SRSNE PRP Group

Southington, Connecticut

Groundwater Technical Memorandum, Soil Study Report, and Additional Studies Report for the SRSNE Superfund Site

Volume I - Groundwater Technical Memorandum

DRAFT

ENSR Consulting and Engineering

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Disclaimer:

This document has been prepared pursuant to a government administrative order (U.S. EPA Region I CERCLA Docket No. I-94-1045) and has not received final acceptance from the U.S. Environmental Protection Agency. The opinions, findings, and conclusions expressed are those of the authors and not those of the U.S. Environmental Protection Agency.

Groundwater Technical Memorandum, Soil Study Report, and Additional Studies Report
for the SRSNE Superfund Site
June 1994

Respondent's Certification

"I certify, to the best of my knowledge and professional judgment, and after appropriate inquiries of all relevant persons involved in the preparation of this Deliverable, that all guidance documents specified in Attachment 1 of the SOW which relate to this Deliverable were reviewed in preparation of this Deliverable. I further certify that the contents of this Deliverable comply with the requirements of the SOW, Attachment 1 thereto, and all guidance documents specified in Attachment 1 which relate to this Deliverable. I am aware that EPA may assess stipulated penalties for submission of a Deliverable that is not in compliance with the requirements of the SOW, Attachment 1 thereto, and all guidance documents specified in Attachment 1 to the SOW which relate to this Deliverable."

AJ Moody

A.J. Moody, Project Coordinator

6-15-94

Date

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EXECUTIVE SUMMARY

E.1 Introduction

This Groundwater Technical Memorandum, Soil Study Report, and Additional Studies Report for the SRSNE Superfund Site provides comprehensive data and evaluations resulting from the investigations performed by ENSR at the Solvents Recovery Service of New England, Inc. ("SRSNE") Superfund Site located in Southington, Connecticut. ENSR performed this work as a contractor for the SRSNE PRP Group during the period from January through June 1994. The investigations described in this document were performed in accordance with the Statement of Work (SOW) for an Adminstrative Order agreed to between the SRSNE PRP Group and U.S. EPA.

The SOW includes planning and implementation of a "NTCRA" (Non-Time-Critical Removal Action), which will be designed to prevent contaminated overburden groundwater from migrating away from the SRSNE Site. The SOW also includes studies to determine the feasibility of removing contaminants from soils on the Site, including some voluntary studies by SRSNE PRP Group. The investigations performed by ENSR provide data necessary to design the NTCRA, and other data necessary to evaluate the feasibility of soil treatment alternatives.

This document provides to U.S. EPA the comprehensive, final results of the NTCRA investigations and additional studies required by the SOW. These results have previously been communicated to U.S. EPA informally through draft submittals and meetings, as described in Section 1.0 of this document. This document also provides U.S. EPA with ENSR's interpretations of the investigation results. The data and the interpretations of the data will be used by U.S. EPA and the SRSNE PRP Group to plan and construct the NTCRA and to evaluate other appropriate remedies for site contamination.

As described in the SOW, the U.S. EPA will review this document and approve it or require revisions. Following U.S. EPA approval, the SRSNE PRP Group will prepare a design document for the groundwater containment and treatment systems required for the NTCRA. Construction of the NTCRA groundwater containment and treatment systems will commence upon U.S. EPA approval of the design.

E.2 Site Overview

In 1955, SRS, Inc. ("SRS") began operating a hazardous waste treatment, storage and disposal facility on a 3.7-acre portion of the Site. This portion of the Site on the west side of the B&M

Railroad tracks is known as the "Operations Area" throughout this document. In 1960, SRS transferred the facility to SRSNE. The 10-acre portion of the Site east of the railroad tracks and west of the Quinnipiac River was used by the Cianci Construction Company for storage of construction equipment and truck washing from 1969 to 1988, and was sold to SRSNE in 1988. This area is known as the "former Cianci property" throughout this document.

From 1955 until 1988, the primary activities of SRS and SRSNE (jointly referred to as "SRS/SRSNE") at the Site were the distillation of spent solvents for recovery and resale. From 1988 until 1991, SRSNE's primary activity at the Site was fuel blending and waste transfer operations. In 1991 SRSNE was forced to close permanently due to its failure to meet the conditions of its RCRA permit.

Contaminants allegedly released by SRS/SRSNE have been detected in soil and groundwater samples from the Operations Area and from the former Cianci property. Detailed descriptions of U.S. EPAs investigations are contained in the Remedial Investigation Report (U.S. EPA, 1994). A summary of the potential sources of contamination at the Site and the regulatory activities of U.S. EPA and CTDEP is provided in the Introduction, Section 1 of this document.

E.3 Project Objectives and Results

The overall goals of the NTCRA are to:

1) Minimize contaminant migration in overburden groundwater, and;

2) Study the appropriateness of reducing the source of groundwater contamination through mass removal of volatile organic compounds (VOCs) from the soils.

To achieve these overall goals, the specific objectives of the NTCRA are to accomplish the following:

- Minimize the migration of contaminated groundwater in the overburden aquifer through installation of a groundwater containment system;

- Study the appropriateness of reducing the source of groundwater contamination through mass removal of volatile organic compounds (VOCs) from the soils in the SRSNE Operations Area. These studies consist of the following components:

  i. Conduct additional field tests and data collection;

ii. Perform pre-design studies and field studies to better define the physical and contaminant characteristics, and;

iii. Assess the effectiveness and costs of contaminant treatment.

Following is a summary of the investigations performed by ENSR under contract to the SRSNE PRP Group in order to address these objectives. Detailed procedures and results for these investigations are provided at the indicated locations in this document.

NTCRA Investigation [SOW reference]	**Location in Report**	**Summary of Investigation**
Geologic and hydrologic data [V.A.3.a.i.(a)]	Volume I Sec. 2.1	The geologic deposits in the area of the proposed containment system were identified, and a cross-section showing the interpreted distribution of these deposits was prepared. This information was used for the conceptual containment system design in section 2.3.
Aquifer tests to determine containment system requirements [V.A.3.a.i.(b)]	Volume I Sec. 2.2-2.3	Measurements of aquifer hydraulic properties in the area of the proposed containment system were collected. The overburden pumping well sustained a pumping rate 1.6 gpm with a 60-90 foot radius of influence. A line of pumping wells is recommended for the NTCRA containment system.
Assessment of containment system effects on wetlands & floodplains [V.A.3.a.i.(c)]	Volume I Sec. 2.2	Water elevation measurements during the overburden pump test indicate no effects on the wetlands adjacent to the Quinnipiac River, and possibly minor effects on the drainage ditch on the east side of the B&M Railroad.
Bench scale tests to optimize the design of an enhanced oxidation treatment system [V.A.3.a.i.(d)]	Volume I Sec. 3.2	Bench scale tests were performed by two vendors of enhanced oxidation equipment. Test results show that enhanced oxidation can achieve discharge goals for organics, but effectiveness and reliability of a full scale system are not well known. Metals removal testing indicates that up to 97% removal of metals is achievable.

NTCRA Investigation [SOW reference]	Location in Report	Summary of Investigation
Aquatic toxicity tests to demonstrate that the enhanced oxidation treatment system will achieve effluent discharge limits [V.A.3.a.i.(e)]	Volume I Sec. 3.2	Effluent from enhanced oxidation treatment will require further treatment to achieve aquatic toxicity limits, based on the bench scale tests and experience with the current full scale system.
Assessment of discharge options for treated groundwater [V.A.3.a.i.(f)]	Volume I Sec. 3.3	Discharge of treated groundwater to the Quinnipiac River appears to be the most feasible option, provided that aquatic toxicity discharge limits can be met.
Evaluation of locations for siting the treatment system [V.A.3.a.i.(g)]	Volume I Sec. 3.5	An area in the northwest quadrant of the former Cianci property is the preferred location for the treatment system.
Evaluation of other groundwater treatment technologies in comparison to enhanced oxidation [V.A.3.a.i.(h)]	Volume I Sec. 3.2	Bench scale tests indicate that biodegradation can achieve similar results compared to enhanced oxidation treatment. Modeling results suggest that air stripping would also be an effective groundwater treatment method, when coupled with an air treatment system.
Subsurface air permeability testing [V.A.4.a.i.(a)]	Volume II Sec. 2	A high degree of soil anisotropy and heterogeneity appears to be present based on the pilot test measurements, and in-situ air permeabilities could not be estimated. Soil vapor extraction (SVE) would not be effective for soil treatment based on site conditions.
A soil gas survey to delineate the distribution of VOCs within the Operations Area [V.A.4.a.i.(b)]	Volume II Sec. 3	Contaminant concentrations were measured in soil gas and soil samples at grid points throughout the Operations Area. Results are consistent with earlier estimates of the general extent of VOCs (HNUS, 1992). Duplicate measurements at some locations indicate a high degree of variability in concentrations within the limits of the contaminated area.

NTCRA Investigation [SOW reference]	Location in Report	Summary of Investigation
Air sparging/extraction testing [V.A.4.a.i.(c)]	Volume II Sec. 2	Pilot test measurements indicate a high potential for preferential flow and lateral migration of contamination during air sparging (AS). The percentage of injected air that was captured during testing is unknown, due to the lack of detection of SF_6 during the tracer gas study, anisotropy, lateral migration, and the low effectiveness of the SVE system.
Evaluation of catalytic oxidation or other technologies for treatment of VOCs [V.A.4.a.i.(d)]	Volume II Sec. 4	Detailed evaluation of air treatment requirements was not completed because results of the SVE/AS test did not allow reliable estimates of air flow rate and concentrations of contaminants.
Bedrock investigations [VII.B.1]	Volume I Sec. 2.2	Bedrock aquifer response to the bedrock pumping test indicates that hydraulic properties of the bedrock are anisotropic and heterogeneous. Interconnection between the bedrock and overburden aquifers was observed in pumping tests of both aquifers.
Dense Non-Aqueous Phase Liquid (DNAPL) investigations [VII.B.2]	Volume III Sec. 2	Evidence of DNAPL presence based on the site history and on measured concentrations of contaminants is presented. The vertical extent of DNAPLs appears to include fractured bedrock and overlying soils, and the horizontal extent appears to extend east from the Operations Area.
Geophysical surveys [VII.B.3]	Volume III Sec. 3	Ground penetrating radar was not effective for mapping the till surface on the former Cianci property. Electromagnetic anomalies were measured in the overburden and shallow bedrock but were not identified with a known distribution of contaminants.
Additional soil investigations [VII.B.4]	Volume III Sec. 4-5	Physical, physicochemical, and biological properties of soil samples from the Operations Area were measured, and bench scale bioventing tests were performed. Results of these tests indicate that in-situ biodegradation would not be effective for soil treatment in the vadose zone of the Operations Area.

E.4 Conclusions

The primary goal of the NTCRA, to minimize the migration of contaminated groundwater in the overburden (upper) aquifer, can be achieved by installation of groundwater containment and treatment systems on the former Cianci property. Data that will be used to design this system, and a conceptual design for the containment system, are provided in Volume I of this document. This system may also capture some contamination migrating in the bedrock (lower) aquifer, based on the interconnection between the overburden and bedrock aquifers that was observed during these investigations.

Studies of the effectiveness of mass removal of VOCs from soils in the Operations Area included evaluations of SVE/AS and bioventing. Neither technology appears to be effective for VOC removal at the Site based on the bench and pilot scale tests and measurements of soil properties. Additional delineation of the extent of VOCs in the Operations Area, beyond that performed by U.S. EPA in the RI, was accomplished. These measurements reaffirm the earlier extent of contamination postulated by U.S. EPA (HNUS, 1992), and also indicate that concentrations are extremely variable within the contaminated area. Soils within the Operations Area exhibit a relatively high level of heterogeneity in physical properties, which may be a cause for the variability in chemical concentrations.

Presence of DNAPL at the SRSNE Superfund Site is highly likely, based on an analysis using U.S. EPA guidance. The primary factors in this determination are the site history and the measured concentrations of volatile organic compounds in groundwater. Secondary factors are the concentrations of contaminants in soil and the presence of a small amount of DNAPL in a groundwater sample. The NTCRA groundwater system will not remove DNAPL from either the overburden or the bedrock aquifer. DNAPL would be a continuing source of contaminants in both aquifers. The probable presence of DNAPL should be considered in all evaluations of remedial action for this Site.

1.0 INTRODUCTION

1.1 Site History

The Solvents Recovery Service of New England, Inc., Superfund Site ("Site") is located on approximately 14 acres of land on Lazy Lane in the Town of Southington, Connecticut. Figure 1-1 shows the location of the Site and important features of the surrounding area, which are discussed further in the following site history. The Site is located approximately fifteen miles southwest of Hartford, Connecticut.

The current property was developed as two distinct areas with separate operating histories. In 1955, SRS, Inc. ("SRS") began operating a hazardous waste treatment, storage and disposal facility on a 3.7-acre portion of the Site. This portion of the Site on the west side of the B&M Railroad tracks is identified as the "Operations Area" throughout this document. In 1960, SRS transferred ownership of the facility to Solvents Recovery Service of New England, Inc. ("SRSNE"). The 10-acre portion of the Site lying to the east of the railroad tracks and west of the Quinnipiac River was used by the Cianci Construction Company for storage of construction equipment and for truck washing from 1969 to 1988, and was then sold to SRSNE in 1988. This area is identified as the "former Cianci property" throughout this document.

From 1955 until 1988, the primary activities of SRS and SRSNE (jointly referred to as "SRS/SRSNE") at the Site were the distillation of spent solvents for recovery and resale. From 1988 until 1991, SRSNE's primary activity at the Site was fuel blending and waste transfer operations. In 1991 SRSNE was forced to close permanently due to its failure to satisfy the conditions of its RCRA permit. During the period of operations from 1955 until 1991, SRS/SRSNE stored waste materials in tanks, drums, and other containers at the Site. It is alleged that during this period, leaks and spills from these tanks, drums, and other containers contaminated the soil and groundwater at the Site.

Between 1955 and 1967, SRS/SRSNE allegedly stored and/or disposed of waste materials in two unlined lagoons at the Site. From about 1967 until 1974, SRSNE allegedly used an open-pit incinerator at the Site to dispose of waste materials. SRSNE also allegedly discharged storm water, surface runoff, and water from cooling towers and from the distillation processes and drum cleaning operations, which contained waste materials, through a storm drain which ran easterly from its main plant building to a drainage ditch and ultimately into a tributary of the Quinnipiac River.

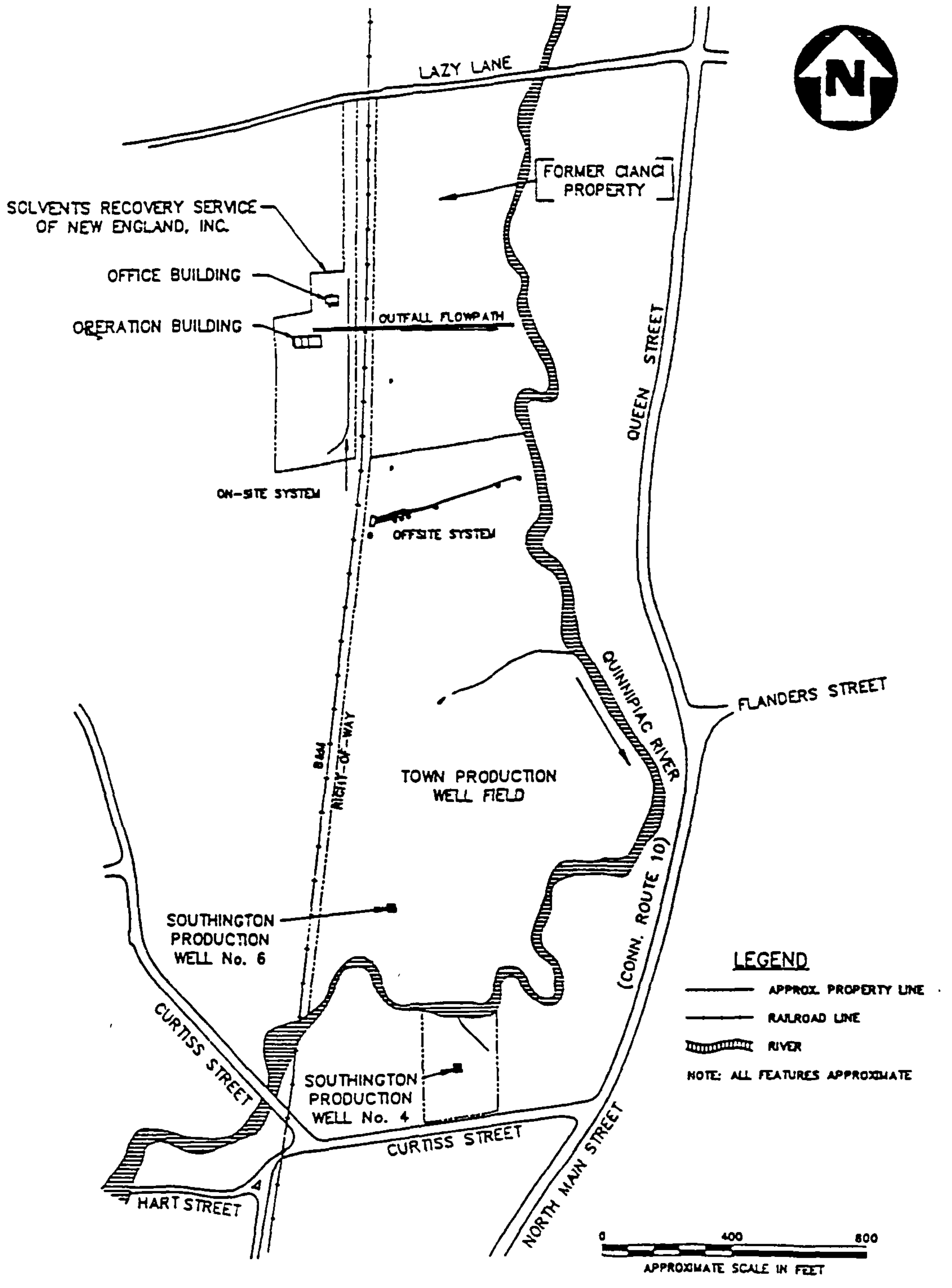


FIGURE 1-1

Study Area Map

SRSNE, Southington, CT

(from U.S. EPA Administrative Order, April 19, 1994)

1.2 U.S. EPA and State Activities

In 1977 and 1979, the Town of Southington shut down two of its public drinking water wells due to the presence of elevated levels of volatile organic compounds (VOCs). These two wells are located approximately 1,900 and 1,300 feet south of the SRNSE facility.

In 1979 the United States Environmental Protection Agency (U.S. EPA) filed suit against SRSNE for allegedly contaminating the two production wells and for unpermitted discharge of pollutants into the Quinnipiac River. In 1983, SRSNE, U.S. EPA, and others entered into a Consent Decree which required SRSNE, among other things, to construct a network of wells (the "On-Site Interceptor System") at the Site in order to reduce the migration of contaminated groundwater from the SRSNE facility, and to construct a cooling tower/air stripper to remove contaminants from the groundwater captured by the On-Site Interceptor System. The Consent Decree also required outer interceptor wells that were never used due to the failure of the Connecticut Department of Environmental Protection (CTDEP) to permit the system. In 1983 U.S. EPA placed the SRSNE Site on the National Priorities List, making it eligible for federal assistance for study and cleanup under the 1980 Superfund law.

In 1986, SRSNE began operating the On-Site Interceptor System and the cooling tower/air stripper at the Site. SRSNE continues to operate the On-Site Interceptor System to the present day. The cooling tower/air stripper that SRSNE operated to treat contaminated groundwater from the On-Site Interceptor System was replaced with an ultraviolet oxidation system, which the CTDEP has operated since June 1992.

U.S. EPA commenced a Remedial Investigation (RI) and Feasibility Study (FS) for the Site in 1990 to evaluate the extent of contamination, risks to human health and the environment, and alternatives for cleaning up the Site. U.S. EPA completed the RI in May 1994. The FS is also expected to be completed in 1994.

U.S. EPA performed a removal action at the Site in September 1992 during which U.S. EPA excavated and disposed of contaminated sediments from two catch basins at the Site; excavated and disposed of PCB-contaminated sediments from a drainage ditch; constructed covered drains in the ditch; erected fencing; and disposed of drums containing decontamination water resulting from previous field investigations at the Site. In January 1994 U.S. EPA performed a second removal action to dispose of waste chemicals in the Operations Building in order to prevent releases from drums and smaller containers.

U.S. EPA's investigations indicate that the existing On-Site Interceptor system is not effectively preventing the continued migration of contaminants into the overburden aquifer. In 1992, U.S.

EPA commenced an Engineering Evaluation/Cost Analysis ("EE/CA") to evaluate potential removal actions that may be implemented for preventing contaminant migration into groundwater. After a public comment period, U.S. EPA issued an Action Memorandum for the Site on April 1, 1993, which requires the implementation of a Non-Time Critical Removal Action (referred to as NTCRA throughout this document). The NTCRA is to consist of:

1. A removal action consisting of a groundwater containment and treatment system to prevent the migration of contaminated groundwater in the overburden aquifer; and

2. Performing certain soil studies which will provide U.S. EPA with information regarding future response actions at the Site.

The NTCRA is expected to be followed by the selection by U.S. EPA of a final remedy after completion of the FS, presentation of U.S. EPA's proposed remedy based on the FS, and public hearings and comment on U.S. EPA's proposal. U.S. EPA has agreed to take into account the results of the NTCRA in selecting the final remedy for the Site.

The "SRSNE PRP Group" has agreed to perform the NTCRA and Additional Studies described in the Action Memorandum. These documents have been prepared by ENSR Consulting and Engineering, an environmental consulting firm under contract to SRSNE PRP Group.

The requirements for the NTCRA are set forth in detail in Appendix B to the Administrative Order on Consent for Removal Action (Order). Appendix B to the Order is referred to as the "SOW" (Statement Of Work) throughout this document. Following is a brief summary of the scope of the NTCRA.

1.3 Overview of the NTCRA

The overall goals of the NTCRA are to:

1) Minimize contaminant migration in overburden groundwater, and;

2) Study the appropriateness of reducing the source of groundwater contamination through mass removal of volatile organic compounds (VOCs) from the soils.

To achieve these overall goals, the specific objectives of the NTCRA are to accomplish the following:

- Minimize the migration of contaminated groundwater in the overburden aquifer through installation of a groundwater containment system;

- Study the appropriateness of reducing the source of groundwater contamination through mass removal of volatile organic compounds (VOCs) from the soils in the SRSNE Operations Area. These studies will consist of the following components:

  i. Conduct additional field tests and data collection;

  ii. Perform pre-design studies and field studies to better define the physical and contaminant characteristics, and;

  iii. Assess the effectiveness and costs of contaminant treatment.

U.S. EPA will evaluate the results of the field data collection and the studies, in conjunction with the results of the Risk Assessment contained in the RI.

The NTCRA will accelerate the overall site cleanup by containing and reducing site groundwater contamination. The Record of Decision (ROD), which will be developed by U.S. EPA after completion of the FS and public comment, will outline a strategy to address any remaining concerns about contaminated groundwater and soils.

The SRSNE PRP Group has worked cooperatively with the U.S. EPA to facilitate the earliest possible implementation of the NTCRA. To this end, the SRSNE PRP Group voluntarily initiated field work on the NTCRA in January 1994. This expedited approach to implementing the NTCRA will result in the earliest possible containment of contaminated groundwater at the Site and development of data necessary for the selection of an appropriate final remedy.

The NTCRA is scheduled to result in an operating groundwater containment and treatment system by Spring of 1995. The exact dates of design, construction, and startup are dependent on various tests and submittals described in the SOW, with the result that this expected startup date could vary by a month or more. NTCRA deliverables include a Groundwater Technical Memorandum by June 15, 1994, and a Soil Studies Report and Additional Studies Report by June 30, 1994.

The SRSNE PRP Group has completed the initial phase of NTCRA work, as reported in this document. This work consisted of pre-design investigations for the groundwater containment and treatment system, investigations of contaminant distribution and remedial alternatives for the Operations Area, and additional studies not required by U.S. EPA which the SRSNE PRP Groups believes are needed in order to fully understand Site conditions and to assess remedial alternatives which might apply to the Site. The detailed procedures for these investigations were provided in the Final Soil, Groundwater, and Additional Studies Workplan for the SRSNE Superfund Site (ENSR, 1994).

1.4 Outline of the NTCRA Reports

This Groundwater Technical Memorandum, Soil Study Report, and Additional Studies Report for the SRSNE Superfund Site provides final data and evaluations resulting from the investigations described in Section V. of the SOW. The document is presented in three volumes:

Volume I	Groundwater Technical Memorandum
Volume II	Soil Study Report
Volume III	Additional Studies Report

An Executive Summary covering all three phases of work is provided at the beginning of each volume.

Volume I, the Groundwater Technical Memorandum, provides the results of investigations performed to determine the appropriate design of a groundwater containment and treatment system to prevent the migration of contaminated overburden groundwater from the Operations Area of the Site. The design of the containment system will be based on location-specific geologic, hydrogeologic, and hydraulic data. The design of the treatment system will be based on the results of the treatability tests. A conceptual design of the containment system and an evaluation of treatment system alternatives are provided in Volume I.

Volume II, the Soil Study Report, provides the results of investigations performed to evaluate Soil Vapor Extraction (SVE) and Air Sparging (AS) technologies for treatment of volatile organic compounds in the Operations Area of the Site. These investigations were designed to provide U.S. EPA with information for its use in planning and directing potential future response actions at the Site, as described in the SOW.

Volume III, the Additional Studies Report, provides the results of additional studies which SRSNE PRP Group has voluntarily undertaken in order to further characterize the Site and to assess the remedial alternatives which may apply to it. These studies included investigation of Dense Non-Aqueous Phase Liquids (DNAPL), geophysical surveys, determination of soil physical properties, and biotreatability testing of soils. Optional deep bedrock investigations described in the SOW were not undertaken due to time constraints affecting completion of the Additional Studies Report, and because this information, while it might be important for a complete understanding of Site conditions, is not considered essential for completing the NTCRA. Shallow bedrock investigations are described in Volume I, as appropriate for a comprehensive understanding of geologic and hydrologic conditions.

Draft data from these investigations were transmitted to U.S. EPA and CTDEP in submittals and meetings during the period of March to June 1994, in accordance with the SOW. These submittals and meetings included the following:

- Weekly progress reports submitted to U.S. EPA, and monthly progress reports submitted to U.S. EPA and CTDEP, during the period of March - June 1994.
- A meeting with U.S. EPA and CTDEP on March 29, 1994, to discuss the progress of the field investigations, with a particular focus on the SVE pilot testing.
- Preliminary draft SVE pilot test data submitted to U.S. EPA and CTDEP on April 5, 1994.
- A meeting with U.S. EPA and CTDEP on April 8, 1994, to discuss problems with the SVE pilot test due to a high water table.
- A meeting with U.S. EPA, CTDEP, and Town of Southington officials on April 27, 1994, to provide information on the NTCRA project.
- A meeting with U.S. EPA and CTDEP on May 4, 1994, to discuss the remedial alternatives currently under evaluation in the FS.
- Draft data submitted to U.S. EPA on May 6, 1994, resulting from the geophysics surveys, soil gas survey, and two enhanced oxidation treatability tests.
- Draft data submitted to U.S. EPA on May 11, 1994, resulting from the aquifer testing (overburden and bedrock) and the DNAPL investigation.
- Draft data submitted to U.S. EPA on May 18, 1994, resulting from the metals removal treatability tests.
- A meeting with U.S. EPA and CTDEP on May 20, 1994, to review the Conceptual Groundwater Containment System Design and the Additional Studies aspects of the NTCRA.

- Draft data was submitted to the U.S. EPA on May 24, 1994, resulting from the geologic/hydrologic investigations.

- Draft data submitted to U.S. EPA on May 27, 1994, resulting from the SVE testing.

- Draft data submitted to U.S. EPA on May 28, 1994, resulting from the evaluations of groundwater treatability by air stripping, and the soil bioventing testing.

Draft data as a result of the RI and FS being performed by U.S. EPA were also received from U.S. EPA during the above meetings.

In general, the PRP Group's consultant (ENSR) and Technical Committee were in regular communication with U.S. EPA during the performance of the NTCRA to share information concerning the implementation and results of the NTCRA and to facilitate U.S. EPA's expedited review of the resulting data, in light of the tight schedule under which this work has been proposed. In addition, the PRP Technical Committee has met with the local citizens and town officials to gain input and share information relative to the NTCRA.

2.0 GROUNDWATER CONTAINMENT

This section was prepared pursuant to deliverable obligations in the NTCRA Statement of Work. As stipulated in the SOW, a groundwater containment system must be designed which prevents the migration of contaminated overburden groundwater from the Operations Area of the Site. The system is to be located within the Containment Area defined by U.S. EPA, as shown on Figure 2-1. This report presents the results of stipulated groundwater activities performed at the Site, as outlined in the Final Soil, Groundwater, and Additional Studies Workplan (ENSR, 1994). The investigations were performed to obtain data necessary to design the groundwater Containment System in accordance with the Performance Standards specified in Section IV.A of the SOW. Containment system design will be based on the site-specific geologic, hydrogeologic, and hydraulic data presented below, and, as necessary, the additional Site data presented in the Final RI (HNUS, 1994).

2.1 Containment Area Geologic/Hydrogeologic Data

2.1.1 Scope of Investigation

Geologic data were obtained in the Containment Area in accordance with Section III.A of the SOW for the purpose of designing the Groundwater Containment System. Existing geologic and hydrogeologic data were reviewed and a Soil Boring Investigation was developed (ENSR, 1994) and implemented during the month of March, 1994. Additional geologic data were obtained during installation of pumping test wells.

2.1.1.1 Soil Boring Investigation

The Soil Boring Investigation consisted of drilling and sampling five test borings (B-401 through B-405) along a north-south line extending through the Containment Area. Surveyed boring locations are shown on Figure 2-1. Boreholes were drilled with the drive-and-wash drilling method, and extended to the surface of competent bedrock. This drilling method involves driving temporary steel casing into the overburden and removing sediment that accumulates in the casing using a roller bit and circulating potable water. To obtain information on local overburden stratigraphy, continuous split-spoons samples were collected from three borings (B-402, B-403, and B-404), and one sample from each five foot depth interval from the remaining two borings (B-401, B-405). Geologic logs recorded during split-spoon sampling are presented in Appendix A.

Seven samples were collected for analysis of physical properties. Parameters included plasticity, grain size analysis, bulk density, direct shear strength, porosity and the weight fraction of organic carbon (foc). The geotechnical parameters (plasticity, direct shear strength, grain size analysis) were measured to address constructability issues during the containment-system design phase (in the event the system consisted of an interceptor trench). These results will be presented and discussed, where applicable, during the detailed design phase. The remaining parameters (bulk density, porosity, and foc) were measured to address contaminant fate and transport issues presented in the Additional Studies report. Four samples were collected from the outwash unit, and three from the till unit overlying bedrock. Samples were collected in 6-inch brass split-spoon liners, sealed, and shipped as intact cores to the analytical laboratory. Sample depths are shown on the geologic logs included in Appendix A. Analytical results that include additional physical-property data collected in the Operations Area for the Soil Investigation are presented in Appendix B.

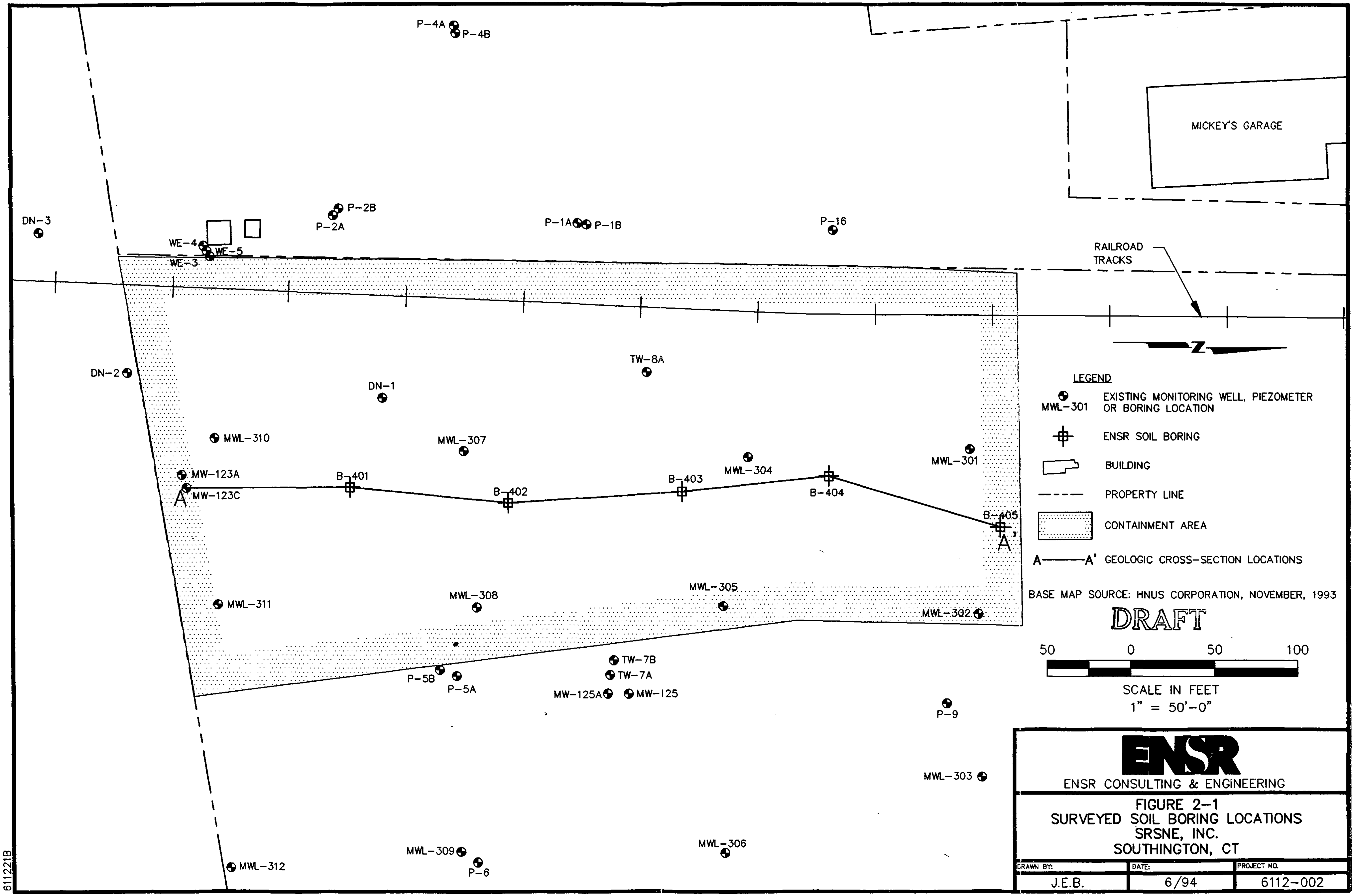
A sub-sample of soil was also collected from each split spoon for field-GC analysis and DNAPL screening as part of the additional studies work performed by the PRPs. In addition, a group of sub-samples were split for confirmatory VOC analysis by EPA Method 8240. Laboratory samples were immersed in methanol in the field in accordance with procedures outlined in the Work Plan. Results of these activities are discussed in Volume 3 - Additional Studies Report.

All water and soil cuttings generated during boring installation were containerized in 55-gallon drums for characterization and ultimate disposal. Water was transferred to a holding tank in the Operations Area prior to characterization.

Following installation, all borings were surveyed by a professional surveyor (Diversified Technologies Corporation, Inc.). At each boring location, ground elevation relative to mean sea level and location relative to the CT State Plane Coordinate System were obtained. Survey data for instrumentation installed during this investigation are presented in Appendix C.

2.1.1.2 Well Installation and Development

Pumping and observation wells for the pumping tests were drilled and installed over the period from March 14, 1994 through March 31, 1994. The 2-inch diameter observation wells were drilled with the drive-and-wash drilling method. Four-inch diameter temporary steel casing was advanced through the overburden. To install overburden observation wells (MW-409, MW-410, MW-412, MW-413, MW-415), temporary steel casing was advanced to the appropriate depth and wells were installed and constructed as the casing was jacked out of the borehole. To install shallow bedrock observation wells (MW-408, MW-411, MW-414, MW-416), temporary steel casings were first seated into the competent bedrock before drilling proceeded into the rock. In



ENSR
ENSR CONSULTING & ENGINEERING

FIGURE 2-1
SURVEYED SOIL BORING LOCATIONS
SRSNE, INC.
SOUTHINGTON, CT

DRAWN BY:	DATE:	PROJECT NO.
J.E.B.	6/94	6112-002

611221B

three of the four bedrock observation well locations, wells were installed in four-inch diameter rock holes drilled in the bedrock using a rotary bit; bedrock cores were not collected from these locations. A 20-foot bedrock core was collected from the remaining bedrock observation well location (MW-408) prior to enlarging the hole with the rotary bit for well installation.

To install the four-inch diameter pumping wells (PW-406, PW-407), an air-rotary drilling rig was used to advance eight-inch diameter temporary steel casing through the overburden. Well construction was completed as described above for the observation wells. A 20-foot core was collected from the bedrock hole, PW-406. A packer test with a single-packer system was then performed in the corehole to evaluate whether the completed well would yield a sufficient quantity of water to perform a pumping test, and to obtain groundwater samples to screen for the presence of DNAPL in the bedrock. Following core collection, the bedrock hole was enlarged for well installation.

All wells were constructed of Schedule 40 PVC well materials, with 10-slot (0.01 inch) well screens. Boring logs and well logs are included in Appendix A. Well construction details are summarized in Table 2-1. Well screens in the overburden were five and 10 feet in length; well screens in the bedrock were 20 feet in length. In the overburden, five foot well screens were used in the two well clusters nearest the bedrock pumping well so that hydraulic response in the till and outwash could be monitored separately.

The overburden pumping well was screened with a 10-foot well screen, from eight to 18 feet below grade; the bottom three feet of the screen may have been located within the till unit. This screen location was chosen to maximize the available drawdown of the well (i.e., place the well screen as deep as possible) while installing the majority of the well screen across the relatively coarse-grained outwash deposits. This screen position allows for an assessment of the conductivity of the outwash and till as individual lithologic units (due to the presence of observation well clusters with screens isolated in each unit), and of the degree of hydraulic connection between the overburden and shallow bedrock aquifers. Depending on the presence or absence of a characteristic pumping response in the till, this configuration also allows for an assessment of whether the overburden responds as a single aquifer or an aquifer/aquitard system within the region affected by pumping (see Section 2.2.2.2).

Wells were constructed using conventional monitoring well construction techniques. In each well, the annular space between the well and borehole wall was filled with a sand pack (#1 Morie) to a height of one to three feet above the top of the well screen, followed by a bentonite pellet seal (two-foot minimum thickness), and a cement-bentonite grout mixture (95% cement/5% bentonite) to grade. To prevent premature hydration of bentonite pellets in the standing water column above the sand pack, the majority of the standing water was removed from the annular space so that

TABLE 2-1

Well Construction Details
SRSNE, Southington, CT

Well I.D.	Installation Date	Dia./Type	Total Depth (ft bgs)	Screen Length	Lithologic Unit	Ground Elev. (ft. MSL)	TOC Elev. (ft. MSL)
PW-406	3/24/94	4 in/PVC	50	20	Bedrock	157.71	160.40
PW-407	3/23/94	4 in/PVC	18	10	Outwash/Till	157.43	160.31
MW-408	3/15/94	2 in/PVC	51	20	Bedrock	156.98	159.56
MW-409	3/16/94	2 in/PVC	16	10	Outwash/Till	157.14	159.60
MW-410	3/25/94	2 in/PVC	12	5	Outwash	157.04	160.01
MW-411	3/18/94	2 in/PVC	51	20	Bedrock	157.22	160.29
MW-412	3/24/94	2 in/PVC	21	5	Till	157.13	159.74
MW-413	3/18/94	2 in/PVC	20	5	Till	158.00	160.66
MW-414	3/17/94	2 in/PVC	50	20	Bedrock	158.29	161.37
MW-415	3/18/94	2 in/PVC	12	5	Outwash	158.15	160.86
MW-416	3/15/94	2 in/PVC	49	20	Bedrock	157.42	160.06

TOC Elev. = Elevation of reference mark on PVC casing.
ft MSL = Feet above mean sea level.
ft bgs - Feet below ground surface.

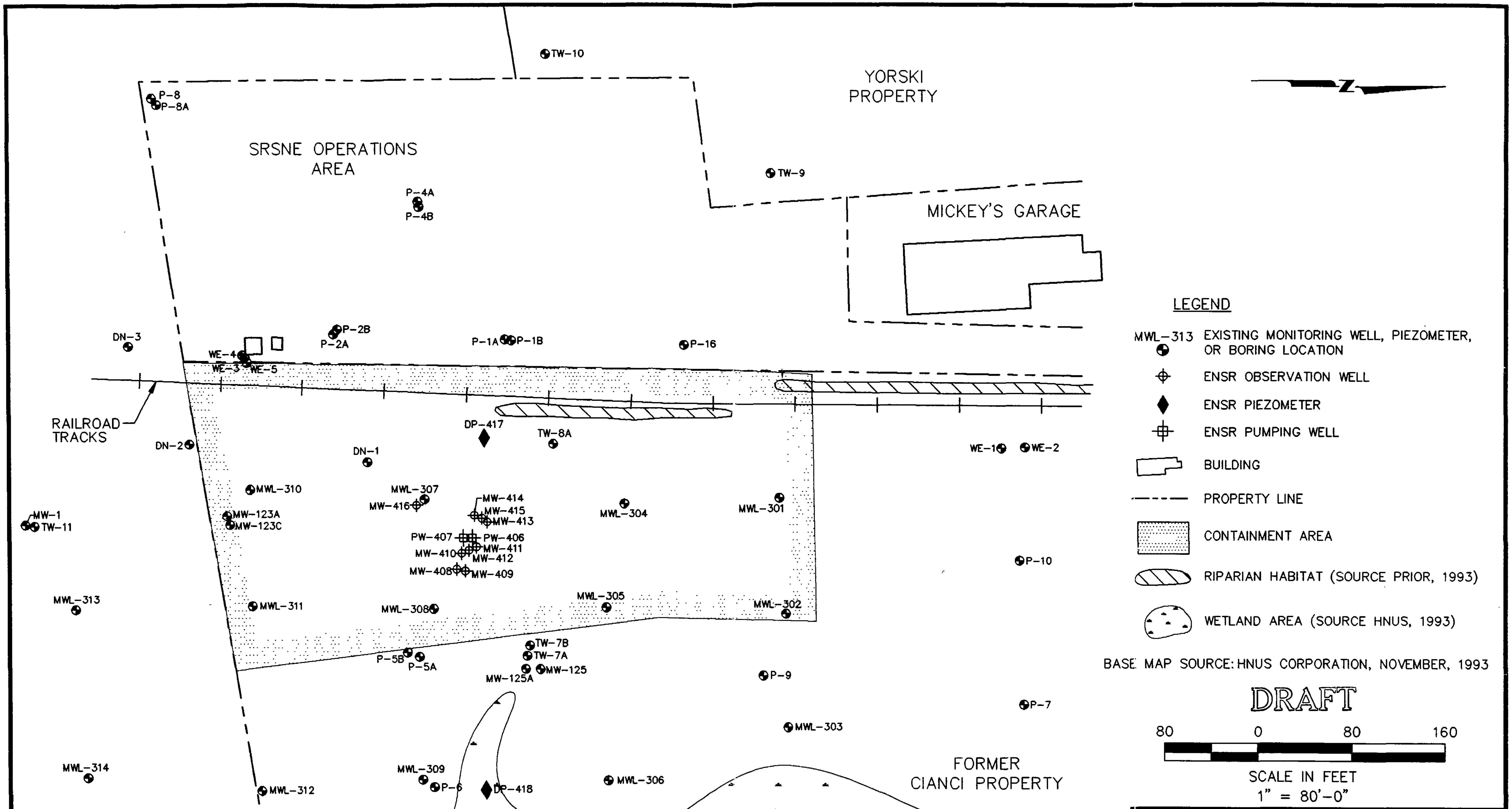


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FIGURE 2-2
SURVEYED LOCATIONS OF PUMPING WELLS, OBSERVATION WELLS AND PIEZOMETERS
SRSNE, INC.
SOUTHINGTON, CT

DRAWN BY:	DATE:	PROJECT NO.
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pellets fell through only several feet of water. The bentonite/cement grout mixture was pumped into the annular space using a tremie pipe. All wells were finished with a locking, protective steel casing.

Following installation, all observation and pumping wells were developed with a surge block and bailer or pump until discharge was visually free of sediment, or sediment production following surging was minimized. In general, observation wells were surged twice, and five to 10 well volumes of water were removed. Poorly-producing wells were surged once and bailed dry several times. Pumping wells were surged with a 4-inch surge block and pumped with a submersible pump. Pumping well PW-407 (overburden) was developed using several surge-pump cycles, removing approximately 300 gallons of water. Minimal silt production was noted during the development procedure. Bedrock pumping well PW-406 produced a poor yield, and therefore, was developed extensively over a six hour period with surge block and pump in an attempt to increase the yield of the well. Despite the packer-testing results, which indicated the well would produce an acceptable flow rate, well PW-406 sustained a rate of only 0.17 gallons per minute (gpm) after development. In the process of developing the well, the drilling contractor's stainless-steel submersible pump became lodged in the bottom two feet of the well. This pump did not appear to be the cause of the poor yield of the well. Because PW-406 could not produce an acceptable yield, bedrock observation well MW-408 was pumped instead for the bedrock pumping test.

All water and soil cuttings generated during well construction were containerized in 55-gallon drums for characterization and ultimate disposal. Water was transferred to a holding tank in the Operations Area prior to characterization.

Following development of bedrock wells, water samples were collected from the bottom of wells for field-GC VOC analysis, and visual inspection for DNAPL. These samples were collected to determine whether DNAPL was present, and if so, to discontinue plans to perform the bedrock pumping test. This precaution was taken to avoid mobilizing DNAPL in response to pumping. These samples did not show any visual sign of DNAPL, and dissolved constituents did not exceed VOC concentrations present in existing shallow bedrock wells in the former Cianci property, so the bedrock pumping test was performed as scheduled. Results of this sampling are presented and discussed in Volume 3 - Additional Studies Report.

The layout of the pumping and observation wells is shown on Figure 2-2. The observation well clusters nearest the pumping wells (MW-410/MW-411/MW-412 at approximately 10 feet and MW-413/MW-414/MW-415 at approximately 20 feet) contained an outwash well, a till well, and a bedrock well. The observation well clusters farther from the pumping wells (MW-408/MW-409 at approximately 30 feet, and MWL-307/MW-416 at approximately 50 feet) contained an outwash well and a bedrock well. The first borehole advanced in each of the 10, 20, and 30 foot clusters (MW-411, MW-414, and MW-408, respectively) was logged by collecting a split spoon sample every five feet to competent bedrock.

2.1.2 Results and Discussion

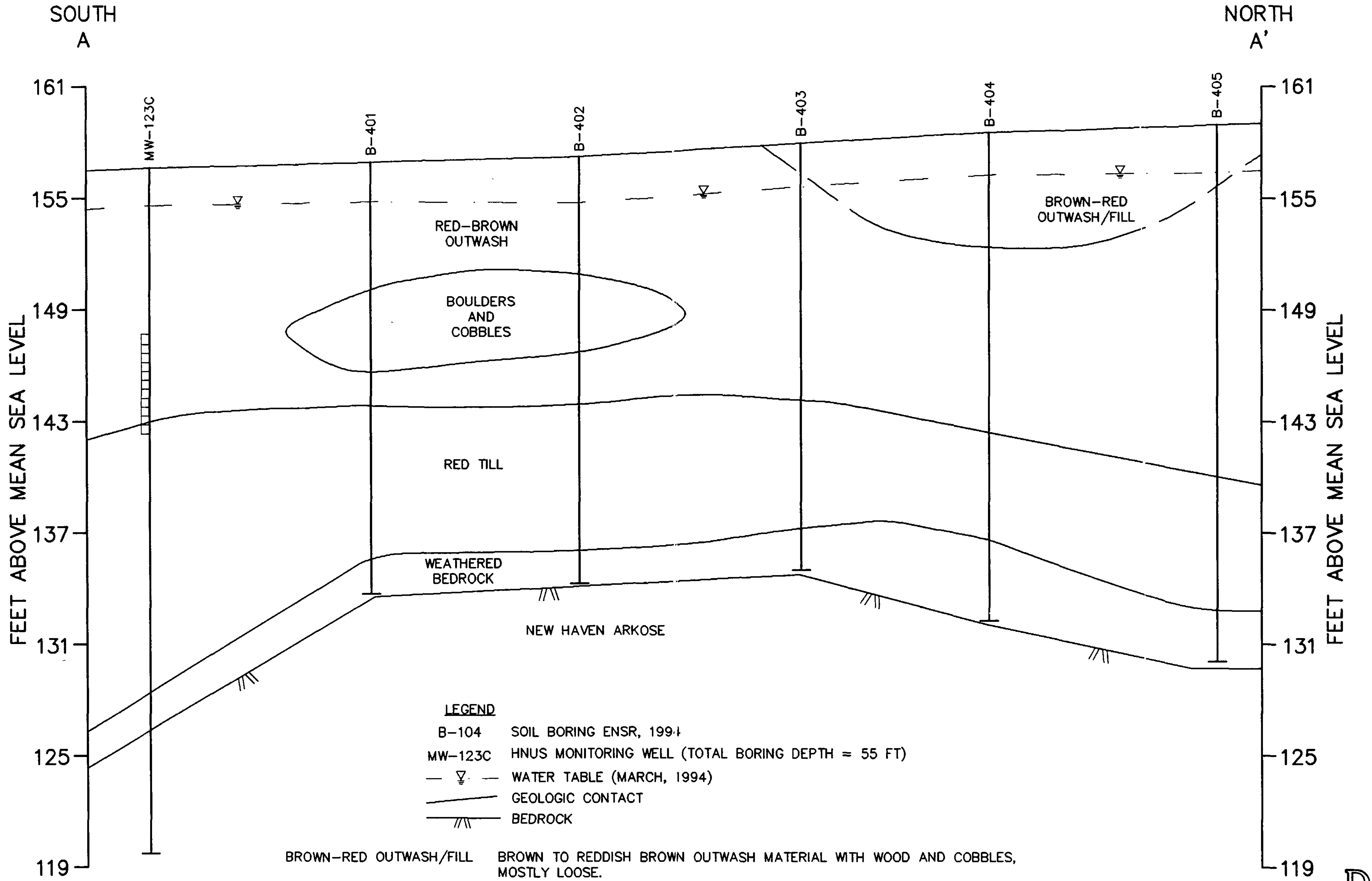
Overburden geology in the center of the Containment Area is summarized on geologic cross-section A-A' (Figure 2-3). The location of the section is shown on Figure 2-1. A relatively coarse-grained glacial outwash deposit underlain by a variable sandy till appeared to be continuously present along Section A-A'. The New Haven Arkose was present beneath the till. The overburden deposits were found to be very heterogeneous. Bedding within units was variable, and generally not continuous between borings.

The uppermost unit is a loose, red to brown glacial outwash deposit which consists predominantly of sand mixed with highly variable quantities of silt and gravel. The unit is stratified with lenses of well-sorted silt from 0.5 to 3.5 feet in thickness noted in some boreholes. Boulders and cobbles are also present in some locations. The outwash unit was relatively fine-grained toward the north end of the line of test borings. On the north end of the section (B-404), wood fragments indicative of fill material in an indigenous soil matrix were present to a depth of six feet. The thickness of the outwash unit varied from 12 to 18 feet.

Below the outwash unit is a loose to dense, red till deposit which is poorly-sorted and highly variable in composition. Along the line of section, the deposit consists primarily of red to red-brown fine to coarse sand with silt, gravel, and little clay. Gravel was angular to subrounded and probably derived locally from the underlying New Haven Arkose (Melvin et al. 1992). Lenses of silt and clay ranging from 0.25 feet to 1.8 feet in thickness were present in the deposit. The thickness of the till varied from five to 15 feet. The contact between the till and outwash units was indistinct in most boreholes.

A zone of heavily-weathered New Haven Arkose was present above the surface of competent rock. This zone was extensively fractured. The degree of cementation varied from well-cemented to friable. In some locations, layering characteristic of the New Haven Arkose was observed in split-spoons. The thickness of this zone varied from two to five feet.

Competent New Haven Arkose was encountered at depths ranging from 23 to 32 feet below grade. As shown on Figure 2-3, the bedrock surface was lowest on the southern end of the cross section. The New Haven Arkose is a red to red-brown arkosic conglomerate and sandstone, with medium- to fine-grained feldspathic sandstone and siltstone (Hanshaw, 1968). Bedding is generally lenticular with bed thicknesses less than 4 feet. In the two cores collected during this



BROWN-RED OUTWASH/FILL	BROWN TO REDDISH BROWN OUTWASH MATERIAL WITH WOOD AND COBBLES, MOSTLY LOOSE.
RED-BROWN OUTWASH	RED TO DARK REDDISH BROWN SAND WITH VARYING QUANTITIES OF SILT AND GRAVEL, ANGULAR TO ROUNDED, MEDIUM DENSE TO LOOSE, MEDIUM SOFT TO MEDIUM HARD, WITH LENSES OF SILT FROM 0.5 TO 3.5 FEET.
RED TILL	RED TO REDDISH BROWN FINE TO COARSE SAND AND SILT WITH LITTLE CLAY, DENSE, HARD, ANGULAR GRAINS, WITH SEVERAL LENSES OF SILT AND CLAY RANGING FROM 0.25 TO 1.8 FEET.
WEATHERED BEDROCK	RED TO GREY WEATHERED NEW HAVEN ARKOSE, VERY FRACTURED, HARD TO FRIABLE, INTERSPERSED WITH SAND AND SILT
NEW HAVEN ARKOSE	REDDISH-BROWN TO ORANGE TO GRAY ARKOSIC CONGLOMERATE AND SANDSTONE, WITH FELDSPATHIC SILTSTONE AND SANDSTONE. BEDDING GENERALLY LENTICULAR.

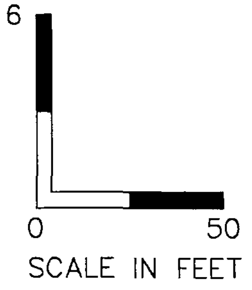


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FIGURE 2-3
GEOLOGIC CROSS SECTION A-A'
OF CONTAINMENT AREA
SRSNE SOUTHINGTON, CT

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investigation, bedrock was characterized as mostly massive red sandstone to conglomerate with horizontal to low-angle bedding. Horizontal to moderate-angle fractures with varying degrees of weathering were noted in both cores. Open, weathered fractures were present in both cores at intervals ranging from two to 10 feet. Core material between fractures was competent and well-cemented, indicating that groundwater flows predominantly through secondary porosity created by discrete fractures.

Analytical data obtained during the drilling program are presented and discussed in Volume 3 - Additional Studies Report.

2.2 Overburden and Shallow Bedrock Hydraulic Tests and Wetlands Monitoring

Hydraulic tests included two pumping tests, wetlands monitoring, and slug tests on individual monitoring wells. The overburden pumping test and wetlands monitoring were performed in accordance with requirements in Section III.A of the SOW for the purposes of designing the Overburden Containment System and assessing the potential impact of the system on the wetlands and floodplain of the Quinnipiac River. The bedrock pumping test and the slug tests were performed as part of the additional studies work performed by the PRPs. Although the bedrock test and slug tests were not explicitly required by the SOW, they are discussed in this report because they provide information that is relevant to understanding the hydrogeology of the Site, as well as to Containment System design.

2.2.1 Step Tests

Prior to performing the pumping tests, PW-407 and MW-408 were step-tested to determined optimal pumping rates. Each test was performed over an eight hour period. Wells were pumped over a range of pumping rates to estimate maximum, sustainable rates for the pumping tests. The step tests indicated that PW-407 would sustain a rate of 1.6 gpm, and MW-408 a rate of 1.2 gpm. Pumping tests were subsequently performed at these rates.

2.2.2 Overburden Pumping Test

2.2.2.1 Scope of Investigation

A constant-rate overburden pumping test was performed over the period from April 4, 1994, through April 7, 1994. Well PW-407 was pumped at a constant rate of 1.6 gpm with a submersible pump for 43.7 hours (2,620 minutes). The drawdown in the pumping well at the end of this period was approximately two feet, for a specific capacity of 0.8 gpm/ft drawdown. A totalizer flow meter used to measure pumping rate indicated that the flow rate was held relatively constant, with variations between 1.55 gpm and 1.60 gpm. All extracted groundwater was containerized in a 21,000-gallon temporary storage tank for characterization and ultimate disposal.

At the time of the test, there was approximately seven feet of water in the pumping well above the top of the well screen (available drawdown). At 2,620 minutes, the pumping rate was increased to 2.8 gpm to utilize the available drawdown and increase the amount of drawdown in the aquifer. The measured specific capacity (0.8 gpm/ft drawdown) indicates that the well should have yielded 5.6 gpm with seven feet of drawdown, assuming the specific capacity remained constant with depth. However, the increased yield could not be sustained, and the water level dropped to the pump intake approximately five hours later. The reduction in specific capacity with depth may indicate that a relatively thin layer of high hydraulic conductivity material was providing the majority of the water to the well. Due to the variable pumping rate near the end of the test, drawdown data after 2620 minutes, and water-level recovery data could not be used for transmissivity estimates. All data presented below include only the first 2620 minutes of pumping test data.

Water levels were measured throughout the test using an 8-channel Hermit Datalogger, and a hand-held electronic depth-to-water meter. Observation wells closest to the pumping well were measured frequently to construct drawdown versus time curves. Synoptic data were also collected from a larger group of wells periodically to develop plan-view maps of the water table before and during the pumping test, and drawdown versus distance curves. Prior to the test, groundwater was flowing essentially due east under a horizontal hydraulic gradient that varied from 0.009 ft/ft to 0.04 ft/ft (Figure 2-4). Water levels were also measured in three piezometers installed in wetland areas for the Wetlands Study. This study is discussed in detail in Section 2.2.5.

Precipitation and barometric pressure were monitored throughout the test. Rainfall was monitored with a rain gauge located near the pumping wells. Cumulative precipitation from April 3, 1994 through April 14, 1994, is shown on Figure 2-5. There was no rainfall during the overburden test. Barometric pressure was recorded continuously on-site with a Taylor Weather-Hawk Recording Barometer, calibrated to barometric pressure at Bradley International Airport located in Hartford, CT. The record of barometric pressure from March 29, 1994, through April 14, 1994, is shown on Figure 2-6. Fluctuations in groundwater levels resulting from changes in barometric pressure were not evident during the pumping test.

During the overburden test, wells P-2A/P-2B, P-4A/P-4B, and P-5A/P-5B were used to monitor background water levels in overburden and shallow bedrock. The Work Plan stated that background data would be collected at 30 minute intervals; however, the datalogger installed in the P-2 cluster was inadvertently programmed to collect data at 30 hour intervals. Consequently,

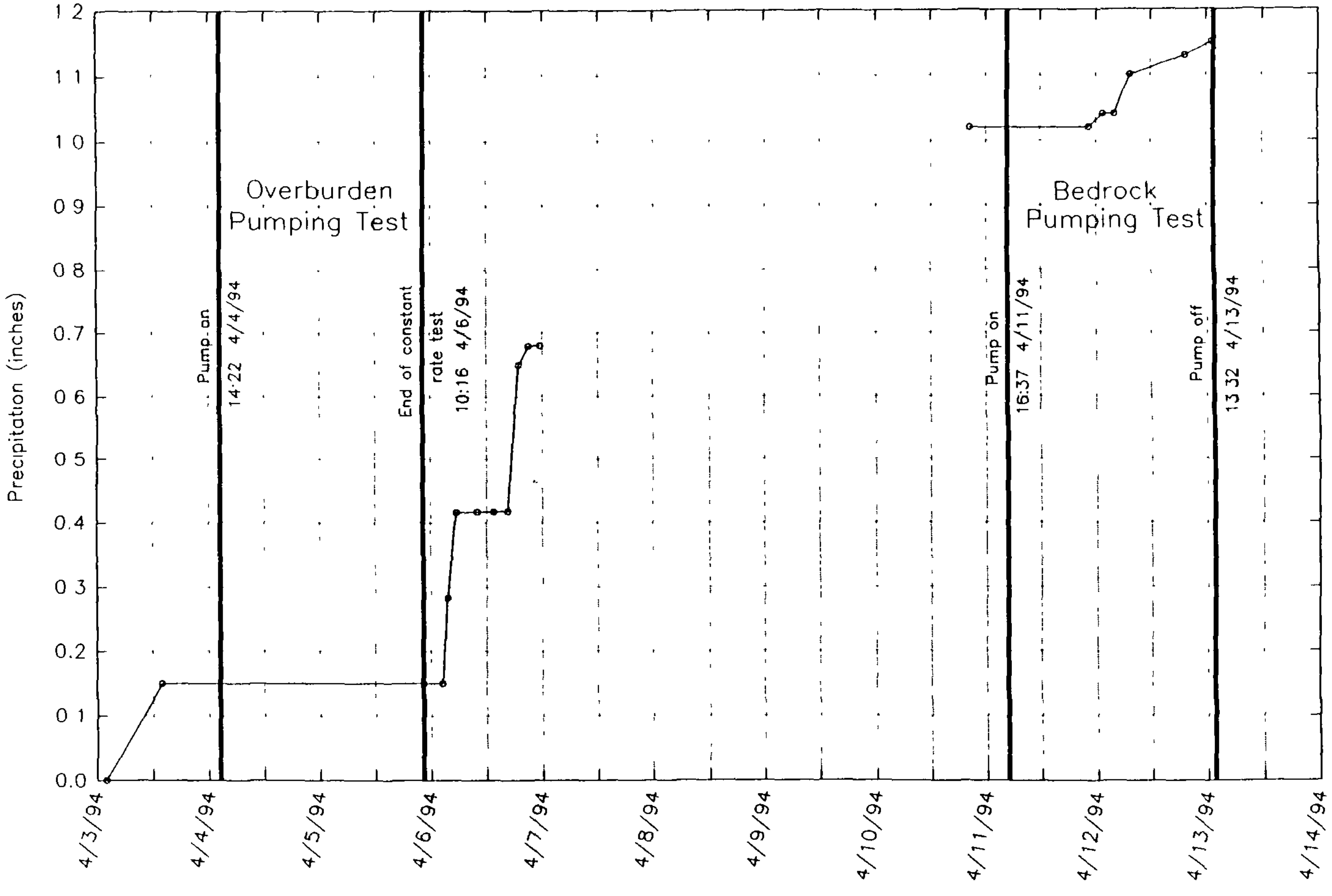


FIGURE 2-5

Cumulative Precipitation
April 3 - 14, 1994
SRSNE, Southington, CT

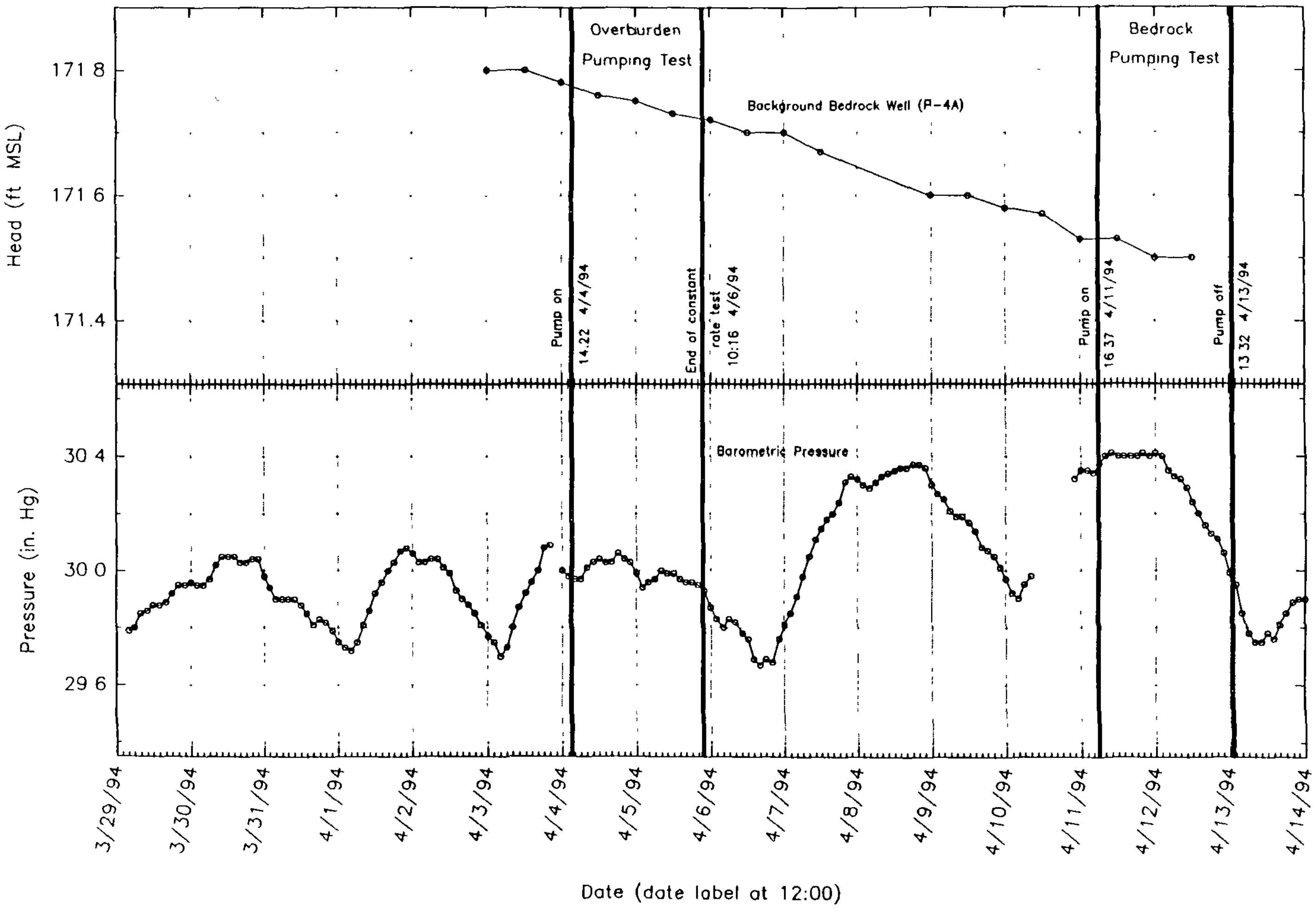


FIGURE 2-6

Barometric Pressure and Head in Background Bedrock Well (P-4A)
March 29 - April 14, 1994
SRSNE, Southington, CT

these results could not be used in the analysis of pumping test data. Wells in the P-4 and P-5 clusters were collecting data at 12 hour intervals as part of the HNUS long-term water level monitoring program. These wells provided sufficient data for monitoring background conditions in the overburden and shallow bedrock. The hydrograph for P-5B, the overburden background well nearest the pumping well, is presented in Figure 2-7. Hydrographs for other overburden and shallow bedrock background wells are presented in Appendix D.

The drawdown data did not require correction for background fluctuations. The hydrograph from overburden well P-5B and additional measurements on MWL-300 series wells in the former Cianci property indicated that overburden groundwater heads outside the influence of pumping dropped by approximately 0.1 feet over the 2,620 minutes of constant rate pumping. Because this decline was evident only in late-time data (data collected near the end of the test), background fluctuations generally did not affect analysis of test data. Fluctuations influenced only the radius-of-influence estimates developed from data collected near the end of the test (discussed below). All drawdown data presented below are in uncorrected form.

Four groundwater samples were collected during the overburden pumping test for assessment of water treatment options. Samples were shipped to the analytical laboratory for analysis of VOC, SVOC, priority pollutant metals, inorganics (hardness, dissolved and suspended solids, alkalinity, Fe, Mn), and water quality parameters (BOD, COD, TOC). Samples were collected from a port located near the pumping well. Samples were collected approximately every 24 hours after pumping started; the initial sample was collected 15 minutes into the test. These results are presented and discussed in Section 3.0.

2.2.2.2 Results and Discussion

Pumping test results were analyzed to determine the transmissivity (T) of the till and outwash units comprising the overburden aquifer, the size and shape of the drawdown cone, the extent of hydraulic connection between the overburden and shallow bedrock units, and the presence or absence of hydraulic boundaries that might influence the operation of the Containment System. Transmissivity is defined as the product of the average hydraulic conductivity of the formation and the saturated thickness. It is a measure of the capacity of the aquifer to produce water to a well.

Semi-log drawdown curves from the pumping well and underlying bedrock well (PW-407/PW-406), the 10-foot cluster (MW-410/MW-411/MW-412), the 20-foot cluster (MW-413/MW-414/MW-415), and the 30-foot cluster (MW-408/MW-409) are shown on Figures 2-8 through 2-11, respectively, with a complete set of log-log and semi-log graphs for overburden and bedrock wells within a 100 foot radius of the pumping well included in Appendix D. Time-drawdown graphs for overburden

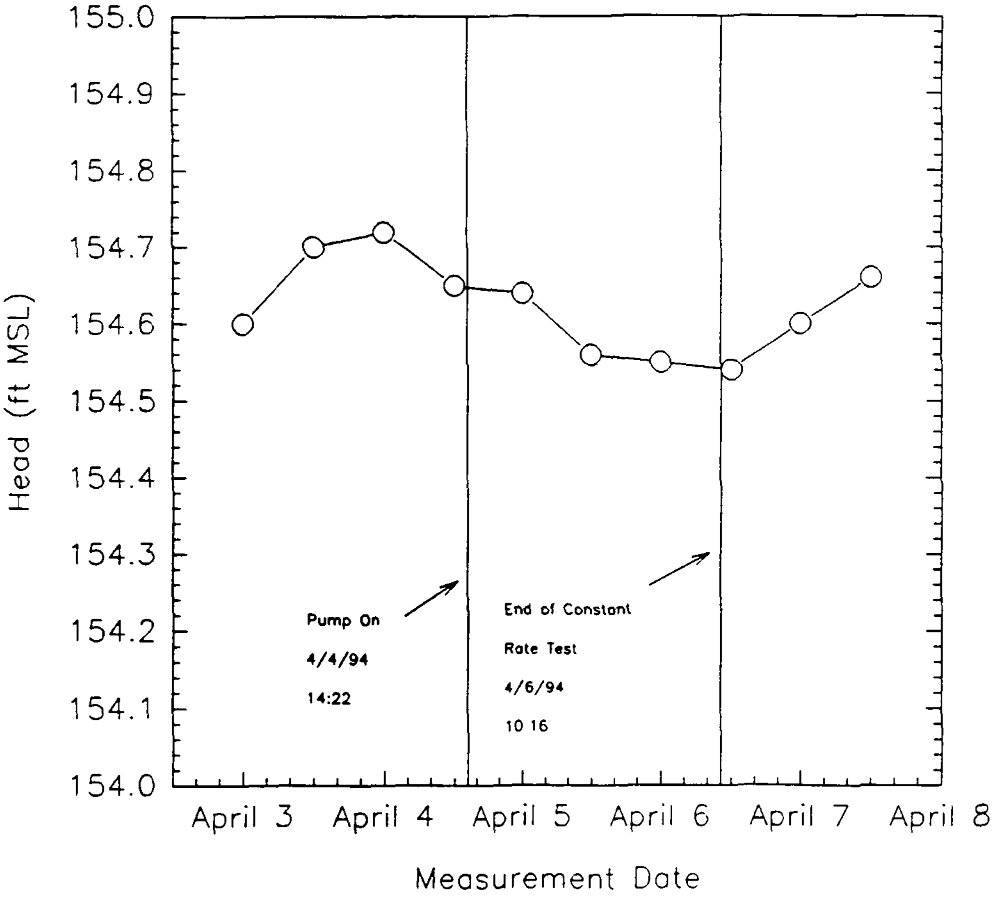


FIGURE 2-7
Background Well Hydrograph (P-5B),
Overburden Pumping Test, April 4 - 6, 1994
SRSNE, Southington, CT

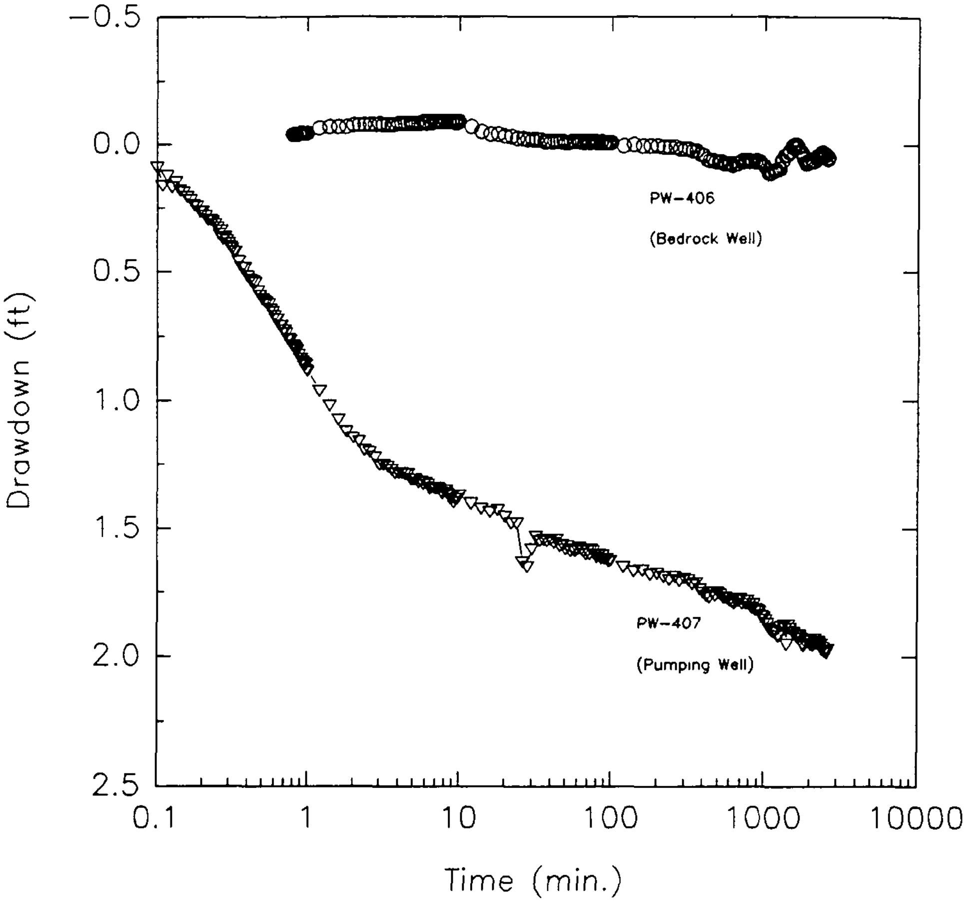


FIGURE 2-8

Drawdown in Well Cluster 0 - 7 Feet from Pumping Well (PW-406), Overburden Pumping Test, April 4 - 6, 1994
SRSNE, Southington, CT

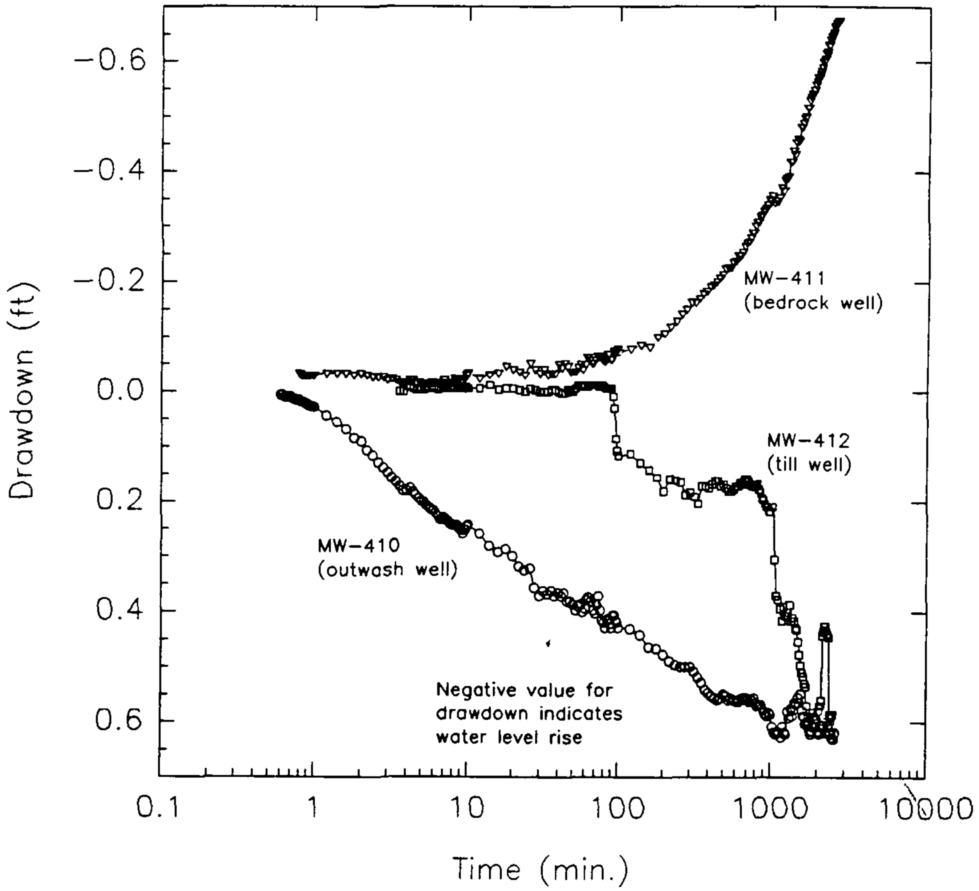


FIGURE 2-9
Drawdown in Well Cluster 12 - 14 Feet from Pumping Well (PW-407),
Overburden Pumping Test, April 4 - 6, 1994
SRSNE, Southington, CT

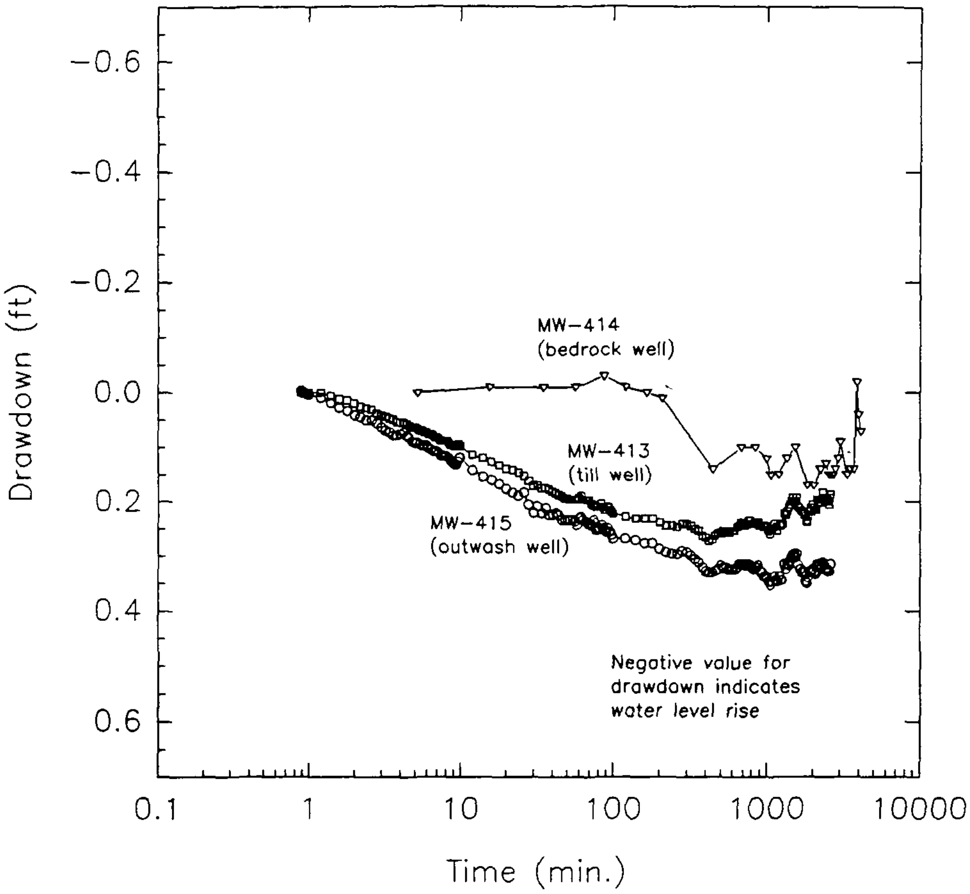


FIGURE 2-10

Drawdown in Well Cluster 20 - 24 Feet from Pumping Well (PW-407), Overburden Pumping Test, April 4 - 6, 1994 SRSNE, Southington, CT

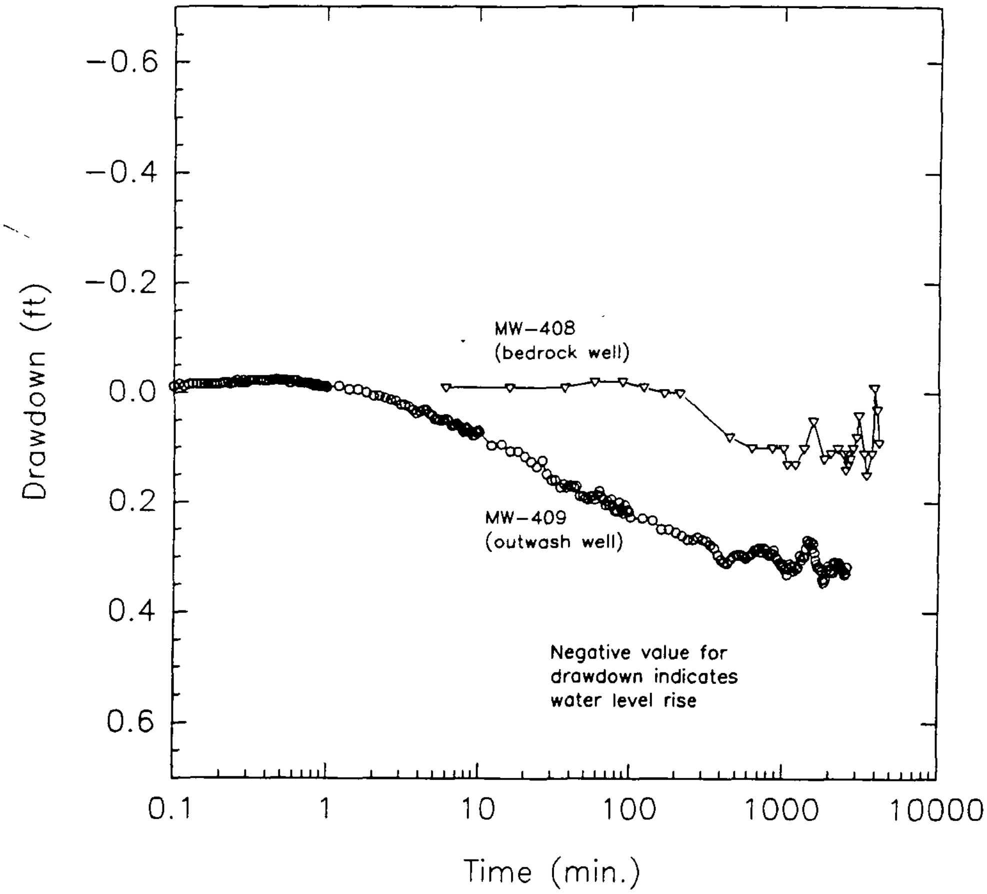


FIGURE 2-11

Drawdown in Well Cluster 28 Feet from Pumping Well (PW-407), Overburden Pumping Test, April 4 - 6, 1994 SRSNE, Southington, CT observation wells generally show a clear response to pumping in the early-time data followed by a slope break which probably indicates that a hydraulic boundary was encountered.

Transmissivity calculations were made with the AQTESOLV™ Ground-Water Modeling Software program (Geraghty & Miller 1991) using a pumping rate of 1.6 gpm. The Theis solution fit the drawdown data well, and therefore, was used to calculate transmissivity values. This solution, while explicitly developed for confined aquifers, provides reasonable transmissivity values in unconfined aquifers when the saturated thickness of the aquifer does not decrease substantially during pumping, as in the overburden pumping test. In general, the late-time data affected by the slope change were not fit by the model. Model-calculated aquifer storage coefficients are not reported because the test length was insufficient to obtain physically-realistic values for an unconfined aquifer. These coefficients are known to vary by a factor of only two, from approximately 0.15 to 0.3, in sandy, unconfined aquifers. AQTESOLV™ log-log and semi-log graphs showing best-fit type curves are included in Appendix D.

Transmissivity values within the cone of influence varied from 250 to 680 ft^2/day (Table 2-2). To assess the difference between outwash and till units, mean values were calculated for each unit. The geometric mean of values from outwash wells was 435 ft^2/day (n=8). The geometric mean of values from till wells was 335 ft^2/day (n=4). The characteristic pumping response in the till (i.e., MW-413) and the similarity of mean values between units suggests that the outwash/till system effectively responds to pumping as a single aquifer in this area of the Site. With the assumption of a single aquifer, the geometric mean transmissivity of all overburden wells is 399 ft^2/day (n=12), and using a saturated thickness of 25 feet, the mean hydraulic conductivity (K) is 16 ft/day.

All overburden wells within a radial distance from the pumping well of approximately 75 feet responded to pumping. Beyond this distance, a hydraulic response from pumping could not be clearly distinguished from background fluctuations. The cone of depression is shown on graphs of drawdown versus distance from the pumping well (2440 minutes after pumping began), with uncorrected data shown on Figures 2-12, and corrected data shown on Figure 2-13. These distance-drawdown graphs show the effect correcting for background fluctuations has on the size of the cone of depression. The cone of depression is 85 feet for data that are not corrected for background fluctuations, and 65 feet for data corrected for the background decline in water levels. A correction factor of 0.09 feet, obtained from the P-5B hydrograph was subtracted from each drawdown value to generate the corrected data. Given the possibility that background fluctuations may have been, on average, less than 0.09 feet, the corrected data probably provide a minimum radius of influence. Therefore, the measured radius of influence from the overburden pumping test is presented as a range, from approximately 60 to 90 feet. Distance-drawdown graphs and a plan view map depicting the water table configuration near the end of the pumping test

TABLE 2-2

Summary of Overburden Transmissivity Calculations
SRSNE, Southington, CT

Well	Lithologic Unit	Transmissivity	Hydraulic Conductivity[2]	Method
MWL-307	Outwash[1]	610 ft^2/day	24.4 ft/day	Cooper-Jacob
		680 ft^2/day	27.2 ft/day	Theis
MW-410	Outwash	330 ft^2/day	13.2 ft/day	Cooper-Jacob
		330 ft^2/day	13.2 ft/day	Theis
MW-409	Outwash/Till	470 ft^2/day	18.8 ft/day	Cooper-Jacob
		380 ft^2/day	15.2 ft/day	Theis
MW-412	Till	250 ft^2/day	10.0 ft/day	Cooper-Jacob
		250 ft^2/day	10.0 ft/day	Theis
MW-415	Outwash	400 ft^2/day	16.0 ft/day	Cooper-Jacob
		400 ft^2/day	16.0 ft/day	Theis
MW413	Till	460 ft^2/day	18.4 ft/day	Cooper-Jacob
		440 ft^2/day	17.6 ft/day	Theis

[1] Lithologic unit assumed based on depth of well screen.

[2] Saturated thickness of 25 feet used to calculate hydraulic conductivity.

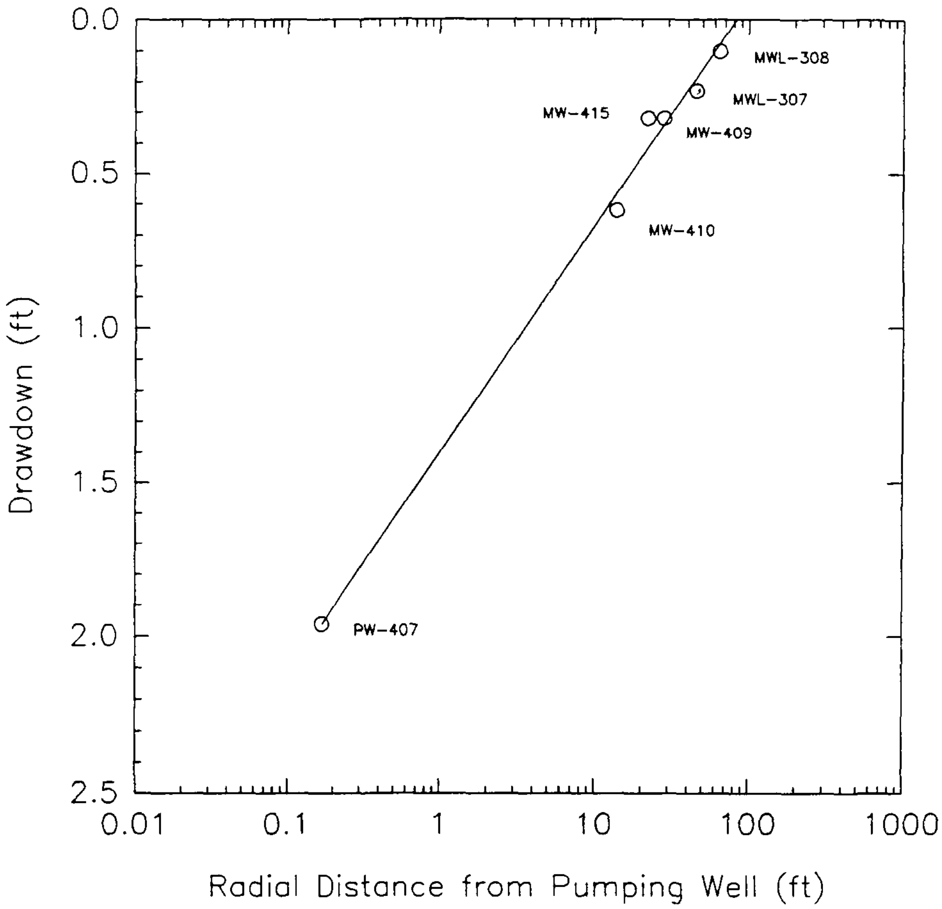


FIGURE 2-12

Distance-Drawdown Plot at 2440 Minutes (Uncorrected Data),
Overburden Pumping Test, April 4 - 6, 1994
SRSNE, Southington, CT

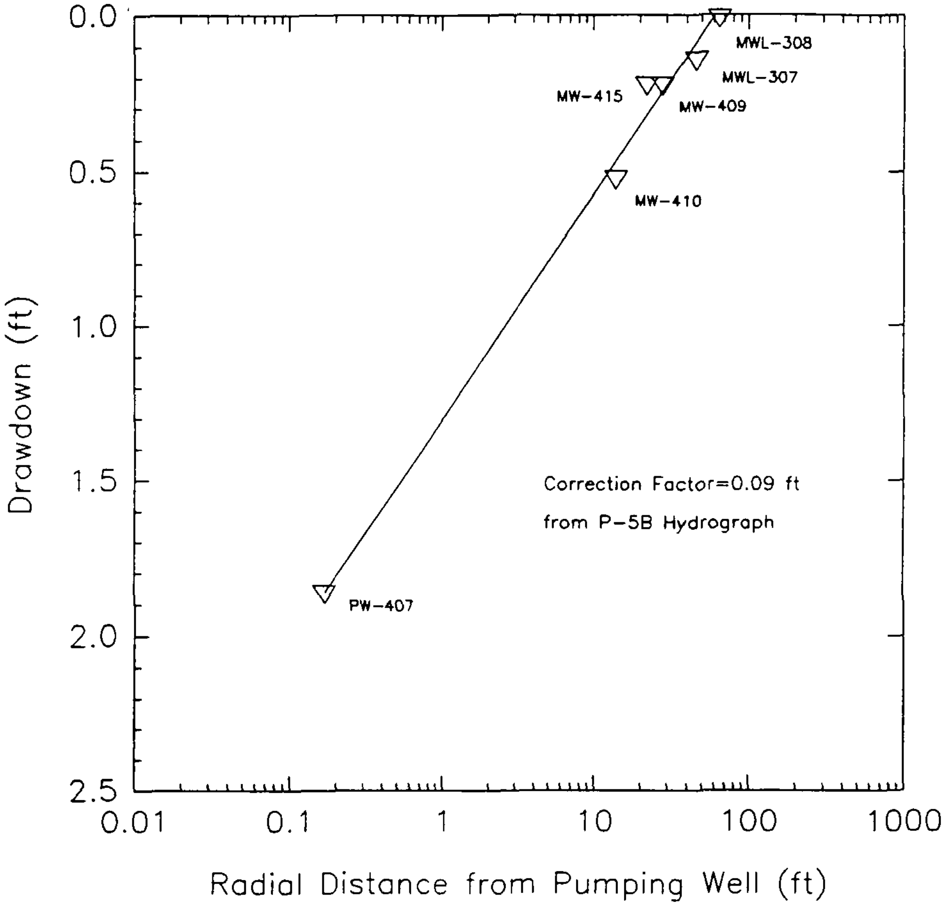


FIGURE 2-13
Distance-Drawdown Plot at 2440 Minutes (Corrected Data),
Overburden Pumping Test, April 4 - 6, 1994
SRSNE, Southington, CT

(Figure 2-14) also reveal that the cone of depression was fairly symmetrical about the pumping well, despite the heterogeneity of the overburden aquifer.

The size of the radius of influence of a pumping well is an important design parameter because it controls well spacing; wells are spaced so that cones overlap and complete hydraulic containment is achieved. On the basis of this pumping test, pumping wells installed in this aquifer will have tight (small) cones of depression that are symmetrical about the pumping well. Small cones are consistent with the relatively low transmissivity of the overburden aquifer. Because the size of the cone is inversely correlated to the aquifer transmissivity, variability in transmissivity also needs to be considered in full-scale system design. The application of these results to containment system design are discussed in Section 2.3.

A transmissivity value of 160 ft^2/day was calculated from the distance-drawdown plot (Figure 2-13) using the methodology presented by Driscoll (1986). This value is within a factor of three of the mean value calculated from time-drawdown data. Given the substantial spatial variability of the hydraulic properties of the aquifer, this is considered good agreement between methods.

Three potential hydraulic boundaries were present in the vicinity of the pumping well: the Lower Till Window (as defined by HNUS), the drainage swale east of the B & M Railroad Right-of-Way, and the bedrock aquifer. Boundaries are important because of their possible influence on Containment System operation. Hydraulic boundaries are geologic or man-made features that limit the extent of aquifers and serve to distort the cone of depression forming around the well. Boundaries are generally manifested in drawdown data plots as slope changes. Slope changes usually indicate that the drawdown cone has encountered a river (recharge boundary) or impermeable layer (discharge boundary) (Driscoll 1986). If a recharge (or positive) boundary has been encountered, an additional source of water is available to the well and the rate of drawdown decreases. Recharge boundary effects were observed in most overburden drawdown data after 200 to 1000 minutes of pumping.

It is unlikely that the Lower Till Window defined by HNUS affected the drawdown data as a boundary condition because the cone of depression did not appear to reach this location. Moreover, the geology at the Lower Till Window may not be sufficiently different from surrounding areas to cause a boundary effect. Based on this study, the till is heterogeneous and does not act as a continuous confining layer within the former Cianci property. This heterogeneity, if present as relatively conductive zones throughout the Site, would reduce the significance of the Lower Till Window as a hydraulic boundary and major flow path between the overburden and bedrock aquifers.

It is possible, however, that the cone reached the standing water in the wetland areas east of the B&M Railroad Right-of-Way (see Section 2.2.5.2 and Figure 2-2). Data from the piezometer in this location suggested that pumping induced downward flow from the standing water in the wetlands to groundwater. It is not known whether or not the rate of induced flow was sufficient to cause the boundary effect.

The other potential hydraulic boundary condition for the overburden aquifer is the bedrock aquifer. In general, upward movement of shallow bedrock groundwater to the overburden is possible if the bedrock is well-fractured at the interface and the till mantling bedrock is permeable. However, interconnection may be spatially variable. The extent of hydraulic connection between the overburden and shallow bedrock was evaluated using drawdown data collected from the overburden/bedrock well clusters located near the pumping well (Figures 2-9, 2-10, and 2-11), and from a hydrogeologic cross-section parallel to the regional flow direction (Figure 2-15).

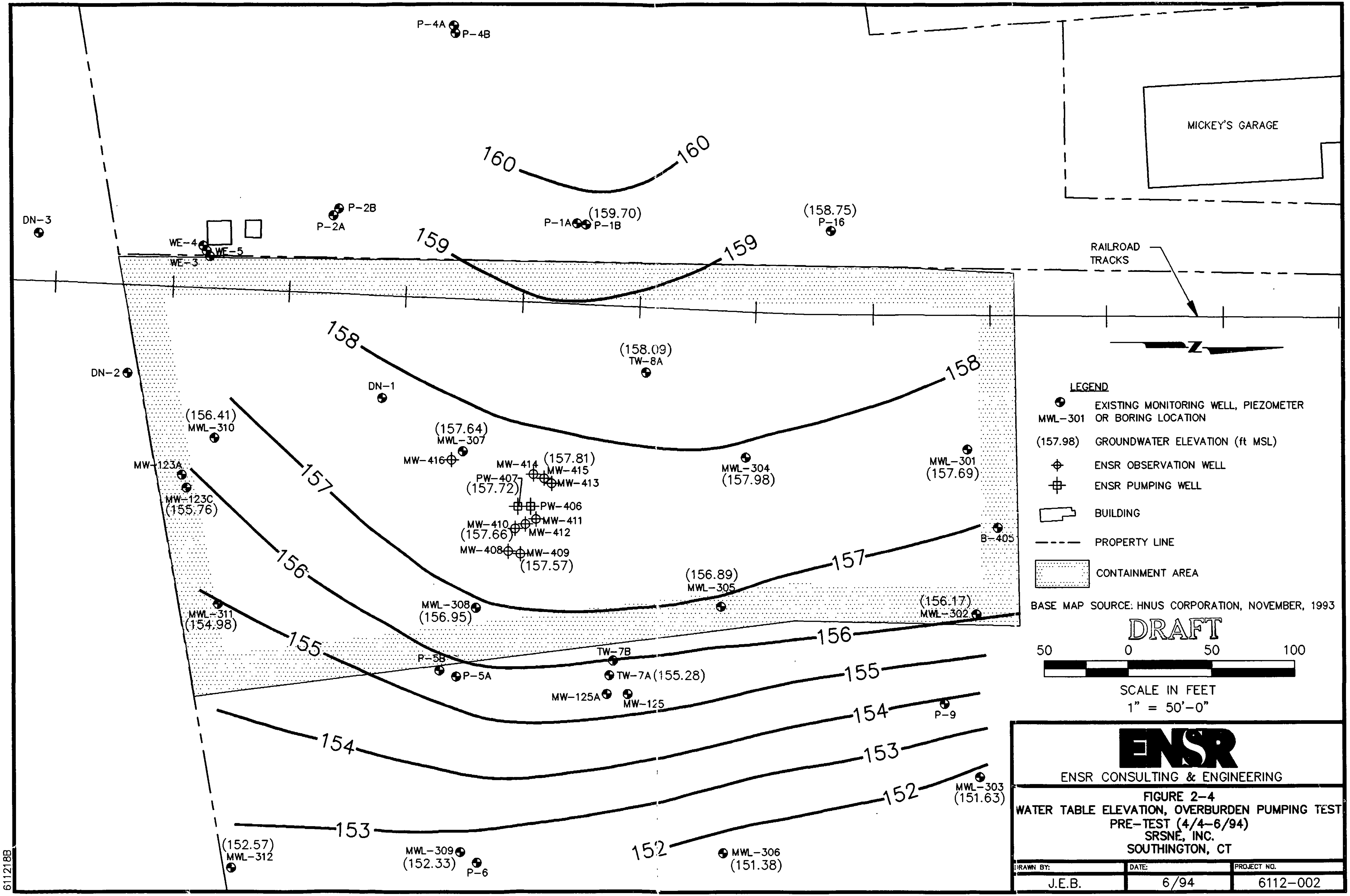
In two well clusters (MW-408/MW-409 and MW-413/MW-414/MW-415), bedrock appeared to respond to pumping 200 minutes after the test began. The bedrock responses coincide with slope changes in companion till and outwash drawdown curves in these clusters. In the third cluster (MW-410/MW-411/MW-412), a hydraulic connection with the shallow bedrock was not evident from the drawdown data. Vertical gradient data before and after pumping indicate that upward gradients from the shallow bedrock to overburden were induced as a result of pumping. If both upward vertical gradients and evidence of hydraulic connection are present, then groundwater will flow upward from the bedrock aquifer to the pumping well. As shown on Figure 2-15, the region of the bedrock that apparently provides water to the overburden was confined to the area beneath the pumping well where upward gradients were induced. This is due to the formation of a small drawdown cone in the overburden.

