downgradient of this area to wells OW-33 and OW-36.

- The PCE isoconcentration map (Figure 2.19) shows that the highest detected concentration of PCE occurred within the FSA at OW-94-R, adjacent to the wetland area to the north of the FSA at OW-112-R and hydraulically downgradient of this area at monitoring wells OW-33 and OW-36. The PCE isoconcentration map is similar to the TCE isoconcentration map.
- Elevated concentrations of daughter product VOCs (1,1 DCA, cis-1,2-DCE and vinyl chloride) relative to parent product VOCs (1,1,1-TCA, PCE and TCE) at bedrock monitoring wells continue to provide compelling evidence of ongoing biodegradation processes.
- Based on a review of the historic analytical results and the results of the recent sampling events, it appears that the VOC plume in the bedrock is stable. This is visually depicted in Figure 2.20 which presents an overlay of the TVOC isoconcentration contours from the Phase 2 and Phase 3 sampling events.
- The nature and extent of the impacted groundwater within the bedrock deposits continues to be well defined by the existing monitoring well network over the majority of the Site. The extent of VOC impacts within the bedrock is consistent with the current understanding of groundwater flow paths and hydrogeology at the Site and the representation of Site fate and transport characteristics as presented in the Draft Groundwater Fate and Transport Modeling report. Thus, the existing monitoring well network is sufficient to support the Conceptual Site Model and to continue to monitor groundwater conditions at the Site.

2.7 Natural Attenuation and Geochemical Conditions

The Phase 4 investigation Fall 2008 groundwater sampling event included the analysis of groundwater samples from select monitoring wells for monitored natural attenuation (MNA) geochemical parameters including chloride, sulfate, iron, manganese, sulfide, nitrate, nitrite, alkalinity, total organic carbon, and dissolved gases (ethene, ethane, methane, hydrogen). Field parameters (DO and ORP) were also monitored during the collection of the groundwater samples and are utilized in evaluating the geochemical setting and capacity for reductive dechlorination. The MNA data collected during the Fall 2008 sampling event is summarized in the Phase 4 Supplemental Field Investigation Report, Appendix K (ESS, 2009). The field parameters are summarized on Table 2.3. Based on a review performed by ESS (2009) of the recent and historic analytical data, it is readily apparent that the chlorinated ethenes are the predominant VOCs at the Site.

The results of the VOC and geochemical parameter analysis of groundwater samples continue to provide compelling evidence that biodegradation processes are active at the Site (ESS, 2009) as presented on Tables 2.1 and 2.2 (VOC data for overburden and bedrock groundwater), and Table 2.3 (field parameters) (see Appendix K of the Phase 4 investigation report for MNA data; ESS, 2009). The observed trends in the ratios and relative concentrations of parent to daughter product VOCs continue to provide similar evidence in both the unconsolidated deposits and bedrock. In addition, the dechlorination process appears to be going to completion based on the production of daughter products, including cis-1,2-dichloroethene and vinyl chloride, within and immediately downgradient of the FSA, the reduction in the detected concentrations of these compounds further downgradient of the FSA and the elevated concentrations of both ethene and ethane (greater than 0.01 mg/L) detected in the vicinity of and immediately downgradient of the FSA (ESS, 2009).

Nobis (2009b) evaluated the Phase 4 investigation data and reported similar observations. Their evaluation indicated the following:

- Natural attenuation in the overburden aquifer appears to be robust in the FSA and downgradient to OW-043. This zone of reductive dechlorination is approximated by the footprint of the PCE and TCE extent exceeding MCLs.
- Both PCE and cis-1,2-DCE concentrations will likely continue to decline. However, cis-1,2-DCE and vinyl chloride presence downgradient of the PCE and TCE extent are increasing and accumulating, indicating that reductive dechlorination has stalled in this portion of the aquifer because of unfavorable subsurface and redox conditions.
- Natural attenuation in the bedrock aquifer appears to be very active in the FSA and downgradient to OW-007. This zone of reductive dechlorination is approximated by the footprint of the PCE and TCE extent exceeding detection limits.
- Reductive dechlorination in the bedrock aquifer appears to occur over a larger area than in the overburden aquifer.
- The natural attenuation screening results suggest that subsurface conditions are conducive for the reductive dechlorination of highly chlorinated VOCs such as PCE, TCE, and a lesser extent, cis-1,2-DCE. However, outside these zones of reductive dechlorination, anaerobic degradation of cis-1,2-DCE to vinyl chloride or of vinyl chloride to ethene is likely very slow or nonexistent, and further degradation of cis-1,2-DCE and vinyl chloride have stalled.

In summary, the VOC and geochemical parameter analytical data and the field parameter data collected during the Phase 2, Phase 3, and Phase 4 monitoring events strongly supports that reductive dechlorination processes are active at the Site in both the overburden deposits and bedrock and that the degradation of the chlorinated VOCs is occurring to completion as evidenced by the elevated concentrations of ethane and ethene. Additionally, the geochemical parameters strongly support the predominance of anaerobic conditions at the Site which are conducive to reductive dechlorination.

2.8 Surface Water Quality

During the Phase 4 investigation three surface water samples were collected from Latham Brook, located northeast of the Site between wells OW-109-O and OW-24 (ESS, 2009). The analytical results indicate the presence of VOCs above detection limits in surface water. VOCs detected in the surface water samples appear to be similar to those detected in groundwater samples and include 1,1,1-TCA, 1,1-DCA, cis-1,2-DCE, PCE, TCE, and vinyl chloride. However, groundwater samples collected from nearby overburden and bedrock monitoring wells closest to the sample stations (i.e., OW-109-O, OW-111-O, OW-110-R, OW-080, OW-109-R) did not contain detectable concentrations of these VOCs. According to Nobis (2010), the results suggest that: 1) groundwater may be discharging to surface water closer to (or perhaps adjacent to) the wetland area that feed into the stream where the surface water samples were collected, or 2) groundwater may be migrating from the Site to Latham Brook via a pathway that is not currently in the vicinity of an existing monitoring well. An additional mechanism for discharge of impacted groundwater to the stream, which may affect the levels of

contaminants detected in surface water, is the trench drain that was installed in the FSA during the performance of the Source Remedy (OU-3). This trench drain captures groundwater within the FSA and discharges directly to the unnamed stream downgradient of the ponded wetland area located immediately to the east of the FSA.

3.0 PRE-DESIGN INVESTIGATION IMPLEMENTATION

As previously described, the PDI includes the performance of six distinct investigation and testing tasks to support the design of the OU-2 remedy, the development of the LTM Plan and ICP Plan and future decision-making associated with the following:

- Direct contact human health risk associated with the previously treated backfill
- Bedrock groundwater (OU-4)
- Surface water and sediment

The following sections provide additional detail on these proposed investigation and testing programs.

3.1 Pre-Design Investigation

The objective of the Pre-Design Investigation is to provide the data necessary to support the design of the OU-2 remedy. Figure 3.1 provides a plan view layout of the FSA and also shows the area where the previously treated backfill was emplaced after the performance of the Source Remedy. Figure 3.2 provides a general schematic of the FSA that shows the relationship between the treated backfill and the Plume Core, which are the focus for the PDI field investigation. These two figures were developed based on the information presented in the Remedial Action Report (LEA, 2002) which documents the performance of the Source Remedy and the backfilling of the FSA. The general stratigraphy within FSA is shown on this conceptual schematic and will be referenced in the subsequent sections of this work plan. Table 3.1 provides some Site-specific information on the thicknesses of the Treated Backfill and the Plume Core based on the survey elevations for the Phase 4 soil borings and information contained in the Remedial Action Report (LEA, 2002) for the Source Remedy.

3.1.1 Plume Core Evaluation

The Plume Core is the principal area of the Site targeted for remediation using the active treatment program proposed as part of the OU-2 remedy. As stated in the SOW, the objective of this PDI task is to characterize the type and extent of contaminants (both soil and groundwater) that are underlying the approximate boundary of the FSA. This evaluation will:

- Provide better estimates of the contaminant mass to be addressed during remediation.
- Collect data for other parameters that may affect in-situ treatment or reagent injection and distribution.

- Provide data to assess the nature and distribution of residual contaminant mass within the different stratigraphic layers previously identified within the FSA (e.g., organic peat, fine-grained silt/sand, and sand/sand and gravel).

Data will be collected within this task to address these objectives and to support the decision processes as outlined in the RDWP.

Additionally, the Plume Core evaluation will be used to provide data to confirm that residual contaminant impacts do not extend beyond the current delineation of the Plume Core (i.e., FSA). To meet this objective, Plume Core delineation wells (PCD-#) will be installed in the overburden around the upgradient perimeter of the Plume Core area. Groundwater quality data from the proposed wells and existing wells will be used to refine the delineation of the Plume Core, if necessary, since, in accordance with the SOW, groundwater quality results will be used to determine the extent of the Active Treatment Zone for the OU-2 remedy and groundwater quality will ultimately be used to assess the performance of the OU-2 remedy.

3.1.1.1 Geostatistical Assessment Approach

In order to determine the number of borings and associated soil samples necessary to provide a statistically significant dataset representative of the Plume Core contaminant distribution, a geostatistical evaluation was performed using historic data generated during the Pre-Excavation Investigation (EnSafe, 1998) and the Phase 4 Boring Program (ESS, 2009). A copy of this statistical analysis is provided in Attachment A. The statistical evaluation concluded that a boring program based on an 80- to 100-foot grid spacing would provide a sufficient sample number to define the proposed Plume Core at a high level of statistical certainty (95% confidence). On the basis of this statistical evaluation, a 90-foot grid spacing has been used to locate the proposed Plume Core borings. The proposed locations of the Plume Core borings are shown on Figure 3.3.

An evaluation of the number of samples required within each of the proposed borings to minimize the potential for missing zones or layers of residual soil impacts was also performed. This statistical evaluation concluded that if a random or uniform spacing was used to determine the sample depths, 3 to 4 soil samples would be recommended for each of the proposed borings. Since it is proposed that the soil samples will be collected using a biased or targeted approach based on field observations and the results of field headspace screening of soil samples, the potential for missing a zone or layer of residual soil impacts is greatly reduced. On this basis, the Plume Core soil sampling program proposes the field screening of all soil samples and collection of a minimum of two soil samples per boring for the full suite of analytes (VOCs, SVOCs, pesticides, PCBs and metals) as required by the SOW. Additional soil samples will be collected within the Plume Core to provide additional data on the nature and extent of residual VOC mass, which is the target of the OU-2 remedy, with soil samples targeting sampling and analysis of each stratigraphic unit encountered within each boring.

3.1.1.2 Plume Core Soil Borings

In accordance with the requirements of the SOW and based on the statistical assessment program described above to support the design of the OU-2 remedy, a drilling and soil sampling program is proposed within the Plume Core to:

- Characterize subsurface conditions within the Plume Core.
- Collect soil samples for laboratory analysis to provide additional data on the nature of residual soil impacts in the Plume Core and for other parameters that might affect the design and/or performance of the OU-2 remedy.

The soil borings will also be used for the installation of additional shallow, deep and targeted monitoring wells. Additional detail on the proposed monitoring wells is provided in Section 3.1.1.3 below.

Based on the 90-foot grid spacing discussed above, a total of twenty-eight (28) soil borings are proposed within the Plume Core, which underlies the FSA. Refer to Figure 3.3 for the proposed locations of the Plume Core borings. The locations of the proposed borings will be established in the field using Global Positioning System (GPS) techniques.

Advancement of Borings

It is proposed that the drilling be completed using direct push drilling techniques to assess the feasibility of performing the proposed OU-2 remedy using this drilling technique. The Settling Defendants (also herein referred to as the Davis Site Group) are proposing to perform the drilling and well installation using a Geoprobe 7822DT direct push rig (or similar) that allows for the drilling of larger diameter boreholes and uses heavier tooling that helps to maintain plumb boreholes. If shallow refusal is encountered in any of the proposed borings, at least one additional attempt will be made to complete the boring at a location within approximately ten feet of the initial location. If an unacceptable amount of refusals are encountered during the performance of the boring program, an alternative drilling technique (e.g., Rotasonic, drive and wash) will be considered for use to complete the Plume Core boring program.

Pertinent details for the advancement of Plume Core borings are as follows:

- Borings will be advanced through the overburden using direct push drilling techniques. Soil boring drilling and sampling specifications are outlined in SOP A-1 of the FSP.
- The lithology of all borings will be recorded in the field on boring logs and/or the field logbook. In addition to lithology, PID/FID readings will be recorded on the field log and/or the field logbook. A sample of a boring log referenced in SOP A-1 is included in Attachment B of the FSP.
- Soil samples will be collected on a continuous basis from the top of the Clean Fill/Screened Material Zone (approximately elevation 409.6 feet MSL) to the bedrock

surface, based on refusal of the drilling equipment. Direct push drilling techniques allow for the withdrawal of up to five feet of sample from the borehole at a time. Unconsolidated samples are collected in disposable core liners in five-foot increments for ease of handling and sample preservation. Field screening of unconsolidated deposits by PID headspace will be conducted at one-foot intervals. Soil samples that have PID readings greater than 100 ppm_v will be screened for non-aqueous phase liquid (NAPL) using the soil-water shake test and Oil Red O screening methodologies as outlined in SOP A-5 in the FSP.

- Competent bedrock will be discerned from weathered bedrock based on observation of the material retrieved from the direct push core barrel and the general drilling conditions encountered when drilling down to the depth of competent bedrock.

SOPs A-1 and A-2, and A-3 in the FSP provide details on boring advancement and sampling techniques. In general, decontamination procedures for the drill tooling will be performed in accordance with SOP A-1 (i.e., pressurized steam cleaning). In addition, if NAPL-containing soil is encountered during the field investigation activities then a more aggressive decontamination process may be required. Both ESS and the drilling company will be prepared to decontaminate the drill tooling utilizing Alconox, isopropyl alcohol and scrub brushes in addition to using a pressurized steam cleaner.

Field Screening

As described in the above section, field screening of unconsolidated deposits by PID/FID headspace will be conducted at one-foot intervals. In general, field headspace screening and equipment calibration will be performed in accordance with SOPs A-3 and A-4 of the FSP. Soil samples that have PID readings greater than 100 ppm_v will be screened for non-aqueous phase liquid (NAPL) using the soil-water shake test and Oil Red O screening methodologies as outlined in SOP A-5 in the FSP.

ESS will photo document the field activities including the Oil Red O shake tests, and that documentation will be provided in the appropriate PDI summary report.

Soil Sampling

The objective is to collect samples from a range of lithologies to provide physical data for the various lithologies present within the FSA. Sample selection will be independent of the level of contamination and will target the primary stratigraphic layers (i.e., peat, grey silt/fine sand/clay, sand and gravel) that were identified during previous sampling events. It is anticipated that at least two soil samples will be collected from each lithologic unit spread out over the area where that lithologic unit is present, and analyzed for physical testing parameters.

The Geoprobe 7822DT and similar direct push rigs allow for the collection of soil samples up to 3 inches in diameter using heavier tooling than smaller direct push drill rigs.

In general, soil samples will be designated for laboratory analysis based on the results of field observations, headspace screening and stratigraphy in accordance with the criteria specified in Table 3.2. All samples will be collected in accordance with SOPs A-1 in the FSP. Sample to be analyzed for SVOC's pesticides and metals will be collected in laboratory supplied bottles. Samples to be analyzed for TCL VOCs will be collected using EnCore sampling devices or the Terracore Method and EPA Method 5035 (methanol).

Soil samples from select locations will be collected for analysis of physical testing parameters (total organic carbon (TOC), porosity, soil bulk density, grain size distribution). Sample locations will be chosen by the field geologist and will be dependent on the lithologies encountered during drilling activities. Physical testing parameter samples will be analyzed by TestAmerica Laboratories.

Select soil samples, representative of the different stratigraphic layers within the FSA will also be collected for laboratory analysis of treatability parameters to provide data in support of the bench testing program. Refer to Table 3.3 for a listing of the soil treatability parameters.

3.1.1.3 Plume Core Monitoring Wells

Additional monitoring wells will be installed within the Plume Core and will be used, in conjunction with the existing monitoring wells, for collection of groundwater samples for:

- Analysis of VOCs to support the delineation of the Active Treatment Zone.
- Analysis of treatability parameters and performance monitoring parameters to support the design of the bench-scale testing program and the pilot testing program.
- Analysis of VOCs to support the further delineation of the Plume Core (i.e., FSA).

In addition, a number of these wells will likely be utilized for monitoring during the pilot test and for performance monitoring associated with implementation of the full-scale remedy.

As shown on Figure 3.4, twelve (12) additional Plume Core characterization wells (PC-#) are proposed for installation. The objective of the additional wells is to provide shallow and deep well couplets throughout the Plume Core. The well couplets will be installed in separate boreholes (i.e., not co-located within a single borehole). Additional, targeted monitoring wells may also be installed to assess groundwater quality within specific stratigraphic layers (e.g., organic peat). All of the proposed Plume Core monitoring wells will be screened within the overburden.

To support the delineation of the Plume Core, three (3) additional Plume Core delineation wells (PCD-#) are proposed for the western and southern areas of the Plume Core. As shown on Figure 3.4, existing wells OW-55, OW-102-O and OW-304-O, along with the proposed delineation wells, will be used to assess the extent of the Plume Core in the cross-gradient and upgradient flow directions.

As necessary, the Plume Core monitoring well network (existing and newly installed) may also be used for evaluation of the hydrogeologic conditions within the FSA. In conjunction with Site-wide groundwater monitoring events, water levels will be collected from all Plume Core monitoring wells to assist in understanding flow conditions. Hydraulic conductivity testing (e.g., slug tests or single well pumping tests) may also be performed in the Plume Core monitoring wells to provide data to support an evaluation of mass flux.

Monitoring well locations may be modified in the field on the basis of field observations and the screening of soil samples. Additional monitoring wells (PC-#Peat, PC-#Silt) may also be installed and screened within either the organic peat deposits or the fine-grained silt deposits. The rationale for the installation of the proposed Plume Core monitoring wells is provided in Table 3.4.

Pertinent details for the installation of monitoring wells in the Plume Core are as follows:

- Wells will be constructed of 2-inch or 1.5-inch diameter PVC well casing and riser. Wells may be constructed using pre-packed well screens to facilitate installation using direct push drilling techniques.
- Screen lengths for overburden wells will be either 5 or less feet.
- Screen intervals for overburden wells will be determined based on the results of field observations, headspace readings and stratigraphy as outlined on Table 3.4. The objective is to establish a monitoring wells network of shallow and deep wells within the Plume Core, including targeted wells screened within individual stratigraphic layers.

SOPs A-1, and A-6 in the FSP provide details on well installation techniques. In general, the completed monitoring wells will be developed in accordance with SOP A-6. The monitoring wells installed as part of this work plan will be developed by pumping and surging with either a Waterra pump or a dedicated polyethylene bailer. It is anticipated that the amount of drilling water lost to the formation will be minimized to the extent possible, and the amount of water lost will be estimated during drilling. When the newly installed wells are developed, an attempt will be made to recover any lost drilling water.

Groundwater Sampling Approach

Initial groundwater sampling will be conducted at select existing and/or newly installed overburden Plume Core monitoring wells, including all of the Plume Core Delineation Wells (VOCs only), for VOCs and select groundwater treatability parameters following the installation and development of the proposed Plume Core monitoring wells. Refer to Table 3.3 for a listing of the groundwater treatability parameters. This initial sampling event is being performed to provide information for the design of the bench scale testing program. Table 3.5 provides a summary and rationale for the proposed Plume Core groundwater sampling. All wells will be sampled in accordance with SOP A-9 of the FSP. Sample handling and quality assurance protocols and field measurement and laboratory analytical methods are detailed in the FSP and the QAPP.

Physical parameters to be measured include the following:

- Depth to groundwater: water level measurements will be collected using an electronic water level sensor or interface probe in accordance with SOP A-8 contained in the FSP. Measurements will be recorded on the Water Level Measurements Form contained in Attachment B of the FSP.
- Depth and thickness of NAPL, if present: gauging of NAPL will be conducted with an interface probe in accordance with SOP A-8 contained in the FSP. This information will be documented on the Water Level Measurements Form contained in Attachment B of the FSP.

Chemical parameters to be measured include the following:

- Field parameters: pH, conductivity, temperature, oxidation/reduction, turbidity, redox potential (Eh), and dissolved oxygen (DO).
- VOCs, and select treatability parameters via laboratory analysis.

Additional sampling of the Plume Core wells will be performed, as necessary, for VOCs, treatability parameters, and/or performance monitoring parameters to support the delineation of the Active Treatment Zone, ongoing bench-scale and pilot testing programs and to provide data to support the evaluation of performance monitoring parameters for the pilot test. This additional sampling will be performed at the direction of the design engineer. Refer to Table 3.3 for a listing of the groundwater performance monitoring parameters.

All Plume Core existing and newly installed monitoring wells will be sampled for VOCs to support the delineation of the Active Treatment Zone in the 30% Design and/or 100% Design. The proposed Plume Core monitoring wells will not be included in the ongoing Site-wide groundwater monitoring program.

3.1.1.4 Investigation Derived Waste Management

Investigation-derived waste (IDW) will be managed in accordance with the Site Management Plan (SMP), RIDEM Policy Memo 95-01, previous ESS correspondence dated February 26, 2003 and previous RIDEM correspondence dated March 19, 2003. The previous ESS correspondence and RIDEM response are attached as Attachment B. Soil cuttings generated during the Source Area borings will be used to backfill the borings at the approximate depth they were generated, to the extent possible. Excess soil cuttings generated during boring advancement will be managed based on the results of field headspace screening using a threshold of 10 parts per million (ppm). Excess soils exhibiting headspace screening results of less than 10 ppm will be spread over ground surface as necessary, in accordance with the previous IDW correspondence for the Site.

In general, purge water generated during well development and purging during sampling activities will be containerized and managed in accordance with the SMP at an off-Site facility unless groundwater sampling results and/or representative drum samples exhibit VOC

concentrations below the RIDEM GA Groundwater Criteria. If detected concentrations are less than the RIDEM GA Groundwater Criteria, the development and purge water will be discharged to the ground surface. ESS will coordinate with the EPA and RIDEM as to the appropriate method for discharging to the ground surface, if appropriate.

3.1.1.5 Data Evaluation

The soil data generated from the Plume Core investigation will be compiled, along with existing data generated during the Phase 4 drilling program, to update the Site Conceptual Model relative to the nature and extent of residual contaminant mass within the Plume Core. In particular, the evaluation will focus on the residual VOC mass, since this is the target of the OU-2 remedy, within the Plume Core and within specific stratigraphic layers. Estimates of the residual VOC mass will be established to support the design of the OU-2 remedy. Soil data collected for the treatability parameters will also be compiled and used in the design of the Bench and Pilot Testing Evaluation.

The groundwater data generated from the Plume Core investigation will be used to support the design of the Bench and Pilot Testing Program and for evaluation of the Plume Core and the Active Treatment Zone. Contour maps of VOC concentrations will be used to assess areas exceeding the Interim Groundwater Remediation Goals (IGRGs), which are the criteria that will be applied to evaluate if impacts extend beyond the current extent of the Plume Core, and for delineation of the Active Treatment Zone relative to these same standards.

3.1.2 Treated Backfill Evaluation

As stated in the SOW, the objective of this PDI task is to collect information to assess whether previously Treated Backfill within the FSA contains residual contaminants that may pose continued threats to groundwater quality or to human health or the environment. Data will be collected within this task to address these objectives and to support the decision processes as outlined in the flowchart presented in Figure 3.5 and previously discussed in the RDWP.

Based on the information presented in the Remedial Action Report (LEA, 2002), the Treated Backfill was emplaced beneath a topsoil cap of 6 inches down to an elevation of at least 409.6 feet AMSL over the majority of the FSA (See Figure 3.2). Table 3.1 provides some Site-specific information on the thicknesses of the Treated Backfill based on the survey elevations for the Phase 4 soil borings and information contained in the Remedial Action Report (LEA, 2002) for the Source Remedy.

3.1.2.1 Treated Backfill Soil Borings

In accordance with the requirements of the SOW, a drilling and soil sampling program is proposed within the Treated Backfill to:

- Characterize subsurface conditions within the Treated Backfill.

- Collect soil samples for laboratory analysis to assess whether previously Treated Backfill within the FSA contains residual contaminants that may pose continued threats to groundwater quality or to human health or the environment.

The Treated Backfill soil borings will be collocated with 20 of the Plume Core soil borings, oriented on a 90-foot grid. The number of proposed Treatment Backfill soil borings is based on the requirement of the RIDEM Remediation Regulations that a minimum of 20 soil samples be collected from intersecting points on a grid to allow the use of a statistical analysis for determining compliance with the RIDEM Direct Exposure Criteria. A minimum of ten samples is also required to calculate the 95% UCL using EPA's ProUCL software.

The locations of the proposed borings will be established in the field using Global Positioning System (GPS) techniques. Refer to Figure 3.3 for the proposed locations of the Treated Backfill soil borings. Table 3.1 provides details on the thickness of the Treated Backfill based on the results of the Phase 4 boring program and the information contained in the Remedial Action Report (LEA, 2002).

3.1.2.2 Advancement of Borings

It is proposed that the drilling be completed using direct push drilling techniques, in a manner generally consistent with the Plume Core borings as described in Section 3.1.1.2 above.

Pertinent details for the advancement of Treated Backfill borings are as follows:

- Borings will be advanced through the Treated Backfill using direct push drilling techniques. Soil boring, drilling, and sampling specifications are outlined in SOPs A-1, A-2 and A-3 of the FSP.
- The lithology of all borings will be recorded in the field on boring logs and/or the field logbook. In addition to lithology, PID/FID readings will be recorded on the field log and/or the field logbook. A sample of a boring log referenced in SOP A-1 is included in Attachment B of the FSP.
- Soil samples will be collected on a continuous basis from the bottom of the topsoil cap (upper 6 inches) to the top of the Clean Fill/Screened Material Zone (approximately elevation 409.6 feet AMSL). Direct push drilling techniques allow for the withdrawal of up to five feet of sample from the borehole at a time. Unconsolidated samples are collected in disposable core liners in five-foot increments for ease of handling and sample preservation. Field screening of unconsolidated deposits by PID headspace will be conducted at one-foot intervals.

SOPs A-1 and A-2, and A-3 in the FSP provide details on boring advancement and sampling techniques. In general, decontamination procedures for the drill tooling will be performed in accordance with SOP A-1 (i.e., pressurized steam cleaning). In addition, if NAPL-containing soil is encountered during the field investigation activities then a more aggressive

decontamination process may be required. Both ESS and the drilling company will be prepared to decontaminate the drill tooling utilizing Alconox, isopropyl alcohol and scrub brushes in addition to using a pressurized steam cleaner.

3.1.2.3 Field Screening

As described in the above section, field screening of unconsolidated deposits by PID headspace will be conducted at one-foot intervals. In general, field headspace screening and equipment calibration will be performed in accordance with SOP A-2 of the FSP.

3.1.2.4 Sampling Approach

The Treated Backfill sampling strategy and rationale are presented in Table 3.6. Samples will be collected from three different depth intervals (shallow: 0.5 to 2 feet bgs, intermediate: 3 to 5 feet bgs, deep: 6 to 8 feet bgs), dependent upon the thickness of the Treated Backfill, to assess for leaching potential throughout the Treated Backfill and to be representative of various potential direct contact exposure scenarios.

3.1.2.5 Soil Sampling

All Treated Backfill samples will be collected in accordance with SOPs A-1 and A-2. Treated backfill samples will be analyzed for VOCs, SVOCs, PCBs, pesticides and metals, in accordance with the SOW. Samples to be analyzed for TCL VOCs will be field preserved using EnCore sampling devices or the Terracore method and EPA Method 5035 (methanol). Pending the initial evaluation of the analytical data compared to the RIDEM standards, additional soil sampling may be performed to collect samples for analysis by the Synthetic Precipitation Leaching Procedure (SPLP) analysis for chlorinated VOCs. This additional soil sampling would target the areas of exceedances identified by the screening of the initial data.

Additional soil samples may also be collected for laboratory analysis of grain size distribution or total organic carbon at the discretion of the field geologist.

3.1.2.6 Investigation Derived Waste Management

IDW generated during the Treated Backfill boring and sampling work will be managed consistent with the methods outlined in the SMP and Section 3.1.1.4 above.

3.1.2.7 Leaching Assessment

The leaching potential of the Treated Backfill will be evaluated in accordance with the flow chart provided in the RDWP and included here as Figure 3.5. In accordance with the right hand side of the flowchart, leaching potential will be evaluated by comparing data from the Treated Backfill soil samples to the RIDEM GA Leachability Criteria. If the soil concentrations of the Treated Backfill samples are below the applicable RIDEM Leachability Criteria, then no further action will be required to assess for leaching potential. If the soil concentrations of the Treated Backfill samples are above the applicable RIDEM Leachability Criteria using the

direct comparison approach, then the nature and distribution of the data will be discussed with EPA and RIDEM, within the context of the OU-2 remedy, to determine what subsequent steps are required.

As stated in the SOW, more detailed evaluations of leaching potential (e.g., SPLP testing, Site-specific modeling) may be proposed for approval by the EPA, after reasonable opportunity for review and comment by the RIDEM, and implemented in a manner consistent with the remedial goals and approach for groundwater, as stated in the ROD Amendment.

3.1.2.8 Human Health Assessment

Threats to human health through direct exposure to the Treated Backfill will be evaluated in accordance with the flow chart provided in the RDWP and included here as Figure 3.5. Threats to human health through direct exposure to the Treated Backfill shall first be evaluated by comparing data from the Treated Backfill soil samples to the EPA's RSLs and RIDEM's Direct Exposure Criteria (DEC). If the soil concentrations of the Treated Backfill samples are below the RSLs and DEC, then no further action will be required to assess for potential human health direct contact risk. If the soil concentrations of the Treated Backfill samples are above the RSLs and DEC, then Exposure Point Concentrations (EPCs) for the compounds that exceeded the RSLs and/or DEC will be calculated consistent with the methodology presented in Attachment C. If the calculated EPCs are below the RSLs and DEC, then no further action will be required to assess for human health direct contact risk. If the calculated EPCs are above the RSLs and/or DEC, then a Site-specific human health risk assessment will be performed as described in Attachment C. If the risks calculated in the risk assessment are shown to not be significant, then no further action will be required to assess for human health direct contact risk. If the risks calculated in the risk assessment are shown to be significant, then remedial options to address direct contact exposures will be evaluated, including the use of land use restrictions.

3.1.3 Bench and Pilot Testing Evaluation

In accordance with Consent Decree (CD) Appendix B - Statement of Work (SOW):

- Bench-scale treatability testing (bench test) will be performed to select the optimal reducing agent for chemical treatment and fermentable carbon substrate for microbial growth in the subsurface overburden materials of the Active Treatment Zone.
- Field-scale pilot tests will be performed to ascertain the ability to distribute the reagent in the formation (i.e. variable permeability soils or high water table) and the effectiveness in addressing contaminants in the overburden Plume Core.

The goals of these evaluations are:

- Select the design reducing agent for chemical treatment and fermentable carbon substrate for microbial growth in the subsurface overburden materials of the Active Treatment Zone.

- Collect appropriate field information (site-specific geochemical, biological, etc.) in the Active Treatment Zone that will be needed to design each of the components identified in the 2010 ROD Amendment for in-situ chemical reduction and enhanced biodegradation, and develop data needed to design the effective distribution of treatment reagent into the subsurface overburden materials in the Active Treatment Zone.
- Identify and field test potential reagent distribution technologies (injection/delivery systems) to evaluate their effectiveness to distribute the treatment reagents into the Active Treatment Zone and in addressing Site contaminants (COCs shown in Attachment D of the SOW) based on site-specific conditions, as appropriate.

Background and Discussion

The ROD Amendment and SOW specify a remedy, as generally depicted in Figure 11 and Figure 12 of the ROD Amendment, consisting of *in situ* treatment of chlorinated VOCs in the water-saturated overburden soils within the FSA (a.k.a. Plume Core) with chemical reducing agents and/or enhanced biodegradation agents coupled with natural attenuation of the remaining untreated portion of the overburden plume. EPA provides that much of the plume is already in a chemically reduced state; therefore the selected remedy is only required to enhance this electrochemical condition through the addition of a reducing agent and electron donor to enhance chemical reduction of chlorinated organic compounds. EPA estimates the ROD-specified remedy will achieve remediation of the overburden plume within a 40 to 45 year time frame.

EPA, in the 2009 Final Conceptual Site Model Technical Memorandum Addendum, estimates that the Plume Core and overburden groundwater is impacted with approximately 261 kg (576 pounds) of VOCs; 237 kg (523 pounds) in 170,000 yd^3 of VOC-contaminated saturated soil plus 24 kg (53 pounds) in 14,300,000 gallons of VOC-contaminated overburden groundwater. EPA estimates the remedy will cost $13,700,000, which comes to a unit remediation cost of approximately $23,785 per pound ($1,486 per ounce) of VOC, $80/$yd^3$, and $0.96/gallon.

The ROD Amendment and SOW provide that:

- In an anaerobic environment, the natural degradation of chlorinated hydrocarbons follows the reductive dechlorination pathway.
- Organic substrate material such as emulsified vegetable oils, lactic acid, or molasses extracts can be added to enhance the growth of reductive dechlorinating microbes.
- In-situ enhanced biodegradation can be completed in conjunction with the in-situ chemical reduction or as a stand-alone injection.
- A slightly buffered solution should be added to assist in the neutralization of any acids that form from reduction processes.
- The chemical reduction and enhanced biodegradation can be combined into a single treatment.

- The organic substrate that promotes microbial growth and reductive dechlorination shall be used as the delivery liquid for the reagent into the Plume Core (saturated soils and groundwater in the FSA) and the overburden plume.

The purpose of the bench and pilot testing described below is to assess the efficacy of the remedial approach to treat the chlorinated VOCs listed in Attachment D of the SOW within differing aquifer soil types and facilitate the detailed design of the remedy including:

- Reagent selection
- Reagent dosage:
  - concentration
  - specific volume
  - rate
- Reagent supplements:
  - pH buffer
  - nutrients
- Reagent delivery:
  - approach (injection, mixing, etc.)
  - spacing
  - frequency
- Performance monitoring requirements and frequency

Key decisions to be answered by the bench and pilot tests include:

- What types of reagents are applicable to the site?
- What reagents should be selected for bench testing by mixed slurry microcosms?
- What are the major controlling/limiting factors identified in the bench-scale tests that need to be considered in the design?
- What are the potential impediments to effective implementation?
- What can bench-scale column tests and field-scale pilot tests do to resolve significant issues?
- What is the best reagent to take to pilot testing?
- What is the likely effective longevity of the applied reagent(s) in the subsurface?

State of the Practice Overview

A short overview of the theory and state of the practice for *in situ* chemical reduction (ISCR) and *in situ* bioremediation (ISB) of chlorinated compounds is provided to facilitate understanding of

the planned approach to making the key decisions toward fostering effective remedy design. The following reference materials are among the most current, comprehensive, and relevant resources for the science and art of applying ISCR/ISB for destruction of chlorinated compounds.

USEPA. 2000. *Engineered Approaches to In Situ Bioremediation of Chlorinated Solvents: Fundamentals and Field Applications*. Division of Solid Waste and Emergency Response. EPA 542-R-00-008. http://www.epa.gov/tio/download/remed/engappinsitbio.pdf.

Air Force Center for Environmental Excellence (AFCEE). 2004. *Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents*. Environmental Security Technology Certification Program (ESTCP). http://costperformance.org/remediation/pdf/principles_and_practices_bioremediation.pdf

Air Force Center for Environmental Excellence (AFCEE). 2007. *Protocol for In Situ Bioremediation of Chlorinated Solvents Using Edible Oil*. Environmental Science Division, Technology Transfer Outreach Office. http://www.afcee.af.mil/shared/media/document/AFD-071203-094.pdf

Air Force Center for Environmental Excellence (AFCEE). 2010. Rates and Impacts of Substrate Delivery for Enhanced Anaerobic Bioremediation: Addendum to the Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents. Environmental Security Technology Certification Program (ESTCP) Project: ER-200627. http://serdp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/ER-200627/Addendum_ER-200627.

Air Force Center for Environmental Excellence (AFCEE). 2011. *Substrate Design Tool: Rates and Impacts of Substrate Delivery for Enhanced Anaerobic Bioremediation: Addendum to the Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents.* Environmental Security Technology Certification Program (ESTCP) Project: ER-200627.http://www.serdp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/ER-200627/ER-2006272/(modified)/04May2011.

Air Force Center for Environmental Excellence (AFCEE). 2008. *Development of a Design Tool for Planning Aqueous Amendment Injection Systems.* Environmental Security Technology Certification Program (ESTCP) Project: ER-200626. http://www.serdp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/ER-200626.

ITRC (Interstate Technology & Regulatory Council). 2008. *In Situ Bioremediation of Chlorinated Ethene: DNAPL Source Zones*. BioDNAPL-3. Washington, D.C.: Interstate Technology & Regulatory Council, Bioremediation of DNAPLs Team. http://www.itrcweb.org/Documents/bioDNPL_Docs/BioDNAPL3.pdf.

U.S. Department of Energy Office of Environmental Management. 2004. *Evaluation of Amendments for Mending the ISRM Barrier*. U.S. DOE Hanford Site, Final Technical

Solutions Report, Technical Assistance Project #33. http://costperformance.org/remediation/pdf/project33_evaluating_amend.pdf

Dolfing, J., et.al. 2008. *In Situ Chemical Reduction (ISCR) Technologies: Significance of Low Eh Reactions*. Journal of Soil & Sediment Contamination. Vol. 17, No.2. (March/April, 2008). http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.169.6991

Jianzhong, H. et.al.2007. *Influence of Vitamin B12 and Cocultures on the Growth of Dehalococcoides Isolates in Defined Medium*. American Society for Microbiology, Journal of Applied and Environmental Microbiology, May 2007, p. 2847–2853 Vol. 73, No. 9. http://superfund.berkeley.edu/pdf/68.pdf.

Haas, J.R. and Shock, E.L. 1999.Halocarbons in the Environment: Estimates of Thermodynamic Properties for Aqueous Chloroethylene Species and Their Stabilities in Natural Settings. Geochimica et Cosmochimica Acta 63(19/20), 3429-3442. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.169.6193&rank=1.

The number, type, and performance of readily available ISCR and ISB reagents continue to evolve. The evolution of new and better reagents follows increasing understanding of the various mechanisms important in dechlorination of chlorinated compounds in general and chlorinated alkenes (chloroethenes like PCE, TCE, DCE, and vinyl chloride) and chlorinated alkanes (chloroethanes like TCE, DCA, and monochloroethane) in particular. The fairly recent emergence and popularity of ISCR stems from fairly recent invigoration of the popular interest and acceptance of the significant role that abiotic and microbially mediated processes play in anaerobic dechlorination as opposed to classic reductive dechlorination through synergistic bacterial processes involving anaerobic fermentation of natural or anthropogenic organic compounds (fermentable carbon substrate) and dechlorinating bacteria.

Popular use of the term "ISCR" is somewhat of a misnomer in the context that popular ISCR reagents typically combine a solid or liquid reducing agent (usually zero valent iron (ZVI) powder or sulfur-based liquids) with a fermentable carbon substrate (like emulsified vegetable oil, lactate, or plant-based cellulose) under the premise that the combined action of the reducing agent and the fermentable substrate leads to better performance than is otherwise achievable with either ingredient if used alone. The popular theory is that the dechlorination activity is proportional to reducing state (more negative oxidation/reduction potential (ORP; as Eh) values infer greater reducing state). This is to say that more robust dechlorination occurs at lower (more negative) ORP (as Eh) values. It appears to have been demonstrated that ISCR reagents that combine reducing agents with fermentable substrates are able to induce and maintain extreme reducing conditions (Eh -400 mV to -800 mV) instead of more moderate reducing conditions (Eh about -200 mV) evoked when either ingredient is delivered alone. So, it can be said that ISCR attempts to realize the synergistic advantage offered by combining an active reducing agent with a fermentable substrate.

Care should be taken when discussing or reading about ORP and Eh (a.k.a. redox potential or redox). Unfortunately, all ORP electrodes are not created equally. Various commercially available

electrodes respond differently from each other. To overcome this limitation, standard practice should be to normalize all ORP readings to Eh, the "standard" oxidation-reduction potential realized by a standard hydrogen electrode. Unfortunately, the practice of normalizing ORP to Eh is not consistently used in the remediation industry. The relationship between ORP values measured by modern instruments and Eh is readily available and straight forward (SM2580B, ASTM D1498-00). Reported ORP values could differ from its normalized Eh equivalent by more than 200 mV if not calibrated or corrected to Eh. The offset to correct ORP to Eh is additive, so an uncorrected ORP is likely to be about 200 mV lower (more negative) than its Eh-normalized equivalent. The implication for redox-sensitive decision-making is to take care to compare like with like (apples with apples) so that a 200-mV misunderstanding does not misguide conclusions. This PDI, including bench and pilot testing, shall capture redox values normalized to Eh and will be reported as Eh (ORP as Eh).

ISCR and ISB reagents are commercially available in a variety of formulations; however, they can be grouped into permeations of the following major characteristics:

- Longevity:
  - Short-lasting (readily soluble); typically days to weeks, <1 year
  - Moderate-lasting (moderately soluble); typically several months to 1 or few years
  - Long-lasting (slow-release, slow-dissolving); typically several years, 5 or more years
- Viscosity:
  - Viscous (thick, like honey or motor oil, at normal temperatures)
  - Non-viscous (thin, like water, at most temperatures)
- Particle Size (solid or oil micelle [a.k.a. droplet]; average):
  - Large (>100 µm)
  - Medium (50 to 100 µm)
  - Small (1 to 50 µm)
  - Very Small (0.1 to 1 µm)
  - Nanoscale (0.001 to 0.1 µm)
- Hydrogen Generation Potential (milligrams H_2/gram active reagent; typical):
  - Lactic acid = 45
  - High Fructose Corn Syrup = 45
  - Sucrose = 47
  - Zero Valent Iron = 50
  - Lactose = 65
  - Sodium Lactate = 70

  - Ethanol = 88
  - Cellulose/Hemicellulose = 120
  - Ethyl Lactate = 140
  - Edible Vegetable Oils = 180
  - Lactic acid ester in glycerol = 220
- Cost ($/pound reagent; typical):
  - High Fructose Corn Syrup = $0.3
  - Lactic acid = $0.5
  - Ethanol = $0.5
  - Sucrose = $0.5
  - Zero Valent Iron = $0.50
  - Edible Vegetable Oils = $1
  - Sodium Lactate = $1.5
  - Ethyl Lactate = $1.5
  - Lactose = $2
  - Cellulose/Hemicellulose = $2
  - Lactic acid ester in glycerol = $8
- Cost ($/pound H_2 Generated; typical):
  - Ethanol = $6
  - High Fructose Corn Syrup = $6
  - Edible Vegetable Oils = $6
  - Zero Valent Iron = $10
  - Sucrose = $10
  - Lactic acid = $11
  - Ethyl Lactate = $11
  - Cellulose/Hemicellulose = $17
  - Sodium Lactate = $22
  - Lactose = $31
  - Lactic acid ester in glycerol = $36

The reader is encouraged to understand that high hydrogen generating potential (at low cost) is a desirable trait for ISCR and ISB reagents; however, it is most important to also consider

characteristics that lead to efficient and cost-effective production and utilization of the molecular hydrogen, some of which are counter-intuitive. For example, too much hydrogen favors methanogenic uptake over reductive dechlorination process; wasting precious hydrogen. Such a condition is more likely to occur with the use of highly soluble (short-lived) reagents. Short-lasting reagents are further plagued with the prospect of frequent repeat delivery (injection) events, which increases cost dramatically and spoil any advantage garnered from microbial acclimation and chemical equilibrium.

Desirable effects of applied reagent(s) include:

- Ability to establish and maintain an extremely low redox state (Eh<-400 mV)
- Establish and maintain a large distribution profile
- Establish and maintain an efficient release rate
- Offer effective pH control
- Offer essential nutrients if needed
- Facilitate effective electron transfer to many, if not all, of the various microbiotic, microbial-mediated, and abiotic dechlorination mechanisms, some poorly understood, that ISCR is intended to enhance
- Limit undesirable byproducts like dissolved toxic metals and toxic or flammable biogenic gases
- Offer long-lasting cost-effective performance

It is reasonable to expect, given the current (and anticipated future) site conceptual model, that the most effective reagent would favor the following characteristics:

- Long-lasting (slow-release, slow-dissolving)
- Non-viscous (thin, like water, at most temperatures)
- Small to smaller particle sizes (<50 µm)
- Large hydrogen generation potential (>100mg/g)
- Self-buffering (or readily buffered) for pH control
- Essential nutrients-fortified (e.g., nitrogen, phosphorus, vitamin B12)
- Low-cost
- Readily available
- Proven track record
- Easily handled and mixed in field
- Stable for weeks or months as delivered
- Safe

The rationale and strategy to implement both bench-scale treatability tests and field-scale pilot tests to evaluate the effectiveness of candidate in-situ chemical reduction and enhanced biodegradation treatment reagents as prescribed by the SOW follows.

3.1.3.1 Rationale

The overarching rationale for performing bench-scale treatability testing and field-scale pilot testing is to facilitate the design of a remedy that has the best chance of success in the shortest timeframe and in a cost-effective manner. A phased approach to bench-scale treatability testing and field-scale pilot tests is required to evaluate the effectiveness of candidate in-situ chemical reduction and enhanced biodegradation treatment reagents. The challenges and potential constraints posed by site conditions and the aggressive implementation schedule have been considered in developing this program. The biotic and abiotic processes that result in degradation of COCs are not instantaneous reactions and by their very nature take time (especially where contaminant back diffusion processes are considerable). This, and the need to better understand the longevity of reagents, necessitates the use of an extensive bench-scale testing program where reactions can be assessed at a smaller scale in a controlled environment, and where enhanced tests (column tests with high pore volume turnovers) can be conducted to assess longevity and other design parameters. These elements could not be fully or confidently evaluated under field conditions (pilot test), considering the schedule constraints.

These evaluations are being conducted to select an appropriate reagent and to maximize the prospect for an effective remedial design for each of the distinct soil types (e.g., peat, silt, sand & gravel) within the target treatment zone in the overburden aquifer at the site.

Following completion of the bench-scale testing, the SOW requires implementation of a field-scale pilot test. The rational for pilot testing the apparent "optimum" reagent is to assess the efficacy of reagent subsurface delivery in each geologic setting and to estimate the achievable distribution sufficient to foster effective full-scale design elements such as of dosage, volume, injection point spacing, vertical injection intervals, repeat injection intervals, and performance monitoring.

Bench-Scale Treatability Testing

Rationale for bench testing is detailed in Table 3.7.

Field-Scale Pilot Testing

The rational for pilot testing is to assess/demonstrate the ability to effectively deliver selected reagent(s) into the three distinct geologic settings of the overburden aquifer where indicated by the PDI, and to foster effective design through determination of design basis parameters such as:

- Injection/delivery point spacing (feet between points)
- Reagent dosage (pounds per gallon)

- Specific injection/delivery volume (gallons of reagent per lineal foot of formation thickness)
- Injection/delivery rate (gpm)
- Injection/delivery pressure (psig at pump)
- Nature and frequency of performance monitoring

3.1.3.2 Strategy

The strategy for performing bench-scale treatability testing and field-scale pilot testing is provided in further detail in the following subsections; however, the overarching strategy to determine and nominate a reagent for full-scale application is shown on Figure 3.6.

In summary, the overall strategy to determine and nominate a reagent for full-scale application is:

- Identify the majority of readily available and potentially applicable ISCR and ISB reagents (See Table 3.8)
- Screen the potentially applicable reagents based on the criteria shown on Table 3.9 and for the following favorable attributes:
  - Long-lasting (slow-release, slow-dissolving)
  - Non-viscous (thin, like water, at most temperatures)
  - Small to smaller particle sizes (<50 µm)
  - Large hydrogen generation potential (>100 mg/g)
  - Self-buffering (or readily buffered)for pH control
  - Essential nutrients-fortified(e.g., nitrogen, phosphorus, vitamin B12)
  - Low-cost
  - Readily available
  - Proven track record
  - Easily handled and mixed in field
  - Stable for weeks or months as delivered
  - Safe
- Select, for mixed slurry microcosm testing, one candidate reagent representative of each of the following functionally distinct groups:
  - Fermentable carbon substrate (contains no reducing agent)
  - Reducing agent (contains no fermentable substrate)
  - Blended reagent that contains fermentable substrate and reducing agent)

- Select the reagent type that performed the best during mixed slurry microcosm testing and evaluate other reagents within that group for candidacy for further testing (either mixed slurry and/or column testing)
- Select the reagent that shows the most promise of success for pilot testing

The mixed slurry microcosm tests are designed to select a reagent type, not necessarily the reagent tested. The rationale for such prospect is that it may become apparent through testing, through results of the PDI, or through further screening and evaluation that there is advantage in considering the merit of selecting alternate reagents within a reagent type (or classification family) as candidates for use. Possible reasons include consideration of longevity, buffering capacity, nutrient load, particle size, viscosity, guarantees, cost, and other reasons. The reagents selected for further column testing or pilot testing, after consultation with EPA and RIDEM, may not necessarily be those that are assessed in the mixed slurry bench tests.

Bench-Scale Treatability Testing

Bench scale testing programs are dynamic by their nature due to the iterative nature of these testing programs. The findings from the initial or preceding bench-scale tests are used throughout the program to define the scope of subsequent bench tests.

Two major classes of bench-scale tests are commonly utilized to assess performance. Each class of bench-scale test has its advantages and disadvantages. These classes of test include:

- Mixed slurry microcosms
- Flow-through column tests

Mixed slurry microcosm tests, as the name implies, focus on a well-mixed regime that provides ideal reagent distribution in the system and offer intimate contact with the contaminants and the matrix being tested. It is not very representative of actual field conditions, as communication in the field between reagent, matrix, and contaminants will be much less uniform. However, mixed slurry microcosm tests serve very well for assessing the candidacy of a reagent type at a proof-of-concept level. Mixed slurry microcosms also provide some level of illumination regarding potential dechlorination rate-limiting mechanisms, such as pH, nutrient load, microbial community structure, and reagent strength.

Flow-through column tests assess interactions under more natural mass transfer conditions. They can be useful to illuminate expectations regarding the degree to which biogeochemical interactions and/or reagent distribution is by advective and diffusive forces.

Key advantages and limitations of the bench scale testing methodologies are described below and have been considered in the development of the testing program.

Mixed Slurry Tests – testing of reagents in well-mixed consortia of soil, groundwater, and reagent provides intimate contact between reagent, matrix, and contaminant:

- **Advantages:**
  - Test that can be used to quickly and rapidly evaluate the efficiency of various chemical reagents.
  - Test is quicker and more easily implemented than column tests.
  - Speed of test allows multiple tests to be completed in a short period to enable assessment of multiple reagents and dosage rates and other potential limitations on biotic and abiotic transformations.
  - Test focuses evaluation on reaction chemistry and removes mass transfer limitations as a limiting factor in the tests.
- **Disadvantages:**
  - Test methodology is not conservative and mass transfer limitations may ultimately limit the effectiveness of a specific reagent.
  - Low volumes limit the type and number of analyses that can be performed.

Flow-through Column Tests – aquifer soils are packed in columns and test reagents are emplaced at varying distributions so that advective and diffusive mass transfers can be considered as impacted groundwater is pumped through the column:

- **Advantages:**
  - Test method better reflects likely treatment efficiencies under field conditions.
  - Column tests can be used to assess a wide range of field and operational conditions at enhanced pore volume turnover rates to assess reactions that may occur over longer time frames. These include:
    - Assessment of diffusion controlled processes (for example hydrogen gas production and mass transfer for iron based products).
    - Assessment of reagent longevity (both for biotic and abiotic processes).
    - Contaminant rebound following reaction of reagents.
    - Quantification of mass degradation rates over time.
    - Assessment of geochemical conditions indicative of biotic and abiotic processes that can be used for development of monitoring programs.
- **Disadvantages:**
  - Time period required to complete column tests can be long.
  - Construction and interpretation of column tests are complicated by the fact that aquifer core samples represent a vertical cross section of the aquifer while groundwater flow is typically horizontal, and thus perpendicular to the core sample.

- Size and number of controls required for assessment of multiple reagents and dosages stresses space and equipment resources.
- Relatively expensive.

Reflecting these advantages and limitations, the Davis Site Group has developed a phased program of bench-scale tests which facilitates assessment of all key controls and recognizes the benefits of both types of bench-scale testing programs. This testing program utilizes an initial program of slurry phase tests to define a preferred reagent type (fermentable substrate, reducing agent, and blended fermentable substrate/reducing agent), assesses the key controls on the preferred reagent chemistry under a column testing regime, and then assesses the injectability, distributability, and field-scale performance of the selected reagent(s) in a pilot test.

Mixed Slurry Microcosm Testing

The approach to mixed slurry microcosm testing is provided in this section. Key components are:

- Identification, screening and selection of test reagents
- Screening and selection of testing laboratory
- Objectives
- Selection, procurement, and delivery of test samples
- Construction and setup
- Monitoring
- Reporting

The overall approach is show in Figure 3.7.Further detail is illustrated in Figure 3.8.

Identification, Screening and Selection of Test Reagents

The approach to selecting candidate mixed slurry microcosm test reagents is:

- Identify commercially available proven reagents that are potentially applicable for enhancing:
  - microbial reductive dechlorination
  - abiotic chemical Dechlorination and microbially mediated dechlorination
  - synergistic microbial dechlorination, microbially mediated dechlorination, and abiotic dechlorination

The list of potentially applicable reagents (and additives) is shown in Table 3.8.

- Screen the potentially applicable reagents based on the criteria shown on Table 3.9 and for the following favorable attributes as reflected in **Table 3.9A**–Screening of ISCR and/or ERD Products for Candidacy:
  - Long-lasting (slow-release, slow-dissolving)
  - Non-viscous (thin, like water, at most temperatures)
  - Small to smaller particle sizes (<50 µm)
  - Large hydrogen generation potential (>100 mg/g)
  - Self-buffering (or readily buffered)for pH control
  - Essential nutrients-fortified(e.g., nitrogen, phosphorus, vitamin B12)
  - Low-cost
  - Readily available
  - Supplier guaranteed
  - Proven track record
  - Easily handled and mixed in field
  - Stable for weeks or months as delivered
  - Safe
- Select, for mixed slurry microcosm testing, one or more candidate reagents representative of each of the following functionally distinct groups:
  1. **Fermentable carbon substrate** (contains no reducing agent) capable of enhancing microbial reductive Dechlorination
  2. **Reducing agent** (contains no fermentable substrate), such as zero valent iron powder in a fluid carrier capable of enhancing abiotic chemical reduction and/or microbially mediated chemical reduction
  3. **Blended reagent** (contains fermentable substrate and reducing agent) capable of enhancing synergistic microbial dechlorination, microbially mediated dechlorination, and abiotic dechlorination

Screening of the potentially applicable reagents results in selection of the following initial candidate reagents for the mixed slurry microcosm tests:

- Fermentable Substrate: **ABC** supplied by Redox Tech (http://redox-tech.com); characteristics include:
  - fermentable substrate capable of enhancing microbial reductive dechlorination
  - moniker for Anaerobic BioChem
  - soluble sodium lactic acid

  - less soluble ethyl lactate
  - phosphate buffer
  - http://redox-tech.com/ABC%20promo.pdf
- Reducing Agent: **ZVI** supplied by Redox Tech, Ground Cast Iron from Peerless Metal Powders (http://www.peerlessmetal.com); characteristics include:
  - zero valent iron powder in carrier capable of enhancing abiotic chemical reduction and/or microbially mediated chemical reduction
  - same ZVI ingredient in ABC+
  - nominal 100-micrometer ZVI manufactured by Peerless Metal Powders
- Reducing Agent: **ZVI** supplied by HePure, HCA-325 ZVI Powder, (http://www.hepure.com/iron-powder-hcacast.html); characteristics include:
  - zero valent iron powder in carrier capable of enhancing abiotic chemical reduction and/or microbially mediated chemical reduction
  - nominal sub-50-micron particle size
- Blended fermentable substrate and reducing agent: **ABC+** supplied by Redox Tech (http://redox-tech.com); characteristics include:
  - synergistic microbial dechlorination, microbially mediated dechlorination, and abiotic dechlorination
  - moniker for Anaerobic BioChemPlus ZVI
  - blend of soluble lactic acid with a phosphate buffer and ZVI
  - http://redox-tech.com/ABC+.pdf
- Blended fermentable substrate and reducing agent: **EHC-F** supplied by Adventus (http://www.adventusgroup.com); characteristics include:
  - synergistic microbial dechlorination, microbially mediated dechlorination, and abiotic dechlorination
  - moniker for Eh Compound-Fine ZVI
  - blend of cellulose/hemicellulose, ferrous sulfate, and ZVI
  - http://www.adventusgroup.com/projects/proj_ehc_f.shtml
  - ZVI particle size <40 micrometers

Redox Tech's brand of reagents selected for bench testing:

- Meet the screening criteria and other desirable attributes.
- Offer experimental advantage afforded by the certainty that all three of these reagents are made up of directly comparable ingredients.

- Contain some fast-acting (short-lived) ingredients preferred for mixed slurry microcosm testing because they enable flexibility in testing variations in amendment composition (dosage, nutrients, pH buffer, and microbial augmentation), and rebound, within a time frames consistent with mixed slurry microcosm trials.
- Provide the opportunity to assess the role and performance of biotic processes, abiotic processes, and synergistic effects.

There is recognition that Redox Tech's brand of ZVI, Peerless ground cast iron, is of a larger average particle size than some other commercially available ZVI products. It is recognized that smaller-sized ZVI may offer advantage of injectivity (distributability) and reactivity, and disadvantage with respect to longevity. These variables are virtually eliminated in a bench test setting where the ZVI is well-mixed, evenly distributed, and or sufficient duration to reach conclusion. It is perceived that the experimental advantage garnered from testing identical (directly comparable) ingredients among the three reagent types outweighs ZVI size considerations. However, there is merit in comparing and contrasting small particle (Peerless) and smaller particle (HePure HCA-325) ZVI products. There is also merit in comparing and contrasting performance of blended reagents where the substrate material and the ZVI size are sufficiently dissimilar to be meaningful. EPA's suggested counterpart to Redox Tech's ABC+, Adventus' EHC-F, meets that criterion.

In summary, the mixed slurry bench testing will; be performed on the following reagents:

- Redox Tech's Substrate (ABC)
- Redox Tech's Reducer (Peerless ZVI Powder)
- HePure's Reducer (HCA-325 ZVI Powder)
- Redox Tech's Blended Reagent (ABC+)
- Adventus' Blended Reagent (EHC-F)

Use of the selected reagents in mixed slurry microcosm tests does not rule out the prospect for use of alternate reagents in further column tests or pilot tests.

<u>Identification, Screening and Selection of Testing Laboratory</u>

Candidate treatability laboratories are identified and screened for selection in Table 3.10. Laboratory selection is based on criteria that values:

- Bench treatability testing is lab's primary business line.
- Laboratory is experienced with testing chemical reducing reagents (not just bioremediation reagents).
- Laboratory is close enough to the site to enable same day delivery of test samples from the field to the lab.
- Significant capacity to provide flow-through column testing services.

- Laboratory is independent of reagent product sales.
- Demonstration of capacity to perform the bench testing when required.
- Confidence engendered through past performance and interviews with principle treatability scientist(s).
- Existing agreeable SOPs & QAPP(s).
- Contract arrangements are agreeable.

The laboratory selected for bench-scale treatability services is Shaw Environmental's Technology Development Laboratory (Shaw TDL) in Lawrenceville, NJ. The proximity of Shaw TDL to the site (250 miles) enables rapid and direct delivery of test samples to the lab.

Mixed Slurry Microcosm Test Objectives

The objectives of the mixed slurry microcosm bench tests are:

1. Determine the performance of the test reagents at dosages recommended by the remediation engineer and the reagent supplier based on evaluation of the actual or estimated properties of the bench test samples:
   - **ABC** supplied by Redox Tech; a relatively short-lived fermentable carbon substrate intended to enhance microbial reductive dechlorination
   - **ZVI** supplied by Redox Tech; a reducing agent intended to enhance abiotic and microbially mediated chemical reduction
   - **ZVI** supplied by HePure, HCA-325 ZVI Powder; a reducing agent intended to enhance abiotic and microbially mediated chemical reduction
   - **ABC+** supplied by Redox Tech; ABC's fermentable carbon substrate blended with ZVI intended to enhance synergistic microbial dechlorination, microbially mediated dechlorination, and abiotic dechlorination
   - **EHC-F** supplied by Adventus; a blend of cellulose/hemicellulose, ferrous sulfate, and ZVI intended to enhance synergistic microbial dechlorination, microbially mediated dechlorination, and abiotic dechlorination
2. Determine rate-limiting factors and evaluate the need or benefit of supplementing the following items:
   - Reagent
   - pH Buffer
   - Nutrients:
     - Nitrogen
     - Phosphorous
     - Vitamin B12

- Other Essential Nutrients

Selection, Procurement, and Delivery of Test Samples

Candidate soil and groundwater samples will be selected based on information gathered during the initial stages of the PDI, particularly during the field investigation of the Plume Core. Test soils (aquifer sediments) and their representative groundwaters that present a relatively high occurrence of chloroethenes, especially PCE will be targeted. The objective is to test each of three mappable aquifer sediment types (arranged top to bottom):

- Peat
- Fine-grained Silt
- Higher-permeability Sand and Gravel

Capture information sufficient to estimate the initial mixed slurry microcosm test reagent dosages. Measure or estimate, at a minimum, the following parameters for the candidate mixed slurry microcosm test samples, which will be used to establish reagent dosages for the test with the aid of ESTCP's Substrate Design Tool (http://www.serdp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/ER-200627/ER-2006272/(modified)/04May2011), the supplier's feedback, the testing laboratory's feedback, and other considerations by the design engineer:

- Aqueous Geochemistry
  - VOCs
  - Oxidation-Reduction Potential (ORP as Eh)
  - Dissolved Oxygen
  - pH
  - Specific Conductivity
  - Temperature
  - Alkalinity
  - Total Dissolved Solids (TDS, or salinity)
  - Nitrate
  - Nitrite
  - Sulfate
  - Sulfide
  - Ferric Iron
  - Ferrous Iron
  - Chloride

  - Carbon Dioxide
  - DOC (or TOC)
- Aquifer Matrix (Soil)
  - VOCs
  - Total Iron
  - Cation Exchange Capacity
  - Neutralization Potential
  - Manganese (IV) (estimated as the amount of Mn (II) produced)
  - Iron (III) (estimated as the amount of Fe (II) produced)
  - Porosity (total and effective)
  - Soil Bulk Density
  - Soil Fraction Organic Carbon (f_{oc})

During the collection of the field samples for the mixed slurry tests, sub-samples may be collected and analyzed for similar treatability analytes that were assessed during the Plume Core Evaluation, at the discretion of the design engineer.

Mixed slurry microcosm sample materials will be delivered to the laboratory unpreserved in sealed containers designed to maintain anoxic condition; oxygen impermeable capped acetate sleeves (or extruded and transported under nitrogen or argon gas blanket) for aquifer soils, and zero headspace (or under nitrogen or argon headspace) for water.

Samples will be delivered to the lab within 24-hours of collection and maintained within plus or minus 10 degrees F of ambient in situ sample temperature. A minimum of 2 kilograms (5 pounds) of qualifying aquifer sediment (soil) and 5 liters of their representative groundwaters will be required for each soil type to be tested.

Importantly, qualifying test material shall be clearly presented to the lab and be identified by soil type. For soils, acceptable methods include:

- Clearly marked containers whose contents hold only qualifying material
- Clearly marked sections on sample tubes identifying location within the tube of qualifying material(s)
- Project geologist on-hand to establish qualifying material when samples are opened by the lab for preparation

Groundwater samples shall be clearly identified as belonging to its companion soil type.

Field sample preparation and microcosm construction shall follow the provisions of the laboratory's typical protocol as amended for site-specific needs and QAPP, SOP A-29 and Attachment D of the FSP.

Mixed Slurry Microcosms Construction, Setup, and Monitoring

Conceptual construction of the bench test follows; however, the ability to make modifications based on interim results is prescribed. The overall approach is summarized in Figure 3.9.