A downgradient divide formed in the overburden between wells MW-409 and MWL-308, and extended down into the bedrock between bedrock wells MW-411 and MW-408 (Figure 2-15). A similar flow field will likely form downgradient of a full-scale extraction well system.

2.2.3 Bedrock Pumping Test

2.2.3.1 Scope of Investigation

A constant-rate bedrock pumping test was performed between April 11, 1994 and April 13, 1994. Information collected during the pumping test was analyzed to evaluate the nature of the bedrock aquifer, and the effect that pumping the bedrock aquifer has on the overburden aquifer. The low yield (0.17 gpm) observed during the step tests performed on April 1, 1994, in the original bedrock pumping well (PW-406) resulted in the decision to utilize MW-408 as the pumping well



BASE MAP SOURCE: HNUS CORPORATION, NOVEMBER, 1993

ENSR

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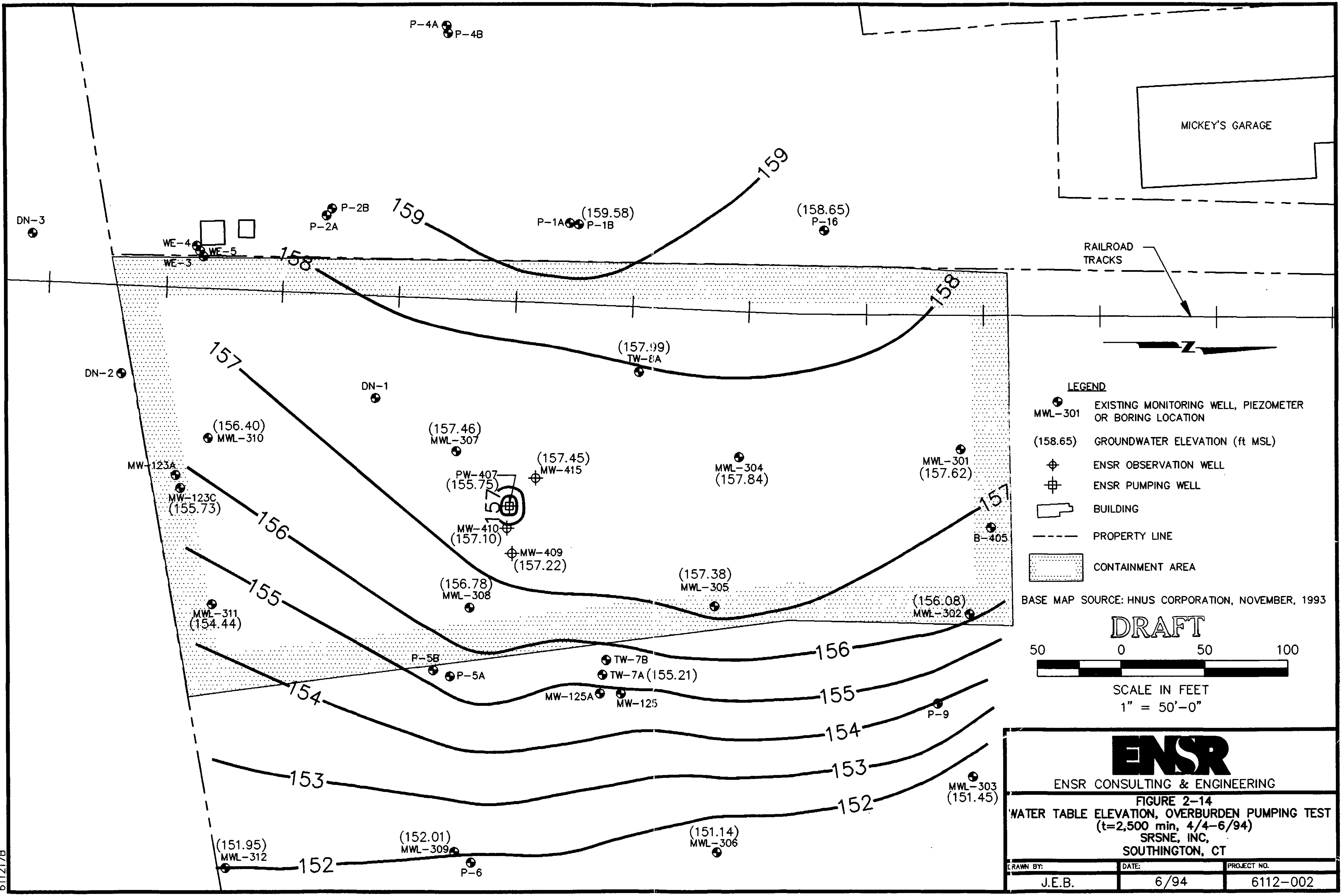
FIGURE 2-4
WATER TABLE ELEVATION, OVERBURDEN PUMPING TEST
PRE-TEST (4/4-6/94)
SRSNE, INC.
SOUTHINGTON, CT

DRAWN BY:	DATE:	PROJECT NO.
J.E.B.	6/94	6112-002

611218B



BASE MAP SOURCE: HNUS CORPORATION, NOVEMBER, 1993

DRAFT

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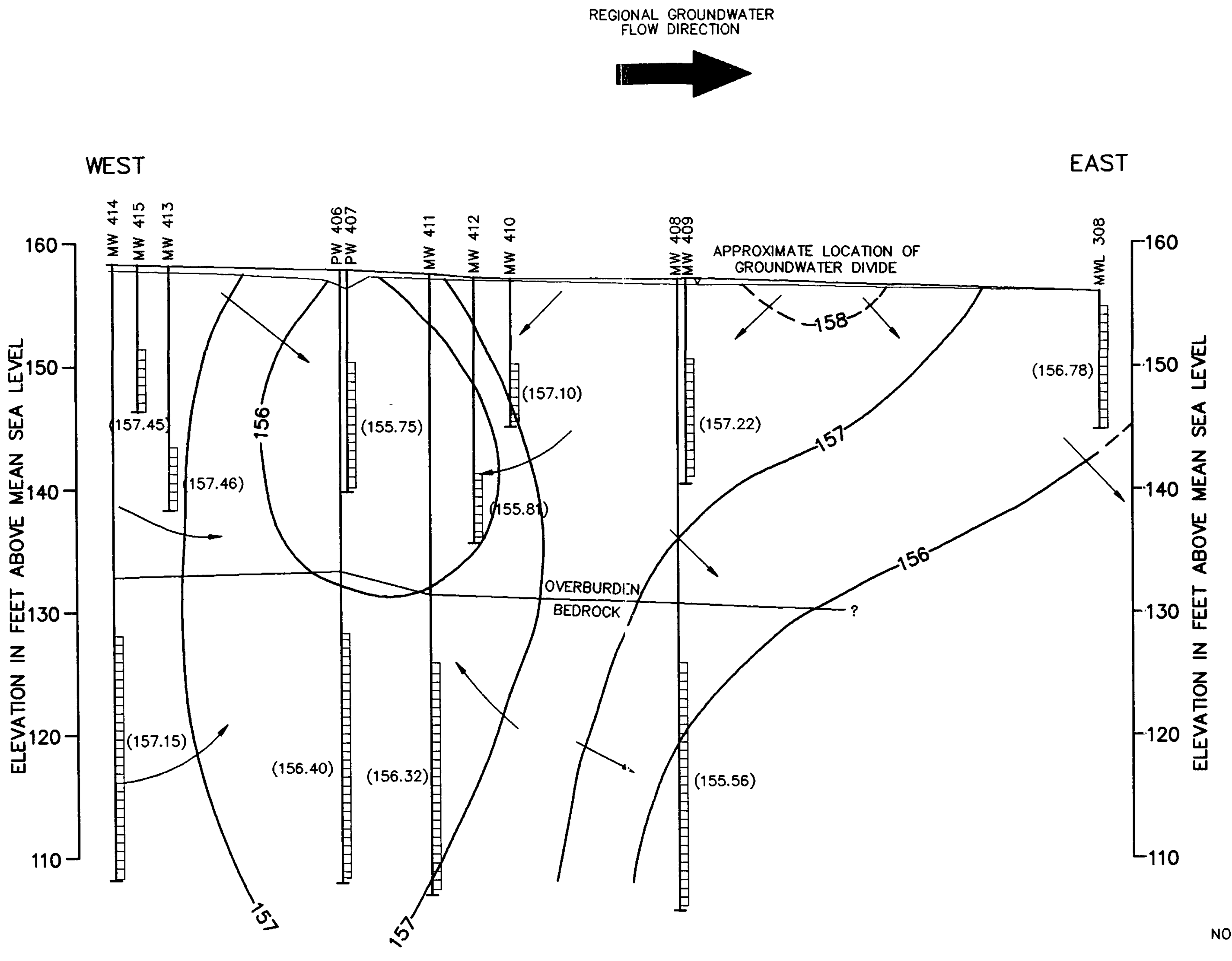
FIGURE 2-14
WATER TABLE ELEVATION, OVERBURDEN PUMPING TEST
(t=2,500 min, 4/4-6/94)
SRSNE, INC.
SOUTHINGTON, CT

DRAWN BY:	DATE:	PROJECT NO.
J.E.B.	6/94	6112-002

611217B



LEGEND

- INTERPERATIVE WATER TABLE IN OVERBURDEN
- (157.22) GROUNDWATER ELEVATION FT MSL
- GROUNDWATER FLOW DIRECTION

DRAFT

NOTE: WELLS PROJECTED ON E-W CROSS-SECTION LINE PASSING THROUGH MW-409.

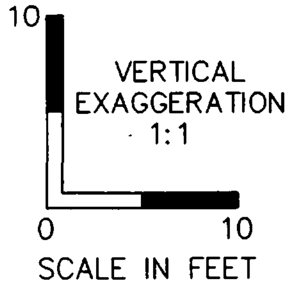


FIGURE 2-15

ENSR

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HYDROGEOLOGIC CROSS-SECTION
OVERBURDEN PUMPING TEST
t=2500 MINUTES, 4/4-6/94
SRSNE SOUTHINGTON, CT

DRAWN BY:	DATE:	PROJECT NO.
J.E.B.	6/94	6112-002

611220B

during the bedrock pumping tests. Well MW-408 was step-tested three days before the pumping test and found able to sustain a rate of 1.2 gpm.

Well MW-408 was pumped at a constant rate of 1.2 gpm for 44.6 hours (2,680 minutes) The drawdown in the well at the end of the pumping test was 14 feet for a specific capacity of 0.09 gpm/ft of drawdown. Due to a failure of the totalizer flow meter (determined before the pumping test began), pumping rate was periodically measured by taking the average time to fill several one gallon containers. The pumping rate was held relatively constant, with fluctuations between 1.13 and 1.30 gpm. All bedrock groundwater was containerized in the same temporary storage tank used for overburden groundwater. At 2,680 minutes the pump was shut down and water level recoveries in the monitoring wells was observed. Although recovery data were collected, typical analytical tests could not be applied to the results due to the observed complex flow in the bedrock.

Precipitation and barometric pressure were monitored as described in Section 2.2.2.1. Figures 2-5 and 2-6 show cumulative precipitation and barometric pressure variations during the bedrock pumping test. Approximately 0.13 inches of precipitation fell during the pumping test. The precipitation began approximately 18 hours after the pumping test began. Variations in barometric pressure did not appear to influence water levels in the background bedrock well (P-4A), as shown on Figure 2-6.

Groundwater levels in monitoring and background wells were monitored throughout the test as described in Section 2.2.2.1. Well P-4A was used to monitor background bedrock groundwater elevation fluctuations. Well P-4A and the bedrock pumping wells are both screened in shallow bedrock horizon, which is known from extensive drilling during the RI to be well-fractured. It was assumed that the background well was connected to the same fracture sets as the pumping wells on the Cianci Property, and therefore, that it provided representative background data. Due to the minor variations in background groundwater levels relative to drawdown induced by pumping, no background corrections were made to the bedrock observation well drawdown data.

Three groundwater samples were collected during the bedrock pumping test for assessment of water treatment options. Samples were shipped to the analytical laboratory for analysis of VOC, SVOC, priority pollutant metals, inorganics (hardness, dissolved and suspended solids, alkalinity, Fe, Mn), and water quality parameters (BOD, COD, TOC). Samples were collected from a port located near the pumping well. Samples were collected approximately every 24 hours after pumping started; the initial sample was collected 15 minutes into the test. These results are presented and discussed in Section 3.0.

2.2.3.2 Results and Discussion

The bedrock pumping test was performed to determine the size and shape of the drawdown cone, the sustainable well yield, and the effect of pumping the bedrock on the overburden aquifer. Order-of-magnitude bedrock transmissivity estimates were also obtained for the shallow bedrock.

Figure 2-16 provides a combined plot of drawdowns in bedrock monitoring wells that responded to pumping. A complete set of individual log-log and semi-log drawdown curves is included in Appendix E. Rates of drawdown in the bedrock monitoring wells decrease once precipitation begins. It is unclear if this apparent boundary effect is due to recharge from precipitation, contributions from the overlying overburden sediments, or a combination of these factors.

A plan-view map of hydraulic head in shallow bedrock near the end of the pumping test is presented in Figure 2-17. The spatial distribution of hydraulic head displayed in Figure 2-17 indicates a strong directional dependence (anisotropy) to the drawdown in the bedrock. This is reinforced by Figure 2-18 which is a plot of the log of distance from the pumping well versus drawdown. In an isotropic aquifer (an aquifer that does not demonstrate any preferential direction in drawdown) these data would plot as a straight line (e.g., Figure 2-13).

The strong directional dependence of drawdown demonstrated in Figures 2-17 and 2-18 can be evaluated by several theoretical approaches. These approaches fall into two general categories 1) assume the aquifer is an anisotropic, porous medium (i.e., the aquifer behaves as a continuum); and 2) assume that the aquifer is a discretely-fractured medium consisting of a single fracture or a network of fractures of more or less uniform characteristics. In some fracture flow models, the fracture network may drain a permeable rock matrix (dual porosity models). Since neither approach appears to fully represent the actual nature of the bedrock aquifer, and input data requirements for approach #2 are prohibitive, the approach taken here was to analyze the data as the aquifer was an anisotropic continuum.

Anisotropic behavior is observed when groundwater will preferentially flow in one direction (e.g. flow along (parallel to) vertical fractures rather than across them). This behavior is typically quantified by measuring the hydraulic conductivity parallel to the preferential flow direction and perpendicular to the preferential flow direction (i.e., the maximum and minimum hydraulic conductivities or the principal components of anisotropy). This type of analysis was used to determine the magnitude and orientation of the principal components of anisotropy in the New Haven Arkose.

A method proposed by Papadopulos (1965) was used to obtain transmissivity values. The results of the analysis indicate that the principal components of anisotropy (i.e. the direction of highest

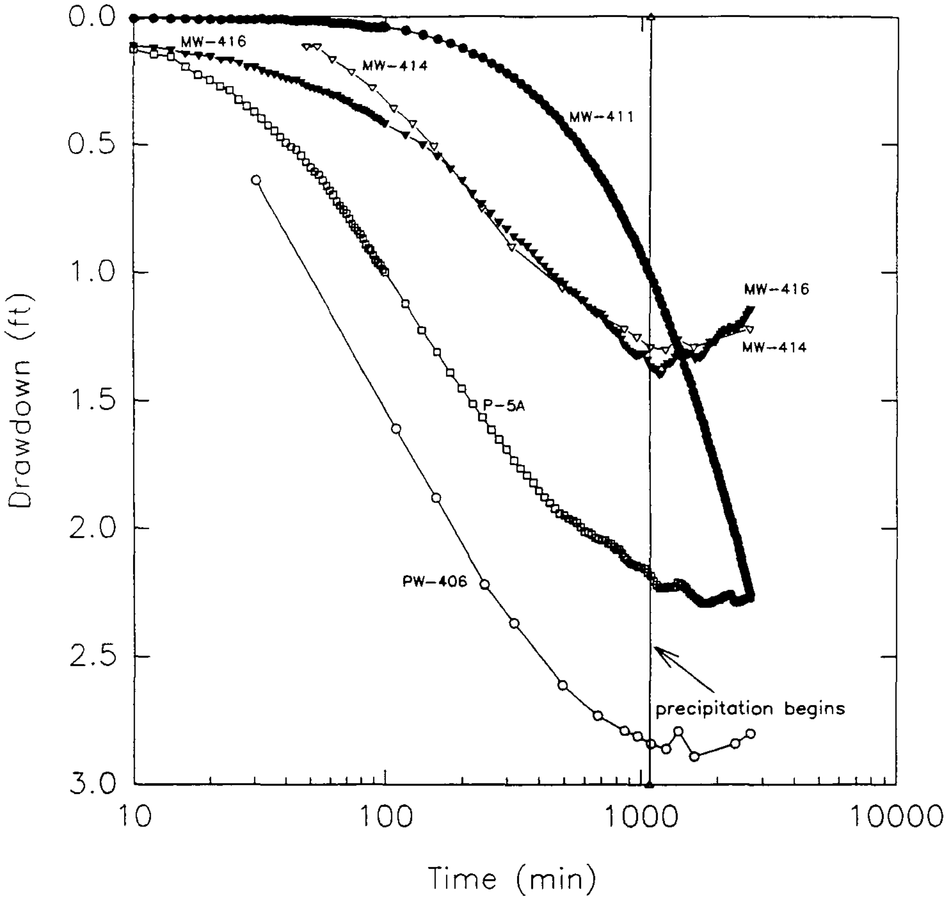
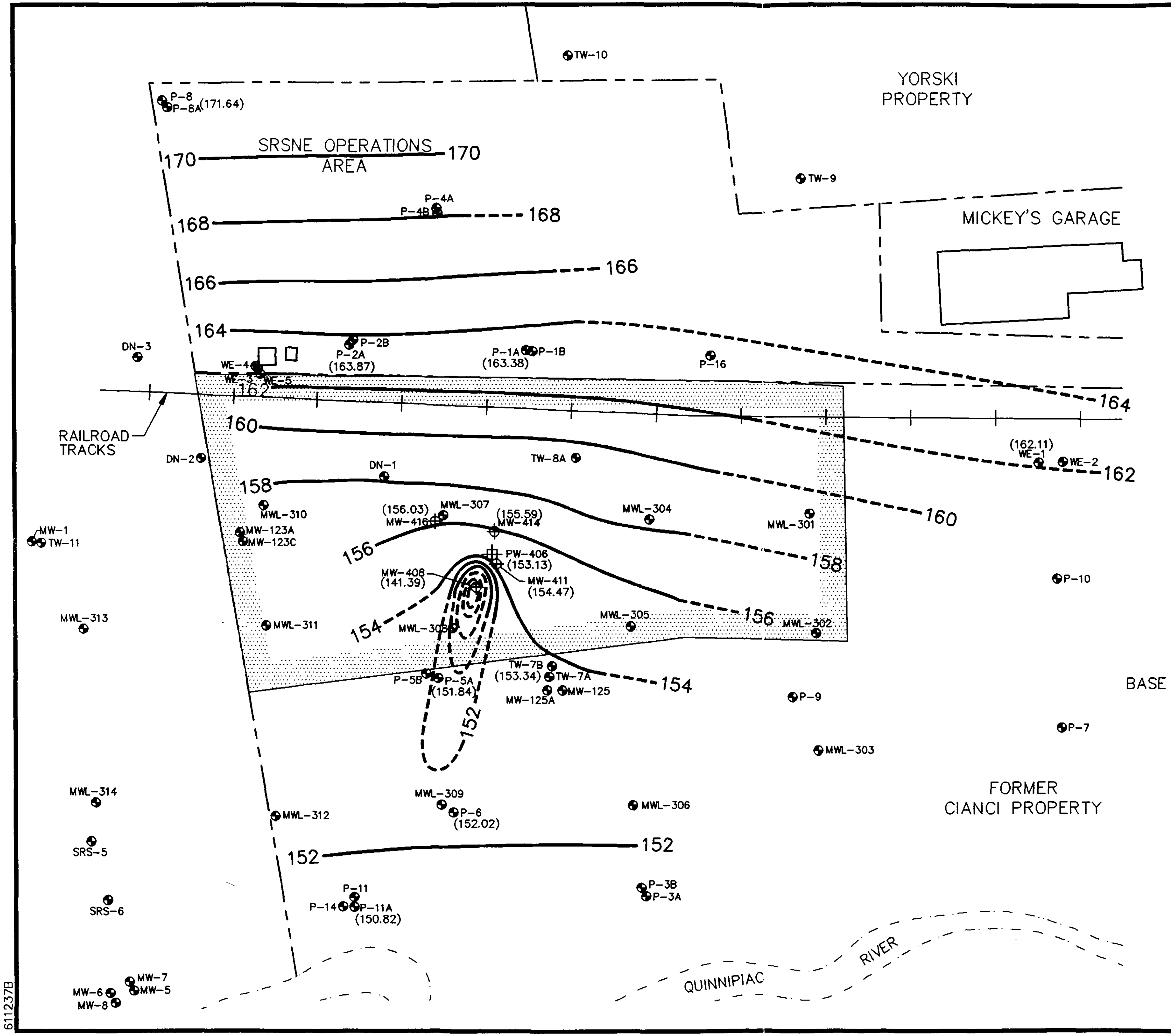


FIGURE 2-16

Drawdown in Bedrock Monitoring Wells,
Bedrock Pumping Test, April 11 - 13, 1994
SRSNE, Southington, CT



LEGEND

MWL-313 ⊕	EXISTING MONITORING WELL, PIEZOMETER, OR BORING LOCATION
(162.11)	GROUNDWATER ELEVATION (ft MSL)
⊕	ENSR OBSERVATION WELL
⊞	ENSR PUMPING WELL
▭	BUILDING
-------	PROPERTY LINE
▨	CONTAINMENT AREA

BASE MAP SOURCE: HNUS CORPORATION, NOVEMBER, 1993

DRAFT

80 0 80 160

SCALE IN FEET
1" = 80'-0"

ENSR CONSULTING & ENGINEERING

FIGURE 2-17
GROUNDWATER ELEVATION IN SHALLOW BEDROCK
BEDROCK PUMPING TEST (t=2400 min, (4/11-13/94)
SRSNE, INC.
SOUTHINGTON, CT

DRAWN BY:	DATE:	PROJECT NO.
J.E.B.	6/94	6112-002

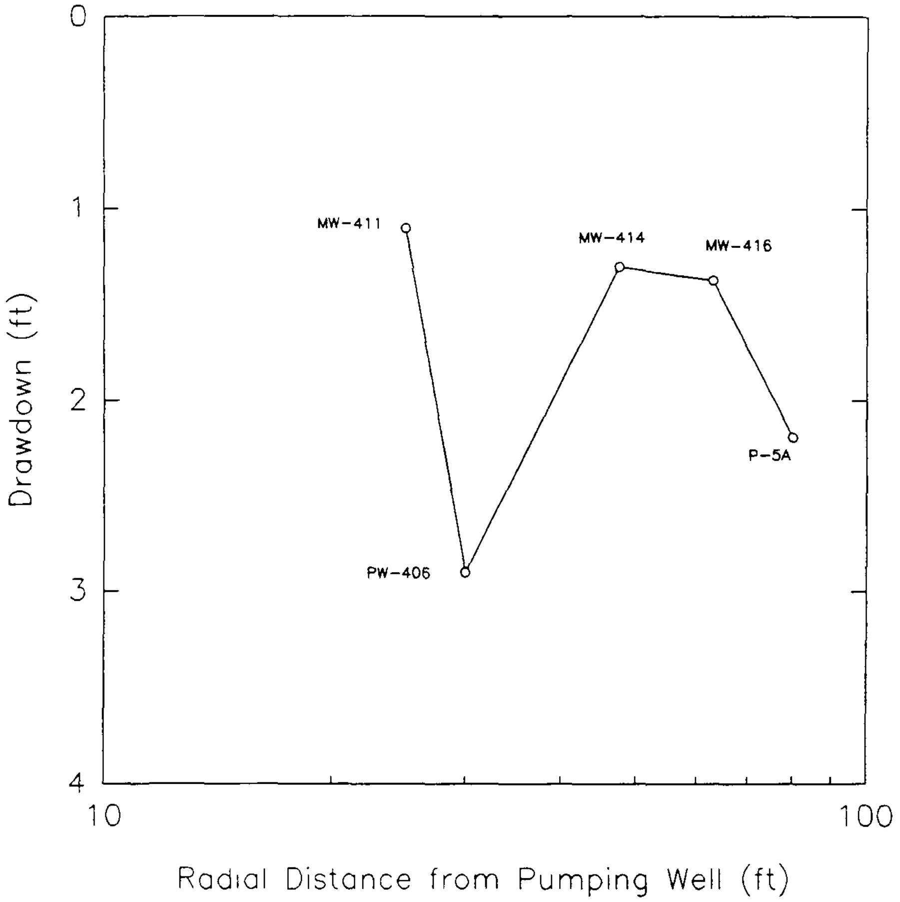


FIGURE 2-18
Distance-Drawdown Plot at t=1180 Minutes,
Bedrock Pumping Test, April 11 - 13, 1994
SRSNE, Southington, CT

and lowest transmissivity) are approximately 1,400 ft^2/day and 1.4 ft^2/day, respectively. The results of the analysis indicate that storativity of the bedrock is approximately 10^{-3}. The calculated direction of maximum hydraulic conductivity has an azimuth of 116 degrees from true north. These results are in very good agreement with the spatial pattern of drawdowns observed during the bedrock pumping test. The plotted bedrock drawdown cone appears to be oriented along an azimuth of approximately 100 degrees from true north (Figure 2-17).

The results of the analysis described above should be considered order-of-magnitude estimates of the directional variability in the bedrock aquifer's hydraulic properties because the theoretical approach is based on a simplified conceptual model being applied to a complex groundwater flow regime. However, the results provide insight into the nature of groundwater flow in the bedrock, and allow a mathematical evaluation of the magnitude and direction of preferential flow in the bedrock. This direction of preferential flow is probably parallel to the major water bearing fracture or set of fractures that appear to have been pumped during the bedrock test.

In addition to the directional dependency, the spatial variations in the drawdown data may indicate that the aquifer is also heterogeneous (the hydraulic characteristics of the bedrock vary with location). This is indicated by a comparison of drawdowns in MW-414 and P-5A. Both of these wells are located in similar locations with respect to the principal axis of preferential flow, however, MW-414 has approximately one-half the drawdown of P-5A even though MW-415 is significantly closer to the pumping well. These results are suggestive of heterogeneity, but the complexity of the groundwater flow in the bedrock and the limited number of bedrock monitoring wells make it difficult to draw definitive conclusions.

The extent of hydraulic connection between the overburden and shallow bedrock was evaluated using drawdown data collected from the overburden/bedrock well clusters located near the pumping well. The responses in the overburden/bedrock well clusters to bedrock pumping are provided in Figures 2-19 through 2-21. The clusters suggest there is spatially-variable interconnection between the outwash, till and shallow bedrock. In well cluster MW-410/MW-411/MW-412 (Figure 2-19), a strong response to the bedrock pumping test was observed in the till well, but the outwash well showed little or no response. In cluster MW-413/MW-414/MW-415 minor slope changes occurred in the two overburden observation wells and the companion shallow bedrock well (MW-414) after approximately 1000 minutes of pumping. In the outwash well (MW-409) nested with pumping well MW-408, a hydraulic response was not evident in the drawdown data. Vertical gradient data before and after pumping indicate that strong downward gradients from the overburden to bedrock were induced as a result of pumping. If both downward vertical gradients and evidence of hydraulic connection are present, then groundwater will flow downward from the overburden to the bedrock in response to pumping. When pumping bedrock, the strong directional dependence of drawdown in the bedrock due to the presence of discrete

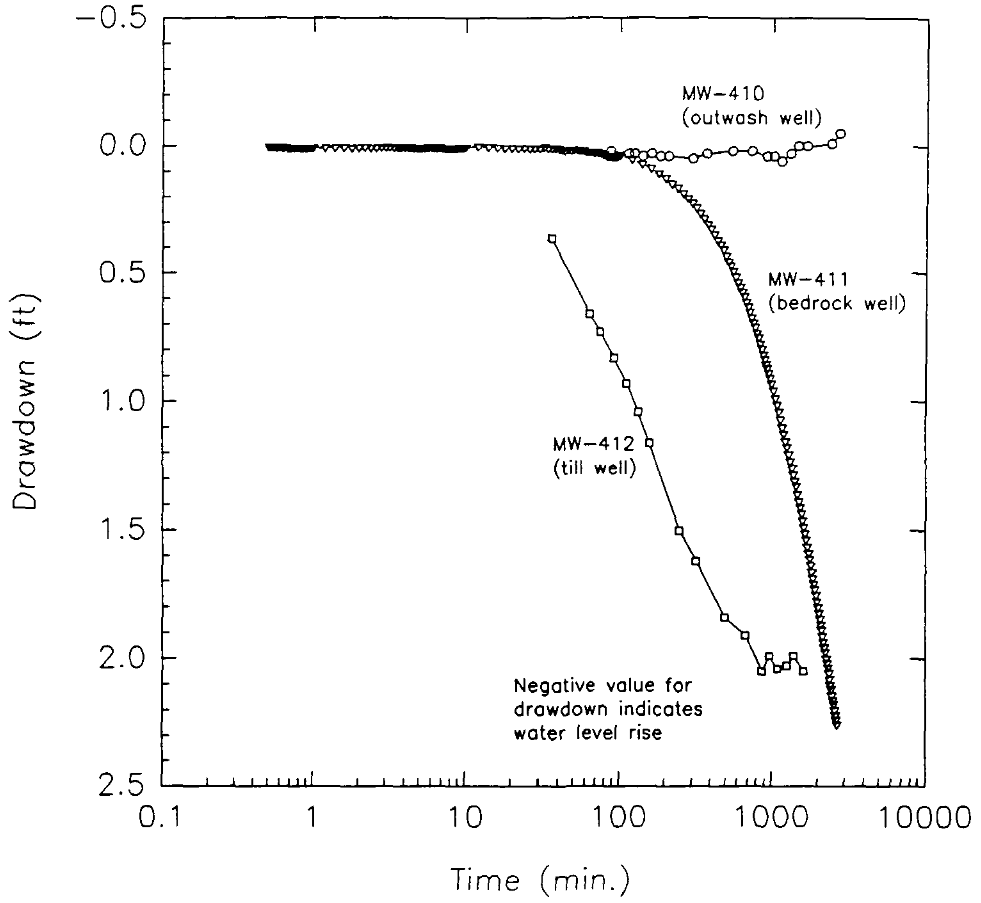


FIGURE 2-19

Drawdown in Well Cluster 14 - 25 Feet from Pumping Well,
Bedrock Pumping Test, April 11 - 13, 1994
SRSNE, Southington, CT

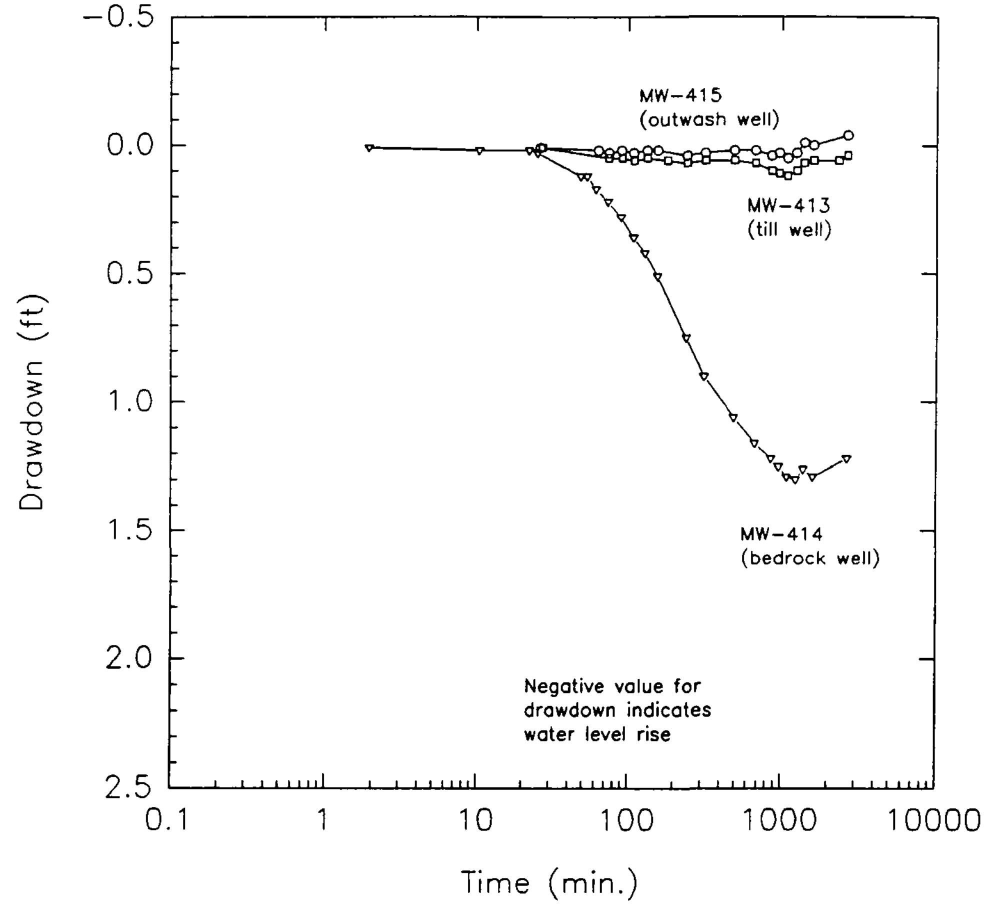


FIGURE 2-20

Drawdown in Well Cluster 48 Feet from Pumping Well,
Bedrock Pumping Test, April 11 - 13, 1994
SRSNE, Southington, CT

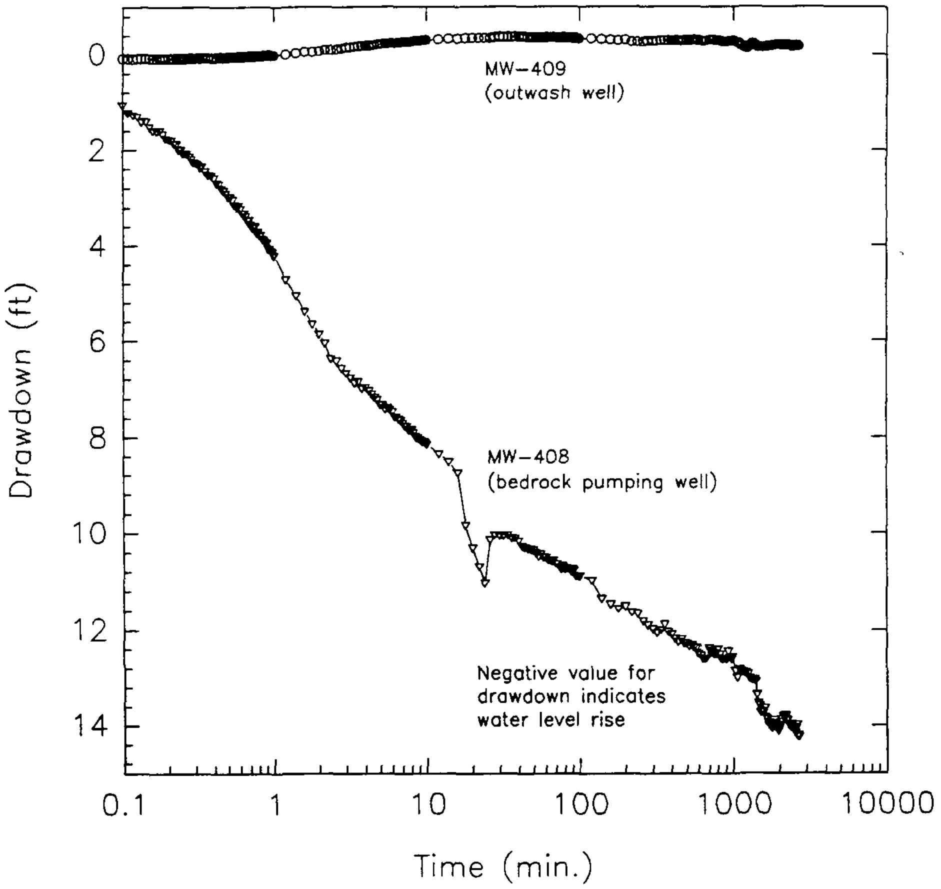


FIGURE 2-21
Drawdown in Well Cluster 0 - 7 Feet from Pumping Well,
Bedrock Pumping Test, April 11 - 13, 1994
SRSNE, Southington, CT

fractures will likely induce spatially-variable recharge from overburden occurs. Evidence of interconnection between aquifers during bedrock pumping is consistent with the results of the overburden pumping test where a similar result was obtained (see Section 2.2.2.2).

2.2.4 Slug Tests

2.2.4.1 Scope of Investigation

Slug tests were performed on ten wells located within the Containment Area to determine hydraulic conductivity. Six wells were located in the outwash unit (MWL-301, MWL-304, MWL-305, MWL-311, MW-123C, MW-410), two in the till unit (MW-412, MW-413), and two in the shallow bedrock (MW-408, MW-416). It should be noted that the presence of outwash at existing wells was assumed based on the elevation of the well screens. The purpose of the slug tests was to collect data on the variability in overburden hydraulic conductivity outside of the area investigated with the pumping test, and to obtain independent estimates of hydraulic conductivity on wells involved in the pumping tests. All wells listed in the Work Plan were slug tested as proposed, with the exception of bedrock well MW-123A because it was under flowing artesian conditions. An additional newly-installed shallow bedrock well (MW-416) was substituted for MW-123A.

Slug tests were performed by instantaneously displacing water in the well and measuring the rate of recovery using a Hermit datalogger. Solid teflon slugs (4 feet long by 1 inch diameter) or sand-filled PVC slugs (5 feet long by 1.3 inch diameter) were used to displace water. The slug was rapidly lowered into the well to provide falling head data, and then retrieved to provide rising head data. Data were analyzed with the Hvorslev method (Hvorslev 1951).

2.2.4.2 Results and Discussion

Slug test results are summarized in Table 2-3, and graphed falling and rising head data are included in Appendix F. The geometric mean hydraulic conductivity of the six outwash wells is 1.4 ft/day. The highest value was obtained from MW-410 (14 ft/day) and the lowest value from MW-123C (0.24 ft/day). Assuming the till and outwash comprise one overburden aquifer, the geometric mean of the overburden wells is 1.9 ft/day. Slug test hydraulic conductivity values from the two till wells (MW-412, MW-413) are within the range of outwash hydraulic conductivity values.

Slug tests provide information on the hydraulic conductivity of a small volume of the aquifer (i.e., the region just outside the sand pack) relative to pumping tests. Pumping tests provide values averaged over aquifer volumes defined by radial distances between observation wells and the

TABLE 2-3

Hydraulic Conductivity (Slug) Test Results
SRSNE, Southington, CT

Well	Lithologic Unit	Test	Hydraulic Conductivity (cm/s)	Average or Rising-Head Hydraulic Conducivity	
				(cm/s)	(ft/day)
MW123C	Outwash	Falling	7.6×10^{-5}	8.5×10^{-5}	0.24
		Rising	9.4×10^{-5}		
MWL301	Outwash	Falling	1.0×10^{-4}	1.2×10^{-4}	0.34
		Rising	1.3×10^{-4}		
MWL304	Outwash	Falling	n/a	2.0×10^{-3}	5.7
		Rising	2.0×10^{-3}		
MWL305	Outwash	Falling	3.3×10^{-4}	4.6×10^{-4}	1.3
		Rising	5.9×10^{-4}		
MWL311	Outwash	Falling	3.0×10^{-4}	3.2×10^{-4}	0.91
		Rising	3.4×10^{-4}		
MW410	Outwash	Falling	4.8×10^{-3}	4.8×10^{-3}	13.6
		Rising	4.8×10^{-3}		
MW412	Till	Falling	6.5×10^{-4}	7.8×10^{-4}	2.2
		Rising	9.0×10^{-4}		
MW413	Till	Falling	2.9×10^{-3}	3.1×10^{-3}	8.8
		Rising	3.3×10^{-3}		
MW408	Bedrock	Falling	n/a	8.3×10^{-4}	2.4
		Rising	8.3×10^{-4}		
MW416	Bedrock	Falling	n/a	6.2×10^{-5}	0.18
		Rising	6.2×10^{-5}		

- All tests analyzed using the Hvorslev method.

n/a - Not analyzed because erratic data obtained from falling head test.

pumping well. The effect of averaging over a larger volume may be to damp out some of the variability that is present at the slug-test scale. Despite the differences in scale, slug- and pumping-test values of hydraulic conductivity obtained for well MW-410 were in good agreement: K = 14 ft/day from slug test, K = 13 ft/day from pumping test, assuming an aquifer thickness of 25 feet.

Given the good agreement from MW-410, the slug test results obtained by ENSR were considered reasonably representative of the variability of overburden hydraulic conductivity within the Containment Area. The results from this investigation and slug test data collected by HNUS indicate that hydraulic conductivity will vary by a factor of at least 50 (this investigation), and possibly by as much as a factor of 10,000 (HNUS, Final RI, May 1994). Although the number of data points (eight wells) is limited, slug test results from this study indicate that the aquifer pumping test was performed in a relatively permeable region of the Containment Area.

2.2.5 Wetlands Study

2.2.5.1 Scope of Investigation

Three galvanized-steel piezometers with one-foot screens were installed in the drainage swale to the east of the B & M Railroad Right-of-Way, and the naturally-occurring wetland areas to the east of the Containment Area to assess the effects of the Containment System on the wetlands and floodplains which might be impacted by pumping. Locations of piezometers DP-417, DP-418, and DP-419 are shown on Figure 2-2. One potential impact of the Containment System would be to lower the water table elevation within the wetland areas. Other factors such as bedrock discharge, surface water runoff, precipitation, and seasonal variability add a significant level of complexity to the assessment.

Piezometers provide a direct measurement of the recharge/discharge condition in the wetlands, and potentially, on changes that occur in response to groundwater withdrawal. Water levels inside and outside the piezometer casings were measured periodically during the overburden pumping test. Casing elevations were surveyed so that water levels could be expressed in elevation relative to mean sea level. Water levels outside casings provided surface water elevations, while water levels inside casings provided groundwater elevations. The difference between water elevations indicates the vertical direction of water movement. When groundwater elevations are higher than adjacent surface water, groundwater is discharging to surface water. Hydrographs showing elevations of surface water and groundwater at each piezometer location are shown in Figures 2-22, 2-23, and 2-24.

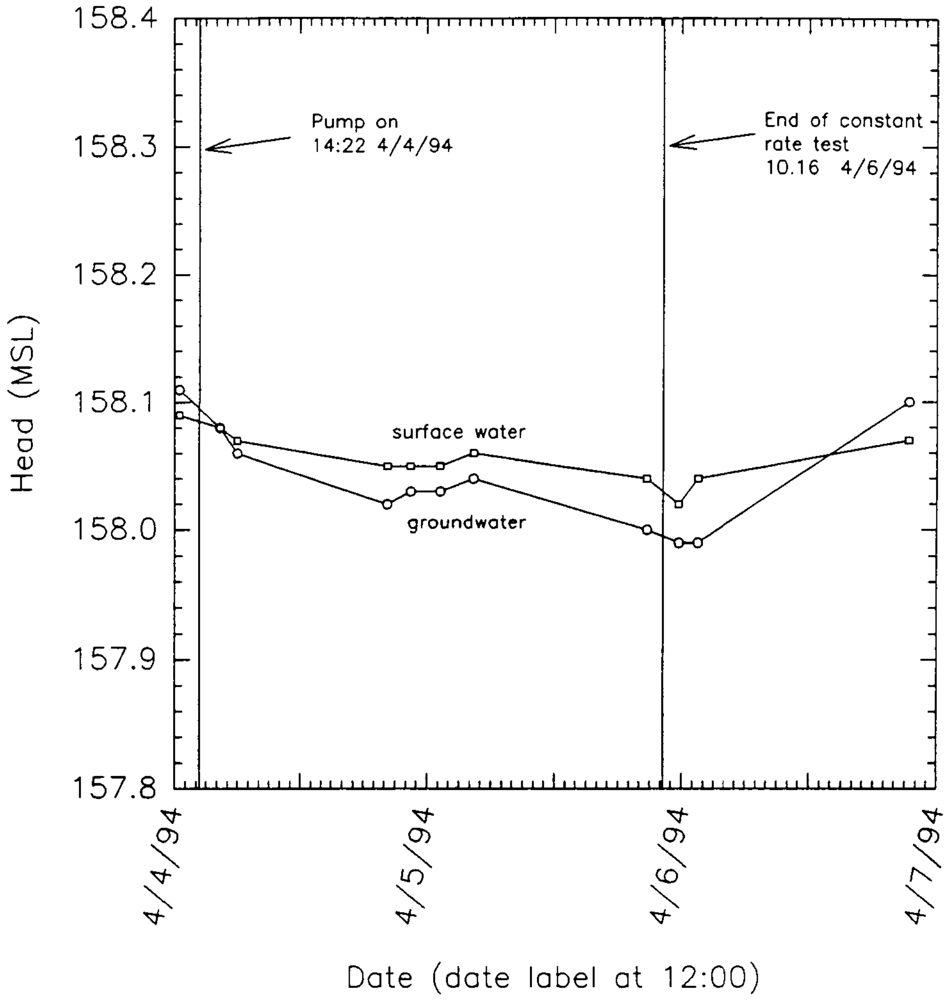


FIGURE 2-22
Water Elevations in Piezometer DP-417,
Overburden Pumping Test, April 4 - 7, 1994
SRSNE, Southington, CT

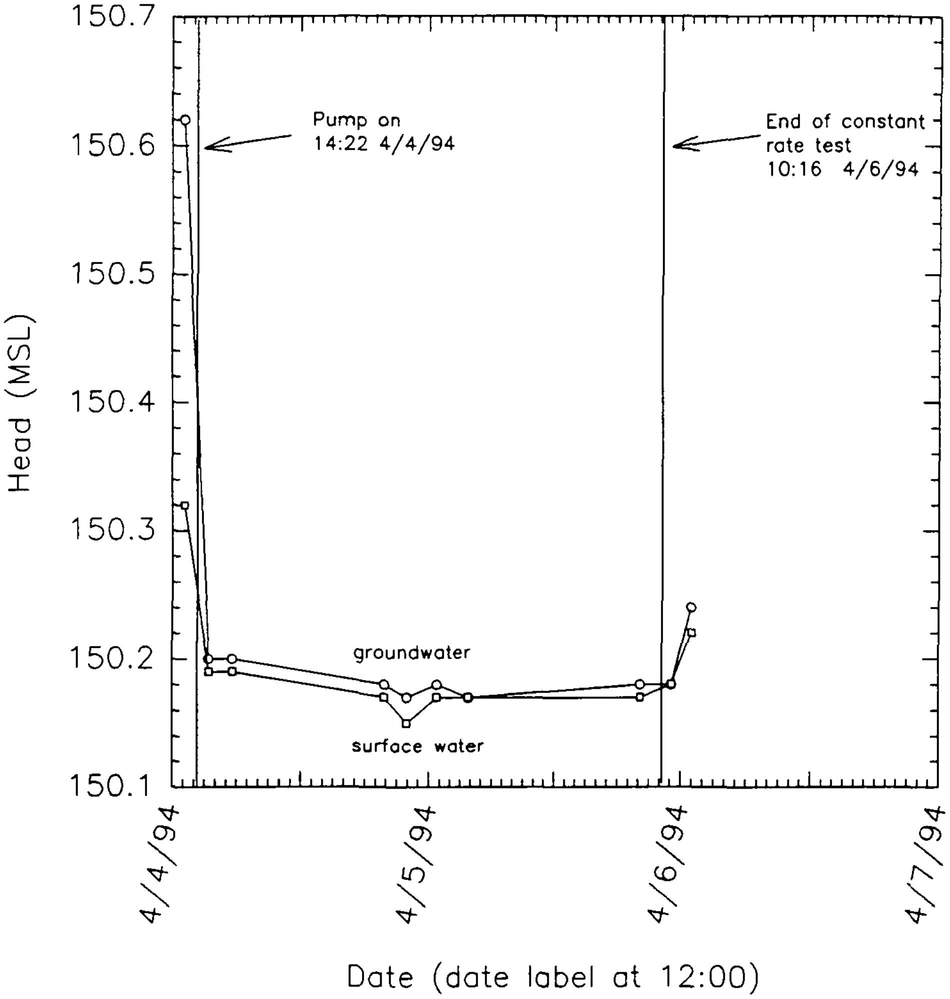


FIGURE 2-23
Water Elevations in Piezometer DP-418,
Overburden Pumping Test, April 4 - 7, 1994
SRSNE, Southington, CT

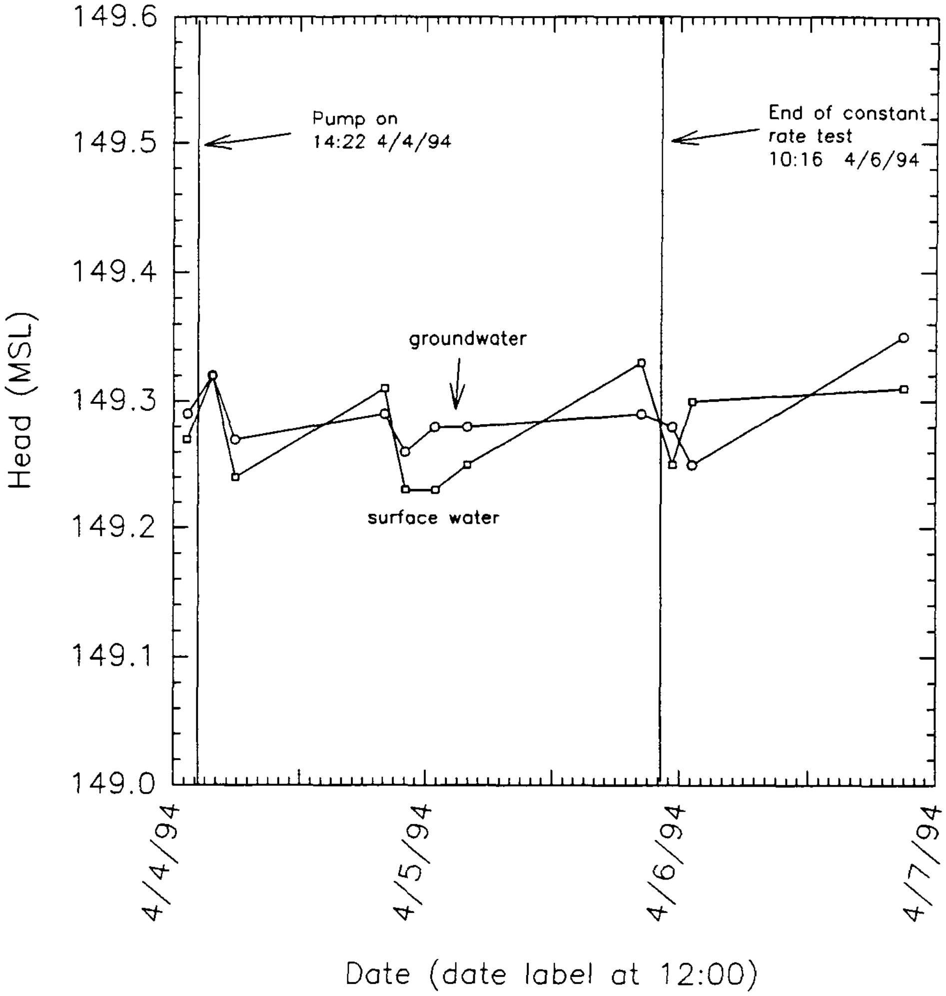


FIGURE 2-24

Water Elevations in Piezometer DP-419,
Overburden Pumping Test, April 4 - 7, 1994
SRSNE, Southington, CT

2.2.5.2 Results and Discussion

In piezometer DP-417, located in a drainage swale approximately 85 feet upgradient of pumping well PW-407 near a region mapped by HNUS as "Riparian Habitat", the groundwater elevation was greater than the surface water elevation prior to the test indicating groundwater discharge conditions. By the third measurement, after 218 minutes of pumping, groundwater had fallen below surface water indicating that a reversal of flow direction had occurred. This condition persisted throughout the constant rate test, suggesting that the cone of depression had reached this location. This would be consistent with the estimated size of the cone of influence (see Section 2.2.2.2). However, there is some uncertainty with this assessment because head differences were very small, and other factors such as regional groundwater fluctuations and precipitation could have affected elevations. It is not known whether the rate of induced flow would be sufficient to affect the performance of the full-scale Containment System.

In piezometers DP-418 and DP-419, the overburden pumping test did not have an observable impact on the wetlands adjacent to the Quinnipiac River. These piezometers were beyond the cone of depression of the pumping well.

2.2.6 Summary of Conclusions from Hydraulic Tests

Conclusions from the overburden pumping test, slug tests, and wetlands monitoring are summarized as follows:

- The overburden pumping well sustained a 1.6 gpm pumping rate with two feet of drawdown, for a specific capacity of 0.8 gpm/ft drawdown. As indicated by the inability of the well to sustain a rate of 2.8 gpm, the specific capacity decreased with depth.

- Based on time-drawdown curves, the overburden aquifer transmissivity within the cone of depression varied from 250 ft^2/day to 680 ft^2/day, with a geometric mean of 399 ft^2/day. Using a saturated thickness of 25 feet, the mean hydraulic conductivity was 16 ft/day.

- Both till wells responded to pumping and had transmissivity values similar to outwash wells, suggesting that the outwash/till system effectively responded to pumping as a single aquifer at these well cluster locations. Based on this study, the till is heterogeneous and does not act as a continuous confining layer within the former Cianci property. This heterogeneity, if present as relatively conductive zones throughout the Site, would reduce the significance of the Lower Till Window as a hydraulic boundary and major flow path between the overburden and bedrock aquifers.

- The measured pumping-well radius of influence was in the range of 60 to 90 feet, and the cone of depression was symmetrical about the pumping well.

- Recharge boundary effects were observed in the drawdown data after 200 to 1,000 minutes of pumping. These effects may be due to recharge from the drainage swale on the east side of the B & M Railroad, recharge from the bedrock aquifer, or a combination of the two.

- Evidence of interconnection between the overburden and bedrock aquifers was obtained. Hydraulic responses were observed in the shallow bedrock wells and strong upward vertical hydraulic gradients were induced during the test.

- Slug tests performed in this investigation suggested that overburden hydraulic conductivity varied by a factor of 50 within the Containment Area. The spatial distribution of hydraulic conductivity values suggested that the pumping test was performed in a relatively permeable area. Values for the two till wells fell within the range of outwash hydraulic conductivity values.

- Wetlands monitoring suggested that pumping well effects (i.e., induced recharge to groundwater) may have been observed in the drainage swale east of the B & M Railroad. Effects were minor and could have been the result of other factors. No effects were observed at the two monitoring stations located in the naturally-occurring wetlands adjacent to the Quinnipiac River.

Conclusions from the bedrock pumping test are summarized as follows:

- Plan-view maps of drawdown in bedrock monitoring wells at the end of the bedrock pumping test and distance-drawdown plots indicate there is a strong directional dependence of drawdown in the bedrock monitoring wells. Fracture flow in the bedrock appears to be the cause of this directional dependency.

- If the directional dependence is assumed to be due to anisotropy, data analysis results in an aspect ratio (ratio of the two principal components of anisotropy) of approximately 1000, from 1,400 ft^2/day to 1.4 ft^2/day.

- The bedrock response to the pumping test indicates that the hydraulic properties of the bedrock are not homogeneous.

- Evidence of interconnection between the overburden and bedrock aquifers was obtained from bedrock pumping. The interconnection between the bedrock and the overburden appears to be spatially-variable, with a strong pumping response observed in one till well, and a lesser response observed in the other till well and outwash wells. A strong downward vertical hydraulic gradient from the overburden to the bedrock was induced above the pumping well as a result of bedrock pumping.

2.3 Conceptual Containment System Design

The field investigation produced several findings that impact the design of the overburden groundwater containment system. These findings relate to the geologic characteristics of the overburden and bedrock, the nature and distribution of contaminants in the Containment Area, and the hydraulics of groundwater flow in the Containment Area. The Containment Area as defined by EPA is shown on Figure 2-2. Based on the results of this field investigation and historical water elevation data presented in the Final RI, a conceptual design has been developed for an overburden groundwater containment system in the Containment Area.

The recommended design of the containment system was based on an evaluation of technical feasibility, construction requirements, air emissions control during construction, disposal of excavated material, and system operation and maintenance requirements. As summarized below, hydraulic testing performed during this investigation indicated that installation of a line of extractive wells would be technically feasible. An interceptor trench, although technically feasible as well, has significant construction, air emission control, and excavated-material disposal requirements associated with installation relative to extraction wells. The conceptual containment system design focuses, therefore, on the design and installation of a line of extraction wells.

In Section V.A.3.b of the SOW, it is stated that the SRSNE PRP Group shall indicate whether the boundaries of the Containment Area should be expanded to achieve the Performance Standards for the groundwater containment system. Based on the data collected during this investigation, the Containment Area does not need to be expanded beyond the area shown in Figure 2-2 of this volume.

Section V.A.3.b of the SOW also states that the SRSNE PRP Group may propose, for EPA approval, an adjustment to the 30-day Compliance Period for the groundwater containment system set forth in Section IV.B.3 of the SOW. Although it is not certain at this time whether such an adjustment will be needed, the SRSNE PRP Group may prepare such a proposal for EPA approval in the Demonstration of Compliance Report, in accordance with Section V.A.3.c.ii of the SOW.

2.3.1 Summary of Hydraulic Test Results

The slug and pumping tests demonstrated that the hydraulic properties of the till unit are similar to the outwash unit. This indicates that the till is not acting as a continuous confining layer within the area of pumping influence. Field observations and field GC work indicated that contaminated groundwater is currently transported through the till layer. Consequently, wells could be screened across the outwash and the till to maximize available drawdown and well yield without increasing the potential for mobilization of contaminants to the bedrock by breaching a confining layer.

The results of the overburden pumping test indicated that the radius of influence of the overburden pumping well was in the range of 60 to 90 feet. The overburden pumping well sustained a pumping rate of 1.6 gallons per minute during the initial portion of the pumping test, which produced a specific capacity of 0.8 gpm/ft drawdown. However, an increased pumping rate of 2.8 gpm could not be sustained. The decrease in specific capacity with depth is probably due to the stratified nature of the overburden aquifer. The geometric mean transmissivity of the overburden measured during the pumping test was 399 ft^2/day.

The results of slug testing at the site indicated hydraulic conductivity in the tested wells varied by a factor of 50 with a geometric mean value of 1.9 ft/day. This value is roughly one order of magnitude lower than the value obtained from the pumping test. The RI slug-test data show a four order-of-magnitude variation in hydraulic conductivity. The lower results for the slug tests could be related to variability in the subsurface (i.e., the pumping test was performed in an area of high hydraulic conductivity) or to biases inherent in slug testing (e.g. slug tests only test a small volume of the aquifer where pumping tests sample a much larger volume in which an averaged response from low and high conductivity material is present), or a combination of the two. These observations imply that the subsurface in the Containment Area is variable, and that the variability should be taken into consideration during the detailed design and installation phases of the groundwater containment system.

On the basis of the two pumping tests, there is spatially-variable interconnection between the overburden and bedrock aquifers. Some bedrock wells responded to overburden pumping, and some overburden wells responded to bedrock pumping (see Section 2.2). In some locations, pumping the overburden aquifer would be expected to induce upward flow from the shallow bedrock beneath the pumping wells. If the contribution of flow from bedrock is sufficiently high, the performance of the overburden containment system during the dry summer and fall months, when the saturated thickness of the overburden aquifer is reduced, would be improved.

The Final RI Report indicates that overburden groundwater elevations varied over 3.5 feet between August 1991 to present in well P-5B (located on the former Cianci Property). Other data presented in the RI are consistent with these observations. For purpose of conceptual system design, water levels at the site are conservatively assumed to vary by approximately seven feet over the design life of the system. The maximum water table elevation was taken as the elevation of the ground surface, and the minimum water table elevation as occurring seven feet below grade. Water elevation fluctuations will affect the transmissivity of the overburden aquifer, and consequently, fluctuations will potentially affect design elements such as well yields and radii of influence. As with the spatial variability of the hydraulic properties of the overburden aquifer, the expected fluctuations in water elevations need to be taken into consideration in the detailed design of the system.

2.3.2 Containment System Design Elements

The conceptual groundwater containment system consists of a line of pumping wells located in the central to eastern portions of the Containment Area. Locating the wells further east would provide some additional aquifer thickness which may influence the well spacing and the pumping rates of individual wells. However, vertical groundwater gradients have been observed in the vicinity of the Lower Till Window identified by HNUS. Assuming that vertical gradients will cause changes in the flow field behind the containment system and interfere with the demonstration of compliance, a primary design criterion will be to design and locate the system to minimize the effects of vertical groundwater flow.

Based on the results of the slug tests and the pumping test, preliminary estimates of radii of influence and well yields were developed. In all cases, Theis-based equations were used to evaluate pumping rates, drawdowns, and radii of influence. Additional assumptions include the assumption that the aquifer is homogeneous, isotropic and of constant thickness, and that the aquifer receives no recharge from precipitation or bedrock. In addition, the effects of regional horizontal and vertical groundwater gradients were not considered. Based on the complexities of the subsurface in the area of the containment system, the results should only be relied on for order-of-magnitude estimates of the system parameters. Additional containment system design evaluations should be performed during the design phase of the containment system.

Four cases were evaluated in this conceptual design analysis. These cases are intended only to bracket the possible pumping responses based on the results of the hydraulic testing, and estimate the possible range in designs. In the first three cases, hydraulic conductivity variations observed in the Containment Area were assessed, and in the fourth case, the effect of moving the containment system further east was evaluated. For the first three cases a minimum aquifer thickness of 18 feet was used. This value was based on a 25-foot depth to bedrock with a water table elevation seven feet below the ground surface. In all cases available drawdown in the well was estimated assuming a 10-foot fully-saturated screen located at the bottom of the well.

Available drawdown was estimated to be 75% of the distance between the water table and the top of the screen to avoid dewatering the well screen. Well yields were estimated assuming a constant specific capacity. Based on the performance of overburden pumping well PW-407, the assumption of constant specific capacity may overestimate actual well yields. Radius of influence estimates were obtained using assumed values for the specific yield, and the time required for the drawdown cone to reach steady state. Estimates of radii of influence and well yields were made assuming low water-table conditions. The low water-table assumption provides the limiting condition for estimating well spacings across the range of hydraulic conductivity variation (i.e., cones of depression will shrink when the saturated thickness of the aquifer declines).

The most conservative case (Case 1) assumed a hydraulic conductivity equal to the geometric mean of the slug tests (1.9 ft/day), the second case assumed an average hydraulic conductivity from both the slug tests and the pumping tests (9 ft/day), and the third case assumed the geometric mean conductivity measured during the overburden pumping test (16 ft/day). The fourth case evaluated the effect of moving the system approximately 50 feet to the east where the bedrock is approximately 30 feet below the ground surface (in comparison to 25 feet in the first three cases). The hydraulic conductivity assumed in Case 4 was 9 ft/day. The results of these calculations are presented in Table 2-4.

The above information provides the range of hydraulic responses that are reasonably anticipated to be present in the Containment Area. Case 1 probably represents a worst case scenario in which the overburden aquifer provides little water across much of the Containment Area. Cases 2 and 3 are considered the most reasonable cases. Case 2 is expected to be a conservative but reasonable estimate. Case 3 is based on the results of the overburden pumping test, and therefore, this case rests upon the best empirical data (measured pumping responses in the aquifer). It should be noted, however, that the hydraulic conductivity value obtained from the pumping test was the upper end of the measured range (see Section 2.2.2.2). Case 4 indicates that well yields will increase due to the increase in available drawdown.

The data gathered during the hydraulic testing as presented in Table 2-4 will be used during the design of the NTCRA containment system to determine well spacings, number of wells, and the expected total groundwater discharge rate. It is anticipated that the due to the heterogeneity observed at the site, the range of characteristics that are identified in Table 2-4 will be encountered.

Pumping well construction details and other system specifications are contingent upon the final design (including location) of the containment system. The following well construction details are recommended for consideration to optimize system performance and minimize operation and maintenance (O&M) costs:

TABLE 2-4

Conceptual Containment System Design Results

Case	Hydraulic Conductivity (ft/d)	Aquifer Thickness (ft)	Radius of Influence[1] (ft)	Total Discharge of Well (gpm)
1	2	18	15	1
2	9	18	30	3
3	16	18	40	6
4	9	23	35	7

[1] Based on an assumed specific yield of 0.15 and 10 days of pumping.

- Wells should be screened across the outwash and till;
- Wells should be constructed of stainless-steel, continuous-slot well screens, and stainless-steel or PVC riser pipe;
- Wells screens should be sized and located to minimize the possibility of dewatering the well screen;
- Sand packs should be extended up as high as feasible to facilitate collection of overburden groundwater above the well screen, and be sized to minimize silt production;
- Individual pumps and controllers should be installed in each well; and
- All system components, including wells, valves, flowmeters, and pumps, and effluent piping, should be selected and designed to accommodate periodic O&M activities.

3.0 GROUNDWATER TREATMENT

The following sections present the results of evaluations of several treatment technologies that are potentially capable of treating groundwater recovered during the Non-Time Critical Removal Action (NTCRA) at the SRSNE Superfund Site in Southington, CT. These technologies include the enhanced oxidation technology that is used in the current on-Site treatment system, and alternative organic removal processes including biodegradation, air stripping, and activated carbon adsorption. General descriptions of these treatment technologies are provided in the EE/CA document. The following evaluations are more detailed than the EE/CA, based on tests using samples from the Site or data from these samples. These site-specific evaluations include: treatability testing using bench scale systems for metals removal, biodegradation, and enhanced oxidation; vendor modeling data to evaluate the air stripping process; and aquatic bioassay tests to evaluate the effects of treated effluent on plants, animals, and crustaceans.

Treatability tests have been performed by Diversey Technologies, Parkson Corporation, and ENSR in order to evaluate pre-treatment for metals removal by chemical addition and clarification. Vulcan Peroxidation Systems, Inc. (VPSI) and SolarChem Environmental Systems, Inc. (SolarChem) have performed testing to evaluate the effectiveness of enhanced oxidation. VPSI is the manufacturer of the enhanced oxidation unit operated in the current onsite treatment system, which also includes pre-treatment for metals removal and post-treatment by activated carbon adsorption. An on-going biodegradation treatability study is being performed by AlliedSignal, Inc. in order to evaluate the costs and effectiveness of this technology. Finally, ENSR contacted North East Environmental Products to obtain a modeling evaluation for their air stripping systems.

The information presented in this section of the report was developed to satisfy the SOW requirements for providing U.S. EPA with sufficient information for selecting a groundwater treatment system for the NTCRA. Design assumptions and data used for these investigations are summarized in Section 3.1, and results of the investigations are presented in Section 3.2. Discharge options for treated groundwater are summarized in Section 3.3. The groundwater treatment technologies are assembled into three potential groundwater treatment alternatives in Section 3.4, and the relative costs and implementability of each alternative is identified and discussed. Section 3.5 presents possible locations for constructing the treatment system.

3.1 Background

The performance requirements for the NTCRA treatment system will be based on the information collected during the containment system investigations described in Section 2.0 above, and on other information regarding contaminant concentrations and potential discharge limits for treated groundwater. The data and assumptions which were used for evaluating treatment technologies are presented in the following subsection.

3.1.1 Estimated Flow

Based on the results of the slug tests and the pump test, estimates of volumes of groundwater that will be recovered by the containment system have been made. In all cases, Theis-based equations were used to evaluate pumping rates, drawdowns, and radii of influence. Assumptions include 1) the aquifer is homogeneous, isotropic and of constant thickness; 2) there is no recharge from precipitation or bedrock; 3) steady flow conditions are achieved after 10 days of pumping. These assumptions do not completely match the Site characteristics described in Section 2.0, but allow some preliminary estimates of system parameters to be made. In addition, the effects of regional horizontal and vertical groundwater gradients were not considered. Based on the complexities of the subsurface in the area of the containment system and the preliminary nature of these design calculations, the results should only be relied on for preliminary estimates of the system parameters. ENSR estimated that the recovery system will produce 15 gpm for low water table conditions (i.e., water tables 7 feet below ground surface) and 30 gpm for high water table conditions (i.e., water table at ground surface).

3.1.2 Concentrations of Contaminants

Due to the expedited schedule of the NTCRA investigations, it was necessary to collect treatability study influent water samples during several different sampling events. The first samples were collected before pump test wells were installed or aquifer tests were performed. Existing monitoring well TW-8A was selected for this sampling, in part based on its location and the results of analyses of samples collected by U.S. EPA during the RI. The well is located within the Containment Area, between the Operations Area and the pumping test location. The analytical results collected by U.S. EPA indicated that the types and concentrations of inorganic and organic constituents were representative of average concentrations measured in the Containment Area.

On March 16, 1994, samples were collected from TW-8A for the biodegradation and enhanced oxidation treatability studies. Approximately 100 gallons of water was purged from the well prior to collection of the treatability study samples. Water samples were analyzed onsite using the field gas chromatograph (GC), and a sample was sent offsite for analysis at an analytical laboratory.

Comparison of field GC analyses for samples collected at the start and end of sampling indicated that the concentrations of monitored constituents increased by as much as an order of magnitude during the sampling event. In addition to increases in chemical concentrations, water level in the well was higher at the end of sampling than at the start. The water level effects are most likely attributable to groundwater recharge through snowmelt during this sampling. Concentrations of detected compounds from laboratory analysis of the sample from TW-8A, which was collected approximately half-way through the sampling event, are presented in Table 3-1. No PCBs were detected in this sample, at detection limits of 0.001-0.002 mg/l. Field GC results and complete laboratory results are provided in Appendix G.

The contaminant concentrations in TW-8A were also used for evaluation of air stripping by modeling by an air stripper vendor. These data were used to be consistent with the evaluations of other organic removal technologies, which were conducted using samples from TW-8A as described above.

Groundwater produced from the pump test is also expected to be representative of groundwater that will require treatment under the NTCRA, since the pump tests produced a relatively large sample of groundwater from the center of the Containment Area. Concentrations of detected compounds in pump test effluent samples collected during the overburden and bedrock pumping tests are summarized in Table 3-1. Laboratory detection limits were somewhat lower for the pump test effluent samples compared to the sample from TW-8A, due to the higher levels of contaminants in the latter. The precipitant and polymer screening discussed in Section 3.2.1.2 was performed on pumping test effluent water collected on April 7, 1994. Complete laboratory results for the pump test samples are provided in Appendix G.

Precipitant and polymer optimization studies were performed on raw water samples collected from MW-415 on April 28 and 29, 1994. MW-415 was used because it was the closest 2-inch diameter overburden well to the overburden pumping test well. Three well volumes were removed from the well prior to collecting the treatability study water. Use of a 2-inch well significantly reduced the purge volume required. The results of metals analyses for treated and untreated samples from the jar tests are provided in Section 3.2.1.2.

Dissolved oxygen levels were measured with a field test kit for all groundwater samples used for treatability testing. No dissolved oxygen levels above the 1 ppm detection limit were measured in these samples.

TABLE 3-1

Analytical Results for TW-8A and Pump Test Effluent Samples (ppm)
SRSNE, Southington, CT

Analytical Parameters		Overburden Pump Test Effluent				Bedrock Pump Test Effluent			
	Sample ID:	C407A	C407B	C407C	C407D	C408A	C408B	C408C	TW-8ATS
	Date Collected:	04/04/94	04/05/94	04/06/94	04/07/94	04/11/94	04/12/94	04/13/94	03/14/94
	Date Analyzed:	04/18/94	04/18/94	04/18/94	04/18/94	04/18/94	04/18/94	04/18/94	03/16/94
VOLATILES									
Vinyl Chloride		1.2	1.3	1.2	1.1	0.76	1.6	1.1	9.2
Chloroethane		0.22 J	0.28 J	0.19 J	0.16 J	1.5	1.2	0.72	0.85
Acetone		1.2	1.8	0.62 U	0.62 U	6.0	12.0	10.0	4.1
1,1-Dichloroethene		0.25	0.25 J	0.18 J	0.20 J	0.23 U	0.37 U	0.38 U	2.0 U
1,1-Dichloroethane		0.35	0.53	0.61	0.53	0.23 U	0.37 U	0.38 U	2.1
Tetrahydrofuran		0.11 J	0.26 J	NA	NA	4.6	3.3	2.5	0.36 J
total-1,2-Dichloroethene		6.1	10.0 E	10.0	8.5	1.6	1.5	0.97	37.0
1,2-Dichloroethane		0.25 U	0.056 J	0.31 U	0.31 U	0.23 U	0.37 U	0.38 U	2.0 U
2-Butanone		4.0	6.5	5.9	5.7	4.4	12.0	9.5	11 0
1,1,1-Trichloroethane		1.1	1.8	2.0	2.2	0.13 J	0.37 U	0.38 U	3.0

TABLE 3-1 (Cont'd)

Analytical Results for TW-8A and Pump Test Effluent Samples

Analytical Parameters		Overburden Pump Test Effluent				Bedrock Pump Test Effluent			
	Sample ID:	**C407A**	**C407B**	**C407C**	**C407D**	**C408A**	**C408B**	**C408C**	**TW-8ATS**
	Date Collected:	**04/04/94**	**04/05/94**	**04/06/94**	**04/07/94**	**04/11/94**	**04/12/94**	**04/13/94**	**03/14/94**
	Date Analyzed:	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**03/16/94**
Trichloroethene		0.3	0.44	0.52	0.46	0.23 U	0.37 U	0.38 U	0.57 J
Benzene		0.25 U	0.25 U	0.31 U	0.31 U	0.074 J	0.0072 J	0.38 U	2.0 U
4-Methyl-2-Pentanone		0.54	0.95	1.2	1.1	2.7	3.6	3.9	3.4
Tetrachloroethene		0.25 U	0.25 U	0.31 U	0.097 J	0.23 U	0.37 U	0.38 U	2.0 U
Toluene		6.7	7.1	6.5	5.9	6.7	8.0	8.6	23.0
Ethylbenzene		3.3	3.7	3.0	2.7	3.9	3.6	3.8	5.5
Xylenes (total)		3.0	2.6	2.2	2.0	1.6	2.0	2.1	9.1
SEMIVOLATILES								43	
4-Methylphenol		0.010 U	0.010 U	0.020 U	0.020 U	NA	NA	0.021 J*	0.040 U
2,4-Dimethylphenol		0.010 U	0.010 U	0.020 U	0.020 U	NA	NA	0.016 J*	0.040 U
Isophorone		0.006 J	0.009 J	0.009 J	0.008 J	NA	NA	0.020 U	0.034 J
1,2,4-Trichlorobenzene		0.006 J	0.006 J	0.006 J	0.005 J	NA	NA	0.020 U	0.010 J

TABLE 3-1 (Cont'd)

Analytical Results for TW-8A and Pump Test Effluent Samples

Analytical Parameters		Overburden Pump Test Effluent				Bedrock Pump Test Effluent			
	Sample ID:	**C407A**	**C407B**	**C407C**	**C407D**	**C408A**	**C408B**	**C408C**	**TW-8ATS**
	Date Collected:	**04/04/94**	**04/05/94**	**04/06/94**	**04/07/94**	**04/11/94**	**04/12/94**	**04/13/94**	**03/14/94**
	Date Analyzed:	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**03/16/94**
Naphthalene		0.027	0.026	0.024	0.021	NA	NA	0.017 J	0.045
2-Methylnaphthalene		0.003 J	0.003 J	0.004 J	0.004 J	NA	NA	0.001 J	0.007 J
Di-n-Butylphthalate		0.004 J	0.002 J	0.002 J	0.002 J	NA	NA	0.002 J	0.040 U
Bis(2Ethylhexyl)Phthalate		0.010 U	0.010 U	0.002 J	0.020 U	NA	NA	0.020 U	0.040 U
Diethylphthalate		0.010 U	0.010 U	0.020 U	0.020 U	NA	NA	0.028	0.003 J
ALCOHOLS									
Ethanol		NA	NA	NA	NA	NA	NA	NA	0.25 U
Methanol		NA	NA	NA	NA	NA	NA	NA	1.0
2-Butanol		NA	NA	NA	NA	NA	NA	NA	4.2
2-Propanol		NA	NA	NA	NA	NA	NA	NA	2.0

TABLE 3-1 (Cont'd)

Analytical Results for TW-8A and Pump Test Effluent Samples

Analytical Parameters		Overburden Pump Test Effluent				Bedrock Pump Test Effluent			
	Sample ID:	**C407A**	**C407B**	**C407C**	**C407D**	**C408A**	**C408B**	**C408C**	**TW-8ATS**
	Date Collected:	**04/04/94**	**04/05/94**	**04/06/94**	**04/07/94**	**04/11/94**	**04/12/94**	**04/13/94**	**03/14/94**
	Date Analyzed:	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**04/18/94**	**03/16/94**
METALS									
Arsenic		0.011	0.011	0.010	0.01	0.003	0.003	0.002	0.008
Chromium		0.006	0.005	0.009	0.006	0.006	0.003	0.002	0.02
Copper		0.004	0.004	0.004	0.004	0.008	0.004	0.004	0.003
Iron		23.2	24.5	27.0	26.0	17.6	24.8	23.7	43.2
Lead		0.0006 U	0.00059 U	0.00082	0.0006 U	0.00098	0.00059 U	0.0006 U	0.00089 U
Manganese		5.39	5.53	5.46	5.43	6.60	9.89	9.57	5.31
Mercury		0.00003 U	0.00003 U	0.00003 U	0.00003 U	0.00004	0.00006	0.00003 U	0.00006
Nickel		0.004 U	0.004 U	0.004 U	0.004 U	0.007	0.004 U	0.004 U	0.004 U
Selenium		0.002	0.001	0.001	0.002	0.002	0.001 U	0.001	0.001 U
Zinc		0.003	0.002	0.006	0.002	0.010	0.018	0.034	0.002
Cyanide		0.006	0.005	0.005 U	0.005 U	0.005 U	0.005 U	0.005 U	NA

TABLE 3-1 (Cont'd)

Analytical Results for TW-8A and Pump Test Effluent Samples

Analytical Parameters		Overburden Pump Test Effluent				Bedrock Pump Test Effluent			
	Sample ID:	C407A	C407B	C407C	C407D	C408A	C408B	C408C	TW-8ATS
	Date Collected:	04/04/94	04/05/94	04/06/94	04/07/94	04/11/94	04/12/94	04/13/94	03/14/94
	Date Analyzed:	04/18/94	04/18/94	04/18/94	04/18/94	04/18/94	04/18/94	04/18/94	03/16/94
INORGANICS									
Total Hardness as $CaCO_3$		138	138	138	138	472	615	580	220
Total Dissolved Solids (TDS)		279	284	257	266	730	820	821	420
Total Suspended Solids (TSS)		31.2	26.6	85.7	22	494	525	74.9	50.2
Alkalinity (as $CaCO_3$)		114	117	130	122	342	340	343	145
WATER QUALITY PARAMETERS									
BOD5		37	75	58	58	150	290	200	NA
Chemical Oxygen Demand (COD)		114	133	137	135	240	207	504	NA
Total Organic Carbon (TOC)		28.5	29.6	32	34	74	126	119	72.8

NA = Not Analyzed
J = Estimated results
J* = Estimated results due to low acid surrogate recoveries
U = Not detected at indicated detection limit
E = Estimated value

3.1.3 Estimated Treatment Goals

Potential treatment system effluent goals were estimated, in order to provide a basis for evaluating treatment system capabilities. One potential set of discharge goals is based on the NPDES discharge limits for the existing treatment system, adjusted to a treatment system discharge volume of 30 gpm and assuming no net change in mass loading. Another potential set of discharge goals is based on maximum contaminant levels (MCLs) for drinking water. The potential treatment goals are presented in Table 3-2.

3.2 Treatability Study Results

Treatability studies were performed to evaluate technologies for treatment of contaminated groundwater. These studies were performed using groundwater samples from the Containment Area, or data from analyses of these samples, as described in Section 3.1. These studies were performed on unit operations which would potentially be combined to achieve complete wastewater treatment.

The following evaluations of treatment technologies also consider the results obtained with the current on-Site treatment system. The existing system treats groundwater recovered from the Operations Area using chemical addition and sedimentation for metals removal, and enhanced oxidation followed by activated carbon polishing for organics removal. The system discharges to the Quinnipiac River under an emergency authorization NPDES permit issued by the State of Connecticut.

3.2.1 Metals Removal

The metals pretreatment investigation was performed in order to evaluate the most effective way to remove metals from groundwater recovered by the containment system. The conditions of the present NPDES emergency permit for the on-site groundwater treatment system require removal of iron in the effluent to a level of 5 ppm. In addition, iron removal would be required as a pretreatment step prior to organics removal by biodegradation, air stripping, or the VPSI enhanced oxidation process, in order to optimize these unit operations as described in Sections 3.2.2 through 3.2.4. The SolarChem enhanced oxidation system does not require pretreatment for iron removal.

The pretreatment investigation consisted of several elements. These included a review of the operation of the existing on-site pretreatment system; vendor investigations; and detailed jar testing performed by ENSR.

TABLE 3-2

Potential Treatment System Discharge Goals
SRSNE, Southington, CT

Analytical Parameter	Potential Flow Adjusted NPDES Based Effluent Goals (ppm)	Potential MCL Based Effluent Goals (ppm)
Methanol	10	
Ethanol	6.67	
2-Butanol	3.3	
Vinyl Chloride		0.002
Chloroethane		
Methylene Chloride	5.0	0.005
Acetone	11.67	
2-Propanol	3.3	
1,1-Dichloroethane		
Tetrahydrofuran	0.17	
1,2-Dichloroethene (Total)	1.7	0.07
2-Butanone	3.3	
1,1,1-Trichloroethane	1.33	0.2
1,1,2-Trichloroethane	0.083	
Trichloroethene	1.0	
4-Methyl-2-Pentanone	0.67	
Toluene	1.33	1.0
Ethylbenzene	0.33	0.7
Xylene (Total)	0.17	10.0
Arsenic		0.05

TABLE 3-2 (Cont'd)

Potential Treatment System Discharge Goals
SRSNE, Southington, CT

Analytical Parameter	Potential Flow Adjusted NPDES Based Effluent Goals (ppm)	Potential MCL Based Effluent Goals (ppm)
Chromium		0.1
Iron	1.67	
Mercury		0.002
Gamma-BHC (Lindane)		0.0002
1,2,4-Trichlorobenzene		0.07
Total Suspended Solids	10	
Acute Toxicity (LC_{50})	>32.5%	
Chronic Toxicity (LC_{50})	>100%	

3.2.1.1 Existing On-Site Groundwater Treatment System

The existing Operations Area groundwater treatment facility presently removes metals by chemical addition and clarification. The metals removal process includes addition of a 3% solution of hydrogen peroxide, followed by addition of an anionic polymer to improve metals removal. The chemical addition takes place in a 2'x 2'x 8' four-chamber fiberglass or plastic reactor. Each chamber of the reactor is an approximate 2'x 2'x 2' cube. The first chamber is used for flash mixing with the hydrogen peroxide. The second chamber has no mixing and pin floc is allowed to form. Polymer is added and slow mixed in the third chamber. The fourth chamber is used for slow mixing and/or sedimentation. The reaction chamber has provisions for removal of sludge from the bottom of each chamber.

After chemical addition, the water is directed through a several hundred gallon sedimentation chamber where floc is removed by gravity settling. The water is finally directed through a bag filter prior to discharge to an on-site holding tank.

Uneven performance of the metals pre-treatment system has been identified by VPSI as the cause for the poor performance in the enhanced oxidation system. Iron concentrations above 5 ppm will result in degradation of the performance of the VPSI system and will exceed the NPDES discharge permit levels. The degradation of performance of the enhanced oxidation system is due to iron oxide coating the reactor tubes and acting as a UV sorbent. Metcalf & Eddy operates the current treatment system under a contract with CTDEP. Metcalf & Eddy was contacted to discuss the performance of the existing system. Based on the discussion, the following information was obtained regarding the existing system:

- The system performance is variable with time. In some cases pre-treated water effluent contains iron levels below 5 ppm while in other cases effluent iron levels exceed 7 ppm.
- Influent metals concentrations can vary by as much as 100%.
- The existing system is controlled in such a way so that chemical addition is not dependent on the quantity or quality of influent water.
- The existing clarifier is undersized.
- Sludge flotation problems have occurred, but this can be minimized by varying the dosing location and method.

- Stainless steel should be used in order to minimize leaching of metals from cast iron housings.

- The bag filters do not appear to be effective in reducing metals concentration. They are now using 1 µm bag filters with no appreciable reduction in metals after filtration.

- Thorough initial mixing of polymers as well continuous mixing is critical in the maintenance of polymer quality.

Incorporation of the above information in the containment system pre-treatment strategy is expected to improve the performance and dependability of chemical addition as a pre-treatment method.

3.2.1.2 Treatability Studies

Vendor investigations were performed on water samples from the Site in order to obtain screening results and vendor quotes for various treatment system components. In some cases, these screening studies were followed up by more detailed, quantitative, studies performed by ENSR.

Precipitants and Polymer Screening

A representative of Diversey Water Technologies, Inc. performed jar testing and an evaluation of proprietary polymer evaluation at the site on April 7, 1994. A representative of ENSR was present during the testing in order to observe the testing as well as to collect laboratory analytical split samples. A letter report by the vendor is presented in Appendix H and the results are summarized below.

A treatability study sample was collected from the overburden pumping test effluent as described in Section 3.1. During the jar testing, iron concentrations were estimated by use of a Hach field test kit, and samples were taken of the raw water and water produced by the final treatment regime and sent to an off-site testing laboratory for iron and manganese analysis. Laboratory results for influent iron and manganese were 22 ppm and 5.8 ppm respectively. Based on results of sampling of the on-site wastewater treatment plant influent, levels of influent metals are quite variable. These concentrations are similar to values measured in the influent to the on-Site wastewater treatment plant during this period. ENSR had a split sample of the raw water analyzed for metals to evaluate Diversey's laboratory results, and comparable concentrations of iron (26.7 ppm) and manganese (5.18 ppm) were obtained.

Metals removal by addition of sodium hydroxide (NaOH) was performed. Sodium hydroxide was added at levels that would result in pHs between 9.5 and 10. After NaOH addition, a pin-floc quickly formed. A Diversey Water Technologies anionic polymer (# 39137A) was used to enhance floc aggregation. The most effective treatment was addition of the anionic polymer to a polymer solution concentration of 3 ppm, resulting in removal efficiencies of greater than 95% for iron and approximately 40% for manganese. In addition to iron, analytical results for other metals in the treated water indicated removal of copper, nickel and zinc to levels below existing discharge standards. The results are included in the vendor's letter report (Appendix H).

Variability was observed in all analytical results during the jar testing, and the precision of analytical results and removal rates must be interpreted with care. The volume of sludge produced by this treatment was approximately 30 ml per liter of water treated.

Addition of hydrogen peroxide and carbamates as precipitants was also planned as part of this investigation. In some cases peroxide appeared to provide equivalent or superior iron removal compared with NaOH addition. However, the floc produced by peroxide addition was less stable then the NaOH floc and, in some cases, would float to the surface of the jar. Carbamates were eliminated from the study prior to testing due to expected high cost and toxicity.

The particle size of the resulting floc was evaluated using a Spectrex SPC Particle Counter at an off-site analytical laboratory. The results of this analysis indicate a mean particle size of 5.6 µm. This would imply that, in the absence of any dynamic forces, a 5 µm bag filter would be adequate to remove approximately half of the floc from solution. Filtration effectiveness will be discussed in greater detail later in this section.

Clarifier Evaluation

A Lamella© gravity settler design investigation was performed by Parkson Corporation on samples collected from MW-415 on April 28, 1994. The sample was iced and shipped unpreserved via Federal Express for analysis by the vendor's laboratory. The water was treated by NaOH addition to a pH of 11.4, and addition of 2 ppm of the anionic polymer Jayfloc 803. Selection of Jayfloc as a polymer was based on ENSR's jar testing described below.

The results of this investigation resulted in a recommendation by Parkson Corp for a clarifier loading rate of 0.43 gallons per minute per square foot. A copy of the vendor's report is included in Appendix H. Parkson's recommended unit is Model LGS-200/55. The vendor also recommends an integral flashmixer/flocculator. This system is a plate separator with the plates oriented 55 degrees from horizontal. The separator has a conical bottom with a bottom outlet for sludge removal. A schematic of Parkenson's proposed system is attached to their proposal.

The clarifier size initially recommended by Parkson was based on a conservative maximum flow rate of 70 gpm. It is anticipated that the actual flow rate from the containment system will be less than this rate, as indicated in Section 3.1.

Iron and manganese samples of treated water were collected by Parkson and shipped to ENSR's analytical laboratory. The result of this sampling indicate that approximately 97% of the iron and 96% of the manganese were removed in the laboratory investigation. The results of the sampling are presented in Table 3-3.

Precipitants and Polymer Optimization

Based on the screening results obtained by Diversey's jar testing, ENSR performed additional detailed, quantitative jar tests on April 28 and 29, 1994. A Hach DR/3000 spectrophotometer was used on-site to provide real time metals analysis, and results from each round of jar testing were used to optimize additional jar tests. Samples were collected from the clarified supernatant of each jar test and stored unpreserved in a 40 ml glass tubes until analyzed.

Samples were split and sent to analytical laboratories for metals analysis during the screening and optimization investigations. Table 3-4 provides the results of all split sampling performed during this investigation.

Raw water samples were collected from MW-415 each day for testing. MW-415 is located in the center of the Containment Area and is the closest 2-inch diameter overburden well to the overburden pumping test well; use of a 2-inch well significantly reduced the purge volume required. Three well volumes were removed from the well prior to collecting the treatability study water. Dissolved oxygen samples were collected each day. The results of the testing indicate dissolved oxygen concentrations less then 1 ppm for all raw water samples. No determinations regarding the concentrations of Fe(II) and Fe(III) were made.

Various precipitants were evaluated alone and in combination during the jar testing. In addition, several polymers were evaluated and an optimum dose of the most effective polymer was evaluated. Additional studies were performed in order to investigate sludge characteristics, investigate sludge production as a function of removal rates, evaluate the kinetics of precipitation as well as execution of a filtration investigation.

Precipitants

Three precipitants were evaluated during the metals removal jar testing: NaOH; 3% hydrogen peroxide, and magnesium hydroxide. Each precipitant was investigated individually and removal

TABLE 3-3

Laboratory Analytical Results for Clarifier Evaluation
SRSNE, Southington, CT

Parkson Sampling		
Sample	**Influent (ppm)**	**Effluent (ppm)**
Iron	44.2	1.16
Manganese	5.37	0.218

TABLE 3-4

Laboratory Split Sample Results for Precipitant and Polymer Optimization SRSNE, Southington, CT

Field Sampling		
Sample	**Field Analysis Iron Concentrations (ppm)**	**Laboratory Analysis Iron Concentration (ppm)**
Raw Water (4/29/94)	58	48.6
Sample 6-6 Supernatent	10	6.3
Sample 6-6 Filtered	3	1.6

efficiencies versus dose are presented in Table 3-5 and Figures 3-1 through 3-3. Additional testing was performed to evaluate the combined addition of sodium hydroxide and peroxide. Polymers were also screened during the preliminary precipitant evaluation.

The results indicate that the most effective individual treatment is addition of NaOH. Removal rates as high as 70% were observed using this amendment alone. Peroxide addition was less effective then NaOH, and $Mg(OH)_2$ was least effective. Addition of both NaOH and peroxide produced high removal efficiencies, however the sludge resulting from this treatment was observed to have gas bubbles attached to the floc and this resulted in the floc frequently floating to the surface of the beaker. Sludge flotation was also observed with NaOH addition only. Addition of polymer approximately 1 minute after flash mixing appeared to reduce sludge flotation as compared with addition of polymer immediately after flash mixing.

The type of precipitant used also resulted in a differing color of floc. Addition of NaOH only resulted in a dark green floc while peroxide addition resulted in a orange floc. It is possible that the addition of only NaOH resulted in the precipitation of $Fe(OH)_2$ while addition of peroxide oxidized the iron prior to precipitation and resulted in precipitation of $Fe(OH)_3$.

Sludge volumes are plotted versus removal efficiency and are presented in Figure 3-4 and Table 3-6. Although the data is not expected to fall on a straight line, a regression was performed on the data in order to provide a general indication of the average sludge volume that would be expected for a given removal efficiency based on all of the various treatments evaluated. The results indicate the volume of sludge produced by addition of Jayfloc 803 is slightly less then would be expected on average, based on removal efficiency.

The sludge from the on-site treatment system is presently disposed of as a F-listed waste. Sludge handling at the on-site facility does not include dewatering. Discussions with Metcalf & Eddy indicate solids concentrations in the gravity thickened sludges range between 10% and 30% with maximum levels as high as 50%.

The results of the oxidant investigation indicate that NaOH addition to a pH of approximately 11 provides the best sludge characteristics and maximum removal efficiency.

Polymers

Two groups of polymers were evaluated during the jar testing. Clarifloc polymers #1015 and 2020 were included, and Exxon Chemical's anionic polymers Jayfloc #802, 803, and 806 were also evaluated. Subsequent discussions with the biodegradation treatability study vendors indicate that, at the concentrations the polymers would be used, toxicity of the polymers are not

TABLE 3-5

Results of Precipitant and Polymer Optimization
SRSNE, Southington, CT

Sample I.D.	pH	Treatment	Final Iron Concentration (ppm)	% Removal
Run #1 - NaOH Addition				
Raw Water	6.4	None	50.9	NA
Sample 1-1	7.7	0.5 mL NaOH	39.3	22.8
Sample 1-2	9.0	1.0 mL NaOH	25.3	50.3
Sample 1-3	10.8	2.0 mL NaOH	14.9	70.7
Sample 1-4	12.0	4.0 mL NaOH	24.8	51.3
Sample 1-5	11.0	2 mL NaOH:6 ppm 1015 Clarifloc	21.6	57.6
Sample 1-6	11.2	2 mL NaOH:2 ppm 802 Jayfloc	11.3	77.8
Run #2 - $Mg(OH)_2$ Addition				
Raw Water	6.4	None	50.9	NA
Sample 2-1	6.1	100 mg/L $Mg(OH)_2$	45.9	9.8
Sample 2-2	6.3	200 mg/L $Mg(OH)_2$	48.1	5.5
Sample 2-3	6.5	500 mg/L $Mg(OH)_2$	43.5	14.5
Sample 2-4	6.6	1 g/L $Mg(OH)_2$	36.8	27.7
Sample 2-5	6.5	500 mg/L $Mg(OH)_2$:2 ppm Jayfloc 802	43.3	14.9
Sample 2-6	6.6	500 mg/L $Mg(OH)_2$:6 ppm Clarifloc 1015	42.8	15.9

TABLE 3-5 (Cont'd)

Results of Precipitant and Polymer Optimization
SRSNE, Southington, CT

Sample I.D.	pH	Treatment	Final Iron Concentration (ppm)	% Removal
Run #3 - H_2O_2 Addition				
Raw Water	6.4	None	50.9	NA
Sample 3-1	5.7	90 ppm H_2O_2	27	47.0
Sample 3-2	5.7	120 ppm H_2O_2	30.3	40.5
Sample 3-3	5.4	180 ppm H_2O_2	49.2	3.3
Sample 3-4	10.4	120 ppm H_2O_2:2 mL NaOH	8	84.3
Sample 3-5	6.2	120 ppm H_2O_2:2 ppm Jayfloc 802	10.9	78.6
Sample 3-6	5.4	120 ppm H_2O_2:6 ppm Clarifloc 2020	45.5	10.6
Run #4 - Optimization Oxidizers				
Raw Water	6.7	None	57.9	NA
Sample 4-1	8.8	1 mL NaOH:2 ppm Jayfloc 802	27.7	52.2
Sample 4-2	10.7	2 mL NaOH:2 ppm Jayfloc 806	8.5	85.3
Sample 4-3	11.0	2 mL NaOH:2 ppm Jayfloc 803	8.5	85.3
Sample 4-4	11.7	120 ppm H_2O_2:3 mL NaOH	6.1	89.5
Sample 4-5	10.7	60 ppm H_2O_2:2 mL NaOH	9	84.5
Sample 4-6	8.2	60 ppm H_2O_2:1 mL NaOH	6.3	89.1

TABLE 3-5 (Cont'd)

Results of Precipitant and Polymer Optimization
SRSNE, Southington, CT

Sample I.D.	pH	Treatment	Final Iron Concentration (ppm)	% Removal
Run #5 - Optimization Polymers				
Raw Water	6.7	None	57.9	NA
Sample 5-1	11.2	2 mL NaOH:1 ppm Jayfloc 803	8.8	84.8
Sample 5-2	11.1	2 mL NaOH:4 ppm Jayfloc 803	4.7	91.9
Sample 5-3	8.8	1 mL NaOH:60 ppm H_2O_2:1 ppm Jayfloc 803	6.5	88.8
Sample 5-4	8.8	1 mL NaOH:60 ppm H_2O_2:2 ppm Jayfloc 803	8.3	85.7
Sample 5-5	8.9	1 mL NaOH:60 ppm H_2O_2:3 ppm Jayfloc 803	7.3	87.4
Sample 5-6	9.1	1 mL NaOH:60 ppm H_2O_2:5 ppm Jayfloc 803	4.3	92.6
Run #6 - Kinetics[1]				
Raw Water	0 min	None	57.9	NA
Sample 6-1	0.5 min	2 mL NaOH:4 ppm Jayfloc 803	5.4	90.7
Sample 6-2	1 min	2 mL NaOH:4 ppm Jayfloc 803	3.9	93.3
Sample 6-3	3 min	2 mL NaOH:4 ppm Jayfloc 803	4.0	93.1
Sample 6-4	5 min	2 mL NaOH:4 ppm Jayfloc 803	3.6	93.8
Sample 6-5	10 min	2 mL NaOH:4 ppm Jayfloc 803	4.1	92.9

TABLE 3-5 (Cont'd)

Results of Precipitant and Polymer Optimization SRSNE, Southington, CT

Sample I.D.	pH	Treatment	Final Iron Concentration (ppm)	% Removal
Run #7 - Filtration Investigation				
Raw Water	None		48	NA
Sample 7-1	20 micron		5.4	90.7
Sample 7-2	10 micron		4.1	92.9
Sample 7-3	5 micron		4.5	92.2
Sample 7-4	0.5 micron		3.4	94.1

Key: 1 - All samples passed through 45 micron filter
NA - not applicable

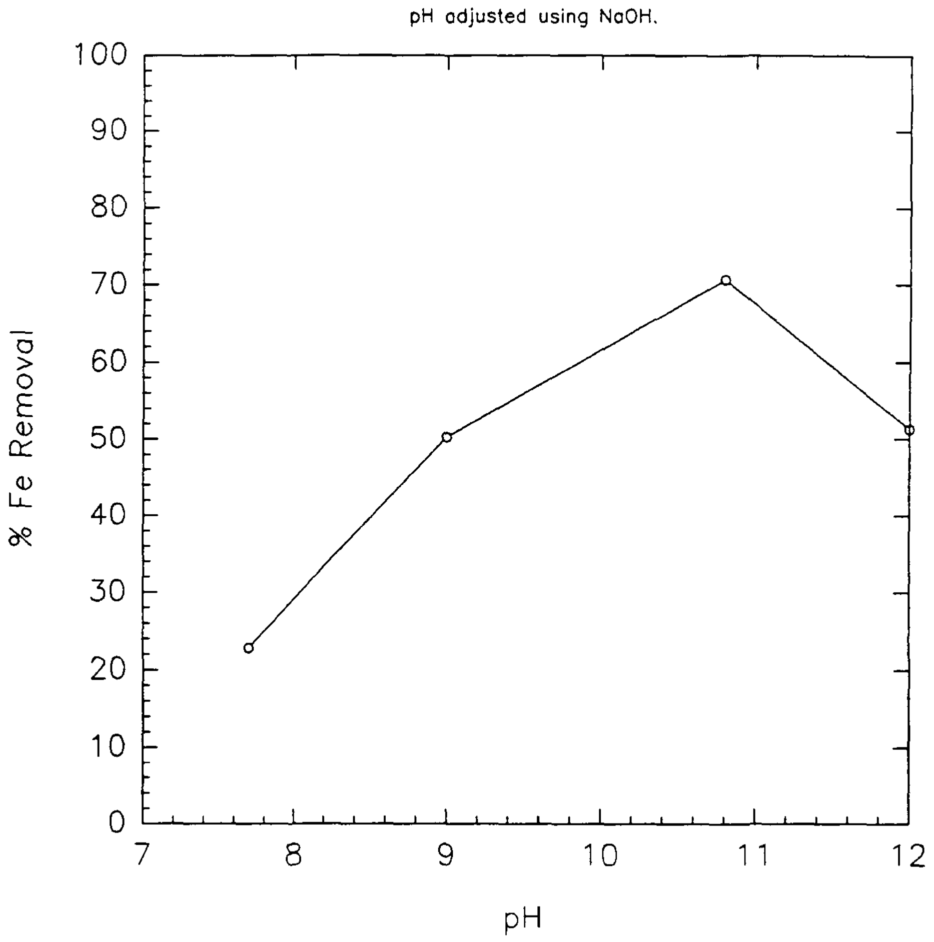


FIGURE 3-1
pH Vs. Percent Removal of Iron
Metals Pretreatment Study
SRSNE, Southington, CT

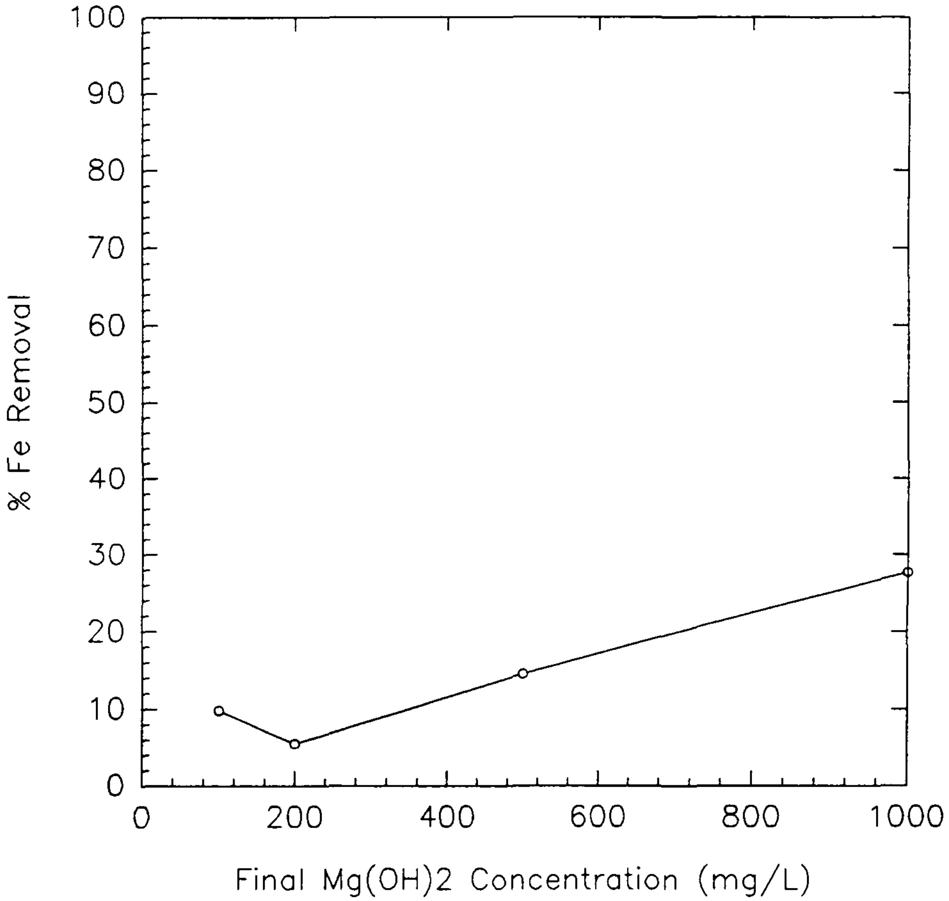


FIGURE 3-2

Final $Mg(OH)_2$ Concentration Vs. Percent Removal of Iron
Metals Pretreatment Study
SRSNE, Southington, CT

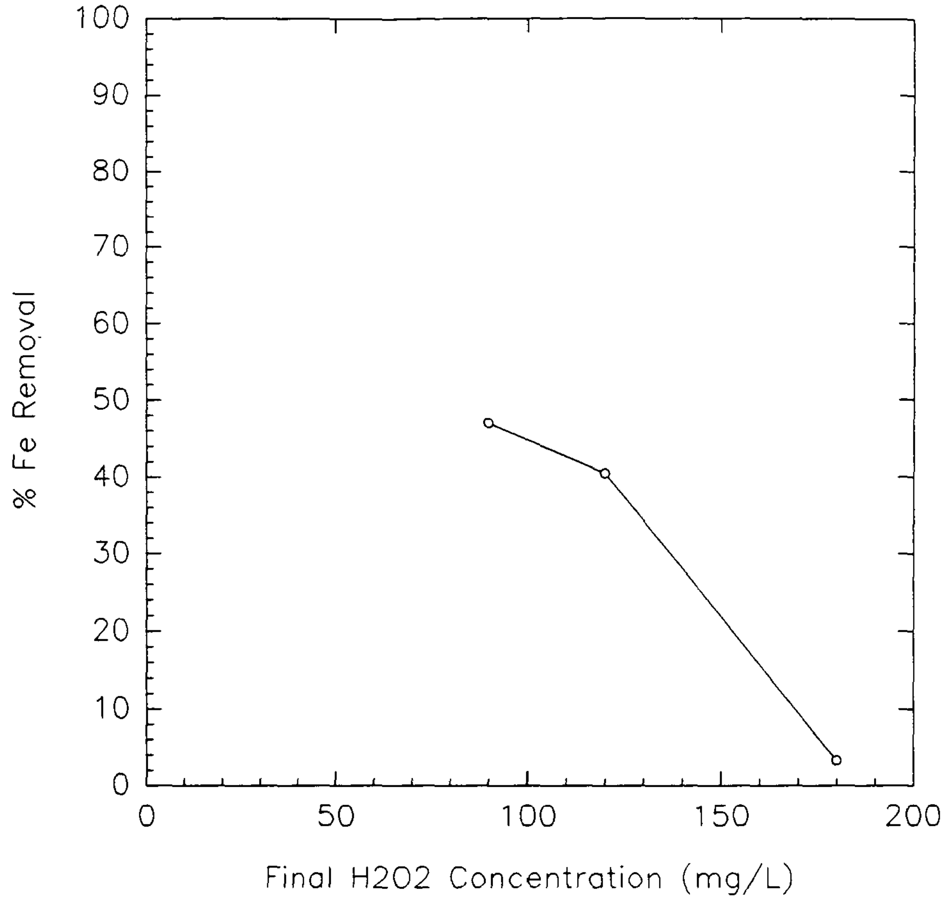


FIGURE 3-3

Final H_2O_2 Concentration Vs. Percent Removal of Iron
Metals Pretreatment Study
SRSNE, Southington, CT

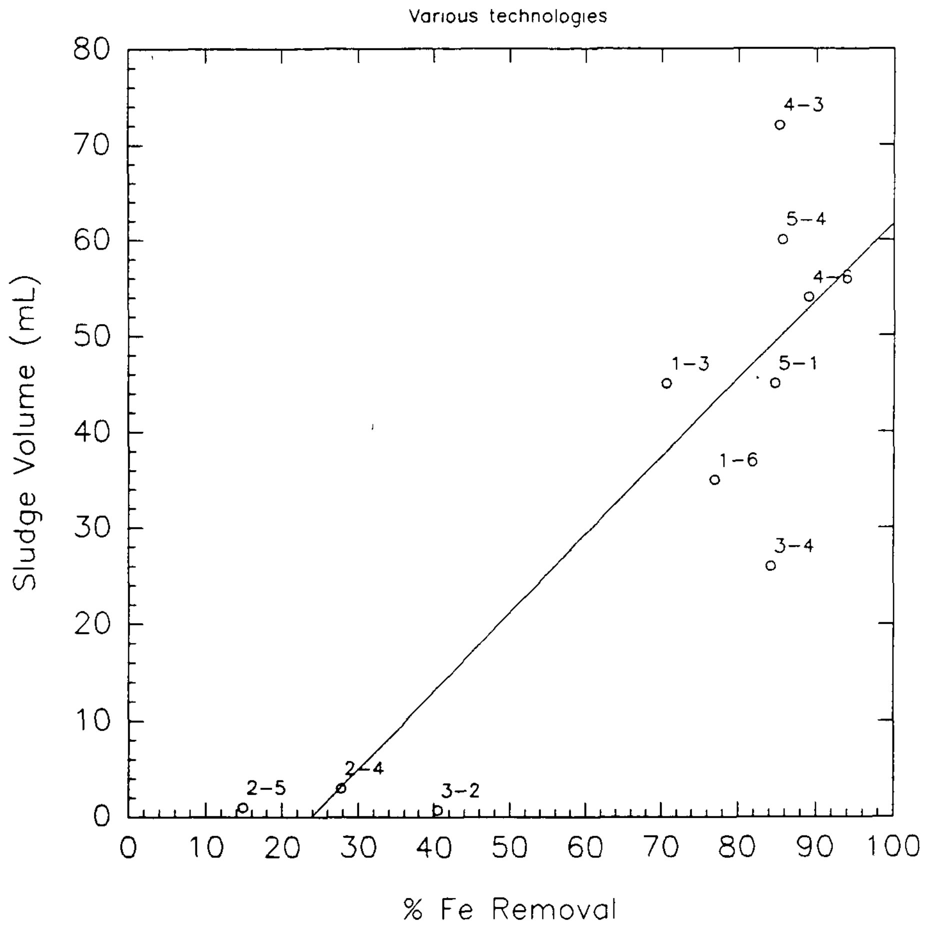


FIGURE 3-4
Percent Removal of Iron Vs. Sludge Volume
Metals Pretreatment Study
SRSNE, Southington, CT

TABLE 3-6

Sludge Volumes for Precipitant and Polymer Optimization SRSNE, Southington, CT

Treatment	Volume (mL)	% Removal
2 mL NaOH	45	70.7
2 mL NaOH:2 ppm Jayfloc 802	35	77.0
1 g/L $Mg(OH)_2$	3	27.7
500 mg/L $Mg(OH)_2$:2 ppm Jayfloc 802	1	14.9
4 mL H_2O_2	0.7	40.5
4 mL H_2O_2:2 NaOH	26	84.3
2 NaOH:2 ppm Jayfloc 803	72	85.3
1 mL NaOH:2 mL H_2O_2	54	89.1
2 mL NaOH:1 ppm Jayfloc 803	45	84.8
2 mL H_2O_2:1 NaOH:2 ppm Jayfloc 803	60	85.7

anticipated to be a problem. In addition to screening polymer type, the jar testing was used to determine the optimum polymer dose.

The investigation was performed by screening several polymers during each of the initial precipitant screening tests (runs 1 through 4 on Table 3-4). By the end of the precipitant screening it was apparent that the Jayfloc polymers were more effective then the Clarifloc. Screening of the Jayfloc polymers indicated that both 803 and 806 were equally effective in metals removal. The fifth run was used to determine the optimum polymer dose as well as to perform a final evaluation on the precipitants. The results of the polymer screening are included in Figures 3-5 and 3-6 and in Table 3-5. The results indicate that polymer addition above concentrations of 1 ppm does not significantly improve metals removal. Sludge volumes produced by the addition of Jayfloc 802 appear to be one-half of sludge volumes produced by Jayfloc 803. A polymer dose rate of 1 ppm of Jayfloc 803 is recommended based on these results.

The effect of peroxide addition on removal efficiencies was also evaluated. The addition of hydrogen peroxide did not significantly increase removal efficiency (Figure 3-6), and sludge flotation was still observed to be a problem.

Kinetics Investigation

A kinetics investigation was performed in order to evaluate the optimum time for flash mixing of the selected precipitant. In this investigation, change in dissolved iron concentration was measured with time from addition of the sodium hydroxide. Samples were collected from the jar at selected times after NaOH addition and filtered through a 0.45 µm filter. The sample was then injected into the metals digestion solution to quench any reaction and the samples were subsequently analyzed. Dissolved iron concentrations were used as the kinetic indicator because the experiment took place in a beaker that was undergoing flash mixing and clarified supernatant could not be obtained.

The results of the investigation indicate that the dissolved metal concentration has stabilized by the time the first sample was collected 1 minute after NaOH addition. This indicates the reaction appears to be complete after the first minute. The results are presented in Figure 3-7. This result will allow design of relatively short flash mixing times. These results are consistent with literature values (Stumm and Morgan, 1981) that indicate that iron precipitation kinetics are very fast.

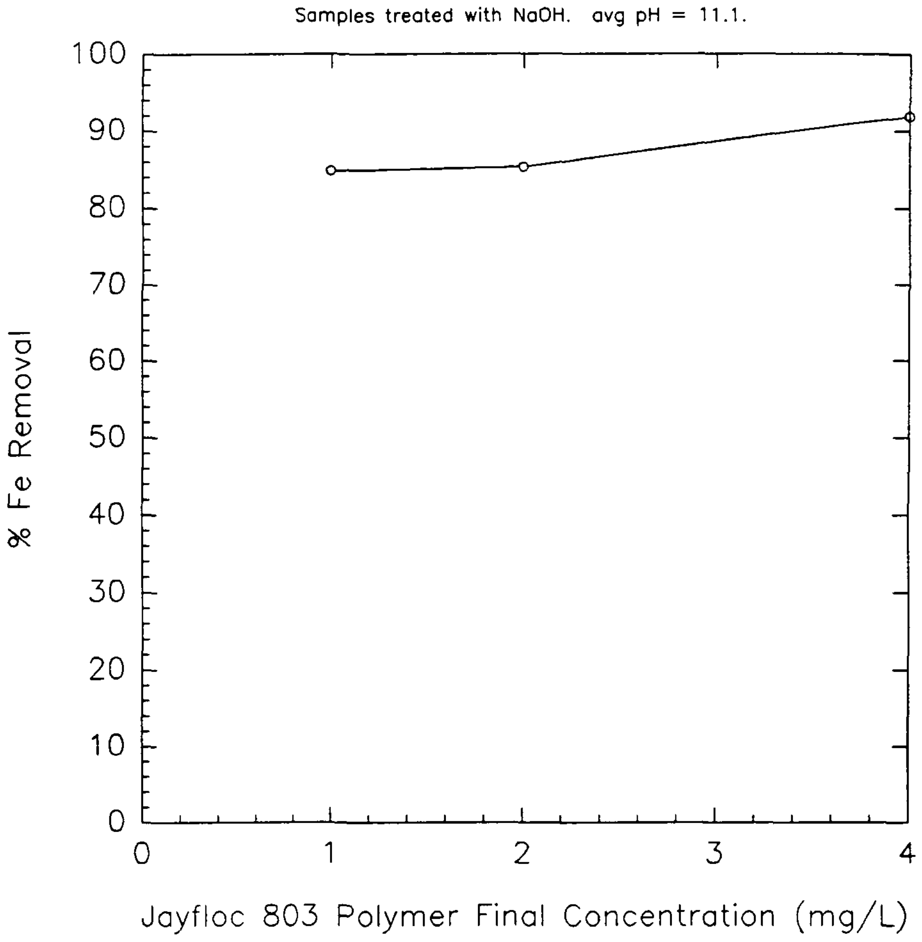


FIGURE 3-5

Polymer Final Concentration Vs. % Removal of Iron - Samples Treated with NaOH
Metals Pretreatment Study
SRSNE, Southington, CT

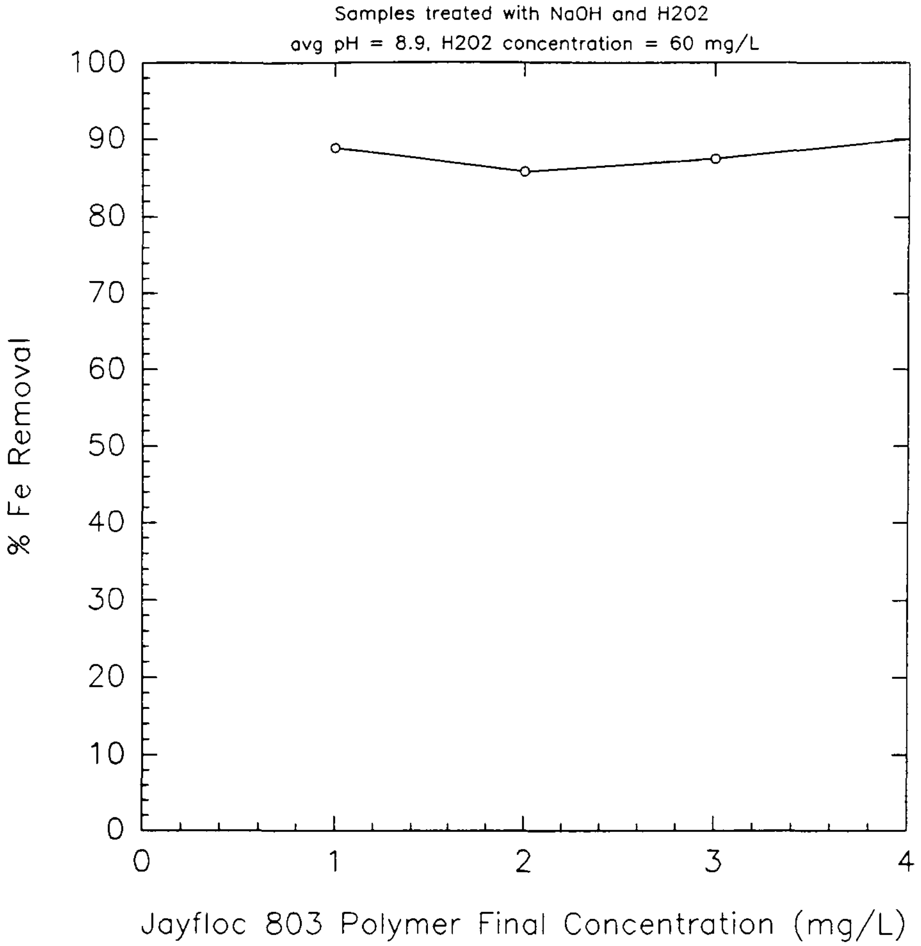


FIGURE 3-6

Polymer Final Concentration Vs. % Removal of Iron - Samples Treated with NaOH and H_2O_2

Metals Pretreatment Study

SRSNE, Southington, CT

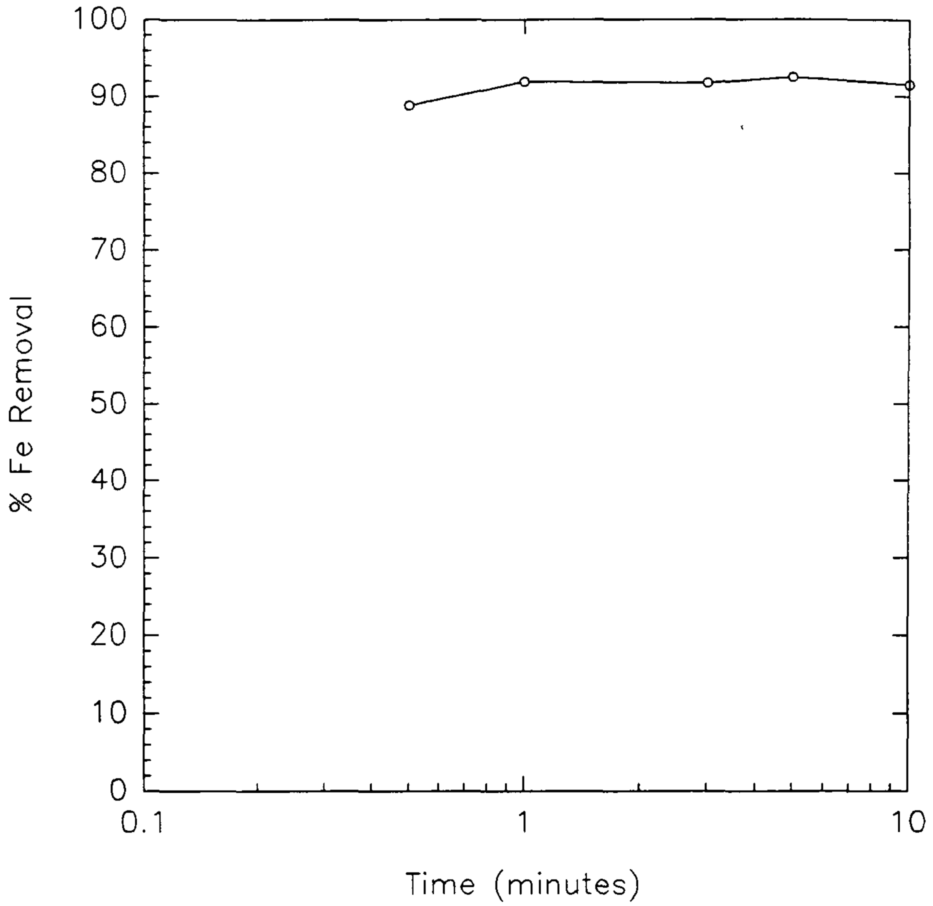


FIGURE 3-7
Time Vs. Percent Removal of Iron
Metals Pretreatment Study
SRSNE, Southington, CT

Filtration Investigation

Filter effectiveness was evaluated in the final test. The water was treated with the optimum mix of hydroxide and polymer after which the samples were allowed to equilibrate. The samples were mixed to maintain floc in suspension and the sample was then filtered through varying size filters. The filtrate was then analyzed for total iron concentration.

The results of the analysis are presented in Figure 3-8 and indicate that filtrate iron concentration does not significantly vary with filter size. Removal efficiencies were above 90% for all of the filter sizes investigated (5, 10 and 20 µm filters). This appears to be inconsistent with the particle size distribution data obtained from the polymer vendor. The vendor data indicates that reducing filter size would be expected to increase removal efficiencies.

The filtration investigation results are consistent with information obtained during discussions with Metcalf & Eddy. M&E reportedly has observed that decreasing the filter mesh of the bag filters used in the on-site treatment system does little to reduce the iron leaving the pre-treatment system. The on-site treatment system is presently operating with a 1 µm bag filter which has reportedly resulted in little improvement over larger mesh bag filters.

The results of this investigation indicate that if a bag filter is used, a 25 µm pleated bag filter is recommended. This pleated filter would minimize the frequency of bag change-out. However, if removal of metals to low levels will be required (i.e., enhanced oxidation by VPSI is selected) additional metals removal by granular media filtration would be anticipated to be more effective than surface filtration by bag filters.

3.2.1.3 Conclusions

Based on the results of the pretreatment investigation, the following should be considered:

1. Chemical dose should be based on volumes of groundwater recovered to insure the optimum pH adjustment and constant dose rates for polymers.

2. Stainless steel or other non-metals leaching material should be used in the design when possible.

3. Addition of NaOH to attain a pH of 11 is anticipated to provide optimum metals removal.

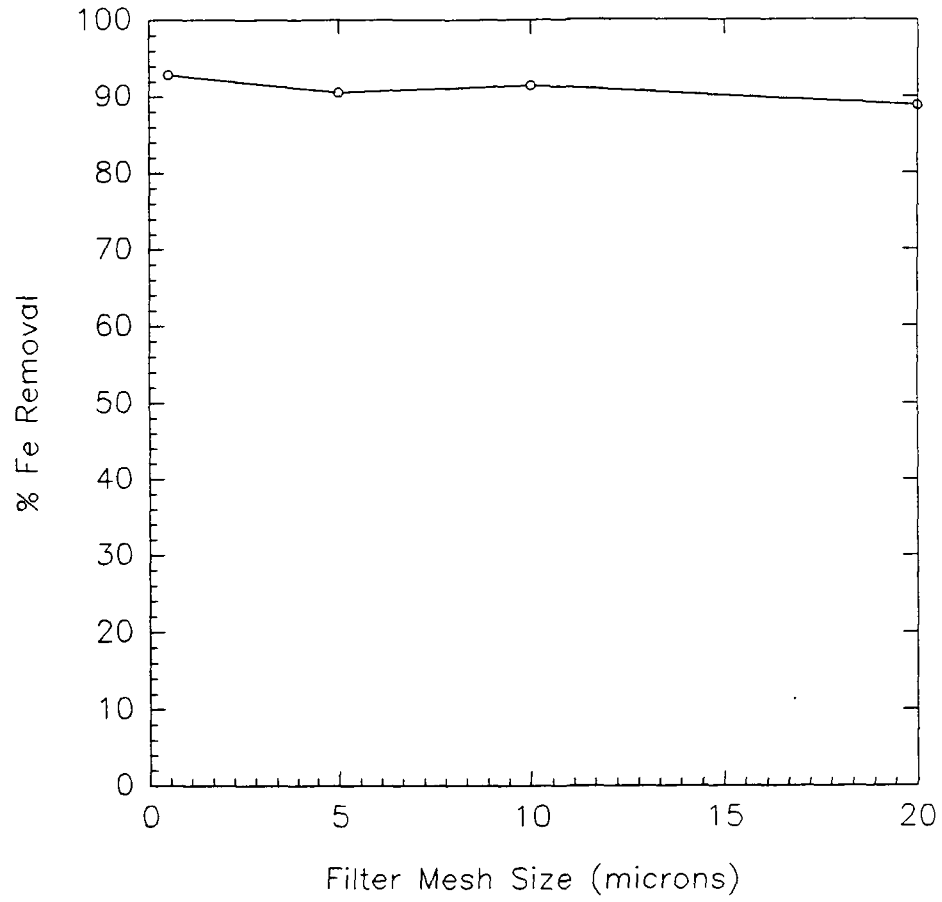


FIGURE 3-8
Particle Size Vs. Percent Removal of Iron
Metals Pretreatment Study
SRSNE, Southington, CT

4. Addition of either Diversey polymer # 9137A at a dose rate of 3 ppm or Jayfloc 802 at a dose rate of 1 ppm would result in satisfactory metals removal. This dosing should take place after pin floc has been allowed to form. The polymer mixing apparatus must be designed to provide a thorough initial mixing of polymers. The polymer handling system should insure a homogeneous polymer feed is maintained.

5. A flash mixing/contact/polymer addition chamber similar to but larger than that presently used at the site should be used for chemical addition. Provisions to remove sludge from this reactor should be included in the design.

6. A clarifier should be incorporated into the pretreatment system design. The system should be designed for a loading rate of no more then 0.43 gallons per minute per square foot. Based on the sensitivity of the floc characteristics to chemical addition, it is not recommended to employ an integral mixer/clarifier (as is costed in the Parkson quote).

7. It does not appear that a bag filter mesh size less than 25 µm will significantly influence the amount of iron removed.

8. The iron removal rate observed by Parkson using 2 ppm Jayfloc 802 and NaOH addition to a pH of 11.3 with a overflow rate of 0.43 gpm/ft^2 was 97%.

3.2.2 Enhanced Oxidation Treatability Tests

3.2.2.1 Background

Treatability tests were conducted of enhanced oxidation to evaluate optimal operational parameters for this technology. Tests were conducted by VPSI, which leases the current system to CTDEP, and by SolarChem, which offers several other enhanced oxidation treatment processes. As discussed in Section 3.1, groundwater was pumped from an existing monitoring well in the Containment Area and sent to both VPSI and SolarChem. Chemical analysis of the untreated groundwater was conducted both by ENSR and the vendors to assure that valid tests were conducted. Each vendor conducted a matrix of tests to optimize their particular oxidation technology. Each vendor submitted samples from their best system configuration for chemical analysis and toxicity testing by ENSR. The vendors developed preliminary system designs and costs based on their best system configurations and on potential effluent discharge requirements.

3.2.2.2 Testing of Untreated Groundwater

In order to obtain valid testing it was essential to assure that both vendors received test water of similar chemical make-up. It was also essential that the water received was representative of groundwater at the Containment Area. Loss of the contaminants, particularly volatiles, during packing and shipping was a major concern. Variations in water chemistry as the well was pumped was also a concern. A sample of the groundwater was collected in the field as the well was being pumped and each vendor sampled the water as received at their facility. Results of the various analyses are shown in Table 3-7. Complete analytical results for the on-Site sample from TW-8A are provided in Appendix G.

With the exception of appearance and iron content, general chemistry parameters were relatively close among the three tests sites. The sample tested at VPSI had a pale yellow color whereas the SolarChem sample was clear. The higher iron level recorded at VPSI may account for the yellow color. The most likely cause for the elevated iron level at VPSI is variability in water chemistry as the well was pumped. It is unlikely that packing or shipping would affect iron levels. Iron level is a critical parameter for both enhanced oxidation technologies tested. The variable concentration of iron noted may have an impact on pretreatment costs and maintenance costs.

Key organic compounds were selected for monitoring based on their concentration in the untreated water. Also key organic compounds were selected to assure the alkanes, aromatics, alkenes and ketones would be monitored. The concentration of key organic compounds as received at VPSI and SolarChem were generally lower than concentrations from the sample collected at the Containment Area. However, the concentrations were on the same order of magnitude. Considering that the compounds are present in the untreated water in the parts per million range, and the potential treatment objectives are in the parts per billion range, the slight loss of contaminants was not considered significant.

In addition to the key organic compounds shown in Table 3-7, the groundwater sampled at the Containment Area was also analyzed for additional organics and metals. The full data set is presented in Appendix G. The treated waste from each vendor was also tested for the additional organics and metals to determine what impact, if any, oxidation treatment had on those compounds.

3.2.2.3 Treatment Objectives

Although final effluent discharge requirements for the NTCRA system have not been established, it was necessary to set treatment goals for the vendor tests. Provided the goals set for the vendor tests are of the same order of magnitude as the final effluent discharge requirements,

TABLE 3-7

Comparison of Shipped and Received Samples for Enhanced Oxidation Tests SRSNE, Southington, CT

Analytical Parameters	Sampled at the Site	Sampled at SolarChem	Sampled at VSPI
General Chemistry			
Appearance		Clear	Pale Yellow
pH		6.5	6.8
Iron (ppm)	43	36	61
Chloride (ppm)		110	112
Alkalinity (ppm)	145	140	181
Turbidity (NTU)	43.5		23
Chemical Oxygen Demand (ppm)		290	409
Total Suspended Solids (ppm)	50		150 to < 5
Total Dissolved Solids (ppm)	419		370
Total Organic Carbon (ppm)	73		68
Key Organic Compounds (ppm)			
Vinyl Chloride	9.2	~10*	8.6
Dichloroethylene	37	29	17
Toluene	23	20	12
Acetone	4.1	3.9	3.5
Total Xylenes	9.1	12.5	5.1
Trichloroethylene	0.57	< 1	0.46
1,1 Dichloroethane	2.1	< 1	1.6
Chloroethane	0.85	< 1	0.62
Methyl-Ethyl-Ketone	11	21	7.8
Methylene Chloride	3	2.0	2.5
Trichloroethane	3	~3.8*	2.7
Ethylbenzene	5.5		3.2

*SolarChem had difficulty analyzing these compounds due to Co-elution with other compounds.

system scale up should be practical. The Federal drinking water standards (MCLs) were selected as the vendor test goals for those compounds that have MCLs, and 0.100 parts per million was selected for compounds without MCLs. Vendor test goals for key compounds are presented with vendor results in Tables 3-8 and 3-9. These treatment goals provide a rigorous test of the systems since destruction efficiencies of over 99% for most contaminants are required to meet the goals. Actual effluent discharge requirements may be higher or lower than the values used for these vendor tests.

3.2.2.4 Results of the VPSI Tests

VPSI's test report as well as that of SolarChem is presented in Appendix H. VPSI conducted a series of 10 tests. The process parameters varied in these tests were pretreatment processes, concentration of hydrogen peroxide, pH, ultraviolet light (UV) density and lamp system.

VPSI obtained their best results with pretreatment to remove iron using hydrogen peroxide followed by filtration. VPSI concluded that pH adjustment was not beneficial and that the initial pH of approximately 6 was optimal. VPSI's results indicate that the optimum hydrogen peroxide concentration in the reactor is 400 mg/l.

VPSI concluded that a UV density of "D-II" and lamp system "C" were best. "D-II" and "A" refer to proprietary designs that VPSI was unwilling to provide further information on. Apparently, the "D-II" design provides a higher UV density compared to the "D-I" design. Results from VPSI's best test run are shown in Table 3-8 along with the independent laboratory results and vendor test goals. The data in Table 3-8 do not incorporate use of lamp system "C", and VPSI expects that still better results would be achieved with the use of lamp system "C".

When compared to VPSI's results, ENSR's laboratory detected higher levels of some of the key organics. This is probably a result of better technique since VPSI's work is more geared to screening. ENSR's lab results did not show any exceedances of vendor test goals. Acetone was found in high levels in both the trip blank and test sample and thus the acetone result from ENSR's laboratory is not valid.

VPSI's results show a relatively rapid destruction of organics and achievement the vendor test goals in less than 4 minutes treatment time. The chloroalkanes, primarily 111-TCA, proved to be the most difficult to oxidize. The ketones, such as acetone, were expected to be difficult to treat but appear to have been rapidly destroyed. Ketone destruction efficiencies exceeded 99%, based on the VPSI laboratory data.

TABLE 3-8

Results from VPSI Optimal Test Run[1]
SRSNE, Southington, CT

Contaminant	Concentrations Measured by VPSI (ppm)				ENSR Lab Results (ppm)	Vendor Test Goal[2] (ppm)
	Oxidation Time (Minutes)					
	0	2	4	6		
Vinyl Chloride	1.923	<0.001	<0.001	<0.001	0.002[3]	0.002
Dichloroethylene (Cis + Trans)	9.068	>0.006	<0.001	<0.001	0.19	0.07
Toluene	3.097	<0.001	<0.001	<0.001	9.8	0.1
Acetone	3.891	0.106	<0.001	<0.001	NA	0.1
Total Xylenes	0.941	<0.001	<0.001	<0.001	2.2	0.1
Trichloroethylene	0.161	<0.001	<0.001	<0.001	ND	0.005
1,1 Dichloroethane	1.339	0.006	<0.001	<0.001	ND	0.1
Chloroethane	0.738	<0.001	<0.001	<0.001	ND	0.1
Methyl-Ethyl-Ketone	7.282	<0.001	<0.001	<0.001	ND	0.1
Methylene Chloride	2,181	0.076	<0.001	<0.001	ND	0.005
1,1,1 Trichloroethane	1.911	0.261	0.003	<0.001	0.029	0.1
Ethylbenzene	0.650	<0.001	<0.001	<0.001	0.02	0.1

1. VPSI Test run #6. Pretreatment H_2O_2 and filtration, H_2O_2 dose 400 mg/l, UV density D-II, UV Lamp System A.
2. Vendor test goals are based on Federal MCLs or 0.100 ppm, whichever is lower. These levels are intended to be conservative (low).
3. Vinyl Chloride value is estimated

ND = Not detected

NA = Not available; acetone was detected in the laboratory blank

TABLE 3-9

Results from SolarChem Optimal Test Run[1] SRSNE, Southington, CT

	Concentrations Measured by SolarChem (ppm)				ENSR Lab Results (ppm)	Vendor Test Goal[2] (ppm)
	UV Dose					
Contaminant	**0**	**16.7**	**83.3**	**123**		
Vinyl Chloride	10	ND	ND	ND	ND	0.002
Dichloroethylene (Cis + Trans)	16.3	<0.05	<0.05	<0.05	ND	0.070
Toluene	12	<0.05	<0.05	<0.05	ND	0.1
Acetone	4.4	0.36	0.37	0.36	0.28[3]	0.1
Total Xylenes	4.5	<0.05	<0.05	<0.05	ND	0.1
Trichloroethylene	NT	NT	NT	NT	ND	0.005
1,1 Dichloroethane	NT	NT	NT	NT	8.6	0.1
Chloroethane	NT	NT	NT	NT	ND	0.1
Methyl-Ethyl-Ketone	16.7	0.1	<0.02	<0.02	ND	0.1
Methylene Chloride	2.1	1.3	0.14	<0.08	120	0.005
1,1,1 Trichloroethane	1.0	1.4	0.69	0.06	100	0.1
Ethylbenzene	NT	NT	NT	NT	NT	0.1

ND = Not detected
NA = Not available; acetone was detected in the laboratory blank

1. SolarChem Test Run #8, Pretreatment to reduce pH, Rayox - A then Rayox - B.

2. Vendor test goals are based on Federal MCLs or 0.100 ppm, whichever is lower. These goals are intended to be conservative (low).

3. ENSR lab results for acetone is an estimate.

Since the current system in the Operations Area is falling far short of 99% destruction efficiency, the differences between this treatability test set-up and the system in the Operations Area bears examination. Further, the ability of VPSI to translate the successful bench-scale tests into a full-scale system must be evaluated. To address these issues, ENSR asked VPSI to respond to specific questions concerning the current system and ENSR interviewed VPSI customers. Results are presented in Appendix H and are discussed below.

The bench scale system and the current system in the Operations Area are fundamentally the same. The bench scale set-up did not include catalysts or other additives nor does the system in the Operations Area. Both systems rely solely on peroxide and UV dose for destruction of organics. One difference is the intensity of UV light delivered. The current system in the Operations Area is a 30 kW unit whereas the unit proposed for the NTCRA would be a 210 kW unit. Since the NTCRA unit would treat more water (30 gpm verses 10 gpm), some of the increased power would be consumed by the larger volume of water. Considering the difference in volume of water treated, the increase in UV power between the two systems is about a two-fold increase. It is unlikely that this increase in power alone can account for an increase in destruction efficiency of below 90% to over 99%.

VPSI believes that changes in the lamp type and configuration also contribute to a higher destruction efficiency. By delivering a denser and more efficient UV input, VPSI believes they can achieve higher destruction efficiencies. VPSI determined that UV density "D-II" and lamp system "C" are more effective than those used in the Operations Area system. Since "D-II" and "C" refer to proprietary designs, ENSR was not able to review the design differences to assess their strengths and weakness. Based on discussions with VPSI, the differences in lamp system are beneficial but do not account for the dramatic improvement between the current system and the bench tests.

Changes in reactor design and power do not fully account for the improved results reported in the bench studies. VPSI contends that the primary reason for poor performance of the current system in the Operations Area is poor pretreatment and poor maintenance of the reactor. In fact, VPSI has presented data (see Appendix H) showing that the system in the Operations Area can effectively treat both acetone and methylene chloride when operated properly. The acetone data is particularly significant in that the normal daily operation of the system results in no effective treatment of acetone. Further, SolarChem's tests suggest that peroxide and UV alone are not effective for acetone. VPSI has demonstrated that acetone treatment is possible under very controlled conditions. Translating this success into daily operation of a full-scale system presents some problems.

The key problem in full-scale system is fouling of the reactor by iron. This problem has been reported by VPSI and confirmed by their customers. In the bench scale tests iron levels were reduced from 61 mg/l to 0.15 mg/l and a clean reactor was used. In the optimization runs at SRS on the current system, iron levels were also reduced and it is likely that the reactor and lamps were new or freshly cleaned. VPSI customers report that the slightest contamination or scaling in the reactor reduces destruction efficiency dramatically. VPSI customers for groundwater applications have also noted that bench-scale results were significantly better than actual operational results presumably as a result of fouling of the reactor in full-scale operation. Thorough pretreatment is essential for the VPSI system to be effective. Based on discussions with VPSI customers, it appears that iron pretreatment can be accomplished but full realization of bench results are not practical. While instances of full-scale application effectively treating contaminant present at the Containment Area were found, treatment to MCL standards for all contaminants was not documented.

A common pretreatment method consists of peroxide dosing, addition of a polymer, and gravity separation and or filtration. Such a system is being used on the current system in the Operations Area. However, VPSI contends that it is not being run properly. Green sand filters are also used as pretreatment for some of VPSI's treatment plants. A further discussion of pretreatment is provided in Section 3.2.

Peroxide residuals in the VPSI system are expected to be 50 to 100 mg/l. This high level of peroxide will require treatment to reduce aquatic toxicity and to meet expected discharge goals. Use of activated carbon has proven to be successful for other VPSI systems and is at least partially successful for the Operations Area system.

3.2.2.5 Results of the SolarChem Tests

SolarChem conducted a series of 8 tests. SolarChem initially experimented with different pretreatment scenarios then focussed on standard treatment regiments (Rayox F, Rayox A and Rayox R) developed by SolarChem. The key aspect of the various Rayox processes is their use of chemical additives to improve system performance.

In direct contrast to the VPSI approach, where pretreatment is required to remove iron, SolarChem concluded that the iron was beneficial and took steps to assure it remained in solution. SolarChem proposed reducing the pH to 3 or 4 so that the iron will remain in solution after the addition of peroxide.

The optimum process proposed by SolarChem involves both their Rayox A and Rayox R processes. This combination involves use of sulfuric acid for the pretreatment pH adjustment, addition of hydrogen peroxide, addition of proprietary catalyst ENOX 910, then irradiation. Following irradiation, the pH is increased with sodium hydroxide to remove the iron. Finally, ENOX 710 and ENOX 810 are added.

Results from SolarChem's best test run together with the independent laboratory results and vendor test goals are presented in Table 3-9. SolarChem's results compared well with the ENSR's Lab results with the exception of methylene chloride. SolarChem reported that methylene chloride levels were reduced to below 80 ug/l but methylene chloride was found at 120 ug/l in ENSR's sample. The result is significantly above the 5 ug/l vendor test goal.

SolarChem was able to achieve high destruction rates with relatively low UV doses for the aromatics and alkenes using their catalysts. However, treatment of ketones (acetone) and chloroalkanes (TCA) proved more difficult. Treatment of these contaminants required SolarChem to add additional processes and to increase UV doses. Even with these improvements, the lowest acetone level achieved in the optimized test run was 360 parts per billion. SolarChem's optimum system required a 330 KW lamp system, addition of acid as a pretreatment, addition of three proprietary additives (ENOX 910,810, and 710) and addition of caustic.

3.2.2.6 Aquatic Bioassay Tests

As part of the treatment system evaluations, ENSR performed bioassays on samples of effluent from the two bench scale treatment systems. These tests include acute evaluations for two organisms (*Daphnia pulex* and fathead minnow) and chronic evaluations for three organisms (*Ceriodaphnia*, fathead minnow, and *Selenastrum*). The test protocols were outlined in Appendix E of the Workplan (ENSR, 1994). Results are summarized in Appendix G.

SolarChem System

The SolarChem system generates effluent that is of moderate acute toxicity to *Daphnia pulex* (LC_{50} = 38.3%, No Observed Adverse Effects Concentration (NOAEC) = 25%). The effluent was not acutely toxic to fathead minnow. The effluent had significant chronic toxicity for *Ceriodaphnia* (e.g., No Observed Effects Concentration (NOEC) of 6.25%), moderate chronic toxicity for fathead minnow, and no observed chronic toxicity for *Selenastrum.*

The source of the toxicity in the SolarChem effluent has not been well established. It is possible that residual hydrogen peroxide from the system may contribute to toxicity. On the other hand, measured residual hydrogen peroxide in the SolarChem effluent is 0.5 to 1 mg/l, suggesting that this may not be the major source of toxicity. The SolarChem process involves addition of iodide and iron-based catalysts that may contribute to effluent toxicity.

The potential limit on acute toxicity of $LC_{50} > 32.5\%$ would apparently be met by the SolarChem system. The SolarChem system would not meet the potential chronic toxicity limit of $LC_{50} > 100\%$. It might be possible to establish permit limits for aquatic toxicity which use the results of the chronic toxicity tests to monitor chronic toxicity, rather than a modification of the acute test results. For some test species, this could allow compliance of the SolarChem effluent with potential toxicity limits.

VPSI System

The effluent from the VPSI process exhibits higher chronic and acute toxicity for each of the test organisms compared to results for the SolarChem process. The LC_{50} were 17.1% and 33% for *Daphnia pulex* and fathead minnow, respectively. The NOEC was 6.25% or below for all three species examined in chronic tests.

Aquatic bioassay tests have also been performed for the existing treatment system, which includes a VPSI enhanced oxidation process. Immediately following installation, the existing treatment system produced effluent that was not in compliance with permit limits for either acute or chronic toxicity. After treatment system modifications, the toxicity of the effluent has declined such that the permit limits for the acute toxicity have been met consistently. The chronic toxicity limits are still exceeded with some regularity.

The observed toxicity of the existing VPSI system effluent has led the State of Connecticut to perform a series of Toxicity Identification Evaluations (TIEs). Among the candidate agents for toxicity were residual hydrogen peroxide, the polymer added to the influent to remove iron, and organic products of the oxidation process. The first two materials have been observed to be toxic in the concentrations added to the wastewater. The set of TIEs performed by the State of Connecticut indicate that residual hydrogen peroxide is the most important toxic agent in the effluent of the existing system. The organic products of oxidation (e.g., ketones) may also play a role in toxicity. The polymer added to remove iron does not appear to be an important role in toxicity.

In the bench scale test of the VPSI process, no polymer was added indicating that it did not contribute to toxicity in ENSR's testing. On the other hand, hydrogen peroxide was measured at a concentration of 50 mg/l in the VPSI bench scale effluent, and oxidized organic compounds were present at very low concentrations. Thus, in the bench scale test, hydrogen peroxide is likely to be the dominant source of toxicity.

Testing performed during the TIEs indicates that toxicity was removed most efficiently from the effluent using activated carbon. This process is effective at removing hydrogen peroxide and oxidized organics. A Peroxide Destruction Module (PDM) operating at the site has been only able to lower the residual peroxide to 10 mg/l (cf. a LC_{50} of approximately 1 mg/l). More complete hydrogen peroxide removal strategies (e.g., two PDMs in series) should consider that the oxidized organics may also contribute to toxicity under some circumstances. A goal of no acute toxicity in the undiluted effluent will likely only be achieved with the efficient destruction of both hydrogen peroxide and the products of the oxidation process.

Conclusions from Bioassay Tests

Both of the candidate enhanced oxidation bench scale treatment systems produce effluent that exhibits some level of toxicity to aquatic organisms. The SolarChem system generally produces water that is less toxic than the VPSI system on both acute and chronic bases. The source of toxicity in the VPSI system has been better characterized and is apparently due to residual hydrogen peroxide and possibly oxidized organics.

The effluent from either treatment system would likely require further treatment to reduce toxicity in order to comply with potential NPDES permit limits for toxicity. Currently, the SolarChem system could meet acute toxicity limits based on the current Emergency Authorization and accounting for the increased system discharge. The SolarChem system effluent would not meet the chronic toxicity limit. The VPSI system unit would not meet either the acute or chronic limits on toxicity.

There is a possibility that negotiation with the State of Connecticut could result in permit limits for chronic toxicity that would be based on test results of chronic toxicity testing. This may allow for compliance with the chronic toxicity limit by the SolarChem system depending upon the selection of test organism.

3.2.2.7 Conclusions

The VPSI system outperformed the SolarChem system for organic compound removal on the bench-scale tests, and is less complicated. VPSI is the preferred vendor for enhanced oxidation. While significant concerns with scale-up and operation of the VPSI system exist, VPSI has demonstrated effective treatment of Site contaminants.

Pretreatment to remove iron is essential for effective operation of the VPSI system.

Toxicity of treated water from the VPSI bench-scale test was high. The likely cause is residual peroxide. Further work to confirm that peroxide removal will result in acceptable toxicity results are required. At a minimum, post treatment to remove peroxide will be necessary.

It is unlikely that a full scale system will be capable of achieving the low effluent levels that were achieved in the bench scale tests. Problems associated with variability in the influent and fouling of the reactor vessel will result in higher effluent levels. A specific example where a full scale VPSI system was achieving all the vendor test goals on a similar waste stream was not identified.

The VPSI system can be expected to greatly reduce organic loading. The combination of enhanced oxidation followed by carbon polishing will result in low effluent levels with relatively low carbon usage rates. Removal of organics to MCLs in the effluent has not been demonstrated in full-scale operation and would be very difficult to achieve. Final design requirements will greatly depend upon required effluent standards and actual influent levels. System performance requirements should be part of any agreement with the vendor.

3.2.3 Air Stripping and Air Treatment

Air stripping technologies have generally been proven effective for removal of volatile organic compounds from groundwater. This technology would be used to remove compounds from the aqueous phase to the gas phase, and would be followed by gas treatment to prevent air emissions. Air stripping was the original method employed for treating the current groundwater containment system wastewater, when the system was started up in 1986. The original air stripper was a relatively crude device that was somewhat effective for wastewater treatment, but had no gas treatment to prevent air emissions.

An evaluation of air stripping requirements was performed by North East Environmental Products of West Lebanon, NH (North East) which produces ShallowTray™ low profile air strippers. ENSR requested evaluation of water treatment to two discharge standards: the first standard based on the existing NPDES permit limits adjusted to a increased treatment system discharge volume of 30 gpm; and the second standard based on MCLs. North East's estimated air stripper performance based on their proprietary model is presented in Appendix H. ENSR did not employ the AIRSTRIP model for verification as originally planned, because AIRSTRIP is not designed for use with tray strippers.

North East's evaluation indicates that the stripper would require pre-treatment for iron removal. Discussions with the vendor indicate that the degree of iron removal impacts the frequency of maintenance and that pre-treatment to an iron concentration of 5 ppm would require shut-down and maintenance of the system for 8 person hours every 3 to 6 months. The carbonate concentrations observed in the pumping test effluent would require shut down and maintenance approximately every 6 to 8 weeks. If this technology is selected, a cost/benefit assessment for hardness reduction should be performed.

No removal of alcohols is indicated in the performance estimate. Based on the concentrations of alcohols observed in the TW8A sampling (Table 3-1), this would not be a problem since sample concentrations are below discharge standards. In addition, no MCLs exist for these constituents. Two stripper sizes were proposed by North East. The smaller unit (air flow rate of 900 cfm) would treat water to MCLs, while a larger unit (air flows of 2400 cfm) would be required to treat water to the estimated NPDES standards.

If only treatment to MCL levels are required, the system is sized with removal of methylene chloride as the limiting constituent. This system will reduce concentrations of ketones, however, these levels will be above those calculated in the flow adjusted NPDES discharge standards.

Treatment to standards estimated in the flow adjusted NPDES requirements would require a larger system. The size of this system is governed by removal of ketones and tetrahydrofuran. Based on the complex interactions between ketones and other VOCs, North East recommends pilot testing to quantify removal rates for ketones. Since ketones are governing the size of the stripper, additional studies would be recommended if this technology is selected.

Treatment of the air produced by the air stripper would be required. The most effective air treatment technologies based on the predicted air stripper performance would be catalytic or thermal oxidation. These methods of air treatment are expected to be more effective than activated carbon adsorption because the air stripper effluent would have a high relative humidity and would contain high vapor pressure gases such as vinyl chloride. High relative humidity and high vapor pressure constituents limit the sorption capacity of activated carbon and would require frequent change-out and disposal of the spent activated carbon. Use of thermal or catalytic oxidizers on this air stream would require special construction techniques to accommodate the corrosive vapors that would be produced in the oxidation process.

3.2.4 Activated Carbon Adsorption

Carbon adsorption is a widely-used technology for wastewater treatment. In this process, contaminants are removed from a fluid by adsorption to the surface of carbon granules. These granules are subsequently disposed or cleaned for reuse. However, as described in the EE/CA document, carbon adsorption would not be effective as a primary treatment process for the SRS groundwater due to the high concentrations and high solubility of many of the contaminants. Activated carbon may be appropriate for removal of residual contaminants after treatment by other processes, if necessary to meet discharge limits. This potential use of activated carbon is considered in Section 3.4.

Limitations to the use of activated carbon have been observed in the operation of the existing on-site water treatment plant. Activated carbon was added to the current treatment system in December 1993 for "polishing" the treated groundwater from the enhanced oxidation process, to remove residual contaminants. These contaminants included organic compounds and hydrogen peroxide, which were suspected to be causing unacceptably high aquatic toxicity. Although aquatic toxicity levels dropped to within acceptable levels shortly after addition of this process, toxicity levels rose again to unacceptable levels after several months of operation. The CTDEP reports that the activated carbon has fostered the growth of bacteria which produce toxic byproducts in the effluent. This problem might be reduced in future systems by increasing removal of organic and inorganic compounds which are bacterial nutrients prior to the activated carbon polishing step.

3.2.5 Biodegradation

A treatability study by AlliedSignal is ongoing and will evaluate the effectiveness and costs associated with biotreatment of the groundwater by use of a fully saturated, aerobic fixed film reactor. The investigation included the following components: enrichment of biodegradation cultures; biodegradation screening; and acclimation and steady state operation of the bench scale system. Details regarding the execution of the treatability study are provided in Appendix H. Final results of this study may be useful for refining this process option and will be provided as soon as they become available.

Samples were collected as discussed in Section 3.1 and shipped to AlliedSignal. Samples were collected by AlliedSignal and analyzed for VOCs in order to quantify losses during shipping. The results are presented in Table 3-10 and indicate losses of vinyl chloride and methylene chloride. AlliedSignal was instructed to spike the sample with any constituents that become 1 order of magnitude lower than the concentrations observed during initial sampling.

Three populations of microorganisms were evaluated during the enrichment phase. These included a population derived from an inoculum of soil and groundwater from the site, a population obtained from the local wastewater treatment plant, and a population provided by AlliedSignal. These populations were incubated for a period of 10 days and O_2 uptake and CO_2 production were monitored. At the end of the incubation period, screening studies were performed to evaluate the culture which demonstrated the highest biodegradation rate of sample water as measured by O_2 uptake and CO_2 production.

The results of this phase of the investigation indicated that all cultures demonstrated O_2 uptake and CO_2 production. In order to maximize the biological diversity, all three populations were combined and used as inoculum into the bench scale investigation.

TABLE 3-10

Comparison of Shipped and Received Samples for Biodegradation Test SRSNE, Southington, CT

Analytical Parameters	**Sampled at TW-8A (ppm)**	**Sampled at Alliedsignal (ppm)**
Vinyl Chloride	9.2	0.670
Dichloroethylene	37	28.3
Toluene	23	20.0
Acetone	4.1	NA
Total Xylenes	9.1	9.5
Trichloroethylene	0.57	0.68
1,1 Dichloroethane	2.1	2.2
Chloroethane	0.85	NA
Methyl-Ethyl-Ketone	11	NA
Methylene Chloride	3	1.13
1,1,1-Trichloroethane	3	2.8
Ethylbenzene	5.5	5.8

NA = not analyzed

The experimental design of the bench scale investigation included four reactors. These reactors were configured in two different modes of operation. One pair of reactors was configured to operate so that aeration gases were vented to the atmosphere (open configuration). Off-gases from the second pair of reactors were collected and recycled as influent air (closed configuration). Oxygen was added to the closed configuration recycled air as necessary. Each pair of reactors consisted of a "live" reactor and sterile control reactor. Sodium azide at a concentration of 2000 ppm was used to inhibit biological activities in the sterile control reactors. This appeared to be successful in inhibiting biological activity in the control reactors. Figure 3-9 presents the hydraulic flow diagram of the reactors.

The initial portion of the bench scale investigation involved inoculation of the test reactors with the combined populations and acclimation of the micro-organisms. This involved running the reactor in batch mode for 10 days. The bioreactors were then run in a continuous mode of operation with a hydraulic retention time (HRT) of 24 hours. The HRT was subsequently reduced to 12 hours, and this is the shortest HRT for which data were available for this report. This investigation is continuing with shorter HRTs at the time this report was written, and results from these continuing investigations may be useful for future design work.

The preliminary results of this investigation indicate that the open configuration is capable of achieving the flow adjusted NPDES discharge standards. The preliminary results are summarized in Table 3-11, and detailed in Appendix H.

The results indicate the performance of the open system appears to be superior to the closed system. This may be due, in part, to stripping of the volatile constituents by aeration of the reactors. Samples of process effluent air have been collected for both reactors. The results of this sampling are not available at this time. If the results of headspace sampling indicate that air emissions from the reactor is in excess of State of Connecticut regulations, treatment of the bio-reactor effluent may be required. The State of Connecticut air regulations are based on mass flux of specific constituents. If the flux of these constituents exceed threshold levels, an air pollution permit application must be submitted to the CTDEP.

Table 3-11 indicates that the closed system is capable of meeting most of the estimated NPDES discharge standards with the exception of methylene chloride and total 1,2-dichloroethene. AlliedSignal has recommended modifying the operation of the closed system by addition of phenol to serve as a co-substrate. It is anticipated that this modification will result in enhanced removal of chlorinated solvents from the influent in the closed system.

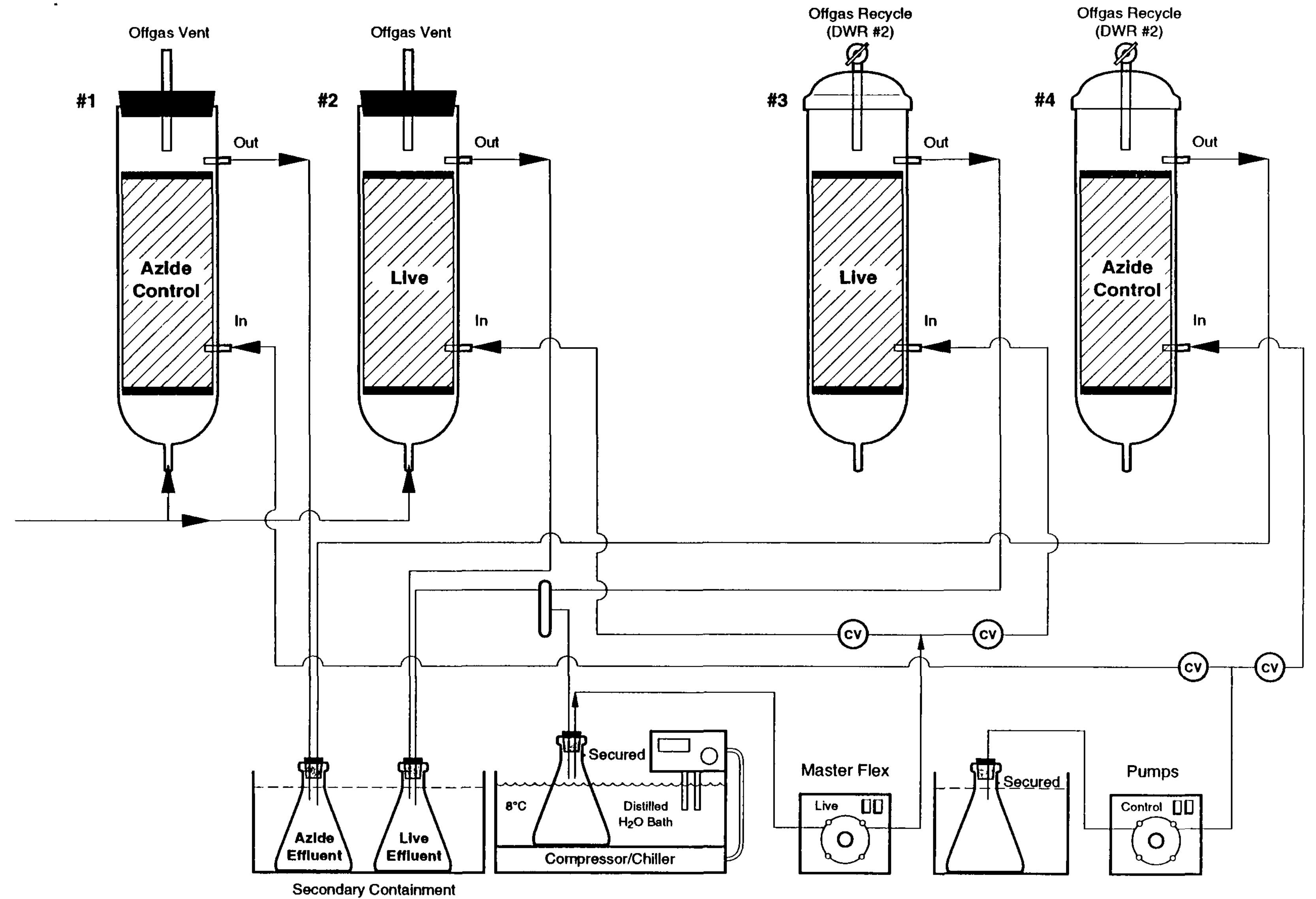


FIGURE 3-9

DWR #1 ENSR Treatability Study - Hydraulic Flow Diagram of BT-ICBs
SRSNE, Southington, CT

CV = Control Valve

TABLE 3-11

Allied Signal Biodegradation Treatability Study Results (12 Hour Retention Time) SRSNE, Southington, CT

Parameter	Influent (ppm)	"Open" ICB Effluent (ppm)	"Closed" ICB Effluent (ppm)	Potential Flow Adjusted NPDES Based Effluent (ppm)	Potential MCL Based Effluent Goals (ppm)
Methanol	NA	NA	NA	10	
Ethanol	NA	NA	NA	6.67	
2-Butanol	NA	NA	NA	3.3	
Vinyl Chlroide	≤2.5	0.002	0.3		0.002
Chloroethene					
Methylene Chloride	≤2.1	<0.3	<0.9	5.0	0.005
Acetone	≤20	<0.01	<0.01	11.67	
2-Propanol	NA	NA	NA	3.3	
1,1-Dichloroethane	≤1.7	<0.002	<0.6		
Tetrahydrofuran				0.17	
1,2-Dichloroethene (Total)	≤20	<0.6	<2.9	1.7	0.07
2-Butanone	≤15.7	<0.2	<0.01	3.3	
1,1,1-Trichloroethane	≤1.6	<0.002	<0.2	1.33	0.2
1,1,2-Trichloroethane				0.08	
Trichloroethene	≤0.5	<0.002	<0.05	1.0	
4-Methyl-2-Pentanone	≤5.4	<0.01	<0.01	0.67	
Toluene	≤11	<0.002	<0.02	1.33	1.0
Ethylbenzene	≤3.3	<0.002	<0.002	0.33	0.7
Xylene (Total)					10

NA - Not available at time of writing

The results of effluent sampling for alcohol were not available at the time this report was written, however, AlliedSignal states removal of these constituents is not anticipated to effect reactor size or costs.

The AlliedSignal bench scale system effluent was relatively toxic to aquatic organisms, compared to the effluent from the enhanced oxidation tests described above. The LC_{50} were 8.6% and 62% for *Daphnia pulex* and fathead minnow, respectively. The NOEC was 12.5% for *Ceriodaphnia dubia* and 25% for *Selenastrum capricorntum*. The source of this toxicity is not clear. It is possible that the biodegradation process results in the formation of toxic organic by-products and/or the release of previously unavailable metals. It may be possible to better resolve the source of toxicity when the analytical characterization of the effluent is available. Bioassay test results are summarized in Appendix G.

The preliminary results of the investigation indicate that a 30,000-gallon Immobilized Cell Bioreactor (ICB) would be adequate to meet the flow adjusted discharge standards. Sludge production from the system is anticipated to be approximately 150 gallons a month.

Completion of treatability optimization tests is expected by the end of June, 1994. It is possible that these additional investigations may indicate that the system can be operated at lower HRTs. If this were to occur, it may result in smaller reactor requirements and reduced costs for implementation of this technology. Selection of a specific process option during the treatment system design phase should be based on the final results of this treatability study.

3.3 Treated Groundwater Discharge Option Assessment

3.3.1 Introduction

Four potential discharge options for treated groundwater were evaluated:

1. Disposal to the Quinnipiac River in accordance with a NPDES permit.
2. Disposal to the Town of Southington sanitary sewerage system in accordance with a State sanitary sewer discharge permit.
3. Disposal of treated groundwater into the area groundwater aquifer in accordance with a State groundwater injection permit.
4. Reuse of treated groundwater by area businesses.

The following sections describe each proposed option, evaluate the feasibility of implementing each option, and identify a recommended discharge option.

3.3.2 Discharge Options

3.3.2.1 Disposal of Treated Groundwater to the Quinnipiac River

This option would involve discharging the treated groundwater to the Quinnipiac River. The CTDEP Bureau of Water Management is responsible for implementing the NPDES permitting program. To obtain a permit to discharge to the river, the site operator must submit a complete CTDEP wastewater discharge permit application form and obtain the discharge permit prior to initiating the discharge. The application must be completed and submitted at least 180 days prior to initiating the discharge. The CTDEP does not guarantee issuance of a permit in that 180-day time span, and the current permit backlog at the State has resulted in some permit applications requiring much more than 180 days for processing. Although an actual NPDES permit may not be required for the NTCRA system since it will be implemented under Superfund demonstration of permit equivalency, it is expected that the NTCRA system will be required to achieve similar treatment results as would be required for permit issuance.

The CTDEP application review process involves: application review (and issuance of notice of deficiencies, if applicable); analysis of instream water quality effects of the chemicals in the wastewater stream; establishment of pollutant parameters, concentration limits, and monitoring frequency; issuance of a draft permit; 30 day public notice of the draft permit (and public hearings, if required); and final issuance of permit. Permitted discharge limits are developed on a case-by-case basis considering instream water quality at the receiving water. Typical discharge limits for total concentrations of volatile organic compounds would be somewhat higher than drinking water quality standards. Limits on aquatic toxicity would be set to reduce acute or chronic effects on aquatic populations in the river.

Discharge of treated groundwater would be accomplished by constructing a pipeline from the treatment plant to the Quinnipiac River. The existing pipeline from the Operations Area could be used if it has sufficient capacity and is properly located.

3.3.2.2 Disposal of Treated Groundwater to the Sanitary Sewer

This option would involve discharging the treated groundwater into the Town of Southington sanitary sewer system, for treatment at Southington's Publicly-Owned Treatment Works (POTW). This discharge option is only feasible if the POTW has sufficient capacity for new wastewater streams. CTDEP is responsible for issuing sewer discharge permits, in consultation with the

Town of Southington. The permit equivalency issue described above for the NPDES discharge option would also apply to the sewer discharge option.

All the same information required to be submitted for a NPDES permit application is also required under this option. However, the site operator may be required to submit information pertaining to the potential effects of the wastewater on the sewage treatment plant (e.g., bench-scale toxicity tests) in lieu of or in addition to the aquatic toxicity testing required for surface water discharges. Permitted discharge limits are developed on a case-by-case basis considering the handling capacity of the POTW, compliance of the POTW with their operating permit, and sewer use limitations.

Discharge of treated groundwater would be accomplished by constructing a pipeline to connect with the town sewer at Queen Street.

3.3.2.3 Disposal of Treated Groundwater into the Area Groundwater Aquifer

This option would involve injecting treated groundwater into the area groundwater aquifer. This option would also require the same wastewater discharge application to CTDEP described for the NPDES option, and this application would be subject to the same equivalency issue as described above. An aquatic toxicity test would not be required under this option. A detailed study on the potential impacts of injecting the treated groundwater back into the aquifer would likely be required. This study would likely include modeling to demonstrate that the injection has no adverse impacts on contaminant distribution in the aquifer. Permitted discharge limits would be set by CTDEP based on drinking water quality.

Discharge of treated groundwater would be accomplished through injection wells screened in relatively coarse soils. The injection system would probably be somewhat similar to the groundwater containment system in terms of number of wells and screen placement.

3.3.2.4 Reuse of Treated Groundwater by Area Businesses

This option would involve distributing the treated groundwater for reuse by area businesses that utilize non-potable water in their operation. Two area businesses were identified as potential high-volume non-potable water users in discussions with the Southington Water Department. These two businesses, the Southington Auto Wash (on Queen Street) and the Sparkle Auto and Truck Wash (on Lazy Lane) were contacted by ENSR to evaluate their interest and suitability for this option.

Owners of both car washes have expressed some initial interest in the reuse proposal, assuming that the water supplied is of sufficient quality. These two businesses require relatively "soft" (demineralized) water to prevent damage to their equipment and to reduce water spots on the car finish. This option would likely require legal agreements between SRSNE PRP Group and the water users, and would possibly require approval from the State and Town considering the potential for changes in the current sewer discharge from these businesses.

Discharge of treated groundwater would be accomplished through a storage and supply system extending from the NTCRA treatment system to each water user. The Sparkle Auto and Truck Wash is located directly across the Quinnipiac River from the northeast corner of the former Cianci property. The Southington Auto Wash is located less than 1000 feet north of the intersection of Lazy Lane and Queen Street.

3.3.3 Analysis of Discharge Options

3.3.3.1 Disposal of Treated Groundwater to the Quinnipiac River

Discharge to the Quinnipiac River in accordance with NPDES permit equivalency requirements is technically feasible provided that a treatment system can remove contaminants to acceptable levels without resulting in unacceptable aquatic toxicity. Evaluations of treatment system capabilities are provided in Section 3.2 above. This discharge option is reasonably likely to gain regulatory approval. This option is currently used for the existing Operations Area treated groundwater discharge.

3.3.3.2 Disposal of Treated Groundwater to the Sanitary Sewer

Discharge to the sanitary sewer is unlikely to gain regulatory approval. The Town of Southington has imposed a moratorium on new industrial discharges to the POTW due to limited capacity. Further, the sewer department currently prohibits the discharge of toxics to the sanitary sewer due to problems in complying with their operating permit.

3.3.3.3 Disposal of Treated Groundwater into the Area Groundwater Aquifer

Groundwater reinjection might be feasible for the Operations Area or for an offsite area, depending on the remedial alternative selected by U.S. EPA for groundwater. For example, the injection system could be used to enhance hydraulic barriers or increase the speed of contaminant migration into a recovery system. Reinjection would probably not be feasible on the former Cianci property or in other low-lying areas where the seasonal high water table is at the ground surface. Reinjection would be relatively difficult to implement considering the extensive equipment and O&M requirements, compared to other discharge options.

Reinjection of groundwater would require careful planning to prevent unintended mobilization of contaminants in the shallow bedrock and overburden aquifers. This mobilization could occur through dissolution of contaminants located in soils above the water table, and through changes in hydraulic gradients which influence movement of non-aqueous phase liquids. Although contaminant mobilization in the overburden aquifer might be acceptable considering the future presence of the NTCRA containment system, mobilization in the bedrock aquifer would have to be avoided since the NTCRA does not extend to this aquifer.

Groundwater injection in the Operations Area could be inconsistent with current remedial alternatives under consideration by U.S. EPA. These alternatives involve containment or dewatering of shallow soils. Studies required for permitting a reinjection system could be difficult to accomplish within the aggressive timeframe of the NTCRA.

3.3.3.4 Reuse of Treated Groundwater by Area Businesses

Reuse of treated groundwater appears to be a relatively infeasible option considering the lack of demand for non-potable water in the immediate vicinity of the site. One of the two major water users in this area has a reported demand of 200,000 to 400,000 gallons per month, which is 15% to 31% of the expected maximum flow rate of treated groundwater. This potential demand is probably subject to considerable daily variations considering the nature of the user's business, such that significant storage capacity might have to be provided onsite. Also, there is no guarantee that these businesses would continue to provide water demand throughout the life of the operation of the treatment system.

Another potential obstacle to the reuse option is the concern if the water users violate their discharge permits, or if reuse of the treated groundwater results in injury or property damage. This issue could probably be addressed through legal agreements and by designing safeguards into the supply system. However, these safeguards would add to the cost and complexity of this discharge option.

3.3.4 Recommended Discharge Option

Discharge to the Quinnipiac River in accordance with NPDES requirements appears to be the most feasible of the four options. The current moratorium on new industrial discharges to the POTW and sewer use prohibitions indicate that the sewer discharge option is not available for the NTCRA discharge. The treated groundwater reinjection option could be investigated if problems arise in pursuing the NPDES option, or if reinjection appears to be appropriate for groundwater remediation strategies identified by U.S. EPA. However, the costs associated with implementing the reinjection option would be much higher than for the NPDES option.

3.4 Conceptual Treatment System Alternatives

The objective of the treatability investigations was to supply the U.S. EPA with sufficient information to select a groundwater treatment system for the NTCRA. To that end, several investigations have been performed in order to evaluate treatment technologies that may be used separately or in combination to treat groundwater recovered by the NTCRA containment system. Based on the results of the investigations summarized earlier in this section, ENSR has identified three treatment alternatives that are potentially capable of attaining the estimated effluent discharge goals described in Section 3.1. These alternatives are described in this section. In addition to discharge standards, the following issues have been identified that will impact the selection of a treatment alternative.

Variability in the chemical composition of influent to the treatment system has not been fully defined in this investigation. Groundwater concentrations are anticipated to vary in space as well as in time. Influent for the treatability studies of organics removal was obtained from sampling TW-8A. Analytical results are also available for samples from the overburden pumping tests. However, these samples were collected from similar locations and at the same time of year. Influent to the treatment system will consist of the average concentrations of contaminants in groundwater in the Containment Area. Developing a more representative influent concentration could be accomplished, in part, by additional focused groundwater sampling in the Containment Area. This information would be used to characterize the spatial distribution of specific constituents and provide additional information on the treatment system influent.

It is anticipated that the installed system will be subject to temporal variations in influent volumes and chemical concentrations. The operational history of the on-Site system indicates that influent organic concentrations can vary by at least a factor of 3 within a one week period. With these variations, it would be important to select a system that can accommodate changes in chemical quality and flow volume without reduction in performance of the system.

In addition to chemical quality standards, the treated effluent must meet bioassay standards. The effluent from the bench scale tests of two of the three systems described in this section did not meet the flow-adjusted standards based on the NPDES permit, as described in Section 3.2. The third system described in this section was not tested on a bench scale, so no bioassay results are available. Additional bioassay studies of effluent from a bench scale system could be performed in order to identify and eliminate the undesirable constituents. It is anticipated that addition of activated carbon polishing to all of the treatment alternatives will assist in eliminating any residual toxic organics or hydrogen peroxide.

3.4.1 Alternative Descriptions

An equalization tank is the first element of each of the three alternatives. This tank will provide damping of short term variations in flow and organic chemical loading to the treatment system. This tank will eliminate the short term variability in the influent, however, the selected alternative must still be able to tolerate significant amounts of longer term variability.

All alternatives include pretreatment by chemical addition for metals removal. A preliminary schematic flow diagram of the metals removal system is presented in Figure 3-10. The system includes an equalization tank, followed by a four chamber metals removal reactor with capabilities for sludge removal, followed by a Lamella® clarifier. A flow sensitive chemical feed system will dose the metals removal reactor with NaOH and polymer. After clarification, pH will be decreased to a level appropriate for the selected organic removal technology. Excess sludge is collected from the reactor and clarifier and fed to a gravity thickener/holding tank where supernatant will be decanted prior to disposal of the sludge.

Enhanced oxidation bench scale results described in Section 3.2 were obtained with pretreatment to iron concentrations less than 1 ppm. It is not anticipated that chemical addition followed by clarification will be able to consistently achieve these low metals levels. Thus, the enhanced oxidation system treatment alternative may require additional solids/metals removal by granular media filtration.

In addition to metals removal, activated carbon polishing is included in all three alternatives as a means of providing a back-up organics removal system and to polish effluents. In the case of enhanced oxidation, VPSI recommends this technology as a means of removing residual hydrogen peroxide. For biodegradation, activated carbon would act as a primary treatment technology during initial acclimation, or if the bioreactor were to be "shocked", or if flow to the reactor were interrupted for an extended period and the biological population was lost. When combined with air stripping, activated carbon would provide a polishing technology for the removal of semi-volatiles and other less volatile constituents from the liquid effluent.

The first alternative uses enhanced oxidation as the primary treatment technology. The system consists of the following elements:

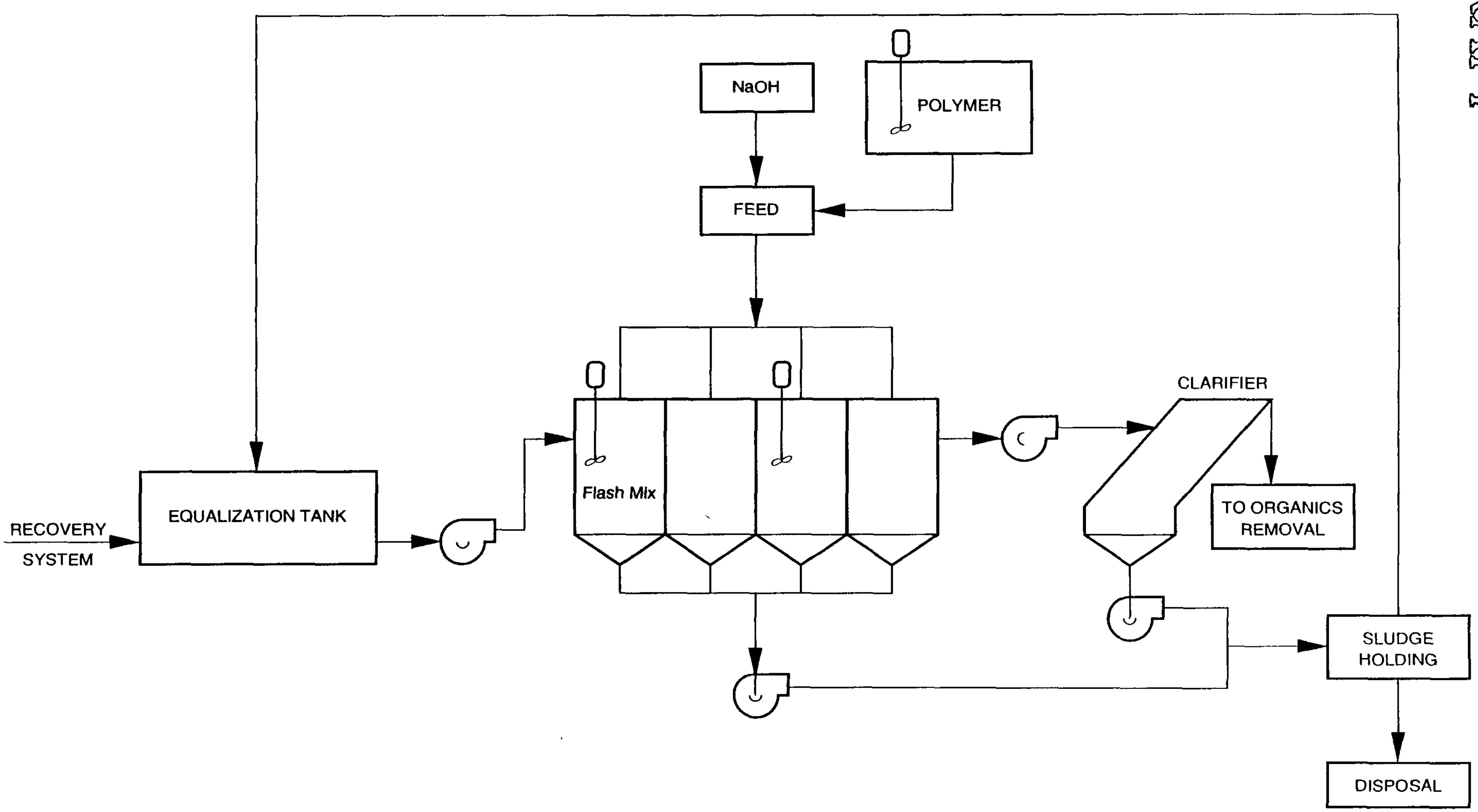


FIGURE 3-10
Conceptual Flow Diagram for Metals Removal Process
SRSNE, Southington, CT

- metals removal pretreatment including: chemical addition followed by a Lamella® clarifier followed by pH adjustment followed by a granular filter;
- enhanced oxidation using a 210 kilowatt VPSI system;
- post treatment with two activated carbon canisters to remove residual peroxide.

Alternative 2 involves treatment of groundwater by biodegradation. This alternative consists of the following elements:

- metals removal pretreatment including: chemical addition followed by a Lamella® clarifier followed by pH adjustment;
- biodegradation using a 30,000-gallon, zero air emissions, Immobilized Cell Bioreactor (ICB) produced by AlliedSignal, Inc.;
- post treatment with two activated carbon canisters to remove residual organics.

The third alternative uses air stripping as the primary treatment technology and includes the following elements:

- metals removal pretreatment including: chemical addition followed by a Lamella® clarifier followed by pH adjustment;
- air stripping using a ShallowTray Model 41231;
- treatment of stripper off-gases by catalytic oxidation;
- post treatment with pound activated carbon canisters to remove residual organics.

These alternatives are evaluated below.

3.4.2 Effectiveness

Evaluation of effectiveness is a measure of whether the treatment system can consistently meet discharge limits for contaminants and for preventing toxic effects on aquatic organisms, whether environmental impacts are minimized, and whether the system is proven and reliable. Effectiveness for all systems is largely dependent on the final discharge standards that will apply to the NTCRA system. Since these standards have not been set, the treatment systems cannot be fully assessed and the following evaluations are necessarily limited to comparisons with the treatment goals described in Section 3.1. Table 3-12 summarizes the effectiveness and implementabilty of each alternative.

TABLE 3-12

NTCRA Treatment Alternative Evaluation
SRSNE, Southington, CT

Alternative	Effectiveness	Implementability
1. Metals Removal; Enhanced Oxidation; Carbon Polishing.	Positive • based on results of treatability study, will meet predicted discharge standards; • system can be designed to accommodate well defined variability in influent chemical loadings and flow; • cost and performance of system are indicated from the treatability study; • minimal air emissions. Negative • metal removal requirements are stringent; • effective suspended solids removal required upstream; • produces metals removal sludge; • alcohol and ketone removal a problem in existing system; • variability in loading and flow must be well understood; • oxygen demand of effluent needs to be quantified; • toxicity of effluent needs further investigation.	Positive • easily installed. Negative • operation and maintenance may be extensive.

TABLE 3-12 (Cont'd)

NTCRA Treatment Alternative Evaluation
SRSNE, Southington, CT

Alternative	Effectiveness	Implementability
2. Metals Removal; Biodegradation; Carbon Polishing.	Positive • based on results of treatability study, will meet calculated discharge standards; • will reduce oxygen demand of effluent; • cost and performance of system are indicated from the treatability study; • can accommodate variability in chemical loadings and flow; • will treat alcohols and ketones. Negative • toxicity of effluent needs further investigation; • system susceptible to upsets due to shocks; • produces bio-sludge; • produces metals removal sludge; • vapor emissions may require treatment (performance of zero emissions configuration is presently being optimized).	Positive • easily implemented. Negative • operation of system susceptible to upsets.

TABLE 3-12 (Cont'd)

NTCRA Treatment Alternative Evaluation
SRSNE, Southington, CT

Alternative	Effectiveness	Implementability
3. Metals Removal; Air Strip; Catalytic Oxidation of Strip Air; Carbon Polishing.	Positive • based on vendor quote, will meet calculated discharge standards; • system able to accommodate variations in influent chemical loading and flow. Negative • toxicity of effluent needs further investigation; • requires vapor treatment; • may require pretreatment for hardness reduction; • treatability study recommended to quantify removal of alcohols and ketones; • polymers added for metals removal may cause fouling in stripper.	Positive • easily installed. Negative • vapor treatment poses additional O&M requirements.

3.4.2.1 Enhanced Oxidation

Bench scale tests of the enhanced oxidation system, which included iron removal but did not include post treatment, achieved the estimated treatment goals for the primary organic contaminants. In full-scale operation it is unlikely that the bench-scale results can be consistently duplicated without post treatment, based on experience with similar systems. It is anticipated that the effectiveness of this system will be heavily dependent on effective suspended solids removal. Post treatment using activated carbon is expected to be effective at removing residual organic and peroxide contamination and may be effective at reducing aquatic toxicity to acceptable levels.

This technology is expected to be capable of accommodating some variability in influent concentration. However, effluent toxicity may be increased during periods of lower organic loadings.

Variability in influent flow volumes can also be accommodated. Since the system is designed to operate at a constant flow rate, the system is often designed to recycling the reactor effluent during periods of low flow. There are some limitations to this approach since water temperatures can be increased to unacceptable levels with excessive recycling. Thus, the system design is sensitive to this parameter and the variability of flow volumes in the system should be well understood prior to the detailed design of this system. It should be emphasized that the system cannot operate effectively in a batch mode.

Enhanced oxidation may not be effective for reducing oxygen demand in the effluent. This water quality parameter may become a key permit parameter at higher flow rates. The existing on-Site enhanced oxidation system has historically produced increased levels of ketones, and has had limited effectiveness in the destruction of alcohols. VPSI's bench scale system does not appear to have this problem, however, these compounds may be problematic in full scale operation of the system.

Since the enhanced oxidation system is primarily a destruction technology, environmental impacts are minimized. Residuals from the treatment process would include contaminated activated carbon from the post treatment step, and iron sludge from the pretreatment step. Contaminated activated carbon could probably be recycled as is currently done for the existing treatment system, resulting in a liquid waste stream which would be disposed off Site. Iron sludge would also be disposed off Site.

3.4.2.2 Biodegradation

As discussed in Section 3.2.5, AlliedSignal's bench scale "closed" biodegradation system (designed for zero air emissions) was less effective in treating influent to the estimated discharge goals, compared to AlliedSignal's vented biodegradation system or VPSI's enhanced oxidation system. AlliedSignal is continuing their treatability study with the closed system to determine if treatment goals can be attained with modifications to the original approach. If ongoing investigations by AlliedSignal are not capable of attaining these discharge standards, the vented configuration would be necessary. This configuration would likely require treatment of the air stream. However, the volume of air requiring treatment would be expected to be lower than that produced by the air strippers. The closed configuration would have minimal air emissions.

Variability in flow volume and influent organic concentration can be accommodated as long as sudden "shocks" are avoided. It is anticipated that short term "shocks" will be eliminated by the equalization system. It is possible that conditions may occur during the operation of the treatment system which may result in killing the bio-reactor's microbiological population. This would result in a period of reduced biodegradation until the system is brought back into steady state operation. It is anticipated that during these system upsets, activated carbon would be used as the primary treatment technology and discharge permit requirements would still be achieved.

This technology would be expected to effectively eliminate alcohols and ketones which may be significant contaminants in the treatment system influent. This process is also expected to be effective in removal of BOD from the treatment system effluent.

Environmental impacts are expected to be small since biodegradation results in destruction of the toxic compounds. Residuals produced by this treatment altemative include bio-sludge, metals removal sludge, and possibly air emissions. The latter may require control of volatile organic compounds.

3.4.2.3 Air Stripping

Air stripping appears to be effective in meeting discharge goals for VOCs based on vendor modeling. Air stripping is expected to be less effective in meeting the discharge requirements for alcohols and ketones. The vendor recommends pilot studies to quantify removal of alcohols and ketones. Additional characterization of the influent is also recommended in order to evaluate the significance of alcohols and ketones in the system influent. BOD in the system effluent must also be evaluated. Reduction of influent hardness may be advisable as a pretreatment step in order to reduce the frequency of system maintenance.

This alternative is anticipated to be the most forgiving of the three alternatives with regard to variable influent concentrations, interruption of influent flow and variability in flow rates. As discussed in the beginning of this section, it may be necessary for the system to accommodate frequent and large swings in influent quantity and quality. This alternative is anticipated to be superior to enhanced oxidation or biodegradation with regards to consistently meeting the discharge goals.

Air stripping must be coupled with an effective destruction technology, such as catalytic oxidation, to minimize environmental impacts. If properly implemented, organic air emissions from this alternative may be lower then fugitive air emissions from the other alternatives. Metals removal sludge would be the primary residual waste resulting from this alternative.

3.4.3 Implementability

3.4.3.1 Enhanced Oxidation

The enhanced oxidation system could be readily implemented. Several similar systems are in operation at various sites and a similar system is in operation at SRS. Vendors offer modular treatment systems that can be shipped to and assembled at the Site. Equipment lease agreements and maintenance agreements are also available for the type of system proposed. Much of the hardware is off-the-shelf. The equipment is readily available and no specific barriers to acceptance by the public or regulatory agencies have been identified.

The current system at SRS fails to meet the NPDES discharge standards on a continuing basis. The likely cause is operational problems which lead to fouling of the UV reactor. A well designed and closely maintained iron removal system is critical. It should be noted that the treatability investigations were performed at iron concentrations of 30 ppb which is well below VPSI's stated influent iron requirement of 5 ppm. Inspection and maintenance of the reactor is also critical. Several systems are being successfully operated and are consistently meeting their treatment goals. All of these systems have extensive maintenance programs and most incorporate post treatment devices similar to that proposed for this application.

If enhanced oxidation is selected, a system could be leased from VPSI. The lease should be negotiated so that lease payments will only be made if the system is meeting discharge standards.

3.4.3.2 Biodegradation

Implementation of biodegradation can be readily accomplished. Numerous similar systems are installed at other sites. Installation of the system would be followed by start-up that would include acclimation of the system. During this period very low flows through the reactor would be required, and primary water treatment would be accomplished using activated carbon adsorption.

Operation and maintenance of the system is not anticipated to be a major cause of concern. The AlliedSignal system is designed to be resistant to upsets. If an upset were to occur it would require more active operator attention until the system is placed back into steady state operation. System maintenance is not anticipated to be excessive.

A lease option has been proposed by AlliedSignal in their preliminary report. AlliedSignal also identifies a "no payment" provision for failure of the system to meet specified performance provided the design criteria are not exceeded.

3.4.3.3 Air Stripping

Air stripping is easily implementable. As discussed in Section 3.2, treatment of the effluent air would require a specialized air treatment system to accommodate the corrosive gases produced by combustion of the chlorinated organic. This technology is well developed and is not anticipated to introduce any implementability issues. The air treatment system may require demonstrating equivalency with air pollution discharge permit requirements.

Operation and maintenance of the system will be dependent on the levels of pretreatment. If no hardness reduction is included in the system the vendor states that the hardness observed at the site would require system maintenance approximately every 6 to 8 weeks. If hardness levels are reduced, maintenance frequency would be reduced to approximately every 3 to 6 months.

3.4.4 Costs

Costs for vendor supplied equipment are provided in each of the vendor's reports. Since the results of bio-reactor off-gas air sampling are not available at this time, it is not possible to evaluate the costs of air treatment for the biodegradation alternative. Comparison of the vendor cost estimates indicate there is no significant difference in the capital and instrumentation costs for the three alternatives described in Section 3.4.1, based on an assumed accuracy of ±50% for the vendor quotes.

Operation and maintenance costs were also estimated for each alternative. The most expensive system to operate is expected to be the enhanced oxidation system due to its high power use. The O&M cost for this system is highly dependent on the cost of electricity. At an assumed power cost of $0.1/kW hr, the O&M of the system is estimated to be approximately 3 times higher then the other two alternatives. The O&M costs for air stripping and biodegradation are anticipated to be similar. The impact of higher O&M costs will become more significant the longer the system is anticipated to be in operation.

3.5 Siting Option Assessment

The groundwater treatment system location should consider the following major factors:

- Access to the underlying soils and groundwater should be maximized to prevent restricting future remedial action. The system should be located in an area of relatively clean soil and groundwater, where it is unlikely that any containment or removal actions will take place.

- The system location must conform with all zoning and wetlands protection requirements. The system must be located more than 50 feet from wetlands, 40 feet from front and rear property lines, and 30 feet from side property lines. The maximum allowable height is 45 feet. The system should be located outside the 100-year floodplain in order to protect against flood damage.

The access issue suggests that the treatment system should be located on the north side of the former Cianci property, where little soil or groundwater contamination was detected during the RI. The south side of the former Cianci property is a less desirable location, considering the groundwater contamination that exists throughout this area. The Operations Area would be least desirable since this area contains the highest concentrations of contaminants in soil and groundwater.

Zoning setback requirements do not significantly limit the choice of locations, since there are many acceptable locations onsite having the requisite area and setback distances. Wetlands restrictions and floodplain considerations limit the potential building locations to the areas west of the floodway fringe indicated in Figure 3-11. The 100-year flood covers more than half of the south side of the former Cianci property, about a third of the north side of the former Cianci property, and none of the Operations Area. Other, less significant, factors which should be considered for siting the treatment system are; proximity to the containment system to minimize energy and material requirements and reduce the potential for accidental releases to the environment, utility requirements, and security arrangements.

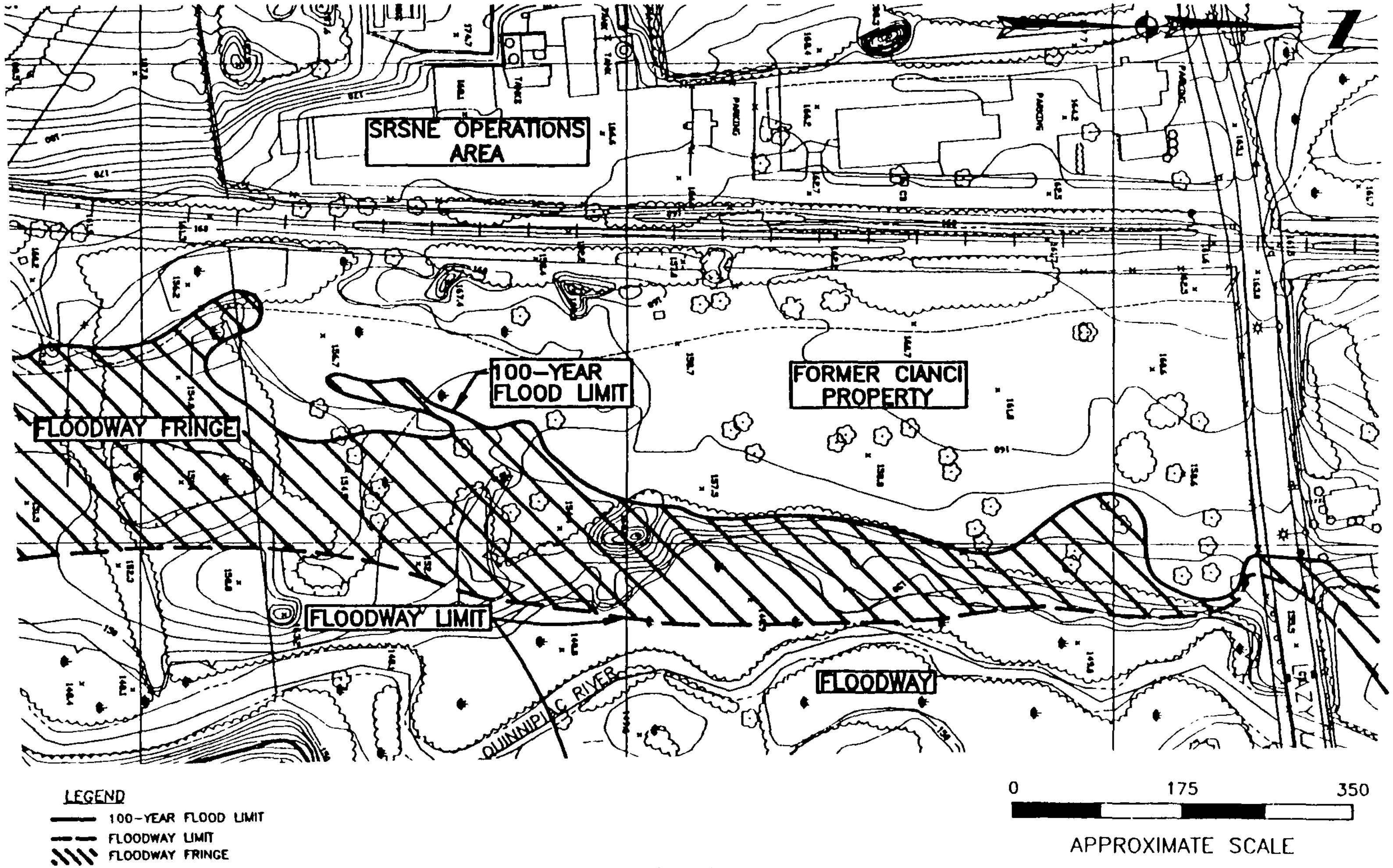
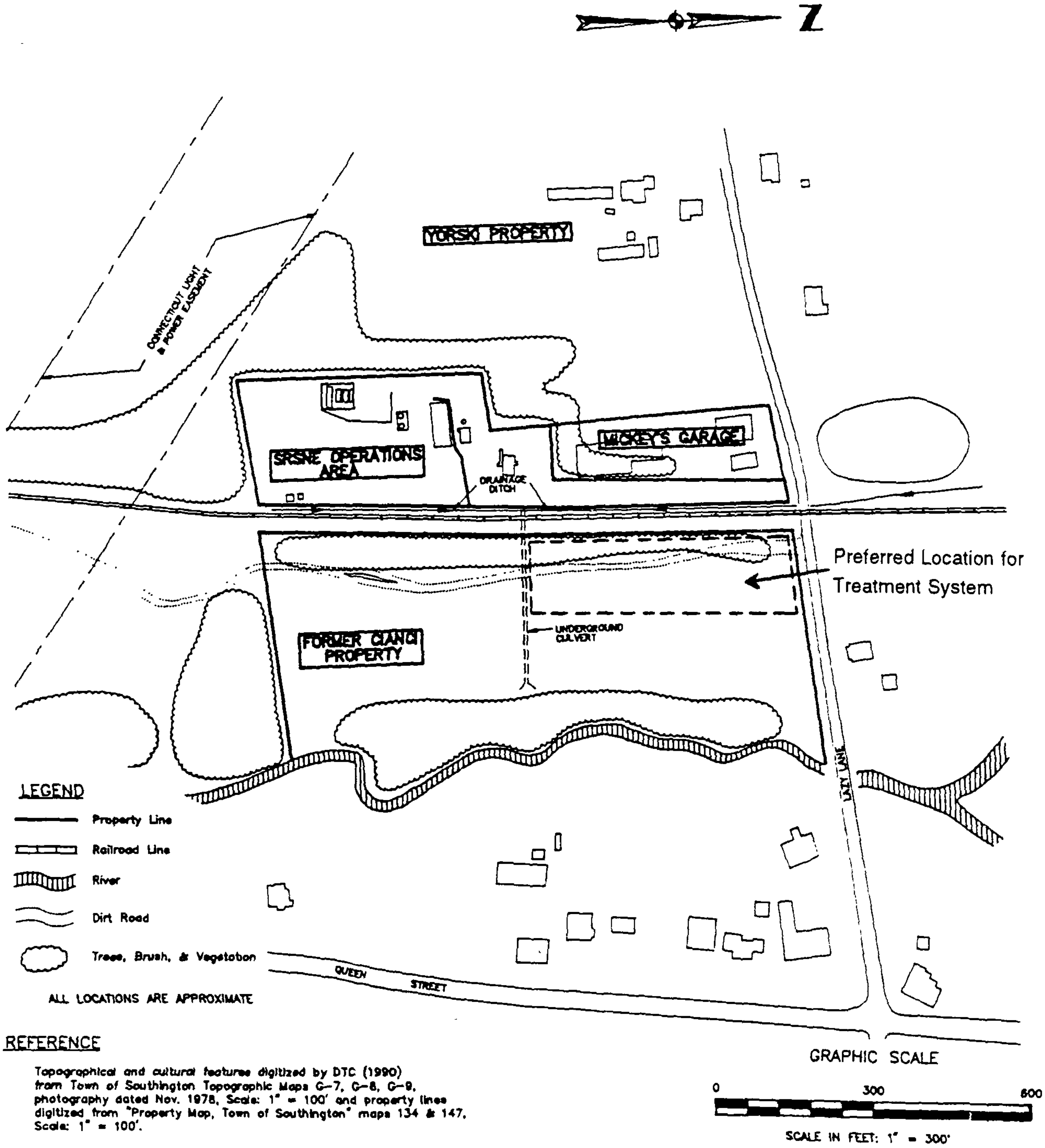


FIGURE 3-11

Floodway Map (from RI Report, May 1994)
SRSNE, Southington, CT

There would be several disadvantages to locating the system in the Operations Area compared to the former Cianci property, including greater piping lengths; need to pipe wastewater under the railroad tracks; and higher elevation (by 8 feet) necessitating greater pumping power. The Operations Area currently has water and electric service and a security fence around the perimeter. However, the current electric service to the Operations Area is only marginally adequate for the current containment/treatment system, and new electric service would probably be needed for the greater utility requirements of the NTCRA system.

Based on the above factors, the preferred location for the treatment system is within the northwestern quadrant of the former Cianci property, as shown in Figure 3-12. This location does not limit future access to soil or groundwater contamination, does not fall within wetlands-regulated areas or the 100-year floodplain, is adjacent to the north end of the containment system, and is relatively accessible for utility hookups. Also, this location would allow easy hookup to the existing discharge pipe to the Quinnipiac River, if allowed in accordance with a NPDES permit.