Bases for Construction and Assumptions

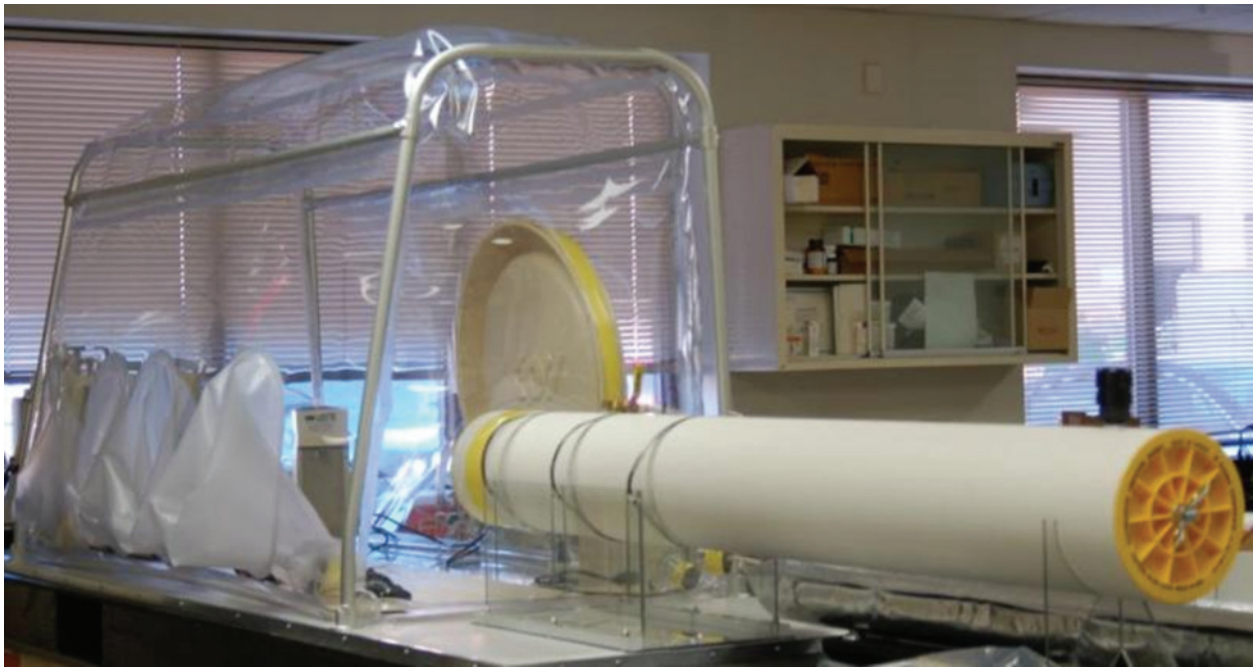
Construction of the bench-scale mixed slurry microcosms is predicated on the following reasonable assumptions:

- Each aquifer soil type will be tested with the following seven (7) microcosms (constructed in quadruplicate and analyzed in duplicate).
  1. (a,b,c,d) - **Natural Control** (represents natural in situ conditions)
  2. (a,b,c,d) - **Sterilized (Killed) Control** (represents natural in situ abiotic transformations)
  3. (a,b,c,d) - **ABC-amended** (represents transformations in presence of fermentable substrate)
  4. (a,b,c,d) - **ZVI-amended [Redox Tech]** (represents transformations due to metallic iron reducing agent)
  5. (a,b,c,d) – **ZVI-amended [HePure HCA-325]** (represents transformations due to metallic iron reducing agent)
  6. (a,b,c,d) - **ABC+-amended** (represents transformation in presence of blended fermentable substrate and metallic iron reducing agent)
  7. (a,b,c,d) – **EHC-F-amended** (represents transformation in presence of blended fermentable substrate and metallic iron reducing agent)
- The neat test reagents all provide some degree of pH buffering.
- Indigenous bacterial community is sufficient.
- Sterilization by autoclave preserves abiotic treatment capacity.
- Sterilization by autoclave results in no significant loss of material.
- Natural essential nutrients are sufficient and sustainable.
- PTFE-lined butyl rubber septa are sufficient to prevent detrimental diffusion or leakage of gaseous into or out of microcosm serum vials for the duration of the test.
- PTFE-lined butyl rubber septa can withstand sterilization by autoclave with insignificant loss of material or long-term functionality.

- Duplicate analysis of replicate microcosms is sufficient to show the degree of variability between replicate microcosms.
- Construction of replicate microcosm samples in quadruplicate enables sufficient sample volume to complete the test.
- Construction of replicate microcosm samples in triplicate enables prospect for modifications during the test if indicated (such as supplementation of reagent dosage, pH buffer, microbes, or nutrients).
- Anticipate maximum test duration of six (6) months; three (3) months for neat amendment testing, and three (3) months for supplemental amendment testing, if indicated.

Mixed Slurry Microcosm Setup

The laboratory shall unpackage and prepare the field samples for testing and construct the microcosms in an anaerobic chamber similar to the one shown in the photograph below. The atmosphere of the anaerobic chamber will be made free of O_2 and H_2 (CO_2 + N_2 only) before constructing the microcosms.



Soils (aquifer sediments) shall be suitably homogenized prior to transfer of approximately 30 milligrams to each 160-ml tare-weighted sterile microcosm test vial. Test water (groundwater sample) shall be added as appropriate to saturate the sediments and fill the vials (less volume for amendment spikes). Amendment spikes shall be added into appropriate microcosms. The microcosm vials shall be sealed with a septum having no meaningful permeability to gases such as water, oxygen, nitrogen, carbon dioxide, methane, ethane,

ethane, and acetylene (even when pierced); PTFE-lined butyl rubber or approved equal. The 'killed control' shall be immediately sterilized by repeated autoclaving. The completed control microcosms will be autoclaved for 20 minutes at 120 °C and 15 psi on three consecutive days, with incubation at room temperature between each autoclave treatment. The autoclaved bottles will be spiked with PCE if necessary to re-establish baseline concentrations. Microcosm bottles will be incubated with gentle shaking on an orbital shaker at 60 degrees F (15°C), plus or minus 5 degrees.

Mixed Slurry Microcosm Monitoring

At each microcosm sampling event, microcosm bottles will be removed from the shaker and placed within insulated containers and in the anaerobic chamber for sampling. Aqueous samples for analyses shall be removed from their microcosm bottles under anaerobic protocol. Removed liquid volume shall be replaced with sterile glass beads before resealing the microcosm bottles.

The nominal frequency of measuring microcosm analytes is:

- Baseline (Day 0)
- Day 15
- Day 45(critical date to determine if supplements should be added to the test)
- Day 90 (key decision points for determination of column test)
- Day 180 (prolonged monitoring used to assess longer term reactions which may be extended based on performance data)

Essential aqueous analytes for testing all microcosms at all intervals are:

- VOCs (short list per Attachment D of the SOW, chloroethenes and chloroethanes)
- Methane, Ethane, Ethene, and Acetylene (MEEA)
- Bench-top analytes (PEST):
  - pH
  - Eh
  - Specific Conductance
  - Temperature

Important aqueous analytes for testing all microcosms at selected intervals are:

- Day 0, Day 45, and Day 90:
  - Fe^{+2}
  - Nitrate

  - Sulfate
  - Chloride
- Day 0, Day 90:
  - TOC
  - VFAs (acetic, butyric, lactic, propionic, pyruvic)

Samples from the mixed slurry microcosms may be collected for bacterial communities' speciation and bacterial counts at a time best indicated by the preliminary VOC results. This data can then be combined with concentration decline data collected from the testing to provide multiple lines of evidence on the robustness and viability of the bacterial populations.

Selected microcosm sediments may be retained upon completion of bench test for additional analysis at the discretion of the design engineer.

Results will be reviewed and interpreted as soon as they are available. It is intended to recognize early indication that lack of substantial performance may be due to conditions such as low (or declining) pH, lack of essential nutrients, insufficient microbial community structure, lack of sufficient reagent, or other discernible reasons. In the event that testing during the mixed slurry microcosms do not indicate any appreciable degradation and/or viable bacterial communities, then bacterial amendments will be made to the existing mixed slurry microcosms to quantify the magnitude of responses to these additions. It is reasonable to expect that these indicators will be evidenced by the time the 15-day results are reviewed, and that modification can be planned and implemented immediately after the 45-day samples are collected. Plans for modification with supplements or other changes could involve only the triplicate or quadruplicate stand-by bottles, or they might be applied to the primary and secondary bottles that have already been sampled, depending on the need.

Furthermore, it is intended that the results of the mixed slurry microcosms testing may guide changes to the scope of the flow-through column testing. Such is the iterative nature of bench-testing; questions are answered and new questions arise, and the test methods are adapted to answer all of the questions.

At the completion of the study, the microcosms will be offered for additional testing, at the discretion of the Remediation Engineer, for some or all of the treatability analytes that were included in the Plume Core Evaluation. Remaining microcosms will be disassembled and all remaining soil and groundwater samples will be disposed.

Mixed Slurry Microcosm Reporting

The laboratory shall communicate regularly with the design engineer. Draft and final analytical results shall be reported immediately to the design engineer. The laboratory and the design engineer shall discuss the prospect for modification to the test based on preceding results. Modifications shall proceed upon notice from, or agreement of, the design engineer. No formal report will be submitted to EPA and RIDEM until the testing is completed (or

substantially completed); however, EPA or its designee shall be provided with verbal updates via telephone or email, as necessary through the process.

The laboratory shall prepare a draft report upon completion of significant testing for submittal to the design engineer. The design engineer shall review and comment on the report. The laboratory shall prepare a final report and submit it to the design engineer.

The laboratory and the design engineer shall discuss the prospect for further testing; mixed slurry microcosm and/or flow-through column testing. A collaborative plan for further testing shall be prepared.

Figure 3.10 conceptualizes how decisions regarding bench testing will be made.

Flow-through Column Testing

The objectives of the flow-through column tests are:

1. Assess design parameters.
    a. Determine reagent(s) candidate for pilot test
    b. Design dosage
    c. Longevity of candidate reagent(s)
    d. Prospect for rebound upon depletion
    e. Mass transfer mechanisms (advective and diffusive) and limitations

The overall approach is shown in Figure 3.11.Key decision-making is summarized in Figure 3.12.

The flow-through column test will be used to evaluate reagent-induced dechlorination in the different aquifer soil types within the overburden aquifer at the Davis Liquid Waste Superfund Site. The column tests intend to:

- More realistically simulate treatability under actual aquifer conditions.
- Identify treatment endpoints.
- Measure the longevity of the candidate treatment reagent and its ingredients.
- Assess the prospect for contaminant rebound following treatment.
- Evaluate the dominant reagent mass transfer mechanisms within each aquifer soil type.

Performing a column test to evaluate diffusion of amendments into, out of, or within different soil types is complicated by the fact that aquifer core samples represent a vertical cross section of the aquifer while groundwater flow is typically horizontal, and thus perpendicular to the core sample. Consequently, pumping groundwater vertically through a column composed of multiple aquifer layers does not necessarily reflect flow in the actually aquifer.

Typically, vertical flow between layers in an aquifer is much slower than what can be tested in a laboratory column, and often vertical movement of contaminants between different layers is limited primarily to diffusion. Nevertheless, column testing provides the best method to replicate actual aquifer conditions in a laboratory setting, and results are sufficient to enable some improved understanding of design constraints. For example, column testing as conceptualized below is sufficiently conservative to enable a conclusion that if agreeable performance is not evidenced on that column then agreeable performance is certainly not anticipated in the field.

The overburden aquifer at the site is composed of multiple layers of different soil types. Notably, it has layers of relatively less permeable organic peat fine-grained silt, and more permeable sands and sand & gravel (in order from top to bottom). If a substrate is added to the aquifer by using traditional injection technology, the substrate is reasonably expected to be preferentially delivered through the higher permeable materials, or to lesser degree in a non-uniform pattern within less-permeable materials. Treatment in the less-permeable materials (e.g., peat, silt, and clay) is reasonably expected to be dominated by:

- Diffusion of reagent (or its ingredients) within the less-permeable materials (if reagent can be emplaced there).
- Diffusion of reagent (or its ingredients) into less-permeable materials from more-permeable neighboring materials.
- Advective vertical flow from more-permeable neighboring materials.

Consequently, to test treatment in the laboratory column test, substrates will be added to a layer of more-permeable material that is overlaid by less-permeable material.

Column Construction

Aquifer columns will be constructed in 3-inch diameter aluminum tubes (Figure 3.13). Use of these columns for evaluating biodegradation of chlorinated alkenes has been described previously (Schaefer et al., 2009, http://www.ncbi.nlm.nih.gov/pubmed/19171368?dopt=Abstract).

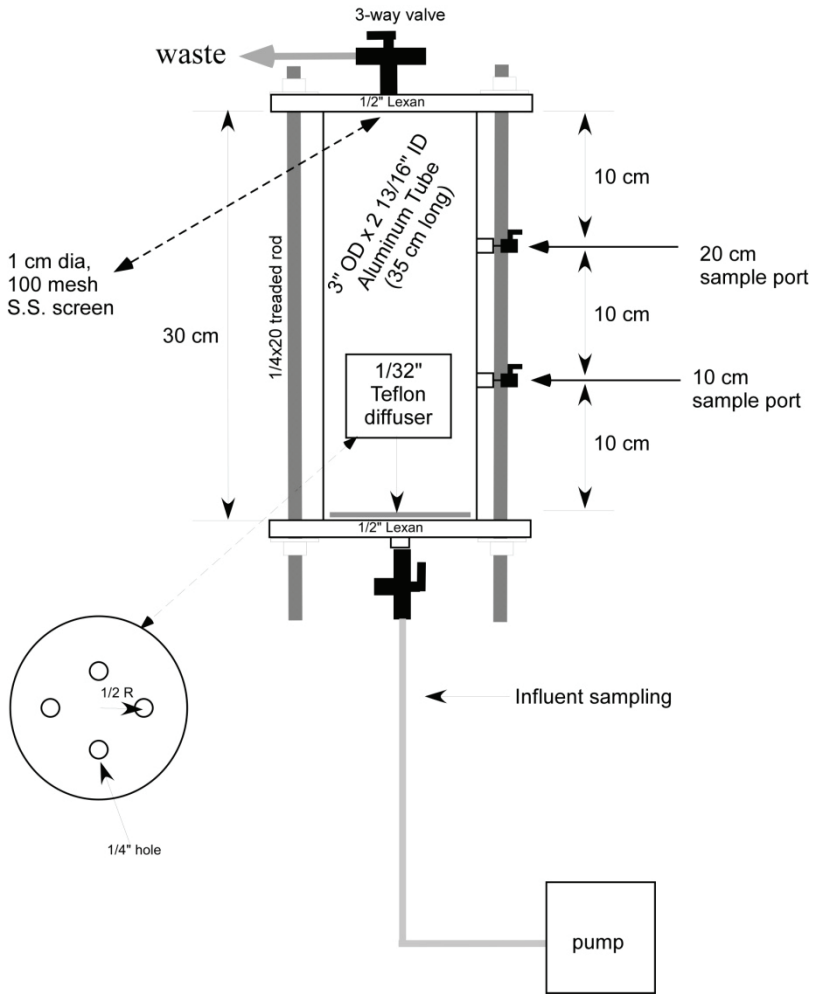


Figure 3.13 Column Test Apparatus

All materials handling and column construction will be performed in an anaerobic glove box. Aquifer sediment (soil) cores will be collected in the field by using either acetate sleeves or Shelby tubes. The tubes will be cut in half in the field if necessary to fit in a cooler, and the ends of the tubes will be capped and secured with tape. The capped cores will be placed on ice in a cooler and delivered (or shipped via overnight courier) to Shaw's Biotechnology Development Laboratory in Lawrenceville, New Jersey.

Upon receipt of the core samples, lab technicians will place the cores in an anaerobic glove box. If acetate sleeves are provided (preferable), the cores will be cut vertically to expose the core materials. Approximately 1 inch of the material on each end of the core (that may have been exposed to oxygen) will be removed and discarded. The remaining material will be visually examined to identify the different layers, and representative material of the peat, silt, and more-permeable sand & gravel material will be collected and combined individually. The composite materials will be homogenized by manual mixing. A subsample of the

homogenized materials will be collected for VOC analysis. If VOC concentrations in the low permeability materials are not sufficiently high to represent field conditions, a contaminant spike of the materials will be considered.

The candidate test reagent(s) (determined from the results of the preceding mixed slurry microcosm and by agreement of all parties after discussions with EPA and RIDEM) will be mixed into the more-permeable sand & gravel material at a dosage recommended by the design engineer after collaboration with the substrate manufacturer and consideration of the expected stoichiometric electron donor requirement of the selected test soils. The reagent-spiked more-permeable sand & gravel material will be packed into the bottom 12 cm of the column.

Low permeability test material will be packed on top of the treated layer to fill the column. The top of the column will then be secured into place. A diagram depicting the loaded columns is presented in Figure 3.14.

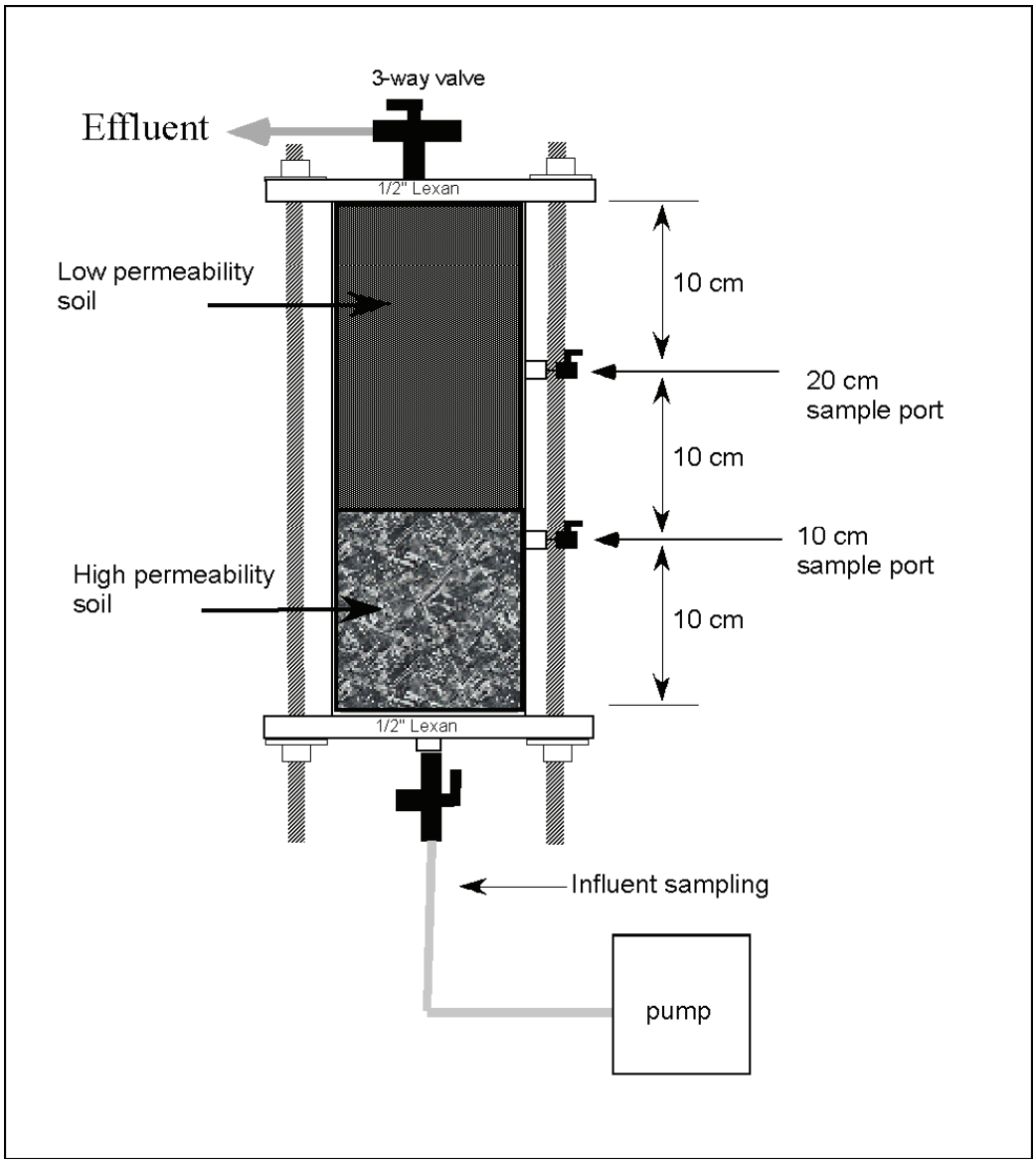


Figure 3.14 Diagram Showing Layering of Soils in Laboratory Columns

Columns will be established in duplicate for each soil type. Consequently, a total of 8 columns will be constructed:

- Column 1a & 1b, sand & gravel spiked with reagent dose #1 + peat
- Column 2a & 2b, sand & gravel spiked with reagent dose #2 + peat
- Column 3a & 3b, sand & gravel spiked with reagent dose #1 + silt
- Column 4a & 4b, sand & gravel spiked with reagent dose #2 + silt

Column Operation

Once constructed, the columns will be sampled at the two sampling ports, one within the high permeable layer and one within the less permeable test material to establish baseline analyte concentrations in the column groundwater. Synthetic anaerobic groundwater (SAGW), based on the geochemical composition of the Site groundwater, will then be pumped into the columns with a syringe pump. The SAGW will be spiked with PCE so that a concentration representative of field conditions is attained. Flow rates will be based on estimates of horizontal flow through the targeted aquifer soils as determined by prior results of the PDI. If it is not possible to closely match the low estimated vertical flow, we will attempt to choose low flow rates that allow reasonable estimates of substrate diffusion or transport into the low permeable layers.

Samples will be collected from the influent reservoir and the 3 column sampling ports at elapsed test times of approximately T=7 days, T=14 days, T=28 days, T=42 days, T=65 days, and T=90 days. The samples will be analyzed for VOCs (Attachment D of the SOW), reduced gasses methane, ethane, ethene and acetylene (MEEA), pH, anions, and volatile fatty acids. Because of the low flow rates, side port sampling may be problematic, and sampling of the side ports will likely be limited to only a few analyses (e.g., VOCs and MEEA). Thus, pH, VFA and anion analysis may be performed only on samples collected at the column effluent.

Sampling and analytical schedules are provided below (Table 3.11 and Table 3.12).

Table 3.11 Number of Samples Collected from Each Column at the Designated Time Points

Treatment	T=0 d	T=7 d	T=14 d	T=28 d	T=42 d	T=65 d	T=90 d	Total
Column 1a	2	4	4	4	4	4	4	**26**
Column 1b	2	4	4	4	4	4	4	**26**
Column 2a	2	4	4	4	4	4	4	**26**
Column 2b	2	4	4	4	4	4	4	**26**
Column 3a	2	4	4	4	4	4	4	**26**
Column 3b	2	4	4	4	4	4	4	**26**
Column 4a	2	4	4	4	4	4	4	**26**
Column 4b	2	4	4	4	4	4	4	**26**
Total	**16**	**32**	**32**	**32**	**32**	**32**	**32**	**208**

Table 3.12 Analyses Performed at Each Sampling Event – Column Testing

Analysis	T=0 d	T=7 d	T=14 d	T=28 d	T=42 d	T=65 d	T=90 d	Total
VOC (EPA 8260)	16	32	32	32	32	32	32	**208**
Reduced gasses (EPA 3810)	16		32		32		32	**112**
pH (EPA 150.1)	8	8	8	8	8	8	8	**56**
VFA (EPA 300m)	8		8		8		8	**84**
Anions (EPA 300.0)	8		8		8		8	**84**

Longevity and Rebound Evaluation

At the completion of the 90-day operation period, groundwater flow will be maintained through the columns to evaluate longevity of the electron donor substrate. The presence of electron donor will be assessed by measuring VFA concentration in the column effluent, or in the first column sampling port, depending on where VFAs are observed during the initial column study. The column will be operated and monitored quarterly until electron donor concentrations are below quantifiable levels as shown in Table 3.13.

Table 3.13 Long-Term Monitoring for Substrate Longevity and Rebound Evaluation – Column Testing

Analysis	T=1 month	T=3 month	T=6 month	T=9 month	T=12 month	T=15 month	T=18 month	Total
VOC (EPA 8260)	8	8	8	8	8	8	8	**56**
Reduced gasses (EPA 3810)	8	8	8	8	8	8	8	**56**
VFA (EPA 300m)	8	8	8	8	8	8	8	**56**

The column flow will then be terminated and the concentrations of VOCs in the pore water of the test material will be determined at flow termination plus T=14 days and T=28 days to evaluate contaminant rebound.

Field-Scale Pilot Testing

The iterative nature of bench/pilot program's decision-making process makes it difficult or impossible to effectively provide a detailed plan for pilot testing until the results of PDI assessments and bench testing are available. Therefore, while a generalized conceptual approach to pilot testing is provided here, a more-detailed Pilot Test Work Plan will be prepared and submitted to EPA after evaluating the results of the PDI field and bench test initiatives.

Objectives

The overarching objectives for pilot testing the reagent(s) nominated for candidacy based on the results of the bench-scale testing effort, as stated in the ROD and/or SOW, include:

- Develop data needed to design the effective distribution of treatment reagent into the subsurface overburden materials in the Active Treatment Zone.
- Ascertain the ability to distribute the reagent in the formation (i.e. variable permeability soils or high water table).
- Ascertain the effectiveness in addressing contaminants in the overburden Plume Core.

It is clear and reasonable, based on EPA's responses to public comments presented in Appendix D (Responsiveness Summary) of the 2010 ROD Amendment, that the pilot test is also intended to provide basis for final selection of the reagent chosen for actual use at the site.

Other items articulated by EPA in its Responsiveness Summary that relate to its preliminary vision for the pilot test include:

- A pilot test will be performed at the Site to evaluate conditions for contaminant treatment. Results of treatment will be evaluated for impacts to the wetlands so that during the full-scale implementation, impacts to the wetlands are minimized.
- A pilot test (on a very small scale) will be performed at the Site to evaluate test conditions and the byproducts of treatment, as necessary, the design of the full-scale treatment will take the generation of byproducts into consideration to ensure minimal impacts to human health or the environment.
- A pilot test will be performed to evaluate site-specific factors so that treatment can be optimized.
- The potential for decreased pH as the result of reductive dechlorination may be offset by the addition of buffers into the treatment reagent, which can be evaluated in a field pilot test.
- EPA anticipates that it will further refine this [sic. chemical reduction] technology to increase its effectiveness at this Site through pre-design studies. Each site is different, and site-specific conditions may favor or inhibit effective treatment. Therefore, a pilot

test is required under the selected remedy as part of the pre-design investigation to assess the potential effectiveness under site-specific conditions.

- Conduct a pilot study to verify the implementability and effectiveness of treatment.
- During the pilot test, the subsurface conditions will be explored and evaluated, and the effectiveness of injection and the radius of influence will be evaluated.
- During the pilot study, these amendments can be tested for their efficacy in addressing SVOCs and pesticides.
- As part of the pre-design investigation and the on-site pilot study, the issue of pH increases and addition of buffering agents will be evaluated for their ability to moderate metals mobilization.
- As part of the on-site pilot test, the effect of ZVI and enhanced biodegradation interactions will be evaluated based on site-specific conditions. Vendors have developed ZVI reagents that are meant to complement enhanced biodegradation activity. Pressure injection may follow preferential pathways. Some vendors have developed delivery systems to address heterogeneities in how the reagents will be distributed into the subsurface.
- The final selection of the appropriate chemical reducing agent will be dependent on the pilot test results.
- One goal of the pilot test is to identify the appropriate chemical treatment reagent for in-situ reduction. ZVI is a good candidate that will be tested to see how well it can be distributed under site-specific conditions. Depending on the reagent delivery system, effectiveness of treating silty or clay soils will be evaluated during the pre-design investigation pilot test.
- The loading of sufficient quantities of ZVI and other treatment reagents will be assessed during the predesign investigation and pilot test to ensure that appropriate subsurface geochemical conditions are attained to ensure proper degradation.
- EPA recognizes the limitation of column or bench-scale studies. Therefore, a pre-design investigation incorporating an on-site pilot test will be conducted to more fully characterize the area or zones to be treated, evaluate the implementation requirements, and assess the effectiveness of treatment.
- Results of the pilot study will be used to determine how best to implement the remedial action at full-scale and to support the remedial design.

Conceptual Approach to Pilot Testing

The framework for a conceptual approach to pilot testing follows:

- Capture and evaluate the results of PDI Plume Core investigation:
  - Nature and distribution of impacts in each distinct aquifer soil type

- Physical properties of each distinct aquifer soil type
- Hydrogeologic properties of each distinct aquifer soil type
- Biogeologic properties of each distinct aquifer soil type
- Lessons learned regarding ability to use direct-push conventional (injection) rods within the overburden aquifer

- Capture and evaluate the results of bench-scale tests resulting in nomination of a suitable reagent type.
- Obtain EPA and RIDEM concurrence on reagent nominated for pilot testing.
- Identify potentially applicable reagent delivery systems.
- Screen potentially applicable reagent delivery systems for effectiveness and implementability.
- Select the most-promising reagent delivery method for pilot testing and obtain EPA and RIDEM concurrence.
- Prepare Pilot Test Work Plan and submit to EPA and RIDEM for approval.
- Typical key elements of the Pilot Test Work Plan include:
  - Overview
  - Objectives and Goals
  - Rationale for Pilot Test
  - Strategy for Pilot Test
  - Basis for Pilot Test
  - Identification of Pilot Test Team:
    - Prime Contractor:
      - ✓ Manager
      - ✓ Engineer
      - ✓ Geologist
      - ✓ Chemist
      - ✓ Biologist
    - Subcontractors and/or Vendors:
      - ✓ Reagent injection/delivery services
      - ✓ Analytical laboratory services
  - Pilot Test Layout:
    - Reagent deliver location(s)

    - Performance monitoring locations
  - Observation Well Design
  - Decision-making framework for conclusion/modification of pilot test
  - Reagent Handling:
    - Delivery
    - Storage
    - Mixing
    - Transfer
    - Injection
    - Safety
  - Short-term Performance Monitoring
    - Means
    - Methods
    - Frequency
    - Interpretation
  - Long-term Performance Monitoring
    - Means
    - Methods
    - Frequency
    - Interpretation
  - Reporting
  - Health and Safety Planning

Consistent with the framework provided in the RD/WP, the pilot testing will utilize a combination of investigative and monitoring techniques. The investigative and monitoring approaches, dependent on the reagent selected, could include any combination of the following:

1. Quantification of reagent injection volumes by depth intervals and location to estimate reagent subsurface mass.
2. Monitoring of groundwater concentrations and general water chemistry in discrete screened monitoring wells.
3. Post injection soil sampling at select locations and assessment on soil geochemistry (pH, redox, TOC and iron content).

4. Geophysical techniques for assessment of changes in soil conductivity and resitivity (only applicable to reagents that contain iron).
5. Post injection and long-term monitoring of COC concentrations in groundwater within the treatment area.

It is anticipated that further definition of the pilot testing program will be provided following completion of the Plume Core investigations and initial slurry phase benchscale tests. This more defined program of pilot testing will be discussed with EPA and RIDEM prior to submission of a pilot test work plan prior to or at completion of the column tests.

3.2 Groundwater Evaluation

The goal of the groundwater evaluation is to establish a groundwater monitoring program that will be used to assess the status of the overburden and bedrock plumes prior to, during, and after remediation, and to assess the potential for off-Site groundwater impacts. Information and data developed under this evaluation will be used in the formulation and refinement of the Long-Term Monitoring Plan, as appropriate. The rationale and strategies to assess the groundwater flow regime, extent of impacted groundwater and potential migration of the impacted groundwater in the overburden and bedrock plumes are provided in the following sections.

3.2.1 Residential Well Monitoring

The goal of the residential well monitoring program is to assess whether contaminated Site groundwater has the potential to impact off-Site areas identified during the public comment period. The areas identified during the public comment period include, but are not limited to, residential properties along Log Road, Williams Road, the Sprague Upper Reservoir and the YMCA's Shephard Reservation property. As a result of the negotiations during the Special Notice Period, this program will be phased and will initially consist of the installation and monitoring of sentry wells within the bedrock that will provide an early warning system designed to detect the migration (if any) of the bedrock groundwater plume towards off-Site residential wells. The second phase of the program (monitoring of residential supply wells) will only be performed if evidence of off-Site migration of Site COCs is identified and confirmed during the monitoring of the sentry wells. A work plan for the implementation of the second phase of the program will be developed and submitted to the EPA for review and approval, if required.

An evaluation of the regional groundwater flow relative to the Site is also presented below to support the locations and design for the proposed sentry wells, which will be used to provide the early warning system for potential off-Site migration of impacted groundwater within the bedrock.

3.2.1.1 Regional Bedrock Groundwater Flow

Local basin-wide bedrock groundwater flow is described in detail in Section 2.0 of this PDI (Site Conceptual Model). In summary, bedrock groundwater flow within the Site is predominately from the eastern, southern and western upland areas towards the central

portion of the Site. It is conceptualized that the regional bedrock groundwater flow is towards Stillwater Reservoir from an approximately northwest to southeast direction. The key assumption in this conceptualization is that the Stillwater Reservoir is the lowest surface water point in the area, with an elevation of approximately 207 ft MSL. The potentiometric head differential between the Site's bedrock groundwater elevation and the Stillwater Reservoir elevation is approximately 200 feet. Therefore, groundwater will flow from the highest elevation to the lowest point in the region. Within the Site, the bedrock plume demonstrates an elongation in the northerly direction while maintaining this generally west to east flow pattern. This northerly elongation is hypothesized to be the result of the predominately north-south orientation of the primary fracture fabric within the crystalline bedrock. Based on the regional flow system and the bedrock flow conditions observed at the Site, relative to the current understanding of the bedrock plume, sentry well locations were selected beyond the current extent of the bedrock plume in the northern, northeastern and eastern directions.

3.2.1.2 Proposed Sentry Well Network

The SOW states that four sentry well pairs consisting of an overburden well and bedrock well will be located downgradient of the bedrock groundwater plume. However, the Davis Site Group is proposing an alternative approach of four bedrock sentry wells and no overburden sentry wells. No overburden wells are proposed in this PDI because: 1) the existing Site-wide groundwater monitoring well network and the ongoing Site-wide monitoring program provide comprehensive monitoring of the lateral contaminant migration in the overburden. This well network will detect if changes in plume migration occur; and 2) the groundwater receptors of concern (residential wells) are principally installed/screened in the bedrock. Therefore, the optimal placement of the sentry wells corresponds with the zone of interest.

Two of the bedrock sentry wells will be assigned to existing bedrock wells (OW-200-R and OW-086); and the other two sentry wells will be newly constructed wells. The locations of the four proposed sentry wells are shown on Figure 3.15 and the locations are identified as SMW-1 through SMW-4. The locations of the sentry wells were developed to provide monitoring points between the bedrock groundwater plume and the residential wells located along Log Road and Bayberry Road to the north, northeast and east of the Site.

The bedrock sentry wells are designed to monitor the bedrock zone that is likely to be used by nearby residential wells. The vertical elevations of the water withdrawal zones were estimated by conducting an analysis of the existing residential wells identified and inventoried by CDM in the 1986 Remedial Investigation (CDM, 1986) reported to have detections of groundwater impacts similar to those observed at the Site. The identified wells were grouped into three geographic regions (north, northeast and east) based on the regional and Site groundwater flow patterns in the bedrock. For each of the well groups, the average elevation of the total well depth (typical) and elevation range of the groundwater withdrawal interval (typical) were compiled and are summarized below. For this evaluation, it was assumed that the residential bedrock wells are open bedrock boreholes from approximately 30 feet bgs to

the bottom of the well (reported well depth). Table 3.14 presents the results of the evaluation of the existing residential supply wells.

Table 3.14 Summary Information for Existing Residential Supply Wells (CDM, 1986)

Geographic Region	Typical Well Depth Elevation (ft MSL)	Typical Water Withdrawal Zone (ft MSL)	Mid-point Elevation of Water Withdrawal Zone (ft MSL)
North (Log Road)	288	288 to 415	352
Northeast (Log Road)	243	243 to 395	319
East (Bayberry Road)	230	230 to 380	305

It is proposed that the sentry bedrock wells be designed to intercept the mid-point of the residential wells' water withdrawal zones assumed for each geographic region discussed above. This approach provides the following advantages: 1) standardizes the monitoring intervals with the residential well water use intervals; and 2) is a basis for well design (depth and screen interval). Table 3.15 presents the proposed well construction details for the new sentry bedrock wells and the construction details for the existing bedrock wells selected to be used as sentry wells. The results of the proposed geophysical logging of existing bedrock wells (OW-79 and OW-89) will be used to refine the screen intervals for the two proposed sentry wells (refer to Section 3.2.2.2). Any proposed changes to the screen intervals for the two sentry wells will be presented in a technical memorandum and submitted to EPA and RIDEM for their approval.

Table 3.15 Construction Details for Existing and Proposed Sentry Wells

Well ID	Geographic Region	Existing or Proposed	Well Depth (ft bgs)	Screen Length (ft)	Well Depth Elevation (ft MSL)	Screen Interval Elevation (ft MSL)
SMW-1	North	Existing	70	15	340	340 to 355
SMW-2	North	Proposed	66	20	340	340 to 360
SMW-3	Northeast	Proposed	95	20	310	310 to 330
SMW-4	East	Existing	101.5	20	282	280 to 302

Note: SMW-1 is existing well OW-200-R and SWM-4 is existing well OW-086.

3.2.1.3 Sentry Well Installation

The proposed new sentry wells will be installed using air rotary drilling methods. Drilling and well construction will be conducted in accordance with SOP A-1 and SOP A-6 of the FSP. The wells will be developed using standard pump and surge techniques in accordance with SOP A-6 in the FSP. If warranted, qualitative yield testing (using a single packer setup to isolate the proposed screen interval) will be performed to assess the potential flow rate within the

proposed screen interval to avoid installation of the well screens within low-yielding competent bedrock. Qualitative yield testing would be performed in accordance with SOP A-7 of the FSP.

3.2.1.4 Monitoring and Sampling

It is proposed that the four sentry wells (SMW-1 through SMW-4) be sampled semiannually during the spring and fall monitoring events. The sampling frequency is designed to assess potential temporal changes in groundwater quality influenced by seasonality changes. It is proposed that the wells be sampled during the typically wet (spring) and dry (fall) seasons. The sentry well samples will be analyzed for VOCs, arsenic and manganese. These analytes were selected for the sentry well monitoring program because VOCs are the principal constituents of the bedrock groundwater plume downgradient of the FSA and arsenic and manganese are the two inorganic Site COCs that could be influenced by the geochemical conditions at the Site. VOCs also represent the most mobile of the Site COCs and therefore are the appropriate analytes for an early warning monitoring system, such as the sentry well program. It is anticipated that subsequent years of the monitoring program will be defined further in the Long-term Monitoring Plan. All wells will be sampled in accordance with SOP A-11 of the FSP. Sample handling and quality assurance protocols and field measurement and laboratory analytical methods are detailed in the FSP and the QAPP.

Physical parameters to be measured include the following:

- Depth to groundwater: water level measurements will be collected using an electronic water level sensor or interface probe in accordance with SOP A-8 contained in the FSP. Measurements will be recorded on the Water Level Measurements Form contained in Attachment B of the FSP.

Chemical parameters to be measured and analyzed for include the following:

- Field parameters: pH, conductivity, temperature, oxidation/reduction, turbidity, Eh, and dissolved oxygen (DO). Field parameters will be measured in accordance with SOP A-11 of the FSP.
- VOCs, arsenic and manganese at sentry wells SMW-1 through SMW-4. The metals analyses will include filtered (0.45 microns) and unfiltered samples (i.e., total and dissolved).

3.2.1.5 Data Analysis

The groundwater data collected from the sentry wells will be evaluated to assess if the sentry wells have detections of Site COCs and if the detected concentrations, if any, exceed the IGRGs established for this Site as specified in the 2010 ROD Amendment. In addition, groundwater analytical data from Site background wells (e.g., OW-82 and OW-201R) may be used as necessary to support the analysis of the sentry well data, particularly to assess the detected concentrations of arsenic and manganese. The detection of Site COCs may be an

indicator that Site contaminants have migrated to the sentry wells. The decision approach to assess the data will be:

- Compare the groundwater sampling results to the IGRGs.
- If no COC(s) are detected above the IGRGs, then continue with the monitoring program.
- If VOCs are detected above the ROD groundwater standards, immediately proceed with resampling of the well to verify the results. If the results are verified for VOCs, proceed with the development of a work plan to implement the Residential Monitoring Program, as specified in the SOW.
- If arsenic and/or manganese are detected at concentrations above the IGRGs, then continue monitoring for two additional sampling events to determine if the arsenic and/or manganese concentrations are influenced by seasonal variability with time and proceed with an evaluation of the Site background well data for arsenic and manganese and any available local or regional water quality data for these two metals. Statistical methods may be used to assess the detected concentrations in the sentry wells versus the available background data (both Site and regional). These methods are discussed below. If after the completion of the two additional sampling events and the evaluation of the background metals data, it is concluded that the arsenic and/or manganese concentrations exceed the IGRGs at the sentry well locations, proceed with the development of a work plan to implement the Residential Monitoring Program, as specified in the SOW.

As discussed above, the groundwater data will be evaluated using graphical methods such as plotting temporal concentration data; and if necessary, statistical methods will be used to evaluate the VOC and metals data to determine if the groundwater quality parameters have exceeded the IGRGs. Two fairly simple and straightforward statistical approaches (Mann-Whitney U test or the Mann-Kendall Test) can be used to evaluate the sentry well groundwater data, if warranted.

As previously stated, the SOW recognizes that elevated (naturally occurring) concentrations of manganese and iron are present in groundwater in the area that may be affected by alteration of the geochemical conditions at the Site. On this basis, the data analyses will take into consideration the natural variability in geochemical conditions and background concentrations of naturally occurring inorganic compounds, such as arsenic and manganese. Also, based upon our experience in New England, there are naturally elevated levels of arsenic and manganese present in the bedrock groundwater. Establishment of the range of naturally occurring background conditions will be based on the results of the background monitoring wells sampled as part of the Site-wide monitoring program and data from publicly available literature and databases. An example of a database that could be utilized in this evaluation is the USGS National Water Information System at http://nwis.waterdata.usgs.gov/ri/nwis. USGS manages this water quality database for water wells and surface reservoirs located in Rhode Island. The USGS database contains organic,

inorganic and geochemical analytical data for water wells and surface reservoirs located in Rhode Island.

3.2.2 Groundwater Investigation

The purpose of the groundwater investigation is to develop data to enhance the current understanding of the overburden and bedrock plumes and to use the results of the investigation to support the preparation of the Long-Term Monitoring Plan. In accordance with the SOW, two objectives will be addressed in the groundwater evaluation and monitoring program: 1) establish a monitoring well network in the overburden plume downgradient of the wetlands to evaluate the performance of the natural attenuation processes in the untreated portion of the plume and assess the ongoing contribution of the wetlands to downgradient impacts; and 2) provide additional characterization of the bedrock aquifer east and downgradient of the FSA. The SOW stated that additional wells shall be installed in areas that are downgradient of the FSA and shall complement the existing monitoring well network. The Focused Feasibility Study (Nobis 2010) also stated that in order to provide a more fully characterized bedrock aquifer, it recommended that four additional deep bedrock monitoring wells be installed in areas that are down-dip of the FSA. These statement were taken into consideration during the design of the proposed additional bedrock monitoring well program discussed herein.

3.2.2.1 Overburden Transect Wells

As stated in the SOW, a series of overburden groundwater monitoring well transects will be established in the overburden plume downgradient of the wetlands to evaluate the performance of natural attenuation processes in the untreated portion of the plume and the ongoing contribution of the wetlands to downgradient impacts. Figure 3.15 provides the approximate locations for the proposed overburden transects. The transects have been located to meet the objectives as outlined in the SOW and to utilize two existing well couplets (OW-41/OW-43 and OW-36/OW-38) which will accomplish the following:

- Provide continuity to the historic groundwater analytical data at the two existing well couplet locations.
- Provide bedrock monitoring wells within each transect that can be used to assess the vertical hydraulic gradients between the overburden and the underlying bedrock.

Well Installation

It is proposed that each transect will consist of six overburden monitoring wells installed as well pairs at three locations per transect (including the two existing overburden monitoring wells). Based on the information available for the existing well couplets, the saturated thickness in the area of the proposed transects ranges from approximately 10 to 20 feet. The saturated thickness will be evaluated at the time of well installation. If the saturated thickness at a proposed transect location is less than ten feet, only one well will be installed at that location. The proposed transect wells will be constructed using five feet of well screen and the shallow well will be screened in the vicinity of the water table and the deep well will

be screened at the bottom of the overburden based on the conditions encountered at each location.

The wells will be installed using either direct push or Rotasonic drilling techniques in accordance with SOPs A-1 and A-6 in the FSP. Well development will be performed in accordance with SOP A-6 in the FSP.

Well Sampling

The overburden transect wells will be incorporated into the ongoing Site-wide monitoring program following installation and development of the proposed wells. Details on the proposed Site-wide monitoring program that will be implemented during the PDI are provided in Section 3.2.3. These wells will also be incorporated into the Overburden MNA monitoring program and details on this program are provided in Section 3.3.2.

3.2.2.2 Bedrock

The additional bedrock wells proposed in this PDI will be used to fill potential data gaps in the bedrock monitoring network and to provide additional data within the FSA. In addition to providing additional data on the lateral extent of groundwater impacts, the data from these additional wells will be used to define:

- Nature of the bedrock structure (e.g., degree of fracturing, hydraulic conductivity) to assess hydraulic interconnectivity of the well network.
- Vertical distribution of VOCs.
- Potential contaminant mass flux out of the bedrock into the overburden and potential for re-contamination of the overburden groundwater via vertical flow from the underlying bedrock.

Provided below is a summary of the bedrock characterization program including a description of the proposed bedrock wells grouped by objectives along with summaries of the hydraulic monitoring program and borehole geophysical surveys proposed to support the bedrock investigation. Details of the bedrock aquifer characterization program such as rationale and investigation methods are provided in Table 3.16. Specific details of the investigation methods presented in Table 3.16 include well installation methods and other investigation tasks that will be conducted during the bedrock investigation program and are presented in Section 3.3.1 (aquifer testing, DNAPL testing, and biodegradation studies).

All of the proposed bedrock monitoring wells will be included in the Site-wide monitoring program that is described in Section 3.2.3. The proposed overburden piezometer (OW-400-O) will only be used for the collection of groundwater elevation measurements.

Field Methods

Details of the field methods used to implement the above proposed scope of work are provided in the FSP. The SOPs for the bedrock investigation are the following.

- SOP A-1 Soil and bedrock boring, drilling and sampling
- SOP A-2 Soil logging and physical parameter soil sampling
- SOP A-4 Calibration of field monitoring equipment
- SOP A-5 NAPL Screening and DNAPL Contingency Plan
- SOP A-6 Monitoring well construction and development
- SOP A-7 Bedrock packer sampling
- SOP A-8 Groundwater level measurement
- SOP A-23 Borehole geophysics
- SOP A-28 In situ evaluation of NAPL with FLUTe liners

Borehole Geophysical Survey

Borehole geophysics will be performed on selected existing bedrock wells completed with open, uncased boreholes. The locations of the well to be logged are shown on Figure 3.15 and a description of the survey program is provided in Table 3.16. The geophysical survey data will be used to:

- Characterize fracture patterns within the bedrock (schistosity / foliation patterns)
- Attempt to identify spatial distribution of fracture patterns and frequency of fractures with depth
- Identify hydraulically, active bedrock fractures
- Determine physical properties of rock fractures and potential connectivity of fractures between the source area and down gradient areas
- Collect data to provide supporting information for the design of the proposed down-dip bedrock wells

The wells selected for the geophysical survey are.

- OW-80: East of plumes (NX-borehole; open between 22.5 to 96.6 feet bgs)
- OW-82: South of FSA (6-inch borehole; open between 40 to 200 feet bgs)
- OW-085: West of FSA (6-inch borehole; open between 34.5 to 90 feet bgs)
- OW-089: North of plumes (6-inch borehole; open between 45 to 200 feet bgs)
- OW-079: Northeast of plumes (NX-corehole; open between 22.5 to 97 feet bgs)

The geophysics that will be performed on the wells will consist of fluid temperature, fluid resistivity, and caliper in each of the five wells and, additionally, heat-pulse flow, acoustic televiewer, and optical televiewer in the larger diameter open boreholes (6-inch boreholes). Fluid temperature, fluid resistivity, and caliper logs will only be performed on the boreholes

cored by the NX drilling method (OW-079 and OW-080) to minimize the risk of the larger-diameter geophysical tools from becoming stuck in the borehole.

Former Source Area Wells

Three shallow bedrock wells will be installed in the FSA. The proposed wells will be co-located with existing overburden wells OW-054, OW-093, and OW-94-O located in the FSA (Figure 3.15). The three shallow bedrock wells are identified below:

- OW-403-R: FSA Central, co-located with wells OW-094-O
- OW-404-R: FSA South Disposal Area, co-located with well OW-093
- OW-405-R: FSA North Disposal Area, co-located with well OW-054

Table 3.16 provides specific details on the rationale and methods to be used to implement the FSA bedrock characterization program. The bedrock boreholes for the proposed FSA wells will be drilled 15 feet into the bedrock and the wells will be constructed with five feet of well screen within the lower portion of the borehole. The wells are designed to target the shallow weathered and fractured bedrock that is most likely hydraulically connected to the overburden and may have been impacted by DNAPL. The boreholes will be drilled using rotary coring drilling methods (NX or HQ method) and the open borehole will be tested using a FLUTe liner to identify the potential absence or presence of DNAPL. The purpose of coring the boreholes is to collect whole rock cores for visual characterization and identification of possible rock fractures. Groundwater samples will be collected from each well in accordance with the Groundwater Monitoring Program.

Down-Dip Delineation Wells

Three deep bedrock wells will be installed east and down-dip of the FSA. The proposed well locations are show on Figure 3.15. The down-dip bedrock wells are identified below:

- OW-400-R: approximately 650 ft east of the FSA South Disposal Area
- OW-401-R: approximately 390 ft east of the FSA Central Area
- OW-402-R: approximately 390 ft east of the FSA Northern Disposal Area and co-located with well couplet OW-102-O/R

The purpose of the down-dip bedrock wells is to delineate the extent of the bedrock plume east of the FSA by targeting bedrock fractures that may potentially originate from the FSA and dip east, which may be conduits for impacted groundwater and/or DNAPL to migrate from the FSA.

The Davis Site Group proposes to determine the well depth of the down-dip bedrock wells by using borehole geophysics to map the fracture patterns in the study area (see previous Borehole Geophysical Survey discussion). The Borehole Geophysical Survey will characterize the fracture patterns of the bedrock (schistosity / foliation patterns) and provide evidence of

the spatial distribution of the facture patterns, if any, particularly with increasing depth. Based on these patterns, the well depths and screened intervals will be determined. A technical memorandum will be submitted to the EPA and RIDEM documenting the results of the borehole geophysical logging and providing recommendations for the installation and construction of the three down-dip bedrock monitoring wells.

If the findings from the geophysical logging are inconclusive and do not support the selection of screened intervals for the down-dip bedrock monitoring wells, qualitative packer sampling will be considered, in one or more of the proposed borings. The qualitative packer sampling will be performed in accordance with SOP A-7 in the FSP using similar methods to those utilized during the Phase 3 well installation program.

Table 3.16 provides specific details on the rationale and methods to be used to implement the down-dip delineation program. The proposed bedrock wells will be installed to a depth determined by the results of the Site-wide geophysical survey program with the lower 10 feet of the well screened. The well depth is designed to target fractures that may be connected to the bedrock underneath the FSA. Proposed well OW-401-R will be cored using rotary coring method. The purpose of coring this borehole is to collect whole rock cores for visual characterization and identification of possible rock fractures. The other two wells (proposed wells OW-400-R and OW-402-R) will be installed using air rotary drilling methods. Groundwater samples will be collected from each well in accordance with the Groundwater Monitoring Program.

As part of this task, one overburden piezometer (OW-400-O) will be installed adjacent to the proposed down-dip bedrock well OW-400-R. The location of the proposed overburden well is shown on Figure 3.15. The purpose of the well is to assess the variance in the vertical hydraulic gradient between the overburden and the underlying bedrock and provide additional groundwater elevation control for evaluation of the overburden potentiometric surface.

Downgradient Delineation Wells

Two deep bedrock wells will be installed downgradient and north of the FSA. The proposed well locations are shown on Figure 3.15. The downgradient bedrock wells are:

- OW-406-R: downgradient of the FSA and co-located with well couplet OW-51/OW-101-R
- OW-407-R: downgradient of the FSA and co-located with well couplet OW-112-O/R

Table 3.16 provides specific details on the rationale and methods to be used to implement the downgradient delineation program. The objective of these wells is to assess the vertical distribution of COC concentrations in the bedrock groundwater. The proposed bedrock wells will be installed to a depth of 310 feet MSL (approximately 95 feet bgs) with the lower 10 feet screened. The depth of 310 feet MSL places the screen interval approximately 30 feet below known groundwater impacts at both of the proposed locations. Both wells will be

installed using air rotary drilling techniques. Groundwater samples will be collected from each well in accordance with the Groundwater Monitoring Program.

3.2.3 Groundwater Monitoring

As stated in the SOW, the objective of this evaluation is to establish a groundwater monitoring program that will be used to assess the status of the overburden and bedrock plumes prior to, during, and after remediation, and to assess the potential for off-Site impacts. Information and data developed under this evaluation will be used in the formulation and refinement of the Long-term Monitoring Plan, as appropriate. The monitoring program to assess the potential for migration of impacted groundwater off-Site was previously presented in Section 3.2.1.

The Site-wide groundwater monitoring program to be performed in support of the Remedial Design will commence with the April 2012 monitoring event. The focus of the monitoring program will include the following:

- Provide data on current conditions within the overburden and bedrock groundwater plumes.
- Provide a snapshot of current geochemical conditions within the plumes.
- Provide analytical data for newly installed monitoring wells.
- Provide hydraulic data to assess overburden and bedrock groundwater flow and interaction.

The Site-wide monitoring network will consist of the following monitoring wells, which includes the additional monitoring wells described above.

- All existing monitoring wells sampled during the Phase 4 Monitoring Event in fall 2008.
- All Overburden deposit transect wells located in transect OBT-1 (up to five additional wells) and transect OBT-2 (up to five additional wells) proposed to be installed within the downgradient portion of the Overburden Plume.
- All proposed additional bedrock monitoring wells (eight wells) to be installed down-dip of the FSA (three wells), downgradient of the FSA (two wells) and within the FSA (three wells).

Refer to Table 3.17 for an overview of the proposed Groundwater Monitoring Program. Figure 3.16 shows the locations of the existing and proposed monitoring wells that will be included in the Groundwater Monitoring Program. The monitoring approach for the proposed Plume Core monitoring wells was addressed in Section 3.1.1 of this work plan. Those wells will not be incorporated into the ongoing Site-wide monitoring program.

The monitoring wells will be sampled three times per year and collected samples will be submitted for laboratory analysis of VOCs (to include 1,4-dioxane), SVOCs, pesticides, PCBs and metals for the initial year of monitoring. It is anticipated that subsequent years of the monitoring program will be defined in the Long-term Monitoring Plan.

All wells will be sampled using low flow sampling techniques in accordance with SOP A-9 of the FSP. Sample handling and quality assurance protocols and field measurement and laboratory analytical methods are detailed in the FSP and the QAPP.

Physical parameters to be measured include the following:

- Depth to groundwater: water level measurements will be collected using an electronic water level sensor or interface probe in accordance with SOP A-8 contained in the FSP. Measurements will be recorded on the Water Level Measurements Form contained in Attachment B of the FSP.
- Depth and thickness of NAPL, if present: gauging of NAPL will be conducted with an interface probe in accordance with SOP A-8 contained in the FSP. This information will be documented on the Water Level Measurements Form contained in Attachment B of the FSP.

Chemical parameters to be measured include the following:

- Field parameters: pH, conductivity, temperature, oxidation/reduction, turbidity, Eh, and dissolved oxygen (DO). Field parameters will be measured in accordance with SOP A-9 of the FSP
- VOCs, SVOCs (including 1,4-dioxane), pesticides, PCBs and metals at all well locations
- Geochemical parameters via laboratory analysis at selected monitoring well locations

The details on which wells will be monitored for geochemical parameters is provided in Section 3.3 of this work plan.

All accessible monitoring wells gauged during the Phase 4 Monitoring Event and proposed in the PDI Work Plan for installation, including the bedrock investigation wells, Plume Core wells and sentry wells, will be included in the groundwater elevation monitoring program. The site-wide water level measurement program will be conducted during each tri-annual groundwater sampling event. All water level measurements will be obtained during a single day within an 8-hour period of time (synoptic event).

3.2.4 Vapor Intrusion Assessment

EPA performed a vapor intrusion screening evaluation that was documented in the Focused Feasibility Study (Nobis, May, 2010). The screening evaluation concluded that overburden and bedrock groundwater VOC concentrations exceeding the EPA Vapor Intrusion Guidance screening values are limited to four of the parcels comprising the majority of the Site. The assessment also concluded that there are no current potential risks posed by vapor intrusion due to VOCs in groundwater because there are no current residences residing above the contaminated groundwater plume.

In accordance with the SOW, a vapor intrusion assessment and response plan shall be prepared, upon EPA's and RIDEM's request in response to a proposal by a property owner to construct an occupied structure within, or in close proximity to, the overburden plume, to assess the potential

for vapor intrusion threats from groundwater. Upon request by EPA and RIDEM, a work plan for performance of these activities will be submitted for their review and approval.

In accordance with the decision making framework outlined in the RDWP, the groundwater investigations discussed above will provide further definition on the area in which vapor intrusion may have to be evaluated.

3.3. Fate and Transport and Natural Attenuation Evaluation

The goal of this evaluation is to assess the fate and transport of impacts and natural attenuation processes in the bedrock plume throughout the Site. Consistent with the SOW, the goal of these evaluations is to demonstrate that natural attenuation is occurring at a sufficient rate to merit selection of MNA as the remedial action for bedrock groundwater (Operable Unit 4) and to evaluate the performance of the selected MNA remedy for the untreated portions of the overburden plume. A key component of the Fate and Transport and Natural Attenuation Evaluation program is to collect site-specific data to supplement the assessment of fate and transport, plume stability and hydraulic properties of the bedrock to better define the constraints on natural attenuation processes or (if required) active remediation.

To evaluate the use of MNA, the SOW requires the collection of three "lines of evidence" in accordance with EPA's OSWER Guidance 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites.* These lines of evidence comprise:

- Historical groundwater chemistry data that demonstrates a clear and meaningful trend of sequential decay and decreasing contaminant mass and/or concentration over time at appropriate monitoring or sampling points. This will comprise an update to the trend evaluations previously conducted.
- Hydrogeologic and geochemical data that can be used to demonstrate indirectly the type(s) of natural attenuation processes active at the Site, and the rate at which such processes will reduce contaminant concentrations to required levels.
- Data from field or microcosm studies (conducted in or with actual contaminated site media), which directly demonstrates the occurrence of a particular natural attenuation process at the Site and its ability to degrade the contaminants of concern (typically used to demonstrate biological degradation processes only).

In conjunction with the assessment of natural attenuation (NA) processes within the bedrock, performance monitoring of natural attenuation processes will be conducted in the overburden plume in areas where Performance Standards for Active Treatment have been met and in the untreated portion of the overburden plume located downgradient of the wetlands, consistent with the OSWER Guidance 9200.4-17P.

3.3.1 Bedrock Evaluation

The bedrock investigation program detailed in this section will provide supplemental data to assess the fate and transport of impacts and natural attenuation processes in the bedrock plume throughout the Site and to update and revise the CSM. This data, as well as historical data collected pre-2010 ROD Amendment, will be used to confirm that NA processes are occurring such as dechlorination of chlorinated VOCs. Table 3.18 provides an overview of the approach and rationale for the NA demonstration process for this Site. The evaluation will focus on key elements that demonstrate the viability of MNA for use as the remedy for bedrock groundwater. These key objectives include:

- Determine the signature of biotic and/or abiotic decay (based on temporal and spatial trend analysis of groundwater concentrations over time)
- Identify the conditions that support the dechlorination process
- Assess occurrence of DNAPL and implications for NA
- Evaluate the hydraulic characteristics of the bedrock
- Establish the occurrence of microbial transformation
- Provide estimates of natural attenuation and biodegradation rates to enable estimation of restoration timeframes

As part of this evaluation the bedrock Fate and Transport and Natural Attenuation Evaluation will assess the:

- Vertical distribution of COC concentrations in groundwater to evaluate mass flux contribution to the overburden via upward groundwater flow.
- Variance in the groundwater gradient between overburden and bedrock aquifers to better understand vertical mass transfers that may be affecting the COC concentrations observed in bedrock groundwater and the role that vertical mass transfers may be having on concentration trends and impact to the overburden aquifer.
- Well yield and bedrock transmissivity to understand how mass transfer and advective transport may be controlling and/or limiting NA processes.
- Physical properties of rock fractures and connectivity of fractures. Data will be used to better understand fate and transport of COCs in bedrock.
- Verify the occurrence of reductive dechlorination of chlorinated VOCs and quantify rates of degradation.

The assessment activities proposed to support the evaluation of NA in the bedrock are provided below.

3.3.1.1 Bedrock Properties

Pumping tests will be conducted on up to eight bedrock wells to assess bedrock properties and interconnectivity with the overburden. The aquifer tests will consists of one or more of the following methods: slug test and/or single well pump tests. If single well pump test are conducted, then select overburden and bedrock wells located near the test well may be monitored using data loggers to assess spatial hydraulic response to the aquifers caused by the well test. The wells that will be targeted for testing include the eight (8) proposed additional bedrock wells previously discussed in Section 3.2 (FSA wells OW-403-R, OW-404-R and OW-405-R; down-dip wells OW-400-R, OW-401-R and OW-402-R; and downgradient wells OW-406-R and OW-407-R). The locations of the wells are shown on Figure 3.15. If the slug tests or single well pump tests are inconclusive or the hydraulic conductivity of the bedrock is too low for these techniques, the use of dilution tracer tests will be considered for implementation in select bedrock wells. Slug testing will be performed in accordance with SOP A-25 in the FSP. Single well pump tests will be performed in accordance with SOP A-24 in the FSP. A protocol for dilution tracer testing will be developed and provided to the EPA and RIDEM for review and comment if the investigation technique is warranted.

3.3.1.2 DNAPL Testing

Testing for the potential absence or presence of DNAPL in the bedrock will be conducted on the proposed FSA bedrock wells OW-403-R, OW-404-R and OW-405-R. FLUTe screening will be conducted on the open bedrock boreholes drilled in the FSA. In addition, hydrophobic dye test may be conducted on the whole rock core samples collected from the boreholes, if feasible. Locations of the bedrock wells to be tested are shown on Figure 3.15. The FLUTe screening was also discussed in the Section 3.2 and will be performed in accordance with SOP A-28 in the FSP.

The collection and submittal of whole rock samples for assessment of contaminant mass will be considered at the three shallow FSA bedrock wells. This information would allow for an assessment of the impacts of bedrock mass on restoration timeframes in both the bedrock and the overburden. This analytical methodology typically has high detection limits and will not detect constituents in the dilute portions of the bedrock plume.

3.3.1.3 Hydraulic Monitoring

Long-term continuous monitoring of groundwater and surface water elevations will be conducted on 15 monitoring wells and two surface water bodies. The locations of the monitoring wells are shown on Figure 3.15 and a description of the monitoring program is provided in Table 3.16. The monitoring program will be conducted for a period of 6 to 12 months. The water level elevations in the wells and surface water staff gauges will be measured using electronic data loggers and periodically field verified with manual measurements. The objectives for conducting the long-term continuous monitoring program are to assess:

- Variance in the groundwater gradient between the overburden and the underlying bedrock to better understand how vertical mass transfers may be affecting the COC concentrations observed in the bedrock groundwater and the role that vertical mass transfers may be having on concentration trends in both the overburden and bedrock.
- Hydraulic relationship between surface water and the overburden and bedrock.
- Temporal changes in the hydraulic system caused by seasonal changes and rain events.

The assessment of hydraulic relationships between surface water and the overburden and bedrock will also be critical in refining the conceptual site model and assessing the potential long-term impacts of groundwater on surface water and sediment.

The wells and surface water bodies to be monitored are:

- FSA at well couplet OW-094-O, OW-094-R and OW-403-R (proposed well)
- Downgradient/north of FSA at well couplet OW-051-O, OW-101-R, and OW-406-R (proposed well)
- East flank of FSA at well couplet OW-102-O, OW-102-R, and OW-402-R (proposed)
- Upgradient/south of FSA at well couplet OW-081 and OW-082
- West flank of FSA at well couplet OW-083 and OW-084
- Diorite dike at well couplet OW-095-O and OW-095-R
- Surface water body due west of well couplet OW-102-O/OW-102-R
- Surface water body due west of well couple OW-081/OW-82

The datalogger monitoring will be performed in accordance with A-8 in the FSP.

3.3.1.4 Quantitative Assessment of Biodegradation

Four bedrock wells in the FSA (one existing well and three proposed wells) will be evaluated to assess the biological degradation processes and determine the degree of biological activity and reductive dechlorination of chlorinated VOCs in the bedrock groundwater. The four wells to be evaluated are: existing well OW-94-R and proposed wells OW-403-R, OW-404-R and OW-405-R (Figure 3.15).

Consistent with ITRC Guidance (Natural Attenuation of Chlorinated Solvents Principals and Practice 1999), a phased program has been developed. Microcosm and baited biotraps provide direct microbiological evidence and are used to: 1) confirm specific chlorinated solvent biodegradation processes and/or 2) estimate site-specific biodegradation rates that cannot be conclusively demonstrated with field data alone. However these studies have limitations (as discussed below) and can be expensive, time consuming and should only be performed when the information cannot be obtained through other means.

Reflecting the limitations associated with more detailed assessments of biological activity, the following phased program has been developed to enable assessment of general biological conditions prior to selection of groundwater sampling locations for more detailed microbiological assessments. This phased program comprises:

1. Phase 1 – an assessment of the bacterial populations present in bedrock which potentially could facilitate the degradation of chlorinated VOCs.
2. Phase 2 – Direct measures of biodegradation capacity and rates using either baited bio-traps or microcosm studies.

Phase 1 Program

As part of the Phase 1 assessment, bedrock groundwater will be tested for the occurrence of Dehalococcoides and other bacteria species capable of reductive dechlorination of chlorinated VOCs to provide direct evidence of biological activity and degradation of target compounds. The testing will be conducted either by groundwater sampling or Bio-Trap methods. It is proposed that the testing be conducted using the CENSUS approach by Microbial Insights (www.microbe.com) for the quantification of *Dehalococcoides* spp. (DHC) and other bacterial species.

CENSUS is based on a technique called qualitative polymerase chain reaction (qPCR) whereby many copies of a specific gene are generated. As each gene copy is made, a fluorescent marker is released, measured and used to quantify the number of the target genes present in the sample. The gene copied during the process (target gene) is determined by short segments of DNA called "primers" which are added to the reaction mixture. The "primers" select which pages (target genes) of the book (DNA) are copied and the counter keeps a running total of how many pages were copied (number of target genes in the sample). The CENSUS testing approach for the Site has been developed to target bio-degradation of the chlorinated ethenes that are the principal components of the bedrock plume.

The candidate CENSUS analytes for chlorinated ethenes include:

- qDHC (Dehalococcoides spp.)
- qTCE (tceA Reductase)
- qBVC (bvcA Reductase)
- qVCR (Vinyl Chloride Reductase)
- qDHB (Dehalobacter spp.)

This technique will allow for a quantification of DHC to support a direct evaluation of the feasibility of using MNA as a remedial approach for the bedrock. This assessment will utilize either groundwater samples, collected using the Microbial Insights Bio-Flow sampling approach, or a Bio-Trap method. Details on these field procedures are provided in SOP A-27 in the FSP.