REFERENCE

Topographical and cultural features digitized by DTC (1990) from Town of Southington Topographic Maps G-7, G-8, G-9, photography dated Nov. 1978, Scale: 1" = 100' and property lines digitized from "Property Map, Town of Southington" maps 134 & 147, Scale: 1" = 100'.

FIGURE 3-12

Preferred Location for Treatment System
SRSNE, Southington, CT

Adapted from Figure 2-12, RI Report, May 1994.

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APPENDIX A

SOIL BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.

ENSR

BORING LOG

Sheet 1 of 1

Project No. 6112 002
Date - Start 3/13/94
Finish 3/14/94
Boring B401
Project Name SRSNE
Drilling Co. Empire
Location Former Cianci Property
Drilling Method Drive and Wash
Total Depth 22'0"
Inspector J. Mosante
Reviewer J. Barbaro
Remarks 300 lb. hammer used to advance split spoon

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~ SAMPLES
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
	S-1	4 - 3 12-16	0-2'	1.8'/2'		Fine to medium SAND, some silt and fine to coarse gravel, hard, moist/frozen, reddish brown	A401A
5	S-2	12-18 28-24	5-7'	1.2'/2'		coarse to very coarse SAND, little gravel and cobbles noted, loose, wet, dark grey (7.5 to 8.2ft. had to drill through boulder)	A401B
10	S-3	11-5 4-8	10-12'	0'/2'		No Recovery coarse gravel noted in drilling water	A401C
15	S-4	13-10 5/0.02	15-16.2'	0.5'/1.2'		SILT, some fine to medium gravel and cobbles, trace fine to medium sand, medium hard, wet, reddish brown.	A401D
20						16.2 to 17.5 hit boulder	
	S-5	75-105	21-22'	4"		Hit boulder at 20' 3/14/94 rollerbitted to 21' red arkose rock fragments with F-C sand, some silt+clay. Interpreted as bedrock. EOB 22'	
25							
30							

M890278

ENSR

BORING LOG

Sheet 1 of 2

Project No. 6112 002 Date - Start 3/9/94 Finish 3/10/94 Boring B402
Project Name SRSNE Drilling Co. Empire
Location former Cianci property Drilling Method drive and wash
Total Depth 23.2 ft Inspector J. Musante Reviewer J. Borbero
Remarks 300 lb. hammer used to advance split spoons

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~ SAMPLES
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
	S-1	18-15 12-12	0-2'	1.7'/2'		SAND, medium to coarse, some silt and gravel, fine to coarse medium hard, dense, moist reddish brown.	A402A
	S-2	11-10 10-11	2-4'	0'/2'		no recovery	A402B
5	S-3	9-29 31-37	4-6'	1.8'/2'		4-5' sand, coarse to v. coarse some gravel and cobbles medium dense, wet, dark grey 5-6' silt, some gravel and cobbles, fine to coarse, hard wet, reddish brown	A402C
	S-4	31-28 41-67	6-8'	1.8'/2'		coarse to very coarse SAND little fine gravel, trace cobbles 3" diameter rounded, loose, wet dark grey	A402D
			8-10'			no spoon collected, boulders or cobbles, advanced to 10 ft	
10	S-5	24-19 18-18	10-12'	0'/2'		large cobble blocking tip of split spoon.	A402E
	S-6	11-11 7-7	12-14'	1.8'/2'		12-12.5 GRAVEL - fine to coarse, loose sand, coarse, loose, wet, grey 12.5-13.5 fine SAND with silt, medium hard, wet, reddish brown solvent odor noted. 13.5-14 SILT, some gravel, fine to coarse trace sand, hard wet, reddish brown	A402F B402F
15	S-7	18-7 9-11	14-16'	1'/2'		14-15 same as from 13.5-14 15-16 SILT, trace clay, wet, soft to medium hard, grey, solvent odor noted.	
	S-8	14-14 13-15	16-18'	1'/2'		16-17 same as from 15-16 17-17.5 SAND, medium to coarse, trace gravel and silt, loose reddish brown, solvent odor 17.5-18 SILT, some gravel and sand, trace cobbles, hard, wet, red brown	A402G A402H
	S-9	15-17 18-23	18-20'	1.3'/2'		SILT, some gravel, fine to coarse, little cobbles, trace sand, hard to v. hard red brown.	A402I

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BORING LOG (continued)

Project SRSNE Boring B402 Sheet 2 of 2

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~ SAMPLES
	Type & No.	Blows per 6 In	Depth Range	Rec.			
	S-10	30 - 31 28 - 40	20-22'	1.8'/2'		SILT, with weathered rock and rock fragments (Arkose sandstone)	
							A402J
	S-11	30 - 31 100/0.02	22 - 23.2'	1'/1.2'		same as above	A402K
						-Arkose sandstone (layered) noted at 23 feet.	
						EOB 23.2'	
25							
30							
35							

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BORING LOG

Sheet 1 of 2

Project No. 6112-002 Date - Start 3/9/94 Finish 3/10/94 Boring B-403

Project Name SRSNE Drilling Co. Empire

Location Former Cianci property Drilling Method drive and wash

Total Depth 22.8 Inspector J. Musante Reviewer J. Barbaro

Remarks 300 lb. hammer used to advance split spoon

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~ SAMPLES
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
	S-1	4-8 11-12	0-2'	2'/2'		SILT, trace fine sand and cobbles hard, slightly moist, reddish-brown.	A403A
	S-2	17-12 12-11	2-4'	1.5'/2'		2-2.5 same as S-1 2.5-4 SAND, coarse to very coarse little fine gravel, loose, wet, dark brown turning to dark grey, solvent odor noted, angular to well rounded.	A403B
5	S-3	14-18 38-30	4-6'	1.5'/2'		4-5 same as from 2.5 to 4 5-6 SILT, some gravel and cobbles trace sand, hard, wet, reddish brown	A403C
	S-4	18-21 28-20	6-8'	1'/2'		same as S-3 from 5-6'	A403D
	S-5	21-16 8-7	8-10'	1'/2'		SAND, very coarse, some gravel fine to coarse, trace silt, loose to medium dense, wet, grey, reddish brown.	A403E
10	S-6	7-4 3-4	10-12'	1'/2'		SAND, fine to medium, loose, wet reddish brown, poorly graded	A403F B403F
	S-7	5-4 5-6	12-14'	0.5'/2'		same as S-6	A403G
15	S-8	8-11 21-20	14-16'	1.5'/2'		SILT, some fine sand and gravel, becoming gravel, fine to coarse, little sand, trace silt, hard to very hard, wet, reddish brown, solvent odor noted.	A403H
	S-9	9-15 18-23	16-18'	1.2'/2'		SILT, with gravel and Cobbles, fine to coarse, hard to very hard, wet, reddish brown.	A403I
20	S-10	28-20 18-23	18-20'	1.5'/2'		SILT, with gravel and cobbles, fine to coarse, very hard, moist, reddish brown.	A403J

BORING LOG (continued)

ENSR Project SRSNE Boring B-403 Sheet 2 of 2

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~ SAMPLE
	Type & No	Blows per 6 In	Depth Range	Rec.			
	S-11	31-22 21-23	20-22'	0.5'/2'		SILT, with gravel and weathered rock, very hard, moist, reddish brown.	A403K
	S-12	60-100/0.3	22-22.8'	0.8'/0.8'		weathered and fractured SANDSTONE, layering noted	A403L
25						EOB 22.8	
30							
35							

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BORING LOG

Sheet 1 of 2

Project No. 6112 002 Date - Start 3/8/94 Finish 3/8/94 Boring B404

Project Name SRSNE Drilling Co. Empire

Location Former Cianci property Drilling Method drive and wash

Total Depth 24 ft. Inspector J. Musante Reviewer J. Barbaro

Remarks 140 lb. hammer used to advance split spoons to 5', 300 lb hammer used after 5'.

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment~~ ~~Installed~~ SAMPLES
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
	S-1	26-21 24-29	0-2'	1.8'/2'		SILT, some gravel, trace sand medium hard to hard (frozen) moist, reddish brown, gravel angular to subrounded	A404A
	S-2	30-23 23-21	2-4'	1.5'/2'		same as S-1, wood noted at tip of split spoon	A404B
5	S-3	39-48 40-42	4-6'	1'/2		weathered and crushed ROCK hard/dense, wet, reddish brown and dark grey	A404C
	S-4	31-19 21-20	6-8'	1.3'/2'		fine SAND, little medium to coarse sand, trace fine gravel, loose wet, dark reddish-brown	A404D
	S-5	14-9 9-11	8-10'	1'/2		fine SAND, some silt, loose, wet reddish brown. slight solvent odor.	A404E
10	S-6	5-5 6-4	10-12	0.5'/2		SAND, medium, loose, wet, poorly graded, reddish brown, solvent odor noted	A404F
	S-7	4-8 11-11	12-14'	2'/2'		same as S-6, solvent odor noted	A404G
15	S-8	5-8 7-8	14-16'	1.5'/2'		14-14.5 same as S-6 14.5-16 SILT, some sand and gravel fine to medium, trace cobbles and clay, medium hard, wet, solvent odor well graded, reddish brown	A404H
	S-9	6-7 9-11	16-18'	1.5'/2'		SAND, coarse, some fine to coarse gravel and silt, clay lenses noted, loose to medium dense, reddish brown, solvent odor, gravel angular to subrounded.	A404I
	S-10	11-15 42-35	18-20'	1.3'/2'		same as S-8 - weathered rock noted at tip of split spoon.	A404J
20							

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BORING LOG (continued)

Project SRSNE Boring B404 Sheet 2 of 2

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~ SAMPLES
	Type & No	Blows per 6 In	Depth Range	Rec.			
	S-11	28-21 18-17	20-22'	0.8'/2'		weathered ROCK consisting of sand, fine to medium, silt, and gravel, fine to coarse, angular to subrounded, medium dense to very dense, moist, reddish brown slight solvent odor	A404K
	S-12	18-22 34-61	22-23'	1'/2'		S-12 same as S-11	A404L
						EOB 24'	
25							
30							
35							

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BORING LOG

Sheet 1 of 1

Project No. 6112 002 Date - Start 3/4/94 Finish 3/4/94 Boring B-405

Project Name SRSNE Drilling Co. Empire

Location Former Cianci property Drilling Method drive and wash

Total Depth 26.4 ft Inspector J. Musante Reviewer J. Barbaro

Remarks 140 lb. hammer was used to advance split spoons

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~ SAMPLES
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
5	S-1	46-31 30-30	5-7'	1'/2'		5-5.5' SAND, coarse, loose, wet brownish grey, poorly graded 5.5-7' GRAVEL, fine to coarse little silt and sand, medium dense, wet, reddish brown well graded, angular to subrounded.	A405A
10	S-2	39-27 26-29	10-12'	1'/2'		GRAVEL, cobbles, sand, silt, fine to coarse, trace clay, hard to very hard, wet, reddish brown, well graded.	A405B
15	S-3	34-28 21-20	15-17'	1.5'/2'		GRAVEL, fine to coarse, little silt and sand, medium dense to dense, wet, reddish brown, well graded angular to subrounded, trace cobbles lense of coarse sand at 15.5 to 16.5 loose, wet, reddish brown, poorly graded.	A405C
20	S-4	19-24 21-18	20-22'	1'/2'		SILT, some clay, little sand, trace gravel, medium hard, wet, reddish brown, gravel angular.	A405D
25	S-5	39-42 38-100/.4	24.5-26.4'	1'/1.9'		SAND, medium, some gravel, fine to coarse, medium dense to dense, wet, reddish brown. This may be weathered sandstone and conglomerates at top of bedrock.	A405E
30						EOB 26.4'	
35							

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ENSR

BORING LOG

Sheet 1 of 2

Project No. 6112 002 Date - Start 3/22/94 Finish 3/23/94 Boring PW-406

Project Name Solvent Recovery Service Drilling Co. Empire

Location Former Cianci Property Drilling Method Air rotary

Total Depth 50 Inspector Klinck Reviewer J. Barbaro

Remarks Boring to bedrock with air rotary on pilot hole logged by Joel Musante
Rock drilling done by drive & wash method; following core collection.

Depth Feet	Sample				Graphic Log	Lithologic Description	~~Equipment Installed~~	run time
	Type & No.	Blows per 6 In.	Depth Range	Rec.				
						- see pilot hole boring log B-402		
5								
10								
15								
20						Bedrock at 24'5"		
25		RQD =90%	25'-30'	5'		even grained red sandstone (arkose) medium grained - massive w/ open joint at 26'8" and 3 low angle fractures		27 min
30			30'-35'	5'		red sandstone coarsening downwards to coarse conglomerate - bedding horizontal, 8 low angle fractures w/ open joints at 31'0" and 31'11"		36 min
35			35'-40'	5'		medium to coarse grained red sandstone/conglomerate mostly massive with 6 low angle fractures and one open joint at 36'4"		25 min

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BORING LOG (continued)

Project Solvent Recovery Service Boring PW 406 Sheet 2 of 2

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No	Blows per 6 In.	Depth Range	Rec.			
		RQD =84%	40'-45'	5'		coarse to very coarse red sandstone /conglomerate - bedding low angle with 9 low to high angle fractures and an open joint at 42'1"	
45			45'-50'	5'		coarse grained conglomerate with 4 medium angle fractures and a sharp contact at 46'10" to medium grained red sandstone with multiple low-high angle bedding planes, and 4 low angle fractures.	
50						EOB 50'0"	

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BORING LOG

Sheet 1 of 1

Project No. 6112-002 Date - Start 3/23/94 Finish 3/23/94 Boring PW-407

Project Name SRSNE Drilling Co. Empire Soils

Location Former Cianci Property Drilling Method 8" Air rotary

Total Depth 18' Inspector D. Klinch Reviewer J. Barbaro

Remarks Installed 4" overburden pumping well

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
5						Refer to pilot hole B-402 for description of geology.	
10							
15							
						End of Boring = 18'	
20							

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BORING LOG

Sheet 1 of 2

Project No. 6112 002 Date - Start 3/14/94 Finish 3/15/94 Boring MW-408

Project Name Solvent Recovery Service Drilling Co. Empire Soil Investigatio

Location Southington CT Drilling Method drive and wash

Total Depth ______ Inspector D. Klinch Reviewer J. Barbero

Remarks ______

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
0						organic Sandy loam w/roots	
	S-1	4-10-10-11	0-2'	17"/24"		brown m-f SAND and SILT with fines trace gravel, medium dense medium plasticity, black mottling (precipitation or oxidation staining)	
5	S-2	40-39-50/3"	5-7'	10"/24"	↑ ▼	S-2 same as above w/ few cobbles	
10	S-3	31-18-19-24	10-12'	11"/24"	↓	brown SILT and CLAY with fines, little gravel, high plasticity, medium dense, little foul odor, gravel angular	
15	S-4	9-11-14-18	15-17'	9"/24"		m SAND and GRAVEL, red-brown w/ little fines and clay, loose, foul odor	
20	S-5	19-11-11-20	20-22'	17"/24"		red-brown c-f SAND and silt with gravel, little fines, medium dense, little or no odor, low plasticity	
25	S-6	19-11-50/2"	25-27' (26.2)	12"/24"	≡	red-brown c-f SAND and silt with gravel and cobbles, little fines - SS has cobble lodged in barrel at 26 feet - bedrock at 26'6"	
30						Rollerbitted to 30', set up for coring.	
35							

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BORING LOG (continued)

ENSR Project SRSNE Boring MW408 Sheet 2 of 2

Depth Feet	Sample: Type & No.	Sample: Blows per 6 In.	Sample: Depth Range	Sample: Rec.	Graphic Log	Lithologic Description	Equipment Installed
30			31'-41'			recovery 9'8" from 10'0" run = red sandstone coarsening downwards from fine to medium grained. Mostly massive with four medium to high angle fractures in top 3ft. Bedding mostly horizontal with occaisonal low angle planes. RQD = $\frac{9'4''}{10'0''}$ = 93%	97%
35							
40							
			41'-51'			recovery: 9'10" from 10'0" run = red sandstone grading to conglomerate. Mostly massive with open joints at 41'-42' and again at 44'. Bedding horizontal to low-angle. RQD = $\frac{9'0''}{10'0''}$ = 90%	98%
45							
50							
						End coring at 51'	

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BORING LOG

Sheet 1 of 1

Project No. 6112-002 Date - Start 3/16/94 Finish 3/16/94 Boring MW-409

Project Name SRSNE Drilling Co. Empire Soils

Location Former Cianci Property Drilling Method 4" Drive & Wash

Total Depth 17' Inspector D. Klinch Reviewer J. Barbaro

Remarks Installed well MW-409

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
						No samples collected. For geology, refer to log for MW-408	
5							
10							
15							
						End of Boring = 17'	
20							

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BORING LOG

Sheet 1 of 1

Project No. 6112-002 Date - Start 3/25/94 Finish 3/25/94 Boring MW-410

Project Name SRSNE Drilling Co. Empire Soils

Location Former Cianci Property Drilling Method 4" Drive & Wash

Total Depth 12' Inspector J. Doherty Reviewer J. Barbaro

Remarks Installed well MW-410

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
5						No samples collected. For geology, refer to log for MW-411.	
10							
						End of Boring = 12'	
15							

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BORING LOG

Sheet 1 of 2

Project No. 6112 002 Date - Start 3/17/94 Finish 3/18/94 Boring MW-411

Project Name Solvent Recovery Services Drilling Co. Empire Soil Investigations

Location Southington CT Drilling Method drive and wash

Total Depth 51' Inspector D. Klinch Reviewer J. Barbaro

Remarks soil below 14-15' may be a weathered till

Depth Feet	Sample: Type & No.	Sample: Blows per 6 In.	Sample: Depth Range	Sample: Rec.	Graphic Log	Lithologic Description	Equipment Installed
0	S-1	3·9·9·11	0-2	22"/24"		15" SANDY LOAM, loose to medium dense 7" F-M SAND and silt w/ little organics, dark brown mottled w/ red sand and silt, little gravel.	
5	S-2	25·25 50/2	5-7	3"/24"	▼	dark brown w/ mottled grey f. SAND and SILT with gravel and shale chips, trace shale cobbles, loose firm, no odor.	
10	S-3	2·9·7·7	10-12	2"/24"		GRAVEL, possibly diorite	
15	S-4	25·20 14·15	15-17	7"/24"		red-brown m-f SAND and SILT medium dense, stiff, little gravel homogeneous, med. plasticity trace clay sized particles	
20	S-5	38·25 29·34	20-22	12"/24"		red-brown m-f SAND and GRAVEL dense, stiff, mottled w/ gray weathered rock - majority of sample is weathered rock	
25	S-6	50/0.2	24 - 24.2	0.2"/24"		red-brow m-f SAND and SILT, little C sand and f gravel, rock fragments, sample is weathered rock	
30	—	—	—	—		HARD ROCK at @26'	
35						rollerbitted to 51'0" no samples collected	
40							

BORING LOG (continued)

ENSR Project SRSNE Boring MW-411 Sheet 2 of 2

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In	Depth Range	Rec			
45 50						rollerbitted to 51', no samples collected	
55 60 65 70 75 80 85						EOB 51'0"	

ENSR

BORING LOG

Sheet 1 of 1

Project No. 6112-002 Date - Start 3/24/94 Finish 3/24/94 Boring MW-412

Project Name SRSNE Drilling Co. Empire Soils

Location Fomer Cianci Property Drilling Method 4" Drive i Wash

Total Depth 22' Inspector D. Klinch Reviewer J. Barbaro

Remarks Installed well MW-412

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
						No samples collected. For geology, refer to log for MW-411	
5							
10							
15							
20							
						End of Boring = 22'	
25							

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BORING LOG

ENSR

Sheet 1 of 1

Project No. 6112-002 Date - Start 3/18/94 Finish 3/18/94 Boring MW-413

Project Name SBSNE Drilling Co. Empire Soils

Location Former Cianci Property Drilling Method 4" Drive & Wash

Total Depth 20' Inspector L. Pannell Reviewer J. Barbaro

Remarks Installed well MW-413

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
						No Samples collected.	
5						For geology, refer	
						to log for MW-414	
10							
15							
20							
						End of Boring = 20'	

ENSR

BORING LOG

Sheet 1 of 2

Project No. 6112 002 Date - Start 3/16/94 Finish 3/16/94 Boring MW414

Project Name SRSNE Drilling Co. Empire Soil Investigati

Location Former Cianci property Drilling Method 4" ID Drive + Wash

Total Depth 50.2 ft Inspector L. Pannell Reviewer J. Barbaro

Remarks

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
	S-1	4 - 7 16-21	0-2'	16"/24"		reddish-brown F-M SAND and SILT, some C-sand, little F-gravel, no odor noted	
5	S-2	15-25 40-40	5-7'	12"/24"		gray C-SAND and GRAVEL, red F-M SAND in spoon tip, chemical odor (boulder at 8'-10')	
10	S-3	20-8 7-5	10-12'	14"/24"		7" of red rock fragments above 7" of gray M-SAND, well sorted Chemical odor.	
15	S-4	5-2 1-1	15-17'	10"/24"		red C-SAND (possibly wash) above 3" F-M SAND + SILT, Chemical odor.	
20	S-5	10-9 10-11	20-22'	12"/24"		red sandstone fragments and pieces up to 1.5" in length mixed with red F-C SAND and SILT (probably weathered rock) (harder drilling at 22.5')	
25	S-6	100/0.4	25-25.4'	4"/24"		F-M red SAND, SILT, CLAY, to C-SAND and F-gravel (weathered rock), no chemical odor noted.	
30						Bedrock at 25.4' rollerbitted from 25.4' to 50.2' no samples collected	
35							

BORING LOG (continued)

ENSR Project SRSNE Boring MW414 Sheet 2 of 2

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No	Blows per 6 In	Depth Range	Rec			
						rollerbitted to 50.2' no samples collected	
45							
50						EOB 50.2'	
55							
60							
65							
70							
75							
80							
85							

ENSR

BORING LOG

Sheet 1 of 1

Project No. 6112-002 Date - Start 3/17/94 Finish 3/17/94 Boring MW-415

Project Name SRSNE Drilling Co. Empire Soils

Location Former Cianci Property Drilling Method 4" Drive & Wash

Total Depth 12' Inspector L. Pannell Reviewer J. Barbaro

Remarks Installed well MW-415

Depth Feet	Sample				Graphic Log	Lithologic Description	Equipment Installed
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
5 10						No samples collected. For geology, refer to log for MW-414	
15						End of Boring = 12'	

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BORING LOG

Sheet 1 of 2

Project No. 6112-002 Date - Start 3/14/94 Finish 3/15/94 Boring MW-416
Project Name SRSNE Drilling Co. Empire Soils
Location Former Gianci Property Drilling Method 4" Drive & Wash
Total Depth 49.2' Inspector L. Pannell Reviewer J. Barbaro
Remarks

Depth Feet	Sample				Graphic Log	Lithologic Description	Sample ID ~~Equipment Installed~~
	Type & No.	Blows per 6 In.	Depth Range	Rec.			
	S1	2-3 3-5	0-2'	1"/24"		Br F-M SAND, little C sand slight odor. No sample collected	A416A (not collected)
5	S2	12-14 17-25	5-7'	10"/24"		Br-gr C SAND & GRAVEL little F-M sand. Single ball of red silt & clay in middle of sample. chemical odor, OVM=0.0	A416B
10	S3	15-25 20-10	10-12'	12"/24"		red F SAND & SILT. little f-m gravel, trace-little F-C gravel (Fill?); loose.	A416C
15	S4	15-15 15-15	15-17'	10"/24"		red F SAND & SILT, little f-m gravel, tr. clay (Fill?); loose.	A416D
20	S5	35-40 45-20	20-22'	14"/24"		reddish-Brown C SAND, some f-M sand & silt. little f-M gravel, slight odor. loose.	A416E
25	S6	100/.3 100/.2	25-25	6"/24"		weathered rock - red - f-m sand, silt, dense, visible structure, small pieces intact as rock, most friable.	A416E
30	S7	Not recorded	30-30	0"/24"		No recovery	
35						Roller-bitted to 49.2' to install well.	

ENSR Project SRSNE **BORING LOG** (continued) Boring MW-416 Sheet 2 of 2

Depth Feet	Sample: Type & No	Sample: Blows per 6 In	Sample: Depth Range	Sample: Rec	Graphic Log	Lithologic Description	Equipment Installed
						No sampling.	
40							
45							
50						End of Boring = 49.2'	

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A2

Project No: 6112-002 Client: SRSNE Site: Southington CT

WELL No: PW-406

Well Location: Former Cianci Property

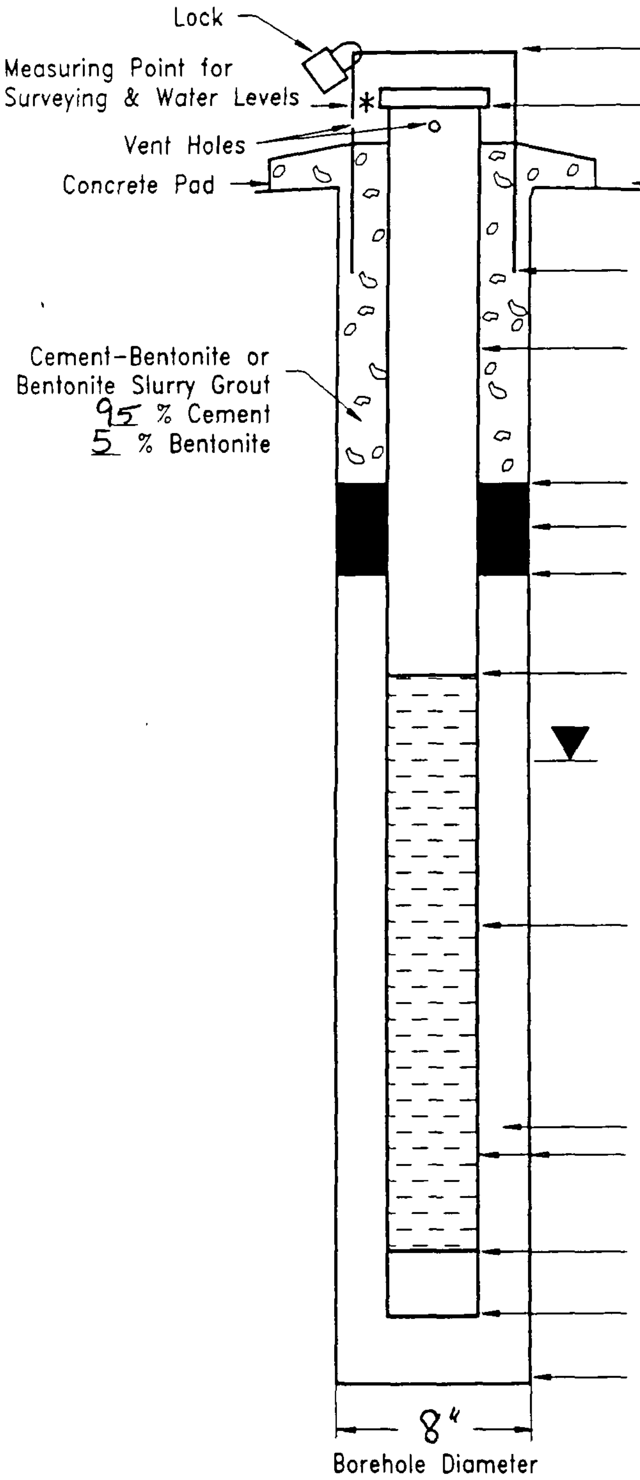
Date Installed: 3/24/94

Contractor: EMPIRE

Method: 8" Air rotary/roller-bit

Inspector: D. Klinch

MONITORING WELL CONSTRUCTION DETAIL



Cement-Bentonite or Bentonite Slurry Grout
95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		2.66	160.37
Top of Riser Pipe		2.69	160.40
Ground Surface (G.S.)		0.00	
Bottom of Steel Guard Pipe		2.34	
Riser Pipe:			
Length	28'10"		
Inside Diameter (ID)	4"		
Type of Material	PVC		
Top of Bentonite Seal		25'9"	
Bentonite Seal Thickness	2'		
Top of Sand		27'9"	
Top of Screen		29'10"	
Stabilized Water Level			
Screen:			
Length	20'		
Inside Diameter (ID)	4"		
Slot Size	.010		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	2"		
Bottom of Screen		49'10"	
Bottom of Tail Pipe:		50'2"	
Length	4"		
Bottom of Borehole		50'2"	

Approved:

Signature

Date

* Describe Measuring Point:
top of PVC riser

ENSR®

Project No: 6112-002 Client: SRSNE Site: Southington, CT

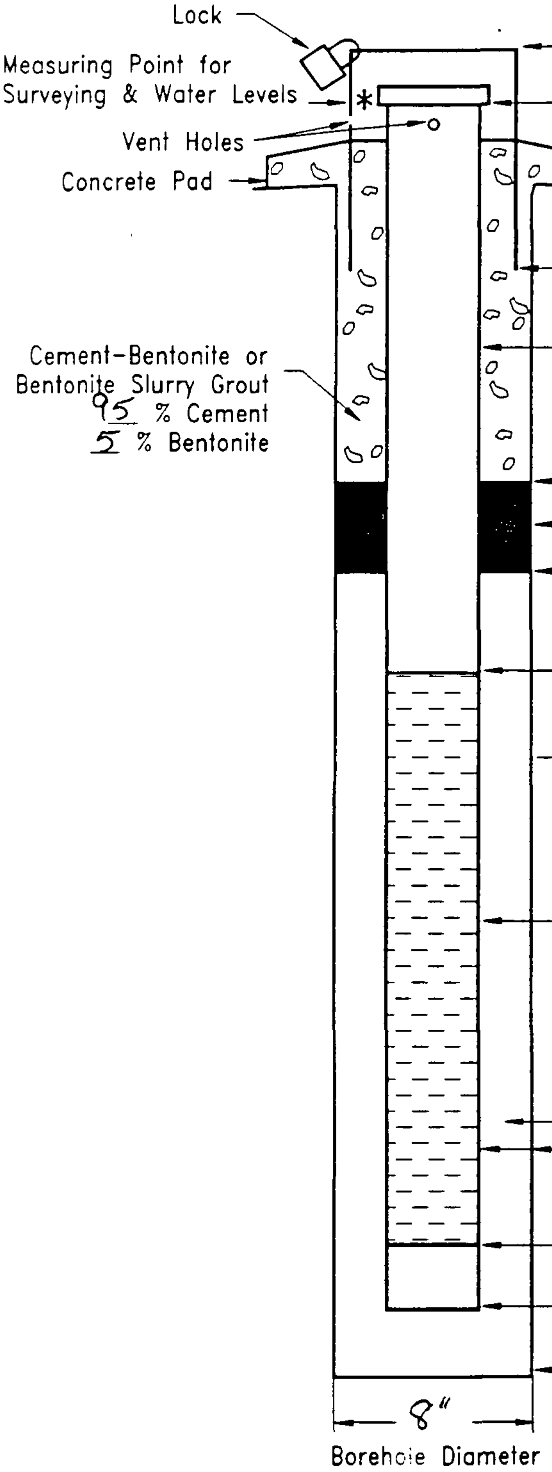
WELL No: PW-407

Well Location: Former Cianci Property

Date Installed: 3/23/94

Contractor: Empire Soils Method: 8" air rotary Inspector: D. Klinc

MONITORING WELL CONSTRUCTION DETAIL



95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		3'2"	160.57
Top of Riser Pipe		3'	160.31
Ground Surface (G.S.)		0.00	
Bottom of Steel Guard Pipe		1'10"	
Riser Pipe:			
Length	10'8"		
Inside Diameter (ID)	4"		
Type of Material	PVC		
Top of Bentonite Seal		3'8"	
Bentonite Seal Thickness	2'		
Top of Sand		5'8"	
Top of Screen		7'8"	
Stabilized Water Level		NR	
Screen:			
Length	10'		
Inside Diameter (ID)	4"		
Slot Size	0.01 in		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	2"		
Bottom of Screen		17'8"	
Bottom of Tail Pipe:		18'	
Length	4"		
Bottom of Borehole		18'	

Approved:

*Describe Measuring Point:
Top of PVC Riser

Signature Date

ENSR®

Project No: 6112 002 Client: SRSNE Site: Southington CT

WELL No: MW-408

Well Location: Former Cianci Property

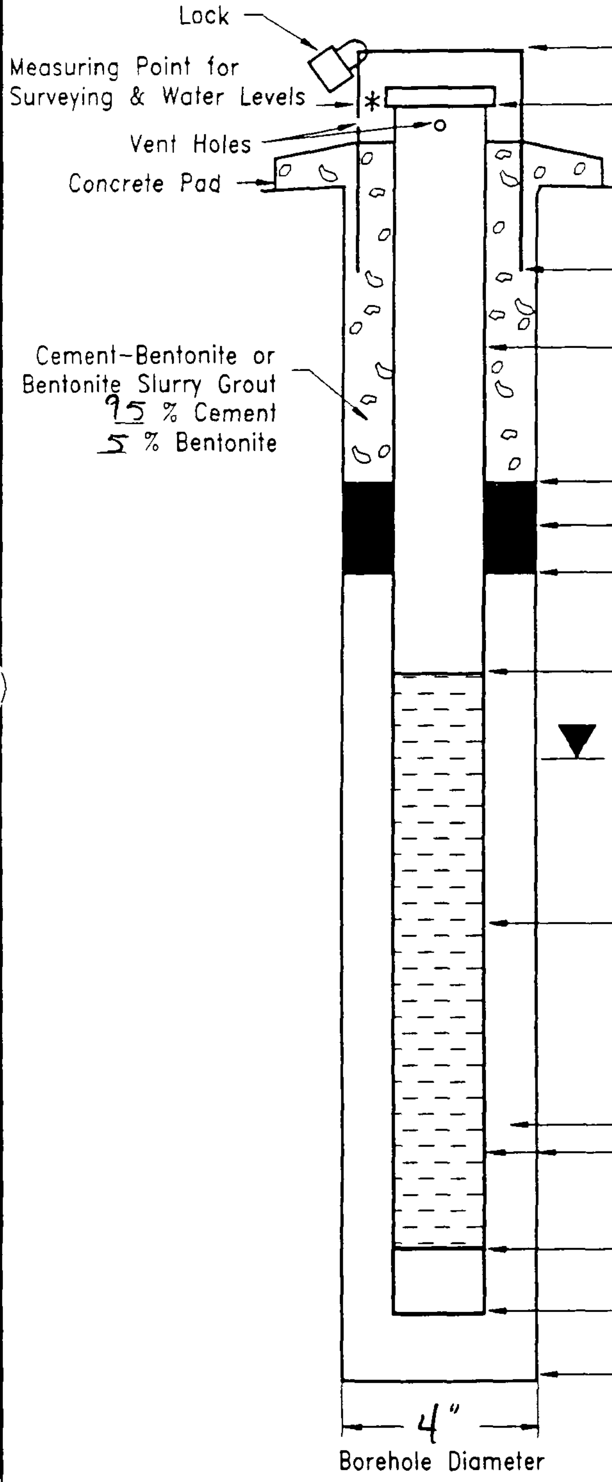
Date Installed: 3/15/94

Contractor: EMPIRE

Method: 4" Drive + Wash / Rollerbit

Inspector: D. Klinck

MONITORING WELL CONSTRUCTION DETAIL



95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		2.30'	159.67
Top of Riser Pipe		2.20'	159.56
Ground Surface (G.S.)		0.00	
Bottom of Steel Guard Pipe		2.70'	
Riser Pipe:			
Length	33.8'		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		27'	
Bentonite Seal Thickness	2'		
Top of Sand		29'	
Top of Screen		31.6'	
Stabilized Water Level			
Screen:			
Length	19.6'		
Inside Diameter (ID)	2"		
Slot Size	.010		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1"		
Bottom of Screen		51.2'	
Bottom of Tail Pipe:		51.6'	
Length	0.4'		
Bottom of Borehole		51.6'	

Approved:

* Describe Measuring Point:
top of PVC riser

Signature

Date

ENSR®

Project No: 6112-002 Client: SRSNE Site: Southington

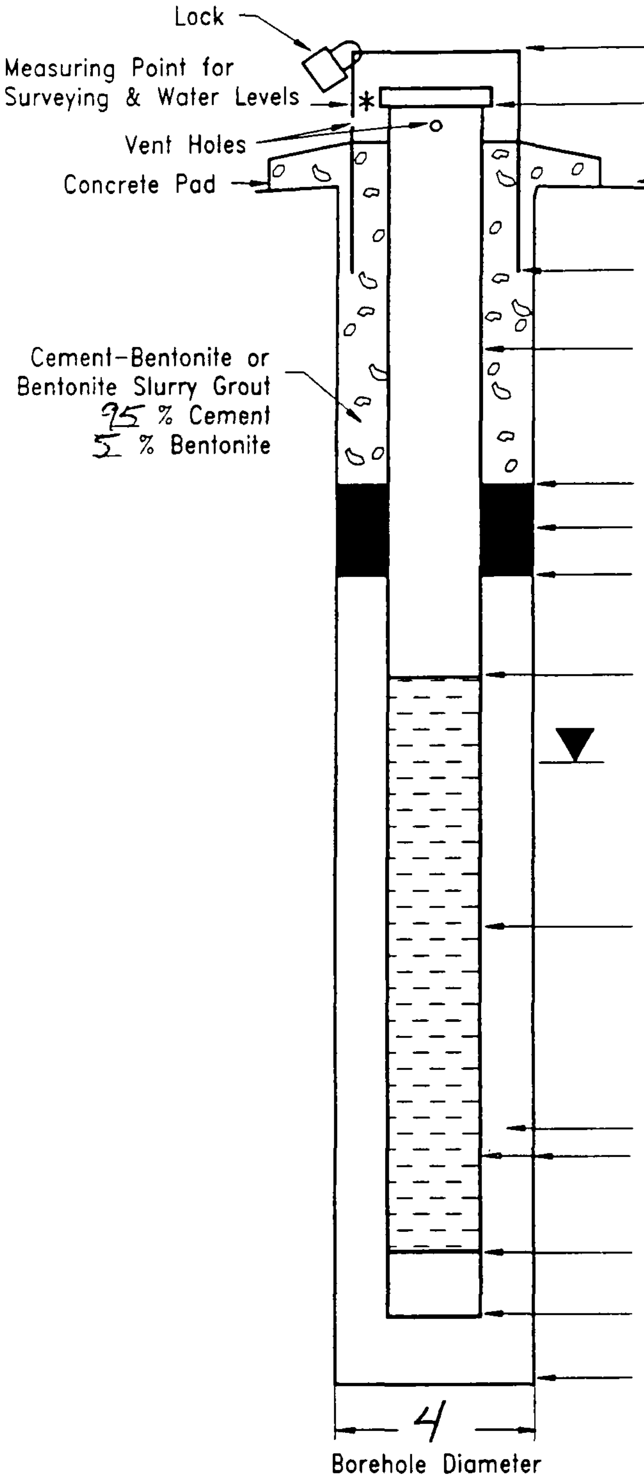
WELL No: MW-409

Well Location: Former Cianci Property

Date Installed: 3/16/94

Contractor: Empire Soil Method: 4" Drive + Wash Inspector: Klinck

MONITORING WELL CONSTRUCTION DETAIL



		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		2.5	159.70
Top of Riser Pipe		2.4	159.60
Ground Surface (G.S.)		0.00'	157.14
Bottom of Steel Guard Pipe		2.5	
Riser Pipe:			
Length	9.1		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		3.0	
Bentonite Seal Thickness	2.0		
Top of Sand		5.0	
Top of Screen		6.7	
Stabilized Water Level			
Screen:			
Length	9.6'		
Inside Diameter (ID)	2"		
Slot Size	0.010"		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1"		
Bottom of Screen		16.3'	
Bottom of Tail Pipe:		16.7'	
Length	0.4'		
Bottom of Borehole		16.7'	

Approved:

* Describe Measuring Point:
Top of PVC riser

Signature Date

ENSR®

A2E

Project No: 6112-002 Client: SRSNE Site. Southington CT

WELL No: MW410

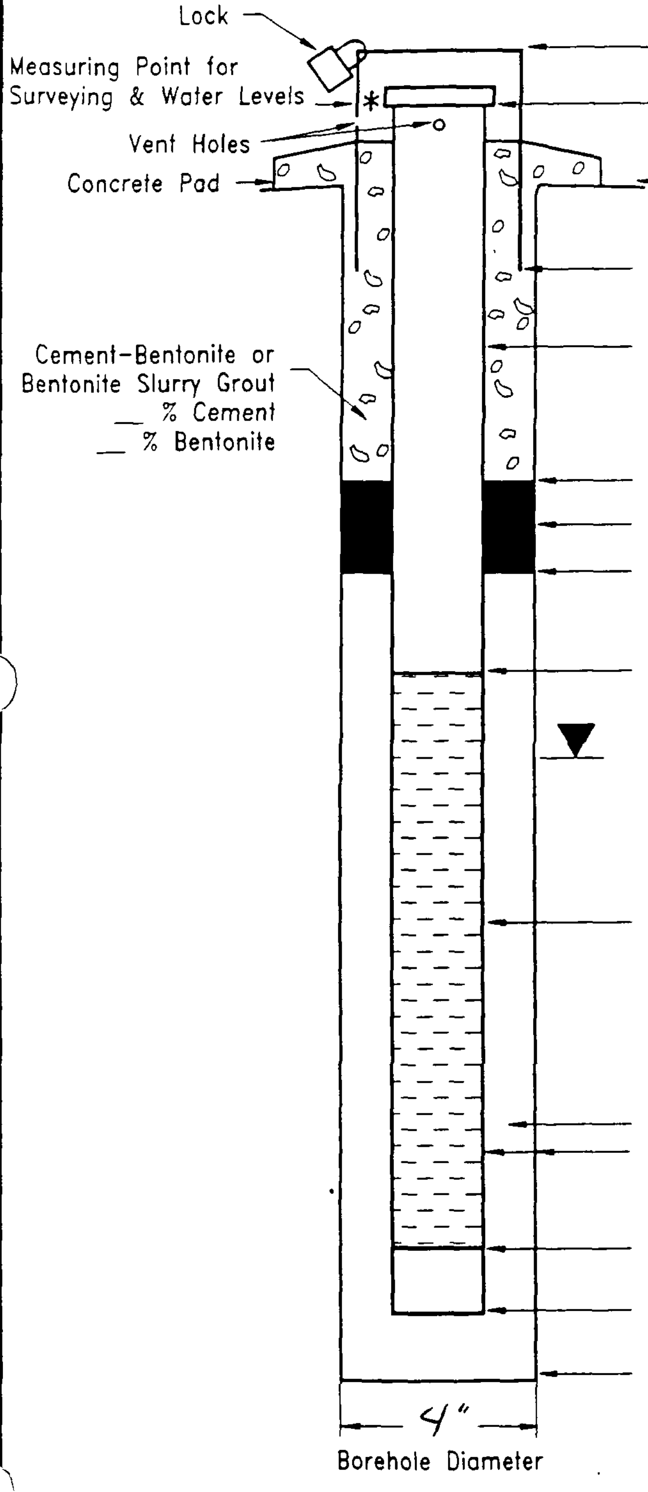
Well Location: Former Cianci Property

Date Installed: 3/25/94

Contractor: EMPIRE Method: 4" Drive + Wash

Inspector: J. Doherty

MONITORING WELL CONSTRUCTION DETAIL



		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		3.09	160.13
Top of Riser Pipe		2.98	160.01
Ground Surface (G.S.)		0.00	
Bottom of Steel Guard Pipe		1.91'	
Riser Pipe:			
Length	10'		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		4.0'	
Bentonite Seal Thickness	1.9'		
Top of Sand		5.9'	
Top of Screen		7.1'	
Stabilized Water Level			
Screen:			
Length	5'		
Inside Diameter (ID)	2"		
Slot Size	.010"		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1"		
Bottom of Screen		11.7'	
Bottom of Tail Pipe:		12.1'	
Length	4"		
Bottom of Borehole		12.1	

Approved:

* Describe Measuring Point:
PVC riser pipe

Signature Date

029

Project No: 6112 002 Client: SRSNE Site: Southington CT

WELL No: MW411

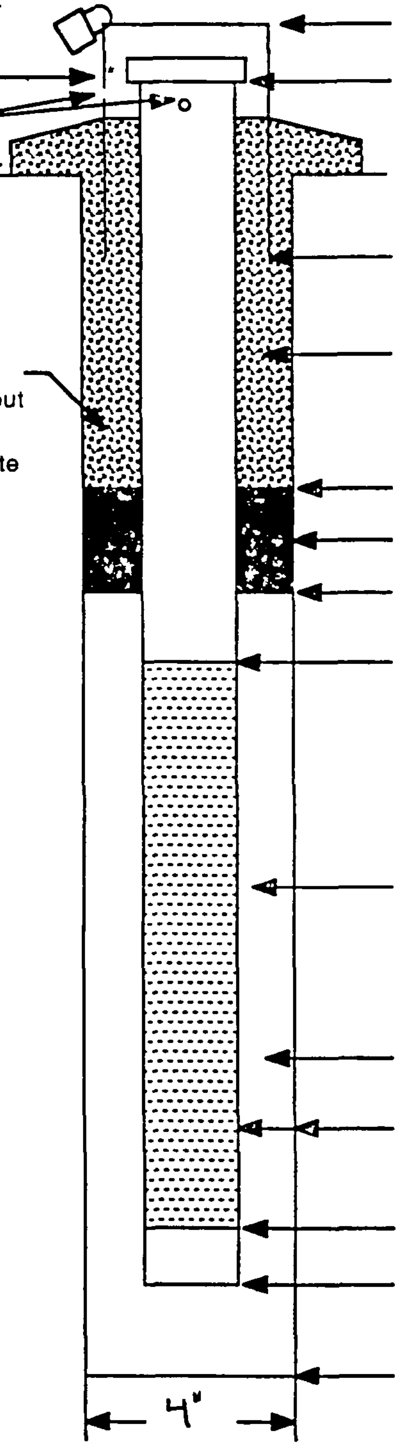
Well Location: Former Cianci property

Remarks;

Date Installed 3/18/94

Contractor: EMPIRE Method: 4" Drive&wash/Rollbit in rock Inspector: L. Pauwell

MONITORING WELL CONSTRUCTION DETAIL



Cement-Bentonite or Bentonite Slurry Grout
95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		3.0	160.39
Top of Riser Pipe		2.9	160.29
Ground Surface		0.00	
Bottom of Steel Guard Pipe		2.0	
Riser Pipe			
Length	34.2		
Inside Diameter	2"		
Type of Material	pvc		
Top of Bentonite seal		27'	
Bentonite Thickness	2'		
Top of Sand		29'	
Top of Screen		31.3	
Screen			
Length	19.6'		
Inside Diameter	2"		
Slot size	0.010		
Type of Material	pvc		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1"		
Bottom of Screen		50.9	
Bottom of Tail Pipe: Length	0.4	51.3	
Bottom of Borehole		51.3'	

* Describe Measuring Point: Top of Pvc Riser.

Signature Date

ENSR

Project No: 6112022 Client: SRSNE Site: Southington CT

WELL No: MW412

Well Location: Former Cianci property

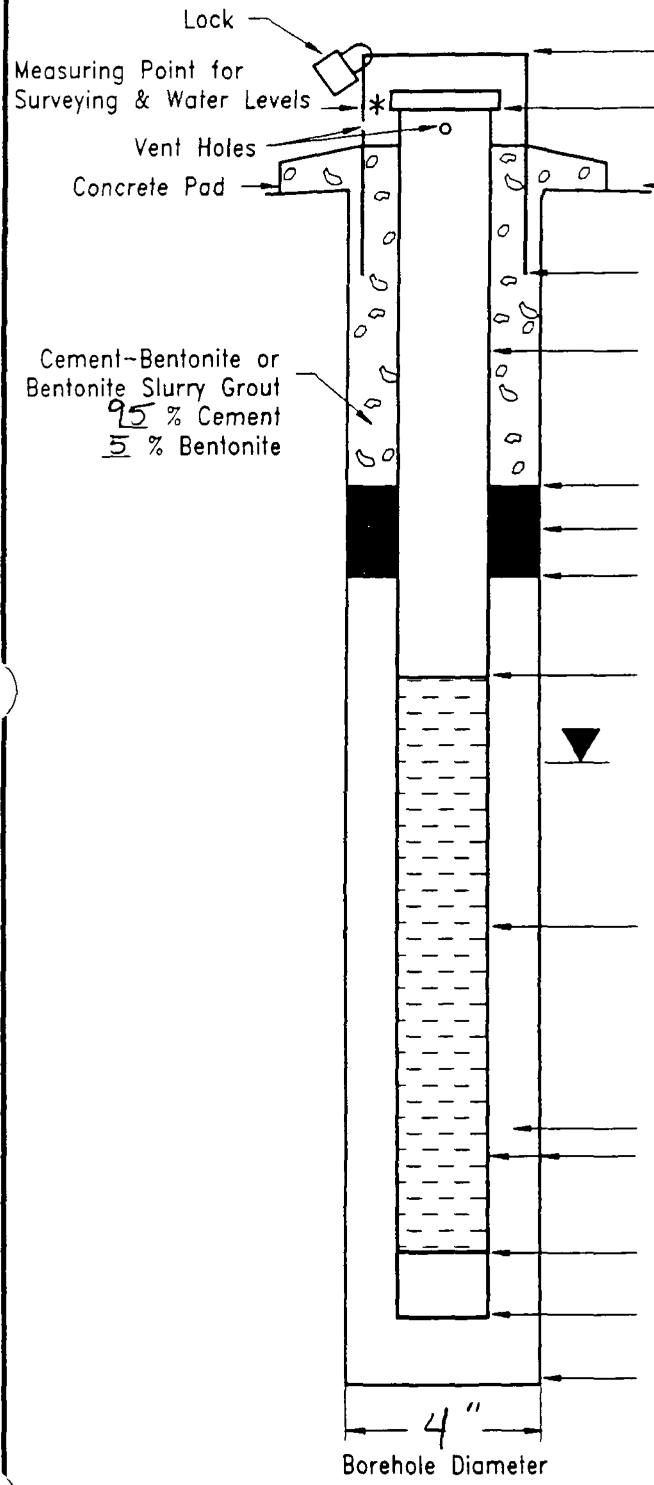
Date Installed: 3/24/94

Contractor: EMPIRE

Method: 4" Drive + Wash

Inspector: D. Klinch

MONITORING WELL CONSTRUCTION DETAIL



95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		2.94	160.07
Top of Riser Pipe		2.61	159.74
Ground Surface (G.S.)		0.00	
Bottom of Steel Guard Pipe		2.06	
Riser Pipe:			
Length	19.5		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		13'0"	
Bentonite Seal Thickness	2'0"		
Top of Sand		15'0'	
Top of Screen		16'0"	
Stabilized Water Level			
Screen:			
Length	5'		
Inside Diameter (ID)	2"		
Slot Size	.010		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1'		
Bottom of Screen		21'0"	
Bottom of Tail Pipe:		21'4"	
Length	4"		
Bottom of Borehole		21'4"	

Approved:

* Describe Measuring Point:
top of PVC riser

Signature

Date

ENSR®

Project No: 6112002 Client: SRSNE Site: Southington

WELL No: MW-413

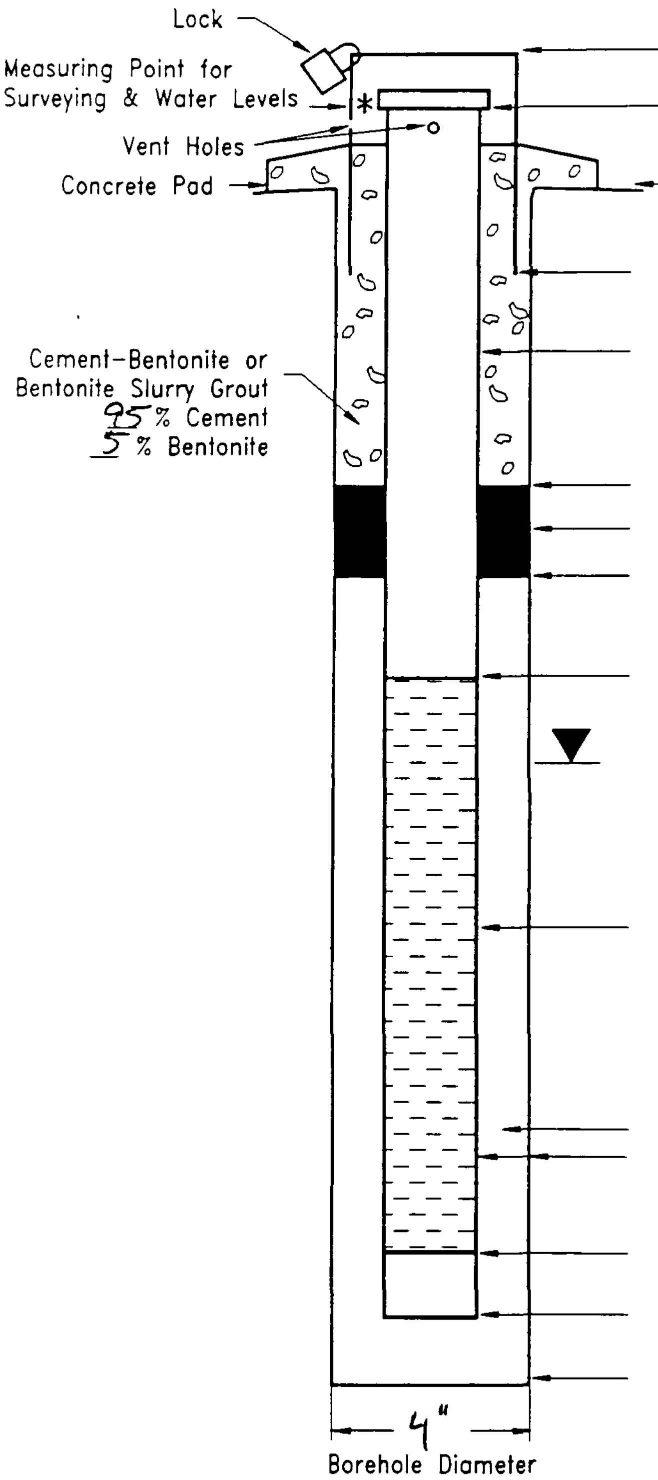
Well Location: Former Cianci Property

Date Installed: 3/18/94

Contractor: Empire Soil Method: 4" Drive + Wash

Inspector: L. Pannell

MONITORING WELL CONSTRUCTION DETAIL



95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		2.6'	160.79
Top of Riser Pipe		2.5'	160.66
Ground Surface (G.S.)		0.00	158.00
Bottom of Steel Guard Pipe		2.4'	
Riser Pipe:			
Length	17.4'		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		11'	
Bentonite Seal Thickness	2.8"		
Top of Sand		13.8'	
Top of Screen		14.8'	
Stabilized Water Level			
Screen:			
Length	5'		
Inside Diameter (ID)	2"		
Slot Size	0.010		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1"		
Bottom of Screen		19.8	
Bottom of Tail Pipe:		19.8	
Length	0		
Bottom of Borehole		19.8	

Approved:

* Describe Measuring Point:
top of PVC riser

Signature Date

ENSR®

A32

Project No: 6112002 Client: SRSNE Site: Southington, CT

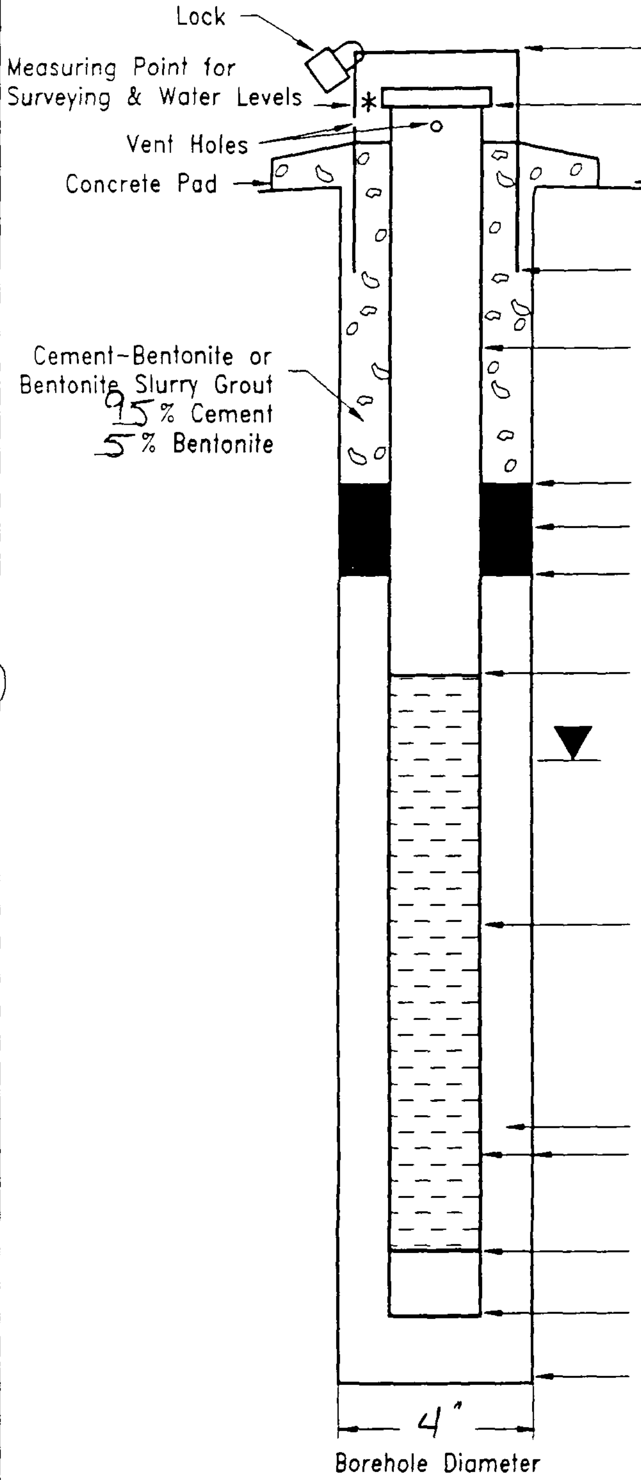
WELL No: MW414

Well Location: Former Cianci property

Date installed. 3/17/94

Contractor: EMPIRE Method: 4" Drive + Wash/Rollerbit Inspector: L. Pannell

MONITORING WELL CONSTRUCTION DETAIL



95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		3.0	161.47
Top of Riser Pipe		2.9	161.37
Ground Surface (G.S.)		0.00	
Bottom of Steel Guard Pipe		2.0	
Riser Pipe:			
Length	27.9'		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		25'	
Bentonite Seal Thickness	2'		
Top of Sand		27'	
Top of Screen		30.2'	
Stabilized Water Level			
Screen:			
Length	19.6'		
Inside Diameter (ID)	2"		
Slot Size	.010		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1"		
Bottom of Screen		49.8'	
Bottom of Tail Pipe:		50.2'	
Length	0.4'		
Bottom of Borehole		50.2'	

Approved:

* Describe Measuring Point:
top of PVC riser

Signature Date

ENSR®

Project No: 6112002 Client: SRSNE Site: Southington, CT

WELL No: MW-415

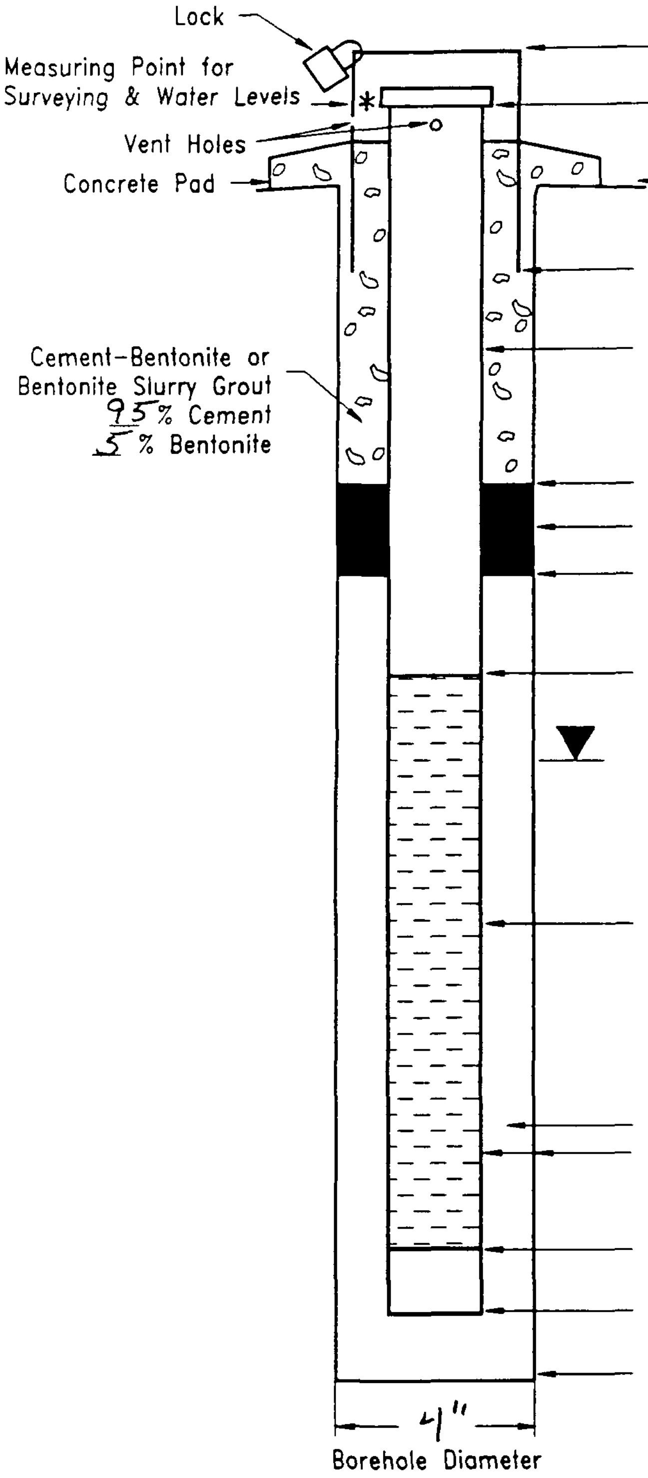
Well Location: Former Cianci Property

Date Installed: 3/18/94

Contractor: Empire Soil Method: 4" Drive + Wash

Inspector: C. Pannell

MONITORING WELL CONSTRUCTION DETAIL



Cement-Bentonite or Bentonite Slurry Grout
95% Cement
5% Bentonite

Borehole Diameter: 4"

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		2.7	160.97
Top of Riser Pipe		2.6	160.86
Ground Surface (G.S.)		0.00	158.15
Bottom of Steel Guard Pipe		2.3	
Riser Pipe: Length	9.4		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		2.0	
Bentonite Seal Thickness	3'		
Top of Sand		5.0	
Top of Screen		6.8	
Stabilized Water Level			
Screen: Length	5'		
Inside Diameter (ID)	2"		
Slot Size	0.010		
Type of Material	PVC		
Type/Size of Sand	#1 morie		
Sand Pack Thickness	1"		
Bottom of Screen		11.8	
Bottom of Tail Pipe:		11.8	
Length	0		
Bottom of Borehole		11.8	

Approved:

* Describe Measuring Point:
Top of PVC riser

Signature

Date

ENSR

A34

Project No: 6112002 Client: SRSNE Site: Southington CT

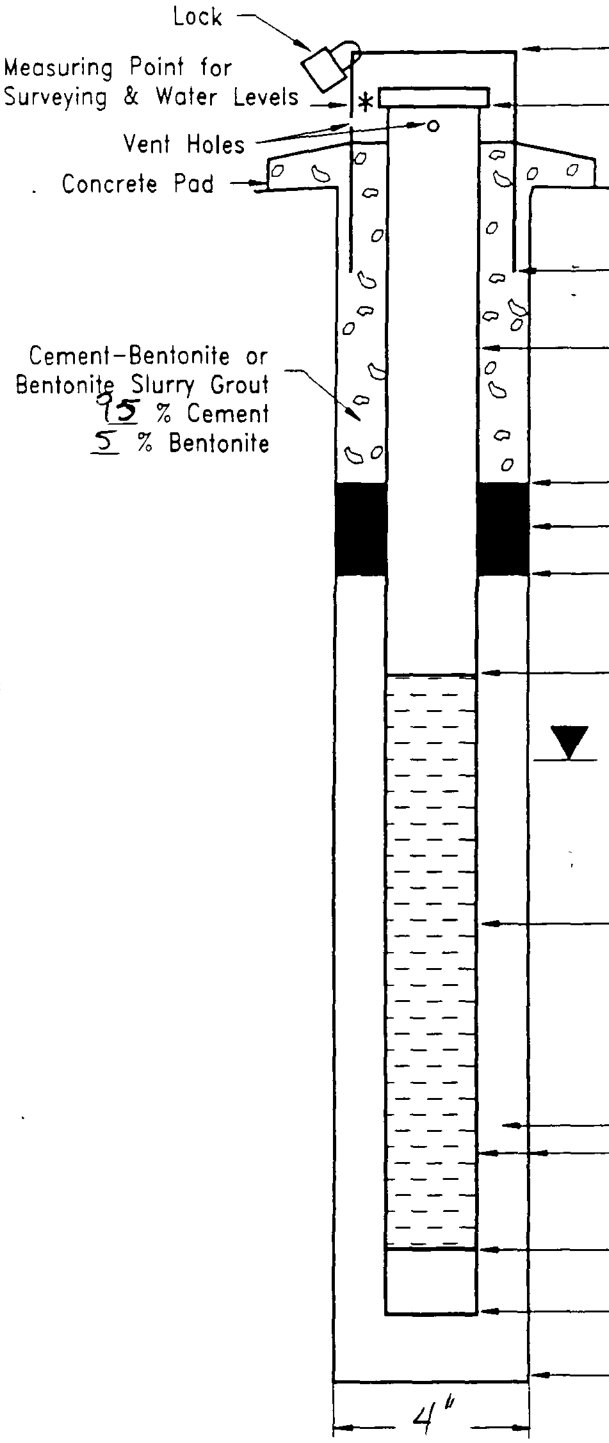
WELL No: MW-416

Well Location: Former Cianci property

Date Installed 3/15/94

Contractor: EMPIRE Method: 4" Drive Wash/Rollerbit Inspector: L. Pannell

MONITORING WELL CONSTRUCTION DETAIL



Cement-Bentonite or Bentonite Slurry Grout
95 % Cement
5 % Bentonite

		Depth from G.S. (feet)	Elevation (NGVD)
Top of Steel Guard Pipe		2.6'	160.16
Top of Riser Pipe		2.5'	160.06
Ground Surface (G.S.)		0.00	
Bottom of Steel Guard Pipe		2.4'	
Riser Pipe:			
Length	32.0'		
Inside Diameter (ID)	2"		
Type of Material	PVC		
Top of Bentonite Seal		23'	
Bentonite Seal Thickness	3.5'		
Top of Sand		26.5'	
Top of Screen		29.4'	
Stabilized Water Level			
Screen:			
Length	19.6'		
Inside Diameter (ID)	2"		
Slot Size	.010"		
Type of Material	PVC		
Type/Size of Sand	#1 Morie		
Sand Pack Thickness	1"		
Bottom of Screen		49.0'	
Bottom of Tail Pipe:		49.4'	
Length	0.4'		
Bottom of Borehole		49.4'	

4"
Borehole Diameter

Approved:

* Describe Measuring Point:
top of PVC riser

Signature Date

ENSR®

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APPENDIX B

SOIL PHYSICAL PROPERTY DATA

The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.

DANIEL B. STEPHENS & ASSOCIATES, INC.
ENVIRONMENTAL SCIENTISTS AND ENGINEERS

LABORATORY ANALYSIS OF SOIL HYDRAULIC PROPERTIES OF SRSNE SOIL SAMPLES

PREPARED FOR
ENSR CONSULTING & ENGINEERING
ACTON, MASSACHUSETTS

MAY 1994

81

6020 ACADEMY NE • SUITE 100 • ALBUQUERQUE, NM 87109 • (505) 822-9400

DANIEL B. STEPHENS & ASSOCIATES, INC.
ENVIRONMENTAL SCIENTISTS AND ENGINEERS

May 27, 1994

0561-4828-94

Mr. John Wiseman
ENSR Consulting & Engineering
35 Nagog Park
Acton, MA 01720

Dear Mr. Wiseman:

Please find enclosed the final laboratory data report for tests on SRSNE soil samples as requested under your Contract No. BOA-92077-ACT. An invoice for this work will be submitted under separate cover to Keith R. Cadieux.

All testing results were evaluated subjectively for consistency and reasonableness, and the results appear to be reasonably representative of the material tested. However, DBS&A does not assume any responsibility for interpretations or analyses based on the data enclosed, nor can we guarantee that these data are fully representative of the undisturbed materials at the field site. We recommend that careful evaluation of these laboratory results be made for your particular application.

We are pleased to provide this service to ENSR and look forward to future laboratory testing on other projects. If you have any questions about the enclosed data report, please do not hesitate to call.

Sincerely,

DANIEL B. STEPHENS & ASSOCIATES, INC.

Joe R. Vinson (for MDA)

Mark D. Ankeny
Senior Scientist/Laboratory Manager

MDA/jt
Enclosures

LAB-94(3)\4828\SRSN-RPT.594

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SUMMARY

The Hydrologic Testing Laboratory at Daniel B. Stephens & Associates, Inc. (DBS&A) has completed laboratory tests on SRSNE soil samples as specified by Mr. John Wiseman and summarized in Table 1. Tables 2 through 7 give the results of the specified analyses. Raw laboratory data and graphical plots of data (where appropriate) are contained in Appendices A through F. Appendix G lists the methods used in these analyses. A detailed description of each method is available upon request.

Before the samples arrived, ENSR notified DBS&A that some of the samples might contain a variety of chlorinated hydrocarbons including TCE, PCE, and styrene. Prior to sample preparation, we used a photoionization detector (PID), equipped with a 11.8 eV ionization lamp and calibrated for isobutylene, to scan the headspace of each sample for volatile organic hydrocarbons. This procedure resulted in a semi-quantitative value of headspace "hits" that was recorded in parts per million (ppm). DBS&A uses a 20-ppm threshold from this headspace measurement to discriminate between hazardous and non-hazardous samples. Of the samples scanned, 6 exceeded the threshold with "hits" in the range of 90 to 800 ppm. These samples were handled using our standard precautions for hazardous materials, and testing of these samples will be assessed with a hazardous surcharge of 60 percent. The sample numbers are AMW488C, AB479C, AB477A, AB478A, AB428B, and ASP485B.

DBS&A received duplicate cores for 7 samples. The duplicate cores were to be tested for unconfined strength at a subcontract laboratory, Huntingdon. However, Mr. Sam Urton of Huntingdon said that unconfined strength tests would be inappropriate because of the coarse-textured nature of the materials. After several consultations with Mr. Urton and Mr. Jeff Barbero of ENSR, Mr. Barbero instructed the lab to substitute direct shear tests for 4 of the samples in lieu of the unconfined strength tests of all 7 (Table 1). The test procedures used by the Huntingdon lab are described by Mr. Urton in Appendix F.

For several samples, the saturated volumetric moisture content exceeds the calculated total porosity. For calculating porosity DBS&A defaults to a value of 2.65 g/cm^3 for particle density

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(that of quartz mineral) when particle density tests are not within the scope of work. A higher true particle density for these samples may account for a portion of these anomalous differences. More often, however, these results are observed in materials rich in clay minerals, perhaps due to the loss of lattice moisture from within the clay micelles.

Originally, particle size distribution of the samples was to be performed using procedures defined in ASTM D422-63. The hydrometer analysis portion of these procedures specifies a single sample preparation step using sodium hexametaphosphate to disperse the colloidal fractions of test samples. However, within the first group of 11 samples to be tested, we found that individual soil particles and aggregates were coated with organic materials that prevented dispersion of the soil by the sodium ion. Soil flocs prematurely settled out of suspension within the hydrometer jars of all of the samples.

We then notified Dr. Ralph Baker of these difficulties. Dr. Baker authorized DBS&A to modify the ASTM procedures with a hydrogen peroxide sample pretreatment step that is described by Gee and Bauder[1]. DBS&A used a 30 percent solution of hydrogen peroxide to oxidize the organic materials of new aliquots of each sample prior to the normal ASTM treatment with sodium hexametaphosphate.

DBS&A laboratory personnel found that the organic materials of the samples were very resistant to oxidation. Ordinarily, the hydrogen peroxide pretreatment requires about 1 to 12 hours to complete. About half of these samples required 48 to 72 hours and several additions of hydrogen peroxide before the oxidation reactions were complete.

A possible complicating factor in this pretreatment was the presence of high levels of manganese within many of these samples, as confirmed by Ms. Laurie Ekes. She said that inductively coupled plasma analysis was used to determine elemental Mn content, but that the precise form of Mn within the samples was unknown. Gee and Bauder report that alkaline salts and MnO_2 may reduce the effectiveness of H_2O_2 action. Without knowing the moiety of the Mn present or

---

[1] Gee, G.W. and J.W. Bauder. 1986. *In* Methods of Soil Analyses, Part 1: Physical and Mineralogical Methods. 2nd Edition. A. Klute, Editor. American Soc. Agronomy, Madison WI, pp. 400-404.

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the identity of other components within these samples, it is difficult to ascertain the overall effectiveness of the hydrogen peroxide pretreatment. However, qualitatively, the behavior of the post-treated samples during hydrometer analyses was consistent with our expectations for these materials.

Overall, the results appear reasonable and internally consistent. However, DBS&A cannot guarantee that these results are representative of the undisturbed materials at the field site, nor can we assume any responsibility for interpretations or analyses based on these data. We recommend that careful evaluation of these laboratory results be made for your particular application.

TABLE 1. SUMMARY OF TESTS PERFORMED

Laboratory Sample Number	Initial Moisture Content	Dry Bulk Density	Calculated Porosity	Moisture Characteristics			Air Permeability	Particle Size Distribution		Atterberg Limits	Direct Shear
				Hanging Column	Pressure Plate	Thermocouple Psychrometer		Sieve	Hydrometer		
AMW488C	X	X	X	X	X	X	X	X	X		
AB479B	X	X	X	X	X	X	X	X	X		
AB479C	X	X	X	X	X	X	X	X	X		
AB480B	X	X	X	X	X	X	X	X	X		
A403C	X	X	X					X	X	X	
A403I	X	X	X					X	X	X	
A402D	X	X	X					X	X	X	X
A402I	X	X	X					X	X	X	X
A401B	X	X	X					X	X	X	
AB477A	X	X	X	X	X	X	X	X	X		
AB478A	X	X	X	X	X	X	X	X	X		
AB481C	X	X	X	X	X	X	X	X	X		
AB482B	X	X	X	X	X	X	X	X	X		
A404D	X	X	X					X	X	X	X
A404J	X	X	X					X	X	X	X
AB483A	X	X	X	X	X	X	X	X	X		
ASP485A	X	X	X	X	X	X	X	X	X		
ASP485B	X	X	X	X	X	X	X	X	X		
AMW488B	X	X	X	X	X	X	X	X	X		

TABLE 2. SUMMARY OF INITIAL MOISTURE CONTENT, DRY BULK DENSITY, AND CALCULATED POROSITY

Sample Number	Initial Moisture Content: Gravimetric (%, g/g)	Initial Moisture Content: Volumetric (%, cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Calculated Porosity (%)
AMW488C	14.1	25.7	1.83	31.1
AB479B	16.8	32.9	1.96	25.9
AB479C	18.8	31.4	1.67	36.9
AB480B	14.6	27.4	1.88	29.2
A403C	14.2	26.9	1.90	28.4
A403I	12.3	26.4	2.15	19.0
A402D	17.0	31.2	1.83	31.0
A402I	8.9	19.6	2.19	17.3
A401B	15.7	29.2	1.86	29.6
AB477A	6.4	12.7	1.98	25.3
AB478A	16.3	25.7	1.58	40.5
AB481C	11.2	22.6	2.01	24.2
AB482B	16.7	30.5	1.83	30.9
A404D	16.6	31.4	1.89	28.7
A404J	10.2	21.5	2.11	20.3
AB483A	8.2	16.4	2.00	24.5
ASP485A	10.2	19.9	1.95	26.4
ASP485B	14.6	27.2	1.86	29.9
AMW488B	31.7	44.5	1.40	47.2

TABLE 3. SUMMARY OF MOISTURE CHARACTERISTICS OF THE INITIAL DRAINAGE CURVE

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
AMW488C	0	31.6
	16	26.6
	28	21.6
	54	16.1
	122	12.3
	1010	9.9
	24751	1.5
AB479B	0	37.1
	36	33.1
	56	32.9
	122	32.6
	255	31.6
	1020	26.6
	16092	7.1
AB479C	0	35.3
	13	31.1
	33	29.5
	60	26.4
	127	24.7
	1010	19.1
	28524	4.3
AB480B	0	30.3
	36	26.9
	56	26.7
	122	26.4
	255	25.9
	1020	21.2
	29024	7.3

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TABLE 3. SUMMARY OF MOISTURE CHARACTERISTICS OF THE INITIAL DRAINAGE CURVE (CONTINUED)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
AB477A	0	32.6
	12	24.2
	30	20.9
	57	17.6
	131	13.8
	1010	8.5
	18683	4.6
AB478A	0	38.4
	11	28.9
	18	16.0
	53	8.5
	132	6.4
	1010	5.2
	17775	1.7
AB481C	0	29.7
	36	23.8
	56	22.7
	122	21.6
	255	20.0
	1020	15.6
	21161	4.8
AB482B	0	30.9
	12	26.7
	31	22.5
	57	18.2
	119	13.6
	1010	9.8
	15725	3.5

TABLE 3. SUMMARY OF MOISTURE CHARACTERISTICS OF THE INITIAL DRAINAGE CURVE (CONTINUED)

Sample Number	Pressure Head (-cm water)	Moisture Content (%, cm^3/cm^3)
AB483A	0	27.4
	16	24.6
	30	22.2
	61	20.4
	127	18.5
	1010	13.7
	15399	6.1
ASP485A	0	31.5
	36	27.4
	56	27.1
	122	25.8
	255	24.0
	1020	20.5
	27749	6.9
ASP485B	0	34.2
	15	31.2
	32	29.2
	61	27.4
	130	25.0
	1010	16.9
	17184	6.4
AMW488B	0	50.1
	36	45.5
	56	44.9
	122	43.9
	255	42.7
	1020	37.1
	21997	13.1

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TABLE 4. SUMMARY OF AIR PERMEABILITY AS A FUNCTION OF SOIL WATER CONTENT

Sample Number	Moisture Content (%, g/g)	Apparent Permeability (millidarcies)
AMW488C	25.7	2.07×10^{2}
AB479B	32.9	2.96×10^{-1}
AB479C	31.4	2.88×10^{1}
AB480B	27.4	ND
AB477A	12.7	2.29×10^{3}
AB478A	25.7	2.83×10^{3}
AB481C	22.6	ND
AB482B	30.5	8.92×10^{1}
AB483A	16.4	5.76×10^{2}
ASP485A	19.9	1.52×10^{2}
ASP485B	27.2	1.07×10^{2}
AMW488B	44.5	9.27×10^{-1}

ND = Flow rate during testing below the air flow measurement limit of 2.75×10^{-3} cm^3/sec.

TABLE 5. SUMMARY OF PARTICLE SIZE CHARACTERISTICS

Sample Number	d_{10} (mm)	d_{50} (mm)	d_{60} (mm)	C_u	C_c	Dry Sieve	Wet Sieve	Hydro-meter
AMW488C	0.075	0.99	1.5	20	1.6		X	X
AB479B	0.0071	0.25	0.51	72	1.1		X	X
AB479C	0.10	0.37	0.46	4.6	1.3	X		
AB480B	0.013	1.5	4.3	300	0.52		X	X
A403C	0.080	0.56	0.70	8.8	1.6		X	X
A403I	0.017	0.77	2.0	100	0.66		X	X
A402D	0.18	0.41	0.51	2.8	1.0		X	X
A402I	0.0033	0.18	0.29	88	3.3		X	X
A401B	0.044	0.40	0.76	17	1.3		X	X
AB477A	0.11	1.1	2.0	18	1.1		X	X
AB478A	0.14	0.46	0.57	4.1	1.3		X	X
AB481C	0.018	0.29	0.55	31	1.5		X	X
AB482B	0.075	4.4	7.6	100	0.36		X	X
A404D	0.024	0.070	0.085	3.5	1.1		X	X
A404J	0.019	0.38	0.64	34	1.9		X	X
AB483A	0.015	0.32	0.49	33	2.3		X	X
ASP485A	0.012	0.41	0.79	66	1.8		X	X
ASP485B	0.018	0.35	0.62	34	2.0		X	X
AMW488B	--	0.11	0.18	--	--		X	X

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* d_{10} not reached with test specified

-- value dependent upon d_{10}

d_{50} = median particle diameter

$$C_u = \frac{d_{60}}{d_{10}}$$

$$C_c = \frac{(d_{30})^2}{(d_{10})(d_{60})}$$

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TABLE 6. SUMMARY OF ATTERBERG LIMITS

Sample Number	Liquid Limit (%, g/g)	Plastic Limit (%, g/g)	Plasticity Index (%, g/g)
A403C	Nonplastic*		
A403I	18	18	0
A402D	Nonplastic*		
A402I	25	15	9
A401B	Nonplastic*		
A404D	Nonplastic*		
A404J	Nonplastic*		

* Due to sample sliding during testing, the sample is considered nonplastic.

TABLE 7. SUMMARY OF DIRECT SHEAR

Sample Number	% Water Content	Dry Density (PCF)	Normal Load (KSF)	Shear Stress (KSF)
A402D	13.6	115	0.71	1.10
A402I	11.3	128	1.62	1.58
A404D	15.6	113	0.75	0.79
A404J	11.1	118	1.54	2.45

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APPENDIX C

WELL AND SOIL BORING SURVEY DATA

The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.

DIVERSIFIED TECHNOLOGIES CORPORATION, INC.
PROJECT: 93054 SRSNE SOUTHINGTON, CT

Current Coordinate Listing (All)

Northing	Easting	Elevation	Description
286569.2300	565124.0207	164.60	G-440 BORING
286518.6987	565121.9318	165.24	G-441 BORING
286514.6705	565073.0220	166.25	G-450-A BORING
286465.6700	565071.5530	166.49	G-451 BORING
286437.5455	565050.9478	166.62	B-481-A BORING
286478.8923	565115.9480	165.97	B-477 BORING
286469.3569	565119.9782	165.95	G-442 BORING
286419.4957	565117.0719	166.13	G-433 BORING
286415.1698	565116.2113	166.17	B-478-A BORING
286411.7051	565117.8639	166.22	B-478-B BORING
286514.2229	565073.6654	166.23	G-450-B BORING
286414.8019	565067.8728	166.50	G-452 BORING
286435.9952	565053.8928	166.61	B-481-B BORING
286432.8006	565013.6803	166.83	G-460 BORING
286400.9376	565082.2979	166.53	AP-493 BORING
286400.6628	565085.5033	166.54	AP-494 BORING
286399.0396	565085.7893	166.61	MW-486 MON WELL
		169.08	TOP PVC PIPE
286384.8668	565099.8071	166.35	AP-495 BORING
286385.3536	565100.1124	166.35	AP-496 BORING
286377.7615	565121.4867	166.08	AP-497 BORING
286377.0292	565111.9692	166.12	AP-492 BORING
286370.6311	565120.5597	166.06	G-444 BORING
286376.4878	565106.6571	166.12	SP-485 MON WELL
286365.9348	565096.5222	166.49	AP-491 BORING
286365.0553	565097.5546	166.50	MW-487 MON WELL
		169.66	TOP PVC PIPE
286365.6200	565095.5684	166.51	MW-488 MON WELL
		169.72	TOP PVC PIPE
286361.2839	565016.6787	166.76	G-461 BORING
286343.6093	565076.9141	166.61	AP-490 BORING
286342.2472	565076.6326	166.79	MW-489 MON WELL
		169.70	TOP PVC PIPE
286322.1456	565127.0629	165.97	B-479 BORING
286319.1080	565113.9300	166.10	G-445 BORING
286324.7679	565089.8596	166.40	B-480 BORING
286269.7375	565112.1045	166.23	G-446 BORING
286250.8770	565116.2593	166.22	B-484 BORING
286264.2798	565057.5535	166.50	G-455 BORING
286273.2714	565046.5619	166.86	B-483 BORING
286287.6841	565037.0537	167.25	TEST PIT
286292.7407	565037.6943	167.11	TEST PIT
286293.2576	565026.6895	167.57	TEST PIT
286287.7114	565026.4069	168.14	TEST PIT
286294.0371	565020.2346	168.02	G-463 BORING
286264.1209	564974.0633	175.88	G-468 BORING
286344.3413	564939.1801	174.33	G-467 BORING
286317.0281	564914.5229	178.21	G-474 BORING
286209.8874	564971.5567	179.16	G-469 BORING
286317.9258	565013.4153	166.88	G-462 BORING

DIVERSIFIED TECHNOLOGIES CORPORATION, INC.
PROJECT: 93054 SRSNE SOUTHINGTON, CT
(CONT'D)

Current Coordinate Listing (All)

Northing	Easting	Elevation	Description
286213.1563	565060.9769	166.65	G-456 BORING
286168.0116	565063.6858	167.52	G-457 BORING
286192.3967	565113.2831	166.62	B-498 BORING
286220.5725	565108.4996	166.43	G-447 BORING
286170.5404	565106.0808	167.24	G-448 BORING
286121.8037	565103.9379	170.07	G-449 BORING
286373.0269	565137.2732	165.95	AD-498 BORING
286391.5595	565135.1358	165.99	AP-506 BORING
286392.2515	565135.2629	165.99	AP-505 BORING
286392.4334	565118.5578	166.32	AP-500 BORING
286397.1042	565108.5761	166.32	AP-501 BORING
286397.0959	565110.0580	166.30	AP-502 BORING
286386.3839	565108.2178	166.27	AP-503 BORING
286386.3389	565109.3228	166.27	AP-504 BORING
286391.8898	565098.8709	166.42	AP-499 BORING
286401.1510	565087.4314	166.47	AP-507 BORING
286400.9046	565086.8398	166.42	AP-508 BORING
286427.8023	564915.3393	178.28	G-472 BORING
286378.5974	564919.6567	178.24	G-473 BORING
286256.7687	564915.0472	177.57	G-475 BORING
286367.8754	565065.0117	167.67	G-453 BORING
286395.8189	565058.5666	166.67	B-482 BORING
286207.0062	564920.8076	179.79	G-476 BORING
287243.6698	566089.9116	156.93	BS STA
287134.7187	565198.4059	162.28	BS STA
286615.9867	565338.1323	158.73	FS STA
286765.9240	565280.2014	159.93	G-425 BORING
286617.6521	565304.3444	159.32	B-405 BORING
286546.0475	565322.2246	157.81	G-426 BORING
286594.7935	565526.5934	153.25	DP-419 MON WELL
286349.0104	565503.2594	154.41	DP-418 MON WELL
286322.4767	565450.1863	153.78	G-427 BORING
286195.5380	565379.2212	155.44	G-424 BORING
286229.6607	565280.7702	156.66	B-401 BORING
286323.9613	565289.7496	157.70	B-402 BORING
286427.8114	565283.4225	158.05	B-403 BORING
286515.3262	565274.3646	158.81	B-404 BORING
286347.6650	565207.3463	162.20	DP-417 MON WELL
286324.4090	565318.1632	156.98	MW-408 MON WELL
		159.56	TOP PVC PIPE
		159.67	TOP CASING
286331.5842	565319.6490	157.14	MW-409 MON WELL
		159.60	TOP PVC PIPE
		159.70	TOP CASING
286328.5830	565304.7002	157.04	MW-410 MON WELL
		160.01	TOP PVC PIPE
		160.13	TOP CASING

DIVERSIFIED TECHNOLOGIES CORPORATION, INC.
PROJECT: 93054 SRSNE SOUTHINGTON, CT
(CONT'D)

Current Coordinate Listing (All)

Northing	Easting	Elevation	Description
286334.6509	565302.1945	157.13	MW-412 MON WELL
		159.74	TOP PVC PIPE
		160.07	TOP CASING
286340.9587	565299.2426	157.22	MW-411 MON WELL
		160.29	TOP PVC PIPE
		160.39	TOP CASING
286337.4775	565291.4394	157.71	PW-406 MON WELL
		160.40	TOP PVC PIPE
		160.37	TOP CASING
286330.7737	565291.2192	157.43	PW-407 MON WELL
		160.31	TOP PVC PIPE
		160.57	TOP CASING
286339.4611	565272.7555	158.29	MW-414 MON WELL
		161.37	TOP PVC PIPE
		161.47	TOP CASING
286345.9158	565275.1906	158.15	MW-415 MON WELL
		160.86	TOP PVC PIPE
		160.97	TOP CASING
286350.3852	565278.2977	158.00	MW-413 MON WELL
		160.66	TOP PVC PIPE
		160.79	TOP CASING
286290.5333	565264.3798	157.42	MW-416 MON WELL
		160.06	TOP PVC PIPE
		160.16	TOP CASING
286392.3140	565128.8385	166.23	SOIL VAPOR TRENCH
286391.5818	565089.0738	166.60	SOIL VAPOR TRENCH
286362.4016	565127.6217	166.24	SOIL VAPOR TRENCH
286361.4000	565087.8260	166.75	SOIL VAPOR TRENCH

DIVERSIFIED TECHNOLOGIES CORPORATION, INC.
PROJECT: 93054 SRSNE SOUTHINGTON, CT

Current Coordinate Listing (All)

Northing	Easting	Elevation	Description
286569.2300	565124.0207	164.60	G-440 BORING
286518.6987	565121.9318	165.24	G-441 BORING
286514.6705	565073.0220	166.25	G-450-A BORING
286465.6700	565071.5530	166.49	G-451 BORING
286437.5455	565050.9478	166.62	B-481-A BORING
286478.8923	565115.9480	165.97	B-477 BORING
286469.3569	565119.9782	165.95	G-442 BORING
286419.4957	565117.0719	166.13	G-433 BORING
286415.1698	565116.2113	166.17	B-478-A BORING
286411.7051	565117.8639	166.22	B-478-B BORING
286514.2229	565073.6654	166.23	G-450-B BORING
286414.8019	565067.8728	166.50	G-452 BORING
286435.9952	565053.8928	166.61	B-481-B BORING
286432.8006	565013.6803	166.83	G-460 BORING
286400.9376	565082.2979	166.53	AP-493 BORING
286400.6628	565085.5033	166.54	AP-494 BORING
286399.0396	565085.7893	166.61	MW-486 MON WELL
		169.08	TOP PVC PIPE
286384.8668	565099.8071	166.35	AP-495 BORING
286385.3536	565100.1124	166.35	AP-496 BORING
286377.7615	565121.4867	166.08	AP-497 BORING
286377.0292	565111.9692	166.12	AP-492 BORING
286370.6311	565120.5597	166.06	G-444 BORING
286376.4878	565106.6571	166.12	SP-485 MON WELL
286365.9348	565096.5222	166.49	AP-491 BORING
286365.0553	565097.5546	166.50	MW-487 MON WELL
		169.66	TOP PVC PIPE
286365.6200	565095.5684	166.51	MW-488 MON WELL
		169.72	TOP PVC PIPE
286361.2839	565016.6787	166.76	G-461 BORING
286343.6093	565076.9141	166.61	AP-490 BORING
286342.2472	565076.6326	166.79	MW-489 MON WELL
		169.70	TOP PVC PIPE
286322.1456	565127.0629	165.97	B-479 BORING
286319.1080	565113.9300	166.10	G-445 BORING
286324.7679	565089.8596	166.40	B-480 BORING
286269.7375	565112.1045	166.23	G-446 BORING
286250.8770	565116.2593	166.22	B-484 BORING
286264.2798	565057.5535	166.50	G-455 BORING
286273.2714	565046.5619	166.86	B-483 BORING
286287.6841	565037.0537	167.25	TEST PIT
286292.7407	565037.6943	167.11	TEST PIT
286293.2576	565026.6895	167.57	TEST PIT
286287.7114	565026.4069	168.14	TEST PIT
286294.0371	565020.2346	168.02	G-463 BORING
286264.1209	564974.0633	175.88	G-468 BORING
286344.3413	564939.1801	174.33	G-467 BORING
286317.0281	564914.5229	178.21	G-474 BORING
286209.8874	564971.5567	179.16	G-469 BORING
286317.9258	565013.4153	166.88	G-462 BORING

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DIVERSIFIED TECHNOLOGIES CORPORATION, INC.
PROJECT: 93054 SRSNE SOUTHINGTON, CT
(CONT'D)

Current Coordinate Listing (All)

Northing	Easting	Elevation	Description
286213.1563	565060.9769	166.65	G-456 BORING
286168.0116	565063.6858	167.52	G-457 BORING
286192.3967	565113.2831	166.62	B-498 BORING
286220.5725	565108.4996	166.43	G-447 BORING
286170.5404	565106.0808	167.24	G-448 BORING
286121.8037	565103.9379	170.07	G-449 BORING
286373.0269	565137.2732	165.95	AD-498 BORING
286391.5595	565135.1358	165.99	AP-506 BORING
286392.2515	565135.2629	165.99	AP-505 BORING
286392.4334	565118.5578	166.32	AP-500 BORING
286397.1042	565108.5761	166.32	AP-501 BORING
286397.0959	565110.0580	166.30	AP-502 BORING
286386.3839	565108.2178	166.27	AP-503 BORING
286386.3389	565109.3228	166.27	AP-504 BORING
286391.8898	565098.8709	166.42	AP-499 BORING
286401.1510	565087.4314	166.47	AP-507 BORING
286400.9046	565086.8398	166.42	AP-508 BORING
286427.8023	564915.3393	178.28	G-472 BORING
286378.5974	564919.6567	178.24	G-473 BORING
286256.7687	564915.0472	177.57	G-475 BORING
286367.8754	565065.0117	167.67	G-453 BORING
286395.8189	565058.5666	166.67	B-482 BORING
286207.0062	564920.8076	179.79	G-476 BORING
287243.6698	566089.9116	156.93	BS STA
287134.7187	565198.4059	162.28	BS STA
286615.9867	565338.1323	158.73	FS STA
286765.9240	565280.2014	159.93	G-425 BORING
286617.6521	565304.3444	159.32	B-405 BORING
286546.0475	565322.2246	157.81	G-426 BORING
286594.7935	565526.5934	153.25	DP-419 MON WELL
286349.0104	565503.2594	154.41	DP-418 MON WELL
286322.4767	565450.1863	153.78	G-427 BORING
286195.5380	565379.2212	155.44	G-424 BORING
286229.6607	565280.7702	156.66	B-401 BORING
286323.9613	565289.7496	157.70	B-402 BORING
286427.8114	565283.4225	158.05	B-403 BORING
286515.3262	565274.3646	158.81	B-404 BORING
286347.6650	565207.3463	162.20	DP-417 MON WELL
286324.4090	565318.1632	156.98	MW-408 MON WELL
		159.56	TOP PVC PIPE
		159.67	TOP CASING
286331.5842	565319.6490	157.14	MW-409 MON WELL
		159.60	TOP PVC PIPE
		159.70	TOP CASING
286328.5830	565304.7002	157.04	MW-410 MON WELL
		160.01	TOP PVC PIPE
		160.13	TOP CASING

DIVERSIFIED TECHNOLOGIES CORPORATION, INC.
PROJECT: 93054 SRSNE SOUTHINGTON, CT
(CONT'D)

Current Coordinate Listing (All)

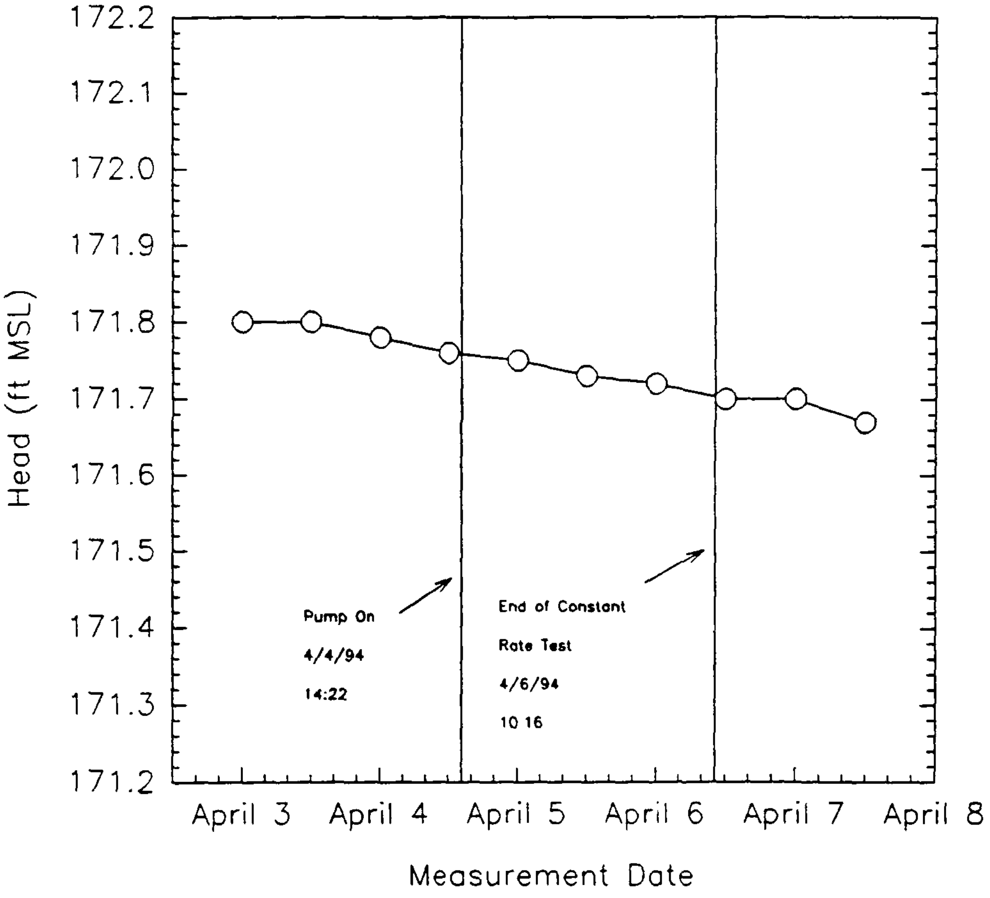
Northing	Easting	Elevation	Description
286334.6509	565302.1945	157.13	MW-412 MON WELL
		159.74	TOP PVC PIPE
		160.07	TOP CASING
286340.9587	565299.2426	157.22	MW-411 MON WELL
		160.29	TOP PVC PIPE
		160.39	TOP CASING
286337.4775	565291.4394	157.71	PW-406 MON WELL
		160.40	TOP PVC PIPE
		160.37	TOP CASING
286330.7737	565291.2192	157.43	PW-407 MON WELL
		160.31	TOP PVC PIPE
		160.57	TOP CASING
286339.4611	565272.7555	158.29	MW-414 MON WELL
		161.37	TOP PVC PIPE
		161.47	TOP CASING
286345.9158	565275.1906	158.15	MW-415 MON WELL
		160.86	TOP PVC PIPE
		160.97	TOP CASING
286350.3852	565278.2977	158.00	MW-413 MON WELL
		160.66	TOP PVC PIPE
		160.79	TOP CASING
286290.5333	565264.3798	157.42	MW-416 MON WELL
		160.06	TOP PVC PIPE
		160.16	TOP CASING
286392.3140	565128.8385	166.23	SOIL VAPOR TRENCH
286391.5818	565089.0738	166.60	SOIL VAPOR TRENCH
286362.4016	565127.6217	166.24	SOIL VAPOR TRENCH
286361.4000	565087.8260	166.75	SOIL VAPOR TRENCH

APPENDIX D

BACKGROUND WELL HYDROGRAPHS AND DRAWDOWN GRAPHS, OVERBURDEN PUMPING TEST

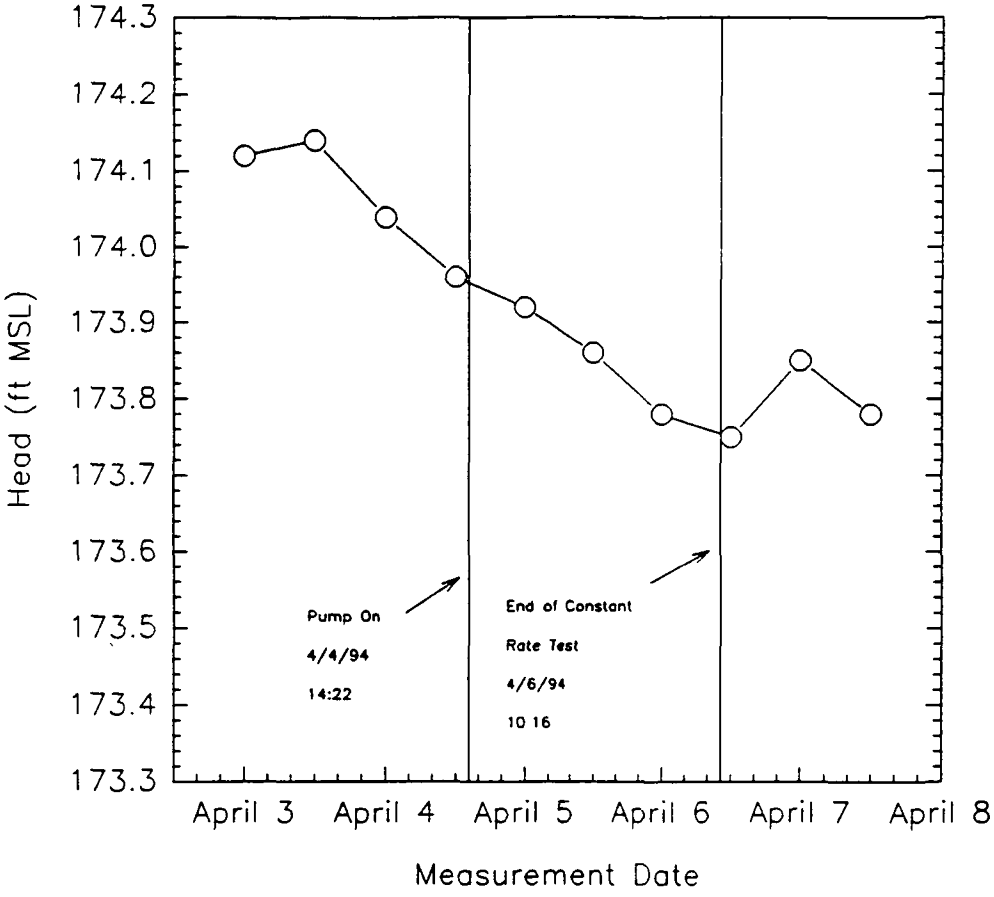
The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.