Phase 2 Program

A combination of methods can be used to provide quantitative demonstrations of biodegradation and estimates of bio-decay rates. Two commonly employed methods included installation of baited biotraps in wells to assess in-situ bio-decay rates and microcosm studies conducted under laboratory conditions using site-derived groundwater. The selection of methodologies is dependent on the results of the Phase 1 assessment which will determine the type of bacteria present, if partial or complete bio-decay is likely to occur and the likely mode of biodegradation (aerobic, anaerobic or cometabolic). Understanding the mode of biodegradation and the process (partial or complete degradation) enables the selection of preferred methodology and scope of the Phase 2 evaluation.

Both baited biotraps and microcosm studies have inherent strengths and weaknesses. A key limitation of baited bio-traps is the inability to bait the traps for smaller molecular weight chlorinated compounds. Baited bio-traps are widely used for the assessment of PCE and TCE degradation but have limitations in quantifying vinyl chloride and cis 1,2 dichloroethylene degradation rates. Where degradation rates for these compounds need to be assessed, microcosm studies are commonly utilized as an alternative. However baited biotraps have the advantage of being able to measure degradation rates directly in the subsurface under both dynamic and transient conditions (for example reversals of vertical hydraulic gradients or ongoing groundwater movement in the bedrock which provides a flux of nutrients, trace minerals and organic carbon critical to biodegradation.

Bio-Trap samplers are utilized in combination with stable isotope probing (SIP) to conclusively demonstrate biodegradation of a specific contaminant of concern. With the SIP method, the Bio-Trap sampler is baited with a specially synthesized form of the contaminant containing C^{13} labeled carbon. The baited Bio-Trap is then deployed in a monitoring well, with the C^{13} labeled contaminant on the Bio-Sep beads depleted via the same physical, chemical, and microbiological processes as the unlabeled contaminant present at the site. The C^{13} label then serves as a tracer which can be detected in the end products of biodegradation. When biodegradation of the contaminant is occurring, the C^{13} label from the synthesized contaminant in the Bio-Trap will be incorporated into microbial biomass and dissolved inorganic carbon (CO2). Quantification of C^{13}-enriched phospholipid fatty acids (PLFA) demonstrates contaminant incorporation into biomass while quantification of C^{13}-enriched dissolved inorganic carbon demonstrates contaminant mineralization. The quantification of these masses and the mass lost from the baited bio-trap can be used to quantify mass degradation rates.

If utilized, the baited bio-traps would likely be deployed in all four wells identified above (wells OW-94-R and proposed wells OW-403-R, OW-404-R and OW-405-R).

Microcosm studies are an alternative that involves the collection of groundwater samples and assessment of biodegradation rates in controlled laboratory conditions. Microcosm studies provide the advantage of being able to assess the sequential decay of chlorinated VOCs including quantification of degradation rates for all chlorinated compounds. However

microcosms are static systems and have to be set up for a defined set of conditions (aerobic, anaerobic and a specific redox and pH conditions). This static and defined condition may result in a low bias for assessment of natural conditions as seasonal fluctuations in redox and pH and groundwater movement with associated nutrients, trace minerals and carbon sources can facilitate degradation in the subsurface. These dynamic elements cannot be replicated in the microcosm under laboratory conditions. Rather, additional microcosms are typically tested with additions of nutrients, trace minerals and organic carbon sources to assess the effect of alternative (and possibly transient) conditions on biodegradation rates. Given this complexity and the variability of possible results, microcosm studies need to be utilized with care and a high level of professional judgement needs to be employed in the interpretation of results.

If microcosm testing is employed it is proposed that BCI Laboratories of Massachusetts will be utilized as the preferred laboratory. The procedures utilized by BCI are generally in accordance with those recommended by Morse et al 1998, (RABITT Protocol). Groundwater for the anaerobic microcosm studies will be collected into Argon-flushed serum bottles containing a small amount of reducing agent to ensure the samples are maintained under anaerobic conditions for testing. For groundwater in 1-Liter serum bottles, 100 ml will be transferred, using an anaerobic technique, to Argon-filled 160 ml serum bottles, leaving 60 cc of anaerobic headspace. For groundwater that had been sampled directly into 160 ml serum bottles, 60 ml of groundwater will be removed from each bottle, and replaced by Argon, creating a 60 ml anoxic headspace.

Groundwater for aerobic microcosm studies (if required) will be collected using standard sampling methods and transferred to the laboratory where the samples will be placed into microcosms with an aerobic headspace.

The performance of the microcosms will be monitored by sampling of dissolved gasses and VOCs. VOC concentrations will be analyzed in the microcosm's according to EPA Method 5021A by removing 100 µL of microcosm headspace by syringe through the septum and injecting directly into a gas chromatograph. Inorganic and organic anions (sulfate, nitrate, organic acids) will be monitored by removing 150 µL of aqueous material from the microcosm.

It is anticipated that water samples from only one well (based on the results of the Phase 1 testing) will be collected for microcosm testing with a number of microcosm tests established including potentially:

1. A killed control microcosm (to act as a reference for biological activities and determine if abiotic or other non-biological mass losses are occurring in the microcosm.
2. A natural conditions microcosm – designed to replicate groundwater conditions at the time of sampling.

3. Induced aerobic conditions microcosm (if required) to assess potentially aerobic biodegradation under transient conditions (recharge etc) or discharge to aerobic environments.
4. Induced anaerobic conditions microcosm (if required) to assess potential anaerobic biodegradation under transient conditions (recharge etc) from the overburden or at the bedrock overburden contact where anaerobic conditions may exist.
5. Induced aerobic conditions with minor nutrient and trace mineral amendments to assess transient and dynamic conditions in natural systems.
6. Induced anaerobic conditions with minor nutrient and trace mineral amendments to assess transient and dynamic conditions in natural systems.

As discussed above, the use of and the scope of microcosm tests will be further refined following completion of the Phase 1 assessment and will be discussed with EPA and RIDEM prior to implementation.

3.3.1.5 Groundwater Sampling

To support the MNA evaluation thirteen (13) existing and proposed bedrock wells will be monitored for the geochemical field parameters such as pH, Eh, specific conductance, dissolved oxygen and temperature and select geochemical parameters focused on assessing the performance of natural attenuation. The MNA geochemical monitoring parameters will include: chloride, nitrate, nitrite, sulfate, sulfide, alkalinity, total organic carbon, and select dissolved gases (ethane, ethane, methane and acetylene), at a minimum. The following existing and proposed bedrock wells will be monitored (sampled) to assess natural attenuation processes in the bedrock plume.

Proposed MNA Monitoring Location	Rationale
OW-082	Upgradient of source area (FSA)
OW-094-R, OW-085, OW-403-R, OW-404-R, OW-405-R	Within source area of bedrock plume (FSA)
OW-101-R, OW-406-R	Within mid-point of bedrock plume
OW-112-R, OW-407-R	Within bedrock plume at leading edge
OW-102-R, OW-402-R	Sidegradient of bedrock plume
OW-110-R	Downgradient of bedrock plume

At this time, all proposed MNA bedrock monitoring wells will also be included in the Site-wide monitoring program. The locations of these wells as well as the locations of the other wells that will be included in the Site-wide monitoring program are shown on Figure 3.16. Groundwater samples will be collected in accordance with SOP A-9 provided in the FSP.

3.3.1.6 Data Analysis

As previously discussed, the data collected within this evaluation program will be used to assess the fate and transport of impacts and natural attenuation processes in the bedrock plume throughout the Site. The hydraulic information will be integrated into the existing CSM to update our understanding of the flow conditions within the bedrock and the interactions between groundwater within the overburden and bedrock and the surface water bodies. The DNAPL screening and analytical results from the bedrock wells within the FSA will also be used to update the CSM and to better understand the nature and extent of the residual contaminant mass within the FSA.

The groundwater data, as proposed for collection in this work plan and previously collected Site data will be compiled and evaluated to assess if natural attenuation is occurring at a sufficient rate to merit selection of MNA as the remedial action for the bedrock plume. The evaluation will be based on EPA's OSWER Guidance 9200.4-17P, *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites.* In addition, EPA's 2004 guidance document EPA/600/R-04/027 entitled *Performance Monitoring of MNA Remedies for VOCs in Ground Water* may also be used. The results of the microbiological testing (CENSUS) proposed herein will specifically address the requirement to directly demonstrate the occurrence of a particular natural attenuation process at the Site and its ability to degrade the contaminants of concern. Data obtained from the Phase 2 program, if performed, will provide quantitative data that will support an assessment of bio-decay rates.

The anticipated outcome of this evaluation is better understanding of the hydraulics and the nature and extent of impacts within the bedrock and a determination of the viability of selecting MNA as the remedy for Operable Unit No. 4 (bedrock groundwater).

3.3.2 Overburden Monitoring

In accordance with the 2010 ROD Amendment and the 2011 SOW for the OU-2 Remedy, monitored natural attenuation is the selected remedy for the untreated portions of the overburden plume. This area will expand to include those areas of the overburden plume where the Interim Performance Standards for Active Treatment have been met following the performance of the initial treatment application. The SOW requires that the monitoring program to assess the performance of the MNA remedy be consistent with the OSWER Directive 9200.4-17P (EPA, 1999). The OSWER Directive specifies that all monitoring programs should be designed to accomplish the following:

- Demonstrate that natural attenuation is occurring according to expectations.
- Detect changes in environmental conditions (e.g., hydrogeologic, geochemical, microbiological, or other changes) that may reduce the efficacy of any of the natural attenuation processes.
- Verify that the plume is not expanding (either downgradient, laterally or vertically).

- Verify no unacceptable impact to downgradient receptors.
- Detect new releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy.
- Demonstrate the efficacy of institutional controls that were put into place to protect potential receptors.
- Verify attainment of remediation objectives.

Based on the modeling evaluations performed in the Focused Feasibility Study (Nobis, 2009), EPA projects that the untreated portions of the overburden plume will require 40 to 45 years to achieve the Final Groundwater Performance Standards.

The first three objectives or bullets will be the focus of this assessment. The Site-wide monitoring program and the sentry well monitoring that were discussed in Section 3.2 and the Long-Term Monitoring Plan, to be developed, will address the approach to accomplishing the remaining objectives, including providing the framework for demonstrating attainment of the remediation objectives (i.e., Final Groundwater Performance Standards). The Site-wide monitoring program will also provide data to support the third objective listed above.

3.3.2.1 Groundwater Sampling

This assessment will utilize groundwater data collected pre-2010 ROD Amendment and data that will be collected during the implementation of the 2011 SOW. The following existing and proposed monitoring wells will be used to monitor the performance of the MNA remedy downgradient of the Active Treatment Zone.

Proposed MNA Monitoring Location	Rationale
OW-81	Background
OW-45	Immediately downgradient of Active Treatment Zone
OBT-1	Within overburden plume
OBT-2	Within overburden plume and downgradient of OBT-1
OW-34	Downgradient of overburden plume

Proposed wells located within the OBT-1 and OBT-2 transects will be included into the Site-wide and MNA monitoring programs following well installation and development. At this time, all of the proposed MNA monitoring wells will also be included in the Site-wide monitoring program which was described in Section 3.2. The locations of these wells as well as the locations of the other wells that will be included in the Site-wide monitoring program are shown on Figure 3.16.

To support an evaluation of the geochemical conditions within the overburden plume, field parameters (pH, Eh, specific conductance, dissolved oxygen and temperature) will be monitored during sampling during all of the Site-wide monitoring events and any additional

sampling events focused on providing data for this assessment. Additionally, select geochemical parameters, focused on assessing the performance of natural attenuation remedies at chlorinated solvent release sites, will also be included for laboratory analysis of samples collected from the proposed MNA monitoring locations. The MNA geochemical monitoring parameters will include: chloride, nitrate, nitrite, sulfate, sulfide, alkalinity, total organic carbon, and select dissolved gases (ethane, ethane, methane and acetylene).

It is currently proposed that three tri-annual monitoring events will be performed during 2012, in accordance with the requirements of the SOW, and that the data from all or some of these events will be used to develop the Long-Term Monitoring Plan. Sampling for the MNA geochemical parameters will be performed in all available MNA monitoring wells during these three events. The frequency of sampling for the MNA geochemical parameters during subsequent groundwater monitoring events will be specified in the Long-Term Monitoring Plan.

3.3.2.2 Data Analysis

As previously discussed, where available, pre-2010 ROD Amendment data will be used in conjunction with data collected during the implementation of the OU-2 SOW to assess the performance of the MNA remedy in the overburden aquifer.

Graphical, and if necessary, statistical evaluations will be used to evaluate the VOC data (parents and daughter products) at each of the MNA monitoring locations to assess stability of the plume. The graphical assessment will focus on concentration vs. time analysis for each of the monitoring locations to assess plume stability. Additionally, isopleths maps of the concentrations of target VOCs will also be used to assess plume stability. If possible, concentration vs. distance downgradient for wells along flow paths will also be utilized.

If warranted, statistical tests will be used to evaluate plume behavior and stability. Two fairly simple and straightforward statistical approaches (Mann-Whitney U test or the Mann-Kendall Test) can be used to evaluate plume stability (AFCEE, 2000).

Additionally, the geochemical data (both field parameter and laboratory analysis) will be used to assess the following:

- Demonstrate that natural attenuation is occurring according to expectations.
- Detect changes in environmental conditions (e.g., hydrogeological, geochemical, microbiological, or other changes) that may reduce the efficacy of the natural attenuation process.

Changes in key indicator analytes (e.g., dissolved oxygen, total organic carbon) will be evaluated over time to assess changes in the geochemistry that could affect the efficacy of the natural attenuation processes or rate of natural attenuation processes over time.

In support of the Five Year Review process, an evaluation of the projected timeframe to reach remedial objectives will be performed. Concentration vs. time rate constants (kpoint) will be used for estimating the timeframe for meeting the remedial goals. The methodology outlined in the following EPA publication will be used to support this evaluation: Newell, C.J., et. al., 2002, *Calculation and Use of First-Order Rate Constants for Monitored Natural Attenuation Studies*, EPA/540/S-02/500.

The findings of these evaluations will be included within the Five Year Review reports to support the assessment of the remedy performance.

3.4 Surface Water and Sediment Evaluation

As stated in the SOW, the objective of this PDI task is to assess potential impacts associated with historic Site activities and the potential for ongoing discharges of contaminated groundwater from the FSA into the adjacent wetlands and Latham Brook. Information and data developed under this evaluation shall be used in the formulation of the Long-Term Monitoring Plan, as appropriate. Data will be collected within this task to address this objective and to support the flowchart and decision processes as outlined in the RDWP. The flow chart for this evaluation is included on Figure 3.17 as was presented in the RDWP.

This evaluation is proposed as an iterative, phased program to strive to obtain the necessary information and data to support the decision framework outlined in the RDWP. Additional investigation and/or sampling may be required depending on the outcome of the program proposed herein. If required, a supplemental work plan(s) will be submitted to the Agencies for their review and approval prior to proceeding with any supplemental activities.

Phase 1 of the evaluation program will utilize traditional wetland characterization techniques to develop conceptual models of the wetland areas to evaluate their interaction with the underlying groundwater. The objective of this phase will be to develop the data and information necessary to identify the areas where groundwater from within the overburden plume is most likely to be discharging to the wetlands or surface water bodies. This information will then be used to select surface water and sediment sampling locations in areas of likely groundwater discharge.

The second phase of the field evaluation will consist of the collection of surface water and sediment samples at various locations within the wetland areas and at downstream locations for comparison to the applicable regulatory standards and historic Site results.

3.4.1 Surface Water/Groundwater Interaction Assessment

The objective of this assessment will be to evaluate the interaction between the various wetland types located proximal to the FSA and the underlying groundwater within the overburden plume.

3.4.1.1 Historical Sampling

Historical surface water and sediment sampling was performed at the Site during the Remedial Investigation (RI; CDM, 1986) and the initial Pre-Design Investigation (Woodward-Clyde, 1992). Figure 3.18 shows the historic surface water and sediment sampling locations

proximal to the FSA and the Overburden Plume. Historic surface water and sediment locations within areas that were remediated during the performance of the Source Remedy (e.g., NDA, NDA Ditch) are not shown. Tables 3.19 and 3.20 provide a summary of the results of the historic sampling relative to the current EPA Region III BTAG Screening Benchmarks (sediment) and RIDEM Ambient Water Quality Criteria. Exceedances of these standards are identified based on the results of the historic sampling for both surface water and sediment and the current standards.

Based on the results of the RI sampling program, the 1987 Record of Decision (ROD) proposed that the sediments be managed in place.

3.4.1.2 Wetland Types

Three types of wetland areas are located proximal to the FSA. These areas are shown on Figure 3.19. The three wetland types consist of the following:

- Swamp-type wetland (Northern and Central wetland areas)
- Ponded wetland (Eastern Ponded Wetland)
- Stream (Unnamed Stream downstream of Eastern Ponded Wetland and adjacent/within the Central Wetland and Latham Brook)

All three wetland types have very different characteristics and mode of interaction with the underlying groundwater. Additionally, all three of these wetland types may have been impacted by historic Site activities via differing mechanisms.

3.4.1.2 Field Program

The initial investigation phase will consist of characterization of the wetland areas within the overburden plume area. A description of the investigation techniques proposed for the Surface Water and Sediment Evaluation and the rationale for these techniques are presented in detail on Table 3.21. As previously outlined in the flowchart and decision making process in the RDWP, Phase 1 of the investigation will comprise characterization of the interactions between the wetland areas and groundwater within the well-defined overburden plume to assist in the selection of surface water and sediment sampling locations.

Wetland delineation and characterization of the swamp-type wetland and the ponded wetland will be performed using standard techniques as outlined in SOPs A-20 in the FSP. Sediment probes will also be performed along transects in the swamp-type wetland areas to collect data to support the development of sediment isopach maps for these areas.

The characterization of the Unnamed Stream will be performed in general accordance with the EPA Rapid Bioassessment Protocol and SOP A-18 in the FSP. The presence and thickness of sediment within the stream will also be evaluated.

Within the Eastern Ponded Wetland, a bathymetric survey and sediment probes will be performed along transects to collect data that can be used to develop contour plans of

bathymetry and sediment thickness. Presence or absence of sediment and sediment thickness within the ponded wetland will be an important indicator of the potential for groundwater discharge. For example, in most surface water bodies, the sediment will accumulate and slough towards the deepest sections and groundwater inflow is typically limited to the shallow perimeter of the water body. To assist in the evaluation of potential areas of groundwater discharge, a survey of pH and conductivity will also be performed within the ponded wetland. Based on our experience, pH and conductivity differentials between groundwater and surface water in this type of environment are likely to be more conclusive than temperature differential.

Sediment cores will be collected at select locations to observe and log the fine-grained sediments present at select sample locations within each of the wetland types, where possible. The potential for sediment coring within the unnamed stream will be assessed during the initial characterization. The sediment coring will allow for characterization of the actual sediment types underlying the wetland areas which will be an important component for the evaluation. Sediment samples may also be submitted for laboratory analysis of total organic carbon or grain size characterization to provide additional data to support the evaluation.

Transect spacing will be determined in the field and will take into consideration the areal extent of the wetland feature to be assessed and the density of data required to develop the contour plan(s). The bathymetric survey and sediment coring will be performed in accordance with SOPs A-14 and A-16 in the FSP.

3.4.2 Surface Water and Sediment Sampling Program

Phase 2 of the proposed evaluation will consist of the collection of surface water and sediment samples. The objective of this program is to collect surface water and sediment samples for laboratory analysis to provide current data on the quality of these matrices within close proximity of the FSA and within the well-defined overburden plume. Based on the previously identified mechanisms associated with historic or ongoing Site activities that may have impacted surface water and/or sediment and historic sampling results, the location of certain surface water and sediment samples that are proposed for collection and laboratory analysis are shown on Figure 3.18. These locations have been selected based on the following:

- Approximate locations of historic sediment sampling results that exceeded the currently applicable EPA Region III BTAG screening benchmarks and/or RIDEM AWQC (to allow for comparison to historic sampling results).
- Estimated discharge area of the drainage ditch associated with the former Northern Disposal Area that reportedly discharged to the Central Wetland Area.
- Estimated discharge area for dewatering water generated during the performance of the Source Remedy.

- Current discharge location for the trench drain installed during the performance of the Source Remedy.

The rationale for the proposed surface water and sediment sampling locations is provided in Table 3.22. Based on the results of the Phase 1 assessment (described above), additional surface water and sediment locations will be proposed. A minimum of ten co-located surface water and sediment sampling locations will be proposed. Surface water samples will be analyzed for VOCs, SVOCs and metals (total and dissolved) and hardness. Sediment samples will be analyzed for VOCs, SVOCs, pesticides, PCBs and metals.

Three additional surface water sampling locations have been proposed (SW-102, SW-101 and SW-100) to provide data on the surface water quality within the Unnamed Stream and Latham Brook downgradient of the Site. The results of the sampling of these locations will be compared to the RIDEM AWQC, EPA National Recommended Water Quality Criteria or the EPA Region III BTAG freshwater benchmarks and the results of recent surface water sampling in 2006 and 2008.

Sediment samples will be collected from the upper 0.5 feet of the sediment column to allow for a comparison to the Threshold Effect Concentrations (TECs) or the EPA Region III BTAG freshwater sediment benchmarks. Surface water and sediment sampling will be performed in accordance with SOPs A-15 and A-17 in the FSP. The field monitoring of parameters within surface water will be performed in accordance with SOP A-18 in the FSP. Field decontamination procedures will be performed in accordance with SOPs A-15 and A-17 in the FSP.

It is currently envisioned that ongoing surface water sampling will be performed on an annual basis and that additional sediment sampling will be performed every five years in support of the Five Year Review process in accordance with the requirements of the SOW. Additional details on the proposed monitoring of these media will be provided in either the associated PDI summary report or the Long-Term Monitoring Plan.

3.4.3 Screening of Analytical Data

The data evaluation and decision making process to be performed using the information and data generated during the implementation of the above-described investigation and sampling assessments is outlined on the flowchart provided in Figure 3.17 and is consistent with the process outlined in the RDWP.

If the outcome of the evaluation program warrants the performance of a Screening-level Ecological Risk Assessment and/or Baseline Ecological Risk Assessment, a supplemental risk assessment work plan will be submitted to the Agencies to outline the proposed approach and associated assumptions.

4.0 PRE-DESIGN INVESTIGATION REPORTING

The SOW requires that within 90 days after the completion of the six (6) PDI evaluations, a written report of the investigation results shall be submitted by the Davis Site Group to EPA for review and approval or modification after an opportunity for review and comment by RIDEM. The RD schedule discussed in

Section 5.0 and presented in the RDWP shows the anticipated reporting schedule for each of the PDI tasks. Based on the scope of each of the tasks, the Davis Site Group is proposing some slight modifications to the reporting approach required in the SOW. These proposed modifications are outlined below.

- The Davis Site Group will be submitting a technical memorandum outlining the proposed approach for the Column Testing based on the initial results of the mixed slurry microcosm tests. The Davis Site Group is proposing the submittal of this technical memorandum to obtain Agency concurrence on the proposed scope before proceeding with the Column Testing.
- The available results of the Bench Testing Program (mixed slurry tests and initial phases of column testing) will be provided in the proposed Pilot Test Work Plan. The Davis Site Group is proposing the submittal of this work plan to obtain Agency concurrence on the proposed scope before proceeding with the Pilot Test.
- The results of the Bench and Pilot Testing will be included in the 30% and 100% Design submittals rather than a separate PDI report.
- The PDI report for the Groundwater Investigation will summarize and provide results for the well installations (sentry wells, additional monitoring wells, overburden transects) and the geophysical borehole logging activities. The results of the three groundwater monitoring events scheduled for be performed during 2012 will be included in Groundwater Monitoring Events reports that will be submitted after each sampling event.

Additional deliverables or reports may be necessary depending on the results of the tasks proposed herein. The Davis Site Group will coordinate with the EPA and RIDEM frequently during the performance of the PDI activities.

5.0 PRE-DESIGN INVESTIGATION SCHEDULE

The detailed schedule presenting the anticipated schedule for the performance of each of the six PDI tasks is included in Section 6 of the RDWP.

6.0 REFERENCES

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Tables

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-021									
			11/8/1991	11/13/2001	6/13/2003	7/28/2004	10/21/2004	4/21/2005	11/8/2005	4/18/2006	9/12/2006	10/20/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		**2.2J**	**3J**	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		**3.1J**	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		ND	20U	20U	**47**	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**5J**	**1J**	5U	**1J**	5U	5U	5U	**0.9J**	**1J**
Diethyl ether	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**1.3J**	**1J**	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	**5J**	**4J**	**1J**	5U	**1J**	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	ND	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**11.6**	**13**	**2**	**47**	**2**	**0**	**0**	**0**	**0.9**	**1**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-034											
			11/8/1991	11/12/2001	6/16/2003	7/29/2004	7/29/2004	10/22/2004	10/22/2004	4/21/2005	11/9/2005	4/17/2006	9/11/2006	10/17/2008
			Primary	Primary	Primary	Primary	Duplicate 1	Primary	Duplicate 1	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	ND	5U	**6**	**1J**	**1J**	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		ND	5U	**7**	**2J**	**2J**	**2J**	**2J**	**2J**	**1J**	**1J**	5U	**1J**
1,1-Dichloroethylene	(µg/L)	7	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		**1.2J**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	5U	**18**	**2J**	**3J**	**2J**	**2J**	**1J**	5U	5U	5U	**0.8J**
Diethyl ether	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	5U	**1J**	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	**4J**	10U	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	**1J**	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	ND	5U	**3J**	**1J**	**1J**	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	ND	1U	**6**	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**1.2**	**0**	**46**	**6**	**7**	**4**	**4**	**3**	**1**	**1**	**0**	**1.8**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-038									
			11/8/1991	11/19/2001	6/13/2003	8/3/2004	10/27/2004	4/26/2005	11/14/2005	4/26/2006	9/20/2006	10/24/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	ND	5U	**4J**	**2J**	**7**	**2J**	**3J**	**2J**	**1J**	**7**
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		**2.3J**	**1J**	**3J**	**3J**	**12**	**3J**	**5**	**3J**	**3J**	**9**
1,1-Dichloroethylene	(µg/L)	7	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	**2J**	5U	5U	5U	5U	**1J**
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		NA	5U	5U	5U	**1J**	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**2J**	**7**	**3J**	**10**	**2J**	**3J**	**2J**	**2J**	**22**
Diethyl ether	(µg/L)		NA	NA	5U	5U	**3J**	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	1U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	10U	10U	**16**	10U	**4J**	10U	10U	**8J**
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	**0.9J**	5U	5U	5U	5U	**1J**
Trichloroethylene	(µg/L)	5	ND	5U	5U	5U	**1J**	5U	5U	5U	5U	**1J**
Vinyl chloride	(µg/L)	2	ND	**2J**	1U	**3**	**19**	**3**	**4**	**2**	**3**	**19**
Xylene (total)	(µg/L)	10000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**2.3**	**5**	**14**	**11**	**71.9**	**10**	**19**	**9**	**9**	**68**

Notes:

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5. ug/L = micrograms per liter
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7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-043										
			11/8/1991	11/13/2001	6/18/2003	8/2/2004	10/25/2004	4/25/2005	11/10/2005	4/25/2006	9/19/2006	9/19/2006	10/22/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Duplicate 1	Primary
1,1,1-Trichloroethane	(µg/L)	200	**1.7J**	**5J**	**2J**	**0.9J**	**5**	**2J**	**14**	**2J**	**4J**	**4J**	**23**
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	**0.9J**
1,1-Dichloroethane	(µg/L)		**14J**	**11**	**28**	**22**	**37**	**28**	**36**	**25**	**26**	**27**	**64**
1,1-Dichloroethylene	(µg/L)	7	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	**0.9J**
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	**2J**	**5J**	**4J**	**8**	**4J**	**9**	**3J**	**5J**	**5J**	**19**
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	**1J**	5U	**2J**	5U	5U	5U	**5J**
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	**1.5J**	5U	**2J**	**2J**	**2J**	**1J**	**2J**	**1J**	**1J**	**1J**	**2J**
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	**1J**	5U	**1J**	5U	5U	5U	**2J**
Chloroethane	(µg/L)		NA	5U	**7**	**5**	**5**	**8**	**5J**	**7**	**5**	**5**	**3J**
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**21**	**1J**	5U	5U	5U	**7**	5U	**2J**	**2J**	**34**
Diethyl ether	(µg/L)		NA	NA	**22**	**21**	**16**	**20**	**14**	**18**	**19**	**21**	**18**
Ethylbenzene	(µg/L)	700	**8.8J**	**8**	**7**	**2J**	**12**	**2J**	**5J**	**1J**	**2J**	**2J**	**11**
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	**2J**	5U	**3J**	5U	5U	5U	**5J**
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	1U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	**1J**	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	**130**	**120**	**110**	**120**	**77**	**91**	**100**	**100**	**98**
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	**0.9J**
trans-1,2-Dichloroethene	(µg/L)	100	NA	**1J**	**1J**	**1J**	**2J**	**1J**	**3J**	**0.8J**	**1J**	**1J**	**6**
Trichloroethylene	(µg/L)	5	**1.6J**	**4J**	5U	5U	5U	5U	**1J**	5U	5U	5U	**5J**
Vinyl chloride	(µg/L)	2	ND	**15**	**3**	1U	**1**	1U	**17**	1U	**5**	**6**	**64**
Xylene (total)	(µg/L)	10000	**2.9J**	**3J**	5U	5U	5U	5U	5U	5U	5U	5U	**3J**
Sum of Constituents	**(µg/L)**		**30.5**	**71**	**208**	**177.9**	**202**	**186**	**196**	**148.8**	**170**	**174**	**364.7**

Notes:

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5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-045											
			11/8/1991	11/16/2001	11/16/2001	9/8/2003	8/4/2004	10/28/2004	4/26/2005	11/15/2005	11/15/2005	4/26/2006	9/20/2006	10/23/2008
			Primary	Primary	Duplicate 1	Primary	Primary	Primary	Primary	Primary	Duplicate 1	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**2.6J**	**6**	**6**	**11**	**23**	**61**	**10**	**30**	**29**	**78**	**74**	**69**
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	0.8U	5U	**0.9J**	5U	5U	5U	**1J**	**2J**	**1J**
1,1-Dichloroethane	(µg/L)		**1.6J**	**20**	**20**	**13**	**16**	**38**	**7**	**19**	**19**	**43**	**46**	**39**
1,1-Dichloroethylene	(µg/L)	7	NA	5U	5U	0.8U	5U	**1J**	5U	**0.9J**	**0.9J**	**2J**	**3J**	**4J**
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	1U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	1U	**4J**	**8**	5U	**1J**	**1J**	**2J**	**5J**	**3J**
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	1U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		**71J**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	1U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	1U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		ND	20U	20U	6U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	0.5U	5U	**0.6J**	5U	5U	5U	5U	**0.5J**	5U
Carbon disulfide	(µg/L)		ND	5U	5U	1U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	0.8U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		NA	5U	5U	1U	5U	5U	5U	5U	5U	**4J**	**3J**	**4J**
Chloroform	(µg/L)		ND	5U	5U	0.8U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**91**	**87**	**45**	**40**	**140**	**36**	**140**	**140**	**300**	**360**	**390**
Diethyl ether	(µg/L)		NA	NA	NA	2U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	0.8U	**1J**	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	1U	**2J**	**5J**	5U	5U	5U	5U	**3J**	**2J**
Methyl ethyl ketone (MEK)	(µg/L)		NA	10UJ	10UJ	3U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	1.3U	5U	5U	2U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**4.5J**	**3J**	**3J**	0.8U	**2J**	**3J**	5U	**1J**	**0.8J**	**2J**	**2J**	**3J**
Tetrahydrofuran	(µg/L)		NA	NA	NA	**7J**	10U	**6J**	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	5U	5U	0.7U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	**2J**	**2J**	**2J**	**3J**	**8**	**1J**	**4J**	**4J**	**9**	**11**	**11**
Trichloroethylene	(µg/L)	5	**12J**	**14**	**13**	**6**	**4J**	**7**	**2J**	**3J**	**3J**	**6**	**6**	**6**
Vinyl chloride	(µg/L)	2	ND	**17**	**17**	**35**	**78**	**230**	**8**	**39**	**37**	**100**	**180**	**170**
Xylene (total)	(µg/L)	10000	ND	5U	5U	0.8U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**91.7**	**153**	**148**	**119**	**173**	**508.5**	**64**	**237.9**	**234.7**	**547**	**695.5**	**702**

Notes:

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5. ug/L = micrograms per liter
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7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-051										
			11/8/1991	11/8/2001	11/8/2001	6/16/2003	8/5/2004	10/28/2004	4/27/2005	11/15/2005	4/28/2006	9/22/2006	10/27/2008
			Primary	Primary	Duplicate 1	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**56J**	**79**	**81**	**140**	**130**	**130**	**120**	**110**	**160**	**130**	**87**
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	**1J**	**1J**	**1J**	**1J**	**1J**	**0.9J**
1,1-Dichloroethane	(µg/L)		**11J**	**33**	**34**	**66**	**50**	**69**	**47**	**51**	**49**	**45**	**43**
1,1-Dichloroethylene	(µg/L)	7	NA	**1J**	**1J**	**2J**	**2J**	**1J**	**1J**	**1J**	**2J**	**2J**	**2J**
1,2,4-Trichlorobenzene	(µg/L)	70	NA	**2J**	**2J**	**1J**	**1J**	**1J**	5U	**1J**	**1J**	**1J**	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	**7**	**7**	**18**	**19**	**20**	**16**	**15**	**16**	**17**	**13**
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		**290J**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	**1J**
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	**5J**	**8**	**9**	**9**	**8**	**8**	**8**	**8**
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	**1J**	**1J**	**1J**	**1J**	**1J**	**0.8J**	**0.8J**	**0.8J**	**0.8J**	5U
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	**3J**	**4J**	**4J**	**4J**	**3J**	**3J**	**3J**	**3J**
Chloroethane	(µg/L)		NA	5U	5U	**2J**	5U	**3J**	**1J**	5U	**2J**	5U	5U
Chloroform	(µg/L)		ND	**3J**	**3J**	**1J**	**1J**	**1J**	5U	**0.9J**	**0.9J**	**0.8J**	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**180**	**190**	**200**	**80**	**73**	**77**	**92**	**180**	**140**	**140**
Diethyl ether	(µg/L)		NA	NA	NA	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	**12J**	**73**	**75**	**130**	**97**	**80**	**76**	**48**	**52**	**49**	**19**
Isopropylbenzene	(µg/L)		NA	**5**	**6**	**15**	**19**	**19**	**15**	**14**	**16**	**16**	**10**
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	12U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	**8**	**8**	**3J**	**5J**	**3J**	**4J**	**3J**	**6**	**4J**	**5J**
Tetrahydrofuran	(µg/L)		NA	NA	NA	**6J**	**6J**	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	**2J**	**2J**	**2J**	**2J**	**1J**	**0.8J**	**1J**	**0.9J**	**1J**	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	**7**	**7**	**9**	**7**	**8**	**5**	**7**	**8**	**8**	**7**
Trichloroethylene	(µg/L)	5	**14J**	**21**	**22**	**8**	**9**	**4J**	**4J**	**3J**	**12**	**5**	**7**
Vinyl chloride	(µg/L)	2	**120J**	**270**	**270**	**340**	**270**	**280**	**260**	**260**	**300**	**350**	**250**
Xylene (total)	(µg/L)	10000	ND	**14**	**14**	**28**	**19**	**18**	**11**	**11**	**9**	**9**	**5J**
Sum of Constituents	**(µg/L)**		**503**	**706**	**723**	**980**	**730**	**726**	**652.6**	**630.7**	**827.6**	**790.6**	**600.9**

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9. Detections are bolded.
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TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-052										
			11/8/1991	12/3/2001	6/17/2003	8/4/2004	10/28/2004	4/28/2005	11/16/2005	4/27/2006	9/21/2006	10/27/2008	10/27/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Duplicate 1
1,1,1-Trichloroethane	(µg/L)	200	**380J**	**140**	**180**	**120**	**170**	**110**	**110**	**240**	**150**	**150**	**150**
1,1,2-Trichloroethane	(µg/L)	5	NA	**2J**	5U	**1J**	**2J**	5U	**1J**	**2J**	**1J**	**2J**	**2J**
1,1-Dichloroethane	(µg/L)		ND	**94**	**55**	**34**	**63**	**25**	**40**	**47**	**45**	**51**	**51**
1,1-Dichloroethylene	(µg/L)	7	NA	5U	**3J**	**0.9J**	**1J**	**1J**	**1J**	**2J**	**1J**	**3J**	**3J**
1,2,4-Trichlorobenzene	(µg/L)	70	NA	**2J**	**1J**	5U	5U	5U	**1J**	**1J**	**1J**	**2J**	**1J**
1,2-Dichlorobenzene	(µg/L)	600	NA	**19**	**18**	**16**	**21**	**10**	**15**	**14**	**17**	**16**	**16**
1,2-Dichloroethane	(µg/L)	5	NA	**1J**	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		**2900J**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	**1J**	**2J**	**3J**	**4J**	**2J**	**3J**	**4J**	**4J**	**6**	**6**
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	**2J**	**1J**	**0.6J**	**1J**	5U	**0.7J**	**0.9J**	**0.8J**	**0.9J**	**0.8J**
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	**1J**	**1J**	**1J**	**2J**	**0.9J**	**1J**	**2J**	**1J**	**2J**	**2J**
Chloroethane	(µg/L)		NA	5U	**1J**	5U	5U	5U	5U	**2J**	5U	5U	5U
Chloroform	(µg/L)		ND	**2J**	**2J**	**0.8J**	**2J**	5U	**0.9J**	**1J**	**1J**	**0.8J**	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**34**	**270**	**33**	**41**	**110**	**34**	**290**	**71**	**150**	**150**
Diethyl ether	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	**630J**	**310**	**130**	**93**	**190**	**59**	**110**	**170**	**150**	**160**	**150**
Isopropylbenzene	(µg/L)		**NA**	**16**	**13**	**11**	**23**	**6**	**15**	**18**	**19**	**22**	**21**
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	**120J**	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	**4J**	**4J**	**3J**	**2J**	**7**	**8**	**3J**	**3J**	**4J**	**4J**
Tetrahydrofuran	(µg/L)		NA	NA	10U	10U	**7J**	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	**500J**	**7**	**4J**	**1J**	**4J**	**0.7J**	**3J**	**4J**	**3J**	**3J**	**3J**
trans-1,2-Dichloroethene	(µg/L)	100	NA	**5**	**13**	**5J**	**6**	**4J**	**5**	**11**	**8**	**11**	**11**
Trichloroethylene	(µg/L)	5	**130J**	**2J**	**10**	**3J**	**1J**	**8**	**4J**	**5**	**3J**	**4J**	**4J**
Vinyl chloride	(µg/L)	2	**430J**	**290**	**360**	**290**	**350**	**220**	**190**	**400**	**410**	**460**	**440**
Xylene (total)	(µg/L)	10000	**2900J**	**160**	**29**	**14**	**53**	**11**	**38**	**37**	**33**	**31**	**28**
Sum of Constituents	**(µg/L)**		**7990**	**1092**	**1097**	**630.3**	**943**	**574.6**	**580.6**	**1253.9**	**921.8**	**1078.7**	**1042.8**

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8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-054								
			6/11/2003	8/4/2004	8/4/2004	10/28/2004	4/28/2005	11/16/2005	4/27/2006	9/21/2006	10/27/2008
			Primary	Primary	Duplicate 1	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**150**	**140**	**130**	**150**	**58**	**140**	**110**	**63**	**80**
1,1,2-Trichloroethane	(µg/L)	5	**0.8J**	**1J**	**1J**	5U	5U	**1J**	5U	5U	**0.9J**
1,1-Dichloroethane	(µg/L)		**32**	**43**	**42**	**48**	**8**	**36**	**24**	**23**	**32**
1,1-Dichloroethylene	(µg/L)	7	**3J**	**2J**	**2J**	**3J**	**1J**	**4J**	**1J**	**1J**	**1J**
1,2,4-Trichlorobenzene	(µg/L)	70	5U	**1J**	**1J**	**1J**	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	**11**	**20**	**19**	**23**	**8**	**12**	**8**	**10**	**8**
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	**2J**	**4J**	**4J**	**3J**	**1J**	**3J**	**2J**	**2J**	**4J**
Acetone	(µg/L)		20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	**0.9J**	**1J**	**1J**	**0.6J**	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		**1J**	**2J**	**2J**	**2J**	5U	**1J**	**1J**	**1J**	**2J**
Chloroethane	(µg/L)		5U	**2J**	**1J**	**2J**	5U	**1J**	**1J**	5U	5U
Chloroform	(µg/L)		**2J**	**1J**	**1J**	**0.9J**	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**540**	**390**	**410**	**470**	**140**	**490**	**290**	**260**	**230**
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	**370**	**260**	**250**	**240**	**2J**	**100**	**46**	**71**	**110**
Isopropylbenzene	(µg/L)		**25**	**19**	**18**	**14**	5U	**6**	**1J**	**4J**	**7**
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**9**	**4J**	**4J**	**8**	**9**	**26**	**7**	**5J**	**5J**
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	**20**	**10**	**10**	**7**	5U	**8**	**5J**	**3J**	**3J**
trans-1,2-Dichloroethene	(µg/L)	100	**15**	**13**	**13**	**13**	**3J**	**11**	**6**	**6**	**8**
Trichloroethylene	(µg/L)	5	**13**	**5**	**5J**	**34**	**11**	**46**	**9**	**4J**	**9**
Vinyl chloride	(µg/L)	2	**250**	**240**	**300**	**290**	**34**	**210**	**130**	**160**	**190**
Xylene (total)	(µg/L)	10000	**600**	**170**	**170**	**140**	5U	**61**	**25**	**33**	**32**
Sum of Constituents	**(µg/L)**		**2044.7**	**1328**	**1384**	**1449.5**	**275**	**1156**	**666**	**646**	**721.9**

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TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-055									
			11/8/1991	11/14/2001	6/17/2003	7/30/2004	10/25/2004	4/21/2005	11/11/2005	4/24/2006	9/18/2006	10/21/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**19J**	**51**	**3J**	**4J**	**2J**	5U	**1J**	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		ND	**13**	**1J**	**2J**	**1J**	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	**4J**	**2J**	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		16U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	**5**	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**170**	**13**	**37**	**17**	**2J**	**4J**	5U	**3J**	**1J**
Diethyl ether	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	4.7U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**150J**	**100**	**4J**	**34**	**14**	**1J**	**5J**	5U	**5**	**5J**
Tetrahydrofuran	(µg/L)		NA	NA	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	**4J**	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	**22J**	**69**	**5J**	**21**	**9**	**1J**	**3J**	5U	**3J**	**1J**
Vinyl chloride	(µg/L)	2	ND	**2J**	1U	**1**	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**191**	**414**	**26**	**103**	**45**	**4**	**13**	**0**	**11**	**7**

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TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-081									
			11/8/1991	12/5/2001	6/3/2003	7/26/2004	10/19/2004	4/18/2005	11/7/2005	4/17/2006	9/11/2006	10/16/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	1.2U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	ND	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

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TABLE 2.1
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DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-093-O									
			6/5/2003	8/6/2004	10/29/2004	10/29/2004	4/29/2005	4/29/2005	11/17/2005	4/26/2006	9/21/2006	10/28/2008
			Primary	Primary	Primary	Duplicate 1	Primary	Duplicate 1	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**290**	**430**	**340**	**340**	**190**	**180**	**130**	**100**	**150**	**47**
1,1,2-Trichloroethane	(µg/L)	5	**1J**	**4J**	**3J**	**3J**	5U	**1J**	**1J**	5U	**1J**	5U
1,1-Dichloroethane	(µg/L)		**20**	**38**	**63**	**60**	**19**	**19**	**30**	**22**	**38**	**16**
1,1-Dichloroethylene	(µg/L)	7	**3J**	**6**	**3J**	**3J**	**0.9J**	**0.9J**	**2J**	5U	**1J**	5U
1,2,4-Trichlorobenzene	(µg/L)	70	**2J**	**2J**	**2J**	**2J**	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	**1J**	**2J**	**1J**	**1J**	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	**1J**	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	**1J**	**0.6J**	**0.5J**	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		**2J**	**1J**	**3J**	**3J**	**2J**	**2J**	**3J**	**2J**	**2J**	**2J**
Chloroform	(µg/L)		5U	**2J**	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**1100**	**1000**	**530**	**530**	**460**	**450**	**310**	**290**	**270**	**200**
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	**290**	**140**	**170**	**160**	**110**	**110**	**72**	**63**	**55**	**25**
Isopropylbenzene	(µg/L)		**5**	**4J**	**4J**	**4J**	**2J**	**2J**	**2J**	**1J**	**2J**	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**6**	**1J**	**1J**	**1J**	**5J**	**5J**	**3J**	**2J**	**0.9J**	**4J**
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	**24**	**17**	**12**	**11**	**6**	**6**	**6**	**2J**	**5**	**1J**
trans-1,2-Dichloroethene	(µg/L)	100	**25**	**24**	**19**	**17**	**9**	**9**	**9**	**7**	**8**	**5**
Trichloroethylene	(µg/L)	5	**26**	**13**	**5J**	**4J**	**10**	**10**	**15**	**4J**	**2J**	**7**
Vinyl chloride	(µg/L)	2	**180**	**320**	**420**	**430**	**98**	**96**	**170**	**140**	**280**	**99**
Xylene (total)	(µg/L)	10000	**390**	**83**	**63**	**60**	**52**	**51**	**23**	**19**	**13**	**9**
Sum of Constituents	**(µg/L)**		**2365**	**2089**	**1639.6**	**1629.5**	**963.9**	**941.9**	**776**	**652**	**827.9**	**415**

Notes:

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5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-094-O								
			6/4/2003	6/4/2003	8/5/2004	10/29/2004	4/28/2005	11/16/2005	4/27/2006	9/21/2006	10/28/2008
			Primary	Duplicate 1	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**340**	**340**	**120**	**78J**	**370**	**190**	**310**	**78**	**88**
1,1,2-Trichloroethane	(µg/L)	5	**2J**	**2J**	**0.9J**	5U	**3J**	**1J**	**2J**	5U	5U
1,1-Dichloroethane	(µg/L)		**31**	**33**	**24**	**22**	**29**	**19**	**26**	**16**	**10**
1,1-Dichloroethylene	(µg/L)	7	**5**	**6**	**2J**	**1J**	**4J**	**4J**	**3J**	**0.9J**	**1J**
1,2,4-Trichlorobenzene	(µg/L)	70	**2J**	**2J**	**2J**	**1J**	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	**3J**	**3J**	**3J**	**2J**	5U	**2J**	**1J**	**2J**	**2J**
1,2-Dichloroethane	(µg/L)	5	5U	**1J**	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	**5**	**6**	**4J**	**3J**	**2J**	**2J**	**3J**	**2J**	**1J**
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		**1J**	**1J**	**1J**	**2J**	5U	5U	5U	**1J**	**1J**
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		**7**	**8**	**2J**	**2J**	**5**	**3J**	**3J**	**1J**	**0.9J**
cis-1,2-Dichloroethylene	(µg/L)	70	**1100**	**1100**	**290**	**150J**	**860**	**470**	**700**	**160**	**250**
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	**370**	**350**	**120**	**81**	**35**	**47**	**76**	**87**	**41**
Isopropylbenzene	(µg/L)		**16**	**17**	**12**	**9**	5U	**4J**	**3J**	**6**	**3J**
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**14**	**15**	**11**	**17**	**69**	**48**	**36**	**21**	**52**
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	**34**	**36**	**5J**	**4J**	**13**	**18**	**4J**	**3J**	**2J**
trans-1,2-Dichloroethene	(µg/L)	100	**29**	**30**	**11**	**8**	**16**	**11**	**17**	**7**	**8**
Trichloroethylene	(µg/L)	5	**41**	**43**	**10**	**10**	**62**	**65**	**15**	**8**	**22**
Vinyl chloride	(µg/L)	2	**650**	**650**	**320**	**280J**	**210**	**210**	**310**	**280**	**240**
Xylene (total)	(µg/L)	10000	**370**	**400**	**17**	**16**	**38**	**58**	**19**	**11**	**6**
Sum of Constituents	**(µg/L)**		**3020**	**3043**	**954.9**	**686**	**1716**	**1152**	**1528**	**683.9**	**727.9**

Notes:

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4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-102-O							
			6/5/2003	7/29/2004	10/22/2004	4/20/2005	11/7/2005	4/21/2006	9/15/2006	10/21/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(μg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(μg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(μg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(μg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(μg/L)		20U	**15J**	20U	20U	20U	20U	**8J**	20U
Benzene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(μg/L)	700	**1J**	5U	5U	5U	5U	5U	**0.8J**	5U
Isopropylbenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(μg/L)	1000	**14**	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(μg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(μg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(μg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(μg/L)**		**15**	**15**	**0**	**0**	**0**	**0**	**8.8**	**0**

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TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-103-O								
			6/4/2003	7/29/2004	10/25/2004	4/22/2005	11/10/2005	4/20/2006	9/14/2006	10/17/2008	10/17/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Duplicate 1
1,1,1-Trichloroethane	(µg/L)	200	5U	**1J**	5U	5U	**6**	5U	**5J**	**2J**	**2J**
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	**1J**	5U	5U	**4J**	5U	**4J**	**1J**	**1J**
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	5U	**2J**	**1J**	5U	**12**	**1J**	**10**	**6**	**6**
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**4**	**1**	**0**	**22**	**1**	**19**	**9**	**9**

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TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-107-O							
			6/4/2003	7/28/2004	10/21/2004	4/19/2005	11/9/2005	4/19/2006	9/13/2006	10/16/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(μg/L)	200	5U	5U	5U	5U	5UJ	5U	5U	5U
1,1,2-Trichloroethane	(μg/L)	5	5U	5U	5U	5U	5UJ	5U	5U	5U
1,1-Dichloroethane	(μg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
1,1-Dichloroethylene	(μg/L)	7	5U	5U	5U	5U	5UJ	5U	5U	5U
1,2,4-Trichlorobenzene	(μg/L)	70	5U	5U	5U	5U	5UJ	5U	5U	5U
1,2-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5UJ	5U	5U	5U
1,2-Dichloroethane	(μg/L)	5	5U	5U	5U	5U	5UJ	5U	5U	5U
1,2-Dichloroethene	(μg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5UJ	5U	5U	5U
1,4-Dichlorobenzene	(μg/L)	75	5U	5U	5U	5U	5UJ	5U	5U	5U
Acetone	(μg/L)		20U	20U	20U	20U	20UJ	20U	20U	20U
Benzene	(μg/L)	5	5U	5U	5U	5U	5UJ	5U	5U	5U
Carbon disulfide	(μg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
Chlorobenzene	(μg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
Chloroethane	(μg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
Chloroform	(μg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
cis-1,2-Dichloroethylene	(μg/L)	70	5U	5U	5U	5U	5UJ	5U	5U	5U
Diethyl ether	(μg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
Ethylbenzene	(μg/L)	700	5U	5U	5U	5U	5UJ	5U	5U	5U
Isopropylbenzene	(μg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
Methyl ethyl ketone (MEK)	(μg/L)		10U	10U	10U	10U	10UJ	10U	10U	10U
Methylene chloride	(μg/L)	5	5U	5U	5U	5U	5UJ	5U	5U	5U
Tetrachloroethylene	(μg/L)	5	5U	5U	5U	5U	5UJ	5U	5U	5U
Tetrahydrofuran	(μg/L)		10U	10U	10U	10U	10UJ	10U	10U	10U
Toluene	(μg/L)	1000	5U	5U	5U	5U	5UJ	5U	5U	5U
trans-1,2-Dichloroethene	(μg/L)	100	5U	5U	5U	5U	5UJ	5U	5U	5U
Trichloroethylene	(μg/L)	5	5U	5U	5U	5U	5UJ	5U	5U	5U
Vinyl chloride	(μg/L)	2	1U	1U	1U	1U	1UJ	1U	1U	1U
Xylene (total)	(μg/L)	10000	5U	5U	5U	5U	5UJ	5U	5U	5U
Sum of Constituents	**(μg/L)**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

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TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-109-O							
			6/5/2003	8/2/2004	10/26/2004	4/25/2005	11/9/2005	4/24/2006	9/18/2006	10/22/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(μg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(μg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(μg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(μg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(μg/L)		**11J**	**61**	20U	20U	20U	20U	20U	20U
Benzene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(μg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(μg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(μg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(μg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(μg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(μg/L)**		**11**	**61**	**0**	**0**	**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-111-O							
			6/3/2003	7/27/2004	10/27/2004	4/18/2005	11/8/2005	4/18/2006	9/12/2006	10/15/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(μg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(μg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(μg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(μg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(μg/L)		20U	**24**	20U	20U	20U	20U	20U	20U
Benzene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(μg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(μg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(μg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(μg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(μg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(μg/L)**		**0**	**24**	**0**	**0**	**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
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3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-112-O								
			6/9/2003	6/9/2003	8/3/2004	10/26/2004	4/27/2005	11/14/2005	4/25/2006	9/19/2006	10/23/2008
			Primary	Duplicate 1	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-200-O			
			11/17/2005	4/20/2006	9/14/2006	10/15/2008
			Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**0.9J**	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**2J**	5U	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**2.9**	**0**	**0**	**0**

Notes:

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3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.1
SUMMARY OF VOC DETECTIONS - UNCONSOLIDATED DEPOSIT WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-300-O 10/28/2008 Primary	OW-301-O 10/29/2008 Primary	OW-302-O 10/29/2008 Primary	OW-303-O 10/29/2008 Primary	OW-304-O 10/29/2008 Primary
1,1,1-Trichloroethane	(µg/L)	200	**5J**	**1J**	5U	**3J**	**1J**
1,1,2-Trichloroethane	(µg/L)	5	5U	**2J**	5U	5U	5U
1,1-Dichloroethane	(µg/L)		**2J**	**11**	**48**	**14**	5U
1,1-Dichloroethylene	(µg/L)	7	5U	**1J**	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	**1J**
1,2-Dichlorobenzene	(µg/L)	600	**1J**	**2J**	5U	5U	**1J**
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	**3J**
Acetone	(µg/L)		20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	**0.6J**	**0.6J**	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	**10**	**2J**	**2J**	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**72**	**260**	**30**	**48**	**11**
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	**500**	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		**25**	5U	5U	**1J**	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**4J**	**17**	5U	**8**	**3J**
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	**61**	**2J**	5U	**1J**	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	**2J**	**2J**	**2J**	5U
Trichloroethylene	(µg/L)	5	**7**	**480**	**1J**	**3J**	**4J**
Vinyl chloride	(µg/L)	2	**4**	**86**	**30**	**28**	1U
Xylene (total)	(µg/L)	10000	**990**	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**1671**	**874.6**	**113.6**	**110**	**24**

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6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-007											
			11/8/1991	11/7/2001	6/11/2003	7/28/2004	10/21/2004	4/25/2005	11/8/2005	11/8/2005	4/21/2006	9/12/2006	9/12/2006	10/20/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Duplicate 1	Primary	Primary	Duplicate 1	Primary
1,1,1-Trichloroethane	(µg/L)	200	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		ND	**7**	**5**	**3J**	**4J**	**3J**	**3J**	**3J**	**2J**	**3J**	**3J**	**2J**
1,1-Dichloroethylene	(µg/L)	7	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		**820J**	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	**0.6J**	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		NA	NA	**6**	**5J**	**6**	**5**	**5J**	**5J**	**4J**	**5**	**5**	**4J**
Ethylbenzene	(µg/L)	700	ND	**4J**	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		**130J**	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	**42J**	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	**5**	**3J**	**3J**	**3J**	**2J**	**2J**	**2J**	**2J**	**2J**	**2J**	**2J**
Tetrahydrofuran	(µg/L)		NA	NA	**44**	**35**	**52**	**29**	**33**	**32**	**19**	**34**	**34**	**34**
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	ND	**2J**	**1J**	**1J**	5U	**1J**	**1J**	**1J**	5U	**1J**	**1J**	**1J**
Trichlorofluoromethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	ND	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	**10J**	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**1002**	**18**	**59**	**47**	**65.6**	**40**	**44**	**43**	**27**	**45**	**45**	**43**

Notes:

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5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-033											
			11/8/1991	11/14/2001	6/16/2003	6/16/2003	7/29/2004	10/22/2004	4/21/2005	11/9/2005	4/17/2006	4/17/2006	9/11/2006	10/17/2008
			Primary	Primary	Primary	Duplicate 1	Primary	Primary	Primary	Primary	Primary	Duplicate 1	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**31J**	**7**	**6**	**6**	**5J**	**5**	**5**	**5**	**5**	**5**	**3J**	**3J**
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		**23J**	**19**	**20**	**20**	**15**	**18**	**21**	**18**	**21**	**21**	**15**	**16**
1,1-Dichloroethylene	(µg/L)	7	**7.4J**	**4J**	**4J**	**5J**	**4J**	**4J**	**4J**	**4J**	**4J**	**4J**	**3J**	**3J**
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	**1.9J**	**1J**	5U	**1J**	5U	5U	**1J**	5U	**1J**	**1J**	5U	5U
1,2-Dichloroethene	(µg/L)		**34J**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	**6J**	5U	**0.8J**	**0.7J**	**0.8J**	**0.8J**	**0.8J**	**0.7J**	**0.7J**	**0.7J**	**0.8J**	**0.7J**
Carbon disulfide	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	**1J**	**1J**	5U	5U
Chloroform	(µg/L)		**9.4J**	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**35**	**34**	**36**	**33**	**34**	**35**	**39**	**37**	**38**	**29**	**31**
Diethyl ether	(µg/L)		NA	NA	**21**	**22**	**18**	**18**	**26**	**20**	**25**	**25**	**18**	**18**
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		ND	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	1.6U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**19J**	**11**	**12**	**12**	**11**	**11**	**9**	**11**	**13**	**13**	**9**	**12**
Tetrahydrofuran	(µg/L)		NA	NA	**67**	**66**	**62**	**68**	**86J**	**62**	**68**	**70**	**66**	**57**
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	**62J**	**40**	**44**	**45**	**36**	**39**	**41**	**41**	**45**	**45**	**30**	**34**
Trichlorofluoromethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	**2.4J**	**2J**	**2**	**2**	**3**	**2**	**3**	**2**	**3**	**3**	**2**	**3**
Xylene (total)	(µg/L)	10000	**2.2J**	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**198.3**	**119**	**210.8**	**215.7**	**187.8**	**199.8**	**231.8**	**202.7**	**223.7**	**226.7**	**175.8**	**177.7**

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5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-036									
			11/8/1991	11/20/2001	6/13/2003	8/3/2004	10/27/2004	4/26/2005	11/14/2005	4/26/2006	9/20/2006	10/24/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**7.4J**	**1J**	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		**56J**	**11**	**8**	**7**	**10**	**7**	**8**	**8**	**7**	**6**
1,1-Dichloroethylene	(µg/L)	7	**1.5J**	**2J**	**1J**	**1J**	**1J**	**0.9J**	**1J**	5U	**1J**	**1J**
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		**50J**	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		260U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	**2.6J**	5U	5U	**0.5J**	**0.6J**	5U	5U	5U	**0.5J**	5U
Carbon disulfide	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**21**	**14**	**12**	**12**	**9**	**12**	**11**	**12**	**12**
Diethyl ether	(µg/L)		NA	NA	**6**	**7**	**8**	**5**	**7**	5U	**8**	**6**
Ethylbenzene	(µg/L)	700	**5.5J**	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		ND	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	1.4U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**5J**	**19**	**13**	**15**	**13**	**10**	**11**	**10**	**13**	**12**
Tetrahydrofuran	(µg/L)		NA	NA	**35**	**43**	**50**	**22**	**41**	**4J**	**42**	**34**
Toluene	(µg/L)	1000	**1.8J**	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	**9.8J**	**18**	**15**	**14**	**14**	**13**	**13**	**13**	**14**	**14**
Trichlorofluoromethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	**5.5J**	**2J**	1U	1U	1U	1U	**1**	1U	1U	1U
Xylene (total)	(µg/L)	10000	**17J**	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**162.1**	**74**	**92**	**99.5**	**108.6**	**66.9**	**94**	**46**	**97.5**	**85**

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8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-041												
			11/8/1991	11/8/1991	11/15/2001	6/18/2003	8/2/2004	10/25/2004	10/25/2004	4/25/2005	11/10/2005	4/25/2006	4/25/2006	9/19/2006	10/22/2008
			Primary	Duplicate 1	Primary	Primary	Primary	Primary	Duplicate 1	Primary	Primary	Primary	Duplicate 1	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**2.6J**	ND	**4J**	**0.8J**	**71**	**8**	**8**	5U	**7**	5U	5U	**70**	**3J**
1,1,2-Trichloroethane	(µg/L)	5	NA	NA	5U	5U	**3J**	5U	5U	5U	5U	5U	5U	**2J**	5U
1,1-Dichloroethane	(µg/L)		**41J**	**45J**	**130**	**52**	**240**	**92**	**93**	**44**	**73**	**39J**	**8J**	**160**	**46**
1,1-Dichloroethylene	(µg/L)	7	ND	ND	5U	5U	**1J**	5U	5U	5U	5U	5U	5U	**2J**	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	NA	**26**	**12**	**62**	**39**	**39**	**10**	**21**	**10J**	**2J**	**49**	**18**
1,2-Dichloroethane	(µg/L)	5	**1.2J**	ND	**1J**	**1J**	**2J**	**3J**	**3J**	5U	**2J**	**2J**	5U	**2J**	**1J**
1,2-Dichloroethene	(µg/L)		ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	NA	5U	5U	**2J**	**2J**	**2J**	5U	**1J**	5U	5U	**3J**	**2J**
Acetone	(µg/L)		**320J**	19U	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U	**6J**
Benzene	(µg/L)	5	**4.4J**	**4.5J**	**7**	**7**	**12**	**24**	**24**	**8**	**10**	**8**	**2J**	**13**	**11**
Carbon disulfide	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	**2J**
Carbon tetrachloride	(µg/L)	5	NA	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	NA	5U	5U	**1J**	**1J**	**1J**	5U	5U	5U	5U	**2J**	**1J**
Chloroethane	(µg/L)		**8.7J**	**9.6J**	**31**	**29**	**78**	**49**	**48**	**39**	**27**	**36J**	**8J**	**33**	**16**
Chloroform	(µg/L)		ND	ND	5U	5U	**1J**	5U	5U	5U	5U	5U	5U	**0.8J**	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	NA	5U	5U	**39**	**2J**	**2J**	5U	**6**	5U	5U	**46**	5U
Diethyl ether	(µg/L)		NA	NA	NA	**70**	**86**	**200**	**200**	**130**	**100**	**120J**	**27J**	**110**	**130**
Ethylbenzene	(µg/L)	700	**32J**	**37J**	**95**	**45**	**100**	**210**	**210**	**43**	**67**	**38J**	**7J**	**100**	**50**
Isopropylbenzene	(µg/L)		NA	NA	5U	5U	**4J**	**4J**	**4J**	5U	**2J**	5U	5U	**5J**	**3J**
Methyl ethyl ketone (MEK)	(µg/L)		**8.6J**	ND	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		NA	NA	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	2.1U	2.7U	5U	5U	**2J**	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	NA	**380**	**600**	**1100**	**1100**	**660**	**510**	**590J**	**310J**	**600**	**600**
Toluene	(µg/L)	1000	**26J**	**29J**	**1J**	5U	**3J**	**3J**	**3J**	5U	**1J**	5U	5U	**2J**	**0.7J**
trans-1,2-Dichloroethene	(µg/L)	100	NA	NA	**4J**	**2J**	**15**	**8**	**8**	**2J**	**5J**	**2J**	5U	**12**	**4J**
Trichloroethylene	(µg/L)	5	**1.6J**	ND	**1J**	5U	**2J**	5U	**1J**	5U	5U	5U	5U	**3J**	5U
Trichlorofluoromethane	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	ND	ND	4U	1U	**36**	**2**	**2**	1U	**9**	1U	1U	**57**	**1**
Xylene (total)	(µg/L)	10000	**26J**	**28J**	**3J**	**9**	**19**	**75**	**77**	**4J**	**10**	**3J**	5U	**16**	**10**
Sum of Constituents	**(µg/L)**		**472.1**	**153.1**	**303**	**607.8**	**1379**	**1822**	**1825**	**940**	**851**	**848**	**364**	**1287.8**	**904.7**

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TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-079							
			9/4/2003	8/4/2004	10/27/2004	4/26/2005	11/15/2005	4/26/2006	9/20/2006	10/23/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	0.8U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	0.8U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		**6**	**6**	**3J**	**5**	**8**	**2J**	**3J**	**3J**
1,1-Dichloroethylene	(µg/L)	7	**1J**	**0.9J**	5U	5U	**1J**	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	1U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	1U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	1U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	1U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	1U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		6U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	**0.5J**	**0.6J**	5U	5U	**0.8J**	5U	5U	5U
Carbon disulfide	(µg/L)		1U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	1U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		0.8U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		1U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		0.8U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**2J**	**3J**	**1J**	**1J**	**5J**	5U	**1J**	**1J**
Diethyl ether	(µg/L)		**8**	**9**	**4J**	**7**	**12**	**3J**	**5J**	**4J**
Ethylbenzene	(µg/L)	700	0.8U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		1U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		3U	**55**	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		3U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	2U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**7**	**7**	**3J**	**5J**	**6**	**2J**	**2J**	**3J**
Tetrahydrofuran	(µg/L)		**55**	**58**	**26**	**41**	**67**	**11**	**22**	**19**
Toluene	(µg/L)	1000	0.7U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	0.8U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	**7**	**7**	**4J**	**5**	**10**	**2J**	**3J**	**3J**
Trichlorofluoromethane	(µg/L)		2U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	0.8U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**86.5**	**146.5**	**41**	**64**	**109.8**	**20**	**36**	**33**