Background Bedrock Well Hydrograph (P-4A)
SRSNE, Southington CT
April 4-6, 1994



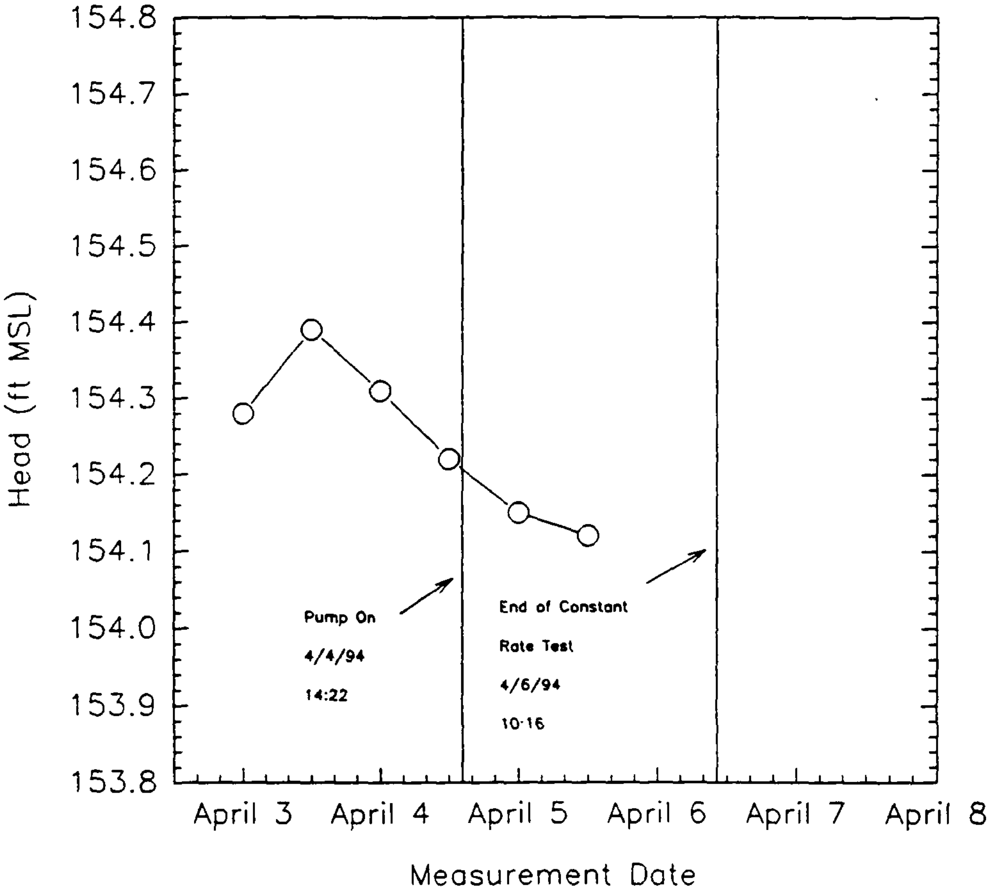
D1

Background Well Hydrograph (P-4B)
SRSNE, Southington CT
April 3-8, 1994



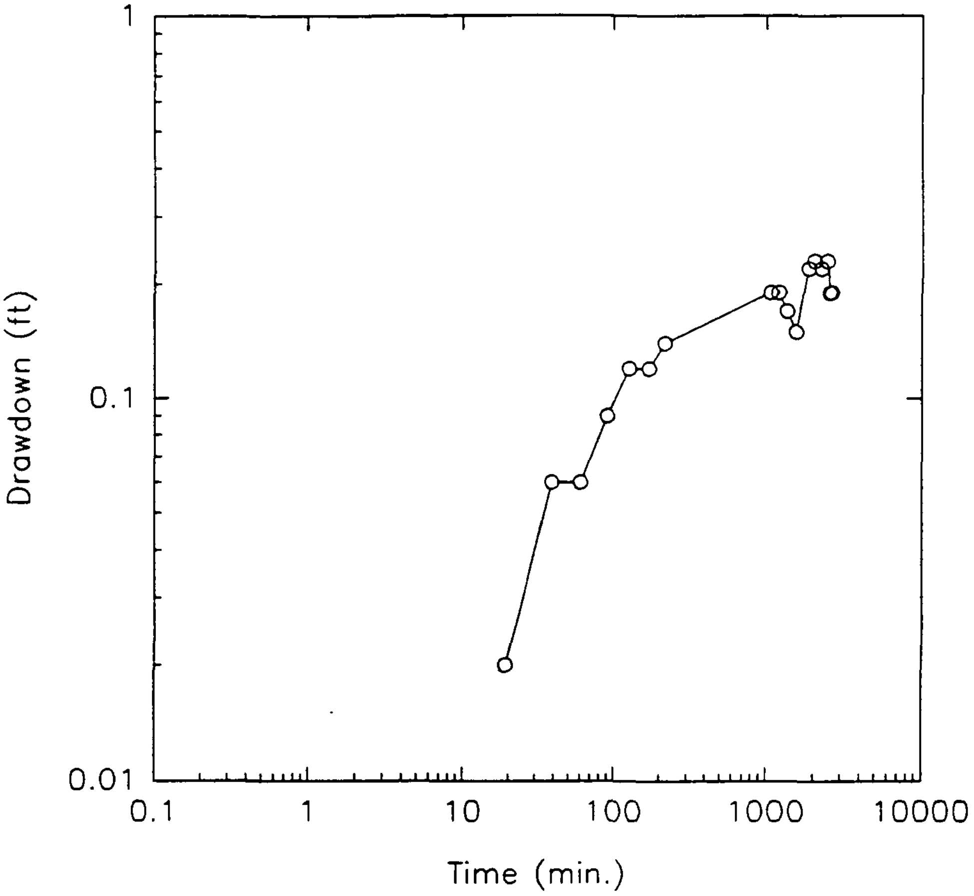
D2

Background Bedrock Well Hydrograph (P-5A)
SRSNE, Southington CT
April 4-6, 1994



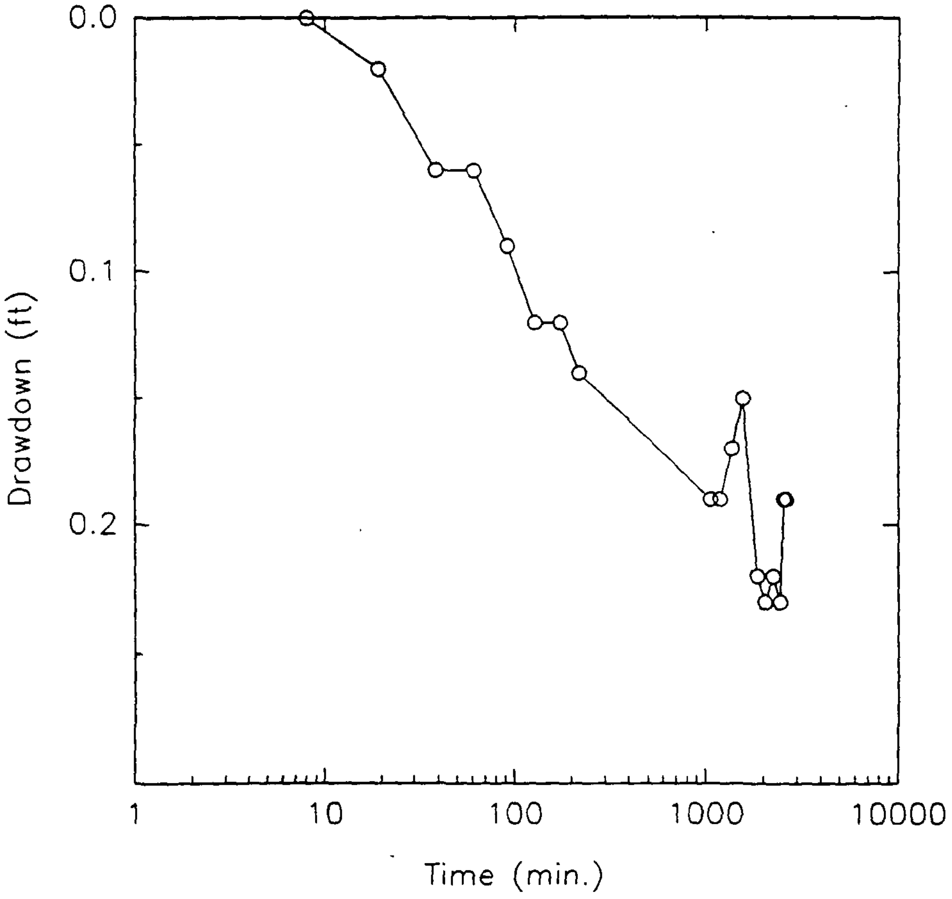
D3

Drawdown in Outwash Well (MWL-307)
SRSNE, Southington CT
April 4-6, 1994



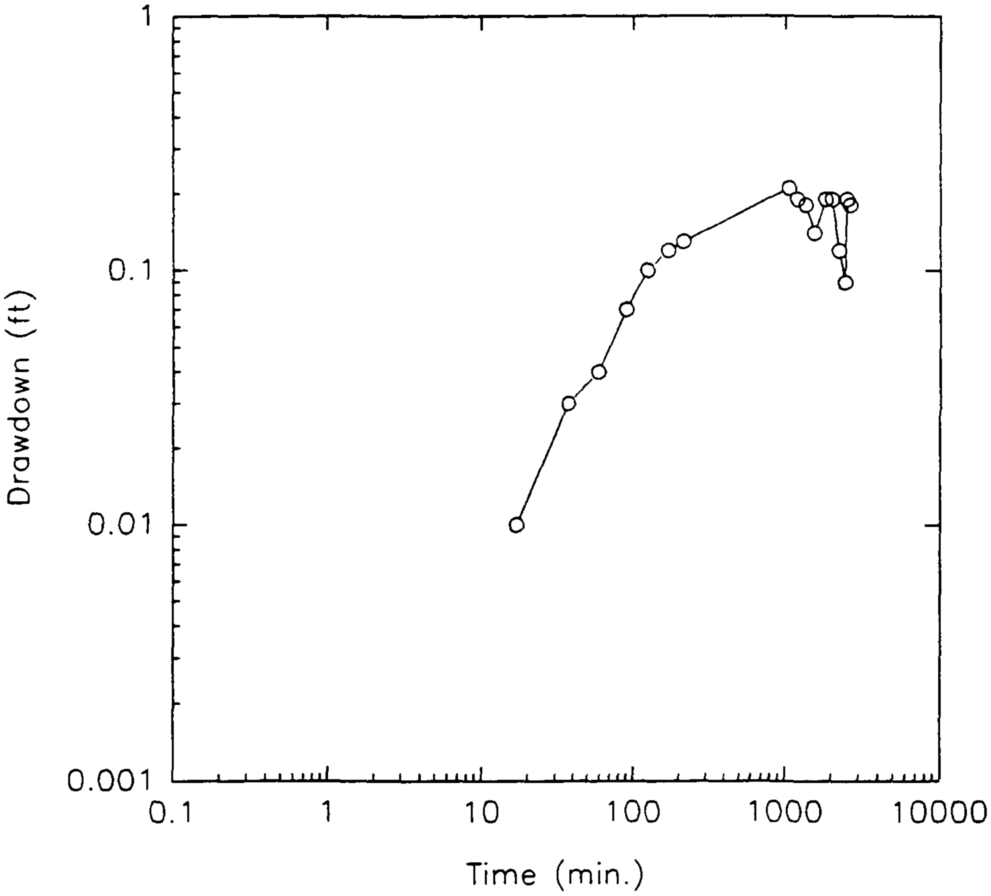
D4

Drawdown in Outwash Well (MWL-307)
SRSNE, Southington CT
April 4-6, 1994

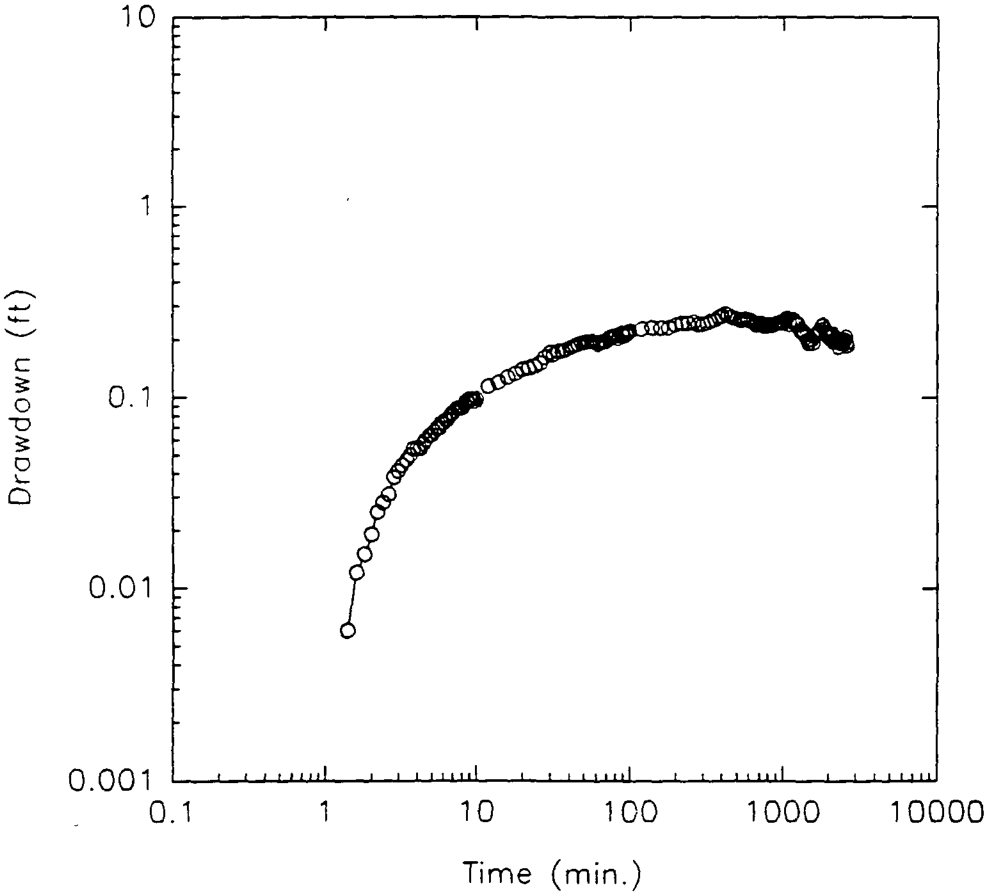


D5

Drawdown in Outwash Well (MWL-308)
SRSNE, Southington CT
April 4-6, 1994



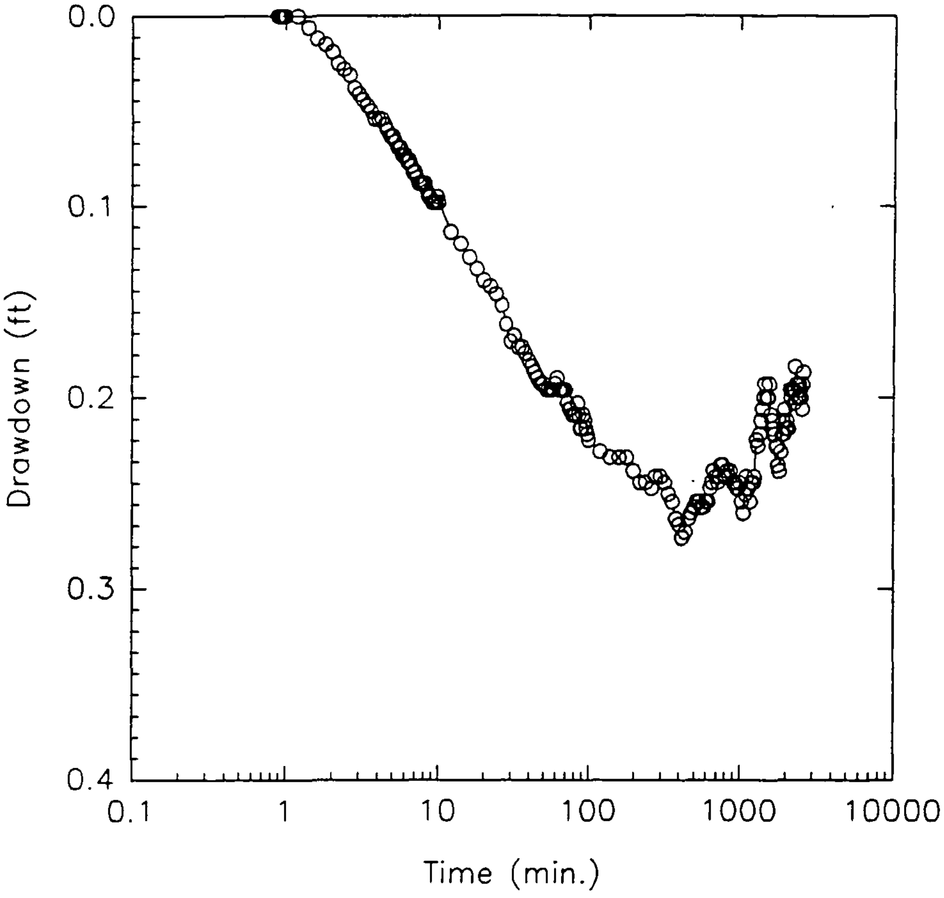
D6



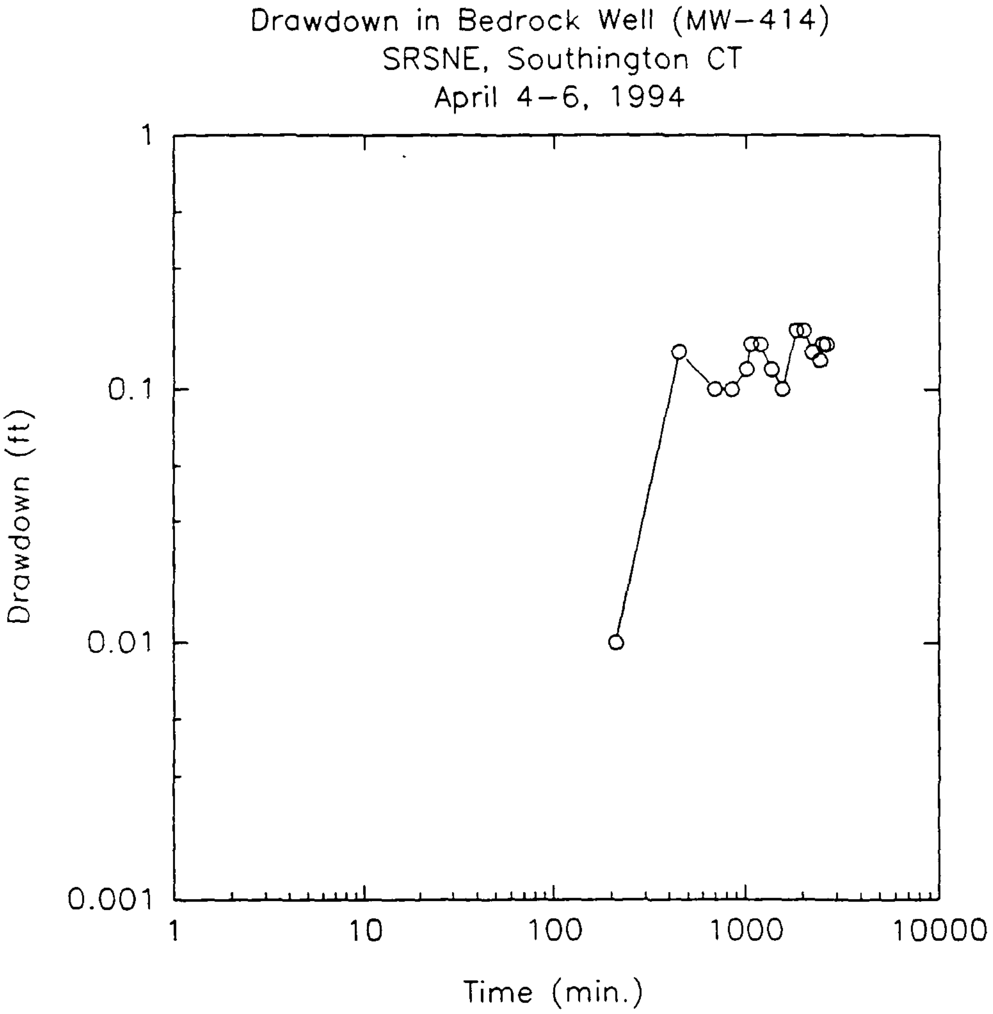
Drawdown in Till Well (MW-413)
SRSNE, Southington CT
April 4-6, 1994

D21

Drawdown in Till Well (MW-413)
SRSNE, Southington CT
April 4-6, 1994



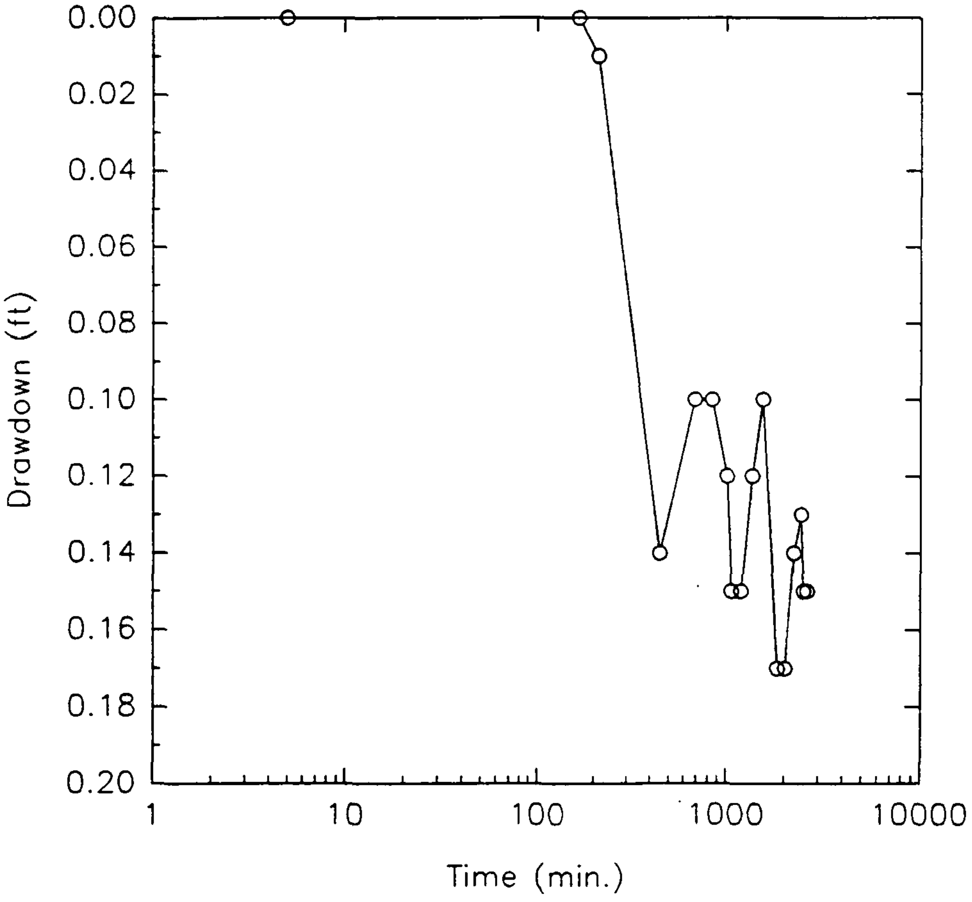
D22



Drawdown in Bedrock Well (MW-414)
SRSNE, Southington CT
April 4-6, 1994

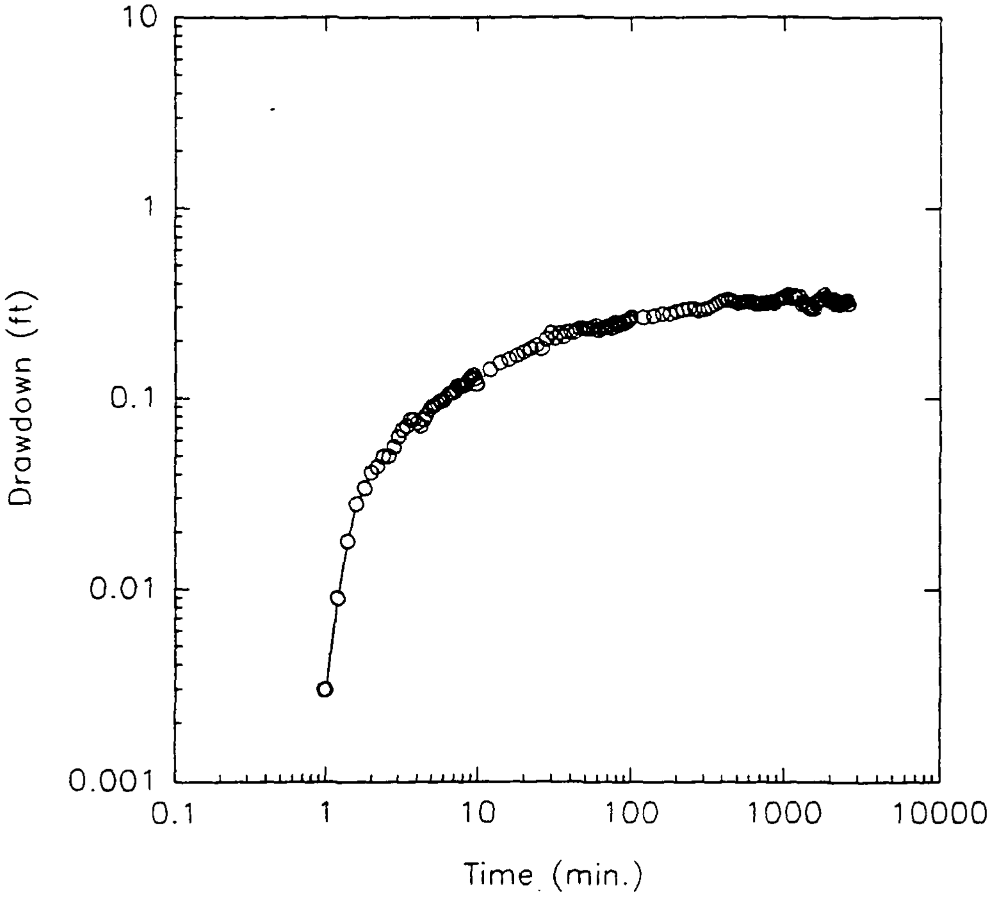
D23

Drawdown in Bedrock Well (MW-414)
SRSNE, Southington CT
April 4-6, 1994



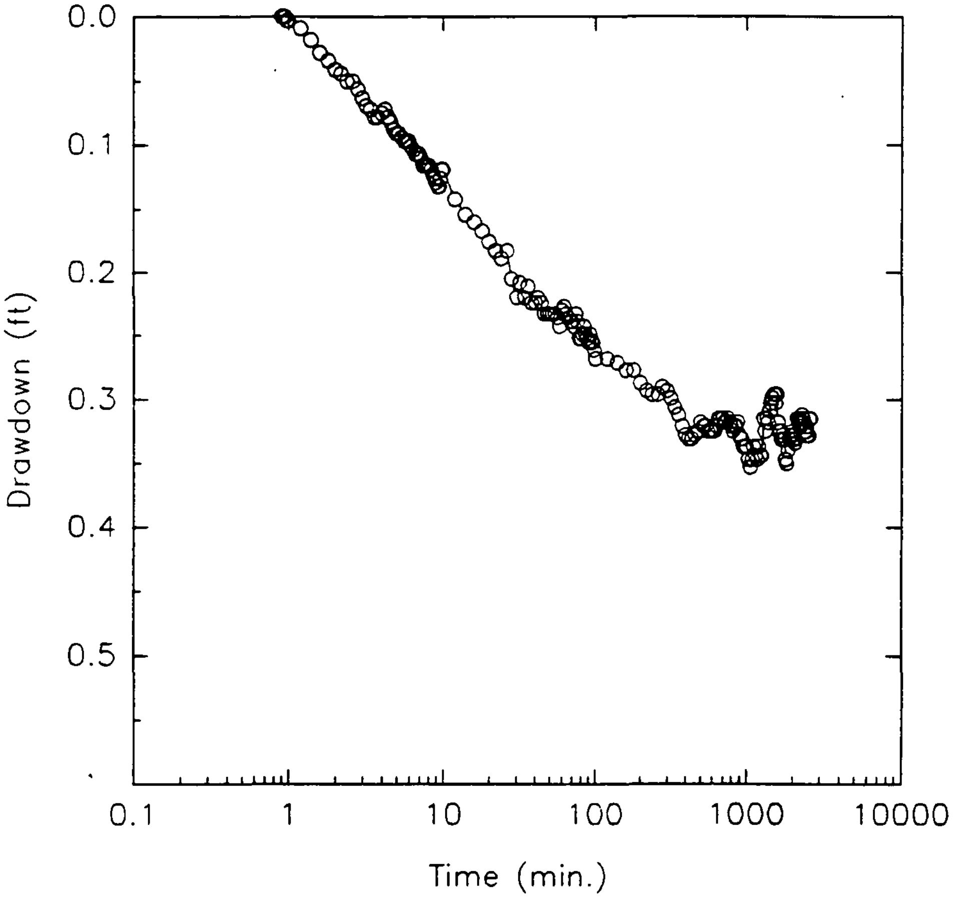
D24

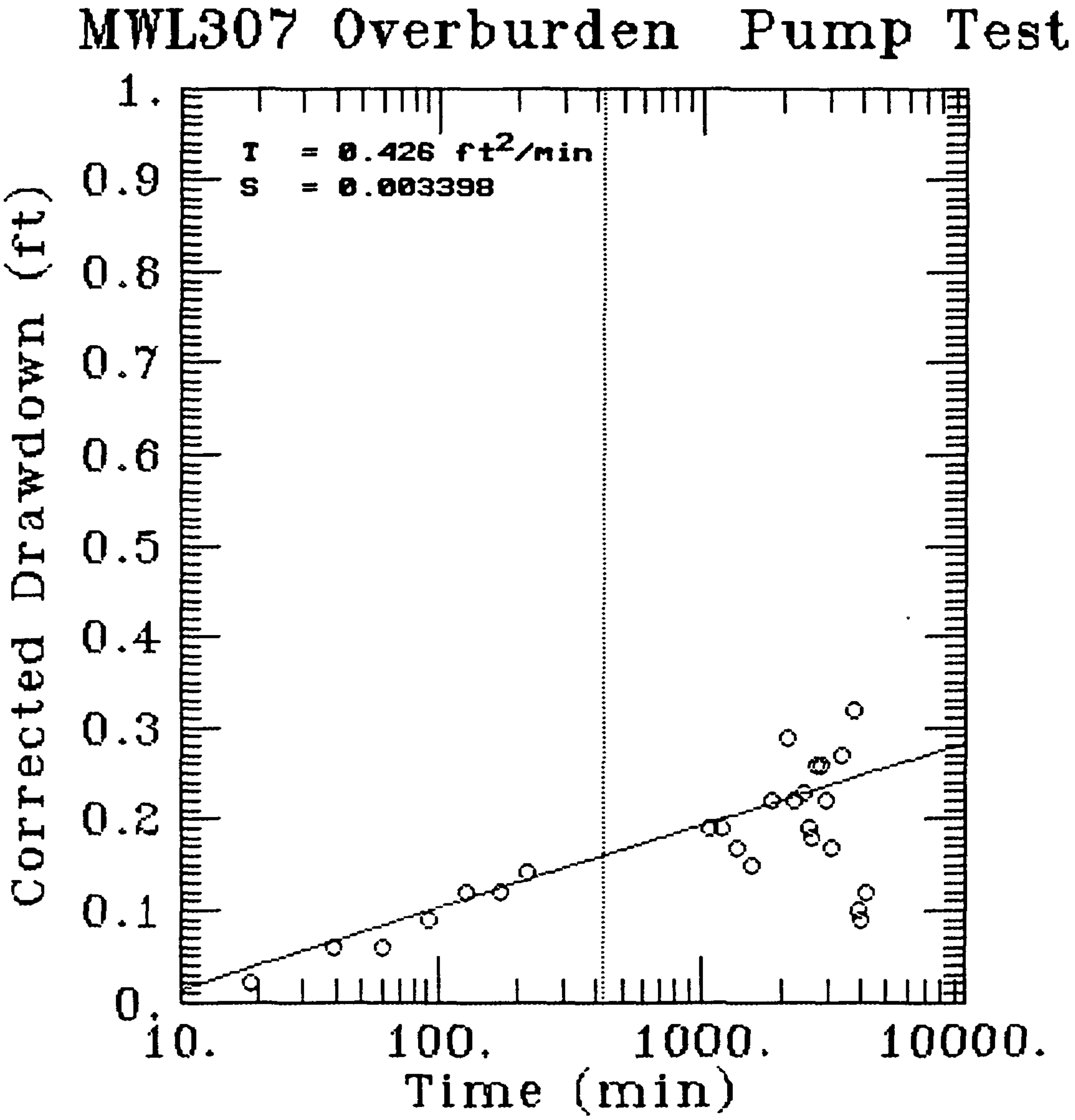
Drawdown in Outwash Well (MW–415)
SRSNE, Southington CT
April 4–6, 1994



D25

Drawdown in Outwash Well (MW-415)
SRSNE, Southington CT
April 4-6, 1994

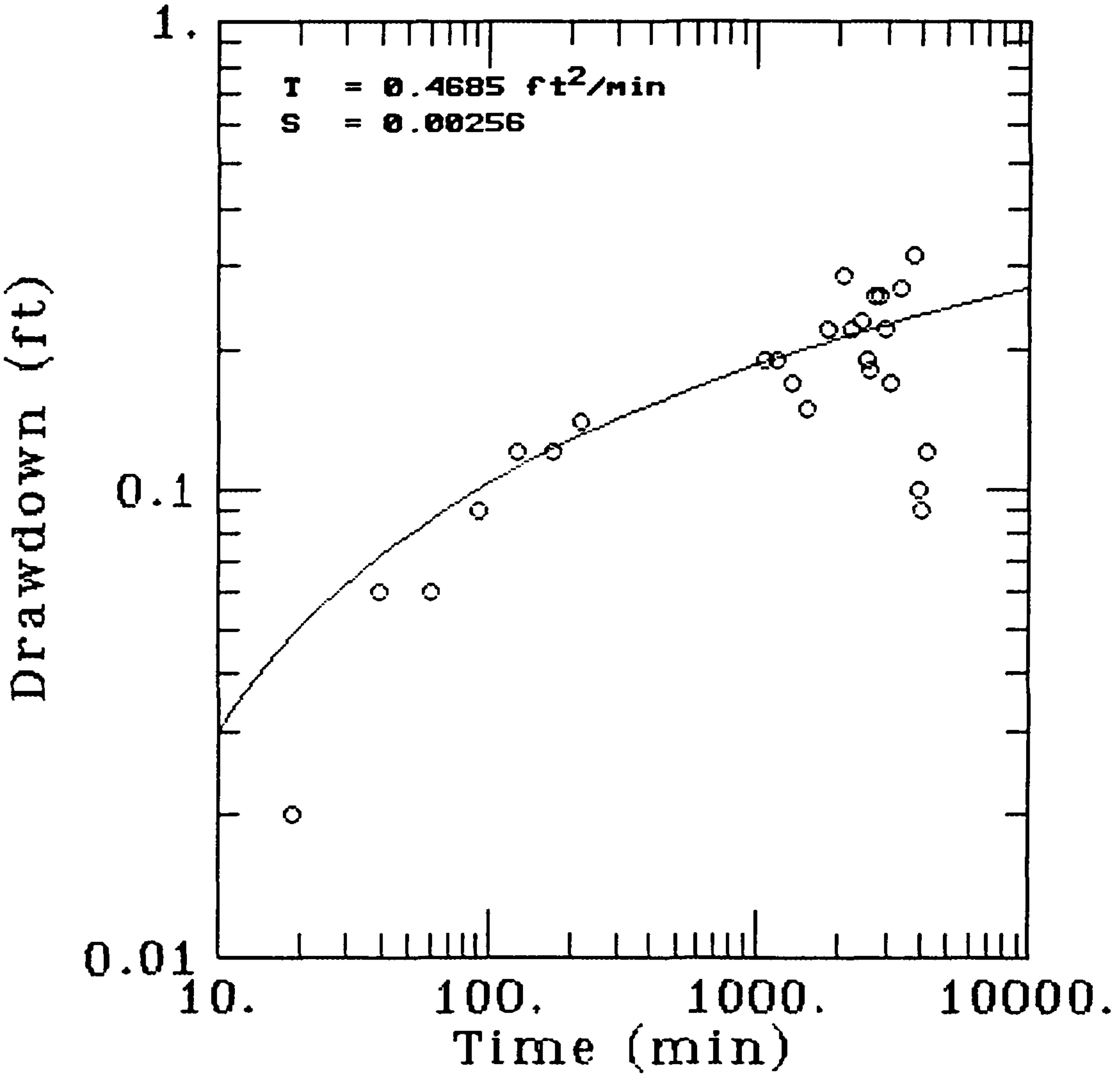




MWL307 Overburden Pump Test
T = 0.426 ft²/min
S = 0.003398
Corrected Drawdown (ft)
1.
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.
10.
100.
1000.
10000.
Time (min)

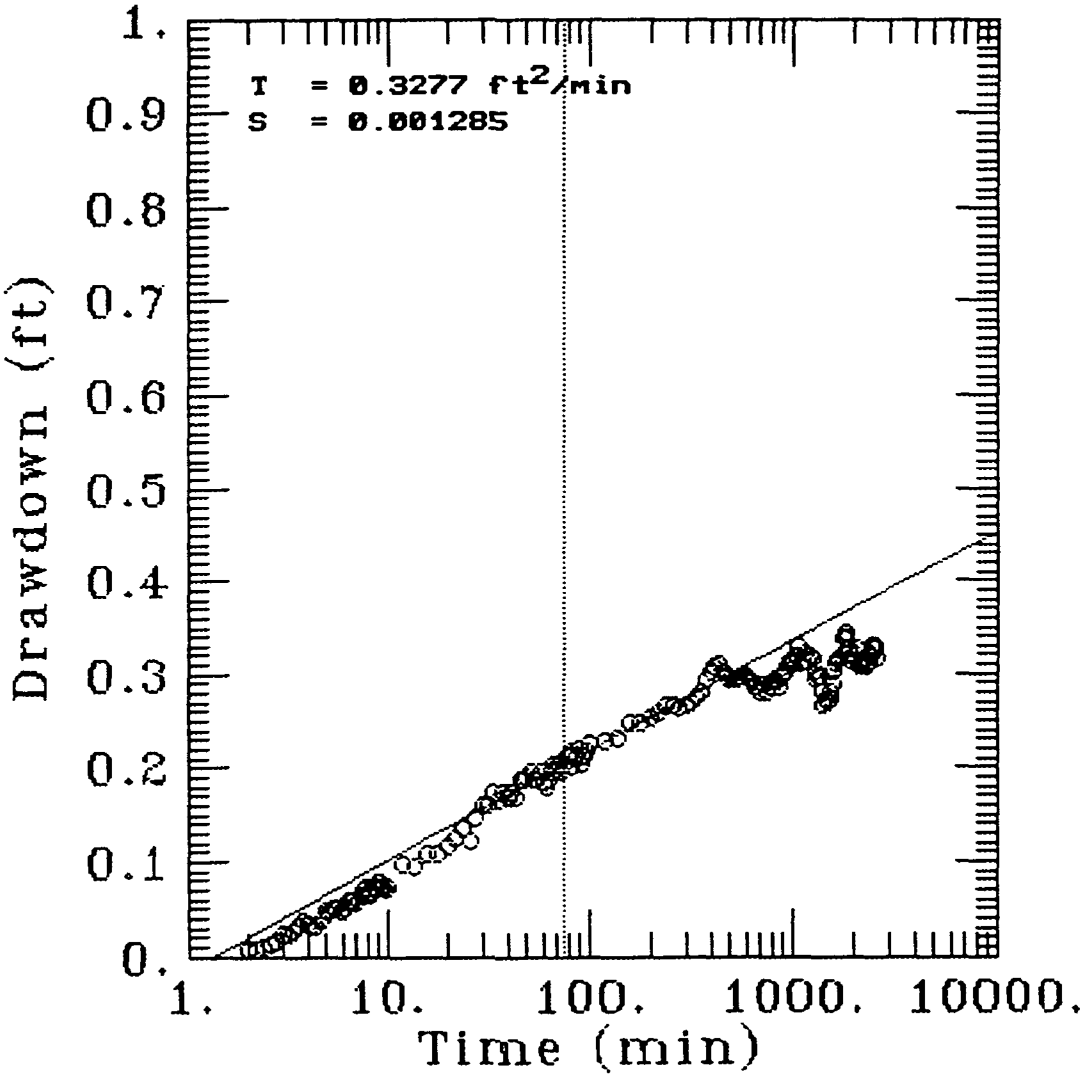
D:29

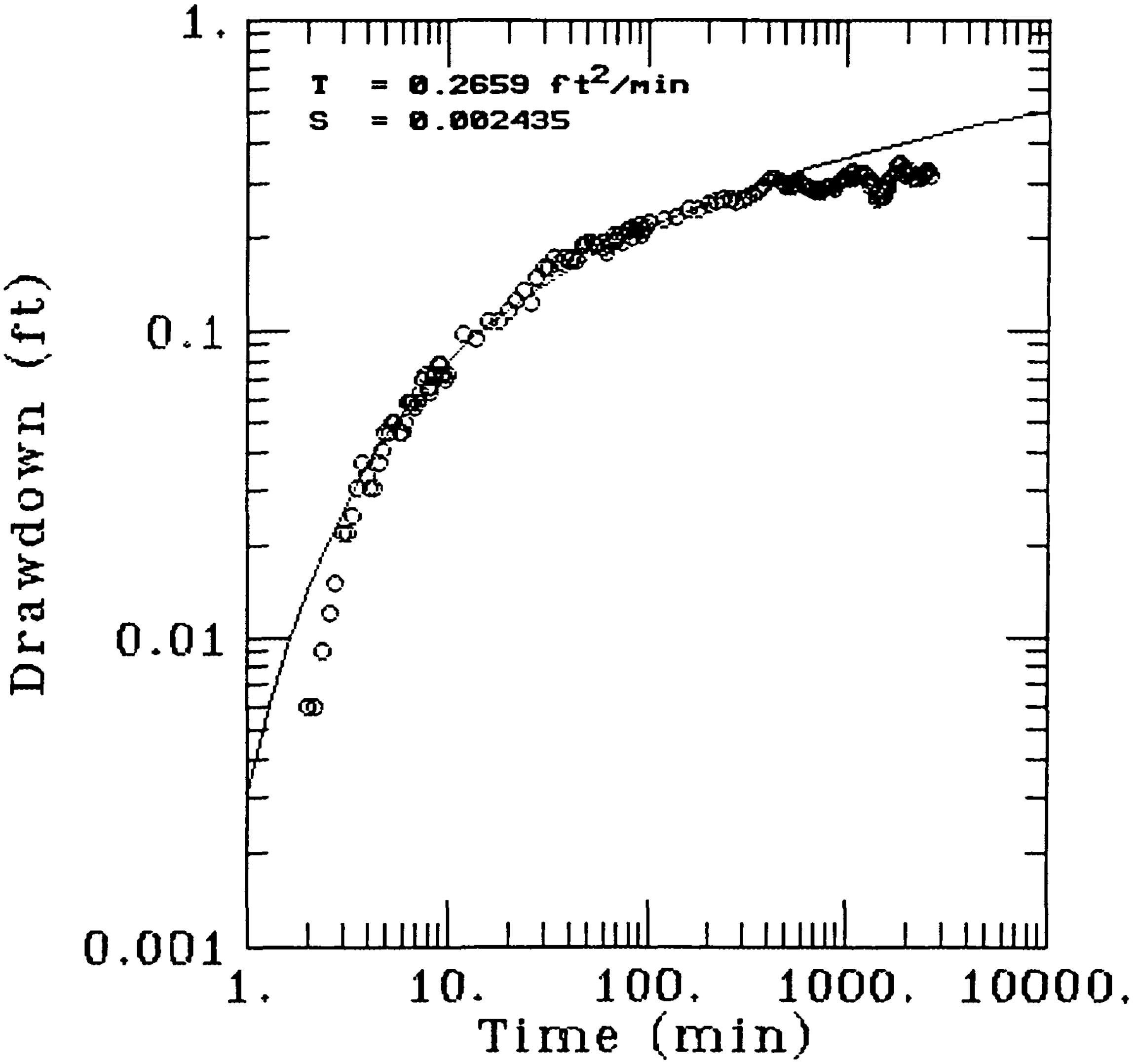
MWL307 Overburden Pump Test



D3C

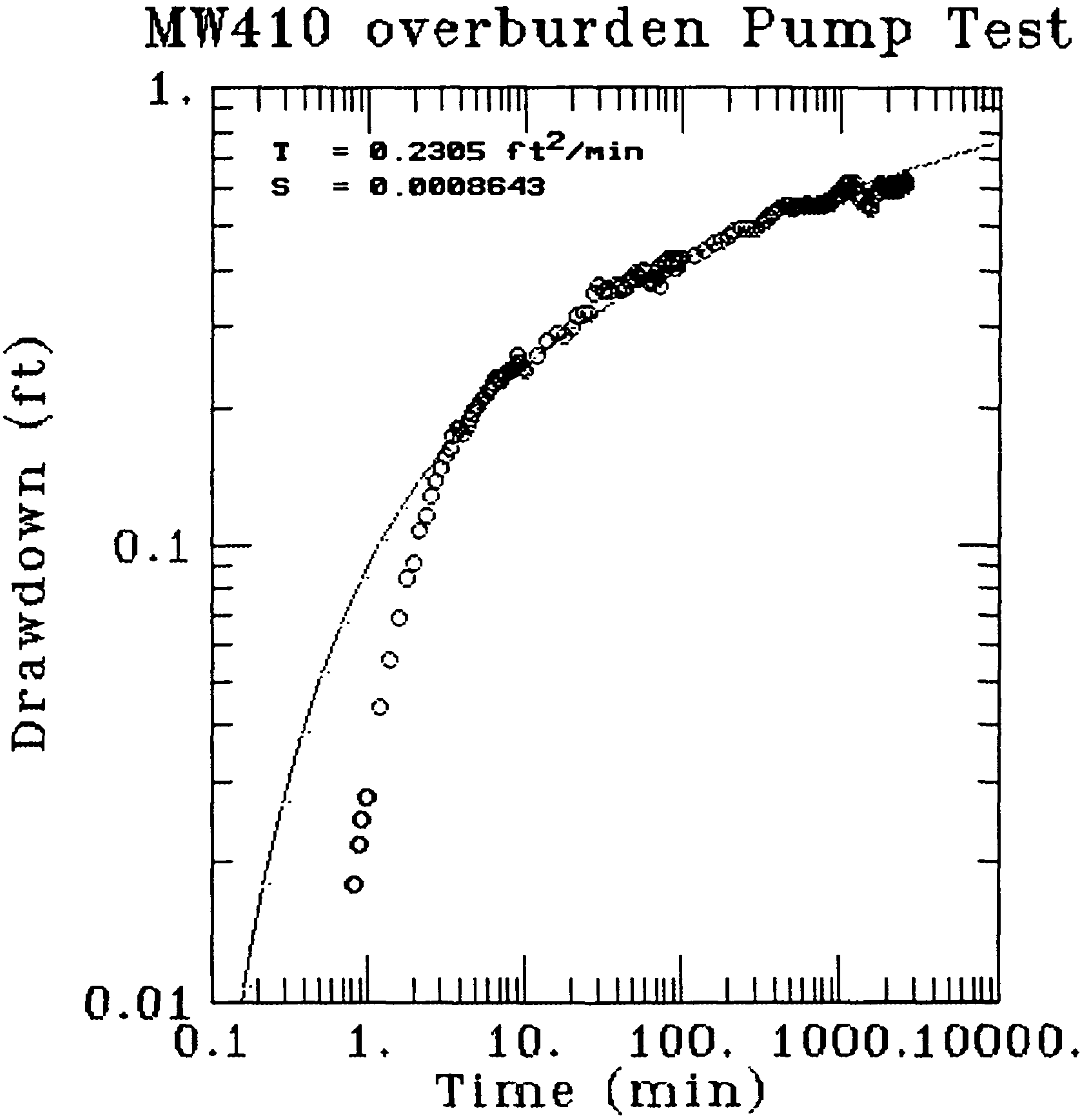
MW409 Overburden Pump Test



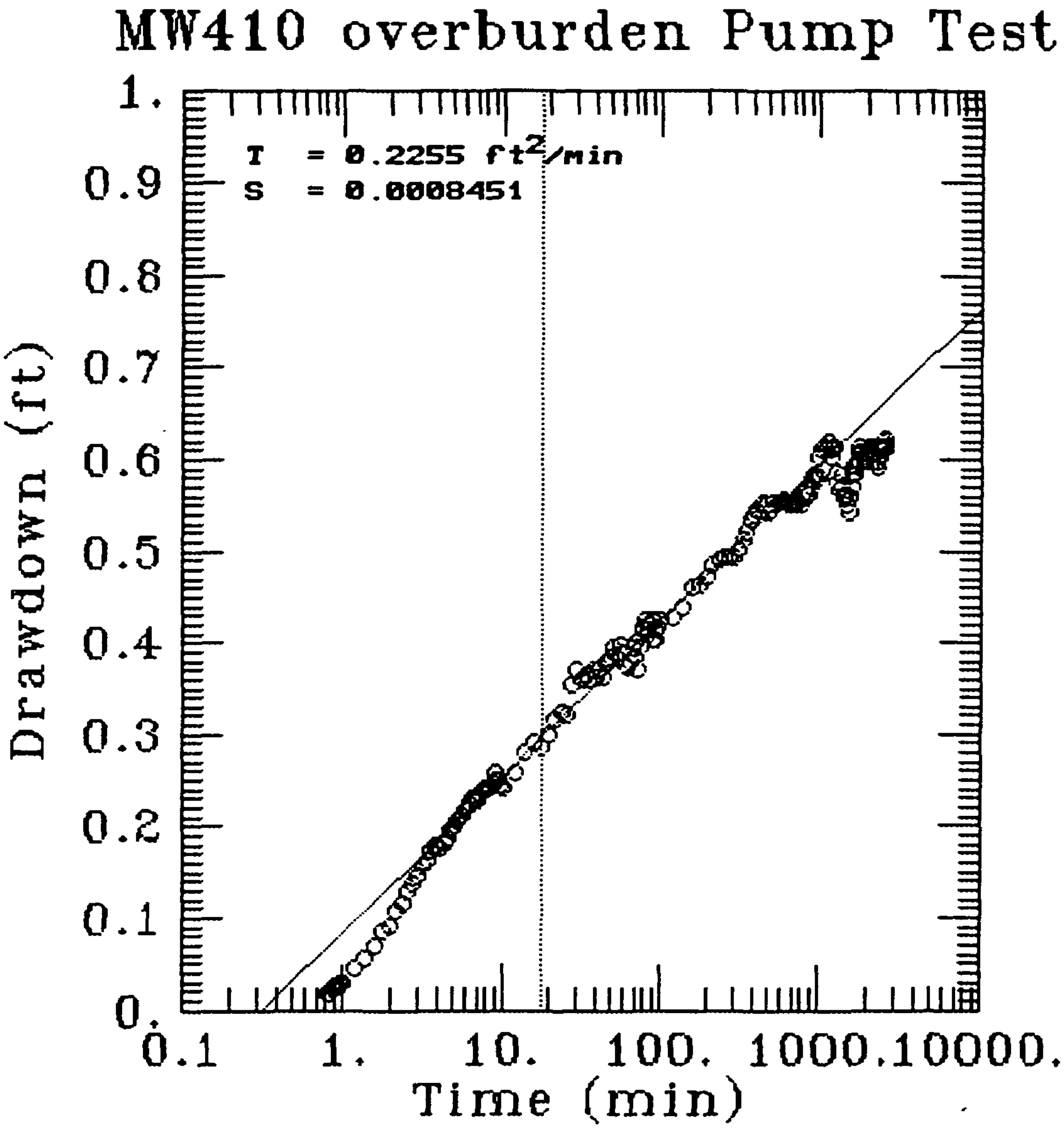


MW409 Overburden Pump Test

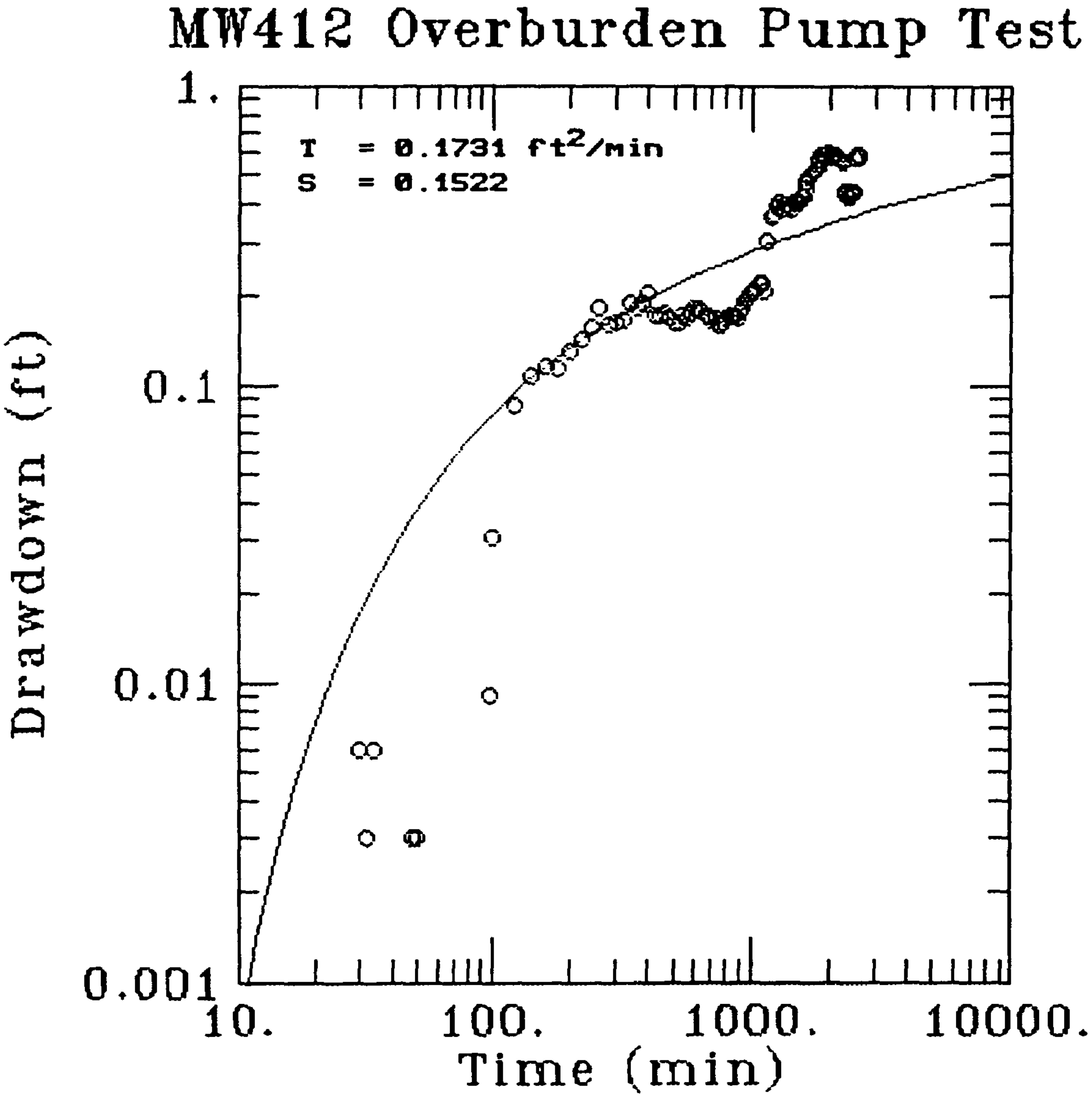
D32

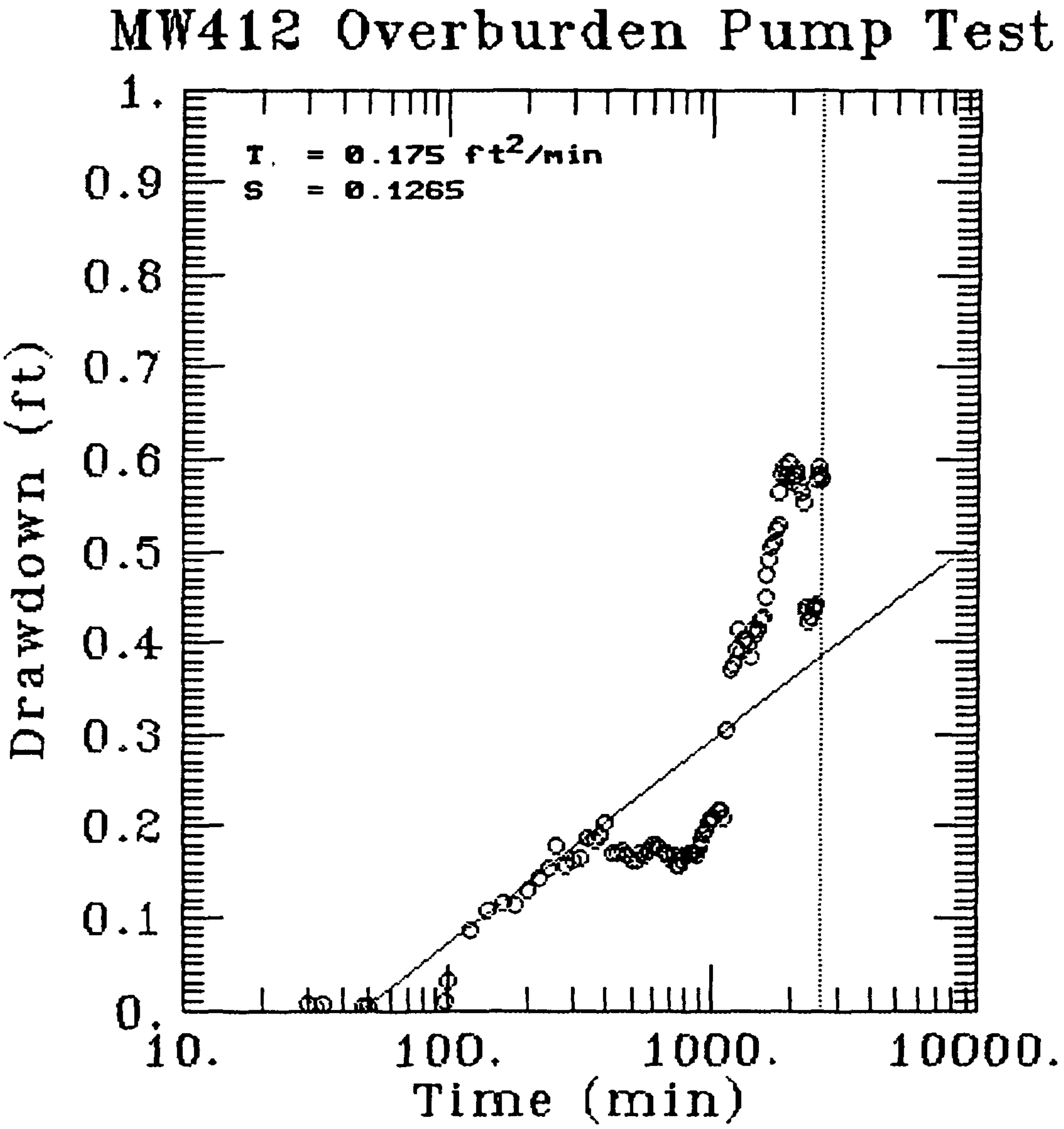

MW410 overburden Pump Test
T = 0.2305 ft^2/min
S = 0.0008643
Drawdown (ft)
1.
0.1
0.01
0.1
1.
10.
100.
1000.
10000.
Time (min)

D33


MW410 overburden Pump Test
T = 0.2255 ft²/min
S = 0.0008451
Drawdown (ft)
0.
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.
Time (min)
0.1
1.
10.
100.
1000.
10000.

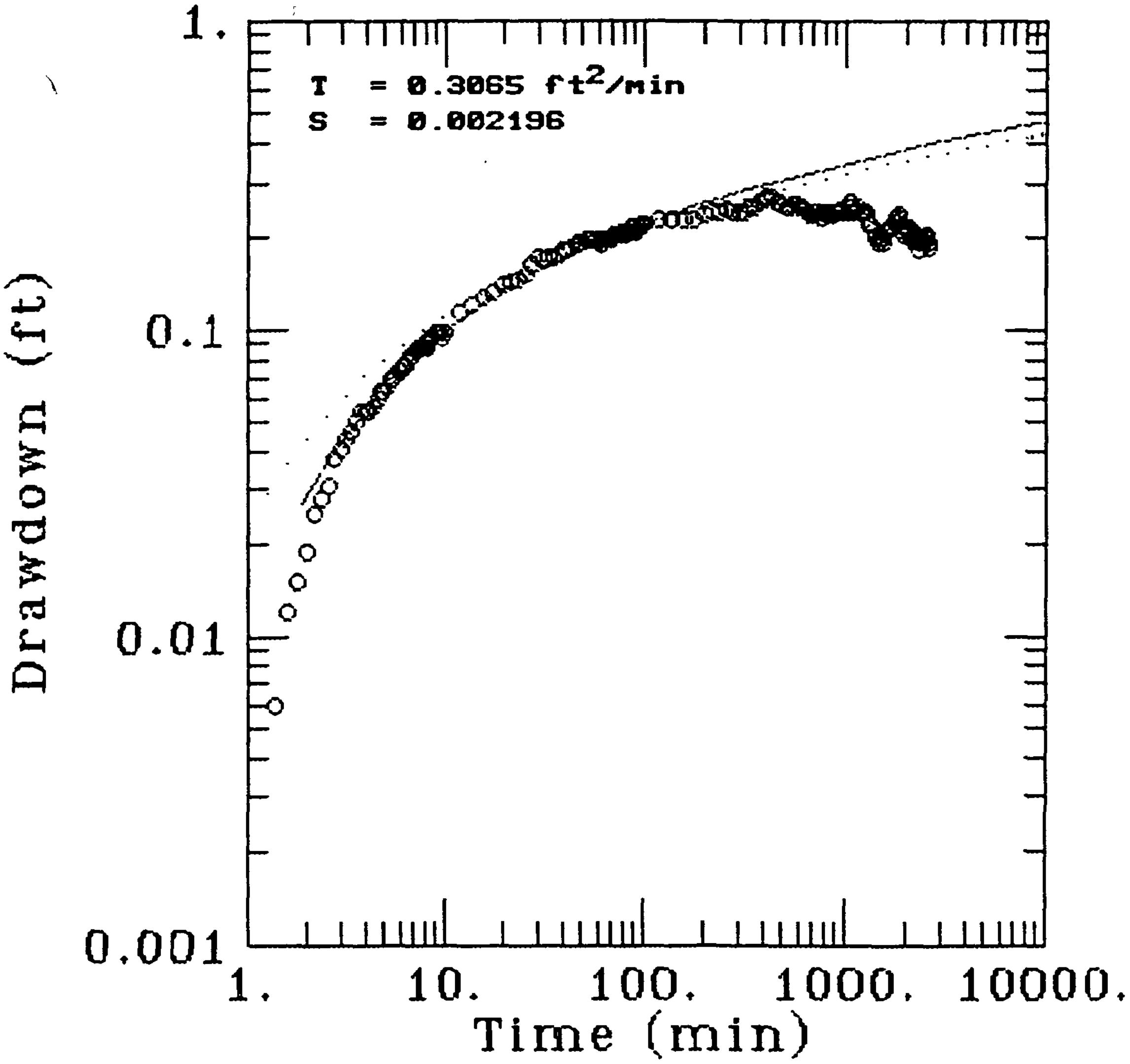
D34


MW412 Overburden Pump Test
T = 0.1731 ft^2/min
S = 0.1522
Drawdown (ft)
1.
0.1
0.01
0.001
10.
100.
1000.
10000.
Time (min)

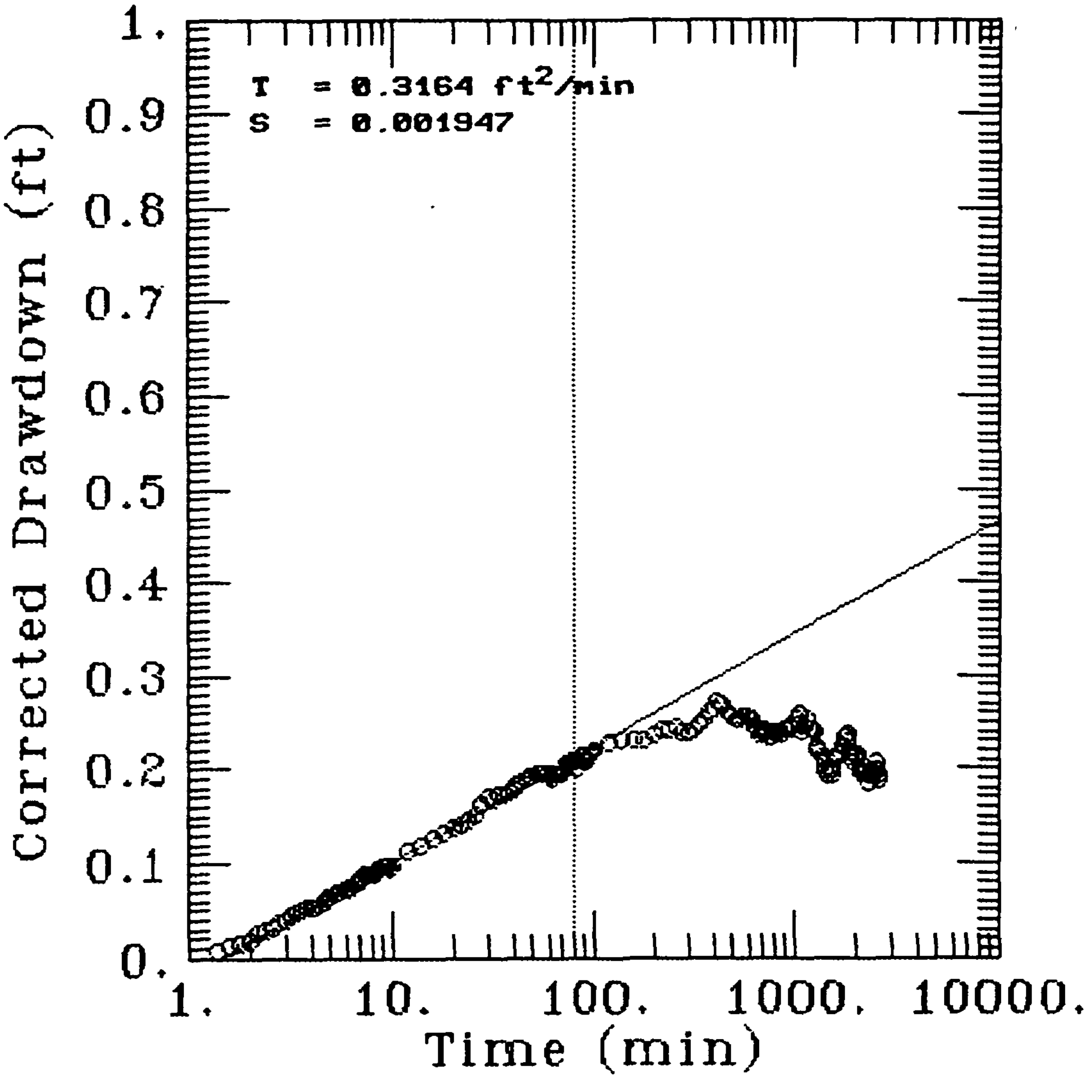

MW412 Overburden Pump Test
T = 0.175 ft²/min
S = 0.1265
Drawdown (ft)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.
Time (min)
10.
100.
1000.
10000.

D36

MW413 Overburden Pump Test



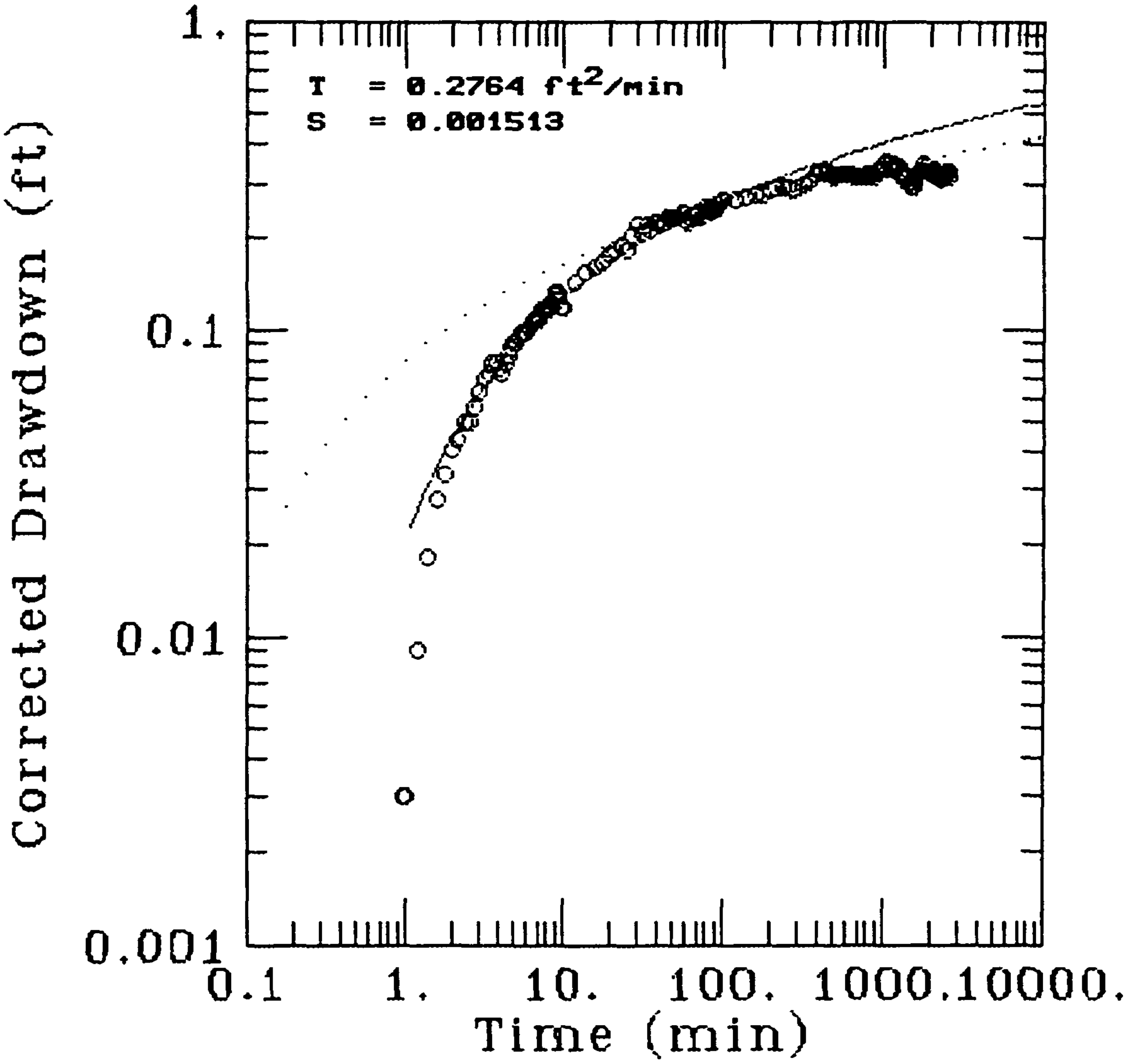
D37

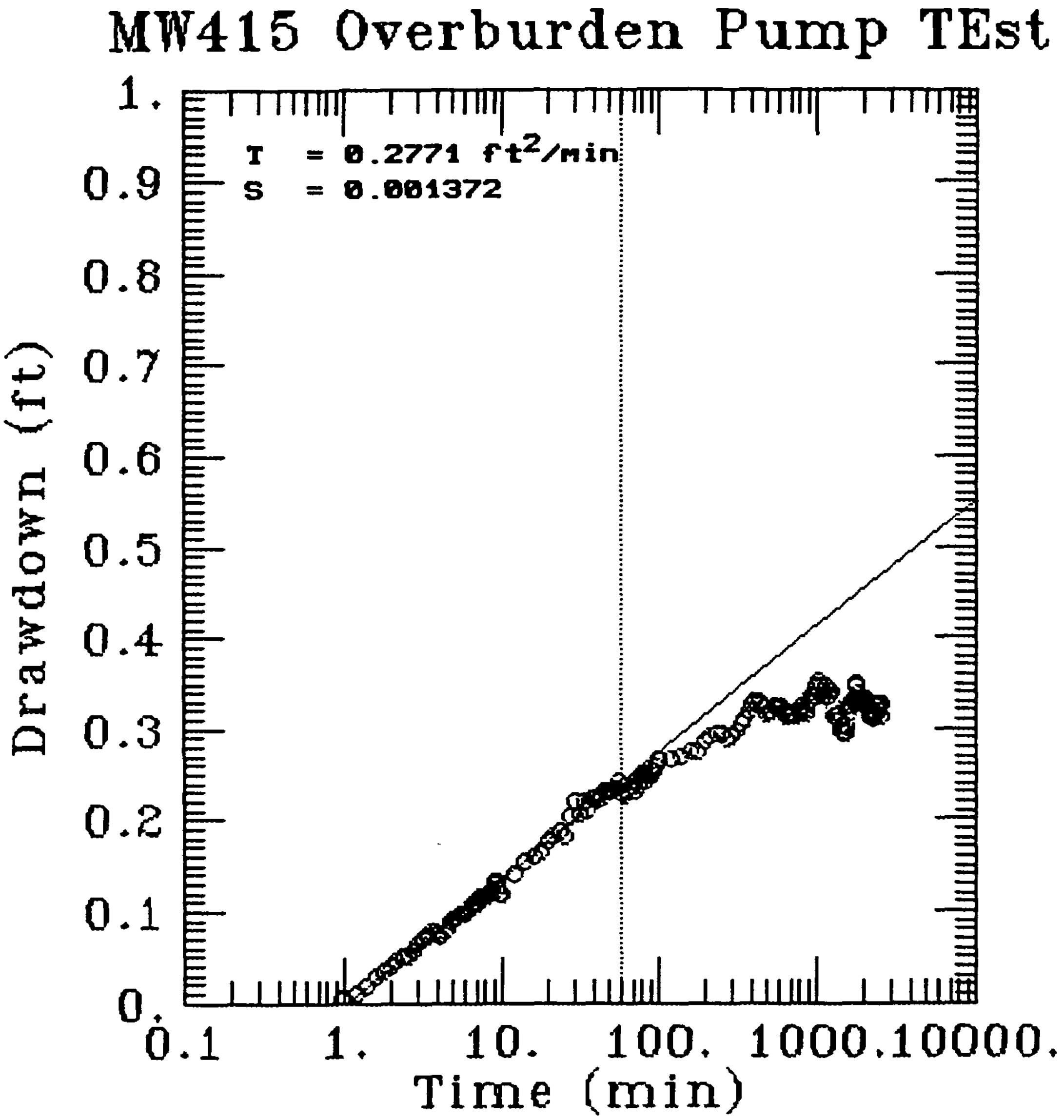


MW413 Overburden Pump Test

D38

MW415 Overburden Pump TEst

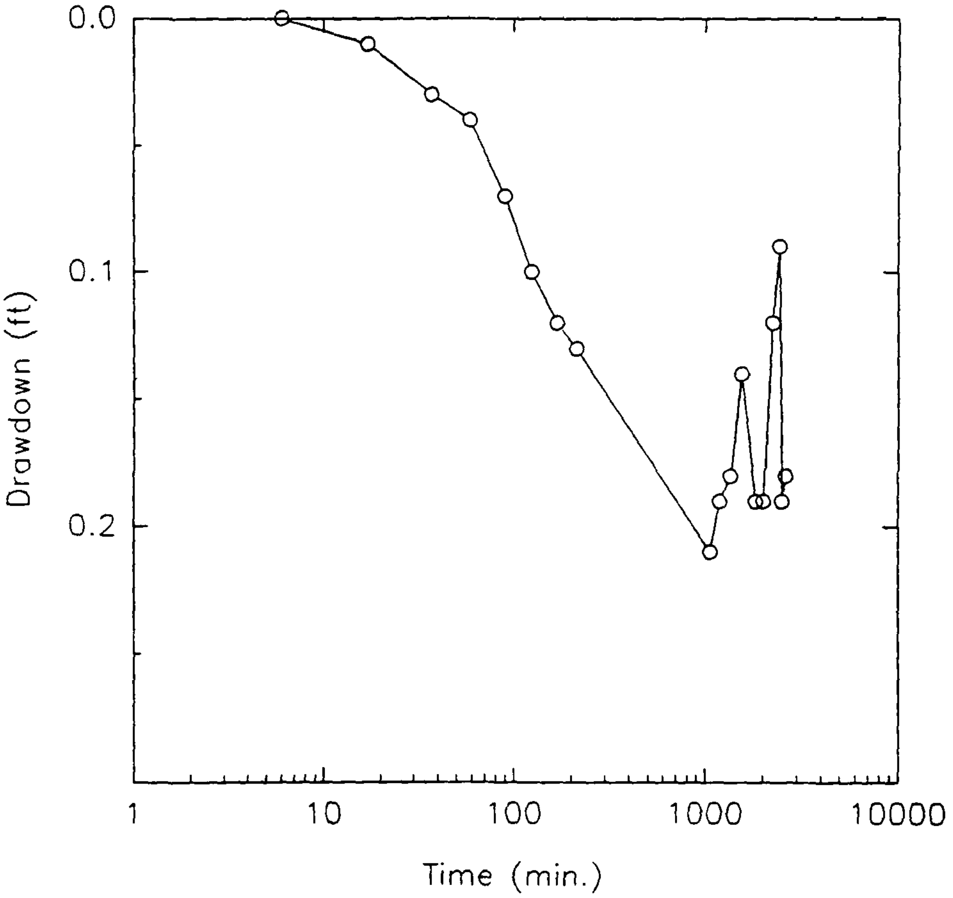



MW415 Overburden Pump TEst
T = 0.2771 ft^2/min
S = 0.001372
Drawdown (ft)
0.
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.
0.1
1.
10.
100.
1000.
10000.
Time (min)

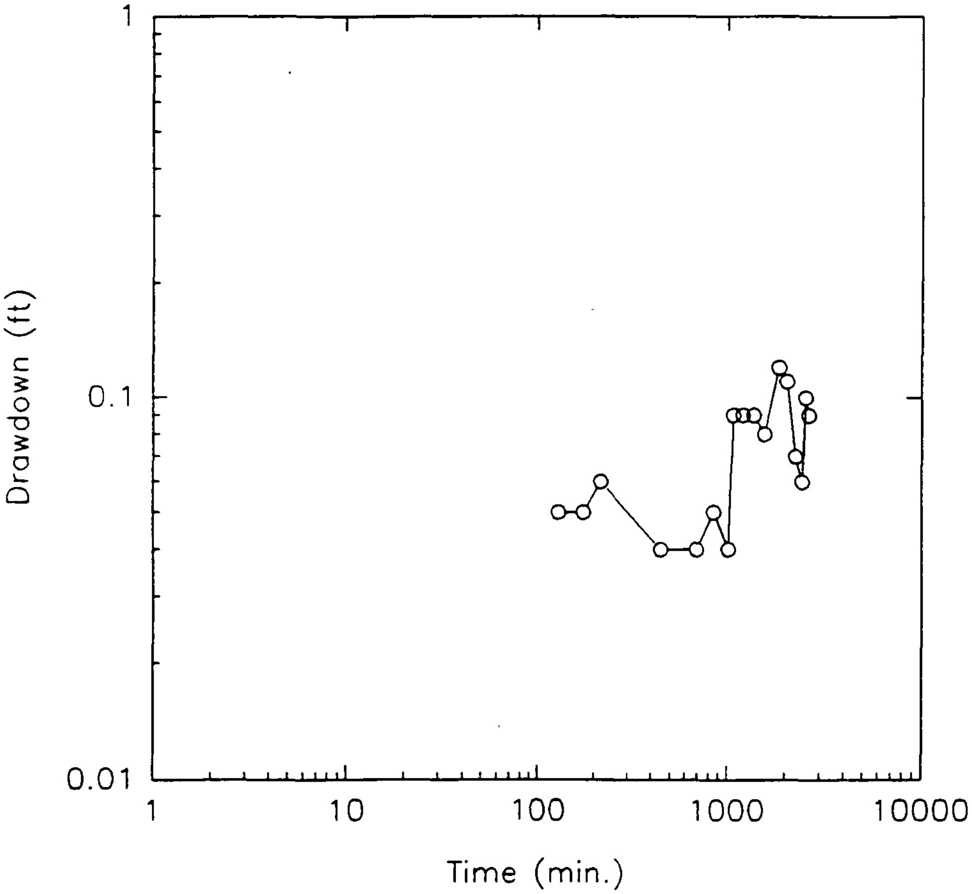
D40

AQTESOLV™ GRAPHS

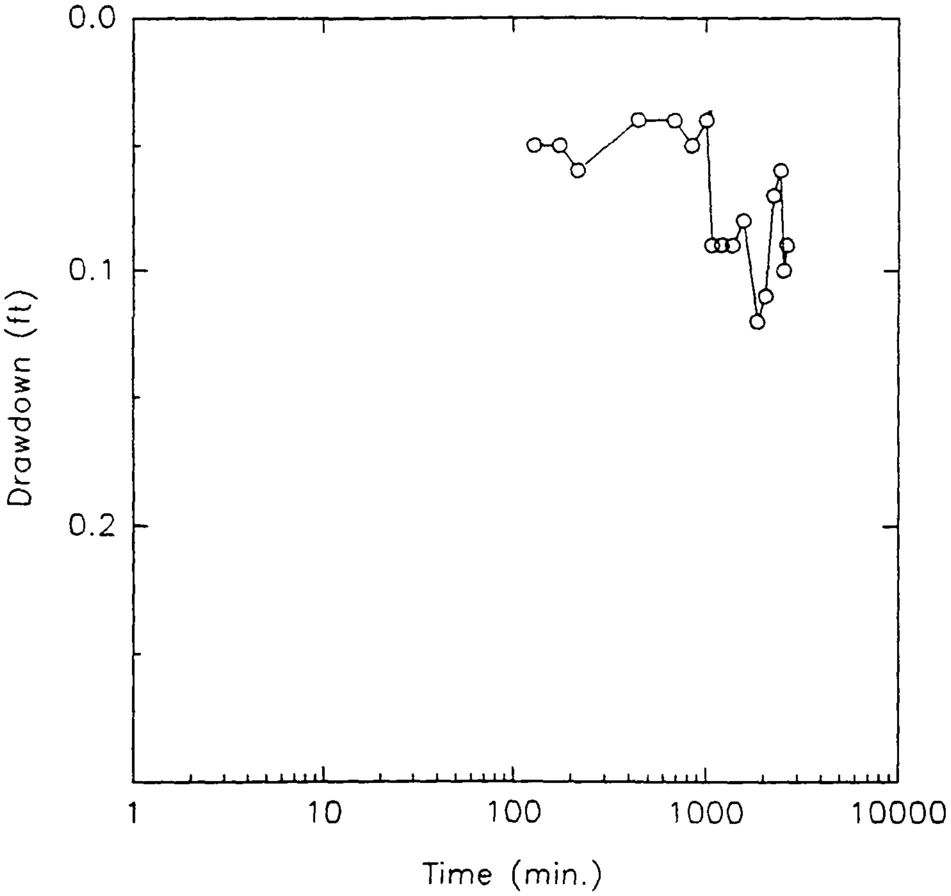
Drawdown in Outwash Well (MWL-308)
SRSNE, Southington CT
April 4-6, 1994



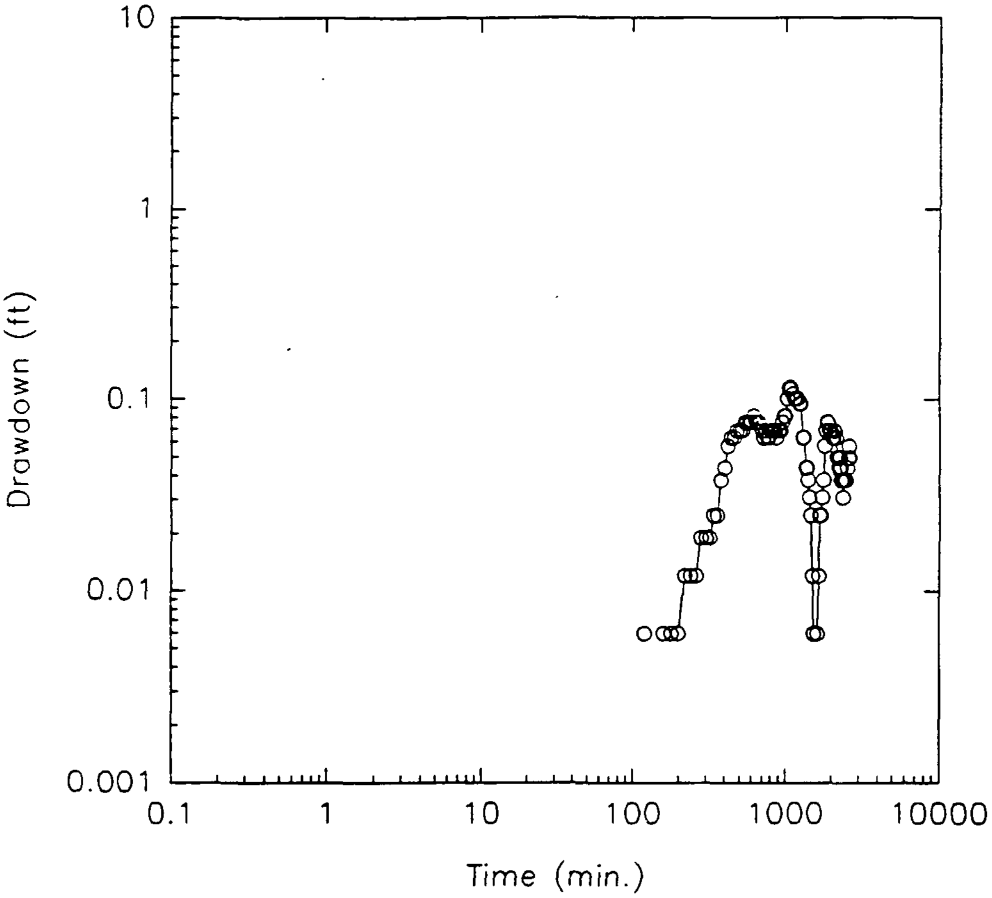
Drawdown in Outwash Well (TW-8A)
SRSNE, Southington CT
April 4-6, 1994



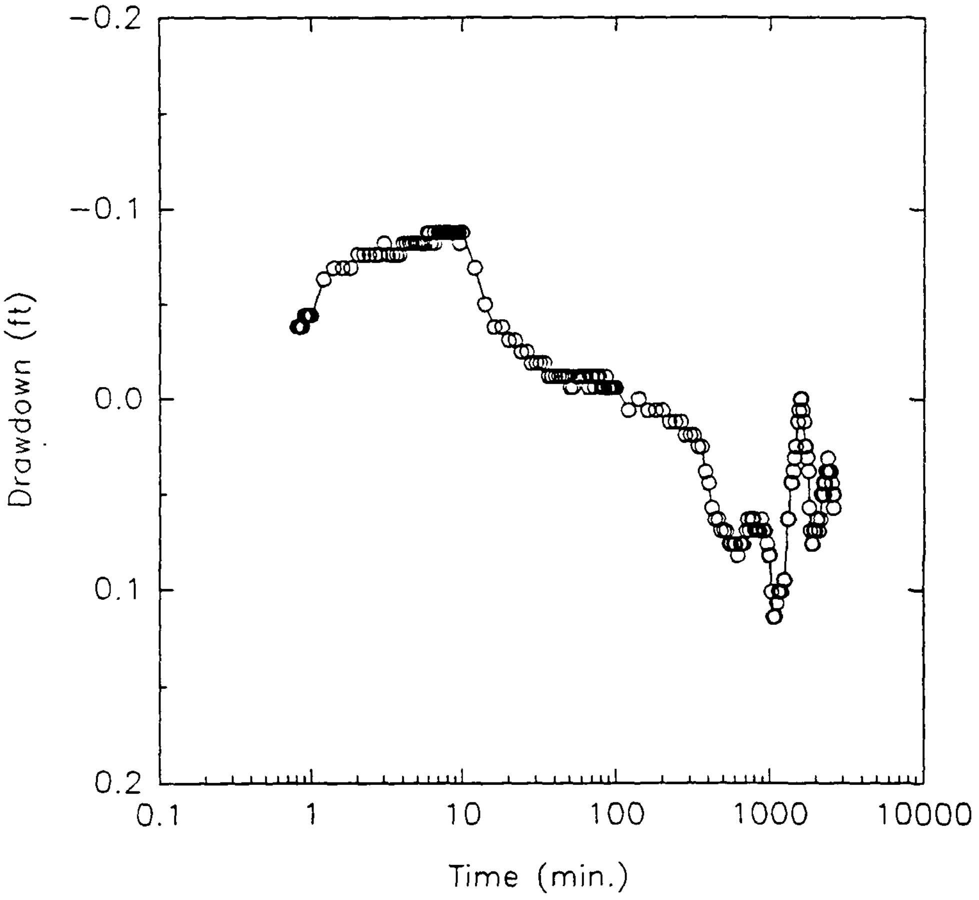
Drawdown in Outwash Well (TW-8A)
SRSNE, Southington CT
April 4-6, 1994



Drawdown in Shallow Bedrock Well (PW–406)
SRSNE, Southington CT
April 4–6, 1994

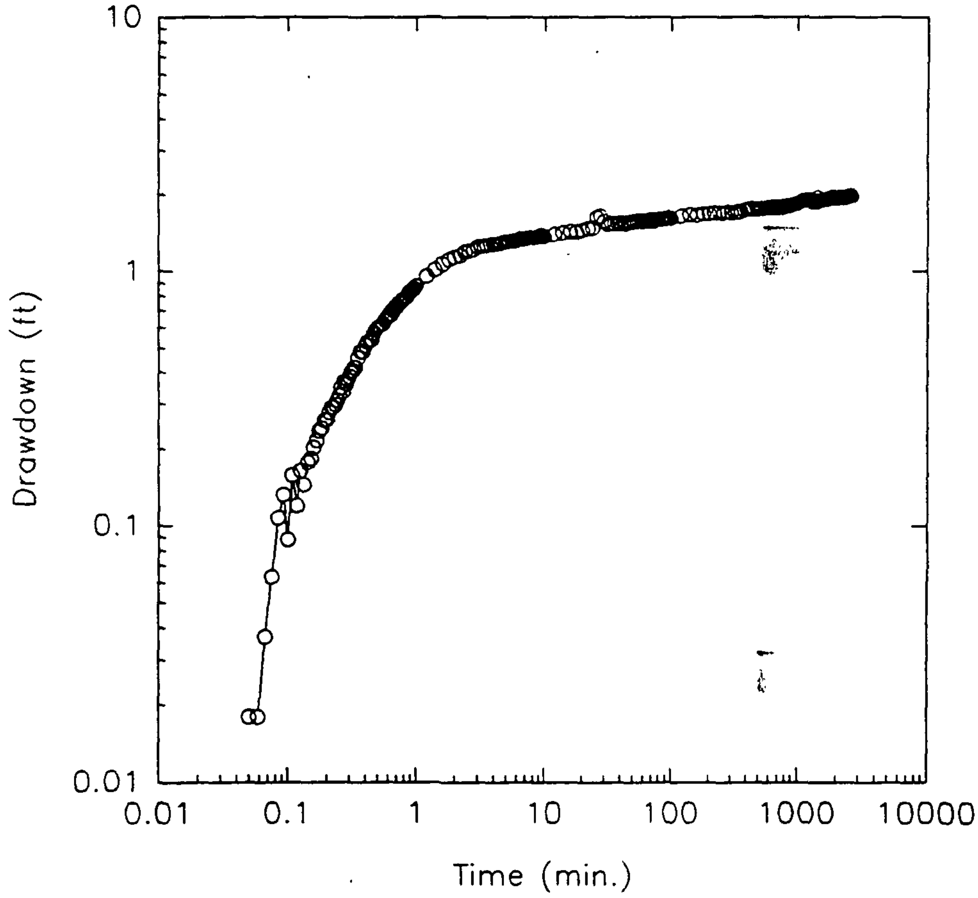


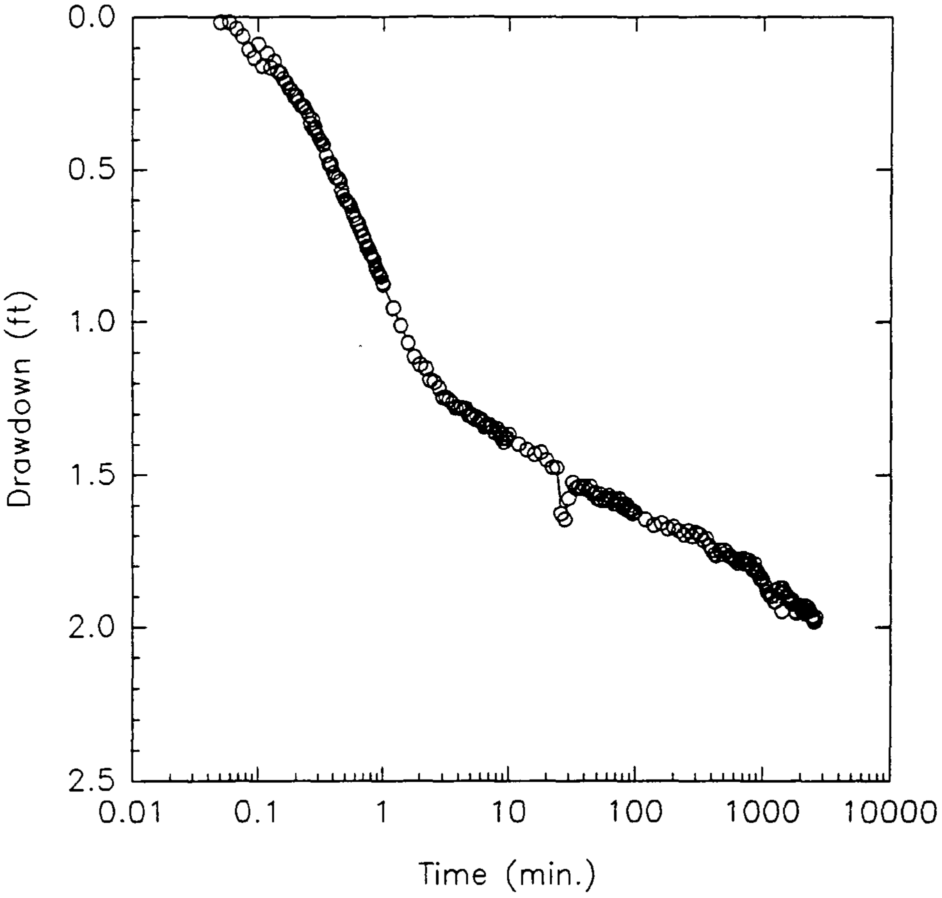
D10



Drawdown in Shallow Bedrock Well (PW-406)
SRSNE, Southington CT
April 4-6, 1994

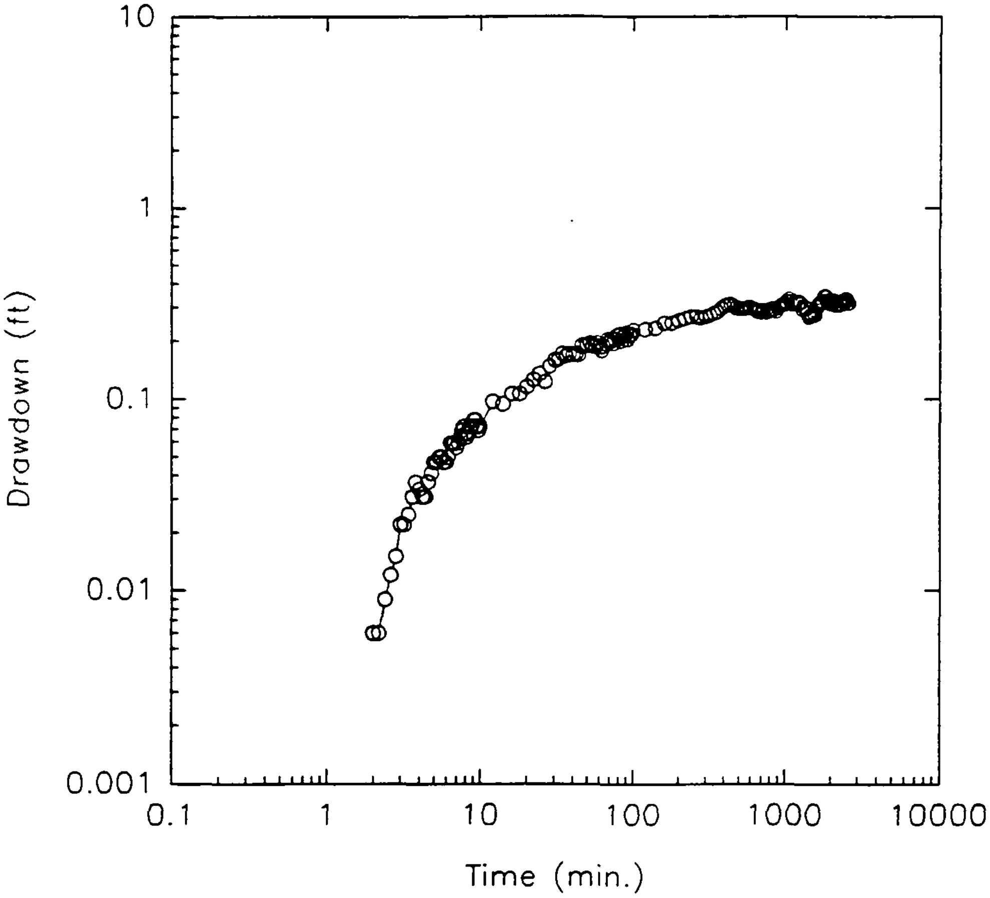
Drawdown in Pumping Well (PW-407)
SRSNE, Southington CT
April 4-6, 1994





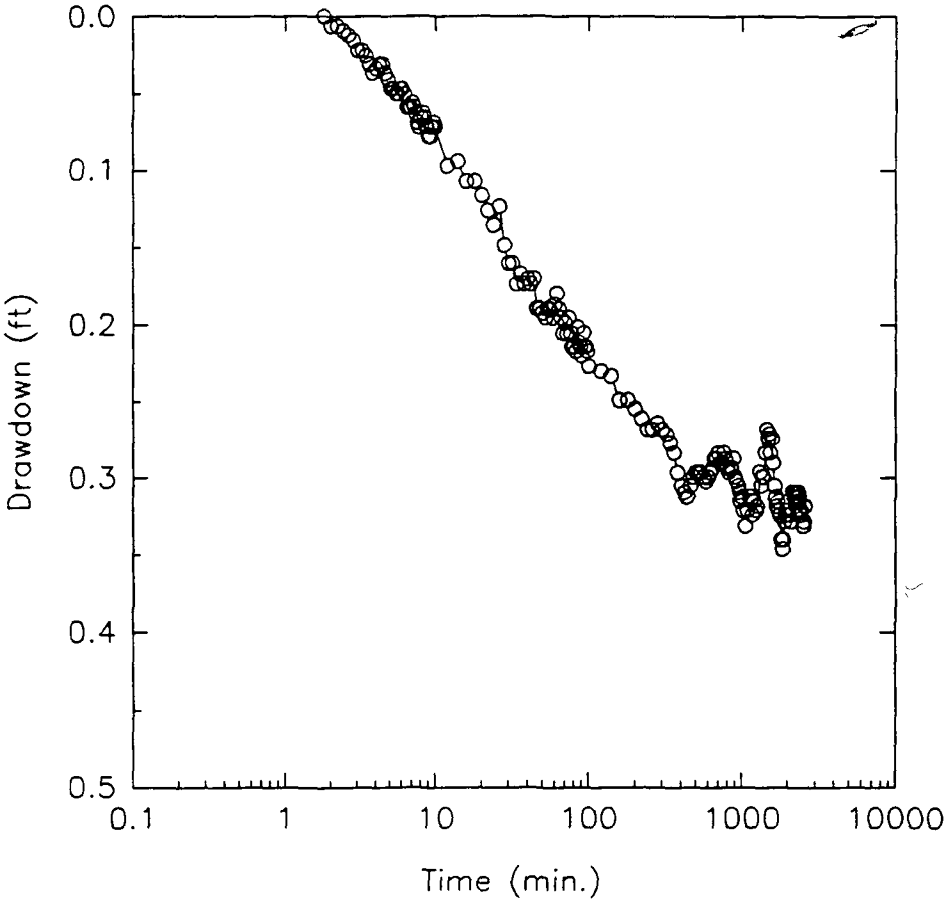
Drawdown in Pumping Well (PW-407)
SRSNE, Southington CT
April 4-6, 1994

Drawdown in Outwash Well (MW-409)
SRSNE, Southington CT
April 4-6, 1994

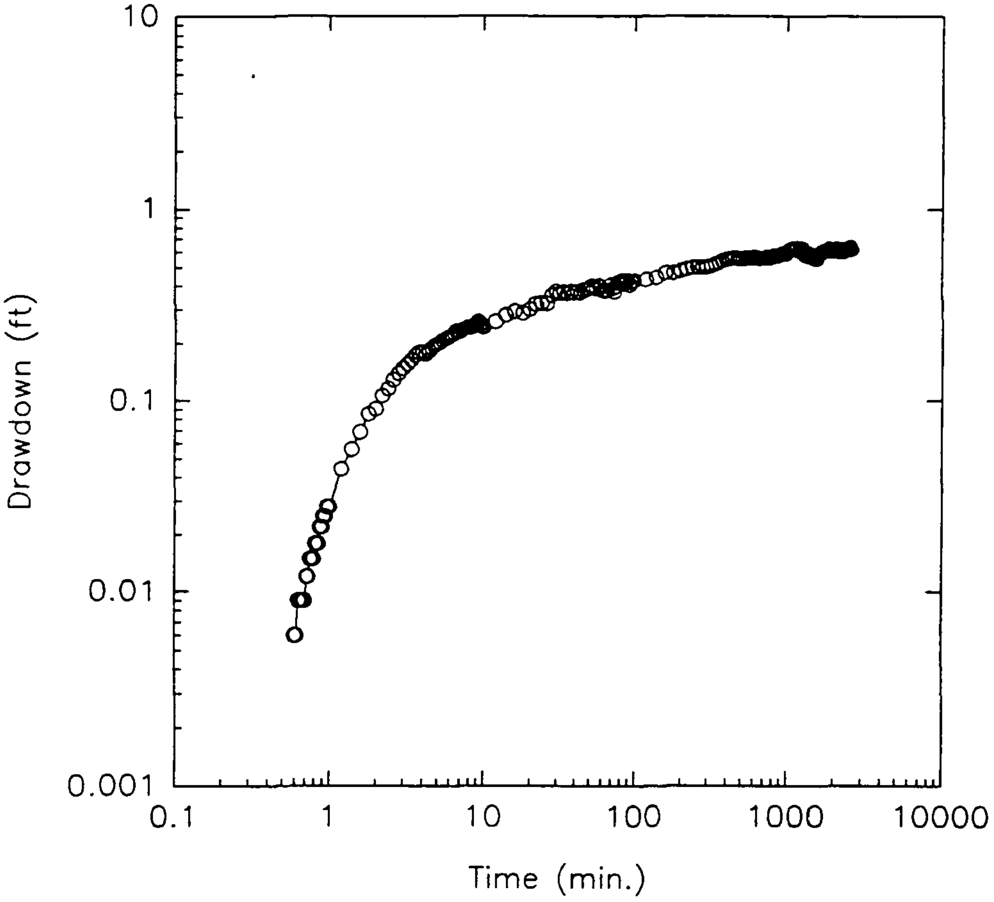


D14

Drawdown in Outwash Well (MW-409)
SRSNE, Southington CT
April 4-6, 1994

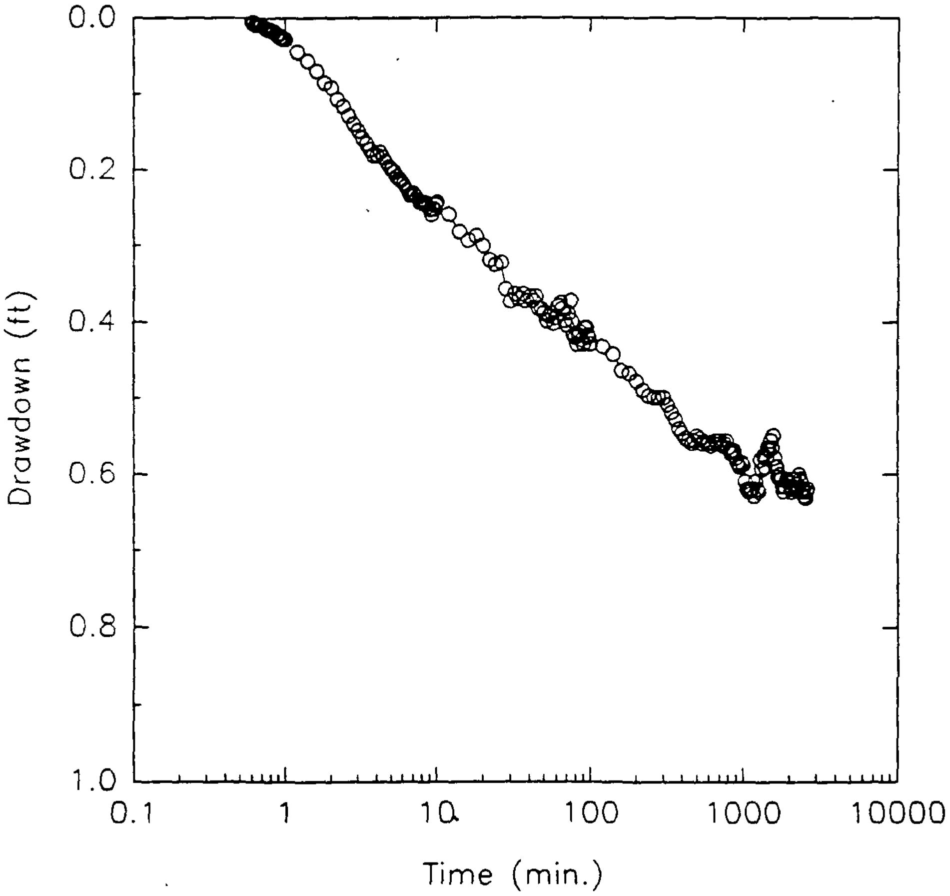


D.5


Drawdown in Outwash Well (MW-410)
SRSNE, Southington CT
April 4-6, 1994

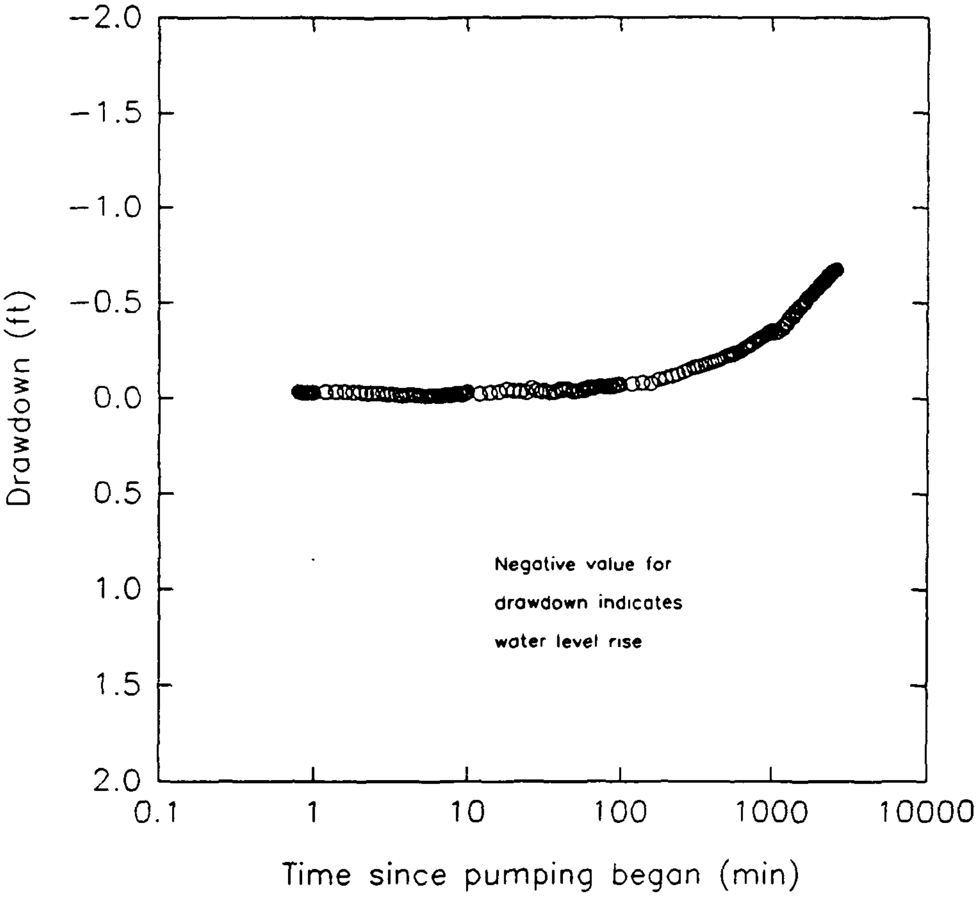
D1K

Drawdown in Outwash Well (MW-410)
SRSNE, Southington CT
April 4-6, 1994



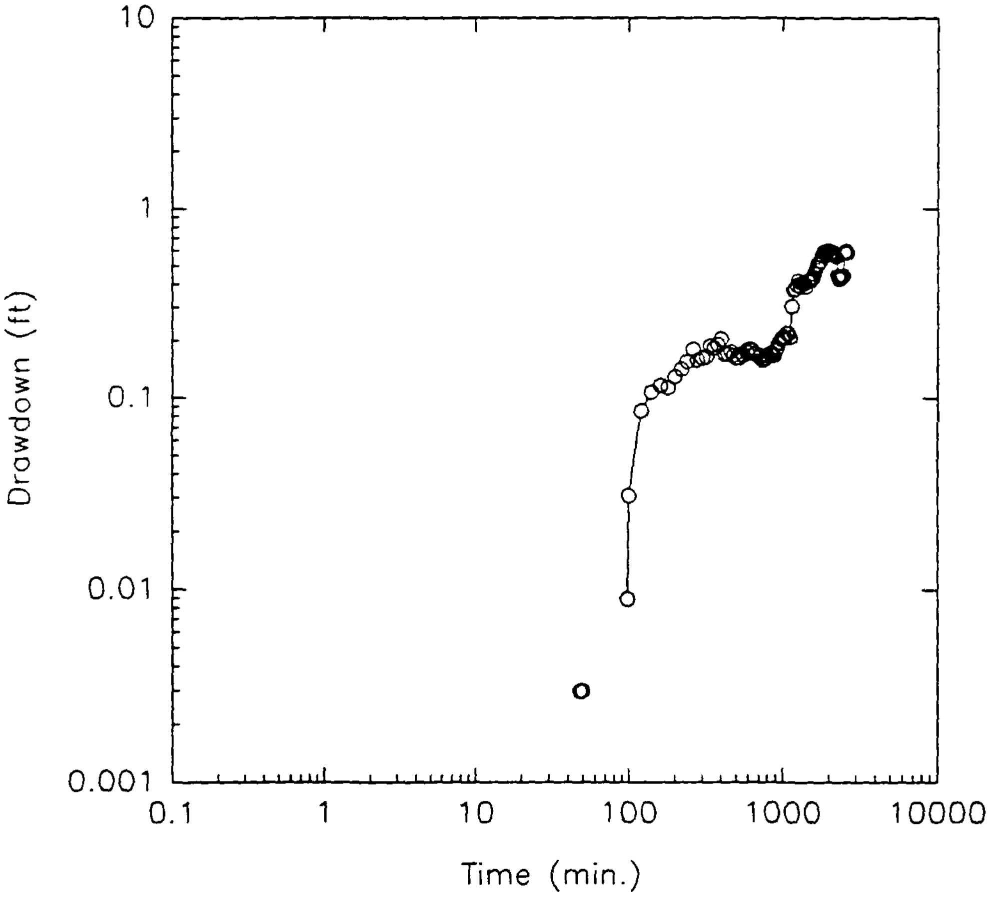
D17

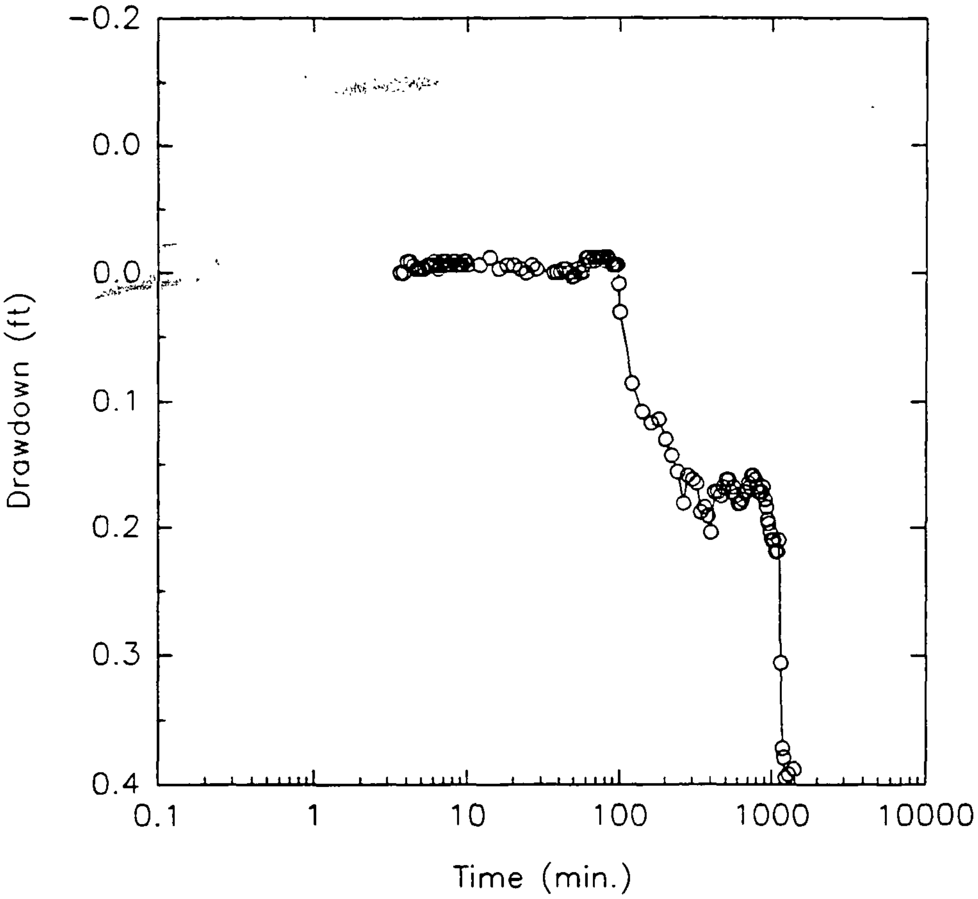
Drawdown in Shallow Bedrock (MW-411)
SRSNE, Southington CT
April 4-6, 1994



D1E

Drawdown in Till Well (MW-412)
SRSNE, Southington CT
April 4-6, 1994





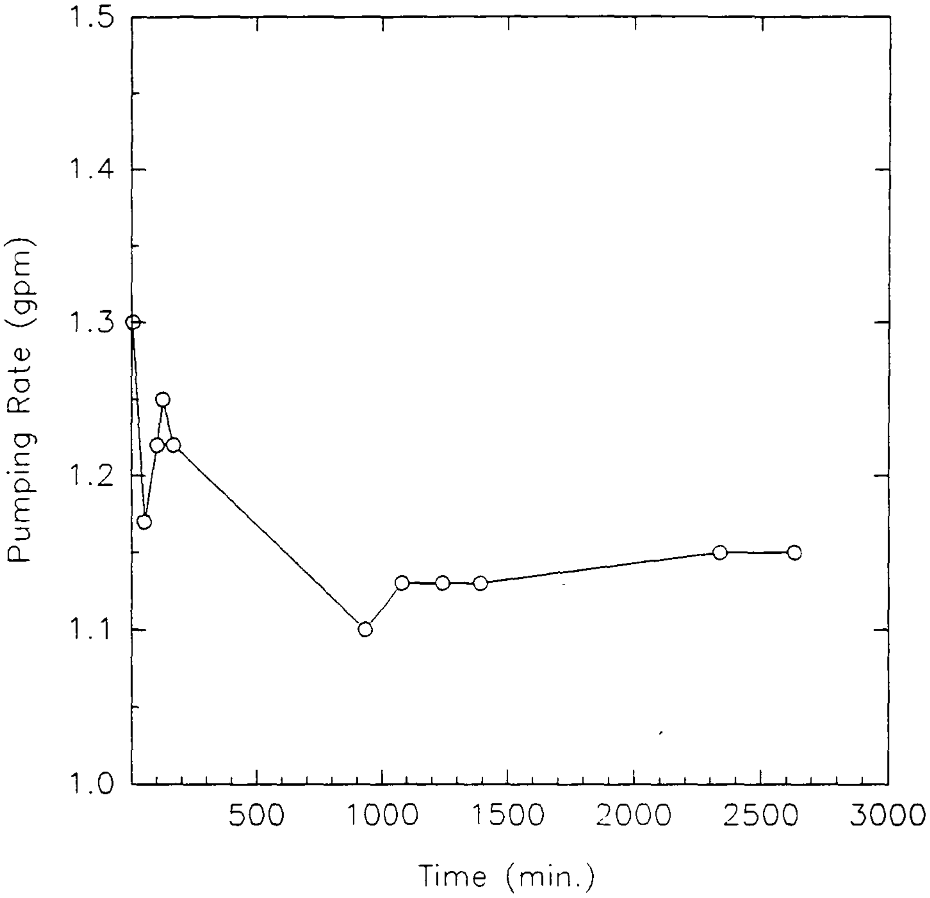
Drawdown in Till Well (MW-412)
SRSNE, Southington CT
April 4-6, 1994

D2C

APPENDIX E

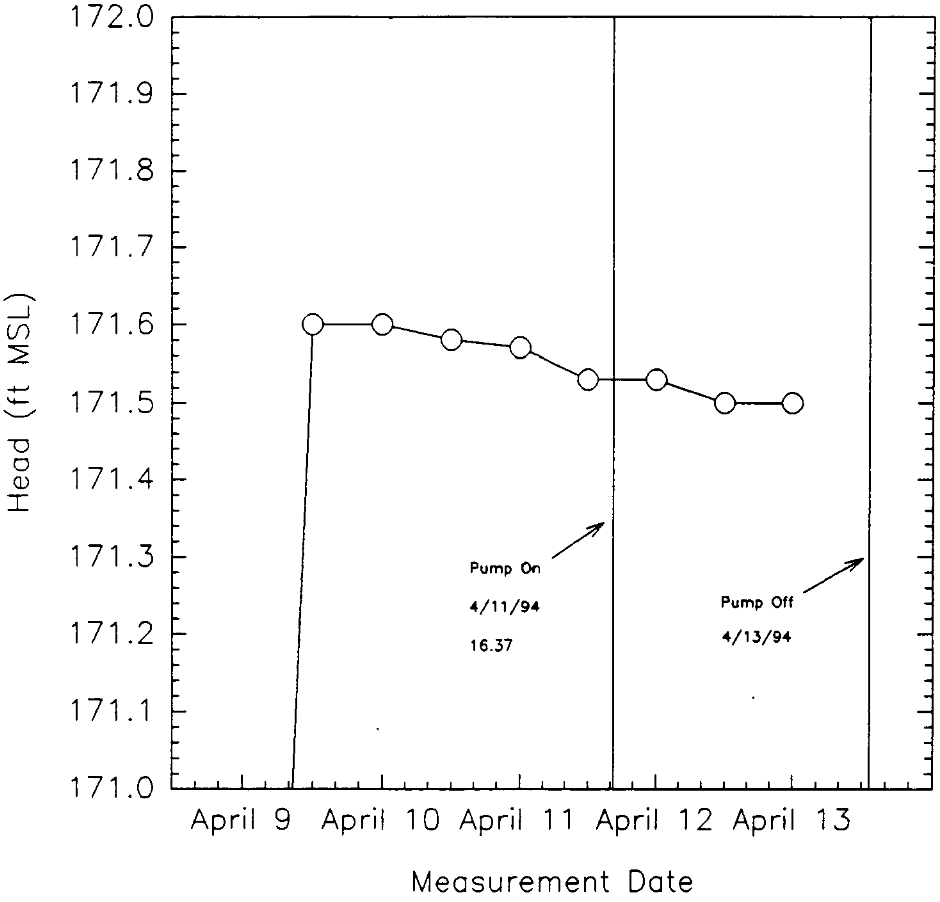
BACKGROUND WELL HYDROGRAPHS AND DRAWDOWN GRAPHS, BEDROCK PUMPING TEST

The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.



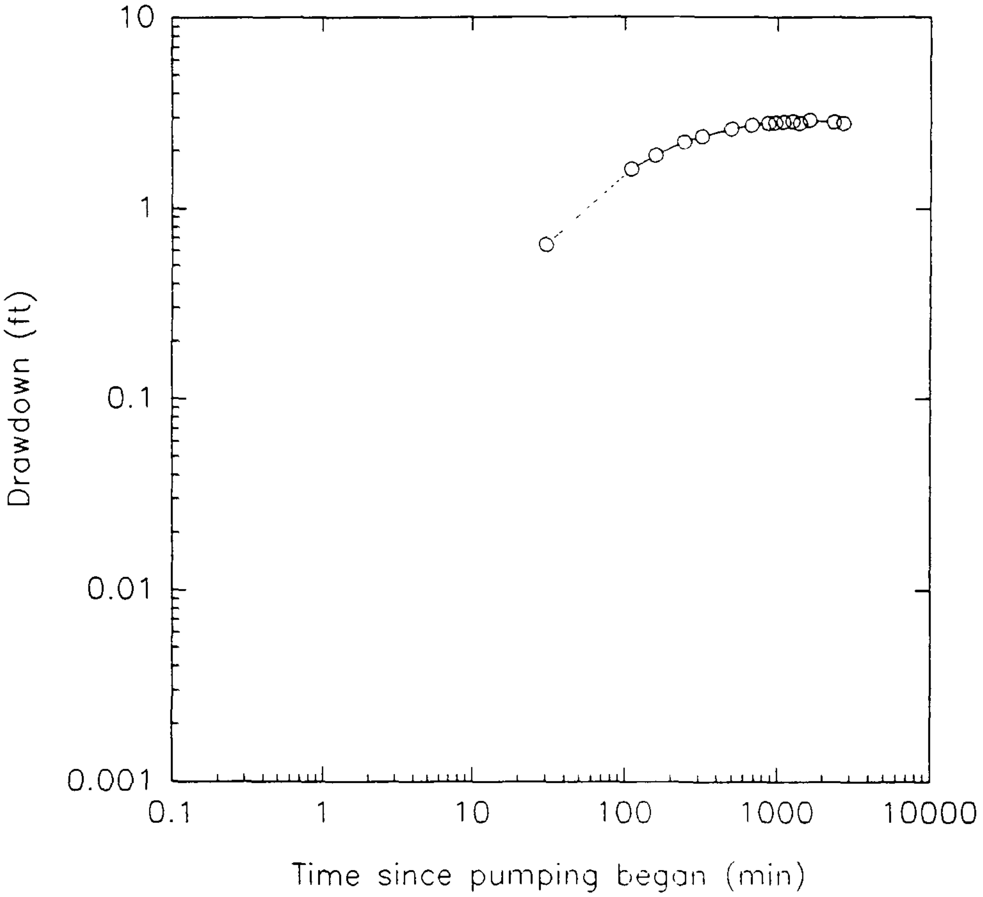
Pumping Rate for Bedrock Pumping Test
SRSNE, Southington CT
April 11-13, 1994

Background Bedrock Well Hydrograph (P-4A)
SRSNE, Southington CT
April 11-13, 1994



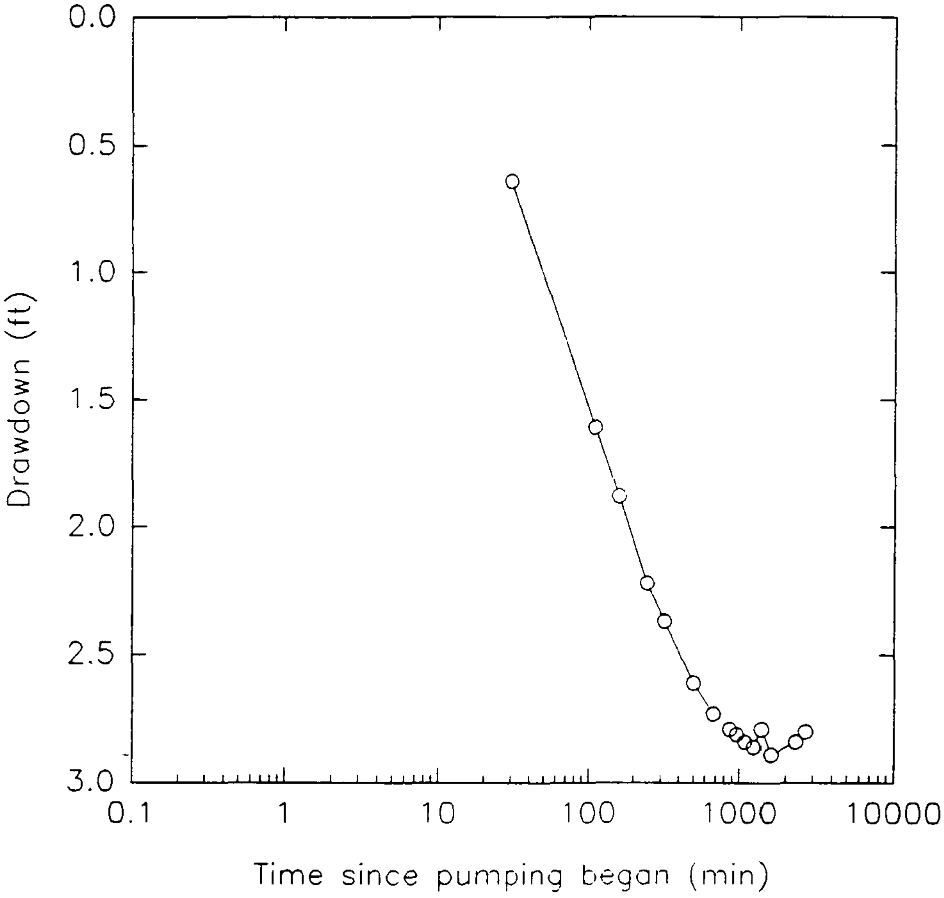
E2

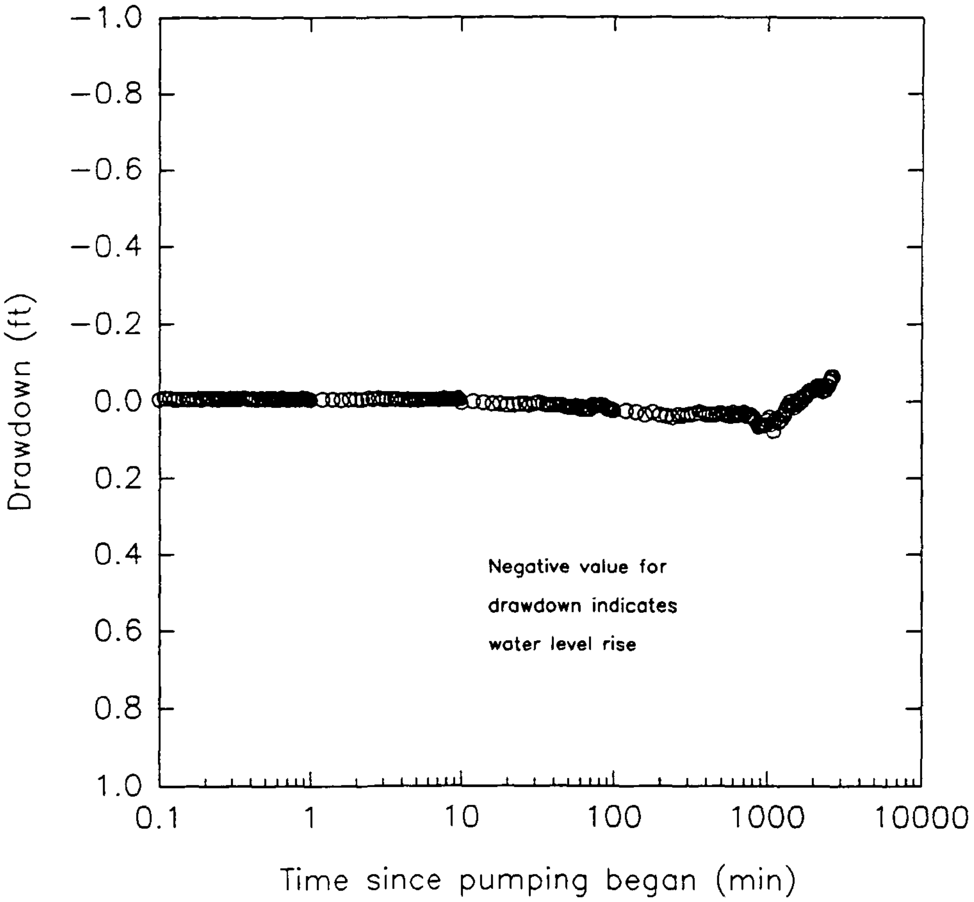
Drawdown in Bedrock Well (PW-406)
SRSNE, Southington CT
April 11-13, 1994



E3

Drawdown in Bedrock Well (PW-406)
SRSNE, Southington CT
April 11-13, 1994

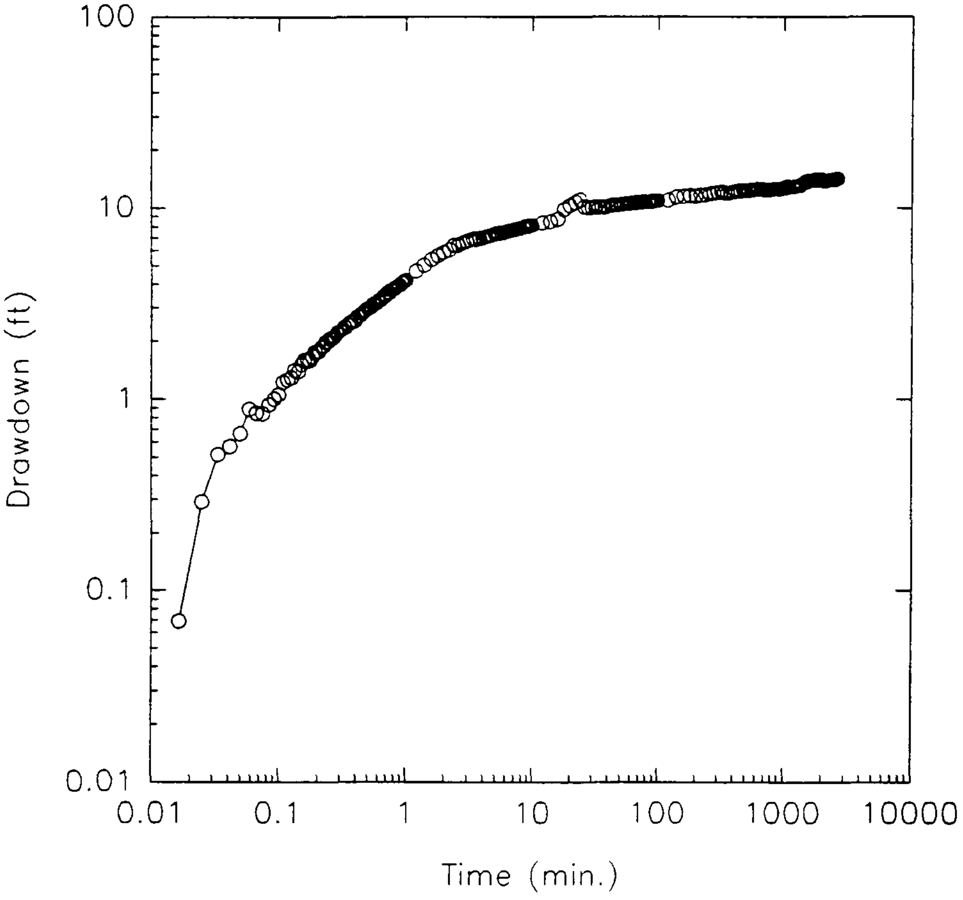




Drawdown in Outwash Well (PW-407)
SRSNE, Southington CT
April 11-13, 1994

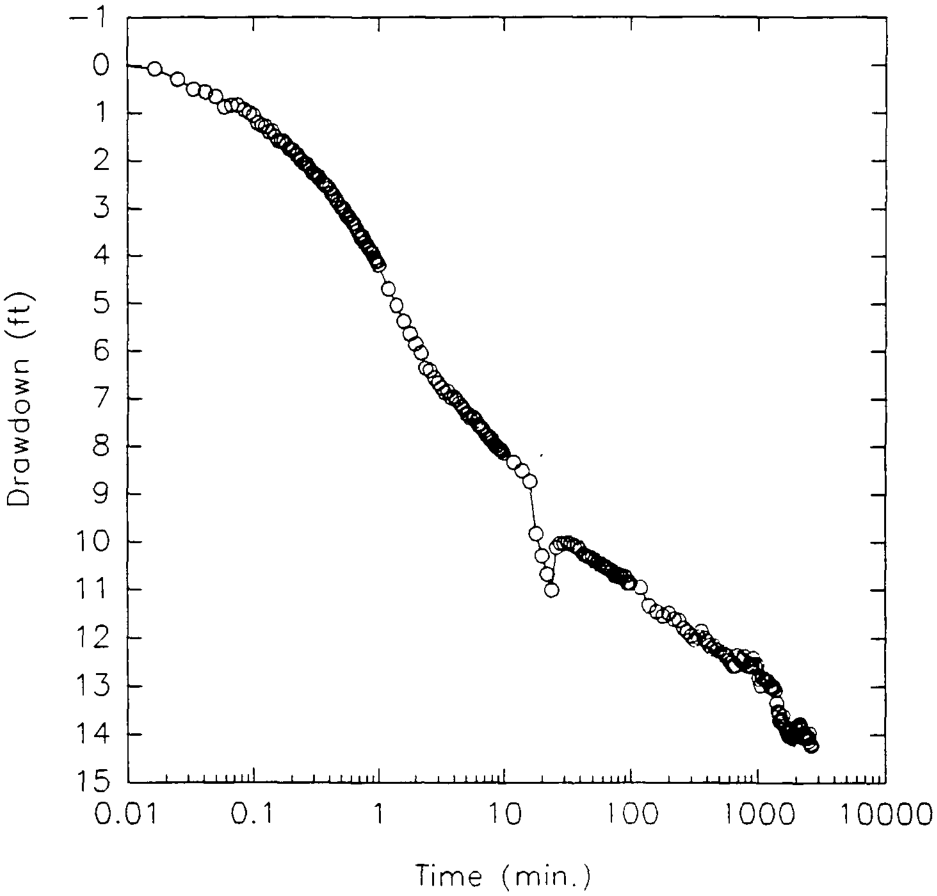
Negative value for
drawdown indicates
water level rise

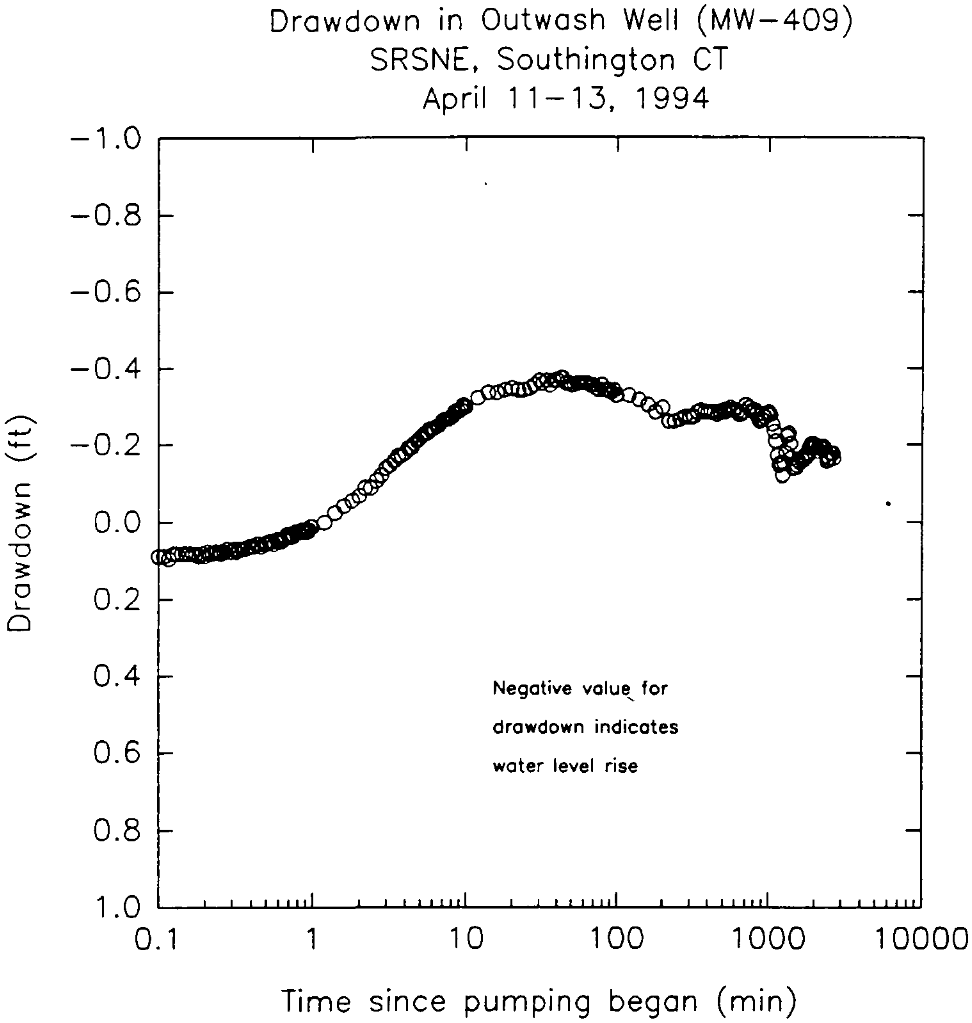
E5



Drawdown in Bedrock Pumping Well (MW–408)
SRSNE, Southington CT
April 11–13, 1994

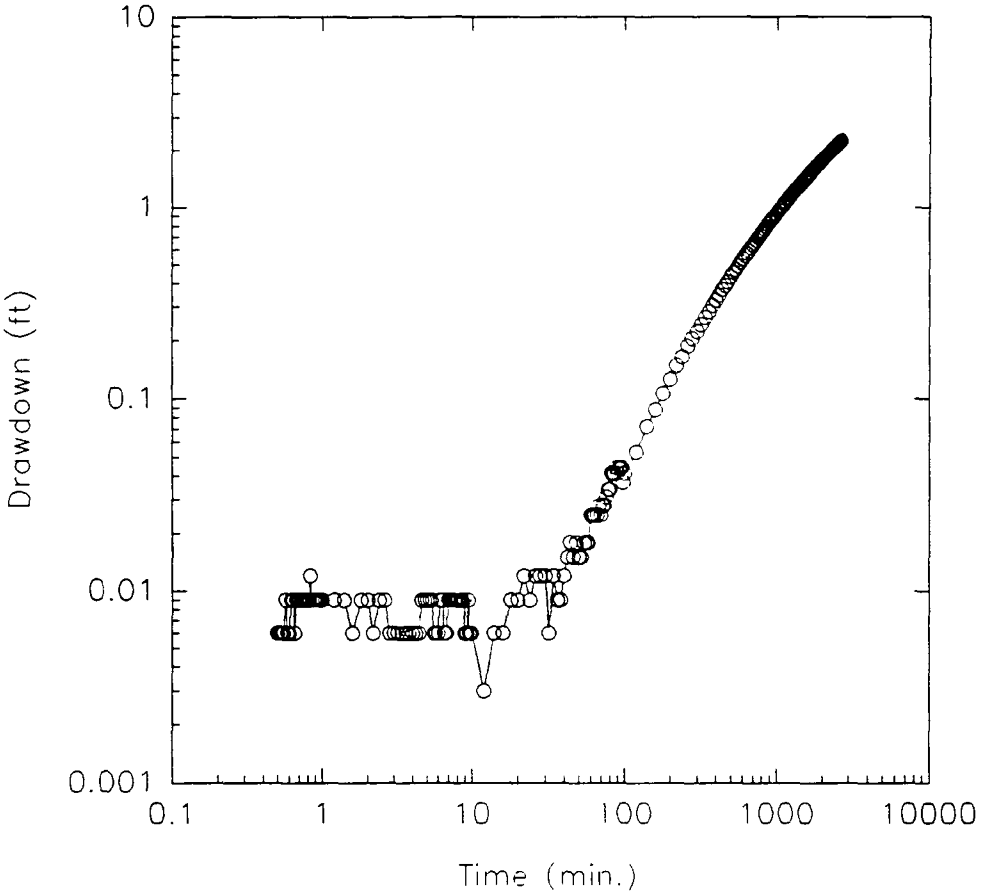
Drawdown in Bedrock Pumping Well (MW-408)
SRSNE, Southington CT
April 11-13, 1994




Drawdown in Outwash Well (MW-409)
SRSNE, Southington CT
April 11-13, 1994
Drawdown (ft)
-1.0
-0.8
-0.6
-0.4
-0.2
0.0
0.2
0.4
0.6
0.8
1.0
0.1
1
10
100
1000
10000
Time since pumping began (min)
Negative value for
drawdown indicates
water level rise

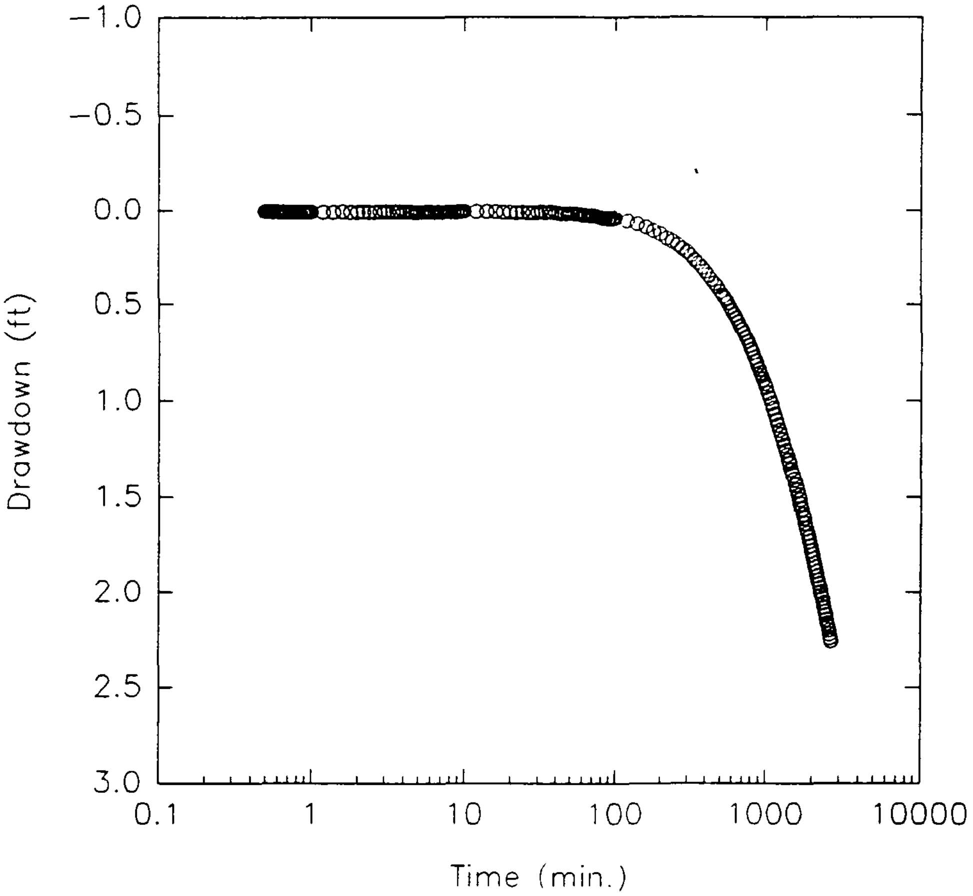
E8

Drawdown in Shallow Bedrock Well (MW-411)
SRSNE, Southington CT
April 11-13, 1994



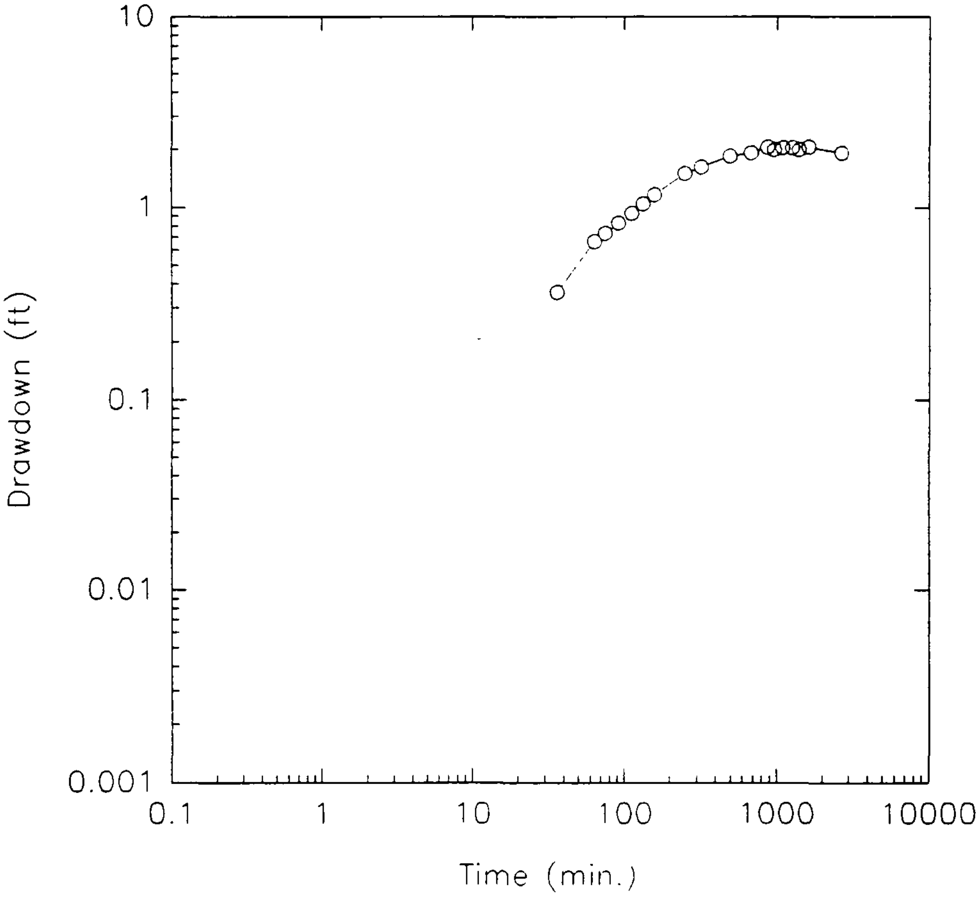
E9

Drawdown in Shallow Bedrock Well (MW-411)
SRSNE, Southington CT
April 11-13, 1994

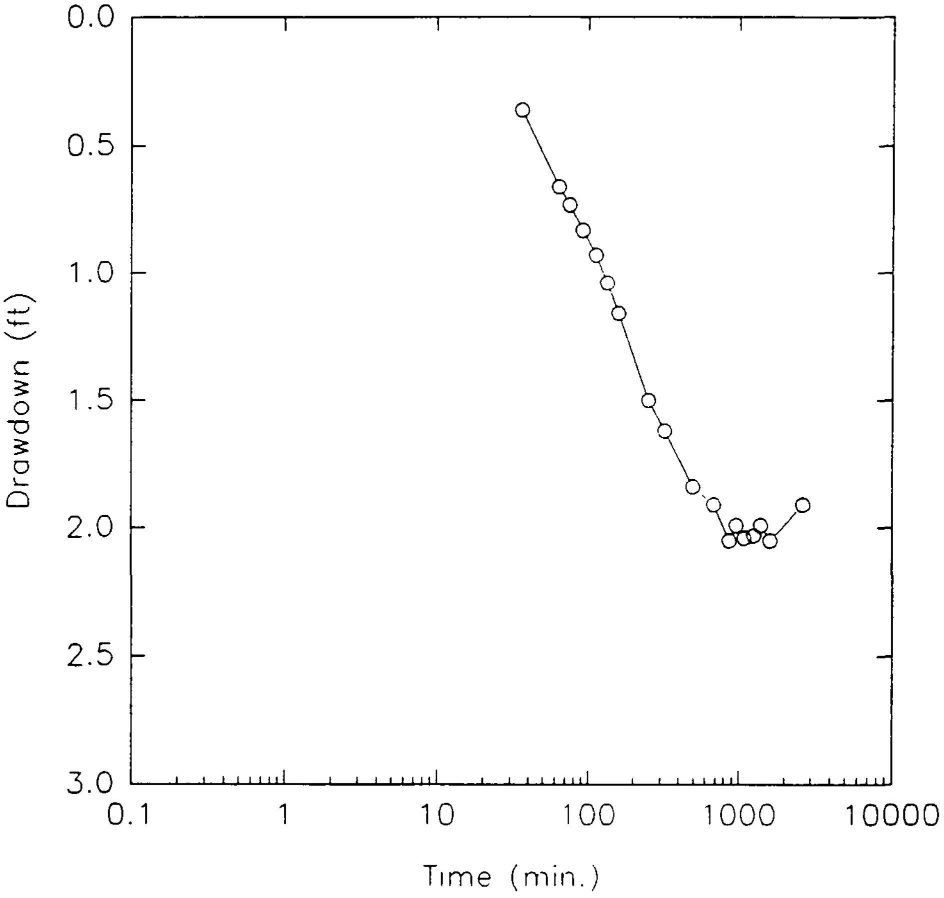


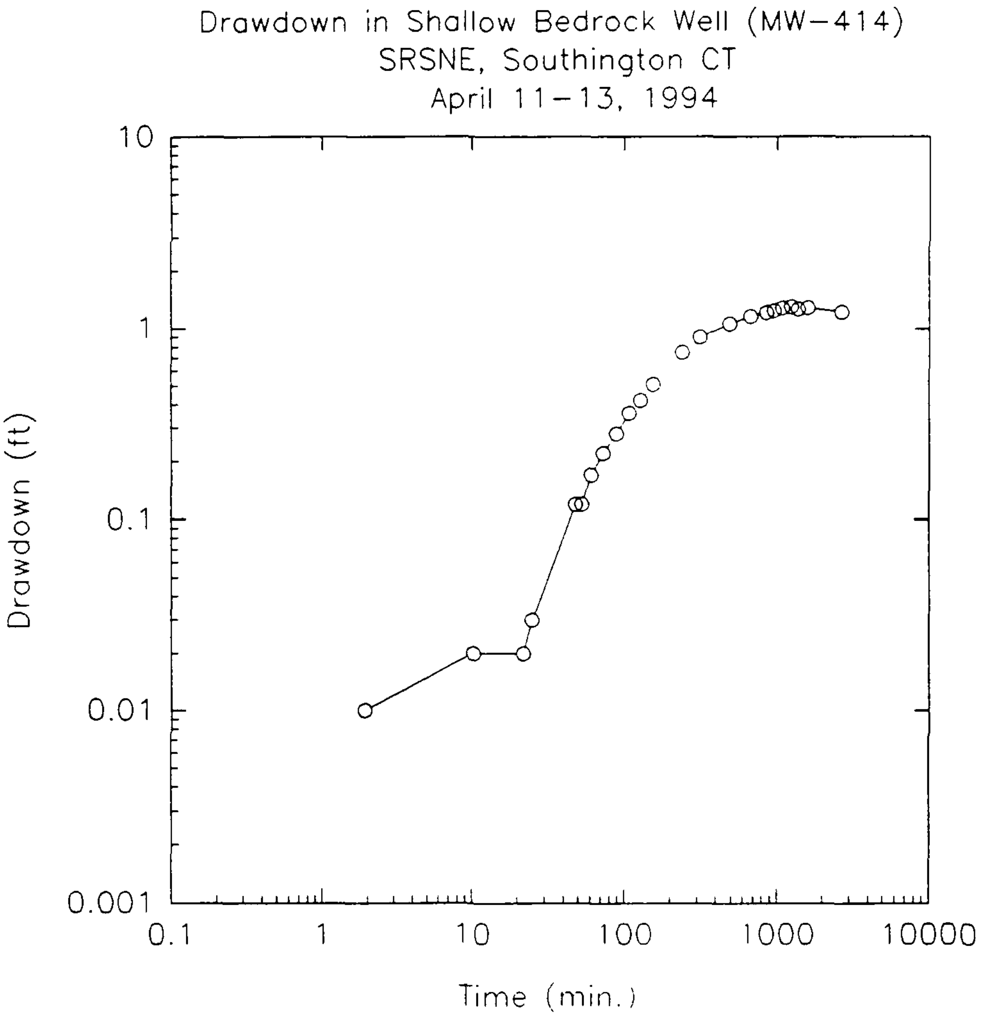
EIC

Drawdown in Till Well (MW-412)
SRSNE, Southington CT
April 11-13, 1994

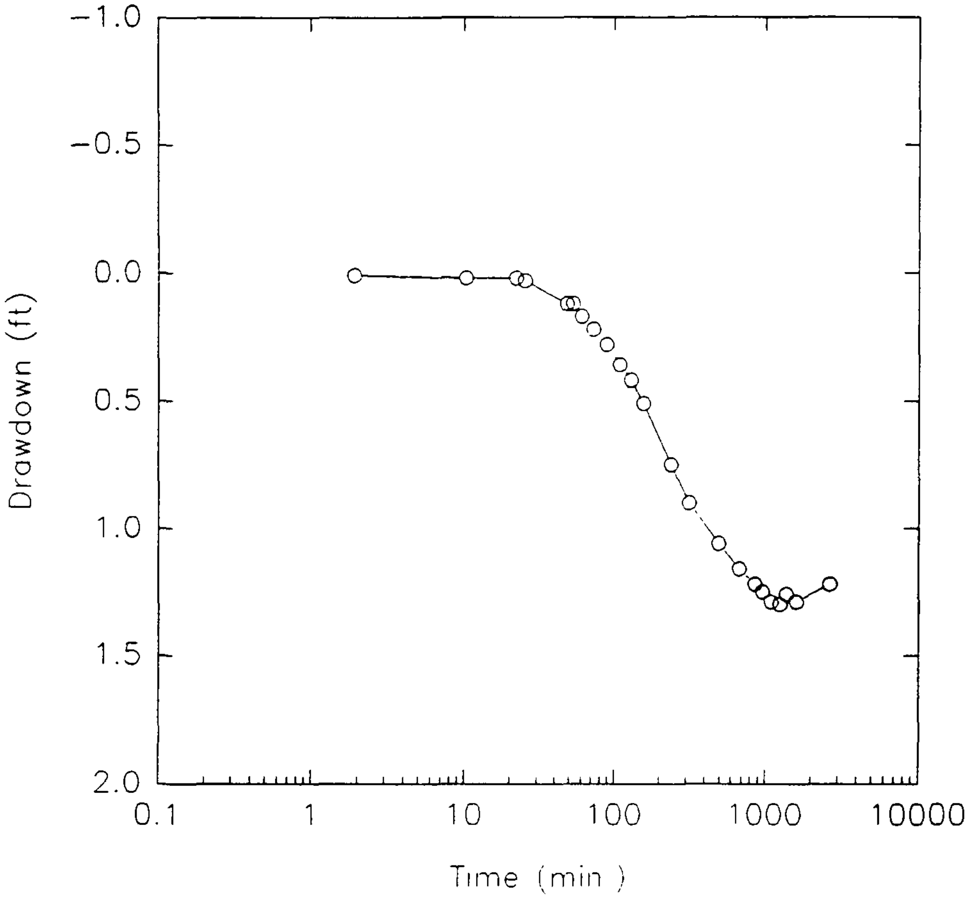


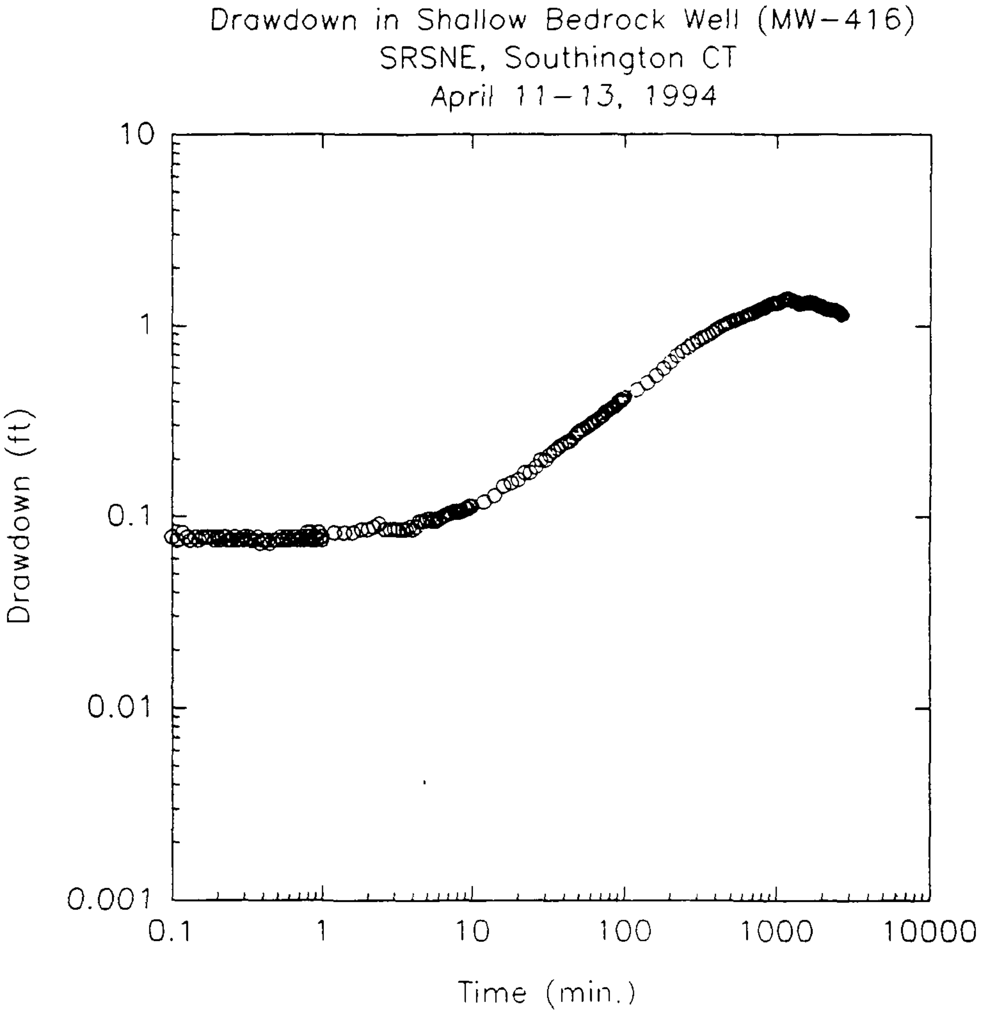
Drawdown in Till Well (MW-412)
SRSNE, Southington CT
April 11-13, 1994




Drawdown in Shallow Bedrock Well (MW-414)
SRSNE, Southington CT
April 11-13, 1994

Drawdown in Shallow Bedrock Well (MW-414)
SRSNE, Southington CT
April 11-13, 1994

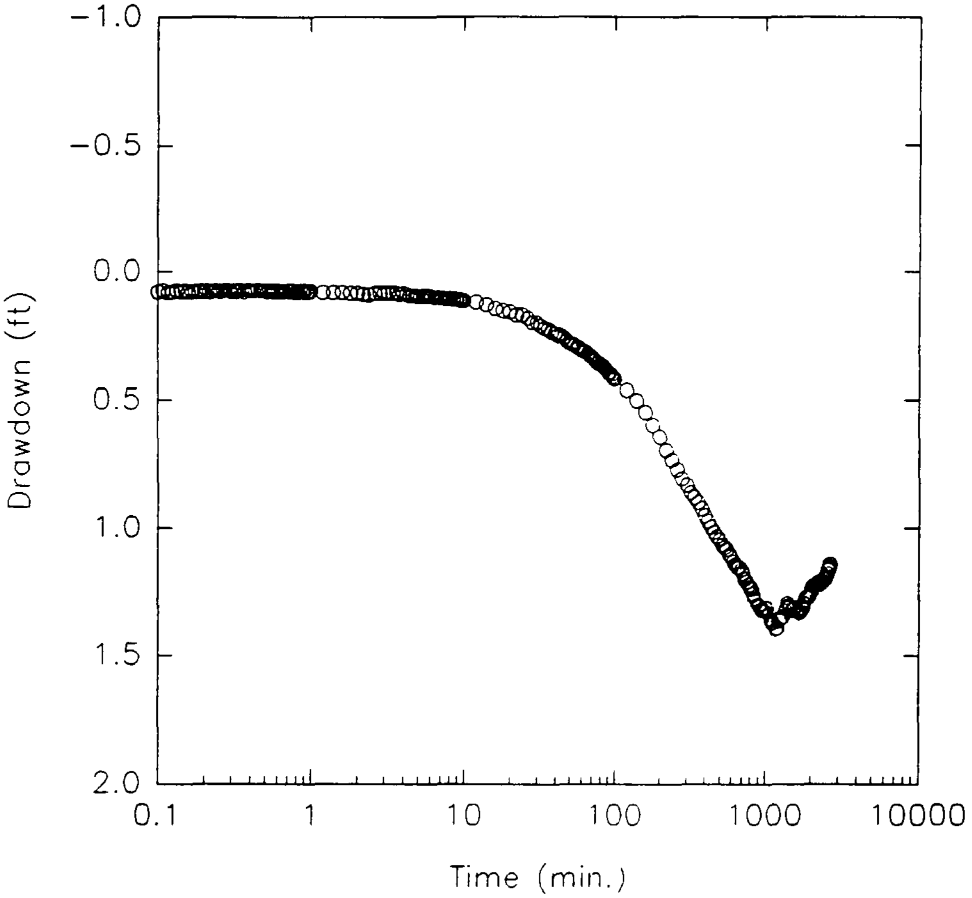




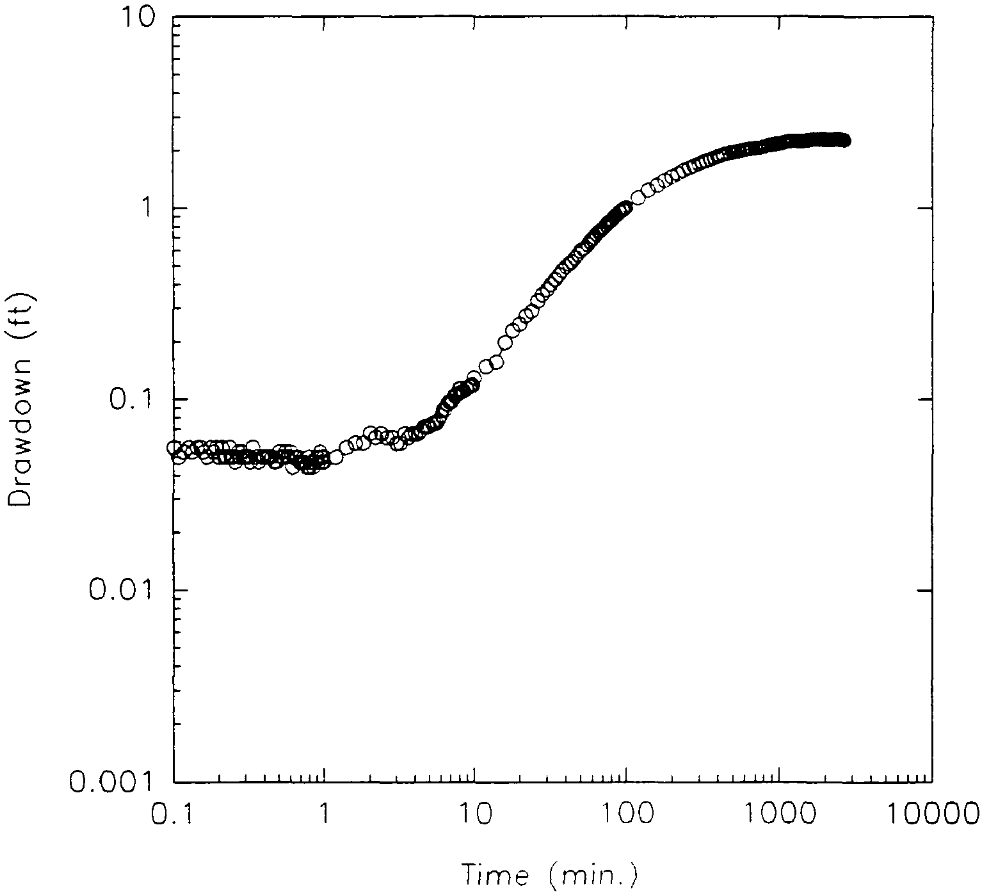
Drawdown in Shallow Bedrock Well (MW-416)
SRSNE, Southington CT
April 11-13, 1994

E15

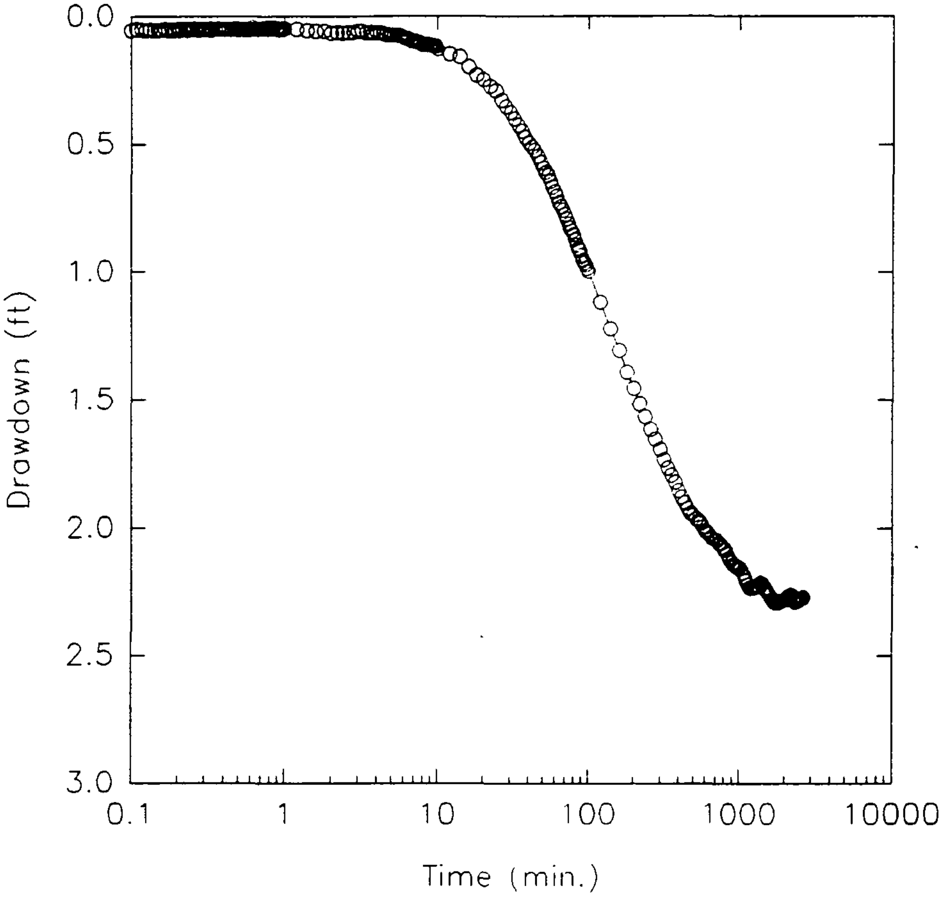
Drawdown in Shallow Bedrock Well (MW-416)
SRSNE, Southington CT
April 11-13, 1994



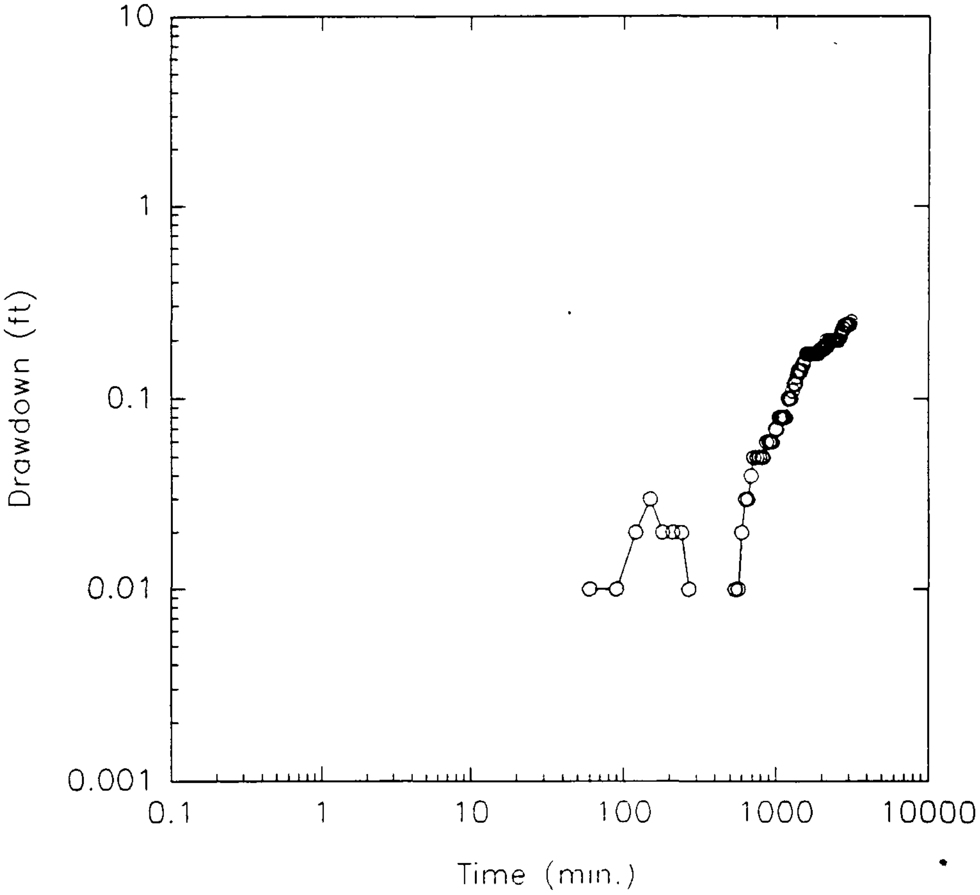
Drawdown in Shallow Bedrock Well (P-5A)
SRSNE, Southington CT
April 11-13, 1994



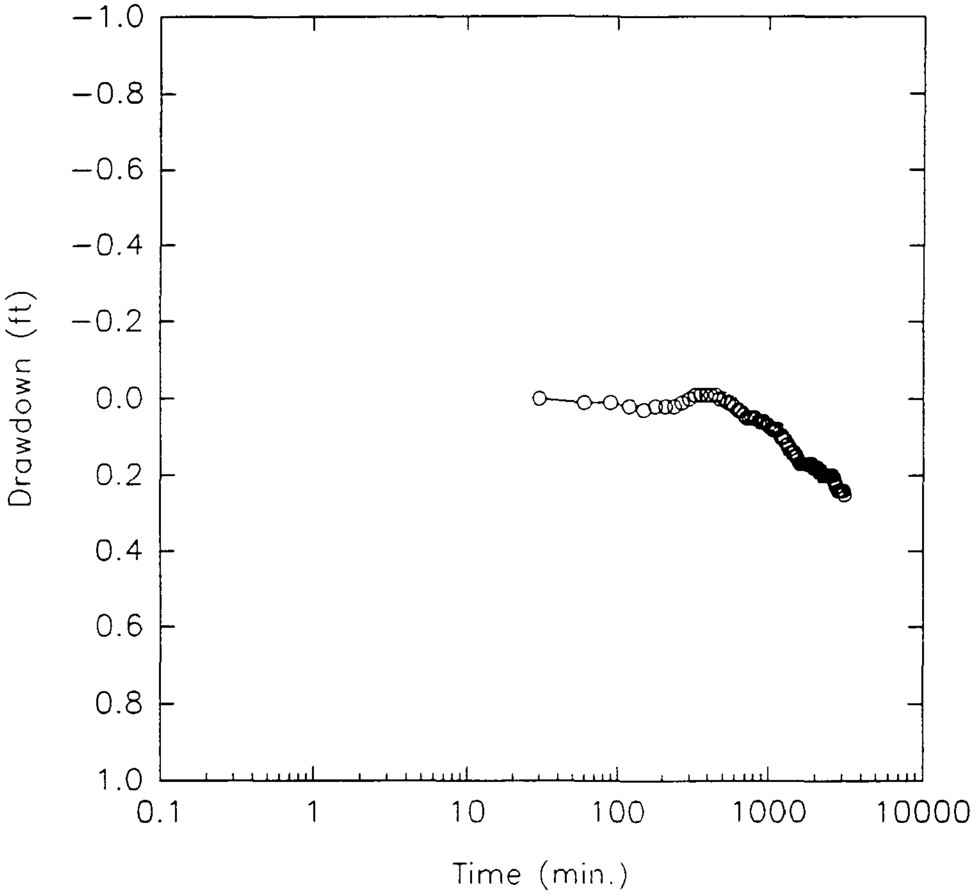
Drawdown in Shallow Bedrock Well (P–5A)
SRSNE, Southington CT
April 11–13, 1994



Drawdown in Shallow Bedrock Well (P-2A)
SRSNE, Southington CT
April 11-13, 1994



E19



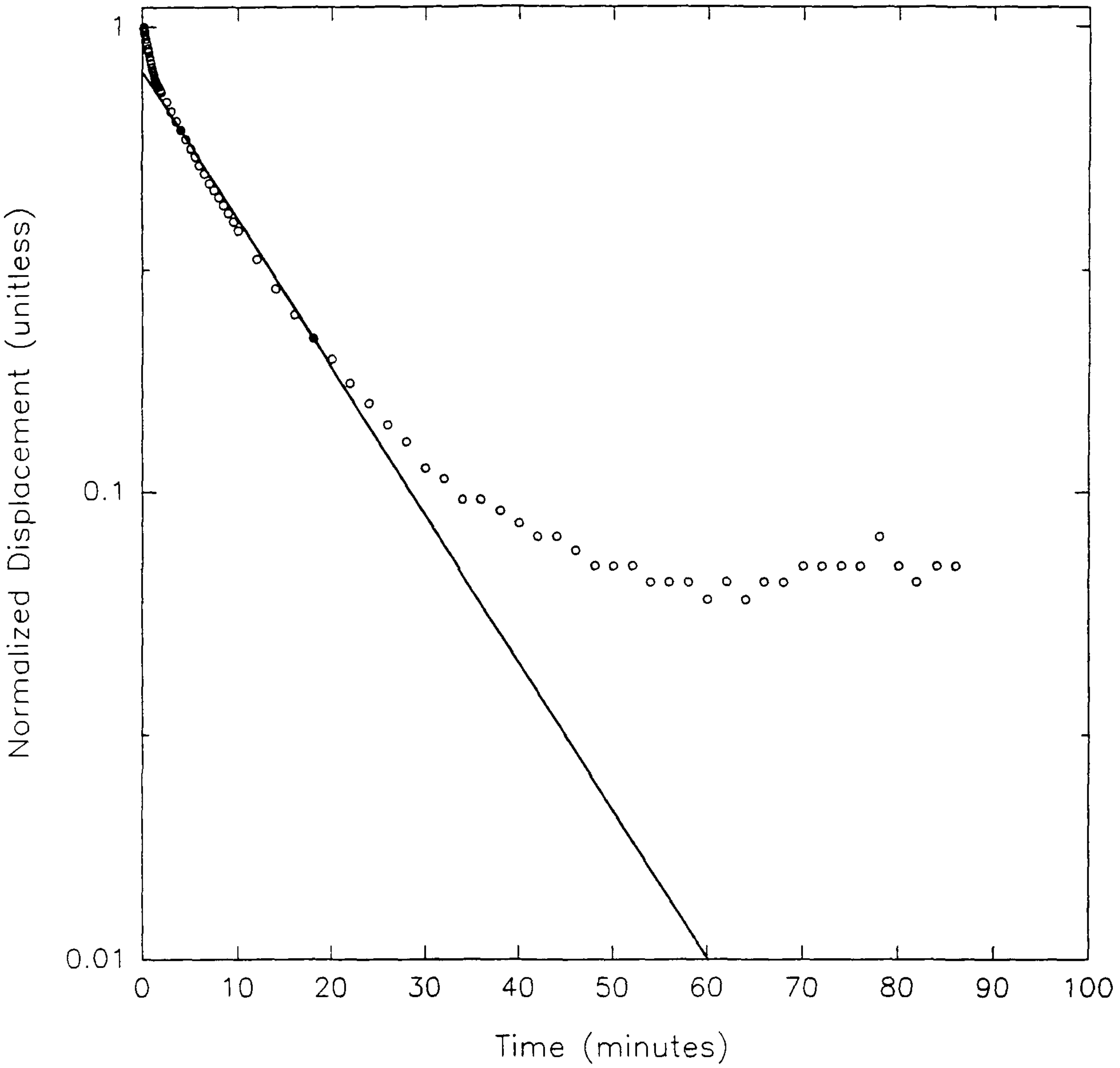
Drawdown in Shallow Bedrock Well (P-2A)
SRSNE, Southington CT
April 11-13, 1994

APPENDIX F

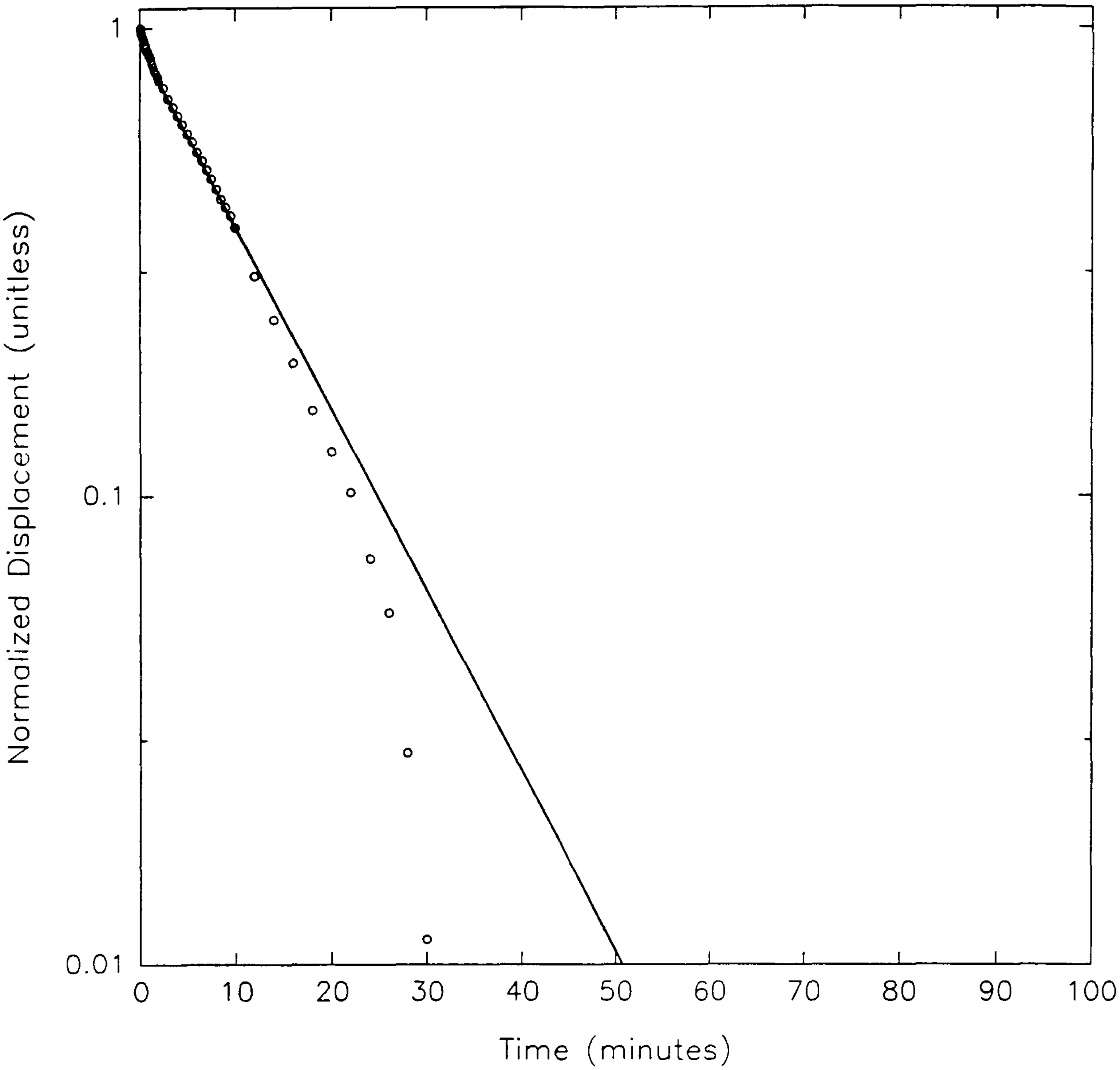
RISING AND FALLING HEAD SLUG TEST GRAPHS

The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.