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10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-082									
			11/8/1991	12/6/2001	6/2/2003	8/2/2004	10/19/2004	4/18/2005	11/7/2005	4/17/2006	9/11/2006	10/16/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		ND	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		ND	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichlorofluoromethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	ND	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-085									
			11/8/1991	12/4/2001	6/11/2003	7/30/2004	10/25/2004	4/21/2005	11/11/2005	4/24/2006	9/18/2006	10/21/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	ND	**3J**	**3J**	**2J**	**1J**	**1J**	5U	**1J**	**0.9J**	5U
1,1,2-Trichloroethane	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		ND	**1J**	**1J**	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		**3.9J**	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	NA	**19**	**16**	**16**	**16**	**12**	**11**	**10**	**9**	**5**
Diethyl ether	(µg/L)		NA	NA	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		ND	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		NA	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	ND	**3J**	**2J**	**1J**	**1J**	5U	5U	**0.8J**	5U	5U
Tetrahydrofuran	(µg/L)		NA	NA	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	ND	**3J**	**2J**	**3J**	**2J**	**2J**	**1J**	**2J**	**2J**	5U
Trichlorofluoromethane	(µg/L)		NA	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	ND	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	ND	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**3.9**	**29**	**24**	**22**	**20**	**15**	**12**	**13.8**	**11.9**	**5**

Notes:

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5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-094-R							
			6/10/2003	8/6/2004	11/1/2004	4/29/2005	11/17/2005	4/28/2006	9/22/2006	10/29/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**1300**	**930**	**1200**	**1600**	**980**	**1000**	**750**	**560**
1,1,2-Trichloroethane	(µg/L)	5	**11J**	**11**	**11J**	**11**	**9J**	**8**	**8**	**6J**
1,1-Dichloroethane	(µg/L)		**330**	**190**	**170**	**230**	**220**	**260**	**230**	**160**
1,1-Dichloroethylene	(µg/L)	7	**99**	**67**	**68**	**79**	**62**	**53**	**59**	**45**
1,2,4-Trichlorobenzene	(µg/L)	70	13U	5U	20U	5U	13U	5U	5U	10U
1,2-Dichlorobenzene	(µg/L)	600	**68**	**94**	**73**	**110**	**72**	**67**	**72**	**57**
1,2-Dichloroethane	(µg/L)	5	**3J**	**2J**	20U	**3J**	13U	**3J**	**2J**	10U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	13U	5U	20U	5U	13U	5U	5U	10U
1,4-Dichlorobenzene	(µg/L)	75	13U	**1J**	20U	**1J**	13U	5U	5U	10U
Acetone	(µg/L)		**1800**	**430**	**320**	**190**	**150**	**110**	**100**	**100**
Benzene	(µg/L)	5	**5J**	**4J**	**3J**	**3J**	**3J**	**3J**	**3J**	**3J**
Carbon disulfide	(µg/L)		13U	**1J**	20U	5U	13U	5U	5U	10U
Carbon tetrachloride	(µg/L)	5	13U	5U	20U	5U	13U	5U	5U	**91**
Chlorobenzene	(µg/L)		13U	5U	20U	5U	13U	5U	5U	10U
Chloroethane	(µg/L)		13U	5U	20U	5U	13U	5U	**3J**	**8J**
Chloroform	(µg/L)		**13**	**4J**	20U	**3J**	13U	**2J**	**2J**	10U
cis-1,2-Dichloroethylene	(µg/L)	70	**3800**	**2000**	**2700**	**2300**	**2200**	**2300**	**2200**	**1700**
Diethyl ether	(µg/L)		**18**	**13**	**10J**	**11**	13U	**10**	**9**	**11**
Ethylbenzene	(µg/L)	700	**17**	**42**	**26**	**37**	**31**	**25**	**30**	**31**
Isopropylbenzene	(µg/L)		13U	5U	20U	5U	13U	5U	5U	10U
Methyl ethyl ketone (MEK)	(µg/L)		**430**	10U	**220**	10U	25U	**180**	10U	**17J**
Methyl isobutyl ketone	(µg/L)		**13J**	**6J**	40U	10U	25U	10U	10U	20U
Methylene chloride	(µg/L)	5	**15**	**9**	20U	**5**	13U	**4J**	**3J**	10U
Tetrachloroethylene	(µg/L)	5	**3J**	**11**	**18J**	**48**	**100**	**10**	**8**	**11**
Tetrahydrofuran	(µg/L)		**160**	**150**	**140**	**140**	**100**	**110**	**95**	**100**
Toluene	(µg/L)	1000	**76**	**76**	**46**	**57**	**47**	**42**	**46**	**50**
trans-1,2-Dichloroethene	(µg/L)	100	**61**	**54**	**59**	**55**	**48**	**48**	**51**	**45**
Trichloroethylene	(µg/L)	5	**170**	**530**	**690**	**1100**	**700**	**570**	**500**	**570**
Trichlorofluoromethane	(µg/L)		13U	5U	20U	5U	13U	5U	5U	10U
Vinyl chloride	(µg/L)	2	**720**	**430**	**790**	**460**	**450**	**370**	**400**	**340**
Xylene (total)	(µg/L)	10000	**150**	**110**	**64**	**77**	**67**	**56**	**64**	**66**
Sum of Constituents	**(µg/L)**		**9262**	**5165**	**6608**	**6520**	**5239**	**5231**	**4635**	**3971**

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9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-101-R							
			6/10/2003	8/5/2004	10/28/2004	4/27/2005	11/15/2005	4/28/2006	9/22/2006	10/27/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**77**	**52**	**71**	**66**	**52**	**90**	**76**	**47**
1,1,2-Trichloroethane	(µg/L)	5	**1J**	**0.9J**	**1J**	**1J**	**1J**	**1J**	**1J**	**0.9J**
1,1-Dichloroethane	(µg/L)		**140**	**94**	**120**	**100**	**85**	**87**	**71**	**62**
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	**2J**	**2J**	**2J**	**2J**	**2J**	**1J**	**2J**	**2J**
1,2-Dichlorobenzene	(µg/L)	600	**36**	**23**	**24**	**23**	**24**	**20**	**21**	**19**
1,2-Dichloroethane	(µg/L)	5	**5**	5U	**4J**	**5J**	5U	**5J**	**3J**	**2J**
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	**1J**	5U	5U	**1J**
1,4-Dichlorobenzene	(µg/L)	75	**5**	**6**	**6**	**6**	**6**	**4J**	**5**	**8**
Acetone	(µg/L)		**750**	20U	20U	**8J**	20U	20U	20U	20U
Benzene	(µg/L)	5	**18**	**12**	**16**	**13**	**15**	**15**	**12**	**8**
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		**4J**	**4J**	**4J**	**3J**	**3J**	**2J**	**3J**	**3J**
Chloroethane	(µg/L)		**7**	**4J**	**7**	**9**	**9**	**12**	**8**	**2J**
Chloroform	(µg/L)		**2J**	5U	5U	**0.8J**	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**35**	**6**	**2J**	**1J**	**1J**	**3J**	**5**	**15**
Diethyl ether	(µg/L)		**200**	**120**	**160**	**190**	**160**	**190**	**140**	**110**
Ethylbenzene	(µg/L)	700	**330**	**200**	**250**	**250**	**180**	**180**	**160**	**78**
Isopropylbenzene	(µg/L)		**26**	**20**	**25**	**26**	**24**	**23**	**24**	**21**
Methyl ethyl ketone (MEK)	(µg/L)		**150**	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		**23**	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	**4J**	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**0.9J**	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		**540**	**370**	**460**	**530**	**370**	**380**	**300**	**200**
Toluene	(µg/L)	1000	**180**	**4J**	**3J**	**3J**	**2J**	**2J**	**3J**	**2J**
trans-1,2-Dichloroethene	(µg/L)	100	**13**	**8**	**9**	**6**	**6**	**6**	**7**	**7**
Trichloroethylene	(µg/L)	5	**3J**	5U	5U	5U	5U	**1J**	**2J**	**3J**
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	**130**	**31**	**30**	**11**	**5**	**17**	**36**	**70**
Xylene (total)	(µg/L)	10000	**400**	**100**	**99**	**83**	**55**	**50**	**43**	**22**
Sum of Constituents	**(µg/L)**		**3077.9**	**1056.9**	**1293**	**1340.8**	**1001**	**1089**	**922**	**682.9**

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8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
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TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-102-R								
			6/5/2003	7/29/2004	10/22/2004	4/20/2005	4/20/2005	11/7/2005	4/21/2006	9/15/2006	10/21/2008
			Primary	Primary	Primary	Primary	Duplicate 1	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U	5U	5U	**1J**	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	**1J**	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	**9J**	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	**1J**	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	5U	5U	5U	5U	5U	5U	**2J**	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**10**	**0**	**0**	**0**	**0**	**4**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-103-R							
			6/9/2003	7/29/2004	10/25/2004	4/22/2005	11/10/2005	4/20/2006	9/14/2006	10/17/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U	5UJ	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		**11J**	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**8**	**5J**	**5**	**4J**	**6**	**5J**	**6**	**6**
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	**0.8J**
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	**3J**	**2J**	**2J**	**1J**	**2J**	**2J**	**3J**	**3J**
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**22**	**7**	**7**	**5**	**8**	**7**	**9**	**9.8**

Notes:

1. "NA" = Not Analyzed
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5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-107-R							
			6/4/2003	7/28/2004	10/21/2004	4/19/2005	11/9/2005	4/19/2006	9/13/2006	10/16/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(μg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(μg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(μg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(μg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(μg/L)		20U	**18J**	**28**	**37J**	**27**	**22**	**25**	**29**
Benzene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(μg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(μg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(μg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(μg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(μg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(μg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Trichlorofluoromethane	(μg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(μg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(μg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(μg/L)**		**0**	**18**	**28**	**37**	**27**	**22**	**25**	**29**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-109-R							
			6/5/2003	8/2/2004	10/26/2004	4/25/2005	11/9/2005	4/24/2006	9/18/2006	10/22/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-110-R							
			6/13/2003	7/28/2004	10/22/2004	4/21/2005	11/8/2005	4/19/2006	9/13/2006	10/20/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	**1J**	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	**0.9J**	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	**2J**	5U	5U	5U	5U	5U	5U	5U
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**3.9**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

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TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-111-R							
			6/3/2003	7/27/2004	10/20/2004	4/18/2005	11/8/2005	4/18/2006	9/12/2006	10/15/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	**48**	20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**0**	**48**	**0**	**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-112-R							
			6/9/2003	8/3/2004	10/26/2004	4/27/2005	11/14/2005	4/25/2006	9/19/2006	10/23/2008
			Primary	Primary	Primary	Primary	Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	**11**	**6**	**6**	**5J**	**4J**	**2J**	**2J**	**2J**
1,1,2-Trichloroethane	(µg/L)	5	**2J**	**2J**	**2J**	**2J**	**1J**	**1J**	**1J**	5U
1,1-Dichloroethane	(µg/L)		**210**	**120**	**130**	**130**	**100**	**100**	**91**	**81**
1,1-Dichloroethylene	(µg/L)	7	**12**	**7**	**7**	**6**	**6**	**4J**	**4J**	**4J**
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	**11**	**14**	**14**	**12**	**12**	**10**	**10**	**13**
1,2-Dichloroethane	(µg/L)	5	**3J**	**3J**	**3J**	**4J**	5U	**3J**	**3J**	**2J**
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	**7J**	20U	20U	**7J**	**11J**	**8J**
Benzene	(µg/L)	5	**12**	**10**	**11**	**8**	**7**	**6**	**5**	**4J**
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Chloroethane	(µg/L)		**66**	**74J**	**95**	**92**	**76**	**78**	**71**	**61**
Chloroform	(µg/L)		**5J**	**3J**	**3J**	**3J**	**2J**	**2J**	**1J**	**1J**
cis-1,2-Dichloroethylene	(µg/L)	70	**27**	**17**	**18**	**14**	**14**	**15**	**12**	**10**
Diethyl ether	(µg/L)		**140**	**120J**	**140**	**150**	**120**	**130**	**120**	**110**
Ethylbenzene	(µg/L)	700	**24**	**18**	**15**	**9**	**6**	**5**	**3J**	**1J**
Isopropylbenzene	(µg/L)		**1J**	**2J**	**2J**	**1J**	**2J**	5U	**1J**	**2J**
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	**66**	**29**	**26**	**20**	**31**	**11**	**15**	**13**
Tetrachloroethylene	(µg/L)	5	**44**	**26**	**27**	**20**	**23**	**13**	**11**	**17**
Tetrahydrofuran	(µg/L)		**1000**	**1000**	**1100**	**1100**	**920**	**900**	**850**	**830**
Toluene	(µg/L)	1000	**2J**	**0.8J**	**0.8J**	**0.7J**	**0.7J**	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	**3J**	**3J**	**3J**	**2J**	**3J**	**2J**	**2J**	**3J**
Trichloroethylene	(µg/L)	5	**28**	**19**	**23**	**17**	**17**	**14**	**13**	**15**
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	**8**	**6**	**5**	**5**	**3**	**5**	**4**	**2**
Xylene (total)	(µg/L)	10000	**24**	**11**	**12**	**5**	**10**	**4J**	**4J**	**4J**
Sum of Constituents	**(µg/L)**		**1699**	**1490.8**	**1649.8**	**1605.7**	**1357.7**	**1312**	**1234**	**1183**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-200-R			
			11/17/2005	4/20/2006	9/14/2006	10/15/2008
			Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(μg/L)	200	5U	5U	5U	5U
1,1,2-Trichloroethane	(μg/L)	5	5U	5U	5U	5U
1,1-Dichloroethane	(μg/L)		5U	5U	5U	5U
1,1-Dichloroethylene	(μg/L)	7	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(μg/L)	70	5U	5U	5U	5U
1,2-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U
1,2-Dichloroethane	(μg/L)	5	5U	5U	5U	5U
1,2-Dichloroethene	(μg/L)		NA	NA	NA	NA
1,3-Dichlorobenzene	(μg/L)	600	5U	5U	5U	5U
1,4-Dichlorobenzene	(μg/L)	75	5U	5U	5U	5U
Acetone	(μg/L)		20U	20U	20U	20U
Benzene	(μg/L)	5	5U	5U	5U	5U
Carbon disulfide	(μg/L)		5U	5U	5U	5U
Carbon tetrachloride	(μg/L)	5	5U	5U	5U	5U
Chlorobenzene	(μg/L)		5U	5U	5U	5U
Chloroethane	(μg/L)		5U	5U	5U	5U
Chloroform	(μg/L)		5U	5U	5U	5U
cis-1,2-Dichloroethylene	(μg/L)	70	5U	5U	5U	5U
Diethyl ether	(μg/L)		5U	5U	5U	5U
Ethylbenzene	(μg/L)	700	5U	5U	5U	5U
Isopropylbenzene	(μg/L)		5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(μg/L)		10U	10U	10U	10U
Methyl isobutyl ketone	(μg/L)		10U	10U	10U	10U
Methylene chloride	(μg/L)	5	5U	5U	5U	5U
Tetrachloroethylene	(μg/L)	5	5U	5U	5U	5U
Tetrahydrofuran	(μg/L)		10U	10U	10U	10U
Toluene	(μg/L)	1000	5U	5U	5U	5U
trans-1,2-Dichloroethene	(μg/L)	100	5U	5U	5U	5U
Trichloroethylene	(μg/L)	5	5U	5U	5U	5U
Trichlorofluoromethane	(μg/L)		5U	5U	5U	5U
Vinyl chloride	(μg/L)	2	1U	1U	1U	1U
Xylene (total)	(μg/L)	10000	5U	5U	5U	5U
Sum of Constituents	**(μg/L)**		**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-201-R			
			11/18/2005	4/21/2006	9/13/2006	10/20/2008
			Primary	Primary	Primary	Primary
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	5U	5U	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		10U	10U	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**0**	**0**	**0**	**0**

Notes:

1. "NA" = Not Analyzed
2. "U" = Not detected above quantitation limit
3. "ND" = Not Detected
4. "J" = Estimated Value
5. ug/L = micrograms per liter
6. Sum of constituents is a sum of detected compounds only.
7. Only constituents detected at least once are presented.
8. Only sites sampled for the Fall 2008 sampling event are shown.
9. Detections are bolded.
10. Phase I, II and III samples were analyzed for both cis- and trans-1,2-DCE (historic samples are assumed to have been analyzed for Total 1,2-DCE).

TABLE 2.2
SUMMARY OF VOC DETECTIONS - BEDROCK WELLS
DAVIS LIQUID WASTE SUPERFUND SITE

CONSTITUENT	UNITS	RI GA GW Quality Standards	OW-202-R				
			11/17/2005	4/21/2006	9/13/2006	10/20/2008	10/20/2008
			Primary	Primary	Primary	Primary	Duplicate 1
1,1,1-Trichloroethane	(µg/L)	200	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	(µg/L)	5	5U	5U	5U	5U	5U
1,1-Dichloroethane	(µg/L)		5U	5U	5U	5U	5U
1,1-Dichloroethylene	(µg/L)	7	5U	5U	5U	5U	5U
1,2,4-Trichlorobenzene	(µg/L)	70	5U	5U	5U	5U	5U
1,2-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U
1,2-Dichloroethane	(µg/L)	5	5U	5U	5U	5U	5U
1,2-Dichloroethene	(µg/L)		NA	NA	NA	NA	NA
1,3-Dichlorobenzene	(µg/L)	600	5U	5U	5U	5U	5U
1,4-Dichlorobenzene	(µg/L)	75	5U	5U	5U	5U	5U
Acetone	(µg/L)		20U	20U	20U	20U	20U
Benzene	(µg/L)	5	5U	5U	5U	5U	5U
Carbon disulfide	(µg/L)		5U	5U	5U	5U	5U
Carbon tetrachloride	(µg/L)	5	5U	5U	5U	5U	5U
Chlorobenzene	(µg/L)		5U	5U	5U	5U	5U
Chloroethane	(µg/L)		5U	5U	5U	5U	5U
Chloroform	(µg/L)		5U	5U	5U	5U	5U
cis-1,2-Dichloroethylene	(µg/L)	70	5U	5U	5U	5U	5U
Diethyl ether	(µg/L)		5U	5U	5U	5U	5U
Ethylbenzene	(µg/L)	700	5U	5U	5U	5U	5U
Isopropylbenzene	(µg/L)		5U	5U	5U	5U	5U
Methyl ethyl ketone (MEK)	(µg/L)		**670**	10U	10U	10U	10U
Methyl isobutyl ketone	(µg/L)		10U	10U	10U	10U	10U
Methylene chloride	(µg/L)	5	5U	5U	5U	5U	5U
Tetrachloroethylene	(µg/L)	5	5U	5U	5U	5U	5U
Tetrahydrofuran	(µg/L)		**370**	**77**	**53**	10U	10U
Toluene	(µg/L)	1000	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	(µg/L)	100	5U	5U	5U	5U	5U
Trichloroethylene	(µg/L)	5	5U	5U	5U	5U	5U
Trichlorofluoromethane	(µg/L)		5U	5U	5U	5U	5U
Vinyl chloride	(µg/L)	2	1U	1U	1U	1U	1U
Xylene (total)	(µg/L)	10000	5U	5U	5U	5U	5U
Sum of Constituents	**(µg/L)**		**1040**	**77**	**53**	**0**	**0**

Notes:

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TABLE 2.3
Monitoring Well Water Quality Measurements
Fall 2008 Monitoring Event
Davis Liquid Waste Superfund Site

Sample Location	Collection Date	Time	Total Volume Purged (L)	Total Volume Purged (gal)	Temp (Celcius)	Specific Conductance (uS/cm)	Dissolved Oxygen (mg/L)	pH	ORP (mV)	Turbidity (NTU)
Bedrock Wells										
OW-200-R	10/15/08	10:35	9.13	2.41	10.73	157	1.72	7.72	-137.3	1.78
OW-111-R	10/15/08	14:40	7.46	1.97	16.23	155	0.53	9.17	107.9	0.00
OW-082[3]	10/16/08	10:15	16.01	4.23	13.01	102	0.34	8.36	-175.0	102.7
OW-107-R	10/16/08	15:11	9.38	2.48	11.93	136	0.54	8.54	-211.3	0.65
OW-033	10/17/08	9:03	6.46	1.71	10.39	208	0.29	7.44	160.0	0.26
OW-103-R	10/17/08	13:36	11.43	3.02	11.71	503	0.32	6.58	-155.8	4.11
OW-007	10/20/08	10:57	4.85	1.28	10.41	170	0.50	8.71	-159.9	0.00
OW-201-R	10/20/08	11:33	10.35	2.73	11.28	102	4.18	6.67	121.9	2.21
OW-110-R[1]	10/20/08	13:50	8.03	2.12	12.05	221	1.64	8.97	-159.7	31.4
OW-202-R	10/20/08	15:00	6.68	1.76	14.35	149	3.11	7.47	185.8	0.78
OW-085[3]	10/21/08	10:13	23.12	6.11	11.32	131	0.16	8.53	-120.5	13.60
OW-102-R	10/21/08	13:50	15.35	4.06	12.34	84	4.38	6.03	-121.2	0.87
OW-109-R	10/22/08	8:30	4.33	1.14	11.07	146	3.20	7.10	191.6	2.63
OW-041	10/22/08	12:00	5.35	1.41	10.90	768	0.38	7.00	-75.5	0.42
OW-112-R	10/23/08	8:59	12.06	3.19	9.45	1180	0.19	8.21	-163.9	2.07
OW-079[3]	10/23/08	13:42	15.25	4.03	10.59	103	0.15	7.17	-101.6	186
OW-036	10/24/08	9:20	5.39	1.42	9.17	172	0.32	8.39	-218.5	0.54
OW-101-R[3]	10/27/08	15:35	11.15	2.95	12.06	345	0.79	6.61	-264.4	6.04
OW-094-R[2]	10/29/08	7:55	19.70	5.20	9.56	522	0.53	6.94	-118.7	1.25
Unconsolidated Wells										
OW-200-O	10/15/08	11:03	20.09	5.31	11.38	141	2.31	4.93	218.3	2.14
OW-111-O	10/15/08	14:23	19.45	5.14	13.94	109	0.45	5.56	-127.0	2.74
OW-081	10/16/08	10:52	30.36	8.02	12.52	22	5.34	4.92	285.4	1.72
OW-107-O	10/16/08	15:05	18.57	4.91	13.81	53	0.23	5.88	120.7	1.43
OW-034	10/17/08	9:04	4.98	1.32	10.85	58	0.61	5.90	-121.1	0.00
OW-103-O	10/17/08	13:40	17.20	4.54	14.49	116	2.47	5.72	206.3	0.14
OW-021	10/20/08	8:55	5.48	1.45	11.72	128	0.28	6.85	-31.9	2.71
OW-055	10/21/08	8:55	4.42	1.17	10.48	50	0.21	5.29	260.1	0.07
OW-102-O	10/21/08	13:30	16.90	4.46	14.76	159	0.55	5.73	-53.3	1.83
OW-109-O	10/22/08	9:14	12.53	3.31	12.57	56	9.87	5.94	-16.9	0.92
OW-043	10/22/08	13:01	11.29	2.98	11.30	318	0.35	6.88	-115.5	3.30
OW-112-O	10/23/08	8:20	6.16	1.63	12.28	34	1.68	5.90	191.3	1.86
OW-045	10/23/08	12:40	3.94	1.04	10.88	119	0.39	6.07	-126.5	0.00
OW-038	10/24/08	9:14	3.35	0.89	9.92	72	0.44	5.47	174.6	0.03
OW-052	10/27/08	9:35	10.04	2.65	11.85	184	1.19	6.29	-245.0	0.83
OW-054	10/27/08	12:07	8.06	2.13	14.69	175	0.96	6.22	-327.0	1.68
OW-051	10/27/08	14:55	4.74	1.25	13.65	124	3.17	5.89	66.3	0.93
OW-093-O	10/28/08	8:55	9.34	2.47	12.10	97	0.20	5.91	-49.6	2.13
OW-300-O	10/28/08	9:30	29.30	7.74	12.39	157	0.53	6.13	-228.3	2.26
OW-094-O	10/28/08	12:50	17.21	4.55	13.01	173	0.29	5.74	44.2	0.51
OW-303-O[3]	10/29/08	10:05	38.90	10.28	11.81	153	0.45	6.00	4.9	76.4
OW-302-O	10/29/08	10:10	6.26	1.65	11.72	727	0.70	6.56	-101.1	4.40
OW-301-O	10/29/08	13:05	14.55	3.84	13.55	185	0.53	6.02	-6.3	4.27
OW-304-O	10/29/08	13:53	24.51	6.48	12.59	77	0.19	6.11	-14.9	1.00

Notes:
1. mg/L = milligrams per liter
2. uS/cm = microsiemens per centimter
3. NTU = Nephelometric Turbidity Unit
4. L = liter
5. gal = gallon
6. ORP = Oxygen Reduction Potential
7. mV = millivolts

[1] = Sampled after a 5-hour period of recharge; parameters recorded from sampling time, while volume = total removed from well.
[2] = Sampled after a 19-hour period of recharge; parameters recorded from sampling time, while volume = total removed from well.
[3] = Samples collected despite turbidity readings >5 NTU; turbidity however was stable (within 10%).

TABLE 3.1
SUMMARY OF PROJECTED ELEVATIONS AND ESTIMATED THICKNESSES
Davis Liquid Waste Superfund Site

Plume Core Boring Location	Projected GS Elevation*	Projected Top of Clean Fill**	Projected Bedrock Elevation***	Estimated Thickness of TB	Estimated Thickness of Plume Core
PC-1	411.7	409.8	390	1.4	14.6
PC-2	413.33	409.85	390.74	3.0	13.9
PC-3	414.60	410.49	387.97	3.6	16.6
PC-4	415.15	411.00	386.57	3.6	18.0
PC-5	414.47	412.53	387.98	1.4	16.6
PC-6	413.65	**N/A**	390.40	**N/A**	14.2
PC-7	409.5	**N/A**	391.5	**N/A**	13.1
PC-8	416.58	411.96	391.48	4.1	13.1
PC-9	417.43	412.17	395.56	4.8	9.0
PC-10	416.80	413.65	389.46	2.7	15.1
PC-11	416.03	411.38	391.35	4.1	13.3
PC-12	414.40	411.85	390.21	2.0	14.4
PC-13	413.01	**N/A**	388.96	**N/A**	15.6
PC-14	412.5	**N/A**	392.0	**N/A**	12.6
PC-15	417.88	411.29	397.07	6.1	7.5
PC-16	418.70	411.21	397.06	7.0	7.5
PC-17	418.15	411.25	393.64	6.4	11.0
PC-18	416.65	410.19	390.28	6.0	14.3
PC-19	414.79	410.0	388.34	4.3	16.3
PC-20	412.76	410.1	383.46	2.2	21.1
PC-21	411.00	**N/A**	386.38	**N/A**	18.2
PC-22	414.8	**N/A**	387	**N/A**	17.6
PC-23	416.08	413.60	382.47	2.0	22.1
PC-24	415.35	412.13	375.91	2.7	28.7
PC-25	413.20	411.0	370.98	1.7	33.6
PC-26	411.29	410.0	369.36	0.8	35.2
PC-27	409.75	**N/A**	370.13	**N/A**	34.5
PC-28	409.0	**N/A**	378	**N/A**	26.6

NOTES:
Estimated thickness of Treated Backfill assumes 6-inch clean soil/loam cap over FSA (Remedial Action Report, LEA, 2002)
Estimated thickness of Plume Core assumes elevation 404.6 feet MSL is top of Plume Core
GS - ground surface
TB - Treated Backfill
N/A - outside mapped area of Treated Backfill (Draft PDI Plan Figure 3.3)
* - based on surveyed ground surface elevations for Phase 4 soil borings and augmented, as necessary, by ground surface elevation contours on Figure 3-4 (Remedial Action Report, As-Built Final Grades, LEA, 2002)
** - based on top of clean fill spot elevations on Figure 3-2 (Remedial Action Report, As-Built Surface of Clean Backfill, LEA, 2002)
*** - based on depth to bedrock information from the existing FSA monitoring wells and the Phase 4 soil borings

TABLE 3.2
PLUME CORE SOIL SAMPLING RATIONALE
Davis Liquid Waste Superfund Site

Stratigraphic Layer	Presence / Absence	Target Analytes	Rationale	Treatability Analytes	Rationale
Clean Fill / Screened Material	P	VOCs only	elevated headspace only	No	N/A
Peat	P/A	VOCs	one/layer/boring when present based on headspace	Yes	one to two samples focused on areas of high concentration and low concentration
Grey Silt/Sand/Clay	P/A	VOCs	one/layer/boring when present based on headspace	Yes	one to two samples focused on areas of high concentration and low concentration
Sand and Sand & Gravel	P	VOCs	one/layer/boring when present based on headspace	Yes	one to two samples focused on areas of high concentration and low concentration
Till	P/A	VOCs	one/layer/boring when present based on headspace	Yes	one to two samples focused on areas of high concentration and low concentration

NOTES:

Full Suite Analysis: two per boring based on field observations and headspace screening of soil samples
samples will be separated by minimum of five feet, where possible
when headspace readings are limited, samples will be biased towards shallow and deep zones within the Plume Core

Physical Testing Parameters: samples will be collected for laboratory analysis at the discretion of the field geologist

- Full Suite Analysis - VOCs, SVOCs, pesticides, PCBs, metals
- Treatability Parameters - Bioavailable ferric iron, AMIBA, cation exchange capacity, acidity/pH buffering
- Physical Testing Parameters - total organic carbon, soil bulk density, total porosity, grain size distribution

N/A - not applicable

- Will include one background location for analysis of the treatability parameters for soil

TABLE 3.3
SUMMARY OF ADDITIONAL ANALYTES
Davis Liquid Waste Superfund Site

TREATABILITY ANALYTES
Soil
Total Organic Carbon*
Soil Particle Size Distribution*
Soil Bulk Density*
Total Porosity *
Cation Exchange Capacity
Bioavailable Ferric Iron
AMIBA
includes: Weak Acid Soluble Iron
Strong Acid Soluble Iron
Acid Volatile Sulfide
Chromium Extractable Sulfide
Acidity / pH Buffering
Groundwater
Nitrate
Nitrite
Ammonia
Sulfate
Sulfide
Total Iron
Total Manganese
Phosphate
Alkalinity
Hardness
Total Dissolved Solids
Ferrous Iron
Ferric Iron
Divalent Manganese (Mn^{+2})
Acidity / pH Buffering
PERFORMANCE MONITORING ANALYTES
Groundwater
Chloride
Total Organic Carbon (TOC)
Dissolved Organic Carbon (DOC)
Total Inorganic Carbon (TIC)
Volatile Fatty Acids (VFA)
Acetic
Butyric
Lactic
Propionic
Pyruvic
Dissolved Gases
Oxygen
Carbon Dioxide
Carbon Monoxide
Nitrogen
Methane
Ethane
Ethene
Acetylene
Hydrogen

NOTES:
AMIBA (Aqueous and Mineral Intrinsic Biodegradation Assessment)
* - physical testing parameters

TABLE 3.4
RATIONALE FOR PLUME CORE WELL LOCATIONS
Davis Liquid Waste Superfund Site

Proposed Well Location	Strata - Screen Interval	Proposed Length of Screen Interval	Basis for Screen Interval	Rationale for Location
PC-#S	Shallow Overburden	5 feet or less	monitor water quality within the shallow overburden within the FSA; well will be screened within the shallow saturated zone taking into consideration the field observations	approximate grid-type well layout within FSA; screen length will be determined based on field observations
PC-#D	Deep Overburden	5 feet or less	monitor water quality within the deep overburden within the FSA; well will be screened in the deeper saturated zone taking into consideration the field observations	approximate grid-type well layout within FSA; screen length will be determined based on field observations
PC-#Peat	Organic Peat	2 feet or less	monitor water quality within the peat deposits within the FSA; well will be screened within the identified layer	will be dependent on field observations and locations of peat deposits
PC-#-Silt	Grey Silt/Sand	5 feet or less	monitor water quality within the grey (lacustrine) silts and fine sands; well will be screened within the identified layer	will be dependent on field observations and locations of grey silt and sand deposits; generally occur within or beneath peat deposits
PCD-#	Overburden	5 feet or less	evaluate water quality near boundary of FSA; well will be screened within the zone exhibiting the highest field headspace reading or in the shallow saturated zone in the absence of elevated readings	plume core delineation wells will be located along the western and southern boundaries of the FSA to verify the extent of the FSA in these directions

NOTES:
FSA - Former Source Area
All wells proposed to be installed using direct push drilling techniques

TABLE 3.5
PLUME CORE GROUNDWATER SAMPLING RATIONALE
Davis Liquid Waste Superfund Site

Wells	Parameters	Frequency
Characterization Wells (PC-#)	VOCs	at least once
Delineation Wells (PCD-#)	VOCs	once

NOTES:

Treatability Parameters: select well locations initially based on the results of the soil boring program focused on potential locations for mixed slurry samples additional sampling for treatability parameters and performance monitoring parameters will be performed to support the ongoing bench-scale program and design of the pilot testing program

Performance Monitoring Parameters: will be sampled as necessary to support the design of the Bench Scale and Pilot Testing Program

- Treatability Parameters - nitrate, nitrite, ammonia, sulfate, sulfide, total iron, ferrous iron, ferric iron, total manganese, divalent manganese, phosphate, alkalinity, hardness, total dissolved solids, acidity/pH buffering
- Performance Monitoring Parameters - chloride, total organic carbon, dissolved organic carbon, total inorganic carbon Volatile Fatty Acids, Dissolved Gases
- Frequency of sampling for Performance Monitoring Parameters to be determined
- Plume Core monitoring wells will not be included in the Site-wide monitoring program

TABLE 3.6
TREATED BACKFILL
SAMPLING STRATEGY AND RATIONALE
Davis Liquid Waste Superfund Site

Condition	Sample Collection	Rationale
≥ 2 feet of Treated Backfill and elevation <409.6 MSL	Collect soil samples from interval with highest headspace reading from 0.5 – 2 feet	Provide data to support human health risk assessment (residential exposure scenario). Assess for leaching potential.
≥ 5 feet of Treated Backfill and elevation <409.6 MSL	Collect soil samples from interval with highest headspace reading from 3 – 5 feet	Provide data to support human health risk assessment (utility worker exposure scenario). Assess for leaching potential.
≥ 8 feet of Treated Backfill and elevation <409.6 MSL	Collect soil samples from interval with highest headspace reading from 6 – 8 feet	Provide data to support human health risk assessment (construction worker exposure scenario). Assess for leaching potential.

TABLE 3.7
RATIONALE FOR BENCH TESTING
Davis Liquid Waste Superfund Site

Experimental Objectives	Benefits
Select best reagent and dosage	Maximize probability of treatment success
	Minimize cost
	Obtain regulatory buy-in
Assess treatment requirements among various soil types	Assess mass removal efficiency and limitations in different soil type and texture (like pH, microbial content, nutrients)
	Maximize probability of effective delivery and dosage design for each geologic setting
	Identify prospect for technical impracticality in some soil types
	Illuminate the key controls on groundwater restoration and justify development of a modified program if indicated
	Foster assessment of mass flux and prediction of restoration time frame
	Determine if technology limitations may exist that need to be considered in the establishment of the final performance goals
Assess rebound rates	Determine the prospect and frequency for retreatment
Identify key field-based analytes and their correlation to performance	Foster design of effective low-cost monitoring program for pilot test and full scale remedy
	Minimize inefficiencies related to data overload and over-frequent groundwater sampling and over-abundant analytes
	Maximize probability of detecting under-performing areas Eliminates repetitive and expensive groundwater sampling and analysis.
Assess prospect for injection (application) challenges	Enable robust assessment and EPA approval of injection methodologies for pilot test
Quantify and compare dechlorination rates due to 1) biodegradation, 2) abiotic reduction, and 3) synergistic pathways	Foster effective reagent recipe design
	Provide basis for negotiation of the scope of the remedy considering limitations and benefits
	Foster reassessment of post-treatment attenuation timeframes for the purposes of optimizing the monitoring plan
Provide direct measurements of remedy performance	Enable reevaluation of EPA model to incorporate more confident assumptions of remedy performance
	Provide basis for optimizing monitoring program to reflect more confident aquifer restoration timeframe
	Foster effective conceptualization of the scale and scope of the remedy

TABLE 3.8
PRODUCTS FOR IN-SITU CHEMICAL REDUCTION AND/OR ENHANCED REDUCTIVE DECHLORINATION
Davis Liquid Waste Superfund Site

Supplier	Product Nomenclature				Characteristics* (Typical, as injected or applied)																Comments		
	Trade Name	Extended Name	Common Name	Link To Product Info	Functional Classification	Effective Use(s)	Target Pollutants	Key Ingredients (in product as delivered)	Longevity	Typical Dosage (g reagent/g matrix)	Hydrogen Potential (g H_2/g active ingredients)	Concentration (active ingredients)	Viscosity	Particle or Droplet Size (µm)	Nutrients	Buffered	Emulsify On-site?	Mix On-site?	Dilute On-site?	Application Method(s)	Product Highlights (according to supplier)	Pros	Cons
Adventus	**EHC**	Eh Compound	EHC (original slurry)	http://www.adventusgroup.com/products/ehc.shtml	Slow-Release Fermentable Substrate with Abiotic Reducing Agent	•Enhanced Reductive Dechlorination •Abiotic Dechlorination	Chlorinated Solvents	•Refined Cellulose •Refined Hemicellulose •Metallic iron (zero valent iron; ZVI)	High (several years)	0.001 to 0.005 (2-10% VP displacement)	0.12	10% to 45% slightly-soluble solids (40% of solids is ZVI)	High (thin or thick slurry)	>100	Yes	Yes	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•EHC is Adventus' flagship product that comes in a variety of formulations (including EHC (original slurry) and liquid versions EHC-A and EHC-L); a controlled-release (long-lasting) amendment that combines fermentable carbon substrate (for bioremediation) and zero valent iron (ZVI) (for abiotic reduction) of chlorinated solvents •Adventus offers in-house bench testing services	•Longevity typically 4 to 6 years •Injected as a slurry of 10% to 40% solids (plant material)	•Injected as a slurry of 10% to 40% solids (plant material)
Adventus	**EHC-A**	Eh Compound-Aqueous	EHC (aqueous solution)	http://www.adventusgroup.com/pdfs/EHC/EHC-A_Product_Summary.pdf	Slow-Release Fermentable Substrate with Abiotic Reducing Agent	•Enhanced Reductive Dechlorination •Abiotic Dechlorination	•Chlorinated Solvents	•Refined Cellulose •Refined Hemicellulose •Ferrous Sulfate (water soluble iron as Fe^{+2})	High (several years)	0.001 to 0.005	0.12	1% to 30% soluble solids (0% of solids is ZVI)	Low (like water)	>100	Yes	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Longevity = ?	•Injected as a aqueous solution 5% to 30% dissolved solids	• Soluble reducing agent is short-lived
Adventus	**EHC-L**	Eh Compound-Lecithin	EHC (liquefied microemulsion)	http://www.adventusgroup.com/pdfs/EHC-L/EHC-L_Technical_Background_JUN2011.pdf	Slow-Release Fermentable Substrate with Soluble Ferrous Iron Abiotic Reducing Agent	•Enhanced Reductive Dechlorination •Abiotic Dechlorination	Chlorinated Solvents	•Lecithin •Ferrous Sulfate (water soluble iron as Fe^{+2}) •Cysteine •Optional additives (nutrients)	Moderate to High (a few to several years)	0.001 to 0.005	0.32	1% to 10%	Low (like water)	<3	Yes	Yes	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Longevity = 2 to 3 years (about half of that for original EHC slurry)	•Microemulsion is more broadly distributable in subsurface than EHC slurry •Particle (droplet) diameter: D60 = 1 um; D90 = 3 um	• Soluble reducing agent is short-lived
Adventus	**EHS-M**	Eh Compound-for Metals	EHC for Metals	http://www.adventusgroup.com/products/ehc_m.shtml	Slow-Release Fermentable Substrate with Abiotic Reducing Agent	•Enhanced Reductive Dechlorination •Abiotic Dechlorination	Chlorinated Solvents	•Refined Cellulose •Refined Hemicellulose •Zero Valent Iron •Ferrous Sulfate (water soluble iron as Fe^{+2})	High (several years)	0.001 to 0.005	0.12	10% to 40% slightly-soluble solids (30% of solids is ZVI)	High (thin or thick slurry)	>100	Yes	Yes	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Much like EHC (original) but provides source of sulfate to promote precipitation of dissolved metals		
Adventus	**EHS-F**	Eh Compound-Fine ZVI	EHC (Soluble Organic Substrate with fine zero valent iron powder)	http://www.adventusgroup.com/projects/proj_ehc_f.shtml	Slow-Release Fermentable Substrate with Zero Valent Iron Abiotic Reducing Agent	•Enhanced Reductive Dechlorination •Abiotic Dechlorination	Chlorinated Solvents	•Refined Cellulose •Refined Hemicellulose •Zero Valent Iron •Ferrous Sulfate (water soluble iron as Fe^{+2})	High (several years)	0.001 to 0.005	0.12	1% to 30% soluble solids (10% of ZVI)	Low (like water)	<45 (ZVI component)	Yes	Yes	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Much like EHC-A but with ZVI instead of Ferrous Sulfate		
Carus	**CAP 18**	Carus Anaerobic Product 18	Unemulsified Vegetable Oil	http://www.caruscorporation.com/content.cfm/cap18	Slow-release Refined Vegetable Oils	Enhanced Reductive Dechlorination Sequester NAPL	Chlorinated Solvents	•Proprietary, Food-Grade, Long-Chain Fatty Acids Refined from Vegetable Oils	High (several years)	0.001 to 0.005	0.18	100%	Moderate (like vegeatable oil)	NA	No	No	No	No	No	•Direct Injection •Wells •LDA Mixing			
Carus	**CAP 18 ME**	Carus Anaerobic Product 18 with Methyl Esters	Unemulsified Vegetable Oil with 10% Methyl Esters	http://www.caruscorporation.com/content.cfm/cap18-me	Faster-release Refined Vegetable Oils	Enhanced Reductive Dechlorination Sequester NAPL	Chlorinated Solvents	•Proprietary, Food-Grade, Long-Chain Fatty Acids Refined from Vegetable Oils	Moderate to High (a few to several years)	0.001 to 0.005	0.18	1% to 10%	Low (like water)	NA	No	No	No	No	No	•Direct Injection •Wells •LDA Mixing			
Carus	**EZVI**	Emulsified Zero Valent Iron	Emulsified Vegetable Oil with ZVI Powder	http://www.ufz.de/data/S7_4_CARUS%20EZVI%2015306.pdf	Faster-release Refined Vegetable Oils	Enhanced Reductive Dechlorination Sequester NAPL	Chlorinated Solvents	•CAP 18 (vegetable oil) •Surfactant •Micrometer-sized Metallic Iron •Water	Moderate to High (a few to several years)	0.001 to 0.005	0.18	1% to 10%	Moderate 1000 cP 10%	<20	No	No	Yes	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Marketed as "primarily" for DNAPL source zone remediation •Probably blended by Toxicological & Environmental Associates, Inc. (TEA), Baton Rouge, www.teainconline.com • Greg Booth, Remquest, 2225.767.3819, gbooth@remquestonline.com		
EOS Remediation	**EQR**	?	Soluble Organic Substrate	http://www.eosremediation.com/products/products.html	Fast-release Fermentable Substrate	Enhanced Anaerobic Bioremediation	Chlorinated Solvents ?	•Under Development and Undisclosed	Low (days to weeks)	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	•Direct Injection •Wells •LDA Mixing			ISCR reagents not available from EOS.
EOS Remediation	**VOS**	Vadose-zone Organic Substrate ?	?	http://www.eosremediation.com/products/VOS.html	Under Development	Anaerobic Bioremediation of Unsaturated Soils	Chlorinated Solvents ?	•Under Development •Thixotropic Gel	High (several years)	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	Undisclosed	•Direct Injection •Wells •LDA Mixing			ISCR reagents not available from EOS.
EOS Remediation	**EOS 450**	Emulsified Oil Substrate	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	Blended Fast-Release and Slow-Release Fermentable Substrate	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Soybean Oil (50%) •Fast-release Substrate (4%) •Fatty Acids (1%) •Emulsifiers/Preservatives (10%) •Extracts (0%) •B12 (No) •Water (35%)	High (several years)	0.001 to 0.005	0.18	1% to 10%	Low (like water)	<5	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			ISCR reagents not available from EOS.
EOS Remediation	**EOS 598**	Emulsified Oil Substrate	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	Blended Fast-Release and Slow-Release Fermentable Substrate	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Soybean Oil (60%) •Fast-release Substrate (4%) •Fatty Acids (0%) •Emulsifiers/Preservatives (10%) •Extracts (0%) •B12 (No) •Water (26%)	High (several years)	0.001 to 0.005	0.18	1% to 10%	Low (like water)	<5	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			ISCR reagents not available from EOS.
EOS Remediation	**EOS 598B42**	Emulsified Oil Substrate	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	Blended Fast-Release and Slow-Release Fermentable Substrate with Extracts and Vitamin B12	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Soybean Oil (60%) •Fast-release Substrate (4%) •Fatty Acids (0%) •Emulsifiers/Preservatives (10%) •Extracts (2%) •B12 (Yes) •Water (24%)	High (several years)	0.001 to 0.005	0.18	1% to 10%	Low (like water)	<5	B12	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			ISCR reagents not available from EOS.
EOS Remediation	**EOS 55 LS**	Emulsified Oil Substrate Low Sodium	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	Blended Fast-Release and Slow-Release Fermentable Substrate	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Soybean Oil (55%) •Fast-release Substrate (8%) •Fatty Acids (0%) •Emulsifiers (0%) •Preservatives (10%) •Extracts (0%) •B12 (No) •Water (27%)	High (several years)	0.001 to 0.005	0.18	1% to 10%	Low (like water)	<5	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			ISCR reagents not available from EOS.
EOS Remediation	**BAC-9**	Dechlorinating Culture # 9	Chloroethene Bugs	http://www.eosremediation.com/products/bioaugmentation.html	Bacteria Culture	Bioaugmentation	Chloroethenes	•Dehalococcoides sp.	High (several years)	NA	0	NA	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			
EOS Remediation	**PJKS-1**	?	High-Alkalinity Bugs	http://www.eosremediation.com/products/bioaugmentation.html	Bacteria Culture	Bioaugmentation in High Alkalinity	Chloroethenes	•Dehalococcoides sp. ? ????	High (several years)	NA	0	NA	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			

TABLE 3.8
PRODUCTS FOR IN-SITU CHEMICAL REDUCTION AND/OR ENHANCED REDUCTIVE DECHLORINATION
Davis Liquid Waste Superfund Site

Supplier	Product Nomenclature				Characteristics* (Typical, as injected or applied)																Comments		
	Trade Name	Extended Name	Common Name	Link To Product Info	Functional Classification	Effective Use(s)	Target Pollutants	Key Ingredients (in product as delivered)	Longevity	Typical Dosage (g reagent/g matrix)	Hydrogen Potential (g H_2/g active ingredients)	Concentration (active ingredients)	Viscosity	Particle or Droplet Size (µm)	Nutrients	Buffered	Emulsify On-site?	Mix On-site?	Dilute On-site?	Application Method(s)	Product Highlights (according to supplier)	Pros	Cons
EOS Remediation	**TCA20**	Trichloroethane-degrading Culture	Chloroethane Bugs	http://www.eosremediation.com/products/bioaugmentation.html	Bacteria Culture	Bioaugmentation	Chloroethanes	•Bacterial Consortium Grown on Chloroethanes	High (several years)	NA	0	NA	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Blend with BAC-9™ to treat mixed chlorinated solvents		
EOS Remediation	**ENV375**		MTBE Bugs	http://www.eosremediation.com/products/bioaugmentation.html	Bacteria Culture	Bioaugmentation	MTBE TBA	•Bacterial Culture Grown on MTBE	High (several years)	NA	0	NA	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			
EOS Remediation	**ENV376**		MTBE Bugs	http://www.eosremediation.com/products/bioaugmentation.html	Bacteria Culture	Bioaugmentation	MTBE TBA	•Bacterial Culture Grown on MTBE	High (several years)	NA	0	NA	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			
EOS Remediation	**AquaBupH**	Aquifer pH Buffering Agent	Carbonate-Encapsulated Oil-In-Water Emulsion	http://www.eosremediation.com/products/AquaBupH.html	Oil-In-Water Emulsion with Buffering Agent	Enhanced Reductive Dechlorination In Poorly-Buffered Aquifers	Chlorinated Solvents	•Carbonate Slurry in Vegetable Oil	Moderate (a few years)	0.01 to 0.1	0	1% to 30%	High (thin or thick slurry)	>10	No	Yes	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			
E-Tec	**Carbstrate**		Soluble Carbohydrate	http://www.etecllc.com/anaerobic-bioremediation.asp	Fast-Acting, soluble, food-grade, nutrient-amended fermentable substrate delivered as a dry powder in 50-lb bags	Typically used with groundwater recirculation applications	Chlorinated Solvents	•Undisclosed water-soluble carbohydrate (probably whey)	Low (several days to a few weeks)	Undisclosed	0.05	Undisclosed	Low (like water)	<5	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Typically used with groundwater recirculation systems	Non-viscous (easy to inject)	•Short-lived
Hepure	**ZVI (H200Plus)**	Zero Valent Iron	Iron Powder	http://www.hepure.com/iron-powder-h200-plus.html	Reactive Metal	Abiotic and Microbially-mediated Reduction	Chlorinated Solvents Dissolved Metals Organochlorine Pesticides Polychlorinated ethyl ethers	70 to 80-micron ZVI	High (several years)	0.0005 to 0.05	0.05	98% in guar gum	High (like honey)	25 to 250 (15-45% <45)	No	Yes	No	Yes	No	•Direct Injection •Wells •LDA Mixing	•May be applied as slurry or dry powder with compressed gas carrier under the "technology" name Ferox by ARS Technologies; http://www.arstechnologies.com/ferox_zero_valent_iron.html		
Hepure	**ZVI (HC15)**	Zero Valent Iron	Iron Powder	http://www.hepure.com/iron-powder-hc15.html	Reactive Metal	Abiotic and Microbially-mediated Reduction	Chlorinated Solvents Dissolved Metals Organochlorine Pesticides Polychlorinated ethyl ethers	5 to 50-micron ZVI	High (several years)	0.0005 to 0.05	0.05	98% in guar gum	High (like honey)	5 to 50	No	Yes	No	Yes	No	•Direct Injection •Wells •LDA Mixing	•May be applied as slurry or dry powder with compressed gas carrier under the "technology" name Ferox by ARS Technologies; http://www.arstechnologies.com/ferox_zero_valent_iron.html		
PARS	**NanoFe**	Zero Valent Iron	Iron Powder	http://www.parsenviro.com/nanofeaw-1.html	Reactive Metal	Abiotic and Microbially-mediated Reduction	Chlorinated Solvents Dissolved Metals Organochlorine Pesticides Polychlorinated ethyl ethers	<1-micron ZVI	High (several years)	0.0005 to 0.05	0.05	98% in guar gum	High (like honey)	<1	No	Yes	No	Yes	No	•Direct Injection •Wells •LDA Mixing	•May be applied as slurry or dry powder with compressed gas carrier under the "technology" name Ferox by ARS Technologies; http://www.arstechnologies.com/ferox_zero_valent_iron.html		
Peerless Metal Powders	**Ground Cast Iron**	Zero Valent Iron	Iron Powder	http://www.peerlessmetal.com/	Reactive Metal	Abiotic and Microbially-mediated Reduction	Chlorinated Solvents Dissolved Metals Organochlorine Pesticides Polychlorinated ethyl ethers	Various size ZVI 100-micron typical	High (several years)	0.0005 to 0.05	0.05	98% in guar gum	High (like honey)	100 to 120	No	Yes	No	Yes	No	•Direct Injection •Wells •LDA Mixing	•May be applied as slurry or dry powder with compressed gas carrier under the "technology" name Ferox by ARS Technologies; http://www.arstechnologies.com/ferox_zero_valent_iron.html	• Directly comperable to ingredient in Redox Tech's ABC+ ISCR product	• 100 to 120-um particle size is in the relatively large particle range
Polymetallix	**NZVI**	Nanoscale Zero Valent Iron	Nano-Iron (Really Small Iron Powder)	http://www.polymetallix.com	Reactive Metal	Abiotic and Microbially-mediated Reduction	Chlorinated Solvents Dissolved Metals Organochlorine Pesticides Polychlorinated ethyl ethers	Nanometer-sized ZVI	Years	0.05 to 5%	0.05	98% in guar gum	High (like honey)	<1	No	Yes	No	Yes	No	•Direct Injection •Wells •LDA Mixing	Year-2005 price quotes from numerous NZVI vendors varied from $20 to $77 per pound depending on the quantity. Zloy, a product from OnMaterials, Inc., was quoted at $20 per pound plus additional shipping of $3 per pound. PolyMetallix, a product manufactured by Crane Company and distributed by Nanitech, LLC, was quoted at a total delivered cost of $77 per pound for 300 lb; an increased quantity of 400 lb would have a slightly lower unit price of $72 per pound. RNIP, a product from Toda America, ranged from approximately $26 to $34 per pound (greater than 10,000-lb quantity to less than 100 lb, respectively), plus additional shipping and handling charges. ARS Technologies, Inc. offered uncatalyzed microscale ZVI for a price between $1.70 to $1.00 per pound for quantities ranging from 1,000 to 1 million pounds, not including freight and tax; www.zerovalentiron.com		
Redox Tech	**ABC**	Anaerobic BioChem	Soluble Organic Substrate	http://redox-tech.com/ABC%20promo.pdf	Blended Fast-Release, Moderate Release, and Slow-Release Fermentable Substrate	•Enhanced Reductive Dechlorination	Chlorinated Solvents	•Sodium Lactate •Ethyl Lactate •C18 Fatty Acids Derived from Vegeatable Oil •Dipotassium Phosphate Buffer and Nutrient	High (several years)	0.001 to 0.005	0.15	1% to 10%	Low (like water)	Not Found	Phosphate	as phosphate	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	• Mixture of fast-dissolving lactates, slow-dissolving fatty acids • Includes a phosphate buffer, which is a micronutrient for bioremediation, and helps to maintain the pH in a range suited for microbial growth	• Blend of short- medium, and long-lasting ingresients • Fairly non-viscous •Contains phosphate buffer • Containes phosphorous nutrient • Directly comperable to ingredients in ABC+ ISCR reagent	
Redox Tech	**ABC+**	Anaerobic BioChem + ZVI	Soluble Organic Substrate with Zero Valent Iron Powder	http://redox-tech.com/ABC+.pdf	Blended Fast-Release, Moderate Release, and Slow-Release Fermentable Substrate with Zero Valent Iron Abiotic Reducing Agent	•Enhanced Reductive Dechlorination •Abiotic Dechlorination	Chlorinated Solvents	•Sodium Lactate •Ethyl Lactate •C18 Fatty Acids Derived from Vegeatable Oil •Dipotassium Phosphate Buffer and Nutrient •Zero Valent Iron	High (several years)	0.001 to 0.005	0.15	1% to 10%	Low (like water)	120 (for ZVI)	Phosphate	as phosphate as ZVI	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Licensed by Adventus •Custom blended to ZVI concentrations up to 50% (w/w)	• Blend of short- medium, and long-lasting ingresients • Fairly non-viscous •Contains phosphate buffer • Containes phosphorous nutrient • Directly comperable to ingredients in ABC ERD reagent	• Peerless ZVI ingredient is is relatively large particle range
Regenesis	**3DMe**	3-D Microemulsion	3DMe	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/3DMe/	Blended Fast-Release and Slow-Release Fermentable Substrate	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Lactate •Glycerol •Glycerol Tripolylactate •Polylactate Esters •Free Fatty Acids •Free Fatty Acid Esters	High (several years)	0.001 to 0.005	0.2	1% to 10%	Low (like water)	Not Found	No	No	Yes	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Evolution of HRC Advanced. Requires On-site emulsification (mechanical mixing with water)	•Claims maximum subsurface distribution through micellar transport (migration); unlike oil products, 3DMe forms micelles which are self-mobilizing in groundwater	•Requires On-site emulsification (mechanical mixing with water) •Viscosity increases significantly below 50 degrees F •Frequent or continuous stirring of neat and diluted product is required •Same-day use of prepared emulsion is required •Poor mixing may result in relatively large average micelle diameter (can blind soil pores) • ISCR reagents not available from Regenesis

TABLE 3.8
PRODUCTS FOR IN-SITU CHEMICAL REDUCTION AND/OR ENHANCED REDUCTIVE DECHLORINATION
Davis Liquid Waste Superfund Site

Supplier	Product Nomenclature				Characteristics* (Typical, as injected or applied)																Comments		
	Trade Name	Extended Name	Common Name	Link To Product Info	Functional Classification	Effective Use(s)	Target Pollutants	Key Ingredients (in product as delivered)	Longevity	Typical Dosage (g reagent/g matrix)	Hydrogen Potential (g H_2/g active ingredients)	Concentration (active ingredients)	Viscosity	Particle or Droplet Size (µm)	Nutrients	Buffered	Emulsify On-site?	Mix On-site?	Dilute On-site?	Application Method(s)	Product Highlights (according to supplier)	Pros	Cons
Regenesis	**3DMe 75**	3-D Microemulsion 75 (factory-emulsified 3DMe; 75% strength)	3DMe 75	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/3DMe75/default.aspx	Blended Fast-Release and Slow-Release Fermentable Substrate	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Lactate •Glycerol •Glycerol Tripolylactate •Polylactate Esters •Free Fatty Acids •Free Fatty Acid Esters	High (several years)	0.001 to 0.005	0.2	1% to 10%	Low (like water)	Not Found	No	No	Yes	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Evolution of 3DMe •Delivered to site ready to inject or ready to dilute with water • Regenisis reports that 3DMe75 can be mixed on-site with ZVI (although this is not standard practice and Regenesis does not supply ZVI)	•Claims maximum subsurface distribution through micellar transport (migration); unlike oil products, 3DMe 75 forms micelles which are self-mobilizing in groundwater •Delivered on-site as a factory-emulsified, dilution-ready product in 5,000-gallon tanker trucks, 2000-lb totes, of 55-gallon drums •pH neutral (good if bioaugmentation is used)	•Viscosity increases significantly below 50 degrees F •Frequent or continuous stirring of neat and diluted product is required • ISCR reagents not available from Regenesis
Regenesis	**HRC**	Hydrogen Release Compound	HRC	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/hrc/	Slow-release Fermentable Substrate	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Glycerol Tripolylactate in Glycerol	High (several years)	0.00001 to 0.0005	0.22	100%	High (like honey)	NA	No	No	No	Yes	No	•Direct Injection •Wells •LDA Mixing	•Regenesis' first ERD Amendment from which evolved HRC-X, HRC Advanced, HRC Primer, 3DMe, and 3DMe75	•May block soil pores (providing sequestering of residual DNAPL)	•Shorter effective life than HRC-X •Viscosity increases significantly below 50 degrees F •May block soil pores • ISCR reagents not available from Regenesis
Regenesis	**HRC-X**	Hydrogen Release Compound-Extended Release	HRC-X	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/hrcx/	Extra Slow-Release Fermentable Substrate	Extended longevity intended to drive desorption, dissolution, and degradation of higher dissolved phase contaminant concentrations and residual DNAPL (source)	Residual Source Chlorinated Solvents (Residual DNAPL)	•Glycerol Tripolylactate in Glycerol	High (several years)	0.00001 to 0.0005	0.22	100%	High (like honey)	NA	No	No	No	Yes	No	•Direct Injection •Wells •LDA Mixing	•First generation evolution of HRC-X	•Longer-lasting than HRC •May block soil pores (providing sequestering of residual DNAPL)	•Viscosity increases significantly below 50 degrees F •May block soil pores • ISCR reagents not available from Regenesis
Regenesis	**HRC Primer**	Hydrogen Release Compound Primer	HRC Primer	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/hrc-primer/	Medium-Fast-Release Fermentable Substrate	Used to scavenge high levels of competing electron acceptors (CEAs), like sulfate, ahead of applying longer lasting fermentable substrates.	Chlorinated Solvents	•Glycerol Tripolylactate in Glycerol	Low to Moderate (several weeks to a few months)	0.00001 to 0.0005	0.05	100%	High (like honey)	NA	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Delivers fermentable substrate faster than HRC-like and EVO-like products, but slower than aqueous solutions of lactose (or other sugars) or ethanol	Easy to inject	•Longevity is small (relative to long-lasting substrates) • ISCR reagents not available from Regenesis
Regenesis	**Bio-Dechlor INOCULUM Plus**		BDI or Bio-Dechlor	http://regenesis.com/contaminated-site-remediation-products/bioaugmentation/bio-dechlor/default.aspx	Bacteria Consortium	Bioaugmentation	Chloroethenes	•Dehalococcoides species •Other dechlorinating species	High (several years)	NA	0	NA	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			• ISCR reagents not available from Regenesis
RNAS	**Newman Zone**		Emulsified Vegetable Oil and Sodium Lactate	http://www.rnasinc.com/newman-zone	Blended Fast-Release and Slow-Release Fermentable Substrate	Enhanced Reductive Dechlorination	Chlorinated Solvents	•Soybean Oil (46%) •Sodium Lactate (4%) •Additives/Emulsifiers (unspecified %) •Water (balance)	High (several years)	0.001 to 0.005	0.15	1% to 10%	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing		•Claims smallest and most uniform oil droplet sizes in the industry	ISCR reagents not available from RNAS
RNAS	**Neutral Zone**		Colloidal Buffering Agent (suspended in water)	http://www.rnasinc.com/neutral-zone	Insoluble Colloidal Buffer Suspended in Water	Raise and Buffer pH During Enhanced Reductive Dechlorination When Natural Buffer Capacity Is Insufficient To Maintain Aquifer pH >5.5	Low pH	•Micron to Sub-micron Sized Calcium Carbonate Particles In Water and Proprietary Blend of Additives	High (several years)	0.01 to 0.1	0	1% to 30%	High (thin or thick slurry)	>100	No	Yes	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Useful When Natural Buffer Capacity Is Insufficient To Maintain Aquifer pH >5.5	•No Potential to Over-shoot pH Too High	
RNAS	**B12YEAST**		Vitamin B12 and Soluble Yeast Extract	http://www.rnasinc.com/newman-zone/b12yeast	Nutrients	Enhance Effectiveness of ERD Amendments	Chlorinated Solvents	•Vitamin B12 (55 mg/L) •Yeast Extract (37.5%)	Moderate (a few years)	NA	0	NA	Low (like water)	>100	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	•Low-viscosity liquid ready to mix		
Tersus	**EDS-ER**	Electron Donor Solution - Extended Release	ESD-ER	http://www.tersusenv.com/component/content/article/74.html	Slow-release water-solubilized vegetable oil	Enhanced Reductive Dechlorination	Chlorinated Solvents	• Soybean Oil • Emulsifiers	High (several years)	Low (like water)	0.18	1% to 30%	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing	• Long lasting water-soluble oil formulated with >92% natural seed oils, provided as water mixable oil, not a water-based oil. There is no water within the formulation. The cost for shipping the electron donor to the project site is reduced by as much as 50%.	• Readily mixes with water to produce milky white aqueous suspension that has consistency of water • On-site mixing with water is readily accomplished with simple in-line blending	ISCR reagents not available from Tersus
	Dithionite		$Na_2S_2O_4$ $K_2S_2O_4$		Soluble Reducing Agent	Abiotic and Microbially-mediated Reduction	Chlorinated Solvents Dissolved Metals Organochlorine Pesticides Polychlorinated ethyl ethers	$S_2O_4^{2-}$ SO^-	High (several years to decades at high and well-buffered pH)	0.000001 to 0.00005	0	<1%	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			
	BNP	Bimetallic Nanoscale Particles			Soluble Reducing Agent	Abiotic and Microbially-mediated Reduction	Chlorinated Solvents	Usually Nickel- or Palladium-Coated ZVI	High (several years)	0.0005 to 0.05	0.05	98% in guar gum	High (like honey)	<1	No	Yes	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			
	SRS								High (several years)	Low (like water)	0.12	1% to 10%	Low (like water)	<20	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			
	HFCS								Low (several days to a few weeks)	Low (like water)	0.05	1% to 10%	Low (like water)	<1	No	No	No	Yes	Yes	•Direct Injection •Wells •LDA Mixing			

* Reagent characteristice derived from liturature and/or scientific judgenment; values may not bevalidated by manufacturers or suppliers.