SRSNE PRP Group
Falling Head Slug Test for MW123C, 4/14/94

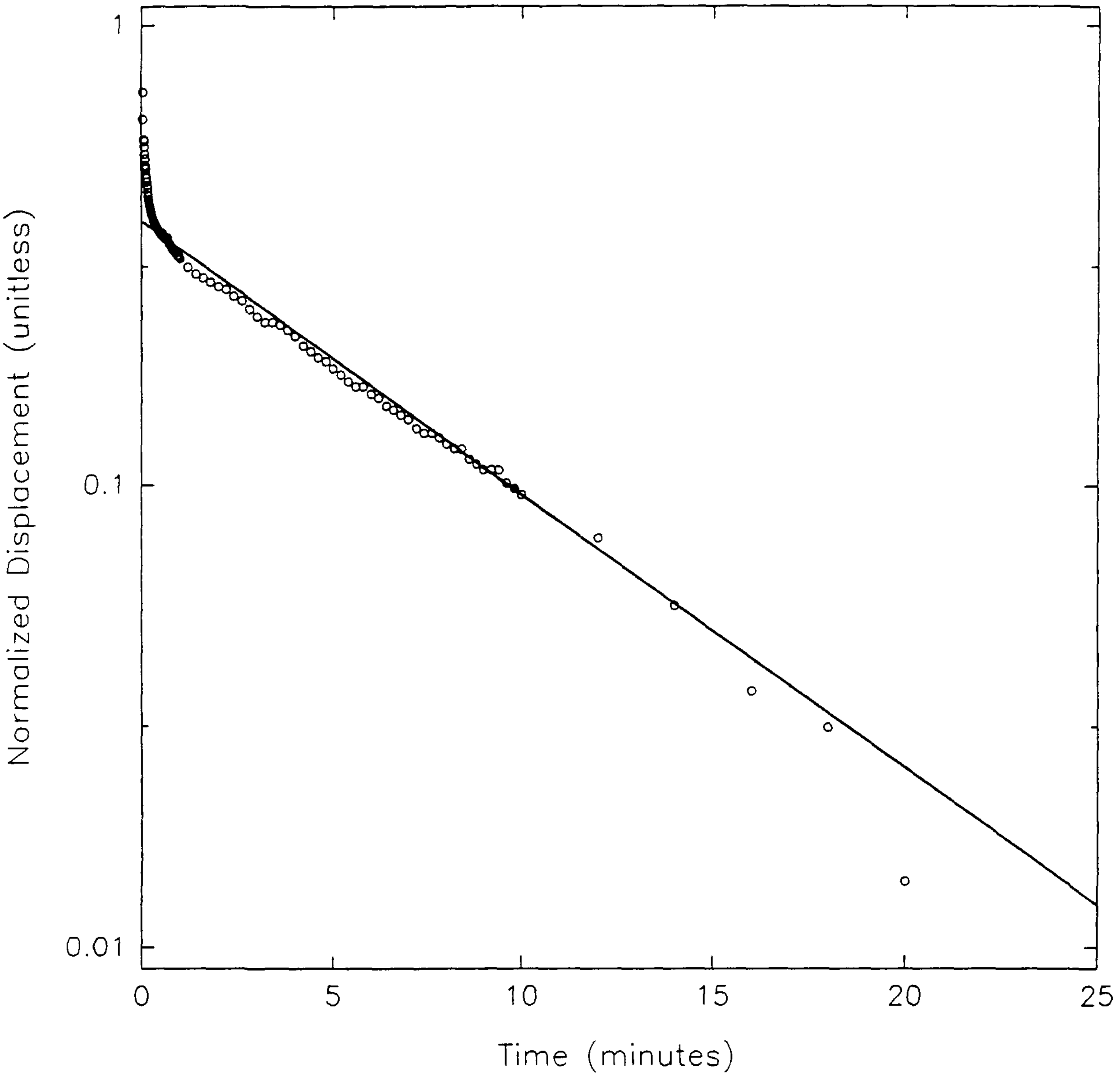


SRSNE PRP Group
Rising Head Slug Test for MW123C, 4/14/94



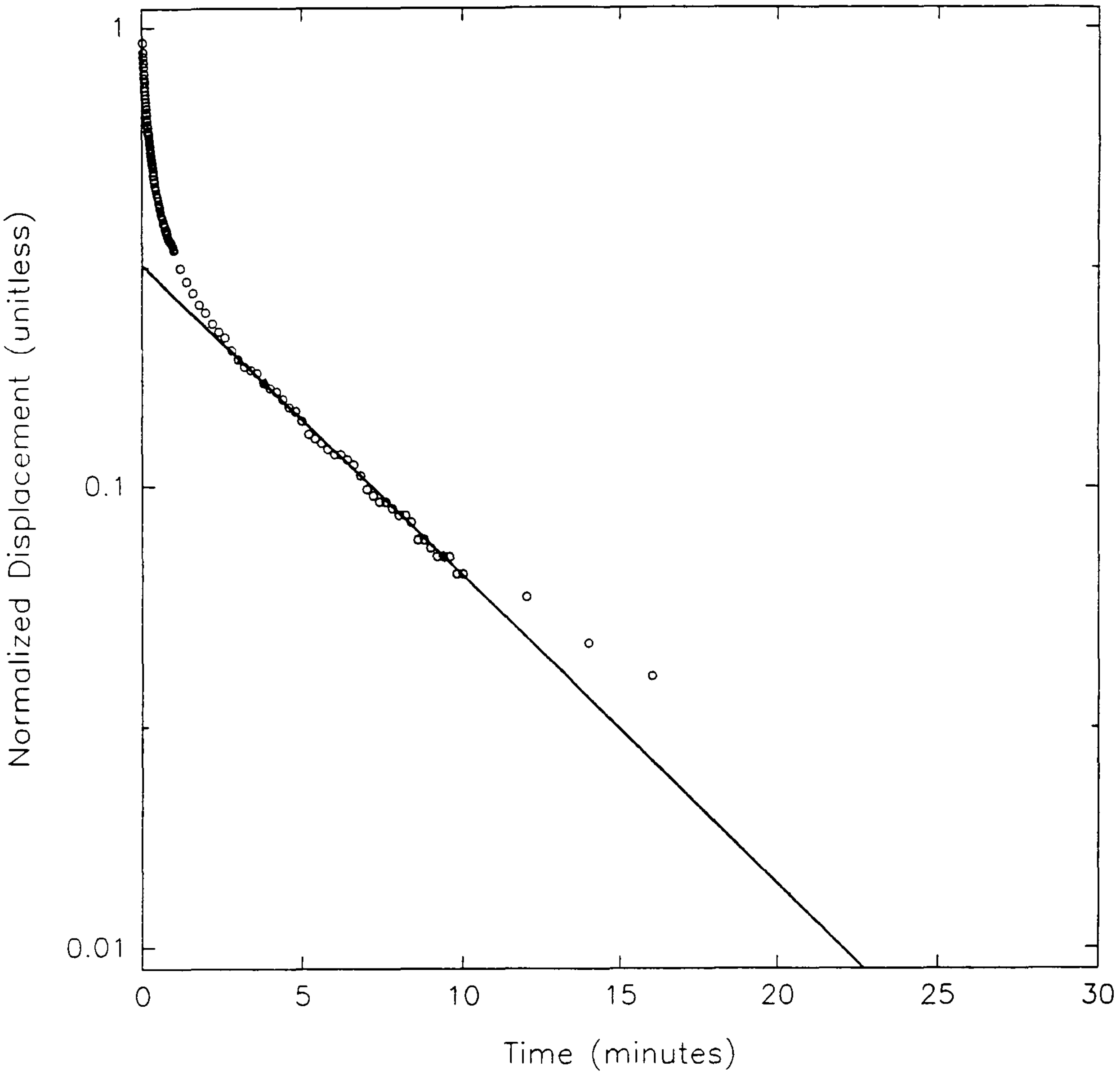
F2

SRSNE PRP Group
Falling Head Slug Test for MWL301, 4/14/94



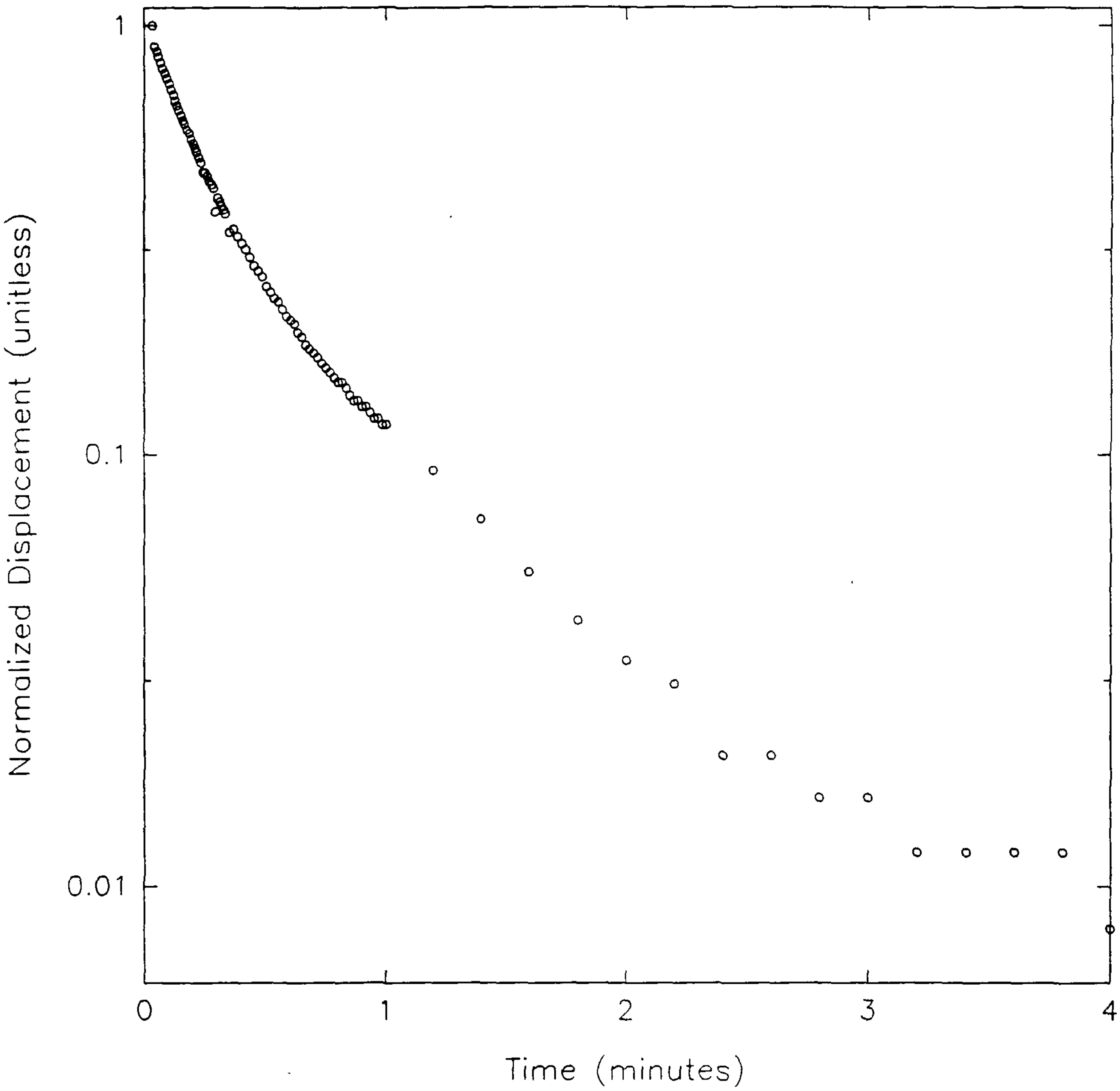
F3

SRSNE PRP Group
Rising Head Slug Test for MWL301, 4/14/94



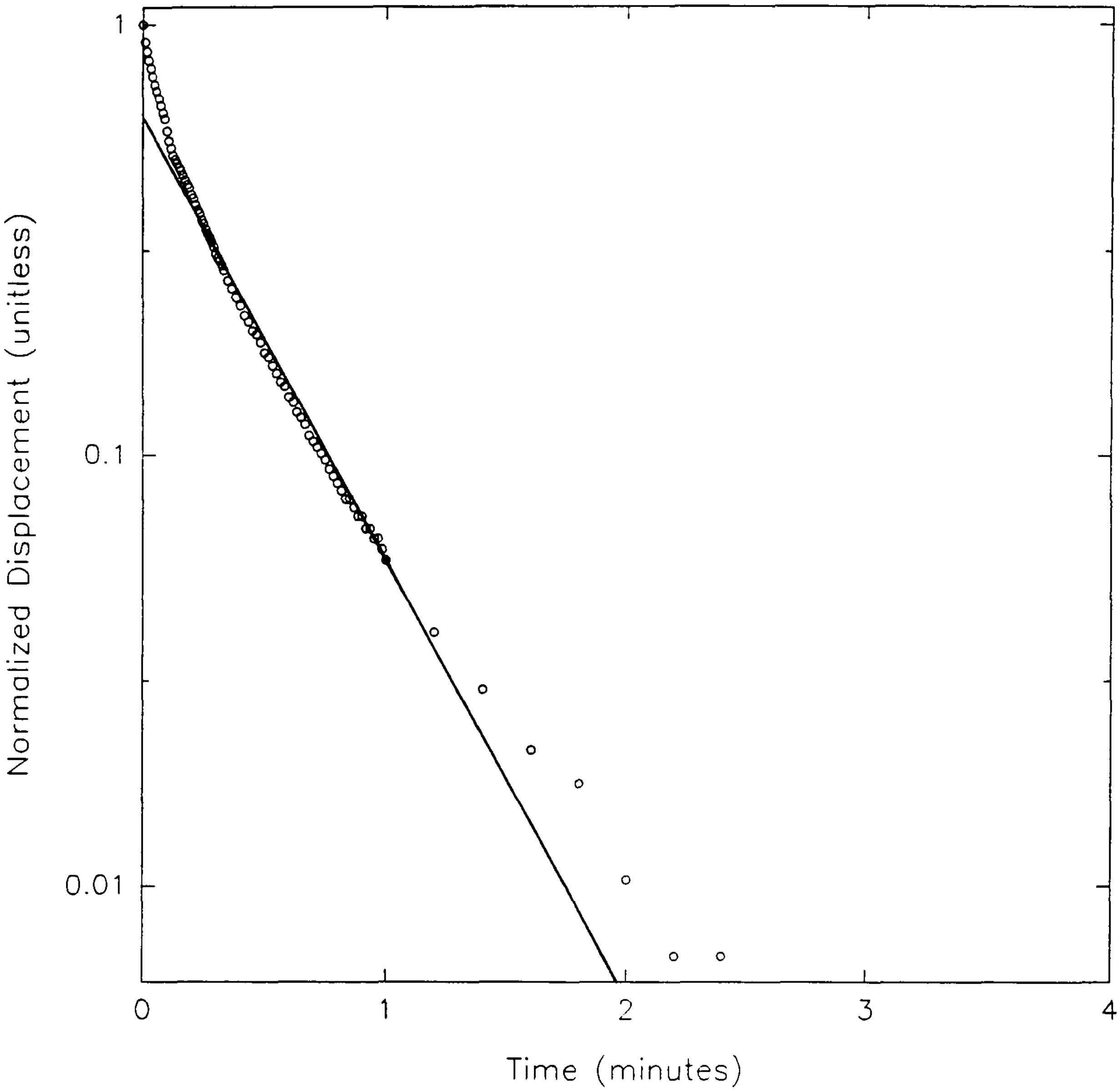
F4

SRSNE PRP Group
Falling Head Slug Test for MWL304, 4/14/94



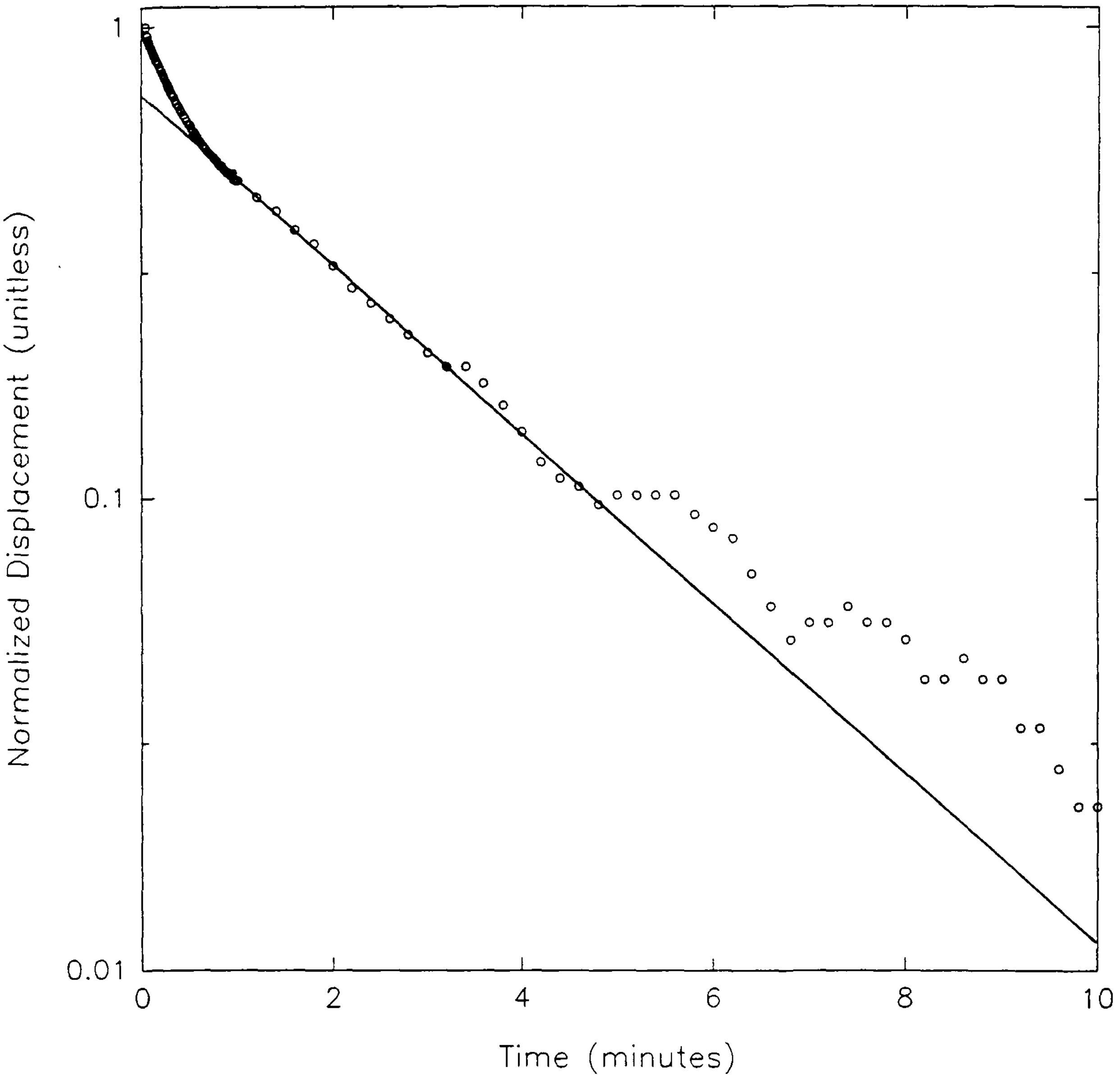
F5

SRSNE PRP Group
Rising Head Slug Test for MWL304, 4/14/94



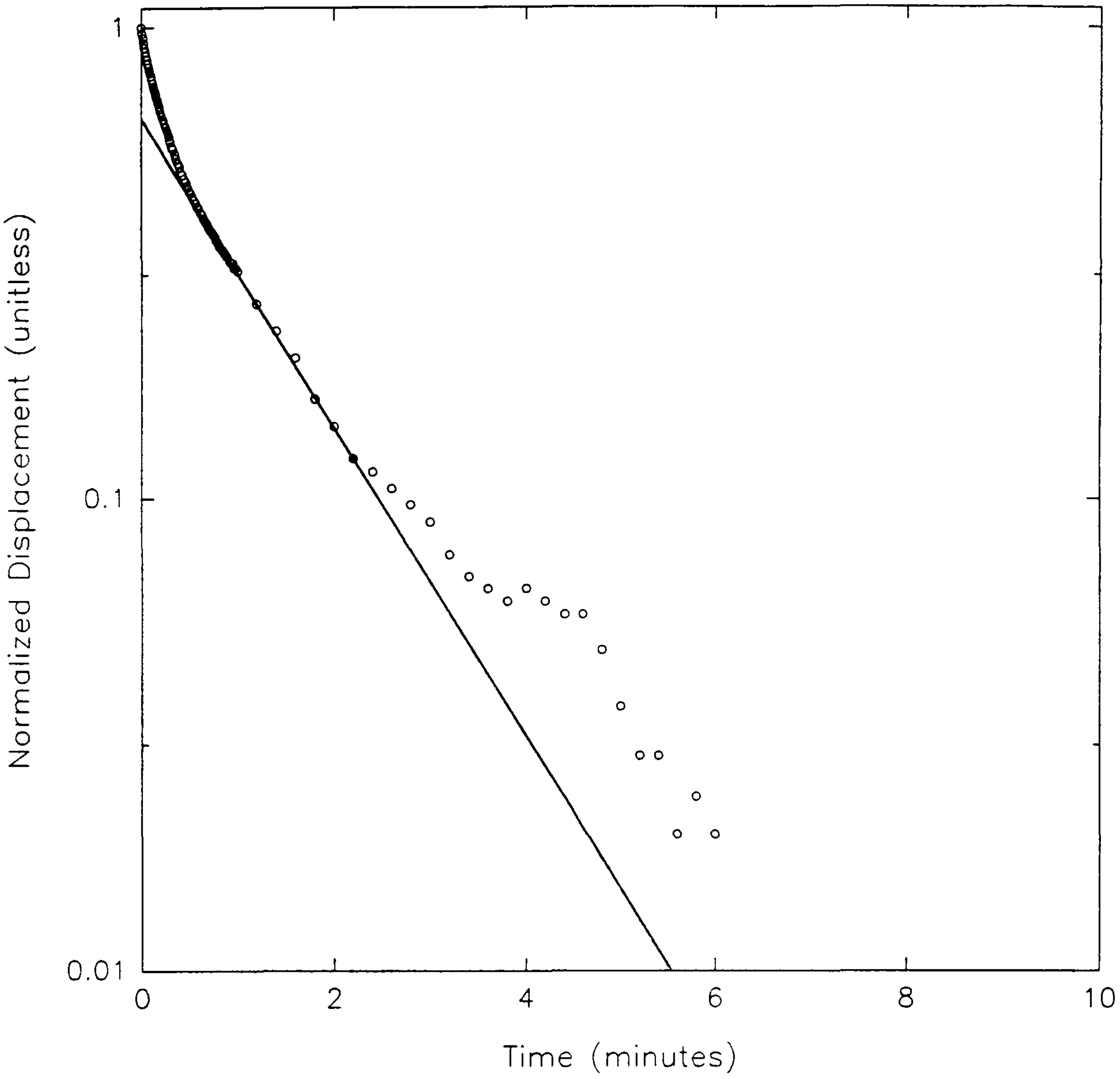
F6

SRSNE PRP Group
Falling Head Slug Test for MWL305 4/14/94



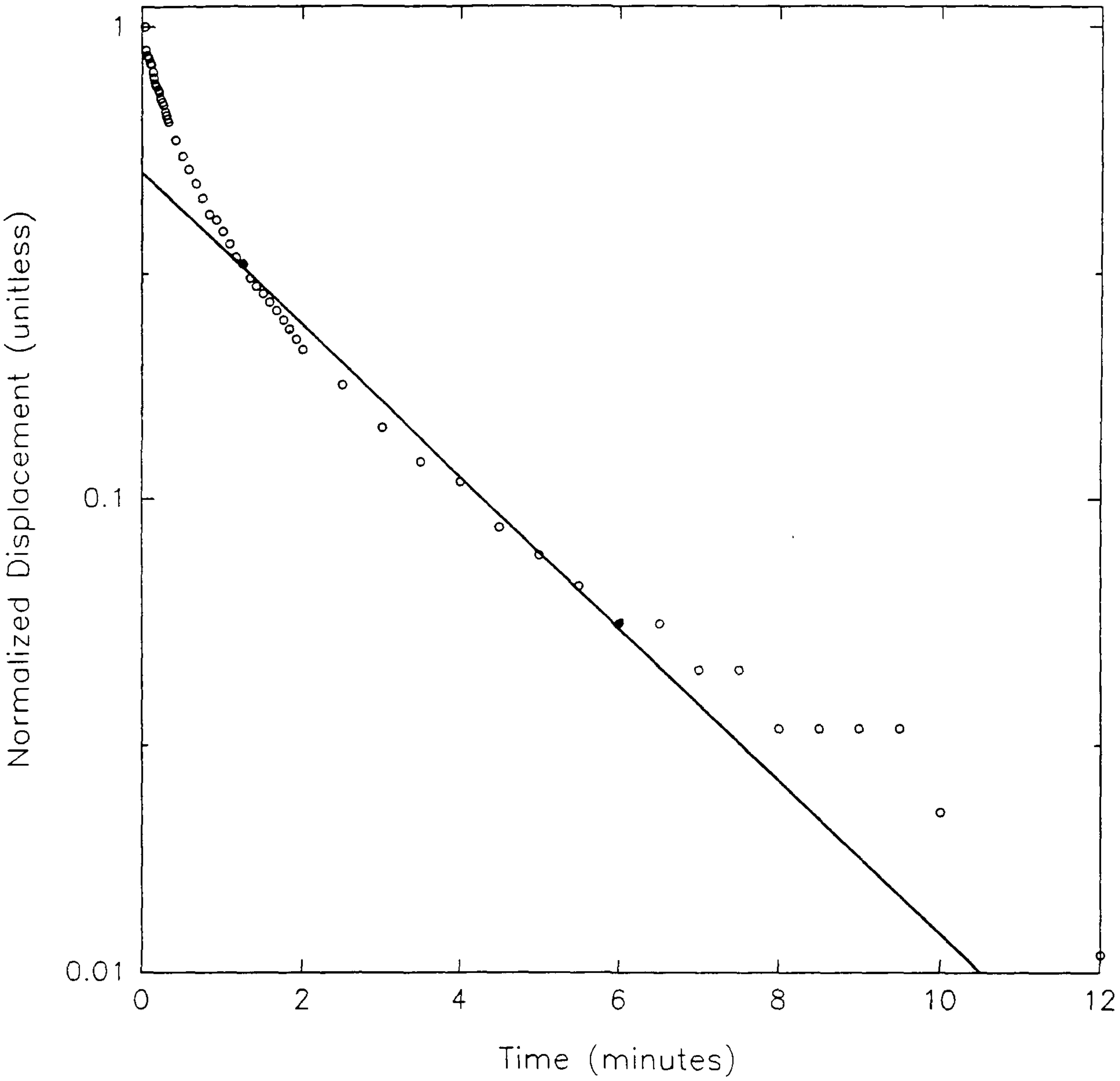
F7

SRSNE PRP Group
Rising Head Slug Test for MWL305 4/14/94



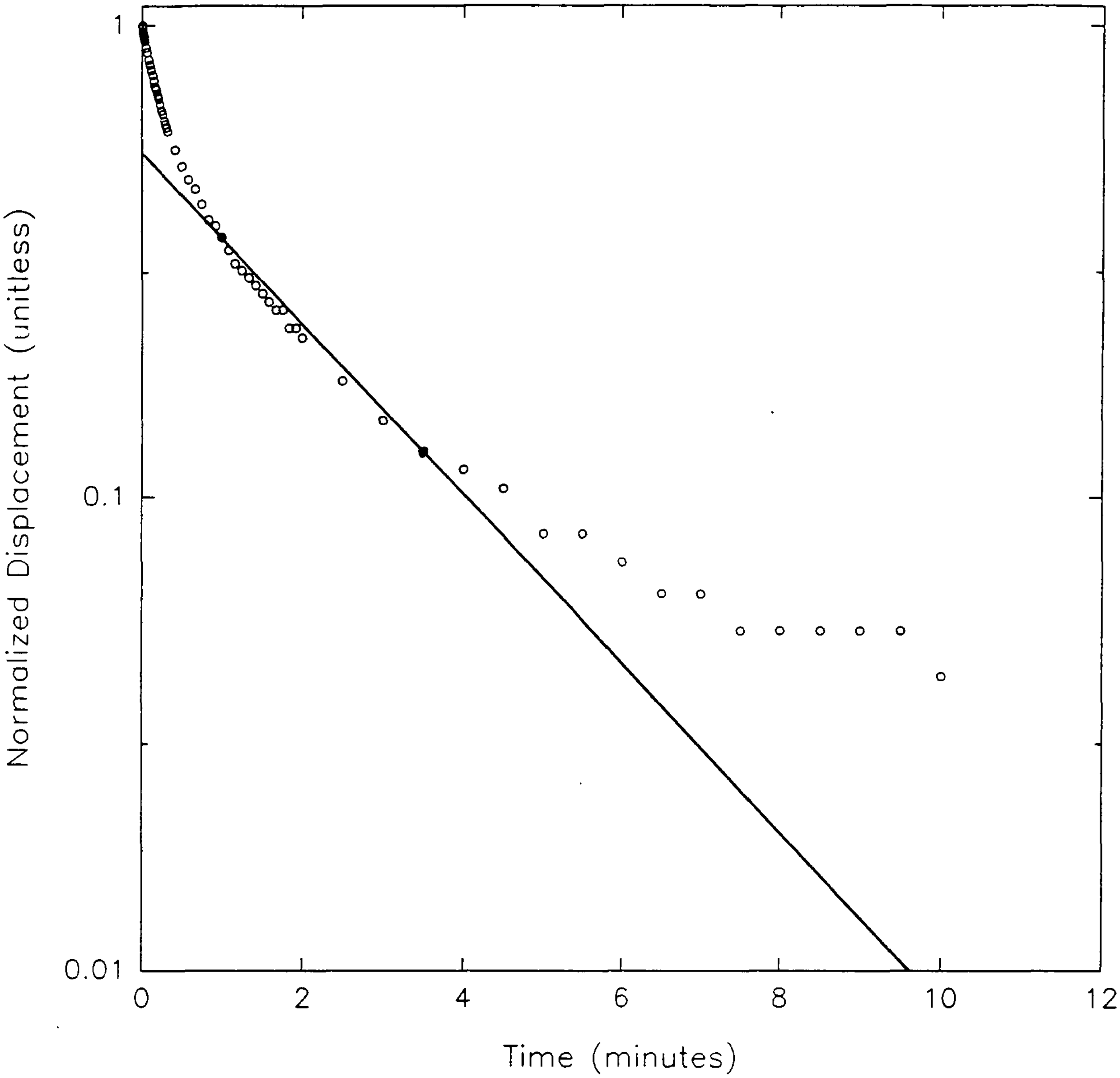
F8

SRSNE PRP Group
Falling Head Slug Test for MWL311, 4/14/94



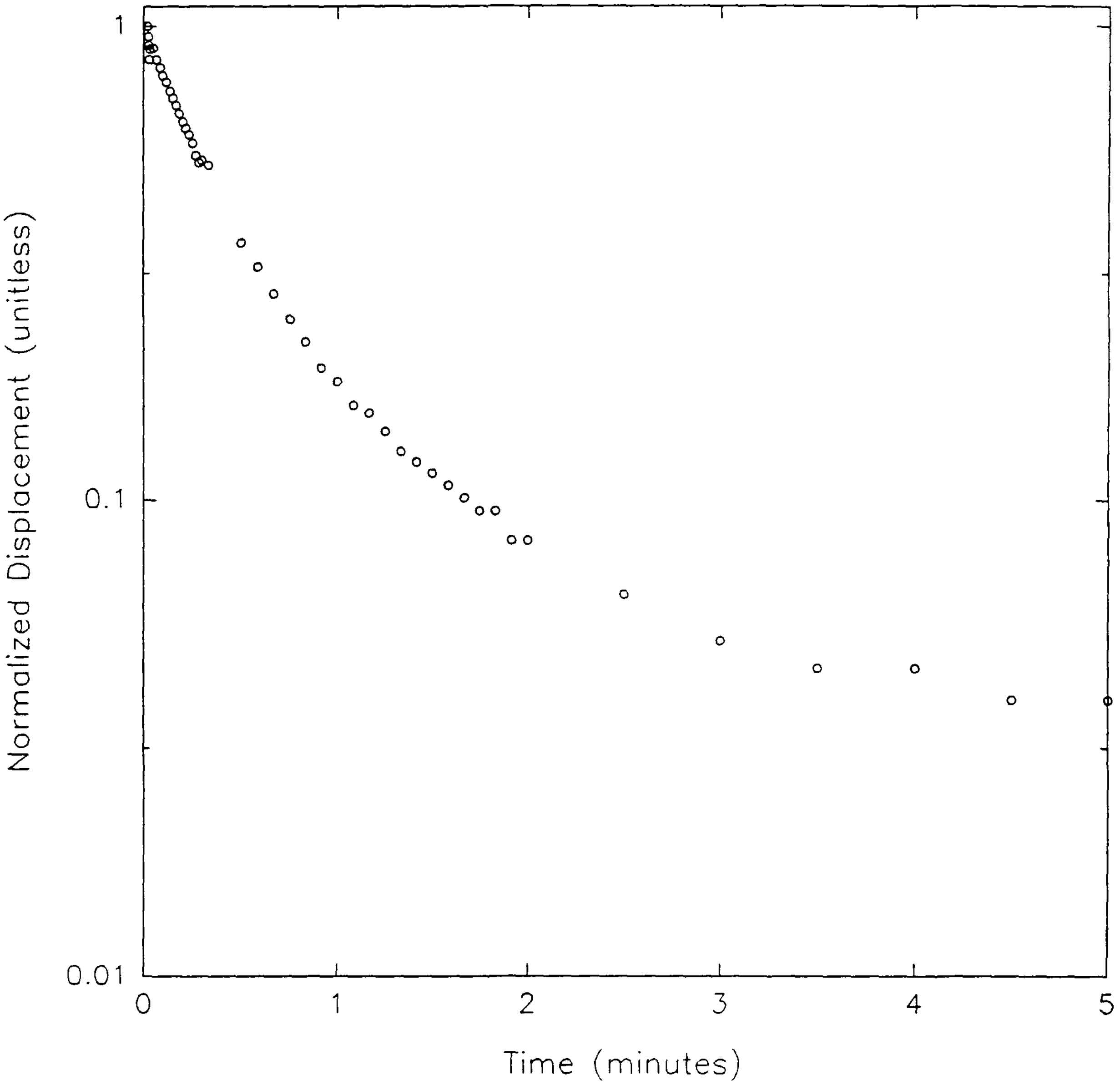
F9

SRSNE PRP Group
Rising Head Slug Test for MWL311, 4/14/94

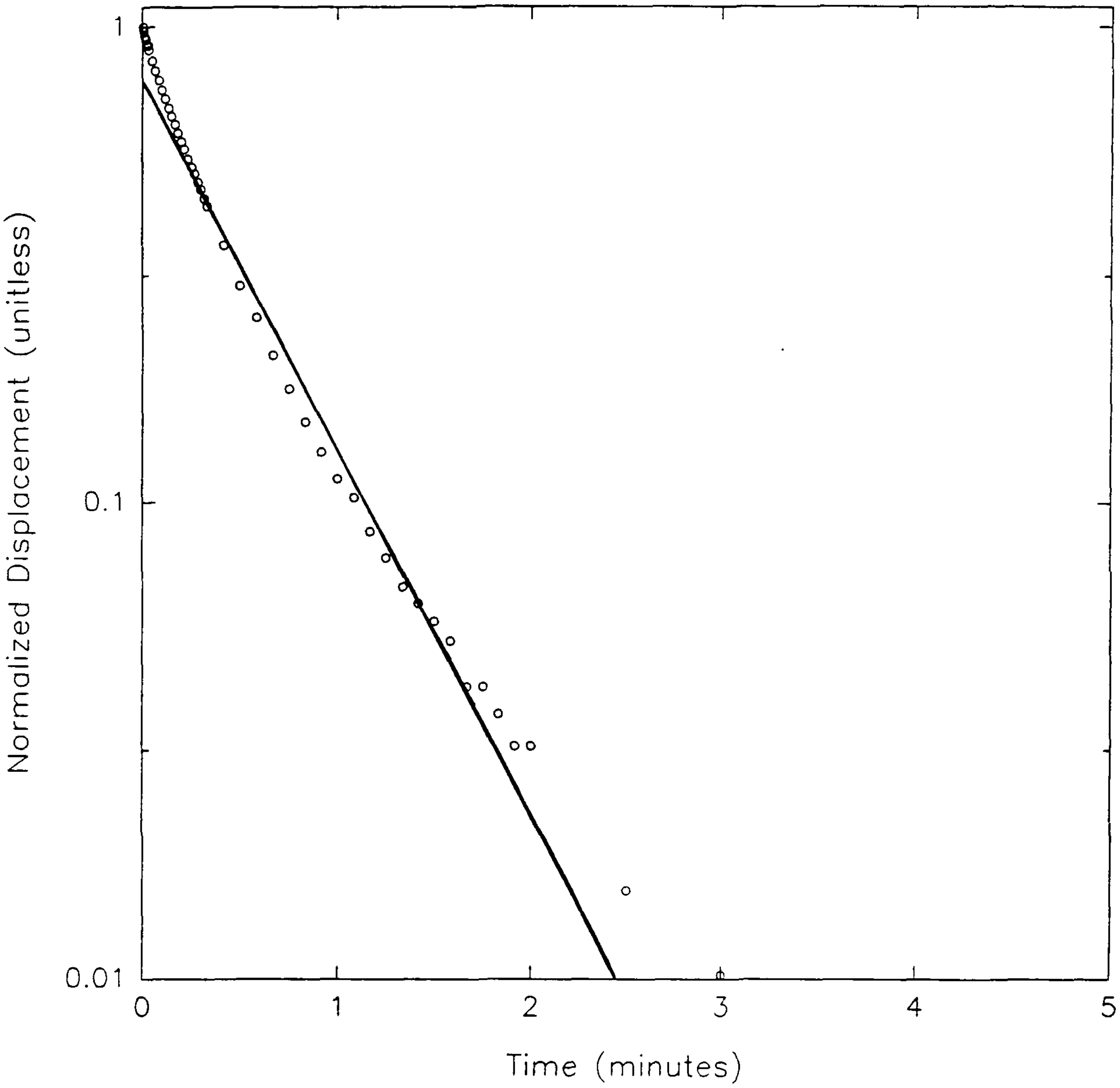


F10

SRSNE PRP Group
Falling Head Slug Test for MW408 4/14/94

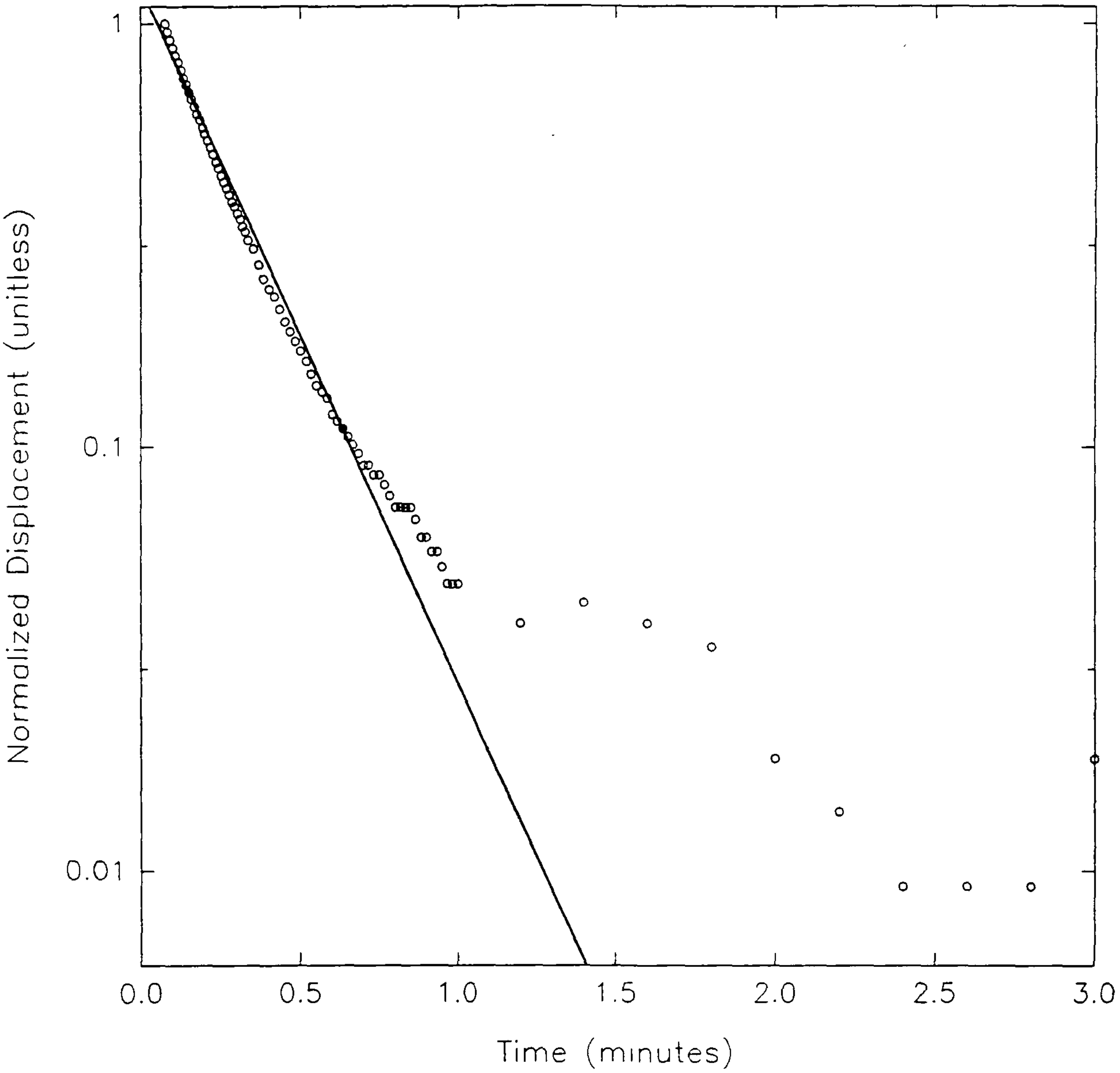


SRSNE PRP Group
Rising Head Slug Test for MW408 4/14/94

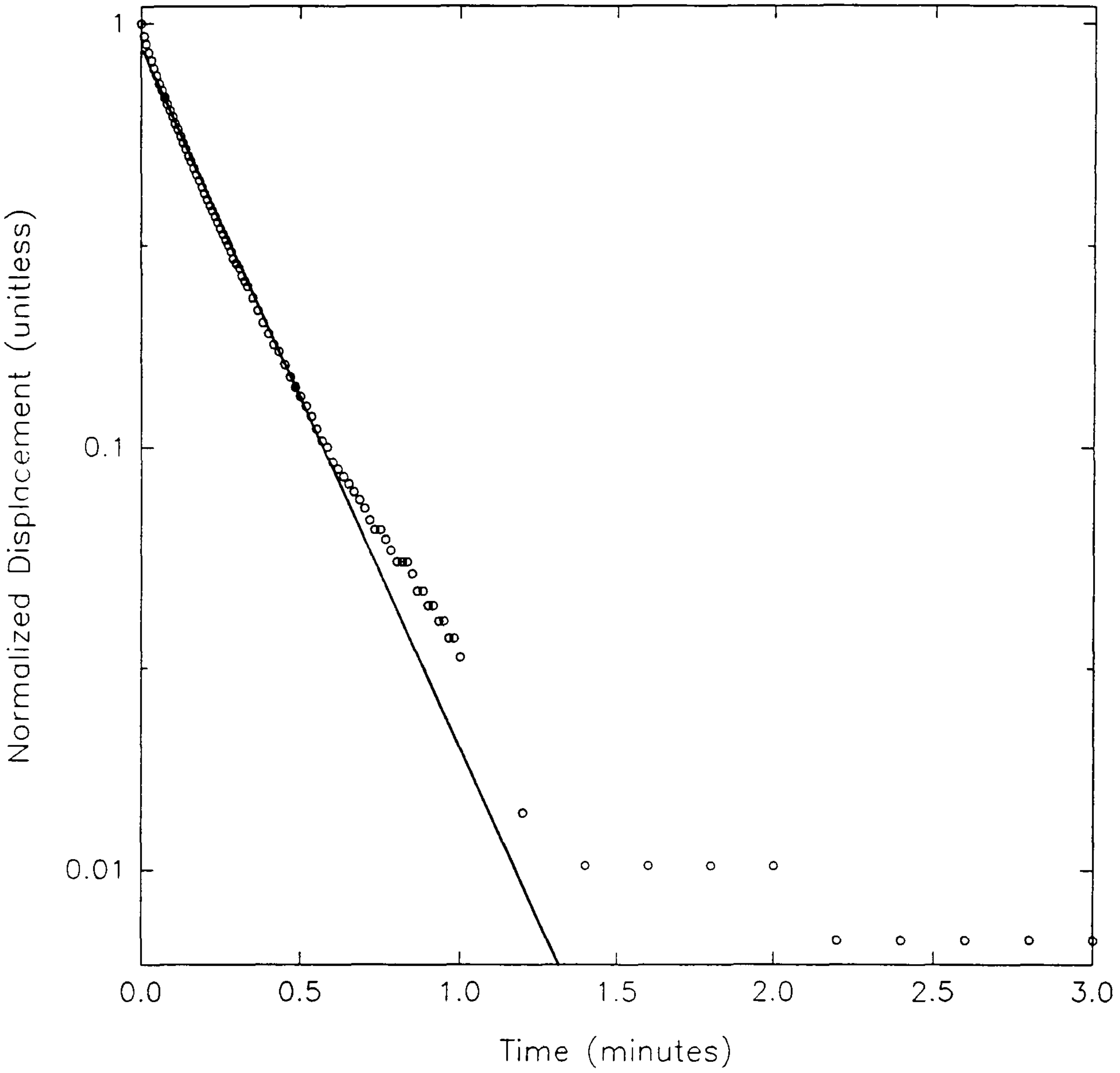


F12

SRSNE PRP Group
Falling Head Slug Test for MW410, 4/14/94

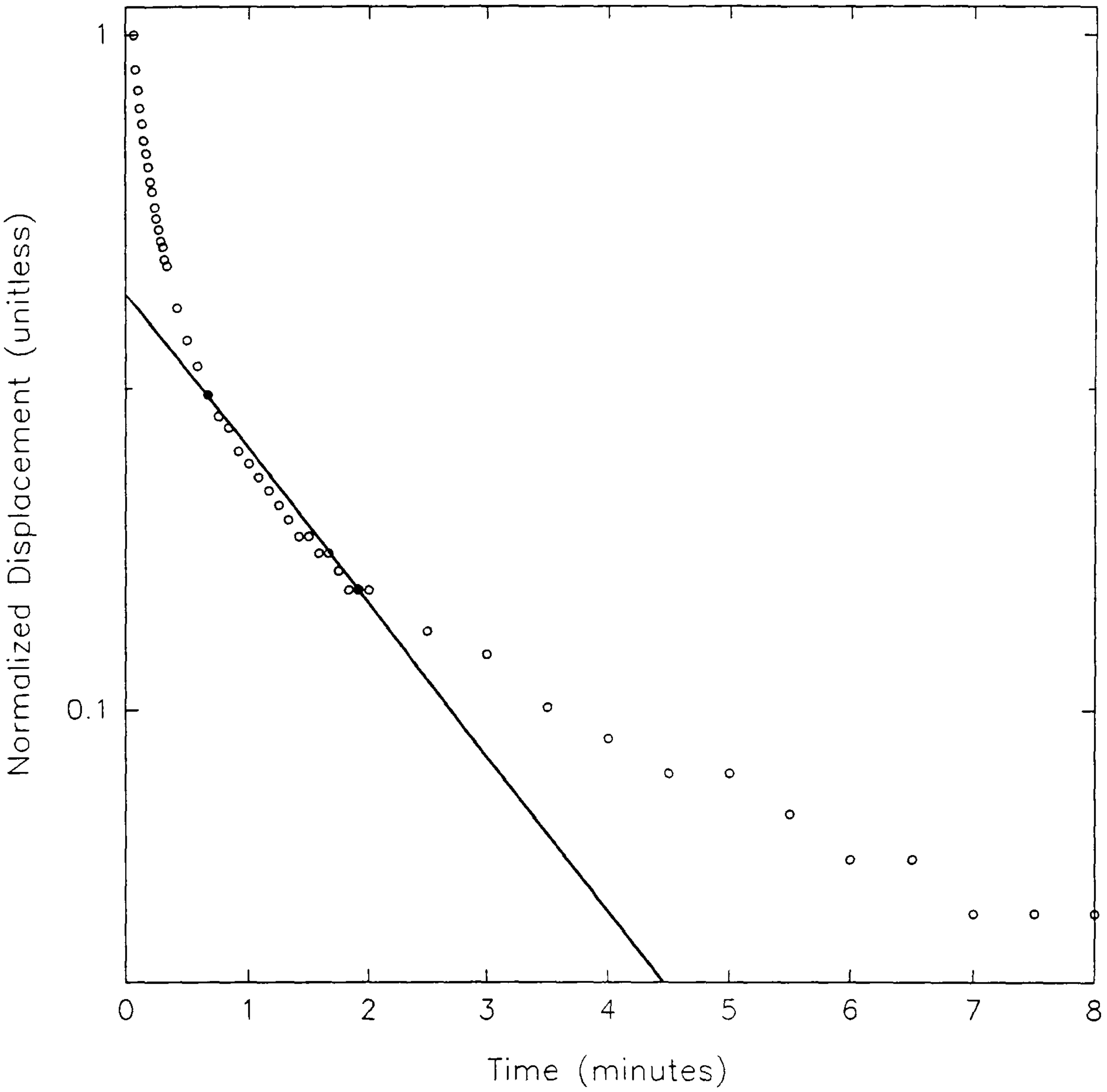


SRSNE PRP Group
Rising Head Slug Test for MW410, 4/14/94



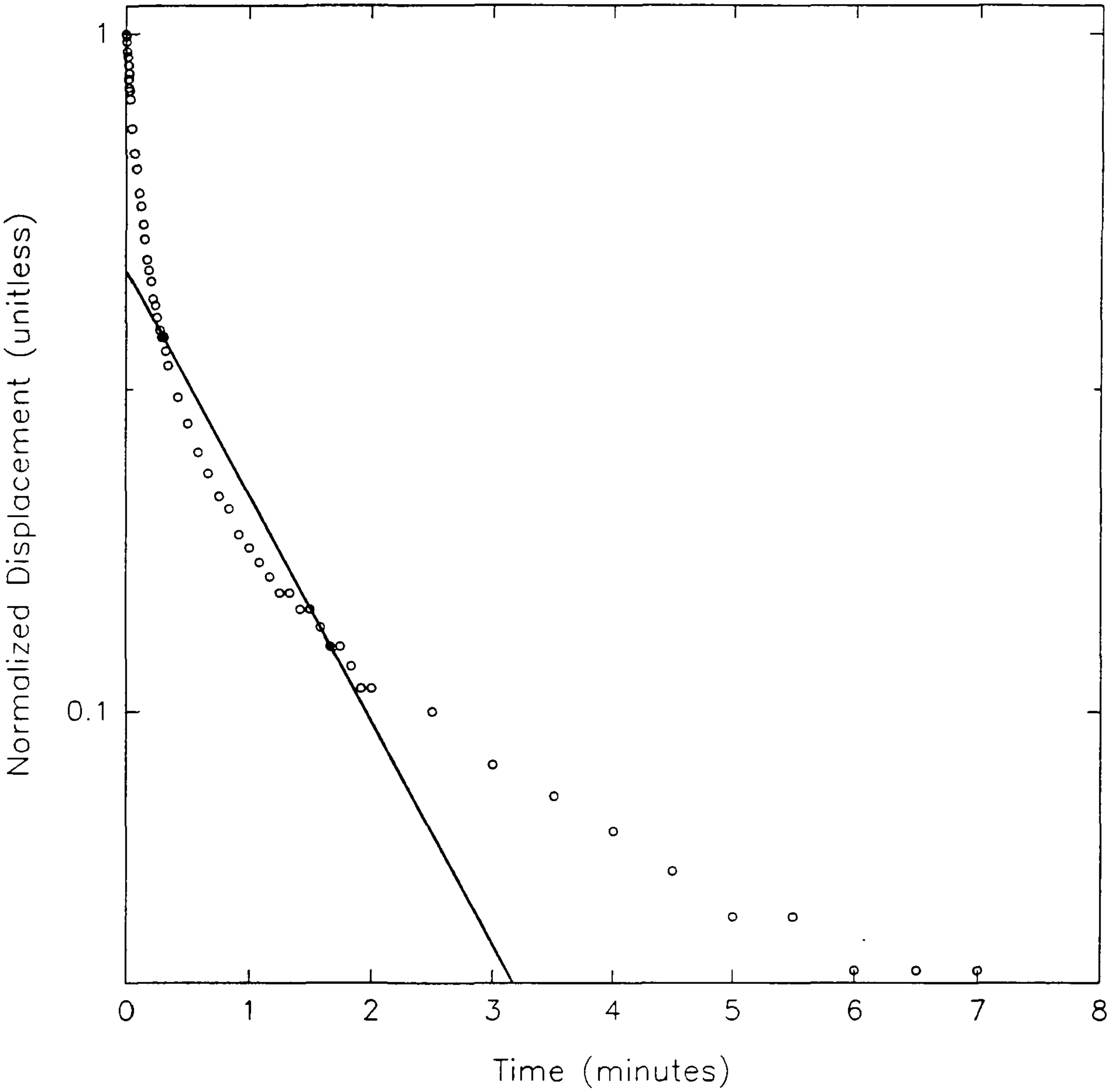
F14

SRSNE PRP Group
Falling Head Slug Test for MW412, 4/14/94



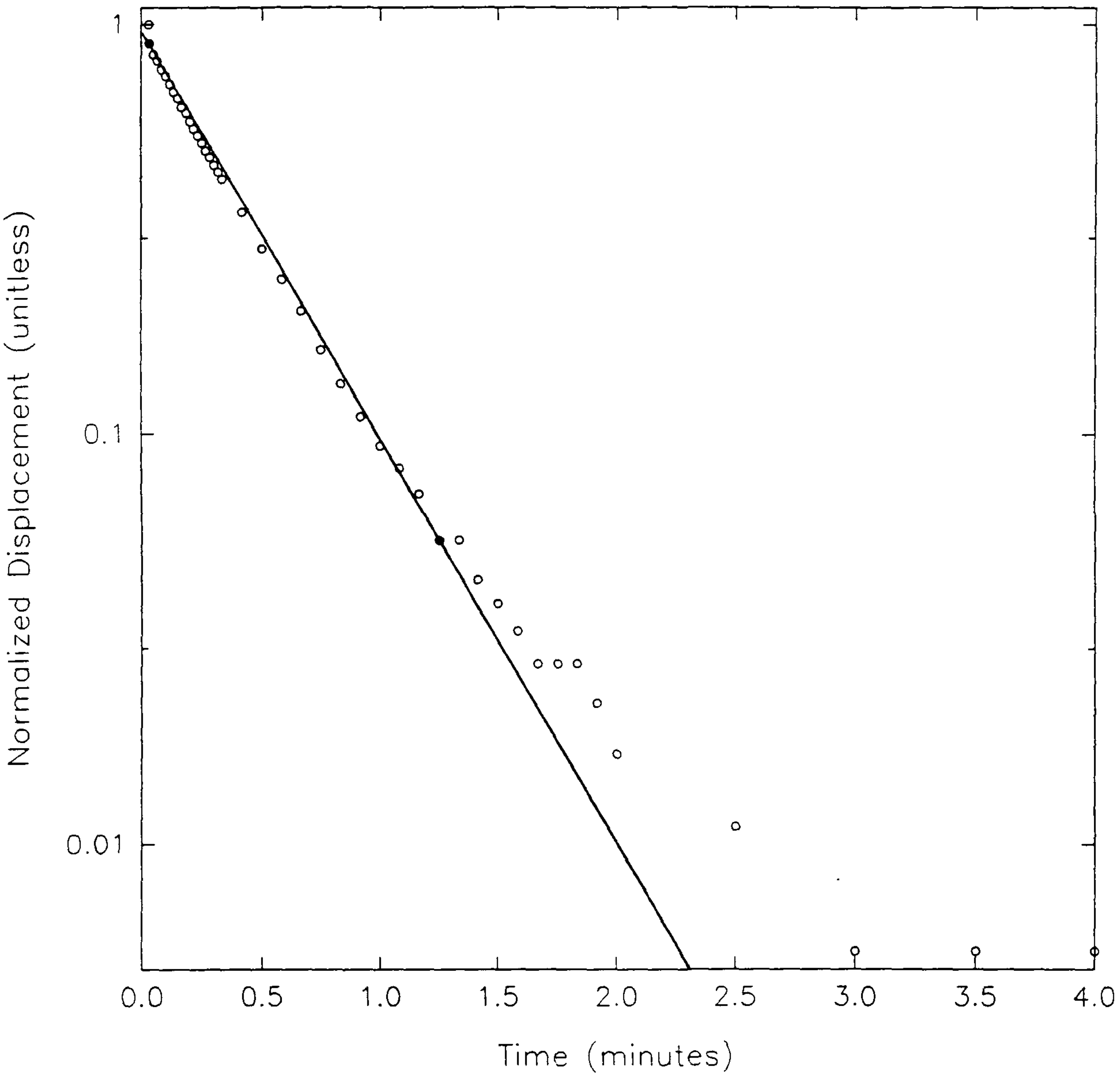
F15

SRSNE PRP Group
Rising Head Slug Test for MW412, 4/14/94



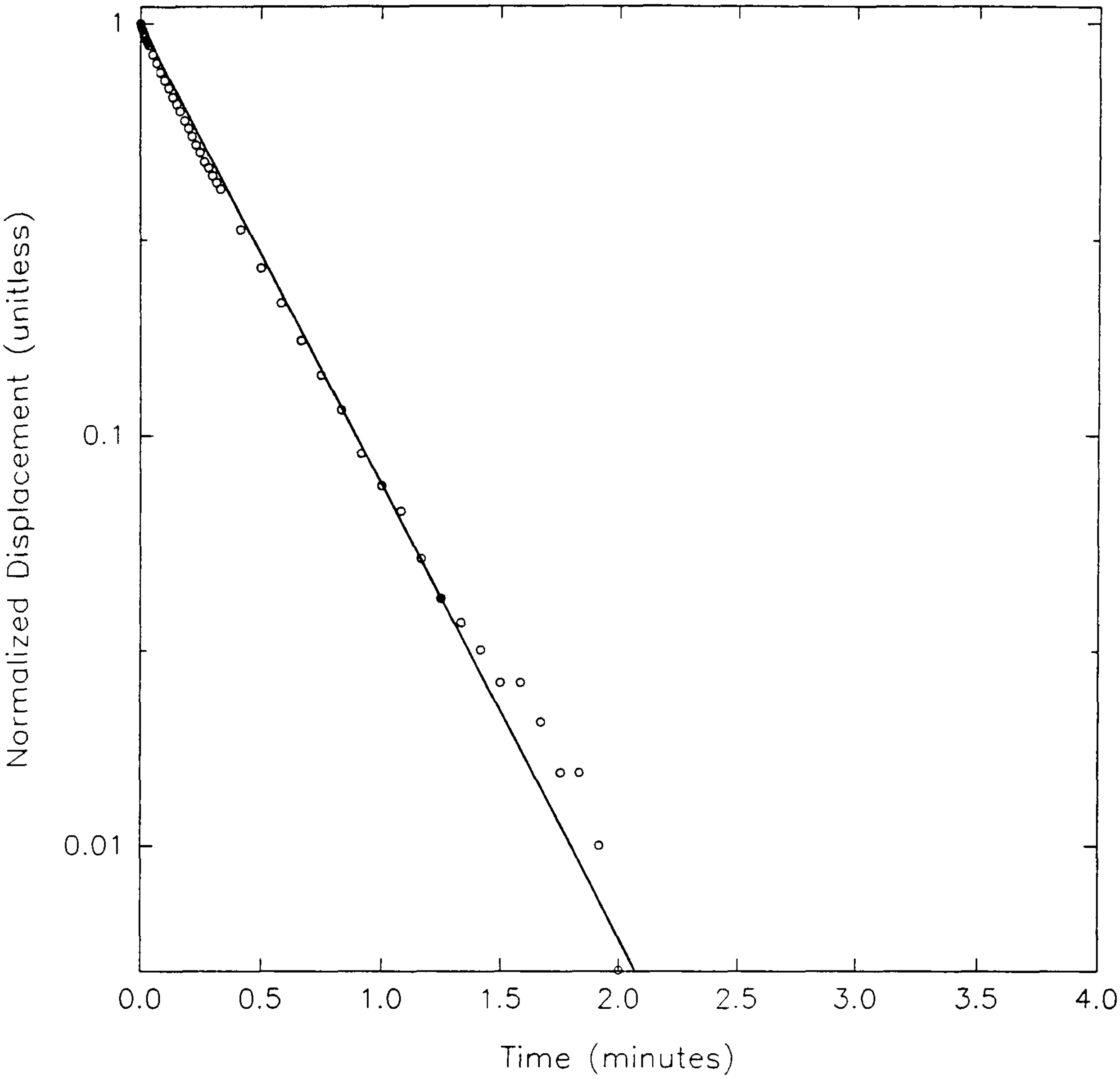
FIG

SRSNE PRP Group
Falling Head Slug Test for MW413, 4/14/94



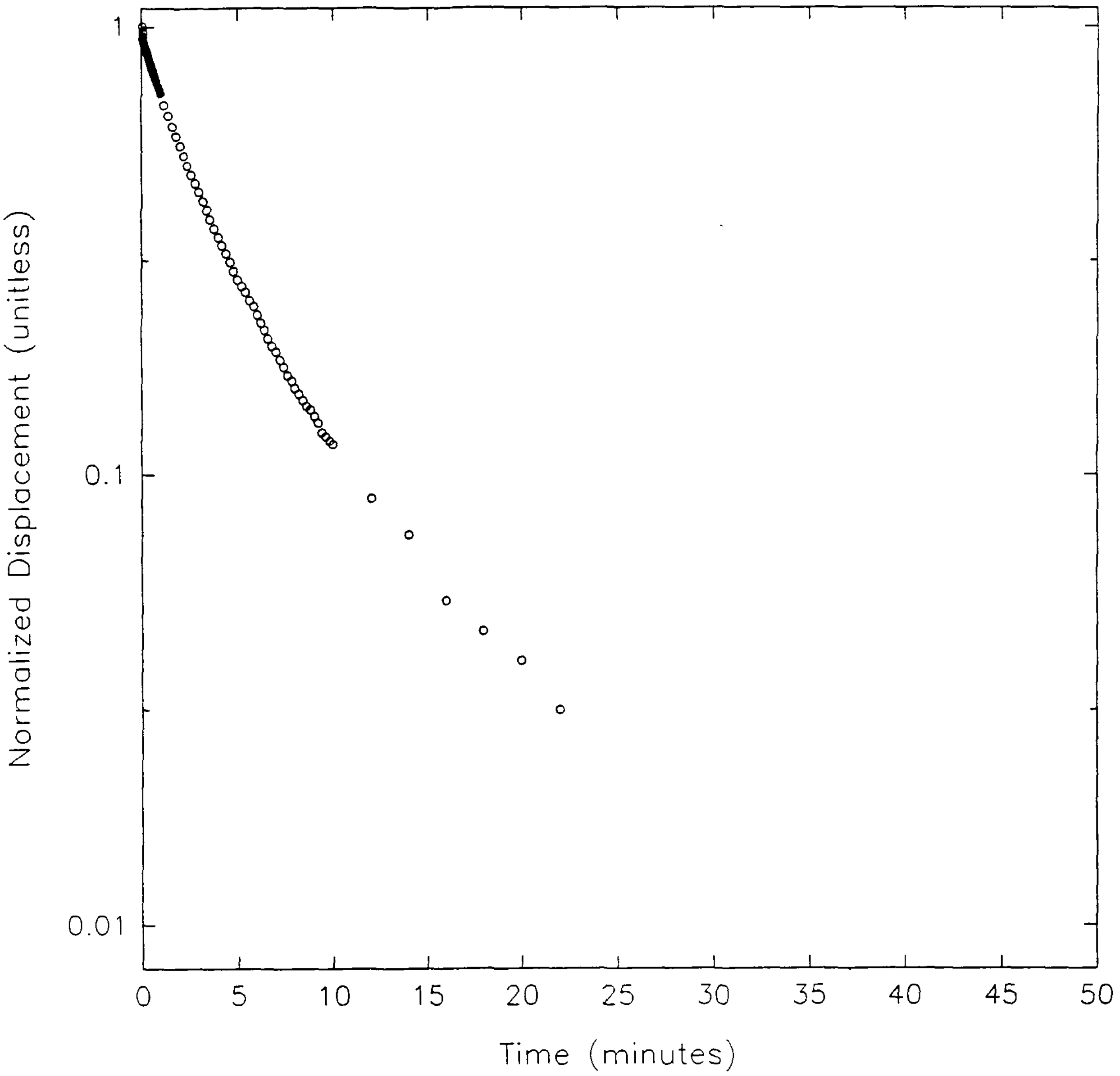
F17

SRSNE PRP Group
Rising Head Slug Test for MW413, 4/14/94



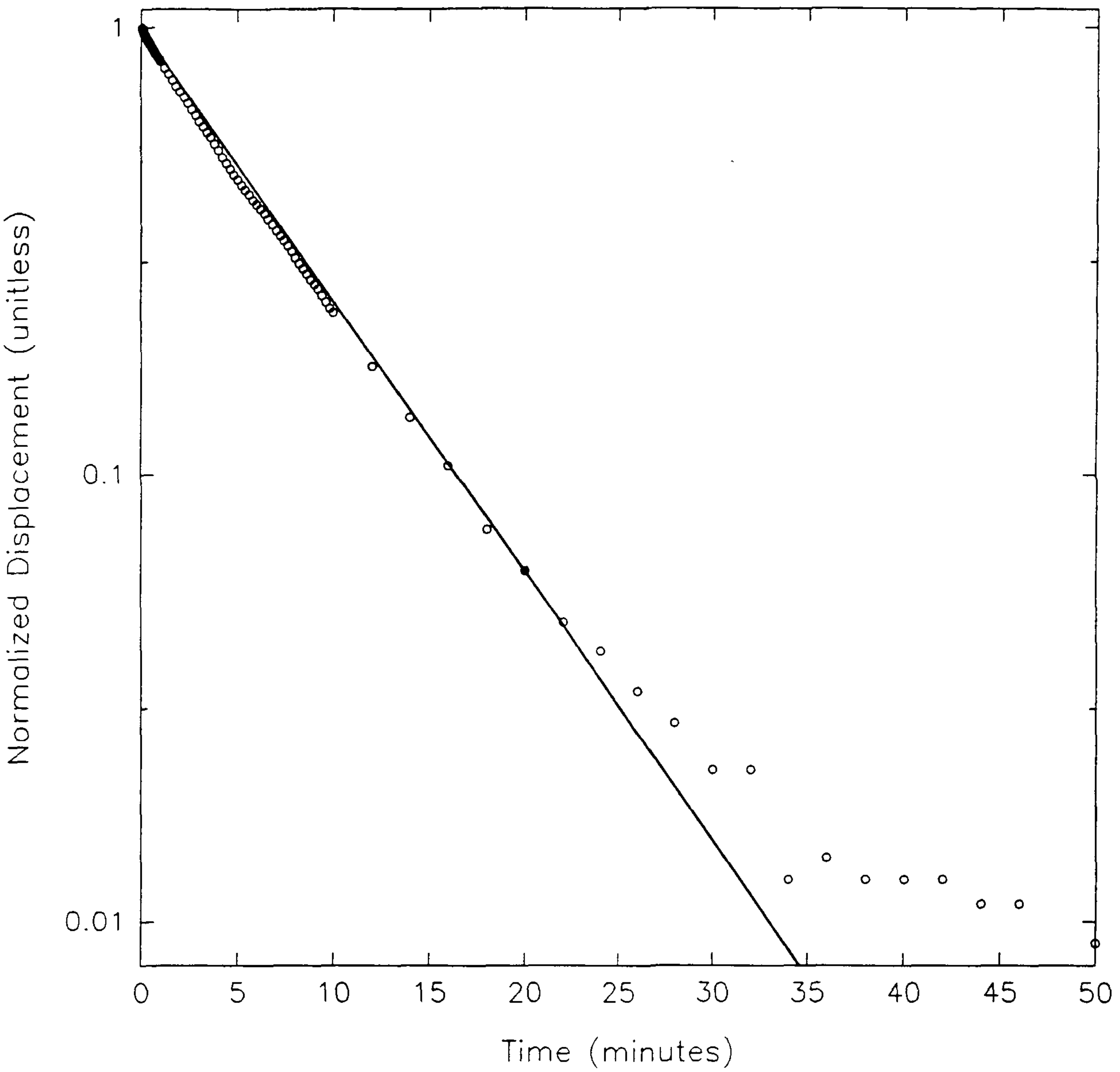
FIB

SRSNE PRP Group
Falling Head Slug Test for MW416, 4/14/94



Fig

SRSNE PRP Group
Rising Head Slug Test for MW416, 4/14/94



F20

APPENDIX G

ANALYTICAL DATA FOR GROUNDWATER TREATMENT STUDIES

The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.

- **Comparison of Field GC Screening Results with Laboratory GC\MS Analysis (ppm) for TW-8A**
- **Laboratory GC\MS Analysis for TW-8A**
- **Laboratory GC\MS Analyses for Pump Test Effluent Samples**
- **Aquatic Bioassay Results for Treatability Test Effluent**

COMPARISON OF FIELD GC SCREENING RESULTS WITH LABORATORY GC\MS ANALYSIS (PPM) FOR TW-8A

COMPARISON OF FIELD GC SCREENING RESULTS
WITH LABORATORY GC/MS ANALYSES (PPM) FOR TW-8A

Sample ID:	TW8A/am	TW8A/pm	TW8A
Method:	field gc screen	field gc screen	lab gc/ms
Date Collected:	03/14/94	03/14/94	03/14/94
COMPOUND Date Analyzed:	03/14/94	03/14/94	03/16/94
1,1-Dichloroethene	0.16	R	2.0 U
trans, 1,2-Dichloroethene	0.02	0.02	
cis, 1,2-Dichloroethene	15	40	
total 1,2-Dichloroethene			37
Trichloroethene	0.55	0.52	0.57
Toluene	12	28	23
Tetrachloroethene	0.077	0.18	2.0 U
Ethylbenzene	0.076	0.039	5.5

ND = Not detected

J = Estimated results

R = Rejected result due to matrix interferences

LABORATORY GC\MS ANALYSIS FOR TW-8A

SRS - TREATABILITY STUDY - SOUTHINGTON, CT
WATER
VOLATILES - 8240

Analyte:	Sample ID: TW8ATS Date: 03/16/94 Units: ug/l	
CHLOROMETHANE	2000.0	U
BROMOMETHANE	2000.0	U
VINYL CHLORIDE	9200.0	
CHLOROETHANE	850.0	J
METHYLENE CHLORIDE	3000.0	
ACETONE	4100.0	
ACROLEIN	2000.0	U
ACRYLONITRILE	2000.0	U
CARBON DISULFIDE	2000.0	U
TRICHLOROFLUOROMETHANE	2000.0	U
2-PROPANOL	2000.0	
1,1-DICHLOROETHENE	2000.0	U
1,1-DICHLOROETHANE	2100.0	
TETRAHYDROFURAN	360.0	J
1,2-DICHLOROETHENE (TOTAL)	37000.0	
CHLOROFORM	2000.0	U
1,2-DICHLOROETHANE	2000.0	U
2-BUTANONE	11000.0	
1,1,1-TRICHLOROETHANE	3000.0	
CARBON TETRACHLORIDE	2000.0	U
VINYL ACETATE	2000.0	U
BROMODICHLOROMETHANE	2000.0	U
1,2-DICHLOROPROPANE	2000.0	U
CIS-1,3-DICHLOROPROPENE	2000.0	U
TRICHLOROETHENE	570.0	J
BENZENE	2000.0	U
DIBROMOCHLOROMETHANE	2000.0	U
1,1,2-TRICHLOROETHANE	2000.0	U
TRANS-1,3-DICHLOROPROPENE	2000.0	U
2-CHLOROETHYL VINYLETHER	2000.0	U
BROMOFORM	2000.0	U
4-METHYL-2-PENTANONE	3400.0	
2-HEXANONE	2000.0	U
1,1,2,2-TETRACHLOROETHANE	2000.0	U
TETRACHLOROETHENE	2000.0	U
TOLUENE	23000.0	
CHLOROBENZENE	2000.0	U
ETHYLBENZENE	5500.0	
STYRENE	2000.0	U
XYLENE (TOTAL)	9100.0	

PRINTED 04/26/94

U = NOT DETECTED AT SPECIFIED DETECTION LIMIT
J = ESTIMATED RESULTS

SRS - TREATABILITY STUDY - SOUTHINGTON, CT
WATER
SEMIVOLATILES - 8270

Analyte:	Sample ID: TW8ATS Date: 03/16/94 Units: ug/l	
PHENOL	40.0	U
BIS(2-CHLOROETHYL)ETHER	40.0	U
2-CHLOROPHENOL	40.0	U
1,3-DICHLOROBENZENE	40.0	U
1,4-DICHLOROBENZENE	40.0	U
1,2-DICHLOROBENZENE	40.0	U
2-METHYLPHENOL	40.0	U
2,2-OXYBIS(1-CHLOROPROPANE)	40.0	U
4-METHYLPHENOL	40.0	U
N-NITROSO-DI-N-PROPYLAMINE	40.0	U
HEXACHLOROETHANE	40.0	U
NITROBENZENE	40.0	U
ISOPHORONE	34.0	J
2-NITROPHENOL	40.0	U
2,4-DIMETHYLPHENOL	40.0	U
BIS(2-CHLOROETHOXY)METHANE	40.0	U
2,4-DICHLOROPHENOL	40.0	U
1,2,4-TRICHLOROBENZENE	10.0	J
NAPHTHALENE	45.0	
4-CHLOROANILINE	40.0	U
HEXACHLOROBUTADIENE	40.0	U
4-CHLORO-3-METHYLPHENOL	40.0	U
2-METHYLNAPHTHALENE	7.0	J
HEXACHLOROCYCLOPENTADIENE	40.0	U
2,4,6-TRICHLOROPHENOL	40.0	U
2,4,5-TRICHLOROPHENOL	100.0	U
2-CHLORONAPHTHALENE	40.0	U
2-NITROANILINE	100.0	U
DIMETHYLPHTHALATE	40.0	U
ACENAPHTHYLENE	40.0	U
2,6-DINITROTOLUENE	40.0	U
3-NITROANILINE	100.0	U
ACENAPHTHENE	40.0	U
2,4-DINITROPHENOL	100.0	U
4-NITROPHENOL	100.0	U
DIBENZOFURAN	40.0	U
2,4-DINITROTOLUENE	40.0	U
DIETHYLPHTHALATE	3.0	J
4-CHLOROPHENYL-PHENYLETHER	40.0	U
FLUORENE	40.0	U
4-NITROANILINE	100.0	U
4,6-DINITRO-2-METHYLPHENOL	100.0	U
N-NITROSODIPHENYLAMINE (1)	40.0	U
4-BROMOPHENYL-PHENYL ETHER	40.0	U
HEXACHLOROBENZENE	40.0	U
PENTACHLOROPHENOL	100.0	U
PHENANTHRENE	40.0	U
ANTHRACENE	40.0	U
CARBAZOLE	40.0	U
DI-N-BUTYLPHTHALATE	40.0	U
FLUORANTHENE	40.0	U
PYRENE	40.0	U
BUTYLBENZYLPHTHALATE	40.0	U
3,3'-DICHLOROBENZIDINE	40.0	U
BENZO(A)ANTHRACENE	40.0	U
CHRYSENE	40.0	U
BIS(2-ETHYLHEXYL)PHTHALATE	40.0	U
DI-N-OCTYLPHTHALATE	40.0	U
BENZO(B)FLUORANTHENE	40.0	U
BENZO(K)FLUORANTHENE	40.0	U
BENZO(A)PYRENE	40.0	U
INDENO(1,2,3-CD)PYRENE	40.0	U
DIBENZ(A,H)ANTHRACENE	40.0	U
BENZO(G,H,I)PERYLENE	40.0	U

PRINTED 04/26/94

U = NOT DETECTED AT SPECIFIED DETECTION LIMIT
J = ESTIMATED RESULTS

SRS - TREATABILITY STUDY - SOUTHINGTON, CT
WATER
PESTICIDES AND PCBS - 8080

Sample ID: TW8ATS
Date: 03/16/94
Units: ug/l

Analyte:	TW8ATS 03/16/94 ug/l	
ALPHA-BHC	0.05	U
BETA-BHC	0.09	
DELTA-BHC	0.05	U
GAMMA-BHC (LINDANE)	0.05	JP
HEPTACHLOR	0.05	U
ALDRIN	0.04	J
HEPTACHLOR EPOXIDE	0.05	U
ENDOSULFAN I	0.05	P
DIELDRIN	0.10	U
4,4'-DDE	0.10	U
ENDRIN	0.10	U
ENDOSULFAN II	0.10	U
4,4-DDD	0.10	U
ENDOSULFAN SULFATE	0.10	U
4,4'-DDT	0.10	U
METHOXYCHLOR	0.50	U
ENDRIN KETONE	0.10	U
ENDRIN ALDEHYDE	0.10	U
ALPHA-CHLORDANE	0.04	JP
GAMMA-CHLORDANE	0.05	U
TOXAPHENE	5.00	U
AROCLOR-1016	1.00	U
AROCLOR-1221	2.00	U
AROCLOR-1232	1.00	U
AROCLOR-1242	1.00	U
AROCLOR-1248	1.00	U
AROCLOR-1254	1.00	U
AROCLOR-1260	1.00	U

PRINTED 04/26/94

U = NOT DETECTED AT SPECIFIED DETECTION LIMIT
JP = ESTIMATED RESULTS WITH GREATER THAN 25%
DIFFERENCE BETWEEN THE TWO GC COLUMNS

SRS - TREATABILITY STUDY - SOUTHINGTON, CT
WATER
WET CHEMISTRY

Analyte:	Sample ID: TW8ATS Date: 03/16/94 Units: mg/l
ORGANIC CARBON, TOTAL	72.80
ALKALINITY (AS CACO3)	145.00
TOTAL HARDNESS AS CACO3	220.00
TOTAL DISSOLVED SOLIDS	420.00
TOTAL SUSPENDED SOLIDS	50.20
NITRATE/NITRITE NITROGEN	0.03
TURBIDITY (NTU)	43.50
PHOSPHATE, TOTAL AS P	0.39

PRINTED 04/26/94

GIC

SRS - TREATABILITY STUDY - SOUTHINGTON, CT
WATER
SELECT METALS

Analyte:	Sample ID: TW8ATS Date: 03/16/94 Units: ug/l	
ANTIMONY	21.50	U
ARSENIC	7.60	
BERYLLIUM	0.40	U
CADMIUM	2.10	U
CHROMIUM	20.00	
COPPER	3.10	U
IRON	43200.00	
LEAD	0.89	U
MANGANESE	5310.00	
MERCURY	0.06	
NICKEL	4.00	U
SELENIUM	1.10	U
SILVER	4.20	U
THALLIUM	1.20	U
ZINC	1.90	U

PRINTED 04/26/94

U = NOT DETECTED AT SPECIFIED DETECTION LIMIT

SRS - TREATABILITY STUDY - SOUTHINGTON, CT
WATER
NON-HALUGENATED VOLATILES - 8015

	Sample ID:	TW8ATS	
	Date:	03/16/94	
Analyte:	Units:	ug/l	
ETHANOL		250	U
METHANOL		1000	
2-BUTANOL		4200	
1,4-DIOXANE		250	U

PRINTED 04/26/94

U = NOT DETECTED AT SPECIFIED DETECTION LIMIT

LABORATORY GC\MS ANALYSES FOR PUMP TEST EFFLUENT SAMPLES

SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
VOLATILES

Analyte:	Sample ID: Date: Units:	C407A 04/04/94 UG/L		C407B 04/05/94 UG/L		C407C 04/06/94 UG/L		C407D 04/07/94 UG/L	
CHLOROMETHANE		500.0	U	500.0	U	620.0	U	620.0	U
BROMOMETHANE		500.0	U	500.0	U	620.0	U	620.0	U
ACROLEIN		500.0	U	500.0	U		NA		NA
FREON TF		250.0	U	250.0	U		NA		NA
TETRAHYDROFURAN		110.0	J	260.0	J		NA		NA
VINYL CHLORIDE		1200.0		1300.0		1200.0		1100.0	
CHLOROETHANE		220.0	J	280.0	J	190.0	J	160.0	J
METHYLENE CHLORIDE		370.0	U	580.0	U	570.0	U	510.0	U
ACETONE		1200.0		1800.0		620.0	U	620.0	U
CARBON DISULFIDE		250.0	U	250.0	U	310.0	U	310.0	U
TRICHLOROFLUOROMETHANE		250.0	U	250.0	U		NA		NA
1,1-DICHLOROETHENE		250.0	U	250.0	U	180.0	J	200.0	J
1,1-DICHLOROETHANE		350.0		530.0		610.0		530.0	
1,2-DICHLOROETHENE (TOTAL)		6100.0		10000.0	E	10000.0		8500.0	
CHLOROFORM		250.0	U	250.0	U	310.0	U	310.0	U
1,2-DICHLOROETHANE		250.0	U	56.0	J	310.0	U	310.0	U
2-BUTANONE		4000.0		6500.0		5900.0		5700.0	
1,1,1-TRICHLOROETHANE		1100.0		1800.0		2000.0		2200.0	
CARBON TETRACHLORIDE		250.0	U	250.0	U	310.0	U	310.0	U
BROMODICHLOROMETHANE		250.0	U	250.0	U	310.0	U	310.0	U
1,2-DICHLOROPROPANE		250.0	U	250.0	U	310.0	U	310.0	U
CIS-1,3-DICHLOROPROPENE		250.0	U	250.0	U	310.0	U	310.0	U
TRICHLOROETHENE		300.0		440.0		520.0		460.0	
DIBROMOCHLOROMETHANE		250.0	U	250.0	U	310.0	U	310.0	U
1,1,2-TRICHLOROETHANE		250.0	U	250.0	U	310.0	U	310.0	U
BENZENE		250.0	U	250.0	U	310.0	U	310.0	U
TRANS-1,3-DICHLOROPROPENE		250.0	U	250.0	U	310.0	U	310.0	U
BROMOFORM		250.0	U	250.0	U	310.0	U	310.0	U
4-METHYL-2-PENTANONE		540.0		950.0		1200.0		1100.0	
2-HEXANONE		500.0	U	500.0	U	620.0	U	620.0	U
TETRACHLOROETHENE		250.0	U	250.0	U	310.0	U	97.0	J
1,1,2,2-TETRACHLOROETHANE		250.0	U	250.0	U	310.0	U	310.0	U
TOLUENE		6700.0		7100.0		6500.0		5900.0	
CHLOROBENZENE		250.0	U	250.0	U	310.0	U	310.0	U
ETHYLBENZENE		3300.0		3700.0		3000.0		2700.0	
STYRENE		250.0	U	250.0	U	310.0	U	310.0	U
XYLENE (TOTAL)		3000.0		2600.0		2200.0		2000.0	

SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
VOLATILES

Sample ID:	C408A		C408B		C408C	
Date:	04/11/94		04/12/94		04/13/94	
Units:	UG/L		UG/L		UG/L	
Analyte:						
CHLOROMETHANE	450.0	U	740.0	U	770.0	U
BROMOMETHANE	450.0	U	740.0	U	770.0	U
ACROLEIN	450.0	U	740.0	U	770.0	U
FREON TF	230.0	U	370.0	U	380.0	U
TETRAHYDROFURAN	4600.0		3300.0		2500.0	
VINYL CHLORIDE	760.0		1600.0		1100.0	
CHLOROETHANE	1500.0		1200.0		720.0	J
METHYLENE CHLORIDE	230.0	U	370.0	U	380.0	U
ACETONE	6000.0		12000.0		10000.0	
CARBON DISULFIDE	230.0	U	370.0	U	380.0	U
TRICHLOROFLUOROMETHANE	230.0	U	370.0	U	380.0	U
1,1-DICHLOROETHENE	230.0	U	370.0	U	380.0	U
1,1-DICHLOROETHANE	230.0	U	370.0	U	380.0	U
1,2-DICHLOROETHENE (TOTAL)	1600.0		1500.0		970.0	
CHLOROFORM	230.0	U	370.0	U	380.0	U
1,2-DICHLOROBENZENE	230.0		370.0	U	380.0	U
2-BUTANONE	4400.0		12000.0		9500.0	
1,1,1-TRICHLOROETHANE	130.0	J	370.0	U	380.0	U
CARBON TETRACHLORIDE	230.0	U	370.0	U	380.0	U
BROMODICHLOROMETHANE	230.0	U	370.0	U	380.0	U
1,2-DICHLOROPROPANE	230.0	U	370.0	U	380.0	U
CIS-1,3-DICHLOROPROPENE	230.0	U	370.0	U	380.0	U
TRICHLOROETHENE	230.0	U	370.0	U	380.0	U
DIBROMOCHLOROMETHANE	230.0	U	370.0	U	380.0	U
1,1,2-TRICHLOROETHANE	230.0	U	370.0	U	380.0	U
BENZENE	74.0	J	72.0	J	380.0	U
TRANS-1,3-DICHLOROPROPENE	230.0	U	370.0	U	380.0	U
BROMOFORM	230.0	U	370.0	U	380.0	U
4-METHYL-2-PENTANONE	2700.0		3600.0		3900.0	
2-HEXANONE	450.0	U	740.0	U	770.0	U
TETRACHLOROETHENE	230.0	U	370.0	U	380.0	U
1,1,2,2-TETRACHLOROETHANE	230.0	U	370.0	U	380.0	U
TOLUENE	6700.0		8000.0		8600.0	
CHLOROBENZENE	230.0	U	370.0	U	380.0	U
ETHYLBENZENE	3900.0		3600.0		3800.0	
STYRENE	230.0	U	370.0	U	380.0	U
XYLENE (TOTAL)	1600.0		2000.0		2100.0	

PRINTED 06/10/94

SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
VOLATILES

Analyte:	Sample ID: Date: Units:	CTB01 02/28/94 UG/L		CTB03 02/28/94 UG/L		CTB04 02/28/94 UG/L	
CHLOROMETHANE		10.0	U	10.0	U	10.0	U
BROMOMETHANE		10.0	U	10.0	U	10.0	U
ACROLEIN		10.0	U	10.0	U	10.0	U
FREON TF		5.0	U	5.0	U	5.0	U
VINYL CHLORIDE		10.0	U	10.0	U	10.0	U
CHLOROETHANE		10.0	U	10.0	U	10.0	U
METHYLENE CHLORIDE		6.0		6.0		3.0	J
ACETONE		10.0	U	10.0	U	21.0	
CARBON DISULFIDE		5.0	U	5.0	U	5.0	U
TRICHLOROFLUOROMETHANE		5.0	U	5.0	U	5.0	U
1,1-DICHLOROETHENE		5.0	U	5.0	U	5.0	U
1,1-DICHLOROETHANE		5.0	U	5.0	U	5.0	U
1,2-DICHLOROETHENE (TOTAL)		5.0	U	5.0	U	5.0	U
CHLOROFORM		5.0	U	5.0	U	5.0	U
1,2-DICHLOROETHANE		5.0	U	5.0	U	5.0	U
2-BUTANONE		10.0	U	10.0	U	10.0	U
1,1,1-TRICHLOROETHANE		5.0	U	5.0	U	5.0	U
CARBON TETRACHLORIDE		5.0	U	5.0	U	5.0	U
BROMODICHLOROMETHANE		5.0	U	5.0	U	5.0	U
1,2-DICHLOROPROPANE		5.0	U	5.0	U	5.0	U
CIS-1,3-DICHLOROPROPENE		5.0	U	5.0	U	5.0	U
TRICHLOROETHENE		5.0	U	5.0	U	5.0	U
DIBROMOCHLOROMETHANE		5.0	U	5.0	U	5.0	U
1,1,2-TRICHLOROETHANE		5.0	U	5.0	U	5.0	U
BENZENE		5.0	U	5.0	U	5.0	U
TRANS-1,3-DICHLOROPROPENE		5.0	U	5.0	U	5.0	U
BROMOFORM		5.0	U	5.0	U	5.0	U
4-METHYL-2-PENTANONE		10.0	U	10.0	U	10.0	U
2-HEXANONE		10.0	U	10.0	U	10.0	U
TETRACHLOROETHENE		5.0	U	5.0	U	5.0	U
1,1,2,2-TETRACHLOROETHANE		5.0	U	5.0	U	5.0	U
TOLUENE		5.0	U	5.0	U	5.0	U
CHLOROBENZENE		5.0	U	5.0	U	5.0	U
ETHYLBENZENE		5.0	U	5.0	U	5.0	U
STYRENE		5.0	U	5.0	U	5.0	U
XYLENE (TOTAL)		5.0	U	5.0	U	5.0	U

SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
SEMIVOLATILES

Sample ID:	C407A		C407B		C407C		C407D	
Date:	04/04/94		04/05/94		04/06/94		04/07/94	
Analyte: Units:	UG/L		UG/L		UG/L		UG/L	
PHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
BIS(2-CHLOROETHYL)ETHER	10.0	U	10.0	U	20.0	U	20.0	U
2-CHLOROPHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
1,3-DICHLOROBENZENE	10.0	U	10.0	U	20.0	U	20.0	U
1,4-DICHLOROBENZENE	10.0	U	10.0	U	20.0	U	20.0	U
1,2-DICHLOROBENZENE	10.0	U	10.0	U	20.0	U	20.0	U
2-METHYLPHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
2,2-OXYBIS(1-CHLOROPROPANE)	10.0	U	10.0	U	20.0	U	20.0	U
4-METHYLPHENOL	10.0	UJ	10.0	U	20.0	U	20.0	U
N-NITROSO-DI-N-PROPYLAMINE	10.0	U	10.0	U	20.0	U	20.0	U
HEXACHLOROETHANE	10.0	U	10.0	U	20.0	U	20.0	U
NITROBENZENE	10.0	U	10.0	U	20.0	U	20.0	U
ISOPHORONE	6.0	J	9.0	J	9.0	J	8.0	J
2-NITROPHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
2,4-DIMETHYLPHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
BIS(2-CHLOROETHOXY)METHANE	10.0	U	10.0	U	20.0	U	20.0	U
2,4-DICHLOROPHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
1,2,4-TRICHLOROBENZENE	6.0	J	6.0	J	6.0	J	5.0	J
NAPHTHALENE	27.0		26.0		24.0		21.0	
4-CHLOROANILINE	10.0	U	10.0	U	20.0	U	20.0	U
HEXACHLOROBUTADIENE	10.0	U	10.0	U	20.0	U	20.0	U
4-CHLORO-3-METHYLPHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
2-METHYLNAPHTHALENE	3.0	J	3.0	J	4.0	J	4.0	J
HEXACHLOROCYCLOPENTADIENE	10.0	U	10.0	U	20.0	U	20.0	U
2,4,6-TRICHLOROPHENOL	10.0	UJ	10.0	UJ	20.0	UJ	20.0	UJ
2,4,5-TRICHLOROPHENOL	50.0	UJ	50.0	UJ	50.0	UJ	50.0	UJ
2-CHLORONAPHTHALENE	10.0	U	10.0	U	20.0	U	20.0	U
2-NITROANILINE	50.0	U	50.0	U	50.0	U	50.0	U
DIMETHYLPHTHALATE	10.0	U	10.0	U	20.0	U	20.0	U
ACENAPHTHYLENE	10.0	U	10.0	U	20.0	U	20.0	U
2,6-DINITROTOLUENE	10.0	U	10.0	U	20.0	U	20.0	U
3-NITROANILINE	50.0	U	50.0	U	50.0	U	50.0	U
ACENAPHTHENE	10.0	U	10.0	U	20.0	U	20.0	U
2,4-DINITROPHENOL	50.0	UJ	50.0	UJ	50.0	UJ	50.0	UJ
4-NITROPHENOL	50.0	UJ	50.0	UJ	50.0	UJ	50.0	UJ
DIBENZOFURAN	10.0	U	10.0	U	20.0	U	20.0	U
2,4-DINITROTOLUENE	10.0	U	10.0	U	20.0	U	20.0	U
DIETHYLPHTHALATE	10.0	U	10.0	U	20.0	U	20.0	U
4-CHLOROPHENYL-PHENYLETHER	10.0	U	10.0	U	20.0	U	20.0	U
FLUORENE	10.0	U	10.0	U	20.0	U	20.0	U
4-NITROANILINE	50.0	U	50.0	U	50.0	U	50.0	U
4,6-DINITRO-2-METHYLPHENOL	50.0	UJ	50.0	UJ	50.0	UJ	50.0	UJ
N-NITROSODIPHENYLAMINE (1)	10.0	U	10.0	U	20.0	U	20.0	U
4-BROMOPHENYL-PHENYL ETHER	10.0	U	10.0	U	20.0	U	20.0	U
HEXACHLOROBENZENE	10.0	U	10.0	U	20.0	U	20.0	U
PENTACHLOROPHENOL	50.0	UJ	50.0	UJ	50.0	UJ	50.0	UJ
PHENANTHRENE	10.0	U	10.0	U	20.0	U	20.0	U
ANTHRACENE	10.0	U	10.0	U	20.0	U	20.0	U
CARBAZOLE	10.0	U	10.0	U	20.0	U	20.0	U
DI-N-BUTYLPHTHALATE	4.0	J	2.0	J	2.0	J	2.0	J
FLUORANTHENE	10.0	U	10.0	U	20.0	U	20.0	U
PYRENE	10.0	U	10.0	U	20.0	U	20.0	U
BUTYLBENZYLPHTHALATE	10.0	U	10.0	U	20.0	U	20.0	U
3,3'-DICHLOROBENZIDINE	10.0	U	20.0	U	20.0	U	20.0	U
BENZO(A)ANTHRACENE	10.0	U	10.0	U	20.0	U	20.0	U
CHRYSENE	10.0	U	10.0	U	20.0	U	20.0	U
BIS(2-ETHYLHEXYL)PHTHALATE	10.0	U	10.0	U	2.0	J	20.0	U
DI-N-OCTYLPHTHALATE	10.0	U	10.0	U	20.0	U	20.0	U
BENZO(B)FLUORANTHENE	10.0	U	10.0	U	20.0	U	20.0	U
BENZO(K)FLUORANTHENE	10.0	U	10.0	U	20.0	U	20.0	U
BENZO(A)PYRENE	10.0	U	10.0	U	20.0	U	20.0	U
INDENO(1,2,3-CD)PYRENE	10.0	U	10.0	U	20.0	U	20.0	U
DIBENZ(A,H)ANTHRACENE	10.0	U	10.0	U	20.0	U	20.0	U
BENZO(G,H,I)PERYLENE	10.0	U	10.0	U	20.0	U	20.0	U

SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
SEMIVOLATILES

	Sample ID:	C408A	C408B	C408C	
	Date:	04/11/94	04/12/94	04/13/94	
Analyte:	Units:	UG/L	UG/L	UG/L	
PHENOL		NA	NA	20.0	UJ
BIS(2-CHLOROETHYL)ETHER		NA	NA	20.0	U
2-CHLOROPHENOL		NA	NA	20.0	UJ
1,3-DICHLOROBENZENE		NA	NA	20.0	U
1,4-DICHLOROBENZENE		NA	NA	20.0	U
1,2-DICHLOROBENZENE		NA	NA	20.0	U
2-METHYLPHENOL		NA	NA	20.0	UJ
2,2-OXYBIS(1-CHLOROPROPANE)		NA	NA	20.0	U
4-METHYLPHENOL		NA	NA	21.0	UJ
N-NITROSO-DI-N-PROPYLAMINE		NA	NA	20.0	U
HEXACHLOROETHANE		NA	NA	20.0	U
NITROBENZENE		NA	NA	20.0	U
ISOPHORONE		NA	NA	20.0	U
2-NITROPHENOL		NA	NA	20.0	UJ
2,4-DIMETHYLPHENOL		NA	NA	16.0	J
BIS(2-CHLOROETHOXY)METHANE		NA	NA	20.0	U
2,4-DICHLOROPHENOL		NA	NA	20.0	UJ
1,2,4-TRICHLOROBENZENE		NA	NA	20.0	U
NAPHTHALENE		NA	NA	17.0	J
4-CHLOROANILINE		NA	NA	20.0	U
HEXACHLOROBUTADIENE		NA	NA	20.0	U
4-CHLORO-3-METHYLPHENOL		NA	NA	20.0	UJ
2-METHYLNAPHTHALENE		NA	NA	1.0	J
HEXACHLOROCYCLOPENTADIENE		NA	NA	20.0	U
2,4,6-TRICHLOROPHENOL		NA	NA	20.0	UJ
2,4,5-TRICHLOROPHENOL		NA	NA	50.0	UJ
2-CHLORONAPHTHALENE		NA	NA	20.0	U
2-NITROANILINE		NA	NA	50.0	U
DIMETHYLPHTHALATE		NA	NA	20.0	U
ACENAPHTHYLENE		NA	NA	20.0	U
2,6-DINITROTOLUENE		NA	NA	20.0	U
3-NITROANILINE		NA	NA	50.0	U
ACENAPHTHENE		NA	NA	20.0	U
2,4-DINITROPHENOL		NA	NA	50.0	UJ
4-NITROPHENOL		NA	NA	50.0	UJ
DIBENZOFURAN		NA	NA	20.0	U
2,4-DINITROTOLUENE		NA	NA	20.0	U
DIETHYLPHTHALATE		NA	NA	28.0	
4-CHLOROPHENYL-PHENYLETHER		NA	NA	20.0	U
FLUORENE		NA	NA	20.0	U
4-NITROANILINE		NA	NA	50.0	U
4,6-DINITRO-2-METHYLPHENOL		NA	NA	50.0	UJ
N-NITROSODIPHENYLAMINE (1)		NA	NA	20.0	U
4-BROMOPHENYL-PHENYL ETHER		NA	NA	20.0	U
HEXACHLOROBENZENE		NA	NA	20.0	U
PENTACHLOROPHENOL		NA	NA	50.0	UJ
PHENANTHRENE		NA	NA	20.0	U
ANTHRACENE		NA	NA	20.0	U
CARBAZOLE		NA	NA	20.0	U
DI-N-BUTYLPHTHALATE		NA	NA	2.0	J
FLUORANTHENE		NA	NA	20.0	U
PYRENE		NA	NA	20.0	U
BUTYLBENZYLPHTHALATE		NA	NA	20.0	U
3,3'-DICHLOROBENZIDINE		NA	NA	20.0	U
BENZO(A)ANTHRACENE		NA	NA	20.0	U
CHRYSENE		NA	NA	20.0	U
BIS(2-ETHYLHEXYL)PHTHALATE		NA	NA	20.0	U
DI-N-OCTYLPHTHALATE		NA	NA	20.0	U
BENZO(B)FLUORANTHENE		NA	NA	20.0	U
BENZO(K)FLUORANTHENE		NA	NA	20.0	U
BENZO(A)PYRENE		NA	NA	20.0	U
INDENO(1,2,3-CD)PYRENE		NA	NA	20.0	U
DIBENZ(A,H)ANTHRACENE		NA	NA	20.0	U
BENZO(G,H,I)PERYLENE		NA	NA	20.0	U

PRINTED 06/10/94

SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
SELECT METALS

	Sample ID:	C407A		C407B		C407C		C407D	
	Date:	04/04/94		04/05/94		04/06/94		04/07/94	
Analyte:	Units:	UG/L		UG/L		UG/L		UG/L	
ANTIMONY		25.40	U	25.30	U	25.30	U	25.30	U
ARSENIC		11.10		10.90		9.70		10.00	
BERYLLIUM		0.20	U	0.20	U	0.20	U	0.20	U
CADMIUM		1.40	U	1.40	U	1.40	U	1.40	
CHROMIUM		5.80		4.70		8.60		6.00	
COPPER		4.40	U	4.40	U	4.40	U	4.40	U
IRON		23200.00		24500.00		27000.00		26000.00	
LEAD		0.60	U	0.59	U	0.82		0.60	U
MANGANESE		5390.00		5530.00		5460.00		5430.00	
MERCURY		0.03	U	0.03	U	0.03	U	0.03	U
NICKEL		3.70	U	3.70	U	3.70	U	3.70	U
SELENIUM		1.80	U	1.20	U	1.20	U	1.60	U
SILVER		3.90	U	3.90	U	3.90	U	3.90	U
THALLIUM		1.00	U	0.99	U	0.99	U	1.00	U
ZINC		3.10		1.50		5.80		2.30	
CYANIDE		6.10		5.00		5.00	U	5.00	U

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SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
SELECT METALS

Analyte:	Sample ID: Date: Units:	C408A 04/11/94 UG/L		C408B 04/12/94 UG/L		C408C 04/13/94 UG/L	
ANTIMONY		25.50	U	25.30	U	25.40	U
ARSENIC		2.70		2.80		1.90	
BERYLLIUM		0.20	U	0.20	U	0.20	U
CADMIUM		1.40	U	1.40	U	1.40	U
CHROMIUM		5.60		2.70		2.30	U
COPPER		8.40		4.40	U	4.40	U
IRON		17600.00		24800.00		23700.00	
LEAD		0.98		0.59	U	0.60	U
MANGANESE		6600.00		9890.00		9570.00	
MERCURY		0.04		0.06		0.03	
NICKEL		7.40		3.70	U	3.70	U
SELENIUM		2.10	U	1.10	U	1.30	U
SILVER		3.90	U	3.90	U	3.90	U
THALLIUM		0.99	U	0.99	U	1.00	U
ZINC		10.40		18.30		36.60	
CYANIDE		5.00	U	5.00	U	5.00	U

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SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
WET CHEMISTRY

	Sample ID:	C407A	C407B	C407C	C407D
	Date:	04/04/94	04/05/94	04/06/94	04/07/94
Analyte:	Units:	mg/l	mg/l	mg/l	mg/l
Total Hardness as CaCO3		138.00	138.00	138.00	138.00
Total Dissolved Solids		279.00	284.00	257.00	266.00
Total Suspended Solids		31.20	26.60	85.70	22.00
Alkalinity (as CaCO3)		114.00	117.00	130.00	122.00
BOD5		37.00	75.00	58.00	58.00
Chemical Oxygen Demand		114.00	133.00	137.00	135.00
Organic Carbon, Total		28.50	29.60	32.00	34.00

PRINTED 06/10/94

SRS - SOUTHINGTON, CT
GROUNDWATER/PUMP TEST
WET CHEMISTRY

Analyte:	Sample ID: Date: Units:	C408A 04/11/94 mg/l	C408B 04/12/94 mg/l	C408C 04/13/94 mg/l
Total Hardness as CaCO3		472.00	615.00	580.00
Total Dissolved Solids		730.00	820.00	821.00
Total Suspended Solids		494.00	525.00	74.90
Alkalinity (as CaCO3)		342.00	340.00	343.00
BOD5		150.00	290.00	200.00
Chemical Oxygen Demand		240.00	207.00	504.00
Organic Carbon, Total		74.00	126.00	119.00

PRINTED 06/10/94

AQUATIC BIOASSAY RESULTS FOR TREATABILITY TEST EFFLUENT

ENSR

Formerly ERT

ENSR Consulting and Engineering

1716 Heath Parkway
Fort Collins, CO 80524
(303) 493-8878

May 5, 1994

Marc Grant
ENSR Consulting and Engineering
35 Nagog Park
Acton, Massachusetts 01720

Dear Marc:

Enclosed are the toxicity test reports for the SRS New England effluent treated by Solarchem. The effluent was not acutely toxic to fathead minnows (*Pimephales promelas*) or chronically toxic to the alga *Selenastrum capricornutum*. The effluent was acutely toxic to *Daphnia pulex* and chronically toxic to *Ceriodaphnia dubia* and fathead minnows. A summary of test results is given below:

Test	**NOAEC (% Effl.)**	**LC$_{50}$ (% Effl.)**	**NOEC (% Effl.)**	**LOEC (% Effl.)**	**ChV (% Effl.)**	**IC$_{25}$ (% Effl.)**
Daphnia pulex Acute	25	38.3	–	–	–	–
Fathead Minnow Acute	100	>100	–	–	–	–
Ceriodaphnia Chronic	–	–	6.25	12.5	8.8	–
Fathead Minnow Chronic	–	–	50	100	70.7	–
Selenastrum Chronic	–	–	100	N/A	N/A	>100

Please contact Dave Pillard or me if you have any questions or comments regarding the enclosed reports. We appreciate this opportunity to be of service.

Sincerely,

Susan L. Burnett

Susan L. Burnett
Laboratory Technician

Enclosures

Ref: 8505-153-165

G 27

ENSR

ENSR Consulting
and Engineering
1716 Heath Parkway
Fort Collins, CO 80524
(303) 493-8878
(303) 493-0213 (FAX)

May 13, 1994

Marc Grant
ENSR Consulting and Engineering
35 Nagog Park
Acton, Massachusetts 01720

Dear Marc:

Enclosed are the toxicity test reports for the SRS New England effluent treated by Peroxidation Systems Inc. The effluent was toxic to *Daphnia pulex*, *Ceriodaphnia dubia*, fathead minnows (*Pimephales promelas*), and the alga *Selenastrum capricornutum*. A summary of test results is given below:

Test	NOAEC (% Effl.)	LC_{50} (% Effl.)	NOEC (% Effl.)	LOEC (% Effl.)	ChV (% Effl.)	IC_{25} (% Effl.)
Daphnia pulex Acute	12.5	17.1	–	–	–	–
Fathead Minnow Acute	25	33.0	–	–	–	–
Ceriodaphnia Chronic	–	–	6.25	12.5	8.8	–
Fathead Minnow Chronic	–	–	6.25	12.5	8.8	–
Selenastrum capricornutum	–	–	<6.25	N/A	N/A	1.9

The results for the *Daphnia pulex* acute test presented above are for a retest initiated on April 23, 1994. Because dissolved oxygen levels measured in the original test were below the acceptable level at test initiation the test was placed in an air-tight glass box and injected with oxygen. Dissolved oxygen levels subsequently were measured at 174 percent of saturation at 24 hours; such high dissolved oxygen levels may have caused mortality in some treatments. The retest was conducted under ambient conditions after aerating the effluent for approximately 2 hours. Please contact Dave Pillard or me if you have any questions or comments regarding the enclosed reports. We appreciate this opportunity to be of service.

Sincerely,

Mark Brady

Mark D. Brady
Laboratory Technician

Enclosures
Ref: 8505-153-165

ENSR

ENSR Consulting
and Engineering
1716 Heath Parkway
Fort Collins, CO 80524
(303) 493-8878
(303) 493-0213 (FAX)

June 10, 1994

Marc Grant
ENSR Consulting and Engineering
35 Nagog Park
Acton, Massachusetts 01720

Dear Marc:

Enclosed are the reports for the SRS New England effluent biomonitoring tests initiated on June 1, 1994. As you know, the effluent was acutely or chronically toxic to each of the species tested. A summary of test results is given below:

Test	**NOAEC (% Effl.)**	**LC_{50} (% Effl.)**	**NOEC (% Effl.)**	**LOEC (% Effl.)**	**ChV (% Effl.)**	**IC_{25} (% Effl.)**
Daphnia pulex Acute	<6.25	8.6	–	–	–	–
Fathead Minnow Acute	25	62.0	–	–	–	–
Ceriodaphnia Chronic	–	–	12.5	25	17.7	–
Selenastrum Chronic	–	–	25	N/A	N/A	19.7

Please contact Dave Pillard or me if you have any questions or comments regarding the enclosed reports. We appreciate this opportunity to be of service.

Sincerely,

Susan L. Burnett

Susan L. Burnett
Laboratory Technician

Enclosures

Ref: 8505-153-165

APPENDIX H

VENDOR DATA FOR GROUNDWATER TREATMENT STUDIES

The following materials are provided as a portion of a Draft document requiring U.S. EPA approval.

- **Diversey Water Technologies, Inc. Report**
- **Parkson Corporation Report**
- **VPSI Report**
- **VPSI Additional Data**
- **VPSI Telephone Call Summary Sheets**
- **SolarChem**
- **North East Environmental Products**
- **AlliedSignal**

DIVERSEY WATER TECHNOLOGIES, INC. REPORT

Diversey

Diversey Water Technologies Inc.

4 Creamery Brook Office Park
P.O. Box 811
East Granby, CT 06026

Tel: (203) 653-7722
Fax: (203) 653-3166

April 14, 1994

ENSR Consulting
35 Nagog Park
Acton, MA 01720

Attention: Mr. Jim Doherty

Dear Jim:

The following is a formal report regarding the testing undertaken on April 7 by Diversey Water Technologies to evaluate the polymer program for your groundwater remediation project. The objectives of the project were to see if metals can be removed from the groundwater prior to an organics removal program. The water, after organics removal, will flow to a nearby stream. Additional objectives of the program were to determine settling rates as well as costs for the polymer and to review your present waste treatment facility. Additionally, a particle size determination was requested and performed.

In reviewing the data, starting with the particle size, please find the enclosed analysis from our laboratory. The analysis indicates that the mean size of the particles was 5.61 microns. That means that a filtration system utilizing a 5 micron filter should be sufficient to remove most of the particulate.

Reviewing the concentrations of the metals in the influent reveals that iron and manganese were the major metal components in this water. Iron was found to be at 22 ppm and manganese at 5.8 ppm. There were trace amounts of copper, chrome, nickel and zinc.

The program scheme utilized elevation of the pH by the addition of sodium hydroxide to approximately 9.5 to 10. After adding the sodium hydroxide, a pin-floc was formed rather readily. To help settle the pin-floc and increase the size of the particles, our anionic polymer, 9137A, was added at 3 and 5 ppm. The end result was a fairly steady floc at the bottom of the beaker and a very clear supernate. This test was repeated several different times at different pH's and we have found that the most efficient pH was 9.8 or so and approximately 3 to 5 ppm of polymer.

Additional tests that were conducted utilized hydrogen peroxide as a source of oxidant. This approach worked fairly well, though the floc was not as heavy and tended to float as opposed to settle. In discussing this with you, we determined that the use of sodium hydroxide would be more beneficial than utilizing hydrogen peroxide.

Samples were sent to our laboratory for metal analysis to determine the efficiency of removal. Please note that both the 5 ppm and 3 ppm polymer samples revealed excellent removal of metals. Iron was reduced to 2 ppm, manganese was reduced to .76 ppm with the 5 ppm of polymer and there were negligible amounts of the remaining metals. At 3 ppm of polymer the results were better for iron removal but worse for manganese removal.

CONCLUSIONS

Based on our one day test, the recommended approach for treating this groundwater is to utilize sodium hydroxide for pH adjustment and our polymer, 9137A, as a flocculent. This, in combination with a properly operated clarifier, will yield excellent results and protect your downstream equipment.

Jim, as per your request, the following is a breakdown of costs for our polymer at different flow rates. Due to your low usage rate, I recommend the purchase of this polymer in 5 gallon pails, since this product's shelf life is approximately 6 months. Additionally, this polymer has to be mixed down properly to maximize its efficient use and a training seminar for their proper use can be provided at your request.

GPM	FEED RATE	LBS./DAY	COST/DAY
5	5 ppm	.3	$1.30
10	5 ppm	.6	$2.60
15	5 ppm	.9	$3.90
20	5 ppm	1.2	$5.20
25	5 ppm	1.5	$6.50
30	5 ppm	1.8	$7.80
35	5 ppm	2.1	$9.10
40	5 ppm	2.4	$10.40

Jim, the cost of our product 9137A, supplied in 5 gallon pails, would be $4.33 per lb., a 5 gallon container weighs 40 lbs., coming to a total of $173.20.

Jim, I hope you find the above and enclosed satisfactory. We feel that Diversey can help you with this project and any other projects relating to a water concern. Please review the enclosed data and I will be contacting you shortly to discuss if there is any additional follow up that is necessary on our end.

Respectfully yours,

DIVERSEY WATER TECHNOLOGIES

Hershel Zamechek

Hershel Zamechek
Area Manager

HZ/sj

Encls.

cc: Tim Brophy
Mark Monroe

Diversey

Diversey Water Technologies Inc.
7145 Pine Street
P.O. Box 200
Chagrin Falls, OH 44022
Tel: (216) 247-5000
Fax: (216) 247-7175

WATER ANALYSIS REPORT

ZAMECHEK, H
14 HILLTOP DRIVE
CANTON, CT 06019
METRO NY

REPORT DATE: April 13, 1994
LOG IN DATE: April 12, 1994
ENSR/SRS
SOUTHINGTON, CT

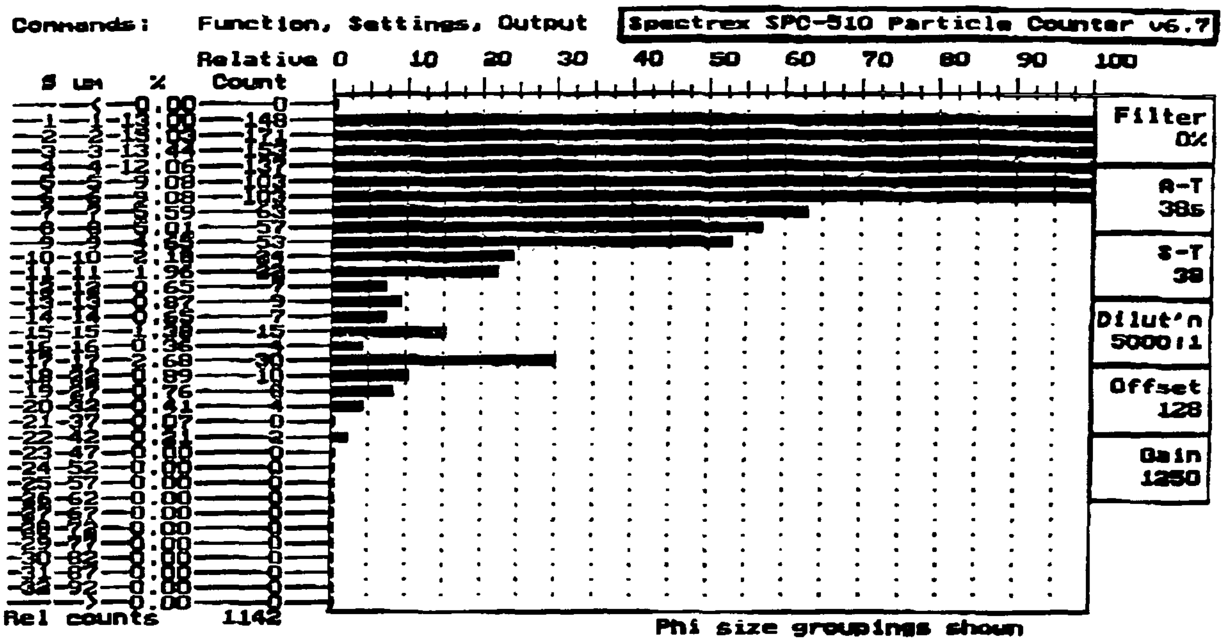
SAMPLE INFORMATION			
SAMPLE NUMBER:	W5588	W5589	W5590
SAMPLE DATE:	4-7-94	4-7-94	4-7-94
SAMPLE TIME:	11:00	11:30	12:00
SAMPLE FROM:	INFLUENT	EFFLUENT 5PPM	EFFLUENT 3PPM
PARAMETERS			
Copper as Cu mg/l	0.01	<0.01	<0.01
Iron as Fe mg/l	22.0	2.00	0.75
Manganese as Mn mg/l	5.80	0.76	3.60
Chromium as Cr mg/l	0.02	0.01	0.01
Nickel as Ni mg/l	0.01	<0.01	<0.01
Zinc as Zn mg/l	0.03	0.01	<0.01

Approved Jeff Koometo

This analysis has a value of $216.00.