TABLE 3.9
AMENDMENT SCREENING CRITERIA SUMMARY
Davis Liquid Waste Superfund Site

Criterion	Screening Parameters (typical values based on case studies and vendor recommendations)	Metric	Definition of Agreeable Metric Value
Effectiveness	Rate of chloroethenes depletion	Change in chloroethenes concentrations over time	>50% Reduction in 4 months >90% Reduction in 1 year >95% Reduction in 2 years >99% Reduction in 5 years
	Amendment mass required	Emplaced mass ratio (kg amendment/kg matrix)	<1%
	Production of undesired reaction by-products	pH (VERY IMPORTANT)	6.5<pH<8.5
		Iron	Persistent Fe^{+2} <11 mg/L (Region9 PRG)
		Manganese	Persistent Mn^{+2} <0.88 mg/L (Region9 PRG)
		Arsenic	Persistent As <0.01 mg/L (MCL)
		Carbon Disulfide	Persistent CS_2 <1.0 mg/L (Region9 PRG)
		Acetone	Persistent Acetone <5.5 mg/L (Region9 PRG)
		2-Butanone	Persistent MEK <7.0 mg/L (Region9 PRG)
		Isoburanol	Persistent Isobutanol <1.8 mg/L (Region9
		Nitrate (as N)	Persistent NO_3^- <10 mg/L (MCL)
		Nitrite (as N)	Persistent NO_2^- <1.0 mg/L (MCL)
		Hydrogen Sulfide (gas)	H_2S(g) <0.001 ppmv in soil gas or headspace; CGI <1% LEL in soil gas or headspace; 2 times background in water
		Methane (gas)	CH_4(g) <5,000 ppmv in soil gas or headspace; CGI <1% LEL in soil gas or headspace; CH_4(a) > solubility limit in groundwater
	Microbial Specificity	Microbial Assay	Does not require anthropogenic microbial species
	Longevity	Consistent with Design Philosophy	Soluble Amendments = days to weeks Fast to Moderate Dissolution = 6 to 12 months Slow Dissolution = 12 to 24 months Very Slow Dissolution = 24 to 60 months DNAPL Sequestering = >60 months
	Delivery	Injectability	Readily injected with direct-push equipment into various geologic settings
		Distribution	Readily and adequately distributed at design volume and concentration into various geologic settings
	Ability to treat sources of chloroethene dissolution in groundwater	Direct destruction	Well-demonstrated
		Accelerate dissolution	Well-demonstrated
		Sequester DNAPL	Well-demonstrated
	Ability to treat secondary COPCs	Bis(chloroethyl)ether	Well-demonstrated
		Aldrin	Well-demonstrated
		Dieldrin	Well-demonstrated
		Arsenic	Well-demonstrated
Implementability	Availability of Resources	Procurement	Amendment is readily obtained
		Delivery To Site	Amendment is readily delivered to site
		Preparation at Site	Mixing machinery, water, electricity, and other provisions are readily available
		Specialty Contractors	Injection or other specialty contractors are readily available
	Accessibility	Legal Access	Legal access to injection sites are readily available
		Physical Impediments	No surficial physical impediments to injection locations; trees, structures, rocks, water bodies, wetlands, etc.
			No subsurface impediments to effective injection; rocks, rubble, utilities, depth, etc.
	Regulatory Acceptance	Permits and Approval	EPA approval for unrestricted use is readily obtained
			UIC approval for unrestricted use is readily obtained
			RIDEM approval for unrestricted use is readily obtained
			All other permits/approvals are readily obtained
	Community Acceptance	Public and Community Opinion	No objection to use by the public or local community
	Vendor	Confidence in Vendor	Vendor reputation
			Vendor willing and able to assist with amendment selection and design
Cost	Design	Total Design Cost	Readily designed; little or no complicating factors such as variable amendment mass (time and space), supplemental pH control, bioaugmentation, permitting complications, vapor control/mitigation, multiple installation methods, etc.
	Amendment	Reagent(s) Cost	Readily predictable costs favoring one or few injection events and high hydrogen generation potential (hydrogen equivalents)
	Injection	Reagent(s) Injection Cost	Readily injected and adequately distributed with conventional equipment and contractors.
	Performance Monitoring	Performance Monitoring Cost	Readily monitored in groundwater with conventional monitoring wells using
	Reporting	Effectiveness Reporting	Effectiveness is readily demonstrated and reported

TABLE 3.9A
SCREENING of ISCR and ERD PRODUCTS
Davis Liquid Waste Superfund Site

Product								Candidacy Rank (0 = Not Applicable, 1 = Poor, 2 = Fair, 3 = Good, 4 = Better, 5 = Best)																	COMMENT
Supplier	Trade Name	Extended Name	Common Name	Link To Product Info	Key Ingredients	Reagent Type		Longevity			Viscosity	Particle Size			pH Buffering	Nutrients	Cost Effectiveness ($/effective pound)	Availability	Supplier Guarantee	Proven Track Record	Easily Handled and Mixed In Field	Stability As Delivered	Safe	Total Score	
						Functional Group	Functional Subtype	Substrate	Reducer	Other		Substrate	Reducer	Other											
Tersus	EDS-ER	Electron Donor Solution - Extended Release	ESD-ER	http://www.tersusenv.com/component/content/article/74.html	• Soybean Oil • Emulsifiers	Substrate	Emulsified Vegetable Oil Extracts	3	0	0	4	4	0	0	0	0	3	4	1	2	3	4	4	32	Good choice for a No-Nutrient, Non-Buffer, Substrate
Redox Tech	ABC	Anaerobic BioChem	Soluble Organic Substrate	http://redox-tech.com/ABC%20promo.pdf	•Sodium Lactate •Ethyl Lactate •C18 Fatty Acids Derived from Vegetable Oil •Dipotassium Phosphate Buffer and Nutrient	Substrate	•Emulsified Veg. Oil •Some Soluble and Moderately Soluble Liquids	3	0	0	3	3	0	0	2	2	3	4	1	3	2	2	3	31	Good Choice for a Buffered and Nutrient-Fortified Substrate; No B12; Experimental Advantage if ABC+ Chosen for Blended Test Reagent
Terra Systems	SRS-B	Slow Release Substrate Buffered	Emulsified Vegeatable Oil	http://www.terrasystems.net/Products/products_SRS.htm	•Soybean Oil (60%) •Fast-release Substrate (5%) •Emulsifiers/Preservatives (10%) •B12 (Yes) •Nutrients (Yes)	Substrate	Emulsified Vegetable Oil	3	0	0	3	3	0	0	3	2	3	4	1	2	2	2	3	31	Good Choice for a Well-Buffered and Nutrient-Fortified Substrate; B12
EOS	EOS 598B42	Emulsified Oil Substrate	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	•Soybean Oil (60%) •Fast-release Substrate (4%) •Fatty Acids (0%) •Emulsifiers/Preservatives (10%) •Extracts (2%) •B12 (Yes)	Substrate	•Emulsified Veg. Oil •Some Soluble Liquid •B12	3	0	0	3	3	0	0	0	2	3	4	1	3	2	2	3	29	Non-Buffered; B12
Terra Systems	SRS_SD	Slow Release Substrate Small Droplet	Emulsified Vegeatable Oil	http://www.terrasystems.net/Products/products_SRS.htm	•Soybean Oil (60%) •Fast-release Substrate (5%) •Emulsifiers/Preservatives (10%) •B12 (Yes) •Nutrients (Yes)	Substrate	Emulsified Vegetable Oil	3	0	0	3	3	0	0	0	2	3	4	1	2	2	2	3	28	Non-Buffered; Nutrient-Fortified; B12
Regenesis	3DMe 75	3-D Microemulsion 75 (factory-emulsified 3DMe; 75% strength)	3DMe 75	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/3DMe75/default.aspx	•Lactate •Glycerol •Glycerol Tripolylactate •Polylactate Esters •Free Fatty Acids •Free Fatty Acid Esters	Substrate	Blend of Sparingly, Moderately, and Very Soluble Liquids	3	0	0	3	3	0	0	0	0	3	4	1	3	2	2	3	27	Non-Buffered; No Nutrients
EOS	AquaBupH	Aquifer pH Buffering Agent	Carbonate-Encapsulated Oil-In-Water Emulsion	http://www.eosremediation.com/products/AquaBupH.html	•Carbonate Slurry in Vegetable Oil	Substrate	Emulsified Veg. Oil with pH Buffer	3	0	0	2	3	0	0	3	0	3	4	1	2	2	1	3	27	Good Choice for a Well-Buffered No-Nutrient Substrate; Possible to Add Nutrients and B12
EOS	EOS 450	Emulsified Oil Substrate	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	•Soybean Oil (50%) •Fast-release Substrate (4%) •Fatty Acids (1%) •Emulsifiers/Preservatives (10%) •Extracts (0%) •B12 (No)	Substrate	•Emulsified Veg. Oil •Some Soluble Liquid	3	0	0	3	3	0	0	0	0	3	4	1	3	2	2	3	27	Non-Buffered; B12
EOS	EOS 55 LS	Emulsified Oil Substrate Low Sodium	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	•Soybean Oil (55%) •Fast-release Substrate (8%) •Fatty Acids (0%) •Emulsifiers (0%) •Preservatives (10%) •Extracts (0%) •B12 (No)	Substrate	•Emulsified Veg. Oil •Some Soluble Liquid	3	0	0	3	3	0	0	0	0	3	4	1	3	2	2	3	27	Non-Buffered; No Nutrients
EOS	EOS 598	Emulsified Oil Substrate	Emulsified Vegetable Oil	http://www.eosremediation.com/products/EOS-formulations.html	•Soybean Oil (60%) •Fast-release Substrate (4%) •Fatty Acids (0%) •Emulsifiers/Preservatives (10%) •Extracts (0%) •B12 (No)	Substrate	•Emulsified Vegeatible Oil •Some Soluble Liquid	3	0	0	3	3	0	0	0	0	3	4	1	3	2	2	3	27	Non-Buffered; No Nutrients
RNAS	Newman Zone		Emulsified Vegetable Oil and Sodium Lactate	http://www.rnasinc.com/newman-zone	•Soybean Oil (46%) •Sodium Lactate (4%) •Additives/Emulsifiers (unspecified %)	Substrate	•Emulsified Veg. Oil •Some Soluble Liquid	3	0	0	3	3	0	0	0	0	3	4	1	3	2	2	3	27	Non-Buffered; No Nutrients
Regenesis	3DMe	3-D Microemulsion	3DMe	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/3DMe/	•Lactate •Glycerol •Glycerol Tripolylactate •Polylactate Esters •Free Fatty Acids •Free Fatty Acid Esters	Substrate	Blend of Sparingly, Moderately, and Very Soluble Liquids	3	0	0	2	3	0	0	0	0	3	4	1	3	2	2	3	26	Non-Buffered; No Nutrients
Regenesis	HRC-X	Hydrogen Release Compound-Extended Release	HRC-X	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/hrc/	•Glycerol Tripolylactate in Glycerol	Substrate	Sparingly Soluble Viscous Liquid	4	0	0	1	3	0	0	0	0	2	4	1	3	2	3	3	26	Non-Buffered; No Nutrients
Carus	CAP 18	Carus Anaerobic Product 18	Unemulsified Vegetable Oil	http://www.caruscorporation.com/content.cfm/cap18	•Proprietary, Food-Grade, Long-Chain Fatty Acids Refined from Vegetable Oils	Substrate	Edible Oil	4	0	0	2	1	0	0	0	0	2	4	1	2	3	3	3	25	Non-Buffered; No Nutrients
Regenesis	HRC	Hydrogen Release Compound	HRC	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/hrc/	•Glycerol Tripolylactate in Glycerol	Substrate	Sparingly Soluble Viscous Liquid	3	0	0	1	3	0	0	0	0	2	4	1	3	2	3	3	25	Non-Buffered; No Nutrients

TABLE 3.9A
SCREENING of ISCR and ERD PRODUCTS
Davis Liquid Waste Superfund Site

Product								Candidacy Rank (0 = Not Applicable, 1 = Poor, 2 = Fair, 3 = Good, 4 = Better, 5 = Best)																	COMMENT
Supplier	Trade Name	Extended Name	Common Name	Link To Product Info	Key Ingredients	Reagent Type: Functional Group	Reagent Type: Functional Subtype	Longevity: Substrate	Longevity: Reducer	Longevity: Other	Viscosity	Particle Size: Substrate	Particle Size: Reducer	Particle Size: Other	pH Buffering	Nutrients	Cost Effectiveness ($/effective pound)	Availability	Supplier Guarantee	Proven Track Record	Easily Handled and Mixed In Field	Stability As Delivered	Safe	Total Score	
Carus	CAP 18 ME	Carus Anaerobic Product 18 with Methyl Esters	Unemulsified Vegetable Oil with 10% Methyl Esters	http://www.caruscorporation.com/content.cfm/cap18-me	•Proprietary, Food-Grade, Long-Chain Fatty Acids Refined from Vegetable Oils	Substrate	Edible Oil	3	0	0	2	1	0	0	0	0	2	4	1	2	3	3	3	24	Non-Buffered; No Nutrients
E-Tec	Carbstrate		Soluble Carbohydrate	http://www.etecllc.com/anaerobic-bioremediation.asp	•Undisclosed water-soluble carbohydrate (probably whey)	Substrate	Whey	1	0	0	3	3	0	0	0	0	1	4	1	2	2	3	3	23	Non-Buffered; No Nutrients
Cargil	HFCS	High Fructose Corn Syrup	Corn Sweetener	http://www.cargill.com/food/ap/en/products/sweeteners/corn-sweeteners/isoclear-high-fructose-corn-syrup/index.jsp	Food Grade Corn Sugar (off-spec OKay)	Substrate	High Fructose Corn Syrup	1	0	0	3	4	0	0	0	0	1	3	1	1	2	4	3	23	Non-Buffered; No Nutrients
Regenesis	HRC Primer	Hydrogen Release Compound Primer	HRC Primer	http://regenesis.com/contaminated-site-remediation-products/enhanced-anaerobic-bioremediation/hrc-primer/	•Glycerol Tripolylactate in Glycerol	Substrate	Sparingly Soluble Viscous Liquid	2	0	0	1	3	0	0	0	0	2	4	1	2	2	3	3	23	Non-Buffered; No Nutrients
EOS Remediation	EQR	?	Soluble Organic Substrate	http://www.eosremediation.com/products/products.html	•Under Development and Undisclosed	Substrate	Soluble Liquid	1	0	0	2	2	0	0	0	0	1	1	1	1	1	1	1	12	Non-Buffered; No Nutrients
Hepure	ZVI (HC15)	Zero Valent Iron	Iron Powder	http://www.hepure.com/iron-powder-hc15.html	5 to 50-micron ZVI	Reducer	ZVI	0	2	0	1	0	3	0	1	0	2	3	1	3	2	2	3	23	Minimicro-sized iron
Peerless Metal Powders	Ground Cast Iron	Zero Valent Iron	Iron Powder	http://www.peerlessmetal.com/	Various size ZVI 100-micron typical	Reducer	ZVI	0	3	0	1	0	2	0	1	0	2	3	1	3	2	2	3	23	Mesomicro-sized iron
Hepure	ZVI (H200Plu	Zero Valent Iron	Iron Powder	http://www.hepure.com/iron-powder-h200-plus.html	70 to 80-micron ZVI	Reducer	ZVI	0	3	0	1	0	2	0	1	0	2	3	1	3	2	2	3	23	Mesomicro-sized iron
	Dithionite		$Na_2S_2O_4$ $K_2S_2O_4$		$S_2O_6^{2-}$ SO^-	Reducer	Soluble Liquid	0	1	0	4	0	4	0	0	0	2	3	1	1	2	2	2	22	Requires Suitable Iron Minerals
PARS	BNP	Bimetallic Nanoscale Particles	Palladium-coated Iron Powder	http://www.itrcweb.org/Documents/sedimentsgillslides.pdf	Nickel- or Palladium-Coated ZVI	Reducer	Catalyzed ZVI	0	2	1	1	0	3	0	1	0	2	2	1	2	2	1	2	20	Nano-sized Bi-metal Powder
Polymetallix	NZVI	Nanoscale Zero Valent Iron	Nano-Iron (Really Small Iron Powder)	http://www.polymetallix.com	Nanometer-sized ZVI	Reducer	ZVI	0	1	0	1	2	3	0	1	0	2	2	1	2	2	1	2	20	Nano-sized Iron
PARS	NanoFe	Zero Valent Iron	Iron Powder	http://www.parsenviro.com/nanofeaw-1.html	<1-micron ZVI	Reducer	ZVI	0	1	0	1	0	4	0	1	0	2	2	1	2	2	1	2	19	Nano-sized Iron
Redox Tech	ABC+	Anaerobic BioChem + ZVI	Soluble Organic Substrate with Zero Valent Iron Powder	http://redox-tech.com/ABC+.pdf	•Sodium Lactate •Ethyl Lactate •C18 Fatty Acids Derived from Vegetable Oil •Dipotassium Phosphate Buffer and Nutrient •Zero Valent Iron	Blended Substrate and Reducer	•Liquid Substrates •Solid Reducer	3	3	0	3	3	1	0	2	2	3	4	2	3	2	3	3	37	Mesomicro-sized ZVI; Experimental Advantage if ABC Chosen for Substrate Test Reagent
Adventus	EHC-F	Eh Compound-Fine ZVI	EHC (Soluble Organic Substrate with fine zero valent iron powder)	http://www.adventusgroup.com/projects/proj_ehc_f.shtml	•Refined Cellulose •Refined Hemicellulose •Zero Valent Iron •Optional Additives (Nutrients)	Blended Substrate and Reducer	•Solid Substrate •Solid Reducer •Liquid Reducer	3	3	0	3	3	3	0	1	3	3	4	1	2	2	3	3	37	Minimicro-sized ZVI
Adventus	EHC	Eh Compound	EHC (original slurry)	http://www.adventusgroup.com/products/ehc.shtml	•Refined Cellulose •Refined Hemicelluloose •Metallic iron (zero valent iron; ZVI)	Blended Substrate and Reducer	•Solid Substrate •Solid Reducer	4	3	0	2	1	2	0	1	3	3	4	1	3	2	4	3	36	Thick Slurry
Adventus	EHC-L	Eh Compound-Lecithin	EHC (liquefied microemulsion)	http://www.adventusgroup.com/pdfs/EHC-L/EHC-L_Technical_Background_JUN2011.pdf	•Lecithin •Ferrous Sulfate (water soluble iron as Fe^{+2}) •Cysteine •Optional additives (nutrients)	Blended Substrate and Reducer	•Liquid Substrate •Liquid Reducer	2	2	0	3	3	4	0	2	3	2	4	1	2	2	3	3	36	No Solid ZVI
Adventus	EHC-M	Eh Compound-for Metals	EHC for Metals	http://www.adventusgroup.com/products/ehc_m.shtml	•Refined Cellulose •Refined Hemicellulose •Zero Valent Iron •Ferrous Sulfate (water soluble iron as Fe^{+2})	Blended Substrate and Reducer	•Solid Substrate •Solid Reducer •Liquid Reducer	4	3	0	2	1	2	0	1	3	3	4	1	2	2	3	3	34	Thick Slurry; Solid and Liquid Iron
Adventus	EHC-A	Eh Compound-Aqueous	EHC (aqueous solution)	http://www.adventusgroup.com/pdfs/EHC/EHC-A_Product_Summary.pdf	•Refined Cellulose •Refined Hemicellulose •Ferrous Sulfate (water soluble iron as Fe^{+2})	Blended Substrate and Reducer	•Solid Substrate •Liquid Reducer	3	2	0	3	2	4	0	1	0	2	4	1	2	2	3	3	32	Similar to EHC-F but Replaces ZVI With Liquid Iron
Carus	EZVI	Emulsified Zero Valent Iron	Emulsified Vegetable Oil with ZVI Powder	http://www.ufz.de/data/57_4_CARUS%20EZVI%2015306.pdf	•CAP 18 (vegetable oil) •Surfactant •Micrometer-sized Metallic Iron •Water	Blended Substrate and Reducer	•Liquid Substrate •Solid Reducer	4	3	0	2	3	3	0	1	0	2	4	1	2	2	2	3	32	Non-Buffered, No Nutrients; Marketed for DNAPL Treatment
RNAS	B12YEAST		Vitamin B12 and Soluble Yeast Extract	http://www.rnasinc.com/newman-zone/b12yeast	•Vitamin B12 (55 mg/L) •Yeast Extract (37.5%)	Supplement	Nutrients	0	0	2	3	0	0	4	0	0	3	3	1	2	3	3	3	27	Nutrioent Package Useable In Many Reagents

TABLE 3.9A
SCREENING of ISCR and ERD PRODUCTS
Davis Liquid Waste Superfund Site

Product								Candidacy Rank 0 = Not Applicable 1 = Poor 2 = Fair 3 = Good 4 = Better 5 = Best																	COMMENT
Supplier	Trade Name	Extended Name	Common Name	Link To Product Info	Key Ingredients	Reagent Type		Longevity			Viscosity	Particle Size			pH Buffering	Nutrients	Cost Effectiveness ($/effective pound)	Availability	Supplier Guarantee	Proven Track Record	Easily Handled and Mixed In Field	Stability As Delivered	Safe	Total Score	
						Functional Group	Functional Subtype	Substrate	Reducer	Other		Substrate	Reducer	Other											
RNAS	Neutral Zone		Colloidal Buffering Agent (suspended in water)	http://www.rnasinc.com/neutral-zone	•Micron to Sub-micron Sized Calcium Carbonate Particles In Water and Proprietary Blend of Additives	Supplement	pH Buffer	0	0	3	1	0	0	2	4	0	3	4	1	2	2	3	2	27	Thick Slurry; Stand-alone Burrer
EOS	BAC-9	Dechlorinating Culture # 9	Chloroethege Bugs	http://www.eosremediation.com/products/bioaugmentation.html	•Dehalococcoides sp.	Supplement	Bacteria	0	0	3	3	0	0	4	0	0	3	2	1	2	2	1	3	24	Other Designer Bacteria Exist
Regenesis	Bio-Dechlor INOCULUM Plus		BDI or Bio-Dechlor	http://regenesis.com/contaminated-site-remediation-products/bioaugmentation/bio-dechlor/default.aspx	•Dehalococcoides species •Other dechlorinating species	Supplement	Bacteria	0	0	3	3	0	0	4	0	0	3	2	1	2	2	1	3	24	Other Designer Bacteria Exist
EOS	ENV375		MTBE Bugs	http://www.eosremediation.com/products/bioaugmentation.html	•Bacterial Culture Grown on MTBE	Supplement	Bacteria	0	0	3	3	0	0	4	0	0	3	2	1	2	2	1	3	24	Other Designer Bacteria Exist
EOS	ENV376		MTBE Bugs	http://www.eosremediation.com/products/bioaugmentation.html	•Bacterial Culture Grown on MTBE	Supplement	Bacteria	0	0	3	3	0	0	4	0	0	3	2	1	2	2	1	3	24	Other Designer Bacteria Exist
EOS	PJKS-1		High-Alkalinity Bugs	http://www.eosremediation.com/products/bioaugmentation.html	•Dehalococcoides sp. ? ????	Supplement	Bacteria	0	0	3	3	0	0	4	0	0	3	2	1	2	2	1	3	24	Other Designer Bacteria Exist
EOS	TCA20	Trichloroethane -degrading Culture	Chloroethane Bugs	http://www.eosremediation.com/products/bioaugmentation.html	•Bacterial Consortium Grown on Chloroethanes	Supplement	Bacteria	0	0	3	3	0	0	4	0	0	3	2	1	2	2	1	3	24	Other Designer Bacteria Exist
EOS	VOS	Vadose-zone Organic Substrate ?		http://www.eosremediation.com/products/VOS.html	•Under Development •Thixotropic Gel	Migration Blocker	Insoluble Liquid	0	0	4	2	0	0	2	0	0	1	1	1	1	1	1	1	15	Vadose-Zone Treatment Product

TABLE 3.10
CANDIDATE BENCH TESTING SERVICE PROVIDERS FOR ISCR AND ERD
Davis Liquid Waste Superfund Site

Supplier/Manufacturer												Comments			
Company Name (Full)	**Company Name (Short)**	**Website**	**Contact Name**	**Phone**	**Email**	**Street Address**	**City**	**State**	**Country**	**Zip Code**	**Distance From Site**	**Highlights** (according to Company)	**Is Their Written Protocol (SOP) Available? Is it Agreeable?**	**Pros**	**Cons**
Bioremediation & Treatability Center (Division of Innovative Engineering Solutions, Inc.)	BTC (IESI)	http://www.iesionline.com/btc/services.htm	Dr. Sami A. Fam	508.668.0033 (221)	s.fam@iesionline.com	25 Spring St	Walpole	MA	USA	02081	35	• BTC provides independent anaerobic microcosm and treatability testing for enhanced anaerobic dechlorination via ISCR and ISB pathways	Standard Protocol = Yes Agreeable As-Is = ?	• Location is close to site (35 miles by interstate), so that samples can be delivered quickly without special handling and shipping provisions • Documented experience testing of ISB and ISCR reagents • High credibility demonstrable as Dr. Sami Fam coauthored remediation textbook In Situ Treatment Technology • No supplier of remediation products, which alieviates prospect for any unwanted bias toward a product • Dr. Sami Fam has expressed strong interest in supporting this project • Dr. Fam is already offering recommendations for alternate approaches such as recirculation of soluble substrate-amended groundwater, and aqueous dithionite redox manipulation • IESI offers close-to-site meeting place	• BTC is the laboratory for parent consulting company IESI • Dr. Fam is already offering recommendations for alternate approaches such as recirculation of soluble substrate-amended groundwater, and aqueous dithionite redox manipulation
Bioremediation Consulting, Inc.	BCI (BCI Labs)	http://www.bcilabs.com/about.html	Dr. Margaret Findlay	617.923.0976	mfindlay@bcilabs.com	39 Clarendon St.	Watertown	MA	USA	02472	60	• BCI provides independent microbiological and analytical services, and is equipped to perform anaerobic microbiological testing, preparing microcosms from site soil and ground water in an anaerobic glove box to document microbial processes such as PCE and TCE dechlorination to ethene	Standard Protocol = Yes Agreeable As-Is = No (uses acidification to steralize control)	• Location is close to site (60 miles by interstate), so that samples can be delivered quickly without special handling and shipping provisions • Positive testimonial from Ashland's JEV regarding credibility of Dr. Sam Fogel as "expert" presenter to regulators • Dr. Findlay and Dr. Fogel appear to be well published (but not too much lately) • Supplier of bioremediation cultures; some claiming to be low-pH-tolerant DHC sp. • QA/QC should alieviate prospect for any unwanted bias toward their bechlorinating bacteria culture(s) • Has anaerobic chamber for preparing samples	• Niche appears geared toward testing of ISB reagents; capability toward abiotic (ISCR) reagents is unknown (but probably sufficient) • Energy is required to assure that QA/QC alieviates prospect for unwanted bias toward their bechlorinating bacteria culture(s) • Staff does not arrive until after 9:00 (or 9:30) • Dr. Findlay and Dr. Fogel appear to be sparsely published since the 1990s • SOP uses acidification to steralize control, which also stiffles abitic transformations
XDD, LLC.	XDD	http://www.xdd-llc.com/services-treatability.html	Dr. Brant Smith	603.778.1100	smith@xdd-llc.com	22 Marin Way, Unit #3	Stratham	NH	USA	03885	120	• Environmental consultant with in-house contaminant treatability laboratory to bench test evolving technologies such as ISCR and ISCO		• Location is close to site (120 miles by interstate), so that samples can be delivered quickly without special handling and shipping provisions • Not a supplier of remediation products, which alieviates prospect for any unwanted bias toward a product	• Niche is geared toward testing of ISCO (and ISCR) reagents; capability toward ISB testing reagents is limited and requires coopereation of a subcontracted lab
Shaw Environmental & Infrastructure, Inc. Technology Development Lab	**Shaw TDL**	http://www.shawgrp.com/capabilities/technology/environmental/bioaug	Dr. Robert Steffan	609.895.5350	rob.steffan@shawgrp.com	4100 Quakerbridge Rd.	Lawrenceville	NJ	USA	08648	250	• Consultant offers in-house laboratory focused on treatability studies through former Envirogen	Standard Protocol = Yes Agreeable As-Is = Yes (uses autoclave to steralize control)	• Location is fairly close to site (250 miles by interstate), so that samples can be delivered fairly quickly without special handling and shipping provisions • Formerly Envirogen, purchased by Shaw, Dr. Steffan operates as independent laboratory with many consultant clients, so competetion for "consultancy" is agreeably contrary to business model • Redox Tech recommends Rob Steffan • Harms' telephone interview with Steffan left good impression of capabilities, and ability to work together effectively • Dr Steffan has expressed a strong interest in supporting this effort • QA/QC should alieviate prospect for any unwanted bias toward their bechlorinating bacteria culture; Shaw Dechlorinating Culture SDC-9 • Has anaerobic chambers for sample preparation and testing; one capable of handling a 6-foot core	• Energy is required to assure that QA/QC alieviates prospect for unwanted bias toward their bechlorinating bacteria culture; Shaw Dechlorinating Culture SDC-9
Site Recovery & Management	SiREM	http://www.siremlab.com/treatabilitystudies.html	Jeff Roberts	519.822.2265 (228)	jroberts@siremlab.com	130 Research Lane, Suite 2	Guelph	Ontario	Canada	N1G 5G3	530	• SiREM offers in-house treatability studies for bioremediation, zero-valent iron, and chemical oxidation including molecular genetic testing for dechlorinating bacteria (Gene-Trac®) and bioaugmentation cultures (KB-1/KB-1 Plus)		• QA/QC should alieviate prospect for any unwanted bias toward their bechlorinating bacteria culture; KB-1 or KB-1 Plus	• Location is far from site; in Canada, requiring special handling and shipping of samples • Energy is required to assure that QA/QC alieviates prospect for unwanted bias toward their bechlorinating bacteria culture; KB-1 or KB-1 Plus
Global Remediation Technologies, Inc.	GRT	http://www.grtusa.com/appliedresearch_labservices.php	Richard Raetz, P.E.	231.941.8622	richard@grtusa.com	1102 Cass Street	Traverse City	MI	USA	49684	900	• Environmental consultant with in-house applied research and laboratory services unit that performs bench-scale treatability studies on undisturbed soil cores and groundwater			• Location is far from site; requiring special handling and shipping of samples
Adventus Americas Inc.	Adventus	http://www.adventusgroup.com/pdfs/LabTreatTestServ_AUG09.pdf	Dr. Jim Mueller	815.235.3503 630.309.1175	jim.mueller@adventusgroup.com	2871 W. Forest Rd, Suite 2	Freeport	IL	USA	61032	1,100	• Supplier of EHC-branded amendments for ISCR and ISB offers in-house bench testing of any amendment.		• QA/QC should alieviate prospect for any unwanted bias toward their products	• Location is far from site; requiring special handling and shipping of samples • Energy is required to assure that QA/QC alieviates prospect for unwanted bias toward their products
Remedius, LLC.	Remedius	http://remedius.com/Remedius/Treatability.html	Thomas J. deGrood	806.457.0800	tjdegrood@remedius.com	2810 Duniven Circle, Suite 102	Amarillo	TX	USA	79109	1,900	• Consultant has completed thousands of treatability studies			• Location is far from site; requiring special handling and shipping of samples
Prima Environmental, Inc.	PRIMA	http://www.primaenvironmental.com/	Dr. Cindy Schreier	916.939.7300	cschreier@primaenvironmental.com	5070 Robert J. Mathews Parkway, Suite 300	El Dorado Hills	CA	USA	95762	3,000	• Independent laboratory that specializes in treatability testing, technology evaluation, custom laboratory work and scientific consulting services for the environmental community			• Location is far from site; requiring special handling and shipping of samples
Environmental Bio-Systems, Inc.	EBS	http://www.ebsinfo.com/BenchTesting.pdf	James Jacobs, P.G.	415.381.5195	jimjacobs@ebsinfo.com	707 View Point Road	Mill Valley	CA	USA	94941	3,100	• Consultant and contractor has performed dozens of bench tests for in situ chemical oxidation (ISCO) and enhanced bioremediation (microcosm studies), and metals stabilization for numerous consulting companies			• Location is far from site; requiring special handling and shipping of samples

TABLE 3.16
OVERVIEW OF BEDROCK CHARACTERIZATION PROGRAM
Davis Liquid Waste Superfund Site

Bedrock Wells: Former Source Area (FSA)

Proposed Well	Location	Rationale	Methods
OW-403-R	FSA Central: co-locate with well OW-094-O/R	1. Install well 15 ft into bedrock (5 ft of screen) to target the weather/fractured bedrock that is most likely hydraulically connected to the overburden aquifer. 2. Assess the vertical distribution of COC concentrations in groundwater to evaluate mass flux contribution to overburden aquifer via upward groundwater flow movement. 3. Assess the variance in the groundwater gradient between overburden and bedrock aquifers to better understand vertical mass transfers that may be affecting the COC concentrations observed in bedrock groundwater and the role that vertical mass transfers may be having on concentration trends and impact to the overburden aquifer. 4. Assess well yield and bedrock transmissivity to understand how mass transfer and advective transport may be controlling and/or limiting MNA processes. 5. Estimate physical properties of rock fractures and connectivity of fractures. Data will be used to better understand fate and transport of COC in bedrock. 6. Provide direct evidence of biological activity and reductive dechlorination of chlorinated VOCs.	1. Wells to be installed by rotary coring drilling method. 2. Collect whole rock cores for visual characterization and identification of rock fractures. 3. Conduct aquifer testing by one or more of the following methods: slug test and/or single well pump test. If single well pump test conducted, monitor selected overburden and bedrock wells using data loggers to assess spatial hydraulic response to the aquifers caused by well test. Dilution tracer tests may be considered, if warranted. 4. Conduct long-term continuous monitoring of groundwater elevation at wells OW-094-O, OW-094-R and OW-403-R (proposed) (see Hydraulic Monitoring below). 5. Conduct FLUTe screening in the open borehole to identify the potential absence or presence of DNAPL. 6. Analyze bedrock groundwater samples in accordance with the Groundwater Monitoring Program. 7. Analyze bedrock groundwater for the occurrence of Dehalococcoides and other bacteria species capable of reductive dechlorination of chlorinated compounds. The analyses maybe by the analysis of groundwater samples or Bio-trap method.
OW-404-R	FSA South Disposal Area: co-locate with well OW-093		
OW-405-R	FSA North Disposal Area: co-locate with well OW-054		

Bedrock Wells: Down-dip Delineation

Proposed Well	Location	Rationale	Methods
OW-400-R	East of FSA: 650 ft east of South Disposal Area	1. Well completion depth will be guided by the results of the geophysical survey and target potential fracture zones that may be connected to the FSA area. Total depth of wells not to exceed 200 ft (completed with 10 ft of screen). 2. Assess groundwater quality east and down dip of the FSA area. 3. Assess the variance in the groundwater gradient between overburden and bedrock aquifers to better understand vertical mass transfers that may be affecting the COC concentrations observed in bedrock groundwater and the role that vertical mass transfers may be having on concentration trends and impact to the overburden aquifer. 4. Assess well yield and bedrock transmissivity to understand how mass transfer and advective transport may be controlling and/or limiting MNA processes. 5. Estimate physical properties of rock fractures and connectivity of fractures. Data will be used to better understand fate and transport of COC in bedrock.	1. One well to be installed by rotary coring drilling method (OW-401-R). 2. Collect whole rock cores from OW-401-R borehole for visual characterization and identification of rock fractures. 3. Two wells to be installed by air rotary drilling method (OW-400-R and OW-402-R). 4. 3. Conduct aquifer testing by one or more of the following methods: slug test and/or single well pump test. 5. Conduct long-term continuous monitoring of groundwater elevation at wells OW-102-O, OW-102-R and OW-400-R (proposed) (see Hydraulic Monitoring below). 6. Analyze groundwater samples in accordance with the Groundwater Monitoring Program.
OW-401-R	East of FSA: 390 ft east of central Plume Core Area		
OW-402-R	East of FSA: 390 ft east of North Disposal Area at well couplet OW-102		

Bedrock Wells: Downgradient Delineation

Proposed Well	Location	Rationale	Methods
OW-406-R	Down gradient of FSA: co-located with well couplet OW-051/101R	1. Install wells to an elevation depth of 310 ft msl (depth approximately 95 ft) with 10 ft of screen to assess the vertical distribution of COC concentrations in bedrock groundwater. The 310 ft msl depth elevation places the screen interval approximately 30 ft below known groundwater impacts at these locations. 2. Evaluate mass flux contribution to overburden aquifer via upward groundwater flow movement. 3. Assess the variance in the groundwater gradient between overburden and bedrock aquifers to better understand vertical mass transfers that may be affecting the COC concentrations observed in bedrock groundwater and the role that vertical mass transfers may be having on concentration trends and impact to the overburden aquifer. 4. Assess well yield and bedrock transmissivity to understand how mass transfer and advective transport may be controlling and/or limiting MNA processes. 5. Estimate physical properties of rock fractures and connectivity of fractures. Data will be used to better understand fate and transport of COC in bedrock.	1. Wells to be installed by air rotary drilling method (no rock coring is proposed). 2. Conduct aquifer testing by one or more of the following methods: well packer test, slug test, matrix diffusion dye tracer test, and/or single well pump test. 3. Conduct long-term continuous monitoring of groundwater elevation at wells OW-51-O, OW-101-R and OW-406-R (proposed) (see Hydraulic Monitoring below). 4. Analyze groundwater samples in accordance with the Groundwater Monitoring Program.
OW-407-R	Down gradient of FSA: co-locate with well couplet OW-112		

TABLE 3.16
OVERVIEW OF BEDROCK CHARACTERIZATION PROGRAM
Davis Liquid Waste Superfund Site

Overburden Piezometer

Proposed Piezometer	Location	Rationale	Methods
OW-400-O	East of FSA: 500 ft east of South Disposal Area. Co-locate with proposed bedrock well OW-400-R.	1. Assess the variance in the groundwater gradient between overburden and bedrock aquifer to better understand vertical mass transfers that may be affecting the COC concentrations observed in bedrock groundwater and the role that vertical mass transfers may be having on concentration trends and impact to the overburden aquifer.	1. Well to be installed by either Rotasonic, direct push or drive and wash drilling method to the approximate middle of the saturated zone in the overburden.

Hydraulic Monitoring: Surface Water, Overburden Aquifer and Bedrock Aquifer

Proposed Piezometer	Location	Rationale	Methods
FSA	OW-094-O, OW-094-R, OW-403-R (proposed)	1. Assess the variance in the groundwater gradient between the overburden and bedrock aquifers to better understand how vertical mass transfers may be affecting the COC concentrations observed in the bedrock groundwater and the role that vertical mass transfers may be having on concentration trends. 2. Assess the effects of the hydraulic loading of the aquifer by surface water. 3. Assess the aquifer hydraulic relationship between the surface water and overburden/bedrock aquifers. 4. Assess the temporal changes in the hydraulic system caused by seasonal changes and rain events.	1. Install miniTROLL data logger/pressure transducers in a stilling well located in the surface water body east of the Core Plume and 11 monitoring wells. 2. Conduct long-term continuous monitoring of groundwater elevations. Data will be recorded in linear mode on 1-hour intervals. 3. Monitoring to be conducted for 6 to 12 months. 4. Periodic field verification of water level elevations at all monitoring points will be performed by manual measurements.
Down gradient of FSA	OW-051-O, OW-101-R, OW-406-R (proposed)		
Upgradient of FSA	OW-083 and OW-084		
East flank of FSA	OW-102-O, OW-102-R, OW-407-R (proposed)		
West flank of FSA	OW-81 and OW-82		
Diorite Dike	OW-095-O and OW-095-R		
Surface water body	Due east of FSA		
Surface water body	Due west of OW-81 and OW-82		

Geophysical Survey: Bedrock Boreholes

Proposed Piezometer	Location	Rationale	Methods
Perform borehole geophysical survey on existing wells completed with open boreholes.	OW-82: South of FSA (depth 200 ft; open hole 40 to 200 ft bls) OW-85: West of FSA (depth 90 ft; open hole 35 to 90 ft bls) OW-89: North of groundwater plume (depth 200 ft; open hole 45 to 200 ft bls) OW-79: Northeast of groundwater plume (depth 97 ft; open hole ?) OW-80: Diorite dike (depth 97 ft; open hole 23 to 97 ft bls)	1. Characterize fracture patterns of the bedrock (schistosity / foliation patterns). 2. Attempt to determine spatial distribution of facture patterns. 3. Identify hydraulically, active bedrock fractures. 4. Determine physical properties of rock fractures and connectivity of fractures between source area and down gradient areas. 5. Data will be used to design the completion depth of the proposed down-dip bedrock wells and to better understand fate and transport of COC in bedrock.	1. Conduct the following geophysical surveys as appropriate for selected wells: fluid temperature, fluid resistivity, caliper, heat-pulse flow (HPF), optical televiewer (OTV) and acoustic televiewer (ATV). 2. Perform only the fluid resistivity/caliper logs on the boreholes cored by NX drilling method (OW-79 and OW-80) to minimize the risk of the larger-diameter geophysical tools from becoming stuck in the borehole. 3. Wells OW-82, OW-85 and OW-89 to be logged with the full geophysical suite.

TABLE 3.17
GROUNDWATER MONITORING PROGRAM
Davis Liquid Waste Superfund Site

Well	Site Location	Sampling Schedule	
		Frequency	Parameters
Groundwater Monitoring Program			
All Existing Wells Sampled During Phase 4 Program (43 wells)	Overburden / Bedrock	3X per Year	VOCs, SVOCs, pesticides, metals (initial year of monitoring); Geochemical Parameters (select wells) *Subsequent monitoring will be in accordance with Long-term Monitoring Plan
OW-400-R	Bedrock		
OW-401-R	Bedrock		
OW-402-R	Bedrock		
OW-403-R	Bedrock		
OW-404-R	Bedrock		
OW-405-R	Bedrock		
OW-406-R	Bedrock		
OW-407-R	Bedrock		
Proposed OBT-1 Wells (up to five additional wells)[1]	Overburden		
Proposed OBT-2 Wells (up to five additional wells)[1]	Overburden		

NOTES:
Geochemical parameters include - nitrate, nitrite, sulfate, sulfide, alkalinity, total organic carbon, ethene, ethane, methane, and hydrogen, at a minimum
Table outlines proposed monitoring during performance of the PDI Program
All proposed monitoring wells will be incorporated into the next scheduled sampling event following installation and development
Subsequent monitoring will be in accordance with Long-term Monitoring Plan
Proposed wells are shown in **BOLD**
1. Number of wells installed will depend on conditions encountered at time of drilling.

TABLE 3.18
SUMMARY OF APPROACH AND RATIONALE
FATE AND TRANSPORT AND NATURAL ATTENUATION EVALUATION
Davis Liquid Waste Superfund Site

Lines of Evidence	Key Element	Approach	Rationale
Historical Chemistry	Signature of biotic and/or abiotic decay	Temporal and spatial trend analysis of groundwater concentrations over time	Evaluate historic COC concentration trends in groundwater. Groundwater trends have been historically assessed and the existing trend plots will be updated to reflect more recent data.
		Groundwater sampling in new and existing wells for COCs	Groundwater sampling will be conducted from both new and existing wells to verify and validate the COC concentration trends observed in historical data.
Geochemical and Hydrogeological	Conditions that support dechlorination processes	Groundwater sampling and geochemical analysis in new wells	Historical geochemical conditions have been evaluated throughout the bedrock plume. Geochemical parameters will be assessed in the three new FSA wells to validate the previous assessments.
	Assess occurrence of DNAPL	FLUTe liner and/or hydrophobic dye tests	FLUTe screening will be conducted on the open bedrock boreholes drilled in the FSA. Hydrophobic dye test may be conducted on whole rock core samples to identify the potential absence or presence of DNAPL. The absence of concentration trends in groundwater in the source area may be a function of ongoing dissolution of DNAPL into groundwater. While groundwater concentrations may appear stable (due to the presence of DNAPL ganglia within or adjacent to the well interval) significant biodegradation may be occurring.
	Hydraulic transport	Vertical gradients between bedrock and overburden	Determine variance in the gradient between overburden and bedrock to better understand the vertical mass transfers which may be affecting the COC concentrations observed in bedrock groundwater and the role that vertical mass transfers may be having on concentration trends.
		Well yield and bedrock transmissivity	Determine well yield and bedrock transmissivity to understand how mass transfer and advective transport may be controlling and/or limiting MNA processes.
		Manual logging and downhole geophysics	Determine physical properties of rock fractures and connectivity of fractures between source area and downgradient areas. Data will be used to better understand fate and transport of COC in bedrock.
Biological	Occurrence of microbial transformation	Quantitative assessment of biodegradation	Prove occurrence of biodegradation - this will conducted as a phased program. In Phase 1 bedrock groundwater will be tested for the occurrence of Dehalococcoides and other bacteria species capable of reductive dechlorination of chlorinated VOCs to provide direct evidence of biological activity and degradation of target compounds. In Phase 2 either baited biotraps or microcosm studies will be utiliZed to verify the presence of reductive dechlorination processes and provide empirical 1st order biodegradation rates.

TABLE 3.19A
SUMMARY OF HISTORIC SURFACE WATER SAMPLING RESULTS - VOLATILE ORGANIC COMPOUNDS
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Sample No.	Location	Date	Acetone	2-Butanone	Carbon Tetrachloride	Chloroform	1,1-Dichloroethylene	1,1-Dichloroethane	1,2-Dichloroethylene	Trans-1,2-Dichloroethylene	1,2-Dichloroethene	Ethylbenzene	Methylene Chloride	4-methyl-2-pentanone	Methyl Ethyl Ketone (MEK)	1,1,1-Trichlorethane	Trichloroethylene	Tetrachloroethene	Toluene	Vinyl Chloride	Total Xylenes
SW-03	Off-Site	Nov-84								6											
SW-03A	Off-Site	Jan-86							10			2				2	4	1	4		9
SW-09	On-Site	Nov-84																			
SW-10	Off-Site	Aug-85				**110**		34		630		**190**	34			170	**180**	**100**	**270**	86	**280**
SW-11	Off-Site	Nov-84	130					5		55						35	23	**18**			20
SW-11	Off-Site	Aug-85						8		68						21	15	**9**			
SW-11A	Off-Site	Jan-86				2		2	50			12	2			14	20	**8**	**24**	1	**51**
SW-15	Off-Site	Nov-84								13						6	5	4			
SW-15	Off-Site	Aug-85	66							5											
SW-16	Off-Site	Nov-84								5											
SW-19	Background	Apr-85																			
SW-23	Off-Site	Apr-85								17											
SW-23	Off-Site	Aug-85		320			**26**			230			41	33			8				
SW-36	On-Site	Aug-85																			
SW-37	Tire Pile	Aug-85	194	490		**710**		73		970			69			38	33				
SW-38	On-Site	Aug-85																			
DS-TB-SW-001	Background	Sep-91	10		ND	ND		ND			ND	ND	2.7		ND	ND	ND	ND	ND	ND	ND
DS-TB-SW-002	Background	Sep-91	7.4		ND	ND		ND			ND	ND	ND		ND	ND	ND	ND	1.2	ND	ND
DS-TB-SW-003	Background	Sep-91	37		ND	ND		ND			ND	ND	ND		16	ND	ND	ND	ND	ND	ND
DS-US-SW-001	Unnamed Stream (Tire Pile)	Sep-91	ND		ND	ND		16			100	ND	8.1		ND	20	ND	ND	ND	21	ND
DS-LB-SW-001	Latham Brook	Sep-91	ND		ND	1.1		3.6			47	4.1	ND		ND	5	3.3	2.2	5	5	22
RIDEM AWQC (ug/L)			NA	NA	30	32	13	NA	NA	NA	NA	36	NA	NA	NA	NA	43	5.3	14	NA	30
SAMPLE MAX (ug/L)			194	490	0	710	26	73	50	970	100	190	69	33	16	170	180	100	270	86	280

NOTES:
units - micrograms per liter (ug/L)
ND - not detected at Contract Required Detection Limit
Blank - compound not included in Detection Summary Table
BOLD - detected concentration exceeds Ambient Water Quality Criteria

TABLE 3.19B
SUMMARY OF HISTORIC SURFACE WATER SAMPLING RESULTS - SEMI-VOLATILE ORGANIC COMPOUNDS AND PESTICIDES
Davis Liquid Waste Superfund Site

Sample No.	Location	Date	Benzoic Acid	Bis (2-Ethylhexyl) Phthalate	Butylbenzylphthalate	4-Chloroaniline	1,2-Dichlorobenzene	Di-n-Butylphthalate	2,4-Dimethylphenol	Di-n-Octylphthalate	2-Methylphenol	4-Methylphenol	Napthalene	4-Nitrophenol	Alpha-BHC
SW-03	Off-Site	Nov-84													
SW-03A	Off-Site	Jan-86													
SW-09	On-Site	Nov-84													
SW-10	Off-Site	Aug-85													0.1
SW-11	Off-Site	Aug-85													0.07
SW-11A	Off-Site	Jan-86													
SW-15	Off-Site	Nov-84													
		Aug-85													
SW-16	Off-Site	Nov-84		10											
SW-19	Background	Apr-85													
SW-23	Off-Site	Apr-85													
		Aug-85													
SW-36	On-Site	Aug-85													
SW-37	Tire Pile	Aug-85													
DS-TB-SW-001	Background	Sep-91	6.6	ND	ND	ND	ND	1.2	ND	ND	ND	ND	ND	ND	
DS-TB-SW-002	Background	Sep-91	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
DS-TB-SW-003	Background	Sep-91	2.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
DS-US-SW-001	Unnamed Stream (Tire Pile)	Sep-91	2.4	2.8	ND	ND	ND	1.2	ND	1.2	ND	ND	ND	ND	0.026
DS-LB-SW-001	Latham Brook	Sep-91	3.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
RIDEM AWQC (ug/L)			NA	12	1.9	NA	1.8	NA	2.4	NA	NA	NA	2.6	NA	NA
SAMPLE MAX (ug/L)			6.6	10	ND	ND	ND	1.2	ND	1.2	ND	ND	ND	ND	0.1

NOTES:
units - micrograms per liter (ug/L)
ND - not detected at Contract Required Detection Limit
Blank - compound not included in Detection Summary Table
BOLD - detected concentration exceeds Ambient Water Quality Criteria

TABLE 3.19C
SUMMARY OF HISTORIC SURFACE WATER SAMPLING RESULTS - INORGANICS
Davis Liquid Waste Superfund Site

Sample No.	Location	Date	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Thallium	Tin	Vandium	Zinc
DS-TB-SW-001	Background	Sep-91	0.430		0.016			2.700			0.006	2.400		0.550	0.043		ND	1.600			2.100	ND			0.022
DS-TB-SW-002	Background	Sep-91	0.440		0.018			2.800			0.007	2.200		0.690	0.100		0.003	2.200			2.300	ND			0.044
DS-TB-SW-003	Background	Sep-91	0.450		0.017			4.100			0.006	1.600		1.100	0.031		ND	2.200			4.100	0.0014			0.016
DS-US-SW-001	Unnamed Stream (Tire Pile)	Sep-91	0.120		0.016			4.700			ND	0.810		0.960	0.042		ND	ND			ND	ND			0.630
DS-LB-SW-001	Latham Brook	Sep-91	0.240		0.011			3.600			ND	1.200		0.740	0.130		ND	ND			ND	ND			0.110
		RIDEM AWQC (ug/L)	87	150	NA	0.17	0.25	NA	11	NA	2.67	1000	2.5	NA	NA	0.77	52	NA	5	NA	NA	10	NA	NA	120
		SAMPLE MAX (ug/L)	0.45	0	0.018	0	0	4.7	0	0	0.007	2.4	0	1.1	0.13	0	0.003	2.2	0	0	4.1		0	0	0.63

NOTES:
units - micrograms per liter (ug/L)
ND - not detected at Contract Required Detection Limit
Blank - compound not included in Detection Summary Table
BOLD - detected concentration exceeds Ambient Water Quality Criteria

TABLE 3.20A
SUMMARY OF HISTORIC SEDIMENT SAMPLING RESULTS - VOLATILE ORGANIC COMPOUNDS
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Sample No.	Location	Date	Acetone	Benzene	2-Butanone	Chlorobenzene	Chloroform	1,1-Dichloroethylene	1,1-Dichloroethane	1,2-Dichloroethylene	Trans-1,2-Dichloroethylene	1,2-Dichloroethane	Ethylbenzene	Methylene Chloride	1,1,1-Trichloroethane	Trichloroethylene	Tetrachloroethylene	Toluene	Styrene	Total Xylenes
SD-03	Off-Site	Aug-85	570	ND	130	ND	ND	ND	ND		ND	ND	ND	750	ND	ND	ND	53	ND	ND
SD-09	On-Site	Nov-84	ND	18	210	ND	13	ND	310		250	18	ND	ND	**150**	**98**	34	150	ND	**28**
SD-10	On-Site	Nov-84	ND	ND	5300	ND	ND	ND	ND		ND	ND	ND	16000	ND	ND	ND	ND	ND	**4200**
	On-Site	Aug-85	48000	ND	46000	ND	ND	ND	ND		ND	ND	ND	8100	ND	ND	ND	6800	ND	**20000**
SD-11	Off-Site	Aug-85	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	320	ND	ND	ND	ND	ND	ND
SD-19	Background	Apr-85	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
	Background	Aug-85	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	230	ND	ND	ND	940	ND	ND
SD-24	Off-Site	Apr-85	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	44	ND	ND	22	ND	ND	ND
SD-30	Off-Site	Aug-85	ND	ND	ND	ND	ND	ND	ND		ND	ND	ND	ND	ND	ND	ND	91	ND	ND
SD-36	On-Site	Aug-85	170	ND	ND	ND	ND	ND	ND		ND	ND	ND	280	ND	ND	ND	ND	ND	ND
SD-37	Tire Pile	Aug-85	310	ND	88	ND	ND	**1600**	ND		190	ND	63	410	ND	ND	ND	940	ND	**340**
DS-SO-SD-01-1	S-7 / S-8 Surface Depressions	Sep-91	10		ND			ND	ND	ND		ND	ND	7.2		ND	ND	10		ND
DS-SO-SD-01-2	S-7 / S-8 Surface Depressions	Sep-91	ND		ND			ND	ND	ND		ND	ND	5.6		ND	ND	ND		ND
DS-SO-SD-02-1	S-7 / S-8 Surface Depressions	Sep-91	190		ND			ND	ND	ND		ND	ND	8		ND	ND	14		ND
DS-SO-SD-02-2	S-7 / S-8 Surface Depressions	Sep-91	ND		ND			ND	ND	ND		ND	ND	6.1		ND	ND	ND		ND
DS-TB-SD-001	Background	Sep-91	ND		ND			ND	ND	ND		ND	ND	2.6		ND	ND	2.2		ND
DS-TB-SD-002	Background	Sep-91	ND		ND			ND	ND	ND		2	ND	4		ND	ND	ND		ND
DS-TB-SD-003	Background	Sep-91	150		19			3.1	ND	ND		10	ND	16		3.8	4	11		3.9
DS-US-SD-001	Unnamed Stream (Tire Pile)	Sep-91	26		5.1			ND	6.6	ND		ND	ND	3.6		ND	ND	ND		4.2
DS-LB-SD-001	Latham Brook	Sep-91	4.4		ND			ND	ND	3.6		17	ND	4.3		ND	ND	ND		ND
		EPA BTAG (ug/kg)				8.42		31			1050		1100		30.2	96.9	468		559	25.2
		SAMPLE MAX (ug/kg)	48000	860	46000	2500	4000	1600	310	220	730	18	100000	16000	49000	44000	101000	82000	23000	430000

NOTES:
units - micrograms per kilogram (ug/kg)
ND - not detected at Contract Required Detection Limit
Blank - compound not included in Detection Summary Table
NDA - Northern Disposal Area
Ditch - Ditch that received runoff from NDA
BOLD - detected concentration exceeds EPA Region III BTAG Freshwater Sediment Screening Benchmark

TABLE 3.20B
SUMMARY OF HISTORIC SEDIMENT SAMPLING RESULTS - SEMI-VOLATILE ORGANIC COMPOUNDS
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Sample No.	Location	Date	Anthracene	Benzo (a) Anthracene	Benzoic Acid	Bis (2-Ethylhexyl) Phthalate	Butylbenzylphthalate	Chrysene	1,4-Dichlorobenzene	1,2-Dichlorobenzene	Di-n-Butylphthalate	Di-n-Octylphthalate	Flouranthene	2-Methylphenol	4-Methylphenol	2-Methylnapthelene	Napthalene	N-Nitrosodiphenylamine	Phenanthrene	Pyrene	1,2,4-Trichlorobenzene	44-DDE	44-DDD
SD-02	Off-Site	Nov-84	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	**3.6**	**11**
SD-03	Off-Site	Aug-85	ND	ND	ND	ND	ND	ND	ND	ND	ND	390	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-10	On-Site	Aug-85	ND	ND	**9000**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1000	ND	ND
SD-11	Off-Site	Aug-85	ND	ND	**7200**	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-19	Background	Aug-85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1400	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-23	On-Site	Apr-85	**130**	ND	ND	**6500**	ND	ND	150	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-30	Off-Site	Aug-85	ND	ND	ND	ND	ND	ND	ND	ND	100	ND	90	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-32	Off-Site	Aug-85	ND	**190**	ND	ND	ND	ND	ND	ND	ND	ND	330	ND	ND	ND	ND	ND	**390**	**410**	ND	ND	ND
SD-33	Off-Site	Aug-85	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	88	ND	ND	ND	ND	ND	ND	91	ND	ND	ND
SD-34	Off-Site	Aug-85	ND	ND	ND	ND	ND	ND	ND	ND	180	ND	130	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SD-37	Tire Pile	Aug-85	ND	ND	ND	ND	ND	**1700**	ND	ND	ND	3000	**690**	ND	ND	ND	ND	2200	**690**	**1200**	ND	ND	ND
DS-SO-SD-01-1	S-7 / S-8 Surface Depressions	Sep-91			**1900**	ND	ND		ND	ND					ND	ND	ND				ND		
DS-SO-SD-01-2	S-7 / S-8 Surface Depressions	Sep-91			**1600**	ND	ND		ND	ND					ND	ND	ND				ND		
DS-SO-SD-02-1	S-7 / S-8 Surface Depressions	Sep-91			ND	ND	ND		ND	ND					ND	ND	ND				ND		
DS-SO-SD-02-2	S-7 / S-8 Surface Depressions	Sep-91			**1100**	ND	ND		ND	ND					ND	ND	ND				ND		
DS-TB-SD-001	Background	Sep-91			420	ND	ND		ND	ND					ND	ND	ND				ND		
DS-TB-SD-002	Background	Sep-91			370	ND	ND		ND	ND					ND	ND	ND				ND		
DS-TB-SD-003	Background	Sep-91			**910**	ND	ND		ND	ND					110	ND	ND				ND		
DS-US-SD-001	Unnamed Stream (Tire Pile)	Sep-91			ND	ND	ND		ND	ND					ND	ND	ND				ND		
DS-LB-SD-001	Latham Brook	Sep-91			ND	ND	ND		ND	ND					ND	ND	ND				ND		
		EPA BTAG (ug/kg)	57.2	108	650	180	10900	166	599	16.5	6470		423		670	20.2	176	2680	204	195	2100	3.16	4.88
		SAMPLE MAX (ug/kg)	130	190	9000	400000	150000	1700	14000	100000	82000	21000	18000	1400	110	370	39000	2200	4000	1200	15000	3.6	11

NOTES:
units - micrograms per kilogram (ug/kg)
ND - not detected at Contract Required Detection Limit
Blank - compound not included in Detection Summary Table
NDA - Northern Disposal Area
Ditch - Ditch that received runoff from NDA
BOLD - detected concentration exceeds EPA Region III BTAG Freshwater Sediment Screening Benchmark

TABLE 3.20C
SUMMARY OF HISTORIC SEDIMENT SAMPLING RESULTS - INORGANICS
Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Sample No.	Location	Date	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Potassium	Selenium	Silver	Sodium	Tin	Vandium	Zinc
DS-SO-SD-01-1	S-7 / S-8 Surface Depressions	Sep-91	5190	ND	237	ND	ND	3350	5.4	ND	17.3	2860	6.6	152	15.3	ND	ND	ND	ND	ND	ND	ND	6.5	12.9
DS-SO-SD-01-2	S-7 / S-8 Surface Depressions	Sep-91	8480	ND	105	ND	ND	1310	6.4	ND	ND	5260	13.9	293	14.8	ND	ND	ND	ND	ND	ND	ND	10.8	17.8
DS-SO-SD-02-1	S-7 / S-8 Surface Depressions	Sep-91	21200	ND	141	0.92	ND	1610	15.1	ND	13.1	5560	31.3	744	46.8	ND	ND	ND	ND	ND	ND	ND	26.5	30.14
DS-SO-SD-02-2	S-7 / S-8 Surface Depressions	Sep-91	20000	1.1	46.9	ND	ND	394	13.8	2.8	7.6	5060	**37.8**	611	32.1	ND	ND	ND	ND	ND	ND	ND	25.3	23.2
DS-TB-SD-001	Background	Sep-91	7140	0.66	39.7	0.37	ND	1970	10.6	3.6	9.1	10400	6.9	2670	159	ND	6.5	1270	ND	ND	ND	ND	19.7	39.3
DS-TB-SD-002	Background	Sep-91	8100	1.4	55.9	0.47	ND	1990	12.7	3.8	12.5	10300	8.2	2860	154	ND	7.6	1270	ND	ND	ND	ND	23.1	46.6
DS-TB-SD-003	Background	Sep-91	18400	ND	87.1	1.5	ND	3080	30.9	5.9	6	9690	9.6	3400	114	ND	10.1	1510	1.7	0.68	ND	ND	21.2	31.1
DS-US-SD-001	Unnamed Stream (Tire Pile)	Sep-91	2110	3.5	25.4	ND	ND	1020	**44.8**	6.3	2.5	12500	15.4	312	**540**	ND	21.5	232	ND	ND	ND	535	7.2	120
DS-LB-SD-001	Latham Brook	Sep-91	4290	0.7	19.8	ND	ND	892	3.8	2.2	6.9	7090	12.4	1040	68.8	ND	3.4	576	ND	ND	ND	ND	7.7	**139**
		EPA BTAG (mg/kg)		9.8			0.99		43.4	50	31.6	20000	35.8		460	0.18	22.7		2	1				121
		SAMPLE MAX (mg/kg)	21200	3.5	237	1.5	1.3	3350	44.8	6.3	17.3	12500	37.8	3400	540	0.27	21.5	1580	1.7	0.68	68.6	535	26.5	139

NOTES:
units - milligrams per kilogram (mg/kg)
ND - not detected at Contract Required Detection Limit
NDA - Northern Disposal Area
Ditch - Ditch that received runoff from NDA
BOLD - detected concentration exceeds EPA Region III BTAG Freshwater Sediment Screening Benchmark

TABLE 3.21
SURFACE WATER AND SEDIMENT INVESTIGATION RATIONALE
DAvis Liquid Waste Superfund Site

TASK	APPROACH	RATIONALE
Wetland Delineation and Characterization	Professional Wetland Scientists (PWS) will delineate the boundary of the wetland resource areas proximal to the FSA and characterize the type and nature of the resource areas and surface water flow patterns.	Will provide information to understand the location of the wetland resource areas to be able to assess potential future uses in the vicinity of the FSA (e.g., residential structures) and to understand the nature of the wetland resource areas which will support an understanding of the interaction between groundwater and surface water.
Bathymetric Survey	A bathymetyric survey of the ponded wetland located adjacent to the FSA will be performed. A conductivity survey will be performed as part of the survey. Surveys will be performed using point-transect methods. Conductivity and pH survey will include measurements around the perimeter of the Eastern Ponded Wetland and within shallow surface water within the center of the water body.	Results of the survey will be used, in conjunction with the probing and coring results, to assess areas of groundwater discharge into the ponded wetland area. The conductivity and pH survey can assist in identifying locations of groundwater discharge into the water body since the conductivity and/or pH of surface water and groundwater are often measurably different.
Tile Probes and Sediment Coring	Tile probes will be advanced to assess the thickness of sediment above the granular outwash/till materials. Core samples will be collected to log the type of sediment present. Probes and coring will be performed within all three wetland types if areas of soft sediment are present. Probes will be performed along transects. Cores will be performed at select locations.	Will provide data and information to understand the nature of the sediment within the three types of wetland resource areas present in the vicinity of the FSA (swamp, ponded wetland and stream) and to better understand the potential for groundwater discharge into each type of resource area.
Unnamed Stream Characterization	The stream section downstream of the ponded wetland and within the Overburden Plume will be characterized in accordance with the EPA Rapid Bioassessment Protocol and associated field sheets. The conditions in the stream will also be photologged.	Will provide data and information on the nature of the stream that will support an assessment of the interaction with the underlying groundwater and selection of candidate sampling locations.