HC

DIVERSEY WATER TECH
ATTN: HERSCHEL ZAMECHEK
ATTN: RAY MALONEY
SAMPLE ENSR/SRS
FLOCED TEST



	Size	Total counts /cc	Counts percent	Surface area percent	Volume percent	Mass/bin ppm
	<	0	0.00%	0.00%	0.00%	0.00
1	1um	742,259	13.00%	0.23%	0.01%	0.39
2	2um	858,366	15.03%	1.04%	0.12%	3.60
3	3um	767,139	13.44%	2.09%	0.37%	10.85
4	4um	688,352	12.06%	3.34%	0.79%	23.07
5	5um	518,337	9.08%	3.93%	1.16%	33.93
6	6um	518,337	9.08%	5.66%	2.01%	58.62
7	7um	319,296	5.59%	4.74%	1.96%	57.34
8	8um	286,122	5.01%	5.55%	2.62%	76.70
9	9um	265,389	4.65%	6.52%	3.47%	101.30
10	10um	124,401	2.18%	3.77%	2.23%	65.14
11	11um	111,961	1.96%	4.11%	2.67%	78.03
12	12um	37,320	0.65%	1.63%	1.16%	33.77
13	13um	49,760	0.87%	2.55%	1.96%	57.24
14	14um	37,320	0.65%	2.22%	1.83%	53.62
15	15um	78,787	1.38%	5.38%	4.76%	139.23
16	16um	20,733	0.36%	1.61%	1.52%	44.47
17	17um	152,860	2.68%	13.40%	13.46%	393.22
18	22um	50,953	0.89%	7.48%	9.72%	284.08
19	27um	43,114	0.76%	9.53%	15.20%	444.34
20	32um	23,517	0.41%	7.30%	13.81%	403.49
21	37um	3,919	0.07%	1.63%	3.56%	103.95
22	42um	11,758	0.21%	6.29%	15.61%	456.14
23	47um	0	0.00%	0.00%	0.00%	0.00
	52um	0	0.00%	0.00%	0.00%	0.00
25	57um	0	0.00%	0.00%	0.00%	0.00
26	62um	0	0.00%	0.00%	0.00%	0.00
27	67um	0	0.00%	0.00%	0.00%	0.00

17

Diversey ENSR / SRS Floced Te

```
 28        72um          0        0.00%      0.00%      0.00%       0.00
 29        77um          0        0.00%      0.00%      0.00%       0.00
 30        82um          0        0.00%      0.00%      0.00%       0.00
 31        87um          0        0.00%      0.00%      0.00%       0.00
 32        92um          0        0.00%      0.00%      0.00%       0.00
              >          0        0.00%      0.00%      0.00%       0.00

                     Total                  Surface
                    counts       Counts       area     Volume    Mass/bin
Phi        Size        /cc      percent    percent    percent       ppm
---     -------    -------      -------    -------    -------   --------
 10       1 - 2    742,259       13.00%      0.23%      0.01%       0.39
  9       2 - 4  1,625,505       28.47%      3.14%      0.49%      14.44
  8       4 - 8  2,044,321       35.80%     17.67%      5.92%     172.96
  7      8 - 16    991,060       17.36%     31.73%     20.70%     605.02
  6     16 - 31    267,661        4.69%     32.02%     39.90%    1166.10
  5     31 - 63     39,195        0.69%     15.22%     32.97%     963.58
  4     63- 128          0        0.00%      0.00%      0.00%       0.00

 Total counts:    5,710,001/cc
   Total suspended
         solids:  2922.49ppm (mg/liter)
   Dilution factor:  5000.00:1
   Spec. gravity:    1.00
   Mean size:        5.61um
   Standard dev:     5.13um

Sample taken on Fri Apr 08 1994 at 12:39:02
```

HE

PARKSON CORPORATION REPORT

PARKSON CORPORATION
. Box 408399
rt Lauderdale, FL 33340-8399
Telephone: 305/974-6610
Fax: 305/974-6182

Fax Message #: 3549
FAX NUMBER: 508/635-9180
Number of Pages: four

TO: Mr. Jim Doherty
ENSR Consulting & Engineering
35 NAGOG PARK
ACTON, MA 01720

COPY VIA FAX TO: WESCOR ASSOCIATES, INC. (#53) FAX MESSAGE #: 3550

FROM: Phil Streat, Senior Process Engineer

RE: Lab Test Summary for ENSR Consulting & Engineering for the Parkson Lamella® Gravity Settler

DATE: May 17, 1994

CC: PPS, MAG, BJH/DDR, MDR, File: Wescor Project.

nclosed you will find our Laboratory Summary for the test work conducted on the recently-submitted samples.

The received sample contained 8 ppm suspended solids at a pH of 6.95.

The best results were obtained by pH adjusting to 11.35 and adding 2.0 ppm of Exxon Jayfloc 803 with sludge recycle. This was followed by 10 seconds of flashmixing and one minute of flocculation.

Also enclosed you will find a drawing depicting the recommended equipment for this application. At a flow rate of 70 GPM and a loading rate of 0.43 GPM/sq.ft., the suggested equipment is one Model LGS-200/55 with a size "A" flashmixer/flocculator.

Coatings and materials of construction should be suitable for pH up to 11.5.

Provision should be made for pH adjustment prior to the LGS unit. Polymer would be added to the flashmixer. Provision should also be made for recycling sludge to the feed at a rate up to 40 GPM.

Should there be additional questions regarding the recommendations, feel free to contact Matt Rebmann. If there are questions concerning the test work, materials of construction, etc., please contact me.

Enclosures as noted

LAMELLA®
GRAVITY SETTLE

Date Tested: 05/04/94 Customer Sample Number: 9730

LABORATORY SETTLING TEST SUMMARY
for the
LAMELLA GRAVITY SETTLER/THICKENER (LGST)

For: ENSR Consulting, Acton, MA.

Application: METAL HYDROXIDES

FEED AS RECEIVED:

Suspended Solids: 8.00 ppm pH: 6.95

FEED PRETREATMENT:

Chemicals Used:	ppm	
SODIUM HYDROXIDE	232	New Suspended Solids Level: 1052.00 ppm
SLUDGE RECYCLE	779	New pH: 11.32
		Temperature: Ambient

FLOCCULATING AIDS:

Manufacturer	Polymer	Dosage ppm	Flash sec	Flocc. min
	EXXON JAYFLOC 803	2.00	10	1

OUR RECOMMENDATIONS:

Based on a maximum feed rate of 70 GPM, we recommend the use of: 1 Model 200/55 LGS. Each unit has 160 sq.ft. of clarification area and 40 sq.ft. of thickening area.
At the maximum feed rate, the surface loading rate is 0.43 GPM/sq.ft.
At this loading rate, the unit will produce an effluent containing less than 20 ppm suspended solids and an underflow containing at least 1.5-2.0% suspended solids, if attainable in static settling tests.

LS1

Date Tested: 05/04/94 Customer Sample Number: 9730

COMMENTS:

The sample as received contined 8 ppm total suspended solids with a pH of 6.95. The customer is concerned with the removal of iron and manganese and suggested the metals be removed by raising the pH to approxiamtely 11.00 and testing with various polymers as well as Exxon Jay-Floc 803. 232 ppm of sodium hydroxide was added to the sample increasing the pH to 11.32 and the t.s.s. to 273 ppm. Bench top flocculation tests were performed using cationic, anionic and nonionic polymers. The best results were obtained by using sludge recycling. This increased the t.s.s. solids to 1,052 ppm. When 2 ppm of Exxon Jay-Floc 803 was added for flocculation an effluent clarity of less than 20 ppm was obtained.

The iron is in the form of ferrous hydroxide which precipatates at a pH of approximately 11.0.

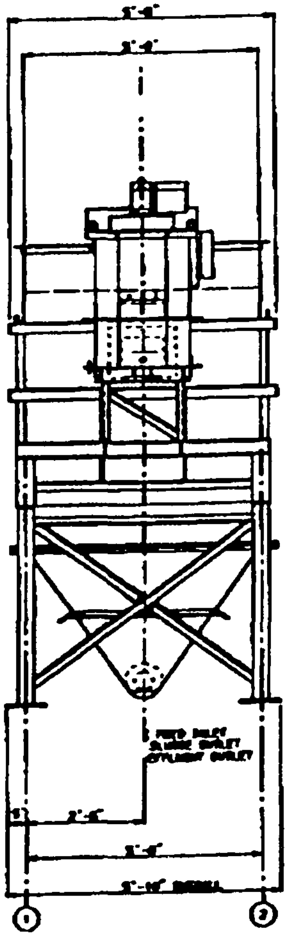
REPORTED BY: Dorothy D. Rich, Laboratory Chemist DDR

REPORT DATE: 05/12/93

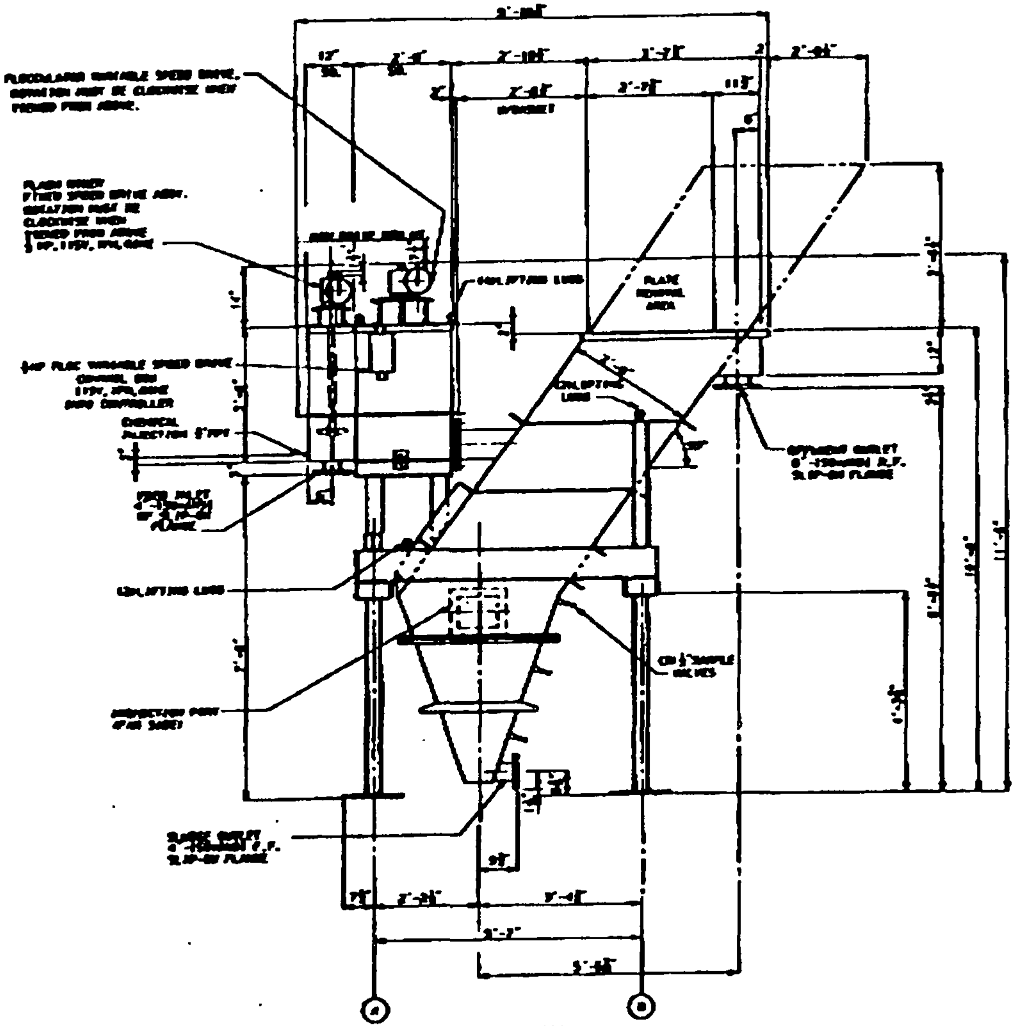
BJH:gjp

H13

L055200FAX



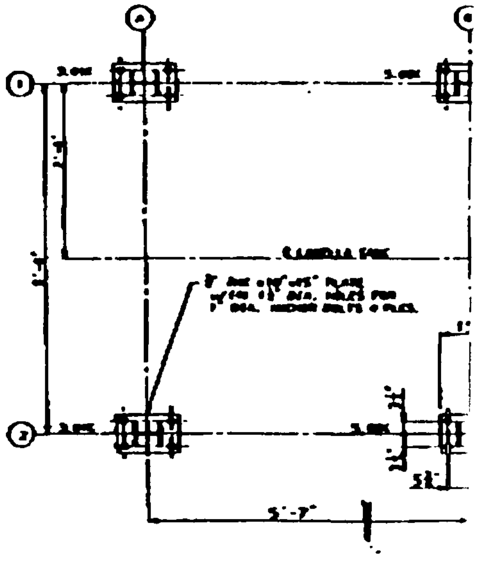
FRONT ELEVATION



SIDE ELEVATION

SHIPPING WEIGHT
LAMELLA TANK, 6700 LB.
FLOC & MIX TANK 900LB.
TOTAL WT. 7100LB.

WEIGHT FULL OF LIQUID
LAMELLA [illegible] 14200 LB.
FLOC & [illegible]NK 2,000LB.
TOTAL W[illegible]200LB.



LOADING DIAGRAM

FOR REFERENCE ONLY
NOT FOR CONSTRUCTION

PARKSON
FLOC-MIX TANK
LGS

VPSI REPORT

415

May 3, 1994

Mr. Craig McPhee
ENSR Consulting & Engineering
35 Nagog Park
Action, MA 01720

RE: **perox-pure™** Treatability Testing on the SRSNE Groundwater
ENSR Purchase Order No. 94139
VPSI Project No. 396

Dear Craig:

Enclosed please find three (3) bound copies of our Process Assessment report entitled "Process Assessment of the **perox-pure™** Process for the Destruction of Organic Contaminants in Groundwater." This report details the design of a treatment system based on two treatment objectives 1) the Federal MCL's and 2) < 100 μg/l for each contaminant as requested. The results of the aquatic toxicity testing and the confirmation test are not available at this time. However, this information will be included as an attachment along with a discussion of the results when received.

If you have any questions regarding this report, please feel free to contact either Mike Donaway of our Cranford, New Jersey office at (908) 276-0044 or myself at (602) 790-8383.

Thank you for your interest in our products and services.

Sincerely,

VULCAN PEROXIDATION SYSTEMS INC.

Lisa M. Thornton

Lisa M. Thornton
Process Engineer

LMT:cmg

cc: Frederick E. Bernardin, VPSI - Tucson, Arizona
Jim Doherty, ENSR
Mike Donaway, VPSI - Cranford, New Jersey
Emery Froelich, VPSI - Tucson, Arizona
Chris Giggy, VPSI - Tucson, Arizona
Norman Olson, VPSI - Tucson, Arizona
Jeff Prellberg, VPSI - Tucson, Arizona
VPSI File

Peroxidation Sy
5151 E. Broadway, Suite 600 [illegible] 602-790-8383 FAX [illegible]

Confidential Process Assessment

Assessment of the perox-pure™ Process for the Destruction of Organic Contaminants in Groundwater

prepared for

ENSR CONSULTING
& ENGINEERING
Acton, MA
Purchase Order No. 94139
VPSI Project No. 396

Submitted by

Vulcan Peroxidation Systems, Inc.
5151 E. Broadway, Suite 600
Tucson, Arizona 85711

May 3, 1994

Peroxidation Systems Inc.

CONFIDENTIAL PROCESS ASSESSMENT

ASSESSMENT OF THE **perox-pure™** PROCESS FOR THE DESTRUCTION OF ORGANIC CONTAMINANTS IN GROUNDWATER

prepared for

ENSR Consulting & Engineering
Acton, MA
Purchase Order No. 94139
VPSI Project No. 396

by

Vulcan Peroxidation Systems, Inc.
5151 East Broadway, Suite 600
Tucson, Arizona 85711

May 3, 1994

The information contained in this report includes descriptions and procedures which are confidential to Vulcan Peroxidation Systems, Inc. The report shall not be copied nor released to third parties without prior approval from Vulcan Peroxidation Systems, Inc.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Vulcan Peroxidation Systems, Inc. (VPSI) has performed a bench-scale evaluation for ENSR Consulting & Engineering (ENSR) to determine the effectiveness of the **perox-pure™** Process in destroying the organic contaminants in the groundwater from the Solvents Recovery Service of New England (SRSNE) site. The organic contaminants of concern include approximately 87 mg/l of volatile and semi-volatile organic compounds.

The **perox-pure™** system provides effective treatment of the contaminated groundwater at the SRSNE site. Destruction of the target contaminants to below the treatment objectives was demonstrated. The unique difference between the **perox-pure™** organic destruction process and other treatment technologies is its ability to actually destroy organics to non-detectable levels. It does this by combining the effects of ultraviolet light (UV) and hydrogen peroxide (H_2O_2) in a closed reactor. The UV light cleaves the H_2O_2, thereby forming the powerful hydroxyl radicals. The hydroxyl radicals oxidize the organics to carbon dioxide and water. Any halogens present are converted to halides.

Two treatment scenarios are presented herein as requested by ENSR. One scenario is the treatment of the groundwater to the Federal MCL's (Case 1). The second scenario is the treatment of the groundwater contaminants to < 100 μg/l each (Case 2). The full-scale design flow rate is 35 gpm.

Successful full-scale treatment of the groundwater at the specified flow rate of 35 gpm is projected to occur with a power requirement of 210 kW for both Cases 1 and 2. The budgetary capital investment for Cases 1 and 2 is $300,000. Including electricity, H_2O_2, and maintenance, the treatment cost is estimated to be $9.83 per 1000 gallons for both Cases.

Both the capital and operating costs would be significantly reduced if the raw water contains the 14 mg/l expected as opposed to the 87 mg/l seen in the sample tested and upon which treatment calculations were made.

The **perox-pure™** Process offers the advantages of a proven, cost-effective treatment system that creates no air emissions, or generation of secondary waste products and is backed by the security of more than 80 successful full-scale installations world-wide.

1.0 INTRODUCTION

The **perox-pure™** Process destroys dissolved organic contaminants in water by means of chemical oxidation. Ultraviolet (UV) light catalyzes the chemical oxidation of organic contaminants in water by its combined effect upon the organic contaminants and its reaction with hydrogen peroxide (H_2O_2). Many organic contaminants absorb UV light and may undergo a change in their chemical structure or may become more reactive with chemical oxidants. More importantly, UV light at less than 400 nm wavelength reacts with H_2O_2 molecules to form hydroxyl radicals. These powerful chemical oxidants then react with the organic contaminants in the water. If carried to completion the reaction products of hydrocarbon oxidation with the **perox-pure™** Process are carbon dioxide and water.

Vulcan Peroxidation Systems, Inc. (VPSI) was contracted by ENSR Consulting and Engineering (ENSR) to perform a bench-scale study on contaminated groundwater using the **perox-pure™** Process. The groundwater reportedly contained an average concentration of 14 mg/l of volatile and semi-volatile organics. The as-received water contained approximately 87 mg/l of volatile and semi-volatile organic compounds. The treatment objective specified by ENSR was the destruction of the organics to the Federal MCL's for one case and to less than 100 μg/l each for the second case at a flow rate of 35 gpm.

A bench-scale **perox-pure™** study was performed on the groundwater during March of 1994 at the VPSI Testing Laboratory in Tucson, Arizona. These tests were designed to provide a range of data from which full-scale treatment criteria and costs would be projected.

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2.0 BENCH-SCALE LABORATORY TESTING

2.1 Testing Procedures

2.1.1 Description of Groundwater

On March 16, 1994, 120 liters of groundwater were received from ENSR at the VPSI Laboratory in Tucson, Arizona. The water was contained in 30 (4) liter glass bottles with no headspace.

Characterization of the water sample was performed by VPSI to determine parameters of importance for **perox-pure™** treatment. The results are shown in Table 1.

Table 1

Sample Characterization Results
for the SRSNE Groundwater

	Raw Water	Pretreated
Visual Color:	Pale Yellow	Pale Yellow
Visual Appearance:	Turbid	Clear
pH:	6.8	6
Iron (mg/l):	61	0.15/36(2)
Chloride (mg/l):	112	121
Chemical Oxygen Demand (mg/l):	409	353
Total Organic Carbon (mg/l):	68	57
Total Dissolved Solids (mg/l):	370	320
Total Suspended Solids (mg/l):	150/<5(1)	<5
Alkalinity (mg/l):	181	86
Turbidity (NTU):	23	0.84
NO_3 (mg/l):	0.4	0.8
Manganese:	7.0	N/A

(1) Water samples were not composited and had different amounts of solids.
(2) Pretreatment with 3 micron filtration and no H_2O_2
N/A Not Analyzed

2.1.2 Testing Protocol

The bench-scale **perox-pure™** test unit was charged by placing an aliquot of the water into a recycle reservoir. A pump was started which circulated the solution through the reactor and back into the reservoir providing continual mixing in the closed system. The UV lamp was illuminated to start a test, and H_2O_2 was added as required to maintain a constant concentration in solution. All materials in contact with the solution were glass, quartz, stainless steel, viton or teflon.

After the appropriate retention times, samples of the treated water were collected in 40-ml septum vials. An untreated sample was also collected the same way. These samples were analyzed by VPSI using EPA Method 601/602/ protocols.

2.2 Testing Results

2.2.1 Pretreatment

Pretreatment of the groundwater was performed to remove iron and solids. The as-received water was found to differ in concentration of turbidity (23 NTU to 7.5 NTU) and TSS (150 mg/l to <5 mg/l) depending on the sample bottle. The iron concentration was approximately 61 mg/l. Two pretreatment methods were evaluated, 1) filtration through a 3 micron cartridge filter, and 2) H_2O_2 addition followed by filtration. The H_2O_2 with filtration pretreatment method provided the best oxidation rates. The H_2O_2 dosage used for pretreatment was 180 mg/l. After H_2O_2 addition, the water became orange in color without forming a settleable floc. The color filtered out along with the iron.

2.2.2 perox-pure™ Testing

Ten (10) **perox-pure™** treatment tests were performed by VPSI on the SRSNE groundwater. These tests were designed to determine the effects of pretreatment, H_2O_2 dosage, UV configuration, and pH adjustment on the rate of contaminant destruction. The test conditions are shown in Table 2.

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Table 2

Bench-Scale **perox-pure™** Treatment Conditions
for the SRSNE Groundwater

Test	**Pretreatment**	**H_2O_2 in Solution (mg/l)**	**Initial pH**	**UV Density**	**UV Lamp System**
1	None	250	4.0	D-II	A
2	Filter	250	4.0	D-II	A
3	H_2O_2/Filter	250	4.0	D-II	A
4	Filter	250	4.0	D-I	A
5	H_2O_2/Filter	250	6.0	D-II	A
6	H_2O_2/Filter	250	4.0	D-I	A
7	H_2O_2/Filter	150	6.0	D-II	A
8	H_2O_2/Filter	400	6.0	D-II	A
9	H_2O_2/Filter	250	6.0	D-II	B
10	H_2O_2/Filter	250	6.0	D-I	C

The test results are shown in Table 3 and shown in Figures 1 through 4. A total of 25 volatile and semi-volatile organics were identified. The unsaturated compounds, such as DCE and TCE, were more rapidly oxidized and were destroyed to below the treatment objectives with 2 minutes of oxidation or less in most tests. The saturated compounds ($MeCl_2$, and 1,1,1-TCA) oxidized slower, but were also destroyed to the treatment objectives with 4 minutes or less of oxidation. In each test $MeCl_2$ and 1,1,1-TCA were the rate limiting contaminants, with $MeCl_2$ being the slowest to oxidize.

Table 3

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

Contaminant (μg/l)	**Oxidation Time (min.)**			
	0	**2**	**4**	**6**
Test 1				
Vinyl Chloride	8556	13	<1	<1
Chloroethane	619	<5	<1	<1
Freon-113	106	12	<1	<1
1,1-DCE	163	1	<1	<1
Methylene Chloride	2510	196	18	<1
1,1-DCA	1624	14	<1	<1
c-1,2-DCE	13200	<5	<1	<1
1,1,1-TCA	2756	754	203	26
1,2-DCA	186	<5	<1	<1
TCE	460	<5	<1	<1
Acetone	3490	483	11	<1
MEK	7854	<5	<1	<1
Benzene	99	<5	<1	<1
MIBK	2963	<5	<1	4
Toluene	12380	<5	<1	<1
Ethylbenzene	3188	<5	<1	<1
m,p-Xylene	3717	<5	<1	<1
o-Xylene	1415	<5	<1	<1
T-1,2-DCE	3484	<5	<1	<1
THF	344	<5	<1	<1
Freon-11	<50	6	3	<1
Chloroform	<50	5	2	<1

Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

Contaminant (μg/l)	**Oxidation Time (min.)**			
	0	**2**	**4**	**6**
Test 2				
Vinyl Chloride	5262	<5	<1	<1
Chloroethane	757	<1	<1	<1
1,1-DCE	118	11	<1	<1
Methylene Chloride	2168	94	3	<1
1,1-DCA	1343	5	4	<1
C-1,2-DCE	9853	<1	<1	<1
1,1,1-TCA	1978	395	61	10
1,2-DCA	164	<1	<1	<1
TCE	237	<1	<1	<1
T-1,2-DCE	2478	<1	<1	<1
Acetone	3115	128	<1	<1
MEK	7475	<1	<1	<1
Benzene	89	<1	<1	<1
MIBK	2668	<1	<1	<1
Toluene	6549	<1	<1	<1
Ethylbenzene	1309	<1	<1	<1
m,p-Xylene	1470	<1	<1	<1
o-Xylene	632	<1	<1	<1
THF	500	<1	<1	<1

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Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results for the SRSNE Groundwater

Contaminant (μg/l)	**Oxidation Time (min.)**			
	0	**2**	**4**	**6**
Test 3				
Vinyl Chloride	727	3	<1	<1
Chloroethane	488	<1	<1	<1
Freon-113	<50	3	<1	1
Methylene Chloride	2111	128	<1	<1
1,1-DCE	67	13	<1	<1
1,1-DCA	1290	13	<1	<1
Chloroform	<50	5	<1	<1
c-1,2-DCE	4680	5	<1	<1
1,1,1-TCA	1950	413	11	<1
1,2-DCA	140	2	<1	<1
TCE	110	<1	<1	<1
T-1,2-DCE	457	<1	<1	<1
Acetone	2680	258	<1	<1
MEK	6670	<1	<1	<1
Benzene	<50	<1	<1	<1
MIBK	1550	<1	<1	<1
Toluene	1580	<1	<1	<1
Ethylbenzene	299	<1	<1	<1
m,p-Xylene	397	<1	<1	<1
o-Xylene	179	<1	<1	<1
Freon-111	<50	7	<1	<1
1,1,2-TCA	<50	1	<1	<1

Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

	Oxidation Time (min.)			
Contaminant (μg/l)	**0**	**2**	**4**	**6**
<u>Test 4</u>				
Vinyl Chloride	5952	<5	11	3
Chloroethane	1014	<5	<1	<1
Freon-11	26	9	9	6
Freon-13	35	11	3	2
1,1-DCE	250	<5	<1	<1
Methylene Chloride	4133	639	282	126
T-1,2-DCE	473	<5	2	<1
1,1-DCA	2779	146	43	8
c-1,2-DCE	23590	<5	<1	<1
Chloroform	<20	10	8	5
1,1,1-TCA	4230	1347	777	483
1,2-DCA	341	10	5	<1
TCE	1037	<5	<1	<1
1,1,2-TCA	80	6	3	<1
PCE	41	<5	<1	<1
Acetone	9779	1876	730	232
MEK	19612	<5	<1	<1
THF	2518	<5	<1	<1
Benzene	161	<5	<1	<1
MIBK	6111	<5	<1	<1
Toluene	17891	<5	<1	<1
Chlorobenzene	25	<5	<1	<1
Ethylbenzene	4092	<5	<1	<1
m,p,-Xylene	4769	<5	<1	<1
o-Xylene	2004	<5	<1	<1

Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

Contaminant (μg/l)	**Oxidation Time (min.)**			
	0	**2**	**4**	**6**
Test 5				
Vinyl Chloride	1220	<1	<1	<1
Chloroethane	433	<1	<1	<1
Freon-113	23	3	<1	<1
1,1-DCE	57	<1	<1	<1
Methylene Chloride	2152	116	<1	<1
T-1,2-DCE	545	<1	<1	<1
1,1-DCA	1345	12	<1	<1
c-1,2-DCE	5915	<1	<1	<1
Chloroform	42	4	<1	1
1,1,1-TCA	1977	373	12	<1
1,2-DCA	172	1	<1	<1
TCE	167	<1	<1	<1
1,1,2-TCA	34	<1	<1	<1
Acetone	5541	236	13	<1
MEK	7793	<1	<1	<1
Benzene	28	<1	<1	<1
MIBK	1803	<1	<1	<1
Toluene	2514	<1	<1	<1
Ethylbenzene	493	<1	<1	<1
m,p,-Xylene	506	<1	<1	<1
o-Xylene	227	<1	<1	<1
THF	354	<1	<1	<1
Freon-11	<20	7	<1	<1
Isopropyl Alcohol	2.4	<1	<1	<1
2-Butanol	3.0	<1	<1	<1

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Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

Contaminant (μg/l)	**Oxidation Time (min.)**			
	0	**2**	**4**	**6**
<u>Test 6</u>				
Vinyl Chloride	2373	42	8	<1
Chloroethane	594	20	<1	<1
Freon-11	<20	10	6	3
Freon-113	<20	4	1	<1
1,1-DCE	103	15	13	<1
Methylene Chloride	2069	672	180	24
T-1,2-DCE	247	<1	<1	<1
1,1-DCA	1263	252	18	<1
c-1,2-DCE	10937	<1	<1	<1
1,1,1-TCA	1652	766	423	190
1,2-DCA	161	26	1	<1
TCE	320	<1	<1	<1
1,1,2-TCA	32	13	1	<1
Acetone	5378	3661	372	14
MEK	9227	24	<1	<1
Benzene	54	<1	<1	<1
MIBK	2891	6	<1	<1
Toluene	5060	<1	<1	<1
Ethylbenzene	897	<1	<1	<1
m,p-Xylene	998	<1	<1	<1
o-Xylene	449	<1	<1	<1
THF	580	<1	<1	<1
Chloroform	<20	11	5	2

Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

	Oxidation Time (min.)			
Contaminant (µg/l)	**0**	**2**	**4**	**6**
Test 7				
Vinyl Chloride	1891	16	43	<1
Chloroethane	534	14	<1	<1
Freon-11	<20	15	8	2
Freon-113	36	5	3	1
1,1-DCE	68	1	<1	<1
Methylene Chloride	2295	688	53	<1
T-1,2-DCE	849	<1	<1	<1
1,1-DCA	1456	263	2	<1
c-1,2-DCE	6528	1	<1	<1
1,1,1-TCA	2074	685	93	2
1,2-DCA	182	33	<1	<1
TCE	152	<1	<1	<1
1,1,2-TCA	36	22	<1	<1
PCE	<20	<1	<1	<1
Acetone	5821	2847	13	<1
MEK	7947	12	<1	<1
THF	452	<1	<1	<1
Benzene	37	<1	<1	<1
MIBK	1896	12	<1	<1
Toluene	2864	<1	<1	<1
Ethylbenzene	596	<1	<1	<1
m,p-Xylene	568	<1	<1	<1
o-Xylene	270	<1	<1	<1
Chloroform	<20	11	2	<1

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Table 3 (cont'd)

Bench-Scale **perox-pure**™ Treatment Results
for the SRSNE Groundwater

	Oxidation Time (min.)			
Contaminant (µg/l)	**0**	**2**	**4**	**6**
<u>Test 8</u>				
Vinyl Chloride	1923	<1	<1	<1
Chloroethane	738	<1	<1	<1
Freon-11	<20	4	<1	<1
Freon-113	28	2	1	<1
1,1-DCE	88	6	<1	<1
Methylene Chloride	2181	76	<1	<1
T-1,2-DCE	797	<1	<1	<1
1,1-DCA	1339	6	<1	<1
c-1,2-DCE	6887	<1	<1	<1
1,1,1-TCA	1911	261	3	<1
1,2-DCA	170	<1	<1	<1
TCE	161	<1	<1	<1
1,1,2-TCA	36	<1	<1	<1
Acetone	3891	106	<1	<1
MEK	7282	<1	<1	<1
THF	<20	<1	<1	<1
Benzene	39	<1	<1	<1
MIBK	1909	<1	<1	2
Toluene	3097	<1	<1	<1
Ethylbenzene	650	<1	<1	<1
m,p-Xylene	649	<1	<1	<1
o-Xylene	292	<1	<1	<1

Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

Contaminant (μg/l)	**Oxidation Time (min.)**			
	0	**2**	**4**	**6**
Test 9				
Vinyl Chloride	1839	5	<1	<1
Chloroethane	841	<1	<1	<1
Freon-11	<20	11	2	<1
Freon-113	54	5	<1	<1
1,1-DCE	86	3	<1	<1
Methylene Chloride	2217	303	<1	<1
T-1,2-DCE	708	<1	<1	<1
1,1-DCA	1359	56	<1	<1
c-1,2-DCE	5610	<1	<1	<1
Chloroform	<20	7	<1	<1
1,1,1-TCA	1881	532	4	<1
1,2-DCA	172	5	<1	<1
TCE	148	<1	<1	<1
1,1,2-TCA	34	5	<1	<1
PCF	<20	<1	<1	<1
Acetone	4618	675	<1	<1
MEK	6918	<1	<1	<1
THF	204	<1	<1	<1
Benzene	26	<1	<1	<1
MIBK	1708	2	<1	<1
Toluene	2514	<1	<1	<1
Ethylbenzene	506	<1	<1	<1
m,p-Xylene	482	<1	<1	<1
o-Xylene	229	<1	<1	<1

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Table 3 (cont'd)

Bench-Scale **perox-pure™** Treatment Results
for the SRSNE Groundwater

	Oxidation Time (min.)			
Contaminant (µg/l)	**0**	**2**	**4**	**6**
Test 10				
Vinyl Chloride	3368	6	<1	<1
Chloroethane	518	32	<1	<1
Freon-11	<20	9	8	3
Freon-113	229	8	4	1
1,1-DCE	135	15	9	<1
Methylene Chloride	2205	848	103	<1
T-1,2-DCE	636	<2	<1	<1
1,1-DCA	1394	332	8	<1
c-1,2-DCE	11303	<2	<1	<1
Chloroform	<20	12	4	<1
1,1,1-TCA	1887	858	350	28
1,2-DCA	185	36	<1	<1
TCE	384	<2	<1	<1
1,1,2-TCA	44	17	<1	<1
Acetone	5071	3411	130	<1
MEK	9682	56	<1	<1
THF	1268	<2	<1	<1
Benzene	60	<2	<1	<1
MIBK	3126	7	<1	<1
Toluene	6556	<2	<1	1
Ethylbenzene	1391	<2	<1	<1
m,p-Xylene	1500	<2	<1	<1
o-Xylene	665	<2	<1	<1

2.3 Discussion

The primary objective of the bench-scale study discussed herein was to determine the best **perox-pure™** treatment conditions for rapid destruction of VOCs in the groundwater. Based on the treatment objectives, $MeCl_2$ was found to be the rate limiting contaminant for Case 1 and 1,1,1-TCA was the rate limiting contaminant for Case 2. The effect of each treatment parameter is discussed below.

2.3.1 H_2O_2

The effects of H_2O_2 dosage on the $MeCl_2$ destruction is shown in Figure 1. The H_2O_2 dosage was varied from 150 mg/l to 400 mg/l. The $MeCl_2$ rate was increased 2.8 times with a H_2O_2 dosage of 400 mg/l (Test 8) as compared to 150 mg/l (Test 7). Although not as significant, the $MeCl_2$ rate was 1.15 times greater with a H_2O_2 dosage of 400 mg/l (Test 8) as compared to 250 mg/l (Test 5). Therefore, the recommended H_2O_2 dosage is 400 mg/l.

2.3.2 pH

Figure 2 shows the effect of pH adjustment on the $MeCl_2$ destruction rate. There was no significant increase in the $MeCl_2$ rate observed in Test 3 (pH 4) as compared to Test 5 (pH 6.5). In addition, pH adjustment was not required to avoid formation of tube coating or scaling during Test 5. Treatment without pH adjustment is recommended.

2.3.3 Pretreatment

Pretreatment was evaluated in Tests 1, 2 and 3. Pretreatment with H_2O_2 and filtration (Test 3) increased the $MeCl_2$ destruction rate 1.7 times as compared to no pretreatment (Test 1) and 1.3 times greater than filtering alone (Test 2) at 4 minutes of oxidation. The destruction rates for 1,1,1-TCA were increased 2 times with H_2O_2 and filtration (Test 3) as compared to no pretreatment (Test 1) and were 1.5 times greater than with filtration only (Test 2). Figure 3 shows the effects of pretreatment comparing the $MeCl_2$ destruction rates for Tests 1,2, and 3. Treatment with H_2O_2 addition followed by filtration is recommended.

2.3.4 Reactor Configuration

The effects of reactor UV density and UV lamp system type were evaluated in Tests 6, 8 and 10 and are shown graphically in Figure 4. The $MeCl_2$ destruction rate was increased 3 fold using density D-II (Test 8) as compared to density D-I (Test 6). This 3 fold increase in which 15% can be attributed to the higher H_2O_2 dosage makes the D-II system more economical. Comparing Tests 6 and 10 where the only difference was the lamp system, a 2 fold increase in the $MeCl_2$ destruction rate was observed in Test 10 (lamp system LS-C) as compared to Test 6 (lamp system LS-A).

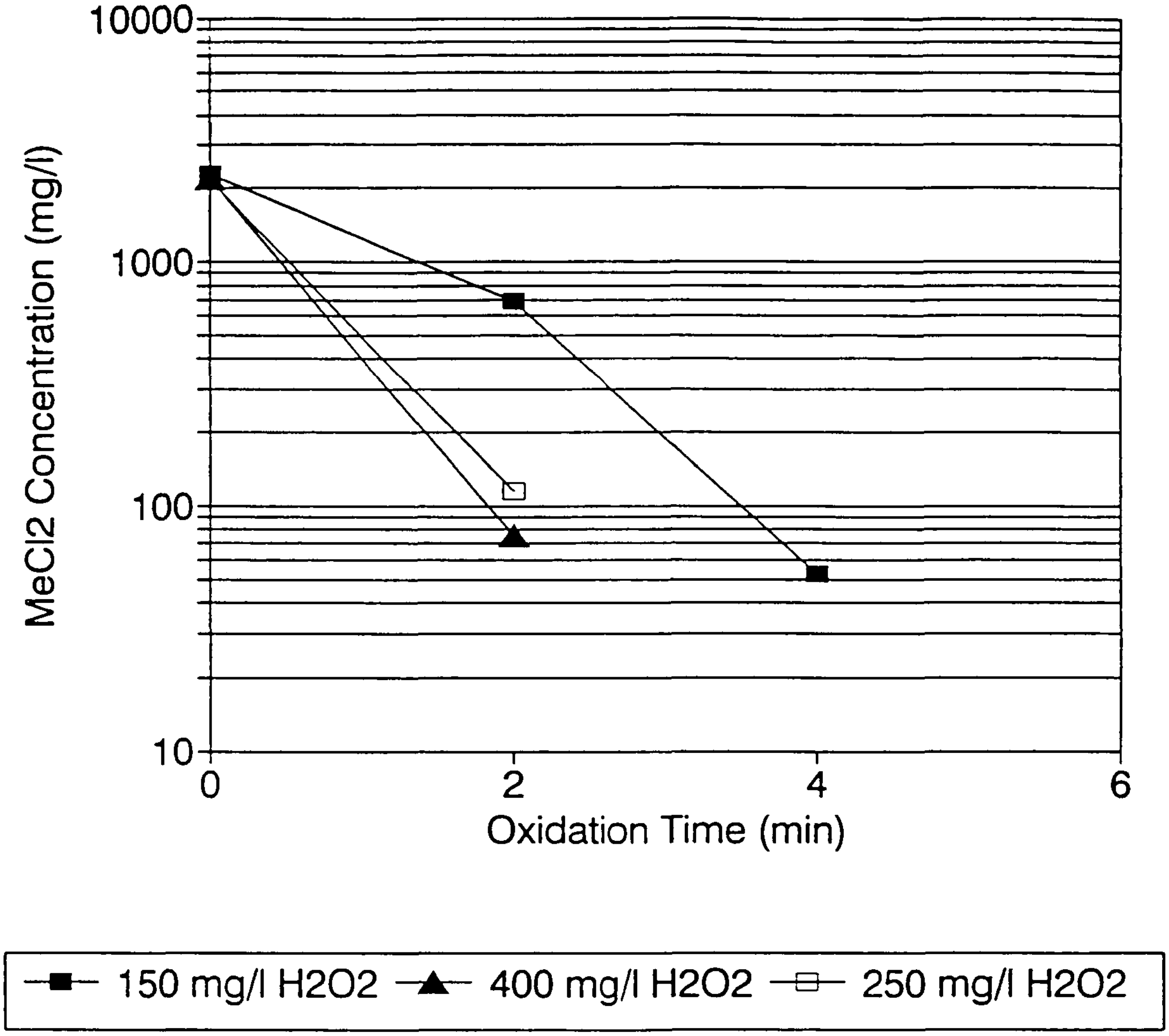
Test 9 was performed to evaluate the lamp system LS-B on the contaminant destruction rates. No benefit to LS-B was indicated.

2.3.5 Summary

Based on the test data, a reactor configuration which combines the positive effects of D-II and LS-C as shown in Figure 4 will be used. The selection will provide the best oxidation rate for the $MeCl_2$ and the 1,1,1-TCA. Other conditions include H_2O_2/filtration pretreatment at an unadjusted pH (approx. 6) and with a H_2O_2 dosage of 400 mg/l in solution.

FIGURE 1

EFFECTS OF H_2O_2 DOSAGE ON THE $MeCl_2$ DESTRUCTION FOR THE SRSNE GROUNDWATER



H4C

FIGURE 2

EFFECTS OF pH ADJUSTMENT ON THE $MeCl_2$ DESTRUCTION FOR THE SRSNE GROUNDWATER

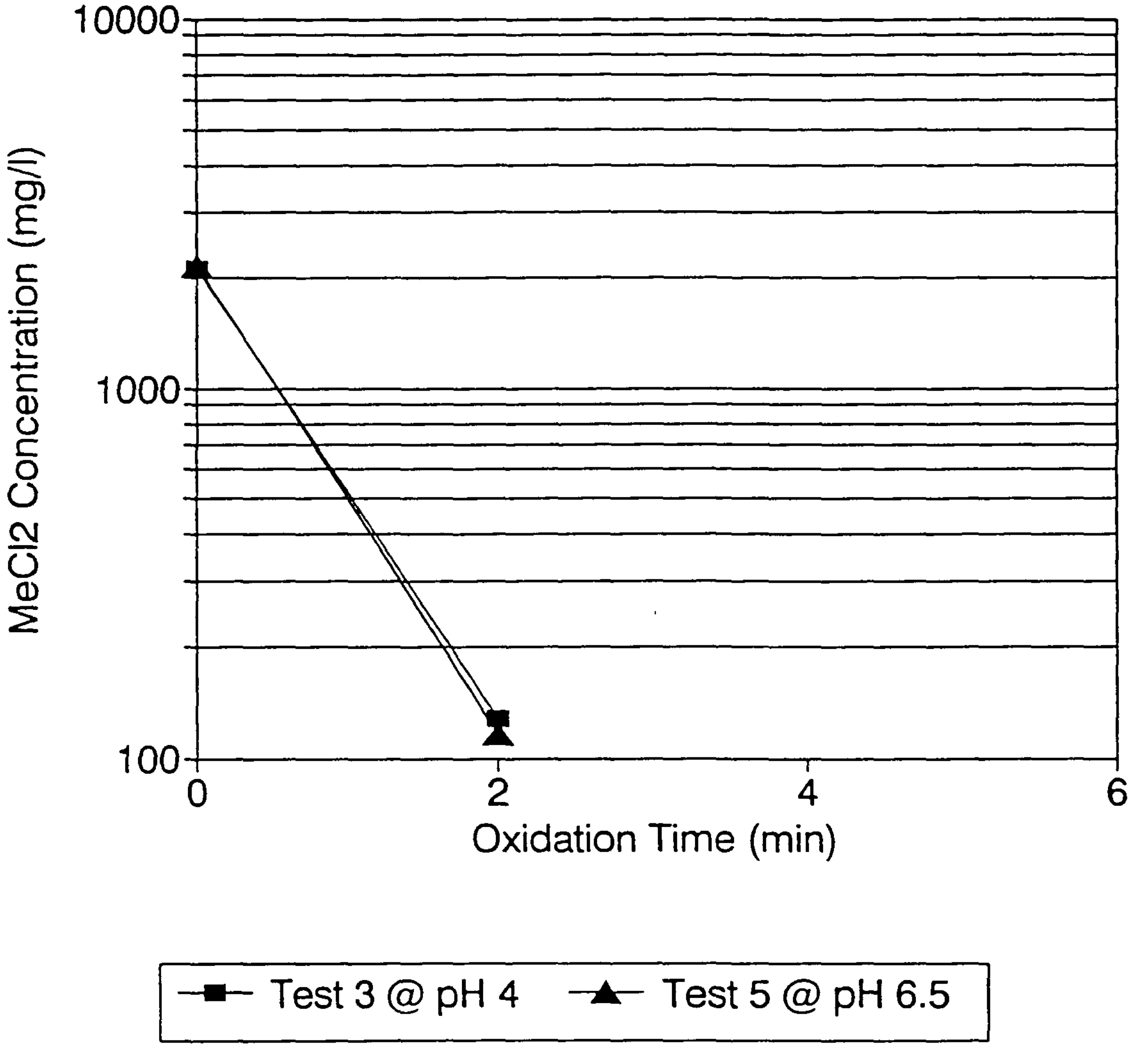
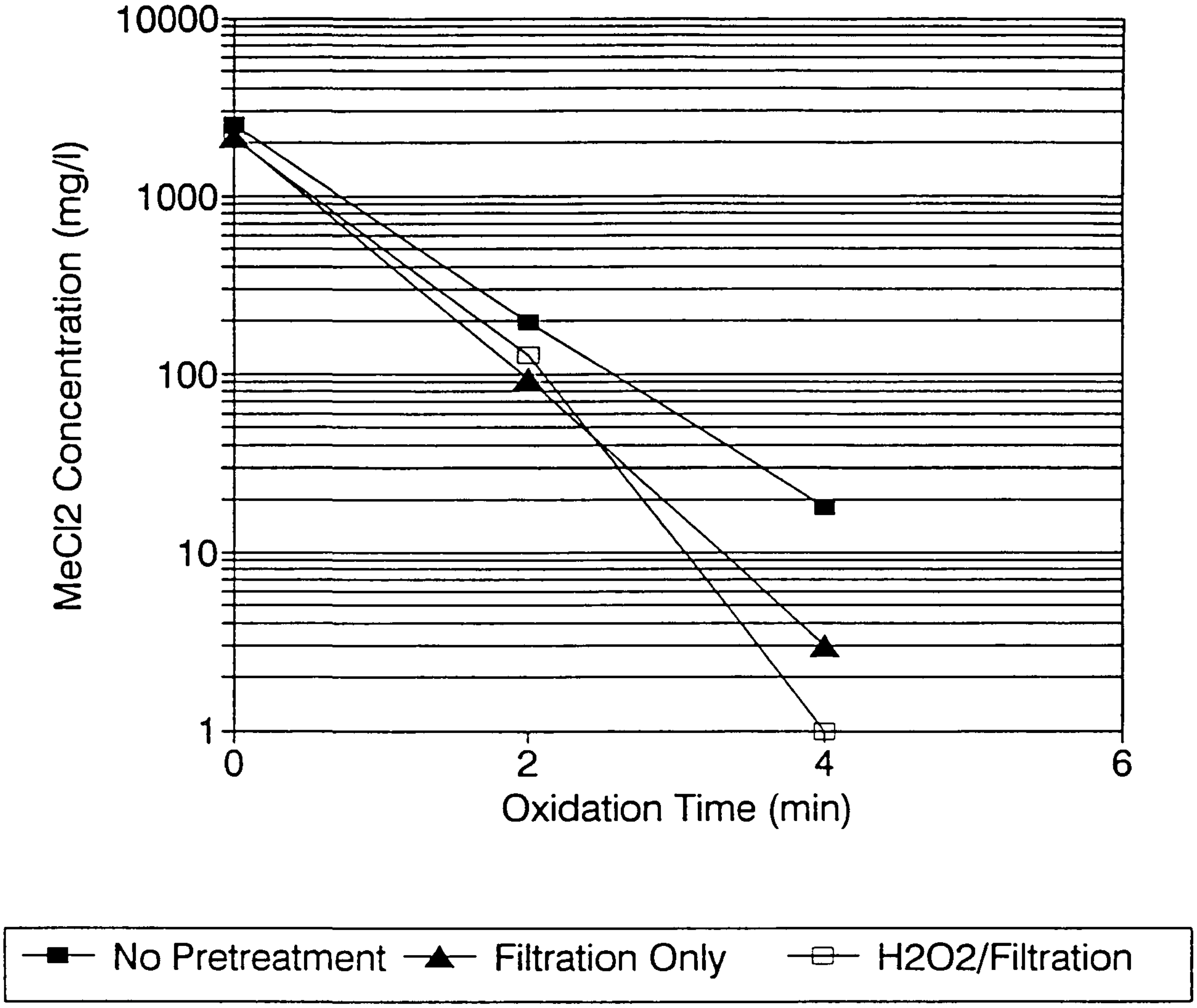


FIGURE 3

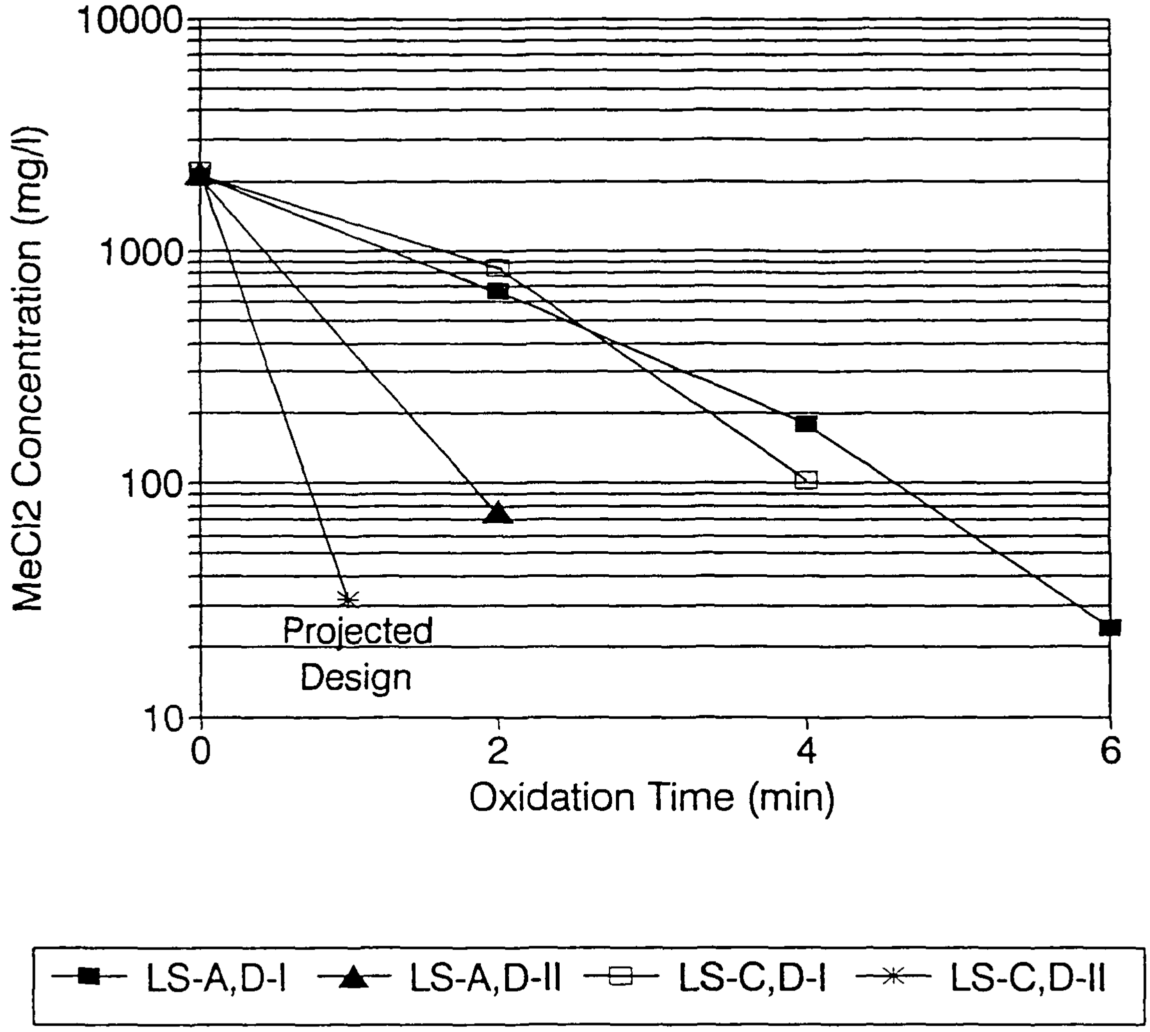
EFFECTS OF PRETREATMENT ON THE $MeCl_2$ DESTRUCTION FOR THE SRSNE GROUNDWATER



H42

FIGURE 4

EFFECTS OF REACTOR CONFIGURATION ON THE $MeCl_2$ DESTRUCTION FOR THE SRSNE GROUNDWATER



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2.4 Laboratory Testing Summary

This bench-scale testing program has demonstrated that the **perox-pure™** Process is an effective method of treating the contaminated groundwater to meet the required treatment objectives. Specific test results and treatment observations are as follows.

1) The as-received groundwater contained approximately 87 mg/l of saturated and unsaturated VOCs.

2) A total of ten (10) bench-scale tests were performed on the SRSNE groundwater evaluating the effects of pretreatment, H_2O_2 dosage, pH adjustment and reactor configuation on the rate of contaminant destruction.

3) The groundwater was pretreated to remove iron and solids. Filtering through a 3 micron cartridge filter and H_2O_2 addition followed by filtration were the pretreatments evaluated. The use of H_2O_2 and filtration improved the contaminant destruction rates significantly as compared to no pretreatment or filtration alone.

4) Methylene chloride was determined to be the rate limiting contaminant for the treatment objectives of Federal MCL's. For the treatment objective of <100 ppb for each contaminant, 1,1,1-TCA was determined to be rate limiting.

5) The best conditions and recommended parameters for full-scale treatment are reactor configuration D-II, LS-C; H_2O_2 with filtration for pretreatment; pH as is; and a H_2O_2 dosage of 400 mg/l. Under these conditions an oxidation time of 1.5 minutes is required to meet the MCL objectives for $MeCl_2$ and the 1,1,1-TCA objective of <100 ppb.

3.0 PROCESS ASSESSMENT

3.1 Full-Scale Treatment Conditions

3.1.1 Treatment Criteria

The treatment criteria and design flow rate specified by ENSR are shown in Table 4. Case 1 represents the effluent objective of the Federal MCL's for each contaminant. Case 2 represents the criteria of < 100 ppb for each contaminant as specified by ENSR. The design flow rate is 35 gpm.

Table 4
Criteria for Full-Scale Treatment of the SRSNE Groundwater

Flow rate (gpm) 35

Contaminant	**Influent (μg/l)**	**Effluent (μg/l)**	
		Case 1 MCL	**Case 2 <100**
Vinyl Chloride	5800	2	100
Chloroethane	1200	NR	100
1,1-DCE	320	7	100
Methylene Chloride	3000	5	100
T-1,2-DCE	87	100	100
1,1-DCA	2100	NR	100
C-1,2-DCE	21000	70	100
1,1,1-TCA	3400	200	100
1,2-DCA	170	5	100
TCE	1000	5	100
1,1,2-TCA	49	5	100
PCE	54	5	100
Acetone	4300	NR	100
MEK	11000	NR	100
THF	1300	NR	100
Benzene	160	5	100
MIBK	3800	NR	100
Toluene	15000	1000	100
Ethylbenzene	5000	NR	100
m,p-Xylene	6000	10000	100
o-Xylene	2300	10000	100

NR - Not regulated by Federal MCL's.

3.1.2 Recommended Process Conditions

Full-scale **perox-pure™** Process conditions are projected in Table 5. The full-scale oxidation time was calculated from the treatment criteria in Table 4 using the contaminant destruction rate data for $MeCl_2$ and 1,1,1-TCA in a reactor configuration combining density D-II and lamp system LS-C. The oxidation time for this system was then used along with the flow rate from Table 4 to determine the necessary power demand. The H_2O_2 dosage listed in Table 5 was calculated from the H_2O_2 concentration used in Test 8.

Table 5

Full-Scale **perox-pure™** Process Conditions
for Treatment of the SRSNE Groundwater

	Case 1	Case 2
Oxidation Time (min.)	1.5	1.5
Power Demand (kW)	210	210
50% H_2O_2 dosage (lbs/1000 gal)	6.7	6.7

3.2 Discussion of Equipment

The bench-scale testing indicates that at the specified flow rate of 35 gpm the target contaminants in the groundwater are oxidized to below the effluent levels specified by ENSR with 1.5 minutes of oxidation using 210 kW of power to the UV lamps for Cases 1 and 2.

A 50% H_2O_2 dosage of 6.7 pounds per 1,000 gallons is projected from the bench-scale testing. This results in a 50% H_2O_2 usage of 1010 gallons per month. VPSI therefore recommends that a 2500 gallon H_2O_2 storage and feed module be used to support the **perox-pure™** system. Assuming continuous operation, this would result in delivery of H_2O_2 to the site every 9 weeks.

The only utilities required include potable water for the safety shower, and 450 amps of 3 phase, 60 cycle.

VPSI's **perox-pure™** system is a complete skid mounted system with all required controls enclosed. Only a minimal foundation with containment dike, and electrical and plumbing connections are necessary. The equipment can operate with infrequent attention from the operator. It does require occasional servicing which VPSI can provide under several service agreement options.

3.3 Investment

The costs associated with the recommended **perox-pure™** system are presented in the following sections. Specifications for the **perox-pure™** equipment are included in Attachment A.

3.3.1 Capital Investment

The capital investment for the **perox-pure™** equipment is shown below. The customer is responsible for freight costs, site preparation and foundation, power to the battery limit, influent/effluent pipes, pretreatment or post-treatment equipment, taxes, special permits, pumps and tanks.

	Case 1/Case 2
Capital Investment	\$300,000
H_2O_2 (~~@ \$0.45/lb.)~~ Storage & Feed(1)	Included(1)
Start-up & Training	\$10,000
Total	\$310,000

(1)No capital investment for H_2O_2 storage and feed equipment when H_2O_2 is purchased from VPSI.

3.4.2 Treatment Cost

The projected costs for **perox-pure™** treatment of the groundwater are shown below. The energy cost is assumed to be \$0.06/kWh. The maintenance fee represents costs for lamp replacement.

	Case 1/Case 2 **perox-pure™** Operating Costs (\$/1000 gal)
H_2O_2 (@ \$0.45/lb)	\$3.00
Electricity (@ \$0.06/kWh)	\$6.00
Maintenance	\$0.83
TOTAL PER 1000 GALLONS	\$9.83

H4E

3.5 Conclusion

The **perox-pure™** Process can provide effective treatment of the contaminated groundwater to the effluent limits specified by ENSR as detailed in the process assessment presented herein. The **perox-pure™** Process offers the advantages of a proven, cost-effective treatment system that creates no air emissions, or generation of secondary waste products and is available under purchase or lease arrangements.

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ATTACHMENT A

SPECIFICATIONS FOR **perox-pure™** EQUIPMENT

SPECIFICATION

Ultraviolet Light/Hydrogen Peroxide Oxidation System

1. General

This specification describes the **perox-pure™** ultraviolet light (UV) - hydrogen peroxide (H_2O_2) oxidation system capable of destroying soluble toxic organic contaminants in water. These specifications are subject to change without notice.

Unloading, handling, installation, excavation, concrete work, finish painting, connecting piping, and electrical hookup are the responsibility of others.

2. Principle of Operation

The System utilizes the chemistry of UV/H_2O_2 reactions, which involves generation of hydroxyl radicals, and other reactive species, by the photochemical action of ultraviolet light on hydrogen peroxide. The hydroxyl radicals attack organic species.

The final products of the noted reaction are carbon dioxide, water, and inorganic ions.

3. Applicable Codes - (Latest Editions)

Uniform Building Code
Uniform Plumbing Code
Uniform Mechanical Code
National Electric Code
NFPA
OSHA

Note: Operating pressure is not to exceed 15 psig, ASME Code does not apply.

4. Equipment Description

UV/H_2O_2 Oxidation Module -

Maximum Inlet Pressure: 15 psig
Power Requirement: 3ph/60Hz/480V

Materials of Construction -

UV/H_2O_2 oxidation chamber, fluorocarbon lined 6063-T6 aluminum or 316L stainless steel.
Chemical tubing - type 316 stainless steel with compression fittings.
Process Piping - Sch. 80 CPVC.
Structural Steel Skids and Supports - carbon steel.
ASTM A-36 with chemical and weather resistant paint.
Electrical Enclosures - Enamelled carbon steel.
Wetted non-metallic components - Quartz, fluoroelastomers, or polymers resistant to UV, H_2O_2 and all chemicals present.

Design Features -

Oxidation Chamber

Lamps shall be horizontally mounted and removable without draining the oxidation chamber.

The lamp end enclosures shall be provided with hinged and gasketed doors.

All UV sensitive materials shall be shielded from the UV rays by material reflective of, or resistant to, UV.

The UV lamps shall be protected against contact with the fluid in the event of a leak.

Water shall be separated from contact with the UV lamps by quartz tubes sized for optimum lamp operating temperature.

The UV oxidation chamber shall be designed to efficiently distribute and collect the process water throughout the entire oxidation chamber in order to eliminate an uneven flow pattern or short-circuiting. Piping connections shall be designed so that the UV oxidation chamber will remain full of fluid after shutdown.

The oxidation chamber shall not have chamber penetrations for automatic quartz tube cleaner actuation mechanism.

Electrical Enclosures

Electrical enclosures shall have hinged and lockable doors.

Electrical enclosure cabinets shall be weatherproof. Lamp drive enclosures will be provided with intake air cooling fans to control the inside temperature. The fans shall operate continuously when the unit is running.

Access doors shall have limit switches to shut the power off should the doors be opened.

Circuitry

All wiring and electrical connections shall be protected against moisture to prevent electrical short or failure. Pressure indicators and temperature switches shall be in weatherproof housings.

All wiring and electrical components within the system shall be designed, constructed and installed in accordance with the latest edition of the National Electrical Code and all applicable State and local electrical codes.

Circuitry within the lamp drive enclosure shall be protected and disconnected by pre-wired circuit breaker rated at 30,000 amp minimum AIC with external ground fault sensor and shunt trip.

Lamp drives shall be of the high-power factor type.

Instrumentation and Controls

The UV system shall be controlled via a touch-screen interface to a programmable logic controller (PLC). Standard PLC is Siemens Model TI 435 or TI 545. The Model of the PLC will vary with the size of the UV system. Controls shall be provided to allow on/off operation of individual UV lamps, on/off operation of (1) chemical feed pump, and shut-down of the UV system.

Alarm contact closures shall be provided on:

1) high temperature in lamp drive enclosure
2) low water flow (adjustable)
3) high water temperature
4) moisture in lamp end enclosure
5) access door opening
6) remote contact closure (10 amp, 120 VAC)
7) low peroxide pressure
8) low peroxide splitter flow (if splitter is provided)
9) overpressure relief flow
10) low oxidation chamber water level
11) tube cleaning system failure
12) lamp low current detection (shut-down optional)
13) lamp contactor failure
14) Emergency Stop
15) Primary Ground Fault
16) Secondary Ground Fault

Alarm conditions shall be displayed on the touchscreen with "First Out" indicator.
Flow indicator calibrated in gpm, with totalizer, shall be provided.
A system to indicate the operating status of each lamp shall be provided.

An elapsed timer meter shall be provided to indicate the number of hours of module operation. Timer shall be resettable with access codes.

H_2O_2 Feed

Connections for injection of H_2O_2 in quantities suitable for the process shall be provided. If required by the process, means for complete mixing of the H_2O_2 and process water, and for variable, staged injection shall be provided.

HS4

Automatic Cleaner

The UV oxidation system shall incorporate an automatic quartz tube cleaning system, programmable by the user for variable operation period frequency and duration dependent upon the requirements of the installation. Cleaner shall be constructed of stainless steel and/or UV resistant materials. The tube cleaner control system shall be capable of changes in both frequency of operation cycles and duration of each cycle. It shall also be capable of automatic variation of these cycles in response to changes in flow rate or signals from a remote control system based on, for example, effluent contaminant concentration.

The tube cleaner mechanism shall not require sliding shaft seals through the wall of the oxidation chamber. It shall effectively wipe the lamp tube to prevent accumulation of deposits that interfere with transmittance of UV light from the lamp. To prevent accumulation of deposits on the wall of the oxidation chamber the wiper shall also clean the inside of the oxidation chamber. The interior of the oxidation chamber shall be finished in a manner to minimize deposits of material.

The wiper mechanism shall wipe any point opposite the UV lamp a minimum of 4 times per pass. For extended tube wiper life, the wiper shall be retained in a recess away from the UV lamps so that it is shielded from UV light during the period between cycles. For even wiper wear distribution, the wiper shall be free to rotate around the longitudinal axis of the quartz tube.

Assembly

Oxidation chamber, control enclosures, instrumentation, controls, and piping shall be shop assembled on a skid and disassembled only as necessary for shipment. Lamps and supports to be shipped separately.

5. Installation, Start-up, and Operator Training

Supplier will supervise initial placement of all equipment provided in this specification.

The mechanical and electrical hookups by others shall be completed per schedule mutually agreed upon by all parties.

Upon completion of installation the equipment supplier shall hydrostatically test all pressure systems provided by this specification. If leaks occur, necessary corrections shall be made and retested until completed without any evidence of leakage. All electrical circuits and equipment shall be tested for continuity and functional performance.

All surfaces to be contacted by H_2O_2 shall be properly passivated by the equipment supplier.

In addition to the above, during a scheduled start-up period of five (5) calendar days, the equipment supplier shall provide start-up operation of the systems furnished by this specification. The Field Service Engineer shall operate the equipment, make all adjustments and calibrations necessary to allow operation at full load for a 24-hour period. Representative samples will be taken as required to determine performance. During this period, the owner's operating personnel are to be trained in the operation and maintenance of this equipment. Any materials deemed defective during this period are to be replaced.

6. Certified Dimension Drawings

Two (2) sets of certified dimension drawings will be furnished.

7. Operation and Maintenance Instructions

Three (3) complete Operation and Maintenance Instruction Manuals will be furnished.

8. Safety

Formal safety policies and procedures for laboratory, manufacturing and field operations activities shall be documented. Supplier shall have a Safety Committee which meets regularly to review and establish safety policies. All equipment shall be designed and constructed to adhere to regulatory requirements and practical consideration. Consideration shall be given to personnel safety during both operation and maintenance of the equipment. The following information outlines the safety features.

1. Changing Lamps and Quartz Tubes. Both lamps and tubes are reliable when handled by proper procedures. However, being quartz they are subject to breakage if dropped or struck on another object. Accordingly, all maintenance on lamps and tubes is done by a technician without the need for ladders, scaffolds or other elevation means.

2. Changing ballasts. Ballasts which may weigh up to 250 pounds are quite reliable and are infrequently changed. If changing is necessary, the unit is to be equipped with a slide out mechanism to eliminate potential personnel problems with moving and securing the ballast.

3. Opening Enclosures. All electrical enclosures are to be built with interlock high voltage position switches which will shut down power to the unit if they are opened.

4. UV Exposure. The units shall be designed such that operators cannot be subjected to UV light.

5. Ground Fault Projection. In addition to conventional grounding and insulation, the unit shall employ an external groundfault sensor and a shunt trip. The shunt trip will activate when the primary or secondary exhibits a electrical short of 4 amps or greater.

6. Hydrogen Peroxide. H_2O_2 is a powerful oxidizing agent which is safe when handled properly. Safety training on handling and use of H_2O_2 is to be provided by Supplier to on-site personnel. In addition, standard H_2O_2 storage and feed equipment is to be equipped with a shower and eyewash station for personnel safety.

7. Equipment Protection. An extensive series or safety interlocks are to be designed into each module to guarantee the safety of the equipment if operating variables should significantly change during operation.

9. Quality

The equipment shall be produced under a versatile quality program that employs resolution inspections and pretested equipment which meets and complies with Quality Assurance/Quality Control Programs.

Supplier shall have a program in compliance with requirements of:

- NQA-1 - Nuclear Quality Assurance
- ANSI/ASME - American National Standard Institute/
  American Society of Mechanical Engineers
- AWWS Specifications - American Water Works Standards
- NASA Specifications - National Aeronautics and Space Administration
- Military Specifications

Supplier's program shall be an on-going QA/QC program to satisfy the provisions and requirements of:

- ASQC Q90 - American Society for Quality Control
- ISO 9000 Series - International Standards Organization

Supplier shall have qualified QA/QC personnel and a system of procedures, checks, audits and corrective activities to ensure that all research, design and performance, environmental monitoring, sampling, plus other technical and reporting actions, are of the highest reasonably achievable quality.

SPECIFICATION

Hydrogen Peroxide Storage/Feed Module

Materials of Construction:

Structural Steel Skids & Supports - carbon steel ASTM A-36 or Aluminum
Chemical Storage Vessels - HDPE
Chemical Piping - 316 stainless steel
Wetted non-metallic components - fluoroelastomers

Design Features:

Chemical feed pumps, controls, and piping will be shop assembled on skid and disassembled only as necessary for shipment.

Electrical enclosures will be weatherproof. All controls and indicator lights will be housed in electrical enclosures with hinged and lockable doors.

All wiring and electrical connections will be protected against moisture to prevent electrical short or failure. All electrical components and installation within the system will be designed, constructed and installed in accordance with the latest edition of the National Electrical Code and all applicable State and local electrical codes.

Terminals will be provided for connection of control wiring and interlocks with each UV/H_2O_2 Oxidation Module control panel.

Terminals will be provided for connection of control wiring and interlocks with each UV/H_2O_2 Oxidation Module control panel.

Operating and spare H_2O_2 pumps will be provided. Each pump will be of the positive displacement type, infinitely adjustable from 0 to 100% flow, electric motor driven for 1 ph/60 Hz/120 V power, 10 amp max. Wetted pump materials will be suitable for continuous contact with 50% H_2O_2. Piping and valves will be provided to allow use of pump for continuous injection of H_2O_2 to each UV/H_2O_2 module and to ease pump flow calibration. A pump calibration system is to be included on the skid.

Optional: Chemical storage tank will be provided with access man-way and connections for drain, H_2O_2 fill, outlet to feed pumps, and vent. Safety shower will be provided, mounted on the skid.

ATTACHMENT B

EQUIPMENT DRAWINGS

HG1

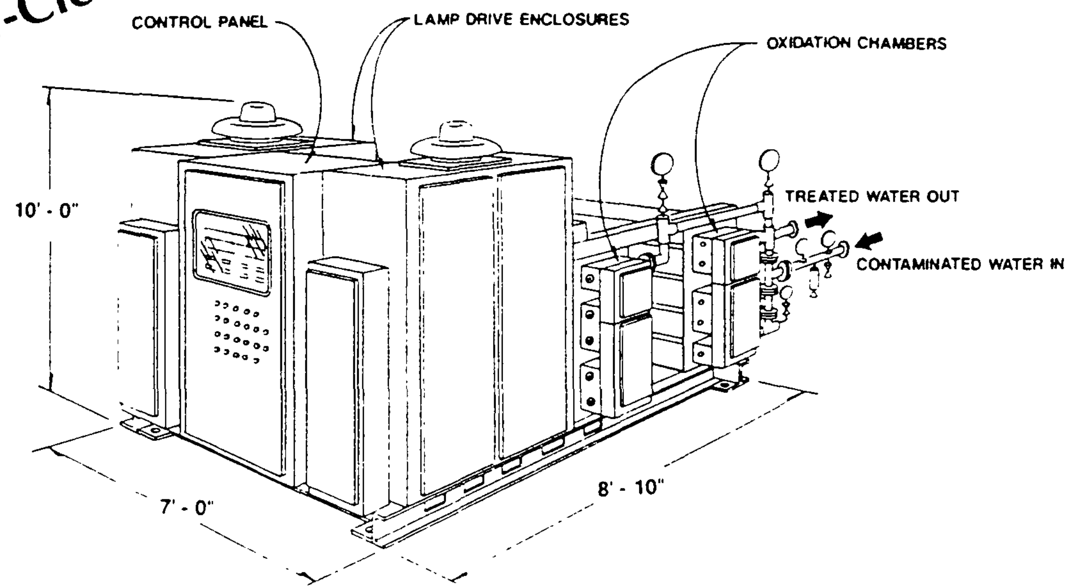
perox-puretm

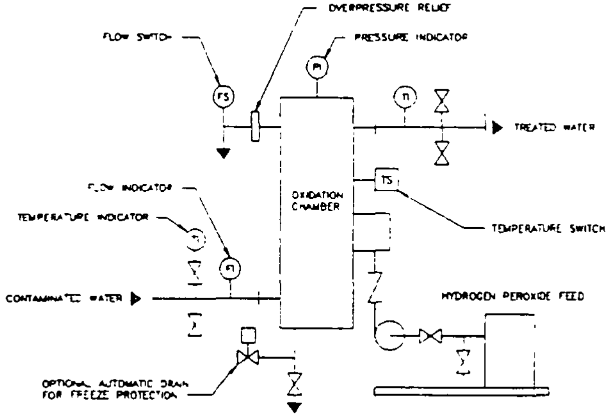
ORGANIC DESTRUCTION PROCESS

MODULAR TREATMENT SYSTEM

MODEL E-270

Self-Cleaning





SPECIFICATIONS	Model E-270	
Flow Rate:		
Maximum	200 gpm	800 gpm
Connections:	150# Flange	150# Flange
Inlet:	3"	6"
Outlet:	3"	6"
Power Supply:	3 pH/60Hz/480V, 270KW, (2 @ 135 KW)	
Electrical Encl.:	NEMA 3R	
Material -		
Wetted Parts:	Quartz, Fluoropolymers	
External Parts:	Enameled Steel	
Weight -		
Shipping:	8000 lbs.	
Operating:	9400 lbs.	

The **perox-pure**™ chemical oxidation system consists of modular, skid-mounted equipment designed to treat water contaminated by dissolved organic compounds. Bench-scale process evaluations will determine pretreatment requirements (if any) and the oxidation time necessary for the desired treatment level. Full-scale oxidation chamber volume, UV requirements and oxidant dosage are then selected.

The **perox-pure**™ system incorporates corrosion resistant fluorocarbon-lined oxidation chambers and horizontally mounted medium pressure UV lamps. Indicators are provided to monitor performance of each lamp. A sequential hydrogen peroxide addition feature provides easy process optimization for maximum economy. In addition, a patented tube cleaning device maximizes performance and minimizes maintenance time. The cleaning device is automatic and self propelled, requiring no external actuating mechanism or sliding shaft seals. Other design features include shop-wired and tested control panels interlocked with personnel and process safety features to shut-off power and display the cause at preset conditions. Installation is quick and easy.

The **perox-pure**™ system and its components are covered by numerous issued and pending patents.

Peroxidation Systems Inc.
5151 E. Broadway, Suite 600 Tucson, Arizona 85711 602-790-8383 FAX 602-790-8008

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VPSI ADDITIONAL DATA

HC 3

May 27, 1994

Mr. Craig MacPhee
ENSR Consulting & Engineering, Inc.
35 Nagog Park
Acton, MA 01720

VIA FAX NO. (508) 635-9180

RE: **perox-pure™** Treatment of the SRSNE Site Groundwater

Dear Craig:

As per our past discussions, and your recent meeting with Chris Giggy and Emery Froelich, you outlined several issues in which you would like clarification or additional information including design calculations, full-scale performance history, H_2O_2 residuals, pretreatment requirements and toxicity data. Each of these issues is addressed in detail below.

Calculations for Determining Equipment Sizing

The 30 kW **perox-pure™** system at the SRSNE site was not selected (sized) to meet a specific treatment objective. The objective at the time of installation was to provide equal or better treatment than the existing air stripper which was accomplished. Specific treatment objectives were established later in the project.

The first step in selecting a piece of equipment is to determine the rate limiting contaminant by calculating a rate constant for each organic contaminant of concern. Methylene chloride ($MeCl_2$) is the rate limiting contaminant in the SRSNE groundwater based upon the treatment criteria you projected. The rate constant for an organic compound is derived from the following pseudo-first order rate equation:

$$K = [1/t] \ln [Co/Ce]$$

Where:

K = pseudo-first order rate constant, min^{-1}
t = oxidation time
Co = influent concentration, $\mu g/l$
Ce = desired effluent concentration, $\mu g/l$

The data below was taken from the Process Assessment report presented to you in May 1994.

Contaminants	Oxidation Time (min.)			
	0	2	4	6
Test 6				
$MeCl_2$ (μg/l)	2069	672	180	24
Test 10				
$MeCl_2$ (μg/l)	2205	848	103	<1
Test 8				
$MeCl_2$ (μg/l)	2181	76	<1	<1

From the above laboratory testing data the following rate constants were calculated. When the contaminant concentration is less than the detection limit (1 μg/l), a concentration of half the detection limit is assumed.

$K = [1/6] \ln [2069/24]$
$K = 0.74\ min^{-1}$ for Test 6 (D-I, LS-A Lamp System)

$K = [1/6] \ln [2205/0.5]$
$K = 1.39\ min^{-1}$ for Test 10 (D-I, LS-C Lamp System)

$K = [1/4] \ln [2181/0.5]$
$K = 2.09\ min^{-1}$ (D-II UV Density with LS-A Lamp System)

The $MeCl_2$ rate constant was two times greater in Test 10 than in Test 6 where the only difference was the lamp system.

The assumption was made that by combining the D-II UV density with the LS-C lamp system, the $MeCl_2$ rate constant from Test 8 would increase two fold yielding the following rate constant:

$K = (2.09)\ (2)$
$K = 4.2\ min^{-1}$

Once the rate limiting contaminant has been determined, the following equation is used to select the power requirement of the **perox-pure™** equipment.

kW = [(Q)(P)/K] ln [Co/Ce]

Where:

kW = kilowatts to achieve desired destruction
Q = flow rate, gpm
P = power density, kW/gal

Based on the water tested and the information you provided, the design influent $MeCl_2$ concentration is 3000 mg/l and the desired effluent objective is 5 μg/l. The design flow rate is 35 gpm. Applying this information to the design equation, using the assumed best rate constant for the D-II UV density and the LS-C lamp system, the power requirement was determined as follows:

kW = [(35)(4)/4.2] ln [3000/5]
kW = 213

Performance History

You expressed concern with regards to the performance of the **perox-pure™** equipment which is being operated by Metcalf & Eddy (M&E) at the SRSNE site in Southington, Connecticut. As we discussed, the data you have received from that system is misleading without knowing the history of the project. The treatment efficiency has varied greatly over the term of the project as you have noted from the field test results you have reviewed. As we discussed, the **perox-pure™** equipment has not been maintained and operated under the recommended conditions due to poor operation of the pretreatment system.

VPSI personnel have made several optimization site visits to provide training and recommendations for treatment. When operated under the recommended treatment parameters, the results from the S-30 at the SRSNE site are comparable to the laboratory results. The UV density and lamp system of the S-30 are comparable to those used in Test 6 of the May 1994 Process Assessment. Figure 1 (attached) compares the destruction of $MeCl_2$, the rate limiting contaminant, for the S-30 (July 1992) and laboratory systems (April 1994). The numerical results from the July 1992 field testing and the April 1994 laboratory testing are provided on Figure 1.

You also expressed a particular interest in the acetone destruction in the field testing. Figure 2 (attached) shows the destruction of acetone under the recommended treatment conditions with the S-30 at the SRSNE site. The numerical results from the April 1993 field testing are provided on Figure 2.

<u>H_2O_2 Residuals</u>

The H_2O_2 residuals from the full-scale **perox-pure™** system at the SRSNE site have ranged from 15 to 50 mg/l when operated properly. Using the H_2O_2 consumption rate from the full-scale system, the estimated residual from the best laboratory test (Test 8) should be in the range of 25 to 50 mg/l based on the recommended initial H_2O_2 dosage of 400 mg/l.

<u>Pretreatment</u>

As we discussed, the pretreatment system supplied by M & E is not removing the iron and solids prior to treatment as recommended. The current pretreatment system is not designed to run automatically and is not well maintained. Therefore, we continue to see variability in the system performance and treatment results.

When ferrous bicarbonate is exposed to an oxidizing environment, such as inside a photochemical oxidation reactor, the iron is converted to ferric ions. In the presence of hydroxyl ions, which are present in neutral or alkaline waters, insoluble ferric hydroxide is formed. The presence of ferric hydroxide is a problem because it interferes with the penetration of UV light inside the reactor, it deposits within the reactor, and it deposits in downstream piping and equipment.

There are two primary methods of reducing the interference of iron in photochemical oxidation reactors: (1) remove the iron from the water before it enters the reactor, or (2) reduce the water pH prior to oxidation in order to keep the ferric ions in solution. When very high concentrations of iron are present, and the later method is selected, a sequestering agent may be added to assist in solubilizing the iron during treatment.

Neither of the methods mentioned above is best for every groundwater. Iron, even in soluble form, absorbs light throughout the UV spectrum and reduces oxidation efficiency. Also, ferrous iron consumes oxidant as it is converted to the ferric state. The extent of the interference of iron on the oxidation reaction will vary depending on the target contaminants and the other water quality parameters.

The only reliable method of determining the most cost effective solution to reducing the iron interference is to perform testing with and without iron present in the subject water. This type of testing is routinely performed by VPSI during bench-scale process assessments. In many cases, VPSI has found that removing the iron before treating the organics is more cost effective than leaving the iron in solution. This is determined by balancing the additional power cost for UV energy, plus the cost for acid and sequestering agents, with the cost for pretreatment equipment and chemicals. The cost for pretreatment of iron before UV oxidation is usually lower than UV oxidation treatment alone when more than 5 to 10 mg/l of iron is present in solution.

A factor that is sometimes overlooked when selecting the method of handling iron is its affect downstream of the oxidation reactor. If the iron is maintained in solution by pH reduction, caustic must be added after oxidation to readjust the pH for discharge. After raising the pH, ferric hydroxide will form. The ferric hydroxide will deposit in pipes, pumps, tanks and other equipment causing long-term maintenance issues. Depending on the discharge point, the iron must be removed anyway. These are all issues that must be addressed in a thorough evaluation.

Iron removal is not practical for some waters because of the type of organic contamination. PCBs and dioxins, for example, are contaminants that will be removed during iron pretreatment resulting in the formation of a hazardous solid waste. In these instances, iron pretreatment is not cost effective and UV oxidation treatment with iron in solution is advisable.

VPSI approaches the issue of iron in water on a case by case basis. The VPSI staff has more than 100 years of combined practical engineering experience in the water and wastewater treatment industry. Rather than arbitrarily selecting one theoretical methodology for every water, VPSI has evaluated the effects and costs for several iron handling techniques on the SRSNE groundwater water while drawing from extensive field engineering experience.

For the SRSNE groundwater, *iron pretreatment is recommended to provide the lowest* overall treatment costs. As documented in the May 1994 VPSI Process Assessment report, the destruction rate for methylene chloride, the rate limiting contaminant, was approximately two times faster when the iron was removed before the **perox-pure™** treatment. This translates to an increase in treatments costs of approximately $7 per 1000 gallons and a significant increase in capital investment. This does not include the acid and caustic for pH adjustment, or the cost of long-term maintenance on downstream equipment.

An iron removal system consisting of an inclined plate clarifier with two chemical mixing tanks, mixers, instrumentation and piping is estimated to cost $30,000. The operating cost for clarification chemicals and power is estimated to be $2 per 1000 gallons. Thus, this is the most effective solution for the SRSNE groundwater.

Toxicity

As shown in the attached report from the DNR (Attachment A), the effluent after removing the residual H_2O_2 with the pilot Peroxide Destruction Module (PDM) showed an LC_{50} of *100% for toxicity. However, the variability of toxicity of other tests shown in the same* report cannot be fully explained. It is possible that besides the obvious H_2O_2 toxicity, toxic metals released during oxidation could also result in increased toxicity. The relative non-toxic results on the raw water contribute to this hypothesis.

We believe that the toxicity of the test samples provided to ENSR may be due to residual H_2O_2 or released toxic metals. In light of this, VPSI would like to propose additional testing at our expense to determine the cause of the toxicity. We will perform the testing at no cost providing ENSR will perform acute toxicity analyses. If this is acceptable to ENSR, we will need enough water to perform three toxicity tests plus an additional 5 gallons. I will call you to discuss this option and if acceptable, arrange a suitable schedule for testing.

Given the projected maximum residual H_2O_2 concentration of 50 mg/l after full-scale **perox-pure™** treatment of the SRSNE groundwater, a VPSI PDM with 9.4 cubic feet of contact volume is recommended. The estimated price for the PDM is $3,000 to $5,000 including a carbon steel vessel with corrosion resistant liner, CPVC piping, instrumentation, and peroxide destruction media. There are no significant operating costs associated with the PDM.

FILOX
Asorbic
Acid

1 ppm
as sord

Conclusion

Craig, I trust that we have addressed your concerns and provided the information needed for your evaluation. We look forward to working with ENSR by providing the technology to reliably meet the treatment requirements at the SRSNE site and future sites. If you have any additional questions, please don't hesitate to call me at (602) 790-8383.

Sincerely,

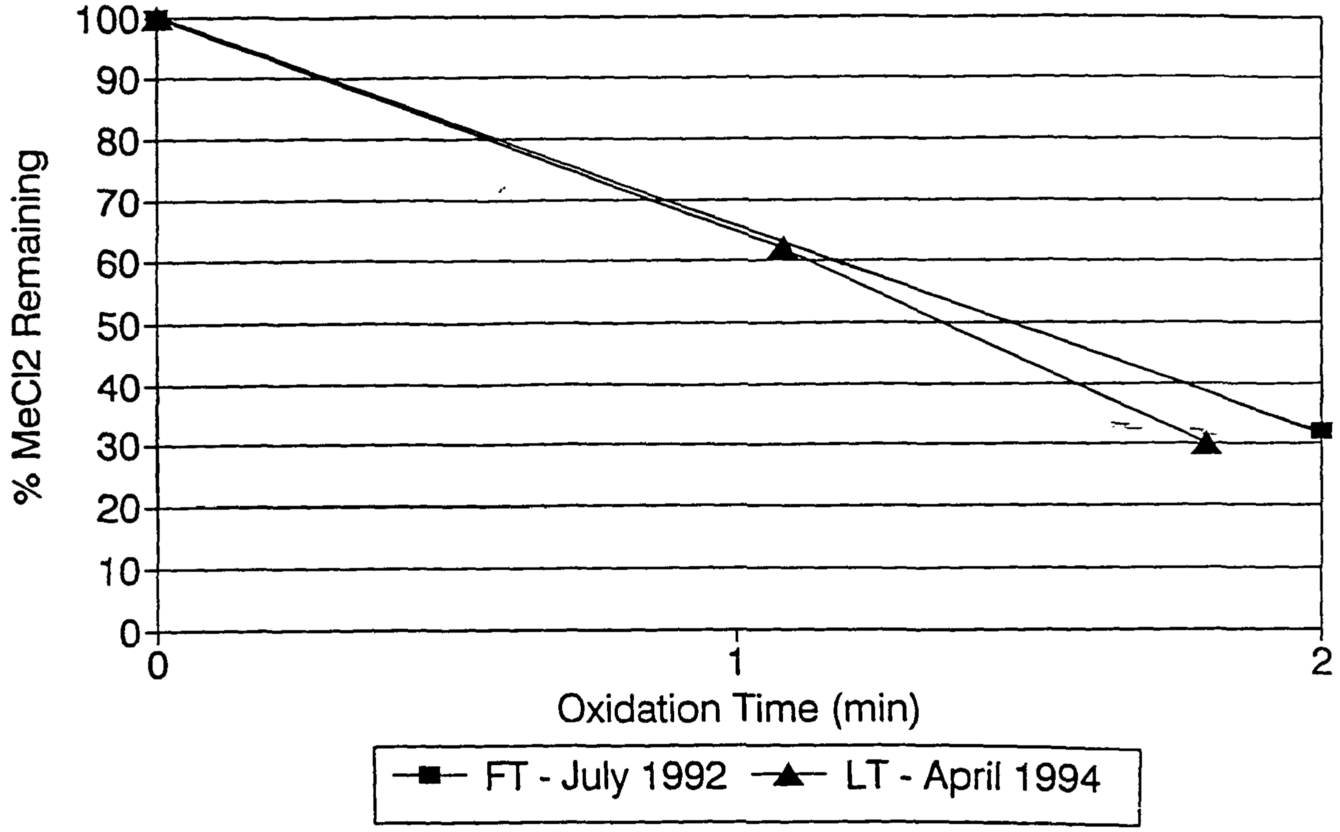
VULCAN PEROXIDATION SYSTEMS, INC.

Lisa M. Thornton
Process Engineer

cc: Fred Bernardin, VPSI - Tucson, Arizona
Vince Brunotts, VPSI - Pittsburgh, Pennsylvania
Chris Giggy, VPSI - Tucson, Arizona
Emery Froelich, VPSI - Tucson, Arizona
Mike Donaway, VPSI - Cranford, New Jersey
VPSI File

FIGURE 1

COMPARISON OF MeCl2 DESTRUCTION IN THE FIELD AND LABORATORY SYSTEMS



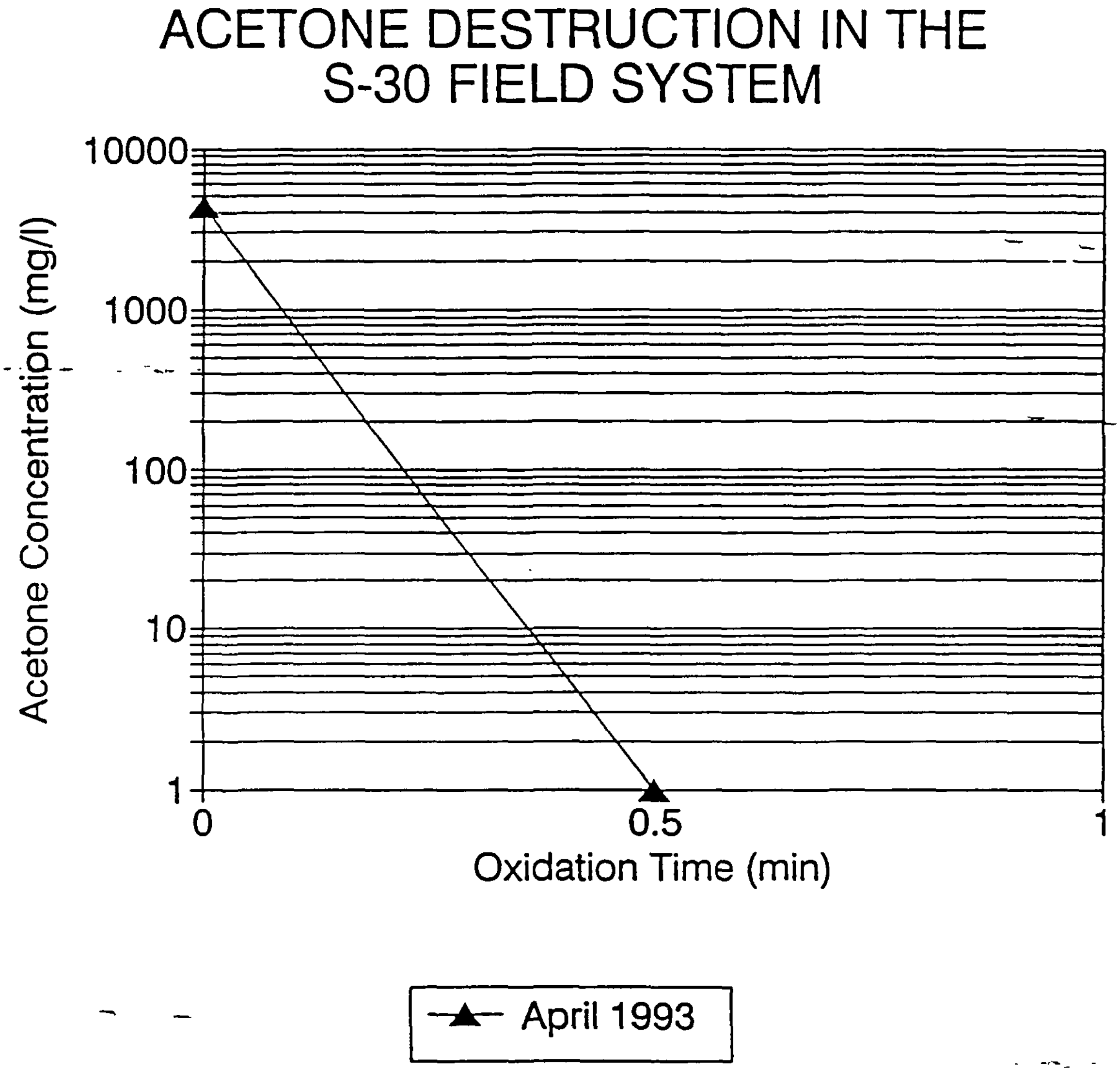
perox-pure™ Treatment Results
for the July 1992 Field Testing

	Oxidation Time (min.)		
Contaminant (mg/l)	**0**	**1.08**	**1.80**
Test 7			
MeCl$_2$	8.2	5.06	2.4

perox-pure™ Treatment Results
for April 1994 Laboratory Testing

	Oxidation Time (min.)		
Contaminant (μg/l)	0	2	4
Test 8			
MeCl$_2$	2181	76	<1

FIGURE 2



perox-pure™ Treatment Results for the April 1993 Field Testing

Contaminant (μg/l)	Oxidation Time (min.)		
	0	0.5	3
Test 2			
Acetone	4370	<2	<2

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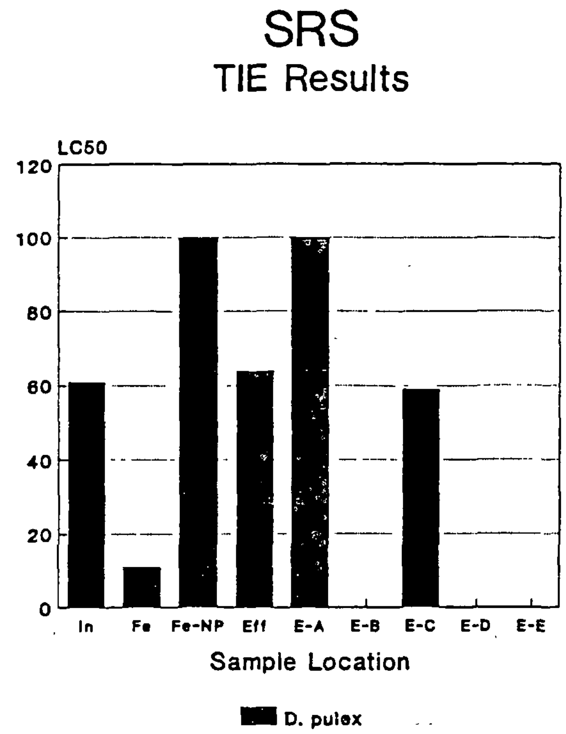
ATTACHMENT A



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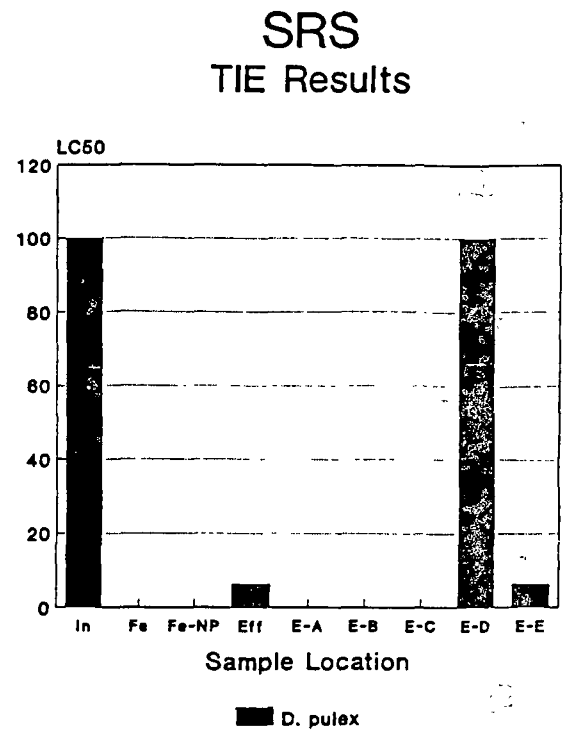

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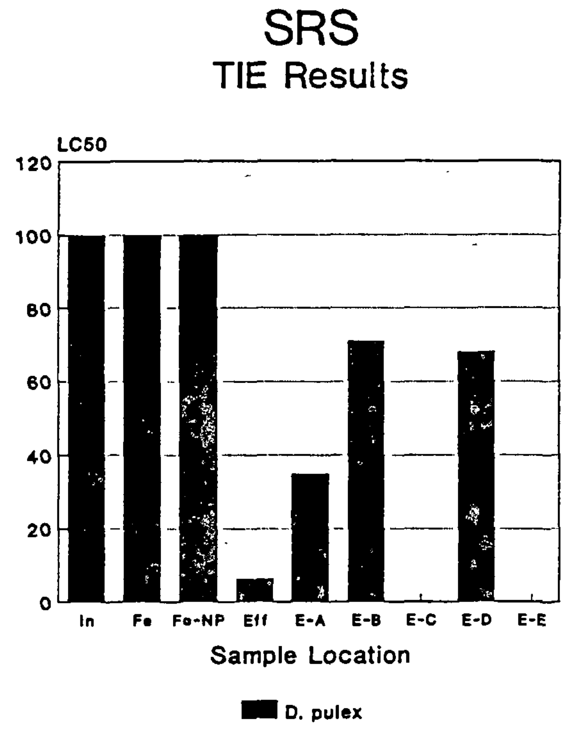
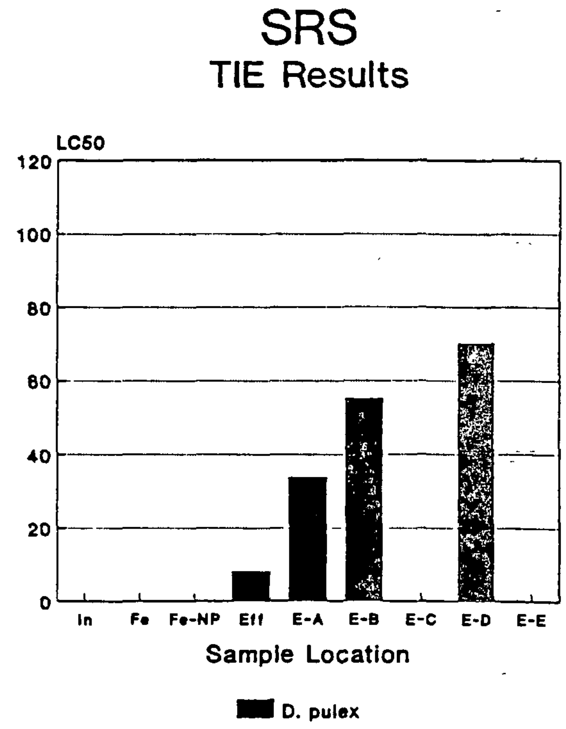


12/14/92



12/21/92

KEY

IN	Influent (Raw Groundwater)
Fe	After Fe Pretreatment
Fe-NP	After Fe Pretreatment - H_2O_2 Removed
Eff	Effluent from UV system
E-A	Effluent - H_2O_2 Removed
E-B	Effluent - H_2O_2 Removed + Filtered
E-C	Effluent - H_2O_2 Removed + Added Back
E-D	Effluent - Carbon Treated
E-E	Effluent - Carbon Treated + H_2O_2 Added