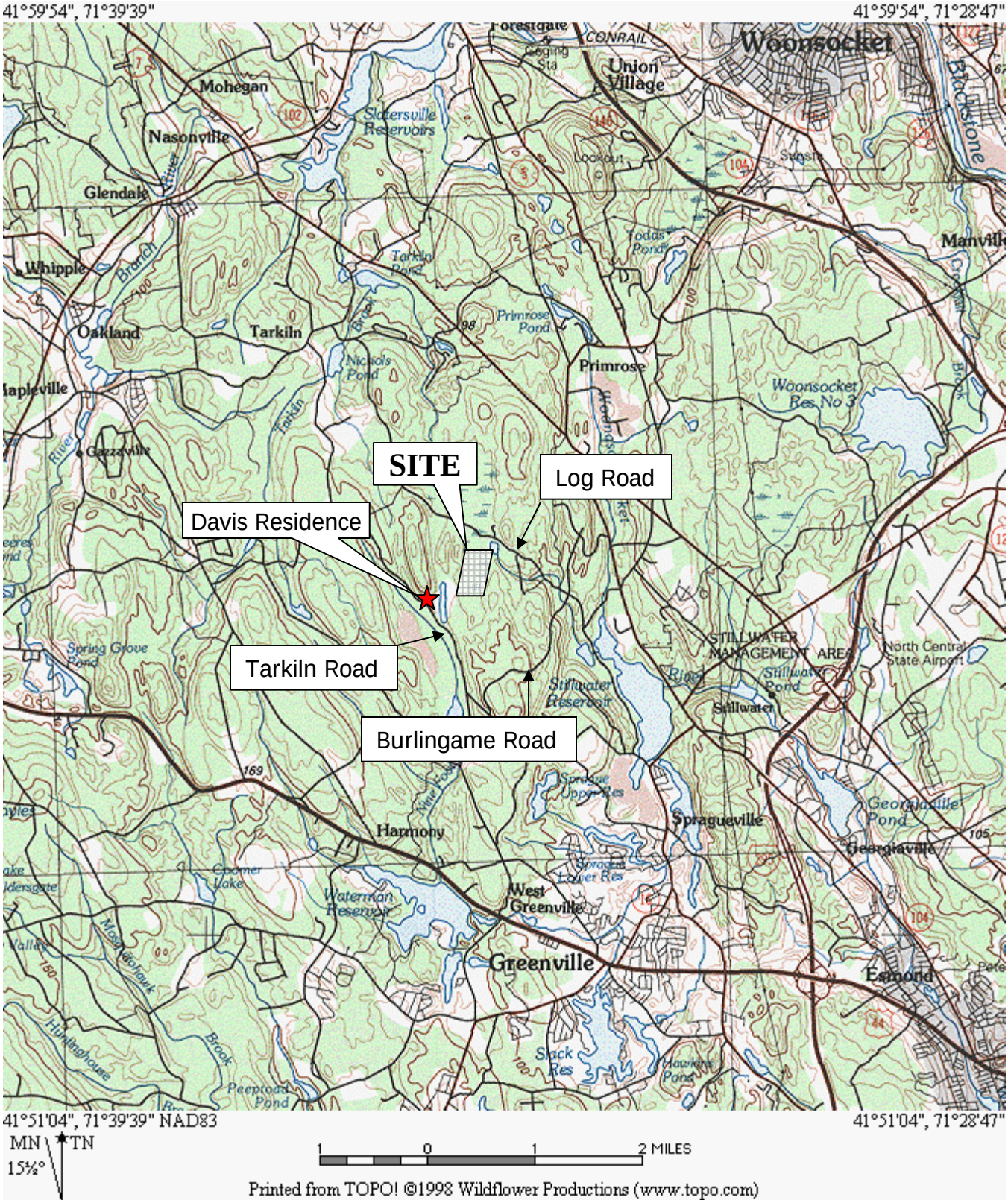
TABLE 3.22
SURFACE WATER AND SEDIMENT SAMPLING LOCATION RATIONALE
Davis Liquid Waste Superfund Site

SAMPLING LOCATION	RATIONALE
Historic Location SD/SW-37	Eastern Ponded Wetland; location of historic exceedances of sediment BTAGs and surface water AWQCs
Historic Location SD/SW-23	Eastern Ponded Wetland; location of historic exceedances of sediment BTAGs and surface water AWQCs
Historic Location SD/SW-9	Northern Wetland Area; location of historic exceedances of sediment BTAGs
Historic Location SD/SW-10	Central Wetland Area or stream; location of historic exceedances of sediment BTAGs and surface water AWQCs
Historic Location US-SD/SW-01	Central Wetland Area or stream; location of historic exceedances of sediment BTAGs
SW-102	recent location of surface water sampling (surface water only); provide surface water quality within Latham Brook downgradient of Site
SW-101	recent location of surface water sampling (surface water only); provide surface water quality within Latham Brook downgradient of Site
SW-100	recent location of surface water sampling (surface water only); provide surface water quality within Latham Brook downgradient of Site
RD-SD/SW-01	approximate location of the discharge of dewatering water during the performance of the Source Remedy
RD-SD/SW-02	approximate location of the ditch associated with the Former Northern Disposal Area

NOTES:
BTAGs - EPA Region III Biological Technical Assistance Group Screening Benchmarks for sediment
AWQCs - RIDEM Ambient Water Quality Criteria

Figures

J:/A365-002 MA Job\A365-002.5\Report_111803\Figures\1.1_Davis_S2003_Site_Locus.ppt



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Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Scale: As Noted
Extent of Site As Shown is Approximate

Site Locus Map

Figure 1.1

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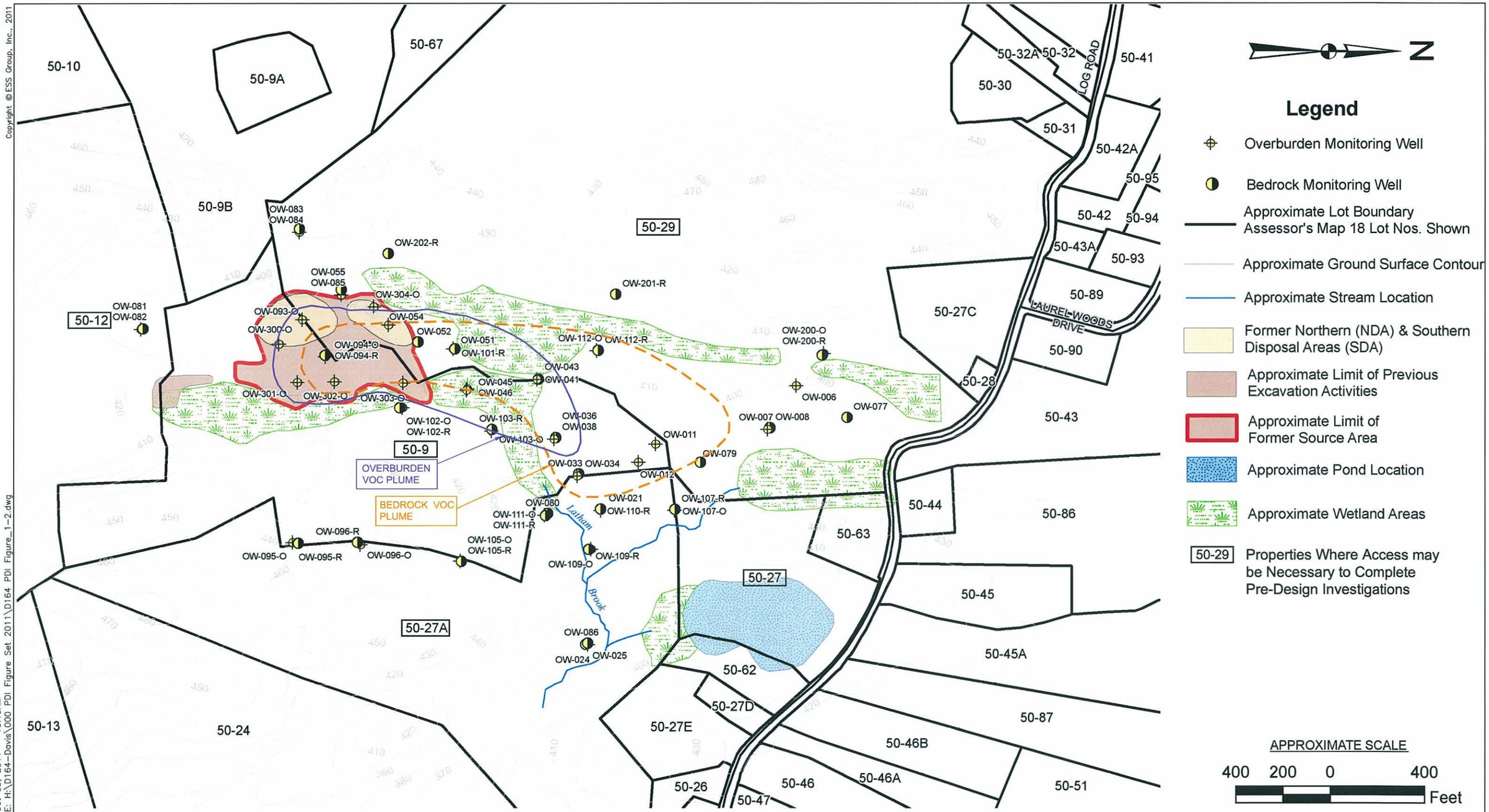

Source: Nobis Engineering, Inc., Figure 1-2 entitled:"SITE AND SURROUNDING AREA", Davis Liquid Waste Site, Smithfield, Rhode Island, Dated: 09/28/09 Rev. 00

DATE: Oct 05, 2011 – 10:19AM
FILENAME: H:\D164-Davis\000 PDI Figure Set 2011\D164 PDI Figure_1-2.dwg

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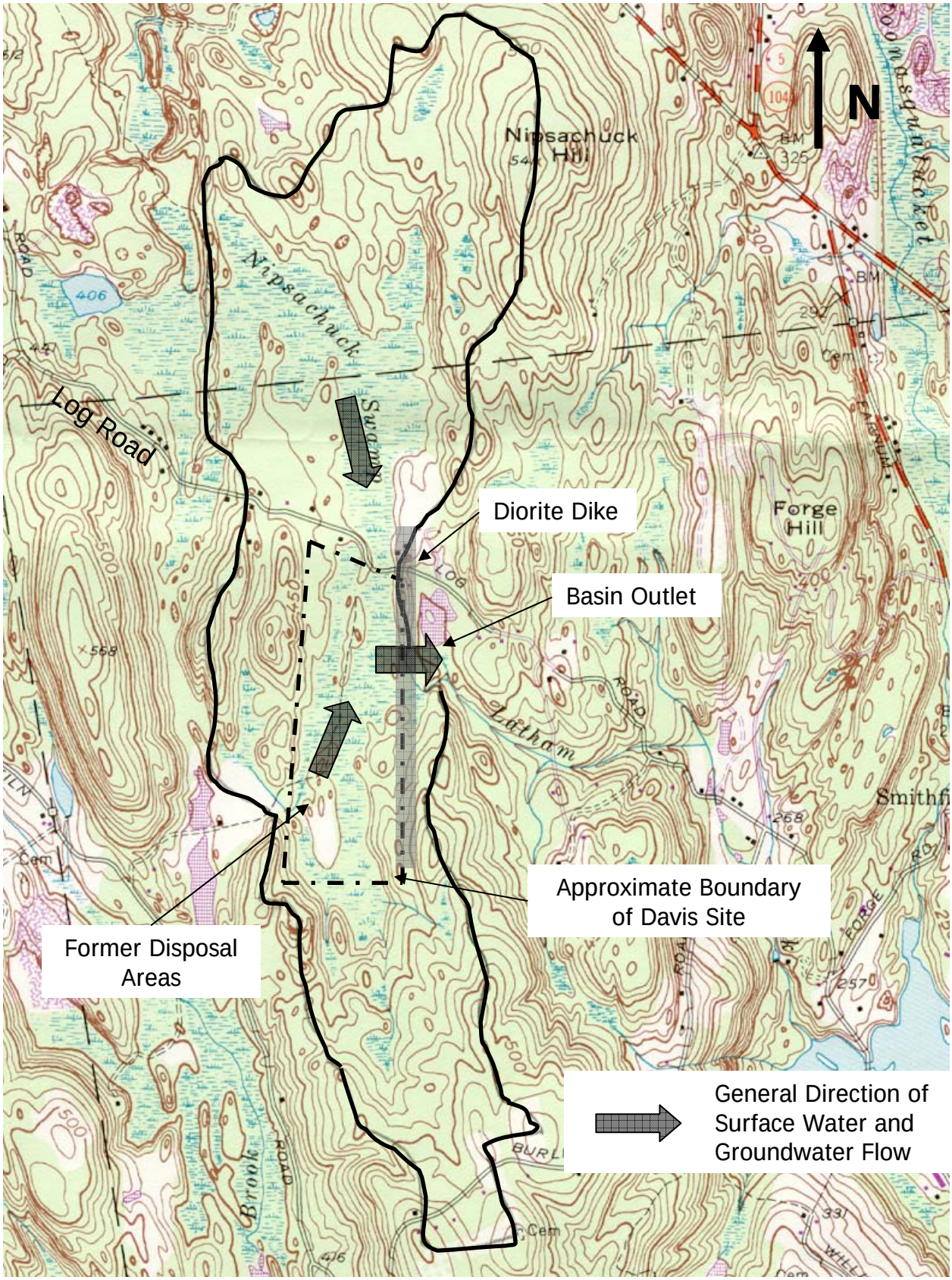
Smithfield, Rhode Island
Project No. D164-000

0 400 FEET

Site Plan with Parcel Layout

Figure 1.2

Y:/GIS/Projects/Ashland_Davis/Maps/Figure2-1_Drainage basin_revised.ppt



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Smithfield, Rhode Island

Source: Georgiaville, RI USGS Quadrangle
Scale: 1 inch = 2,300 feet (approximate)

Nipsachuck Swamp and Latham Brook Drainage Basin

Figure 2.1

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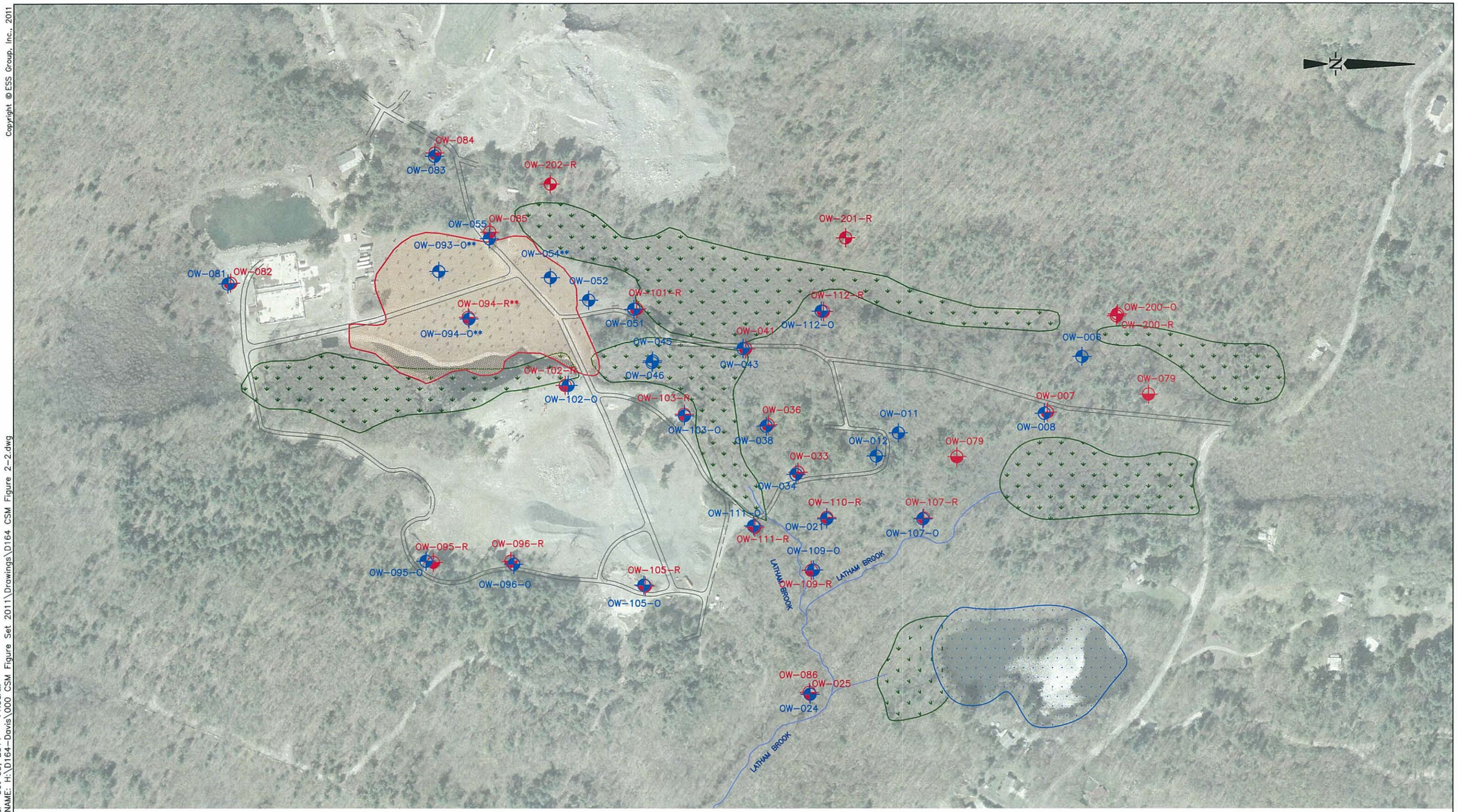

Source: Aerial photograph 2005

DATE: Oct 05, 2011 – 11:06AM
FILENAME: H:\D164-Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2-2.dwg

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Smithfield, Rhode Island
Project No. D164-000

Date: September 2011
Scale: Not To Scale

Site Aerial Photographic Map

Figure 2.2

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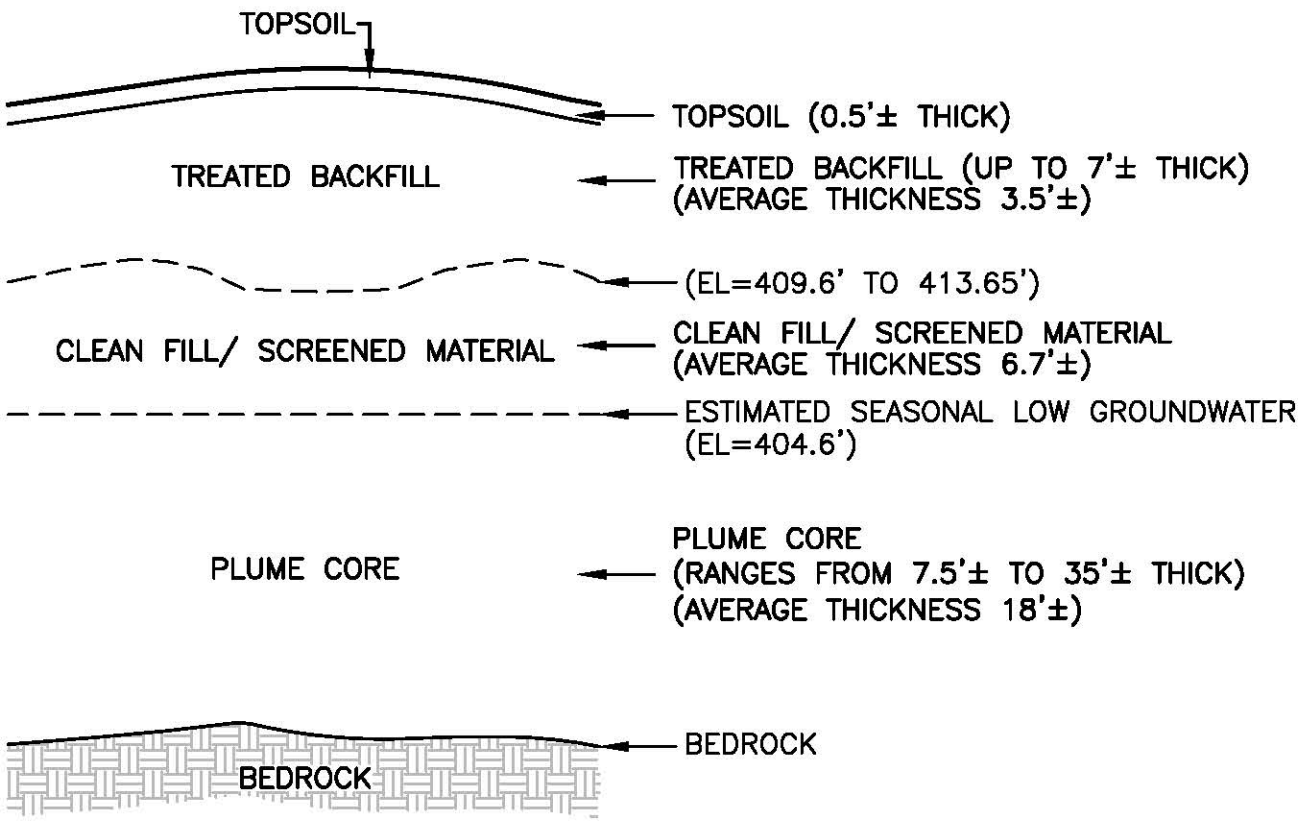
APPROXIMATE AREAS

TREATED BACKFILL	196,925± SF (4.5 ACRES)
PLUME CORE (FSA)	274,622± SF (6.3 ACRES)



CONCEPTUAL SCHEMATIC – FORMER SOURCE AREA

NOT TO SCALE

DATE: Mar 01, 2012 – 2:24PM
FILENAME: H:\D164-Davis\000 CSM Figure Set 2011\Drawings\Revised Drawings\D164 CSM Figure 2-3rev.dwg

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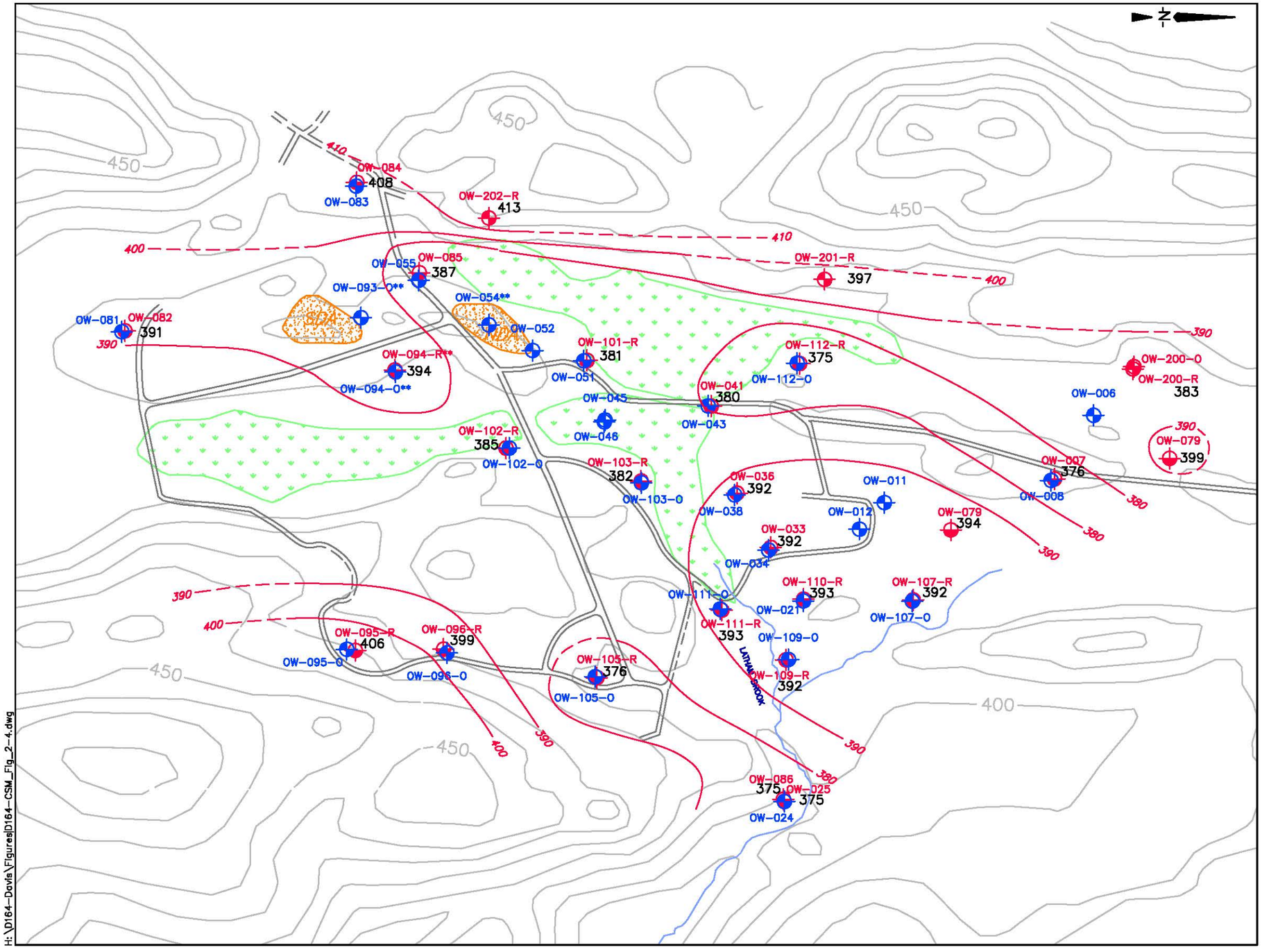
Smithfield, Rhode Island
Project No. D164-000

Date: September 2011

Conceptual Schematic
Former Source Area (FSA)

Figure 2.3



LEGEND:

- OW-081 — UNCONSOLIDATED DEPOSIT MONITORING WELL
- OW-082 / 391 — BEDROCK MONITORING WELL WITH ELEVATION OF COMPETENT BEDROCK SURFACE
- ROADS (UNPAVED)
- SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
  NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)
- WETLAND AREAS (APPROXIMATE)
- BEDROCK ELEVATION CONTOUR (FEET) DASHED WHERE INFERRED

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. ** REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.

0 300 600
SCALE IN FEET

H:\D164-Davis\Figures\D164-CSM_Fig_2-4.dwg

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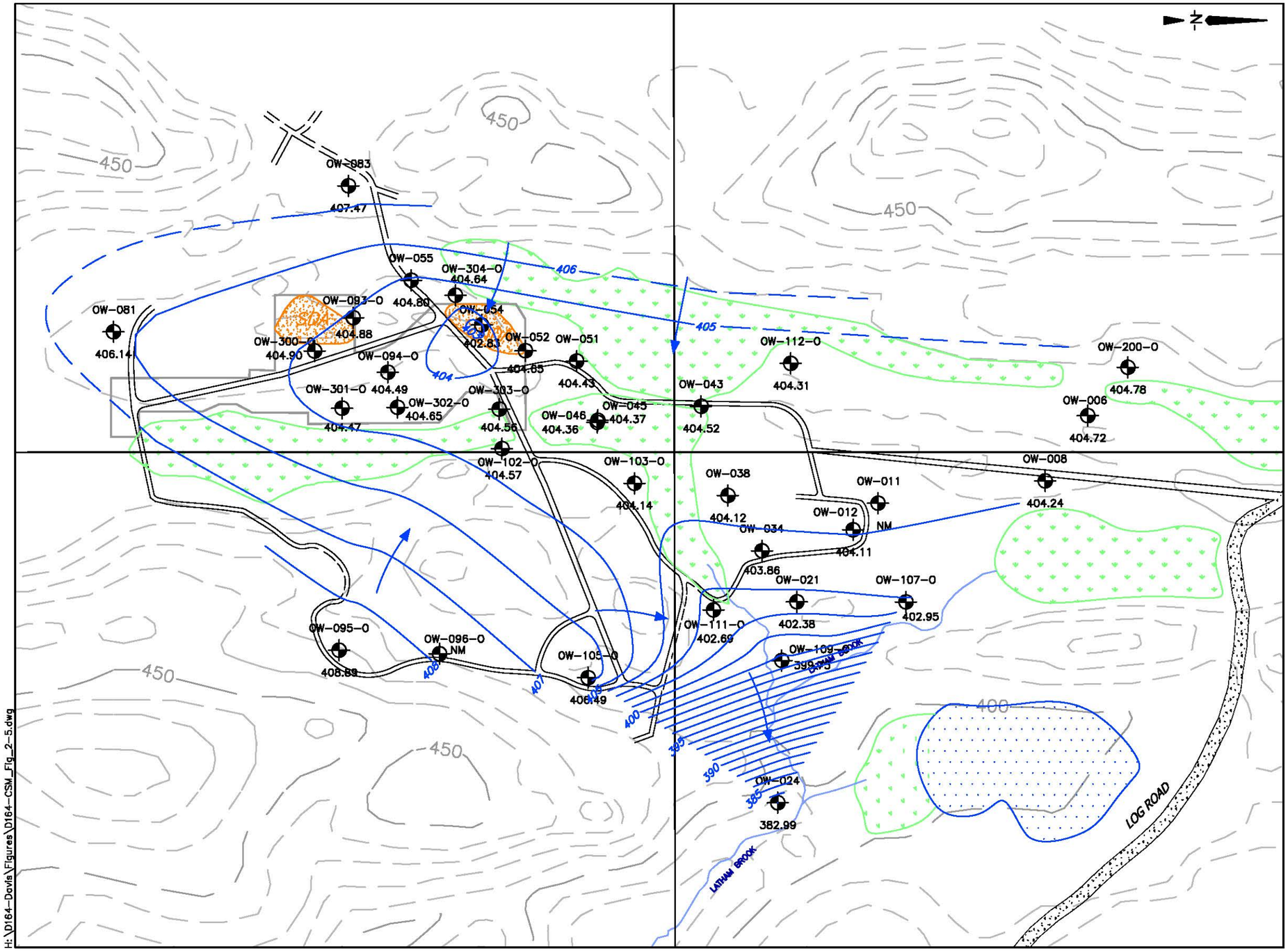
Smithfield, Rhode Island
Project No. D164-000

Scale: 1" = 300'

Bedrock Elevation Contour Map

Figure 2.4



LEGEND:

- OW-024 / 382.99 — OVERBURDEN MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (FEET)
- ROADS (PAVED)
- ROADS (UNPAVED)
- SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
  NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)
- WETLAND AREAS (APPROXIMATE)
- POND (APPROXIMATE)
- GROUNDWATER ELEVATION CONTOUR (FEET) DASHED WHERE INFERRED
- INFERRED GROUNDWATER FLOW DIRECTION

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.
3. WATER LEVELS COLLECTED ON OCTOBER 31, 2008.

0 300 600
SCALE IN FEET

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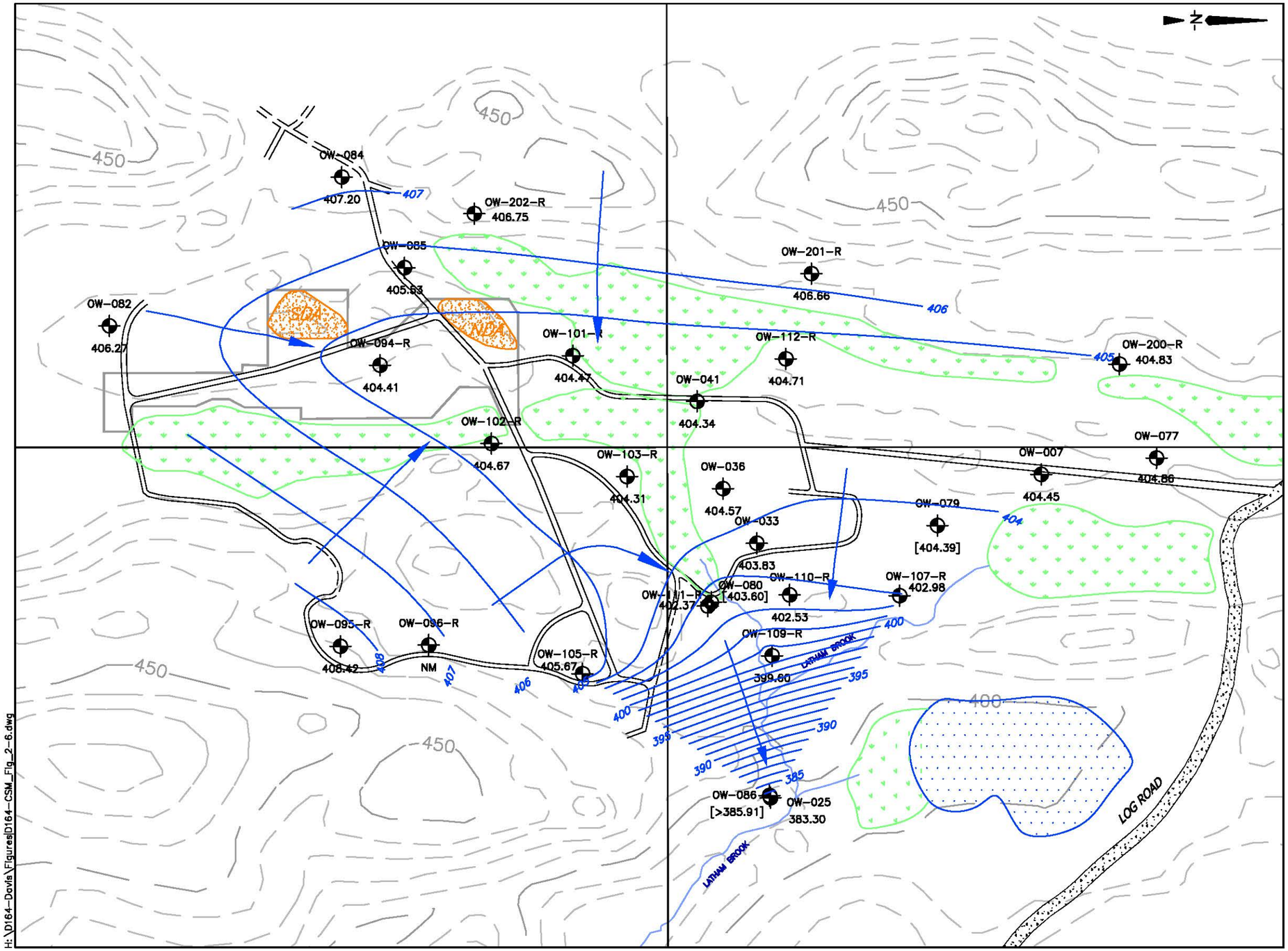
Project No. D164-000

Scale: 1" = 300'

Overburden Potentiometric Contour Map (October 31, 2008)

Figure 2.5



LEGEND:

OW-007
404.45 — OVERBURDEN MONITORING WELL WITH MEASURED GROUNDWATER ELEVATION (FEET)

ROADS (PAVED)

ROADS (UNPAVED)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

GROUNDWATER ELEVATION CONTOUR (FEET) DASHED WHERE INFERRED

INFERRED GROUNDWATER FLOW DIRECTION

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.
3. [ ] ELEVATIONS NOT INCLUDED IN CONTOURING DUE TO DEPTH AND/OR LENGTH OF SCREEN/ BOREHOLE INTERVAL AND AVAILABILITY OF OTHER NEARBY WELLS.
4. WATER LEVELS COLLECTED ON OCTOBER 31, 2008.

0 300 600
SCALE IN FEET

H:\D164-Davis\Figures\D164-CSM_Fig_2-6.dwg

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Scale: 1" = 300'

Bedrock Potentiometric Contour Map (October 31, 2008)

Figure 2.6

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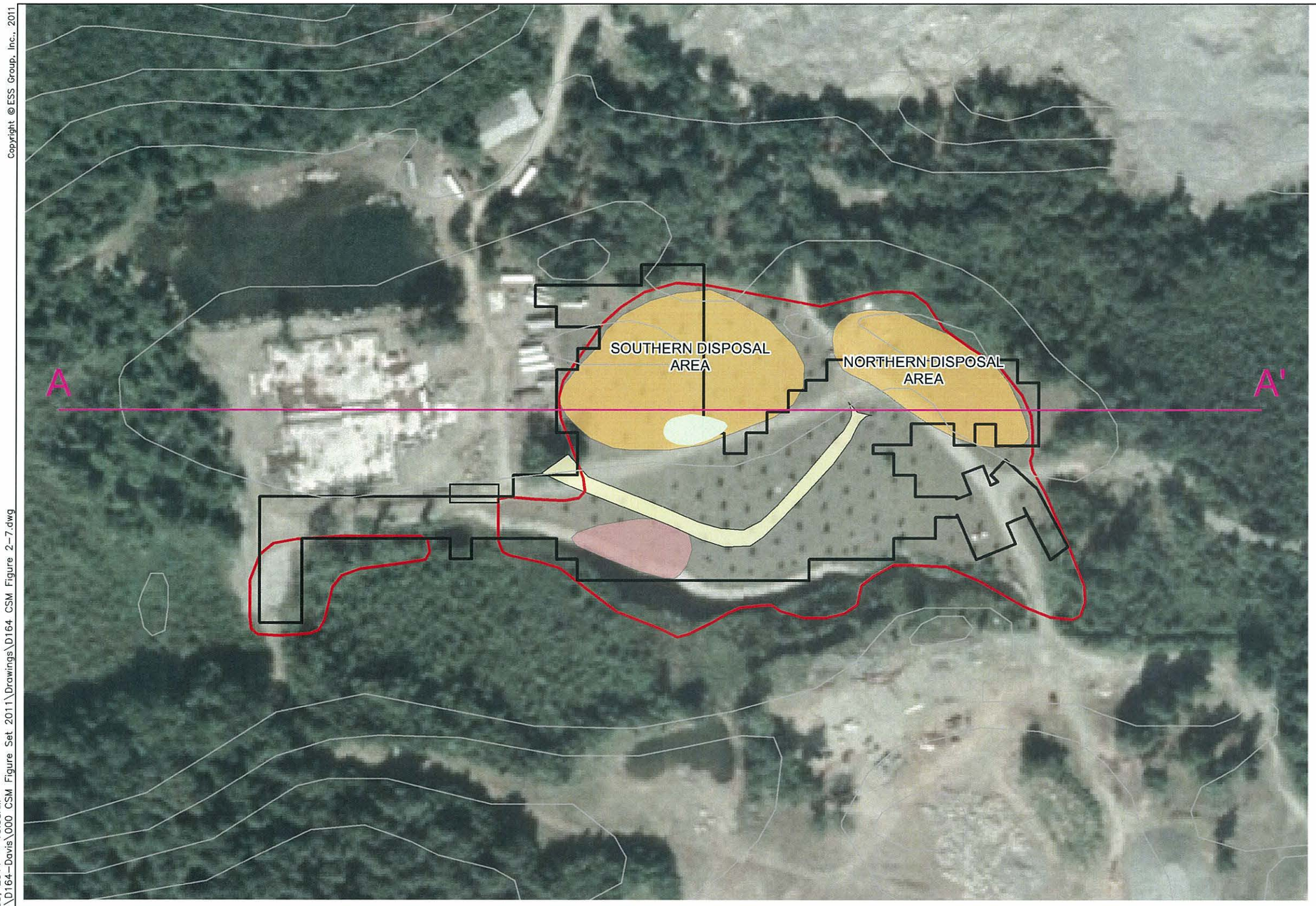

N

Legend

- Approximate Limit of Remediation Excavation to Elevation 404.6 FT MSL & Approximate Limit of Source Area
- Limit of Preliminary Design Investigation
- Approximate Surface Contour
- Former Northern & Southern Disposal Areas
- Western Access Road
- Drum Removal Area1
- Bunker C Area
- A A' Cross Section Line

APPROXIMATE SCALE

150 75 0 150 Feet

Source: Nobis Engineering, Inc., Figure 3 entitled:"FORMER WASTE AREA LOCATIONS", Davis Liquid Waste Site, Smithfield, Rhode Island, Dated: 02/23/09 Rev. 00

DATE: Oct 05, 2011 – 10:35AM
FILENAME: H:\D164-Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2-7.dwg

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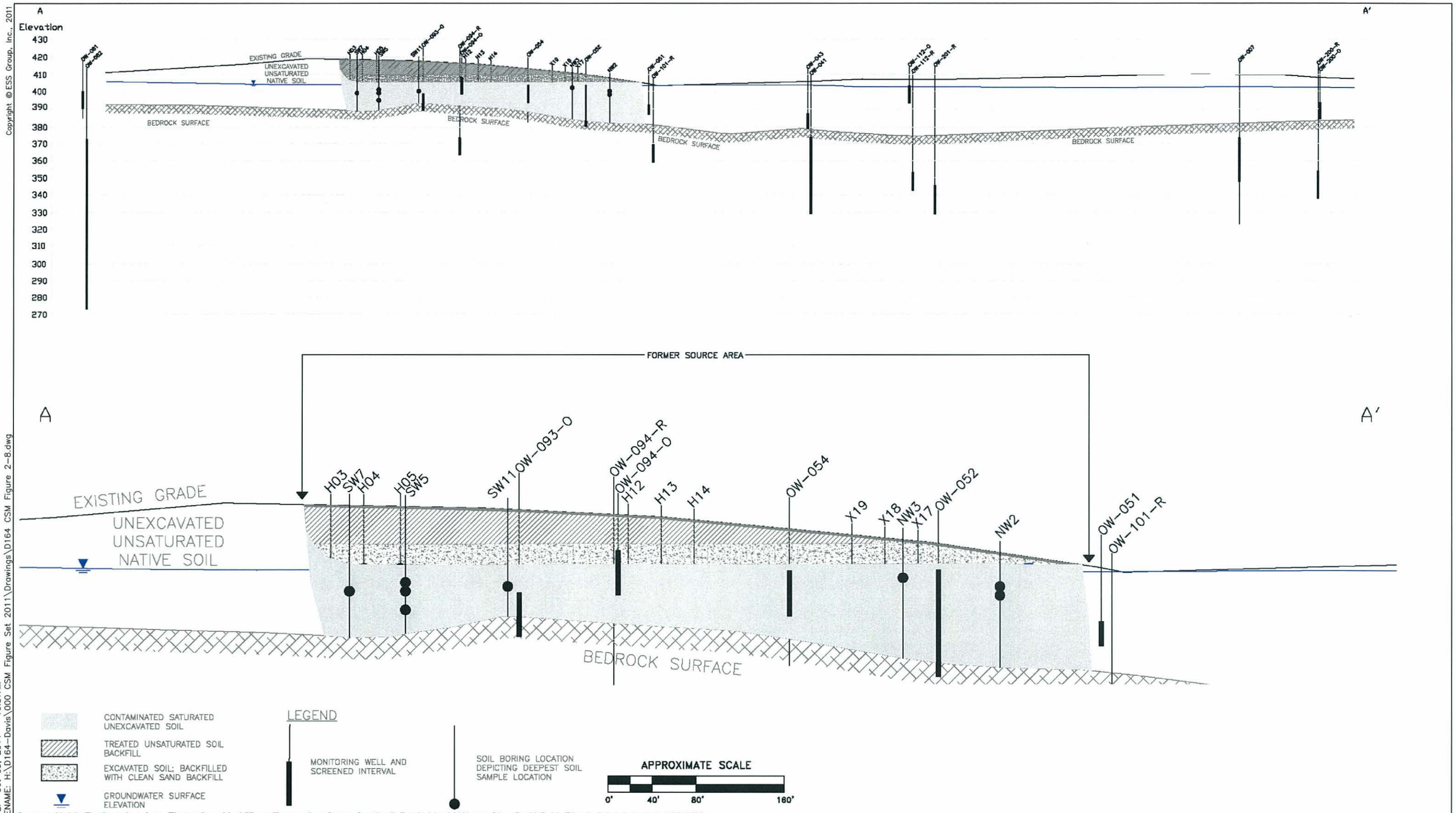
Project No. D164-000

0 150 FEET (Approx)

Former Waste Area Locations

Figure 2.7



Source: Nobis Engineering, Inc., Figure 9 entitled:"Post-Excavation Cross Section", Davis Liquid Waste Site, Smithfield, Rhode Island, Dated: 02/23/09

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DATE: Oct 05, 2011 – 10:37AM
FILENAME: H:\D164-Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2-8.dwg

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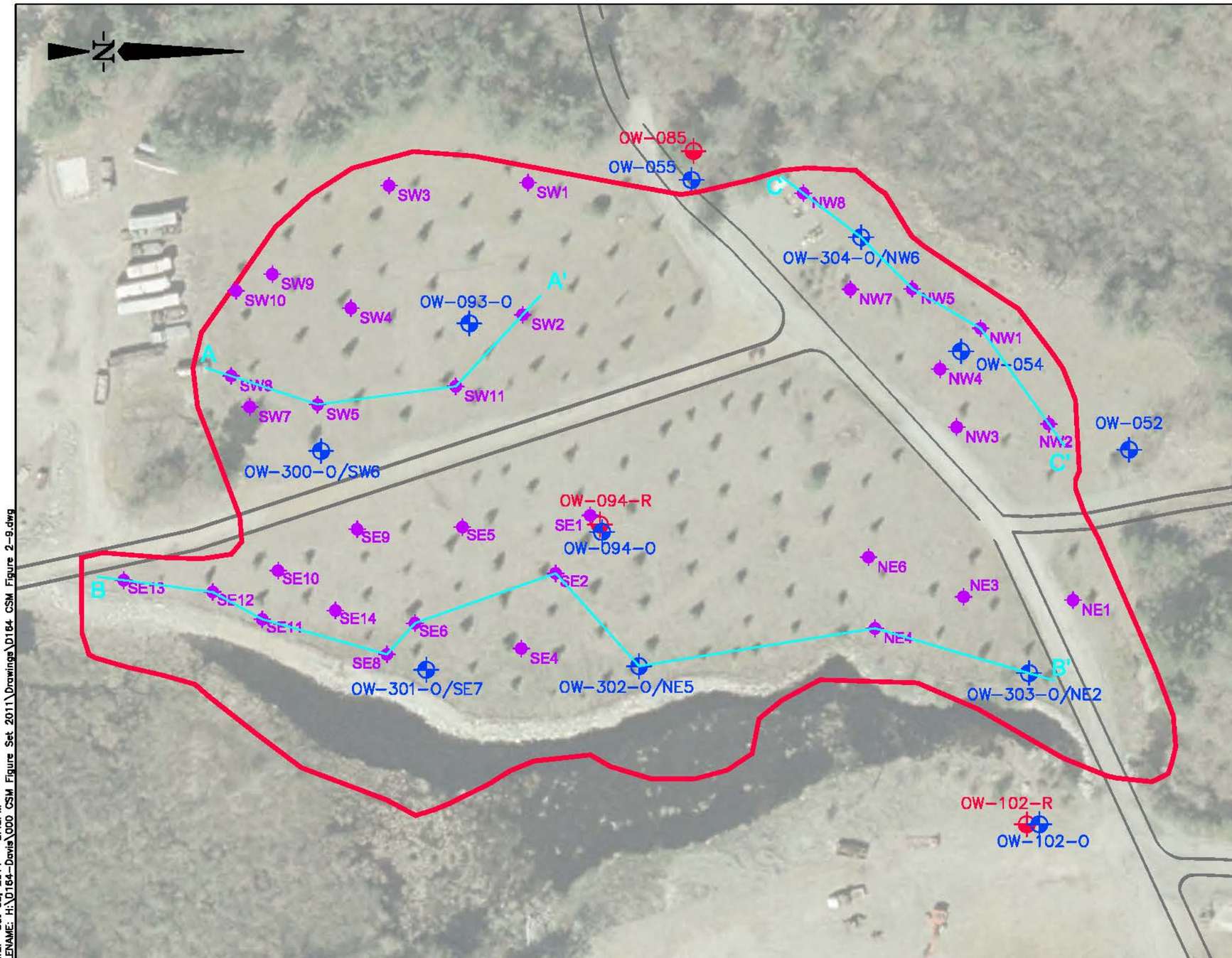
Smithfield, Rhode Island
Project No. D164-000

0 80' (Approx)
Date: September 2011

Post-Excavation Cross Section

Figure 2.8



LEGEND:

- NE2 — PHASE 4 BORING LOCATION
- OW-303-O — UNCONSOLIDATED DEPOSIT MONITORING WELL "O" ON WELL DESCRIPTIONS DESIGNATES OVERBURDEN
- OW-085 — BEDROCK MONITORING WELL
- ROADS (PAVED)
- ROADS (UNPAVED)
- APPROXIMATE LIMIT OF REMEDIATION EXCAVATION TO ELEVATION 404.6' MSL & 2 mg/Kg TOTAL VOCs
- A A' — CROSS-SECTIONS

NOTES:

1. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.
2. LIMIT OF PRELIMINARY DESIGN INVESTIGATION, EXCAVATION, AND DISPOSAL AREAS ARE BASED UPON REMEDIAL ACTION REPORT (LEA, 2001).
3. DRAFT DATA SUMMARY DERIVED FROM INVESTIGATIONS COMPLETED BY ENSAFE (1998), INC., WOODWARD-CLYDE CONSULTANTS (1991/1992), AND CAMP, DRESSER & McKEE (1986), AND COMPILED BY NOBIS ENGINEERING (2008).

0 80 160
SCALE IN FEET

DATE: Oct 03, 2011 – 3:45PM
FILENAME: H:\D164-Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2-9.dwg

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Project No. D164-000

Date: September 2011
Scale: 1" = 80'

2008 Phase 4 Investigation
Soil Boring Locations

Figure 2.9

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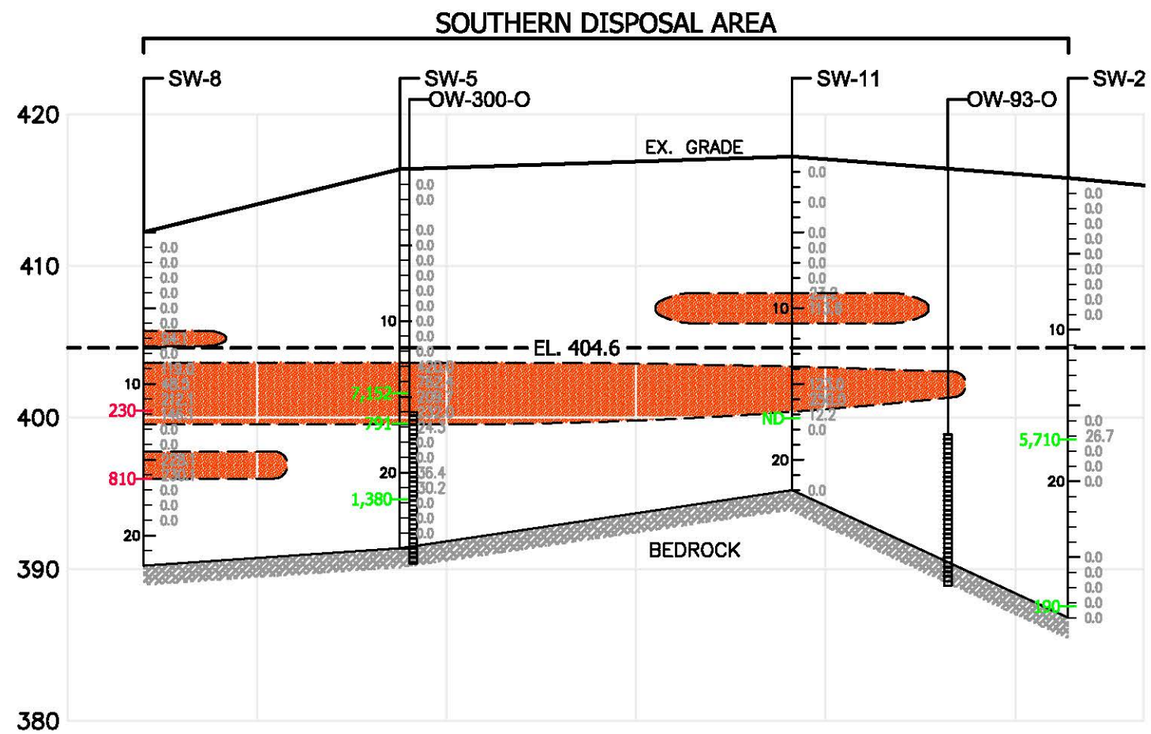

SCALE:
HORIZONTAL: 1"=40'
VERTICAL: 1"=10'

PROFILE A–A'

LEGEND:

94.1	FIELD HEADSPACE READING (PPM)
230	TVOC (ug/kg) INCLUDING CONSTITUENTS AT CONCENTRATION EXCEEDING RI GAL
1,380	TVOC (ug/kg) WITH ALL CONCENTRATIONS LESS THAN RI GAL
	FIELD HEADSPACE (ppm) GREATER THAN OR EQUAL TO 50

DATE: Oct 03, 2011 – 3:46PM
FILENAME: H:\D164–Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2–10.dwg

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Smithfield, Rhode Island
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Date: September 2011
Scale: As Shown

2008 Phase 4 Investigation
Cross Section
A - A'

Figure
2.10

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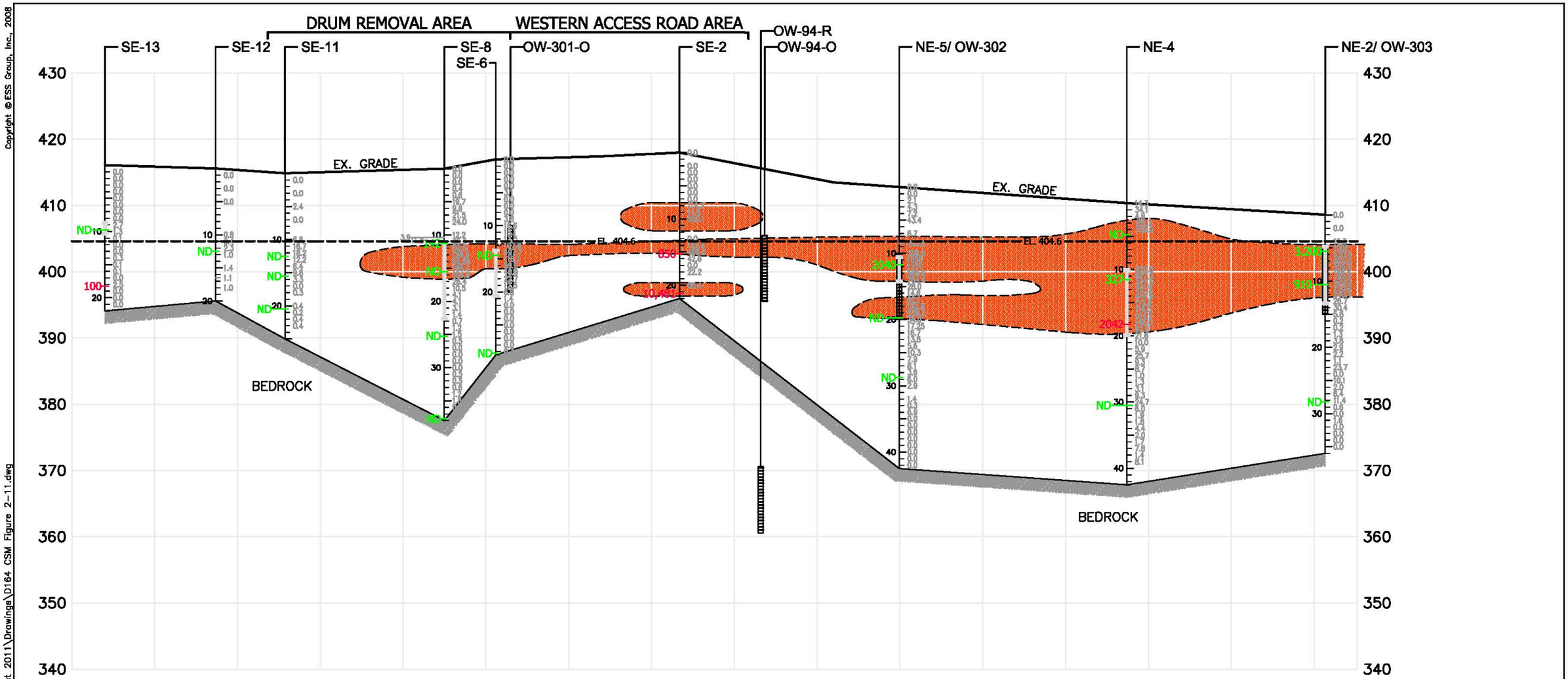

SCALE:
HORIZONTAL: 1"=60'
VERTICAL: 1"=15'

PROFILE B–B'

LEGEND:

94.1	FIELD HEADSPACE READING (PPM)
100	TVOC (ug/kg) INCLUDING CONSTITUENTS AT CONCENTRATION EXCEEDING RI GAL
327	TVOC (ug/kg) WITH ALL CONCENTRATIONS LESS THAN RI GAL
	FIELD HEADSPACE (ppm) GREATER THAN OR EQUAL TO 50
	ZONES OF ORGANIC DEPOSITS AND/OR GRAY FINE-GRAINED DEPOSITS

DATE: Oct 03, 2011 – 3:47PM
FILENAME: H:\D164–Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2–11.dwg

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Date: September 2011
Scale: As Shown

2008 Phase 4 Investigation
Cross Section
B - B'

Figure
2.11

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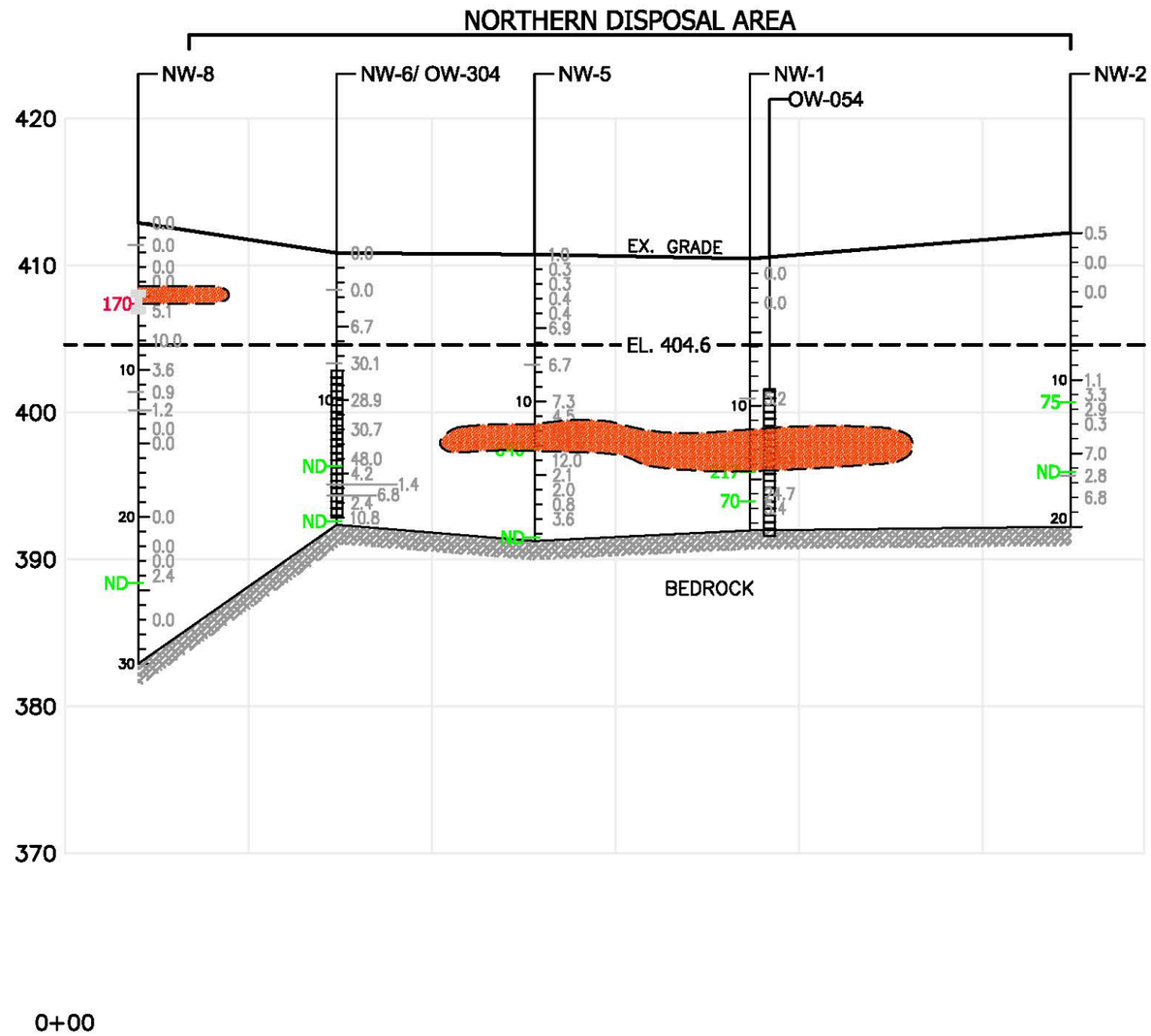

SCALE:
HORIZONTAL: 1"=40'
VERTICAL: 1"=10'

PROFILE C–C'

LEGEND:

94.1	FIELD HEADSPACE READING (PPM)
170	TVOC (ug/kg) INCLUDING CONSTITUENTS AT CONCENTRATION EXCEEDING RI GAL
1,380	TVOC (ug/kg) WITH ALL CONCENTRATIONS LESS THAN RI GAL
	FIELD HEADSPACE (ppm) GREATER THAN OR EQUAL TO 50
	ZONES OF ORGANIC DEPOSITS AND/OR GRAY FINE-GRAINED DEPOSITS

DATE: Oct 03, 2011 – 3:48PM
FILENAME: H:\D164–Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2–12.dwg

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Date: September 2011
Scale: As Shown

2008 Phase 4 Investigation
Cross Section
C - C'

Figure
2.12

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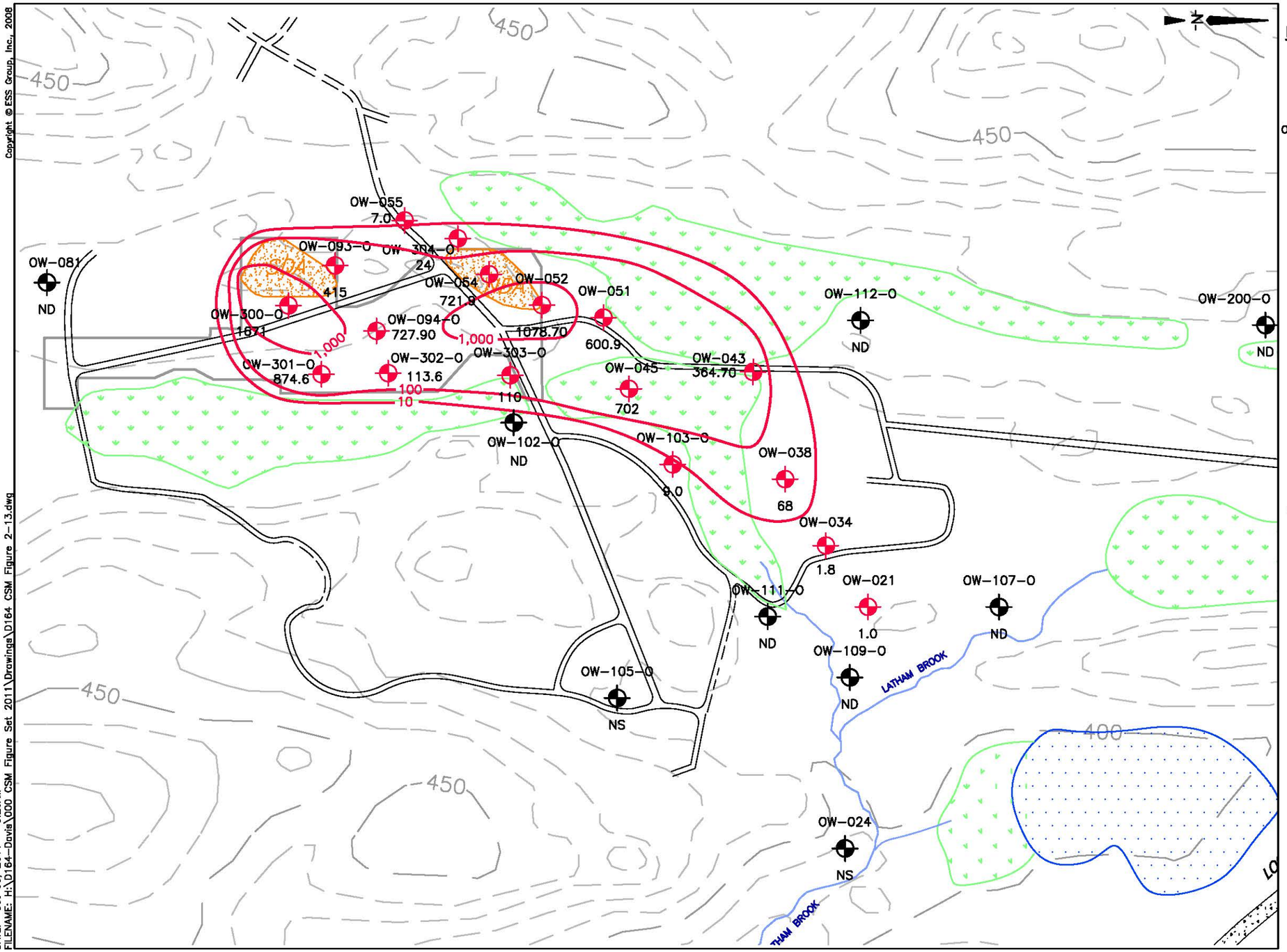

LEGEND:

- OW-081 / ND — MONITORING WELL WITH NO VOC DETECTIONS
- OW-103-O / 9.0 — MONITORING WELL WITH DETECTED VOCs (ug/L)
- OW-024 / NS — MONITORING WELL WITH NO SAMPLE COLLECTED
- ROADS (PAVED)
- ROADS (UNPAVED)
- TVOC ISOCONCENTRATION CONTOUR (ug/L)
- SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
  NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)
- WETLAND AREAS (APPROXIMATE)
- POND (APPROXIMATE)

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.

0 250 500
SCALE IN FEET

DATE: Oct 06, 2011 – 9:26AM
FILENAME: H:\D164-Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2-13.dwg

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Date: September 2011
Scale: 1" = 250'

TVOC Isoconcentration Map - Unconsolidated Deposit Wells

Fall 2008

Figure 2.13

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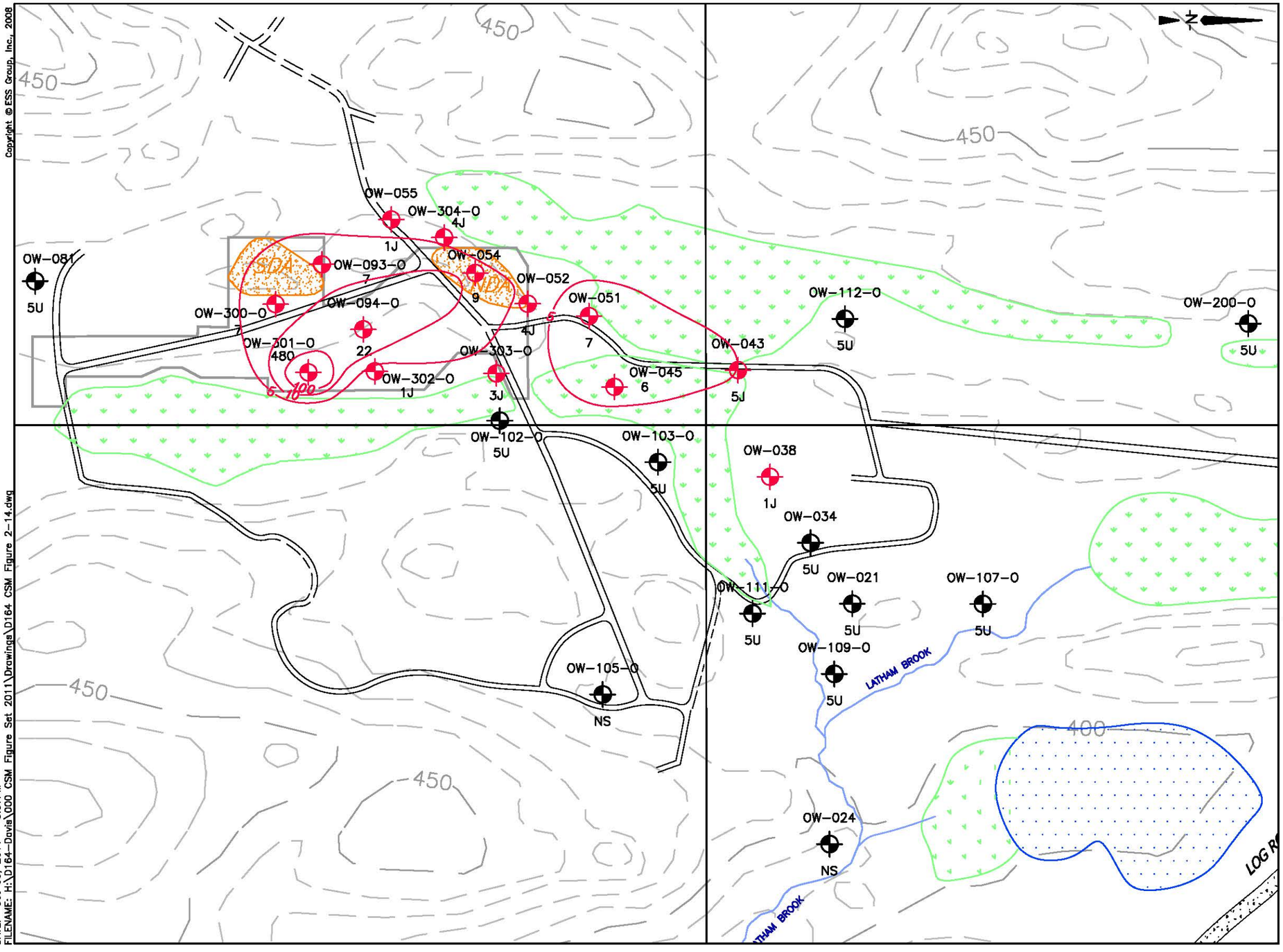

LEGEND:

OW-081 — MONITORING WELL WITH TCE NOT DETECTED (5U)

OW-051 — MONITORING WELL WITH DETECTED TCE (ug/L) (7)

OW-024 — MONITORING WELL NOT SAMPLED (NS)

ROADS (PAVED)

ROADS (UNPAVED)

TVOC ISOCONCENTRATION CONTOUR (ug/L)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.

0 250 500
SCALE IN FEET

DATE: Oct 03, 2011 – 3:57PM
FILENAME: H:\D164-Davis\000 CSM Figure Set 2011\Drawings\D164 CSM Figure 2-14.dwg

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Smithfield, Rhode Island
Project No. D164-000

Date: September 2011
Scale: 1" = 250'

Trichloroethylene Isoconcentration Map - Unconsolidated Deposit Wells

Fall 2008

Figure 2.14

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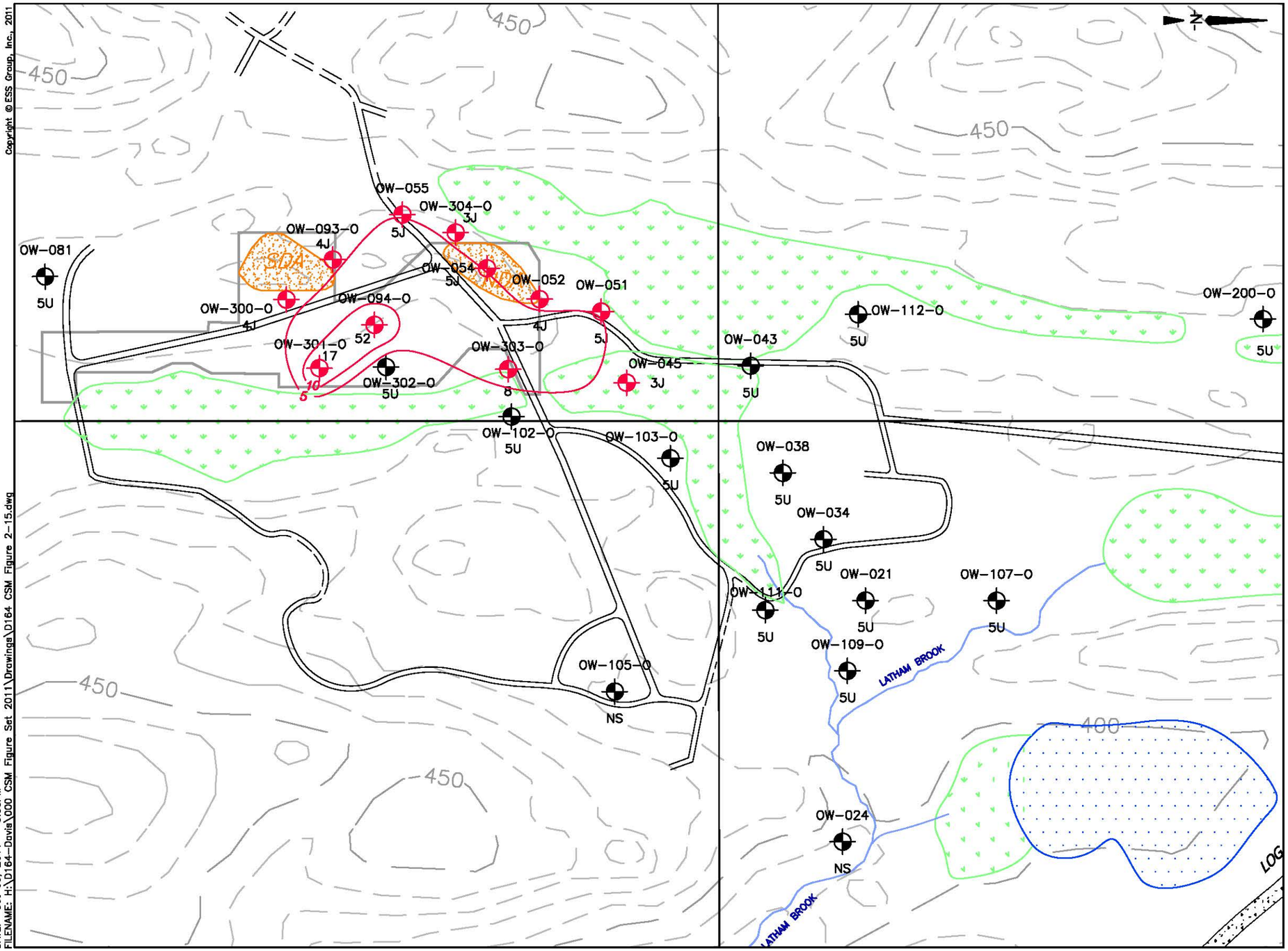

LEGEND:

OW-043 — MONITORING WELL WITH PCE NOT DETECTED (5U)

OW-94-O — MONITORING WELL WITH DETECTED PCE (ug/L) (52)

OW-024 — MONITORING WELL NOT SAMPLED (NS)

ROADS (PAVED)

ROADS (UNPAVED)

TVOC ISOCONCENTRATION CONTOUR (ug/L)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

NOTES:

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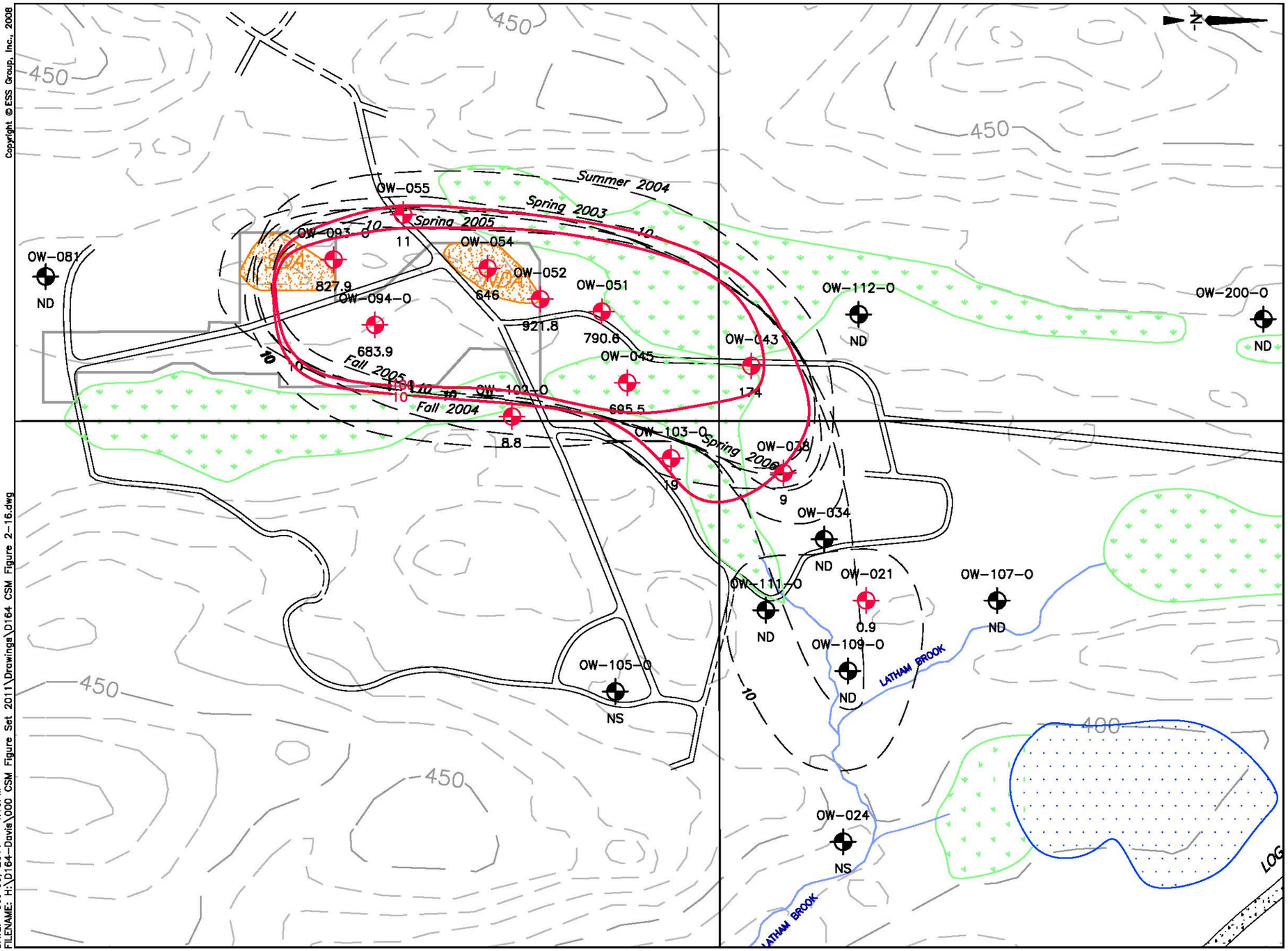
Tetrachloroethylene Isoconcentration Map - Unconsolidated Deposit Wells

Fall 2008

Figure 2.15



LEGEND:

OW-051
790.6 — MONITORING WELL WITH FALL 2006 TVOC RESULT (ug/L)

OW-024
NS — MONITORING WELL NO SAMPLE COLLECTED

ROADS (PAVED)

ROADS (UNPAVED)

HISTORICAL TVOC ISOCONCENTRATION CONTOURS (ug/L)

FALL 2006 TVOC ISOCONCENTRATION CONTOUR (ug/L)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

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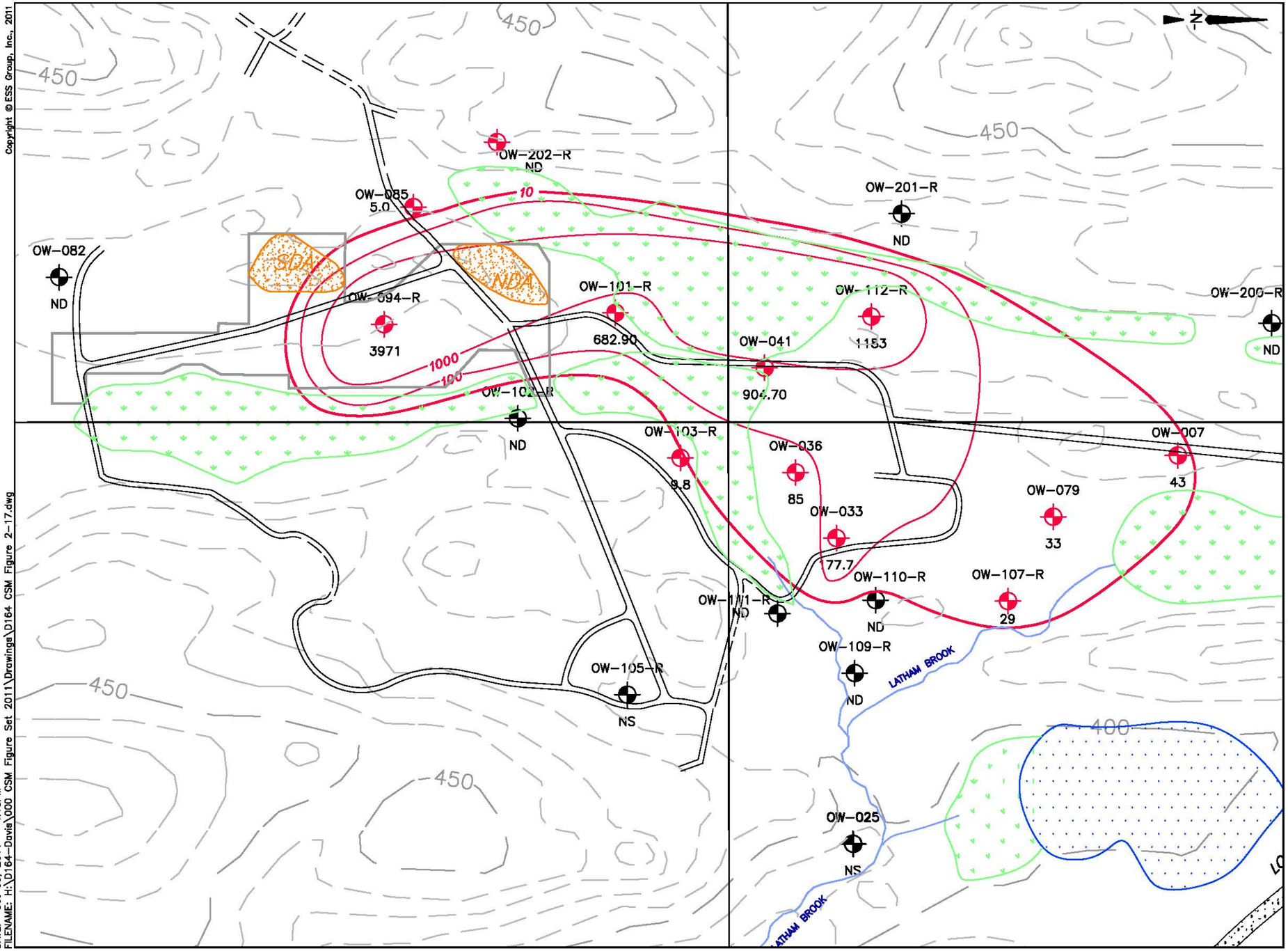
TVOC Isoconcentration Map (Plume Overlay) - Unconsolidated Deposit Wells

Fall 2008

Figure 2.16



LEGEND:

OW-109-R
ND — MONITORING WELL WITH NO VOC DETECTED

OW-007
43 — MONITORING WELL WITH DETECTED VOCs (ug/L)

OW-025
NS — MONITORING WELL NOT SAMPLED

ROADS (PAVED)

ROADS (UNPAVED)

TVOC ISOCONCENTRATION CONTOUR (ug/L)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

NOTES:

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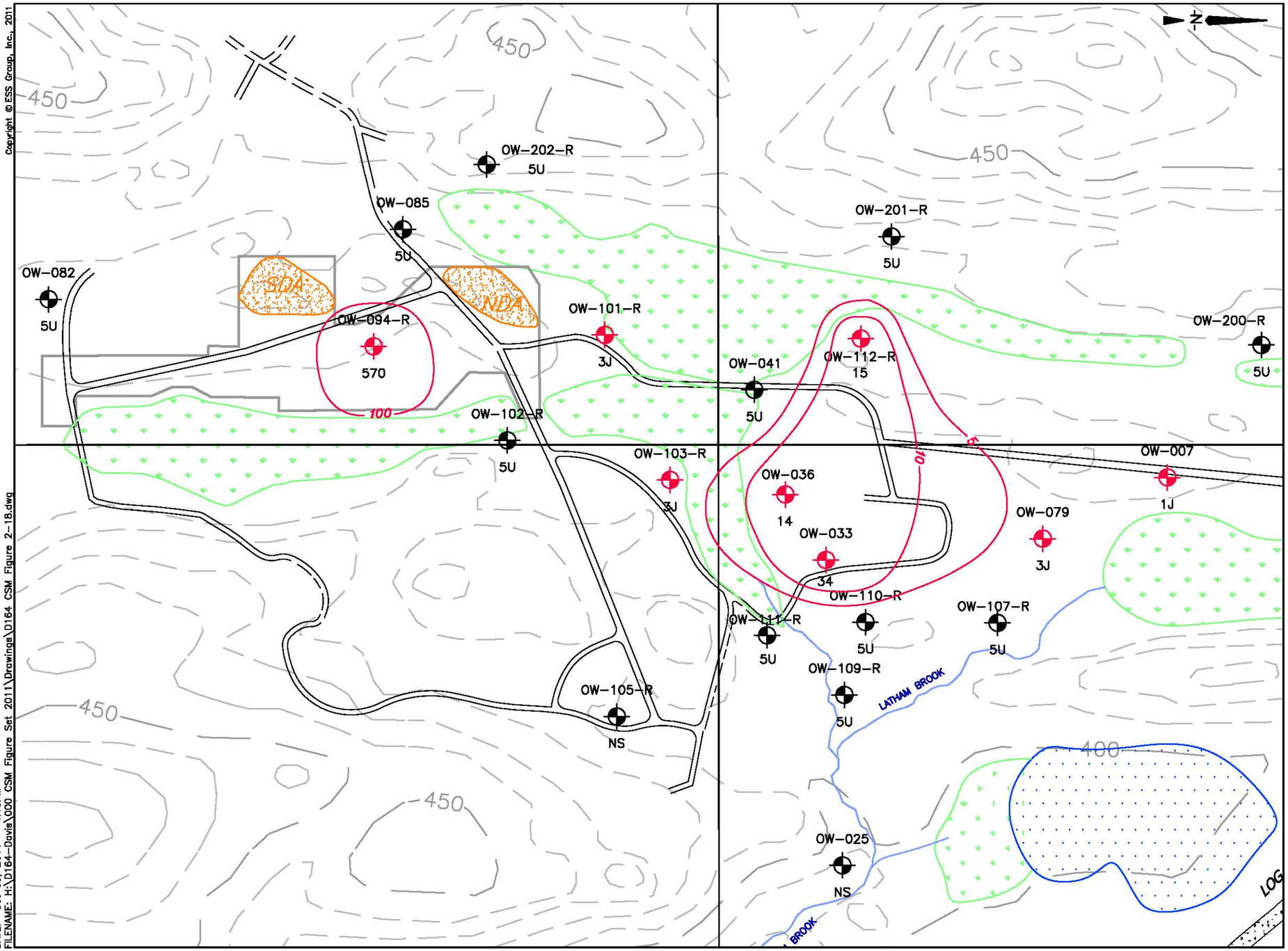
TVOC Isoconcentration Map - Bedrock Wells

Fall 2008

Figure 2.17



LEGEND:

OW-082 / 5U — MONITORING WELL WITH TCE NOT DETECTED

OW-036 / 14 — MONITORING WELL WITH DETECTED TCE (ug/L)

OW-025 / NS — MONITORING WELL NOT SAMPLE COLLECTED

ROADS (PAVED)

ROADS (UNPAVED)

TCE ISOCONCENTRATION CONTOUR (ug/L)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

NOTES:

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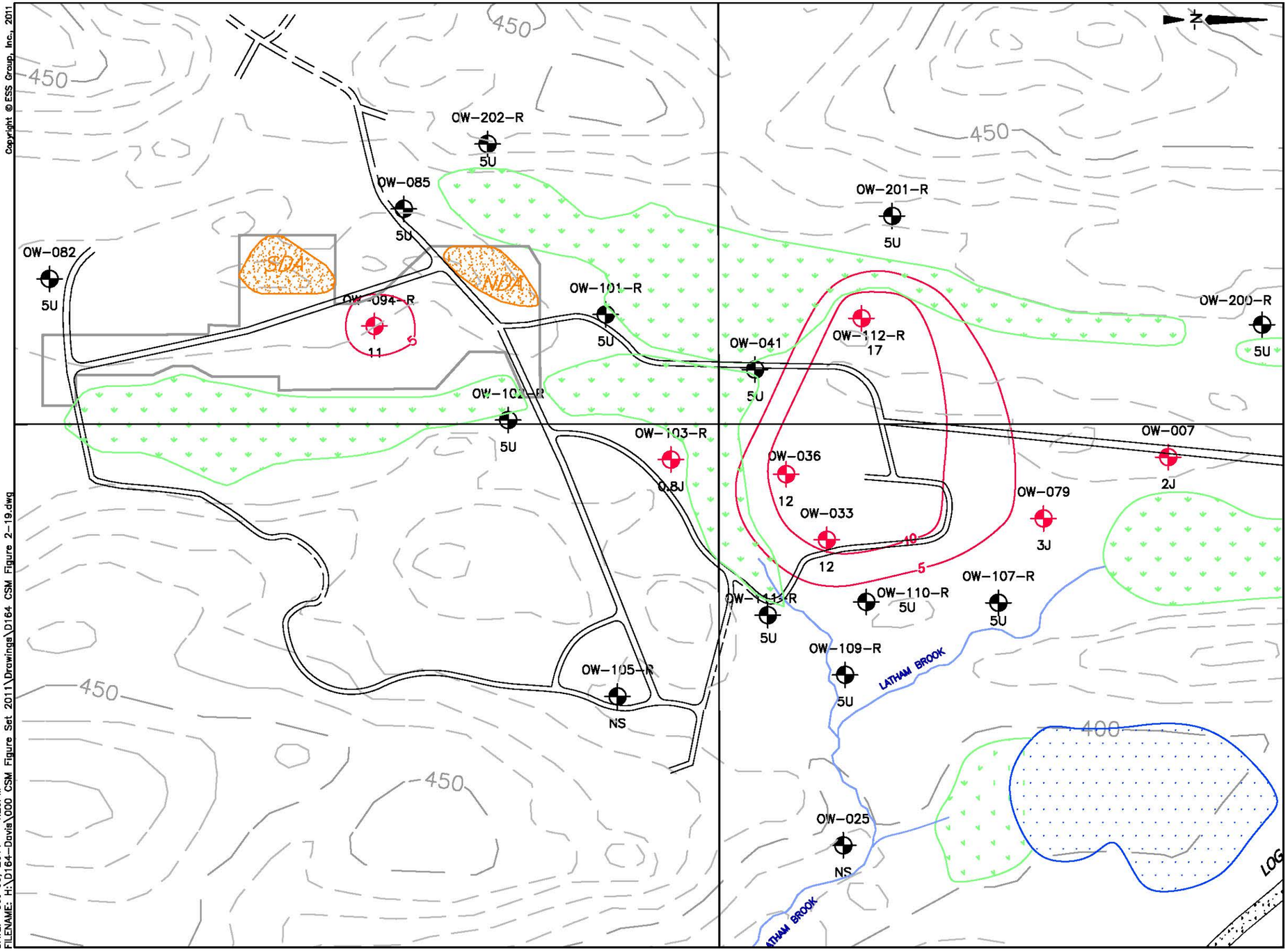
Trichloroethylene Isoconcentration Map - Bedrock Wells

Fall 2008

Figure 2.18



LEGEND:

OW-085 / 5U — MONITORING WELL WITH PCE NOT DETECTED

OW-112-R / 17 — MONITORING WELL WITH DETECTED PCE (ug/L)

OW-025 / NS — MONITORING WELL NOT SAMPLED

ROADS (PAVED)

ROADS (UNPAVED)

PCE ISOCONCENTRATION CONTOUR (ug/L)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

NOTES:

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Tetrachloroethylene Isoconcentration Map - Bedrock Wells

Fall 2008

Figure 2.19

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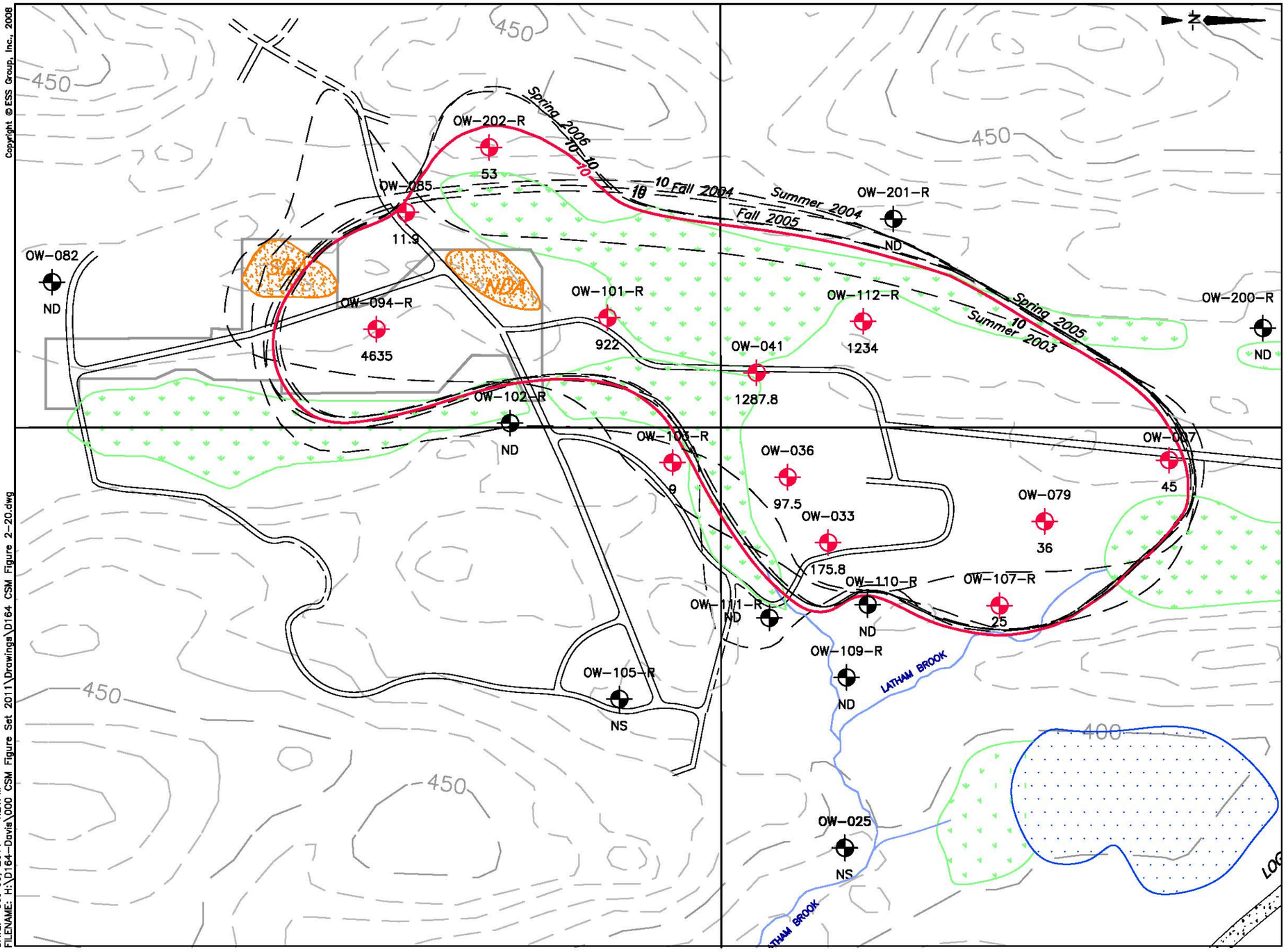

LEGEND:

OW-007
45
MONITORING WELL WITH FALL 2006 TVOC RESULT

OW-025
NS
MONITORING WELL NO SAMPLE COLLECTED

ROADS (PAVED)

ROADS (UNPAVED)

HISTORICAL TVOC ISOCONCENTRATION CONTOURS (ug/L)

FALL 2006 TVOC ISOCONCENTRATION CONTOUR (ug/L)

SDA - SOUTHERN DISPOSAL AREA (APPROXIMATE)
NDA - NORTHERN DISPOSAL AREA (APPROXIMATE)

WETLAND AREAS (APPROXIMATE)

POND (APPROXIMATE)

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2. OW-094-R IS A REPLACEMENT WELL INSTALLED IN THE GENERAL LOCATION OF WELL DECOMMISSIONED DURING SOURCE REMEDIATION.

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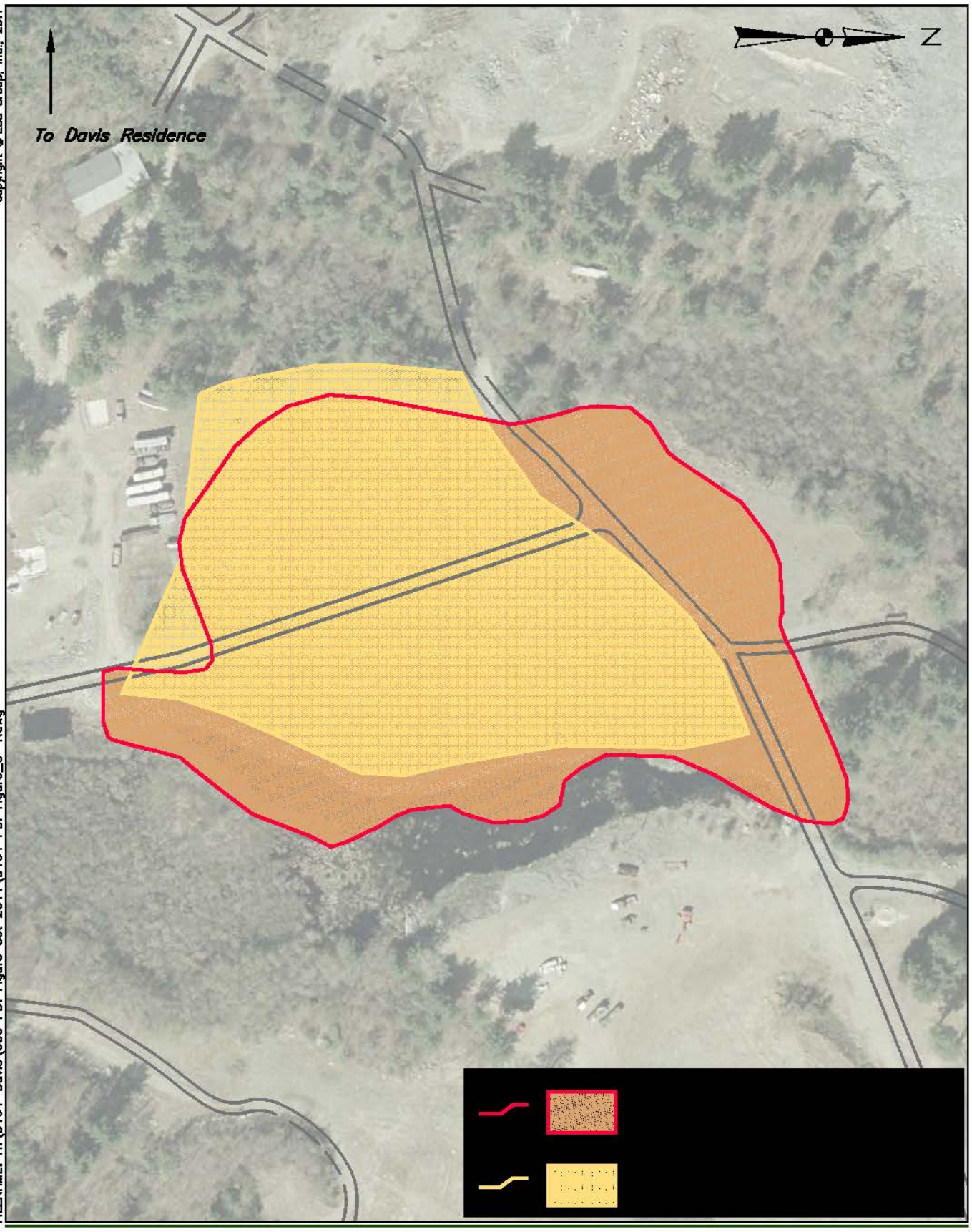
TVOC Isoconcentration Map (Plume Overlays) - Bedrock Wells

Fall 2008

Figure 2.20



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0 150 FEET

Former Source Area and Treated Backfill

Figure 3.1

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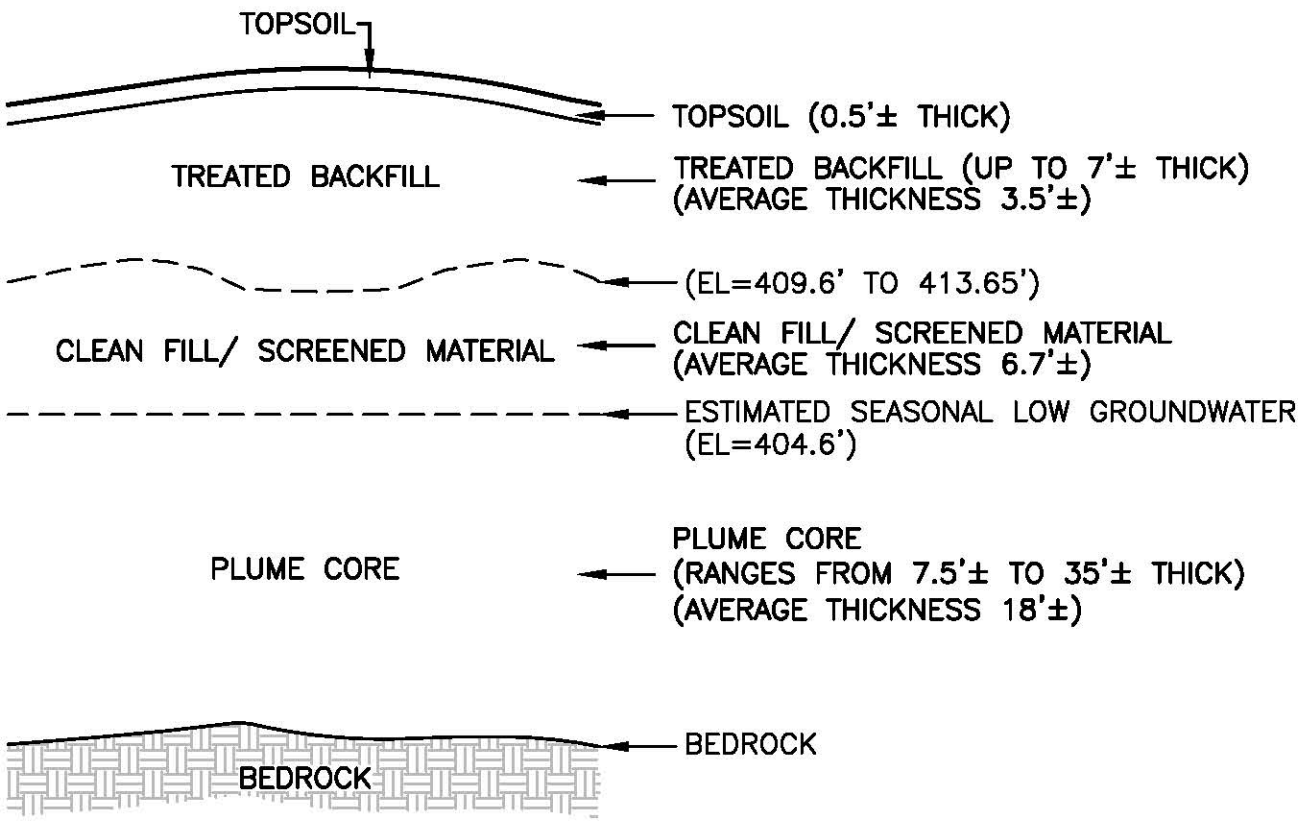
APPROXIMATE AREAS

TREATED BACKFILL	196,925± SF (4.5 ACRES)
PLUME CORE (FSA)	274,622± SF (6.3 ACRES)



CONCEPTUAL SCHEMATIC – FORMER SOURCE AREA

NOT TO SCALE

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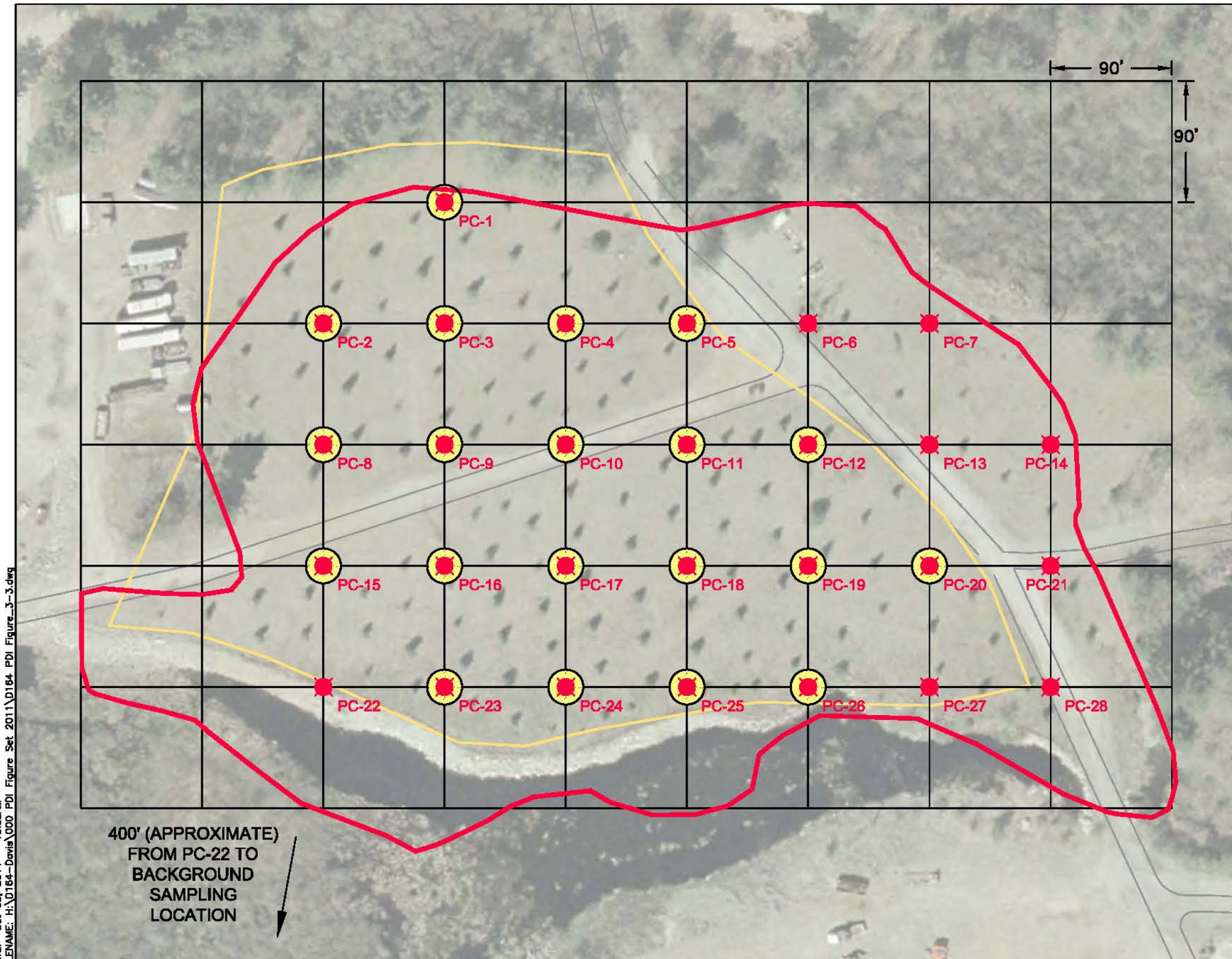
Conceptual Schematic
Former Source Area (FSA)

Figure 3.2



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LEGEND:

- PC-6 — PLUME CORE BORING
- TREATED BACKFILL BORING
- ROADS (UNPAVED)
- APPROXIMATE LIMIT OF SATURATED UNEXCAVATED SOIL
- 90' GRID SPACING
- APPROXIMATE EXTENT OF TREATED BACKFILL

NOTES:

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3. ACTUAL LOCATION OF PROPOSED FEATURES TO BE DETERMINED AND/OR ADJUSTED BASED ON FIELD OBSERVATIONS.

0 80 160
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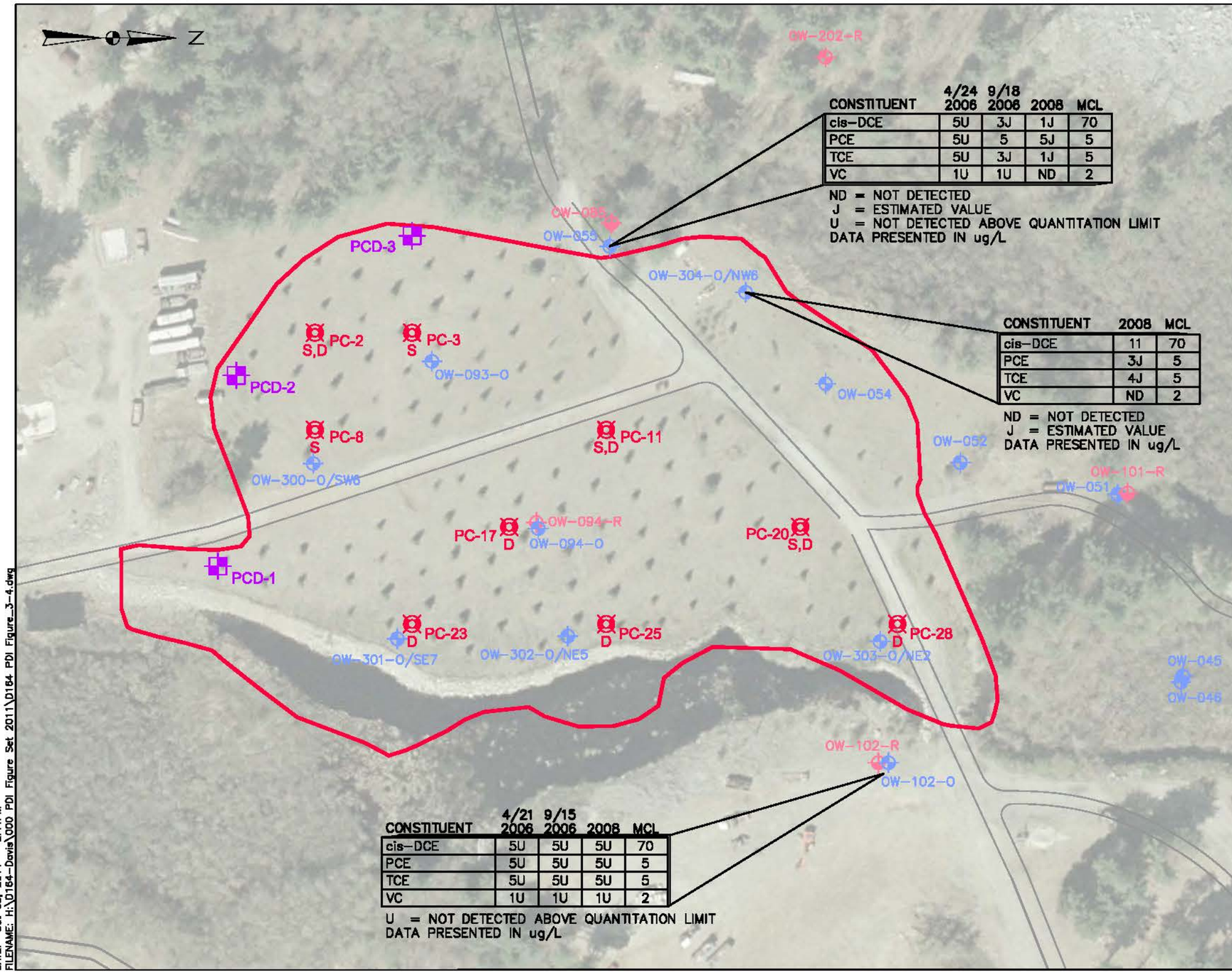
Plume Core and Treated Backfill Boring Plan

Figure 3.3



CONSTITUENT	4/24 2006	9/18 2006	2008	MCL
cis-DCE	5U	3J	1J	70
PCE	5U	5	5J	5
TCE	5U	3J	1J	5
VC	1U	1U	ND	2

ND = NOT DETECTED
J = ESTIMATED VALUE
U = NOT DETECTED ABOVE QUANTITATION LIMIT
DATA PRESENTED IN ug/L

CONSTITUENT	2008	MCL
cis-DCE	11	70
PCE	3J	5
TCE	4J	5
VC	ND	2

ND = NOT DETECTED
J = ESTIMATED VALUE
DATA PRESENTED IN ug/L

CONSTITUENT	4/21 2006	9/15 2006	2008	MCL
cis-DCE	5U	5U	5U	70
PCE	5U	5U	5U	5
TCE	5U	5U	5U	5
VC	1U	1U	1U	2

U = NOT DETECTED ABOVE QUANTITATION LIMIT
DATA PRESENTED IN ug/L

LEGEND:

- OW-054 — UNCONSOLIDATED DEPOSIT MONITORING WELL
- OW-094-R — BEDROCK MONITORING WELL
- PC-2 S,D — PROPOSED PLUME CORE MONITORING WELL (S-SHALLOW, D-DEEP)
- PCD-1 — PROPOSED PLUME CORE DELINEATION WELL
- ROADS (UNPAVED)
- APPROXIMATE LIMIT OF SATURATED UNEXCAVATED SOIL

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3. ACTUAL LOCATION OF PROPOSED FEATURES TO BE DETERMINED AND/OR ADJUSTED BASED ON FIELD OBSERVATIONS.

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Plume Core Monitoring Well Plan

Figure 3.4

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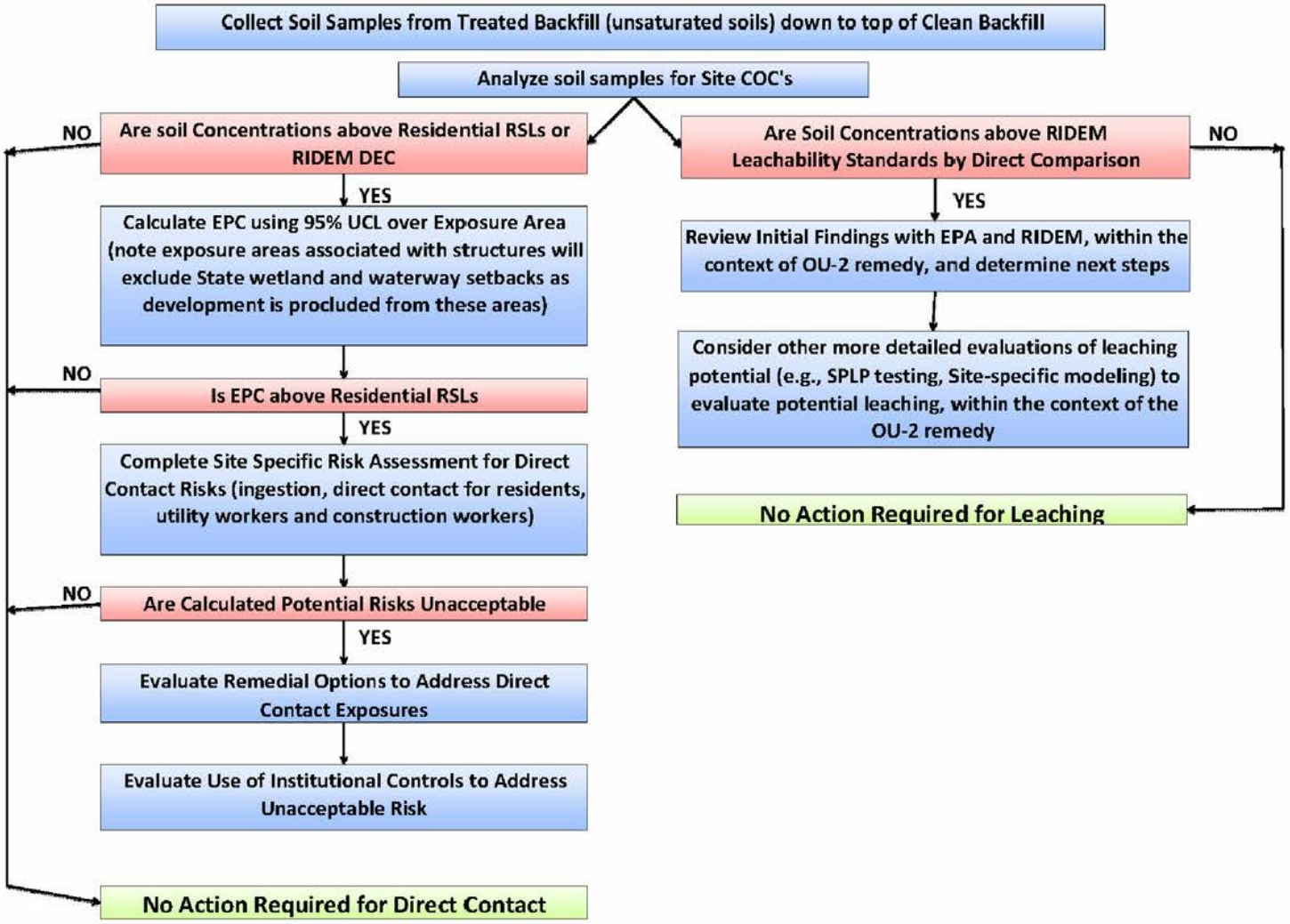

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Treated Backfill Decision Matrix

Figure 3.5

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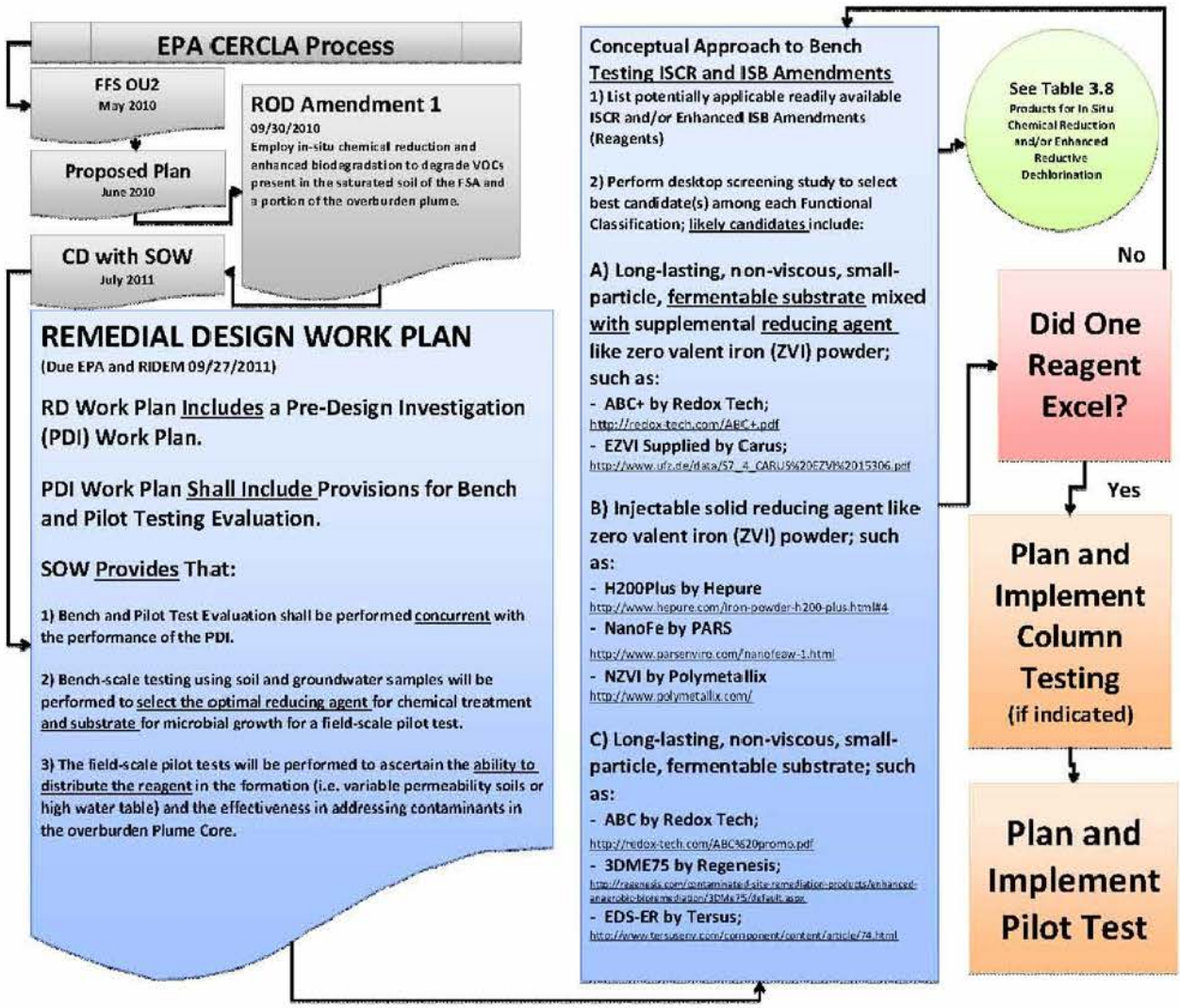

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Roadmap to Bench and Pilot Testing

Figure 3.6

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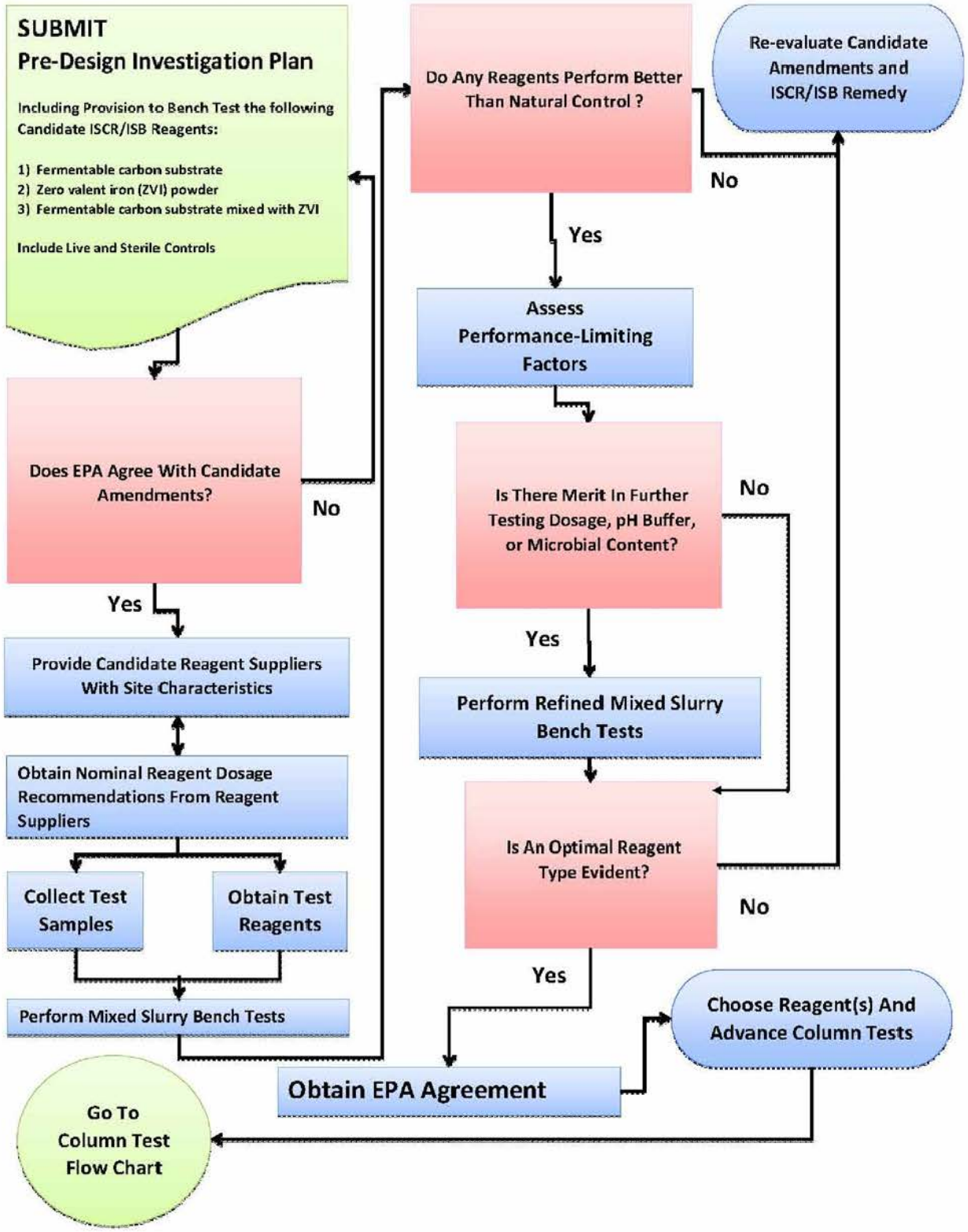

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Mixed Slurry Bench Testing Flow Chart

Figure 3.7

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Potentially Applicable Reagents

See Table In PDI Plan
Products for ISCR/ERD

Evaluate
Potentially Applicable Reagents

- PDI Plan: Rational for Bench Test
- PDI Plan: Roadmap Bench/Pilot Testing
- PDI Plan: Bench Testing Flow Chart
- PDI Plan: Amendment Screening Criteria
- PDI Plan: Bench Test Strategy

Select
Candidate Reagents

1) Fermentable Carbon Substrate:
ABC
2) Zero Valent Iron (ZVI) Powder:
Peerless 100-µm / HCA-325
3) Fermentable Carbon Substrate Mixed with ZVI:
ABC+ / EHC-F

Potential Bench Test Providers

See PDI Plan Table
Bench Test Providers for ISCR/ERD

Evaluate
Potential Bench Test Service Providers

Value:
- Testing Is Primary Business Line
- Experienced with ISCR (not just ISB)
- Close to Site
- Capable of Column Testing
- Independent of Reagent Product Sales
- Demonstration of Capacity
- Confidence Through Interview(s)
- Existing Agreeable SOP & QAPP

See PDI Plan
Bench Test Providers for ISCR/ERD

Select
Candidate Bench Test Service Provider

Shaw Environmental
(Technology Development Laboratory):
- Dr. Rob Steffan
- 609.895.5350; rob.steffan@shawgrp.com
- Lawrenceville, NJ; 250 Miles From Site

Candidate Mixed Slurry Microcosm Samples

See PDI Plan Bench Test Strategy:
- Test Each Mappable Soil Type:
1) Peat
2) Fine -grained Silt
3) Sand and Gravel
- Containing Relatively High CVOCs

Select
Mixed Slurry Microcosm Samples

Base Selection On Early Indicators During PDI Boring Program:
- Field & Lab Screening Results
- Representativeness of Soil Types
- Ability to Preserve Anaerobic Condition

Select
Mixed Slurry Microcosm Reagent Dosages

Base Selections On Preliminary Lab Results From PDI Source Assessment:
- Chloroethenes
- Biogeochemical Parameters
- Apparent Hydrogen Demand x 2

Coordinate Construction of Microcosm Bench Test:
- Laboratory Ready To Receive And Prepare Test Samples
- Qualified Samples Collected And Delivered At Proper Time
- Qualified Reagents Delivered to Lab At Proper Time

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Bench Testing Strategy
Mixed Slurry Microcosm
Reagents, Laboratory, and Samples

Figure 3.8

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Samples To Laboratory

Deliver Anaerobic Core Of Each Aquifer Soil Type To Laboratory:

I. Peat
II. Fine Sand and Silt
III. Sand and Gravel

Deliver 5-liter (minimum) Unpreserved Anaerobic Groundwater Samples Representative Of Each Aquifer Sediment Type To Laboratory

Laboratory Preparation

Lab Prepare 5 Anaerobic Mixed Slurry Microcosms (In Quadruplicate) For Each Aquifer Soil Type:

1 (a,b,c,d) - Natural Control
2 (a,b,c,d) - Sterile Control
3 (a,b,c,d) - ABC-amended
4 (a,b,c,d) - ZVI amended
5 (a,b,c,d) - ABC+ amended

Each Microcosm:

- 160-ml Glass Serum Vial
- PTFE-lined Butyl Rubber Seal
- 30 Grams of Aquifer Material
- Amendment Spikes
- Filled with Groundwater
- Sterile Glass Volume Filler
- Sterilize Control By Autoclave

Laboratory Monitoring
(in duplicate)

Nominal Monitoring Frequency:

- Baseline (Day 0)
- Day 10
- Day 20
- Day 30
- Day 60
- Day 90
- Day 180 (if indicated)

Aqueous Analytes:

All Microcosms; All Intervals:
- CVOCs
- Methane, Ethane, Ethene, Acetylene
- pH
- Eh
- Specific Conductance
- Temperature

All Microcosms; Day 0, 30, 90:
- Fe^{+2}
- Nitrate
- Sulfate
- Chloride

All Microcosms; Day 0, 90:
- Volatile Fatty Acids (VFAs)
- Essential Nutrients (volume permitting)
- Other Optional Analytes (volume permitting)

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Bench Testing Strategy
Mixed Slurry Microcosm
Construction and Monitoring

Figure 3.9

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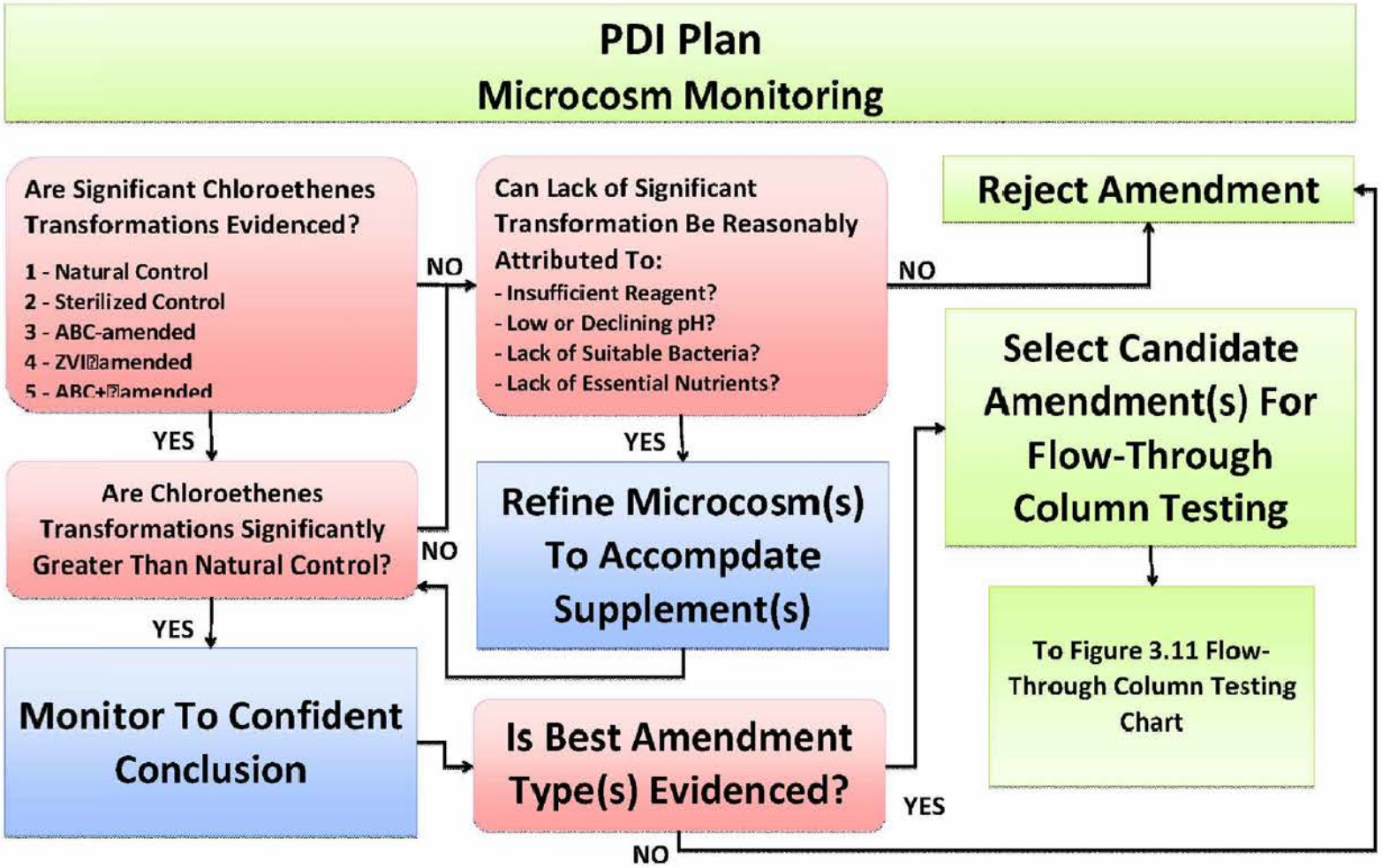

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Bench Testing Strategy
Mixed Slurry Microcosm
Decision-Making Flowchart

Figure 3.10

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Samples To Laboratory

Deliver Anaerobic Core Samples Of Each Qualifying Aquifer Soil Type To Laboratory Under Anaerobic Protocol

Lab to Manufacture Synthetic Anaerobic Groundwater (SAGW) Representative Of Geochemcial Composition Aquifer Soil Samples' Pore Water

Laboratory Preparation

Objective

Design Basis Parameters:

- Amendment Dosage
- Longevity of Amendment(s)
- Prospect for Rebound
- Assess Mass Transfer Limits

Lab Prepare Triplicate Anaerobic Columns For Each Qualifying Aquifer Soil Type

Each Column:

- 3-inch x 12-inch Nominal
- Spike Saturated Soils with Candidate Amendment(s)
- Pump Groundwater for 3 Months At Rate To Simulate Aquifer Flow Conditions

Laboratory Monitoring

Nominal Monitoring Frequency:

- Baseline (Day 0)
- Day 7
- Day 14
- Day 28
- Day 42
- Day 65
- Day 90
- Extend As Indicated for Longevity and Rebound Assessment

Aqueous Analytes:

- VOCs
- Methane, Ethane, Ethene, Acetylene
- pH
- Anions
- Volatile Fatty Acids (VFAs)

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Bench Testing Strategy
Flow-Through Column Testing

Figure 3.11

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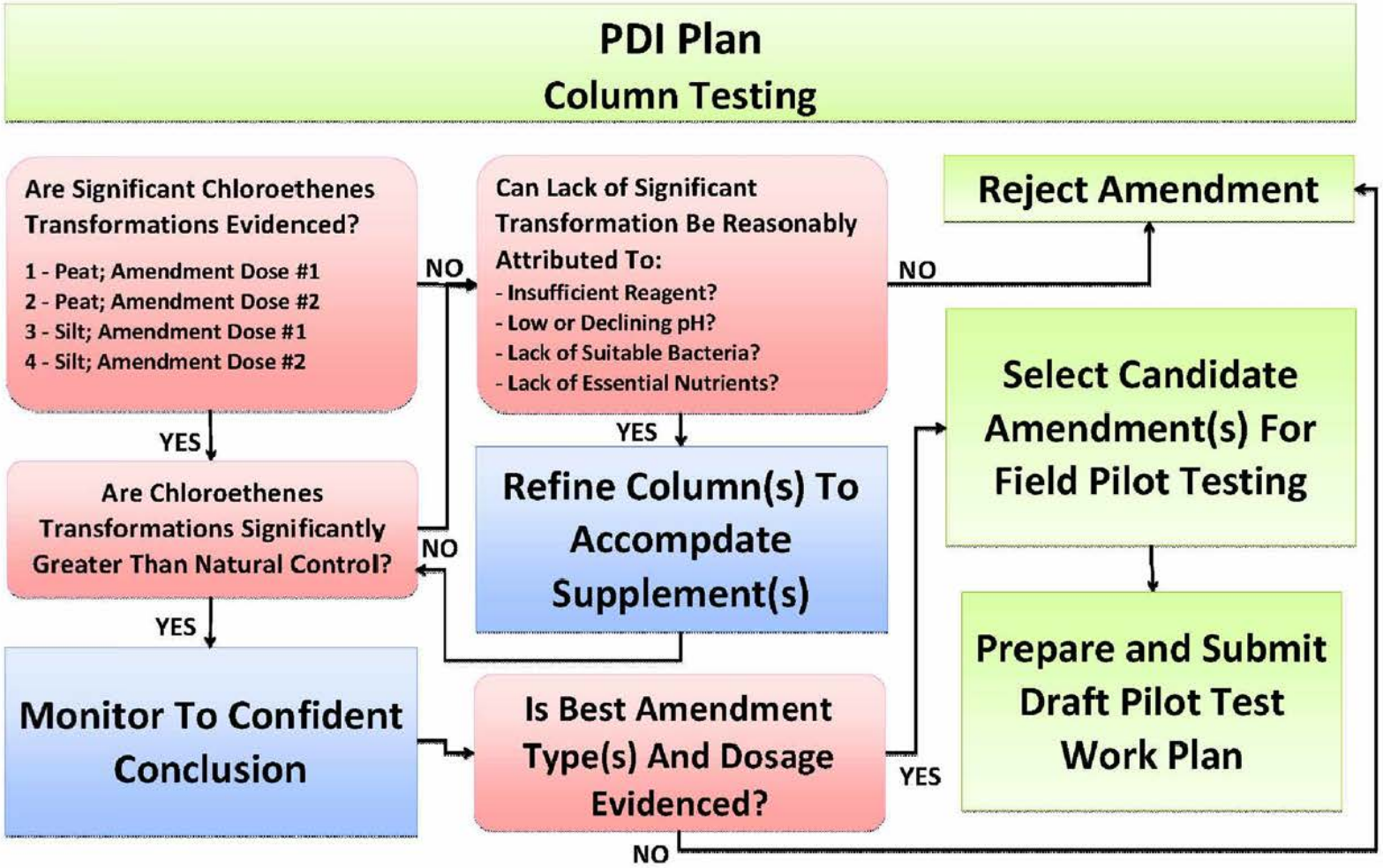

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Smithfield, Rhode Island
Project No. D164-000

Bench Testing Strategy
Column Test
Decision-Making Flowchart

Figure
3.12

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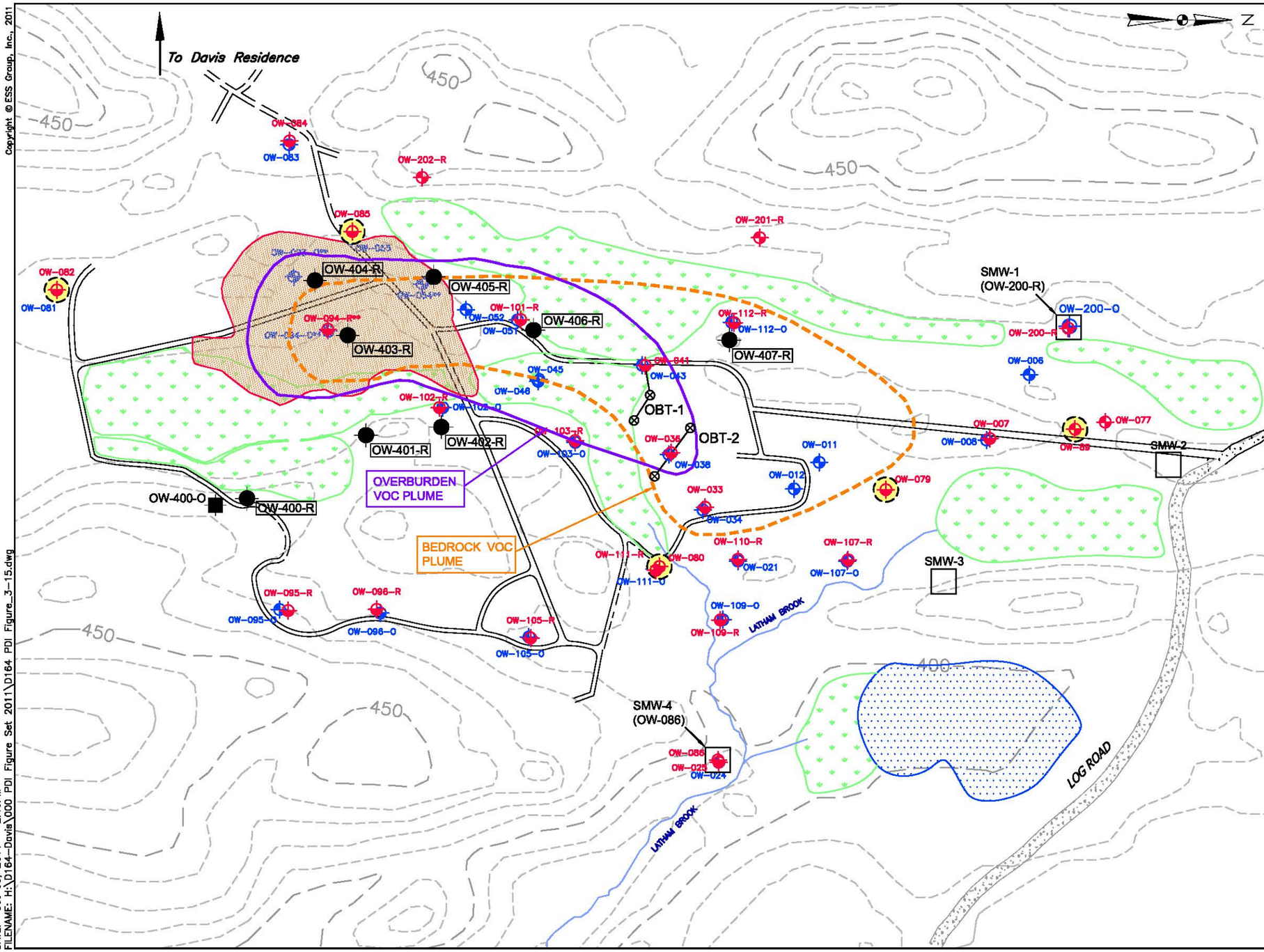

LEGEND:

- OW-200-O — UNCONSOLIDATED DEPOSIT MONITORING WELL
- OW-077 — BEDROCK MONITORING WELL
- OW-400-O — PROPOSED UNCONSOLIDATED DEPOSIT MONITORING WELL
- OW-400-R — PROPOSED BEDROCK MONITORING WELL
- PROPOSED BOREHOLE GEOPHYSICAL LOGGING LOCATIONS
- OBT-1 — PROPOSED UNCONSOLIDATED DEPOSIT TRANSECT
- SMW-2 — PROPOSED SENTRY WELL LOCATIONS
- ROADS (UNPAVED)
- APPROXIMATE LIMIT OF SATURATED UNEXCAVATED SOIL (FORMER SOURCE AREA)
- WETLAND AREAS (APPROXIMATE)
- POND (APPROXIMATE)

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.
3. ACTUAL LOCATION OF PROPOSED FEATURES TO BE DETERMINED AND/OR ADJUSTED BASED ON FIELD OBSERVATIONS.

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0 300 FEET
Date: September 2011
Scale: 1"= 300'

Groundwater Investigation

Figure 3.15

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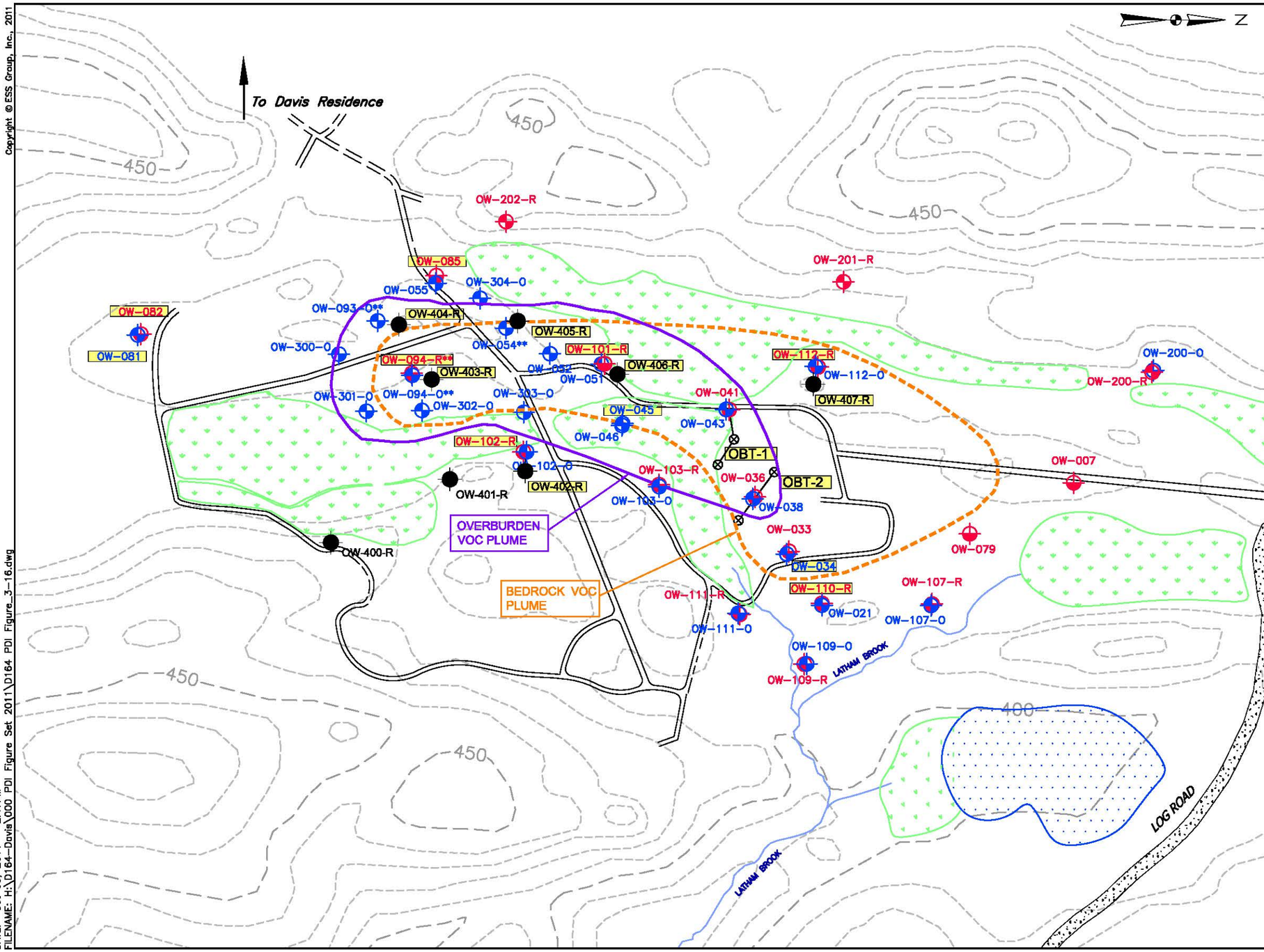

LEGEND:

- OW-200-O — PHASE 4 UNCONSOLIDATED DEPOSIT MONITORING WELL
- OW-200-R — PHASE 4 BEDROCK MONITORING WELL
- OW-400-R — PROPOSED BEDROCK MONITORING WELL
- OBT-1 — PROPOSED UNCONSOLIDATED DEPOSIT TRANSECT
- MNA MONITORING LOCATIONS
- ROADS (PAVED)
- ROADS (UNPAVED)
- WETLAND AREAS (APPROXIMATE)
- POND (APPROXIMATE)

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.
3. ACTUAL LOCATION OF PROPOSED FEATURES TO BE DETERMINED AND/OR ADJUSTED BASED ON FIELD OBSERVATIONS.

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Site - Wide
Groundwater Monitoring Program

Figure
3.16

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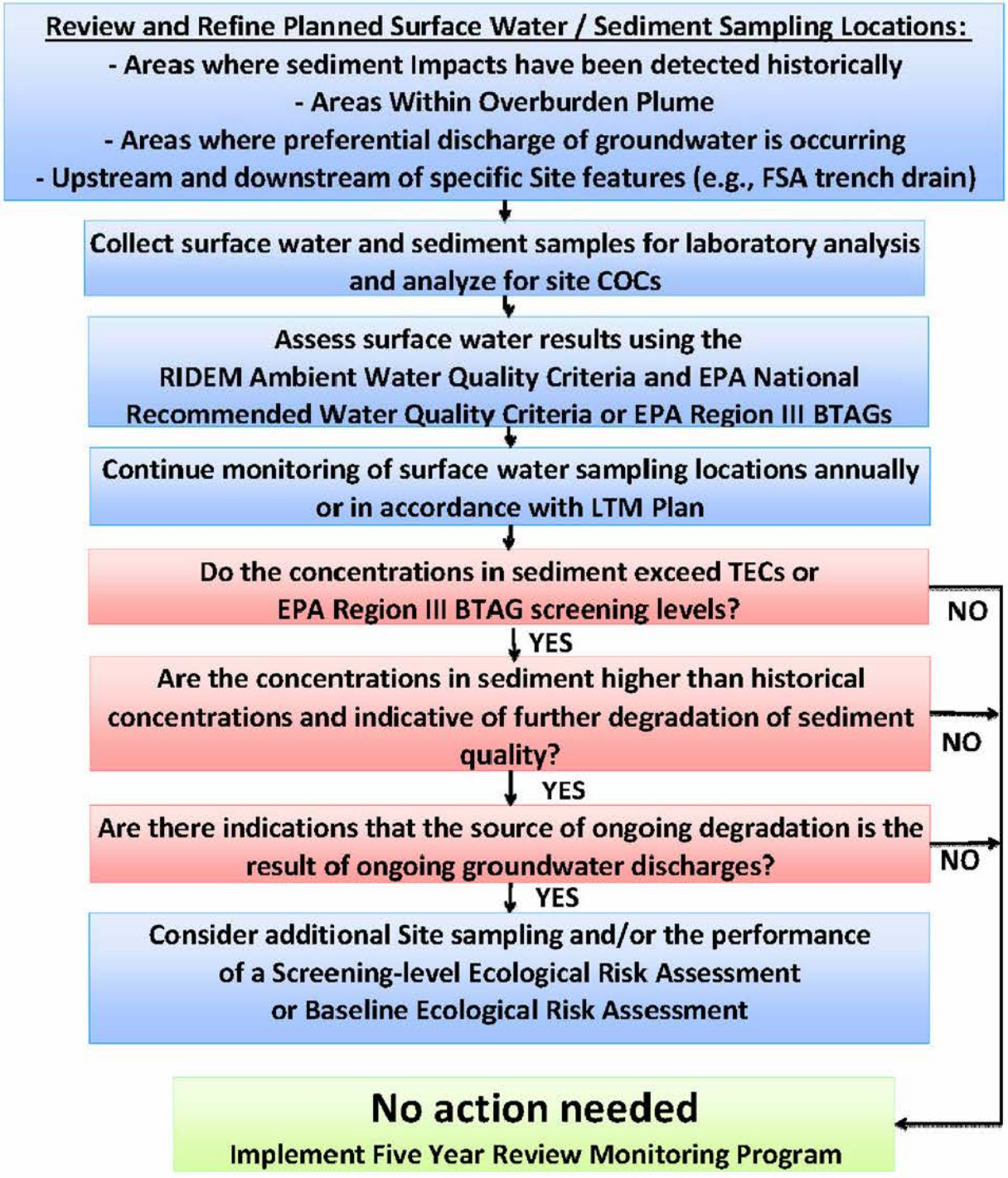

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Project No. D164-000

Surface Water and Sediment Decision Matrix

Figure 3.17

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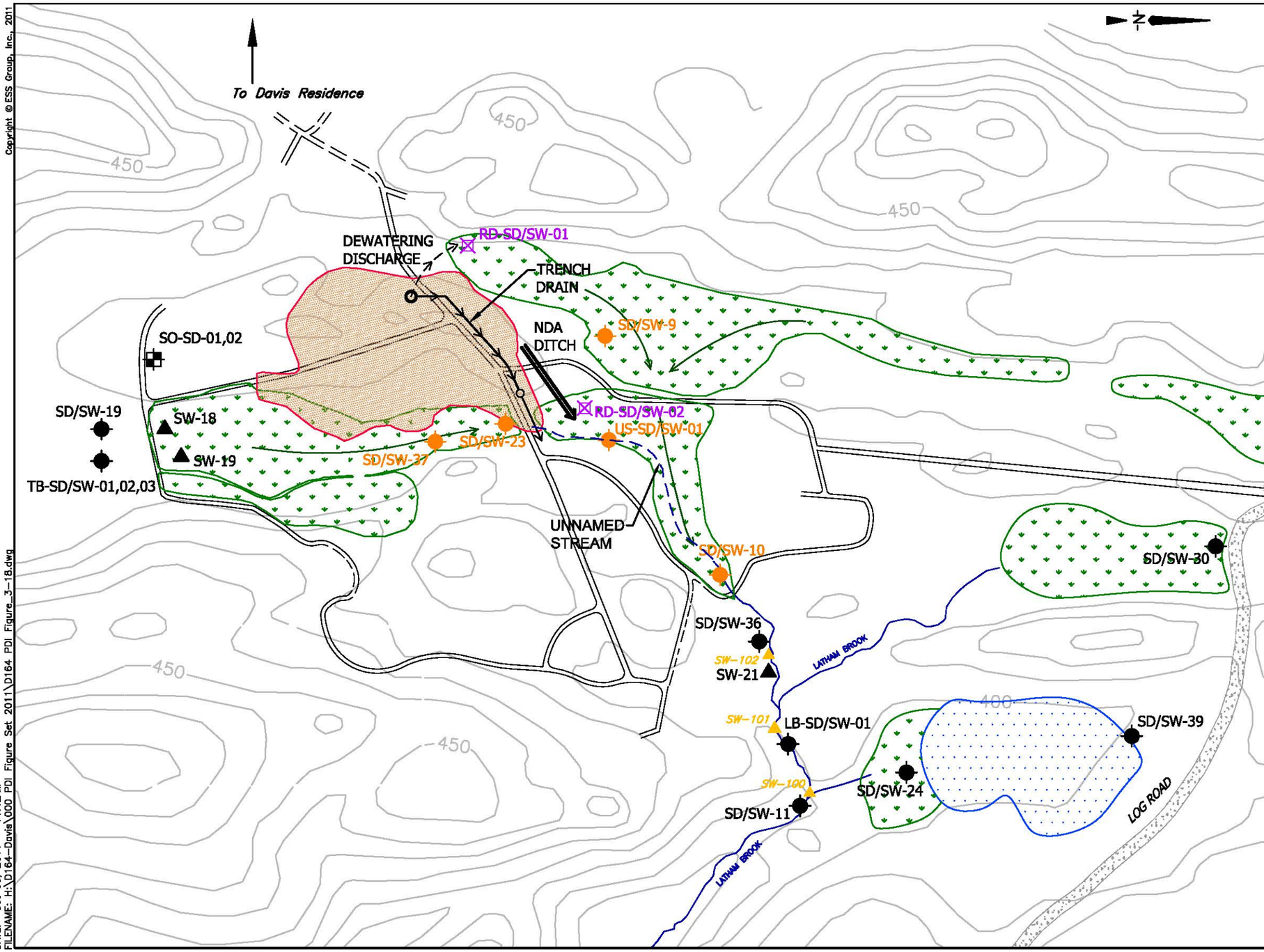

LEGEND:

- SO-SD-01,02 — HISTORIC SEDIMENT SAMPLING LOCATION
- SD/SW-36 — HISTORIC SURFACE WATER & SEDIMENT SAMPLING LOCATION
- SW-18 — HISTORIC SURFACE WATER SAMPLING LOCATION
- SW-101 — PROPOSED AND RECENT SURFACE WATER SAMPLING LOCATION
- SD/SW-9 — PROPOSED AND HISTORIC SURFACE WATER & SEDIMENT SAMPLING LOCATION
- RD-SD/SW-01 — PROPOSED SURFACE WATER & SEDIMENT SAMPLING LOCATION
- ROADS (UNPAVED)
- APPROXIMATE LIMIT OF SATURATED UNEXCAVATED SOIL (FORMER SOURCE AREA)
- WETLAND AREAS (APPROXIMATE)
- POND (APPROXIMATE)
- GENERALIZED SURFACE WATER FLOW PATTERN

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.
3. SURFACE WATER SAMPLING LOCATIONS ARE APPROXIMATE ONLY.
4. WETLAND AND STREAM LOCATIONS ARE APPROXIMATE ONLY.

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FILENAME: H:\D164-Davis\000 PDI Figure Set 2011\D164 PDI Figure_3-18.dwg

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Project No. D164-000

0 300 FT
Date: September 2011

Surface Water and Sediment Sampling Locations

Figure 3.18

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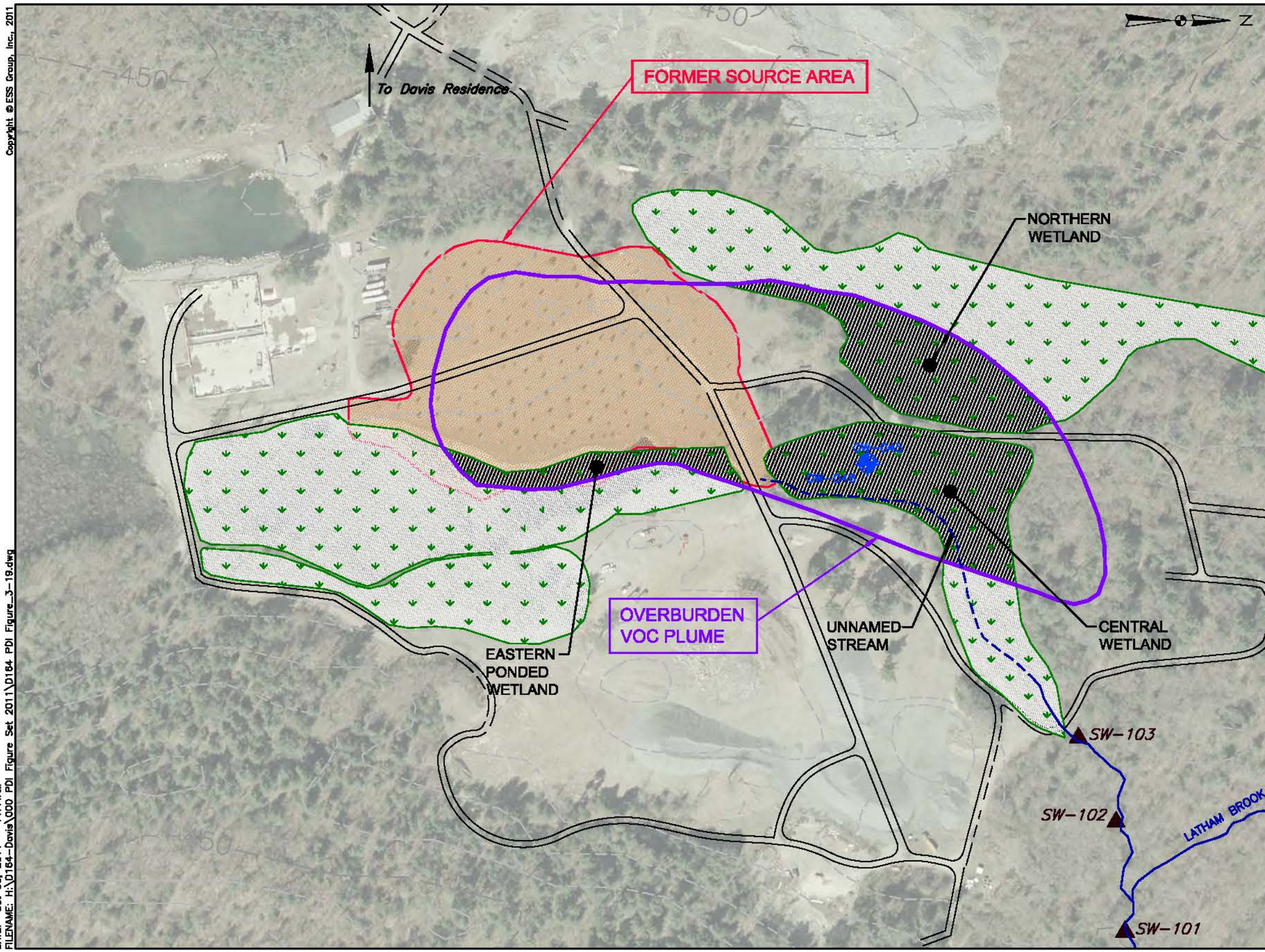

LEGEND:

- OW-046 — UNCONSOLIDATED DEPOSIT MONITORING WELL
- SW-102 — SURFACE WATER LOCATION (OCTOBER 2008)
- ROADS (PAVED)
- ROADS (UNPAVED)
- APPROXIMATE LIMIT OF SATURATED UNEXCAVATED SOIL (FORMER SOURCE AREA)
- TARGET WETLAND AREAS
- WETLAND AREAS (APPROXIMATE)

NOTES:

1. BASE PLAN HAS BEEN COMPILED FROM SITE SURVEY CONDUCTED BY MARK N. NYBERG ASSOCIATES, INC. (DECEMBER 2001 AND MAY 2003) AND WOODWARD-CLYDE FINAL PRE-DESIGN ENGINEERING REPORT II (OCTOBER 1993).
2. OW-054, OW-093-O, OW-094-O, AND OW-094-R ARE REPLACEMENT WELLS INSTALLED IN THE GENERAL LOCATION OF WELLS DECOMMISSIONED DURING SOURCE REMEDIATION.
3. WETLAND AND STREAM LOCATIONS ARE APPROXIMATE ONLY.

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Davis Liquid Waste Superfund Site
Smithfield, Rhode Island
Project No. D164-000

0 200 FEET
Date: September 2011
Scale: 1"= 200'

Wetland Area Schematic

Figure 3.19

Attachment A

Plume Core Statistical Evaluation

Geostatistical Basis for Sample Design
Plume Core Investigation

A geostatistical analysis of VOC data previously collected at the Davis Liquid Waste Superfund Site (the Site) has been conducted in order to determine a suitable sampling design for characterizing the Plume Core. Two data sets were available for use in the analysis:

(1) Unsaturated zone soil samples on a 30 foot grid (this area has since been excavated and backfilled with treated soils and clean fill) (EnSafe, 1998)

(2) Saturated zone soil samples focused on areas of suspected impacts (ESS, 2009)

The unsaturated zone data revealed variable concentration levels of VOCs, with little or no contamination in the intervening areas.

The saturated zone soil samples were taken at locations in the vicinity of areas of elevated concentrations as defined during the 1998 boring program in order to provide an initial characterization of the saturated zone.

Additional soil sampling in the saturated zone is planned in order to characterize the Plume Core area, including analysis for VOCs, SVOCs, pesticides, PCBs and metals. Additional soil sampling focused on VOCs is also planned. A geostatistical analysis using the existing data sets has been performed to determine a suitable sampling interval for the sampling program. The geostatistical analysis is focused on establishing correlation length scales, or the distances over which the contamination exhibits similar patterns.

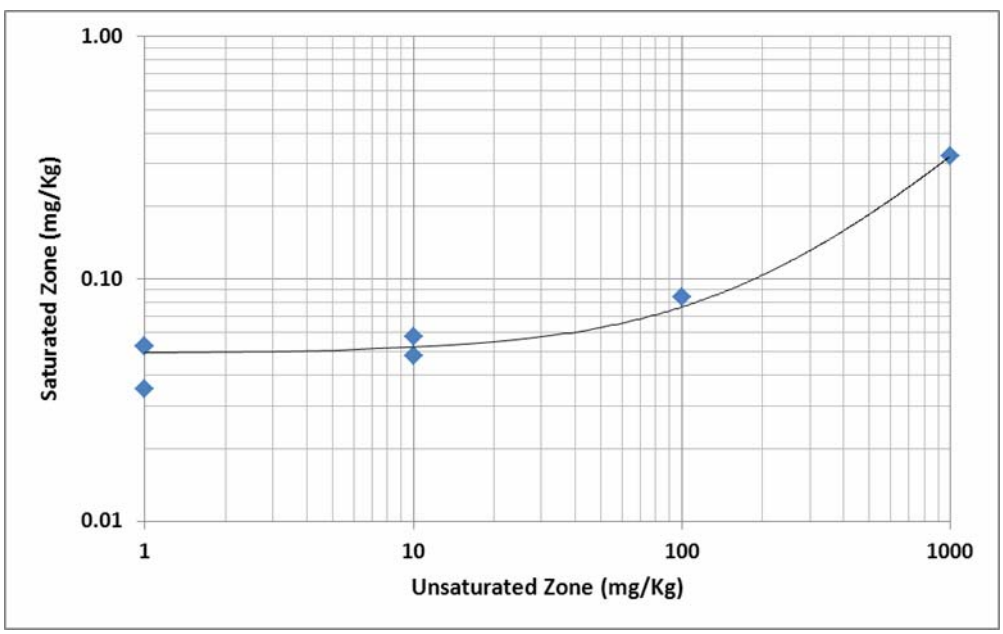

Figure 1 Correlation between Saturated and Unsaturated Zone PCE data

Ideally the existing data from the saturated zone would be used directly in the analysis. However, the borings were focused in certain areas of the Former Source Area and the small sample size is not amenable to geostatistical analysis. However, the saturated zone data exhibits a high degree of correlation with the unsaturated zone data, and therefore the more comprehensive unsaturated zone data can be used to determine the suitable sampling interval.

To demonstrate the correlation between the unsaturated and saturated zone data, the maximum PCE level at corresponding pairs of unsaturated and saturated zone sampling locations were plotted. The resulting plot is shown in Figure 1 and the trend line shows the correlation.

A correlation length scale was subsequently derived form the unsaturated zone data using a variagram. The variagram explores the varaitions between data at distinct spatail scales. An indicator variagram was developed for the unsaturated zone soil data and is shown in Figure 2.

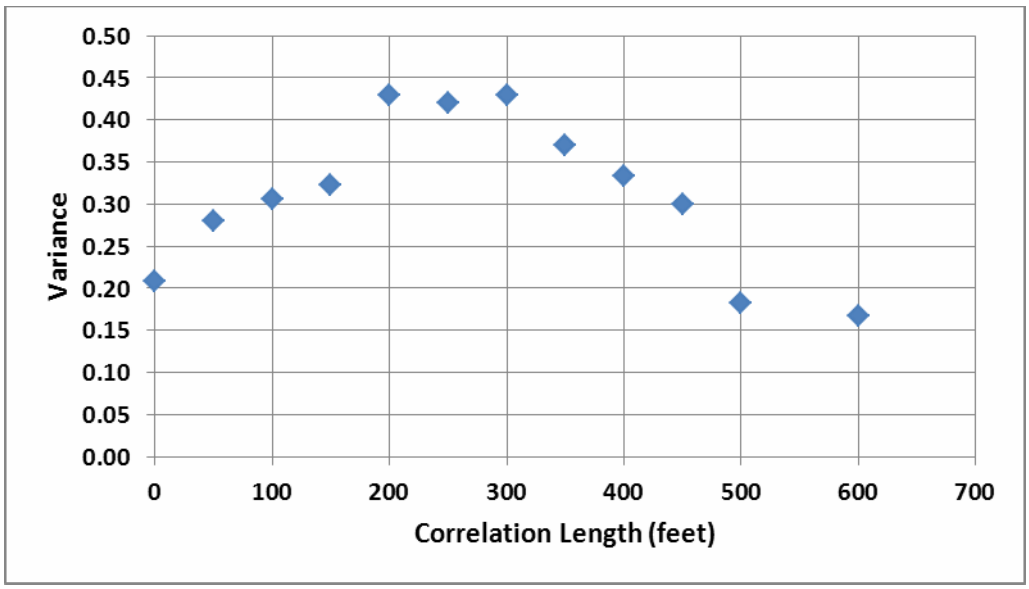

Figure 2 Variogram for Unsaturated Zone PCE Data

The variagram indicates that the contamination is fairly well correlated on spatial scales from 0 to about 160 feet, and then the correlation decreases with increasing length scales until about 350 feet, at which the correlation improves. The correlation at the smaller scales represents the variations in each quadrant, and the improved correlation at the larger scales represents the correlation between the four quadrants.

The appropriate sampling scale is drawn from the smaller scale correlation which, based on the variagram, is in the range of 80 to 150 feet. A value of 80 to 100 feet is recommended for spacing the sampling locations as a conservative approach. An 80 to 100 foot grid should be placed over the Plume Core area, and a sampling station selected within each grid cell. The specific location within each grid

can be placed at the cell center or grid intersections, but can also be located to avoid structures or to align with known high unsaturated zone concentrations.

In order to assess the number of soil samples required per each boring location, an analysis of the vertical distribution of contamination was completed. The field sampling previously completed in the saturated zone used headspace field screening to guide the sample selection within each boring. As it is the intent that the proposed field program will use a biased or targeted approach for the collection of the full suite soil samples within the Plume Core by using field observations and soil headspace screening, the probability of missing the residual contamination within each boring is greatly reduced. The existing analytical results and headspace screening have been reviewed to aid in the determination of an optimal vertical sampling strategy and suitable number of samples for each boring.

The head space data were collocated with the analytical results for Total VOCs (TVOCs) and a number of observations were made:

1. When the headspace was below 26 ug/Kg, there were no detected TVOC.
2. Some borings had all headspace values below 26 ug/Kg and no detected TVOCs in the samples analyzed.
3. When the headspace was above 26 ug/Kg, the data fell into two groups, values of head space for which there were no detected TVOCs and values of head space for which there was detected TVOCs.
4. For the samples with detected TVOCs, there appears to be a correlation between headspace and TVOCs. There is a large degree of scatter in the correlation, typical of VOC data.
5. When borings encounter a peat layer, the layer was sampled. In the NE area, it always had a detectable TVOC. In the other areas, there was no discernible pattern.
6. The headspace vertical patterns typically follow one of three profiles, (1) low values with no discernible pattern, (2) one layer within the boring in which the headspace values were high (> 200 ug/Kg), (3) two layers within the boring in which the values were high

A plot of the correlation between headspace and detected TVOCs is shown in Figure 3. The characteristics described in bullet items 1 and 3 above are indicated on the plot. Based on these characteristics the following sampling strategy has been developed. The general plan is to collect two (2) samples per boring, but also to make use of the headspace screening and field observations to optimize the sample selection.

After the borings have been screened for headspace, the sampling strategy should consider these guidelines:

If the headspace values in the boring are all below 10 ug/Kg, no sample is required.

If the headspace values exceed 10 ug/Kg but are all below 20 ug/Kg, then one sample should be taken at the location of the highest head space value, or if this location is not clear, then in the range of the historic detected TVOC values which is approximately 10 to 20 feet below land surface.

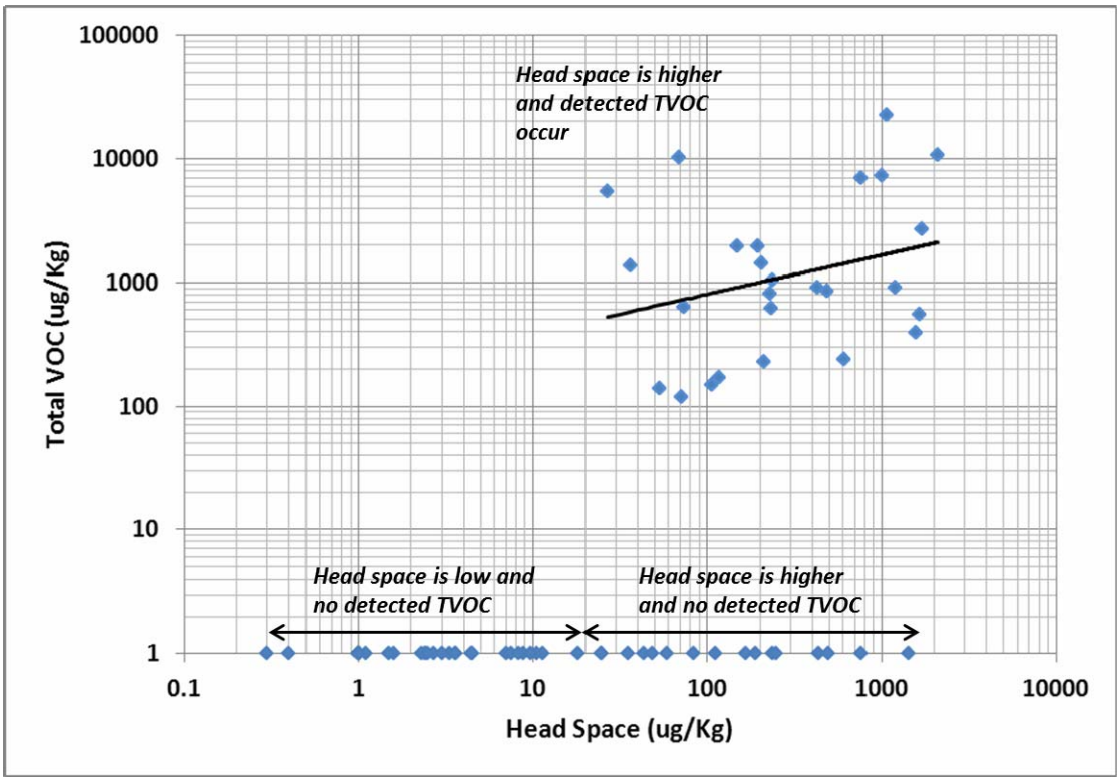

Figure 2 Correlations between Head Space and Detected TVOC

In borings with one clear zone of high headspace, two samples should be taken in the zone one at or near the peak and one either below or above. The second location, either above or below, should be selected based on the headspace vertical profile near the peak values. The section with higher values, or that extends over a longer interval should be targeted for the second sample.

In borings with two clear zones of high headspace, a sample should be taken at or near the two peak values.

REFERENCES

EnSafe, 1998, Preliminary Design Report. Davis Liquid Waste Site, Smithfield, Rhode Island. February 6, 1998.

ESS Group, Inc., 2009. Draft Phase 4 Supplemental Field Investigation Report (Fall 2008). Davis Liquid Superfund Site, Smithfield, Rhode Island. April 20, 2007.

Attachment B

Historic IDW Correspondence

February 26, 2003 **VIA FACSIMILE**

Mr. Gary J. Jablonski
Rhode Island Department of Environmental Management
Office of Waste Management
235 Promenade Street
Providence, Rhode Island 02908-5767

Re: Management of Investigation-Derived Waste (IDW)
Davis Liquid Waste Superfund Site
ESS Project No. A365-002

Dear Gary:

Environmental Science Services, Inc. (ESS) has performed a review of existing Phase I analytical results in order to evaluate procedures for the management of investigation-derived waste (IDW), in particular, drill water, purge water and development water generated during the proposed Phase 2 drilling program. Based on the results of the evaluation, ESS is of the opinion that the water quality at the following proposed Phase 2 drilling locations will meet the applicable GA groundwater standards:

Proposed Phase 2 Well Location	Phase 1 Water Quality Location
OW-106(O)	OW-08, OW-34, OW-38
OW-107(O)	OW-08, OW-34
OW-109(O)	OW-21, OW-34
OW-111(O,R)	OW-21, OW-34, OW-80

Therefore, it is proposed that IDW water generated at these locations not be containerized.

IDW water generated at the other proposed Phase 2 drilling locations, including within the bedrock at the above-referenced overburden well locations, will be containerized and evaluated based on the results of the packer sampling, discrete IDW sampling, or the Phase 2 groundwater sampling results. This IDW water will be managed in accordance with the Site Management Plan (SMP) and RIDEM Policy Memo 95-01.

In addition, based on the previous investigations completed at the Site, ESS is proposing to spread drill cuttings and soil generated during the drilling program, except at the replacement well locations within the former source areas, on the ground surface at each location unless elevated headspace readings (greater than 25 parts per million (ppm)) are encountered during the soil screening. If elevated headspace readings are encountered, the soil will be containerized and managed in accordance with the SMP and RIDEM Policy Memo 95-01. Soils generated during the installation of the proposed replacement wells will be managed in accordance with the SMP and RIDEM Policy Memo 95-01.

Please contact us to acknowledge your agreement with the proposed management of IDW water and soil at the above referenced locations. If you have any questions, please contact me at (781) 489-1106 or Jeff Hershberger at (781) 489-1102.

Sincerely,

ENVIRONMENTAL SCIENCE SERVICES, INC.

Peter E. Nangeroni, P.E.
Project Director

C: Neil Handler, USEPA
Mark Metcalf, Ashland, Inc.

19 March 2003

Peter E. Nangeroni
Environmental Science Services, Inc.
888 Worcester Street, Suite 240
Wellesley, MA 02482

RE: Management of Investigation-Derived Waste (IDW) Letter
Davis Liquid Waste Superfund Site
Smithfield, RI

Dear Mr. Nangeroni:

The Office of Waste Management at the Rhode Island Department of Environmental Management has conducted a review of the above-mentioned letter dated 26 February 2003 at the Davis Liquid Waste Superfund Site, Smithfield, RI. As a result of this review, this Office generally agrees with the proposed handling of the IDW generated during the proposed Phase 2 drilling program with one exception. Specifically, the upper exceedance soil screening reading of 25 ppm to containerize and manage the drill cutting soil is inconsistent with our IDW Guidance and past practice at this Site. An elevated soil screening reading above 10 ppm is the recommended soil screening level to be consistent with what has been used at this Site in the past as well as at numerous other Superfund Sites in Rhode Island that have similar contaminants of concern. As a result, please change 25 ppm to 10 ppm in the IDW letter.

If you have any questions please contact me at (401) 222-2797, extension 7148 or by e-mail at gjablons@dem.state.ri.us.

Sincerely,

Gary Jablonski, Senior Engineer
Office of Waste Management

cc: M. DeStefano, RIDEM
N. Handler, USEPA

IDW Ltr 031903

Attachment C

Human Health Risk Assessment Approach

EHS Support
consider it done

HUMAN HEALTH RISK ASSESSMENT APPROACH

Treated Backfill Evaluation

Prepared For:
Davis Liquid Waste Superfund Site

Prepared By:
EHS Support, Inc.

September 19, 2011

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FIGURES

Figure 1 Site Locus Map
Figure 2 Former Source Area and Treated Backfill

ACRONYMS

ATSDR	Agency for Toxic Substances and Disease Registry
CAL EPA	California Environmental Protection Agency
CERCLA	Comprehensive Environmental Response Compensation, and Liability Act
CSF	cancer slope factor
COPCs	chemicals of potential concern
DEC	Direct Exposure Criteria
EPC	exposure point concentration
HHRA	human health risk assessment
HI	hazard index
HQs	hazard quotients
MOA	mutagenic mode of action
MRLs	Minimal Risk Levels
NCEA/STSC	National Center for Environmental Assessment/Superfund Health Risk Technical Support Center
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NOAEL	no observed adverse effect level
PPRTVs	Provisional Peer Reviewed Toxicity Values
RAG	Risk Assessment Guidance
RfC	reference concentrations
RfDs	reference doses
RIDEM	Rhode Island and Providence Plantations' Department of Environmental Management
RME	reasonable maximum exposure
RSLs	Regional Screening Levels
Site	Davis Liquid Waste Superfund Site
UCL	upper confidence level
URF	unit risk factors
US EPA	United States Environmental Protection Agency

1.0 RISK ASSESSMENT APPROACH

The purpose of the risk assessment is to determine whether there are potential unacceptable human health risks associated with future exposures to chemicals of potential concern (COPCs) from the previously treated backfill within the Former Source Area at the Davis Liquid Waste Superfund Site (the Site). The risk assessment will be conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), 42 USC § 9601 et seq., and to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) as amended, 40 CFR Part 300.The technical approach for the risk assessment is based on previous investigations, analyses, and modeling conducted for the Site, and is focused on the evaluation of potential risk to human receptors from direct contact with soils in the Treated Backfill. Additional potential exposure pathways for human and ecological receptors will be address in the later in the risk assessment process.

This risk assessment approach discusses the selection of media-specific COPCs, identifies current and future potential receptors, and characterizes potentially complete exposure pathways for the identified COPCs that will be evaluated in the human health risk assessment (HHRA).
The risk assessment will be conducted in accordance with the U.S. Environmental Protection Agency (EPA) guidance and the State of Rhode Island and Providence Plantations' Department of Environmental Management (RIDEM) guidance including:

- Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Remediation Regulations – RIDEM 2004)
- Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual Part A (RAGS, EPA 1989)
- Risk Assessment Guidance for Superfund Volume 1: Human Health Evaluation Manual Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments (EPA 2001a)
- Guidance for Data Usability in Risk Assessment (EPA 1992)
- Regions 3, 6, and 9 Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites (EPA 2011a)
- Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual Part F, Supplemental Guidance for Inhalation Risk Assessment (EPA 2009b)

It is proposed that the HHRA will be performed in two stages. Initially, the data will be screened using the RIDEM Direct Exposure Criteria (DEC) and the EPA RSLs. As a second tier, if the initial screening results in exceedances of the screening values, a HHRA will be performed to assess the potential for direct contact risks. The risk assessment will be developed based on a range of potential future land uses, and will take into consideration potential future restriction(s) on land use (i.e., Institutional Controls). The findings of the risk assessment would then be used with EPA approval to obtain restrictive covenants over areas where potential future residential exposures are unacceptable, if appropriate.

1.1 Site description and history

The Site, a former waste disposal facility, is located between Tarkiln Road and Log Road in the northwestern corner of the Town of Smithfield, Providence County, Rhode Island (**Figure 1**).

The 7-acre Former Source Area is defined as the principal area where past disposal and releases of hazardous substances originally occurred and is bounded approximately by the excavation footprint of the source control remedial action (Source Remedy) initiated in 1999 and completed in 2001 (**Figure 2**). The area of Treated Backfill emplacement covers approximately 4.5 acres based on the information provided in the Remedial Action Report (LEA, 2002). The Site is bounded by till-covered hilly uplands and forested land to the east and west, and by wetlands and swamps to the north and south. The Nipsachuck Swamp is located to the north of the Site.

Latham Brook, the primary surface water feature on the Site, originates in the hilly uplands surrounding the Site and to the north of the Site. The south branch of the brook flows through wetland resource areas on the Site and converges with the north branch, which drains the northern portion of Nipsachuck Swamp and eventually discharges to Stillwater Reservoir, located approximately 1½ miles to the east of the Site.

Throughout the 1970's, the Site accepted liquid and solid wastes that included paint and metal sludges, oily wastes, solvents, acids, caustics, and phenols. Liquid wastes were reportedly transported in drums and bulk tank trucks and were dumped directly into unlined lagoons and seepage pits. The Site operator excavated the semi-solid lagoon materials, dumped these materials at several locations on the Site, and covered them with soil. Other operations included the collection of salvaged vehicles and machine parts, metal recycling, and tire shredding. Dumping activities, which were permanently enjoined in 1987 by the United States District Court for the District of Rhode Island, resulted in soil, surface water, sediment, and groundwater contamination, both on- and off-site.

1.1.1 Potential Receptors

Potential receptors are selected from all current and foreseeable land uses based on the potential frequency and duration of exposure and potentially complete exposure pathways. Typical receptors evaluated include residents, site inspectors, maintenance workers, trespassers (child 7 through 18 years), construction workers, and utility workers. Based on the focus of the HHRA on the potential for direct contact, the potentially complete future onsite receptors and exposure pathways include the typical receptors exposed to surface and subsurface soils in the previously treated area.

2.0 HUMAN HEALTH RISK ASSESSMENT

The HHRA process involves four components: hazard identification, exposure assessment, toxicity assessment, and risk characterization.

- The hazard identification includes the statistical evaluation of the environmental media data, and the selection of COPCs to be used in the remainder of the risk assessment.
- In the exposure assessment, the potential for exposure to COPCs for the potential human receptors identified in the CSM is characterized. Potential exposure pathways are evaluated to determine which, if any, are potentially complete. Next, the exposure point concentrations of COPCs in each affected medium are calculated, and are used in conjunction with exposure assumptions to determine systemic doses for the applicable potential receptors. Finally, the magnitude, frequency, and duration of these potential exposures are integrated to calculate estimates of daily intakes over a specified exposure period of time.
- The relationship between the potential extent of exposure and the toxicological effects of the exposure is estimated for each COPC in the toxicity assessment. The COPC-specific toxicity criteria are presented, including cancer slope factors (CSFs) or unit risk factors (URFs) for carcinogens and reference doses (RfDs) or reference concentrations (RfCs) for non-carcinogens.
- Integration of the results of the toxicity assessment and the exposure assessment to derive quantitative estimates of human health risks is accomplished in the risk characterization for carcinogens and non-carcinogens. This component also includes a discussion of the uncertainties and limitations inherent in the estimation of the potential risks, and the potential risks associated with background concentrations.

The HHRA evaluates onsite receptors associated with the previously treated area and potential for exposure by direct contact with the surface and subsurface soils.

2.1 Hazard Identification

The purpose of the hazard identification process is to summarize the environmental media data, and to screen the data to determine the COPCs that will be evaluated further in the risk assessment process.

2.1.1 Data Management

The environmental media data to be used in the HHRA will be managed in an electronic database, and will be compiled by constituent, medium, sample location, and sample depth, if applicable. All descriptive and statistical analysis of the data will be performed using ProUCL Version 4.1 that was developed for the EPA (2010).

2.1.2 Selection of COPCs

Soil quality will be determined by geometric gridding of the previously treated area, with at least twenty surface and subsurface soil samples obtained for laboratory analysis at the intersecting points of the grid. Selection of COPCs is based on a two-step process, in accordance with the RIDEM guidance. First, the maximum concentration of each COPC will be compared to the DEC and RSLs. If no maximum COPC concentrations exceed either the DEC or RSLs, then the soil quality will be considered compliant, and no further action will be required in the HHRA

process. If any maximum COPC concentration exceeds the DEC or RSLs, those COPCs will be evaluated further in step two.

In step two of the COPC selection process, surface soil and subsurface soil COPC concentrations that exceed either the DEC or RSL will have an exposure point concentration (EPC) calculated as the reasonable maximum exposure (RME) statistic. The RME, which is based on the 95 percent upper confidence level (UCL) of the mean, will be calculated using ProUCL Version 4.1 (EPA 2010), and will be dependent on the distribution of the data. If the RME exceeds the maximum detected concentration of a COPC, then the maximum detected concentration will be used as the RME for that EPC. All COPCs detected at least once within a medium will be included as an EPC. Sample results that are qualified as being below the detection level (non detect) will be evaluated based on recommendations from the ProUCL software. The EPC for each COPC then will be compared to the DEC and RSL. The selection of COPC methodology will also meet the following RIDEM criteria:

- No single sample result exceeds the soil objective by a factor of 5
- No more than 10 percent of the individual sample results exceed the soil objective
- No single sample result exceeds any Upper Concentration Limit

If any of the COPCs have an EPC that exceeds either the DEC or RSL, or the three specific RIDEM criteria, the HHRA process will continue with the exposure assessment for those selected COPCs.

2.2 Exposure Assessment

The purpose of the exposure assessment is to predict the magnitude and frequency of potential human exposure to each identified COPC as a result of the hazard identification. Section 1.1 describes the potential receptors and media of concern.

The EPCs for the selected COPCs will be used as the EPC for the remaining portions of the HHRA. The exposure assumptions used in the HHRA are based on site-specific conditions or default exposure assumptions presented in the following guidance documents.

- Remediation Regulations (RIDEM 2004)
- Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual Supplemental Guidance – "Standard Default Exposure Factors" (EPA 1991)
- Exposure Factors Handbook, Volumes I, II, and III (EPA 1997b) and Update (EPA 2009a)
- Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part A) (Interim Final) (EPA 1989)
- EPA RSLs Table (EPA 2011a)
- Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual (Part F) (Final) (EPA 2009b)

The equations for calculating the intake of COPCs will be used based on the EPA and RIDEM guidance documents noted previously.

2.3 Toxicity Assessment

The purpose of the toxicity assessment is to determine the relationship between the dose of a constituent taken into the body, and the probability that an adverse effect will result from that dose. The hierarchy of toxicity values (EPA 2003a) includes: the Tier 1 Integrated Risk Information System (IRIS - EPA 2011b) toxicity values; Tier 2 toxicity values include the Provisional Peer Reviewed Toxicity Values (PPRTVs) from the National Center for Environmental Assessment/Superfund Health Risk Technical Support Center (NCEA/STSC); and, Tier 3 toxicity values include other EPA and non-EPA values including California Environmental Protection Agency (Cal EPA) toxicity values, the Agency for Toxic Substances and Disease Registry (ATSDR) Minimal Risk Levels (MRLs), and the EPA Health Effects Assessment Summary Tables (EPA 1999). Constituents with dermal adsorption factors will be evaluated for dermal soil exposure in accordance with RAGS Part E Exhibit 4-1 (EPA 2004).

Quantitative estimates of the potency of COPCs include two sets of toxicity values, one for carcinogenic effects and one for non-carcinogenic effects. For carcinogenic effects, EPA assumes a non-threshold toxicological mechanism that assumes there is no level of exposure that does not pose a probability that an adverse effect will result from that dose. Toxicity criteria for non-carcinogens assume that there is a threshold effects level, below which adverse health effects are not expected to occur.

2.3.1 Carcinogenic Effects

For carcinogenic effects, EPA (2005) assigns a weight-of-evidence descriptor to each constituent and then, if applicable, a CSF or URF is calculated. The weight-of-evidence descriptor is based on the likelihood that the constituent is a human carcinogen. The following are the weight-of-evidence descriptors:

- Carcinogenic to humans – convincing epidemiologic evidence demonstrating causality between human exposure and cancer, or exceptionally when there is strong epidemiological evidence, extensive animal evidence, knowledge of the mode of action, and information that the mode of action is anticipated to occur in humans and progress to tumors
- Likely to be carcinogenic to humans – available tumor effects and other key data are adequate to demonstrate carcinogenic potential to humans, but does not reach the weight-of-evidence for the descriptor of carcinogenic to humans
- Suggestive evidence of carcinogenic potential – evidence from human or animal data is suggestive of carcinogenicity, which raises a concern for carcinogenic effects but is judged not sufficient for a stronger conclusion
- Inadequate information to assess carcinogenic potential – available data are judged inadequate to perform an assessment
- Not likely to be carcinogenic to humans – available data are robust for deciding that there is no basis for human hazard concern

EPA determines CSFs for oral exposure and URFs for inhalation exposure for those chemicals that are known or likely human carcinogens. The CSFs and URFs are upper-bound estimates of the excess cancer risk due to continuous exposure to a constituent averaged throughout the course of a 70-year lifetime. A CSF has units of 1mg/kg-day^{-1}. A URF is expressed in units of

1/microgram (μg) of constituent/cubic meter (m^3) air or ($\mu g/ m^3$)$^{-1}$. The basis of CSFs and URFs are data from lifetime animal bioassays, although human data are used when available. The carcinogenic dose-response values, as well as their sources and health effects of concern, will be included in the HHRA in the RAGS Part D format.

The EPA-recommended procedure for addressing chemicals that have been determined to cause cancer by a mutagenic mode of action (MOA) will be incorporated in the HHRA. A cancer caused by a mutagenic MOA is thought to pose higher risks to early life than other non-mutagenic MOA chemicals. In evaluating carcinogens with mutagenic MOAs, age dependent adjustment factors are used to calculate risks associated with early-life exposures (EPA 2005).

2.3.2 Non-Carcinogenic Effects

Non-carcinogenic effects, such as organ damage or reproductive effects are evaluated by RfDs for oral exposure, or RfC for inhalation exposure. The basis of a chronic RfD or RfC calculation is usually the highest dose that results in a no observed adverse effect level (NOAEL) after chronic (usually lifetime) exposure in animal experiments. The NOAEL is then divided by an uncertainty factor, and occasionally an additional modifying factor, to obtain the RfD or RfC. Uncertainty and modifying factors are typically factors of 10 that account for interspecies variation and sensitive human populations. Additional factors of 10 are included in the uncertainty factor if the RfD or RfC is based on the lowest observed adverse effect level instead of the NOAEL, or an experiment that includes a less-than-lifetime exposure. The non-carcinogenic dose-response values, as well as the source and primary target organ, which is the organ that is most affected and experiences critical organ effects, will be included in the HHRA in the RAGS Part D format.

2.4 Risk Characterization

The purpose of the risk characterization is to provide a conservative estimate of the potential risk resulting from exposure to COPCs identified in the environmental media of the Facility. Included in this section is a quantitative estimate of potential carcinogenic and non-carcinogenic risks for each complete exposure pathway for each receptor.

Risks will be summed across pathways and media for each receptor under current and future site use conditions. A summary of the total site cancer risks for each receptor group will be presented in the HHRA and compared to the target risk range of 1×10^{-4} to 1×10^{-6}.

For non-carcinogens, the individual hazard quotients (HQs) will be summed for an overall hazard index (HI). If the HI is less than 1.0, then no adverse health effects are likely associated with exposures at the individual parcels. However, if the total HI is greater than 1.0, separate endpoint-specific HIs will be calculated based on target organs (e.g., HQs for neurotoxins are summed separately from HQs for renal toxins). Only if a target-organ-specific HI is greater than 1.0 is there a reason for concern about potential health effects for that target organ.

3.0 UNCERTAINTY ANALYSIS

The procedures and inputs used to assess potential human health and ecological risks in this and similar HHRA are subject to a wide variety of uncertainties. In general, there are five main sources of uncertainty and variability in risk assessments of well-characterized sites:

- environmental chemistry sampling and analysis
- environmental parameter measurements
- fate and transport modeling
- toxicological data and dose-response extrapolations
- updated risk assessment methodologies, exposure assumptions, and toxicological data
- combinations of the above

These sources of uncertainty as they pertain to this HHRA will be discussed.

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FIGURES

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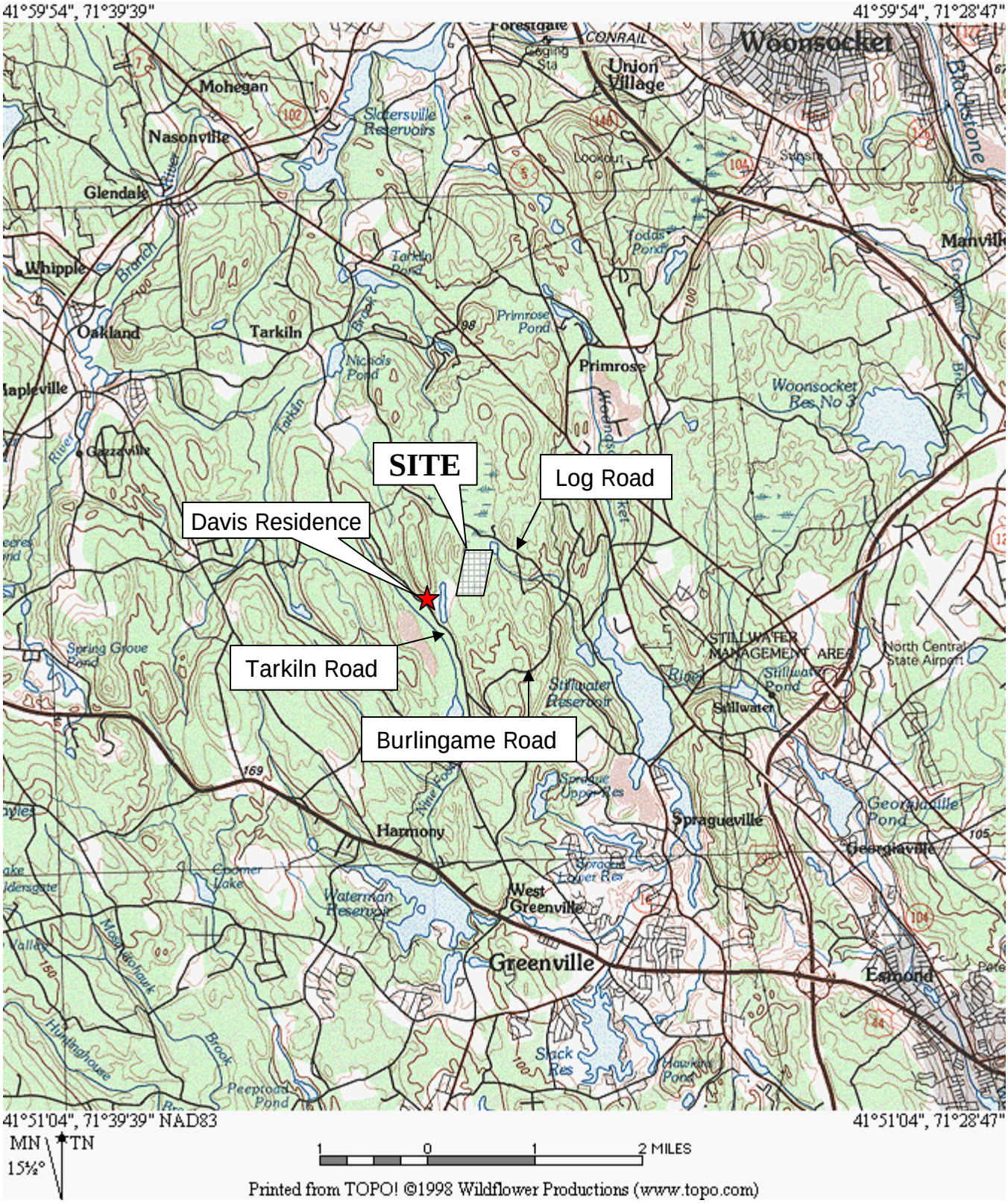


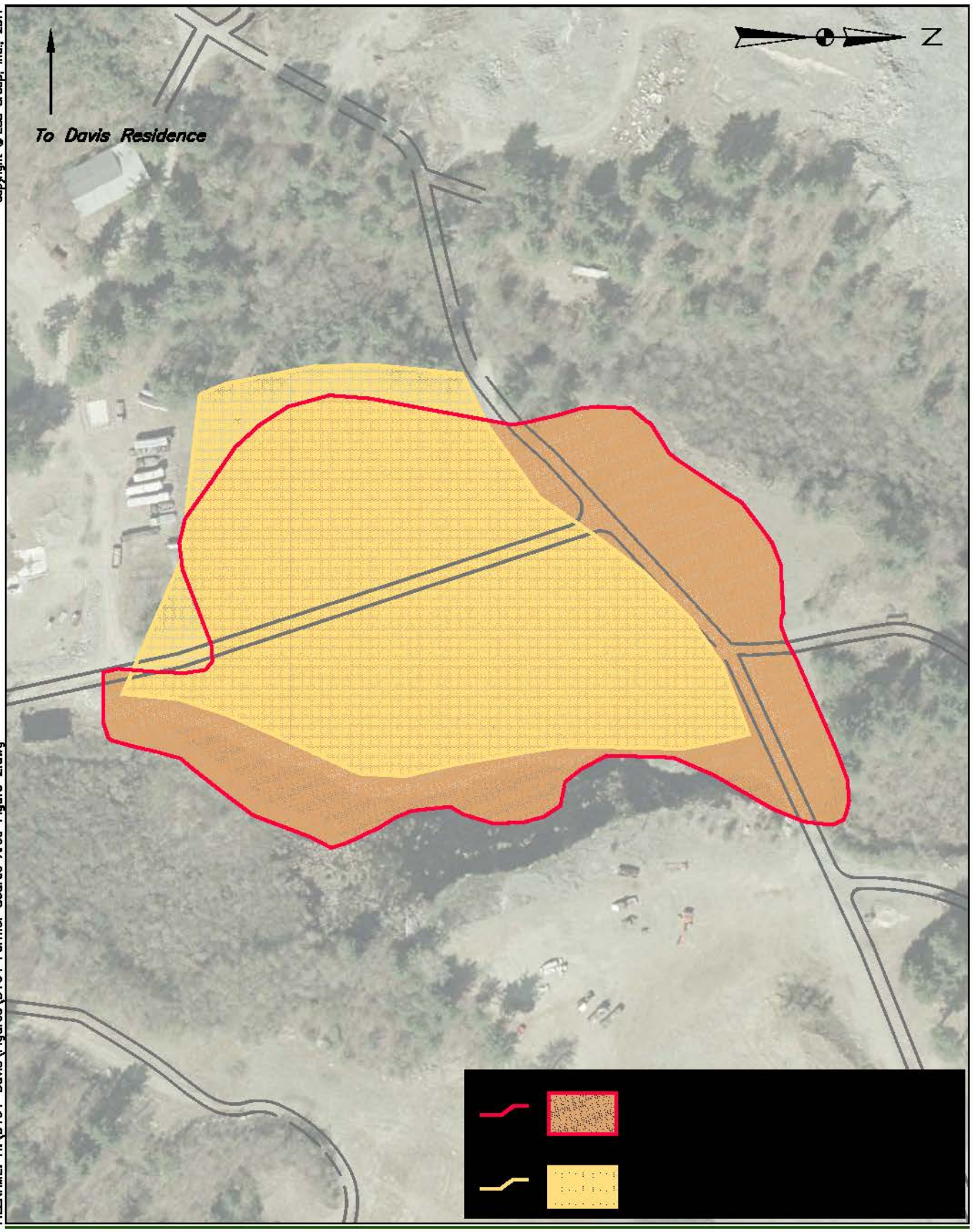
ESS Group Inc.
Engineers
Scientists
Consultants

Davis Liquid Waste Superfund Site
Smithfield, Rhode Island

Scale: As Noted
Extent of Site As Shown is Approximate

Site Locus Map

Figure 1



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Engineers
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Davis Liquid Waste Superfund Site
Smithfield, Rhode Island
Project No. D164-000

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Former Source Area and Treated Backfill

Figure 2